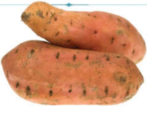



ENCYCLOPEDIA OF Cultivated Plants



From Acacia to Zinnia

Christopher Cumo, Editor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of Cultivated Plants

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FROM ACACIA TO ZINNIA

Volume 1: A–F

Christopher Cumo, Editor

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Preface

The author of Genesis placed the first humans in a garden. The word "garden" evokes images of lush vegetation, as though the writer were telling the reader that from their origins, humans have had an intimate relationship with plants. Indeed, the association between humanity and plants may predate the emergence of anatomically modern humans. By one account *Homo erectus*, one of humankind's forbearers, might have been the first to brew tea. If this conjecture is true, the link between human-like animals and plants might be more than 1 million years old. The *Encyclopedia of Cultivated Plants: From Acacia to Zinnia*, a three-volume reference work, aims to document this long relationship between humans and plants. It also seeks to convey some of the enthusiasm and affection that humans have had for plants. There is seldom a home owner or apartment dweller who does not adorn his or her residence with at least one potted plant. The home owner typically has a lawn of turf grass, an area for ornamentals, several trees, and perhaps a vegetable garden. If one considers the sheer number of plants that the home owner has, he or she may seem to appreciate them more than the family dog or cat. At its core, this encyclopedia seeks to communicate something of the magnitude of humans' dependence on plants. Even as hunter-gatherers, humans relied on plants for sustenance. This dependence only grew with the rise of agriculture. According to one tale, a poor man survived the Great Depression on a diet of only peanuts. Whether true or not, this story underscores the potent role food plants play in human existence. Without them, the human population would crash.

High school, undergraduate, and graduate students should benefit from the entries in this encyclopedia. The interdisciplinary nature of this work should attract students of botany, agronomy, plant pathology, plant breeding, genetics, taxonomy, entomology, chemistry, soil science, history, folklore, religion, anthropology, and geography. Because the study of plants is tied to the migration of humans, the student or professional who reads any of these entries will enrich his or her knowledge of geography and the interconnectedness among different groups of people and the plants that they exchanged. The most celebrated transfer of plants occurred during the Columbian Exchange, after the discovery of the New World in 1492, when people from Africa, Asia, Europe, Australia, and the Americas carried plants between the Old and New Worlds. A classic case of this transfer involved the potato, an American native plant that by the 19th century had become the staple of the Irish tenant and laborer. The late blight of potato disease that occurred between 1845 and 1849 destroyed the crop. The scientists who study late blight of potato customarily capitalize it. One million Irish perished and 1.5 million more, among them the ancestors of President John F. Kennedy, immigrated to North America. Similar plant transfers occurred countless times in innumerable places. The reader of this encyclopedia will appreciate the enormous extent to which plants have shaped history. In this sense, the *Encyclopedia of Cultivated Plants* is more than a work of science. The social sciences and humanities loom large.

Scope

Perhaps the most notable features of the encyclopedia are its globalism, its vast time span, and its interdisciplinary content. Beginning with the first appearance of *Homo erectus* about 1.5 million years ago, this reference work spans more than 1 million years to reach the present. Geographically, the *Encyclopedia of Cultivated Plants: From Acacia to Zinnia* touches upon every locale where humans have cultivated plants. The tropics, subtropics, and temperate zone all receive treatment. There are plenty of scientific treatises on plants. Far fewer are as interdisciplinary as this study.

The 282 entries in this work include crops, ornamentals, and trees harvested for timber. Plants are listed under their common names because it is by these forms that the nonspecialist knows them. One does not speak of "a delicious *Lycopersicon esculentum*" but simply of "a delicious tomato." Wherever possible, this encyclopedia also furnishes the names of the plant family, genus, and species, which not only are widespread in the scientific literature but also permit more precise description. Many entries will discuss cultivars, shorthand for cultivated varieties. Because all the plants in this encyclopedia are cultivated, there is no distinction between a cultivar and a variety. Because of this work's focus on the importance of plants to humans, the major crops—corn, rice, potatoes, soybeans, sugarcane, wheat, and many others—receive extended treatment. The 26 contributors who wrote the entries in this work include professional botanists and plant pathologists, some who hold a terminal degree. Others are historians, folklorists, gardeners, and writers, and many who have made plants their avocation. Each entry concludes with at least two references for further reading or research.

The encyclopedia also includes an introduction to the topic of cultivated plants, providing background and a historical overview of plants and human civilization, including their economic, nutritional, social, cosmetic, and religious uses, and plant scientists may be discussed. The end of the third volume of the *Encyclopedia of Cultivated Plants* provides a selected bibliography of recommended print resources and a list of organizations and their Web sites. Many of these groups, botanical gardens, and agencies provide additional authoritative information about cultivated plants in their online offerings. The encyclopedia concludes with a comprehensive index.

Acknowledgments

A work of this kind requires the talents of many people. I thank the contributors. Their efforts were essential in completing a project of this scope. Without them, this encyclopedia would have been a lonely undertaking. I also wish to thank my acquisitions editor, David Paige, who responded enthusiastically when I proposed this three-volume work. Alexander Mikaberidze deserves thanks for shepherding me through the first one-quarter of the writing process, and Senior Development Editor Anne Thompson deserves thanks for helping me negotiate the last three-quarters of the journey. My daughters, Francesca and Alexandra, deserve special mention. They are adolescents now, and every day brings forth fresh confirmation of their many gifts. No father could be prouder of his children than I am of mine. Lastly, I thank my wife, Gerianne. Although she does not share my interest in plants, she did not protest too loudly the countless hours of research and writing that went into this project.

Please Note

Many of the entries in this book refer to health properties of the plants discussed. The information presented here is not intended to diagnose or suggest treatment, or substitute for consultation with a qualified medical or mental health professional. Information presented here is not intended to endorse or recommend any treatment, medication, product, or service. Especially in the case of diagnosis and treatment of health disorders, this book is intended only to provide information and resources for the reader to access other valid sources of information.

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"Without Plants We Would Not Be Here": An Introduction to Cultivated Plants

Because plants have an evolutionary history, their definition has evolved over time. This encyclopedia, concerning cultivated plants, spans only the last 10,000 years and so is concerned with the definition of the modern plant. As used in this text, the word "plant" means a multicellular organism with two parts: root and shoot. The root is the part or parts of a plant underground: roots and underground stems (if it has any). The underground stem may be swollen, as in the case of the potato. The roots too may be swollen, as in the case of the sweet potato. Although both are called potatoes, they are not closely related. The shoot is the part of a plant above ground and includes stem, leaves, buds, and flowers, fruit, and seeds, if it has any of the last three. Along with algae and some types of bacteria, plants photosynthesize, converting sunlight, carbon dioxide, water, and elements from the soil, the most important being nitrogen, into sugar and oxygen. Because plants absorb carbon dioxide and release oxygen, they have over time altered the atmosphere, giving it enough oxygen to support the myriad animals that inhabit Earth. Without plants, we would not be here.

Classification and Nomenclature

All plants are members of the plant kingdom, the kingdom being the largest division of organisms. Below the kingdom in descending order of size are phylum, class, order, family, tribe, genus, and species. Wherever possible, this encyclopedia furnishes the names of the family, genus, and species. All grasses, for example, are members of the Gramineae or Poaceae family. The grass corn is a member of the genus *Zea* and the species *mays*. The scientific name for corn is thus *Zea mays*. The name of the genus and species are italicized. The names of all the taxa above the genus are not italicized. Further, the generic or genus name is capitalized and the specific or species name is all lowercase letters. The 18th-century

Swedish naturalist Carl Linnaeus was the first scientist consistently to use this system of naming plants and animals, the binomial nomenclature. Although scientists admit the existence of common names for plants, they prefer the binomial system because its names are precise. No two plants share the same scientific name. The parlance of ordinary names, however, does not permit this precision. In the United States, for example, corn is *Zea mays*, whereas in Europe corn is a generic term for grain. This encyclopedia uses corn in the American sense to mean only *Zea mays*. In the *Encyclopedia of Cultivated Plants: Acacia to Zinnia*, plants are listed first by their common name, which is the most familiar name for most nonspecialists. The scientific name for plants may include the name of the discoverer of a new plant or the name of someone being honored, such as the plants known as *Rudbeckia* (familiarly known in the United States as black-eyed Susan or coneflower plants). *Rudbeckia* was named by Carl Linneaus in honor of his Uppsala University professor Olof Rudbeck the younger (1660–1740) and his father, Olof Rudbeck the elder (1630–1702), who were botanists.

Scientists divide all plants into nonvascular plants or the bryophytes and vascular plants or tracheophytes. The nonvascular plants are the more primitive and include mosses, liverworts, and hornworts. The vascular plants may be seedless, as are the ferns, whisk ferns, horsetails, and club mosses. The vascular plants that produce seeds are either gymnosperms or angiosperms. The gymnosperms include conifers, cycads, ginkgo, and gnetophytes. The angiosperms or flowering plants are either monocots, germinating a single leaf, or dicots, germinating a stem with two leaves. The monocots include palms, grasses, orchids, and lilies. The dicots include a large number of plants, among them legumes, roots and tubers, vegetables, and fruit trees. The angiosperms include all the crops on which humans depend.

The Origin and Evolution of Plants

Algae arose 1.2 billion years ago, marking a milestone in the history of life because they were capable of manufacturing their own food by photosynthesis. From algae, the first plants evolved between 630 and 500 million years ago. Algae may have given rise to nonvascular plants, which in turn evolved into vascular plants. It is also possible that nonvascular and vascular plants, taking separate pathways, evolved from algae. Scientists favor the first hypothesis. The first plant may have originated from a type of algae that had filaments and lived in fresh water. These ponds may have dried up during periods bereft of rain. This protoplant must have evolved tolerance for aridity that made it possible to dwell on land. The evolution of vascular plants tied the fate of plants to terrestrial conditions. They had an outer layer that was waterproof to conserve water, and stomata that could close during periods of water stress. The vascular system of these plants, able to transmit water and nutrients over distances, allowed plants to grow tall. Height gave vascular plants an advantage because they were not shaded by neighboring flora and so could make full use of sunlight. Roots may have arisen early during the evolution of plants. Fossilized soil from the Late Silurian Period (about 420 million years ago) may bear the imprint of roots, but fossilized plants from this time do not appear to have roots. Leaves arose about 360 million years ago and may have first been spikes to deter herbivores. Over time they expanded and flattened to provide a large surface area to capture sunlight. In the Late Devonian Period (about 360 million years ago) arose the first plants with seeds. The first conifers, arising about 310 million years ago, were adapted to arid conditions and radiated across the land between 248 and 206 million years ago. The angiosperms, evolving about 140 million years ago, spread rapidly in the mid-Cretaceous Period, about 100 million years ago. By 65 million years ago, angiosperms totaled 70 percent of the world's flora. Today, angiosperms tally 300 to 400 families and 250,000 to 300,000 species. Evolving between 65 and 50 million years ago, the grasses total 10,000 species today, among them the grains and sugarcane on which humans erected civilization.

The Origin and Development of Plant Cultivation

Humans have always depended on plants. Even as hunter-gatherers, they must have obtained a large portion of their calories and nutrients from edible roots, tubers, grasses, nuts, and berries. Between 10,000 and 4,500 years ago, people in at least seven regions of the world began to cultivate plants. They planted seeds and portions of a root or tuber, weeded the soil to keep other plants from competing with theirs, irrigated their plants, and harvested them. This change in the relationship between plants and people occurred gradually, over millennia, though the process is called the Neolithic or Agricultural Revolution. The deliberate cultivation of plants marked a watershed in human existence. As a rule, agricultural societies produced more food than did hunter-gatherers, making possible large populations. Migration was no longer necessary to follow game. Farmers became sedentary and founded civilization. All of the subsequent inventions—writing, the wheel, the plow, the monotheistic religions, the automobile, the airplane, the computer, and so much else—were the product of plant cultivators.

The first people to cultivate plants appear to have lived in western Asia, in a region known as the Fertile Crescent, bound by the Mediterranean Sea in the west and Mesopotamia in the east. The first cultivated plants were barley, wheat, lentils, and the pea. About 10,000 years ago, the inhabitants of Jericho in the Jordan Valley, and Jarmo, Iraq, may have been the first to cultivate plants, emmer wheat (a type no longer cultivated) being possibly the earliest domesticate. The pea and lentil may have been domesticated about this time. Eikorn wheat (another type no longer cultivated), native to Turkey, may have been domesticated near Damascus, Syria, about 9,700 years ago and along the Euphrates River about

9,500 years ago. At the same time, barley became an important domesticate. Farmers grew barley with two rows of seeds near Damascus about 9,700 years ago and barley with six rows of seeds approximately 9,500 years ago. The domestication of wheat and barley over the 300 years between 10,000 and 9,700 years ago appears to have been a rapid event. From these early beginnings, the cultivation of wheat and barley spread throughout the Fertile Crescent and Turkey by 6000 BCE.

From western Asia, agriculture spread to Mediterranean Europe, Egypt, and North Africa between 6000 and 4500 BCE. Trade between the Levant and the rest of the Mediterranean brought hunter-gatherers in contact with the farmers of the Near East. This intercourse between farmers and hunter-gatherers brought the idea of agriculture and the seeds of cultigens to the latter. Italy and Greece were early adopters of plant cultivation, and agriculture in Mediterranean Europe may have predated its rise in Egypt about 4500 BCE. Sub-Saharan Africa depended on a different suite of crops: millet, sorghum, and rice. Millet and sorghum must have been prized for their drought tolerance. Farmers may have domesticated sorghum about 4000 BCE in the central Sahara Desert and millet about 3000 BCE in the southwestern Sahara. Africans domesticated rice, a different subspecies than Asian rice, about 200 CE along the Niger River.

In East Asia, the valleys of the Yellow and Yangtze Rivers may have been the regions of the earliest plant cultivation. The earliest cultivation of rice in East Asia is not settled. One thesis holds that farmers domesticated rice along the Yangtze River about 6500 BCE and later spread it to Southeast Asia and India by 4000 BCE. At first farmers grew rice in paddies and only later adopted cultivars suitable for dry-land cultivation and others suitable for cultivation in deep ponds. A cultivar is shorthand for cultivated variety. Because all plants in this encyclopedia are cultivated, there is no real distinction between a cultivar and a variety. Millet appears to have been first cultivated about 5500 BCE along the Yellow River. Southeast Asia arose as a separate site of plant cultivation. Farmers there may have domesticated taro, yam, arrowroot, coconut, sago palm, citrus, banana, and breadfruit. To this suite of crops, most scholars believe rice to be a latecomer, though Southeast Asia is today a land of rice farmers.

In the New World corn, beans, and squash dominated agriculture from Argentina to southern Ontario. In South America, farmers grew manioc and sweet potato and in the Andean highlands potato and quinoa. Farmers in Mesoamerica were the first to cultivate corn, beans, and squash more than 5,000 years ago. Of the three, corn was probably the earliest domesticate, being grown in the Tehuacan Valley of Mexico as early as 5000 BCE. The people of Mexico and the Andes independently domesticated beans, including the lima bean. In Mexico, corn and beans may have been domesticated around the same time. The people of the Andes domesticated four tubers: oca, moshua, ullua, and potato, the last being a world staple. In the central Andes, the potato may have been domesticated between 3000 and 2000 BCE. From its center in southern Mexico, corn migrated both south and north, reaching the American Southwest by 1200 BCE and the eastern woodlands by the time of Christ. In Mexico, South America, and the eastern United States, farmers domesticated goosefoot about 2000 BCE. In addition to goosefeet, the woodlands Native Americans added march elder and sunflower about 2000 BCE. They also grew squash, an import from Mexico. About 1000 BCE, farmers grew corn and squash in the Southwest, though only by the time of Christ was corn important in this region. Only about 1000 CE was corn dominant in the eastern woodlands.

The Major Groups of Plants in this Encyclopedia

Grasses are arguably the most important group of plants for sustaining civilization. The great civilizations of Mesoamerica laid a foundation on corn culture. China depended on rice and millet, the Near East and Egypt on wheat and barley, Europe on wheat, barley, oats, and rye, and sub-Saharan Africa on millet and sorghum. Humans rely on a precariously small number of grasses for sustenance: corn, wheat, rice, barley, oats, rye, millet, and sorghum. All grasses are monocots and account for 25 percent of the world's flora. The cereals are annuals whereas turf grass and sugarcane are perennial. The flowers are plain and may lack petals and sepals. Some grass flowers are perfect, bearing both male and female parts in each flower, but corn bears separate male and female flowers, an attribute that made it suitable for the spectacular success of 20th-century plant breeding. Wheat, rice, and corn account for half the calories consumed worldwide. The grass sugarcane is the world's principal source of sugar, being rivaled only by sugar from sugar beet and high-fructose corn syrup from corn.

Legumes include several world crops: soybeans, beans, peas, and peanuts. The soybean is the principal legume of Chinese civilization. The peanut has nourished the civilizations of South America and Africa. Farmers have long grown beans throughout the Americas. The pea has long been a staple of the Near East and Europe. The Romans prized peas, lentils, and chickpeas. They knew that legumes enriched the soil, though they were not aware of the science of nitrogen fixation. In the nodules of legume roots live bacteria that combine nitrogen and oxygen into nitrate ions and nitrogen and hydrogen into ammonium ions, both of which plant roots readily absorb. It is in this sense that scientist say that legumes fix nitrogen in the soil. Because legumes enrich the soil, a soybean-corn rotation is ubiquitous in the Corn Belt. In some states of the Corn Belt, Ohio for example, soybeans occupy more acreage than corn. All legumes are in the Fabaceae or Leguminosae family. In addition to food legumes, alfalfa and clover are also legumes and, along with soybeans, nourish livestock.

Roots and tubers flower and produce seeds, though farmers have for millennia propagated them vegetatively. Remarkably productive, roots and tubers yield the most food per acre of any crop. They may have gained popularity in part because during wars soldiers carried off grain but did not bother to dig up roots and tubers, leaving the peasant something on which to subsist. Among roots and tubers are the world crops cassava, yam, sweet potato, and potato. We have noted that tubers and roots are not the same types of crop. A tuber is an enlarged underground stem whereas a root crop is a swollen root. Tubers and roots evolved as nutrient storage organs that survived unfavorable conditions. When the rains returned, a new plant germinated from the tuber or root.

In the parlance of the workaday world, fruits and vegetables are often confused with one another. A fruit is the ripe ovary of a flower containing seeds. According to this definition the tomato, often considered a vegetable, is really a fruit. Among fruits are the world crops tomato, apple, peach, cherry, apricot, coconut, olive, banana, plantain, grape, citrus, pear, date, fig, and pineapple. Nuts are also fruits. Botanists classify coffee and cacao as fruits, adding to the list of world crops. Americans tend to think of fruits as dessert, but in the tropics bananas and plantains are staples. The tomato is the most popular fruit of the home gardener. Coffee is the beverage of millions of people worldwide. The grape is the source of wine, the principal beverage of Greco-Roman civilization. Olive oil is a staple fat in the Mediterranean Basin.

This encyclopedia uses the term "vegetable" in a narrow and technical sense to mean the vegetative part of a plant. The leaves of some cultivated plants—lettuce and cabbage for example—are vegetables. The vegetable garden, where it is still tended, is a source of pride. During World War I and World War II, the U.S. government encouraged home owners to plant a Victory Garden. Too often the produce of a vegetable garden is not vegetables. The typical home garden may have beans and peas (legumes), tomatoes (fruit), potatoes (tuber), carrots (roots), and cauliflower and broccoli (flowers). Among true vegetables, cabbage sustained the medieval peasant, and the Irish ate it with potatoes in a diet that was otherwise bland. Today, lettuce may be the most popular vegetable. The McDonald's Big Mac would be just a hamburger without lettuce. Indeed, fast-food restaurants are avid consumers of lettuce.

Fiber crops are used to make cloth, rope, paper, baskets, and other items. Cotton is a world crop, though its history is darkened by its association with slavery in the United States. Half the world's textiles come from cotton. Less important is flax, the source of linen. Flax was to ancient Egypt what cotton is to the modern world, though today linen accounts for just 2 percent of the world's textiles. Plants of the genus *Corchorus* are made into jute, a fiber with many uses. Papyrus was once a writing material. Cannabis yields hemp.

Trees that yield lumber are of two types. Hardwood derives from angiosperm trees whereas softwood comes from conifers. About 35 percent of the world's forests are conifers, though in North America coniferous forests are more extensive than hardwood forests. The United States and Canada yield more lumber than any other nation. About half the wood harvested in the United States is used in construction. Conifers are favored for the construction of homes. Oak is the world's chief hardwood tree. In the developing world, people use wood as fuel and for cooking in addition to its use in construction.

Carnivorous plants have long inspired fascination and in some cases disbelief. Linnaeus refused to believe that the Venus's Fly Trap ate insects. The 19th-century English naturalist Charles Darwin was so fascinated by the Venus's Fly Trap and its ilk that he wrote a whole book about them. Science fiction writers have described plants large enough to eat humans. Carnivorous plants are a favorite of plant enthusiasts and are easy to care for. Earth is home to seven families, 15 genera, and about 600 species of carnivorous plants ranging in size from the diminutive bladderworts and Venus's Fly Trap to three-feet-tall pitcher plants. The large carnivorous plants are not simply insectivores. They trap rodents, birds, frogs, and lizards. These plants attract prey with fragrance and colorful flowers. Carnivorous plants exude juices that consume the soft tissue of an insect, leaving only the exoskeleton intact. Some plants exude a chemical potent enough to dissolve even the exoskeleton. These plants evolved the carnivorous habit to supplement the dearth of elements in their poor soils.

Economic, Social, and Religious Significance of Plants

The world's economy rests on a foundation of plants. Depending on the productivity of plants, agriculture is the largest sector of the economy in many parts of the world. Humans use all parts of a plant as food: roots, tubers, leaves, flowers, fruit, and seeds. Trees supply lumber and paper. Fiber crops yield textiles. Ornamentals are prized for their beauty. The tulip once commanded outrageous prices. Some plants—cinchona is an example—supply medicine, whereas others alter one's consciousness. In the developed world, humans drive cars, heat and cool buildings, and generate electricity by burning coal, oil, and natural gas, the remains of plants from the Carboniferous Period. In the developing world, people cook and heat their homes by burning firewood. In ancient Mexico, corn kernels were currency. There is scarcely an economic activity that does not involve plants. Even the typing of this manuscript would be impossible but for the electricity generated by a coal- or natural-gas-fired power plant.

Plants are a status symbol. A well-manicured lawn announces the presence of a devoted home owner. Not only must it be well kept, the lawn must be a monoculture of turf grass. Weeds, especially dandelions, reveal the home owner to be careless and lazy.

Because they yield abundantly, many plants have been thought to be aphrodisiacs and have been associated with fertility rites. In the United States, well-wishers shower a bride and groom with rice to ensure that they will have many children. In the *Epic of Gilgamesh*, the goddess Inana nurtured a sacred tree. The Garden of Eden had an abundance of plants, among them the Tree of Life and the Tree of the Knowledge of Good and Evil. Jewish tradition holds that the Tree of Life conferred immortality on the first humans, but in eating from the Tree of the Knowledge of Good and Evil they became mortal and lost paradise. The author of Psalm 104 credited God with planting cedars on Earth. The Hebrews and Egyptians regarded the date palm as a symbol of longevity given its ability to survive arid conditions. According to legend, the prophet Mohammed built a mosque in Medina from date wood. The Koran mentions the date palm more than 20 times. The Christmas tree commemorated a pagan festival before Christianity co-opted it. The Egyptian sun god Ra traveled across the sky in a boat of cedar. Osiris was the Egyptian god of vegetation. The goddesses Demeter of Greece and Ceres of Rome ensured the bounty of the harvest. The Aztecs worshipped Pitao Cozobi, the corn god.

The Role of Plants in Human Nutrition

Plants are the foundation of sound nutrition. The U.S. Department of Agriculture's Food Pyramid recommends that one consume 6 to 11 servings of whole grains per day: brown rice or whole wheat bread, for example. Modern methods of processing strip the bran and germ, and with them vitamins and minerals, from grains, yielding white rice and white bread. Nutritionists recognize that one should eat the whole grain, including the bran, to obtain optimal nutrients and fiber. Whole grains supply carbohydrates, protein, vitamins, minerals, and little fat. In this group may be added roots and tubers, which supply carbohydrates, vitamins, and minerals, but little protein and fat. Although the quantity is not large, the quality of protein in the potato rivals the protein in egg whites. Orange-fleshed sweet potatoes are rich in beta-carotene, the precursor of vitamin A. The Food Pyramid suggests three to five servings of vegetables. The green leafy vegetables—spinach, Swiss chard, lettuce, and cabbage—contain vitamins and minerals but little protein and fat. The Food Pyramid recommends that a person eat three or four servings of fruit, which supply vitamins and minerals. Citrus fruits have long been renowned as a source of vitamin C. The Food Pyramid includes two or three servings from the meat group, including legumes. Legumes are a source of protein. Although legumes may not supply all essential amino acids, when combined with whole grains they have a balance of amino acids. A dish of beans and rice, for example, supplies all essential amino acids. Nuts, also part of the meat group, supply protein and fat. The sugar from sugarcane or sugar beet supplies calories but no nutrients. Roots, tubers, legumes, and whole grains supply starch. Fruits, vegetables, whole grains, and legumes have fiber. Oil from olives, peanuts, and canola contains monounsaturated fat. Oil from corn, soybeans, and safflower supplies polyunsaturated fat. Coconut oil, palm oil, and cocoa butter have saturated fat.

Leafy greens and yellow- and orange-fleshed roots supply beta-carotene. Seeds and leafy greens contain vitamins E and K. Whole grains, legumes, seeds, and nuts are good sources of thiamine. Whole grains and leafy greens provide riboflavin. Seeds and legumes are rich in niacin. Fruits and leafy greens have vitamin B6. Fruits, seeds, leafy greens, and nuts contain pantothenic acid; legumes, whole grains, and vegetables folic acid; legumes and vegetables biotin; and fruits and vegetables vitamin C. Whole grains, nuts, fruits, vegetables, legumes, and seeds are sources of minerals. Leafy greens and seeds supply calcium, and leafy greens, fruits, legumes, and whole grains contain iron.

The Biogeography of Cultivated Plants

The biogeography of cultivated plants is an area of research complicated by the fact that humans have taken these plants wherever they have migrated and so have carried them far from their origin. Of course there are limits to where cultivated plants will grow. Tropical sugarcane cannot withstand frost and so cannot be grown in the temperate zone. Temperate sugar beet is not normally grown in the tropics. Some cultivated plants are more plastic. Corn grows in the tropics, subtropics, and temperate locales. Accordingly, humans have carried it to virtually every region on Earth. Of the other grasses, oats, wheat, rye, and barley are temperate plants whereas millet and sorghum are fit for the tropics and subtropics. Initially a weed in wheat and barley fields, rye grew where the climate was too cold and dry for wheat.

Of legumes, peas, chickpeas, and soybeans are temperate plants, whereas beans, like corn, may be grown in the tropics, subtropics, and temperate locales. Peanuts are a crop of the tropics, subtropics, and warm temperate zones. Of roots and tubers, the potato is surprisingly a tropical crop, but one grown at cool elevations. Consequently, it does well in cool, temperate locales. Sweet potato, yam, and cassava are tropical and subtropical plants. The carrot is a temperate plant. Among fruits, citrus grows in the tropics and subtropics. Pineapple is a tropical crop. Watermelon is a crop of the subtropics and warm temperate zone. The tomato may be cultivated in the tropics, subtropics, and temperate region. Grapes and cherries are temperate crops, and the olive is grown in warm temperate regions. Bananas and plantains are tropical crops. Among vegetables, leafy greens are temperate crops that will bolt in hot weather. The seedpod okra may be grown in warm temperate regions and the subtropics. The ornamental tulip is a cool temperate plant, whereas the rose grows throughout the temperate zone. The fiber crop cotton grows in the tropics, subtropics, and warm temperate locales.

The Plant Scientists and Humanists

The founder of botany, Theophrastus (372–288 BCE) was born on the island of Lesbos. In Athens, he studied under Plato and Aristotle. The ancients credited him with writing 227 treatises. Of the works that survive, two are botanical: *An Enquiry into Plants* and *On the Causes of Plants*. Theophrastus named more than 300 plants and identified the male and female parts of a flower. He was aware that beans and wheat produced different types of leaves upon germination, a distinction that would lead to the differentiation between dicots and monocots.

The "father of pharmacology and herbalism" Pedanius Dioscorides (40–90 CE), known simply as Dioscorides, was a physician to the Roman armies who used plants to treat sick and wounded soldiers (Huxley 2007, 33). He listed nearly 1,000 medicinal plants, identifying antiseptics, anti-inflammatory agents, stimulants, contraceptives, and plants that enhanced fertility. His principal work on plants, *De Materia Medica*, was influential into the 19th century.

The Roman encyclopedist Pliny the Elder (23–79 CE) wrote a 37-volume *Natural History*, the only extant work by this prolific author. The volumes contain information on botany and pharmacology. He conceived botany as a science in its own right, one concerned with all plants, not merely crops and medicinals. Pliny was not entirely reliable. He believed, for example, that wheat seeds could germinate as oats. The *Natural History* was influential through the Renaissance.

Flemish physician and botanist Carolus Clusius (1526–1609) established one of the earliest botanical gardens at Leyden, the Netherlands. He bred tulips, being perhaps the first to describe the phenomenon of breaking and wrote about the plants and mushrooms indigenous to Europe.

English herbalist John Gerard (1545–1611) apprenticed with a barber-surgeon and became a physician in 1569, though plants were his real passion. He maintained a garden that gained him such renown that a member of the House of Lords appointed Gerard superintendent of his garden. An advocate of the potato, Gerard created Cambridge University's botanic garden. His *Herball* (1597) was part catalogue of plants he grew in his garden and part plagiarism of earlier works. He was interested in the culinary and medical uses of plants.

The founder of taxonomy, Carl Linnaeus (1707–1778), we have seen, applied binomial nomenclature to all life. His father was a minister who tended a garden and introduced Linnaeus to botany. His three great treatises on plants—*Fundamentals of Botany* (1736), *Science of Botany* (1751), and *Species of Plants* (1753)—made clear that the order he found in the Plant Kingdom mirrored the order God bestowed on nature. He classified plants based on the number of stamens and pistils in a flower. The Linnean Society houses Linnaeus's publications.

French botanist Alphonse de Candolle (1806–1893) studied law but like his father was more interested in botany. He used history, language, archaeology, and botany to establish the origin of cultivated plants. His works are consulted today.

Austrian monk Gregor Mendel (1822–1884) laid the foundation of genetics with his experiments with peas. He conceived of particles (genes) that coded for traits that pea plants passed to offspring. He identified genes that coded for plant height, color of the seeds (peas), and whether a pea had a wrinkled or smooth coat. These traits came in pairs—tallness or shortness, green or yellow, or wrinkled or smooth—assorted independently, and were dominant or recessive.

Russian agronomist Nikolai Vavilov (1887–1943) likewise sought the origin of cultivated plants. He reasoned that the more diverse a species, the more ancient it was and the longer it had been subject to human manipulation. These areas of diversity were the places where crops had originated. Vavilov identified seven centers of diversity, most in the Old World. It is possible, however, that a plant might have originated in a locale only to be taken to another area where it diversified. This possibility led some scientists to dismiss Vavilov's contributions to the study of plant origins. An acquaintance of Soviet revolutionary Leon Trotsky, Vavilov suffered when Soviet dictator Joseph Stalin turned against Trotsky. Stalin jailed Vavilov, where he died.

American plant breeder and plant pathologist Norman Borlaug (1914–2009) bred semidwarf wheats that launched the Green Revolution in Mexico, India, and Pakistan. He envisioned the potential of new cultivars to feed a hungry world. In his scientific work and advocacy for a humanitarian role for agriculture, Borlaug was awarded the Nobel Peace Prize in 1970, the Presidential Medal of Freedom in 1977, and the Congressional Gold Medal in 2007.

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A

Acacia

Acacia, a genus of shrubs and trees, is found all over the world. But it is more common in Australia, Africa, South Asia, Southeast Asia, and the Americas. In the plant kingdom, *Acacia* is the largest genus of vascular plants. It belongs to the subfamily Mimosoideae of the pea family Fabaceae. Globally, there are approximately 1,300 species, out of which roughly 1,000 are indigenous to Australia. The plant goes by different names depending on its inhabitation. In Australia, the plant is referred to as wattle. The national flower of Australia is *Acacia pycnantha*, the golden wattle. In Africa as well as the United States, the plant is called acacia tree. The plant possesses thorns, and hence it is also designated as whistling thorn plant. In Indian languages, the most common name of this deciduous tree is *khair* (*Acacia catechu*). The genus *Acacia* is generally divided into five species: *acacia* (species from Australia and tropical Asia), *acaciella* as well as *mariosousa* (species from the Americas), and the last two, *vachellia* and *senegalia*, for species outside Australia. Some of the common species found in Australia are *Acacia dealbata* (silver wattle), *Acacia decurrens* (tan wattle), *Acacia mearnsii* (black wattle), *Acacia melanoxylon* (blackwood), *Acacia longifolia* (coast wattle), *Acacia baileyana* (cootamundra wattle), *Acacia adunca* (wallangarra wattle), *Acacia acinacea* (gold dust wattle), and others. In the Middle East, *Acacia albida* and *Acacia tortilis* are wild plants. The *Acacia sphaerocephala*, *Acacia cornigera*, and *Acacia collinsii* species are found in Central America. In Southeast Asia, species such as *Acacia pennata* and *Acacia auriculiformis* are common.

Origin and History

The origin of the acacia's name is derived from the Greek word *akis*, which means "a thorn or barb." Discorides (ca. 40–90), the Greek botanist of the first century CE, called the plant *Acacia nilotica* in his treatise *Materia Medica*. The acacia plant was interwoven with Egyptian civilization. It was a sacred tree in its mythology. The Egyptian vessels were made from wood of the plant. First-century CE Roman encyclopedist Pliny the Elder in *Natural History* (book XIII) mentioned the utility of acacia wood and flower as well as its medicinal value. In the beginning of the 17th century, the seed of the acacia was introduced to Europe by herbalist Jean Robin from North America. Botanists and writers of the 17th century also referred to the plant. Carl Linnaeus, the famous naturalist of Sweden, described the plant in 1773. As a timber tree in the United States, it was being used in shipbuilding. It was also a good source of fuel. Acacia was cultivated widely in Kensington and Barnes of the United Kingdom beginning from the first decade of the 19th century. The plant has retained its utility in modern times for its industrial and medicinal uses.

Attributes and Cultivation

The acacia tree is short lived, grows fast, and reaches a height of 70 to 80 feet with a diameter of 3 feet. Its shape is very unusual, with branches and stems growing in an upward direction. Its leaves and flowers are on the tip of its branches. The foliage colors are varied, ranging from green to blue or silver-gray. The exquisitely divided and tiny leaflets provide petioles a fern-like or pinnate appearance. But the leafstalks of the Australian and Pacific islands species are very flat (phyllodes) and thus serve the purpose of leaves. The *Acacia glaucoptera* species is devoid of leaves but has cladodes serving the purpose of leaves. The glands of leaf and phyllode produce a sugary substance that attracts ants, bees, and butterflies. Small blooms make up the acacia flower, which looks like a yellow ball. As a bud, the blooms are white to light yellow. The tiny petals are situated behind long stamens and are positioned in globular or cylindrical clusters. Although the petals are yellow in general, they are of purple and red color in *Acacia purpureapetala* and *Acacia leprosa*, respectively. The pods or legumes contain seeds of the plant.

The cultivation of the acacia is done by seeding, grafting, and cutting. These semievergreen plants do not need much care and are very easy to grow. But certain precautions are required. The acacia plant abhors very wet soil. The acacia needs a warm climate to survive, and it cannot survive severe winter. It is put indoors in winter and taken back to the garden in summer months. Direct sunlight of six hours is necessary for the growth of a healthy acacia plant with its numerous and bright green foliage. The application of nitrogen fertilizer makes the blooms very beautiful. The roots of the plant are delicate and very much susceptible to excess water. They also grow very fast; therefore soil must be free from rocks and pebbles.

Usefulness of Acacia

The unique and colorful acacia plant, along with its products, is very useful to humankind. It increases the beauty of a garden, public parks as well as side streets, and hence is grown for ornamentation. The woolly flowers with their vivid yellow color and sweet fragrance not only beautify the environment but also help in preparing perfume. The fresh leaves as well as boiled inner bark juice have been used by some for ailments like diarrhea and stomachache. The seeds are sometimes used by those who practice folk medicine as a treatment for a sore throat. The leaf extract has been used by some as a remedy for tuberculosis. The bark of acacia is a good source of gum resin. Particularly, the gum arabic of *Acacia arabica* is of very good quality. Furniture made from acacia timber is very popular in many households. The timber from Australian blackwood is of prized quality because of its durability and high polish. Hawaii's *Acacia koa* is native to the islands and other species are native to the island of Réunion. Some indigenous people of North America were known to present blossoming branches of acacia to their loved ones. The shittah tree of the Bible is *Acacia seyal*, believed by some to be used in construction of the Ark of the Covenant. The acacia is also a symbol of the eternal soul.

Patit Paban Mishra

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Agave

There are roughly 166 species in the genus *Agave*. Although many species are cultivated around the world as ornamentals, they are native to the arid and semiarid regions between the southwestern United States and northern South America. It is in tropical highland central Mexico, however, where agaves are densest and particularly well adapted to the cool, dry conditions.

Agaves are succulents and monocarpic (they reproduce only once then die). Agaves have a large, circular arrangement of leaves that extends outward from the stem. The leaves tend to be wide and flat with spines on their edges. Because members of the *Aloe* genus tend to be more familiar to people, agaves are often mistaken for aloes. A difference between agave and aloe is that the leaf of agave is fibrous whereas the leaf of aloe is gelatinous.

In central Mexico, the Otomí- and Nahuatl-speaking cultures have cultivated agaves since the pre-Hispanic period, and the plants continue to hold economic and cultural significance among indigenous peoples. The relatively recent commercial cultivation of agaves by multinational corporations as well as cooperatives of local growers, however, has insinuated agaves into the diets of people at the global scale. The species that have dominated—and are emblematic of—

Blue agave plant (Jorge M. Vargas Jr./Dreamstime.com)

indigenous and commercial agave production are the maguey (pronounced *muh-gey*) and the blue agave, respectively.

Maguey

The maguey (*Agave americana*) typically grows 6 to 10 feet tall and up to 13 feet wide. Its leaves are 6 to 10 inches wide and 3 to 6 feet long. The plant thrives from below sea level to above 9,800 feet in elevation. It has been suggested that it was the cultivation of the maguey that enabled Mesoindians to settle permanently in the cool, semiarid highlands of central Mexico (the *tierra fría*). Maguey can reproduce both vegetatively and with seeds, but because it produces seeds only upon reaching maturity it is almost always cloned vegetatively when under cultivation. Some of the earliest cultivators, however, may have selectively planted seeds to obtain the current variety of maguey that is most useful to people.

When maguey is interplanted with annual seed crops, the density of maguey averages around 80 plants per acre. When planted exclusively, maguey density can reach 160 plants per acre. The interplanting of maguey with corn and other annual seed crops in the *tierra fría* appears to have been common among the pre-conquest natives of central Mexico. The importance of maguey as a cultivated plant generally increases as aridity increases because other staple crops, including corn, tend to be less tolerant of dry conditions. Maguey, then, provided a crucial source of nutrition during periods of drought.

Because of central Mexico's rough topography, indigenous peoples have for many centuries constructed agricultural semiterraces in order to increase the amount of land available for crop production. A single or double row of magueys is commonly planted on the embankment that separates each field on a semiterraced hillside. The maguey's lateral root system strengthens the embankment, and its wide leaves absorb the erosive impact of raindrops.

Indigenous peoples have many uses for wide leaves of the maguey. Occasionally, for want of better wood, people used the leaves for laths and roofing tiles. Withered leaves could serve as a backup supply of firewood. Women often ground corn kernels over a clean maguey leaf, which caught and preserved the fallings. Medicinal uses abounded. To treat cuts heated leaves were held over the wound, and the dripping juice served as an ointment. To treat snakebites the roots of a small maguey were mixed with the juice of a wormwood plant. A leaf's fiber could be beaten away from the pulp with a wooden club and then washed and sun-dried. This fiber could then be woven into rope, clothing, sandals, fishing nets, and a variety of other products. Occasionally, maguey and other agaves are cultivated to collect and consume the caterpillars (*Aegiale hesperiaris*) that infest their roots. These worms are rather dense sources of protein and represented a key nutritional component in the pre-Hispanic diets of native peoples.

In addition to the famine food and erosion control mentioned already, maguey does not mature in a particular season so a certain percentage of plants are available year-round. As such, in central Mexico's dry winter seasons people had nourishment when their stores of annual crops were exhausted. In the dry months when seed crops did not need tending, maguey offered people an occupation: they could spin and weave their stockpile of maguey fiber.

A maguey is most useful to people when it reaches maturity and begins to produce sap, which can take 7 to 25 years depending on climate and soil characteristics. The fermented sap of the maguey is called pulque, a beverage that is 3–5 percent alcohol. The Otomí word for it was *octli*, but it was called *pulcre* by the conquistadors and eventually came into its current corrupted form, pulque. Collecting the maguey sap, or *aguamiel*, is an involved process. A central stalk forms inside the plant when it reaches maturity. Over the next five to six weeks the stalk grows vertically out of the plant 12 to 24 feet high. During this growth period, the production of *aguamiel* is intense, and within a few months the plant dies. The first step in making pulque is to castrate the stalk just before it emerges from the plant. There is only a two- to three-week window to do this, and thus a cultivator needs to be aware of which plants are showing signs of reaching maturity and to castrate them at the appropriate time. If the castration is too late or too early, aguamiel production will be low and the taste will be poor. From a few weeks to a few months after castration, the collection of aguamiel begins. The top of the central stalk of the plant is gouged and cut to make a bowl-like cavity. A rock or maguey leaf is placed over the opening to keep out rain and animals. Scraping the sides of this bowl stimulates aguamiel production. Scraping and collection occurs twice daily for two to six months until the plant dies. During this period, the average plant will produce 132 to 264 gallons of *aguamiel*.

Pulque has continuously been used in place of water from preconquest times until the early 20th century. It was even a regular part of the diets of babies and small children. In a diet of traditional Otomí foods, pulque provides 48 percent of the vitamin C, 24 percent riboflavin, 23 percent niacin, and 20 percent iron. Traditionally, medicines that had to be drunk were mixed with pulque.

Blue Agave

In the 16th century, the fermented sap of various *Agave* species began to be distilled to produce a type of spirit called mescal. Mescal is believed to be the New World's first distilled spirit. Mescal produced from the sap of the blue agave (*Agave tequiliana*) is called *mescal de tequila*, or simply tequila. Blue agave is native to the state of Jalisco in west-central Mexico, and this region continues to be the epicenter of blue agave cultivation. Today, around half of all blue agaves are cultivated in roughly 90,000 acres around the city of Tequila in the state of Jalisco. The vast majority of blue agaves are cultivated for tequila; however, since the 1990s blue agave has been the primary species of *Agave* for producing a natural sweetener called "agave nectar." Agave nectar is produced by expressing juice from the plant's pineapple-like root bulb then filtering, heating, and concentrating it into a syrup. Agave nectar is roughly one and a half times sweeter than sugar and can be used as a sugar or honey substitute in food preparation.

Blue agave and maguey cultivation differ in some important respects. First, maguey has been cultivated for pulque for at least a thousand years, but since the early 20th century its popularity has declined as a result of competition from beer. Tequila has been produced only less than half as long as pulque, and its popularity has increased enormously in recent decades. Second, magueys are most often cultivated by individual small-scale growers who cultivate the plant for a variety of purposes. Blue agave cultivation, however, is highly commercialized and occurs almost exclusively to produce tequila. Third, the sap of the maguey needs only to ferment to produce pulque whereas the sap of the blue agave must be distilled to produce tequila. As a result, tequila can be 40 percent alcohol, roughly 10 times more alcoholic than pulque.

Richard Hunter

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Ageratum

Ageratum is a large genus of herbs and shrubs in the aster family, Asteraceae, which is native to Central America and the Caribbean. There are about 60 species of both annuals and perennials in this genus. Many cultivars of *Ageratum houstonianum* are widely grown as annuals in flowerbeds and sometimes as cut flowers. Ageratum species can become naturalized in tropical and semitropical areas and become pernicious weeds. This has been the case for *Ageratum conyzoides*. It produces a number of secondary metabolites that cause it to have both insecticidal activity and allelopathic activity against other plant species, thus increasing its efficacy as a weed. Paradoxically, it is used as a control agent for other weeds in China. *Ageratum conyzoides* is also effective at treating burn wounds and has been shown in laboratory tests to have antibacterial activity.

The genus *Ageratum* was named by Swedish naturalist Carl Linnaeus in 1753. Its name derives from the Greek *geras*, meaning "aging," and *a*, which translates to "not." This is thought to refer to the ability of the flowers to remain on the plant for a long period. *Ageratum houstonianum* is named after William Houston, the collector who obtained the first ageratum plants. The species name of *Ageratum conyzoides* is derived from the Greek word *konyz*, the name of the elecampane plant (*Inula helenium*) that resembles it.

Horticultural Uses

Often known as flossflower, ageratum is widely grown in gardens and as a houseplant in the winter. Numerous hybrids of *Ageratum houstonianum* are available in shades of lavender, white, or pink. Also available are blue flowers, which are prized, since blue is not a common color for garden flowers and combines well with other colors.

Ageratum is grown as an annual for its flowers in the summer and fall in cooler climates and over the winter in more mild areas. Many of the varieties grown are compact, remaining below 6 inches. They have many uses in gardens and are commonly used in borders, for edging, or in rock gardens. Ageratum cultivars also make good container plants. Other varieties grow to 18 inches tall and make attractive cut flowers. Some plants are grown commercially for this purpose.

While ageratum can frequently be purchased at local nurseries, it is easy to grow from seeds. They require light to germinate, and the plants perform best when kept moist. They do not have tolerance for frost and will die if exposed to it. Ageratum should be grown inside over the winter months, unless one lives in a subtropical climate. Shade is preferred in warmer climates, although plants grown in cool areas can tolerate full sun. With most cultivars, the dead flowers remain on the plants and should be removed to keep the plants flowering continuously.

Medicinal Uses of *Ageratum conyzoides*

The plant has been used in traditional folk medicine in Africa and South America to treat a variety of ailments. A common custom is to treat burns and wounds. Laboratory studies have verified the antibacterial activity of *Ageratum conyzoides* extracts against the human pathogens *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli*. Studies have been conducted on the efficacy of this plant in treating human systemic illnesses; however, the plants contain toxic pyrrolizidine alkaloids that can cause liver damage in humans.

Effects of Ageratum on Agriculture

The breadth of secondary metabolites found in this plant causes it to affect a number of other species, both invertebrate and botanical. *Ageratum conyzoides* produces the compound ageratochromene, which inhibits the growth of insects by interfering with their juvenile growth hormone. The leaves of this species of ageratum have been used as moth repellants, and extracts of the leaves have been shown to interfere with the development of a number of types of insects, including the domestic fly, a type of moth, and several types of mosquitoes. It is considered a promising candidate for the development of natural insecticides.

Another class of invertebrates affected by ageratum is nematodes. In this case, *Ageratum houstonianum* was found to suppress the growth of nematodes just by using the plants as a mulch. The research was inspired by the knowledge that *Crotalaria* species were used to inhibit nematodes because of their production of pyrrolizidine alkaloids. The production of these toxic compounds is a common trait of ageratum.

Ageratum conyzoides is one of three species of plants listed as the most economically destructive weeds in the world. It is able to invade cultivated fields and is extremely difficult to eradicate. Part of the reason is that it spreads by stolons and has wind-borne seeds, but the major factor is that the plant is allelopathic. It produces chemicals that inhibit the growth of plants around it, including crops. One strategy of weed control is to identify the chemicals responsible for this effect and incorporate them into herbicides. Another is to utilize the plant as a mulch, or even a counter crop, to help control other weeds. Such approaches fit nicely into sustainable agricultural programs. For instance, *Ageratum conyzoides* has been grown on the floor of citrus orchards in southern China for a long period. It crowds out other weeds and inhibits the growth of pathogenic fungi. Unexpectedly, there was also an increase in predatory mites when ageratum was planted. These mites cause a decrease in the levels of parasitic citrus red mites in the orchards. This effect was found to be due to volatile chemicals released from the essential oil of *Ageratum conyzoides*.

The data so far suggest that the prolific production of secondary metabolites by ageratum species will facilitate their incorporation into new and alternative methods of pest, pathogen, and weed control.

Helga George

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Alfalfa

A perennial legume, alfalfa (*Medicago sativa*) is a member of the Fabaceae or Leguminosae family and is related to clover, pea, bean, soybean, lentil, chickpea, lupin, peanut, vetch, and cowpea. Known as the Queen of Forages because it fixes nitrogen in the soil and feeds livestock, alfalfa is the world's most widely grown legume. In 1753, Swedish naturalist Carl Linnaeus named alfalfa, the genus *Medicago* deriving from the Latin *medica*, denoting the belief that the plant had originated in Mesopotamia (now Iraq). Italians knew alfalfa as *erbo medica*, meaning the "median herb." In Spanish, alfalfa is *mielgo* and in Turkish *kayseri trefoil*. Indians refer to alfalfa as *Ashue-Bal*, meaning "strength to horses," surely a reference to the practice of feeding the legume to equines. The Chinese knew alfalfa as *mu-su*. The Arabic word *ratba* means "green alfalfa," and *quatt* means "alfalfa hay." The Persian word *aspo-asti* for alfalfa means "horse fodder," suggesting the same use as in India. From the Persian, the Babylonians derived aspasti for alfalfa. In turn, the Arabs derived the term "alfalfa" from *aspasti*. The Syrians used a similar word, *aspasta*, to refer to alfalfa. The Swiss and people in other parts of Europe, South Africa, New Zealand, and Australia knew alfalfa as lucerne, perhaps because the Swiss grew alfalfa in the region of Lake Lucerne. Another

Alfalfa (iStockPhoto)

possibility is that the term derived from the Lucerne River in Italy. Alphonse de Candolle, the 19th-century French botanist, rejected both possibilities, instead asserting that lucerne derived from the French *laouzerde*.

Origin and Diffusion

Several scholars believe that alfalfa was the only forage grown in prehistory even though written records of alfalfa, when they appeared, do not date from the beginning of the historical period. By one account we have seen, alfalfa originated in Mesopotamia. By another, Iran was the homeland of the legume. Yet another broadens the geography, maintaining that alfalfa originated in western Asia, Iran, Transcaucasia, and Turkmenistan. The legume grows wild from China to Spain and from Sweden to North Africa, though humans may have assisted it in diffusing so widely. If this is correct, the wild plants may have escaped from cultivation. Having evolved in a region of cold winters and hot, dry, short summers, alfalfa tolerates cold weather, though curiously it does not yield well in hot weather, instead becoming dormant. One scientist pinpoints two regions of origin. The first, Transcaucasia, gave rise to the varieties of alfalfa grown in Europe. Having evolved in a region of frigid winters, these varieties are hardy. The second region, Central Asia, had a dry climate. The varieties that evolved there did not acquire resistance to the fungal diseases that accompanied humidity. Another school of thought traces the lineage of alfalfa to Medicago falcate. The varieties that descended from this proto-alfalfa were hardy, drought tolerant, and resistant to diseases. Alfalfa is drought tolerant because the taproot, penetrating 20 feet into the soil, absorbs underground water when the topsoil is dry. The plant tolerates drought and cold, moreover, because it becomes dormant during adverse conditions.

The earliest written reference to alfalfa dates to 1300 BCE in Turkey. Given that the cultivation of alfalfa might have begun in prehistory, it seems surprising that there are no earlier records of it. About this time, the Hittites fed the legume to livestock during winter, regarding it as nutritious. By the first millennium BCE, the people of northwestern Iran widely cultivated alfalfa. It was the fodder of cavalry and chariot horses in Iran, Greece, and Rome. Greek dramatist Aristophanes (440–380 BCE) and fourth-century Greek philosopher Aristotle mentioned alfalfa, implying that it was cultivated in Greece. In the fourth century BCE, Aristotle's pupil Greek botanist Theophrastus related the story of alfalfa's introduction to Greece. According to him, the Persians, invading Greece in the fifth century, planted alfalfa to feed their warhorses and cattle. Although the Greeks ejected the Persians, they adopted the practice of cultivating alfalfa for forage. In turn the Romans, in the second century BCE, adopted alfalfa from the Greeks. In the first century BCE, Roman agricultural writer Varro and Roman poet Virgil mentioned alfalfa. Varro recommended that stockmen seed it at a rate of 34 pounds per acre. He observed that alfalfa attracted bees. In the first century CE, Roman encyclopedist Pliny the Elder repeated Theophrastus's account that the Persian army brought alfalfa to Greece. He recommended that farmers plant alfalfa in well-drained soil, add lime to the soil, and cut alfalfa upon flowering. Pliny's contemporary, Roman agricultural writer Columella, cautioned against overfeeding alfalfa to livestock for fear of bloating. He understood that alfalfa improved the soil, though the Romans had no knowledge of nitrogen fixation. Columella believed that alfalfa could cure livestock of various ailments. One authority estimates the yield of alfalfa at 12 tons per acre in Rome. By one account, Columella planted alfalfa in southern Spain. By another, the Romans introduced alfalfa to Gaul (now France), Germany, and Switzerland in addition to Spain. The fall of Rome marked a decline in alfalfa culture in parts of Europe, though Arabs grew it in Spain in addition to North Africa. If Columella planted alfalfa in Spain in the first century, the Arab introduction in the eighth century must have marked a reintroduction of the crop. Medieval records contain few references to alfalfa, suggesting that it was not widely grown during the Middle Ages. Renaissance stockmen showed a renewed interest in the legume. In the 16th century, the Spanish reintroduced alfalfa to Italy and in about 1550 to France. In 1565, farmers spread alfalfa to Belgium and the Netherlands, in 1650 to England, in 1750 to Germany and Austria, in 1770 to Sweden, and in the 18th century to Russia.

Outside Europe, the Chinese adopted alfalfa from Turkestan in 126 BCE. In the 16th century, the Spanish introduced alfalfa to Mexico and Peru. By 1775, stockmen grew alfalfa in Chile, Argentina, and Uruguay. From Mexico, missionaries brought the legume to Texas, Arizona, New Mexico, and California. Another account holds that Chile was the source of the Californian introduction in the 19th century. In 1851, farmer W. E. Cameron planted alfalfa in the Sacramento River Valley in California, though its introduction to the state may have occurred earlier. By 1858, Cameron had 270 acres of alfalfa. Alfalfa thrived in the dry climate of the American Southwest. In 1836, Major Jacob Downing planted alfalfa in Colorado. By 1894, stockmen widely planted alfalfa in Kansas. Farmers began growing alfalfa in Ohio in 1886, in Montana by 1890, and in Iowa and Missouri by 1900. In the eastern United States, immigrants made separate introductions of the forage to Georgia in 1736, North Carolina in 1739, and New York in 1791. In Virginia, accomplished gardener Thomas Jefferson in 1793 and George Washington in 1798 planted alfalfa. Yet the acidic soil and humidity of the eastern United States were not ideal for alfalfa, and by 1899 farmers grew only a small portion of alfalfa east of the Mississippi River. By contrast, the land west of the Mississippi River totaled the majority of alfalfa acreage in 1949.

Attributes and Nutrients

Adapted to temperate regions, alfalfa does not tolerate temperatures above 95°F. Better adapted to cold weather, alfalfa withstands temperatures as low as 23°F when it is not hardened and as low as –4°F when it has undergone hardening in autumn. The short days of autumn spur the plant to harden. Alfalfa initiates hardening when temperatures dip below 50°F. A hydrated alfalfa plant cannot endure temperatures below 28°F without water freezing in its cells. In response to cold weather, alfalfa reduces the amount of water in its cells and so can withstand colder temperatures. For this reason, drought aids alfalfa in hardening. Soil moisture no greater than 50 percent of saturation helps alfalfa harden. Because saturated soil reduces hardiness, farmers should not irrigate alfalfa in autumn. Where snow insulates the land, alfalfa does not develop maximum hardiness. Excessive nitrogen and a dearth of other nutrients in the soil impair hardiness. The application of potassium and phosphorus to the soil increases hardiness. Plants with a store of carbohydrates and amino acids for the lean months of winter are hardy.

Removing more nutrients from the soil than grains, alfalfa is a heavy feeder. In 1988, one scientist estimated that the U.S. alfalfa crop removed 1.7 million tons of potassium from the soil. This amount totaled 40 percent of the potassium applied to all crops in the United States and more than twice the amount applied to corn. Alfalfa removes 10 times more potassium from the soil than an equivalent amount of corn. Cool temperatures slow the uptake of nitrogen, phosphorus, and sulfur. Alfalfa leaves contain less phosphorus, potassium, iron, boron, copper, zinc, and manganese and more calcium and magnesium in cool rather than warm weather.

Alfalfa favors a soil pH between 6.6 and 7.5, though the pH may be as low as 4 if the soil has enough calcium. As a rule, however, the yield decreased when the pH falls below 5.2 because aluminum, iron, and manganese may reach toxic levels in acidic soil. A neutral pH reduces the solubility and uptake of these elements. The addition of lime to acidic soil increases the availability of calcium, magnesium, phosphorus, and molybdenum. One recommendation holds that the farmer should add lime to the soil at least 26 weeks before planting or immediately after planting.

In addition to potassium, alfalfa is a heavy feeder of nitrogen. The legume removes more nitrogen from the soil than any other nutrient, yet the bacteria that inhabit the nodules of the roots make good much of this loss by fixing nitrogen in the soil. By one estimate, alfalfa removes 980 pounds of nitrogen per acre. One study found that alfalfa obtains 43–64 percent of its nitrogen from the bacteria in its nodules. Because of nitrogen fixation, the crops that follow alfalfa in rotation yield well. Corn in rotation with alfalfa needs 70 percent less nitrogen applied as fertilizer than corn grown in monoculture.

Alfalfa needs less phosphorus than nitrogen and absorbs it in the form of orthophosphate. The farmer should apply phosphorus at the time of planting. One scientist recommends the application of manure to the soil as a source of phosphorus. Farmers in the Pennsylvania Alfalfa Growers Program applied manure from dairy cows to the soil. The reader may remember that alfalfa is a heavy feeder of potassium. Young plants are ravenous in their appetite for the element. Some farmers applied potassium twice per year—once in spring and again in autumn—though one scientist believes that the number of applications does not affect yield. Alfalfa absorbs potassium in the topsoil more efficiently than at depth. Potassium chloride is the most common source of potassium, though one scientist favors potassium sulfate because it does not add chlorine, which can be toxic to alfalfa, to the soil.

Alfalfa absorbs more calcium and magnesium than do grains. Being rich in these nutrients, alfalfa entices some stockmen to feed it rather than grain to their animals. Limestone and dolomite are the chief sources of calcium and magnesium. Soils with too little organic matter may lack sulfur. Cool weather, acidic soil, or drought may limit the availability of sulfur, though it is abundant enough in most soils so that the farmer need apply it only every third year.

Breeding and Cultivars

The discovery of new varieties aided alfalfa in its spread throughout the United States and Canada. In 1857, German immigrant Wendelin Grimm brought a new cultivar, named Grimm in his honor, to Minnesota. A hardy variety, Grimm was ideal for the northern United States and Canada. The Minnesota Agricultural Experiment Station sent Grimm to other states, promoting its cultivation.

In 1908, Canadians began cultivating Grimm. Despite its hardiness, Grimm was susceptible to bacterial wilt. Farmers grew Baltic, a hardy variety named for Baltic, South Dakota, in the northern United States. Baltic, like Grimm, was susceptible to bacterial wilt. From Baltic, the Michigan Agricultural Experiment Station selected Hardigan, a variety prized for its hay. Like Baltic and Grimm, Hardigan was vulnerable to bacterial wilt. A third hardy variety was Cossack, which the U.S. Department of Agriculture imported from Russia in 1907. Although not resistant to bacterial wilt, Cossack was less susceptible than Grimm. Even hardier than Grimm was Ladak, which the U.S. Department of Agriculture imported from India in 1910 and which farmers cultivated in Ontario, Canada. Somewhat resistant to bacterial wilt, Ladak yielded well on the Great Plains. In 1927, the Arnold brothers of Nebraska planted Hardistan, a hardy variety that was soon grown in Canada. Peruvian alfalfa, unable to tolerate temperatures below 10°F, was confined to the American South and Southwest.

In the mid-19th century, the French introduced alfalfa to South Africa, where it was first used to feed ostriches. South African farmers grew the Provence variety, the name suggesting French origin. They also grew Chinese, a variety from Tibet. Around 1800, alfalfa from Europe or Argentina was introduced to New Zealand, where Marlborough was the chief cultivar. In the 18th century, farmers cultivated alfalfa in the Hunter and Peel river valleys in Australia. By 1833, farmers in New South Wales boasted 2,000 acres and by 1920 100,000 acres. Australians grew primarily the variety Hunter, a derivative of Provence, Smooth Peruvian, Arabian, or American Common.

Since 1956, the genetic improvement of alfalfa through breeding has contributed only 3 percent to the increase in yield. The gain in yield has been smaller for alfalfa than for grains. This state of affairs may have resulted from the emphasis on breeding alfalfa resistant to diseases and pests rather than for yield and from the fact that scientist know less about the genetics of alfalfa than of corn. As with corn, hybrid crosses of alfalfa varieties display heterosis.

The efforts to breed disease-resistant cultivars began in the 1930s when scientists identified Ladak and the Turkestan varieties as sources of resistance to bacterial wilt. From them the Nebraska Agricultural Experiment Station and the U.S. Department of Agriculture derived Ranger, and the Kansas Agricultural Experiment Station and the U.S. Department of Agriculture bred Buffalo. Since 1965, virtually all new cultivars have been resistant to bacterial wilt. The variety Vernal is among the most resistant. In 1968, scientists began to breed varieties resistant to anthracnose fungi. In 1974, they released Arc, the first anthracnose-resistant cultivar. Resistant varieties yielded 10 percent more alfalfa than susceptible cultivars where anthracnose is present. In 1977, the discovery of a new race of anthracnose in North Carolina, Maryland, and Virginia spurred scientists to intensify their efforts. Whereas Arc was resistant to only one race, the new Saranac AR was resistant to both.

In 1934, the first variety resistant to the pea aphid was discovered, though a breeding program followed only later. In 1966, scientists released resistant Washore and Apex, in 1967 Dawson and Mesilla, and in 1969 Kanza. Between 1967 and 1983, scientists released more than 75 varieties resistant to the pea aphid. Resistant cultivars yielded two to three times more alfalfa than susceptible varieties under infestation. Kanza, for example, yielded as much as three times more alfalfa than susceptible Buffalo, Ranger, and Vernal. In 1957, scientists released Moaspa and Zia, cultivars resistant to the spotted alfalfa aphid. Farmers grew Zia in New Mexico. Cody, another resistant cultivar, is a derivative of Chilean varieties. Between 1957 and 1983, scientists bred more than 100 resistant varieties. These cultivars have saved growers $35 million per year according to one estimate.

Christopher Cumo

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Almond

Often classified as a nut, botanists consider almond (*Prunus dulcis*) a drupe, that is, a type of fruit. In the family Rosaceae, almond is related to the rosebush, plum, cherry, peach, nectarine, apple, apricot, and pear. One hundred grams of almond contain roughly 600 calories, 2.6 to 3 grams of fiber, 230 to 282 milligrams of calcium, 475 to 540 milligrams of phosphorus, 4.4 to 5.2 milligrams of iron, 4 to 14 milligrams of sodium, 432 to 773 milligrams of potassium, 0.24 to 0.25 milligram of thiamine, 0.15 to 0.92 milligram of riboflavin, 2.5 to 6 milligrams of niacin, and small amounts of beta-carotene, vitamin C, and folic acid. The more protein an almond has, the less fat it contains. The converse is also true. Not surprisingly, the larger the almond the more protein it has. High protein correlates with high magnesium content. Processors prefer almonds with high protein and low fat. Oleic acid is the principal lipid in almonds. Almonds with a high content of oleic acid are slow to become rancid. Processors regard linoleic acid, another lipid, with almonds of low quality. High ash content correlates with a high concentration of potassium. The almond tree resembles the peach tree in size, flowering, and shape of leaves. The almond tree prefers mild, wet winter and hot, dry spring and summer. The Mediterranean Basin and parts of Asia and California approximate these conditions. Insects, chiefly bees, pollinate almond flowers. Bees pollinate almond flowers best at 57°F. Cold, rainy weather diminishes pollination and hastens the spread of fungal diseases. Nitrogen, boron, and zinc are essential to prompting an almond flower to set fruit. The application of boron and zinc yielded 39.5 percent fruit set among almond flowers according to one study. The farmer should apply boron in autumn for best results. Insufficient boron decreases pollen production and, accordingly, the production of almonds. Boron increases a flower's production of nectar, thereby attracting insect pollinators. Flowers are white, pink, or red. Almond requires little cold weather to initiate dormancy and is slow to become dormant in autumn. Almond may lower cholesterol and reduce the risk of heart disease and diabetes. Almond oil is a monounsaturated fat similar to olive oil in its health benefits. Almonds contain manganese, magnesium, copper, phosphorus, riboflavin, and vitamin E. Sweet-flavored almond extract, typically made of almond oil, water, and alcohol, is used in baking.

Origin, History, and Production

Almond originated in the desert and low mountains slopes of west Central Asia, a region where it evolved to tolerate mild, wet, or dry winter and hot summer. Wild almonds contain toxic hydrogen cyanide, necessitating the selection of nontoxic types during the process of domestication. Humans domesticated the almond in the Bronze Age as early as 3000 BCE. The almond was among the earliest domesticated fruit trees because of the ease of raising trees from seeds. In the 14th century BCE, the Egyptians, perhaps having gotten the almond from the Levant, buried almonds in Pharaoh Tutankhamun's tomb. The Chinese have cultivated almond since the 10th century BCE. Humans carried the almond from Asia to Southern Europe including Greece and North Africa. The Old Testament mentions almond, evidence that the Hebrews cultivated it. Humans grew almond in the Mediterranean Basin by the time of Christ. From the Mediterranean, almond spread to India, southern Africa, the United States, and Australia. The tree is cultivated in the United States, Turkey, Turkmenistan, Uzbekistan, Tadzhikistan, Afghanistan, Spain, Tunisia, Iran, the Tien Shan plain, Hendokosh, Italy, Chile, South Africa, and Australia. Worldwide, the almond was grown on more than 4.3 million acres in 2004. Production totaled 1.8 million tons. The United States had the highest yield at 3,100 pounds per acre and the greatest production with 900,000 metric tons in 2004. Syria ranked second with 153,000 tons that year. Iran totaled 121,000 tons, Spain 105,200 tons, and Italy 100,100 tons in 2004. Between 1995 and 2004, the United States increased production from 303,600 to 900,000 tons. During these years, Spain decreased production from 174,800 to

105,200 tons. Production increased during these years in Iran from 87,500 to 121,000 tons, in Syria from 40,000 to 153,000 tons, and in Morocco from 50,300 to 77,900 tons. Despite this gain, Morocco is not a leading producer (Javansha 2006, 141).

Asia and the Mediterranean: The Homeland of the Almond

In 2004, Iran grew almonds on 300,000 acres. Although the almond tree, with its deep roots and narrow leaves that expose little surface area to transpiration, is drought tolerant, much of Iran's almond land is arid. Consequently, farmers irrigate about half the country's almond acreage. In Iran, almond is grown in the provinces of Khorasan, Chaharmahal va Bakhtieri, Fars, and Kerman. Late-blooming almonds, which are less susceptible to spring frost than early bloomers, are grown in Kashmar, Mianeh, Khorasan, and Shahrekard. Iran grows cultivars from Italy and Spain. Many old orchards in Iran grow almond trees from seeds, though recent efforts have concentrated on propagating superior cultivars by grafting them on rootstock. Peach tree is the standard rootstock. In Gaznia province, Iranians propagate almond by seeds. The arid lands of Iran challenge growers with their salinity and alkalinity. About 12 percent of Iran's land is saline and alkaline. The Food and Agriculture Organization of the United Nations characterizes 21 acres of Iranian soil as high in salts, which burn the tips of the leaves of almond trees. Cultivated almond varieties are more susceptible to salt damage than wild types. Sodium concentrations as low as 0.55 percent in a leaf injury an almond tree. Salt in the soil impairs the ability of almond leaves to photosynthesize. Trees shed their leaves when salts are numerous in the soil. The highest levels of salts kill almond trees.

Almond is the chief horticultural crop in Chaharmahal va Bakhtieri province. The principal cultivars in the province are Mamaei, Rabi, and Safid, all of which flower early and so are susceptible to frost. Almond is so early that it flowers before it puts forth leaves in spring. Indeed, almond is the earliest deciduous fruit tree to flower in spring. The varieties Monagha and Dehahreh also flower early. The cultivars Texas, Tardy Nonpareil, Ferragnes, and Tuono-283 flower late and so are safe from frost.

In 1977, France gave Iran 22 almond cultivars. The next year Iran began breeding new varieties, among them Azar, Shekafe, and Sahand. Kerman province has 25,000 acres of almond trees, most on gravel and sandy soil. This soil is infertile. Trees that suffer from nutritional deficiency are susceptible to the Rosaceae branch borer, a pest of almond trees in Kerman and Shahrbabak provinces. Because of Kerman's inhospitable soil and pests, growers harvest fewer than 1,320 pounds per acre of almonds. In Iran, almonds were more likely than pistachios to suffer from poor soil. In addition to the Rosaceae branch borer, almond trees in Iran suffer from the wood borer and the species *Tecapis asiatica*. In addition to Iran, Turkey, Afghanistan, Syria, and Azerbaijan suffer from these pests. Almond trees most susceptible to these pests are grown on light, coarse, thin soil with inadequate irrigation. These soils tend to be deficient in phosphorus, zinc, and nitrogen, to be alkaline, and to have little organic matter.

Farmers in Gaziantep, Turkey, irrigate almond trees. Among cultivars in Turkey are Nonpareil, Ferragnes, Cristimorto, Picantili, Desmayo Langueta, Garrigues, Drake, Tuomo, Primorski, Nikitski, Texas, Yaltinskl, and Ferradual, all of foreign origin. In Turkey, as well as in Spain and Tunisia, farmers rely on rainfall to sustain their almond trees. Turks and Syrians eat whole, fresh almonds.

In Afghanistan, almond is the most important crop in Kandoz, Takhor, Balkh, Beghha, Heart, and Samangan. Pakistan and India import Afghan almonds. In contrast to Turkey, Spain, and Tunisia, Afghanistan irrigates most of its almond acreage. In contrast to Turkey, Afghanistan grows local varieties. In some areas, Afghans plant almond trees along the edge of grain fields.

In Spain, breeders aim to develop late-flowering cultivars that are not vulnerable to frost, and early-ripening varieties suitable for a short growing season. Among cultivars, Antoneta flowers late and ripens early and so is ideal for Spain's climate. Less desirable is Ramillete, which flowers early and ripens early. Desmayo Langueta flowers early and ripens late and is the least desirable of the four. Wawona flowers and ripens late. The traditional cultivars, Marcone and Desmayo Langueta, despite their drawbacks, are the foundation of almond culture in Spain. Marcone is grown on the Mediterranean coast and Desmayo Langueta in the interior. As a rule, Spanish cultivars flower early. Spain also cultivates Atocha, Cartayera, Garrigues, Peroleja, Ramillete, Rumbeta, and Planeta.

Christopher Cumo

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Aloe Vera

There are over 250 species of the aloe plant, but aloe vera is a common houseplant. In addition, it is cultivated for its medicinal and cosmetic properties. Although previously thought to be part of the Liliaceae or Lily family, it has recently been classified under the Asphodelaceae family, which includes poker plants and asphodels. Other common names for aloe vera include true aloe, medicine aloe, medicine plant, burn plant, and Barbados aloe. While sometimes confused with agave, also called American aloe, aloe vera and agave are not in the same family. Agave blooms rarely and has no gel in its leaves. Aloe vera, on the other hand, is a succulent perennial that is 99 percent water with fibrous roots and that produces erect spikes with yellow flowers most of the year in hot, dry soils.

Aloe vera (Skynetphoto/Dreamstime.com)

In addition to over 120 other aloe species, aloe vera is native to East and South Africa, where it is often harvested in the wild for commercial use. It is cultivated in the West Indies, specifically the Netherland Antilles, for its fleshy leaves filled with gel and latex. The gel is the leaf pulp collected by cutting close to the stem and draining. Aloe leaves are edged with spines to keep away large animals, and a further deterrent is the yellow sap from tubules under the plant's skin. The sap is a bitter fluid that can be dried and used as a purgative or laxative. In fact, the name aloe comes from the Arabic *alleoh*, meaning "shining bitter substance."

The aloe plant has unique survival characteristics. The leaves often have a waxy substance that reflects light and retains moisture. The skin of aloe plants absorbs water and releases it slowly through its crassulacean acid metabolism (CAM). Plants with CAM open their pores only at night to absorb carbon dioxide. In the process, the plant loses little moisture. An aloe plant can take several weeks to shrivel when pulled from its roots and left in the hot sun; and once dried, it takes only a few hours of immersion in water to refresh to its original state.

History

Aloe has a long history of being cultivated for medicinal and cosmetic purposes. Pictures of aloe were drawn in Sumerian tablets as early as

2200 BCE. One of the oldest preserved medical documents, the Ebers Papyrus written in 1550 BCE, includes 12 medical recipes listing aloe as an ingredient. During the 10th century BCE, King Solomon grew and used aloe. The Song of Solomon mentions "myrrh and aloes, along with all the finest spices." Arab traders brought aloe to Persia (now Iran) and India in 600 BCE, and by 400 BCE it was commonly traded in the Near East and Asia. In the fourth century BCE, it was produced on the Island of Socotra, near the Horn of Africa, and traded in Tibet, India, and China. In 333 BCE, Aristotle convinced Alexander the Great to capture Socotra in order to claim its aloe plantations, and it was a favorite skin lotion for the beautiful Nefertiti, wife of Egyptian pharaoh Akhenaton. Cleopatra used aloe to keep her youthful appearance, and first-century Greek physician and botanist Pedanius Dioscorides included it in his herbal encyclopedia, *Regarding Medical Materials*. A seventh-century Chinese herbal text included aloe vera as a treatment for sinusitis and skin conditions.

Aloe has a history as a religious symbol with sacred properties. The Muslims and Jews of Egypt believed it could protect a household from evil if hung over the doorway. Hindus believed that aloe grew in the Garden of Eden and called it the "silent healer." It was also frequently used in biblical times as an embalming lotion. The Gospel of John says, "He came therefore, and took away His body. And Nicodemus came also, who had first come to Him by night; bringing a mixture of myrrh and aloes, about a hundred pounds weight." During the Crusades, the Knights Templar drank wine named "the Elixir of Jerusalem" made with aloe pulp, claiming it improved health and longevity. In the 16th century, the Spaniards brought aloe vera to the New World. Christopher Columbus once said, "Four vegetables are indispensable for the well being of man: Wheat, the grape, the olive, and aloe."

However, attempts to import aloe as a healing product were unsuccessful since the pulp's efficacy depended on freshness. Finally in 1970, a technique of cold pressing the gel as well as separating the rind from the key compound aloin provided an expanded market. Aloe vera is now a multibillion-dollar, worldwide business.

Medicinal and Cosmetic Uses

Several species of aloe have medicinal properties, but many others are poisonous. Aloe vera has been documented as a healing plant for over 3,000 years. It has been used as a purgative, laxative, antidiabetic, anticancer, antimicrobial, antiarthritic, and antiobesity agent. It aids in healing burns, dryness, and other conditions. In Asia, it has been used as an immune booster. In 1934, the first modern medical paper was published about aloe vera, identifying its ability to treat radiation dermatitis, increasing its popularity during the atomic bomb era.

There are two parts of the aloe vera plant. Aloe gel is the opaque liquid inside the large part of the plant's leaf. It can be easily cut and squeezed or drained. Many people keep aloe vera as houseplants, using the gel as a home remedy for minor skin burns or irritations. The gel hydrates and protects wounds while stimulating new growth of skin cells during the healing process. Aloe gel has gained immense popularity as a skin product, not only for healing common ailments such as sunburns, dry skin, and minor wounds but also as a general moisturizer. It is found in skin lotions, cosmetics, soaps, toothpaste, and even facial tissues.

The latex or yellow sap is a bitter fluid found in small pustules under the outer rind. This "aloe juice" includes the compound aloins made of barbaloin and isobarbaloin, which create the crystalline aloin. Aloin is dried and can be used as a laxative, purgative, and vermifuge, and is even sometimes the bitter agent in alcohol. In smaller doses, aloe juice is used to aid digestion, and some maintain that it can aid in some control of irritable bowel syndrome. Dried sap "tea" has been said to help cleanse wounds and wash irritated eyes, but it must be applied very carefully.

Erika Stump

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Amaranth

Known as "love-lies-bleeding," "velvet flower," and "tassel flower," amaranth comprises roughly 60 species in the genus *Amaranthus*. Indians know amaranth as "king seed" and "seed sent by God." The word "amaranth" derives from the Greek *amarantos*, meaning "unwithered" or "never waxing old," meanings that reveal the Greeks' belief that the plant symbolized immortality. Greek storyteller Aesop (620–564 BCE) wrote that amaranth envied the rosebush for its beauty and the rosebush envied amaranth for being immortal. The Egyptians shared this belief and, along with the Greeks, chiseled images of amaranth plants on tombs and temples. A versatile plant, amaranth is cultivated for seeds and leaves and as an ornamental. The seeds and leaves are edible. People term the seeds grain, though amaranth is, unlike wheat, corn, rice, barley, oats, and other true grains, not a grass. Its seeds and leaves are nourishing. The leaves contain more calcium than beet greens and more protein than spinach. A half cup of amaranth leaves has 14 calories, 138 milligrams of calcium, 47 milligrams of phosphorus, 1.5 milligrams of iron, 423 milligrams of potassium, and 27 milligrams of vitamin C. The seeds have the amino acids threconine, valine, leucine, methionine, and lysine, the last being deficient in several grains. Amaranth seeds have twice the lysine of wheat and thrice that of corn, and as much as milk. The seeds are 16 percent protein, more than milk, soybeans, wheat, rice, and corn. The amaranth seed is 26 percent germ and bran, roughly the same percentage as in wheat. The germ is 30 percent protein and 20 percent oil. The bran has fiber, protein, vitamins, and minerals.

History

Amaranth is native to Africa, India, Mexico, Central America, and South America as far south as Peru. The people of Mexico ate amaranth seeds as early as 8000 BCE, though the plant was not likely a cultigen this early. Cultivation dates to the fourth millennium BCE, when the people of Mexico and Guatemala began raising the species *Amaranthus cruentus* for seeds and leaves. The inhabitants of central Mexico domesticated *Amaranthus hypochondriacus* about 500 CE. The species is the hardiest and highest yielder of the amaranths grown for seeds. The time of origin of *Amaranthus caudatus* appears to be less certain, though the region of origin overlapped with the area where the Amerindians domesticated the potato in the Andes Mountains. The Spanish called *Amaranthus caudatus* Inca wheat, apparently because of its status as a staple.

One thesis holds that the Amerindians regarded amaranth as almost as important as corn and beans. The Aztec emperor levied a tax of 200,000 bushels of amaranth seeds from his territory. Amaranth was not merely a food. It was an object of veneration. In eating amaranth seeds and leaves, the Aztecs honored Huitzilopochtli, the god of agriculture and eternal life. Like the Greeks and Egyptians, Amerindians regarded amaranth as a symbol of immortality. The Aztecs mixed amaranth seeds with honey or blood, forming them into images of snakes, birds, deer, mountains, and gods. The Spanish were shocked that the Aztecs ate images of their gods and condemned the practice as a perversion of the Catholic sacrament of the Eucharist. Accordingly, the Spanish banned cultivation and consumption of amaranth and executed those who violated this prohibition. In stamping out Aztec lifeways, the Spanish reduced amaranth to a minor crop grown in the outposts of the Spanish empire, away from the center of power. In addition to the Aztecs, the Inca, the Tarahumora of Mexico, and the Hopi and Tohono O'odham of Arizona grew amaranth for food.

Amaranth's history in Europe is difficult to trace. The Greeks cultivated Mediterranean amaranth (*Amaranthus graecizans*), but the plant may not have been widely grown in the Mediterranean because Spain, importing Amerindian species of the plant in the 16th century, appears to have regarded them as new cultigens. Although the Spanish recoiled at the Aztecs' use of amaranth, they took an interest in the plant, but as an ornamental rather than a crop. The green, red, and purple flowers caught the fancy of gardeners, and a brief mania for the plant held Spain in its grip. The fad passed and the Spanish appear to have nearly forgotten about amaranth. Meanwhile, amaranth made slow progress elsewhere. By 1700, the people of Central Europe and Russian grew *Amaranthus hypochondriacus* for seeds. By the 19th century, the people of Ethiopia, southern India, Nepal, and Mongolia grew amaranth for seeds and leaves. By the 1980s, India boasted the largest area to grow amaranth. Today, amaranth seeds and leaves feed the people of Mexico, Central and South America, India, the Middle East, and parts of Africa. The United States, Canada, and Europe grow little amaranth. The Chinese feed amaranth to livestock but seldom eat it themselves. The people of the Himalayan Mountains make a flat bread from amaranth seeds. In the hills of northwestern India, farmers plant as much as half their nonirrigated land with amaranth. Indians combine amaranth seeds with honey as the Aztecs had done. Hindus eat amaranth seeds on days when their religion prohibits the consumption of grain. The people of Africa, Malaysia, Indonesia, southern China, southern India, and the Caribbean cultivate *Amaranthus tricolor*, *Amaranthus dubius*, and *Amaranthus cruentus* for their leaves, which they add to soup and salad. The Greeks boil the leaves. Amaranth seeds may be baked in bread and cake. Some health food stores sell amaranth seeds for roasting like peanuts or popping like popcorn, which makes them suitable as a snack. Many Asians eat amaranth leaves as a substitute for spinach, some favoring the species *Amaranthus tricolor*. The Amerindians of the American Southwest cultivate amaranth as a vegetable where the climate is too hot and dry for lettuce and cabbage.

Attributes and Cultivation

Amaranth grows to 12 feet tall, a height agronomists regard as excessive for machine harvest. Whether grown as an ornamental or crop, amaranth should be planted less than one centimeter from the top of soil because seeds must be exposed to light to germinate. Seeds germinate between 61°F and 95°F in three to five days with the fastest germination at the highest temperature. Of its 60 species, some are adapted to the temperate zone. *Amaranthus caudatus*, for example, tolerates cold weather. Most species, however, are native to the tropics and subtropics and are cultivated between 30° north and 30° south. *Amaranthus* *hypochondriacus* and *Amaranthus cruentus*, for example, do not tolerate frost. They cease growth at 46°F and suffer injury below 39°F. Amaranth, especially those species grown for leaves, benefits from the addition of nitrogen and potassium to the soil. Amaranth grown for seeds prefers well-drained soil with a pH above 6. Some species tolerate alkaline soils with pH as high as 8.5. *Amaranthus tricolor* tolerates levels of aluminum in soil that are toxic to other crops. Seedlings are vulnerable to water shortage, but mature plants tolerate drought by closing their stomata under stress. As a rule, amaranth grown for seeds prefers a dry climate whereas amaranth grown for leaves prefers wet environs. The former tolerates as little as eight inches of rain per year. Amaranth grown for seeds should be sown at a density of 80,000 plants per acre. Amaranth, a particularly efficient photosynthesizer, needs full sun. It does not tolerate humidity and waterlogged soil. Tropical species do not flower in the long hours of daylight typical of the summers at high latitudes. *Amaranthus caudatus*, for example, needs fewer than eight hours of daylight to flower. Amaranth may be grown between sea level and 9,600 feet in elevation. *Amaranthus caudatus* is the best yielder at elevation.

In the 1980s, scientists turned to amaranth, believing that it had potential to feed large numbers of the world's burgeoning population. Amaranth had been an important crop in pre-Columbian America, scientists reasoned, and might now become a world crop. Scientists labored to adapt amaranth to the machine age, aiming to breed varieties with uniform height and ripening to ease machine harvest. They sought to breed short, sturdy plants that would not lodge and would stand erect at harvest. They aimed to mechanize planting, weeding, harvesting, and threshing of seeds. They encouraged farmers in the developing world to cultivate amaranth as a way to diminish their dependence on wheat imports. Scientists aimed to supply farmers with a surplus of amaranth seeds that could be fed to chickens, a rapidly growing sector of the economy of the developing world.

The gardener who grows amaranth as an ornamental may start seeds indoors eight weeks before the last frost. Seedlings are ready for transplant two weeks after germination. The gardener may plant seedlings outdoors when the temperature gets no colder than 50°F, spacing plants 10 to 12 inches apart. Amaranth, grown as an ornamental, flowers in midsummer. Flowers persist until autumn frost. Heirloom varieties of amaranth are popular today.

Christopher Cumo

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Anemone

The botanical name anemone derives from the Greek *anemos*, meaning "wind," possibly because the seeds of the genus can be carried on the wind or because some species of the genus have delicate leaves and flowers that quiver in the breeze. This has led to windflower becoming the common name of the anemone. The genus *Anemone* is a diverse group of around 120 species of flower belonging to the Ranunculaceae family of buttercups, cultivated in gardens of the temperate zones of the Northern and Southern Hemispheres and growing wild in Europe, Japan, and North America. The anemone is closely related to the Pasque flower, *pulsatilla*, and to *hepatica*. Indeed, some plant taxonomists include both *pulsatilla* and *hepatica* within the *Anemone* genus.

Attributes

Species of anemone can grow up to four feet tall. Anemone flowers are one to three inches in diameter and cup or saucer shaped with a central tuft of stamens. The flowers are composed of sepals rather than true petals, in shades of pink, purple, lilac, red, white, and blue, and can either be borne one per stem or in clusters in single, semidouble, or double forms, such as the anemone De Caen series and the anemone St. Brigid series. Leaves are deeply cut and fern-like. The diverse nature of the anemone genus is reflected in both the root systems and flowering times of the plant. Some species of anemone grow from fleshy stems or rhizomes while others originate from tubers, which should be treated like spring-flowering bulbs. Flowering times for species of anemone range from early in the year to fall, with some species, such as *Anemone canadensis* and *Anemone sylvestris*, flowering in spring, and some, such as *Anemone hupehensis*, *Anemone tomentosa*, and the hybrids of *Anemone Xhybrida*, blooming in autumn. These autumn-flowering species are known collectively as Japanese anemones. While early-flowering species of anemone will grow in full sun, both early- and late-flowering species enjoy environments that are partially shady, with rich but light, moist soil. A woodland setting is ideal for anemones. In North America the American wood anemone, *Anemone quinquefolia*, is the earliest anemone to flower under such woodland conditions, followed by *Anemone canadensis* and then later still by *Anemone virginiana*.

Mythology

Classical mythology cites two origins of the anemone. One myth tells that the goddess Venus loved Adonis and that when Adonis was gored by Ares, in the form of a bull, an anemone bearing scarlet petals sprang from the blood of the fallen youth, and also that an anemone grew where the tears of the goddess Venus fell to the ground as she mourned her dead lover. A less well-known myth is that Anemone was a nymph beloved of the west wind, Zephyr. The goddess of flowers, Flora, became jealous that Zephyr favored Anemone and transformed the nymph into a flower. When Zephyr learned of Anemone's transformation, he abandoned her to the brutal north wind, Boreas, whose chill and roughness caused Anemone to wither rapidly. This myth is very similar to a German legend in which beautiful Anemone became the beloved of Zephyrus, the god who breathed life into all plants. Chloris became envious of Anemone and drove her from her home. Cowardly Zephyrus deserted Anemome and changed her into a flower.

Both the second classical myth and the German legend attempt then to explain both why the early-flowering anemone seems to open with the first warm wind of the year and also why spring anemone has such a short flowering period. It may also suggest why, in the Victorian language of flowers, the anemone symbolized ill-health, an association with sickness and death that transcends cultures. For instance in Chinese culture, the anemone is synonymous with death, and in ancient Rome anemones were used to garland the deceased. Despite the association with death, the Romans, who believed anemones to possess antimalarial properties, cultivated the flower. The Romans also chose anemones to decorate ceremonial altars, especially those dedicated to Venus. The death symbolism of the anemone corresponds with its association, in some parts of Europe, with immortality and Easter. In this context, the anemone is known as the flower of resurrection. This association is prominent in Germany, where the anemone is used to garland a cow each Easter. In some areas of the Middle East, the anemone is known as the blood drops of Christ for it is said that the blood of Christ fell on the anemones that had bloomed on Calvary, turning the flowers bloodred. The Christian mythology of the anemone combined with the flower's three-petal form has led to the anemone being known as the herb trinity. The anemone also features in pagan folklore. For instance in British fairy lore, the flower of the European wood-anemone, *Anemone nemorosa*, was said to be used by fairies as a shelter from rain. *Anemone nemorosa* is rich in the toxin anemonine, and anemonine and another toxin, protoanemonin, are present in most anemone species. Anemonine is thus poisonous to both humans and wildlife, and on contact with the skin causes severe irritation; while ingestion of anemonine results in a burning sensation in the mouth and severe gastrointestinal discomfort including the vomiting of blood. However, extracts of anemone are used in homeopathic medicine, especially for the treatment of eye conditions and headaches.

Victoria Williams

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Anise

Anise, classified by 18th-century Swedish naturalist Carl Linnaeus as *Pimpinella anisum* in 1753, is a flowering spice plant native to Egypt, Greece, Crete, and Asia Minor. It was first cultivated by the ancient Egyptians and was later cultivated by the Greeks and Romans before spreading to Central Europe during the Middle Ages. It resembles plants of the carrot family (Umbelliferoe), including dill, fennel, coriander, cumin, and caraway, and is related to parsley. Anise's flavor resembles licorice, and its seeds, called aniseeds, are used to flavor licorice candy. Anise is sometimes referred to as *anís*, with the stress on the second syllable.

Origin and Description

The early Arabs called anise *anysum*, which later became *anison* in Greek and *anisun* in Latin. It may be one of the oldest spice plants, dating back as early as 1500 BCE. The ancient Greeks and Romans used anise in several ways, including as a cure for asp bites when mixed with wine. Fifth-century BCE Greek physician Hippocrates believed it could relieve cold symptoms, while Pliny the Elder, a first-century Roman encyclopedist, recommended anise to cure bad breath. The Romans also baked anise into cakes called mustacae, which they ate after meals to aid digestion. In biblical times, the spice was used as a form of payment for taxes. Its name appears in the 23rd chapter of the Bible's Gospel of Matthew in the line "Ye pay tithe of Mint, Anise, and Cummin." In the early 1300s, anise was a drug that King Edward I of England taxed as a means of funding the maintenance of London Bridge.

Anise grows in any moderately warm climate. It is an annual that reaches about two to three feet high and is made up of delicate, white flowers and bright green leaflets that grow from feather-like stalks. The name *Pimpinella* derives from *dipinella*, meaning "twice pinnate," or having similar parts arranged on opposite sides of the stem, which is a reference to the appearance of the leaves.

The larvae of some butterflies and moths (*Lepidoptera*), including the wormwood pug, use the anise plant as food.

Anise's Culinary and Other Uses

Both the roots and leaves of the anise plant are edible, but the gray-green or brown small seeds are the most used part of the plant. Seeds, whole or ground up, are added as a flavoring in soups, candy, and a cordial liqueur known as anisette. Other alcoholic drinks flavored with anise are Italian pizzelle, French absinthe, German Jägermeister, and the Turkish raki. Anise is also used as a flavoring agent in some root beers and in the Mexican hot chocolate drink called champurrado. In the Middle East, a hot tea called Yansoon is made by boiling about one tablespoon of aniseed per cup of water. The leaves of the plant can be used to flavor liqueurs and are likewise used in curry dishes and other spicy meat recipes.

Anise's aromatic essential oil from the seeds, containing 70–90 percent of a phytoestrogen called *anethole*, is considered good bait to entice mice into traps. The oil is poisonous to some animals, such as pigeons. Because of their sweet and spicy aroma, the seeds are incorporated into arts-and-crafts projects, as in the making of sachets and potpourri, and are used as an additive in perfume to create a spicy scent.

In addition, according to folklore, anise is able to ward off the curse of the evil eye and to keep nightmares at bay when placed under a pillow. Fishermen have been known to rub anise's oils on their hooks to lure fish. Dogs also are attracted to anise, and dog food manufacturers sometimes incorporate the ingredient in the food. It also is used as a distraction to throw dogs off their tracks in hunts and is inserted into the "rabbit" lure in greyhound races.

Although unrelated, anise and star anise both contain anethole and its licorice flavor. Because of its abundance and low cost to produce, star anise (the eight-horned pericarp of *Illicium verum*, a small evergreen tree) has overtaken anise in its use in cooking.

The Medicinal Uses of Anise

During the U.S. Civil War, a nurse named Maureen Hellstrom is said to have used aniseeds as an antiseptic to treat soldiers' wounds. The use was discontinued after high levels of toxins were discovered in the blood of patients who were administered the antiseptic.

Anise is used in modern day for medicinal purposes. As in Roman times, it is still used as a digestive aid as well as an antiflatulent. For centuries, it has been used to treat colds and ease coughs. The anethole oil has expectorant properties, too, which helps bring up phlegm, easing congestion. Teas made from anise are believed by some to improve memory as well as stop excessive oil production in skin.

Nursing mothers sometimes drink anise tea to stimulate milk production and ease heartburn, indigestion, and other digestive problems. The antispasmodic properties in anise that help control coughs may also relieve menstrual pain, and may ease asthma attacks, bronchitis, and whooping cough. The essential oil has been used by some as a topical treatment for lice and scabies.

Cultivation

The anise plant grows best in well-draining, dry, light soil that has plenty of sun exposure. Anise plants should be thinned and weeded. They have a taproot and are not easily transplanted. Therefore they should be transplanted only while the seedlings are still small, or they should be left to grow in the place in which they are established. The anise plant flowers in midsummer, and the seeds are harvested in the fall. The harvested seeds have a grayish green color, are oval in shape, contain ribs, and are about one-fifth of an inch in length. The stems of the flower are sometimes cut and hung upside down to dry. Seeds are collected as they fall from the flower or the seeds are dried in trays.

Rosemarie Boucher Leenerts

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Apple

A perennial fruit tree, the apple is known by several names. In Latin, the word for apple is *ponum*, from which the French derive *pomme* and the Italians *pomo*.

Apple trees (Corel)

In Irish, the word for apple was *abhel*, in Welsh *afel*, in Celtic *abello*, in Old English *aeppel*, and in German *apfel*. The genus name of the apple, *Malus*, once referred to any fruit tree. In the Rosaceae family, the apple is related to the rose, pear, and quince. Some botanists see in apple blossoms a resemblance to the rose. Scientists know the apple as *Malus* × *domestica*, a name that denotes its status as a hybrid. One medium apple contains 81 calories, 21 grams of carbohydrate, 4 grams of fiber, 10 milligrams of calcium, 10 milligrams of phosphorus, 25 milligrams of iron, no sodium, 159 milligrams of potassium, 8 milligrams of vitamin C, 73 international units of vitamin A, and 4 micrograms of folic acid. It is important to eat the skin because much of the vitamin C is immediately beneath the skin of an apple.

Origin and Diffusion in Antiquity

In the 1920s, Russian agronomist Nikolai Vavilov discovered a wild apple tree in Kirghizia, a region in the Tien Shan Mountains, proposing it as the place where the apple originated. Others have identified the Caucasus Mountains as the homeland of the apple. According to another school of thought, the modern apple may have arisen in the mountains of Kazakhstan or perhaps south of the Caucasus Mountains in Georgia, Armenia, or Turkey. It is also possible that the apple originated in the Baltic region of Latvia, Lithuania, and Estonia. Another possibility is that the apple originated in Finland and Poland. The first apple was not impressive.

Small and sour, it resembled the crab apple rather than the large sweet apple of modernity. Because bees pollinate apples, they must have crossbred innumerable times over the millennia. Some of these crosses must have yielded large apples that were the progenitors of the modern apple. Several species of apple may have contributed genes to the genome of today's apples. The Asian species *Malus sieversii*, which grows wild from the Tien Shan Mountains to lands near the Caspian Sea, may be one proto-apple in the lineage of the modern apple. Another progenitor may have been *Malus orientalis*, an apple of the Caucasus Mountains. The European crab apple, *Malus sylvestrius*, native to the lands between the United Kingdom and northern Turkey, may have been an ancestor of the modern apple. Other progenitors may have been the Siberian crab apple *Malus baccata*, the Manchurian crab apple *Malus mandshurica*, and the Chinese crab apple *Malus primifolia*.

Because apples cross-pollinate and because each seed is a unique genotype, the populations of ancient apples must have varied a great deal. Some trees must have produced large, flavorful apples whereas others must have yielded small, sour apples. Furthermore, the progeny of a large apple might revert to small, inconsequential fruit. From an early date, humans must have selected apples for size and flavor, but they must have been disappointed that apples do not breed true. In contrast to seeds, a vegetatively propagated tree had the same genotype and thus characteristics of the parent tree. In practice humans, around the third millennium BCE, accomplished the aim of deriving clones of superior trees by grafting a branch onto a sturdy rootstock. In the best circumstance, the branch bore apples with the desiderata of size and flavor, and the rootstock was resistant to diseases and pests.

Archaeologists have dated apples to 6500 BCE in Jericho in the West Bank and Catal Huyuk, Turkey, and to 6000 BCE in Switzerland. These dates are too early for these apples to have come from grafts and they may even be too early for the apples to have come from cultivated trees. Humans may simply have gathered them wild. The tomb of Queen Pu-abi of Ur, dating to 2500 BCE, contained apples, which the Sumerians may have gotten from lands hundreds of miles distant. This possibility suggests long-distance commerce in apples though it does not prove that they were cultivated. A Sumerian text from the same period, however, mentions the growing of figs and apples, establishing the third millennium BCE as the origin of apple culture. The practices of cultivating apples and of grafting them may have arisen at roughly the same time. It is possible, however, that the people of the Indus River Valley in India cultivated the apple earlier than the third millennium. From about 2500 BCE, humans grew apples in Georgia, Armenia, Turkey, Iraq, and Iran. The Hittites recorded the existence of orchards with 40 trees. Grown as far west as the Aegean coast of Turkey, the apple may have migrated south to Egypt. In the 13th century BCE, Pharaoh Ramses II claimed to have planted apple trees in his garden, but some scholars doubt this boast because Egypt's warm winters are not ideal for apple culture.

Europeans probably cultivated the apple, likely a larger variety of crab apple that they had selected for size before the arrival of migrants, apple in hand, from the Caucasus Mountains. In the ninth century BCE, Greek poet Homer remarked that King Laertes, father of Odysseus, grew apples in his garden. That century Assyrian kings tended apples. In antiquity, Armenia and Turkey were renowned for their apples. The Persians (now Iranians) planted apples throughout their empire. Persian cuisine combined apples and other fruit with meat and legumes. The Persians prized apples from Georgia for their flavor. One authority dates the cultivation of apples in Greece and Etruria to 600 BCE. In the fourth century BCE, Greek botanist Theophrastus knew several varieties of apple and recommended those from the Crimea as the best. Etruscan farmer Appius—his name is not associated with the word "apple"—cultivated a variety known as Api in his honor. The Romans, absorbing Etruscan culture, prized Api. Today, the French know this variety as *pomme de' Api* and Americans term it Lady Apple. Api may be the oldest variety still in cultivation. In the second century BCE, patrician and agricultural writer Cato the Elder, writing in *On Agriculture*, understood that apple seeds germinated a tree that often bore small, sour fruit. He recommended vegetative propagation to be sure of deriving satisfactory apples. By 50 BCE, the Romans were cultivating apples in Gaul (modern France). In antiquity, Normandy emerged as an apple producer. The Basques of Spain may have cultivated apples in the pre-Roman period. It is possible that the Basques taught the people of Gaul to grow apples. In the first century CE, Greek historian Plutarch named the apple as his favorite fruit, remarking that only it satisfied all the senses. According to one authority, the Romans grew more varieties of apple than any other fruit. First-century CE Roman encyclopedist Pliny the Elder listed 36 varieties. He urged workers to pick apples after the autumn equinox, doing this task in late September or early October. Pliny recommended the storage of apples in a cool, dry place. The Romans sometimes coated apples in plaster or wax, perhaps to preserve them. They ate dishes of apple, pork, coriander, liquemen, and honey. Pompeii's paintings feature apple trees, though it is possible that these trees, like lemon trees in antiquity, were ornamentals. The physicians of Greece and Rome, who believed the theory of the four humors, classified apples as cool and moist and so as a complement to hot meat. In the first century CE, Roman poet Juvenal and agricultural writer Columella gave advice on growing and storing apples. The Persians, Greeks, and Romans thought that the apple was an aphrodisiac. According to Persian custom, a girl could eat nothing but apples on her wedding night to ensure that she was at the peak of fertility. According to one school of thought, the apple was not, however, widely grown in antiquity. The people of the Caucasus who had favored apples jettisoned them for grain and meat when they migrated to the

Mediterranean Basin. The Greeks and Romans, according to one authority, considered the apple a luxury. If this is true, the masses must not have eaten it. The ancients may have preferred grapes, dates, and figs to apples.

The Middle Ages and Modernity

However widespread it was, the apple went into decline with the fall of Rome. The art of grafting may have been lost as farmers were content to raise apples from seeds. The large, flavorful apples of the Persians, Greeks, and Romans ceded ground to wild crab apples. In the Middle Ages, people seldom ate fresh apples. After the fall of Rome, sweet apples became uncommon, depressing the demand for fresh apples. Instead, most apples were pressed for cider. The monks of Europe cultivated apples for cider, but because cider may be made from any apple no matter how small or misshapen, there was no need for the aesthetically pleasing apples of antiquity. Hard cider was a common beverage in the Middle Ages and possibly in antiquity, though it may not have challenged the supremacy of wine in the Mediterranean and beer in Northern Europe. The alcohol in hard cider killed microbes so that it was safe to drink even when the water was contaminated. Some people doubtless consumed cider in preference to water.

In the ninth century, Frankish king Charlemagne, evidently intent on making apples more widely known, ordered them to be planted in the royal gardens. In the 10th century, the abbot of Ely planted apples in his monastery in England. That century Heywal Dda, a Welsh prince, set the price of a sweet apple at twice that of a sour apple. The Normans, conquerors of England in 1066, drank cider. As the Cistercian Order spread in the 12th century, its monks tended apples throughout Europe. From Burgundy, France, the Cistercians brought the apple to Germany and from Paris they brought it to Denmark. The Arabs, perhaps deriving their interest in the apple from the Persians, were avid apple growers. In 1080 Ibn Bassal, an official in Toledo, Spain, gave advice on planting, grafting, pruning, and fertilizing apples in the *Book of Agriculture*. From the 13th century, perhaps because of Arab influence and the work of monks, the cultivation of apples spread throughout Europe.

Yet it is difficult to know how prevalent the apple was in the diet. Many medieval physicians abandoned the ancient belief that apples were wholesome. They counseled children and wet nurses not to eat apples. The fruit caused, physicians believed, stomachache and fever. The identification of the apple as the forbidden fruit in Genesis may have deepened suspicion of it. Not everyone was so negative, however. Cooks prepared apples with sugar to sweeten them and added apples to porridge. In England, monks ate apples during Lent. The custom of eating an apple at the beginning of a meal to aid digestion may have been widespread. In medieval Europe, the fruit was added to stew, stuffed into meat, and made into sauce. In the 13th century, Count Albert of Ballstadt recommended apple trees as ornamentals because of their attractive fruit and fragrance. In 1280, Queen Eleanor of Castile planted apple trees as ornamentals in England. In 1390, the chef of King Richard II of England published a recipe for applesauce, possibly the first of its kind. In 1398, King Charles VI of France planted 100 apple trees and 12 miniature paradise apples in his garden. The latter must have been dwarf trees. In the 15th century, Italian Pietro de Crescenti likewise remarked that apple trees were suitable as ornamentals.

In the Middle Ages, domestic demand for apples may have exceeded supply in England because it imported them from France. The French imports Costard and Blandural were popular in England. The English cooked Costard, perhaps adding sugar, as was the custom. Blandural stored well, sweetening over three months of storage. The English cultivated the Pearmain variety for cider. The growth of cities in the Late Middle Ages increased the demand for apples. In the 15th century, Renaissance artists Sandro Boticelli and Giovanni Bellini included apples in their works, much as the Romans had done. The walls of the Medici villa of Poggio a Cainno were decorated with frescos of the goddess Pomona tending an apple orchard and of Hercules amid an apple tree in the garden of the Hesperides. Renaissance Italians prize the paradise apple.

The discovery of the Americas opened new lands to the apple. To be sure the apple was not a novelty in the New World. The crab apple populated the temperate regions of the Americas, though it is unclear whether the Amerindians took much interest in it. The pre-Columbian people of America appear not to have cultivated the apple. Although they knew the crab apple, Native Americans had never seen the sweet apple until Europeans arrived in the New World. In the 16th and 17th centuries, the French planted apples in Canada. Presumably the earliest introductions were seeds rather than grafts. Indeed, until the 19th century grafting was uncommon in the United States. In the 16th and 17th centuries, the English, French, Dutch, Germans, and Scandinavians planted apple trees along the Atlantic coast of North America. In 1625, cleric William Blaxton may have planted the first apple orchard in Massachusetts. Later he claimed credit for growing the first apples in Rhode Island. In 1648, William Endicott, the first governor of Massachusetts, planted an orchard of 500 trees. Perhaps following the custom in Europe, many colonists drank hard cider rather than water. In the 17th century, New York governor Peter Stuyvesant planted apple trees on Manhattan. By the 1730s, the American colonies were exporting apples to the Caribbean. In the 18th century, George Washington tended apple trees at Mount Vernon, Virginia. That century Colonel William Fitzhugh boasted of an orchard of 2,500 trees. In the 1830s, a barrel of apples fetched $4 in New York City. In the 19th century, the United States imported trees from Scandinavia, Germany, and Russia, crossing them with American varieties. That century, John Chapman, today known as Johnny Appleseed, established orchards throughout the Northeast and Midwest. By 1850, U.S.

farmers could choose among more than 500 cultivars. With the standardization of production in the 20th century, the number of apple varieties decreased from 1,000 in 1872 to 100 in 1975. Outside North America, the Spanish and Portuguese tended apples in South America and the Spanish introduced the apple to the American Southwest and California.

Europeans took the apple to other regions of the world. In 1654, Jan van Riebeeck, founder of the Dutch East India Company, planted apple trees in South Africa. In the late 19th century, apple acreage increased in South Africa as disease killed grapevines, convincing many farmers to switch to apples. In 1788, Captain Arthur Phillip brought apples to Australia. Around the same time, Captain William Bligh planted apples in Tasmania. In 1814, British missionaries introduced the apple to New Zealand. In the 19th century, South Africa, Australia, and New Zealand exported apples to Europe, giving its inhabitants access to fresh fruit out of season. In the 20th century, China, Korea, Japan, India, and Pakistan adopted U.S. cultivars. Because these varieties were productive, Asia became an apple exporter. Today, China and the United States are the world's largest producers. India, another important producer, yields two times more apples than does the United Kingdom. Argentina, Brazil, and Chile are large exporters. In the Ukraine, a single orchard yields more apples than all the orchards in the United Kingdom.

Today, Washington, New York, and Michigan lead the United States in apple production, but apples are grown in every state in the country, with 2,500 varieties of apples grown, and 7,500 types grown throughout the world (University of Illinois Extension 2011). Until the 1970s, McIntosh, Red Delicious, and Golden Delicious were the most popular and prevalent in U.S. grocery stores. But since then, new varieties, many introduced from other countries, have become more available in supermarkets, including Granny Smith (Australia), Gala and Braeburn (both from New Zealand), Fuji (from Japan), Jazz, and Honeycrisp. But as with tomatoes and other fruits and vegetables, a new interest in long-ago-grown heirloom varieties is surfacing.

In commercial orchards, farmers contract hives of bees to hasten pollination. Under the proper conditions, an apple may be stored one year without loss of flavor. People eat apple muffins, apple pie, apple dumplings, applesauce, apple cake, apple fritters, apple pancakes, and apple butter. They drink apple juice and apple cider. Swedes eat apples, Canadian bacon, and sautéed onions for Sunday breakfast. Germans eat baked apples with sour cherries and also apple pudding. Turks eat apples with fish. Israelis make applesauce from green apples.

Mythology and Religion

The apple was central to the mythology, folklore, and religion of several peoples. It was an important fruit in Greek mythology. The Greeks sculpted likenesses of the goddess Aphrodite holding an apple. The association between Aphrodite and the apple leads one to suppose that it symbolized love and lust. The association between Aphrodite and the apple may stem from the story of the wedding of Peleus and Thetis. The couple had not invited the goddess Discord to the ceremony. Angry about this slight, she engendered conflict by placing a golden apple in the room. The goddesses Hera, Aphrodite, and Athena claimed it. When none of the three prevailed, they asked Prince Paris of Troy to choose the victor. Each goddess disrobed before Paris to sway his decision. Aphrodite promised him the most beautiful woman in the world, Helen. Eager to have her, Paris gave the apple to Aphrodite. In taking Helen, Paris precipitated the Trojan War.

The association between Aphrodite and the apple is part of another Greek myth. The maiden Atalanta learned from an oracle that she would become mortal if she wed. Her father, however, wanted her to marry. To preserve her status as a maiden while seeming to satisfy her father, Atalanta agreed to marry whoever could beat her in a footrace. Because she was so swift, she had no difficulty defeating the suitors who challenged her. Hippomene, wishing to marry Atalanta, prayed to Aphrodite for help. Aphrodite gave the young man three golden apples. During the race, Hippomene slowed Atalanta by throwing an apple at her feet each time she surged ahead. Bending over to pick up each apple, she lost her momentum and the race. The two married.

One tradition holds that Aphrodite got the golden apples from a tree in the garden of Hera. Mother Earth had given the tree to Hera upon her marriage to Zeus. Hera planted the tree, instructing the goddesses Hesperides to guard it. Despite their vigilance, Hercules stole the apples from the tree. Because the Greeks associated the apple with the sun, one authority believes that Hercules's theft of the apples marked his claim to be the sun god, a position he may have held in a primitive religion assimilated by the Greeks.

In Christian tradition, the apple may have been a symbol of immortality. According to one account, the martyr Dorothea, who died about 300 CE, encountered the lawyer Theophilus on her way to execution. Skeptical of the claims of Christianity and perhaps wishing to mock her, he asked Dorothea to bring back fruit from heaven. In answer to Theophilus, Dorothea stopped to pray. Out of the crowd emerged a boy with a basket of apples. Dorothea gave them to Theophilus, promising him more when he entered heaven. After eating an apple, Theophilus converted to Christianity. The apple had given him immortality.

The best-known myth of the apple is its association with the forbidden fruit in Genesis. In the fourth century, Saint Jerome identified the apple as the biblical fruit, though the apple may have been unknown to the Hebrews, and nothing in Genesis leads one to nominate it as the forbidden fruit. In keeping with the association between the apple and immortality, Adam and Eve, in eating it, may have sought immortality. Instead, God exiled them from the garden.

Christopher Cumo

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Apricot

A perennial fruit tree, the apricot yields small, firm produce. The apricot is related to the plum. The two may be hybridized to yield the pluot. The term "apricot" derives from the Old English *abrecock*, which in turn owes its origin to the Middle French *abricot*. In Catalan, the word for apricot is *abercoc* and in Spanish *albericoque*. The people of Argentina and Chile know the apricot as *damasca*, a word that derives from the belief that the fruit originated in Damascus, Syria. Scientists know the apricot as *Prunus armeniaca*. Farmers do not plant apricots from seed because the new plant may vary from the parents, but instead produce clones of the parent tree by grafting branches onto plum or peach rootstock. Ideally, the clone will yield quality fruit and the rootstock will resist diseases and insects. Preferring a well-draining, deep soil, the apricot does best in soil with a pH between 6 and 7, that is, slightly acidic to neutral. The apricot is difficult to trellis. The farmer should prune a tree little in the first two or three years for fear of damaging it. The farmer may prune an apricot tree after the harvest so that wounds have time to heal before it flowers next year. One fresh apricot provides nearly a day's supply of beta-carotene. Three apricots contain 2.5 grams of fiber and 300 milligrams of potassium. Apricots also contain vitamin C. According to its partisans, the fruit shows promise in protecting one against cancer.

Origin, Diffusion, and Production

The apricot is not a cultigen of Syria. In the 20th century Russian agronomist Nikolai Vavilov proposed China as the place of origin, and many scientists now pinpoint the Great Hsingan Mountains of China as the homeland of the apricot. The Chinese have cultivated the apricot for millennia. Since 3000 BCE, the people

Apricots (Jianbinglee/Dreamstime.com)

of India have tended the fruit. In antiquity, Armenia emerged as a center of apricot culture. So close was the association between the apricot and Armenia that as late as the 18th century Europeans thought that the fruit was native to this region. The army of Alexander the Great, perhaps acquiring the apricot from India, introduced it to Greece in the fourth century BCE. Roman commander Lucullus, acquiring the apricot from Armenia, planted it in Italy in the first century BCE. Throughout antiquity, the Persians traded dried apricots. The Spanish, having participated in the discovery of the New World, introduced the apricot to California and the American Southwest in the 18th century. These early varieties were the source of the modern cultivars. U.S. production is centered in California, Washington, and Idaho.

The Mediterranean Basin remains a center of apricot culture. One authority believes that production will increase in this region. In Greece production, peaking in 2000, slumped thereafter. Losses from plum pox virus, known as Sharka disease, a decline in domestic demand, and competition from Spain accounted for this diminution. As other European countries turned to Spain for apricots, Greece's share of the export market declined. As production has fallen, farmers have taken land out of cultivation. Production is concentrated in southern Greece and the Haikidiki Peninsula. Although aggregate demand is down, farmers continue to find a market for canned and fresh apricots. As a percentage of the harvest that is canned, Greece surpasses Australia but trails South Africa and Spain.

Among fruit, including olives, the apricot ranks fifth in tonnage in Greece behind olive, citrus, peach, and apple. Mild winters and hot, dry summers characterize the climate in which apricots are grown in Greece. The climate poses little danger of spring frost, an important consideration given that the apricot blooms early and that frost kills flowers. Because of the dry climate, farmers must irrigate apricot trees beginning in June, though water for irrigation is scarce in Greece. Troublesome is the situation in the Peloponnesos, where the water is saline.

In Italy, the production of apricots peaked in 2004. Italians grow most apricots in Campania, Emilia-Romagna, and Bassilicate. Blessed with volcanic soils near Naples and Salerno, Campania produces the largest total of apricots of Italy's regions. Emilia-Romagna ranks second. The soils near Bologna and Ravenna are especially productive. Most apricots from this region are sold fresh. Not ideal for the fresh market, the fruit is small, but because Bassilicate's apricots ripen early they are able to enter the fresh market with little competition. Because Bassilicate's apricots are small, most are processed. Because apricot production is not mechanized in Italy, labor is intensive, requiring about 20 hours per acre. Farmers pay laborers to pick and thin apricots and to prune trees. In Italy, wages total half the cost of production.

Domestic demand for apricots is strong in Turkey, as is the export market. On the Mediterranean coast, farmers pick apricots in mid-May. In Malatya, the harvest is in late summer. Much of Malatya's crop is dried. Turkey supplies apricots to Europe and Arab nations. The leading producer, Turkey supplies one-fifth of the world's crop. Because the market for fresh apricots is small, most of the harvest is dried. Turkey is the world's leading exporter of dried apricots. In Turkey, apricots flower in early April and are vulnerable to late frost. Malatya, Igdar, and Erzincon in East Anatolia are important apricot growing regions. Apricots grown at elevation in Turkey have better color and fragrance than those grown at sea level.

In Hungary, the first reference to the apricot dates to 1400 CE. In the 16th century, the Turks encouraged the growing of apricots in Hungary and the fruit is now widespread. In 1652 Jan van Riebeeck, founder of the Cape colony, introduced the apricot to South Africa. Until the early 20th century, farmers propagated apricots by seeds rather than by grafts. The western cape of South Africa has emerged as the center of apricot culture. Farmers have planted few apricots in the northern cape and the fewest in the Transvaal. Farmers grow apricots near Swellendam, Robertson, Montago, Oudtshoons, Joubertine, and Ladysmith, areas between latitudes 33° 30′ and 34°. This region is the southernmost in South Africa and lies 210 to 2,400 feet above sea level. In recent years, farmers have planted apricots near Kimberley. The domestic demand for apricots is small, leading farmers to export most of the crop. Southern Australia has emerged as the center of apricot culture. The majority of the harvest is dried. Dried apricots store up to nine months before they become discolored.

Breeding Programs and Cultivars

Apricot varieties have a narrow geographical range. Most are confined to a single country or even to a region of a country. In Greece, the variety Bebecou commands 95 percent of acreage. Bebecou supplies both the fresh market and canning. Maturing in June and July, Bebecou produces an abundance of large fruit. The variety is, however, susceptible to Sharka disease. Cultivated on just 5 percent of acreage, the variety Tirynthos is grown in Peloponnesos. Most of the harvest is sold fresh. The yield is high and fruit large, but consumers prefer the taste of Bebecou. Maturing at the end of May, Tirynthos enters the market before Bebecou is ready to harvest. Like Bebecou, Tirynthos is vulnerable to Sharka disease. The Pomology Institute at Naossa, Greece, has initiated a program to derive cultivars resistant to plum pox virus. The varieties Early Orange and Stella were the first to be resistant to Sharka disease. Also resistant are the U.S. cultivars NJA, Sunglo, Veecot, Harloyne, and Henderson, though they are not well adapted to cultivation in Greece. They are useful, however, as breeding stock. Crosses between the American varieties and Stella have yielded 96–98 percent of their progeny resistant to Sharka disease. The percentage is lower in crosses between Early Orange and Bebecou. Only half the progeny of the cross between the variety Kaliopoulou and Veecot are resistant. Stella may be more useful as breeding stock than as a cultivar because it yields small, soft fruit.

Three cultivars dominate the orchards of Hungary. Cegledi arany, a hybrid, produces large, round fruit with a pleasing appearance. Durable enough to withstand rough handling, the cultivar supplies both the fresh market and canning. Cegledi arany is, however, susceptible to *Gnomania* and *Monilinia* fungi. Cegledi kedves ripens in midsummer. The fruit is neither large nor round, though the orange color is striking. The flesh is firm and the flavor acceptable. The flavor is best when the fruit is fully ripe. Hardy and tolerant of Sharka disease, the variety is good for canning. Cegledi piroska yields fruit that is medium to dark orange. With firm flesh and acceptable flavor, the variety is suitable for the fresh market and canning. The yield is high.

In Australia, farmers have selected varieties since the early 20th century. In 1983, the government initiated a breeding program to supplant these old cultivars with new ones. Receiving money from the Dried Fruit Research and Development Council as well as from government, the South Australia Research and Development Institute and the University of Adelaide have bred new varieties. The situation is similar in Spain, where farmers have selected varieties for generations. The most popular cultivars are Moniqul, Gitano, and Pepito del Rubio. Of the three, Gitano may have the best flavor. Gitano is the earliest to mature, being ready to pick by June 18. Pepito del Rubio matures by June 22 and Moniqul by June 27. Farmers prize Moniqul because its fruit does not crack. Although the fruit of

Pepito del Rubio cracks, the progeny of the cross between it and Moniqul do not crack. The progeny are also attractive because they ripen earlier than either parent.

In South Africa, only six varieties total 98 percent of acreage. Of these, Palsteyn is the most widely grown cultivar. In Turkey, where the market for dried apricots is large, Hacihalilogin is the leading cultivar, though it is not ideal. Among its shortcomings, Hacihalilogin yields small fruit, is intolerant of drought, is susceptible to frost and fluctuations in winter temperatures, and does not produce abundant pollen. Yield, quality, and resistance to frost and disease are the most important traits of Turkish varieties. The challenge for breeding programs in Turkey and elsewhere is to derive varieties that combine tolerance to both cold and heat, early flowering, and quality of fruit. Scientists use recurrent selection to breed for large, firm fruit, fragrance, flavor, and attendant sugar content. Programs to breed Sharka-resistant varieties are widespread in Europe, where the disease is prevalent. The emphasis on quality may emerge at the primary desideratum given that some high-yielding varieties produce tasteless fruit and so cannot command the allegiance of consumers. Other breeding programs concentrate on the fungal disease apricot brown rot. Although it is possible to control the disease with fungicides, their presence in the food supply is worrisome. The breeding of resistant varieties may allow farmers to eschew the use of fungicides. Yet breeders have searched the apricot genome for resistant genes without success. The best one may hope to do is to derive varieties tolerant of brown rot. Whereas a resistant variety will not contract a disease, a tolerant cultivar is susceptible to it. A tolerant variety will not succumb to a disease but will yield well despite an infection. Several genes confer tolerance of brown rot. Breeders concentrate these genes in a cultivar through recurrent selection.

Diseases and Pests

In the 1960s, scientists isolated plum pox virus, discovering that several species of aphids transmit it to apricots. Curiously, not every strain of the virus is subject to insect transmission. Although Sharka disease was first detected in plums, it infects other fruits including apricots. The disease is most severe in apricots and plums. The virus causes chlorosis of leaves and may cause the bark of an infected tree to split. It reduces the value of apricots in two ways. First, it deforms fruit, rendering it unappealing to the consumer. Second, the virus reduces sugar content, causing fruit to be tasteless. Sharka disease may reduce yields 20 to 30 percent. Although the disease may not kill a tree, its productivity declines during the course of infection. In some cases, fruit fall from an infected tree before ripening. Farmers have little recourse but to destroy diseased trees in hopes of containing the virus.

We have seen that apricot brown rot is a troublesome disease. Known as brown rot blossom blight and fruit rot, the disease results from infection by the fungi

Manilinia lax and *Manilinia fructicola*. *Manilinia lax* withers flowers. Leaves fall from a tree and the branches exude a gum. The fungus overwinters in fruit left on a tree and in branch cankers. Spores develop in December, building large populations by spring. Wind and rain spread the spores. The infection rate peaks about 75°F. Flowers in bloom are the most susceptible to infection. *Manilinia fructicola* accumulates as mycelia in fruit, whether left on a tree or rotting on the ground. The fungus infects anthers and stigmas in a flower. The riper the fruit the more vulnerable it is to infection. Rain, fog, dew, and wind spread *Manilinia fructicola*. Insects, picking up the fungi by chance, spread it from apricot to apricot while they feed. The farmer may seek to control both types of fungus by cleaning apricots from tree and ground. The farmer should avoid irrigating trees with a sprinkler because an abundance of water may trigger an outbreak. The cultivars Royal, Derby Royal, and Modesto are vulnerable to brown rot. With the caveat that they are not to enter the food supply, fungicides may be effective. The farmer may apply them in late November or early December and again when a tree blooms.

Several other diseases plague the apricot. The bacterium *Pseudomonas syringae* causes bacterial canker. Pernicious in winter and spring, the bacterium kills the bark of apricot trees. An infected tree exudes a liquid near the boundary between dead and live tissue. The diseased area turns brown, becomes moist, and emits a sour odor. Trees aged two to eight years appear to be the most vulnerable to bacterial canker. Trees grown on sandy soil, shallow soil, or nitrogen-poor soil are vulnerable to bacterial canker. Accordingly, the application of fertilizer may improve the condition of trees. Bacteria may infect flowers during cold, wet weather. Leaves may also succumb to infection, developing brown spots. Brown lesions cover infected fruit. In addition to fertilizer, irrigation helps control the disease because a vigorous tree is less prone to bacterial canker. One may treat an infected tree by spraying it with a fungicide containing copper.

Pests may be less problematic than diseases because the apricot flowers early, yielding fruit before pest populations have had time to multiply. Nonetheless, several pests pose a danger to apricot trees. The European red mite, *Pananychus ulmi*, known as the European red spider mite, speckles leaves when an infestation is small. Heavy infestation causes leaves to turn bronze and pale. In the heaviest infestations, mites defoliate a tree. Mites cause fruit to be small. An afflicted tree yields few buds next year, reducing the harvest. For this reason, the farmer expects a downturn in production in the year after an infestation. Female mites lay their eggs on the underside of leaves in summer. Females deposit eggs on a tree's bark in winter. Mites overwinter as eggs. If the climate is warm, adults may overwinter in trees. Eggs hatch in spring. Larvae feed on young leaves. Larvae, nymphs, and adults suck sap from leaves.

Known as the Chinese scale, the California scale, and the pernicious scale, the San Jose scale, *Quadraspidious pernicious*, feeds on new wood. Afflicted wood discolors, dries, and dies. The scale deforms fruit, causing it to be small. When infestations are large, the scale is able to kill trees. In California, female scales may overwinter in trees. The scale begins to feed in February, when a tree's sap starts to rise. Crawlers emerge in May and insert their mouthparts into wood, leaves, or fruit. As it feeds, the scale inserts toxins into afflicted trees. The farmer may use insecticides to combat the scale.

The peach twig borer, *Amarsia lineatella*, despite its name, feeds on apricots and other fruit in addition to peaches. The borer infests ripe fruit or fruit that has cracked. The insect rarely infests overripe fruit. Moths may invade apricot orchards from nearby peach or almond trees. The borer is troublesome in the San Joaquin and Sacramento valleys of California. Larvae overwinter in hibernacula, beginning to feed on a tree just beneath the bark in January and February. Feeding on new shoots, the borer wilts them. Larvae exit the shoots in April and May, infesting cracks in the bark, where they pupate. Moths emerge in late April and May. The borer produces three generations per year. The farmer may collect fallen fruit and burn pruned wood to deprive larvae of places to overwinter. Insecticides may be applied in spring to kill larvae.

Christopher Cumo

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Arrowroot

A perennial herb grown in the tropics and subtropics, arrowroot (*Maranta arundinacea*) is known as "obedience plant," "maranta indica," *Maranta ramosissima*, "maranta starch," "Bermuda arrowroot," "marcanta," "Saint Vincent arrowroot," and "West Indian arrowroot." The genus *Maranta* was named to honor 16th-century physician Bartommeo Maranto. Because the edible part of arrowroot, contrary to its name, is a tuber not a root and because one gardener compares the flavor to that of potato, comparisons are made between the plants, though nutritionally arrowroot is much less attractive than potato. The arrowroot tuber is

63 percent water, 27 percent starch—the principal carbohydrate—2 percent protein, fiber, fat, sugar, albumen, gum, and ash. Arrowroot is bereft of vitamins and minerals. Once widespread as a food additive, arrowroot starch has fallen out of favor in this nutrition-conscious age.

Attributes

The arrowroot plant, a member of the Marantaceae family, may grow to three to six feet tall and the leaves 10 inches long. The plant has white flowers whereas the Australian arrowroot has red flowers. Arrowroot may have originated in Guyana and western Brazil and was cultivated as early as 5000 BCE. From South America, arrowroot spread to the Caribbean, which is today the chief region of cultivation. The Arawak of the Caribbean called the plant "aru-aru"—from which the word arrowroot may derive—meaning "meal of meals," testament to its importance in their diet. Another tradition held that the name "arrowroot" derives from the practice of using the plant's pulp to extract poison from an arrow wound. More recently, arrowroot migrated to Florida.

One author mentioned arrowroot as a wild plant of Florida. The Seminoles of Florida called arrowroot "conti," meaning "flour-root," evidently using the plant's tubers to make flour. The term "conti" has the variants "coontie," "coontia," "compte," "comtie," "koonti," and "koonnee." Either the Amerindians or the European inhabitants of Florida made a type of bread—Seminole bread—from arrowroot starch. Perhaps this was flat bread because arrowroot starch is incapable of rising when baked. Alternatively, the starch might have been combined with wheat flour to make leavened bread. By the 1920s, Key West was an importer of arrowroot starch, though this author feared that the pace of land clearage might make arrowroot extinct in Florida. Floridians grew arrowroot as an ornamental.

From the Americas, the Columbian Exchange carried arrowroot to Australia, South and West Africa, Mauritius, Korea, Vietnam, the Philippines, and India. Arrowroot was imported into Great Britain in about 1732, though being frost intolerant, it could scarcely have survived the cold. Perhaps greenhouses and botanical gardens grew it as a curiosity. Botanists Alphonse de Candole and Asa Gray were apparently familiar with arrowroot.

Arrowroot thrives in rich soil but does yield an acceptable crop in poor soil and arid conditions. Arrowroot prefers full sun but tolerates partial shade. The plant prefers a temperature between 77°F and 81°F and rainfall between 59 and 71 inches. The soil should drain well. Alluvial and igneous soils are best, though latosol is favored on Saint Vincent. Pieces of tuber, like those of potato, are planted in lieu of seeds. One gardener recommends plantings 30 inches apart. Arrowroot tubers need 10 or 11 months of hot, wet weather to mature, though if left in the ground too long they become tough. As a rule, tubers are ready to harvest at one year old. The gardener knows the harvest is imminent when the leaves yellow and the stem collapses. An acre of arrowroot may yield six tons of tubers, from which may be extracted one ton of starch.

Cuisine and Medicine

An easy-to-digest starch, admittedly one with little flavor according to one gardener, arrowroot was once important to the cuisines of Old and New Worlds. Tubers may be consumed raw, steamed, roasted, or barbecued. Because of the paucity of flavor, arrowroot is best combined with other food, for example in stir-fry, casserole, stew, and soup. The arrowroot tuber must be cooked longer than the potato. In the Caribbean—especially in Jamaica and Saint Vincent—arrowroot starch is added to biscuits, pudding, jelly, cake, and sauce. In Korea and Vietnam people add arrowroot starch to noodles. A food of children and the infirm, arrowroot fell out of favor because of its poor nutrition. Arrowroot is used to sooth mosquito, spider, scorpion, and snakebite and to treat gangrene, stomachache, nausea, diarrhea, and vomiting.

Christopher Cumo

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Artichoke

The artichoke, *Cynara scolymus*, is part of the sunflower family, Asteraceae. A head (capitulum) on a long stem, flower leaves (corolla rays), and then a flower disk (corolla disk) characterize this family of flowering plants. The artichoke is a cultivated plant with a history dating back 3,000 years. Humans use the artichoke in cooking, teas, liquor, and medicine. The artichoke is characterized by an edible bud that grows on a long stem. The leaves of the artichoke are somewhat spiny. The flower itself is composed of several triangular layers. When it blooms, it is a purple thistle with many feathery petals. The unbloomed artichoke is what is used in the culinary arts. The spiny leaves are dipped into a sauce and the bottom of the leaves are eaten. The heart of the choke, its base, is oft-touted as a gastronomical delight.

History of the Artichoke

The artichoke was first discovered and cultivated in the Mediterranean Basin. The plant may have been native to the Maghreb region of North Africa. It is believed

Artichokes (Marion429/Dreamstime.com)

that humans have been eating artichokes for more than 3,000 years. The Greeks ate artichoke flower buds, and the Romans found the artichoke during the excavation of Egyptian sites.

There is much debate about the origins of using the artichoke as food. While some believe the ancients did not eat the artichoke (this was a practice historians have found not to have occurred until later), legends date back to the ancient Greeks about the creation of the artichoke. The god Zeus came upon a young woman in a field, fell in love, and decided to take her back to Mt. Olympus. When she became homesick and Zeus tired of her, he sent her back to Earth—as an artichoke. Because the young woman was the object of Zeus's affections, it was believed that anyone who would eat the artichoke would experience its aphrodisiac effects. The artichoke was also associated with having male children.

Legends were not the only places where artichokes appeared in literature. Greek botanist Theophrastus wrote of artichokes that were growing in the late fourth and early third centuries BCE. Theophrastus was a student of Aristotle. He was the first to describe the artichoke in detail. He mentioned that boiling the artichoke was the best way of extracting the flavor. In the first century CE, Greek physician Dioscorides wrote a book discussing the use of artichokes in medicine and claimed that artichoke roots could be used as an underarm deodorant and could be cooked with wine as part of a beverage.

Shortly after the popularity of the artichoke grew, so did the taboo against women eating it. By the 1500s CE, only men were allowed to eat the artichoke. Women who ate this flower were considered to be "forward" as the association of the artichoke with aphrodisiac properties remained prevalent. Only in the 19th century did Americans begin cultivating artichokes, first in the Louisiana territory when the French brought the plant with them. Italians who came to the United States also brought artichokes. When Italian-Americans settled California's Monterey County, they began cultivating the plant. By the early 20th century, the cultivation of artichokes in California had grown so popular that they were being exported to Boston and the rest of the East Coast, and their price was quite high. In fact, the cultivation of artichokes in the Monterey region became so popular that it became known as the artichoke capital of the world.

A famous Mafioso, Ciro Terranova (1889–1938), became known as the Artichoke King. He purchased crates of artichokes that had been shipped from California to New York, and then sold them at an inflated price. Mayor Fiorello LaGuardia (1882–1947) was displeased with the mafia gangsters and the pushcarts in New York City. Because of the artichoke's association with crime, New York law outlawed the sale, display, and even possession of artichokes. However, this law was soon revoked. In California in 1947, an artichoke festival was held, and at this festival an artichoke queen was crowned. The queen of the artichoke was Norma Jean Baker—better known as Marilyn Monroe. At around the same time, the consumption of artichokes became associated with status in California. Only those in the upper class ate artichokes.

Cultivation of the Artichoke

Artichokes take about six months to grow. The majority of artichokes come to maturity twice a year—at the end of winter and again at the end of summer. Artichokes grown in California typically thrive in colder, damper weather. The plants produce the edible flowers for 5 to 10 years and are therefore perennials.

Artichokes need to be planted in an open space that is not exposed to the wind. The plants take root in damp, but not saturated, soil. Should the soil dry out during the summer, the plants will die. Artichokes are often taken from suckers on plants at least three years old and are cut between February and April. When the suckers are cut, at least three shoots must be left on the plant. The suckers can then be planted, with their roots about two inches deep and about three feet apart from one another. The artichoke shoots must be protected from the sun until their roots take hold in the soil. A second method for cultivating artichokes is to raise them from seeds. Artichokes grown this way can be started indoors and then transferred outdoors in March. Plants need to be nurtured during their first season, especially by keeping the soil damp and weeded. About one-third of the plants grown each year need to be replaced in order to keep a steady stream of plants that produce a good yield. When they are ready to be harvested, artichokes will be plump, soft, green, and almost ready to open. They should be cut along with two to three inches of stem. Harvesting the plants stimulates them to yield a second harvest.

Growers must watch for two types of diseases to which artichokes are susceptible. Gray mold can cause the flowers to shrivel. It can be prevented by ensuring that the plants are not too damp and that they are kept clean and are spaced properly. Lettuce downy mildew is another potential threat to artichokes. This disease causes yellow spots to grow on the leaves and mold to grow underneath the leaves. Diseased leaves should be removed. In the case of a widespread infection, entire plants may need to be removed.

Artichoke Varieties

Green Globe Artichoke grows in winter and in spring and is in a conical shape in the summer and fall. The globe artichoke has a large heart. During the summer harvest, the artichoke may be purple at its base. Desert Globe Artichoke varies in shape between the different seasons and can be a cone or globe. The Desert Globe has thorns and is compact in its appearance. Big Heart Artichoke is conical and lacks thorns. It has a wide base and a purple tinge throughout the season. Imperial Star Artichoke is round, thornless, and has a glossy appearance. Frost enhances its flavor.

Cooking, Nutrition, and Medicine

Artichokes are generally boiled in water and eaten, one petal at a time, until reaching the artichoke heart. Artichokes are served with dips, roasted, or used in Mediterranean cuisine. A single artichoke contains about 25 calories and no fat, and is a good source of vitamin C, fiber, folic acid, and magnesium. Additionally, artichokes contain phytochemicals that aid in protecting against cancers, especially those affecting the liver.

In herbal medicine, the artichoke is used as a diuretic and choleretic. The artichoke may be beneficial to the liver. The leaves may increase bile production in the liver, and they may reduce cholesterol in the blood. In Germany, the herb is used to stimulate the appetite. Additionally, artichokes have been found to relieve hangover. Individuals with metabolic disorders have improved with the administering of the phytochemicals found in artichokes. Also, the artichoke has been used to alleviate bloating, indigestion, and nausea. Finally, the artichoke may lower lipids that may otherwise be found in the blood.

The only side effects of artichokes involve allergies to them, the occasional blocking of bile ducts, and at worst, a possible contribution to the formation of gallstones. For these reasons, artichokes (or any plant) should not be used for medicinal purposes without the supervision of a physician.

Ronda Lee Levine

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Ash

A versatile tree native to the United Kingdom, ash is popular throughout Europe. The ash also grows in North America, North Africa, and all parts of Asia. The 18th-century Swedish naturalist Carl Linnaeus placed ash in the kingdom Plantae, the order Lamiales, the family Oleaceae (the olive family), and the species *Fraxinus*. Ash encompasses about 65 species of hardy trees that grow medium to large in size. The ash is mostly deciduous, although a few varieties of subtropical species are evergreens. The name ash derives from the Old English word æsc, while "fraxinus" is of Latin origin. Both words mean "spear."

The ash's seeds are popularly called "keys" or "helicopter seeds" because of their slender elongated shape. The pods contain a one-seeded fruit at one end, called a samara. When loose from the tree, the seeds spin and fly through the air like helicopter blades.

North American varieties of ash, of which there are a total of 17, include *Fraxinus anomala*, commonly called singleleaf ash; *Fraxinus dipetala*, whose common names are California ash or two-petal ash; *Fraxinus americana*, or white ash or biltmore ash; and *Fraxinus uhdei*, whose common names include shamel ash or tropical ash. The ash never grows in stands, and it tolerates all types of soil, wind conditions, and air quality.

Appearance

The common ash in Europe, *Fraxinus excelsior*, is taller than the North American varieties. It can reach a height of 140 feet. In North America, the ash typically grows to 50 feet in height. The tallest of the North American ashes is *Fraxinus americana*, which can reach 120 feet, although it averages between 80 and 90 feet tall. The ash is unique for its opposite branching, which is characterized by buds or branches growing directly opposite from other buds or branches on the same limb or twig. Three other varieties of trees have such a characteristic: maple, dogwood, and horsechestnut.

The ash is also characterized by its compound leaf. Unlike a simple leaf that has a bud at the base of the leaf stem (a petiole), a compound leaf has more than one leaflet growing out of the bud at its stem base. These 6- to 12-inch leaves have around five to nine leaflets. Each leaflet can grow to be several inches long. As a whole, the soft-textured leaves form a full canopy that allows grass and other groundcover to thrive underneath. These trees are suitable in areas that require light shading, although their seeds are abundant and can cover the ground beneath.

Because there are so many varieties of ash, leaf colors vary. The majority of deciduous varieties of ash, such as the *Fraxinus excelsior*, known as the common ash or European ash, turn golden or yellow in fall. The *Fraxinus americana*, or white ash, however, can become deep yellow or purple in autumn. The intensity of green in the ash's summer leaves also varies by type of tree. For instance, the green ash (*Fraxinus pennsylvanica*) has leaves of medium green, while the leaves of the flowering ash (*Fraxinus ornus*) are a much darker green.

The most widely distributed of North American ash trees is *Fraxinus pennsylvanica*. Not only does it grow naturally and abundantly from the Midwest to the East Coast, but it also is one of the most widely planted trees. It is a popular tree to adorn city streets in Canada because of its resistance to pollution. Canada also plants and harvests ash for its lumber. The lumber from ash alone is a multibillion-dollar industry in that country.

Threats to the Ash

The most common insects that feed on the ash are the ash sawfly, the oystershell scale, and the ash borer. The wood-boring beetle called the emerald ash borer (*Agrilus planipennis*) has killed millions of trees in North America, especially those in the midwestern United States and Ontario, Canada. The beetle entered the continent in 1998 along with ash products shipped from eastern Asia. The ash-borer has killed millions of North American ash and threatens some 7 billion others. To stem the spread of the pest, the public has been warned to keep unfinished ash products, such as firewood, local and not transport them into outside areas.

The Many Uses of Ash

The wood of the ash is a hardwood that has a straight grain and open pores. The white (*Fraxinus americana*) and black (*Fraxinus nigra*) varieties are often used in cabinet making, in crafting, and as firewood. At 41 pounds per cubic foot, ash is not an extremely heavy hardwood. It does, however, have an excellent strength-to-weight ratio, making it one of the best woods for baseball bats and other sporting equipment, including hockey sticks, boat paddles, and canoe oars. It is also often used to make tool handles, gates, and fence posts.

Ash is easy to bend and therefore is a good wood for making chairs, snowshoes, and boats. Because ash has no significant odor or taste, it was used historically to make food bowls, baskets, plates, and utensils. In fact, Native American basket weavers in Maine, the Passamaquoddy, refer to the brown ash as the “Basket Tree.” The oil in ash is similar to olive oil. The leaves are rich in nutrients and are the second most used leaf, behind that of the elm, for fodder for cattle, goats, sheep, and deer.

Ash has been used as an herbal remedy for centuries, including the fourth century BC. Then, Greek physician Hippocrates treated gout and rheumatism with ash leaves, because of ash’s ability to increase urine flow and release uric acid. As a tea, the boiled leaves have been used as a laxative.

The Ash in Folklore

The ash is associated with intuition and knowledge. According to Norse mythology, Odin, the supreme god and creator, hung from Yggdrasil, the World Tree, for nine days and nine nights in order to be granted the virtue of wisdom. Yggdrasil was believed to be an ash tree around which nine worlds existed, and Odin’s spear also was believed to be made of ash wood, but these beliefs have since been discounted in favor of Yggdrasil being a conifer.

Nonetheless, the ash still stands for wisdom and lives on in legends of other peoples, including the ancient Greeks. They believed that the Myliae, or the nymphs of the ash, were the daughters of the spirits of the clouds and sea. The ash was also sacred to the sea god Poseidon, and the wood was placed on seagoing vessels for good luck.

In Celtic legends, the ash is seen as a sacred and divine tree, and the Celts made their spears and shields from ash wood. Other traditions believe that the ash tree can bring good luck, especially those trees with an even number of leaflets on their leaves. The Druids believed that using an ash branch to make a staff connected the user to the realms of Earth and sky.

The Species of Ash

Among the most popular varieties of ash in North America is *Fraxinus americana*. The species grows to a height of 80 to 90 feet, with a gray-brown, thick deeply furrowed bark and twigs that are stout gray, brown, or greenish brown. Its terminal buds are one-quarter inch long and are grayish brown to brown. Its pinnate leaves are 8 to 12 inches long, with green on top and gray underneath. Its fruit is 1 to 2 inches with each wing partially surrounded by seed. The seeds propagate in 90 days. *Fraxinus americana* grows from Nova Scotia, Canada, south to east Texas, and east to Florida.

Fraxinus nigra, known as black, swamp, basket, or hoop ash, grows to a height of 40 to 70 feet, with a corky irregular reddish brown to gray bark with upright branches and moderately stout, light orange-brown to gray twigs. Its terminal buds are one-quarter of an inch long and are long, dark brown to black and ovoid in shape. The pinnate leavers are 10 to 16 inches long, with 7 to 11 leaflets that are dark green above and light green beneath. Flowers are purple. The samara are 1 to 1.5 inches long. The wood is dark brown and semisoft. The species' habitat is the cold wet soils of the upper northern states and Canada.

Fraxinus pennsylvanica, known as green ash, grows to a height of 60 to 80 feet. It resembles *Fraxinus americana* in its habitat and bark. Its twigs are stout gray to grayish brown, with a lightly hairy appearance. Its gray-brown buds are one-quarter inch long and can be covered with rusty hairs. The pinnate leaves are 6 to 10 inches long, with yellow-green on top. *Fraxinus pennsylvanica* produces a half-inch-long fruit. The wood is a light brown hardwood. The species is found from Nova Scotia west to Manitoba, Canada, south to Kansas, and east to Georgia.

Fraxiunus profunda, known as red or pumpkin ash, is similar in habitat, twigs, and buds to *Fraxinus pennsylvanica*. The bark is brown to gray-brown and the leaves are 8 to 16 inches long and dense and hairy. The fruit is 2 to 3 inches long and the wood is brown, heavy, and hard.

Fraxinus quadrangulata, known as blue ash, is a medium to large tree at 60 to 80 feet tall. The bark is bluish-gray to brown. The twigs are stout and light green to gray. Buds are one-quarter of an inch long. Leaves are pinnate, 8 to 12 inches long, yellow-green, and smooth on top and pale and hairy beneath. The species' range is the dry upland areas from Ontario, Canada, west to Iowa, south to Oklahoma, and east to central Tennessee. Its wood is light yellow and streaked with brown.

Rosemarie Boucher Leenerts

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Asparagus

In the Liliaceae or Lily family, which has 150 species, asparagus (*Asparagus officinalis*) is a perennial. Asparagus derives from the Greek word for "stalk." A stalk is known as a spear. The British call asparagus "sparrowgrass." The planting of asparagus may yield spears for more than 20 years. One planting in England has produced spears for more than 100 years. The rhizome and roots are known as the crown, and the foliage is termed the fern. Asparagus has fiber, potassium, folic acid, beta-carotene, vitamin C, vitamin D, vitamin B6, thiamine, and riboflavin. The vegetable has little sodium and no fat. Four asparagus spears, roughly 60 grams, have only 10 calories, 2 grams of carbohydrate, and 1 gram of protein.


Asparagus (Nutthawit Wiangya/Dreamstime.com)

Origin and History

Asparagus is native to Bulgaria, Hungary, and southern Poland. It may be found wild in the sandy soil of west central Russia, the Crimea, Great Britain, Poland, and central Wisconsin. In antiquity the Syrians, Egyptians, and Spanish cultivated the vegetable. The Greeks knew of asparagus but they were not avid consumers of it. The Romans had a higher opinion of the crop, prizing it for its flavor and as a medicine. Roman agricultural writer Cato the Elder (234–149 BCE) urged every Roman to grew asparagus in his garden. He advised farmers to add manure, preferably sheep dung, at the time of planting. The Romans used the saying "in the time it takes to cook asparagus" to mean a short duration. They dried asparagus so they could eat it through the winter. The Romans planted asparagus in France and Britain, though one author believes that England and France did not cultivate it until the 16th century. The Chinese candy asparagus. In some areas, people use asparagus seeds to make a type of coffee or ferment them into alcohol. The Dutch and Italians cultivate a purple cultivar. The Germans, Swiss, and Austrians eat white asparagus, which is grown without exposure to sunlight so that it does not manufacture chlorophyll and is not green. In the United States, the third president, Thomas Jefferson, grew several cultivars. One author claims that asparagus was Jefferson's favorite vegetable.

The Italians and Eastern Europeans who settled California cultivated asparagus, making California the leading producer in the United States. California grows 80 percent of U.S. fresh asparagus and more than half of all asparagus in the country. The Sacramento and San Joaquin river valleys produce most of California's asparagus, though it is also grown in the Imperial Valley. Another writer holds that Washington produces more than half of all canned asparagus in the United States. Michigan produces about 10 percent of U.S. asparagus. Asparagus is grown as a winter crop in southwestern Arizona and northwestern Mexico. The United States must compete against imports from Mexico and Peru. In addition to Europe and North America, asparagus is grown in Taiwan, Japan, Peru, Chile, Australia, New Zealand, and South Africa. Production in the Southern Hemisphere meets out-of-season demand in the North.

Attributes

Asparagus produces a mass of spears. Those in the center tend to be thicker than those on the periphery. Thick asparagus must be peeled to yield a tender core. The bottom of a spear is tough and should be removed. Asparagus is best used fresh because sugar, vitamin C, and flavor deteriorate in only a few days. Asparagus may be stored in a refrigerator. The humidity must be high, the vegetable should be stored in the back of the refrigerator where it will receive little light when the refrigerator door is open, and the temperature should be near freezing. One writer recommends that asparagus be wrapped in a wet paper towel to keep it moist. Stored in this way, asparagus may keep 10 days. Fresh asparagus is widely available in the United States, though as late as the 1960s Americans consumed canned asparagus in quantity. Fresh asparagus has superior nutrition and flavor. Asparagus may be dried, canned, or frozen to extend its shelf life.

Since antiquity, humans have known that asparagus is a diuretic and laxative. Asparagus imparts an odor to urine. In antiquity the roots, shoots, and seeds were used as a sedative, a painkiller, and a liniment. Some physicians have credited asparagus with improving eyesight and relieving toothache, cramps, and sciatica. Asparagus promotes the health of the urinary tract. Asparagus contains glutothione, a chemical that may protect the body against cancer. Asparagus may be eaten raw, in salad, or cooked no longer than 10 minutes. A spear has a low content of chlorophyll. Photosynthesis increases as light intensity increases. Asparagus is most efficient in photosynthesis when the temperature is less than 68°F. Asparagus accumulates carbohydrates in the form of fructose, a sugar.

Cultivation

Asparagus requires patience. When planted from crown, it does not yield spears for two years. When planted from seeds, the wait is three years. Planting from seeds is the cheaper method. Seeds germinate in one to two weeks at 68°F to 86°F. Seeds may be started indoors 12 to 14 weeks before transplantation outdoors. The gardener may plant seeds in trays one inch deep. Seedlings grow best between 55°F and 61°F and require 12 to 14 hours of light per day. Seedlings may be transplanted in the garden in early summer. A cool-weather crop, asparagus grows best between 60°F and 70°F. Alternatively, seeds may be planted directly in the garden in mid- to late spring. Because asparagus is long lived, the gardener should select a site with the idea of permanence. When planted directly in the garden, some people sow asparagus with radish. Quick-germinating radish marks the spot where asparagus will later germinate. Seeds should be put in a mixture of water and bleach, rinsed with water, and then planted.

The other method is to plant crowns. To plant crowns the gardener may dig a hole 15 inches deep for each crown and 6 size inches of organic matter. Well-rotted manure is best, but compost or peat is acceptable. In addition to organic matter, the gardener may add superphosphate at the time of planting at five pounds per 100 feet of soil. Crowns should be soaked in warm water several hours before planting. Crowns should be spaced 18 inches apart.

Whether grown from seeds or crowns, asparagus should be fertilized twice during the growing season with a 10-10-10 fertilizer of nitrogen to phosphorus to potassium. Alternatively, asparagus benefits from applications of rock phosphate, bonemeal, greensand, or wood ashes for phosphorus; wood ashes or greensand for potassium; and cottonseed meal for nitrogen. The gardener should mulch the soil with four to six inches of grass clippings, leaves, or other matter to minimize weeds. The gardener must be wary of the asparagus beetle, a common pest in North America. The mulch should be removed in autumn to deprive the beetle of the debris it needs to overwinter. Some gardeners interplant asparagus with tomato in the belief that tomato repels the beetle and asparagus repels the tomato nematode. Ladybugs and a species of wasp eat the beetle. Anthracnose is the most severe disease. Where rust is endemic, the gardener may plant the resistant cultivars Mary Washington and Jersey Giant.

The soil should be fertile sandy loam. Clay is acceptable provided it contains lots of organic matter. Asparagus tolerates saline soil. The soil pH should be between 6.5 and 6.8 or between 6.3 and 7.5 depending on whom one consults. Organic matter should be added to the soil in the autumn before next spring's planting. The gardener should plant 10 seeds or crowns per person for a suitable harvest. Because asparagus may grow to seven feet, it should not be exposed to wind for fear of lodging. Some gardeners stake asparagus for this reason. In the second or third year, depending on whether one planted crowns or seeds, asparagus may be harvested for six to eight weeks beginning in mid-spring. Spears should be harvested every few days, when they are five to seven inches long. In autumn, asparagus should be cut to the ground. Asparagus will not grow in the tropics because it must have cold weather to initiate dormancy.

Christopher Cumo

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Avocado

Avocado (*Persea Americana*)—like corn, dates, and figs—is a cultigen, or a cultivated species domesticated in the distant past and altered by prehistoric human selection so that its ancestry is unknown. The avocado tree is likely native to Mexico and Central America, and it produces a large berry, also called an avocado or alligator pear, that is spherical or egg-shaped and contains around 20 essential nutrients, including B vitamins, antioxidants, potassium, and fiber. The fruit is also high in mono- and polyunsaturated fats, the good fats that can lower cholesterol levels and reduce the risk of heart disease.

With small, yellow green flowers, the avocado tree is a subtropical species that requires a climate with little wind and no frost. The tree is evergreen, can grow up to 60 feet tall, and produces more than 100 avocados per year. Like bananas, avocados are climacteric, meaning that they mature on the tree but ripen off the tree. As a result, commercial avocados are mature, but hard and green when harvested. They are kept in coolers until they reach their final destination, and then they are allowed to ripen at room temperature.

Origin and History

The native, undomesticated variety of avocado—referred to as the *criollo*—is small, has a black skin, and contains a large seed. Most scholars agree that it

Avocados (Stuart Taylor/Dreamstime.com)

originated in the Mexican state of Puebla, where archaeological excavations of a series of caves and open sites yielded well-preserved remains of avocados dating to 10,000 BCE. Domesticated avocados have been cultivated throughout Central America for more than 7,000 years, and there is evidence that they had reached as far south as Peru before Columbus arrived in the New World. For instance, developed between 800 and 300 BCE, the Mayan civil calendar, which bases the name of each month on seasonal and agricultural events, symbolizes the 14th month with a glyph representing the avocado. And in *Los Comentarios Reales de los Incas*, or *The Royal Commentaries of the Incas* (1605), Garcilaso de la Vega recounts how the Incan warrior Tupac Yupanqui conquered some northern provinces between 1450 and 1475 and brought the avocado to the Inca valleys of Peru.

Prior to the arrival of the Spanish, the diet of the Mesoamericans consisted of three main crops, maize or corn, the common bean, and pepo squash, as well as a number of other fruits and vegetables, such as the chili pepper, papaya, cacao, guava, and avocado. Thus, even without significant quantities of fat and protein from meat, the Mesoamericans enjoyed a healthy, well-balanced vegetarian diet.

The avocado, however, proved useful as more than food. The wood from its tree was used in house construction and for firewood as well as in the creation of tools. According to Franciscan monk Toribio de Motolinia, who spent much of his career in Mexico, "the fruit [of the avocado tree] is so wholesome that it is served to the sick." The seed also was cut into pieces, roasted, pulverized, and then given to sufferers of diarrhea and dysentery. One ripe avocado mashed and mixed with a small amount of lemon juice can be applied as a mask to the face and neck for an effective toner/firmer.

The Mesoamericans valued the avocado as well for its aphrodisiac effect. Defined as substances that claim to increase the libido, aphrodisiacs are not currently recognized by the U.S. Food and Drug Administration (FDA), which maintains that the purported libidinous effects associated with certain foods are based on folklore and not scientific fact. In making this claim, however, the FDA is discounting about 5,000 years of tradition in several dissimilar cultures around the globe, including the ancient Greeks who coined the term "aphrodisiac" in honor of Aphrodite. Among many civilizations, a food's resemblance to genitalia, especially in certain fruits, was thought to indicate a natural connection between that food and human fertility. This is the case with the avocado. The association between sexuality and the avocado dates back to the fruit's discovery by the Aztecs. Because of the shape of the fruit and its tendency to hang in pairs, the Aztecs called it *ahuacatl*, which means "testicle," and this is the origin of the word "avocado." The Mesoamericans may also have observed the quetzal bird, a crucial bird in many of their creation myths, nesting close by avocado trees because consuming the healthful fruit assists the females in creating eggs.

Sexuality and reproduction were serious business in pre-Columbian times. Analogous to most ancient cultures, the Mesoamericans considered procreation an essential moral and religious obligation. They acknowledged the connection between fertility and nutrition, and because food was more difficult to obtain than it is now, they revered the foods that contained the nutritional values necessary for successful reproduction. Because it grows in such a way as to resemble the testicles and because it contains around 20 essential nutrients, the avocado would have certainly been recognized as a fruit that was not only high in nutrients but also capable of sexual stimulation. This libidinal application probably helps explain why a village site excavated in Oaxaca, Mexico, was found to contain higher than normal incidence of avocado remains. Likewise, written history provides confirmation that the avocado was believed to enhance sexuality. To use just one example, the 19th-century British adventurer William Dampier wrote of the avocado, "It is reported that this Fruit provokes to Lust."

Shortly after the Spanish conquest of Central and South America, Europeans developed an appreciation for this exotic fruit. Spanish author Martín Fernández de Enciso was the first to attempt a written description of the avocado. Published in Spain in 1519, his *La Suma de Geografía* described the fruit as "an orange, and when it is ready for eating it turns yellowish; that which it contains is like butter and is of marvelous flavor, so good and pleasing to the palate that it is a marvelous thing." As palatable as the fruit was, however, the Spanish found the Aztec name for it highly distasteful and nearly unpronounceable. Thus they changed it to *aguacate*, a word that the English subsequently contorted into "avocado."

Soon European colonialists introduced avocados to the Caribbean, and by 1750 the fruit had reached Indonesia. Around 1850, avocados arrived in California via Mexico and quickly became and remain a cash crop there. Today, about 60,000 acres in California are devoted to the harvest of the avocado, with San Diego County being the acknowledged avocado capital of the nation. As of the year 2000, the United States was producing between 160,000 and 200,000 tons of avocados, second only to Mexico where avocados are referred to as *oro verde* or "green gold."

Though its production is based largely in North America, the avocado is consumed around the global from the Americas to Europe to Ethiopia and South Africa to India and beyond. More than 500 cultivars (cultivated varieties of plants deliberately selected for specific desirable characteristics) are descended from three horticultural races: the Mexican, the Guatemalan, and the West Indian. One of the most common cultivars is a Mexican-Guatemalan hybrid called Hass, which produces fruit year-round. Another popular cultivar, also a Mexican-Guatemalan hybrid, is *Fuerte*, meaning "strong" in English. It earned its name after withstanding a severe frost in 1913. The Pinkerton, the Gwen, the Reed, and the Zutano are other varieties seen often in the supermarket or farmer's market. Valued these days more for its nutritious qualities than for its purported aphrodisiac effect, this unlikely fruit with a long history has a strong global market, and many associations and societies oversee its production and protection, ensuring a stable future for this cash crop.

Dana Nichols

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Azalea

In the 18th century, Swedish naturalist Carl Linnaeus placed azalea and rhododendron in separate genera, probably because their flowers had different numbers of stamens. Later taxonomists, recognizing the similarities between azalea and rhododendron, put them both in the genus *Rhododendron*. The tendency to see similarities has tempted Geoff Bryant, author of *Rhododendrons and Azaleas*, to maintain that azalea is merely a human construct that does not exist in nature. What humans call azaleas are really rhododendrons. This thesis ignores the fact that azaleas represent two of the eight subgenera of the genus *Rhododendron*. The two subgenera correspond to the two types of azaleas: deciduous azaleas, which are in the subgenus *Pentanthera*, and evergreen azaleas, which are in the subgenus *Tsutsutai*. Even these labels may be a bit misleading. To be sure, deciduous azaleas lose their leaves in autumn, but the phenomenon is more complicated for evergreen azaleas. In spring, evergreen azaleas issue forth bright green leaves, but in autumn shed them just as deciduous azaleas shed their leaves. In summer, evergreen azaleas put forth dark green leaves that grow in summer and autumn and tend to remain on the plant in winter. Exceptionally cold winters, however, may make evergreen azaleas shed all their leaves. This phenomenon has led some botanists to classify evergreen azaleas as "persistent-leaved" and to deny that a true evergreen azalea exists (Bryant 2001, 17). The gardener who wishes to retain the appearance of a true evergreen and who does not live in an exceptionally cold climate may prune the spring foliage so that all that will be left on the plant in winter are the dark green leaves that tend not to shed. Azaleas are ornamentals, chosen for their colors and ability to enhance a yard or garden.

History

The question of where azaleas originated has not been answered. One hypothesis, saying nothing about evergreen azaleas, holds that deciduous azaleas are native to North America, Europe, China, Japan, and Korea. Even if this is true, it says nothing about the origin of azalea. It seems possible that azaleas established themselves in both the Old and New Worlds before human habitation. The fact that azaleas are not native to Africa, the cradle of humanity, suggests that they spread to their current habitats millennia ago, when humans were yet confined to Africa. An Asian origin is possible.

If the question of origins cannot be answered, the origin of cultivation may be known. The earliest mention of azaleas comes from a Japanese poem, and the Japanese may have been the first to hybridize azaleas, possibly with rhododendrons. Since 759 CE, when azaleas were mentioned in verse, they have been a favorite of Japanese gardeners. Buddhist monks may have taken azaleas from Japan to China and other parts of Asia. If, however, azaleas are truly native to China, then these must have been secondary introductions, or the first human-assisted

Azalea (iStockPhoto)

migration of azaleas from Japan to China. From Asia, gardeners brought azaleas to Europe. Again, this may have been a secondary introduction. It is likely that of the azaleas that came from the gardens of China and Japan, some were hybrids. Azaleas readily hybridize with rhododendrons to yield 73 azaleodendron hybrids. Because the offspring of hybrids differ from the parents more starkly than do the progeny of pure types, many gardeners prefer true azaleas to azaleodendrons. As azaleas moved from Asia west to Europe, they also migrated east from North America to Europe. Europe, the meeting place for the disparate germplasms of Asia and the Americas, must have been the source of new varieties derived from Old and New World parents. From Virginia, the species *Rhododendron viscosum* was grown in England by 1680. In the 1870s, American botanist John Bartram may have introduced three species to Europe: *Rhododendron perichymanoides*, *Rhododendron calendulaceum*, and *Rhododendron viscosum*. The third must have been a secondary introduction. These three were hardier than the species the United Kingdom had and so gardeners bred hybrids to introduce the genes for hardiness into British germplasm.

Most evergreen azaleas may have originated in Japan, though only in the 20th century did Europeans import them. In 1918, British plant collector E. H. Wilson introduced 50 evergreen species to the United Kingdom, many of which later made their way to the United States. In 1892, botanist Charles S. Sargent at the Arnold Arboretum in Massachusetts introduced *Rhododendron kaempferi*, noted for its extreme hardiness, to the United States. The species has become a favorite of gardeners in the northeastern United States. Some hybrids of *Rhododendron kaempferi* can tolerate temperatures as low as –15°F.

In the 1870s, amateur plant breeder Anthony Watener and his son crossed European imports with Chinese azaleas, naming the new hybrids after their nursery Knap Hill. Newer still are the Windsor hybrids that Sir Eric Savill bred in the Savill Gardens, England. In the 1980s, the University of Minnesota released the Northern Lights cultivars, renowned for their ability to withstand temperatures as low as –35°F. These varieties also do well in warm climates.

Climate and Geography

In the tropics, azaleas bloom year-round. The higher the latitude the briefer is the period of bloom. To compensate for this brevity, azaleas at high latitudes reward the gardener with abundant flowers. In central Florida, azaleas bloom between October and March. In San Francisco, California, the period is between mid-September and May. The Belgian and Glenn Dale hybrids flower from August through winter. In Washington, D.C., and Seattle, Washington, they flower from mid-April to July. The Southern Indian hybrids grow well in the American South. *Rhododendron kaempferi* and deciduous species may be grown as far north as Maine. Gardeners may grow deciduous azaleas almost anywhere in the United States. Evergreen azaleas do well in the eastern United States, whose climate is similar to their native Japan. Surprisingly, evergreens are not hardy enough for Canada. The Canadian gardener should choose a deciduous variety.

The Soil and Its Nutrients

Azaleas evolved as compact shrubs that formed the under story of forests. Tall trees shaded them part of the day, and long tree roots absorbed nutrients at depth, leaving nutrients to be absorbed in shallower soil. Azalea roots are accordingly short, seldom longer than two feet, though they may spread as widely underground as does the part of an azalea plant above ground. Within this two-foot zone, an azalea derives water and elements. Leaf litter from nearby trees decay in the soil, making it rich in organic matter and acidic. For this reason, the gardener should add abundant organic matter to the soil. Organic matter retains moisture in the soil to the benefit of azaleas, which do not tolerate drought, though deciduous azaleas are more drought tolerant than evergreen azaleas. Azaleas also do not tolerate waterlogged soil. Azalea roots need loose soil and will not penetrate clay. A plant that languishes after first thriving has likely had its roots hit the subsoil or a high water table. Both conditions prevent roots from absorbing enough nutrients. The gardener, aware of the importance of organic matter, should dig leaves, pine needles, straw, garden debris, or manure into the soil where he intends to plant an azalea. Peat, bark, and sawdust are also sources of organic matter, but they have few nutrients. The soil pH should be 4.5 to 5.5, though azaleas tolerate a pH as high as 6.5.

Azaleas sometimes have the misfortune of being grown in soils deficient in nitrogen, iron, or magnesium. A lack of nitrogen causes azaleas to grow slowly and to yellow old foliage. To correct this deficiency the gardener may add urea in a concentration of one ounce of urea to one-and-one-half gallons of water. Too potent a concentration of urea may burn azalea roots. The gardener may also supply nitrogen by adding ammonium sulfate or ammonium nitrate to the soil. Leaves that yellow while retaining green veins betray iron or magnesium deficiency. When the soil is alkaline, iron and magnesium may be unavailable for absorption. Azaleas grown in iron- or magnesium-deficient soil should benefit from the addition of one ounce each of iron sulfate and magnesium sulfate to one-and-one-half gallons of water, applying the solution to the soil. The sulfate ions in the mixture reduce soil alkalinity. Premature leaf shedding and lack of vigor may be traced to poor drainage.

Christopher Cumo

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Baby's Breath

Baby's breath is the common name of a large number of species of herbaceous plants belonging to the genus *Gypsophila*, which 18th-century Swedish naturalist Carl Linnaeus classified. The species include both annuals and perennials, whose flowers range from white to a deep pink. The plant that is commonly known as baby's breath in North America, presumably because of its delicate light-colored petals, is sometimes referred to as "soap wort" in the United Kingdom. Approximately 100 species encompass the genus *Gypsophila*, which belongs to the family Caryophyllaceae, a plant family that also includes the common carnation. It is native to Central and Eastern Europe, Asia, the Mediterranean, and North Africa. The botanical name *Gypsophila* derives from the Greek words *gypsos*, meaning "chalk," and *phylos*, meaning "loving," which refers to the fact that the plant species grows in alkaline soils rich in calcium carbonate.

Baby's breath is grown as an ornamental plant in gardens and is cultivated for its small white or pink flowers that typically grow on tall stems. The stems and flowers are commonly used in the floral industry as filler plants. Baby's breath sprays are added to bouquets, corsages, and arranged flowers. A common accompaniment to white baby's breath is red roses. Baby's breath is also popular in dried arrangements and is added to wreaths and craft projects. It lasts up to one week in floral arrangements and is available year-round. Flowers to be used in arrangements should be cut when half the blooms are open. In gardens, baby's breath typically is grown to hang over walls and to adorn rock gardens. The pure-white blooms also mix well with wildflower varieties.

Annual and Perennial Species

Gypsophila elegans, or annual baby's breath, is a fast-growing and easy-to-grow plant that can reach a height of 20 inches. The species has many branches and narrow leaves that are blue-green. Its flowers are about one-half of an inch and either white or pink. Popular varieties of the annual plant include Carminea, with its deep-rose-colored flowers; Grandiflora Alba, whose flowers are large and white; and Rosea, with rosy pink flowers. As an annual, *Gypsophila elegans* lives just one year and dies with the first frost. New plants can regenerate near the old if the seeds fall on bare ground.

Gypsophila paniculata is a perennial species that grows to a height of two to four feet when in full bloom. This shrubby plant bears panicles that anchor single small white or pink flowers in the mid- to late-summer months. The leaves are gray-green. The two-feet dwarf varieties include Pink Fairy and Viette's Dwarf, while the three- to four-feet full-size plants include Snowflake and Perfecta. *Gypsophila paniculata* is one of the most widely used cut flowers. It attracts butterflies and is deer resistant. *Gypsophila* paniculata is sometimes called double baby's breath. Three common varieties include Bristol Fairy (white), Pink Fairy (pink), and Alba (white).

Gypsophila repens, also known as creeping baby's breath, is another perennial species. It is a dwarf cousin to the taller baby's breath plant. It grows to a height of just 4 to 8 inches and has a spread of about 12 to 18 inches. It bears loose, broad clusters of pink or white flowers that are about 0.5 inch wide. Foliage is gray-green. This variety blooms from early to midsummer. It attracts butterflies and is resistant to deer. It is an excellent cascading plant. Three common varieties are Alba (white), Rosea (pink), and Pink Beauty (pink).

Habitat and Ecological Impact

Baby's breath can withstand both hot and cold temperatures as well as various levels of moisture. It is not hardy enough to withstand winter temperatures, however, so the seeds should be sown in early spring. Optimum soil temperature for germination is 70°F. The depth of plantings should be one-sixteenth of an inch. The blooming period for baby's breath generally is from April through August. The plant can grow in both fine and coarse soils, but the soil should be nonacidic. Root growth of *Gypsophila paniculata* is fast during the first two years, as the root system penetrates deeply. It can be found in a wide variety of habitats, including pastures, roadside ditches, and fields, growing best in bright sunlight and in soil that is evenly moist and well draining. It is easily grown in rock gardens, beds, and borders.

Baby's breath seeds germinate in 10 to 20 days, and a single plant can produce as many as 14,000 seeds. Seeds are easily dispersed by the wind and from humans collecting the plant. Because baby's breath is such an aggressive seeder, it is considered a noxious weed in several U.S. states, including California and Washington, and in the Canadian province of Manitoba.

Baby's breath's ability to germinate quickly and be easily dispersed has caused the plant to grow in abundance. It tends to invade areas along waterways, including beaches, streams, and lakes, and has the capacity to colonize the habitat of plants that are native to the area and sometimes rare. It can become a problem to farmers, as well, when fields and pastures reserved for planting and grazing become clogged by the plant. Baby's breath is hardy. It is used as food by the larvae of some moths and butterflies, but, overall, insects do not pose a problem to the plant. Disease is also rare.

Baby's breath is popular because of its wide-branching stems and delicate flowers, which offer a frothy appearance that florists prefer. A symbol of everlasting love, as well as purity of heart and innocence, baby's breath is sometimes worn in the hair of girls at weddings. It also has religious connotations and is sometimes referred to as the breath of the Holy Spirit. The root of *Gypsophila repens* is boiled and mixed with sugar to make a whipping cream that is a typical topping of *kerebic*, a Turkish dessert.

Rosemarie Boucher Leenerts

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Bamboo

The Poacea or Gramineae family contains more than 600 genera and some 10,000 species. Among them is the subfamily bamboo, an aggregation of genera and species. A grass, bamboo is related to several important crops including wheat, barley, rye, rice, corn, oats, millet, sorghum, triticale, and sugarcane. Bamboo has tropical, subtropical, and temperate representatives. The tropical, and presumably subtropical, species are known as sympodial or clumping bamboo. Some tropical bamboos are hardy enough to endure temperatures just below freezing. At the onset of the rainy season, tropical bamboos grow culms, a process that continues from summer to autumn. Where rainfall is evenly distributed throughout the year, tropical species grow continuously. Temperate bamboos are known as monopodial or running species. They can endure temperatures below 0°F. They do not thrive in areas where winter is severe, preferring warmth. They can, however, tolerate snowfall. Dormant during winter, temperate bamboo resumes growth in spring. The Vietnamese term bamboo "the brother." The Chinese know bamboo as "the friend of the people." The people of India refer to bamboo as "the wood of the poor."

Origin and History

Bamboo originated in the early Cretaceous Period (135–65 million years ago) on the supercontinent Gondwanaland. When it broke apart, bamboo spread to vast areas of the world. Bamboo diversified into numerous species in the Tertiary Period (65–2 million years ago). Fossils of bamboo have been found in what is today France in the Miocene Epoch (6.5 million years ago). Fossils from other parts of the world date to the late Tertiary Period (2 million years ago). When China and North America were linked, bamboos on these landmasses shared a common gene pool. When they separated, a bamboo in China evolved into the species *Pseudosasa anabils*. The population of bamboos in North America evolved into *Arundinaris gigantea*, the only species native to the continent. The Chinese and North American species are closely related, evidence of the linkage between China and North America. Temperate bamboo might have evolved first, giving rise later to tropical bamboo.

Bamboo did not colonize arid regions or areas with severe winter and so is confined to warm temperate locales, the tropics, and the subtropics. The ice ages depopulated Europe and North America, leaving no species of bamboo in Europe and only a single species in North America. A plant of the forest, bamboo has colonized all continents except Europe and Antarctica. Asia, South America, and Africa have a large number of species of bamboo. Botanists once thought that China harbored roughly half of all bamboo genera and species. Today, they think that Central and South America have more than half of all genera and species of bamboo, displacing China as the leading continent of bamboo biodiversity. Two authorities allot 41 genera of bamboo to the Americas, 16 to Africa and Madagascar, 65 to southern and eastern Asia, and 2 to Australia. Bamboo grows as far north as 60° north and as far south as South Africa. Bamboo has colonized the Himalayas, the Chilean Andes, and Argentina. Bamboos from the mountains tend to tolerate the climate of North America, and for this reason gardeners have transplanted them there. The fit is not, however, perfect. Mountain bamboos need higher light intensity and humidity than are common in North America. Bamboos that have colonized the mountains of the tropics, to the extent that they experience cold, have low temperatures daily, presumably at night, and are not ideal for transplantation in North America because the climate subjects flora to a season of unremitting cold.

Hardy bamboos tolerate temperatures as low as –20°F. Temperate China subjects bamboo to hot summers and cold winters. Chinese bamboos tolerate temperatures as low as –15°F. Where summer is cool, bamboo grows small and compact. Temperate species of bamboo tolerate more heat and aridity than mountain species. Japan and Taiwan have hardy species of bamboo adapted to hot, humid summers. The genus *Sasa* is widespread in Japan as far north as the Kuril Islands. *Themocalamus tesellatus* of South Africa is a temperate species, but the specimens of equatorial Africa, Madagascar, Australia, southern and eastern Asia, the Pacific islands, and Central and South America are all tropical species.

Attributes and Cultivation

Bamboo is the world's fastest-growing plant, able to grow 47 inches in a single day. Bamboo reproduces principally vegetatively. A rhizome yields a new plant that is a clone of the parent. Alternatively, bamboo may reproduce sexually. Bamboo may flower every year or as remotely as every 120 years. When one bamboo of a species flowers, all bamboos of that species flower, even those on other continents. This synchronicity ensures the production of ample pollen. Wind pollinates bamboo flowers. Bamboo pollen is capable of fertilizing the flowers of sugarcane and rice. Some species of bamboo are interfertile, resulting in the production of hybrids. Fertilized flowers yield seeds, which resemble kernels of wheat. A bamboo plant may die after seeding, and a new seedling may require 12 or 13 years to reach maturity. Under cultivation, a seedling may mature in 6 years. Some species do not reproduce sexually because they are sterile.

A bamboo seedling grows well in high humidity and rainfall. Some farmers grow bamboo in rice paddies to obtain water. Bamboo prefers alluvial soil or loam. It tolerates sand and clay, though these are not ideal. The soil should be fertile, well drained, and contain gravel. Bamboo benefits from the addition of compost or fertilizer to the soil. The gardener may add 10 parts nitrogen, 5 parts phosphorus, and 5 parts potassium to the soil one month before shoots emerge in spring. A second application should follow before the rhizome resumes growth. Bamboo benefits from the application of 80 pounds of nitrogen, 40 pounds of phosphorus, and 40 pounds of potassium per acre. Leaf litter should be allowed to cover the ground to minimize weeds.

Bamboo grows well on slopes, where it lessens soil erosion. One may plant bamboo at the base of a hill or near a river that has deposited alluvial soil in its valley. The black bamboo tolerates direct sunlight. Many other species benefit from partial shade. As a rule, bamboo should not be planted in a western orientation because the afternoon sun may be too harsh. In warm regions, a northern exposure is best. In cool locales a southern exposure is preferred. The Chinese grow bamboo in infertile soil and in arid conditions to derive strong, hard bamboo. Egyptians grow bamboo along canals so that it has a source of water. Algerians irrigate bamboo. Indians must contend with the bamboo powder post beetle (*Dinoderus minutus*), which reduces bamboo to dust. Rats, porcupines, squirrels, rabbits, deer, and monkeys eat the rhizome, shoots, and seeds.

Uses

Bamboo was the source of Europe's silk industry. Two monks, visiting China, hid the eggs of a silkworm in a stalk of bamboo, giving them to Byzantine emperor

Justinian in 552 CE. Bamboo branches have been used to thatch roofs in Asia. The Chinese have used bamboo as spears and guns. That bamboo could withstand the firing of a gun derives from the fact that pound for pound bamboo is stronger than steel. Large culms were used as baskets and cooking pots. Small culms served as cups or containers. Since 200 BCE the Chinese have used bamboo canes to drill for oil to a depth of 3,000 feet.

The people of Japan and the Andes Mountains make musical instruments from bamboo, the Japanese stringed instruments and the Andeans pipes. Malaysians make flutes from bamboo. Bamboo is made into furniture, blinds, room dividers, screens, fences, houses, paper, chopsticks, mats, baskets, weapons, the skin of airplanes, and phonographic needles and slide rules before these technologies were eclipsed. An extract of bamboo may be used as medicine for asthma, as salves for hair and skin, as an eyewash, as an aphrodisiac, and as a poison. Asians eat bamboo shoots. The Chinese and Japanese eat *Phyllostochy edulis* raw, though other species must be boiled to remove bitterness. Bamboo ashes are used to polish jewels and make batteries. Bamboo has been used to construct bicycles, dirigibles, windmills, scales, and retaining walls strong enough to hold back flood and the tide. China has made bridges as long as 750 feet from bamboo. American inventor Thomas Edison (1847–1931) used a bamboo fiber in his lightbulb.

Christopher Cumo

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Banana

Although the casual observer might consider a banana plant a tree, botanists classify it a perennial herb. The banana is the world's largest herb, growing as tall as 30 feet. It is the world's largest fruit crop and the fourth-leading crop, trailing wheat, rice, and corn. A crop of the tropics, the banana will not grow at high latitudes. Farmers cultivate the banana in Florida, but perhaps because of the latitude it is not grown on a large scale there. Instead, farmers grow the banana in Southeast Asia, western Asia, China, India, Pakistan, Bangladesh, several Pacific islands, Africa, the Caribbean, and Central and South America. An indigene of

Banana trees (Corel)

Southeast Asia, the Columbian Exchange brought the banana to the Americas in the 16th century. In much of Asia, Africa, and the Pacific, small farmers raise bananas for local consumption, whereas growers in the Caribbean and Central and South America export much of their fruit to the United States, Canada, and Europe. Americans and their counterparts in the rest of the developed world eat the banana as dessert whereas it is a staple in the developing world. A single banana plant yields three or four harvests in its life. Six months after it flowers a banana plant yields mature fruit. In total, a banana plant needs 8 to 10 months to grow from seedling to maturity. Bananas remain green as long as they are on a plant. As soon as they are picked, however, they begin to ripen. During ripening, they convert starch into fructose. A green banana has 1 percent fructose whereas a ripe banana has 80 percent sugar. Once picked a banana releases ethylene gas, a chemical that hastens ripening. The banana is a source of carbohydrates, potassium, vitamin C, and vitamin B6. In some regions of the world, manufacturers make bananas into chips, flour, and puree.

Origin and Diffusion

In Asia and Africa, people describe the origin and importance of the banana in myth. Notorious in the creation story in Genesis is the forbidden fruit. Saint Jerome thought the fruit was the apple, a belief that lingers today, though another tradition identifies the banana as the forbidden fruit. The Koran populated Eden with banana plants. Some Arab scholars consider the banana the "tree of paradise." In the 18th century, Swedish naturalist Carl Linnaeus named the banana *Musa paradisiaca*, meaning the "banana of paradise." After eating the banana, Adam and Eve clothed themselves in banana leaves. The belief that they used fig leaves may be mistaken because people confused the banana and the fig. Alexander the Great, for example, called the banana a fig. The author of Genesis may have known of the banana, which may have been grown in the Near East. Wherever Eden is thought to be, farmers today grow the banana in Jordan, Egypt, Oman, and Israel.

In India, the banana has religious significance. Indian mystics meditate beneath banana plants. According to one tradition, the banana is the incarnation of Lakshmi, the goddess of wealth, beauty, and wisdom. At an Indian wedding, the groom gives the bride a banana as a symbol of fertility. In India, the banana is the subject of Hindu art. In the Vedic tradition, a banana grove is home to the monkey god Hanuman. India grows roughly 17 million tons of bananas per year, 20 percent of the global total. India's production is thrice that of Ecuador, the second-leading producer. India grows the banana for local consumption whereas Ecuador produces for export. The people of Ecuador eat less than 2 percent of the country's bananas. In India, banana chips are the most popular snack. Indians even eat fried banana peels with black-eyed peas. As unappealing as it may seem to Westerners, Indians make bananas into ketchup. In New Guinea, farmers use the banana in rainmaking ceremonies. Africans include the banana in one of their creation accounts. Kintu, the first human, married Nambi, the daughter of Gulu, the creator god. Her brother, unhappy that she had married a mortal, expelled the couple from Eden. Leaving paradise, Kintu and Nambi carried a banana root, presumably for planting, in their wandering. Some scholars believe Uganda was the African Eden. So important is the banana to Uganda that people sometimes use it as money. A farmer, for example, might repay a loan with bananas. Ugandans eat a special variety of banana at the birth of twins and another to mark the passing of kin. A husband or wife might eat a particular variety to encourage his or her spouse to be faithful. Another variety, Ugandans believe, increases sperm production. Uganda produces 11 million tons of bananas per year, a figure that computes to more than 500 pounds per person per year. This amount is 20 times more than the per capita consumption in the United States. In some Ugandan villages, farmers produce 970 pounds of bananas per person per year. Although this figure seems large enough to encourage exports, Ugandan farmers grow bananas for local consumption.

So central is the banana to the concept of food in Uganda that the word *matoke* means both "banana" and "food." On Samoa, *mei'a* means "banana." In New Zealand and Easter Island, *maike* means "banana." The Hawaiian *mai'a* means "banana." The people of Indonesia, the Philippines, Malaysia, and New Guinea render *pisang* as banana. The Papua *pudi* and fud *both* mean "banana." *Buti* means "banana" on the Solomon Islands. The people of Fiji call the banana *vud*. On Tonga, the banana is *feta'u* and on Tahiti *fe'i*. Hindus term the banana *kalpatharu*, meaning "virtuous plant." The English word "banana" derives from the Arabic *banan*, meaning "finger" because each banana in a bunch is a finger.

The banana originated in Southeast Asia. Wild bananas are inedible, leading one to wonder why the ancients selected them for eventual domestication. The people who took an interest in these wild bananas selected for seedlessness and flavor. Wild bananas arose in southern China, Southeast Asia, and India. As early as 7000 BCE, the people of New Guinea ate the banana and may have been the first to cultivate it. Around 5000 BCE, people throughout Southeast Asia began cultivating the plant. In antiquity, the banana spread to Samoa, New Zealand, Hawaii, Easter Island, Indonesia, the Philippines, Malaysia, New Guinea, India, Taiwan, southern China, and Borneo. Around 300 CE, Indonesians brought the banana to Madagascar, from which it spread to East Africa. The fact that many African bananas are descended from Pacific cultivars suggests a second introduction. In 650 CE Arabs brought the banana to the Middle East. At first, European explorers did not know what to make of the banana, often confusing it with the plantain. In 1350 one European explorer found the banana in Sri Lanka. In 1482, the Portuguese found bananas being grown in Sierra Leone, Liberia, and Gambia. Around 1500, the Portuguese planted the banana in the Canary Islands. In the late 16th century, travelers observed the banana in the Nicobar Islands and India.

Some scholars speculate that the banana arrived in the Americas before Columbus's voyages. One school of thought holds that bananas from West Africa reached the Americas ahead of the Genoese explorer. Another school of thought traces the banana's putative trek across the Pacific to the west coast of South America. The first mention of the banana in the Americas dates to 1516, when Spanish missionary Tomás de Berlanga introduced it to Santo Domingo (today the Dominican Republic), marking the advent of banana culture in the Caribbean and possibly in all the Americas. From Santo Domingo, the banana spread to the rest of the Caribbean and to Central and South America. In Central America, planters have established large estates, especially in Ecuador, Colombia, Honduras, Guatemala, Costa Rica, and Panama.

Planted in the Caribbean from the 16th century, the banana became an export only in the 19th century. In the 1860s, the United States began to import bananas from Jamaica. Planters, sensing an opportunity to profit, converted abandoned sugarcane estates to banana plantations. In the 20th century, United Fruit Company monopolized the shipping of bananas from the Caribbean to the United States. On Saint Lucia, farmers converted hilly terrain from sugarcane to banana. The Dominican Republic grew banana and coffee. On Grenada farmers raised banana and nutmeg. In 1902, the eruption of Mount Pelée on Martinique covered sugarcane plantations with ash. Some farmers replanted their land to banana. Between 1987 and 2002, banana exports on Martinique rose from 191,140 tons to 341,720 tons. The latter figure totaled 40 percent of the island's exports. Martinique ships most of its bananas to France, Italy, and the United Kingdom. Since 1950, bananas have been the leading export on Saint Vincent. In 1981 bananas totaled 72 percent of the island's exports. On Guadeloupe, the banana harvest increased in the 1990s, rising 30 percent in 1991 alone and another 13 percent in 1992. In the latter year, the harvest tallied 163,470 tons, 122,430 of which went to export. In 2000, however, drought and Hurricane Debbie decreased production to 127,320 tons.

In Central Africa, people ferment bananas into beer. In Uganda, the variety Mbidde is used to make beer. In Zaire, the variety Makandili serves this purpose. In Zaire, farmers plant bananas and coffee. In Burundi, growers intercrop the banana with taro, beans, peas, and cabbage. In Rwanda, farmers grow the banana and sweet potato. So important is the banana in Rwanda that it adorns the 20-franc coin. In some areas, farmers intercrop bananas with cocoa. In this system, the banana provides income during the four or five years during which cocoa matures. When cocoa is mature, farmers cut down their banana plants for mulch. Today, Cameroon, Cote d'Ivorie, the Canary Islands, and Israel export bananas to Europe. The Philippines, adopting varieties from Latin America, began exporting bananas in the 1970s and today exports them to Japan, the Middle East, and Hong Kong. Bananas total half the value of exports in the Philippines, Dominica, Grenada, Saint Lucia, Saint Vincent, Martinique, and Guadeloupe.

Banana Varieties and the Quest for Disease Resistance

By one estimate, the banana comes in more than 1,000 varieties. Small farmers grow most of these and they are consumed locally. Among banana-growing countries, India, which grows more than 670 varieties, has the greatest diversity. In Tamil Nadu alone, farmers grow more than 50 varieties. Growers on Sri Lanka cultivate more than 25 varieties. The Philippines grows more than 75 varieties. Rwanda is home to roughly 85 cultivars and Uganda to more than 30 varieties. In parts of Asia, local varieties are more important in sustaining people than is rice. Because these varieties do not enter the export market, Americans, Canadians, and Europeans are unfamiliar with their flavor.

Since the 19th century, North Americans and Europeans have consumed just two varieties, Gros Michel and Cavendish. Gros Michel (Big Michael) originated in Southeast Asia. In the early 19th century, French naturalist Nicolas Baudin introduced it to Martinique. In 1835, French botanist Jean Francois Pauyat transplanted Gros Michel from Martinique to Jamaica. From the Caribbean, Gros Michel spread to Central and South America. Between the 19th century and World War II, Gros Michel was the only variety that Americans ate. Because it does not seed, Gros Michel is propagated vegetatively. That is, a banana plant produces suckers, which grow into new plants. Unfortunately, each sucker is a clone of its parent. Gros Michel, being only a single variety and being propagated by clones, was dangerously uniform. The rise of new pathogens or the recrudesce of old ones threatened Gros Michel with extinction.

From an early date, scientists understood this danger and labored to breed new varieties to increase the banana's diversity. In 1922, the Imperial College of Tropical Agriculture in Trinidad and the Banana Research Station in Jamaica began programs to derive new varieties. Imperial College continued this work until 1960, when it transferred its research to the Banana Research Station. By 1980, a lack of funds forced the Banana Research Station to cease work, but Canada's International Development Research Centre restored its funding. In 1959, United Fruit Company inaugurated a breeding program in Honduras but, dissatisfied with results, stopped research in 1983. Again, other agencies came to the fore. The Food and Agriculture Organization of the United Nations, the U.S. Agency for International Development, and the International Development Research Centre funded the research program in Honduras. In Nigeria, the International Institute of Tropical Agriculture funds banana research.

Much of this research has concentrated on the derivation of disease-resistant cultivars. Scientists have crossed disease-resistant wild varieties with susceptible cultivars to yield resistant cultivars. Simple in principle, the derivation of disease-resistant cultivars has been difficult to achieve in practice. Flavor, shelf life, resistance to bruising, and texture are all difficult to control. Several promising varieties ripen too quickly to be suitable for export. Some new triploids show promise, lasting three weeks after picking, a full week longer than tetraploids.

The effort to breed new varieties did not save Gros Michel. The rise of a fungal disease known as Panama disease doomed the cultivar. So virulent is Panama disease that in the early 20th century it killed nearly every banana plant in Suriname. In 1931, Scottish agronomist Claude Wardlaw found Panama disease in 15,000 acres on Jamaica and 50,000 acres in Panama, from which it derives its name. Since 1931, Panama disease has spread to 8 countries in Asia, 5 in the Pacific, 12 in Africa, and 22 in the Americas, including the Caribbean. United Fruit Company attempted to combat the Panama disease by flooding fields in the belief that water would wash away the fungus. Instead, water spread the fungus to other farms. A soil-borne pathogen, the fungus adheres to anything in contact with infected soil and so is spread by human activity. Farm tools, shoes, and bicycle tires can all spread the disease. From its home in Panama, the disease spread throughout the Americas, claiming banana plants farm by farm. By the 1960s, Panama disease had ravaged Gros Michel. Banana growers might have lost their livelihood but for the discovery of a resistant cultivar, Cavendish. In 1826, plant collector Charles Telfair discovered this new banana variety in China. He sent seedlings to England, where they found their way to the greenhouse of the Duke of Devonshire. Because his surname was Cavendish, it became synonymous with the new variety. The missionary John Williams planted Cavendish on Samoa, Tonga, and Fiji around 1850. By 1855, farmers grew Cavendish in Tahiti, Hawaii, New Guinea, Egypt, and South Africa. By the 1870s, farmers were growing Cavendish in the Caribbean. In 1939 Standard Fruit experimented with Cavendish, discovering its resistance to Panama disease. In the Americas, Cavendish had its greatest effect. In the 1960s, growers planted it in place of Gros Michel and today it is the only variety of banana that Americans, Canadians, and Europeans eat. Growers who had once planted Gros Michel in monoculture now plant Cavendish in monoculture.

In the 1980s, some farmers in Malaysia switched from oil palm to banana to satisfy growing urban demand for the fruit. They planted Cavendish, by then the world's principal export banana. That decade, however, disease afflicted the hitherto resistant Cavendish. The symptoms resembled Panama disease but scientists rejected the connection. After all, Panama disease was a problem in the Americas, not in Asia. Isolation of the fungus proved, however, that the Asia sickness was Panama disease. Scientists were initially puzzled that Cavendish had lost its resistance until they realized that they were confronting distinct races of Panama disease. Cavendish was resistant to the race that was malignant in the Americas but vulnerable to the Asian race. Panama disease, it turned out, was indigenous to Asia and only later spread to the New World. In the 1990s Indonesia, following Malaysia, converted some of its land from oil palm to banana, but disease has reduced yields. Given these losses in Asia, scientists wondered whether disease would claim Cavendish as it had ousted Gros Michel. Fortunately, the Asian race of Panama disease has yet to invade the Americas. The advent of Panama disease in China in 2007 caused consumers not to buy bananas in the mistaken belief that they might contract the affliction. Newspapers fed this misconception, labeling the disease "banana cancer." Some Chinese feared that diseased bananas might cause AIDS. Since then, Panama disease has spread to Pakistan, the Philippines, Indonesia, and Africa.

This does not mean that Cavendish is safe. The fungal disease Black Sigatoka is nearly as virulent as Panama disease. Arising on Fiji in 1935, the fungus reached Honduras in 1972, Zambia in 1973, Gabon in 1979, Costa Rica in 1980, and Colombia and Venezuela in 1981. Whereas Panama disease spread slowly because it required human intervention to transmit it, Black Sigatoka, an airborne pathogen, spread rapidly. In Uganda, the disease killed so many banana plants that bananas are scarce in some districts. Their price has risen and the poor who depend on bananas for sustenance have difficulty affording them. Fungicides are effective but laborious to apply and expensive. In Central America farmers must apply fungicide up to 45 times per year. United Fruit Company used Bordeaux mixture to kill Black Sigatoka fungi. Small farmers who could not afford the fungicide in bulk succumbed to the disease, allowing United Fruit Company to buy their land. Bordeaux mixture was toxic to workers, turning their skin blue. Symptoms were progressive. One lost the sense of smell, then began vomiting, and in the worst cases of Bordeaux poisoning died. Growers spend $60 million per year on fungicides (Bordeaux mixture is now banned) to combat the disease. Some varieties are resistant, but Cavendish is not. The fungus rots bananas and kills plants. Even a putatively healthy plant may be infected. Workers might cut what appear to be healthy bananas only to have them rot during shipment.

Mako disease can likewise be severe. Insects that burrow into bananas transmit the causal agent, a bacterium. Large insect populations cause a high rate of infection. When the bacterium gets on farm tools, it may spread to bananas by this route. Common in the Caribbean and in Central and South America, Mako disease rots bananas from the inside out. Aphids transmit Bunchy Top, a viral disease, to bananas. In 1889, the disease arose on Fiji and spread thereafter to Pakistan, Australia, Sri Lanka, India, Bangladesh, Myanmar, and Hawaii. The virus caused 30 percent losses in Hawaii and as much as 75 percent losses in parts of Pakistan. Nematodes are a significant pest, feeding on banana roots and turning leaves red, purple, or black.

The Business of Bananas

In 1885 Boston Fruit, now Chiquita, formed to ship bananas from the Caribbean to the United States. Because bananas are perishable, Boston Fruit was the first company to ship them in refrigerated compartments. In New Orleans arose Standard Fruit to supply bananas to the South. Because Boston Fruit and Standard Fruit depended on the volume of sales to generate profit, they priced bananas cheaply. In the 19th century, bananas were half the price of apples, and around 1900 Americans could buy a dozen bananas for 25 cents. This price fetched only two apples. The inexpensiveness of bananas encouraged Americans to buy them, and consumption rose from 15 million bunches in 1900 to more than 40 million bunches in 1910. Although it dipped in the 1940s, per person consumption of bananas has risen 43 percent in the United States since 1970. Buying bananas throughout Latin America and the Caribbean, the United States nonetheless imports most of its bananas from Ecuador.

In Central America, cattle rancher Minor C. Keith, building lines in Panama, Guatemala, Honduras, Nicaragua, Colombia, and Ecuador, planted bananas alongside the tracks. Initially, bananas fed railroad workers, but Keith came to understand that he could ship the surplus to the United States and so supply the American Southwest with them. In 1899 Keith merged with Boston Fruit to create United Fruit Company. This conglomerate grew bananas on land the size of Connecticut. United Fruit was an early investor in Cuban bananas, owning

300,000 acres of bananas and sugarcane. As United Fruit grew in size and wealth, it gained influence in the Caribbean, in Central and South America, and in the United States. When aroused to action, the United States used force to compel recalcitrant government to do the bidding of United Fruit. In 1912, the United States invaded Honduras, forcing the government to concede to United Fruit the right to build railroads and grow bananas. Depending on cheap labor, United Fruit was hostile to labor activism. In 1918, U.S. troops, acting at the behest of United Fruit, crushed strikes by banana workers in Panama, Colombia, and Guatemala. In 1925, American soldiers crushed another banana strike in Guatemala. United Fruit was equally ruthless toward competitors, buying them or bankrupting them by undercutting their prices. By the late 1920s, United Fruit was worth more than $100 million, had 67,000 workers, owned 1.6 million acres, and counted banana estates in 32 countries. Workers did not share this prosperity. At the peak of operations, laborers worked up to 72 hours with little respite, harvesting bananas and loading fruit on ships. They had no access to a toilet, could not unionize, and were seldom paid cash. Instead, they received scrip, which they could redeem only at United Fruit stores, whose prices were high and that sold products from the United States rather than locally produced goods. Always eager to increase sales, United Fruit hired physicians to approve the practice of feeding bananas to infants, knowing that mothers did the grocery shopping. United Fruit advertised the combination of corn flakes with sliced bananas as the ideal breakfast. The company put coupons for free bananas, paid for by cereal manufacturers, in cereal boxes.

United Fruit's actions in Colombia precipitated the banana massacre. In 1899, the year of its founding, the company acquired its first banana plantation in Columbia. To its dismay labor became restive in the early 20th century. In October 1928, 32,000 banana workers, seeking better working conditions, went on strike. Their demands seem moderate. They wanted medical care, the use of a toilet, payment in cash rather than scrip, and classification as employees rather than independent contractors so they could enjoy the protection of Colombia's labor laws, weak though they were. Rather than negotiate, United Fruit denied that its workers were discontent. The strikers would not relent, and on December 5, 1928, Colombia's government, surely under pressure from United Fruit, declared martial law. Soldiers fired on workers after they had attended a Catholic mass on Sunday, killing more than 1,000 of them.

Events in Guatemala were no more reassuring. In the early 20th century, United Fruit established its first banana plantations and from an early date seems to have dominated the weak Guatemalan government. The government required its people to labor 100 days per year on banana estates, a system of forced labor that was too common in the Americas. If United Fruit loathed workers, it also appears to have disdained the government, refusing to pay taxes on the land it owned. The growth of a middle class in Guatemala in the 20th century raised the people's consciousness. Educated, the middle class understood that United Fruit was exploiting the country. They resented the fact that the company ran Guatemala as a banana plantation. Indeed, bananas companies owned 4 million acres, 70 percent of Guatemala's arable land. In 1944, schoolteachers went on strike. Shaken, the government legalized unions but barred banana workers from joining them. The fall of one government led to the rise of Jacobo Arbenz, who founded a liberal government. Arbenz demanded that United Fruit pay taxes and give up some of its land so that the people might farm as they wished. Sympathetic to United Fruit and branding Arbenz a communist, President Dwight D. Eisenhower ordered the Central Intelligence Agency (CIA) to overthrow the government. Using misinformation, the CIA created confusion in Guatemala. Convinced they were on the verge of defeat, military leaders refused to muster their troops against the CIA. Arbenz fled Guatemala. United Fruit had made the world safe for the banana.

Christopher Cumo

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Barley

An annual grass in the Poaceae or Gramineae family, barley is among the most ancient cultivated plants. First grown in the Near East, barley was also one of the original plants in the Columbian Exchange. Humans grow barley for the kernel (seed), using it as food, beer, and feed. Grown from the Arctic Circle to the tropics, barley tolerates a range of climates and soils. Able to grow in alkaline soils where most grains cannot, barley survives in arid and hot locales, though as a temperate crop it does best in cool, moist regions. With shallow roots, barley tolerates soils that are too thin for wheat and oats. It also tolerates saline

Barley (Corel)

soils better than other grains. Barley cannot, however, endure both heat and high humidity. Scientists familiar with barley are able to judge its value by appearance. Barley with heavy kernels is rich in starch and protein. The plumper the kernel the more starch it has. Between 8 and 18 percent of a barley kernel is protein. The average of 13 percent protein compares favorably to the 12 percent protein of wheat. Ten to 15 percent of a kernel is the hull, which contains cellulose, pectin, lignin, some of the protein, and fiber. The rest of the kernel is carbohydrate. Of the carbohydrates, 55 percent is starch. In addition to protein, barley contains the minerals potassium, calcium, and magnesium. Barley is of two types depending on planting date. As its name suggests, spring barley is planted in spring and matures in roughly three months. Winter barley is sown in autumn. It germinates and grows several inches before frost. It becomes dormant during winter, resumes growth in spring, and is ready to harvest in early summer. To mature properly winter barley needs 2 to 10 weeks of temperatures below 50°F. Winter barley is a popular crop in Pennsylvania, California, and the Pacific Northwest. In the United States, 75 percent of the crop is spring barley and 25 percent winter barley. Barley has some 5 billion pairs of nucleotide bases, constituting 25,000 genes. These genes represent less than 5 percent of the barley genome. To date scientists have identified less than 10 percent of barley's genes. Barley is related to corn, rice, rye, oats, sugarcane, sorghum, bamboo, and timothy.

Origin and Diffusion in the Old World

Myth celebrates the origin of barley. The Egyptians believed that Isis, the goddess of bread and beer, taught them to grow barley. Another tradition holds that the goddess Hanthor, also identified with bread and beer, gave the Egyptians barley. In some instances, the Egyptians conflated Isis and Hanthor into a single goddess of barley. The Egyptians believed that the germination of barley reenacted the resurrection of Osiris, the brother and husband of Isis. In Catal Huyuk, Turkey, the ancients associated a fertility goddess with barley. One statue displays a fertility goddess resting her arms on the heads of two leopards. She tamed these wild animals as humans domesticated what had once been wild barley. In Greece, Demeter, the goddess of grain, gave humans barley. In Rome, the goddess Ceres bestowed barley on humans.

Because of its antiquity, several scholars have been eager to trace the origin of barley. Among the first to take up this topic was French botanist Alphonse de Candolle. In 1882, he asserted that cultivated six-row barley had derived from wild two-row barley. In fact, recent research has demonstrated that three mutations may have transformed two-row barley to six-row barley. The transition from wild to cultivated barley may therefore have occurred rapidly. De Candolle also considered the possibility that the ancestor of barley might be extinct. In 1923, Russian agronomist Nikolai Vavilov thought that barley originated in Ethiopia, though he later backtracked, holding that Ethiopia was merely a secondary center of domestication and that barley had arisen elsewhere. In 1932, scientist Elizabeth Schiemann posited that an unknown wild barley was the progenitor of cultivated barley. In 1939, scientist E. Aberg suggested that barley originated in Tibet. In 1953, archaeologist Robert Braidwood asserted that humans first grew barley for beer. Scientist Hans Helbeck and American agronomist Paul Mangelsdorf disagreed, claiming that humans first grew barley for food. Scientist Leo Oppenheim synthesized these positions, asserting that humans first grew barley for both beer and food. In 1966, American agronomist Jack Harlan proposed the Fertile Crescent as the place where humans domesticated barley. In seeking the origin of barley, scientists have debated whether two- or six-row barley arose first. As we have seen, de Candolle among others supposed that two-row barley gave rise to six-row barley. Aberg, on the other hand, thought that six-row barley predated two-row barley. In fact, the earliest archaeological remains are of two-row barley, vindicating de Candolle.

The chronology of cultivation corroborates Harlan's Fertile Crescent thesis. Humans may have harvested wild barley as early as 17,000 years ago on the shore of the Sea of Galilee. Barley then grew wild in southwestern Asia and North Africa. About 10,000 BCE, the Natufians harvested wild barley in the Near East. About 7000 BCE, humans grew barley in parts of Israel, Jordan, southern Turkey, Iraq, Kurdistan, and southwestern Iran, a region now known as the Fertile Crescent. In this period, people farmed as well as gathered wild barley, and several generations must have passed before farming became the principal way of obtaining barley. In the late seventh millennium, the people of Tell Ramad II, Syria, grew barley for consumption as porridge. By 6000 BCE, skeletons in Syria displayed dental caries, leading one scholar to suggest that the people of this time ate barley in the form of porridge. The barley stuck to the teeth, causing the growth of bacteria and the consequent development of cavities.

From the Fertile Crescent, barley spread west to the Aegean and eastern Mediterranean in the sixth and fifth millennia BCE. In Egypt, farmers grew barley in the Nile Delta by the fifth millennium. From the Nile River, barley migrated south to the highlands of Ethiopia. In the fifth millennium, barley spread east to the Caucasus Mountains and India. By the fourth millennium, farmers in the western Mediterranean were growing barley. By 3000 BCE, the Swiss were growing barley. By 2500 BCE, barley had spread throughout Europe. The ancients of Britain grew barley for livestock and wheat for humans. Because barley prefers cool weather, moderate rainfall, and low humidity, farmers grew it in abundance in Northern Europe. In the Netherlands, barley may have been the first crop grown because it tolerated the saline soils that killed other crops.

These early barleys were all six row. Only in the Middle Ages did Europeans grow two-row barley, which the Crusaders had introduced from the Levant. Among the regions of North Africa, Morocco may have been an independent center of domestication. From Greece, barley migrated north to the Danube River, and from the Danube, it spread throughout the Balkans, Ukraine, and Poland. In the second millennium, farmers adopted barley in China, Korea, and Japan. Barley must have been an important crop in China, where one text listed it as one of the five sacred grains.

From an early date, farmers in Israel and throughout the eastern Mediterranean grew barley in preference to wheat, probably because barley yielded better than wheat on saline soils, alkaline soils, and poor soils. With little gluten, barley was not ideal for making bread. Instead, people ate it in soup and porridge. The transition to eating bread in the Greco-Roman world caused farmers to cultivate wheat at the expense of barley, though they continued to grow barley for making beer. In Greece and Rome, a two-tiered hierarchy arose in which elites ate wheat bread and commoners ate barley porridge. In the first century CE, the Roman agriculturalist Columella classified barley a famine food, perhaps meaning that Romans ate it when they were desperate for food. What barley the elites grew they fed to livestock.

As early as the fourth millennium, the people of Godin Tepe, Iran, raised barley for making beer. The making and drinking of barley beer must have been an important activity in antiquity. The Sumerians brewed eight types of beer from barley. From the third millennium, beer was common in Egypt. Employers sometimes paid workers in beer. In an era when the water might harbor the microbes that caused cholera, dysentery, and other diseases, many people eschewed water for beer, even drinking it at breakfast. The beer-drinking Sumerians worshipped Ninkasi, the goddess of brewing. About 1700 BCE, the Sumerians wrote the first set of instructions for growing barley.

The first step in making beer was to malt barley. Malting required the beer maker to begin germinating barley from kernels. Germination released from the kernel a-amylase and b-amylase, enzymes that converted the starch to sugar. One scholar believes that the biblical "land flowing with milk and honey" referred not literally to honey but rather to malted barley, whose sugar gave it sweetness. Once malted, barley was fermented to convert the sugar into alcohol. Malted barley may have had other uses. The ancients of Europe may have mixed malted barley or perhaps even beer with milk to create a nutritious mix. Because malted barley provides humans with B vitamins, and milk contains protein and calcium, one scholar believes that the consumption of malted barley and milk improved health and may have increased life span. In Northern Europe, beer making was an important activity. From an early date, the people of Moravia, Bavaria, and Frankonia grew barley for beer. People thought that fermentation was a magical process, imbuing barley with an element of the sacred.

Barley in the Americas

In 1492, Christopher Columbus brought seeds of various plants to the island of Hispaniola (now Haiti and the Dominican Republic). Whether barley was among these plants is unclear. Columbus did not mention barley by name, though one authority believes that he had barley among these plants because it was common for migrants to carry seeds of important crops in their journey to new lands. Even had Columbus introduced barley to Hispaniola, there is no way to know whether the colonists of La Navidad cultivated it, because the Amerindians killed them. The problem of whether Columbus introduced barley to the New World in 1492 may be insoluble.

There is no doubt, however, about his second voyage. In 1493, Columbus wrote in a letter to King Ferdinand that he brought barley to Hispaniola. Even this evidence does not reveal much. Whether barley flourished in the tropical Caribbean is unclear. Barley can be grown in the tropics, but as a crop of temperate locales, it may not have thrived in the Caribbean. Where and how successfully barley was grown in the 16th century is unknown because the historical record is silent about this grass. Early in the 17th century, however, barley reentered the historical record. In 1602, a man known only by the last name of Gosnold introduced barley to Martha's Vineyard and the Elizabeth Islands off the coast of Massachusetts. In 1611, the London Company brought barley to Jamestown. By 1648, the crop was widely grown in Virginia, but thereafter farmers abandoned it for the more profitable tobacco. In 1620, the Pilgrims introduced barley to Plymouth, Massachusetts. In 1626, the settlers of Newfoundland and Manhattan began raising barley. In 1629, farmers first grew barley in the Massachusetts Bay Colony. By the end of the 18th century, barley had emerged as the principal crop in Rhode Island. Throughout New England, farmers grew barley for beer. Around 1771, California growers raised the variety Coast for beer. Others grew the variety Atlas for beer, exporting much of the crop to Great Britain.

The history of barley culture in the United States is tied to the history of immigration. Each nationality of immigrants brought to the United States the varieties of barley that they had grown at home. In 1701, the Spanish introduced varieties from North Africa into Arizona and later California. These varieties, adapted to the arid climate of North Africa, did well in the American Southwest. In the 18th century, immigrants imported varieties from Switzerland and the Balkans to the South. The British and Dutch settlers of North America introduced two-row spring barleys, but these varieties did poorly. The Scots had better success with their six-row varieties. German settlers brought Russian varieties to the United States.

After the American Revolution, pioneers carried barley to the new lands of the West. Western New York emerged as an ideal region for the cultivation of barley, and by 1839 the state grew 60 percent of U.S. barley, making New York the leading grower. By 1849, New York's percentage had risen to 69. In the 19th century, barley was grown near the major cities to provide beer to urbanites. Detroit, Cincinnati, Toledo, Pittsburgh, St. Louis, and Chicago all imported barley for brewing. Throughout the 19th century, barley production increased in New York, Maine, Ohio, Pennsylvania, Michigan, and Illinois. Most barley in the Northeast and Midwest went to make beer. In the Southwest and California, barley fed livestock. The gold rush of 1849, by increasing the population of California, increased the demand for barley. Whereas California produced 0.2 percent of U.S. barley in 1848, it produced 28 percent in 1859. Between 1859 and 1869, barley acreage increased in Minnesota. During the 1870s, barley acreage increased in Nebraska and the Dakotas. In 1879, farmers were growing barley in Oregon and Washington.

The saga of barley involved more than geographic expansion. In 1850, a German traveler—his name is lost to history—collected seed from a vigorous stand of barley on a visit to Manchuria. Upon returning to Germany with the seed, his activities were unclear, though the variety came to the attention of Herman Grunow, an American scientist visiting Germany. Grunow brought the seed to the United States in 1861, apparently growing it over several years. In 1872, he gave seed of the variety to the Wisconsin Agricultural Experiment Station, which distributed it to farmers. Not surprisingly, the variety was known as Manchuria, though confusingly scientists and farmers also called it Manshury, Mandsheuri, Minnesota 6, and North Dakota 787. The number may refer to the plot of land. Minnesota 6 therefore would have been grown on the sixth plot of land, likely at the Minnesota Agricultural Experiment Station of the experimental farm at the University of Minnesota. The story of Manchuria does not end here. In 1881, Canada's Ontario Agricultural Experiment Station obtained the variety from Russia, though how Russia came to have it is unclear. Scientists at the Ontario Agricultural Experiment Station gave Manchuria to the Minnesota and North Dakota Agricultural Experiment Stations in 1894. Scientists at the Minnesota Agricultural Experiment Station released their own varieties, Minnesota 32 and Minnesota 105, which were derivatives of Manchuria. By another account, the variety Manchuria does not derive its name from Manchuria but from the village of Manshury in Egypt's Nile Delta. This account would explain the origin of the name Manshury, by which the variety Manchuria was sometimes known.

Other varieties rose to prominence. Around 1880, scientist F. H. Horsford of Charlotte, Vermont, first hybridized barley, obtaining three varieties: Beardless, Success, and Success Beardless. In 1894, the U.S. Department of Agriculture (USDA), alert to the need to preserve the genetic diversity of barley, began collecting varieties and now has several thousand. In 1905, the USDA collected seed from the variety Tribi, which originated in Samsun, Turkey. In 1909, the Minnesota Agricultural Experiment Station grew Tribi, and farmers in Chico, California, did likewise in 1910. Results were discouraging, but when farmers irrigated the variety at Aberdeen, Idaho, the yield was high. Early-maturing varieties are ideal for arid regions because they seed before the high temperatures and low rainfall of midsummer. Late-maturing varieties do well in moist, cool locales with long growing seasons. The improvement in varieties has increased yields. Since the 1940s, superior varieties have contribute more than one-third of the gain in yield.

Seeking to protect U.S. farmers, the McKinley Tariff, named in honor of high-tariff advocate President William McKinley, placed a 30-cents-per-bushel duty on imported barley in 1897. In addition to domestic production, New York breweries relied on cheap barley from Canada. The tariff made Canadian barley too expensive, sending New York breweries into decline. Whereas New York had been the center of brewing, cities in the Midwest took the lead in the early 20th century. Farmers in southern Wisconsin, northern Illinois, and eastern Iowa grew barley for brewing in Milwaukee and Chicago. Benefiting from the tariff, American farmers, who had grown 100 million bushels of barley in 1895, raised 200 million bushels in 1915. During World War I, the demand for wheat increased, causing some farmers to switch from barley to wheat. Because so much barley went to make beer, Prohibition hurt farmers as barley production declined in Wisconsin, Iowa, Minnesota, North Dakota, and South Dakota. During Prohibition, farmers were keen to export surplus barley. During the 1920s, exports reached 25 percent of

U.S. barley, a percentage that was not matched until the 1950s. Yet even before the repeal of Prohibition, barley rebounded as farmers discovered that malted barley was good for livestock. With this use of barley demand soared, and in 1928, five years before the end of Prohibition, barley production reached 300 million bushels. The repeal of Prohibition should have led farmers to grow more barley, but in the short term the drought of 1934 reduced barley yields. In the 1930s, production increased in western Iowa, eastern Wisconsin, and Michigan. After 1940, however, the expansion of acreage to hybrid corn and soybeans led farmers to grow less barley in the Midwest.

Like many farmers, barley growers suffered during the Great Depression. Between 1868 and 1932, the price per bushel of barley fell more than sixfold. Part of the problem was overproduction. Between 1895 and 1928, production had tripled. The practice of feeding barley to livestock had limits because farmers believed barley inferior to corn as livestock feed. Barley had too much fiber to feed to poultry, and hogs did not gain weight as rapidly on barley as on corn. With little of the amino acid lysine, barley is less valuable as feed than corn.

In the United States, farmers rotate barley with corn, cotton, sugar beets, tobacco, and potatoes. In the West, farmers doublecrop barley with alfalfa. In other areas, farmers doublecrop barley with milo, beans, soybeans, corn, sudangrass, and cowpeas. In parts of the West, farmers grow barley the first year, wheat the second, and fallow the land in the third year. Elsewhere, a barley clover rotation is common. American farmers grow barley for beer in the Red River Valley of Minnesota and North Dakota and under irrigation in Idaho, Wyoming, and Montana. During the 20th century, production increased in Idaho, Washington, Oregon, Kansas, and Colorado. By 1990, North Dakota, South Dakota, Minnesota, and Montana produced the majority of U.S. barley. Yields per acre have increased over time. Between 1950 and 1990, the yield more than doubled. Today, the western edge of the Midwest specializes in growing barley for beer. By contrast, California farmers feed barley to livestock.

Barley in the Modern World

Americans eat relatively little barley compared with other parts of the world, but it is growing in popularity in the United States, especially among those who are vegetarians or eating more plant-based foods. Barley is found in soups, stews, stuffings, salads, and other grain dishes. In 1959, however, less than 1 percent of the U.S. barley crop nourished Americans. In the United States, soup and baby food contain barley, as do some breakfast cereals. In North Africa, southwestern and South Asia, Italy, Germany, Finland, Ethiopia, Tibet, Nepal, and Peru, barley is an important source of nourishment. Peruvians grow barley in the highlands of the Andes Mountains. In these regions, people eat barley in flat bread, gruel, and porridge. Barley that goes to make beer has less protein than the barley that feeds livestock. The barley that is fermented into beer needs a long growing season, cool temperatures, and uniform moisture.

In 1990, Germany was the leading grower of barley. Canada was second and France third. The United States was fifth. Europe's climate, with its cool summers (temperatures range between 54°F and 76°F in July) and uniform rainfall, give farmers the best yields. Yields are high in Switzerland. Belgium, Luxembourg, Denmark, France, Ireland, the Netherlands, and Czechoslovakia all boast yields above 100 bushels per acre. Thanks to this productivity, Europe produced 69 percent of the world's barley in 1990. In contrast to Europe's fecundity, hot, dry North Africa was not an ideal region for the cultivation of barley. In 1990, Morocco averaged just 16.6 bushels per acre of barley. Yields were worse in Tunisia with 16.2 bushels per acre and Algeria with 12.5 bushels per acre. Worldwide, barley is fourth in acreage, trailing corn, rice, and wheat. Europe and Asia plant 75 percent of the world's barley acreage.

The success of hybrid corn led to efforts to hybridize barley on an ambitious scale. Progress was initially slow. The production of a hybrid required scientists to emasculate the barley plants that they designated the female lines. Barley has small flowers with anther and stigma close together. To emasculate a plant, scientists must penetrate the flower, removing the anther before it sheds pollen. Although this procedure may be done on a few plants without too much trouble, it is too time consuming and labor intensive to emasculate acre after acre of barley. Once an anther is removed, its pollen is used to fertilize the stigma of another plant to yield a hybrid. The discovery of genes that cause barley to produce no pollen eased the production of hybrids. Scientists now derive hybrid barley by using male sterile lines as the female line, crossing them with fully fertile plants as the male line. Hybrid barley yields between 15 and 35 percent more grain than its parents. Some progeny have even achieved 50 percent more grain than their parents.

In areas of Canada and Australia unsuitable for corn, farmers grow barley for livestock. These countries export barley to Asia for feed. Because of the oversupply of wheat on the world market, some farmers have switched from wheat to barley. In southeastern Europe, however, some farmers have switched from barley to corn because of its superiority as feed. Since 1991, barley acreage has declined 14 percent worldwide as farmers has converted acreage to corn. Worldwide, 85 percent of barley is used as feed. Yet barley faces competition from wheat, whose surplus is also used to feed livestock.

Some 18 million tons of barley are fermented into the world's 1.3 million liters of beer. Increasing beer consumption in Asia and South America should stimulate the demand for barley. In Moravia, farmers grow the variety Hanna for making beer. In Scandinavia, farmers grow Binder, Kenia, Opal, and Maja, all derivative of Hanna. Scientists crossed Kenia with the variety Britburly to yield Proctor.

Scientists have found challenging the attempt to breed varieties that have both high yield and suitability for malting. In addition to its use in making beer, malted barley is an ingredient in candy bars, milkshakes, chocolate flavored beverages, and vinegar.

Christopher Cumo

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Basil

Basil is an herbaceous member of the mint family, Labiatiaceae, that originated in India and has been used for about 5,000 years. The most common type of basil in cultivation is *Ocimum basilicum*, a heterogeneous species with a number of different cultivars. Even the same cultivar may vary greatly in morphology and also in chemical composition. There is a rich history surrounding basil and a great deal of mythology. Its use once limited to royalty, the name derives from the Greek *basilikos*, meaning "royal." Now, basil is grown all over the world for its culinary use as a spice. Essential oil is also produced from the leaves and the flowers for flavoring and industrial purposes, and there has been a great deal of study on the antimicrobial properties of the herb and its oil.

Basil Folklore

There is a large amount of tradition about basil on all of the continents on which it has been grown for long periods. One common thread is consideration of the herb as an enticement to love, either as a part of sacred ceremonies such as weddings or as an ingredient in aphrodisiac dishes. Holy basil, *Ocimum sanctum*, has long been used in sacred Hindu ceremonies and is part of both traditional Hindu weddings and funerals. In some parts of Europe, acceptance of a sprig of basil by a man indicates that he will love the woman who gave it to him forever or even formal acceptance of a marriage proposal.

Alternatively, in Greece, basil has been considered a symbol of hatred and sorrow. The plant was vilified by the influential Greek philosopher Chrysippus in

200 BCE as causing one to become dim-witted. The ancient Romans cursed basil as they planted it, believing this would cause it to grow better.

Taxonomy of Basil

As with many plants, the assignment of taxonomic systems to *Ocimum* species has been an active and contentious area. The genus was named by Swedish naturalist Carl Linneaus in 1753 and enumerated into five species. In the past 250 years, there have been a number of taxonomic systems proposed, greatly expanding the species number of *Ocimum*. These systems were based on the structure of the plants, particularly those of the flower parts. The most recent system in common use is that of British plant taxonomist Alan Paton and his fellow researchers from 1999, in which *Ocimum basilicum* is placed within the *Ocimum* section of this genus.

The morphology of the plants can vary greatly, however, given the crossbreeding between various cultivars and species. The science of chemistry was in its infancy when the original *Ocimum* taxonomic schemes were proposed. Since then, the advent of analytical chemistry has enabled the study of the numerous aromatic compounds found in all species of *Ocimum*, particularly those of the essential oils of these plants. This has enabled researchers to classify types of basil based on their chemical profile—a field called chemotyping. One problem with this avenue of research is that the particular chemicals in a given plant can vary widely depending on the environmental conditions, seasons, and soil and region in which the plant is grown.

Other methods of taxonomic classification of basils include examining the geographic origin of the plants and whether or not they can be crossed with one another. With the discovery of DNA and cell nuclei, karyotyping became a viable method of analysis. This technique involves determining the number and appearance of chromosomes per cell in an organism. One problem with using this technique in basil is that researchers have found the chromosome count to vary widely within the same species.

The advent of molecular biological techniques, such as the polymerase chain reaction (PCR), have ushered in a new era in plant taxonomy. A class of techniques based on PCR amplification of small amounts of DNA takes advantage of minor changes in the structure of genes. This enables genetic fingerprinting to be performed in plants and gives a much more rigorous analysis of genetic relatedness. Croatian scientist Klaudija Carović-Stanko and coworkers published such research in 2010 comparing 28 accessions of basil, including 22 of *Ocimum basilicum*. In addition to PCR techniques that had been previously used in studies of basil taxonomy, along with chromosome counting, they also examined nuclear DNA content.

Of the two PCR methods used, AFLP (amplified fragment length polymorphism) was successful in separating all of the accessions from one another. The commonly used technique RAPD (random amplified polymorphic DNA) did not distinguish between all of the accessions. In tandem, both of these techniques enabled the researchers to successfully classify all of the plants tested.

The researchers found a high level of genetic diversity among the basil accessions, which adds credence to the taxonomic system of Paton with its large number of species. They were able to clearly separate taxa, with a grouping of *Ocimum basilicum* type species and one of *Ocimum americanum*. All of the *Ocimum basilicum* cultivars and varieties fit within that species' group. Surprisingly, *Ocimum minimum* fit within the group also and could be a subspecies or variety of *Ocimum basilicum*. An additional surprise was that two Russian accessions of *Ocimum basilicum* ssp. *purpurascens* were found to be genetically identical to the *Ocimum americanum* group, which has a different number of chromosomes.

The current classification of basil includes several varieties and a very large number of cultivars. The primary variety of *Ocimum basilicum* in cultivation is *basilicum*, in particular cultivars Sweet Basil and Genovese. Also notable are varieties *purpurascens* Benth. (purple basil), and *difforme* Benth.

Basic Biology of Basil

Ocimum basilicum is an herbaceous plant originally from tropical areas such as southern Asia, including India, and Africa. In such climates, it can grow as a perennial. In much of the world, it is cultivated as an annual, however, since the plant cannot tolerate frost. Basil grows best in long days with full sun and requires consistent moisture.

Being a member of the mint family, basil has square stems. The leaves are dotted with glands containing oil comprising a number of aromatic secondary metabolites. The composition of the oil varies greatly between different cultivars. It is the oil that gives basil its distinctive, slightly mint-like smell.

Basil leaves are formed opposite to one another and are velvet green or purple, depending on the cultivar. The plants grow to about one-and-seven-tenths to four feet in height and produce white flowers in a terminal spike. Normally when cultivated as an herb, the flowers are cropped off, so the plant will keep producing leaves. The flowers set seeds that are also rich in oils. The seeds produced by a particular plant can vary greatly in their morphological characteristics and oil production. This lack of genetic uniformity can complicate the growth of cultivars from seeds. All of the members of the *Ocimum basilicum* group have 48 chromosomes.

Uses of Basil

Basil is used around the world as a culinary ingredient. Dried and fresh basil leaves are among the most popular herbs in Italian, Mexican, Greek, and French cuisines. The flavoring is added to vinegars, pickled vegetables, and salads. One common association of basil is as an ingredient in pesto, the classic Italian dish that uses this herb as a primary ingredient. Basil is also an important herb in Asian cuisines. The plant is versatile for so many cuisines partly because its taste varies over different regions. This is due to variation in the types of chemicals found in the plants in various parts of the world.

The use of dried or fresh basil can greatly affect its utility as a spice. The process of drying causes the plant to lose a high percentage of its oil content. Thus the resulting herb is less aromatic and flavorful. Drying can be highly important for storage, however, to keep pathogens from growing on the herb. Also, the tissue turns black fairly quickly after being harvested if it is not rapidly used or stored in a special manner. Once dried, the herb keeps its essential oils for several years if stored properly. Frozen basil is becoming a more popular commodity, since it can be used in the same manner as fresh basil, which is subject to seasonal availability in cooler climates.

The essential oil can be isolated from the leaves of the plants or from the flowers. The flowers contain a smaller percentage of oil, but it is considered superior to that from the leaves. Basil oil is an important industrial item and is used primarily in the food industry and in the making of perfumes. Sweet basil grown from seed is the primary source of essential oil for industrial purposes. Because of the variability of oil composition in plants grown from seed, along with other factors, the chemotype is determined before the plant is used for this purpose.

The food industry uses basil oil in a range of products, from candies to meat products and liqueurs. It dissolves in fatty acids and can be added to perfumes, shampoos, soaps, and dental products. The essential oils are produced by the distillation of flowering plants grown in favorable climates where it is economically feasible to produce them on a large scale.

Basil has been used in traditional medicine for millennia to treat a number of conditions. Its oil has long been considered to be antimicrobial. Research has shown promise with some *Ocimum basilicum* oils and is being vigorously pursued.

Chemicals Found in Basil

Basil contains a number of low-molecular-weight, volatile, aromatic compounds in its essential oil that give the characteristic aroma and flavoring to the plant. The herb contains 0.5–1.5 percent of essential oils that vary in their composition. Most of the compounds distilled from the essential oil have oxygen groups on them. Studies have found up to 54 different chemicals in the distilled oil of *Ocimum basilicum*. Prominent compounds include estragole, linalool, cardinol, ocimene, 1,8-cineole, and bornyl acetate. Seeds are the source of a nonvolatile oil known as "fixed oil" that is rich in fatty acids. This oil can be obtained by cold pressing. It is rich in polyunsaturated acids, with approximately 50 percent of the oil being composed of linoleic acid and around 22 percent composed linolenic acid. The monounsaturated fatty acid oleic acid is the next most prominent fatty acid at 8–15 percent of the total. Found in lesser quantities are the saturated fatty acids palmitic acid and stearic acid, while free fatty acids were found to comprise only 0.5 percent of the total.

The whole plant contains up to 10 percent of tannins. It also contains the phytosterol ß-sitosterol. Several phenolic compounds have been isolated, both unconjugated and with sugars attached (glycosides). The quercetin glycosides rutin and isoquercetin have been isolated from *Ocimum basilicum*. In addition, several flavonoids and flavones have been identified. The polyphenols caffeic acid and rosmarinic acid have both been isolated, as has p-coumaric acid—an important intermediary compound in phenolic compound biosynthesis.

The analytical techniques of secondary plant compound isolation are constantly being refined and improved, so it is highly likely that additional compounds will be discovered in this prolific producer of secondary metabolites.

Helga George

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Beans

Most species of beans are annual legumes, though a few are perennials. In the tropics limas and scarlet runner beans are perennials. The majority of beans fall under the genus *Phaseolus*. These are the beans native to the Americas. A second group of beans, in the genus *Vigna*, is indigenous to East Asia. A third category, in the genus *Vicia*, is the fava bean of western Asia and Europe. All beans, being

Beans (Shutterstock.com)

members of the Fabaceae or Leguminosae family, have seed pods and are related to chickpea, lupin, peanut, vetch, clover, alfalfa, pea, soybean, lentil, and cowpea. An ancient food, beans have nourished people of all social classes. The poor, their diet bereft of meat, have depended on beans for protein. In many cultures, the affluent eat meat for protein, disparaging beans as peasant fare. Where population is dense and grazing land scarce, people have eaten beans for protein. One writer regards beans as "poor man's meat." Because people of varied cultures grew and ate beans, many languages have a word for bean. In Latin, bean is *faba*. In Greek, bean is *kyamos*, which is related to the verb *kyein*, meaning "to swell." The fact that bean pods swell as they grow may explain the relationship between *kyamos* and *kyein*. In this context, beans may be connected to pregnancy and regeneration. The Aztec word for bean is *ayocotl*. In Old German bean is *bauno*, in Saxon *bona*, in German *bohna*, in Dutch *boan*, in Danish and Norwegian *bonne*, in Swedish *boens*. Beans are between 21 and 25 percent protein, an amount that compares favorably with the protein content of grains. Beans also have thiamine, riboflavin, iron, copper, manganese, molybdenum, and magnesium. One cup of beans has 230 calories, half the daily requirement of fiber, 46 percent of the daily requirement of iron for men, and 25 percent for women. Snap beans have vitamins A and C. Under domestication beans evolved pods that do not shatter. Having lost the ability to disperse seeds, beans depend on human intervention for survival. Moreover, cultivated beans have dormant seeds, enabling people to store them, in some cases for years, for later consumption. Domesticated beans tolerate different amounts of light and so can be grown at different latitudes, and they ripen uniformly so that they can be harvested over a brief period. In 2008, Brazil, India, and China were the leading producers. The United States ranked sixth.

Folklore, Folk Medicine, Festivals, Politics, and Religion

The best-known tale about beans may be the story of Jack and the Beanstalk. Jack and his mother were so poor that they had to sell their cow. Rather than command a price for it, Jack traded the cow for magic beans. Neighbors thought Jack foolish. Nonetheless, ignoring their opinion, Jack planted a bean. It grew to the heavens, allowing Jack to climb to the lair of a giant. From him Jack stole a bag of gold, a hen that laid golden eggs, and a magic harp. The bean had transformed Jack's fortunes from destitution to wealth. A twist on the beanstalk as ladder story is the New Guinean account of a man and his mother who climbed a beanstalk to kill Tauni-kapi-kapi, a man-eating giant.

Another story, set in Hungary, also featured a poor man as protagonist. One day as he wandered the streets the man came upon a bean. Reflecting on its potential, the man thought that if he planted the bean he would harvest many beans. Planting these, he would harvest many more. Repeating this process over several generations, he would have thousands of beans to sell. Sure that he would become wealthy, the man put the bean in his pocket and hurried to the king's castle. Receiving an audience with the king, the man asked for barrels and loading docks for his crop. Impressed by this request, the king assumed that the man must be rich. Wanting his daughter to marry a rich may, the king offered her to him in marriage. Once more, the bean catapulted a man from poverty to affluence.

Amerindians told the story of two hunters who killed a deer. While they roasted it, a woman materialized out of a cloud. Willing to share their kill, they offered her some venison. She accepted their invitation and joined them in conversation. In the course of their meal, she asked why they ate only deer meat. They replied that they had nothing else. Finishing the meal and wishing to repay their kindness, the woman invited the men to rejoin her the next day when she would treat them. The next day the hunters returned to find a bean plant growing up a corn stalk. The story underscores the centrality of beans and corn in the transition from a hunter-gatherer way of life to agriculture and the close relationship between beans and corn in Amerindian agriculture. Indeed, corn and beans were two of the Three Sisters, the third being squash, in Native American agriculture. Corn and squash supplied the Amerindians with carbohydrates and bean gave them protein. The beans also enriched the soil in which the corn and squash grew, and the squash leaves retarded the growth of weeds. Another Amerindian tradition holds that a crow gave humans beans and corn.

In spring, the Hopi celebrated Powamu, a bean festival. During Powamu, the Hopi planted beans in pots of soil. When the seeds germinated, masked dancers, representing the spirits of nature, blessed the new plants. The blessing ensured that the harvest would be bountiful. At festival's end, the Hopi cooked bean sprouts in stew, internalizing the blessing by eating the stew.

Celebrating the festival of the Bean Calends on June 1, the Romans offered beans to the dead. In one ritual, Romans tossed beans over their shoulders, asking the souls of their ancestors to depart. This ritual became All Saints' Day and later Halloween. At funerals, the Romans offered beans to the deceased to ease their passage into the afterlife. As early as 3000 BCE, the Egyptians put beans in tombs to feed the dead in the afterlife. Egyptian priests, however, did not eat beans they thought them unclean. In another context, some ancients thought that beans were an aphrodisiac, a belief that may explain the reluctance of priests to eat them. To the ancients beans were more than food for the living and the dead. Some Greeks and Romans believed that beans harbored the souls of the dead. In this context, one should not eat beans for fear of harming the dead. One should not walk through bean fields for fear of disturbing the dead. This reasoning may have led Greek mathematician Pythagoras to forbid his disciples from eating beans. It is also possible that this injunction derived from a disdain for politics and court proceedings. The Greeks and Romans used beans to vote for or against a measure. The person who cast a white bean affirmed a measure whereas a black bean negated it. Similarly, in a trial a juror who cast a white bean declared the innocence of a defendant whereas a black bean was a vote of guilty. The term "blackballing" may derive from the practice of voting with black beans. Whatever the reason, Pythagoras's injunction against beans may have cost him his life. According to one account Pythagoras, fleeing his enemies, came upon a bean field. Rather than go through it he stopped, allowing his pursuers to catch and kill him. Peculiar as it may seem, at least one account counseled people not to eat beans because when dried in the sun they smelled like semen or the blood of a murdered person.

So important are they that beans are part of the idiom of English. The phrase "full of beans" means that a person is full of health and vigor. A person who is not worth a bean or who does not amount to a hill of beans has no value. One who does not have a bean has no money or property. This association between beans and property may have arisen out of confusion between the word "bean" and the French *biens*, meaning "property." In England, beans were central to the Twelve Days of Christmas. During this festival, the host of a party made raisin cakes for the guests. One cake, however, contained beans rather than raisins. The guest who got the bean cake became the bean king or queen. Reigning over the festival, the king or queen performed a ritual to ensure good weather the next year. In China, beans were a symbol of good luck. A person who wore a necklace of beans was thought to have magic powers.

Because beans look like kidneys, people thought they were good for treating kidney ailments. For example, beans were a putative diuretic, helping the kidneys rid the body of excess water. Women and men, soaking bean pods in wine or vinegar, rubbed the liquid on their face to improve their complexion. Another way to enhance the complexion, they believed, was to rub a mixture of bean meal and milk on their face. Roman women rubbed bean paste on their skin to remove wrinkles. The Romans believed that beans boiled with garlic could suppress a cough. People drank potions of bean flowers and leaves to reduce inflammation. Some thought that bean pods, rubbed on a wart, caused it to disappear, but only if one buried the pods in a secret place.

Phaseolus Beans in the Americas and Beyond

In 1753, Swedish naturalist Carl Linneaus put the beans of America in the genus *Phaseolus*, though he mistakenly thought that they had originated in India. Meaning "boat shaped," *Phaseolus* is an apt name for beans, because their pods look somewhat like boats. The beans in the genus *Phaseolus* are what most people have in mind when they think of beans. The familiar kidney, pinto, black, navy, great northern, scarlet runner, green, lima, and hundreds more are all members of *Phaseolus*. People eat young pods of *Phaseolus* as snap or string beans. Varieties with yellow pods are known as wax or butter beans. A widely distributed genus, the wild ancestors of *Phaseolus* grew from northern Mexico to Argentina. Named for Lima, Peru, lima beans are members of the species *Phaseolus lunetus*. Scarlet runner beans are in the species *Phaseolus coccineus*. Tepary beans are members of *Phaseolus acutifolius*. Kidney beans and their ilk are members of *Phaseolus vulgaria*. The French called *Phaseolus vulgaris* haricots because they cooked these beans with a type of lamb known as haricot. *Phaseolus vulgaris* may have originated in Central America.

Farmers domesticated *Phaseolus* beans independently in Peru about 6000 BCE and in Mexico around 5000 BCE. As early as 3000 BCE, the Amerindians of the Southwest grew tepary beans because they are drought tolerant. The Spanish dubbed the Papago of Arizona "the bean people" because they grew beans. When the Spanish asked the name of the bean plant, the Papago replied "T'pawi," meaning "it is a bean." The Spanish transliterated T'pawi into *tepary*, the name by which it is known today. Along with the Papago, the Pima of Arizona still grow tepary beans.

By 2500 BCE, the Woodlands Indians of what is today the eastern United States were growing beans. The Mississippians grew beans as early as the eighth century CE. The Cherokee made bread from corn and beans. The Iroquois adopted an agriculture based on the Three Sisters sometime in prehistory. In North America, the Amerindians boiled beans with corn, a dish they called "sickqquatasch" but that Americans know as succotash. Today, limas are the bean of choice in making this dish. Amerindians harvested, shelled, and dried beans in the sun. Sometimes they dried and cooked beans in the pod, shelling them before eating them. Like the Cherokee, the Maya made bread from beans and corn. At other times, they ate beans with squash seeds and onions and beans with chili peppers. The descendants of the Maya eat black beans, onions, and epazote. The Aztecs offered loaves of corn and beans to the gods. In Tenochtitlan street vendors sold bean dishes. Spanish priest Bernardino de Sahagun determined that the Aztecs grew 12 types of beans at the time of conquest.

In Peru, the Moche painted images of lima beans on pottery in the first millennium CE. Throughout South America, archaeologists dated pottery with beans to the eighth century CE. Amerindians had decorated these jars with images of men and women holding beans in one hand and corn in the other, though the meaning of such images is unclear. They may simply record the bounty of the harvest and suggest the close relationship between beans and corn in Amerindian agriculture. On other jars, Amerindians painted images of men with human heads and the body of a lima bean. Some of these lima bean men were depicted as warriors, suggesting perhaps that Amerindian armies ate beans.

In Jamaica, cooks made kidney beans with rice and coconut milk. Cubans made black beans with rice and pork or ham, a dish derived from the Moors of Spain and known as Moros y Cristianos. Throughout the Caribbean, people ate kidney beans with coconut and thyme.

In 1493, Christopher Columbus came upon haricots in Cuba. In 1519, Spanish conquistador Hernando Cortez witnessed the growing of *Phaseolus vulgaria* in Mexico. In the 1520s, Spanish explorer Alvar Nunez Cabaza de Vaca reported on the cultivation of beans in Texas and New Mexico, and in 1528 he found beans being grown in Florida. In the 1520s, French explorer Jacques Cartier witnessed the culture of beans as far north as the Saint Lawrence River.

Beans were part of the Columbian Exchange. In 1493, Columbus brought *Phaseolus* beans to Spain. Europeans adopted these beans more quickly than they did the tomato, potato, and other American crops, probably because they considered American beans to be merely a variant of their fava beans. *Phaseolus* beans were therefore familiar whereas other American crops were novel and strange. In the early 16th century, Europeans began to grow *Phaseolus* beans. In 1528, for example, the Spanish introduced them into Italy. Italians used white kidney beans, known as cannelloni, in making minestrone. They also used white kidneys to make pasta e fugioli (pasta and beans). Italian Americans called this dish pasta fazool. The French ate a dish of *Phaseolus* and meat known as cassoulet. Taking a culinary interest in green beans, the French popularized them. So keen was their interest in American beans that the French developed new varieties, for example the flageolet bean. Perhaps because of French influence green beans were the most popular bean in North America. In the 16th century, English herbalist John Gerard grew scarlet runner beans in his garden. Europeans called this variety the "painted lady" because of its red flowers. Only in the mid-16th century did botanists conclude that *Phaseolus* beans were not simply an iteration of fava beans. They were unique. *Phaseolus* beans were novel after all, but this news did not deter Europeans from cultivating them. In fact, they planted *Phaseolus* beans in preference to fava beans, probably because *Phaseolus* beans lacked the thick seed coat that fava beans had and that had to be removed before favas were eaten. In the 17th century, the gardener of England's King Charles I introduced the scarlet runner bean from Virginia to England, where he planted it as an ornamental. It remains an ornamental in the United States though Europeans eat it as food.

Established in Europe, *Phaseolus* provisioned ships. Slaves, encountering lima beans in their transatlantic crossing, transplanted them in Africa. In the American colonies, English settlers followed the Amerindian practice of growing beans between rows of corn. The first Thanksgiving meal included beans. The Amerindians taught the colonists to make baked beans. Soaking navy beans in water, the Amerindians baked them with deer fat and onions. Adopting baked beans as their own, the colonists traditionally ate them at Saturday dinner. Bostonians developed their own tradition, baking beans with pork fat and brown sugar. Every Saturday morning in Boston the baker gathered a pot of beans from each house, baking them in the community oven and returning the beans in time for Saturday dinner. So important were baked beans to Bostonians that the city earned the moniker of Beantown. Baked beans also nourished colonists on Sunday. Because many Christian denominations forbade work on Sunday, women baked beans Saturday, serving them Sunday and freeing them from having to cook that day.

In the United States, beans captivated Henry David Thoreau, who tended more than two acres of them at Walden Pond. Several recipes called for beans. In 1796, Amelia Simmons's *American Cookery* recommended beans with lamb. In 1851, *Miss Leslie's Complete Cookery* recommended that cooks boil green beans and scarlet runner beans for at least one hour to tenderize them. The pods of these beans must have been tough to demand such effort. In 1853, *The Improved Housewife* urged cooks to bake beans overnight. In 1886, *Mrs. Rorer's Philadelphia Cookbook* included a recipe of black beans with lemon and hard-boiled egg. That year the seed company Burpee marketed a variety of pole bean with a tender pod, the Golden Wax Flageoler. In the late 19th century, cooks did not need to go to great lengths to prepare beans. In 1875, the American company Burnham and Morrill was the first to can and sell baked beans, and in 1895 H. J. Heinz began to sell baked beans.

Old World Beans

In the pre-Columbian era the people of western Asia, North Africa, and Europe grew and ate beans of the species *Vicia faba*, better known as fava beans. Favas may have originated in Africa though farmers domesticated them in western Asia. Resembling large lima beans, favas were a staple crop of the prehistoric people of Iran, North Africa, and the rest of the Mediterranean Basin. Egyptians, Hebrews, and Greeks all grew favas. In Assyria, Phoenicia, and Palestine, people ate favas. Cooks ground them into flour for bread or made them into pottage. Today, the people of Italy, Spain, and the Middle East still eat them. The species name *faba*, we have seen, is Latin for bean. The tern *faba* gave its name to Fabius, one of the patrician families of Rome. In taking this name, the Fabius family claimed that their ancestors had been bean farmers. Although it may seem strange for a wealthy family to claim so humble a pedigree, one must remember that the Romans, even those who did not farm, idealized the life of simple peasants, believing that the Roman virtues of self-reliance, hard work, piety, and frugality had their origin in the countryside. The Fabius family, in identifying with beans, claimed to have these rural values.

Of course fava beans predated the Fabius family. As early as 6500 BCE, the people of Nazareth gathered beans, though they may not have cultivated them this early. Sometime before the third millennium humans domesticated favas, probably in the Fertile Crescent, and by this millennium were growing them in Spain, Portugal, northern Italy, Switzerland, Greece, and the Middle East. In class-conscious Egypt and Europe, the poor ate favas as a substitute for the meat that they could not afford. As a rule, an inverse relationship existed between beans and meat. The more beans one ate, the less meat one consumed. In Egypt, the poor still derive their protein chiefly from beans. Egyptians eat favas with garlic, olive oil, lemon, cumin, and parsley. They eat favas even at breakfast, taking them with flat bread. The Talmud called this dish hamin. The Jews cooked hamin on Friday so that housewives did not cook on the Sabbath. According to II Samuel, beans sustained David in the wilderness.

Because fava beans tolerated frost, farmers grew them in Northern Europe. In the Roman world, as in Egypt, commoners ate beans. We have seen, however, that priests did not eat beans, a fact that Roman encyclopedist Pliny the Elder, writing in the first century CE, attributed to the belief that beans caused insomnia and weakened the senses. Pliny, and before him the poet Horace, wrote that peasants ate beans. The Roman agriculturalist Columella, writing in the first century CE, asserted that beans were the fare of artisans and the poet Martial noted that construction workers ate them. The Greeks and Romans ate favas with garlic and onion. Other people in Europe and Asia ate beans with wheat, millet, or rice. The Romans knew that beans enriched the soil and devised a two-field system, growing grain one year and a legume, often beans, in the second. Although the Romans appreciated the value of this rotation, only modern science discovered why beans restored the soil. Like all legumes, beans form nodules on their roots. These nodules are home to a type of bacteria that converts nitrogen gas in the soil into ammonium nitrate, a compound of nitrogen that plant roots can absorb. Not only do beans absorb this nitrogen, but also some of it is left over to feed next season's crop. The Romans took favas to the lands they conquered, aiding the spread of beans throughout Europe.

In the ninth century Charlemagne, king of the Franks, ordered farmers to plant beans and chickpeas so that his army could feed on them as it marched through the land. Christians, observing a Spartan diet during Lent, ate beans then. Monks who did not eat meat got their protein from beans. After the 10th century the cultivation of beans became widespread throughout Europe. Because they are nutritious, one writer credits beans with increasing population and longevity in the Middle Ages.

Not everyone celebrated beans. One Greek medical authority remarked that gladiators who ate beans grew fat and had bad dreams. The physician Benedict of Nursia believed that beans caused depression. A third commentator remarked that pregnant women who consumed beans might give birth to a lunatic or fool.

The British, who still grow favas, call them Windsor or broad beans. John Gerard christened the fava bean as the "Great Garden Bean." The contribution of beans to British agriculture and cuisine may have prompted friends to call one another "old bean." Stockmen in Europe feed favas to their animals. Despite widespread cultivation, favas are not entirely safe. Some Europeans developed favism, a rare allergic reaction to fava beans that causes anemia and jaundice. Because *Phaseolus* did not cause this reaction, it is possible that Europeans adopted these beans partly because they did not cause favism. Today, China is the world's leading producer of favas, though they must compete with soybeans and corn for acreage.

Whereas Europeans linked the consumption of beans with poverty, no such stigma existed in India, where all classes, even priests, ate beans. Although the people of India ate meat in antiquity, about 600 BCE the diet shifted from meat to beans. Indian religious dogma upheld beans as a pure food fit for all. Beans contributed a greater proportion of protein to the people of India than to the people in any other land. Indians ate several species of beans including mung beans, urd beans, moth beans, and rice beans. Because urd beans were black, they were known as kali, meaning "black." Indians made urd beans into pancakes. At funerals, Indians offered beans to the deceased to aid their transition to another life. Approving of beans, Buddha found them "full of soul qualities." Mung beans and rice are a typical and nourishing dish in India. The people of southern India make urd beans into steamed bean cakes. Like tepary beans in America, farmers in India prize moth beans for their drought tolerance. Rice beans grow wild in India, Thailand, and Vietnam and were domesticated in Southeast Asia. Nutritious, rice beans have a high content of calcium. The guar bean, a native of India, is used as food and fodder. In the United States, manufacturers process guar beans into guar gum, which is used to make explosives, ceramics, crayons, detergents, ink, clothes, ice cream, sausage, cheese, and cosmetics.

In China and Japan, farmers grow adzuki beans, renowned for their sweetness. The people of East Asia make red bean paste from adzukis. The Japanese make a cake of rice and adzukis. Adzuki beans are found in soup and as a paste that is spread on toast. People make adzukis into pancakes and even ice cream. The Chinese make mung beans into noodles. In China, Japan, and Southeast Asia, people eat the bean sprouts of mung beans.

Christopher Cumo

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Beet

In the Chenopodiaceae or Goosefoot family, beet (*Beta vulgaris*) is a biennial herb grown as an annual. In the first year beet fills its root, and in the second it flowers and seeds. The beet may be gold, garnet, purple red, red, maroon, orange, vermilion, or white, and either solid color or striped. Beet is a source of beta-carotene, the precursor of vitamin A, folic acid, phosphorus, and potassium.

Origin and History

One scientist believes that beet originated in Europe or North America. One writer focuses on the Mediterranean Basin, positing an origin in Italy. Beets grow wild in the Mediterranean, Turkey, and the Near East. Beet may be a hybrid between *Beta vulgaris* ssp. *maritima* of the Mediterranean and *Beta patula*, a related species native to Portugal and the Canary Islands. Expanding its range, today *Beta vulgaris* ssp. *maritima* grows wild in the United Kingdom, Continental Europe, and Asia to the East Indies. In prehistory, the people of the Mediterranean may have been the first to use beet leaves. It is possible that beet was a medicine first and a food second. The Romans knew of beets, but they seem to have disliked them. In the first century CE, Roman encyclopedist Pliny the Elder disparaged them as "those scarlet nether parts." In the second and third centuries, opinions changed. Roman cooks added beets to several dishes and opined that the flavor was better than that of cabbage.

Because of their dark color, Europeans called beets "blood turnips." The beet's spread to Northern Europe appears to have been slow. The Germans first noted it in 1558, naming it the "Roman beet." The beet was introduced into England in 1576, and in the 17th and 18th centuries farmers had just two varieties, Red and Long Red. The beet's introduction into the United States is a matter of debate. It must not have originated in North America, as one scientist supposed, because it would not have been necessary to import it. One writer asserts that as late as 1828, U.S. farmers grew just four varieties, allowing one to infer that the beet must have been introduced into the United States before 1828. Another holds, however, that the beet was not imported into the United States until 1880. Americans knew beet as the "garden beet." Sometime earlier beet was introduced into India, from where the Arabs exported it to China about 1850.

Attributes, Cultivation, and Breeding

In the second year, beet flowers. The flowers are green. Each has five stamens that surround one ovary. When beets are ready to reproduce, flowers open between 7 a.m. and 5 p.m. They are fully open between 11 a.m. and 1 p.m. The anthers shed pollen between 8 a.m. and 6:30 p.m. The anthers shed the most pollen between 12:30 and 2:30 p.m. Pollen is abundant. The wind carries it from anther to stigma. The stigma is receptive to pollen during the hours it is shed. High temperature and low humidity are the best conditions for fertilization. Flowers aggregate in clusters. When fertilized, they form a ball of seeds. Each seed contains three or four embryos, accounting for the fact that three or four plants germinate from a single seed. Beets therefore germinate thickly. Each seed is shaped like a kidney, brown, and one-and-one-half to three millimeters in diameter.

Preferring full sun, beet adapts to partial shade. Most varieties of beet mature in 45 to 65 days. Seeds germinate in 3 to 14 days at 68°F to 86°F. According to one writer, beet germinates between 50°F and 85°F. One may plant seeds in early spring for a spring and summer harvest and in late summer for an autumn and winter crop, provided winter is mild. In spring one may plant beet from mid-March to early June. One gardener recommends the planting of beets indoors in February to obtain the earliest harvest. Another, however, warns that beet does not transplant well. For an autumn and winter crop, one may plant beets in the first three weeks of August. The gardener may soak seeds in warm water the night before planting them to increase germination. Some gardeners plant beet with radish. The quickly germinating radish marks the spot where beet will germinate. Radish roots keep the soil loose for the development of beetroots. The harvesting of radishes opens space in the garden for beets to grow. Beet seeds should be planted half an inch deep and one inch apart. Two weeks after germination plants should be thinned to two inches apart. A final thinning yields beet plants four inches apart.

Preferring neutral, well-drained soil, beet does best when the pH is 7. A heavy feeder of phosphorus and potassium, beet should be fertilized with a 5-10-10 fertilizer of nitrogen to phosphorus to potassium before planting. The gardener may also add well-rotted manure to the soil. Fresh manure should not be used because it hinders the root's development. Beet benefits from the addition of organic matter to the soil. The soil should be cultivated to a depth of at least 6 inches. One gardener recommends a depth of 8 to 10 inches. Beet should be fertilized and watered weekly. The root may crack or become tough if beet receives too little moisture. Beet may be harvested when the root is as small as 1 inch in diameter, though it is common to wait until the root is 2 to 5 inches in diameter. Beet should be picked before a severe frost. Light frost improves the flavor. Beets may be stored in a refrigerator five to seven months provided the humidity is high or in a damp basement at 32°F to 40°F.

The commercial harvest goes to processing as boiled or pickled beets. Beet may also be frozen and canned. Beets may be boiled, baked, steamed, coated with oil and cooked, mashed, sautéed, shredded, or stir-fried. Beet leaves are edible and are widely consumed in Indonesia and Japan. The root and leaves may protect one against infection and cancer. Beet juice is a popular health beverage. Beet juice is added to tomato sauce and paste to darken the redness. Scientists aim to breed beet for yield, dark redness, uniform color, the absence of white rings on the root, uniform shape and size of the root, slowness to bolt, and appearance in the shape of a sphere, cylinder, or cone depending on consumer preference.

Cultivars

The variety Golden Beet is prized for its color and flavor. As its name suggests, the root is golden. It lends itself to pickling and to its addition in salad. The flavor is best when the root is harvested early, but it may be left in the soil without fear that it will toughen with age. Because germination is low, Golden Beet should be seeded thickly. The variety matures in 55 days and is favored by cooks because the color does not bleed. With a long cylindrical root, Cylindra yields three or four times more root than a round beet. Small, dark red, sweet, and tender, Little Bull is suitable for pickling. Bred in the mid-19th century, Chioggia matures in 55 days. A cross section of the root reveals concentric circles of red or pink alternating with white or cream. One gardener remarks that "the flavor is unusually sweet." Native to Italy, Chioggia is known as the "candy cane beet." Detroit Dark Red matures in 60 days. D. M. Ferry and Company introduced the variety in 1892. The beet is round with a root two to four inches in diameter. Suitable for canning, the flesh is sweet and tender. Detroit Dark Red traces its lineage to the 19th-century variety Early Blood Turnip. Bred in the 19th century, Bull's Blood was first prized for its leaves. Some gardeners grow the variety as an ornamental. Leaves are ready to harvest 35 days after planting. The root is ready to harvest 58 days after planting. For the best flavor, the gardener should harvest Bull's Blood early. Crosby's Egyptian appears to have no association with Egypt. Rather, it is a German variety introduced into the United States about 1880. Ready to harvest in 50 days, the root is deep red. Known as Snow White, Albina Verduna, as its name suggests, has a white root. A Dutch variety, Snow White matures in 55 days. Known as Winter Keeper, Lutz Green Leaf is a large beet. The root may grow six inches in diameter. The purple red root needs 60 to 80 days to mature. Lutz Green Leaf sweetens during storage.

Christopher Cumo

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Begonia

A gardener could fill both a house and a yard with a wide variety of beautiful plants all from just one family. Easily more than 1,000 species of begonias populate tropical and subtropical areas, especially in the Americas and exempting Europe and Australia. Naturally crossbreeding with ease and at the hands of hybridizers, now more than 10,000 new varieties exist.

History

Begonias began to be discovered and described for the West as new territory was explored. In China, descriptions of begonias existed as early as the 14th century. In mid-16th century Mexico, Spanish priests identified native begonias. In 1690 Franciscan monk Charles Plumier named six previously unidentified plants in the West Indies after Michel Begon, the governor intendant of Haiti, who shared the monk's interest in botany, gave the genus its name.

Other begonias came to be known by chance. In 1821, a wild Brazilian begonia hitchhiked with other plants to Berlin's Botanical Gardens. Later in the century it was hybridized to become our wax begonias. Likewise, a Rex type stowed away with orchids from India, arriving in England in 1856. Its loud leaf design wasted no time in gaining appreciation. It formed the base for today's Rex Cultorum hybrids.

Attributes

Great in containers and hanging baskets, as houseplants, and as bedding plants in mass plantings and borders, members of the begonia family provide attractive leaves. Most display abundant blooms, and many supply both attractive flowers and leaves while being the classic answer to what will thrive in shady areas.

Begonias are tender perennials suited to gardening zones 9–12, but they generally are grown everywhere as annuals. A species found in Japan and China, *Begonia grandis* has heart-shaped leaves and is hardy enough to survive down to zone 6. Begonias are more cold sensitive than many other popular plants. Temperatures should be above 50°F before they are set out. The succulent stems and leaves collapse after too much of a chill.

Unlike many other plants in the category that are generally grown as annuals—for instance, petunias—begonias make good houseplants thanks to their preference for less than full sunlight. Indeed, their claim to fame is the wide range of light that satisfies them. So as frost approaches, the begonias that enjoyed the summer outdoors can be repotted to continue life on a windowsill. Moreover, new plants for inside can be propagated from stem cuttings taken from outside plants.

Types

Although interbreeding blurs distinctions in many cases, hybrids can be generalized into eight groups: cane-type, shrub-like, semperflorens, tuberous, Rex Cultorum, rhizomatous, thick-stemmed, and trailing. The cane-type and shrub-like begonias are tall. The cane group includes "angel-wings," which have woody, erect stems up to six feet tall, with drooping clusters of blossoms called sprays. Some exotic-looking varieties have silvery leaves with dark vein patterns, while others have dark leaves with white polka dots. Many varieties have six-inch leaves with red undersides. The shrub-like types are bushier and shorter at up to a yard tall. They have multiple stems but theirs are succulent and therefore softer. Both cane and shrub types can benefit from staking or a fence or other tall, sturdy neighbors to serve as windbreaks.

Besides being classified by leaf, stem, and flower forms, begonias can be divided into three types based on roots: fibrous, rhizomatous, and tuberous. *Begonia semperflorens*, commonly known as wax begonias, have fibrous roots. These roots are ordinary clusters of thin, fiber-like strands. This well-known group excels in mass plantings and as a border. Compact, up to about one foot high, and wide, its members are covered with blossoms until frost. The nickel-sized, four-petaled flowers come in white, pink, red, or bicolor. Best of all, they do not require deadheading to encourage more blooms. In fact, "semperflorens" means "everblooming."

Besides the basic single-flowered form, new hybrid doubles and semidoubles are available. The Prelude and Senator early-blooming series both include white, pink, and red varieties. The Lotto series has larger, two-inch blossoms with green leaves. Other popular series include Cocktail, Olympia, and Ambassador. Their leaves are thick and shiny, resembling wax. They are close to round, are slightly cupped, and have scalloped edges. In shades of green, variegated green, or reddish bronze to burgundy, they grow densely packed on succulent stems. Patterns in flowerbeds can be designed by using groups of plants with contrasting leaf and blossom colors. Large flowerbeds in public areas make increasing use of wax begonias now that sun-tolerant hybrids are available. A trailing species from Brazil, *Begonia solananthera*, is also fibrous. It has glossy green three-inch leaves and fragrant white flowers with red centers. Besides being a good hanging basket plant, it can be planted in the ground and the stems trained to climb up a structure such as a trellis.

Cultivation

Begonias will be most tolerant of less-than-ideal conditions if they are grown in rich, evenly moist but never soggy soil. Some will withstand more sun if temperatures are cool. A generous mulch around them will both retain moisture and keep their roots cooler. Because such conditions also favor slugs and snails, which love succulent plants, one must monitor and protect against them. Regular fertilization will encourage and maintain steady, healthy growth. If watering is excessive or erratic, begonias will be prone to fungal diseases and mold, particularly at the base of the plant and leaf joints. Water spots and sun scald may also result from harsher days. Generally, however, begonias are comparatively carefree.

Shady woodland settings can be enlivened with spots of color furnished by begonias. Whether in the ground or in containers, begonias make good companions for ferns, hostas, and impatiens. Another shade lover, coleus, has many varieties with reds and greens that perfectly partner with wax begonias as well as other types. Although wax begonias can be grown from their tiny seeds, it is more practical for average gardeners to buy them, as well as other varieties of begonias, in the pots or six-packs that are readily available. Germination time is two to three weeks, and they can take up to five months to bloom.

With another of the root types, rhizomatous begonias make elegant houseplants. Distinctive foliage is their noteworthy feature. Many have large arrow-shaped leaves with a metallic shine and striking vein and spiral patterns, often reddish underneath. Some varieties have dark edges on the leaves. The species Iron Cross, *Begonia masoniana*, has a dark brown design on green rippled leaves. This group grows wider than high, up to about 8 inches in height to 30 inches across. Planted in a wide, shallow container, this species will furnish a lot of vegetation without blocking a window. Outdoors, a single plant can make a statement in a flowerbed or a rhythm and balance can be made with several separated specimens. Rhizomatous roots are shallow, thick, sometimes fuzzy, rope-like structures that creep over the edge of containers. They can be trimmed and used to sprout new plants. Rex Cultorum hybrids grow from rhizomes. These are among the most popular, boldly marked foliage plants that have been appreciated indoors for generations. They prefer high humidity and do well in greenhouses. There is a holiday-named series that includes the varieties Merry Christmas and Tinsel.

The begonia type known for eye-catching, saucer-sized camellia-like blossoms are tuberous. They grow from tubers rather like small potatoes. Their best use is in containers or hanging baskets that let them cascade over the sides. When mature, they are one to two feet in height and spread. In glowing shades of peach, pink, yellow, orange, red, white, and bicolor, with some varieties ruffled and looking like giant carnations, the showiest flowers are males in doubles and semidoubles, which are flanked by two single-flowered female blossoms. Pinching off the female flowers will direct more of the plant's energy into the males. Picotee is the striking blossom pattern with a dark outer edge on the petals. Can Can is a yellow variety with red edges. Bouton De Rose is white with red. Dedicated fanciers categorize the tuberous varieties into 13 types based on flower style—single, double, and ruffled—and growth habit. Tuberous begonias, like all begonias, do not tolerate cold, but they also suffer in heat. Shade and thick mulch help keep them in their preferred temperature range. Provide them with frequent fertilizing, as they are heavier feeders than many other begonias. Good drainage is necessary to prevent rot. Once the plant starts to go dormant in the fall, cease watering. The leaves and stems will die and fall away from the tubers. Then they can be stored over winter in a cool dry place until it is time to bring them back out for another season.

Common names for begonias reflect the family's great variety. There is a hollyhock begonia—which is tuberous despite having upright stems and looking like a miniature pink hollyhock—a fuchsia begonia, a maple-leaf begonia, and countless others resembling their namesakes in some manner with their own ease of care, consistent growth, and few problems. Most plant lovers' wishes for outstanding foliage and flowers can be filled by begonias, a plant genus of nearly endless variety.

Tamara Stromquist

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Belladonna

Atropa belladonna is commonly known as the cultivated medicinal belladonna or perennial deadly nightshade. Due to its highly toxic properties, it has also been historically referenced as Devil's Herb, Devil's Cherry, or Poison Black Cherry. Other names include Dvale (Norse: "trance"), Dwayberry, Great Morel, Bladona, and Naughty Man's Cherry. In the 18th century, Swedish naturalist Carl Linnaeus gave the plant its genus name based on one of the Greek fates. Clotho spins the thread of human life; Lachesis measures the thread of human life; and Atropos (the Inflexible) cuts the thread of human life. The species name, *Belladonna*, is Italian for "beautiful lady," referring to the 16th-century use of the plant by women in Venice as an eye ointment to dilate the pupils.

Belladonna is from the Solanaceae family, which also includes potatoes, tomatoes, eggplants, tobacco, and chili peppers. Considered a weed in some areas, it is also planted in perennial gardens as an herbaceous, flowering ornamental. It is a two- to six-foot sensitive perennial with a thick root, simple alternate leaves, and a sharp, unpleasant odor. The red- to green-hued purple flowers are solitary, drooping, and tubular with five lobes. The fruit are glossy purple-black berries that are the most poisonous part of the plant; ingesting one bitter-tasting berry can lead to death in some humans and domestic animals (exceptions include cattle and rabbits).

Atropa belladonna's active compounds are tropane alkaloids: atropine, hyoscyamine, and scopolamine. In 1831, the German pharmacist A. Mein isolated atropine from dried belladonna root, and it was first synthesized by the German chemist Richard Willstatter in 1901. The amount of alkaloids depends on the part of the plant, development stage, growing conditions, and time of harvesting. Dry weather and nighttime cultivation make for the highest concentrations, suggesting the plant may have evolved to fend off nocturnal eaters. This, as well as its dark-colored berries, could also be an origin of its name, deadly nightshade. Although native to Europe, East Asia, and North Africa, belladonna has become naturalized in much of the world. It is commercially cultivated and harvested in the United States—California, Oregon, Washington, Michigan, New Jersey, and New York—and Europe as a pharmaceutical crop. It is high yielding in fertile soils blocked from the wind but is susceptible to wilt caused by potato and flea beetles. Harvests of the leaf occur in the spring, while the two-year-old to four-year-old roots are harvested in the fall. For general medicinal uses, the plant is dried and crushed to be used alone or in combination with other medicinal powders, pills, plasters, etc. In homeopathic medicine, the plant is broken apart to extract the juice, and then mixed with a water/alcohol solution at a ratio of 1:10 or 1:100. In accordance with common homeopathic production of remedies, this process is repeated up to 30 times to create a highly diluted form of the plant's properties. As a perennial, belladonna can be harvested for one to four years, and then it is cut down and replanted since the alkaloid content does not increase after this time.

History

Although the alkaloid commonly used today in medicine was isolated for use in 1831, belladonna's chemical uses can be found even before the Middle Ages. Some people believe the Greek worshippers of Dionysus (Roman: Bacchus), the god of wine and fertility, dissolved belladonna in wine during initiations to induce trances of dancing and sexual lewdness. The plant is also claimed to have taken the lives of Roman soldiers retreating from the Parthians. In 1579, *Buchanan's History of Scotland* by George Buchanan included a description of the Swedish army's use of "sleepy nightshade" to taint the drink they were required by a truce to supply to the armies of Sweno the Dane. Svein Knutsson, the king of Norway between 1030 and 1035, lost most of his men when they were killed in their drugged sleep after drinking the mead. The story of King Sweno is also an important backdrop to William Shakespeare's play *Macbeth*, which includes the magic and potions of the infamous three witches. In fact, witches, wizards, and healers believed belladonna to be the Devil's Herb, claiming Satan anointed the plant with his blood every night as well as taking it for his own evil apothecary uses. Since the tropane alkaloids can be absorbed by the skin, 17th-century witches used belladonna and henbane (*Hyoscyamus niger*) "flying ointments." These salves were rubbed on sensitive skin to induce hallucinations and delusions of flying, frenzy, and elevating above reality.

In the 16th century, fashionable women of Venice reintroduced the use of the plant as a seduction tool by putting drops of the juice of "herba bella donna" in their eyes, considered windows to the soul. This caused dilated pupils, which also occur during arousal and are said to make eye contact more intense, but this practice can also cause glaucoma. During this time, herbalists and apothecaries began studying and classifying dangerous vegetation, so this plant also known as deadly nightshade (solatrum mortale) started to appear in various publications, pharmacopoeias, and dispensatories. Andrew Duncan stated in the Edinburgh Dispensatory of 1803 that Atropa can be used to relieve symptoms of the plague and nervous diseases and to facilitate the removal of cataracts.

Mein's 1831 isolation of atropine from the roots of belladonna allowed this alkaloid to be used in plasters and liniments as an analgesic and counterirritant. However, this also led to numerous poisonings, intentional and unintentional, in the mid-19th century. After 1911, deaths from atropine poisoning become rare, probably because plasters and cosmetic eye drops using the drug were obsolete or banned. Uses for atropine continued to be developed. In 1943, it was found to be the only antidote for German tear gas in World War II, although neither was ever used. It was used as an antidote to save many lives of people in Tijuana, Mexico, in a 1967 incident of humans eating bread exposed to a toxic insecticide.

Current Medicinal Uses

In contemporary traditional medicine, the key components of *Atropa belladonna* are the anticholinergic alkaloids, which first stimulate then block nerve impulses in parasympathetic nervous systems. These systems control involuntary functions and reflexes such as heart rate, secretion release, pupil dilation, muscle cramping, etc. Atropa alkaloids, given in controlled doses, slow the action of the smooth muscle system, reducing the symptoms of Parkinson's disease, irregular heart rate, motion sickness, asthma, peptic ulcers, whooping cough, hay fever, and menstrual cramps. Atropine is prescribed as a drug for heart functions and cardiopulmonary resuscitation (CPR). Compounds are also used to resolve issues dealing with an overabundance of bodily fluids causing excessive sweating, nasal mucus, diarrhea, and vomiting. Although the cosmetic use of eye drops was discontinued, atropine drops are still used to dilate pupils for eye exams.

The other compounds isolated in 1831 from the belladonna plant are also developed for medicinal use. Scopolamine, named after the 18th-century Italian naturalist Giovanni Scopoli, was introduced to medicinal practices in 1901. In the past, it was used to treat heroin and cocaine addiction and is currently being researched as an aid for overcoming nicotine addiction as well as a possible treatment for depression. Until the late 1960s, it was commonly a part of hospital child birthing in combination with morphine to induce "twilight sleep." At this time, it is used in the form of a skin patch to prevent motion sickness and as a general anesthetic or preanesthetic agent.

In homeopathy, prescriptions address symptoms and mood and are given in accordance with the patient's temperament. The remedies usually have characteristics that mirror the symptoms healing response. Belladonna is a common homeopathic remedy for earaches, fever, menstrual cramps, headaches, migraines, muscle pain, acute pain, sunstroke, mastitis, and respiratory infections. It is usually prescribed to people who are physically fit and full of energy when healthy but suffer from a sudden onset of an acute sickness that makes them agitated and restless. The National Cancer Institute of Milan, Italy, has research results that demonstrate that homeopathic remedies of belladonna provide some relief for breast cancer patients suffering from radiodermatitis (red, swollen skin as a result of radiotherapy).

As with many powerful medicinal plants, a wide range of beneficial uses have been discovered and even more are continuing to be researched for *Atropa belladonna*. However, as the name deadly nightshade suggests, it is a highly toxic plant that has been historically lethal when not taken in controlled, prescribed amounts.

Erika Stump

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Bellflower. *See* Campanula

Birch

In 1753, Swedish naturalist Carl Linnaeus placed birch in the family Betulacea and the genus *Betula*. Betulacea consists of around 60 deciduous species that can grow in mountains, heaths, moors, and woodlands and are common in the Northern Hemisphere. Birch is a relative of the beech and oak, both of which belong to the family Fagaceae. *Betula* species vary in height from small to large and present themselves as either small shrubs or tall trees. The bark of the birch is what distinguishes each species from the other and is the source of the common names of the trees: gray, white, black, silver, and yellow birch.

Birch fossils date from the Upper Cretaceous Period and were abundant in the Eocene Period, an era about 45 million years ago. To wit, birch is an extremely hardy tree and can withstand cold winters and heavy wind. It is able to grow on land masses and islands that encircle the North Pole and is common in North America and Eurasia.

Appearance and Habitat

Birch is distinguished by long horizontal markings on its bark, or lenticels. The many-colored bark, depending on species, often separates into thin paper-like sheets, especially noticeable on the paper birch (*Betula papyrifera*) variety. Several varieties have a white bark and most varieties produce a white timber. The birch's leaves are delicate and shimmering and produce abundant color in the autumn months.

The birch has a diverse habitat. It exists in every type of environment from temperate lands to the extreme cold of the North. It can be found near bodies of water, such as the banks of streams and shores of lakes, along roadsides, in moist wooded areas, in alpine forests, and on open land. Birch is pollinated by the wind and produces an abundance of pollen. It is a tree that is prone to hybridizing (polyploidy).

Threats to the Birch

Birch in the northeastern United States is threatened by the birch leafminer, a native insect of Europe. It is also a problem, but to a lesser degree, in the upper Midwest, Alaska, and the Pacific Northwest. This insect is a type of sawfly that feeds on the leaves of birch, primarily the tissue between the upper and lower surfaces of the leaf. The small, white, and flat larvae can live within the birch leaves. The adults grow to about three-sixteenths of an inch.

Other threats to birch include several types of fungi, especially *Armillaria mellea*, a species of honey fungus that forms as mushrooms around the base of the trees and causes root rot, and *Piptoporus betulinus*, a whitish-brown mushroom that is specific to birch trees and that can severely damage or destroy the tree.

The Many Uses of Birch

Birch produces an attractive white timber that is good for furniture making. The betulin in the bark makes it waterproof and lends itself to the production of water vessels, such as canoes, and for roofs and other objects meant to keep water from penetrating, such as containers and household utensils. Native peoples of many lands, including North America, Russia, Siberia, and Northern Europe, have long used birch in a number of ways, including in the manufacture of wigwams, baskets, yurts, roof tiles, canoes, and shoes.

Because of the thin paper-like quality of the birch tree's bark, it has been used as a writing material. In fact, as early as 1800 BCE birch was manufactured into Hindu manuscripts. As well, its twigs are flexible and can be bent into brooms. It is also a common material in mallets for keyboards and is used as tonewood for acoustic and semiacoustic guitars.

Birch burns hot, making it a good firewood as well as a hardy charcoal product and source of gunpowder. It burns well even when wet because of the oils in the wood. Those oils along with the starch produced in the bark and the resins found in the leaves have made the tree a source of food in times of famine.

The sap of the *Betula lenta*, or sweet birch, which is grown in the Appalachian Mountains of North America, is tapped and used in the production of birch beer. Other food products made from birch include birch syrup, vinegar, wine, and the artificial sweetener Xylitol. *Betula lenta* and *Betula alleghaniensis*, or yellow birch, also produce oil of wintergreen, or methyl salicylate, which is used as a flavoring and to make rubefacients and other medicines.

Birch in Folklore

The Welsh associate the birch tree with love, and in German folklore the birch is considered the tree of life. Traditionally, it was used in crafting maypoles. The Russians revere birch and have nicknamed it the "lady of the forest." It is one of the country's national trees. Shamans living in Siberia use the birch in their initiation rituals by having the candidate carve nine notches into the birch's trunk, which represent the nine steps to heaven.

Common Species of Birch

Betula lenta, or sweet birch (also called black birch or cherry birch), gets its name from the aromatic fragrance of wintergreen that it produces in its leaves. *Betula lenta* is grown mostly in the northeastern United States but is also found in the Appalachian Mountain states and parts of western North Carolina. *Betula lenta* reaches a height of 50 to 75 feet. Its bark is a brownish-black color, similar to that of the black cherry tree.

Betula nigra, or river birch, is also called red birch, water birch, or black birch. The species grows primarily in the hot and humid southeastern United States, approximately from Texas to Virginia. It grows to heights of 40 to 70 feet.

Betula papyrifera is commonly known as canoe birch, white birch, or silver birch. It has a showy white bark that peels off into strips or sheets. It grows in the northern regions of North America, from Newfoundland in Canada to Alaska, and can be found in Appalachia as well. The species grows to a height of 70 to 80 feet. *Betula papyrifera* is the state tree of New Hampshire.

Betula alleghaniesis is referred to as yellow birch. It grows from Canada to the northern parts of Georgia and is distinguished by its shiny yellow-bronze to reddish-brown bark. It grows to a height of 75 feet.

Rosemarie Boucher Leenerts

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Bird of Paradise

Known as "the empress of house plants," the tropical bird of paradise plant (*Strelitzia reginae*), also known by the names wild banana and giant bird of paradise, is a large, very colorful specimen in the banana (Muscaceacea) family. This plant should not be confused with the aviary species Bird-of-Paradise, which inhabits Molucca and Australia. It comes in an array of different shades, including blue and orange blossoms.

The bird of paradise is in the kingdom Plantae and the phylum Magniliophyta. *Strelitzia nicolai* (giant bird of paradise), the largest of the several different species of the plant, can grow to be up to 30 feet tall. However, the average size of these plants hovers about 4 or 5 feet when mature. Because of the flamboyant and distinctive coloring of this plant, it is often grown for ornamental uses and is popular as a decoration. The South African *Stretzilia reginia* is used for cut flower bouquets worldwide. In general, the bird of paradise plant is popular because of its wide array of colors, and it is cultivated mainly for this purpose.

Species and Origin

The bird of paradise originated and is native to South Africa and South America. Different species are found in various regions of the world, depending on their needs and the temperatures they thrive in most successfully. Each species of the bird of paradise is unique and requires a particular setting to be harvested appropriately. The different species of bird of paradise flower differently, with varying rates of growth.

These unique and illustrious plants earn their name from their resemblance to a brightly colored bird or crane in flight, and are not to be confused with aviary species bearing the same name. The genus *Stretzilia* encompasses four different species, including *Stretzilia alba*, the white bird of paradise, found only in South Africa; *Stretzilia caudata*, the African desert banana; the *Stretzilia reginae*, crane lily; and *Stretzilia junceau*.

Stretzilia alba (white-flowered wild banana) is the rarest of the four species and the least commonly cultivated, the two most common species of the plant being *Stretzilia reginia* and *Stretzilia nicolai*. *Stretzilia alba* is also the only member of the *Stretzilia* genus that has been proven to have a distinct chromosomal composition from its counterparts. A 1955 study by geneticists Cyril Dean Darlington and Phillipa Wylie came to the conclusion that because the flowers of the bird of paradise are separated by character and distribution of genetic components, *Stretzilia alba* is the only species of *Stretzilia* with a different number of somatic chromosomes. *Stretzilia alba* has a haploid number of 11, while the remainder of the species of the bird of paradise has a haploid number of 7.

Stretzilia junceau has stems that are long and spiky, with upright needle-like leaves that turn into orange or yellow flowers. This species is the slowest-growing bird of paradise, taking three to four years to flower fully. Each species of *Stretzilia* has slightly different physical characteristics. For example, a similar plant in the same family, *Strelitzia parvifolia*, is smaller and slightly different in shape.

Maintenance and Care

The bird of paradise plant is generally not too difficult to care for. It does, however, have certain stringent requirements for maintenance and care. It can thrive only in temperatures of 50°F to 84°F. Freezing temperatures can damage its leaves, though these plants can tolerate a mild degree of frost. It is advisable, in colder weather, to move any bird of paradise flowers that are outside into a pot indoors. Bird of paradise has monocotyledonous roots, which are extremely durable and tough. These types of plant generally do not require a great deal of water.

Bird of paradise is propagated by division or by seeds. The germination of seeds is very erratic, but takes only a few weeks at most. The bird of paradise flower is orthinapalous, requiring nectar-eating birds to pollinate it. In this symbiotic relationship, birds sip the nectar while the pollen coats their breasts and feet and causes the blue petals to open. The nectar birds that feed on bird of paradise are a vital part of the pollination process. When the seeds are pollinated, the bird of paradise seeds develop over a period of six months and transform into pods with three sections of black seeds and bright orange arils.

The leaves of the bird of paradise vary from four to eight inches long. Bird of paradise is not deciduous, making these species an ideal indoor plant, and it can also be optimal for outdoors if the temperature permits. Though the bird of paradise is a direct relative of the banana, its rate of growth is much slower; some bird of paradise plants can take years to fully mature.

Basin or flood irrigation is the recommended method of care for these plants, for preventing the accumulation of salty water in the soil below the plant. The plants require as much sunshine as can be delivered, regular planting, and a good fertilizer at least once a year. Birds of paradise can produce as many as three dozen flower spikes a year, each of which lasts up to two weeks when cut. If these plants are maintained properly, the bird of paradise is a flamboyant addition to the home, indoors or outdoors.

Bonnie Ellman

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Blackberry

A member of the Rosaceae family, the *Rubus* genus, and the *Eubatus* subgenus, blackberry numbers more than 350 species. Blackberry is related to raspberry, rose, apple, pear, apricot, and strawberry. Although related to the raspberry, blackberry differs from it in retaining a portion of the stem when picked whereas raspberry separates cleanly from the stem so that it is hollow at the center. One hundred grams of blackberry contain 86 grams of water, 52 calories, 13 grams of carbohydrates, 0.7 gram of protein, 0.4 gram of fat, 4 grams of fiber, 0.5 gram of ash, 32 milligrams of calcium, 0.6 milligram of iron, 20 milligrams of magnesium, 21 milligrams of phosphorus, 196 milligrams of potassium, no sodium, 0.3 milligram of zinc, 0.1 milligram of copper, 1.3 milligrams of manganese, 21 milligrams of vitamin C, 0.03 milligram of thiamine, 0.04 milligram of riboflavin, 0.4 milligram of niacin, 0.2 milligram of pantothenic acid, 0.06 milligram of vitamin B6, and 165 international units of vitamin A.

History, Attributes, and Cultivation

Blackberries are of three types—erect, semierect, or trailing—and may have or lack thorns. In prehistory blackberries colonized temperate locales and the subtropics. They are absent from the tropics. Humans have harvested wild blackberries for millennia. In some regions of the world, people still harvest wild blackberries. Wild blackberries are, for example, widespread in the United Kingdom, a circumstance that limits the cultivation of blackberries. Wild blackberries are picked for local consumption and never enter the market. Because the earliest types of blackberries had thorns and grew vigorously, farmers regarded them as an impediment to the expansion of agriculture. The clearing of land necessarily reduced blackberry populations.

The selection of new varieties from wild populations increased interest in the cultivation of blackberries. The discovery of a thornless blackberry, Thornless Evergreen, about 1930 gave impetus to blackberry cultivation. Thornless Evergreen was popular in the Pacific Northwest, where it yielded abundantly. Today, blackberry farms sell fruit directly to customers or allow them to pick berries. Oregon processes blackberries. California and the American South are important producers. The portion of the harvest that is not sold fresh may be packed in sugar and frozen. Other blackberries are made into jam, jelly, pie filling, yogurt, ice cream, juice, and wine. Only a small amount is canned.

The blackberry flower has five sepals and five petals. Roots, fibrous and shallow, are perennial whereas the stem and foliage are biennial. Blackberries fruit in their second year. In much of the temperate zone, new canes develop annually and die after fruiting. In Guatemala, where farmers grow blackberries at elevation, they yield year-round because the canes do not die after bearing fruit. Blackberries are most hardy between mid-November and mid-December, though they do not tolerate temperatures below 0°F. Most plants are sensitive to late spring frost, which may damage flowers. Erect blackberries are hardier than trailing blackberries. Thorny varieties are hardier than thornless blackberries. Blackberries tolerate high temperatures and humidity better than raspberries.

Blackberries grow well on fertile, deep, well-drained sandy loam or loam. Sandy soil needs the application of organic matter and, because it may not retain water, may need irrigation. Blackberries do not tolerate clay or soil with a high water table. Because this is so, blackberries do not tolerate waterlogged soil. When the soil is too wet, blackberry roots suffocate for lack of oxygen. Soil that is too wet may harbor fungi. The farmer should not plant blackberries where strawberry, pepper, tomato, potato, or eggplant have been grown because this soil may be infected with *Verticillium* fungi. The farmer should not plant blackberries in soil that has a history of harboring *Phytophthora* fungi. The soil pH should be slightly acidic, between 5.5 and 6.5. Sandy soil is not alone in needing organic matter. Whatever the soil type, blackberries need at least 3 percent organic matter. One authority recommends the application of 10 to 20 tons of dairy cow manure per acre to add organic matter to the soil. Less desirable are horse manure, which may contain weed seeds, and pig and chicken manure, which has too little organic matter. The farmer should apply manure in late fall or early winter. Where the soil is deficient, the farmers should apply phosphorus, potassium, magnesium, zinc, and boron before planting blackberries. Fertilizer should not be applied at the time of planting because it may injure roots. Once plants have germinated, the farmer may apply nitrogen to the soil. In a plant's second year, fertilizer may be applied when it resumes growth in spring. The farmer may divide nitrogen into two applications, with the second occurring when blackberries flower. Blackberries absorb more nitrogen than any other element. Where temperature and rainfall are high and the soil light, blackberries may need large amounts of nitrogen. The farmer may apply between 30 and 100 pounds of nitrogen per acre. Blackberries, when the amount of nitrogen is adequate, yield a large number of large canes. Phosphorus appears to have little effect on blackberry yields. Blackberries absorb large quantities of potassium. One authority recommends potassium sulfate or potassium magnesium sulfate as sources of potassium. Muriate of potash is another possibility, though the farmer must guard against too much chlorine in the soil. The addition of too much potassium to the soil impairs the ability of blackberry roots to absorb magnesium. Magnesium sulfate, dolomitic lime, or potassium magnesium sulfate is a source of magnesium. In addition to fertilizer, blackberries need water, especially in spring and summer when growth is robust. Insufficient water causes plants to produce small berries. Where irrigation is necessary, the farmer must guard against applying too many salts to the soil.

Species and Cultivars

We have seen that blackberry numbers more than 350 species. Among them *Rubus argutus* and *Rubus frondosus* are erect, producing primocanes from both root and crown. These species are hardy and yield large, sweet berries. *Rubus procerus*, native to Iran, has migrated to Southern Europe, the United Kingdom, New Zealand, and the American West. A thorny species, *Rubus procerus* grows vigorously. Some *Rubus procerus* plants are wild. Humans have cultivated others. The species yields small, round berries. Plants are disease resistant and yield abundantly. Like *Rubus procerus*, *Rubus laciniatus* has thorns and grows vigorously. This species, known as the Evergreen blackberry, retains its leaves throughout the year. *Rubus laciniatus* grows wild in Washington and Oregon, though it is also cultivated in these states. *Rubus thyrsinger* is prized for the quality of its fruit. *Rubus nitidioides* is notable for its flavor, large berries, and early maturation. *Rubus rustianus* may be the parent of Bedford Giant, the United Kingdom's leading cultivar. *Rubus baileyanus* is a trailing blackberry indigenous to the eastern United States. It is renowned for the quality of its berries. This species is the parent of the varieties Lucretia and Austin Thornless. *Rubus ursinus* and *Rubus macropetalus* are native to the American West. *Rubus ursinus* is, along with the raspberry, the parent of the loganberry. Ideal for the subtropics, *Rubus trivialis* is grown in the American South. The species needs little cold weather to initiate dormancy. *Rubus trivialis* tolerates drought and frost.

Popular Thornless Evergreen is still the most widely grown variety in Oregon, Washington, and British Columbia and remains among the highest yielders. Marion is the second leading cultivar in these regions. The new varieties Silvan and Waldo may challenge Thornless Evergreen and Marion for acreage. In California, Olallie is processed into a variety of foods. It is popular because the farmer may harvest it by machine. Erect varieties do well in Arizona, Oklahoma, and Texas. Most of the harvest in these states is sold fresh. Shawnee is the chief variety in the South. Other popular cultivars are Brazos, Cheyenne, and Cherokee. Challenging these are the new varieties Rosborough and Choctaw. Farmers cultivate the thornless varieties Navaho, Hull Thornless, Arapaho, Flordegard, and Gem in Florida and Georgia. In the Midwest and northeastern United States, farmers grow blackberries on small plots near cities to satisfy urban demand. Popular varieties include Darrow, Illini Hardy, and Hendrick, all of them erect cultivars. Less hardy are the thornless varieties Smoothstem, Thornfree, and Black Satin. New varieties in the Midwest and northeastern United States are Hull Thornless, Dirkson, and Chester. Brazos, Cheyenne, Navaho, Arapaho, and Rosborough are grown in Guatemala and Costa Rica. Farmers in southern Brazil cultivate U.S. varieties. Marion and Youngberry are grown in Australia and New Zealand. The new variety Silvan is popular in southern Australia. Waldo is gaining ground in Australia and New Zealand. Bedford Giant, the United Kingdom's leading cultivar, is widely grown in southern Great Britain.

Christopher Cumo

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Black-Eyed Susan (Rudbeckia)

North America's own yellow daisies, commonly called black-eyed Susans, populated grand expanses of prairies and meadows across the wild landscape. Now they decorate roadsides and mixed garden borders across the United States and Canada, plus innumerable foreign gardens as cherished imports. Known also as coneflowers and gloriosa daisies, their botanical designation is the genus *Rudbeckia*. It is a distinguished name for such a common plant. Swedish naturalist, Carl Linnaeus (1707–1778), considered the father of taxonomy for creating the basic system for plant classification and the first civilian to be knighted in Sweden, named rudbeckia for Uppsala University Professor Olof Rudbeck the Younger (1660–1740) and his father, Olof Rudbeck the Elder (1630–1702), both of whom were botanists along with their other scientific interests.

Now all states—except Hawaii, Alaska, and those in the desert Southwest—and subarctic Canadian providences have a native species or more out of the 25. Some varieties have small ranges, such as the Texas coneflower, *Rudbeckia texana*; the California coneflower, *Rudbeckia californica*; and the grassleaf coneflower, *Rudbeckia graminiflora*, of Florida's wetlands. The plant referred to as black-eyed Susan is *Rudbeckia hirta*. Although not native to Maryland, it has been the state flower since 1918 and a good color match with the Baltimore oriole. The other best known Rudbeckia, *Rudbeckia fulgida*'s popular cultivar Goldsturm, does not grow true from seed but spreads through its rhizome. This Perennial of the Year for 1999 fills its space quickly in good, well-drained soil with plentiful water. Two to three feet tall and across, Goldsturm has dark green, fairly sparse, simple foliage that when mature has a rough feel while being less hairy than *Rudbeckia hirta*.

The bristle-coated stems and rough leaves help to make rudbeckias unpalatable to deer and rabbits unless no better forage exists. In pasture and prairie, livestock and other herbivores usually ignore these low-food-value, prickly plants as long as grasses and others are available. As herbaceous perennials, various rudbeckias can be grown as annuals, biennials, or short-lived perennials, depending on the gardener's preference and the particular variety's tendency to reseed or to form clumps. They yield plentiful blooms from seed the first year. Rudbeckia may be grown from zones 3 to 10, with less hardiness in extreme weather or under other stressful conditions such as inadequate watering and poor sandy soil.

Coming in a variety of sizes—from one to nine feet tall—rudbeckia is suitable for nearly any flowerbed or container. Double gloriosa and Indian summer cultivars seem to be copying their big cousin the sunflower with blooms of six to eight inches across. The variety Cherokee sunset has double, chrysanthemum-like blossoms. Small cultivars, such as the dwarf Viette's little Suzy or Toto, which will stay about a foot high, enliven a border as if lighting the way of the path with their sunny petals. Rudbeckia's hardy and prolific blooms are perfect for taking over the impact after the spring-blooming flush of bulbs and pale-flowering shrubs and trees with hot yellows, golds, oranges, new dark reds, and combinations with contrasting centers of black or dark brown cones. Their enthusiasm carries well into the fall. Later, their seed-filled cones punctuate the winter until birds or snow finishes them off. The plants may be deadheaded to prevent self-sowing.

While rudbeckias are a perfect addition to any varied garden or wildflower area, they also will anchor an area of similar plants. A gardener could do worse than to have a large flowerbed of rudbeckias plus asters, chrysanthemums, marguerites, shasta daisies, chamomile, coreopsis, gaillardia, echinacea, or other plants with charming daisy-like blooms.

Besides their garden duty, wild prairie lives, and roles as splendid cut flowers, rudbeckias have been used for dye. Wool absorbs the pale yellow, dusty green, and greenish-gold colors produced from simmering dye baths of petals and leaves or the whole plant. As a medicinal plant, black-eyed Susans make a tea made from the root by Native Americans for the treatment of colds and worms and as a salve for wounds.

Other genera share the common name of coneflower. Rudbeckia's close siblings in the huge plant family Asteraceae are echinacea, dracopsis, and ratibida. *Echinacea purpurea* especially is cross-referenced from rudbeckia listings. Rudbeckia thrives in unplowed, ungrazed areas. Indeed, it is an indicator of a healthy prairie. Old and neglected cemeteries serve as islands of preservation and also seed sources. States including Illinois, Kansas, Ohio, Nebraska, Texas, Indiana, Minnesota, Missouri, Wisconsin, Oklahoma, and North and South Dakota foster active prairie restoration programs. Cemetery prairies, old railroad beds, steep and rocky hills, and even a former U.S. Army parcel of more than 19,000 acres are forming the pieces that gradually are growing into viable representatives of former pristine prairie land.

Efforts at natural diversity can be particularly challenging. Besides reestablishing the diversity of native plants that numbered in the hundreds of species, exotic plants must be eradicated. Minimal mowing, controlled burns, labor performed by the Civilian Conservation Corp of the 1930s, and the efforts of the modern green movement to seed and monitor the ecology contributed to the steady, if slow, return of true prairies. *Rudbeckia hirta* is a pioneer plant, meaning it is one of the first to grow back after a fire or in an area that has been otherwise disturbed.

Whether a home gardener or prairie restorer, sowers of rudbeckia must eliminate one step in planting by omitting a cover of soil. With plenty of sun and enough water, coneflowers will host bees including their own designated ones of *Andrena rudbeckiae* and *Heterosarus rudbeckiae*, flies, butterflies, and when the cones become seeds, birds. Goldfinches especially enjoy them. Seeds that they miss will self-sow the next spring.

So, whether replacing a labor-intensive lawn with a wildflower meadow, inserting a statement of sunny joy in an established bed, or wanting long-lasting blooms for eye catching arrangements, gardeners will find rudbeckias that provide solutions.

Tamara Stromquist

See also Daisy (Bellis)

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Bladderwort

A carnivorous plant, the bladderwort is in the genus *Utricularia*. It derives its name from the fact that its traps look like miniature bladders. With 214 species, *Utricularia* is the largest genus of carnivorous plant. A widely distributed plant, the bladderwort grows in the wild in Alaskan swamps that are frozen much of the year, in acidic ponds in Florida, and in the land between these states. It grows in wet regions of Central and South America, Europe, Asia, and Africa and in the deserts of Australia. Some bladderworts even live on other plants. Some die down to buds to survive winter whereas others survive drought by issuing forth tubers no larger than a grain of rice. Although many bladderworts are perennial, the annuals propagate by seeds. The flowers look like those of small orchids. Flowers may be as small as an ant, measuring one-eighth of an inch in diameter, or as large as a butterfly, measuring two inches in diameter. Flowers may be white, pink, purple, violet, yellow, red, or a combination of these colors. Although most bladderworts are terrestrial, 15 percent is aquatic, floating in ponds. Terrestrial species grow in wet or waterlogged sand, mud, or moss in bogs and swamps near lakes. At least one species grows on wet rocks under a waterfall. Curiously, bladderworts have no roots, leading some botanists to wonder whether they are truly plants. Most of a bladderwort is underground or immersed in water. It produces photosynthetic stolons, which resemble leaves. In the smallest plants, stolons are less than one inch long. In the largest, stolons grow to several inches. The plants vary in size from only a few inches to several yards.

Carnivorous Habit

The carnivorous habit of the bladderwort has fascinated scientists for more than a century. In 1797 Sowerby—his first name and occupation may be lost to history—identified the traps of an aquatic plant but assumed they enabled it to float. Because traps are only two cells thick, they are translucent, and Sowerby saw insects in them. He thought they were hiding, perhaps from predators. Botanist Ferdinand Cohn found insects in a herbarium specimen. In 1875 Cohn, obtaining a live specimen, put water fleas in its aquarium. Within 24 hours, the bladderwort had captured all fleas. British naturalist Charles Darwin mistakenly thought that insects entered the traps without any provocation. While European scientists labored to understand the behavior of bladderwort traps, American botanist Mary Treat, arriving at the solution in 1873, observed that the traps captured insects in a rapid sucking movement akin to the action of a vacuum cleaner.

A single plant may have hundreds, even thousands of traps. In some species these traps are no larger than the head of a pin whereas in other plants traps are one-eighth to one-quarter of an inch in diameter. One Australian species has traps that measure one-half of an inch in diameter. At the end of each trap is a door that opens only inward. When closed, mucilage seals the door shut. A trap's walls are concave, forming a vacuum in it. Outside the door are long filaments that, forming a funnel, guide an insect or other prey toward it. Glands at the door secrete a substance that attracts prey. At the door are trigger hairs. Prey that contact a hair set off the trap. The door opens and the vacuum pulls in the prey. Once inside, the prey has no hope of escape because the door shuts. A bladderwort sucks in prey in just one one-hundredth of a second. The trap, having imprisoned its prey, pumps out water and secretes digestive juices. These drown the prey, dissolving its innards in hours. The glands absorb this liquid. One trap may capture more than a dozen prey during its life. The bladderwort's varied diet includes paramecia, cyclops, rotifers, water fleas, worms, mosquito larvae, and even small tadpoles. More than most prey, mosquito larvae and tadpoles meet an unpleasant end. Often caught by their tails, this part of their anatomy is digested while they live. As they struggle, they trigger the trap repeatedly, so that ever-larger portions of their bodies are digested in turn until only their heads, too big to fit in the trap, remain.

Diversity

The 214 species of bladderwort may be grouped into several categories. Among these are terrestrial bladderworts, which gardeners prize for their ease of cultivation. Collectively, terrestrial bladderworts grow in all climates. Some species grow in diverse climes, inhabiting perpetually wet mixtures of sand and peat. In some cases, they grow on flooded land. Often, they may be found with other carnivorous plants. Of terrestrial bladderworts, *Utricularia subulate*, native to the Americas from Canada to South America, Africa, and Southeast Asia, produces abundant seed. Growing in flooded soil, this species flowers in warm weather, producing yellow blooms one-quarter inch in diameter. *Utricularia livida* grows in subtropical Africa and Mexico. Tolerating light frost, it flowers in warm, sunny locales, producing blooms one-third of an inch in diameter. Despite its flowering habit, *Utricularia livida* seldom seeds. *Utricularia sandersonii* is native to South Africa. Its flowers, growing to one-half of an inch in diameter, make it a popular plant at Easter. Flowering in late summer and autumn, *Utricularia graminifolis* is an indigene of Japan and southern Asia. *Utricularia bisquamata*, native to South Africa, tolerates light frost. Its flowers are a combination of yellow, violet, orange, and white. Producing yellow flowers, *Utricularia corquta* is indigenous to the United States, growing from the Great Lakes to the American Southeast. Native to Canada, the United States, Cuba, and Central America, *Utricularia resupinata* yields purple flowers with a yellow throat.

Seasonal bladderworts are native to Australia. Among these is *Utricularia menziesii*, indigenous to southwestern Australia. Growing in winter, it produces tubers to survive hot, dry summers. *Utricularia denstaniae* and *Utricularia capilliflora*, native to northern Australia, rely on gnats to pollinate their flowers. Native to northern Australia, *Utricularia fulva* yields yellow flowers with red speckling. Also native to northern Australia, *Utricularia chrysantha* produces yellow and white blooms.

Tropical bladderworts are native to the Caribbean and Central and South America. Among tropical bladderworts is *Utricularia reinformis*, which flowers from spring to autumn, producing blooms that measure one-and-one-half inches in diameter. Rare, *Utricularia quelchii* is confined in the wild to the border between Venezuela and Guyana. Its flowers are purple and red. *Utricularia asplundii*, also from the border between Venezuela and Guyana, produces white, violet, and gold flowers. Producing among the largest flowers of any bladderwort, *Utricularia humboltis* yields blooms that measure two inches in diameter and that are pink and white.

Aquatic bladderworts grow in ponds with acidic water. Among aquatic bladderworts, *Utricularia vulgaris*, native to Europe, is more than 10 feet long. Also more than 10 feet, *Utricularia macrorhiza* is indigenous to North America and China. *Utricularia minor*, growing in the Northern Hemisphere, produces yellow flowers. Dormant during cold weather, *Utricularia inflata* is native to the American Southeast and Washington. *Utricularia volubilii*, native to western Australia, grows in winter.

Cultivation

Gardeners grow bladderworts more for their flowers than for their carnivorous habit. The fact that some bladderworts flower over several months entices gardeners to grow them. One gardener recounted a visit from a neighbor who was unimpressed by a barren bladderwort. When it flowered, however, the neighbor wanted a cutting so that he too might cultivate it. Bladderworts do well by a sunny window or in a terrarium or greenhouse. Where the climate permits outdoor cultivation, bladderworts may be grown in a bog garden. *Utricularia sandersonii*, *Utricularia subulate*, and *Utricularia livida*, for example, may be cultivated by a sunny window or in a terrarium, greenhouse, or bog. *Utricularia cornuta* does well in a bog. Tropical bladderworts may be grown by a sunny window or in a greenhouse of terrarium. The gardener may grow *Utricularia gibba* and *Utricularia reinformia* by a sunny window.

For aquatic plants, the soil should be one cup of peat for every gallon of water. Terrestrial bladderworts should have a soil of equal parts peat and sand. Terrestrial plants may be potted and the pot placed in a saucer of water. One may flood the soil. The gardener should frequently pour a container of water on the soil of tropical bladderworts. The water of aquatic plants should be changed when algae appear. The gardener may feed bladderworts water fleas. Using fertilizer at one-quarter strength, one may apply it once per month during the growing season. Bladderworts may be propagated by sections of a plant, by seed, and by leaf cutting.

Christopher Cumo

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Blueberry

A perennial shrub, blueberry is a member of the Ericaceae family and *Vaccinium* genus. Among the types of blueberry are the important lowbush, highbush, and rabbiteye. Of these three, the most important commercially is highbush, which is divided into northern and southern cultivars. Lowbush differentiates from highbush by being the shorter of the two. One cup of blueberries contains only 93 calories. Blueberry is rich in fiber, potassium, manganese, copper, iron, and zinc. The antioxidant and flavanoids in blueberry may protect one against cancer, aging, degenerative ailments, and infection. In small amounts, blueberry contains vitamins A, C, and E. Among its B vitamins are niacin, folic acid, pyridoxine, vitamin B6, riboflavin, and pantothenic acid. The chlorogenic acid in blueberry may reduce the amount of sugar in the blood, aiding diabetics.

Lowbush Blueberries

One writer refers to lowbush blueberries as wild, but this designation obscures the fact that they are cultivated. Lowbush blueberries were likely the type that Native Americans harvested, though they may not have cultivated them, before the advent of Europeans. Amerindians ate blueberries fresh, dried, and in preserves, cornbread, and porridge. In the 17th century, New Englanders bought blueberries from Native Americans, making them into gruel and pudding, substituting them for cherries and currants. European settlers combined blueberries with flour, milk, and eggs. When colonists added blueberries to cornmeal, they called the product Indian fruit pudding. Colonists made blueberry pie with brown sugar.

Native Americans burned blueberry fields to kill shrubs and trees that encroached on them. This method of clearing land was not entirely deleterious because blueberries thrived on the charred soil. Without the cover of trees, however, the wind blew snow off the land, exposing blueberry bushes to winter injury. In the 19th century, those farmers who grew blueberries commonly burned one-third of their land each year. In the late fall or early winter, the grower mowed or burned blueberry land to kill pests and pathogens. A burned area will not bear fruit the following year.

In the 1860s, Americans began to can the lowbush harvest to extend its shelf life. The availability of canned blueberries stoked demand. By the 1920s, Maine had emerged as the leading canner. In 1926, Maine canned 70 percent of the U.S. harvest. The Great Depression forced growers to sell blueberries fresh because consumers could not afford the price of processed berries. Since World War II, freezing has replaced canning as the method of preserving blueberries. The consumer may store frozen blueberries two years.

In the 1980s, the yield of lowbush and other types of blueberry increased with the application of the herbicide Velpar, available in Canada in 1982 and the United States in 1983. Farmers apply herbicide in spring and fertilizer before the bush resumes growth in April. Given the requirement of nutrient-poor soil, the application of fertilizer must be infrequent. In May, the grower rents beehives to hasten pollination. The grower must guard against bear, fox, raccoon, robin, thrush, and grouse, all of which plunder the crop. Since the 1980s, farmers have harvested lowbush blueberries by machine. Less than 1 percent of the lowbush harvest is sold fresh. Most of the fresh crop goes to local hotels and restaurants. Most of the rest is frozen with a small portion being canned. Since the 1920s, the United States has exported lowbush blueberries to the Unied Kingdom. Since 1990, Germany and Japan have emerged as lowbush importers. Notable cultivars include Russell, which U.S. Department of Agriculture (USDA) scientist Frederick Coville bred in 1909, and Augusta, Brunswick, and Chignato, which the Kentville Research Station in Nova Scotia released in 1978.

There are two species of lowbush blueberry: *Vaccinium augustifolium* and *Vaccinium myrtilloides*. The first is more numerous in North America. A dwarf shrub, lowbush blueberry, like other types of blueberry, needs acidic soil, with a pH between 2.8 and 6. The soil may be peat or sand and, contrary to expectations and as we have seen, must be nutrient poor. Flowers, which may be white or pink, develop in May. Berries, ripening in late July in southern Maine and late September in Newfoundland, are one-eighth to one-half of an inch in diameter. Farmers cultivate lowbush blueberry from New Hampshire to northeastern Maine, and in New Brunswick, Nova Scotia, Prince Edward Island, northern Michigan, Minnesota, Wisconsin, and West Virginia. *Vaccinium myrtilloides* is grown in the Appalachian Mountains north to Labrador. Flowers, smaller than those of *Vaccinium augustifolium*, are white or pink. Berries are one-quarter to one-third of an inch in diameter.

Highbush and Rabbiteye

The hardiest blueberry, northern highbush grows 4 to 12 feet tall. It needs 750 hours of temperatures below 45°F to initiate dormancy. Berries, being between one-eighth and three-quarters of an inch in diameter, ripen over six to eight weeks. Whereas a green berry has 7 percent sugar, a ripe one has 15 percent sugar. Berries at the top of a bush, receiving the most sun, ripen first. Berries at the top of a bush have the most sugar and are largest.

In the 1890s, the attempt to grow northern highbush blueberries failed, probably because farmers did not appreciate that the soil must be acidic and poor. In the early 20th century, private growers and the USDA promoted the cultivation of blueberries, highbush and lowbush alike. In 1908, Frederick Coville bred the northern highbush variety Brooks. The next year he demonstrated that northern highbush berries, like all blueberries, need acidic soil. In the early 20th century, Coville bred six varieties: Adams, Dunphy, Grover, Harding, Rubel, and Sam. Farmers grew these cultivars in North Carolina, Michigan, Washington, Oregon, New England, New York, New Jersey, Connecticut, and British Columbia. Highbush was a lucrative crop. Expanding his work, Coville crossed northern highbush and lowbush cultivars, deriving the hybrids Pioneer, Katherine, and

Cabot. These hybrids grew no taller than four feet, yielded abundantly, and matured early. In the 1920s, Coville derived the varieties Concord, Greenfield, Jersey, and Ramcocas, and in the 1930s Catawba, Dixi, June, Redskin, Scammell, Stanley, Waraham, and Weymouth. Among these, Jersey is still grown in Michigan.

In the United States, Italian immigrants tried to grow peaches and grapes as they had in Italy, but because the climate and soil did not favor these crops, they turned to northern highbush. Before World War II, New Jersey was the leading northern highbush producer. After the war, Michigan overtook New Jersey. North Carolina, Washington, D.C., and British Columbia maintain large plantings of northern highbush. In the 1990s, Oregon emerged as a large producer.

The Netherlands may have been the first European country to plant northern highbush, in 1923. Poland began growing northern highbush in 1924, though the initial planting perished in the severe winter of 1929. After 1929, German scientist Walter Heerman bred the varieties Blauweiss-Goldtraube, Blauweiss-Zukertraube, Heerman, Pekord, Ama, and Gretha. Today, Germany, with more than 1,500 acres of northern highbush, has the largest acreage in Europe. In addition to the Netherlands and Germany, France, Spain, Portugal, Romania, and Denmark produce northern highbush. The Japanese, large consumers of blueberries, prefer northern highbush to other types. In the Southern Hemisphere Australia, New Zealand, Chile, and South Africa grow northern highbush. These ripen between December and April, supplying the Northern Hemisphere with fresh blueberries out of season. Since 1950, New Zealand has grown northern highbush and rabbiteye and exports to Japan. In 2000, New Zealand emerged as an exporter of northern highbush. In 1969, Australia first planted blueberries from U.S. seeds. Farmers grew northern highbush in Victoria and Tasmania and southern highbush and rabbiteye in New South Wales. Corindi, where the harvest is year-round, produces the majority of Australia's crop. Australia exports to Europe, the United States, and Asia, especially Japan. In 2000, Chile exported northern highbush blueberries to 26 countries including the United States, Canada, Japan, the Netherlands, the United Kingdom, Italy, and Germany.

Farmers grow southern highbush and rabbiteye where the climate is too warm for northern highbush. Rabbiteye, being of the species *Vaccinium ashei*, needs 400 to 500 hours of temperatures below 45°F to initiate dormancy. Southern highbush needs 400 to 660 hours of temperatures below 45°F. Farmers grow rabbiteye and southern highbush from central Florida to eastern North Carolina and from northern Arkansas to eastern Texas. Florida has grown rabbiteye since 1892. In 1926, the University of Georgia began research to derive new varieties of rabbiteye and southern highbush. In 1939, the North Carolina Agricultural Experiment Station and the USDA joined this effort, releasing Calloway and Coastal in 1949, Homebell in 1955, Briteblue, Delite, and Southland in 1969, and Bluebelle in 1974. In a separate breeding program, the University of

Florida had derived varieties of southern highbush suitable for the United States and Australia.

Christopher Cumo

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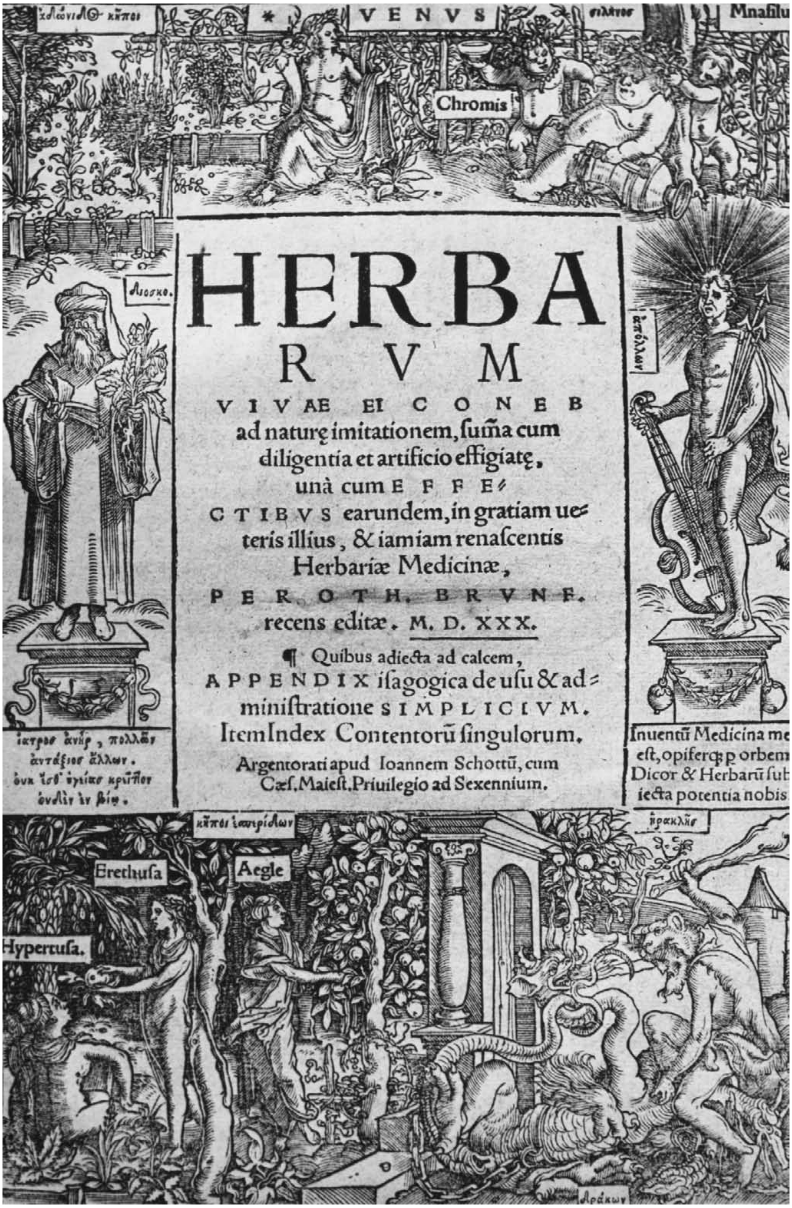
Botanical Illustration

Botanical illustration is immediate intimacy: easily accessed through familiar profiles, its intricate combinations of swirls, curving expanses, and definitive lines charm the viewer into an understanding of plant functions and anatomy. Yet appreciative audiences are perhaps one of the smallest constituencies involved with this genre today. Hobbyists and professionals, botanists, gardeners, classically trained artists, commercial illustrators, and many others have dabbled in botanicals. For the sake of narrowing an overly broad scope, this article focuses on the interplay between art and science. The 20th-century art historian Wilfred Blunt (1994, 4) adds another element, "soul":

> A great botanical artist must have a passion for flowers. You can set a good architectural draughtsman to draw a flower, and he will give you—if he thinks the subject worthy of real effort—a careful and precise study of the plan before him. But unless he *loves* what he is drawing, unless he *knows* the flower in all its moods, in all stages of its development, there will be something lacking in his work. . . . The artists, poets, and philosophers of the Far East have shown how little . . . is the gulf that separates man from the rest of Nature; we in the West have still much to learn from them.

There are two general types of botanicals, herbal and floral, that emerged with pharmacology and global exploration, respectively. Early civilizations—when confined to their own territories—took plant life for granted. The temple of


HERBA
RVM
VIVAE EICONES
ad naturę imitationem, sūma cum
diligentia et artificio effigiatę,
unà cum EFFE-
CTIBVS earundem, in gratiam ue-
teris illius, & iamiam renascentis
Herbariæ Medicinæ,
PER OTH. BRVNF.
recens editæ. M. D. XXX.
¶ Quibus adiecta ad calcem,
APPENDIX isagogica de usu & ad-
ministratione SIMPLICIVM.
Item Index Contentorū singulorum.
Argentorati apud Ioannem Schottū, cum
Cæs. Maiest. Priuilegio ad Sexennium.

In 1534 German theologian and botanist Otto Brunfels published a herbal of medicinal plants. Here is the cover to this volume. (Library of Congress)

Pharaoh Thutmose III at Karnak, Egypt dates to 1450 BCE. It displays 75 limestone bas-relief botanicals, artistically well in advance for their era, that commemorate the unusual plants found during Thutmose's military campaign in Syria.

Although few of the early herbal illustrations survive, we know of them through classical writings. Perhaps the first practitioner was Aristotle's pupil, Greek botanist Theophrastus (371–287 BCE), who wrote a book titled *Enquiry into Plants*. In his *Natural History*, Roman encyclopedist Pliny the Elder (23–79 CE) stated that Krateuas, Dionysius, and Metrodorus "painted likenesses of the plants and wrote under them their properties." (Krateuas, who served as physician to King Mithridates VI of Pontus, exemplifies the then-common link between botany and medicine.) The earliest surviving herbals owe to first-century CE Greek physician Dioscorides, who has been called the "father of modern pharmacology." His *De Materia Medica*, a compendium of classical writings, remained authoritative—and in print—through the 1500s. The original publication may or may not have contained illustrations, though later editions certainly did.

Art, Science, and Technology

As with most other creative and scientific endeavors, the fall of Rome and ensuing Middle Ages saw a qualitative decline in botanical illustration. Classical works were reinterpreted from copies, with subsequent "generations" of images losing integrity. Beginning in the early 15th century, however, new technologies and heightened commerce revived botanical illustration. The woodcut appeared in Europe again around 1400, and Gutenberg's first printing press followed 50 years later. The cost of publications soon fell. Movable type and woodcuts worked well and easily together on pages destined for printing. Botanicals were introduced into border designs, and chapter-opening drawings sometimes contained natural motifs. Botanical illustrators found a use for their skills, though relatively few entered the artistic limelight.

The genre also became increasingly refined. The 16th and 17th centuries are associated with the movement toward naturalism, but the issue is more complex: art and scientific thinking converged through the concept of perspective. The Florentine artist Giotti (ca. 1266–1336) first turned away from flat surfaces, portraying his subjects as rounded objects with spatial relationships to each other. Drawing on classical art and architectural theories, Italian architect and artist Filippo Brunelleschi (1377–1446) and, later, Italian architect and artist Leon Battista Alberti (1402–1472) imparted more precise, mathematical thinking. The polymath Leonardo da Vinci (1452–1519), who invented an early printmaking technique, also insisted on real models for his artist works. People and other subject matter—including plants—thus assumed three dimensions.

Two period publications of herbal woodblocks provide a snapshot of botanical illustration in the mid-16th century and offer insight into the ways it would evolve. Otto Brunfels's *Herbarum Vivae Eicones* (1534) and Leonhart Fuchs's *De Historia Stirpium* (1542) are remembered by the names of their editor-compilers, medical practitioners both. *Herbarum* was illustrated by Hans Weiditz (1495–1536), a student of the respected German painter-printmaker Albrecht Durer (1471–1528), who nevertheless remained anonymous. Fuchs proved a more gracious editor than Brunfels, crediting several members of his publishing team.

In fact, increasingly complex printing technologies necessitated collaborative approaches—often diluting individual credentials. As the woodcut yielded to more detailed engravings, artists and craftsmen could be appreciated for their separate talents. Collectors later would compare differences between the original drawings and the finished prints, and editor/text compiler, botanical illustrator, calligrapher, printmaker, and publisher all had distinct roles in period productions. (The term "editor/text compiler" is used because most of the named authors borrowed from the ancient pharmacological experts.)

At the time, however, Brunfels and Fuchs both grappled with the spatial problem of placing an odd-shaped plant on a linear page. Yet their visions—balancing naturalism with art—varied. Weiditz (Brunfels's anonymous artist) showed the plant in whatever way he found it, sometimes withering from disease or, simply, a declining life cycle. Fuchs's illustrators overlooked the flaws or elevated their subjects to more perfected forms. Both herbals nevertheless revealed the desire to serve science. The less attractive (and spatially challenging) root and stem structure generally had been hidden or reduced in proportion to leaves and flowers. Weiditz dealt with the geometry at one point by cutting the stem, and running the lower part of the plant horizontally along the bottom of the page. Fuchs displayed the flowering plant; buds and seeds appeared on the same page, too, but apart from the graceful stalk.

Whatever the case, increased learning revealed much more about botanical subjects, and advanced art techniques of the late Middle Ages and Renaissance elevated their composition. Just as art, science, and printing technologies seemed to converge, however, the original function of herbal illustrations faded. In 1533, a professorship in botany was created at the University in Padua, establishing plant study as distinct from medicine. Fifty years later, the physician-botanist Andrea Cesalpino (1519–1603), began grouping plants by their characteristics, or morphology (specifically, their fruits and seeds), rather than medicinal values—or simple alphabetical order. His *De Plantis Libri* (1583) gained the scientific authority so long relegated to the early Greco-Romans. As academic disciplines solidified, plants with no outstanding function were once again viewed as everyday features of the local landscape.

At the same time, Europeans developed a potent attraction to exotic species from new worlds. The first printed illustration of a tobacco plant, for example, was published around 1570. Monarchs, barons, and city-states subsequently cultivated these treasures on their own turfs. Meticulously tended estate gardens soon flourished in much of the continent, and patrons needed botanist-illustrators to publicize their status—and formally document the contents. Actual botanic gardens in Pisa (1543), Padua (1545), Florence (1545), and Bologna (1567) inspired more scientific interest, with illustrative approaches to match.

Rapidly rising in popularity and purpose, floral drawings thus overtook the traditional herbals. However, the terms are not exact. "Florals" more accurately refer to *cultivated* species; the genre grew to embrace ornamental, decorative, and edible plants.

The early illustrators tended to be multidisciplinary, too: botanists, gardeners, general artists—per chance employed in or near a garden. Nor did they render just one picture. Botanical illustration benefited from, and contributed to, a growing publishing industry. The physician Pietro Andrea Matthioli (1501–1577), updated Dioscrides's work with new and revised text, as well as quality woodblocks. *Discorsi* (Commentaries) was printed first in Latin during 1544 and, 10 years later, in Italian—reputedly selling 30,000 copies. More than 40 Matthioli editions were to enter the market, also in Czech and German, and containing new illustrations.

Hortus Eystettensis (1613) was a pioneering celebration of place, rendered by professional artists. The largest single book published to that time, its 367 plates covered over 1,000 species. The idea germinated with Johann Conrad von Gemmingen, descendant of an ancient, affluent line, who came to the southern German town of Eichstatt as its new bishop. Seeking to elevate both worship and church property, he built what was said to be the first botanical garden north of the Alps, a rambling wonder of eight differently planted parterres; herbs, vegetables, and fruits descending from the palace above to the river below; and exotic displays from abroad, including cactus, peppers, and potatoes.

Basilius Besler, an apothecary and physician from Nuremburg (35 miles distant), was what we might today call Gemmingen's procurement officer, negotiating on his behalf with Dutch merchants for rare species. Besler also was charged with cataloguing the garden; among other duties, he conveyed live flowers from Eichstatt to premiere local artists for illustration. Gemmingen advanced some of the money needed to print these works. When he died in 1612, Besler opted to proceed with the publication anyway. His plan was a black-and-white edition for the book trade—and special, hand-colored versions commissioned by individuals wealthy enough to afford them. The *Hortus Eystettensis* illustrations are united by a Baroque character, full utilization of the page, visible species names, and (following a certain tradition) diminished representation of roots and stems. Yet artists' individuality and talents managed to surface. A few florals are full-face portraits, while most appear from a slight distance. One or more varieties grace each page. These partners possess different scientific relationships to each other. Some layouts seem to allocate equal space to each of the smaller illustrations, rendering an ordered, box-like appearance; other placements are unifying and creative, even showing movement.

If these anthologies did little to further the careers of most Renaissance illustrators, some achieved lasting recognition. Before going to war, the soldierly Charles de Sainte-Maure (1610–1690), later Duke of Montausier, decided to secure his future with the much sought-after and cultured Julie D'Angennes. He commissioned Nicolas Robert (1614–1685) to craft an extraordinary birthday gift. The resulting album, the *Garland of Julie*, featured spectacular, skillfully rendered flowers that appeared individually—and together on the title page, forming a circle around the recipient's name. It was a multimedia production, too, as Robert snared the era's best known calligrapher and one of its revered poets for their respective artistic contributions. The *Garland* sealed the baron's marriage proposal; it simultaneously bolstered Robert's reputation as an artist. In short order, he catalogued a baronial garden, served the court of French king Louis XIV (1638–1715) and, with a turn toward more scientific work, became chief illustrator for a landmark history of plants published by France's new Royal Academy of Sciences.

Botanicals nevertheless filtered to the average person. The Dutch had become masters of the flower trade. Blooms in general—and tulips in particular—were universally admired, but generally not affordable. According to legend, one aficionada engaged the Flemish artist Jan Brueghel (1568–1625) to paint the flowers that were beyond her purchasing power. Jan Brueghel was the son of the Flemish artist Pieter Bruegel the Elder (1525/1530–1569), who so memorably depicted the era's folk culture. Originally dedicated to landscapes and historical scenes, the younger Brueghel gained lasting recognition for his floral still lifes. And while not exactly botanical illustration, oil paintings of flowers (revealing the period's dark backgrounds and rich color schemes) became popular throughout the Low Countries.

The Golden Age of Botanical Illustration

The period from approximately 1700 to 1840 has been called the Golden Age of Botanical Illustration. It was an era when botanical drawing reached its height—sustained by both popular tastes and supportive infrastructures. In addition to the Dutch penchant for commercial cultivation and the German appreciation for quality printing, the English were establishing a reputation for horticultural science and the French for art. Dutch seed catalogues seemed a likely progenitor to such works as the *Gardener's Dictionary*, complied by Arthur Miller, and *Catalogus Plantarum* (1730), a project of the Society of Gardeners, an English trade guild.

These publications sought to clarify differences between plants, creating more knowledgeable patrons who would be less apt to blame the horticulturalists for their purchasing mistakes. Both English books employed Jacob van Huysum (1686/87–1740), a Dutch flower painter with an artistic pedigree; his father and brother were similarly engaged, rendering their work in a similar style.

Indeed, the era's luminaries traveled between countries and, frequently, between trades. Georg Dionysius Ehret (1708–1770) is one of the most brilliant examples. The son of poor German growers and vendors, he learned how to draw from his father at an early age. The boy was placed as a gardener's apprentice, soon to become an overseer, all the while impressing employers with his developing artistry. At first, his talent yielded nothing but engravers' jobs for which he received little pay. But the young man did amass a portfolio—and the confidence of Christoph Jacob Trew (1695–1769), a wealthy Nuremburg physician with an immense interest in botany. Trew became Ehret's collector, promoter, and sometime publishing collaborator. (It should be emphasized, however, that Trew's productions extended well beyond Ehret.)

Reinforced with letters of introduction, the artist traipsed through Europe, often on foot, painting interesting, new flowers and sending his works to Trew. One of his contacts led him to the pioneering Swedish naturalist Carl Linnaeus (1707–1778), who developed a uniform system for classifying and naming species that remains, at least partially, in practice today. Moving permanently to London during 1736, Ehret illustrated Linnaeus's *Genera Plantarum* (1737)—for which he was paid, but not credited. The artist nevertheless maintained a collaborative, long-distance relationship with Trew. He also counted a number of other partners and elite patrons (notably the Duchess of Portland) and gained distinction toward the end of his life as the only foreign-born Fellow of the Royal Society. Some botanical illustrators felt comfortable with a limited repertoire of flowers; Ehret could handle virtually all. He painted them in an oversized way for striking presentation. Most of all—as someone who claimed both spheres of influence—he balanced accurate representation with artistry.

Pierre-Joseph Redouté (1759–1840) was the most popular figure of the Golden Age. In fact, his name remains synonymous with botanical illustration. Unlike the happenstance career path foisted upon Ehret, Redouté came from a long line of Belgium painters. He flailed about as a traveling artist during his teenage years, but took the opportunity to study the Flemish masters and, when visiting Amsterdam, developed a passion for the work of the recently deceased flower painter Jan van Huysum. Van Huysum's bountiful bouquets consumed entire canvases, yet captured details: dew drops, insects, thin streams of light. On the other hand, they were not flowers that might be seen at the same time or grown in the same place.

Inspired, the now mature and motivated Redouté sojourned to the Jardin du Roi and the mentorship of the well-healed and connected botanist Charles Louis

L'Héritier (1746–1800). Besides granting the young man access to a voluminous library and personally providing him with botanical instruction, it was likely that through L'Héritier, Redouté became draftsman to the cabinet of French queen Marie Antoinette (1755–1793). This was a largely ceremonial title that nevertheless enhanced Redoute's reputation. He soon benefited from close association with Dutch artist Gerard van Spaendonck (1746–1822), a brilliant professor of flower painting—and another follower of Van Huysum.

Redouté transitioned nicely from the Revolution to the Empire: Empress Josephine Bonaparte (1763–1814) put him on salary to capture for posterity the living treasures at Malmaison; a number of beautiful published volumes ensued, further contributing to Redouté's legacy. Living the noble life as far as his money would take him, Redouté also attracted his own students, including royal scions. He rose to the top tier of botanical illustration for many reasons. A natural talent descended from artistic lineage, Redouté quickly learned from—indeed, copied the style of—the masters, notably Van Spaendonck. His career also coincided with some complementary new technology. Stipple engraving used dots instead of lines, presenting more natural, gradual color changes. The technology put a different spin on his work, elevating it above those of his predecessors.

With Redouté as with Ehret, we see evolving public patronage (initially exemplified by paying students), diversifying artists' economic options, and gradually starting to replace a dependence on royalty. In addition, a growing professionalism and mentoring relationships helped to establish careers. The Golden Age of Botanical Art also transferred from nobility to government what was to become a global institution: the Kew Gardens. Highly placed staff there nurtured botanical illustration and forums for presenting it. A veteran of Captain James Cook's worldwide voyage, British explorer and naturalist Sir Joseph Banks (1743–1820) acquired and archived some of Ehret's works, donated his herbarium and personal library collection to public repositories, and permanently instituted the position "draftsman" at Kew. That job was filled by Franz Bauer (1758–1840), whose brother Ferdinand (1760–1826) became known for botanicals illustration and traveled on expeditions to capture plant life in the Mideast, Maritius, and Australia—where he named a small group of islands after Banks. As leading botany professors and successive directors of the Kew, Sir William Jackson Hooker (1785–1865) and his son, Sir Joseph Dalton Hooker (1817–1911), installed the highly skilled Walter Hood Fitch (1817–1892) and, later, his similarly talented nephew, John Nugent Fitch (1840–1927), as illustrators of the respected *Botanical Magazine*—and other publications.

With global exploration graduating to colonization, the lack of Asian influence in botanical illustration is puzzling. Flower painting was firmly established in China by the T'ang dynasty (618–906 CE) and in Korea about the same time. It subsequently came to Japan. Among other differences, East Asian artists relied more on black-and-white shading—and less on the imposition of color—than

Europeans. India had a floral tradition, too, derived in part from Persian-Mogul antecedents, which yielded a highly stylized, symmetrical appearance.

Europeans expropriated neither. Instead, they either brought their botanists and illustrators with them (Ferdinand Bauer provides a good example) or instructed native artists in Western styles. Still, Asia fused with Europe through creative, commercial hybrids. Mary Delany (1700–1788), a friend of the German composer George Frederic Handel, British writer Jonathan Swift, and the arts the patron Duchess of Portland, earned a place for herself at the British Museum through her intricate floral "mosaics." According to contemporary testimony, Sir Joseph Banks said that "he would venture to describe botanically any plant from Mrs. Delany's imitations without the least fear of committing an error." Her medium was imported Chinese paper, finely cut and formed into flowers.

And while Westerners did not fawn over Asian floral illustration (at least initially), they adored its porcelain. By the 1700s, European manufacturers were beginning to produce their own. "China painting" often employed Western "flower books" as a reference for artists decorating this increasingly popular dining ware. However, some of the finest, most valued products—the German Meissen designs immediately come to mind—did, in fact, incorporate Oriental-style flowers and themes, among other motifs.

Whatever the subgenre, the creators often remained anonymous from the earliest days when herbal silhouettes were copied to oblivion, through the early modern era when publishers co-opted flower paintings and illustrations without giving artists any credit. The Statute of (Queen) Anne in 1709 reduced the publishers' guilded advantage, instituting copyrights for writers and artists—and introducing the concept of public domain. As befitting a culturally connected former colony, the U.S. Copyright Act of 1790 borrowed heavily from the statute.

The Victorian Era to Today

As with creative rights, new technologies brought botanical illustrators closer to publication processes. Straightforward printing eliminated the need for middlemen who would copy or otherwise interpret their work. Henry Bradbury patented a method during the 1850s with two similarly sized plates: a soft lead portion held plant material directly, as a steel component forced an impression of it. The final stage was electroprinting. Inspired by photography, botanist Anna Atkins (1797–1871) published *British Algae* in 1854. She used the process of cyanotype to duplicate 400 minute species within her herbarium: plants with details that could easily evade a draftsperson. Cyanotype was very direct. The botanist laid her plants on photosensitive paper, exposed briefly to sunlight. The result was an image in "cyan" blue. For whatever their merits, both printing processes captured the plant's profile and internal arteries—but not their textures, depth, or dimensions. Photography, of course, became both a practical and creative aid in botanical illustration.

An increasingly middle-class Victorian public bought into flower arrangements of all types. The arts-and-crafts designer William Morris (1834–1896) entered floral themes into his stained glass, tapestries, wallpapers, and other furnishings. Morris's swirling, two-dimensional patterns in varying color schemes were not botanically accurate, yet his use of woodblocks as a design tool recalled early botanical illustration.

Herbaria evolved during the Age of Discovery as a way of transporting and preserving unique botanical specimens. They consisted simply of dried plants, pressed and mounted. Both scientists and artists nevertheless came to appreciate them. *The River Jordan* (1900), published by the Boulos Meo Company as a tourist souvenir book, boasted olive wood covers that opened to complementary folios: photos of holy sites on one side and drawings with local (Middle Eastern) dried flowers affixed on the other. The pressed-flower fad continued through the early 20th century and enjoys periodic revivals.

On view at Harvard's Museum of Natural History are more exotic species: the Ware Collection of Glass Plants. Created by a German father and son, Leopold and Rudolph Blaschka, they were commissioned over a 50-year period, from the late 1880s to 1936. The idea began with George Lincoln Goodale, Harvard professor and Botanical Museum founder, initially in rebellion against pressed flowers, as well as wax or papier-mâché models that he believed would not hold up well to classroom uses. The botanical detail, artistry, and use of glass together form a uniquely beautiful presentation.

As gardening became a middle-class leisure pursuit in the 20th century, botanical illustration made its way into mainstream publishing and related commercial enterprises. Professional, serious hobbyist, and popular magazines satisfied a craving for practical information. Illustrators and photographers worked together on these gardening periodicals. Such practice is evident in Sunset Magazine's *Western Garden Book*, considered a bible by several generations of home growers. Seed and catalogue companies engaged illustrators, too, as did culinary publications. The covers of *Cook's Illustrated* magazine provide a contemporary view, though sometimes with Dutch backgrounds and Impressionistic influences. A recent book lists over 35 resources for British botanical illustrators and artists, including several formal education programs. The Royal Botanic Gardens, Kew (or simply, Kew), is the largest and most varied resource of its type in the world. It currently employs 800 staff, and contains an herbarium of 7 million species, a seed bank, a 750,000-volume library, and publishing program that produces over 20 new titles annually. Many will agree that Shirley Sherwood, author, collector, and benefactor of the Shirley Sherwood Gallery of Botanical Art at the Kew, is the individual most responsible for reviving the genre today.

Botanical gardens in the United States are owed to both commercial forces (cemeteries inspiring naturalistic parklands) and government initiative. Congress appropriated grounds to establish a horticultural center and museum on the Washington Mall during 1820, but the impetus came more than two decades later, after the Wilkes Expedition brought plants from the South Seas. The U.S. Botanic Garden opened to the public in 1850. Privately funded agencies as diverse as the Huntington Library, Art Collections, and Botanical Gardens near Los Angeles and the Hunt Institute for Botanical Documentation at Carnegie-Mellon University, Pittsburgh, contribute greatly to the field. Finally, membership organizations hold sway here, with practitioners banding together under the American Society of Botanical Artists (ASBA) and Guild of Natural Science Illustrators.

Some technical experimentation occurs. Still, botanical illustrators generally adhere to low-tech media: graphite (pencil); pen and ink; scratchboard; colored and watercolor pencils; watercolor, gouache, and acrylic paints. What further defines an illustration is the canvas. Like Ehret, Redouté, and the classicists, a significant number of today's experts prefer vellum, stretched calfskin.

Day jobs in illustration aside, practitioners can gain a reputation through juried shows. ASBA requires that the judges include both botanists and artists. And while methods may be traditional, the exhibition topics tend to be more contemporary. A 2011 ASBA show, also its first international venue, focused on "Losing Paradise? An Exhibition of Endangered Plants Here and Around the World." Over in England, Prince Charles published his *Highgrove Florigium* (2008). The first step was inviting leading botanical artists to capture in watercolors the trees, flowers, vegetables, and herbs growing organically at his Highgrove estate. Their work was submitted to an expert panel for publication review. Traditions notwithstanding, botanical art has a more global character. Several Japanese practitioners are members of the Botanical Artist Guild of Southern California.

Illustrators who work for publishers or for archival purposes now draw their plants directly into computers. Automation allows them to customize some of their techniques—their style of stippling (showing texture through dots) or hatching (via lines). Some say that computer printers need to be calibrated every day for the truest color effects. Still, the fondness for intimacy and tactile interactions with plants and drawing implements remains unchanged. The contemporary illustrator initially applying his or her stylus to filmy computer paper is not that far removed from the engraver-artist Crispin de Passe (1590–1664) who, perhaps tentatively at first, approached his plates with the then-newfangled burim.

Lynn C. Kronzek

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Bougainvillea

Bougainvillea is a hardy ornamental viny shrub of the four o'clock family or Nycataginaceae, which originated in subtropical and tropical South America. *Bougainvillea* was first classified in Rio de Janeiro in 1768 by the French botanist Philibert Commerçon (1727–1773), who named the plant after the navigator Louis-Antoine de Bougainville (1729–1811), with whom he had served in the French navy. There are now around 34 genera. However, there seems to be no definitive agreement on the number of bougainvillea species in existence, with estimates ranging from 4 to 350. This lack of accord is due to frequent hybridization in the genus in India and Malaysia, which makes the identification of individual species extremely difficult. Bougainvillea grows across the globe in areas with warm climates. Although some species will tolerate cooler environments and high altitudes, with *Bougainvillea spectabilis* the most cold-tolerant of all bougainvilleas, bougainvillea cannot survive temperatures much below freezing and should be planted in areas that do not suffer from frost. In cooler areas bougainvillea can be raised as a houseplant or in a conservatory.

Attributes

Bougainvillea is a quick-growing impenetrable hedge the height of which varies depending on the species or cultivar, with a dwarf species called Bougainvillea Temple Fire available. The stem of the bougainvillea has hook-like spines, which

Bougainvillea (Wilm Ihlenfeld/Dreamstime.com)

allow the plant to climb over rough surfaces. While the spines allow for scrambling over coarse-textured surfaces, wires, trellises, or other supports may be needed for bougainvillea to spread over the exterior of smooth walls or arbors. Bougainvillea has round to oval, alternate, opposite leaves, which can be evergreen or semievergreen. The most striking aspect of the bougainvillea is the brightly hued bracts, which are petal-like and are most often to be found in shades of purple, red, yellow, orange, pink, and white with the latter tending to be particularly tender. The tissue-paper-like texture of the bracts has led to the bougainvillea gaining the soubriquet "the paper flower." In some plants, bracts of two colors can be found on the same shrub, while some cultivars see the bracts change color with age thus giving the appearance of several colors growing together. The actual flower of the bougainvillea is a small, creamy-colored tube-like structure attached to the base of the bracts.

Species and Hybrids

There are three main horticultural species: *Bougainvillea spectabilis*, *Bougainvillea peruviana*, and *Bougainvillea glabra*. From these, three major hybrid groups have emerged *Bougainvillea* × *buttiana* (a hybrid of *Bougainvillea peruviana* and *Bougainvillea glabra*), *Bougainvillea* × *spectoperuviana* (a hybrid of *Bougainvillea peruviana* and *Bougainvillea glabra*), and *Bougainvillea* × *spectoglabra* (a hybrid of *Bougainvillea spectabilis* and *Bougainvillea glabra*). The horticultural cultivars have originated from both natural and artificial hybrids, and among the bud sports are some variegated and double-bract sports. One frequently grown species of bougainvillea is *Bougainvillea* × *buttiana* Holttum and Standley. This is made readily distinguishable by its vicious spines of up to two inches in length and shrubby habit. The species scrambles and can climb into trees. The plant has white flowers surrounded by red, purple, white, or orange bracts, and the leaves are a dull green shade and ovate. This species flowers year-round, with the flowers borne either in one to three clusters of three each or in panicles on top of a stalk that develops into a spine. Each flower is connected to a bract. Another frequently grown bougainvillea is *Bougainvillea glabra* Choisy. Like *Bougainvillea × buttiana* Holttum and Standley, *Bougainvillea glabra* Choisy has sharp spines and dull ovate leaves. The bracts of *Bougainvillea glabra* Choisy are magenta. *Bougainvillea glabra* Choisy is occasionally misidentified as *Bougainvillea × buttiana*, but the two plants differ in that the leaf tip of the latter has leaves with a duller upper surface and, rather than the attenuated leaf tip of *Bougainvillea glabra* Choisy, the leaves of *Bougainvillea × buttiana* have an acute tip. *Bougainvillea glabra* and *Bougainvillea × buttiana* can hybridize, leading to greater confusion as to nomenclature.

Cultivation

Bougainvillea can be grown as a shrub, a specimen plant climber, or a climber, though the object the bougainvillea will scramble over must be sufficiently strong to stand the weight of a plant, which may grow to 65 feet tall and therefore weigh a considerable amount. In areas of India, such as Bangalore, bougainvillea is trained to grow into a ground-covering mound. This is achieved by pegging the stems of the plant to the ground as it grows and removing all upward-growing branches. However, this will diminish the colorful impact of the plant as the frequent cutting necessary to achieve the lateral spread removes flowering growth. The dense foliage of both *Bougainvillea × buttiana* and *Bougainvillea glabra* makes both species ideally suited to the creation of topiary shapes.

Bougainvillea prefers full sun and will grow in any soil that is not saturated with water. Once the plant is established, it will form a deep root system and will need very little watering or care in general. Bougainvillea grown in full sun produce the best colors as the plant does not enjoy shade. Bougainvillea can be propagated by budding, by air or ground layering, or from hardwood leafy cuttings of around eight inches in length, the recommended method for *Bougainvillea × buttiana*. Tip cuttings may also be used for the propagation of species such as *Bougainvillea cypheri*. Bougainvillea infrequently bears a single-seed fruit known as an anthocarp. *Bougainvillea glabra* new cultivars and hybrids may be raised from seeds.

Victoria Williams

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Boysenberry

Boysenberry is a large compound fruit species known as *Rubus ursinus* ssp. *idaeus*, whose scientific classification places it in the family Rosaceae (the Rose family) and the genus *Rubus*. The boysenberry is a dark reddish-black fruit that is a cross among the European raspberry (*Rubus idaeus*), the common blackberry (*Rubus fruticosus*), and a loganberry (*Rubus loganobaccus*). It hails from the United States and is chiefly grown along the Pacific Coast, from Southern California to Oregon, but also in the American South and the Southwest.

History of the Boysenberry

The boysenberry grows on a bramble, or prickly shrub, and was first cultivated in California in the 1920s by horticulturist Rudolph Boysen (1895–1955). Boysen, the chief horticulturist and parks superintendent of the city of Anaheim, in Orange County, California, at the time, abandoned his experiments on berry plants and sold his farm. U.S. Department of Agriculture agent George M. Darrow tried to find the origins of Boysen's berry production, and sought the aid of berry expert and local farmer Walter Knott. Knott helped Darrow track down the boysenberry on Boysen's old farm, discovering frail vines in a weed-infested field. The vines were transplanted on Knott's farm, where they were nurtured until they once again produced the fruit that Knott named after its founder, Boysen. In 1935, Knott began selling boysenberries on the Southern California farm he and his wife, Cordelia (Hornaday) Knott, owned. The fruit became a highly requested variety, and Cordelia Knott began turning the boysenberries into preserves, with which she filled pies. The pies were sold at the Knotts' farm, and along with chicken dinners, were the foundation for what became a restaurant and then the current popular amusement park called Knott's Berry Farm in Buena Park, California. Although since sold to another company, Knott's Berry Farm still houses the Knotts' original restaurant, the Chicken Dinner Restaurant.

Description, Appearance, and Nutrition and Medical Benefits

Boysenberry shares its membership in the Rosaceae family with more than 3,400 species of flowering plants, making it one of the largest families of such plants. Several varieties of fruit belong to Rosaceae besides the berry. These include apples, peaches, plums, and cherries. The genus *Rubus* contains 13 subgenera and more than 300 species, most of which have woody stems that contain prickles, spines, and bristles.

The boysenberry's glossy, large, dark, reddish-black or purple fruit is similar in appearance to the blackberry, a fruit it is related to and often classified as. The boysenberry is made up of numerous drupelets, fleshy fruit in which the seed is encased in a single shell. Boysenberries are a slightly tart, juicy fruit that is rich in vitamin C, vitamin A, calcium, iron, fiber, and anthocyanins that work as antioxidants. The antioxidant level of the boysenberry is nearly double that of the blueberry, a fruit known for its high level of antioxidants. A typical serving of boysenberries contains nine grams of sugar and one gram of protein as well as 66 calories, 3 of which are from fat.

Ellagic acid is another compound found in boysenberries that promotes health. It has been found to prevent certain types of cancer by slowing the growth of tumors. For example, in studies ellagic acid has reduced the effect of estrogen on breast cancer cells, and it has been proven to help the liver rid the blood of carcinogens. Ellagic acid as well has been credited with promoting the healing of wounds and decreasing the risk of heart disease.

Boysenberries also contain gallic acid in high concentrations. Gallic acid aids in cancer prevention by inducing cytotoxicity in cancer cells. A study by the University of Colorado in Denver established that oral gallic acid inhibits cancer cell growth, as evidenced in prostate cancer victims, and lowers the incidence of adenocarcinoma.

A 2007 Japanese project found that rats that were fed food containing boysenberries were less likely to develop symptoms of mesothelioma, a disease of the lungs that is induced by exposure to asbestos. The head of the research group at Sagami Women's University in Sagamihara, Kanagawa, Japan, suggested that the polyphenol in boysenberries was responsible for the prevention of mesothelioma in the laboratory rats exposed to asbestos. According to the Oregon Raspberry and Blackberry Commission, boysenberries may also prevent certain illnesses caused by viruses, bacteria, and carcinogens.

Boysenberry's Uses

The berries can be eaten fresh off the vine or can be manufactured into jams and jellies, preserves, pie fillings, syrups, and wine. They are sometimes used in fruit salads or as a decorative edible topping to cheesecakes and tarts. Turned into a fruit sauce, boysenberries are a popular accompaniment to fowl, such as duck and goose. The boysenberry's growing season is relatively short, typically occurring between early July and early August. Its shelf life is also short. The fruit can spoil if left for more than two or three days after picking. Washing ahead of time can shorten the life span of the fruit even more.

Threats to Boysenberries

A common threat to boysenberry harvests is the fungus botrytis, which infects many plants. The fungus thrives in moist conditions and can survive the winter months as sclerotia, evident as small, black lesions, or as mycelia, a thread-like growth, both of which can form on dead or decaying plant matter.

Boysenberry decline is a common term for *Cercosporella rubi*, a plant fungus that causes a disease known as rosette disease. Boysenberry decline can cause a symptom called witch's broom, a plant deformity or disease that changes the structure of the plant, and can cause the production of double blossoms, which can lead to low yields. *Cercosporella rubi* is a problem exclusive to the southeastern United States.

Rosemarie Boucher Leenerts

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Breadfruit

The breadfruit tree, *Artocarpus altilis*, is a good representative of a group of plants that have been cultivated since antiquity. Early Polynesian people recognized its importance for providing a source of food and for other uses in everyday life. They brought it with them when they settled the Hawaiian Islands, Asia, and elsewhere in the South Pacific. Breadfruit belongs to the Moracceae family and is identified by the characteristics of fig and mulberry trees. Growing to heights of 60 to 85 feet, a tree's long branches span up to 60 feet. The fruit is harvested just before it ripens and can be cooked immediately or after it is fully ripe. Canoes, tools,

Breadfruit (Rajeshbac/Dreamstime.com)

and other objects were made from the lightweight wood. There were many uses for the sticky sap, a latex substance that oozes from the stem of cut fruit. Although the tree needs plenty of room for spreading roots, it can be easily grown from root cuttings. The cultivation of many different varieties of breadfruit is a result of the need to grow breadfruit in slightly different conditions. Today, nearly 100 varieties can be found growing in the Kahanu Gardens of the National Tropical Botanical Garden of Maui, Hawaii.

The Cultural Significance of Breadfruit Is Seen in Its History

Migrating Polynesians were primarily responsible for introducing the plant to countries throughout the tropics. The Hawaiians believe that breadfruit was first brought to Oahu around 750 to 1200 CE. Europeans were not aware of breadfruit until the early 17th century. English captain William Bligh is credited for sailing to Tahiti on the *Bounty* to collect 1,000 breadfruit seedlings meant for the West Indies as food for slaves. The crew mutinied, however, and some accounts suggest it was partially due to the plants' requiring more water than was available for all. The seedlings, Captain Bligh, and his loyal men were all put off the ship. They survived and eventually returned to Tahiti for more breadfruit. These were planted in the West Indies and did well, but the slaves refused to eat the fruit. Around the same time, the plant was brought to Mexico and Central America. Sources report that both seeded and seedless varieties were popular. In some countries the fruit was considered livestock feed, in others, sustenance for the poor. Today, some cultures still consider breadfruit a daily staple. Others turn to it only in emergency. In still other countries, breadfruit is considered a gourmet item.

Stories are told that corroborate the significance of breadfruit to Hawaii's history, in particular. While taro was considered the major staple in this land, the people also ate breadfruit regularly. *Ulu*, Hawaiian for "fruit," is the name they gave to the breadfruit tree. It is said that traditionally, the *Ulu* is planted at the time of the birth of a child in order to provide a lifetime of food. Legends describe how the plant originated from the war-god, *Kuka'ilimoku*, who married a mortal wife and had children. During a time of hardship and famine, *Kuka'* told his wife that he must leave. He buried himself in the ground where he stood. The tears of his family watered the earth and a healthy breadfruit tree grew from that spot. *Kuka*'s body was the trunk and his arms, the branches. His head was the fruit and he told his wife to feed their children. Thus *Kuka'* saved his family from starvation. A Hawaiian saying goes as follows, "Look for the oozing breadfruit." In other words, "when searching for one to marry, find the one who will be able to feed you."

As the years passed, *Ulu* came to play a significant, nonfood role in daily life. Hawaiians used the wood for many everyday items such as parts for canoes, buildings, furniture, and surfboards. Although the branches were somewhat brittle, the wood itself was lightweight and useful for items such as *poi* boards and drums. The inner bark could be made into the pounded *tapa* cloth, although it was not as desirable as that made from the paper mulberry tree. When the fruit is cut from the tree, it releases a sticky sap used as medicine to relieve diarrhea. The sap was painted on poles as birdlime to attract and trap birds for their colorful feathers. Afterward, the birds were released and the feathers used in ceremonial garments. The rough leaves were often used for the final polishing of bowls and the nuts used in leis. Clearly, the Hawaiian people would need to determine the best growing conditions for a plant that was so predominant and central to their society. As a symbol of this cultivation and to honor the survival of the Hawaiian people, the shape of the breadfruit leaf is found on many special objects throughout the country even today.

The Breadfruit Tree Offers Much to the Land on Which It Grows

Old groves of breadfruit trees are often found at elevation levels below 1,000 feet, planted there by Polynesians as they migrated throughout the tropics. They will grow and fruit, however, year-round, from sea level to over 5,000 feet. They grow best in well-drained, fertile soil but are highly adaptable. Tall, with smooth gray-green bark, the breadfruit tree forms a canopy of long branches covered in large, distinctively shaped leaves. The bright green leaves can be up to three feet long, ruffled, deeply lobed, and leathery. It is common practice to plant one or two trees in a backyard or on a small farm. The breadfruit is an attractive tree, offering shade and food.

Large plantations grow the trees at approximately 25 per acre. Seedless breadfruit are easily propagated by planting sections of root that have sprouted a new shoot or by grafting sections on to *Artocarpus camansi*, the seeded breadfruit, which is almost always started from seed. In general, the cultivated variety is seedless while the wild variety has seeds. The seeds themselves cannot be saved since they germinate immediately or lose viability within a few weeks. They are, however, edible. They can be roasted and taste similar to chestnuts. All parts of the breadfruit, the stems, the leaves, and the unripe fruit, contain a gummy, latex-like sap. The fruit is considered mature enough to pick when drops of the latex sap can be seen on its surface. Breadfruit begins producing in 5 years and is productive for 50 years.

The mature breadfruit tree can produce 200 to 700 fruits per year since it is in season almost continuously. One to three fruits grow at the end of each branch. They have a circular or ellipsoid shape that is actually a syncarp, or compound form, made up of hundreds of small fruits arranged around a core. The results of this can be seen in the thin rind, patterned with a repeating four- to six-faced structure left over from each flower. Depending on the cultivar, the rind may be smooth, rough with a sandpaper-like quality, or prickly, the result of a small spine at the center of each repeating structure. When unripe, the fruit flesh has a starchy texture similar to potato and tastes similar to fresh bread, giving the fruit its name. As it ripens, however, the starch converts to sugar, resulting in a sweet, pulpy consistency. The color of the rind varies with the cultivar, but in general it is green at first, changing to yellowish-brown when ripe. Each weighs around 10 pounds. Breadfruit is usually harvested while it is still firm, two to three days before ripening. Otherwise, the fruit tends to fall from the tree, smashing on the ground.

Eating Preference for Breadfruit Varies among Cultures

It is not surprising that there are as many different ways to enjoy breadfruit as there are countries that grow it. Most breadfruit is not eaten raw because it can have a purgative effect, although there are some cultivars that do not pose this problem. The underripe breadfruit, like other starchy vegetables and fruits such as bananas and plantains, can be steamed, boiled, or roasted. Roasting breadfruit in the Pacific Islands traditionally utilizes a buried oven with hot rocks. Breadfruit is sometimes stuffed with a coconut or mixed with sugar prior to roasting. People of Malaysia often peel the underripe fruit, slice it, roll it in sugar, and fry it. Alternatively, in Hawaii and the Bahamas the green fruit might be chopped with other vegetables, simmered with water until thickened, and made into chowder with the addition of butter, milk, and salted pork.

The ripe breadfruit is considerably sweeter and is often steamed and baked similar to recipes for other fruit. When the pulp is mixed with coconut milk and sugar, it can be made into a pudding or an even more elaborate dessert with the addition of eggs, butter, and flour. People of some countries make candied or pickled breadfruit.

Some unusual or old ways of preparing breadfruit are dependent on the time given to ferment. In Micronesia, the fruit might be soaked in the ocean for hours while being trampled, drained, and buried in leaf-lined boxes for months while the mass ferments. In Samoa, the buried fruits might be left to ferment in pits, covered with leaves and rocks for years, forming a pasty mass known as *masi*. This is eventually dug up, mixed with coconut cream, and baked for hours; it is considered a delicacy.

An adaptable food, breadfruit has also been boiled, pounded, and kneaded into *poi* and eaten as is, or mixed with *poi* made from taro to increase the overall food value. Some cultures partially cook the fruit and then dry it for hours, forming slices or loaves that can be stored. Even "fruit leather" can be made from drying the pulp spread out thinly in the sun and then wrapped in leaves. Nutritionally, breadfruit in any form provides energy in the form of carbohydrates and some protein and fat. It is a great source of dietary fiber, calcium, potassium, and magnesium. Also beneficial are small amounts of thiamin, riboflavin, niacin, and iron.

Diseases and Pests Can Affect Breadfruit

Breadfruit trees are subject to many plant diseases and pests common to the tropics. Before the young trees are planted, the site is prepared by setting fires in the troughs in order to sterilize the soil. The roots are protected from grubs by the addition of insecticides. Once the trees are mature and producing, ants may infest branches that have died back after fruit has been harvested. Ants are also attracted to overripe fruit. Keeping the area around the tree free of fallen ripe fruit and broken branches is a good strategy. Other pests, such as soft-scales and mealybug infestation, require treatment or the health of the tree may diminish. One problem is fungal disease. Depending on the species of fungus, there may be fruit rot or root rot, there may be wilting leaves, branches may die back, or entire trees may succumb to the infection. Farmers have various fungicides available to them but good farming practice can also make a difference.

Breadfruit Symbolizes the Lush Growth and Abundance of the Tropics

The breadfruit tree deserves its name and reputation for providing "bread for the hungry." Native people recognized its significance from early on, spreading the plant from country to country and cultivating it to grow optimally in each new environment. The fruit itself has provided food for many, each community putting its own twist on breadfruit preparation, both sweet and savory. They were resourceful enough to recognize the usefulness of other parts of the plant also, ranging from feeding livestock to making caulking glue for canoes, from medicines to cloth. Modern people are not as dependent on all components of the tree, although undoubtedly there are those who still appreciate and utilize them. The fruit, however, is still recognized for what it offers as a valuable food item, both for people in the southern countries, who still consider breadfruit a staple and for people in the north for which breadfruit is gourmet.

Gwendolyn Vesenka

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Brier

Brier is the common name for a widely distributed, yet unrelated, group of thorn-producing, thicket-forming plants, including varieties of the rose genus *Rosa*, which belongs to the rose family Roseaceae, and *Smilax* of the family Smilacaceae. The brier-rose is related to the horticultural rose. Brier is the folk name for the wild rose, a plant of economic and nutritional value, which has a rich cultural history. The common brier-rose is the dog-rose, *Rosa canina*, which gained its name from the ancient belief that it could cure those infected by the bite of a wild dog. *Rosa canina* is a hedgerow rose that forms many thorny branchlets from older stems and produces fragrant white or pale pink flowers of up to five petals with yellow stamens. The flowers are followed by distinctive large, plump, orange to red hips. This brier-rose is robust and in the past has been used by rose growers to provide the rootstock on which to graft hybrid roses. The brier-rose itself may be raised from seed or propagated from semiripe hardwood cuttings. *Rosa rubinginosa*, known as the sweet-brier or englantine, is also prized for its pink flowers and round hips. *Rosa rubinginosa* also produces fragrant leaves. The hips of both *Rosa canina* and *Rosa rubinginosa* are packed with a multitude of small seeds that are edible and nutritionally very rich. The seeds are an extremely good source of vitamins C and E. Although sour to the taste, when mixed with sugar and cooked; the hips can be used to make syrups and jams. The rich vitamin content of the hips has resulted in brier-rose hips being prepared as waters, liniments, poultices, teas, and brandy to treat a range of conditions from respiratory infections, stomach disorders, and joint pain to boils and syphilis. Many references have been made to the brier-rose in literature and art, one of the most striking of which is the *Briar Rose* series of paintings by the English artist Sir Edward Burne-Jones (1833–1898). The paintings are based on the fairy tale "Sleeping Beauty" and show a prince battling through a forest of wild roses to reach a slumbering maiden.

The Genus *Rubus*

The genus *Rubus* is a diverse group consisting of various species and hybrids and 12 subgenera, many of which have hundreds of species. This variety is reflected in the distribution of the genus, which reaches from the Arctic with the Arctic cloudberry, *Rubus chamaemorus*, to the tropics where the Mysore raspberry, *Rubus niveus*, is grown. The plants of the genus include both evergreen and deciduous shrubs, which are most commonly herbaceous perennials and are grown as ornamental plants or as food crops. The genus displays simple leaves that can be pinnate, palmate, or tennate and flowers held singularly or in racemes or panicles. The hypanthium—that is, the part of flower where the petals, sepals, and stamen are fused together, is flat. The nectar-producing flowers of the genus *Rubus* attract bees, are white or pink, and display numerous carpels and stamens. While the flowers of the genus are attractive, the genus is rarely grown for flowers alone. *Rubus spectabilis*, the salmonberry, is an exception for the species produces eye-catching pink flowers and large fruit and so is included in the garden as an ornamental shrub.

However, plants of the genus are grown principally for their fruit, which consists of many single-seeded drupes. Notable species of *Rubus* cultivated for their edible fruit include the raspberry, *Rubus idaeus*, and the blackberry, sometimes referred to as *Rubus eubatus*. Important edible hybrids of the raspberry and blackberry include the loganberry, the boysenberry, and the tayberry. Like the brier-rose, plants of the *Rubus* genus have many uses in traditional medicines. *Rubus coreanus* and *Rubus hirsutus* are used as medicine in China, while *Rubus ursinus* was eaten by Native Americans to treat swellings and sores.

The Genus *Smilax*

Smilax is a genus of aggressive, evergreen or semievergreen, climbing vines equipped with tendrils and renowned for its many thorns. Classical myth tells that the youth Crocus fell in love with the shepherdess Smilax. Unable to wed, the couple prayed to the goddess Flora who transformed the pair into flowers. As plants, Smilax's tendrils allowed her to embrace Crocus. Smilax grows worldwide in tropical, semitropical, and temperate areas, though the exact number of species has yet to be determined as, except for leaf variations, many species appear very similar. Smilax is commonly called catbrier, greenbrier, or sarsaparilla, although the common greenbrier is botanically *Smilax rotundifolia* and the catbrier *Smilax auriculata*. However, both the greenbrier and catbrier are also listed as *Smilax* *bona-nox*, despite the fact that the berries of *Smilax auriculata* deepen from red to purple, the berries of *Smilax Rotundifolia* are blue-black, and the berries of *Smilax bona-nox* are purely black.

Smilax is often considered a weed. However, some species are cultivated as ornamentals for their attractive fruits, others as a food source or for their medicinal qualities. Sarsaparilla, alone or with sassafras root, is used to make root beer and has a long tradition of use in homeopathic medicine. For instance, sarsaparilla has been used to treat disorders including syphilis, skin infections, and dropsy. Sarsaparilla is thought by some to balance hormones, and, as sarsaparilla may boost circulation in the joints, it may also be used to ease gout and rheumatism.

Victoria Williams

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Broccoli

A cole crop, broccoli (*Brassica oleracea* ssp. *iltalica*) is of two types. Calabrese yields a single large head. According to one gardener it usually does not need fertilizer. The gardener may plant calabrese between mid-spring and early summer for a summer harvest. Calabrese may also be planted in autumn for harvest next spring. In this case, calabrese must overwinter in a cold frame or greenhouse. Seedlings are unsuitable for transplanting, though the practice apparently continues. Calabrese seeds should be planted three-quarters of an inch deep and one foot apart. Calabrese is grown on Long Island, in western New York, Texas, and the mountains of Colorado, and on the coasts of California and Washington. In addition to these areas, the second type, sprouting broccoli, is grown in the South.

Broccoli (Kartos/Dreamstime.com)

Sprouting broccoli yields several small florets rather than a single head. A late maturer, sprouting broccoli yields florets in winter and the next spring. Sprouting broccoli should be planted in spring. Taking up more room than calabrese, sprouting broccoli plants should be spread two feet apart. When densely planted, broccoli forms small heads. Densely spaced plants produce few side shoots and leaves, requiring less trimming before sale. Sprouting broccoli is hardy enough to overwinter well. The genus *Brassica* derives from the Italian *brocco*, meaning "shoot." Broccoli is known as Italian broccoli or Italian calabrese from the district in southern Italy, Calabria, where it is grown. Broccoli is related to cabbage, Brussels sprouts, cauliflower, and kale. They are all cruciferous vegetables and may provide some lowering of the risk of cancer.

Origin, History, and Cultivation

Broccoli may trace its lineage to a wild cabbage that grew along the coast of Europe. One authority places the origin of broccoli along the coast and islands of the Mediterranean Sea, spreading thereafter as far north as Scotland. This progenitor was a perennial herb. Because the proto-broccoli was bitter, humans selected plants low in glucosinolates, the chemicals that impart bitterness to the plants. The first European text to mention broccoli dates to the 17th century, making it a recent domesticate. About 1925, Italian immigrants introduced broccoli to the United States. The United States grows twice as much broccoli as cauliflower.

California grows most of the crop, which is harvested in the southern Imperial Valley in autumn and winter and north in Salinas in summer. Where the climate is hot, broccoli, which bolts in summer, is harvested in spring and autumn. Broccoli prefers temperatures below 68°F. In addition to the domestic supply, the United States imports broccoli from Mexico. A recent cultigen, broccoli has none of the history of corn, potatoes, soybeans, wheat, sugarcane, and other ancient crops.

Broccoli needs exposure to full sun. The gardener may plant seeds indoors five to six weeks before the last frost. Seedlings may be transplanted in the field three weeks before the last frost because broccoli tolerates light frost. One authority recommends that seedlings be transplanted in the field when four to seven weeks old. Seeds germinate in 3 to 10 days and need temperatures between 70°F and 80°F to germinate. From the date of transplantation in the field, broccoli matures in 55 to 85 days.

Broccoli requires fertile, well-drained soil. It should not be loose but instead packed down to anchor roots. Some gardeners stake broccoli to prevent lodging. Because continuous cultivation may exhaust the soil, broccoli should not be planted in the same plot year after year. The gardener may add a fertilizer with a ratio of 5:10:10 of nitrogen to phosphorus to potassium to the soil. Wood ashes are a suitable amendment because they contain phosphorus. The gardener may apply 53 to 70 pounds of nitrogen per acre at the time of planting with one to three additional dressings during the growing season of 35 pounds of nitrogen per acre. Broccoli benefits from the application of 176 pounds of phosphorus and 176 pounds of potassium per acre. Despite its appetite, broccoli is less ravenous in feeding on soil nutrients than cauliflower. One authority recommends that the soil pH be at least 6.8. Another puts the figure between 6.5 and 7.5. The gardener should not plant broccoli on land where cabbage, kale, or cauliflower has been grown. Broccoli should follow a legume to benefit from residual nitrogen in the soil. In addition to fertilizer, broccoli benefits from the addition of organic matter to the soil. A thirsty crop, broccoli should be watered frequently. Irrigation is desirable on light soil. The gardener may mulch the soil to retain moisture. Broccoli tolerates saline soil.

Broccoli heads are tiny, closely spaced flower buds that must be harvested when large but before the flowers mature. Broccoli spaced at wide intervals is ready to harvest before densely planted broccoli. The central head matures first. When it is harvested, lateral shoots mature. Because most broccoli does not mature uniformly, as many as 10 pickings may be necessary. In some areas, the harvest spreads over two months. Broccoli is typically harvested with six inches of stem.

Consumption, Nutrition, and Preparation

Since the 1970s the consumption of broccoli has increased in North America and Europe. Wherever the consumption of cabbage has decreased, that of broccoli has risen. One hundred grams of fresh broccoli have 3.3 grams of protein, 0.3 gram of fat, 4.5 grams of carbohydrates, 0.9 gram of fiber, 118 milligrams of vitamin C, 2.1 milligrams of beta carotene, 0.1 milligram of thiamine, 0.2 milligram of riboflavin, 0.1 milligram of niacin, 0.3 to 0.7 milligram of pantothenic acid, 0.03 to 0.08 milligram of folic acid, 0.1 to 0.3 milligram of vitamin B6, 130 to 180 milligrams of calcium, 76 to 90 milligrams of phosphorus, 1.3 milligrams of iron, 50 milligrams of sodium, 410 to 440 milligrams of potassium, 260 to 300 milligrams of sulfur100 milligrams of chlorine, and 20 to 30 milligrams of magnesium. Cooking reduces the content of vitamin C to 29 to 109 milligrams, of beta-carotene to 0.02 milligram, of thiamine to 0.03 to 0.09 milligram, of riboflavin to 0.06 to 0.24 milligram, and of niacin to 0.3 to 0.8 milligram.

Broccoli buds have more vitamin C than do stems. A light frost does not affect the content of vitamin C, but severe frost diminishes it. Broccoli exposed to full sun develops the most vitamin C. Soil deficiency in molybdenum yields broccoli with only half the vitamin C as broccoli raised on molybdenum abundant soil. Broccoli may lose more than half its vitamin C when stored only a few days. Storage at low temperature retards the loss of vitamin C. Buds lose more vitamin C than stems do when frozen or cooked. Cooked in one-quarter cup of water for 10 minutes, broccoli loses about 4 percent of its calcium, 31 percent iron, 6 percent magnesium, 7 percent potassium, 21 percent vitamin C, 11 percent riboflavin, 9 percent niacin, 14 percent pantothenic acid, 26 percent folic acid, and 6 percent vitamin B6. A reduction in the amount of water used in cooking diminishes the loss of vitamins and minerals. When cooked at least one hour, broccoli loses 60–80 percent of its vitamins. Cooked broccoli that is not consumed promptly loses 10–25 percent of its vitamin C. Young broccoli has more beta-carotene than old plants. Stems have little beta-carotene. Frozen broccoli stored more than one year loses 40 percent of its beta-carotene. Salted broccoli loses more than 50 percent of its beta-carotene in three months. Riboflavin content is greatest in broccoli leaves. One scientist recommends that broccoli be cooked one-half to 3 minutes in a pressure cooker, boiled 10 to 20 minutes and steamed 15 to 20 minutes. Broccoli should be cooked until tender. Overcooked broccoli has an unpleasant taste caused by the buildup of sulfur compounds.

Cultivars

Old varieties decline in yield when densely spaced whereas new cultivars may be planted at a density of 100 plants per square yard without diminution in yield. A new cultivar, Atlantic tolerates dense spacing. A dwarf, Atlantic yields a compact head. An early variety, it is suitable for autumn harvest in the northeastern United States. Another early cultivar, Coastal is cultivated in the West. A short, compact plant, Coastal yields uniform heads. Yet another early variety, DeCicco yields abundantly, producing a large number of lateral shoots. DeCicco freezes well.

Another early variety, Spartan Early yields uniform heads in spring and summer. Ideal for freezing, Green Sprouting Medium is a midseason variety grown on the Pacific coast and in the South. It matures too late to be grown in the northeastern United States. Green Sprouting Medium is a large, vigorous plant with a large, compact head. As its name suggests, Green Sprouting Late is a long-season crop grown in California. Grown in the northeastern United States, Waltham 29 has a large, blue green head. Waltham 29 is a large plant that produces heads suitable for freezing. Tolerating hot weather, Green Comet matures 40 days after transplanting.

Christopher Cumo

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Brussels Sprouts

A cole crop, Brussels sprouts (*Brassica oleracea*) are related to cabbage, broccoli, cauliflower, and kale. They are all cruciferous vegetables and have been found to possibly lower the risk of cancer. So strong is the resemblance to cabbage that one gardener likens Brussels sprouts to miniature cabbages. Brussels sprouts contain the vitamins folic acid, K, C, and other antioxidants and fiber.

Origin and History

The progenitor of Brussels sprouts was a perennial herb native to the Mediterranean coast and islands. There it thrived in hot summers and mild winters. From the Atlantic coast of the Mediterranean it migrated north as far as Scotland. During this migration, it adapted to cool summers, and all but a few cultivars do better in cool than hot weather. The exceptions flower without exposure to cold weather, a trait they must share with their warm-adapted ancestor. Early specimens were bitter, leading humans to select plants for the absence of glucosinolates, chemicals that impart bitter flavor. These selections gained adherents in

Belgium, from where they derived the name Brussels sprouts. Their domestication in the 18th century makes them a recent cultigen with none of the history of corn, potatoes, soybeans, sugarcane, and other ancient crops. Only in the 19th century did farmers in northern Europe widely cultivate Brussels sprouts. The coast of the Netherlands, Belgium, Spain, and the United Kingdom provides ideal conditions for Brussels sprouts. Even then they were a minor crop. The United Kingdom is Europe's leading producer, though the harvest totals only 3 percent of the vegetable harvest. In the United States, California is the leading producer with most acreage on the coast between Salinas and Santa Cruz.

Attributes and Cultivation

Brussels sprouts need exposure to full sun. Once seedlings raised indoors, a popular practice among gardeners, are transplanted to the field they require an average of 90 to 100 days to mature. Early varieties mature in 60 to 70 days, midseason cultivars are ready to harvest between 72 and 85 days, and winter sprouts may be picked in 105 days. Plants grow best between 60°F and 70°F. Brussels sprouts plants respond to cold by thickening their stem and enlarging the axillary buds, known as sprouts. These changes occur after a plant has formed roughly 30 leaves. These buds form at the axil of the leaves. The number of buds correlates to the number of nodes that a plant produces. A plant forms nodes until June, so its carrying capacity reaches its maximum then. Roughly half the nodes produce sprouts large enough to harvest, and a plant produces these by mid-July. The other nodes yield sprouts too small to harvest or no sprouts. After September, a plant produces no new nodes.

The growing season must be long if the gardener or farmer hopes to harvest a sizable crop. Because a Brussels sprouts plant is heavy and tall, it may lodge, particularly in windy conditions. For this reason, the farmer should plant seedlings in soil that, if not compact, is firm to allow roots to anchor the plant. Frequent watering causes roots to enlarge, reducing the risk of lodging. As a precaution, some growers stake plants to prevent lodging. Densely spaced plants are susceptible to lodging and disease. Plant size and the number of sprouts decrease. Dense planting, however, confers the benefit of uniform sprouts that may be harvested in a single picking. Varieties meant to be frozen are also uniform and permit one harvest. Widely spaced plants produce large sprouts at the bottom of the stem, with size decreasing at the top. The bottom sprouts ripen first with subsequent sprouts ripening as one moves up the stem. These sprouts may need to be harvested four or five times to ensure that only ripe sprouts are picked at a given time. To encourage sprouts to ripen at the same time, one may remove the top six inches of the plant, a practice known as topping or stopping depending on whom the reader consults. Topping is done one to two months before the harvest, when sprouts are about one-half of an inch in diameter, half their mature size. A plant should be topped, if at all, late in the season to permit the largest number of sprouts to form. Where plants are spaced densely one may top them later than where they are planted at wide intervals. Topping is more common with early than late varieties. Plants may be topped after the first or second picking. Thereafter only one more harvest is necessary. Topping often occurs in September or October. Topping may be done by hand. In the past the farmer used the chemical succinic acid-2,2-dimethylhydrazide to top a plant, but regulators have banned its use. Other chemicals have been tried—gibberellic acid, ethrel, and carbamates—but these are ineffective. One may prod a plant into producing more sprouts by removing the lower branches. The plant will respond by growing taller and yielding more sprouts. Sprouts may be harvested at a leisurely pace because, left on the stem, they remain ripe several months. The only danger is that overripe sprouts may split. One may harvest sprouts by uprooting a plant, allowing them to cling to the stem. Stored in this manner, sprouts may remain ripe as long as three months. Otherwise, one should pick sprouts from the stem, proceeding up the stem where they ripen sequentially or all at once where they ripen uniformly. Brussels sprouts remain in good condition so long that they may be picked from late July to November.

A Brussels sprout is a nonflowering part of the plant. From the point of view of economics, a flowering plant is of little value unless the grower needs seeds. In fact the production of flowers diminishes the quality of the crop. To yield seeds a plant must be exposed to temperatures between 39°F and 50°F for 60 to 80 days, though as we have seen some varieties do not need cold to flower. Once a plant has yielded seeds, they may be planted indoors to lengthen the growing season, transplanting in spring after the last frost. Seeds germinate in 3 to 10 days. Temperatures must be between 68°F and 86°F for germination. Seedlings should be four or five weeks old before being transplanted outdoors. Seeds may also be sown outdoors one-half to three-quarters of an inch deep. The gardener should plant dwarfs 18 inches apart for a yield of small, uniform sprouts. Large varieties should be spread at least two feet apart. Brussels sprouts may be planted in early or mid-spring for a harvest in late fall and winter. The frosts of autumn and winter improve the flavor of sprouts. In the United Kingdom, growers may plant Brussels sprouts in August or early September, allowing plants to overwinter in the field. Alternatively, sprouts may be planted between February and April for harvest in late July. Another possibility is a planting in May or early June, though the later the planting the greater the risk of low yield.

Before planting, the grower may apply well-rotted manure of a fertilizer in a ratio of 5:10:10 of nitrogen to phosphorus to potassium. Because Brussels sprouts are a heavy feeder of nutrients and water, the grower should enrich the soil with monthly feedings of two teaspoons of fertilizer, compost, or manure per plant. The soil should be mulched to retain moisture. As a rule, early-maturing sprouts are grown on light soil, which may need irrigation, whereas late sprouts are grown on heavy soil. Brussels sprouts tolerate saline soil, though plants will be short. Brussels sprouts tolerate temperatures as low as 14°F. Areas with brief autumns or autumns with high temperatures produce poor sprouts.

The soil pH should be above 6.8 or between 6 and 7.5 depending on who one reads. At low pH, manganese reaches toxic levels and molybdenum is unavailable for absorption. Too much nitrogen reduces the quality of sprouts. Brussels sprouts need 88 to 264 pounds of nitrogen per acre. The farmer may divide nitrogen into three applications with the first at planting, the second some weeks later, and the third after the first or second picking. Brussels sprouts should receive 44 to 132 pounds of phosphorus per acre and more than 176 pounds of potassium per acre with a second application of phosphorus and potassium in autumn.

The variety Purple Red Bull, named for its color, has maroon leaves and dark red sprouts that retain their color during cooking. Sprouts are sweet, though plants are not as vigorous as green varieties. Oliver, a dwarf, grows to 30 inches. Sprouts are small and bright green. Jade Cross E Hybrid yields large, firm, blue-green sprouts for eating fresh or freezing.

After the harvest Brussels sprouts are trimmed for sale, an action that discards as much as 30 percent of a sprout. One writer urges the consumer to buy the smallest sprouts because they are sweetest and require the least cooking. Sprouts may be boiled or steamed but only for seven minutes. Longer cooking causes Brussels sprouts to emit hydrogen sulfide, which has an unpleasant odor. Brussels sprouts produce two times more hydrogen sulfide than broccoli.

Christopher Cumo

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Buckwheat

Buckwheat is the common name of several plants in the Polygonaceae family. The genera of this family include *Fagopyrum*, *Erigonum*, and *Fallopia*. *Erigonum* and *Fallopia* are referred to as "wild buckwheat," whereas *Fagopyrum* is "common buckwheat." Despite the name, common buckwheat (*Fagopyrum esculentum* and

Fagopyrum sagittatum in North America) is not related to wheat (*Triticum*), nor is it a cereal or a grass. It instead is a seed that is considered a pseudocereal. It is used in much the same way as cereals, including grinding the seeds into flour, but it is a broadleaf plant unrelated to cereal plants. *Eriogonum* is a common chaparral that grows throughout the western United States. It is especially common in California.

Description

Common buckwheat (*Fagopyrum*), which accounts for 90 percent of the world's production of buckwheat, is a fast-growing, broad-leafed plant that typically begins to produce seed in 6 weeks and ripens at 10 to 11 weeks. Common buckwheat plants grow to about 30 to 50 inches in height. They contain five-petaled flowers, which appear in 25 to 30 days. Plants have a fibrous superficial root and deep taproots.

The optimal climate for growing buckwheat is moist and cool, but it is sensitive to frost, which can kill the crop. If temperatures become too high and the air too dry, flowers may blast forth, preventing seed formation. Buckwheat can grow far north and at various altitudes and enjoys a variety of soil types. It grows well in infertile, poorly drained soils as long as the climate is moist and cool. Germination occurs at temperatures of 45°F to 105°F. One cup of buckwheat seeds, about 170 grams, contains only 154 calories, 34 percent of the recommended daily allowance of manganese, 25 percent of the amino acid tryptophan, 21.4 percent of magnesium, 18.1 percent of fiber, and 12.5 percent of copper. Buckwheat lowers insulin and glucose in the body and may protect against diabetes.

History

Buckwheat has been grown in North America since colonial times. It was a common crop on farms of the northeast and north-central states. Peak U.S. production occurred in the mid-19th century, when the crop was used primarily as livestock feed and in the production of flour. One century later the crop was grown on only 50,000 acres of U.S. land, with the leading producers being New York and Pennsylvania in the East and Michigan, Minnesota, Wisconsin, and North Dakota in the upper Midwest. Today, Canada grows more buckwheat than the United States. Buckwheat gained a resurgence in popularity in the mid-1970s in step with the rising demand for commercially prepared breakfast cereals. Buckwheat was also shipped to Japan at this time to be used in the production of buckwheat noodles. The upsurge in buckwheat's popularity coincided with the release of statistics compiled by the U.S. Department of Agriculture's Agricultural Research Service that claimed that the amino acid composition in buckwheat made it superior in nutritional value to all types of cereal, including wheat and oats. This information boosted sales of the product. At the beginning of the 20th century, Russia was the world's leader in buckwheat production, where 6.5 million acres of land was devoted to growing the crop. China took over as the world's production leader until 2005, when Russia again resumed the title.

Buckwheat Fit for Human and Animal Consumption

Prior to the 1970s, about 75 percent of buckwheat was turned into livestock and poultry feed. Today, the predominant use of buckwheat seeds is to feed humans. It is mainly turned into flour. One hundred pounds of dry buckwheat yield 60 to 75 pounds of flour. This flour is commonly marketed in the form of pancake mixes, which is often a combination of buckwheat and other grains such as oats, corn, rice, and wheat. Some of the seeds are sold as groats, the part of the seed that remains after the hulls are removed from the kernels. The groats are turned into breakfast foods and porridge or are used to thicken soups, gravies, and dressings. The shelf life of buckwheat and products made from it short, especially in summer due to its high fat content. Buckwheat and its by-products should be eaten promptly to prevent the food from becoming rancid.

When ground and mixed with grains, such as corn, oats, or barley, buckwheat is a good source of nutrition for livestock. However, when offered as the sole grain, buckwheat has been known to cause skin rashes in animals and humans. These rashes appear only in the hide covered with white hair or fur, and they are evident only when the animal is exposed to light. Buckwheat hulls are the catalyst for the rash.

Buckwheat middlings are considered a good source of feed for cattle due to their richness in protein, fat, and minerals, and poultry feed is often made from tartary buckwheat, also known as golden buckwheat (*Fagopyrum tataricum*). This grain has a smaller, rounder seed than common buckwheat, making it easier for poultry to eat and digest. For humans, tartary buckwheat is considered a good source in fighting what is sometimes termed the "three deadly highs": high blood pressure, high blood sugar, and high triglyceride levels. Buckwheat hulls have little or no nutritional value, although they do contain the majority of fiber of the seed. Hulls are used as soil mulch and as pillow stuffing. The seed itself is sold as an ingredient in birdseed mixes.

Along with buckwheat's value as a grain, it is also valuable when used in honey production. The blooming period of buckwheat's flowers is long and extends into September, when many other flowers and sources of nectar are limited. Honey from buckwheat is dark and strongly flavored. At one time in the northeastern United States, buckwheat honey was in high demand, so much so that demand exceeded supply. Today, however, buckwheat has declined as a crop and therefore as a source of honey.

Other Uses of Buckwheat

Buckwheat is sometimes used as a smother crop, to control weeds. Its rapid growth and dense leaf canopy provide shade for the soil and inhibit weed growth.

Used in this way, buckwheat has been known to eradicate such weeds as Canada thistle, quackgrass, sowthistle, creeping jenny, leafy spurge, and other perennial grasses. Buckwheat is also used as a green manure crop. It can produce as much as three tons of dry matter per acre in just six to eight weeks. The plant material decays rapidly and soon provides nitrogen and other minerals for the primary crop.

Rosemarie Boucher Leenerts

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Butterbur

With its magnificent leaves, pink butterbur draws attention where it is found growing in parks and gardens. This perennial plant blooms early in the spring—in February and March—before its leaves come out, hence its local name Son before the Father in Scotland. The pink flowers are somewhat unusual in shape, with several inflorescences clustered on a stem that grows up to 15.75 inches long. For the most part, nowadays, butterbur serves as an ornamental plant in connection with ponds and watercourses. In earlier times, however, it was grown first and foremost for medicinal and ethnoveterinary purposes. It had a variety of other uses too for earlier generations, among other things on account of its extremely large round leaves. These have a diameter of 15.75 to 39.37 inches, and they grow on stout stems between 23.6 and 47.5 inches tall.

Butterbur is a common cultivated plant in many European countries. It also grows naturalized in much of Europe, as well as in many parts of the eastern United States. It is considered an invasive plant and spreads mainly by vegetative reproduction from fragments of the rhizome Not everyone has viewed it with favor, among other things because its roots spread widely and are almost impossible to eradicate. Its appearance and its weed-like traits have earned it some less-than-flattering names, such as Dog Rhubarb and Gipsy's Rhubarb in the English county of Somerset, and Snake's Rhubarb in Dorset.

Origin and Cultivation

Butterbur originated, botanists believe, in Southern and Central Europe, in western Siberia, and in the Caucasus Mountains. Several writers of antiquity cited its value as a medicinal herb. It has probably been cultivated at least since the Middle Ages.

Male plants are dominating in many places like Scandinavia and the United Kingdom. These are thought to be clones from deliberately planted specimens, which are supposed to have been introduced in order to provide nectar for domestic bees. Because of the early flowering, many butterbur plants were sown near beehives in antiquity. Because of its large leaves and great capacity to spread, cultivators kept it separate from herbs and vegetables. In southern Sweden, it was often grown close to the village pond. This seems to have been the case in many parts of Europe.

Medicinal Plant

The rhizomes of the plant contains two active ingredients: petasin and isopetasin. Greek physician Dioscorides (ca. 40–90 CE) stressed the plant's medicinal value. If ground up and then smeared on the skin, for example, it could help to ease malignancies and other diseases. Medieval physicians prescribed it for gout.

In olden times, butterbur was known as Pestilence Wort: in German *Pestwurtz*, in Danish *Pestilensrod*, in Swedish *Pestrot*, in Estonian *katkujuur*. The common assumption, accordingly, is that it was used against plague. Although this is a widespread belief, the first report to this effect is found only in a work from 1530, by the German physician Hieronymus Bock. The claim is then repeated in later handbooks of medicine. According to British herbalist John Gerard's *Herball* (1597), for instance, the dried powdered root of butterbur, mixed with wine, furnished a superior medicine against the plague and pestilent fevers.

Some European pharmacopeias commended the use of the highly aromatic rootstock for diaphoretic purposes in connection with chest diseases, fevers, gout, and epilepsy and for external application on boils and skin ulcers. Manuals on the gathering of medicinal herbs instructed that the root was to be harvested late in autumn or early in spring. Butterbur also figured in traditional medicine in many areas. Sources from Central Europe cite its use as an expectorant and for the relief of insect stings. In England, a cream made from it was applied to skin blemishes and sores.

More recently, experiments have shown that the rhizomes contain ingredients that can help reduce the frequency and severity of migraine symptoms. Extracts of the root are available within alternative medicine for this purpose, while extract of butterbur leaf is said to work as an antihistamine in reducing allergy symptoms. German companies are therefore buying roots and leaves from various parts of Europe in order to produce herbal medicine.

For Treating Animal Diseases

Prior to the turn of the 20th century, farmers in Northern Europe appear to have used butterbur mainly for ethnoveterinary purposes. Thanks to a study by the amateur botanist Gösta Ilien, we now have detailed documentation about the role played by butterbur in popular botany in southern Sweden during preindustrial times. Ilien found that, in many cases, it was in connection with pig breeding that butterbur was grown on Scanian farmsteads. It was thus in the vicinity of the hog pen that it often grew most profusely. Many of the plantings could be dated to the 18th and 19th centuries. Farmers used the leaves, according to Ilien's informants, for prophylactic purposes in connection with pig raising. They cut up the leaves and stems, blended in some grits, and fed the resulting mixture to the pigs. Other sources explained that the farmers boiled the roots, and used the resulting solution to treat erysipelas, a contagious and malignant bacterial infection that is found among pigs, and that is caused by the bacterium *Erysipelothrix rhusiopathiae*. The same use is also known from Denmark.

Finally, in many parts of Europe, the root was used to combat lung and liver diseases in horses.

For Use as a Fodder

Butterbur has also served as a livestock fodder, particularly during spring. Farmers in Northern Europe believed it encouraged the production of milk, and so planted it in horse and cattle pastures. It probably served as an important fodder in an era when the underfeeding of stabled livestock during winter was common. As late as in the 1940s, in fact, farmers in some parts of southern Sweden continued to use the leaves as a stable feed for their cows. According to reports, the effect was a rapid increase in the milk yield and without any alteration in the flavor of the milk.

The leaves were also used as a fodder for the pigs, to the satisfaction of the latter. Around midsummer, farmers in some parts of southern Sweden made hay by harvesting the leaves of the plant together with meadow grass. Butterbur has also served as a fodder elsewhere in Northern Europe. In some parts of Italy, its fresh leaves are still used as fodder for hens.

Butterbur can also be utilized as human food. In Turkey, the peasants still grind and boil the petioles, which are cooked like a vegetable meal.

Attributes

Many Europeans believed that butterbur conducts lightning. This is reflected in several folk names given to the plant: thunderdock in England, *tordenskræppe* in Denmark, and *tordönskräppa* in southern Sweden. It was observed in the late 19th century that household servants in Scania would place butterbur leaves in the eaves of buildings on Midsummer's Eve, in the hope of ensuring that lightning would not strike there. There are also reports that, even as late as the 19th century, village folk would plant butterbur in order to keep evil spirits away.

Furthermore, butterbur is not merely decorative, nor is it useful just as animal feed. In the 18th century, Swedish naturalist Carl Linnaeus noted that chickens found protection under the large leaves of this plant from rain and from birds of prey. Observers from a variety of countries found that free-running chickens, turkeys, domestic ducks, and the like sought protection under butterbur leaves when it rained. The name butterbur—recorded for the first time by Wilhelm Turner in the mid-1500s—comes from the use made of its leaves for wrapping bars of butter.

The leaves also served as a kind of toy. Reports from Scandinavia and the Balkans tell of children using them "as umbrellas." Indeed, butterbur has been known in some parts of the United Kingdom, in Somerset for example, as the umbrella plant. Gerard claimed in 1598 that the leaves were large enough "to keepe a man's head from raine, and from the heate of the sunne." In Catalan and Portuguese, butterbur is known as *sombrera* and *sombreiro* respectively, meaning "hat." Indeed, the Greek word that Dioscorides used for it was *petasides*, which derives from a kind of wide-brimmed hat known as a petasos.

Ingvar Svanberg

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Butterwort

A carnivorous plant, the butterwort is in the genus *Pinguicula*, Latin for "little greasy one." The name derives from the greasy texture of the leaves. Some people have likened this texture to the slipperiness of melted butter, a circumstance that gave rise to the name butterwort. Before scientists understood its carnivorous habit, the people of Northern Europe rubbed butterwort leaves on the wounds of cattle. This treatment was effective because butterwort leaves produce an antiseptic secretion. Others used the leaves to curdle goat's milk into cheese. Norwegians used the leaves to make a thick milk. One tradition hold that a girl who puts butterwort leaves beneath her pillow will dream of her future husband.

Carnivorous Habit

No one apparently appreciated that the butterwort was a carnivore until the 19th century. In the early 1870s, W. Marshall—his first name and occupation may be lost to history—noticed a butterwort whose leaves were covered with insects. He informed British naturalist Charles Darwin of this find. In 1875, Darwin amassed the evidence that the butterwort and several other species of plants were carnivores. Journalists and religious leaders mocked Darwin for this conclusion. Objections to the idea that plants may be carnivores go back at least to the 18th century, when Swedish naturalist Carl Linnaeus took up the crusade against this heresy.

For more than a century, the carnivorous habit of the butterwort has fascinated scientists. The leaves appear unremarkable to the casual observer, but close inspection reveals that glands cover them. Many of the glands support short hairs atop, which are globules of mucilage. Sunlight makes the mucilage sparkle, and this effect may attract insects. Moreover, the leaves emit an earthy aroma, which may attract insects. It is also possible that insects perceive the leaves as landing pads. Whatever the reason, an insect that alights on a leaf finds itself stuck in mucilage, which is an adhesive. The butterwort therefore functions as flypaper, though it has the capacity to digest insects whereas flypaper is a passive trap. As an insect struggles to free itself, it contacts other hairs and becomes entangled in a film of mucilage. An insect may struggle so violently that it loses a leg, but its efforts are usually futile. Covered in mucilage, an insect drowns or suffocates, though hours may elapse before death conquers the suffering arthropod.

As soon as an insect is caught, the sessile glands, which are inactive when a leaf is bereft of prey, begin to secrete digestive juices, which contain acids and enzymes and which liquefy the innards of an insect. The glands produce copious amounts of these juices, and they might run off a leaf but for the fact that the leaves of temperate species curl to prevent the loss of juices. Curiously, the leaves of tropical bladderworts do not move. In hours or at most days, the digestive juices accomplish their task. The sessile glands absorb the liquefied insect, leaving only the exoskeleton, which may remain adhered to the mucilage. The exoskeleton may break apart, or wind or rain may remove it. Because butterwort leaves are small, they trap tiny insects: gnats, springtails, and fruit flies. A springtail may succumb after contacting just two hairs on a leaf. Large, strong insects may break free, though butterworts have captured flies and craneflies. One specimen even captured a praying mantis.

Diversity of Species

Butterworts inhabit a range of ecosystems. They grow as far north as the Arctic Circle and may be found in North America, Central and South America, Europe, Asia, and Africa. Species native to the tropics produce flowers as striking as those of orchids and African violets. Flowering in spring, they yield one bloom per stalk. In the arid lands of Mexico, they grow alongside cacti. In parts of the Northern Hemisphere, they may be found with the sundew and pitcher plant. Tropical butterworts are most diverse in Mexico, Central America, and the Caribbean. More species of butterwort grow in Mexico than anywhere else. In the dry season, tropical butterworts are not carnivorous, producing leaves that do not capture insects. Some species grow at elevation, enduring chilly nights during winter and hot, wet summers. Flowering over several months, the tropical *Pinguicula morenesis* blooms twice per year, issuing forth pink or white flowers. The plant flowers in winter and spring and again in late summer. *Pinguicula esseriana*, despite its tropical habit, tolerates frost. *Pinguicula heterophylla* and *Pinguicula macrophylla* are dormant during the dry season. *Pinguicula filifolia*, native to western Cuba, grows in sandy soil near lagoons, yielding white, blue, purple, or lilac flowers. *Pinguicula albido*, *Pinguicula jackii*, and *Pinguicula lignicola* also inhabit Cuba. An epiphyte *Pinguicula lignicola* grows in trees and bushes. *Pinguicula cladophila* is native to Haiti.

Temperate butterworts survive cold winters by dying down to buds known as hibernacula, meaning "hibernate." They may lose their roots during winter, allowing flowing water to move them. The movement of temperate butterworts in this way may account for their diverse geography. Dormant in winter, temperate butterworts resume growth in spring. They flower in spring, yielding purple, violet, or white flowers. Growing in wet, acidic peat in North America and Europe, they may be found with ferns. Along with the pitcher plant, temperate butterworts inhabit rocky soil near the Great Lakes. Some temperate species grow in neutral or alkaline soil. They do well in full sunlight, though planted near grasses and ferns, the latter will shade them.

The temperate butterwort *Pinguicula vulgaris* is renowned as the species Darwin studied. It grows in North America, Europe, and Northern Asia. Preferring rocky soil, it grows near lakes in acidic or basic soil. *Pinguicula macraceras* inhabits the western United States, Canada, Japan, and Russia. One subspecies may be found with the *Darlingtonia* pitcher plant in the Pacific Northwest. *Pinguicula grandiflora* inhabits the hilly regions of Ireland, France, Switzerland, and Spain. *Pinguicula alpina* grows in the mountains of Europe and in Scandinavia and Scotland. The rare *Pinguicula remosa* is an indigene of northern Japan. Nearly extinct in the wild, only two colonies remain. Cultivation may be the only way of perpetuating this species. Perhaps because it is so rare, the Japanese have memorialized it on a postage stamp. *Pinguicula villosa* inhabits the Arctic regions of Asia, Northern Europe, and North America.

Some temperate species, dubbed "warm temperate butterworts" by one gardener, are accustomed to warm weather, surviving in the subtropics. They tolerate frost, but a hard freeze may kill them. Preferring wet, acidic soil, several of these species inhabit the American Southeast with the pitcher plant, the sundew, Venus's Fly Trap, and the bladderwort. A bog plant, *Pinguicula coerulea*, known as the violet butterwort, inhabits the southeastern United States from North Carolina to Florida. *Pinguicula primuliflora* and *Pinguicula plenifolia* grow from the Florida panhandle to Louisiana. Growing in wet peat or sphagnum, *Pinguicula primuliflora* inhabits land near streams and ponds. Native to the American South, *Pinguicula pumila* grows from the Carolinas south to Florida and west to Texas. *Pinguicula lusitanica* grows in wet peat in Britain, Spain, and northwestern Africa.

Cultivation

Temperate butterworts prefer a soil of two parts peat, one part sand, and one part perlite. Warm temperate species should be given a soil of equal parts peat and sand. Tropical butterworts like a mixture of sand, perlite, vermiculite, and peat. To these ingredients one may add dolomite, gypsum, lava rock, and pumice. Temperate and warm temperate plants may be potted with the pot placed in a saucer of water. In addition to this method of watering, the gardener should wet the soil by pouring a container of water on it. Cool water is best. Tropical butterworts should also receive water from a saucer and a container in summer and autumn, but they should have less water in winter. *Pinguicula gypsicola*, *Pinguicula heterophylla*, and *Pinguicula macrophylla* must have a dry soil in winter. Cuban species should be kept wet year-round with slightly less water in winter. All butterworts relish abundant sunshine. *Pinguicula morenensis* is among the most popular species in cultivation and may be grown by a sunny window, in a greenhouse, or in a terrarium. Warm-temperate butterworts do well in a greenhouse with or without heat. In cultivation, *Pinguicula lusitanica* may be found in greenhouses with or without heat, terrariums, a sunny window, or a bog garden outdoors. Most temperate plants do poorly indoors unless kept in a greenhouse. The gardener may feed indoor plants fruit flies, small ants, and dried insects. Butterworts bereft of insects may receive fertilizer. Temperate species may be sprayed periodically with dilute fertilizer. Tropical butterworts should be sprayed twice per month with fertilizer at one-quarter strength. The gardener should confine fertilizer to the leaves because it may discolor flowers.

Christopher Cumo

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C

Cabbage

A member of the Cruciferae family, cabbage is of two species, common cabbage (*Brassica oleracea*) and Chinese cabbage (*Brassica rapa* ssp. *pekinensis* and *Brassica rapa* ssp. *chinensis*). Common cabbage is of three types, white, savoy, and red. The word "cabbage" is *kappes* in German, *kappertjes* in Dutch, *cabut* in French, *apuccio* in Italian, *keposta* in Slavic, and *cabaiste* in Irish. A cole crop, which is any member of the Cruciferae family, cabbage is related to Brussels sprouts, broccoli, cauliflower, kale, and kohlrabi. Cabbage is the most widely grown cole crop.

Common Cabbage

Wild species of cabbage are native to the Mediterranean Basin, leading to the inference that humans may have first cultivated cabbage in this region. The ancient Egyptians and Hebrews did not cultivate cabbage, though the plant was known in classical Greece. In the fourth century BCE, Greek philosopher Aristotle and his pupil and botanist Theophrastus were familiar with cabbage. In the second century BCE, Roman agricultural writer Cato the Elder and first-century CE Roman agricultural writer Columella mentioned cabbage. Columella's contemporary, Roman encyclopedist Pliny the Elder, listed several varieties: Pompeii cabbage, Sabellian cabbage, Lacuturna cabbage, Tritian cabbage, Bruttioim cabbage, Cumae cabbage, and Le Riccia cabbage. The ancients grew cabbage primarily as a medicine. They believed the consumption of cabbage was useful to treat gout, diarrhea, colic, stomachache, headache, and curiously deafness. The ancients drank cabbage juice to counteract the effect of poison mushrooms and to cure hoarseness and hangover.

In the Middle Ages, cabbage spread from the Mediterranean Basin to Europe. In the ninth century Frankish king Charlemagne cultivated it in his garden. The Arabs were familiar with a type of cabbage that they called Spanish cabbage. The monks in Europe grew cabbage for their own sustenance. The fact that Europeans grew cabbage for food suggests that it was no longer primarily a medicine. Medieval peasants preferred white cabbage, though the herbals of the 16th century also mentioned savoy and red cabbage. The fact that people in the early modern era called vegetable gardens cabbage gardens suggests that the crop must have been a staple. Europeans made white cabbage into sauerkraut, and Captain James

Cook, recognizing its value in preventing scurvy, issued it to his sailors in the 18th century. So important was the use of cabbage against scurvy that Great Britain funded the making of sauerkraut to supply sailors. In the 18th century, Europeans grew several varieties: York, Brunswick, Strasbourg, Ulm, Ambervilliers, de Bonnenil, and Saint Denis. Curiously, Pliny's varieties appear not to have made the list.

By the 20th century, farmers grew cabbage in virtually every country, cultivating it as far north as the Arctic Circle. In Eastern Europe, cabbage totaled roughly one-third of vegetable crops. Yet the consumption of cabbage has declined where incomes have risen. Worldwide, consumers prefer white cabbage. Savoy and red cabbage area confined to Europe. Cabbage does well in most soil as long as it has enough water. The later the maturity of cabbage the heavier the soil should be to retain water. Nevertheless, the soil should drain well. Tolerant of slightly acidic soil, cabbage grows best in a soil with a pH between 6 and 6.5. Tolerant of moderate salinity, cabbage is nonetheless susceptible to diseases in soil that contains too much salt. Farmers may rotate cabbage with several crops, thought it may absorb so much water that it is in shortage for the following crop. The roots grow laterally so that 70–80 percent is in the upper 20 to 30 centimeters of soil. After one to two months of growth, roots penetrate more deeply. Cabbage responds to a dearth of water by sending roots deep into the soil. Because cabbage consumes large quantities of water, the provision of water through rainfall or irrigation is important. The more mature a cabbage plant the greater is its consumption of water.

In temperate locales, cabbage is biennial, producing vegetative growth in its first year and seeding in the second. Above 57°F, cabbage grows vegetatively and beneath this temperature it seeds. Temperatures between 59°F and 68°F are best for vegetative growth. Cabbage will not grow above 77°F, though young plants are more tolerant of high temperatures than mature plants. A crop may begin to grow just above 32°F. It can endure temperatures as low as 14°F. Below this temperature, it suffers frost damage.

Cabbage is not an ideal crop where winter temperatures fall below 32°F. Instead, it may be grown year-round in areas with mild winters and cool summers. In the United States, farmers grow cabbage year-round with a winter and spring harvest in the South and a summer and autumn harvest in the North. Commercial growers often sow seeds in a seedbed, transplanting young plants in the field. Although, as we have seen, seeds will germinate above 32°F, they germinate at higher temperatures quicker. Whereas plants germinate in 14 days at 50°F, they germinate in 7 days with temperatures above 68°F. The farmer may transplant cabbage 4 to 10 weeks after germination. Excessive nitrogen may injure young plants, though applications of phosphorus and potassium may be beneficial. One authority recommends the application of 264 to 528 pounds per acre of superphosphate as a source of phosphorus and 264 to 528 pounds per acre of muriate of potash or potassium sulfate as a source of potassium. By 1969, cabbage yielded 10 to 100 metric tons per hectare. The largest white cabbages produced heads that weighed more than 10 kilograms. White cabbage yielded more than savoy and red cabbage. The latter two produced 10 to 40 metric tons per hectare.

Popular in the 1990s and again in recent years, the cabbage soup diet promises to help the overweight shed 10 pounds in only one week. One version of the diet promised a loss of 17 pounds per week. The diet works because one cup of shredded cabbage contains only 17 calories. The body must burn more calories in chewing and digesting cabbage than it derives from the vegetable. The centerpiece of the diet is a soup of cabbage, carrots, red pepper, onion, celery, and tomato, which the dieter may eat in unlimited quantities. The diet is so hard on the body that its proponents counsel the dieter to discontinue the regimen after one week, resuming it only after consuming a normal diet for at least two weeks.

In 2008, China was the leading producer of cabbage. India ranked second, Russia third, South Korea fourth, and Japan fifth. Not a leading producer, the United States ranked ninth.

One cup of cabbage contains 91 percent of the recommended daily allowance of vitamin K and 50 percent of vitamin C. Cabbage also has fiber, manganese, vitamin B6, folic acid, thiamine, riboflavin, beta-carotene, calcium, potassium, tryptophan, magnesium, and protein. Cabbage may protect one against cancer.

Chinese Cabbage

As its name suggests, Chinese cabbage likely originated in China. A Chinese text mentions the cultivation of cabbage in the fifth century BCE. One authority believes that Chinese cabbage arose from a chance cross between pak-choi and turnip. In the second half of the 20th century, China rapidly expanded the production of Chinese cabbage. In China, Chinese cabbage is the most widely grown vegetable. In northern China, people derive one-fourth of their vegetables from Chinese cabbage. In northern China, Chinese cabbage totaled 80 percent of vegetable consumption in the winter and spring, when other vegetables are in shortage. In southern China, Chinese cabbage trails only pak-choi as a vegetable. In recent years, Chinese cabbage has spread to Inner Mongolia, Sikiong Uighur, the plateau of Chianghai Province, and Tibet. The Chinese grow thousands of cultivars.

In the 13th century Korea, having imported Chinese cabbage from China, began cultivating it, first as a medicine. In 1527, a Korean text mentioned Chinese cabbage among 43 vegetables, evidence that the crop had made the transition from medicine to food. In Korea Chinese cabbage was first a food of the elites. For centuries, Koreans have used Chinese cabbage to make kimchi, the national dish. Kimchi contains Chinese cabbage, radish, leek, red pepper, garlic, ginger, fish, and salt. In Korea, Chinese cabbage is the leading vegetable in production and consumption.

In 1866 the Japanese, having imported Chinese cabbage from China, began to cultivate it. In 1905, Japanese soldiers returning from China brought Chinese cabbage seeds. After 1910, Japanese scientists began breeding new varieties. Although the Japanese have access to more than 300 varieties, they grow only a small number of them. Farmers cultivate Chinese cabbage between 30° and 46° north in Japan, where scientists have bred varieties for each latitude. Year-round demand for Chinese cabbage has prodded breeders to develop new varieties. Because diseases may be severe in Japan, scientists have labored to breed-resistant cultivars. In summer, farmers grow Chinese cabbage in the highlands of Japan. Japanese farmers grew most Chinese cabbage in autumn. In 1980, Japan produced more than 1.7 million tons at a yield of 16 tons per acre. In area, Chinese cabbage ranks third behind radish and common cabbage in Japan. The Japanese grow Chinese cabbage in the prefectures of Ibaragi, Nagano, Aichi, Hokkaido, Gunma, and Hyogo. As the demand has increased, farmers have aimed for an early harvest to get Chinese cabbage to market when the supply is low and price high. In Japan, farmers lime the soil, adding compost and fertilizer before planting their crop. One authority recommends the application of 220 to 264 pounds of nitrogen per acre, 132 to 176 pounds of phosphorus per acre, and 220 to 264 pounds of potassium per acre. Volcanic soil may require more phosphorus. The farmer may add a side dressing of 26 pounds of nitrogen per acre and 26 pounds of potassium per acre after thinning plants and again when Chinese cabbage heads. In Japan, Chinese cabbage trails only the radish among vegetables.

Native to East Asia, Chinese cabbage is today grown in China, Korea, Japan, Bangladesh, Taiwan, Central America, West Africa, the United States, Canada, and Europe. Because Chinese cabbage does poorly in excessive heat, it is grown during cool weather and in the highlands of Southeast Asia. In Asia, small farmers grow Chinese cabbage as a cash crop. Chinese cabbage contains fiber, vitamin C, and calcium.

Diseases and Pests

The fungal disease yellows threatened cabbage from Long Island, New York, to Colorado. Prevalent in warm climates, yellows was the most severe cabbage disease in New Jersey, Maryland, Ohio, Indiana, Illinois, Wisconsin, and Iowa. Infected cabbage display symptoms two to four weeks after transplantation. Fungi spread from the base to the top of a plant, turning leaves yellow-green. As a plant ages, the yellow leaves turn brown and die. Death ensues two weeks after the onset of symptoms. The causal organism, *Fusarium oxysporum*, is related to the *Fusarium* fungi, which cause disease in cotton, tomato, watermelon, cowpea, and pea. Fungi multiply in the soil. Once established, the disease is difficult to eradicate. Having colonized the soil, fungi enter cabbage roots. Fungi are inactive in soil below 60°F and above 90°F. Crop rotation is ineffective against *Fusarium* because fungi remain in the soil no matter what crop is grown. Resistant cultivars are the best defense, and as early as 1940 the Wisconsin Agricultural Experiment Station released the cultivar Wisconsin Golden Acre. The name derived from Golden Acre, a popular variety in the United States since 1923.

A second fungal disease, blackleg, is known as dry rot. Symptoms emerge two to three weeks before transplantation, when leaves and stems betray spots. Fungi destroy roots so that cabbage, deprived of anchorage, topples over from the weight of its head. Other plants, unable to extract nutrients and water from soil, wilt. The causative agent, *Phama lingam*, may accrue on cabbage seeds and in this way infect the next generation. Fungi can survive as long as two years on plant debris. They spread in wet weather. Crop rotation may be effective provided the farmers allows two to three years to elapse between cabbage plantings.

The bacterium *Xanthomones campestris* causes the disease black rot. As the name suggests, the disease blackens cabbage leaves and stems. Infected leaves may fall from the plant. The bacterium dwarfs young plants. In some cases infected cabbage will not head. Although harvested cabbage may appear to be fine, the disease may cause it to rot in storage. Insects, wet weather, and wind spread the disease. Infecting the stomata, bacteria are often numerous in seedbeds and in this way plague new plants. Crop rotation may be effective against black rot.

Among insects, caterpillars may plague cabbage. The cabbageworm, the juvenile stage of the small white butterfly, is native to Europe. It entered the United States about 1850 and New Zealand and Australia in the 1930s. The small white butterfly, appearing in May in the temperate locales of the Northern Hemisphere, deposits one egg per cabbage leaf. Caterpillars hatch in 3 to 10 days, first appearing in June, and immediately begin feeding. Fully grown 10 to 30 days later, a second brood emerges in late July. Late cabbage may suffer acutely from cabbageworm. Also troublesome is the caterpillar known as the cabbage looper. The female lays her eggs on cabbage leaves. Hatchlings appear 3 to 10 days later. They feed at the base of a cabbage plant, proceeding up the leaves. The cabbage looper may yield three generations per year. A third caterpillar, the cutworm, lays eggs on cabbage plants, weeds, or the soil. A poorly cultivated field containing many weeds may support a large population of cutworms. Cutworms feed on cabbage stems and leaves and produce one generation per year in temperate locales. They may overwinter in plant residue. With worldwide distribution, the cutworm has the potential to cause great losses. The caterpillar of the cabbage moth is troublesome in Europe and Asia. Other caterpillar pests include the cabbage webworm and the cross-striped cabbageworm in the United States. Farmers have used biological agents to thwart caterpillars. Among treatments is the dispersal of the bacterium *Bacillus thuringiensis*, which infects the cabbage looper and cabbage webworm. In the United States, farmers have used a virus to kill the cabbage looper. Insecticides, applied every one to two weeks, are also effective.

Another pest of cabbage, the cabbage aphid lays its eggs on stems, leaves, and petioles in spring. Hatchlings appear in April or May and suck sap from plants. Because the cabbage aphid tolerates frost, it can amass a large population early in spring. With populations numbering in the millions, the cabbage aphid may yield 5 to 10 generations per year. Other pests include the small and large cabbage flies. The small cabbage fly, *Chortophila brassicae*, is abundant north of 40° north and has infested Europe and the United States. The large cabbage fly, *Chortophila floralis*, threatens cabbage in Europe, Asia, and the United States. The maggots of these flies feed on cabbage roots. From the roots, they infest the stems and petioles. Infested roots rot with the result that plants grow slowly. In the worst infestations, cabbage plants wither and die.

Christopher Cumo

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Cacao

In the Sterculieceae family, the cacao tree (*Theobroma cacao*) yields a seed, known as a bean, that is made into chocolate. Throughout prehistory and much of history, humans consumed the pulverized bean as a beverage, though today the chocolate bar is a common item in the grocery store. In 1753, Swedish naturalist Carl Linnaeus created the genus *Theobroma*, meaning "food of the gods," into which he placed cacao. Today, *Theobroma* has 22 species. For the species name, Linnaeus chose *cacao*, a word that coincides with the name of the cacao tree. Cacao means "the chocolate tree." Linnaeus's term "cacao" derives from the

Cacao (iStockPhoto)

Aztec word *cacahuatl*, meaning "that which is extracted from the cacao bean." Cacao is also known as cocoa. In the parlance of the workaday world, cocoa is a beverage made from the cacao bean. Cocoa may be a hot beverage, though in this article the term will mean a beverage irrespective of temperature. This distinction between food and beverage will obtain in this article. Cacao should not be confused with coca or coco. They are different plants. In the same way, the cacao bean should not be confused with beans, which are a legume.

The Tree

The average cacao tree lives 50 to 60 years, though some are as old as 80 years. A tree of the tropics, cacao grows no farther from the equator than 20° north and 20° south. Cuba marks the northernmost point of cacao culture, and the island of Reunion in the Indian Ocean the southernmost limit. Even these limits do not tell the whole story, because more than 75 percent of all cacao is produced between 8° north and 8° south. The cacao tree cannot tolerate temperatures below 60°F, though in its natural habitat it will grow between 1,300 and 2,300 feet in elevation. A tree of the tropical forest, cacao is an understory tree that depends on its tall neighbors for shade. In the forest, cacao is a slender tree reaching a height of more than 50 feet. In a plantation, a cacao tree is pruned to 15 feet to make easier the task of harvesting the pods. In a plantation, the branches of a cacao tree produce a dense canopy, and the tree loses the slender appearance that it has in the forest.

Cacao Production

An illustration of the world's cacao-producing regions. (ABC-CLIO)

The genus *Theobroma* may have originated in eastern South America, possibly in the lower elevations of the Andes Mountains, long before the advent of humans in the New World. The cacao tree may have originated in southern Mexico, Belize, Guatemala, and parts of El Salvador and Honduras. It is also possible that the tree originated in South America, from where it was introduced into Mesoamerica. It may have been domesticated in South America or Mesoamerica. Because cacao seeds are viable only three months, one author doubts that the Amerindians took cacao from its southern limit to its northern outpost or from north to south. It is possible that cacao grew wild between Mesoamerica and the Amazon River Basin. In the past, the intermediate population died out, leaving two swaths of cacao, one in Mesoamerica and the other in South America. Mesoamerican trees have long, soft, ridged pods, which have seeds with white cotyledons. The South American cacao tree has hard, round pods with seeds with purple cotyledons.

There are three types of cacao tree: criollo, forastero, and trinitorios. The criollo tree derives its name for the Spanish word for "indigenous." The criollo was the type of tree grown by the Amerindians of Mesoamerica. Enthusiasts prize the criollo bean as the most flavorful. The criollo bean yields a pleasant aroma and delicate flavor. Because the yield is low, the criollo tree produces only 7 percent of the world's cacao beans. The tree is grown principally in Venezuela, Mexico, Nicaragua, Guatemala, Colombia, Trinidad, Grenada, and Jamaica. Given its high quality and dearth, the criollo bean must be expensive.

The forastero tree derives its name from the Spanish word for "foreign." The forastero tree originated in the Amazon River Basin. The Portuguese introduced forastero trees into the African island of Sao Tome, from where it migrated to West Africa. Having been transplanted into Africa, forastero produces most of the continent's cacao beans. Growers also cultivate forastero in Brazil and other parts of South America, Central America, and the Caribbean. Forastero is a fast-growing tree, hardier than criollo, and a higher yielder than criollo. Forastero produces the majority of the world's cacao beans, but it cannot claim the quality of criollo. Forastero beans have a strong, bitter flavor and an acidic aroma. Forastero beans, like coffee beans, are often blended with other types of cacao beans. One variety of forastero, Amendolado, produces a cacao bean whose quality rivals that of the criollo bean. The Amendolado bean is known as the Nacional bean. The variety is cultivated in Ecuador.

The trinitorios tree derives its name from the Caribbean island of Trinidad, where it originated by hybridization. The Spanish planted criollo trees on Trinidad, but when a hurricane swept through the island in the 18th century, the islanders replanted the land with forastero trees. These crossbred with the extant criollo trees, producing the trinitorios hybrids. Trinitorios beans have a high fat content. The trinitorios tree produces 7 percent of the world's cacao beans. Grown in Central and South America, Indonesia, and Sri Lanka, trinitorios yields the highest-quality cacao bean on Trinidad.

A seedling forms a long taproot, though if the water table is high the taproot will be short because cacao tolerates waterlogged soil for only a short duration. Secondary roots grow near the soil surface. The cacao tree needs between 70 and 90 inches of rainfall per year, temperatures between 70°F and 85°F, little variation in temperature throughout the year, and high humidity. The tree must have moisture year-round. Irrigation is necessary during dry spells. When moisture is insufficient, the trees shed leaves to reduce the loss of water through transpiration. The tree is susceptible to many diseases, among them pod rot, wilt, and fungal witches' broom. In the hot, humid environs of the cacao tree, fungal diseases are ubiquitous. The tree bears flowers and the resultant pods on the trunk and largest branches in contrast to temperate trees, which bear fruit on the secondary and smaller branches. Each flower, having both anther and stigma, is only 15 millimeters in diameter. Each flower has five sepals, five petals, and 10 stamens. Sepals and petals are pink or white. The style is two to three millimeters long, at the end of which are five stigmas. In the Americas and Africa, cacao flowers at the beginning of the rainy season and between February and July in Malaysia and Ghana, Africa. Blooms are transitory, lasting only one day. The Amendolado variety is self-fertile, but most are self-sterile and so must be cross-pollinated. Midges, aphids, and thrips pollinate cacao trees. Midges are the principal pollinators. Having evolved in the forest, midges, aphids, and thrips must have forest-like conditions. Trees must surround them, and leaf litter and debris must cover the ground. The grower who insists on a neat plantation unwittingly reduces pollination because he has reduced the habitat of the insect pollinators. This circumstance must account for the fact that in a plantation only a few percent of cacao flowers are pollinated and so form pods. A pod has 30 to 40 seeds, which resemble almonds. Surrounding the seeds is sweet, juicy pulp. Curiously, cacao has no way to release seeds from a pod. In the wild, monkeys, eager to eat the pulp, open the pods, scattering the seeds. In cultivation humans do this job. A pod requires four to five months to attain full size and another month to ripen. A pod may resemble a small rugby ball, a cucumber, or a large gourd. In South America, the average cacao tree yields 30 to 35 pods per year and only 20 in Africa.

Where there is a rainy season, growers harvest the pods at the end of the first rainy season and again at the beginning of the second rainy season. In Malaysia, workers pick pods year-round. In Surinam, workers judge the ripeness of a pod by thumping it with a finger, the method that people use to gauge the ripeness of a watermelon. When ripe, a pod makes a "dull sound" and the seeds rattle in it. Immature pods are green or red violet. When ripe, they turn yellow or orange. On many plantations, men cut the pods from trees and women gather them in baskets. Either a worker or a machine opens the pods to remove the seeds. Once picked, cacao beans are fermented to sweeten them. Criollo beans are fermented two or three days. Forastero and trinitorios beans are fermented more than one week. At the end of fermentation, a cacao bean is 60 percent water. Drying, the next step in processing a cacao bean, reduces moisture to 8 percent. Sun drying is the traditional method, though in Africa and Southeast Asia electric driers are used or the beans are dried by fire. Cacao beans are dried one to two weeks. A dried cacao bean is 50 percent cocoa butter, a type of fat. After the cacao beans are dried, they are roasted and winnowed to produce the kernels that are used to make chocolate.

The ancient practice of carving a cacao plantation out of the jungle persists, though growers also create stand-alone estates, interplanting cacao with banana, coconut, mango, palm, or lemon trees for shade. Cacao plantations are small, covering only a few acres. Some estates are less than two acres. Today, the trend is toward larger plantations, but they remain the exception. Cacao trees are most efficient in photosynthesis when they receive only 25 percent of the sun's light, the rest being shaded. For centuries, planters believed that cacao trees could not survive without shade. In Hawaii, the only place in the United States where cacao is cultivated, growers have succeeded in growing cacao in direct sunlight. The application of fertilizer and hormones causes cacao trees to form a dense canopy, which shades the rest of the tree.

Squirrels, monkeys, and rats steal cacao pods for their pulp, eschewing the seeds because of their bitterness. Seeds, perishing in low temperature and humidity, germinate in a few days. Trees bear pods in the third or fourth year. Cacao is also propagated by cuttings to derive a clone of the parent. Propagation by cutting is common in today's plantations. The extremes of sand and clay are not ideal for a cacao tree. Sand holds too little water and nutrients. Clay drains poorly. The soil pH should be between 5 and 7.5. Cacao will not grow in soil with a pH below 4 or above 8. If the pH is too low, aluminum reaches toxic levels.

The preparation of land for a cacao plantation begins at the beginning of the dry season, when workers remove the undergrowth. During the dry season, workers cut down some of the forest trees. Before they are cut down, the trees should be killed so that they cannot transmit the fungus *Armillaria mellea* to cacao roots. Land should be cleared two years before the planting of cacao trees. Before planting cacao a grower may plant a legume on the site of a plantation to add nitrogen to the soil. The grower should plant shade trees, allowing them to become large before planting cacao. In Papua New Guinea, cacao is planted before any forest tree is felled. When forest trees are cut down the grower makes certain that their absence does not diminish shade. Cacao should not be planted where severe wind is common. Wind can injure a tree, causing it to shed leaves.

Seed for planting should be taken from a pod not more than 15 days underripe. Cacao germination rates are high. A grower may anticipate the germination of 90 percent of seeds within 15 days of planting. The removal of the mucilage that covers the seeds causes them to germinate in only 7 days. Growers plant seeds in a shaded nursery. The new seedlings must be watered twice a day. The rubber tree or oil palm is used for shade in a nursery. Seedlings seldom need fertilizer.

Cacao Becomes a World Crop

The Olmecs of Mesoamerica may have been the first to cultivate the cacao tree, perhaps as early as 1000 BCE. Sometime in prehistory, the Maya and later the Aztecs cultivated cacao. Apparently unaware of Olmec priority, legend holds that the third Mayan king, Hunahpu, was the first to cultivate cacao. The Maya and Aztecs made a beverage from the cacao bean. The Aztecs regarded the cacao tree as sacred, holding ceremonies to mark the stages of its cultivation. A cacao grower was to remain celibate 13 days before planting a seed, which had been placed under the moonlight 4 days before planting.

At the time of the European conquest, farmers in the Yucatan Peninsula tended cacao trees, shipping the pods to the Aztec capital, Tenochtitlan (today Mexico City). In the 16th century, the Spanish monopolized cacao production. The cacao bean was the leading export crop from Spanish America. In the 16th century, the Spanish, as Aztec kings had done, demanded tribute in cacao beans from their American holdings. The Spanish cultivated cacao in Mexico, Venezuela, and Ecuador. The Portuguese established plantations in Brazil. In the Caribbean, Spain planted cacao trees in the Dominican Republic. About 1660, the French planted cacao in the Caribbean islands of Martinique, Saint Domingue, and Saint Lucia to compete with Spanish cacao. In 1746, France planted cacao in Bahia, Brazil. The English planted cacao in Jamaica. In 1836, the Spanish and Germans expanded cacao production in Bahia, Brazil.

For millennia an American tree, in 1590 cacao, presumably through seedlings, was planted in the island of Fernando Po (now Bioko) off the coast of West Africa. This marked the first Old World planting. The trees on Bioko had originated in Venezuela. In 2002 Bioko, affiliated with Guinea, produced thousands of tons of cacao beans, generating the majority of the island's exports. In 1665, the Spanish planted cacao seedlings from Acapulco, Mexico, to Manila, Philippines. Cocoa quickly became a coveted beverage in the Philippines. Filipinos grew several trees in a garden, interplanting them with mango or banana. The Dutch East India Company may have acquired cacao from the Philippines, transplanting trees on the Indonesian islands of Java and Sumatra. After 1778, cacao was profitable in Indonesia. In 2002, Indonesia produced tens of thousands of tons of cacao beans. In 1825, Portugal imported seedlings, presumably from Brazil, to the African islands of Sao Tome and Principe. The Portuguese thereafter were able to compete with Spain, France, and the Netherlands. Between 1895 and 1900, the islands ranked fifth in global production, yielding tens of thousands of tons of cacao beans. By the 1890s, the United Kingdom and Germany refused to buy cacao beans from Sao Tome and Principe because the islands used slave labor. By 2002, the islands produced just a few thousand tons of cacao beans. Even this amount, little as it was, totaled the majority of the islands' exports. In 1857, the Danish Basel Mission planted cacao seedlings from Surinam in Ghana, but they died. Additional trees were planted to 1877, but disease and pests claimed them. In the late 1870s, cacao finally took hold in Ghana. Cameroon, where Germany had earlier planted cacao, was the source of these trees. Under British rule, Ghana emerged as Africa's leading cacao producer. At its peak Ghana, the world's leading producer, harvested several hundred thousand tons of cacao beans per year. In 2002, Cote d'Ivoire was the world's leader with still more tons of cacao beans. In the Americas, Brazil was the leader, followed by the Dominican Republic, Ecuador, Colombia, Venezuela, and Mexico. In Asia, Malaysia harvested a few hundred thousand tons of cacao beans in 2002. Indonesia and Papua New Guinea, which began cultivating cacao in the early 20th century, were important Asian producers. The British planted cacao in Sri Lanka. In the early 20th century, cacao was introduced into the Pacific island of Samoa. Guayaquil, Ecuador, is renowned for the sweetness of its cacao beans. The island of Madagascar produces cacao beans with strong flavor. The island of Sri Lanka yields slightly acidic cacao beans. Ecuador and Samoa are noted for the aroma of their cacao beans.

Like sugarcane, cotton, and tobacco, cacao was a slave crop. Wherever Europeans planted cacao, they enslaved men and women to grow it. In the New World, Europeans might have enslaved the Amerindians had they not died from the diseases that Europeans transmitted to them. The dearth of labor led Europeans to enslave Africans to labor on the cacao estates. Because it was a tropical crop, cacao was often paired with sugarcane. One might suppose that labor requirements were lighter on the cacao plantations, but to the slaves the essential fact was that they were not free. In 1720 a priest, apparently unable to grasp the incompatibility of Christianity and slavery, calculated the profitability of slave labor, remarking that "a cacao plantation is a veritable gold mine."

Cocoa and Chocolate

On his fourth voyage, Italian-Spanish explorer Christopher Columbus encountered cacao. Aztecs on the Caribbean island of Guanaja gave him a bag of cacao beans. The Aztecs prepared a beverage of cocoa, but Columbus thought it too spicy and bitter. The Aztecs called the beverage *tcholctl*, from which the word "chocolate" derives. In 1519, Aztec king Montezuma gave Spanish conquistador Hernando Cortez cacao beans. The Aztecs, other Amerindians, whites, and mestizos used them as money. Four cacao beans bought a pumpkin, 10 bought a rabbit, 12 bought sex with a prostitute, and 100 bought a slave.

The Aztecs reserved the beverage cocoa for the wealthy. Commoners did not drink it. According to Cortez's compatriot, Spanish soldier and historian Bernal Díaz del Castillo, Montezuma drank cocoa every day. The Aztecs believed that cocoa was an aphrodisiac. To make cocoa the Aztecs dried the cacao beans, pulverized them, and added water and chili peppers to the cacao powder.

In the 16th century, cocoa made a favorable impression on Italian botanist Girolomo Benzoni, who, visiting Mexico, declared the beverage "not bitter." "It nourishes and refreshes the body and is not intoxicating," he wrote. Another visitor to Mexico noted that the Amerindians added honey to sweeten cocoa. Others added vanilla. On Martinique, cocoa was, in contrast to Mexico, a democratic beverage. Commoners drank it every morning. Europeans who settled Mexico and the Caribbean added sugar to cocoa, linking the cultivation of cacao to that of sugarcane. Europeans added half a pound of sugar for every 100 beans used to make cocoa. In addition to sugar, the European settlers in the New World added cinnamon, clove, aniseed, almond, and hazelnut to cocoa. Others made a paste from cacao beans.

Europeans came to enjoy cocoa as avidly as they coveted sugar. Columbus appears not to have been the first to introduce cocoa to Europe. In 1527 Cortez, returning to Spain, gave cacao beans to the king, who, like Columbus, apparently disliked the beverage. The Jesuits, numerous in Spain where they were founded, took a leading role in preparing cocoa. In 1606, Italy began importing cocoa from Spain. In 1615, Princess Anne of Austria brought cocoa to France. In 1657, a French businessman opened a "chocolate house" in London, England. The chocolate house came to rival the coffeehouse in popularity. Like cacao, coffee was a tropical crop. The chocolate houses attracted the middle class, principally men, who found them a convenient place to discuss politics and news while indulging in cocoa. Women took their cocoa at home. In the 18th century, in Austrian composer Wolfgang Amadeus Mozart's opera *Cosi Fan Tutte*, a servant prepared cocoa for her female master. Some women found cocoa more appealing than coffee. Aristocratic ladies, perhaps aware of Amerindian beliefs, took cocoa as an aphrodisiac. In 1660, Spanish noblewoman Marie Therese married French king Louis XIV, converting him to the pleasures of cocoa. Monks drank cocoa during fasts. It served as a stimulant that kept them awake for night prayers. Some clerics objected to this practice, holding that cocoa was food rather than a beverage and so could not be taken during a fast. The controversy reached the pope, who sided with the monks. Cocoa was a beverage and so could be indulged in during a fast.

European medical authorities deemed cocoa a treatment for hypochondria and tuberculosis. In 1712, one physician remarked that cocoa was effective against the common cold, pneumonia, diarrhea, dysentery, and cholera. By 1712, cocoa was a popular beverage in Boston, Massachusetts. In the 18th century, some

Europeans, notably Englishman Nicholas Sanders in 1727, began to prepare cocoa with milk rather than water. In 1780, the British navy introduced cacao as a ration for sailors. In the 18th century, the Dutch obtained cocoa from the Netherlands, which in turn presumably got it, at least the cacao beans, from Indonesia, for consumption in New York. Third U.S. president Thomas Jefferson predicted that cocoa would eclipse coffee and tea.

From an early date, Europeans relegated the tropics to producing cacao beans and insisted at the end of the 16th century on processing the beans themselves. In the mid-17th century, Europe erected the first chocolate factory. This factory presumably produced chocolate bars, a popular treat that dated to 1674, the year a London chocolate house began selling them. By the mid-18th century, North America began importing chocolate, presumably from Mexico, the Caribbean, and Central and South America. In 1765, physician James Baker opened a chocolate factory in Massachusetts. In 1895, Pennsylvania caramel manufacturer Milton Hershey began selling chocolate bars. In 1907, Hershey introduced the popular Kiss. In 2005, Hershey produced 30 million Kisses per day. Perhaps because of its connection to sex, the Japanese, Europeans, and Americans associate chocolate with Saint Valentine's Day and Easter. In one sense, Easter is a festival of fecundity, and so is linked with sex. In Japan, tradition holds that the woman gives her man chocolate on Saint Valentine's Day. As of 2005, the Swiss consumed 19 pounds of chocolate per person per year. Norwegians and Britons consumed 17.5 pounds per year. Belgians, the Dutch, Germans, and Austrians ate more than 14 pounds per person. Americans ate 10 pounds per person, and the svelte Japanese consumed only 3 pounds per person. Koreans chew chocolate-flavored gum.

Chocolate may have played a role in the race to the South Pole. Because it is calorie dense and because the effort to reach the pole was strenuous, explorers took chocolate as a ration. British explorer Robert Scott allotted each member of his team 4,430 calories, including 24 grams of chocolate per day. The allowance was not enough. Scott's party failed to reach the South Pole and perished on the return journey. Chocolate cannot bear all the blame for Scott's failure. Terrible weather probably doomed the men. Norwegian explorer Roald Amundsen, perhaps having learned from Scott, allocated each member of his expedition 4,560 calories per day, including five times more chocolate than Scott and his men had eaten. Fortified with chocolate, Amundsen and his team were the first to reach the South Pole.

Christopher Cumo

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Cactus

A member of the Cactaceae family, cacti inhabit one of three subfamilies. The cacti of Pereskioideae grow in dry woodlands. The cacti of Opuntioideae have leaves, which they shed in the dry season. The third subfamily, Cactoideae, has the largest number of species. All but one genus of cactus is indigenous to the New World. The exception, *Rhipsalis*, is native to Africa, Madagascar, several islands in the Indian Ocean, and Sri Lanka. One botanist believes that *Rhipsalis*

Cactus (iStockPhoto)

was once native to the Americas. He theorizes that birds dispersed its seed to the Old World, after which it died out in its ancestral homeland. The discovery of the Americas brought cacti to the attention of Europeans. In the 18th century Swedish naturalist Carl Linnaeus, who knew only 20 species, grouped all cacti in the genus *Cactus*. Today, botanists know 130 genera with more than 1,600 species. Because cacti are endangered, U.S. law prohibits the taking of cacti from the wild.

Origin and Diffusion

The fossil record reveals nothing about the origin of cacti because their imprint is absent from rocks. The absence of fossils makes difficult the attempt to pinpoint the origin or cacti, which may have originated as early as 100 million years ago or as late as 30 million years ago. Arising in South America, according to one account, cacti reached North America during the Tertiary Period. About 36 million years ago, cacti migrated to the Caribbean and Central America. When cacti appeared on Earth, Colombia and Venezuela were at the equator and the Andes Mountains had not uplifted. Northwestern South America was hot, humid, and only intermittently dry. The region was not yet a desert. By 17 million years ago, the Andes Mountains had risen far enough to create deserts. Brazil and Bolivia were then deserts and had been colonized by cacti. In this distant era three centers of cactus diversity emerged: the Andes Mountains, the Caribbean, and eastern South America. Today, the three centers of diversity are Mexico and the American Southwest, the southwestern Andes of Peru, Bolivia, Chile, and Argentina, and eastern Brazil.

The date when humans migrated to the Americas remains a topic of debate, but they may have encountered cacti soon after their arrival. About 12,000 years ago humans painted images of cacti in a cave in Serra de Capivora Piaui, Brazil. One cave in Peru contains cactus seeds that date to 11,800 years ago. According to one authority humans collected cacti more than 9,000 years ago, probably to eat their fruit. The use of cacti predates the invention of agriculture in the New World. The Chavia of Peru encountered the San Pedro cactus, *Echinopsis panchanoi*, more than 3,000 years ago. Some Amerindians used cactus spines to make fishhooks. According to legend the Aztecs founded Tenoctitlan on the spot where an eagle, a snake in its mouth, perched on a cactus. This image adorns the seal of Mexico. The Aztecs used two species of cactus for medicine. Native Americans have revered cacti for millennia, using them in their religious rites and as medicine and food.

Spanish explorer Christopher Columbus may have found cacti in the Caribbean and brought them to Europe as early as 1493. Over the centuries, the Columbian Exchange brought cacti to the Mediterranean Basin, Africa, Asia, and Australia, where they are now numerous. In the 15th century Spanish conquistador

Hernando Cortez encountered cacti in Mexico. In the 16th century Spanish historian Gonzalo Fernández de Oviedo y Valdés noted that the indigenes of the Caribbean used cacti for medicine and wine and as a dye. Even after the fall of the Aztec Empire, the Amerindians of Mexico used cacti in their religious services. Catholic priests, thinking this practice pagan, tried without success to stop it. At the center of Amerindian religious ritual, the peyote cactus had enemies among Europeans. Priests called it *raiz diabolica*, the "devil's root." They considered the eating of cactus a sin. Distrust of the peyote cactus was strong because it has an alkaloid that produces effects similar to those of LSD. In altering their state of consciousness, the Amerindians believed that the peyote cactus allowed them to communicate with the dead. In the 19th century its use spread to the Apache and Plains Indians in the United States. The peyote cactus remains a sacrament in the Native American Church.

Attributes

The outstanding characteristic of the cactus, a perennial succulent, is its ability to survive in arid climates. The cactus withstands drought by storing water in its stems against lean times and by conserving water. In this context, cacti are renowned for their frugal use of water. Roots are efficient absorbers of water. With a low surface area-to-volume ratio, cacti expose little flesh to evaporation. A waxy substance covers cacti to minimize water loss. The genus *Pereskia* bears leaves, which it sheds during dry weather to conserve water. With only one-tenth as many stomata as other plants, cacti transpire little water. Keeping the stomata closed during the day to conserve water, cacti absorb carbon dioxide only at night. Although rainfall may bloat cacti to a state in which they are 95 percent water, they shrink to 20 percent water in drought. The loss of water causes cacti to shrivel. In winter the ability to shrivel is a survival advantage because freezing temperatures will not cause water, in expanding, to burst cacti cells. Spines shade cacti from the sun and absorb dew.

Cacti may have spines, scales, bristles, or hair. Spines are a signature trait. Some spines are so short that they are barely visible. Others are as long as one foot. The genera *Rhipsalis*, *Epiphyllum*, and *Lephophora* have no spines whereas the genera *Echinocactus* and *Mammillaria* have a large number of spines. In addition to their role in absorbing water, spines protect cacti from predators.

Cacti inhabit latitudes from 56° north to 52° south. In the Americas they grown from Canada's Rocky Mountains to Patagonia near the Strait of Magellan. They may be found in deserts, semideserts, and even rain forests. Most cacti of the rain forest are epiphytes. Many cacti inhabit the Andes Mountains of Peru, Bolivia, and Chile and the highlands of Mexico. They survive as high as 15,700 feet. Cacti occupy a range of soils including the damp rain forest soils rich in organic matter, the clays of the plains and woodlands, the sand of deserts, and the quartz sand of northeastern Brazil and Campo Rupestre of eastern Brazil. The genera *Melocastus, Uebelmannia*, and *Pilosocereus* grow in quartz sand. Cacti endure a range of temperatures. The species of the American Southwest, Mexico, Brazil, Bolivia, Chile, and Argentina survive temperatures as high as 125°F. In addition to heat, cacti need 40 to 70 days of cool weather per year to initiate dormancy. Many cacti, having evolved in mountains, tolerate hot days and cool nights. Cacti must have cool weather to flower. For example the genus *Epiphyllum*, known as the orchid cactus because of the beauty and fragrance of its flowers, needs cool nights to flower. Because many species of cactus need cool nights, they may be difficult to cultivate in the tropics, whose nights are too warm. Cacti tolerate winter temperatures between 40°F and 50°F. The genus *Rebutia* survives cooler temperatures. The species *Coryphantha sulcate* and *Coryphantha vivipara* tolerate temperatures as low as –10°F. The subspecies *Escobaria sneedii* var. *sneedii* endures temperatures as low as –15°F. The species *Echinocereus fendleri* and the subspecies *Escobaria sneedii* var. *leei* survive to –20°F. *Coryphentla missouriensii* tolerates temperatures as low as –25°F, and *Opuntia fragilis* survives temperatures as cold as –35°F.

Many species cross-pollinate, the flowers attracting birds and insects. Cacti with red flowers attract birds. The nectar of several species' flowers attracts hummingbirds. Butterflies pollinate the genus *Rebutia*. White flowers emit a fragrance that attracts moths and bats to pollinate them at night. Yellow and magenta are the most common colors of flowers, though blooms may also be white and pink. No cactus has blue flowers. In some species flowers are less than 1 inch in diameter. The genera *Hylocereus* and *Selenicereus* bear flowers as large as 16 inches in diameter. Once pollinated, flowers bear fruit, enticing animals to eat it, thereby dispersing seeds. Birds consume the fruit of many genera. Ants dispense the seeds of the genera *Blossfeldia* and *Aztekum* and some species of *Capiapoo*. The fruit of *Piendoacanthocereus brasiliensis* and *Pereskia bahiensis* fall to the ground. Ripening, they give off an odor that attracts reptiles, which disperse seeds. On the Galapagos Islands the giant tortoise eats the fruit of the genus *Opuntia*. Spines on the fruit of *Cylindropuntia* and *Opuntia* latch onto the fur of visiting mammals, dispersing seeds in this way. Wind disperses the seeds of some species of *Eriosyce*. The genera *Opuntioideae* and *Cylindopuntia* reproduce vegetatively. Parts of the stems of *Cylindopuntia*, having spines, fasten to the fur of mammals, being thus dispersed.

The genera *Ariocarpus*, *Astrophytum*, *Aztebium*, *Cylindropuntia*, *Eschinocereus*, *Penioceretus*, *Selenicereus*, *Trichocereus*, and *Turbinicerpus* yield substances that humans use as medicine. Applied as a topical ointment, the juice of *Ariocarpus fissurtus* deadens pain from wounds, snakebites, and bruises. Native to Mexico and southern Texas, this species produces juice that, mixed with water and boiled, may be consumed to treat fever and rheumatism. Long-distance runners chew the tubercles of *Ariocarpus fissurtus* for stamina. The Amerindians of the Chihuahua Desert used *Ariocarpus retusus* in their harvest festival. The Huichol of Mexico believe this cactus to be toxic, but it is used to reduce fever. Used to treat rheumatism, the juice of *Obregonia denegrii* is an antibiotic. The species is known as the artichoke cactus because of its shape, though others think it resembles a green pinecone. Native to Tamaulipus, Mexico, *Obregonia denegrii* is endangered. In 2002 only 5,000 specimens inhabited the wild. It is threatened by erosion, livestock grazing, and collection from the wild for medicinal purposes.

Cultivation

Where cacti are endangered, cultivation is an important means of preserving species. One gardener recommends the cultivation of cacti because they survive even when neglected whereas most other houseplants die. Despite their exceptional durability, the needs of cacti are not radically different from those of other plants. Cacti need light, water, carbon dioxide, and minerals from the soil. Because of their need for light, cacti do well by a sunny window, though they benefit from shade during the hottest part of the day. During summer cacti may be placed outdoors. As a rule young cacti need warmer temperatures than old specimens. The need for water varies. During hot weather a cactus that is growing and is confined to a small pot may need watering every day. By contrast a cactus that is dormant during winter and in a large pot may need watering only once every three or four weeks. A few drops of water per week may suffice. Alternatively, one may copiously water a cactus, wait until the soil dries out, and then rewater. The gardener should never waterlog the soil because too much moisture may rot the roots. Rainwater or tap water is best. Hard water should be avoided because it may have too much calcium or magnesium. The water should be slightly acidic. Cacti do well in various soils. One gardener recommends a mix of potting soil and sand. The addition of sand allows the soil to drain rapidly, avoiding the excessive moisture that cacti dislike. Soil may also be mixed with gravel to maximize drainage. The genus *Schlumbergera*, the Christmas cactus, does well in peat, but the medium may not be ideal for other cacti. When it dries, peat is difficult to rehydrate. As peat decays its detritus may harm roots. The gardener may also use pumice or perlite. Although some gardeners use a balanced fertilizer with a ratio of 20:20:20, nitrogen to phosphorus to potassium, others assert that because cacti grow slowly they may not need nitrogen. Too much nitrogen leaves cacti vulnerable to pest and diseases. Moreover, nitrogen tends to stimulate vegetative growth at the expense of flowers. A fertilizer with phosphorus and potassium may suffice. The gardener should apply fertilizer sparingly and not at all after August to prevent cacti from issuing forth new growth that may suffer frost damage in winter. Newly potted cacti need no fertilizer.

Genera and Species

The genus *Astrophytum* has four species, all of them indigenous to Mexico and the American South. Breeders have derived several hybrids by crossing these species. *Astrophytum* thrives in hot, sunny weather and needs little water even in summer. Gardeners may propagate *Astrophytum* by seed, which should be sown within one year to ensure viability. The diminutive species of the genus, *Astrophytum asterias* yields attractive yellow flowers. Because it grows slowly, it needs little water. The species is popular in Japan. *Astrophytum capricorne* produces large yellow flowers with a red throat. *Astrophytum myriostigma* produces no spines. When it reaches two-and-one-half inches in diameter the species flowers, producing small blooms. The largest species of the genus, *Astrophytum ornatum* reaches three feet in height. The species yields yellow flowers on its crown.

The genus *Cleistocactus* is popular because of its ease of cultivation and its abundant flowers. The nectar in the flowers attracts hummingbirds. Indigenous to the Andes Mountains, *Cleistocactus* evolved in a region with appreciable rainfall in the summer. The genus must have a regular supply of water to flower. *Cleistocactus* rewards the gardener with blooms throughout summer. *Cleistocactus straush* grows more than three feet tall. Easy to propagate by seed, this species produces maroon blooms. The subspecies *Cleistocactus baumannii* ssp. *chacoanus* flowers over several months. It grows rapidly enough to need pruning. *Cleistocactus brookeae* yields red-orange blooms. Given enough water, the species flowers throughout summer. This cactus may produce more than 200 flowers per year. *Cleistocactus neoroezlii* yields red flowers near the crown. Native to northern Peru, this cactus needs winter temperatures no colder than 50°F. The gardener may propagate the species by seed. Native to Bolivia *Cleistocactus winteri* yields pink or orange flowers.

Pests

Durable plants, cacti are nonetheless vulnerable to insects and arachnids. Aphids damage cacti by sucking sap. Where they are numerous they may cause cacti to yellow, shrivel, and stop growing. The application of alcohol to aphids kills them, though it may harm cacti. The mealy bug, known as the woolly aphid, likewise sucks sap and may be just as distressing as aphids to the gardener. Mealy bugs breed rapidly, forming large colonies that may overwhelm cacti. Large infestations may kill cacti. Some mealy bugs burrow into the soil, where they feed on roots. Where mealy bugs have infested the soil, the gardener should remove it, inserting new soil in its place. Mealy bugs lay eggs on cacti, encasing them in a white web that may be conspicuous. The gardener who comes upon the eggs should coat them with vegetable oil to prevent their hatching. Water and detergent may be used to wash off cacti, thereby removing mealy bugs. Insecticides may be effective, though some mealy bugs are resistant. Aphids and mealy bugs infest cacti in warm, dry weather. Because ants use the honeydew of the aphid and mealy bug, their presence may indicate an infestation of aphid or mealy bug.

Like aphids and mealy bugs, red spider mites suck the sap of cacti. Cacti develop gray, yellow, or brown spots at the point of attack. Active in warm, dry conditions, red spider mites thrive where ventilation is poor. The genera *Rebutias*, *Lobivias*, *Corypharthas*, *Melocactus*, *Sulcorebutia*, *Mammillaria*, *Lophophora*, *Turbinicarpus*, *Pelecyphera*, and *Faucaries* are susceptible to mites. In heavy infestations cacti develop brown scars at the place of feeding. A concoction made from cinnamon oil may be effective against mites.

Thrips feed on stems and pollen, their appetite voracious above 90°F. They thrive in hot, dry conditions. The gardener who suspects an infestation need only tap a flower. Startled thrips will scurry about, revealing their presence. In damaging a flower, thrips may cause it to be small and misshapen. Stems may have small yellow spots, betraying the activity of thrips. Tiny black dots, thrip excrement, may appear on flowers and stems. Multiplying rapidly, a female may lay 50 to 200 eggs during her lifetime. Hatching in a few days, larvae begin feeding at once. Larvae of the fungus gnat feed on cactus roots. Adult plants may have a sufficiently mature root system to withstand damage without ill effect. Young plants, however, are vulnerable. In only a few weeks, larvae may kill an entire flat of seedlings. Where seedlings survive they may be stunted.

Christopher Cumo

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Calendula

Calendula officinalis is the most common cultivated species of calendula, also known as Pot Marigold and called Golds or Ruddes in Old English. There are about 20 species in this family, including Field Marigold (*Calendula arvensis*) and Sea Marigold (*Calendula maritima*), and over 100 varieties. Calendula is of the same family (Asteraceae) as daisy, chrysanthemum, and ragweed. This family also includes what is commonly called "marigold" in North America but is actually the *Tagetes* genus. Calendula is not closely related to the common marigold.

The name is derived from the Latin *kalendar* or *calends*, meaning "the first day of the month." It is believed this refers to Calendula's easy cultivation and constant blooming from early spring to first frost. Its common name, Pot Marigold, is said to come from its frequent use to color a pot of soup or broth and provide comfort for the spirit. It is a hardy annual that is native from the Mediterranean to Iran but has been cultivated since the Middle Ages and is now a worldwide ornamental flower. In 1941, the variety Plamen was registered and is considered the direct ancestor of many ornamental varieties. Many varieties are still not widely available due to exclusive production rights. Rinathei is heavy with faradiol triterpenoids that provide calendula's anti-inflammatory qualities and was registered in 1998 by a German herbal medicine manufacturer. The most common European and North American variety is the Erfuter Orangefarbinge with a bright orange double flower. Resina and Carola varieties are considered higher seed yield crops and the richest in seed oil. Resina has only recently become available outside Europe.

The plant grows in many soils but does best in rich, well-drained soil with full sunlight in a cool temperate environment. It can also be easily overcome by weeds. *Calendula officinalis* is usually 12 to 30 inches tall and quickly produces yellow, red, or orange flowers that open with the rising of the sun and close with the setting sun. In fact, Swedish naturalist Carl Linnaeus's observation indicates that they open at nine in the morning and close at three in the afternoon, so he attributed the names *solsequia* and *solis sponsa* to the plant. This characteristic is also referenced in William Shakespeare's play, *A Winter's Tale*:

> The Marigold that goes to bed wi' th' sun
> And with him rises weeping.

History

Calendula has been used medicinally since the 12th century. It was referenced in writing as early as 1578 in Henry Lyte and Rembert Dodoens's text, *A Niewe Herball*, as having "pleasant, bright and shining yellow flowers." Nicholas

Culpeper included it in his infamous book of treatments, *The English Physician* (1642), as a treatment for headaches, toothaches, and swelling. Culpeper compared the plant to the courageous lion, therefore also prescribing it for heart disease. In the Civil War and World War I, calendula salves were used to treat wounds and prevent infection. In folk medicine, the whole plant was added to milk as a cure for certain types of cancer.

The rich carotene pigment in the orange flowers of calendula has prompted farmers for many years to add it to butter and cheese to deepen their yellow color. Even currently, calendula petals are added to chicken feed to darken the egg yolk color.

Medicinal Uses

Historically, it was suggested that dried calendula petals have antiviral, anti-inflammatory, stimulant, and diaphoretic properties. It is an edible flower and used as a tincture for chronic ulcers, varicose veins, acne, inflammation, and soothing irritated skin. Tea brewed from dried calendula is said to help heal sore eyes, and direct application of blossoms relieves symptoms from insect bites or stings. As a topical ointment, it is considered safe for humans and increases blood flow to the affected skin area, helping to treat hemorrhoids, burns, skin irritations, and abrasions. It is also considered an antibacterial and is used in foot powders.

Recently, drops containing calendula have been found to be possibly effective at healing ear infections in children, and the plant is used in treatments of eczema, dry skin, and scars. Antimicrobial compounds may help inhibit *Staphylococcus*, *Candida*, and *Escherichia coli*. In homeopathy, calendula tinctures and creams are used with skin problems and cuts, and may help control bleeding as well as provide an antiseptic for broken skin, burns, and abrasions. Homeopathic remedies have been developed to internally treat jaundice and fever, and tinctures are used as gargles to help heal mouth ulcers and sore throats.

Medical and pharmacological studies involving calendula have identified the plant as having high numbers of flavonoids, which are plant-based antioxidants. These protect the skin from cell-damaging molecules known as free radicals. Calendula ointments may have some use in treating radiation dermatitis in some cancer patients. Studies have also found a conjugated trienoic fatty acid in the oil of calendula seed and named it calendic acid. Biologically, it has been suggested that this acid can be a signaling molecule, resulting in body fat loss and reducing colon cancer cells.

Recent Industrial Application

In 1985, research into the biosynthesis of calendic acid revealed that it was highly susceptible to oxidation. Continued studies have determined that it shortens the drying process and makes a more resistant coat of paints, varnishes, binders, and resins. Due to this recent discovery of calendic acid, industrialized cultivation as well as mechanical harvest and cleaning of calendula seeds has been explored, but it has been found to be a labor-intensive crop. The flowers bloom quickly so must be harvested regularl,y and are easily overcome by weeds, which reduce productivity. Agricultural productivity is still being explored and tested.

Erika Stump

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Campanula

Campanulas are native to the whole of the Northern Hemisphere but are especially diverse across Western Europe, particularly in lands that border the Mediterranean Sea. The genus *Campanula* belongs to the family Campanulaceae, or bellflower family, and comprises around 300 species, which can be annual, biennial, or perennial. The botanical name means "little bell" and derives from *campana*, the Latin for "bell," as campanula flowers are often bell shaped, although they can also be cup, saucer, or star shaped. Campanula flowers are available in shades of blue, purple, red, pink, white, and lilac, feature five petals, and are usually borne in clusters. Species of campanula vary in height between 3 inches, such as *Campanula cochleariifolia*, also known as fairies' thimbles, and five feet, including *Campanula latiloba*, known as the delphinium bellflower. One of the shortest-growing varieties, *Campanula carpatica*, also known as the Carpathian bellflower, is particularly prized by gardeners for the plant's favorable ratio of flower size to height, for the plant grows to between 8 and 12 inches tall but produces many blooms, which are around 2 inches in diameter, in shades of white, lilac, and blue. *Campanula carpatica* forms clumps up to two feet in diameter and has a long flowering period as it blooms from spring to summer.

Campanula laciflora, also known as the milky bellflower, and *Campanula latiloba*, are two of the tallest-growing campanulas as they can reach heights of up to five feet. *Campanula lactiflora* produces masses of small, white or lavender flowers on plants bearing many branches, whereas *Campanula latiloba* produces blooms that are attached to the plant's two-feet-tall stems in the fashion of a delphinium plant and are available in shades of white, purple, and blue. These campanulas differ from low-growing campanulas as they flower in mid- to late summer instead of in spring.

Attributes

Campanulas do not enjoy hot conditions, preferring climates that have overnight temperatures below 70°F and daytime temperatures no higher than 90°F. When these temperatures are exceeded, campanulas will not flourish and will be short-lived, although a site that has partial shade at midday benefit the plant. In general, campanulas prefer to grow in full sun to partial shade in rich, evenly moist soil that is well drained. During dry spells, it is necessary to water campanulas well and mulch around the plants to keep the surrounding soil cool. Regular deadheading will encourage repeat flowering. Propagation is by the division of roots or by seed, although the flower color of species such as *Campanula laciflora* will differ between parent plant and offspring. White Clips and Blue Clips are cultivars of *Campanula carpathica* that do grow true from seed.

Folklore and Mythology

One of the most celebrated species of cultivated campanula is the biennial *Campanula medium*, commonly known as Canterbury Bells. *Campanula medium* grows to a height of three feet and produces flowers up to two inches long from spring to midsummer. There are two English legends that explain why Canterbury Bells are so named. In one legend, three evil men were transformed by a priest into swans and cursed to fly without rest for over a thousand years. Then, when flying over Canterbury, the men heard the ringing of church bells and felt such contrition for their pasts that the curse was broken. With the spell lifted, the men fell to Earth at Canterbury where they were discovered by North African scholar Saint Augustine, who led them into a church. Where the men trod, tiny campanulas grew, and the flower was subsequently dedicated to Saint Augustine and later to England's Saint Thomas à Becket who was murdered in Canterbury Cathedral. The other legend tells that campanulas were so named because of their resemblance to the bells carried by pilgrims to Canterbury. Classical myth explains the origins of another campanula, *Campanula speculum*, which is also known as Venus's looking glass. According to myth, Venus's mirror bestowed beauty upon anyone reflected in it. However, one day the goddess lost her mirror, and it was found by a shepherd who proceeded to gazed at himself in the mirror. It so angered Cupid that his mother's mirror had been used by a mortal that Cupid knocked the glass from the shepherd's hand, and where it landed sprang forth a campanula.

A tea may be brewed from *Campanula americana*, the American bellflower, and it is used as a remedy for respiratory conditions by the Meskwaki tribe of Native Americans. Similarly, *Campanula rapunculoides* is often grown in vegetable gardens for the leaves, shoots, and the white tap root. This may be eaten in salads and is known as rampion, which is rich in vitamin C. Rampion grows up to four feet tall and is extremely invasive, spreading quickly via subterranean stolons and by self-seeding. It is from *Campanula rapunculoides* that the Brothers Grimm developed the name Rapunzel for their fairy-tale heroine as it is rampion leaf that Rapunzel's mother craves from the witch's garden at the start of the tale. Rampion was also fed to the gods by Apollo and used to decorate funerals at his temple at Delphi. The association of campanula with death is part of Scottish folklore, for in Scotland *Campanula rotundifolia*, commonly known as the harebell, is called auld-man's-bell and is left untouched, for the plant is thought to be the bell belonging to a graveyard ghost. To hear the ghost's bell ring above the sound of a storm is regarded as a harbinger of death.

Victoria Williams

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Canna

Cannas are lush tropical plants with huge leaves and vibrant blossoms on tall stalks. Many varieties have multicolored and patterned leaves, making them a season-long focal point. The common species *Canna indica* provides two possible clues to its origin. Because the species came to Europe from the East Indies and because a European—16th-century Flemish botanist and physician Carolus Clusius—named the plant, it is tempting to think that the species name *indica* suggests an East Indies origin. But Clusius was a careful scholar, and the consensus appears to be that he was correct in inferring a New World origin, namely the West Indies. If *Canna indica* originated in the West Indies, one wonders whether 15th- and 16th-centuries Spanish-Italian explorer Christopher Columbus encountered the species, though there appears to be no evidence one way or the other.

Canna is an American genus. Without exception, all *Canna* species that have been introduced into Europe can be traced back to the Americas, and it can be asserted with confidence that *Canna* is solely an American genus. If Asia and Africa provided some of the early introductions, they were only varieties resulting from *Canna indica* and *Canna glauca* cultivars that have been grown for a long time in India and Africa, with these species having originally imported from Central and South America, though it is not clear whether these migrations occurred with human assistance.

Cannas were unknown to the ancients of the Old World, and only after the discovery of the New World did they make their appearance in Europe. Since cannas have very hard and durable seed coverings, it is likely that seeds would have survived in the right conditions for a voyage across the Atlantic Ocean and then would have been found by archaeologists in the Old World. If the soils of India or Africa had produced some of them, they might have been imported before the 1860s into European gardens, though the prevailing opinion is for a direct transfer of cannas from the Caribbean to Europe, rather than the circuitous route from the Americas to Africa or India and then to Europe. *Canna* is the only genus in the family Cannaceae. The angiosperm phylogeny group system (APG III) recognizes the family. Canna is sometimes consumed as a vegetable or juice. It is reputed to prevent dehydration. Its carbohydrates are a source of energy. It is reputed to aid the function of the kidneys. It is thought to prevent prostate and breast cancers.

Types

The plants are large tropical and subtropical perennials. The broad, flat, alternate leaves grow out of a stem in a long narrow roll and then unfurl. The leaves are typically solid green, but some cultivars have glaucose, brown, maroon, or variegated leaves. Flowers are red, orange, or yellow or a combination of those colors. There are 19 species of *Canna* recognized by the American Horticultural Association.

Although gardeners enjoy these odd flowers, nature intended them to attract pollinators such as bees, hummingbirds, and bats. As do potato plants, cannas grow from rhizomes, which store starch, having the largest starch particles of all flora. This is the desideratum of the plant to agriculture, though canna is unlikely ever to rival the potato in its ubiquity in the temperate zone. *Canna* is the only member of the Liliopsida class in which seeds hibernate because of their hard, impenetrable seed covering.

Cultivation

In the temperate zone, the gardener may plant canna in the spring after danger from hard frost has passed. A good rule of thumb is to plant canna when it is time to plant potatoes. The best results are achieved when planted in a loose, fertile, and well-drained soil. The rhizomes should be kept moist but not wet. Canna should be watered thoroughly once a week by slowly soaking the area around the roots. Emerged plants may receive more water. They may flourish in poorly drained areas and in shallow ponds.

Canna will tolerate a wide range of growing conditions, though it prefers full sun and a minimum of four hours of direct sunlight. Rhizomes should be planted 12 to 18 inches apart and covered with 2 inches of soil. The gardener may place the long part of the rhizome horizontally in the ground with the eye up, if visible. Canna rhizomes do not have a top or bottom, so they cannot be planted upside down.

In colder regions, gardeners may start canna in pots and place it in greenhouse conditions six to eight weeks prior to planting outdoors. When all danger of frost is past, the gardener may remove canna from pots and plant outside. For optimum performance, organic matter such as composted manure as well as a high-nitrogen fertilizer may be added to the soil. Rose and tomato fertilizers are also good products to use on cannas and are readily available. It is not necessary to deadhead the spent flowers and seedpods to induce new blooms; however, the flowerbed is more striking without the old blooms.

Symbolism and Uses

The name canna originated from the Celtic word for a cane or reed; it is a common feminine first name in Australia. In Italy, canna is a measure of length, varying from six to seven feet. Canna is a small island in the Inner Hebrides, off the coast of Scotland, about six miles long by half a mile across, and with a population of 18. Gaelic scholar John Lorne Campbell donated the Isle of Canna to the National Trust for Scotland in 1982.

The canna rhizome is rich in starch, and it has many uses in agriculture. All of the plant has commercial value, the rhizomes for starch (consumption by humans and livestock), the stems and foliage for animal fodder, the young shoots as a vegetable, and the young seeds as an addition to tortillas. Canna is the flour source for arrowroot cookies. The seeds are used as beads in jewelry, and as the mobile elements of the kayamb, a musical instrument from Réunion, as well as the hosho, a gourd rattle from Zimbabwe, where the seeds are called *hota* seeds. In more remote regions of India, cannas are fermented to produce alcohol. The plant yields a fiber from the stem used as a jute substitute and to make paper. The seed produces a purple dye when boiled. Smoke from the burning leaves serves as an insecticide. Cannas are natural filters and are used to extract pollutants in a wetland environment as canna has a high tolerance to contaminants. In Thailand, cannas are a traditional gift for Father's Day. In Vietnam, canna is called dong *riềng* and its starch is used to make cellophane noodles known as *miền dong*.

Deb Carlton

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Cannabis

An annual in the tribe Cannabinaceae and the family Urticaceae, *Cannabis* is the genus name encompassing three species. In 1753, Swedish naturalist Carl Linnaeus named *Cannabis sativa*, deriving the genus name from the Greek *kannabis*, meaning "hemp." Hemp is the common name for cannabis plants used to derive fiber. The Greek *kannabis* derives in turn from the Sanskrit *cana*. Cannabis is rendered *quetuba* in Assyrian, a word that means "noisy" because the Assyrians used it in religious rites that must have been quite loud. Cannabis is *knopla* in Slavic, *qanneh* in Hebrew, *qannah* in Arabic, *quonnah* in Persian, *quannah* in Celtic, and *canano* in Spanish. The third syllable in cannabis—bis—may derive from the Hebrew *bosom* or the Aramaic *bussma*, meaning "aromatic," recognition that cannabis is a fragrant plant. In the early 19th century, French naturalist Jean-Baptiste Lamarck named the second species, *Cannabis indica*, meaning "cannabis from India," a sensible appellation that noted the country of origin of this species. In 1924, a Russian botanist named the third species, *Cannabis rudernis*.

Origin and Diffusion

Cannabis originated in Central Asia, where it still grows wild. Cannabis grows wild between the Pamir-Altai Mountains and the Caucasus Mountains. It was first cultivated in western China or Turkestan. The oldest evidence of cannabis may come from Taiwan, where pottery as old as 12,000 years contained pieces of hemp rope, though the use of cannabis on Taiwan may predate its cultivation. Around 5000 BCE the Chinese, perhaps marking the advent of cannabis culture, grew the fiber in the Yellow River valley for making cloth and netting. This fact

Marijuana (AP Photo/Ted S. Warren)

suggests that humans first used cannabis as a fiber and only later for food, medicine, and recreation. During the Han dynasty, the Chinese made burial shrouds of hemp. These garments must have been for commoners, who wore cannabis cloth. The Chinese reserved silk garments for the aristocracy.

The use of cannabis for food is also ancient. In the 16th century BCE, the Chinese agricultural text *Xia Xiao Zheng* reported that cannabis was an important food. Between the fifth and third centuries, the *Book of Songs* and *The Annals* list six food crops, cannabis among them. The Chinese roasted cannabis seeds or ground them into flour. As a source of oil, cannabis appears to have been a staple in the diet until the sixth century BCE when the Chinese came increasingly to rely on rice, barley, millet, soybeans, and sorghum for food.

Aware of the sexuality of plants before Europeans made this discovery, the Chinese understood that cannabis is a dioecious plant, bearing male and female flowers on separate plants. During the Han dynasty, the Chinese began to make cannabis fiber into paper. From an early date, Chinese shamans used cannabis in rites to expel demons. In the fifth century BCE, shamans used cannabis to induce dreams, which they used to predict the future. As early as the third millennium BCE, Emperor Shen Nung, anticipating the medicinal uses of the plant, recommended that sufferers of gout and malaria drink tea made from cannabis leaves and flowers. Indeed, humans have used cannabis as a medicine for at least 3,000 years. So important was cannabis that Nung accepted it as tribute. In the second century, physician Hua Tuo mixed cannabis resin with wine, offering it to patients as an analgesic. Yet cannabis may not have been widespread in ancient China. Taoists were suspicious of its hallucinogenic properties. In any case, the Chinese appear to have preferred alcohol and opium to cannabis. From China, the annual spread to Japan. The Japanese wove cannabis fiber into a fabric as fine as silk.

Around 2000 BCE, cannabis spread from Central Asia to India. According to one tradition, Hindus believe that the god Shiva took cannabis from the Himalayan Mountains, planting it in India. Another account holds that Shiva entered a garden on a hot day. Seeking shade, he lay beneath a cannabis plant. Growing hungry he ate the plant, perhaps feeding on the leaves and seeds. So satisfying was cannabis that Shiva declared it his favorite food. The author of the *Atharva Veda*, apparently aware of the connection between cannabis and Shiva, recommended it to the person who wished to commune with the god. The *Veda* listed cannabis among the five sacred plants and devised a prayer to the gods to protect cannabis users from disease and demons. The Indians, holding that cannabis had spiritual qualities, used it to cleanse their sins. Indian priests and holy men used cannabis to bring them to enlightenment. Cannabis helped them endure hunger, thirst, and pain. According to one tradition, Buddha subsisted six years on cannabis seeds, eating just one seed each day. Having an erotic element, cannabis may have been used in India as an aphrodisiac. The practitioners of Tantrism may have used it to prolong sex. As a medicine, cannabis was used to treat dysentery, insomnia, and fever. In India, cannabis tea was a popular wedding beverage, and a host gave cannabis tea to the guests who visited his home. Indians made tea from cannabis leaves, milk, and sugar. In addition to these uses, Indians crushed cannabis leaves, adding the powder to food.

By 1500 BCE, cannabis had spread to Iran, Turkey, Greece, the Balkans, Germany, and France. By 900 BCE, the Assyrians used cannabis, apparently as incense, in religious rites. In the seventh century, Iranian religious reformer Zoroaster, writing in the *Venidad*, ranked cannabis as the most important of 10,000 medicines. In the 15th century, Muslim chronicler al-Maqrizi told the story of Heydar, an Islamic monk in Iran. In 1155 Heydar, in a story reminiscent of the tales told about Shiva, entered a garden on a warm day, encountering a cannabis plant. His curiosity aroused by the fact that the heat had not wilted the plant, he plucked a few leaves, chewing them. Heydar became high, telling his fellow monks of his discovery. So delighted was he with the effects of cannabis that Heydar chewed its leaves the rest of his life. Until the 20th century, cannabis use among the ancient Hebrews remained controversial, though in 1936 etymologist

Sula Benet asserted that a passage in Exodus referred to cannabis as incense and a drug. The Hebrews appear to have used cannabis incense in religious rites until 621 BCE, when King Josiah suppressed its use. Some authorities believe that Jesus used cannabis in his ministry to treat eye and skin ailments. By the time of Jesus, India, China, and Europe had emerged as centers of cannabis culture. By the first century CE, cannabis spread from India to South Africa and Sumatra. From South Africa, cannabis spread north throughout the rest of Africa.

The Egyptians used hemp to make rope. Scholars discovered pieces of hemp in the tomb of pharaoh Akhenaton. The discovery of cannabis pollen on the mummy of pharaoh Ramses II has led to the supposition that the Egyptians used cannabis in their funereal rites, at least for the nobility, though not everyone accepts this interpretation. Yet the Egyptians had no word for cannabis, suggesting that it was not an important plant to them.

Before 800 CE, the Scythians brought cannabis to Europe, though Europeans may have grown cannabis before the Scythian introduction. Archaeologists have found it in Neolithic Germany, Romania, and the Ukraine. Europeans were familiar with cannabis as early as China's experiments with the plant, though Europe surely lagged behind China in cultivating it. Europeans may have first used cannabis in their religious rites. By the fifth century BCE, Europeans were using cannabis to make burial clothes. In the fifth century BCE, Greek historian Herodotus noted that the Scythians inhaled cannabis incense after a funeral. Herodotus observed that the people of the Balkans used cannabis to make cloth. Curiously, fourth-century BCE Greek botanist Theophrastus did not mention cannabis, leading one to wonder how important it was to Greek agriculture and life. In the first century CE, Greek physician Dioscorides wrote favorably about cannabis. He differentiated plants by sex, remarking that cannabis was used to make rope and recommending it to treat earache. He noted that it suppressed the libido, a conclusion that put him at odds with the beliefs of India. In the second century CE, Galen, physician to Emperor Marcus Aurelius, noted that cannabis produced a feeling of well-being. Taken in too large a quantity, cannabis intoxicated the user, causing dehydration and impotence. The Romans grew little cannabis in Italy, instead importing it from the provinces. The Romans used cannabis to make rope and sail. First-century CE Roman encyclopedist Pliny the Elder approved of its use to make rope. In the early Middle Ages, the Franks grew cannabis for fiber. Sixth-century Frankish queen Arnegunde was buried beneath a blanket of cannabis cloth. In medieval England, farmers grew cannabis with flax. The Vikings used cannabis to make rope, fishing line, and sail. The Arabs used cannabis to make paper, introducing the technology of papermaking to North Africa and Spain. Europe's first paper factory, which began operation in the 12th century, used cannabis. German inventor Johan Gutenberg printed the Bible on cannabis paper in the 15th century. The growth in maritime commerce increased demand for cannabis for sail.

In Europe, northern Asia, and East Asia, humans grew cannabis for fiber and food. The people of Africa, the Middle East, and southern Asia used cannabis as a drug and secondarily as food and fiber. As early as 1545, the Spanish, English, and French brought cannabis to North America, using it to make rope and sail. In the 19th century, India introduced a second group of cannabis varieties to the United States. In 1835, the Caribbean and South America adopted cultivars from India. Until the late 19th century, cannabis was among the most widely grown plants, being used for fiber, cloth, lighting oil, medicine, and in some cases food. People prized it as a durable fiber for making twine, rope, and canvas. In the 19th century, however, the widespread adoption of the cotton gin allowed cotton to supplant cannabis in making textiles. At the same time, kerosene replaced cannabis oil for lighting, and acid process pulp replaced it in making paper. Into the early 20th century, physicians continued to use cannabis as an analgesic.

Around 1900, California growers adopted cannabis cultivars from Japan, and Kentucky farmers began to grow varieties from China. In Kentucky, one variety is appropriately known as Kentucky. In modernity, humans have eaten cannabis seeds during times of food shortage. During World War II, Europeans averted starvation by eating cannabis seeds, and the Chinese did the same during leader Mao Zedong's catastrophic Great Leap Forward. Poor Indians still eat cannabis seeds, combining them with amaranth seeds and rice. In sub-Saharan Africa, people feed ground cannabis seeds to babies.

Attributes and Cultivation

Cannabis grows from the equator to subarctic regions. Farmers raise it from Manchuria and Mongolia to southern Great Britain and from the Ganges River in India to Hokkaido, Japan. As a rule, cannabis requires four months to produce fiber and five months to yield seeds, though under ideal conditions cannabis may mature in as little as 2 months. By contrast, poor conditions delay maturity until 10 months. Fifty percent of seeds remain viable for three to five years. In the United States, cannabis needs 4 to 5 months to yield fiber. Farmers plant cannabis in spring. Seeds germinate in three to seven days. Long days stimulate vegetative growth. Cannabis flowers with short days. As we have seen, cannabis is dioecious, though an occasional plant is monoecious, bearing male and female flowers on the same plant, as do most plants. Male cannabis plants tend to be taller than female plants. Males die soon after dispersing pollen. Like corn, cannabis is wind pollinated. Seeds mature three to six weeks after pollination. A tall plant, cannabis reaches heights up to 13 feet. Cannabis tolerates frost better than corn. Warm temperatures produce the best yield of fiber and seeds. Cannabis does not tolerate waterlogged soil. A uniform distribution of rainfall throughout the growing season is best. A climate with high humidity yields the best fiber. Cannabis does best in fertile soil that drains well, although it survives in poor, sandy soils, which hold little water and few nutrients. Cannabis can survive with little rainfall. Intolerant of cold weather, cannabis languishes in shade. Farmers sow seeds at a density of 1,300 pounds per acre, roughly 10 seeds per seven square feet of land. Of the plants that germinate, farmers thin them to three to five per seven square feet. As a rule, farmers plant cannabis densely to derive plants suitable for fiber. Dense planting causes cannabis to grow tall with few branches.

In the United Sates, cannabis often follows corn. Typically, a farmer plants corn on the perimeter of cannabis fields, harvesting it before cannabis. Few insects and diseases plague cannabis in the United States. In Europe, however, cannabis suffers from the corn stem borer. Larvae of the semilooper attack seedlings. Sensitive to competition from weeds, cannabis yields diminish in the presence of broomrape weed. Cannabis fiber, derived from the stalk, is 60–70 percent cellulose. When bleached in water, the fiber increases to 95 percent cellulose.

Humans use cannabis fiber to make string, twine, rope, carpet, canvas, and paper. Cannabis oil is used to make soap and paint. Farmers grow cannabis for fiber in Russia, Europe, Chile, and the United States. Russia, Italy, and Poland produce 75 percent of the world's crop. Significant yields are also reported in the former Yugoslavia, Hungary, and Romania. In the United States Kentucky is the leading producer. Cannabis can be found as high as 8,000 feet and has colonized the Himalayan Mountains and the Hindu Kush. Varieties of cannabis are often named for the place of cultivation: Lebanese Gold, Colombian Gold, Hawaiian Blue, Jamaican Blue Mountain, Nigerian Black, and Mexican Green.

Cannabis as a Drug

Cultivating *Cannabis indica*, the people of India may have been the first to exploit the hallucinogenic properties of the plant. Since this early use in India, humans have associated *Cannabis indica* with its capacity to produce psychotropic effects. In antiquity, its psychotropic effects caused cannabis to be used in religious rites. The ancients thought cannabis a magical plant. The compound 9-tetrahydrocannabinol (THC) causes these effects. Young plants have the highest concentration of THC, which declines as they age. A cannabis plant is up to 5 percent THC by weight. Made from cannabis, marijuana is 5–10 percent THC. The dried leaves of cannabis comprise marijuana, though one may add the flowers to increase potency. Since 1938, the word "pot" has become slang for marijuana because Moroccan men kept marijuana in a small jar or pot. "Weed" is also slang for the drug because cannabis is a weed in many places. In the 1960s and 1970s, the United States imported illicit cannabis from Jamaica, Mexico, Colombia, and Southeast Asia.

THC affects the cerebrum, which coordinates movement and balance; the hippocampus, which stores memory; and the rostral ventromedial medulla, which receives pain stimuli. The brain has THC receptors, leading some medical authorities to assert that humans are predisposed to use cannabis. At low doses, cannabis causes euphoria. High doses alter perception. Among its common effects, cannabis induces a feeling of well-being, lack of inhibition, an altered sense of time, an increase in imagination, and a decrease in concentration. Cannabis rarely induces violence or aggression. Cannabis heightens touch, taste, smell, and hearing. The cannabis user is aware of latent thoughts and images. Cannabis increases heart rate, metabolism, and blood pressure. The eyes redden and the mouth and tear ducts dry. Cannabis stimulates appetite and causes the sweat glands to emit odor. Since antiquity, some people have believed cannabis to be an aphrodisiac, though few medical authorities now accept this view.

More potent than marijuana, hashish is also more dangerous. Hashish is 20 percent THC and hashish oil 85 percent. The user may experience paranoia, schizophrenia, mood changes, panic, and delirium. Fortunately, these symptoms subside with cessation of use. Cannabis appears to be nontoxic. No physician has reported death from overdose. By one estimate, the user would need to smoke 800 joints to die, and then death would result from carbon monoxide poisoning rather than the accumulation of THC in the brain. Nevertheless, cannabis smoke is as deleterious as cigarette smoke, aggravating respiratory ailments. Cannabis has tar and cyanide in addition to carbon monoxide. Cannabis is far less addictive than many other drugs, including tobacco. Cessation of use causes irritability, anxiety, restlessness, and insomnia, symptoms that are similar to those experienced by a person who quits caffeine.

Cannabis grown at altitude produces the most THC. As a rule, temperate regions produce cannabis suitable for fiber, whereas the tropics yield cannabis used for its psychotropic effects. Farmers grow cannabis for its psychotropic effects in India, Southeast Asia, the Caribbean, Central and South America, Africa, and Southern Europe. According to one authority, cannabis is the world's most widely grown hallucinogenic plant.

Christopher Cumo

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Canola

Canola is one of the world's major oilseed crops. Canola fields are easily recognizable by the plant's bright yellow four-petaled flowers. The crop belongs to the Brassicacea, or mustard family, and encompasses cultivars of three species. The first canola cultivars were bred from *Brassica rapa* (formerly misclassified as *Brassica campestris*) and *Brassica napus*. More recently, *Brassica juncea* was used to create new canola varieties. Canola is cultivated for the production of vegetable oil for human consumption, animal feed, industrial oil, and biofuel. The edible oil is used primarily for cooking, in salads, and for the production of margarine.

History

The use of *Brassica rapa* as a crop dates back more than 2,000 years. Written evidence indicates that it was first grown in Asia and Northern Europe. *Brassica napus* is probably of Mediterranean origin and was already known in the Roman Empire where it was appreciated for its turnips. The use of rapeseed as an oilseed crop is believed to have started in Europe during the Middle Ages when rapeseed was made into a lamp oil.

Canola was developed from traditional rapeseed varieties by Canadian plant breeders in the early 1970s. The canola-breeding program was initiated when Canada found itself short on oil for human consumption after the World War II. The program aimed at improving the plants in a way that would convert the industrial rapeseed oil to an edible oil by lowering the natural contents of glucosinolates in the seed meal and of erucic acid in the oil. Glucosinolates are metabolites that are characteristic of the Brassicaceae family and cause the sharp taste of mustard. Together with erucic acids and other compounds, glucosinolates deter herbivores from eating wild plants. Both substances are mildly toxic to humans and animals and cause an unpleasant taste of the oil. When the breeding goals had been reached, the new cultivars were named by combining the words "Canada" and *oleum*, the Latin word for "oil." "Canola" can also be read as an acronym for "Canadian oil low acid." The name is now a registered trademark of the Canadian Canola Association.

In order to qualify as canola, *Brassica* varieties must contain less than 2 percent of erucic acid in their fatty acid profile and less than 30 micromols of glucosinolates per 0.035 ounce of seed. They are also referred to as "double low" varieties. In addition to canola production, the production of industrial rapeseed oil with high erucic acids content continues. This industrial rapeseed oil is mainly used as lubricant or for hydraulic fluids.

Canola oil is produced from crushed seeds, which contain around 40 percent oil. It has low levels of saturated fatty acids and high levels of omega-3 fatty acids, and is considered by many consumers as a healthy choice of vegetable oil. The seeds also contain high amounts of protein, which makes the seed meal, that is, the dry matter left after the extraction of the oil, useable as high-protein animal feed. Like palm and soy, canola is also a major source of oil for biodiesel production. Biodiesel is produced from plant oils through transesterification, an industrial refinery process in which the oil reacts with an alcohol to remove the glycerin. The glycerin can be collected as a by-product of the refinery and used in cosmetics, pharmaceutical products, and foods.

Current Uses

Today, canola is grown on a large scale in Europe, North America, Asia, and Australia. It is available in spring and winter varieties. Winter canola varieties planted in the fall tend to have a higher yield than spring varieties. This yield increase is probably due to the increased time between planting and harvest, which gives the plant more time to develop in the field, and the fact that it can flower under cooler and therefore more suitable weather conditions. However, winter canola cannot be grown in areas with very harsh and cold winters. As a result, breeding efforts aim to develop a stronger cold hardiness in winter canola. This is particularly relevant since the main canola-growing regions in North America have continental climates with hard winters. In 2009, the Canadian prairie provinces, North Dakota, and Minnesota accounted for over 90 percent of the canola acreage in North America.

With the increasing demand for biodiesel and the popularity of canola oil, the acreage is expected to increase over the next decade and to spread into neighboring regions. The large acreages planted with canola in the last decade have increased the occurrence of so-called volunteer canola, that is, canola that grows as a weed in other crops. Canola is not easy to control as a weed, as it has a number of characteristics that it shares with "traditional" unwanted plants that reduce crop yield. Its ability to respond to environmental fluctuations is pronounced, and it produces a large number of seeds per plant, which can have a high persistence in the soil due to their ability to enter a metabolically inert stage in which they can survive extended periods of time.

Farmers grow canola in rotation, usually with cereals, because continued planting of canola or related species increases the risk of pest and pathogen attacks. Canola is susceptible to a range of insects and mites. The most important fungal pathogen of canola is *Leptosphaeria maculans*, which leads to blackleg disease. Blackleg, whose symptoms include lesions and a black coloring of the base of the stem, can lead to dramatic yield losses and can be carried over from year to year on infected canola stubble. Scelerotinia stem rot, caused by fungi of the *Sclerotinia* genus, is another major disease of canola that can lead to huge losses, particularly if the infection occurs during flowering.

Canola can be improved through both traditional breeding and genetic engineering. Hybrid canola has been successfully bred and marketed on a large scale for 20 years. Hybrids are appreciated for their increased vigor and other desirable traits, which derive from crosses between two inbred lines. Hybrids tend to be more robust and have good agronomic characteristics, such as quick seedling emergence and higher yield. Genetic modifications in canola have thus far been used to create herbicide or pesticide resistant varieties. These genetically modified canola cultivars are grown on around 90 percent of the current canola acreage in North America. Although canola is a primarily selfing plant, in which the pollen from one plant tend to fertilize egg cells from the same plant, canola flowers, with their bright color and high sugar concentration, attract bees and other insects. As a result, a certain amount of crossing between individuals occurs by insect as well as wind pollination. This has led opponents of genetic modification in plants to raise concerns about outcrossing of traits inserted into canola plants by genetic modification to genetically unmodified or wild plants. In addition, genetically modified seeds can end up in fields devoted to nonmodified crops. This issue came to worldwide attention in a high-profile lawsuit (*Monsanto Canada Inc. v. Schmeiser*), in which the agricultural corporation Monsanto sued a Canadian farmer, Percy Schmeiser, for patent infringement. Some plants of Monsanto's patented herbicide-resistant Round-Up Ready Canola were found in his fields. As the plants had by all evidence grown from wind-transplanted seeds, the case became a symbol for the power of multinational corporations in the world's seed market. When Monsanto won the first instance of the lawsuit as well as an appeal before the federal court, Schmeiser took the issue to the Canadian Supreme Court. In 2004, the court affirmed Monsanto's patent, but determined that Schmeiser would not have to pay the technology fee Monsanto demanded as he did not profit from the presence of Roundup Ready canola in his fields.

Because of the comparative ease with which canola can be genetically engineered and the large number of seeds per plant, scientists have started using canola seeds as a host to produce technically or pharmaceutically relevant proteins in large quantities, an approach known as molecular farming. Oilseed crops such as canola are particularly well suited to the production of certain types of proteins in seeds, because the seeds contain oil droplets to which the proteins of interest can be targeted. The proteins can then be easily extracted from the surface of the oil droplets. Use of canola in molecular farming is still at an experimental stage.

Kerstin Müller

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Cantaloupe

A vine that produces a type of melon, the cantaloupe (*Cucumis melo*) derives its name from Cantalupo, the papal gardens near Rome where it was cultivated. The connection between cantaloupe and "wolf bowl," the literal meaning of Cantalupo, is unclear. Confusion has arisen over the proper domain of the word "cantaloupe." The term originally applied only to the subspecies *Cucumis melo* var. *cantalupensis*, a cultigen of Europe and Asia. In the United States, however, the meaning is broader, applying also to the subspecies *Cucumis melo* var. *reticulus*, a cultigen grown in the Americas. The American cantaloupe is a muskmelon, but it is seldom designated as such. One may distinguish the two subspecies of cantaloupe by inspecting their skin. The Eurasian cantaloupe has rough, warty skin, whereas the American cantaloupe has netted skin. A member of the Cucurbitaceae family, cantaloupe is related to cucumber, squash, pumpkin, and gourd. In addition to muskmelon, cantaloupe is also known as cantaloup, cantalope, mushmellon, rockmellon, and spanspek. Cantaloupe is eaten fresh as dessert, in salad, or with ice cream or custard. In 1941, the U.S. Department of Agriculture isolated a mold, which yielded a superior grade of penicillin, from a cantaloupe. This discovery marked the beginning of the modern era of antibiotics.

A cup of cantaloupe has only 56 calories, 0.5 gram of fat, no cholesterol, 68 milligrams of vitamin C (113 percent of the recommended daily allowance), 494 milligrams of potassium, and beta carotene, the precursor of vitamin A. Half a cantaloupe has 5 milligrams of beta carotene, half the recommended daily allowance of this nutrient. The riper the cantaloupe the more beta-carotene it contains. Once cut, cantaloupe loses vitamin C. After six days, it has lost one-quarter of its vitamin C. The health-conscious consumer should eat cantaloupe soon after slicing it. Moreover, because cantaloupe may spoil in as few as three days after being cut, it is best consumed quickly. With only one gram of protein per cup of cantaloupe, the fruit is not a good source of this nutrient. Cantaloupe has adenosine, a blood-thinning anticoagulant that may benefit people with heart conditions. The substance may protect one from cancer. One of the few fruits and vegetables rich in both vitamins A and C, cantaloupe may lower blood pressure. Cantaloupe contains carotenoids, the cancer-fighting pigments that color it. A study in the Netherlands documented that people who consumed cantaloupe lowered their risk of developing macular degeneration by 35 percent. Cantaloupe may also reduce the incidence of cataracts.

Origin and History

A plant of the tropics, cantaloupe may have originated in India and Africa. Another hypothesis pinpoints the highlands of Iran, Pakistan, and India as the homeland of cantaloupe. Humans domesticated the vine about 5000 BCE, spreading it the Levant and North Africa. By 2000 BCE, the Egyptians cultivated it. The writers of the Old Testament, apparently familiar with cantaloupe, wrote about a variety of melons. The Greeks and Romans grew cantaloupe, though its cultivation appears to have waned in the Middle Ages, when trade in the fruit declined between the Near East and Europe. In the 11th century, Crusaders discovered cantaloupes in Arab markets, though they were not sufficiently impressed to bring seeds back to Europe. In 1273, Italian adventurer Marco Polo tasted cantaloupe in Shibarghan in the Iranian desert, judging the fruit "excellent, a good of trade that is deservingly widely sold throughout the countries." Italians brought seeds from Armenia to Europe, and by 1620 the pope was growing cantaloupe in Cantalupo. In the 18th century, French writer Francois Voltaire complained that the wealthy were addicted to the fruit. He had a low opinion of it, asserting that cantaloupe "turns bad too early in the stomach."

In 1494, Spanish-Italian explorer Christopher Columbus planted cantaloupe in Hispaniola (now the island of Haiti and the Dominican Republic), from where it spread to North America, perhaps through the agency of Spanish missionaries. In the 1920s, Armenian immigrants began cultivating a hybrid cantaloupe in California. In the early 20th century, Colorado was an important producer, growing enough cantaloupe to seed 100,000 acres. Today, California and Arizona yield two-thirds of the U.S. crop. Texas and Georgia supply the rest.

Attributes and Cultivation

In the early 20th century, gardeners nearly everywhere in the United States grew cantaloupe, though its commercial cultivation was restricted to the South and Southwest. Although cantaloupe may be grown in any medium, sandy soil is best. Heavy soil may delay maturation. Soil that is ideal for cucumber, pumpkin, and squash should yield cantaloupe. The soil should drain well. Cantaloupe responds to the application of manure and compost better than to inorganic fertilizers. Farmers aimed for an early harvest in order to get their cantaloupe to market before the glut of summer. In the early 20th century, the farmer who harvested an early crop could increase earnings $200 to $300 per acre.

Cantaloupe needs five frost-free months. In June, July, and August, the daily temperature should reach a maximum of 80°F to 95°F. Nighttime temperatures should not dip below 60°F. Rainfall should be moderate and sunshine abundant. Cantaloupe yields well when it follows a legume in rotation because the vine absorbs residual nitrogen from the legume. For this reason, farmers rotated it with alfalfa in the West, clover in the East, and cowpea in the South. Because sugar beet and corn are heavy feeders, cantaloupe yields poorly when it follows them. Because vines must absorb sufficient water for cantaloupe to increase in size and weight, winters should be wet so that the soil will be moist in spring. The farmer irrigated seeds at planting and again when vines were seedlings. Thereafter vines were watered every week or 10 days. One authority preferred light, frequent applications of water rather than heavy, infrequent soakings. When fruit set, the farmer watered vines more heavily until melons reached maximum size, thereafter returning to light watering. When cantaloupe was ready to harvest, the farmer ceased watering it to prevent fungal diseases. The application of too much water too early in the season caused the vine to grow at the expense of fruit.

Farmers bought seeds rather than saving a portion of the harvest. In 1910, cantaloupe seeds cost $1 to $2 per pound. One authority preferred seeds from cantaloupe grown at elevation. The farmer planted seeds a few days before the last frost was expected. At Rocky Ford, Colorado, farmers planted seeds about May 1. Planted in hills, one pound of seeds sufficed for one acre. Planted in rows, two or three pounds of seeds were needed for one acre. Seeds were planted one-and-one-half inches deep or two inches deep where the climate was dry. The farmer thinned plants to one vine every two feet.

Where insects, especially the grasshopper, cutworm, striped cucumber beetle, or melon aphid, plagued cantaloupe, the farmer cultivated the soil in autumn, winter, and early spring to destroy eggs and larvae. The grower dusted hills with lime and sprayed Bordeaux mixture to kill insects. The ladybug, syrphus fly, and lace winged fly preyed on the melon aphid. Insect-damaged vines were destroyed. The farmer sprayed fungicides against pathogenic fungi.

The harvest required judgment. A cantaloupe could not be picked green like a tomato or lemon. It could not show color like an apple before picking, otherwise it was too ripe. One authority recommended that a cantaloupe be picked when the flesh was sweet but still too hard to be eaten for one or two days. One axiom, though perhaps extreme, held that a cantaloupe progressed through the stages of green, ripe, and rotten in three days. In the early 20th century, farmers sold ripe cantaloupe locally, withholding for transit only those that would ripen in a few days. Once a cantaloupe has been purchased, it should be stored in the dark at room temperature until ripe and thereafter in a refrigerator.

Varieties

In the early 20th century, seed catalogues listed a large number of cantaloupe varieties. Many of these were likely duplicates, with seed companies having renamed a variety that they had appropriated from another company. The most popular variety of the era had a mysterious origin. One account holds that Netted Gem originated in France and became established in the United States in 1880. Another account holds that W. Atlee Burpee, an American seed company, bred Netted Gem in 1881. Whatever its origin, the variety produced small, uniform fruit that packed well in crates and retained its flavor when shipped long distances. By 1910, Netted Gem was the most widely grown variety in Colorado.

The virulence of the fungal disease melon rust led farmers to seek resistant varieties. Colorado farmer J. P. Pollock derived a rust-resistant cultivar, Pollock, named in his honor. Pollock was known as Rust Resistant, Eden Gem, Netted Rock, and Ironclad. A large melon, Pollock yielded sweet, spicy flesh. With green and salmon flesh, Pollock produced a thick, fibrous vine. Ryan's Early Watters, maturing about August 1 (10 days earlier than Pollock), resembled it in appearance and flavor. With green or yellow flesh, Ryan's Early Watters was susceptible to rust. Also susceptible was Defender, known as Burrell's Gem, Osage Gem, and Pink Meat. With salmon flesh, Defender stored well though it matured late and tended to crack when ripe.

Pollination

Cantaloupe has both male flowers, which contain only pollen, and perfect flowers, which have both pollen and ovum. Because only the perfect flowers have ova, only they can bear fruit. On a cantaloupe vine, male flowers outnumber perfect flowers 12 to 1, a circumstance that appears wasteful because only a fraction of the pollen is necessary to fertilize each ovum. Each perfect flower must set at least 400 seeds to produce fruit, so each ovum must receive at least 400 pollen grains. A cantaloupe flower opens after sunrise and closes in the afternoon of the same day. An ovum is receptive to pollen only a few hours in the morning. In hot weather, an ovum may be receptive to pollen only a few minutes, a curious circumstance give the vine's tropical habit.

Although cantaloupe is self-fertile, the perfect flowers do not self-pollinate. Pollen is too heavy for wind to disperse. Cantaloupe must rely on insects to do the task. By cross-pollinating cantaloupe, insects aid the fruit in attaining maximum weight. The honeybee is the most common pollinator in North America, Israel, and West Africa. Ants, thrips, and beetles also pollinate cantaloupe. Farmers rent honeybee hives in spring for the purpose of pollination. The more bees that visit cantaloupe flowers the greater are the yield, weight, and sweetness of the fruit. New Zealand farmers use bumblebees to pollinate cantaloupe.

Bumblebees visit cantaloupe from dawn to dusk, though late visits must be unproductive given that cantaloupe's perfect flowers are receptive to pollen only in the morning.

Christopher Cumo

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Caraway

Caraway is often regarded as an ancient spice—sometimes described as one of the oldest cultivated plants—used by humans since time immemorial. It is believed that the seeds, actually the fruits, were used in the kitchen and as a medicine since prehistory. In 2005, remnants of caraway were found in a 5,000-year-old grave in Iran. First-century CE Greek physician Discorides mentioned caraway as a medicinal plant. First-century Roman encyclopedist Pliny the Elder referred to caraway as a foreign plant. A fourth- or fifth-century collection of Roman recipes, known as *De re coquinaria* and attributed to Apicius, mentions caraway as an ingredient. These references may, however, have been to wild plants, though for Pliny it was obviously a foreign plant and so was probably imported.

However, the evidence of its presence as a cultivated plant in Western Europe is from the early Middle Ages and even later. It is mentioned as *careium* in Frankish king Charlemagne's edict *Capitulare de villis vel curtis imperii* from around 812. Archaeological findings are reported from a site at Schaffhausen in Switzerland dating from the Middle Ages, from Cologne, Villingen, and other sites in Germany dating from the 14th to the 16th centuries, and from London probably as late as the 16th century. In Scandinavia, caraway is mentioned as a cultivated plant in the Danish king Valdemar I's land register of around 1230 and as a remedy in a medicinal work by Roskilde canon Henrik Harpestræng in the 13th century. The first mention of this culinary herb in England is from a recipe of 1390. The name caraway was recorded first in 1440. Some say it is of Arabic origin (*al-karawaya*). It was called *kümmel* in German, *kommen* in Danish, *kummin* in Swedish, and *köömen* in Estonian because it was confused with cumin (*Cuminum cyminum*) in older herbals and medicinal handbooks. Germany seems to have played a crucial role in its spread throughout Europe, because it is sometimes referred to as German cumin in many languages, such as *cumino tedesco* in Italian, *tysk kummin* in Swedish (ancient Swedish *thydzk komin*), and *saksankumina* in Finnish. Also, some local Turkish names indicate that it was associated with strangers or minorities, for example, *Ermeni kimyonu* (Armenian cumin) or *Frenk kimyonu* (Frankish cumin). In French and in Faroese, Norwegian, and some Swedish dialects, it was called *carvi* and *karvi* respectively. In Central Asia, it was known as *zire*. The Arabs probably brought it to India, where it is still used in large quantities for producing curry.

Caraway was widely cultivated by the peasantry in Denmark and Sweden during the 17th and 18th centuries. For the Swedish peasantry, its blooming was a sign to begin the harvest of hay in the 19th century. Commercial plantations existed on Bornholm in 1750s. It seems to have reached North America with European settlers as a garden plant by the turn of the 19th century. Nowadays, it is introduced to most countries where it can grow. Caraway easily escapes and has become naturalized in many parts of the world.

The Plant and Its Origin

Caraway is a biennial umbelliferous plant with a taper root, like a parsnip, but much smaller, running deep into the ground. The stems rise from 18 to 25 inches, with spreading branches and finely cut deep green leaves. The fruit is about one-fifth of an inch long and tapered at the ends. Two different kinds of caraway exist in cultivation, winter caraway and annual caraway. The former is cultivated in Northern Europe, including Russia, while the annual caraway is predominant in Israel, Egypt, and Sudan.

Its origin is disputed. Caraway might have originated in southwest Asia and the eastern Mediterranean region, but early on it spread as a cultivated plant through Eurasia. It may be indigenous in Europe, although it has been cultivated in spice and medical gardens for centuries. However, harvesting fruits from wild or naturalized plants has been common as well. This extensive system of gardening has been typical for the peasantry in premodern Europe.

A Culinary Herb for Many Purposes

Caraway has a wide use as a condiment and medicine. Caraway consists of essential oils whose aroma is determined by carvone and limonene. The other constituents of the seed are carveol, dihydrocarveol, α-pinene, β-pinene, and sabine.

Caraway is first and foremost a spice crop. It is a very typical spice for Central, Eastern, and Northern Europe, used in many different kind of dishes. The ripe fruits have a long tradition of flavoring bread, buns, curry, cheese, dishes of eel, goulash soup, liver, pickled beets, pickled herring, porridge, potatoes, pretzels, sauerkraut, and sausage, and it is a must for the kind of flavored Scandinavian spirit known as aquavit. There are liqueurs made with caraway. Caraway is still widely used for food flavoring and as aroma. The fruits are supposed to stimulate the appetite, but they can also be chewed in order to freshen the breath. Raki, the strong aperitif of the Balkan Peninsula and Turkey, is sometimes flavored with caraway oil. The oil is also used for taste correction in medicine.

There are historical records from the United Kingdom and from Scandinavia that people ate the carrot-shaped taproots as vegetables, but this seems to be an obsolete practice nowadays. It was commonly harvested in many parts of Sweden in the 18th century. The fresh leaves can be eaten chopped in salad or stew. This has a long tradition in Northern Europe. The leaves have also been gathered as fodder for cattle and sheep.

Caraway also has a reputation as a medicinal plant. During the Middle Ages, caraway had some reputation in the treatment of snakebite. It has traditionally been used for headache, for colic, and as a carminative. That is, the plant is said to relieve gas. Distilled caraway water has been used as a folk remedy to ease flatulent colic in small children until recently. It was mentioned by the medieval and Renaissance herbalists and medicinal authors, and survived in scholarly medicine until the 19th century. English botanist Nicholas Culpeper wrote in 1652 that the caraway seed "is conducing to all cold griefs of the head and stomach, bowels, or mother, as also the wind in them, and helps to sharpen the eye-sight. The powder of the seed put into a poultice, takes away black and blue spots of blows or bruises. The herb itself, or with some of the seed bruised and fried, laid hot in a bag or double cloth, to the lower part of the belly, eases the pains of the wind cholic."

Caraway has also been used to treat malaria. Caraway beer was used in Denmark for colds. The oil pressed from the fruits has been available through pharmacies. Carvone is reported to have some cancer-preventative properties. It is also used as anthelmintic against hookworm. Tea of caraway is popular in modern herbal medicine. The fruits have also been used in many remedies within folk veterinary medicine.

Other uses of the oil include making perfumes and scented soap. Caraway has also been used by pigeon breeders. Baked caraway dough, placed in homing pigeon lofts, was said to ensure that the birds would always return. According to German folk tradition, bread made with caraway was used to drive away evil beings.

Commercial Crop for the Future

The demand for caraway fruits and oil in the international food industry is increasing. Several cultivars exist. Nowadays, caraway is a commercial crop chiefly cultivated in Finland, Russia, the Netherlands, Germany, Morocco, Egypt, Canada, and the United States. It is said to benefit from northern conditions, and the long summer days seem to yield the highest level of aromatic oils in the fruit. For these reasons, caraway is increasingly important as a crop in Finland and Canada. It is also grown in Kashmir and the foothills of the Himalayas in northern India.

Ingvar Svanberg

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Cardamom

Historical and Origin of Cardamom

Cardamom is a large perennial, rhizomatous monocot, belonging to the family Zigniberaceae. It is native to the forests of Western Ghats of southern India. Cardamom is often referred as the "Queen of Spices" because of its pleasant aroma and taste. It is considered to be the third most expensive spice in the world. This spice was highly valued from ancient times. It is grown in the hilly regions of South India at 800 to 1,300 yards. Large fields of cardamom plants can be found in Sri Lanka, Papua New Guinea, Tanzania, and Guatemala.

Cardamom belongs to the genus *Elettaria* and species *cardamomum*. The genus name is derived from the Tamil root *Elettari*, meaning "cardamom seeds." Cardamom is known to have been in use in India from antiquity. It is known as *Ela* in Sanskrit texts; however, the ancient Indian Ayuvervidic texts, *Charaka Samhita* and *Susrutha Samhita* (1400–600 BC), mentioned cardamom on many occasions without clarifying if *Ela* is cardamom or large (Nepal) cardamom. The earliest attested form of the word *kardamon* is the Mycenaean Greek *ka-da-mi-ja*, written in Linear B syllabic script. In the New Testament, which was largely written in Greek, *amooman* appears in reference to the aromatic plant cardamom.

Babylonians and Assyrians used many herbs for medicinal purposes. Plants known to be used by Assyrian doctors and chemists included cardamom, cumin, dell, origanum, thyme, saffron, and sesame. Cardamom spread along land routes and was known in ancient Greece and Rome. Wrecks of luxury cargos revealed that spices were an exotic and rather rare material in ancient times. In antiquity, spices were symbols of luxury and had an important role in ceremonies and cultural events. Dioscorides (40–90 CE), a Greek physician and author of *Materia Medica*, mentioned cardamom among many herbs as useful medicine. Greek physician Hippocrates appreciated the therapeutic effect of *Kardamomom*. *Kardamono* is a Greek verb derived from cardamom that means "to become strong." Cardamom was suggested as an important remedy for digestion after heavy meals. Cardamom was listed among the Indian spices liable to duty in Alexandria in 176 CE.

After the fall of Rome, Venice became an important trade city and harbor connecting East and West. Spices such as cardamom, pepper, cloves, and cinnamon were imported to Constantinople and Venice in exchange for salt and salted meat exported to Levantine countries. Dutch merchant Jan Huygen van Linschoten in his *Journal of Indian Travels* gave a description of the two forms of cardamoms used in South India. It is known that Arabs, trying to keep secret the sources of the spices, were the major traders of Indian spices. Cardamom was an exceptional spice that Arabs sold to the West. Valerius Cordus (1515–1544), a German physicist and herbologist, was the first to describe cardamom as an essential oil. With the discovery of the sea route to the west coast of India, the Portuguese started collecting and exporting cardamom to Europe. European colonizers did not care much about cardamom cultivation and production until the 19th century. Officers working for the British East India Company described cardamom and its cultivation in South India.

Cultivation of Cardamom

Today, cardamom is produced mainly in India and Guatemala. It was introduced in Guatemala only in the early 1920s from Sri Lanka or India. After World War II, cardamom production expanded to 13,000 to 14,000 tons annually. India is the main producer, with cardamom-growing areas in Kerala. Kerala is in the districts of Idukki, Palakkad, and Wynad. The cardamom-growing regions of South India are located at 8° and 30° north latitudes and 75° and 78° east longitudes. Two varieties of cardamom plants are identified: *Elettaria cardamomum* ssp. *major*, comprising wild types of Sri Lanka; and *Elettaria cardamomum* ssp. *minor*, comprising cultivars like Mysore, Malabar, and Vazhukka. These types are grown in different tracts and are identified mostly by the nature of panicles, the size of plants, and other morphological characters. Cardamom varieties are highly location specific.

Tillers emerge from axils of underground stem, and from their bases vegetative buds emerge throughout the year. The majority of vegetative buds are produced between January and March. It takes almost 10 months for a vegetative bud to develop and about a year for the panicle to emerge from the newly formed tillers. Generally, two to four panicles emerge from the base of a tiller. Shoots mature in 10 to 12 months. The flowers of the plant are bisexual, zygomorphic, white, and one-and-two-tenths to one-and-four-tenths inches long. The structure of the cardamom flower accommodates insect pollination as indicated by the prominent labellum, stigma positioning above anthers, and the presence of nectar glands. The fruits of cardamom are ellipsoidal, almost spherical, fleshy and green. Color does not vary with biotypes or varieties. The essential oil of cardamom is derived from the fruits of the plant.

Cardamom is affected mostly by cardamom mosaic virus (car-MV-Katte), cardamom necrosis virus (car-NV-Nilgiri necrosis virus), and cardamom vein-clearing disease (car-VCV-Kokke kandu). The last two pathogens are endemic. Crop losses are caused mostly by cardamom mosaic virus. Cardamom is affected by a number of diseases caused by various pathogens including fungi, bacteria, and nematodes. More than 25 fungal diseases have been reported not only in plantations but also in nurseries. Capsule rot (*Azhukal*) is caused by *Phytophthora meadii*, *P. nicotianae* ssp. *Nicotianae*. Rhizome rot is caused by *Pythium vexans*, *Rhizoctonia solani*, and *Fusarium oxysporum*. Chenthal is caused by *Colletotrichum gloeosporiodes*, and Root knot nematode is caused by *Meloidogyne incognita.*

Pharmacological Properties of Cardamom

In Ayurvedic texts, cardamom seeds are described as aromatic, acrid, sweet, cooling, stimulative, carminative, diuretic, cardiotonic, and expectorant. The use of cardamom was a subject of extensive ethnopharmacological and ethnobotanical research, but there are few studies for cardamom's pharmacological properties. Cardamom seeds and oil have carminative action (it expels gas from the intestines or stomach). In British and U.S. pharmacopoeias, cardamom is an aromatic stimulant, carminative, and flavoring agent. In addition, tincture cardamom is used in many preparations that are carminative, stomachic, and used to relieve colic. In animal experiments, the essential oil caused an increase in the secretion of bile and a reduction in gastric juice production.

The terpenoid constituents of cardamom oil seem to have mycostatic and antibacterial effects. In addition, cardamom oil exhibits mild antioxidant (increase of glutathione-s-transferase enzyme activity) and anti-inflammatory properties according to several in vivo models. Its anti-inflammatory effect is due to the activation of the complement system of the human immune system. However, no toxicity was reported for cardamom, as its main use is as a spice and flavor. The concentration of cardamom in food preparation is small; higher concentrations could not be used because of their intense smell and taste.

Culinary and Other Features of Cardamom

Nowadays, the major use of cardamom is for culinary purposes. Asiatic cuisines use cardamom (whole or ground) in a variety of dishes. In Indian cooking, cardamom is one of the main ingredients of *garam masala*, a combination spice for many vegetarian and nonvegetarian dishes. Cardamom is a peculiar and exotic spice used in the Middle East's religious ceremonies. In addition, cardamom in these countries is used to flavor coffee (*Gahwai*). Arabs also adopted a large number of Indian recipes; cardamom is used in rice dishes. Europeans appreciated the exotic flavor of cardamom, and as a result they included it in many food preparations, dishes, confectioneries, and others. In Sweden, cardamom is popular and is included in many baked foods. In addition, cardamom produces colorless or pale yellow oil in small quantities. The essential oil is used not only in perfumes but also in bitters and liquors.

Cardamom is a source of protein (10.8 percent by weight of cardamom seed) and carbohydrates (68.5 percent by weight). In addition, cardamom contains phosphorus, potassium, iron, sodium, vitamin C, calcium, magnesium, potassium, zinc, fiber, iron, and manganese. Cardamom is low in saturated fat, cholesterol, and sodium.

Charalampos Dokos

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Carnation

A perennial ornamental, the carnation is in the family Caryophyllaceae, a Greek term meaning "clove leafed." The carnation's genus, *Dianthus*, contains more than 100 species, several of them also being ornamentals. *Dianthus* is a Greek word for "divine flower." This meaning may derive from the belief that the god Zeus was the guardian of the carnation. The English word "carnation" may derive from the Old English "incarnaycion," which in turn may derive from the Latin *coronarin*, a word that suggests a festive use of carnation. It is possible that the word

Carnations (Cowardlion/Dreamstime.com)

"carnation" comes from the Latin *caro* or *carnis*, meaning "flesh colored." By the 16th century, the English word "carnation" was in widespread use.

Origin and History

One writer believes that the carnation originated in Central and Southern Europe or in Asia. *Dianthus coryophyllus*, the progenitor of all carnations, grows wild in the Pyrenees Mountains of France and Spain. One authority believes that the people of Europe and Asia cultivated the carnation in prehistory. In the fourth century BCE, Greek botanist Theophrastus was the first to describe the carnation. Some scholars believe that the carnation was thereafter absent from the historical record in antiquity and the Middle Ages. Others believe that the Romans cultivated the flower, though like the Greeks, they treated it as an herb and medicine rather than an ornamental. The Romans may have added the carnation to wine to flavor it. One hypothesis, identifying the carnation in the Atlas Mountains of northwestern Africa, asserts that the Romans planted it in North Africa and Spain. The hypothesis that the carnation was a late introduction to Europe implies that the Greeks and Romans did not cultivate it. One authority believes that monks or soldiers brought the carnation to England in the 11th century. The troops of English monarch William the Conqueror may have introduced the carnation to England about 1066. The 14th-century English poet Geoffrey Chaucer may have mentioned the carnation, but some scholars believe he referred to an unrelated plant, *Eugenia* *aromatica*. Another contentious point concerns a portrait of 15th-century English king Edward IV. His hand grasped a flower, which some botanists have identified as a carnation and others as a rose.

By 1500, the people of Turkey, the Middle East, and Europe cultivated the carnation. In 1597, English herbalist John Gerard remarked that the carnation was widely grown. He was the first to mention a yellow carnation, which he received from a merchant, Nicholas Lete, who had acquired it from Poland. English playwright William Shakespeare (1564–1616) mentioned the carnation in *Henry V* and *A Winter's Tale*. In the 17th century, English herbalist John Parkinson described carnations with large flowers. In 1676, John Rea listed 360 varieties of carnation. Germany, the Netherlands, and Flanders were the source of carnations for growers throughout Europe. In the 19th century, Europe hosted exhibitions to showcase the best carnations. Competition was keen. In 1820 London, England, schoolteacher Thomas Hogg catalogued some 500 varieties.

The carnation was the favorite ornamental of U.S. president William McKinley. A friend and gardener who raised carnations stoked McKinley's interest in the flower. The president wore a scarlet carnation on his lapel as a token of good luck. At the Pan-American Exposition in Buffalo, New York, in 1901, McKinley greeted a crowd of visitors. Shaking hands with a long line of people, he encountered a girl who remarked that her friends would not believe that she had met the president. McKinley gave the girl his carnation, urging her to show it to her friends as proof that she had met him. Bereft of his good-luck token, McKinley succumbed to the next person in line, the assassin Leon Czolgosz. Thereafter Ohio, McKinley's home state, adopted the carnation as the state flower. Another admirer of the carnation, Anna Jarvis, considered it the flower of purity, strength, and endurance. Because she believed that these traits were the hallmark of motherhood, she sent 500 white carnations to the Methodist Episcopal Church in Grafton, West Virginia, on the first Mother's Day in May 1908 with instructions to give every churchgoer one carnation and every mother two. In 1909, Jarvis sent 700 carnations to this church. During her lifetime, she gave the church more than 10,000 carnations. By the mid-20th century, the carnation had declined in popularity, though it has rebounded, enjoying some of its former renown. Today, the carnation marks weddings and funerals. California, Colorado, Israel, Kenya, and several countries in Europe and South America are the leading carnation growers.

Attributes, Cultivation, and Types

The carnation needs neutral soil with a pH between 6.5 and 7.5. The gardener should cultivate the soil to the depth of a spade. Carnation benefits from the addition of well-rotted manure, compost, or peat to the soil. The gardener should favor a fertilizer with roughly equal proportions of nitrogen, phosphorus, and potassium at three ounces per square yard. A fertilizer with a ratio of 6:5:4 of nitrogen to phosphorus to potassium may be applied at a rate of two ounces per square yard. One authority recommends the application of 10-10-10 fertilizer. The carnation does well in aerated soil. Rocky soil is ideal. The carnation does not do well in clay and does not tolerate waterlogged soil. It does not thrive in sandy soil because sand does not hold moisture. The addition of potassium to the soil increases the number of flowers and improves their color. The gardener should guard against the indiscriminant use of nitrogen because too much causes the carnation to produce foliage at the expense of flowers. In 1820 Thomas Hogg, perhaps falling into this trap, recommended the addition of chicken and pigeon manure, blood, soot, limen, and gypsum to the soil.

The carnation yields perfect flowers, each with 10 stamens and two or three styles. Petals may be purple, red, pink, yellow, or white. Carnations known as selfs contain one color, whereas fancies have two colors. Among types are annual, border, perpetual-flowering, and malmaison carnations. The name "annual carnation" is misleading because this type, like other carnations, is a perennial. It is known as an annual because gardeners tend to treat it as an annual, planting new carnations every year. Tracing its lineage to the species *Dianthus chinensis* and *Dianthus caryophyllus*, the annual carnation is widely grown in the United States. Reaching a height of one to two feet, the annual carnation produces smaller flowers than those of the border carnation. Annuals will survive mild winters. Popular varieties of annual include Margaerite, Chaband, and Grenadin.

The border carnation is cultivated in the United Kingdom, North America, and New Zealand. A hardy ornamental, the border carnation can survive temperatures as low as –40°F. Growing 15 to 24 inches tall, the border carnation reaches only 6 inches in height when potted. In its second or third year, a plant may yield more than 100 flowers, which are two-and-a-half to three-and-a-half inches in diameter. Border carnations may be selfs, white, yellow, or apricot ground fancies, picotees, or cloves. Selfs may be white, yellow, apricot, pink, scarlet, crimson, gray, or purple. White, yellow, or apricot fancies are striped with another color. Apricot ground fancies may be buff apricot, orange apricot, golden apricot, or coppery apricot. The picotee has small flowers. Border carnations must be staked and for this reason may not be as popular as other types.

The perpetual-flowering carnation, originating about 1850, derives its name from the fact that it bears flowers year-round provided the temperature does not dip below 45°F. The perpetual-flowering carnation is the florist's ornamental of choice. Cut flowers last three weeks in water. The perpetual-flowering carnation may be a cross between the Flemish carnation and the Mayonnais carnation, the latter having been popular in mid-18th-century France. *Dianthus arboreum* may be another ancestor of the perpetual-flowering carnation. Known as the standard carnation, the perpetual-flowering carnation lives two years. It does not tolerate humidity or frost and is grown in greenhouses because it is not hardy. Flowers are 3 inches in diameter on 30-inch stalks. The perpetual-flowering carnation is grown more widely in the United Kingdom than in North America. Dwarfs are popular today and may be selfs or apricot or yellow ground fancies.

The malmaison carnation, popular among the wealthy at the end of the 19th century, may derive its name from its resemblance to the Bourbon rose, Souvenir de la Malmaison. Alternatively, the name may derive from La Malmaison, the residence of French emperor Napoleon Bonaparte and Empress Josephine. Josephine grew carnations in her garden. One authority, however, believes that the malmaison carnation was not cultivated until 1857 and so must not be connected to Josephine. Malmaison needs a drier, warmer environment than the perpetual-flowering carnation. It needs partial shade in summer. Twentieth-century tastes deemed the malmaison carnation old-fashioned, and today specialists grow it.

Christopher Cumo

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Carrot

One scientist judges carrot (*Daucus carota*) the "most important of all the root crops." Tropical varieties of carrot are annual whereas temperate cultivars are biennial, though they are grown as annuals. A biennial carrot fills its taproot in the first year and flowers in the second. The largest portion of a carrot is the edible taproot. In the Umbelliferae or Parsley family, carrot is known a *keroton* in Greek. One cup of carrots has 20,000 international units of beta-carotene, the precursor of vitamin A, four times the recommended daily allowance. The University of Wisconsin has bred carrots with three to five times the beta-carotene of other varieties with the aim of planting these new cultivars in the developing world where vitamin A deficiency is acute. Among its benefits, 18th-century religious reformer John Wesley thought carrot cured asthma.

Origin and History

According to one scientist, the carrot is a variant of the Eurasian flower Queen Anne's lace. It originated in the Himalayan and Hindakush Mountains of Asia and was domesticated in Afghanistan, Russia, Iran, Pakistan, and Turkey. Wild specimens may still be found in southwestern Asia, the Mediterranean Basin, Africa, Australia, and the Americas. Humans first cultivated carrot 2,000 to 3,000 years ago. Archaeologists have found carrot seeds in Switzerland dating to this period. From Afghanistan, carrot migrated to the Mediterranean Basin. By 500 BCE, the Greeks cultivated the root, using carrot juice to treat stomachache. In antiquity, farmers and gardeners grew purple, yellow, or white carrots. The orange carrot would be a latecomer. Arabs may have brought carrot from Afghanistan to Northern and Western Europe. In the ninth century, Frankish king Charlemagne may have known of the carrot, though according to one authority carrot was not introduced into Europe until the 11th through the 14th centuries and into China, India, and Japan between the 14th and 17th centuries. By one account, the Flemish introduced carrot into England in 1558. The orange carrot arose as a sport in the Netherlands in the 17th century. Its superior flavor led to its adoption throughout Europe. In the 18th century, English queen Anne and her friends admired carrots in the royal garden. The queen challenged them to make lace as delicate and beautiful as carrot flowers. The queen's lace was judged the best, and thereafter the carrot flower was known as Queen Anne's lace.

In the 16th century, the Spanish introduced the carrot into the Americas, planting it on the island of Margarita near Venezuela. In either 1609 or 1610, the English may have introduced the carrot into Jamestown, Virginia. Another account holds that the American colonists did not grow carrot until about 1620 and then in Salem, Massachusetts. In the early 17th century, the Dutch derived the cultivar Hoorn, named after Hoorn, the Netherlands. A popular cultivar, Europeans brought it to the American colonies, where it was known as Early Dutch Hoorn. In 1870, Americans planted Danvers, a cultivar named for Danvers, Massachusetts. The variety Nantes originated in Nantes, France.

In 2006, China was the leading producer of carrots. The Chinese interplant carrot with other crops. They add carrots to recipes as a source of color, though they find the root flavorless. The United States ranked third, trailing China and Russia. California produces 80 percent of U.S. carrots. Florida, Michigan, and Washington are also important producers. Americans add carrot to beef or vegetable stew, spaghetti sauce, and minestrone. The carrot is ubiquitous in salad. The French slice carrots, cooking them in chicken broth with parsley and tarragon. The Turks combine carrot with ginger and sour cream, a dish known as carrot plaki. The Poles add cream and dill to carrots. Germans make carrot nut bread, from which Americans derive carrot cake.

Attributes and Cultivation

Carrots have more sugar than any other vegetable except beets. Farmers and gardeners grow carrots for fresh consumption or processing. The carrot may be black, red, yellow, or orange. The essential oils extracted from the roots kill bacteria. The essential oils from the seeds are used to treat kidney ailments and dropsy. The carrot may be planted as soon as the temperature reaches 45°F, though seeds will not germinate until the temperature is at least 68°F. Seeds will not germinate above 80°F according to one gardener or above 86°F according to another. Seeds germinate in 6 to 21 days. Because carrot does not transplant well, it is best planted where the gardener intends to grow it. Some gardeners sow carrot and radish. Radish germinates quickly, marking the spot where carrot will later germinate. Radish roots keep the soil loose for the enlarging carrot taproot. Alternatively, one may plant carrot with bok choy. In 30 to 45 days, the gardener may harvest bok choy, opening space in the garden for young carrots. For a continuous harvest, one may plant new seeds after harvesting half the crop. The carrot reaches the peak of flavor when planted in early spring, though carrot may be planted in late summer for an autumn harvest. Seeds may be planted three-quarters of an inch deep and four inches apart. Carrot grows best between 60°F and 80°F, the tops reaching a height of three-and-a-half to seven-and-a-half inches. The soil should be cultivated deeply and should be loose to allow carrot to enlarge its taproot unimpeded. The soil should drain well to prevent it from harboring fungi. Where the soil is heavy, the gardener may plant varieties with a short taproot. One gardener recommends the application of a balanced fertilizer to the soil. Carrot benefits from the addition of organic matter to the soil. The gardener may add wood ashes to the soil as a source of potassium and to sweeten the flavor of carrot. Carrots may be harvested when they are young for maximum flavor and nutrition. The gardener may leave carrots in the ground, harvesting only as much as she needs for a meal. After a severe frost, all carrots should be picked and stored in a cool, humid place. The tops should be removed.

Science and Breeding

Current cultivars are genetically uniform because they derive from only a few 18th-century Dutch varieties. With the aim of increasing the genetic diversity of current varieties, Russia's Vavilov Institute, named for 20th-century Russian agronomist Nikolai Vavilov, has amassed a collection of more than 1,000 cultivars. The U.S. Department of Agriculture's North Central Regional Plant Introduction Station in Ames, Iowa, has amassed a collection of 800 cultivars. The United Kingdom, France, the Netherlands, and Japan also maintain collections. Worldwide gene banks hold some 5,600 varieties. Breeders aim to derive cultivars with early-maturation, high-yield, high-beta-carotene content; the ability to set seeds under poor conditions; uniform root size, shape, and color; small tops; tender roots; improved flavor, texture, sugar content, and dry matter; resistance to cracking and breaking during the harvest; roots that taper uniformly; slowness to bolt; tolerance of poor soil and climate; wide adaptability; and resistance to diseases, especially leaf blight, black rot, powdery mildew, bacterial soft rot, and carrot yellows, and to pests including caterpillars and the carrot fly.

Bearing perfect flowers and male flowers, a carrot may have more than 1,000 flowers. The outer flowers mature first, though flowers in the core have the most fertile pollen. Each flower has five sepals, five petals, five stamens, and two carpels. Each carpel has two ovules. Because the pollen and ova of a single perfect flower are fertile at different times, the carrot is not normally a self-pollinator. In 1937, scientists made the first hybrid cross of two inbred lines of carrot. Because carrot is, with the aid of insects, a cross-pollinating plant, the production of inbreds reduces the number of seeds. A hybrid yields a taproot three times more massive than the root of either parent. Hybrids have more beta-carotene than the parents. The degree of heterosis, hybrid vigor, is 20–22 percent higher when one parent in the cross is male sterile than when neither parent is male sterile. Male sterility is of two types. In the first, the anthers shrivel before anthesis and so do not shed pollen. In the second case, a flower does not produce anthers. The second type of sterility is more commonly used in breeding programs. Male sterile plants are therefore useful only as the female in a hybrid cross. In 1953, scientists discovered the first male sterile carrot near Orleans, Massachusetts, naming it the Cornell cytoplasm. The Cornell cytoplasm has been used to produce the majority of U.S. hybrids. Hybrids are three-way crosses. First, the breeder crosses two inbred lines to yield hybrid progeny. Second, these progeny are crossed with another line, presumably a cultivar rather than another inbred, to yield a second-generation hybrid. In the production of a hybrid, the breeder discards progeny with undesirable characteristics, for example bolting, poor color, or irregular length or shape of the taproot.

Christopher Cumo

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Cassava

A perennial shrub in the Euphorbiaceae family, cassava, like the sweet potato, develops from a root. It does not produce tubers notwithstanding the tendency of one scientist to refer to cassava as a tuber. Accordingly, cassava is not closely related to the potato. Like sugarcane and several other plants, cassava is propagated from sections of stem. The Tainos of Hispaniola (now the island of Haiti and the Dominican Republic) who greeted Spanish explorer Christopher Columbus in 1492 called cassava *casabe* or *cazabe*, which the Spanish misunderstood as *cassava*. The Tupi-Guarani Amerindians of the Amazon River valley called cassava tapioca and used the pulp from the root in pudding. So important is cassava that the people of Ghana, Togo, and Benin know it as *agbeli*, meaning "there is life." Other names for cassava include manioc, manioca, mandioca, Brazilian arrowroot, and yucca. The scientific name *Manihot esculenta* refers only to cultivated varieties of cassava. No wild varieties of this species exist, suggesting that cassava has long been in cultivation. Cassava is low in fat, cholesterol, and sodium. It has vitamin C and manganese. One hundred grams of cassava contain 550 calories, 30.5 grams of carbohydrate, and 2 grams of fiber.

Cassava (Satit Srihin/Dreamstime.com)

Origin and Diffusion

A New World cultigen, cassava may be descended from the wild *Manihot flabelifollia*. One school of thought places the origin of cassava south of the Amazon River in Brazil. Another school of thought proposes broadly that cassava originated in Mexico and Central and South America. From this region, cassava spread to the Caribbean at an early date. The Amerindians of Brazil cultivated cassava as early as 8000 BCE, a date that makes the root among the oldest crops. One authority holds that humans began growing cassava as early as 7000 BCE. This antiquity draws strength from the observation that humans may have domesticated vegetatively propagated crops before seed crops. As early as 1827, one researcher posited Brazil as the region where cassava culture began. By 6600 BCE, farmers were growing cassava in lands along the Gulf of Mexico. The Tapi-Guarani grew cassava about 3000 BCE in Colombia and Venezuela. The Peruvians began to grow cassava about 2000 BCE. The Mexicans were growing cassava by the time of Christ. From antiquity, cassava was grown intensively in northern and eastern Brazil, southern Brazil and eastern Paraguay, Colombia, Cuba, Haiti, and the Dominican Republic. Not everyone accepts a date of great antiquity. Those who hold out for a later period assert that the most ancient fragments of cassava date only to 600 CE in El Salvador.

The Maya, who may have cultivated cassava first in the Yucatan Peninsula, and the Aztecs cultivated different types of cassava. The Maya grew sweet varieties, which had little hydrocyanic and prussic acid, toxins that can be fatal if ingested. Because sweet varieties had few toxins, they were safe to eat. The Maya may have eaten cassava raw or cooked. The Aztecs on the other hand grew bitter varieties. These had high concentrations of toxins and so were lethal if not prepared properly. To remove the toxins one may grate the root, allowing the liquid to drain. Alternatively, one may soak cassava in water for five hours, a process that allows the enzyme linamarese to degrade the toxins. A third option is to ferment cassava in water for several days, a process that renders the toxins harmless.

By the 15th century, the people of Mexico, Central and South America, and the Caribbean cultivated the root. The Tainos brought cassava to the attention of Columbus, preparing cassava bread for him. The Spanish thought the bread, which in the absence of yeast was not leavened, insipid, ranking it well below wheat bread. Cassava bread, whatever one thought of its taste, could be stored as long as two years without a loss in quality. Cassava bread was a staple of commoners. The Amerindians issued it as a ration to soldiers. Some Amerindians ate unprocessed cassava to kill themselves so that they would be free of Spanish oppression.

Notwithstanding the judgment of Columbus and his party, cassava, once adopted by the Spanish and Portuguese, spread throughout the tropics of the Old World. In the 16th century, the Portuguese brought cassava from Brazil to Africa, using it to feed slaves aboard ship. The root quickly became a staple in Cameroon, Gabon, the Congo, and Angola. In the 18th century, the Portuguese introduced cassava to the island of Reunion and from there to Madagascar, Zanzibar, and India while the Spanish planted it in the Philippines and Southeast Asia. Thailand quickly emerged as an exporter. By 1850, cassava was widespread in Africa and Southeast Asia. By 1900, farmers everywhere in the tropics grew cassava.

Cassava in the 21st Century

In 2002, Africa was the largest producer of cassava. Asia ranked second, and South America occupied third place. Asia boasted the highest yield per acre and Africa the lowest. In 2008 the leading producers were Nigeria, Thailand, Indonesia, and Brazil. Nigeria, the Congo, and Tanzania produce the majority of Africa's cassava. In East and West Africa, less than half of the harvest goes to make flour and pellets. The leading exporters are Thailand, Vietnam, Indonesia, and Costa Rica. Thailand, Vietnam, and Indonesia account for the majority of the world's exports in the form of starch and pellets. Worldwide 80 countries, all of them in the tropics, grow cassava. As a source of calories, cassava ranks third behind rice and corn in the tropics. Cassava ranks second to corn in tonnage. In southern China, cassava ranks fifth in tonnage behind rice, sweet potato, sugarcane, and corn. Unable to meet demand through domestic production, China imports cassava from Vietnam and Thailand. China converts a portion of its harvest to ethanol much as the United States converts corn to ethanol, a practice that may increase demand for the root. Brazil harvests the majority of the Latin American crop. Brazil, Colombia, Cuba, Haiti, Paraguay, Peru, and Venezuela produce virtually all Latin American cassava. According to one authority, cassava yields more calories per acre than any other crop, though this honor may belong to sugarcane. Cassava may be the world's least expensive "source of starch." Today, the root supplies one-sixth of the daily calories of the people of Madagascar, Ghana, Nigeria, Liberia, the Congo, Uganda, Tanzania, and Mozambique. In Ghana and Nigeria, per person consumption of cassava has increased in the last 40 years, whereas consumption has declined in the Congo, Tanzania, and Uganda.

Intolerant of frost, cassava is grown between 30° north and 30° south and at elevations no higher than 6,000 feet above sea level. Cassava needs a temperature between 64°F and 77°F and 2 to 200 inches of rain per year. Tolerant of acidic and alkaline soils, cassava may be grown in soil with a pH between 4 and 9. Cassava yields best in sandy loam. High humidity favors the growth of roots. Because cassava tolerates low rainfall, it is a famine food, supplying calories and some nutrients when other crops fail. Some Africans eat cassava every day, sometimes at breakfast, lunch, and dinner. In Africa, nearly half of the population eats cassava as the primary food. One might question whether cassava deserves to be a dietary staple. Seventy percent water, the dry matter of the root is carbohydrate, 64–72 percent of its starch. The root has only 1–2 percent protein, an amount that compares poorly with the protein in legumes and grains. Cassava has vitamin C and calcium, but little thiamine, riboflavin, and niacin. So deficient is cassava in iodine that women in the Congo who eat primarily the root develop goiter. After the harvest, roots begin to rot within two days, making it imperative that they be processed or eaten quickly. Perhaps because cassava has toxins, is vulnerable to insects and diseases, deteriorates rapidly unless processed, and has little protein, researchers have not lavished the money on the root that corn and soybeans have received. Cassava, unlike corn, has few uses aside from the feeding of humans. The people of Africa eat most of the harvest. Less than 10 percent goes to livestock and industry. Industry uses cassava starch in the manufacture of clothes, adhesives, packaging material, food products, pharmaceuticals, and batteries. In Africa as elsewhere, corn rather than cassava feeds livestock. In an effort to increase the use of cassava as livestock feed, Nigeria refused to import corn in 1985. In the 1980s, high grain prices led Europeans to import cassava from Asia and Latin America to feed livestock. After 1992, the decline in grain prices caused European stockmen to jettison cassava for corn.

Small farmers grow most cassava, using it for their own sustenance. Most cassava, destined for the dinner table, never enters the market. Farmers who grow corn and cassava do not harvest cassava unless corn yields poorly. In this circumstance, farmers harvest cassava to stave off hunger. Farmers may leave cassava in the ground as long as four years without a loss in quality. In the Congo, farmers have adopted cassava because of its drought tolerance. Cote d'Ivoire, Ghana, and Uganda grow sweet varieties of cassava, whereas the Congo, Nigeria, and Tanzania grew bitter varieties. Most cassava varieties are bitter, perhaps because they are more resistant to insects and disease than sweet varieties. Today, high-yielding cultivars increase yields 40 percent over traditional varieties.

Some farmers fallow cassava land, especially where population is sparse. Throughout Africa, farmers grow cassava in preference to yams. It competes well with millet, banana, and yams. In West Africa, farmers intercrop cassava with yams. In Nimbo, Nigeria, farmers plant yams, corn, and melon in April and cassava in June. After the harvest, farmers fallow the land three years. In Uganda, banana is the primary crop and cassava secondary. Farmers intercrop cassava with corn, beans or peas, millet, and sesame. They plant cassava in March, harvesting it in November. Fallowing the land four months, they replant it to cassava. Where the soil is poor, farmers plant cassava rather than banana. Throughout the tropics, farmers intercrop cassava with beans, peas, soybeans, mung beans, peanuts, banana, plantain, rice, millet, sorghum, yam, and sweet potato. In the Congo and Tanzania, people eat cassava leaves as a vegetable, though they must be cooked to destroy the toxins. Leaves have more protein than the root as well as vitamins A and C, calcium, and iron. Despite these nutrients, Ugandans consider the leaves a food of the poor and so will not eat them. Although cassava is a subsistence crop, it has grown in importance as a cash crop in recent years. In Africa and South America, middlemen buy cassava from farmers, transport it to market, and sell it for profit. In India, Brazil, and Nigeria, women do much of the work of tending cassava. In Nigeria, half of all working women are cassava farmers, though they earn little money. Whereas men clear the land, plow it, and plant cassava, women weed the land, harvest the roots, and process them. Men prefer to take wage labor rather than to grow cassava. Women's contribution to the cultivation of cassava is especially large where it is a subsistence crop. Men do more work where cassava is a cash crop. Cassava's popularity may be ebbing. As its price has increased, the poor have had to buy cheap rice.

Cassava is a staple in the cuisine of several people. Rwandans combine cassava and beans. Liberians make gari foto from cassava, onion, tomato, and egg. Fufu, another Liberian dish, combines cassava, vegetables, and meat or fish. The people of Thailand coat fish, shrimp, or squid with cassava starch, frying the dish. In Kerala, India, cassava and fish are a popular combination. Cassava bread is widespread throughout the Caribbean. Puerto Ricans make chili de yucca from cassava and beans. Guatemalans make cassava soufflé. Peruvians combine cassava, cheese sauce, and chili peppers. Colombians make yucca frita by frying slices of cassava much as Americans make fries from the potato.

Diseases, Pests, and Weeds

Pathogens and pests are numerous in the tropics, and cassava suffers from several of them. Fungi afflict many plants. In the case of cassava, however, viruses appear to be the principal threat. Widespread in the Americas is Cassava Common Mosaic Virus, which has reduced yields more than 30 percent in Brazil, Peru, Colombia, and Paraguay. Worrisome is a new variant of the virus, which appeared in Venezuela in 1995. In Africa, the threat comes from African Cassava Mosaic Disease, which is the continent's most damaging disease and the most significant insect-borne disease of cassava. Scientists initially blamed the disease on African Cassava Mosaic Virus, which the whitlefly *Bemisia tabaci* transmits to cassava. Scientists identified African Cassava Mosaic Virus as early as 1891. As late as 1959, the virus was virtually the only threat to cassava in Africa. Since then bacterial blight, the mealybug, and the cassava green mite have assailed the root. African Cassava Mosaic Virus is not alone in causing African Cassava Mosaic Disease. East African Mosaic Virus and South African Mosaic Virus also cause the disease. Often more than one virus attacks a plant. One study found the disease in more than 80 percent of cassava plants in West Africa. Uganda has suffered severe infections of the disease. *Bemisia tabaci* has migrated to Cuba and Brazil, leading scientists to fear that the disease will follow. Latin American cultivars appear to be especially vulnerable to African Cassava Mosaic Disease. The bacterium *Xanhomonas axonopodia* causes cassava bacterial blight, which has led to the total loss of the cassava crop in the worst infections. The disease spreads through stem cuttings, which, when sown, germinate infected plants. In 1972, scientists pinpointed the disease in Nigeria. During the 1990s, the bacterium spread throughout Africa. Damp weather hastens the spread of the bacterium, which reduces yields and sometimes kills plants by defoliating them. Nigeria has reported severe losses from the disease.

In Africa, the most serious pests are the mealybug and the cassava green mite. Native to South America, they are troublesome because they have no natural predators in Africa. In 1973, the mealybug migrated to the Congo, from where it has spread throughout Africa. The bug feeds on the stem, petiole, and leaf. Conscious of the lack of natural predators, scientists in 1981 released a species of wasp that feeds on mealybugs. By 1990, the wasp had established colonies in 24 African countries. First reported in Uganda in 1971, the cassava green mite, native to Colombia, reached West Africa in 1979. Sucking sap from cassava leaves, it weakens plants. In the 1990s, scientists identified three species of mite that prey on the cassava green mite and released them in Benin in 1993. Despite this effort at biological control, green mites remain entrenched in Africa, threatening the cassava crop. In Latin America, mites of several species, cutworms, scales, and lace bugs plague cassava. The worst pests are the hornworm and stem borer. The stem borer has caused severe losses in Colombia. Insecticides are effective, but many farmers cannot afford them. Genetically engineered cassava holds the promise of helping these farmers. Genetically engineered varieties have genes from the bacterium *Bacillus thuringiensis*, which code for the production of a chemical toxic to insects. This toxin does not harm humans, making genetically engineered cassava safe to eat. The success of Bt corn leads one to hope for similar success from genetically engineered cassava. Also damaging are termites, which feed on cassava stems, and rodents, which devour roots.

Cassava does not compete well against weeds. Their presence lowers yields 40 to 70 percent. To combat weeds farmers have increasingly relied on herbicides in Africa and South America, though the poor cannot afford them. The derivation of herbicide-resistant cassava may not, in increasing the reliance on herbicides, help poor farmers. It is unclear whether herbicide resistant cassava will be as successful as herbicide resistant soybeans.

Christopher Cumo

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Castor Bean

Castor bean, or ricinus, is a plant that belongs to the family Euphorbaceae and is therefore not a true bean. The seeds of the castor bean plant resemble a tick, which has led scientists to name it *Ricinus communis*, also translated as "common tick." Known as the most toxic plant in the world, ricinus is a favored plant for scientific study and also for forensic research.

Cultivation

Castor bean is region sensitive. That is, it may be either an herb or a shrub and an annual or a perennial depending on the habitat. It is a native of Africa, parts of the Middle East, and India, where it has been cultivated for thousands of years. More recently, it has been cultivated in South America and also in the southeastern United States. It thrives in dry to tropical climates and requires moist and well-manured soil, full sun, and a slightly acidic to neutral soil of pH ranging from 6.1 to 7.5. According to the U.S. Department of Agriculture hardiness chart, ricinus is adapted from zones 9a to 11. Castor bean drains the soil of its nutrient and depletes it of nitrogen. This can be a cause for concern if this plant spreads to areas of other crops.

The castor plant is regarded as a noxious weed that can become difficult to control if left unchecked. In the United States, the main states for castor cultivation are Florida, Texas, California, Arizona, Alabama, North Carolina, and Georgia. It is commonly found near rivers and streams or alongside rail tracks or roadways.

Botany

Ricinus possesses a taproot that is branched. Stems range from a few feet to 15 feet in height. When ricinus plants are herbs, their stems are tender and slim. In shrubs, the main stem can get tough and hard. Stems, greenish blue in color, are referred to as glaucous and are free of stem or leaf hairs (glabrous). Most often as the plant gets older, the stem turns woody at the base (suffrutescent) for the herbaceous subspecies. Stems branch profusely with branches red, green, or purple in color. Stems are also erect and cylindrical.

Leaves are alternate, simple, with a leaf petiole each, broad and in the shape of a palm, also referred to as palmately lobed. Lobes are like six to eight leaflets united at the base margins. The edges of the leaves are serrated or toothed and with a reticulate or network-like vein pattern.

The inflorescence is a terminal panicled cyme. Here, the flower stalk is a long peduncle sometimes growing to a length of 20 inches. On it, male flowers are arranged at the lower half while the female flowers are at the upper half. Flowers are unisexual and both types of flowers are found on the same plant (monoecious). Flowers are actinomorphic and can be cut into halves along any plane of their cross section. Flowers are also described as incomplete as they may lack either the female or the male reproductive flower parts, or the petals. They are also hypogynous, where the ovary of the flower is raised above the other flower parts. The male flowers can be identified by their pale green color, many stamens, and branching anthers. Petals and pistil with ovary, style, and stigma are absent. Female flowers are showier. There are no petals as in the male flowers. The female flower has many green-colored, spiny outgrowths, and three bifid stigmas, which are bright red. There are three seeds per female flower. The fruit is a capsule that is schizocarpic or splits up into three separate locules upon maturity. There are many spiny outgrowths on the fruit. The seed is oval, brown, and shaped like a tick—hence the name ricinus, which is the Latin name for "tick." Each plant can produce as much as 10,000 seeds.

Toxicity

The castor plant is considered to be the most toxic plant in the world. Every part of the plant is poisonous, the seeds being the most lethal. The plant contains a protein toxin called ricin, which, when consumed, ingested, inhaled, or injected, affects metabolism of the animal cells. When consumed, this toxin replaces particular enzymes that are responsible for protein synthesis. When proteins are unable to be synthesized due to the lack of the protein-synthesizing enzymes, degeneration of the cells happen, causing the death of the organism. While seeds are the most toxic part of the plant, swallowing seeds whole does not cause as many problems as seeds that are broken down or chewed. Whole seeds are likely to be expelled through the digestive track, but broken or opened seeds can be fatal as early as two hours of consumption. As few as two to four seeds are enough to be fatal in children.

Uses

Apart from their toxicity, castor beans are a source of castor oil. Castor oil is extracted from the seeds by a process of pressing. The oil does not contain the toxin; however, the toxin remains in the seed cake that is the residue from the oil press procedure. The oil is used as a purgative and as a lubricant. It is also used in the soap industry for the manufacture of textile soaps and transparent soaps. Other uses of the oil can be seen in the manufacture of typewriter inks, paints, varnishes, perfumes, and aromatics.

In India, castor oil is regarded with great respect and is one of the most important of oils in ayurvedic medicine for the treatment of arthritic ailments, dating back to 2000 BCE. Castor oil is also used in massage therapies. In Egypt, it is believed that first-century BCE pharaoh Cleopatra used it to massage her skin and to brighten the white of her eyes. It has also been used as an oil to light lamps.

There are virtually no pests known to attack ricinus. Beetles and aphids that feed on its leaves die from poisoning.

On an international security front, ricinus is a plant that is always under vigilance. Ricin has been used in international terror plots, in assassinations, and in attempted creation of weapons of mass destruction. Inhalation, consumption, and injection are the three ways that ricinus can affect an organism. However, while acute poisoning may not happen due to touch, the ricinus plant is known to cause skin allergies. Hence gloves are a necessity in the handling of *Ricinus communis*.

Amanda Mittra

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Cauliflower

A cole crop, cauliflower (*Brassica oleracea* ssp. *botrytis*) is related to broccoli, cabbage, kale, and kohlrabi. With a reputation as a difficult plant to cultivate, cauliflower is sensitive to variations in soil pH, moisture, and temperature. The immature flower buds are edible. These buds are reproductively inactive in the sense that less than 10 percent flower. In addition to white, flower buds may be purple, lime green, or orange. A temperate plant, cauliflower is not grown in the tropics. Most cauliflower varieties are annuals, though a few are biennials.

Origin, History, Attributes, and Cultivation

Cauliflower may be descended from a wild cabbage that grew along the coast of Europe. Cauliflower has been an important crop only since the 18th century. The United States grows half as much cauliflower as broccoli, though the demand for cauliflower has increased in recent years. California grows most U.S. cauliflower, which is harvested in the southern Imperial Valley in autumn and winter and north in Salinas in summer. In addition to California, cauliflower is grown on Long Island and the coast of Washington and in western New York, Texas, and the mountains of Colorado.

Cauliflower needs exposure to full sun. Seeds, planted either indoors before the last frost or outdoors a few weeks before the last frost, germinate in 3 to 10 days. Cauliflower needs at least eight weeks of cool weather, so it should be grown in spring or autumn. When planted in spring, cauliflower may be started indoors six to eight weeks before the last frost. Tolerant of light frost, cauliflower does not tolerate severe frost, hot sun or high temperature. Cauliflower bolts in warm weather or with too little moisture. When seedlings are two inches tall, they are ready to transplant in the field. Seedlings taller than two inches may not develop properly and should either be discarded or transplanted at once. When planted in spring, cauliflower yields a summer crop. The gardener may plant cauliflower in midsummer for an autumn harvest. As a rule, the later cauliflower is planted the larger it grows. One authority advises the gardener to wet the soil the day before transplanting seedlings. Germinating between 68°F and 86°F, cauliflower grows best between 60°F and 70°F.

The head of a cauliflower plant contains the edible portion and is a composite of tightly packed flower buds called curds. When a head is two to four inches in breadth, it may be blanched by folding the outer leaves over it. Some varieties grow leaves that cover a head without human aid and are known as self-blanchers. When a head is firm, it is ready to harvest. As a rule, cauliflower is ready to harvest roughly 60 days after transplantation, though the number varies by variety. If left on the plant too long, a head discolors and becomes loose. The head and leaves may turn brown if temperatures are too cold, the soil is deficient in boron, or nitrogen is in excess. Cauliflower forms a head about 63°F. Above 68°F a head will be of poor quality, and above 77°F no head will form.

One gardener recommends that the soil be prepared two years prior to planting cauliflower to give the ground time to settle. At this time, the gardener should add compost or manure to the soil to increase its content of organic matter. The addition of organic matter is important to retain moisture in the soil. Cauliflower should not be planted in loose soil because the roots must be able to anchor in the ground. A plant that does not anchor firmly yields a small head of poor quality. The gardener should choose heavy, fertile soil because it retains moisture. Light soil is ill suited to cauliflower because it does not retain moisture and because cauliflower produces loose heads.

Cauliflower is a heavy feeder of water and nutrients. Irrigation is necessary on light soil or where the climate is dry. The gardener should not allow the soil to dry out. The soil should be mulched to retain water and minimize weeds. Cauliflower benefits from the addition of manure and fertilizer. In the United Kingdom, some farmers add chicken manure, guano, and soot to the soil. One recommendation urges farmers to add to the soil 11 to 33 tons of manure per acre. In the Netherlands one study documented the benefits of applying to the soil 176 pounds of nitrogen per acre. Where nitrogen is in shortage, cauliflower grows poorly. One recommendation calls for the addition to the soil of 264 to 440 pounds of ammonium sulfate, calcium nitrate, or Chilean nitrate per acre. During the growing season, the farmer should add one to three dressings of 132 to 264 pounds of nitrogen per acre. Where possible, cauliflower should follow a legume to benefit from residual nitrogen in the soil. In the Netherlands, research confirmed the value of adding 176 pounds of phosphorus pentoxide or between 176 and 440 pounds of superphosphate per acre. Some farmers have used as much as 700 pounds of superphosphate per acre. One study recommended the addition to the soil of at least 220 kilograms of potassium oxide or between 88 and 440 pounds of potassium chloride per acre. The farmer who uses potassium chloride must guard against adding too much chlorine to the soil because of its toxicity. Potassium sulfate may be substituted for potassium chloride. One gardener recommends that the soil pH be between 6.5 and 7.5. Another favors a value of at least 6.8. A third puts the figure at 7 when the soil has 2.5 percent organic matter and 6 when the soil has 8–10 percent organic matter. At low pH, manganese reaches toxic levels and molybdenum becomes unavailable. The gardener should not grow cauliflower on the same land year after year because pathogens may accumulate in the soil. Likewise, cauliflower should not be planted where another cole crop has been grown.

Nutrition and Preparation

One hundred grams of fresh cauliflower have 26 calories, 4.5 grams of carbohydrates, 2.3 grams of protein, 0.3 gram of fat, 0.9 gram of fiber, 20 to 22 milligrams of calcium, 30 to 72 milligrams of phosphorus, 0.5 to 1.1 milligrams of iron, 15 to 24 milligrams of sodium, 300 to 350 milligrams of potassium, 85 milligrams of sulfur, 29 milligrams of chlorine, 18 milligrams of magnesium, 50 to 91 milligrams of vitamin C, 0.03 milligrams of beta carotene, 0.11 to 0.15 milligram of thiamine, 0.1 to 0.12 milligram of riboflavin, 0.6 milligram of niacin, 0.2 to 0.7 milligram of pantothenic acid, 0.01 to 0.04 milligram of folic acid, and 0.09 to 0.32 milligram of vitamin B6. Cooking reduces the amount of vitamins and minerals. The longer cauliflower is cooked the greater the losses. Cooked cauliflower has 28 milligrams of vitamin C, 0.02 milligram of beta-carotene, 0.06 milligram of thiamine, 0.08 milligram of riboflavin, and 0.5 milligram of niacin. Cooked in one-quarter cup of water, cauliflower loses 8 percent of its calcium, 11 percent of its iron, 9 percent of its magnesium, 1 percent of its potassium, 27 percent of its vitamin C, 26 percent of its thiamine, 16 percent of its riboflavin, 15 percent of its niacin, 31 percent of its pantothenic acid, 50 percent of its folic acid, and 36 percent of its vitamin B6. An hour of cooking may reduce vitamins and minerals 60–80 percent. A whole cauliflower head should be cooked 3 minutes in a pressure cooker, boiled 20 to 30 minutes, or steamed 25 to 30 minutes. Small sections of a head should be cooked 1.5 to 3 minutes in a pressure cooker, boiled 8 to 15 minutes, or steamed 10 to 20 minutes. Yet the temptation to overcook cauliflower may be appreciable because, having few sulfur compounds, its flavor does not deteriorate with long cooking. The smaller the amount of water used in cooking the fewer vitamins and minerals are lost.

A light frost does not diminish the amount of vitamin C in cauliflower, but a severe frost reduces it. Molybdenum-deficient soil produces cauliflower with little vitamin C. Young cauliflower plants have more vitamin C than mature plants. Cauliflower loses vitamin C during storage. Cooking may reduce vitamin C content 50–75 percent. If not consumed promptly, cooked cauliflower loses 10–25 percent of its vitamin C. Not a rich source of calcium, cauliflower has only 10 percent as much of the mineral as do kale and collard.

Cultivars

Suitable to regions with a short growing season, Early Snowball matures in 50 to 60 days after transplantation. A dwarf, Early Snowball yields a compact, white head. Suitable for canning or freezing, Super Snowball matures in 55 to 60 days. A dwarf, Super Snowball has blue-green leaves and a white head. Maturing in 60 to 65 days, Snowdrift is a large plant that yields a large head. Danish Giant, also known as Dry Weather, is unusual in tolerating a dry climate. Grown in the Midwest, Danish Giant matures in 70 to 80 days, yielding a white head seven inches in breadth. Self-Blanche, as the name suggests, blanches its head without human assistance. A late variety, Self-Blanche produces seven- or eight-inch heads. A hybrid, Snow King matures in 55 days. Growing vigorously, Snow King is unusual in tolerating heat. Its head may weigh more than two pounds. A hybrid, Snow Crown is similar to the snowball varieties. Another self-blancher, Purple Head has distinctive purple curds. Yet another self-blancher, Early White Hybrid yields a head as large as nine inches in breadth. Gypsy is unusual in growing vigorously even in poor soil. It yields a large white head. Romanesco has a distinctive chartreuse head, though scientists debate whether the variety is cauliflower or broccoli. An heirloom variety, Igloo may be planted densely for a small head. Graffiti has a large purple head that retains its color during cooking. Winter varieties, among them Early Pearl, Christmas, February, March, Saint Valentine, and Late Pearl, mature in 150 days. Farmers grow them on the coast of California. In many cases, the name reflects the time of harvest.

Christopher Cumo

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Cedar

Fragrant, stately, and useful, cedar has been important to humans from antiquity to the present. Through the ages, Native Americans used cedar for canoes, shelter, furniture, tools, clothing, and medicine, and as a prominent character in myths. Today, we relax on cedar decks, store blankets in grandma's cedar chest, and keep bugs at bay with cedar-based pesticides. In botanical terms, most cedars are not true members of the Cedrus family, which contains merely three Old World species. These may be geographical variants of the same original species. In the New World, people have erroneously attributed the cedar-like characteristics of fragrant, reddish wood with fan-shaped branches of overlapping scales rather than needles, to trees and shrubs in the large Cypress family. The proper scientific designations include *Thuja*, *Chamaecyparis*, *Calocedrus*, and *Juniperus*.

Western Red Cedar

Champion among these is the remarkable, majestic western red cedar, *Thuja plicata*, of the Pacific Northwest. Renowned more for its usefulness than as a decorative landscape plant, this giant conifer, or cone-bearing evergreen, reaches a height of 200 feet under favorable conditions. The ideal climate is the temperate rain forest along the 2,000 miles of Pacific Coast of what are now southern Alaska, British

Columbia, Washington State, and Oregon. Ocean currents and jet streams driving across the Pacific Ocean maintain a temperature above freezing while lavishing a prodigious amount of rain up the steep slopes of the coast range. The 160 to 200 inches of rain per year and nearly year-round moisture, and the mild growing season produce the massive straight trunks with wide, fluted bases. Such wood in the hands of craftsmen yielded giant canoes. Several dugout canoes, plus innumerable smaller items, could be made from one tree. Whether a large ocean-going vessel or a smaller craft to maneuver inlets and rapids, cedar canoes were prized for their strength and admired for their excellence. Canoes were decorated with carved and painted images and designs that added a final statement of their utility and importance. At up to 65 feet long and 4 feet wide, the biggest dugouts were perfectly suited for transporting goods along the varying conditions of the coast, making trade flourish from Alaska to Mexico at a rate unique to Pacific coast peoples.

The Nuu-chal-nuth or Nootka of Vancouver Island and the Makah across the Strait of Juan de Fuco on Washington's Olympic Peninsula hunted sea mammals and ventured far out onto the ocean for whales, where swiftness and maneuverability were premium. Extra thickness left on the bottom contributed to the canoes' stability. On less benevolent missions, canoes would carry back loads of plunder, hostages, and slaves captured from battles waged by aggressive cultures such as the Haida of the Queen Charlotte Islands. So ideal were the dugout canoes that they were a hot item of commerce and a source of serendipity. It is not hard to imagine the delight of a southern tribe such as the Chumash on finding cedar logs that had drifted down the coast to what is now California. They built effective seaworthy boats by splitting and lashing together cedar planks rather than using the dugout method. Their crafts were flat-bottomed and smaller, but also elaborately decorated.

When dugout canoes returned from fishing, whaling, trading, or battles, they were pulled up onto the beaches of coves, islands, bays, or river banks. Their passengers and crews then entered houses, also constructed of cedar. Logs of various sizes formed the framework with planks as long as 40 feet, 3 feet wide, and four inches thick for the walls. Overlapping sections of bark formed the roofs. Within each home were myriad other items of cedar: furniture, storage boxes, baskets, fishing nets, tools, food containers, ceremonial masks, ropes and straps, and even clothing.

Cedar bark can be softened by pounding. Then the tribe's women could cut it into strips and weave clothing and blankets. "Dance aprons" resembled grass skirts. Cedar's versatility extended to the roots, which could be woven tightly enough to make watertight baskets and raincoats. More dramatic applications of cedar included ceremonial gear and armor. Wooden slats were formed into panels of vertical strips held together with sinew. Paneled tunics and heavier armor were joined by carved helmets to complete the battle garb.

Some villages were small, just several extended families, each with its own home. In other instances, hundreds of people formed a large community that included communal buildings. Next to homes of dominant families in the hierarchy stood carved cedar totem poles to represent the importance of the inhabitants, the spirits allied with them and ancestral histories and major events. Families of higher status gained and maintained their wealth through control of cedar groves, hunting and fishing grounds, and other natural assets of the tribe's territory.

Other Cedars

Not many yards can accommodate the big western red cedar. However, it can be grown and is popular as bonsai. Many Web sites explain how to soak the cones to obtain seeds and how to grow and graft the saplings into artistic expressions of their huge versions. Also, plenty of smaller shapes and sizes of other cedar-like evergreens thrive for the home gardener.

Thuja occidentalis, called northern or eastern white cedar, or eastern arborvitae, is the tall, narrow evergreen of countless privacy hedges and windbreaks. The popular modern variety is "Emerald green," and it will recover from severe trimming or snow damage. Arborvitae came to the rescue of French explorer Jacques Cartier's 1535 expedition along the Saint Lawrence River. A native guide brewed bark and leaves, which contained enough vitamin C to alleviate the men's scurvy. Asthma and arthritis were two other afflictions treated by the use of cedar ingredients.

Incense cedar, *Calocedrus decurrens*, showcases aromatic wood. The attractive bark grows in distinctive layers of slanted strips that look like lattice. The oils in mature wood and bark are responsible for the fresh scent as well as the toxic repellant terpene thujone that inhibits decay, fungi, and insects. Its other claim to fame is as the eco-friendly main source of pencil wood. The soft wood is easy to sharpen and rarely splinters. This slow grower is drought tolerant and withstands both high and low temperatures in its southern Oregon and Sierra Nevada range.

Atlantic white cedar, *Chamaecyparis thyoides*, does well in moist soils, along ponds and in swampy areas. Native to the East Coast wetlands from Maine to Florida, western Florida, and Mobile Bay on the Gulf Coast, much of the original forests were cut and drained for agriculture by European settlers. Early land speculators of the Great Dismal Swamp in New Jersey included George Washington. Much swamp cedar was used to produce charcoal for the manufacture of gunpowder for Revolutionary troops. In New Jersey in 1791, pirates were to blame for deforestation as more than 5,000 acres were burned in an effort to eliminate their hiding places.

White cedar is in demand for lumber and other products. Restoration efforts are under way to meet consumer demand as well as ecological considerations to reestablish the woods. Natural and nursery methods to improve propagation are under study and development. Eastern red cedar, *Juniperus virginiana*, is another source of moth-repelling, reddish wood. As a note of trivia, this wood led to the name, Baton Rouge, so called by the French Canadians of Louisiana.

True Cedars

The three true cedars are *Cedrus libani*, *Cedrus atlantica*, and *Cedrus deodara*. In the *Epic of Gilgamesh*, the gods lived in a cedar forest. Those enchanted woods could be the Himalayas of the deodara, the eastern Mediterranean mountainous region including Lebanon, Syria, and Turkey of the libani, or the Atlas Mountains of northwestern Africa of the atlantica.

None of the big evergreen true cedars has more distinction in history than the *Cedrus libani*, the Cedar of Lebanon, legendary as the material for King Solomon's temple. A biblical reference in Ezekiel closes with the line, "nor any tree in the garden of God was like unto him in his beauty." Praise enough to make any gardener with room want to grow one as a focal point.

Heights of 50 to 90 feet are not the main consideration. The Lebanon cedar grows massive horizontal branches reaching 30 to 50 feet around the base. This size makes the tree perfect for sweeping across a mansion's lawn or a public park's open area, or for making a focal statement near a monument. The Lebanon cedar is easy to grow from seed and unfussy about soil, which it prefers alkaline. Much real estate can be saved if cedar is grown as a bonsai. The clusters of small needles on the true cedars, especially the atlas cedar, contribute to their veracity of appearance as bonsai.

Whether in yards or ceramic containers, the blue cultivar of atlas cedar rivals the blue spruce for bringing stunning silvery blue to a landscape's palette. Make it the weeping variety and it becomes a conversation piece. With support and training, it grows horizontally with narrow elegant branches hanging down, making a magnificent living fence and truly an unfussy focal point.

Tamara Stromquist

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Celandine

A native of Europe and western Asia, celandine has been naturalized across the United States. Celandine belongs to the poppy family Papaveraceae and has the Latin name *Chelidonium* as the genus. The plant's Latin name is derived from the Greek word *chelidonia*, meaning "of the swallow," and refers to the ancient folkloric belief that the plant flowered with the coming of the swallow in spring and continued until the fall when the swallow left. This belief has roots in reality as celandine begins to bloom in April and finishes in September. That celandine is commonly called swallow wort alludes to this belief. Celendine is also commonly known as tetterwort.

Species

There are three species of celandine: the greater celandine *Chelidonium majus*, the lesser celandine *Ranunculus ficaria*, and the celandine-poppy, *Stylophorum diphyllum*. However, the genus *Chelidonium* contains only one species, *Chelidonium majus*, as *Ranunculus ficaria* belongs to the buttercup family and *Stylophorum diphyllum* to the poppy family, and so both are distinct botanically from celandine. Celandine will grow in sun or shade and in any earth, although the plant prefers shady conditions and rich, well-drained soil. Woodland conditions are perfect, but celandine will grow along paths, by fences, and on waste ground and riverbanks. Developing from a fleshy root, celandine is a short-lived perennial that forms a spindly, yet fully branched, plant that can grow up to two feet tall. The flowers of celandine form from pear-shaped buds and grow in open clusters along a yellow-tinged stem, which in turn develop from the axils of upper leaves. The poppy-like flowers consist of four yellow obovate petals and two green sepals and are up to three-quarters of an inch in diameter. A double-flowered variety called Flore Pleno has been cultivated since 1771. The leaves of celandine, appearing in an alternate pattern along the stem, are large and smooth, yet not fleshy, and can grow up to eight inches long. The leaves tend to be deeply cut in pinnate fashion with rounded edges and feature up to seven lobes. The base of the leaf is expanded and may reach part of the way around the stem. The veins of the leaf are obvious. The foliage of celandine is a distinctive yellow-green color, and when the stem of a plant is broken, it yields both an unpleasant odor and an orange-colored juice that produces a long-lasting stain. Celandine has one ovary, which produces a fruit in the form of a roughened, cylindrical capsule about one inch in length, which splits from the base to form two valves. The fruit contains multiple shiny, crested, smooth seeds from which the plant self-seeds. Each seed contains an elaiosome, a fleshy structure rich in proteins and lipids, which attracts ants. Ants take the seeds to their nest and feed the elaiosome to their young. When the young ants have finished with the elaiosome, the adult ants remove the elaiosome to the waste area of their nests where the seed germinates. This process of seed transportation is known as myrmecochory. Propagation of celandine is by either self-sowing or division. However, celandine does not thrive when transplanted and may become weedy if allowed to self-sow.

Medicinal Use

Celandine has a long history of use in medicinal preparations. Celandine was most probably brought to the United States from Europe by early doctors, for the plant contains alkaloids such as chelidonine, chelerythrine, protopine, berberine, and sanguinarine. The latter is particularly lethal, so that, in the United Kingdom, *Chelidonium majus* appears on the Royal Horticultural Society's list of Potentially Harmful Garden Plants. It is poisonous and an irritant of both skin and eyes. However, it should be noted that a large amount of raw celandine must be ingested to be deadly. Doctors in early history used the juice of the plant to treat conditions such as warts and hemorrhoids despite the fact that celandine juice is a skin irritant. Practitioners of the "Doctrine of Signatures," a system going back to the first century CE with the Greek physician Dioscorides and based on the principle that plants bearing a physical resemblance to either parts of the body or illnesses may be used to treat illnesses or body parts that the plants resemble, advocated the use of celandine juice to treat jaundice, presumably because both celandine sap and the jaundiced body present a yellow tinge. It was also common until the mid-17th century for celandine juice to be used to treat eye conditions. This error may have originated in the belief that swallows used the juice to cure blindness in their young, as swallow eyes and the juice of the celandine are similar in color. Extracts taken from the aerial parts of celandine may contain antiviral, antimicrobial, and anticancer properties. Celandine is used today in homeopathic and conventional medicine as a purgative, a sedative, an antispasmodic, and an anti-inflammatory. Modern homeopaths use celandine to treat respiratory conditions including asthma, bronchitis, and whooping cough, as well as gallstones. The latex extracted from the plant has been used as a topical application for the treatment of ringworm and corns. Ukrain, a drug formed from a semisynthetic triphosphate derivative of the alkaloids found in celandine, has been found in tests to show some promise in inhibiting or being toxic to cancer cells, but more testing is needed (Ernest and Schmidt 2005). Other semisynthetic medicines produced from celandine alkaloids have been developed as part of the fight against AIDS. However, the potential for unwanted side effects from the medicinal use of celandine, including hemolytic anemia, hepatitis, and colitis, has led the Australian Complementary Medicines Evaluation Committee to suggest that celandine-containing products be labeled clearly.

Victoria Williams

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Celeriac

The root crop celeriac or celery root (*Apium graveolens rapaceum*) belonging to the parsley (Apiaceae) family has a checkered history from early times. Indigenous to the Mediterranean region, evidence of its cultivation has been discovered from the sarcophagi of Egypt around 1100 BCE. Designated as *selinon* by the Greeks, it is mentioned in *The Odyssey* of ninth-century BCE Greek poet Homer. A type of celery wine was provided to Greek athletes. It has been reported that celeriac arrived in China around fifth century CE. Celeriac spread from the Mediterranean to Western Europe in the Middle Ages. During the reign of ninth-century CE Frankish king Charlemagne, it was listed as a culinary and medical herb to be grown in imperial garden.

Attributes

A relative of celery, celeriac, with its different names such as celery root, knob celery, and turnip-rooted celery, is grown mainly in Europe, North America, the Middle East, and North Africa. This root vegetable is cultivated specifically for its robust, large, and globular hypocotyl rather than stem and leaves. With a long growing period, the root generally takes about 200 days for full maturity, when it measures four inches in diameter. Alabaster, Diamant, and Prague are three main types of celeric. Its creamy white and crisp inside is grated to use in salad. The leaves are used as seasoning for soups and sauces. Celeric is cooked like any other root vegetable. But the chefs soak it with acidulated water or lemon juice before cooking. In the kitchens of the United States and Europe, preparations from celeriac have become an item on the menu.

Uses and Nutrition

Celeriac is notable for its medicinal and nutritional value. Celeriac juice has been used by some to treat nervous debility, insomnia, urinary malfunctioning, rheumatism, and high blood pressure. It may stimulate the brain as well as the formation of red blood corpuscles. Some people may use it as an antidote to alcoholic hangovers. Celeriac has been used as a cosmetic product for people with dehydrated skin. The great nutritional value of celeriac is due to its low content in calories and fat, though it is also low in protein. Fat is virtually absent, and celeriac possesses only 18 calories per serving size of 3.9 ounces. Celeriac has about 0.07 ounce of fiber per serving. Celeriac contains calcium, iron, potassium, magnesium, and phosphorous. Vitamins A, C, K, and B6 are found in celeriac. About 44 percent of an adult's vitamin K requirement is in a serving of celeriac. Likewise, the same serving has 6–14 percent of vitamin C and 10 percent of vitamin A for an adult's daily need. However, people on a low-sodium diet are advised to be careful about eating celeriac as it has high sodium content. Apart from being a food and medicinal plant, celeriac was used as a garland during funerals in earlier days.

Patit Paban Mishra

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Celery

Celery, *Apium graveolens*, bears an edible stalk and is one of the few vegetables for which the whole plant is used in food and medicine. Celery can grow to be up to three feet tall, and the leaves of the plant grow in a conical shape connected at the bottom by a common base. The plant produces small white flowers. The celery plant is related to carrot, fennel, parsley, and dill. Celery is used for all its parts including the ribbed stalks, leaves, seeds, and even the root. The plant is biennial, which means that it takes two years for the plant to mature fully. Celery is so ubiquitous that many nations claim responsibility for being the first to discover and cultivate it including China, India, the United Kingdom, Sweden, and several countries in Africa.

History

Celery may have originated in the Mediterranean Basin. The ancient forms of celery had fewer stalks and more leaves. It would be hundreds of years before the plant was cultivated as a source of food, but the ancients used the plants in many ritual ceremonies. The Egyptians did not cultivate celery, but they used wild celery in their ceremonies. Garlands were made of celery leaves and water lily petals, and then placed in the tombs. Such garlands were found in 14th-century BCE pharaoh Tutankhamen's tomb during archaeological excavations. While wild celery mostly had ornamental value, it is believed that celery also played a role in Egyptian medicine as treatment for impotence.

While the Egyptians were buried with celery, the Greeks decorated sports heroes with laurels made of celery leaves. They believed the plant was an aphrodisiac. Around the ninth century BCE, Homer referred to celery in *The Iliad*, and called it *selinon* in this work. It appears at the passage where the horses of Myrmidons are grazing on celery and lotus. Homer additionally mentions the plant in his work, *The Odyssey*. Here, when the hero, Ulysses, and his men are at Calypso's cave, they find themselves surrounded by meadows of wild celery and violets. Greek physician Hippocrates (460–370 BCE) wrote about celery as a medicine for calming one's nerves. The original usages of celery included medicinal purposes, seasonings, and horse feed. Celery was used to treat many medical ailments in ancient times, including colds, flu, and digestive problems. The ancient Romans used celery as a seasoning.

Ninth-century CE Frankish king Charlemagne mentioned celery in an edict. He advised that every garden in his empire grow celery. This edict, titled *Capitulare de villis vel curtis imperii Caroli Magni*, described all the herbs that he deemed necessary to grow in gardens. The popularity of celery in Europe grew following this edict. It was not until the 17th century that celery was discovered to be edible as a vegetable (as opposed to an herb or seasoning). Around 1623, in Italy, celery stalks and leaves were paired with a dressing. Around this time, in Italy, France, and England, growers began to cultivate celery with the aim of developing the desirable characteristics of the vegetable to create stouter stems and to eliminate undesirable characteristics such as hollow stems and the bitter taste. In the 18th century, the upper classes began storing celery in cellars to use during the winter. Once this occurred, the use of celery became widespread.

In the 19th century, Europeans determined that the bitter flavor and green color of celery were undesirable. Cooks began to blanch celery to make it taste better and to rid it of its green color. Also during this time, George Taylor, an award-winning market gardener who was born in Scotland, brought celery with him when he emigrated to Kalamazoo, Michigan. Once there, Taylor began growing celery at his farm in 1847. He had a difficult time getting the people living in

Kalamazoo to try the vegetable. Celery was not a widely known vegetable, and many who lived in the area had not previously encountered it. Many people believed it to be poisonous. Taylor peddled celery door to door to increase its popularity. Once it became popular, Kalamazoo earned the nickname Celery City. Celery was an important part of Kalamazoo's history. Not only was celery an important crop, but it also brought migrants into the area to practice a new kind of farming. In the past 50 years, new breeds of celery have been developed, including an easy-blanching variety that has a milder flavor than its predecessors.

Cultivation of Celery

Celery needs copious amounts of water and very moist soil to thrive. It has a long growing season, and because it can take a long time for the seeds to germinate, it is advisable that growers start celery indoors about 10 weeks before the planting season begins. A few seeds should be placed in individual containers. The seeds should be between two and three years old and ought to be kept in a refrigerator over the winter. Before planting, the gardener should soak the seeds overnight. When planting, the seeds should be sprinkled over high-quality potting soil. Seeds then must be pressed into the soil with either wood or a finger. While watering plants is often done directly, with celery the best results are achieved by filling a tray with water so that the soil soaks up the water in order to keep the seeds from clumping together. The containers in which seeds are planted should be closed to retain moisture.

Celery germinates in two to three weeks. Seedlings should be thinned after germination and again when plants have reached a height of four to six inches to reduce competition for water and nutrients. After the threat of frost passes, plants may be transplanted outside. They should be planted in rows two feet apart, and the plants should have six to eight inches between them. Celery requires space, especially since its roots can become large. The gardener may mulch around the plants to retain water. The growing season lasts 120 to 140 days, so it is vital that the soil be kept hydrated to prevent celery from drying out. During the growing season, it is important to weed the area around plants. Celery should be harvested when the stalks are about one foot tall, about three months after they have been planted outside. Should there be any frost damage, the outer stalks can be removed. The inner stalks should remain useable.

Celery is susceptible to a few pathogens and a nutritional deficiency. Leaf blight is caused by fungi and appears as yellow spots on the leaves. Blight kills celery leaves. Black heart is a nutritional deficiency caused by a lack of calcium in the leaves. Black heart can be prevented by ensuring that the plants are provided with enough water. Pink rot occurs when the plant is too damp and the temperatures are cool to moderate.

Celery Varieties

The Wild Celery variety grows underwater. It is not eaten today. However, it was widely used for medicinal and ceremonial purposes during ancient times. The Utah variety produces 11- to 12-inch stalks in 120 days. This celery is a medium-dark green and the product is crisp. The variety Pascal takes 125 days to mature. The stalks produced by the Pascal variety are large and weigh 10 to 15 pounds per dozen stalks. Golden Self-Blanching celery matures in 85 days and is disease resistant. The stalks are thick and heavy. Detroit Golden, a self-blanching variety, has heavy yet compact stalks with broad and thick stems.

Cooking, Nutrition, and Medicine

Celery is used in a variety of dishes and for a variety of cooking purposes. Celery stalks are used in salads, as appetizers, and in stews and soups. Celery leaves are often chopped up and used as flavoring, and celery seeds are often used in pickling and in other dishes as a flavoring. Celery is high in fiber and naturally low in fat. The vegetable is a good source of vitamins A, C, and K, folic acid, potassium, riboflavin, vitamin B6, calcium, magnesium, phosphorus, manganese, and pantothenic acid. Celery has a relatively high sodium content.

Celery has had a variety of medical uses. For example, celery has been used by some as a diuretic, to aid in alleviating arthritic symptoms, as an anti-inflammatory, as an antiseptic, and for antibacterial purposes. Celery seed has been used by some to treat alcoholism, depression, anxiety, and bronchitis, and even to lower high blood pressure. Moreover, celery seeds have been used to treat liver damage, kidney inflammation, gout, and urinary tract infection. There are some reports that celery may reduce swelling in glands, reduce blood pressure, induce a sensation of calm, and clear uric acid from painful joints. For weight loss, celery juice may be ingested before meals to reduce appetite. Pregnant women should not eat celery seeds because they may cause uterine muscle contractions and bleeding during menstruation.

Ronda Lee Levine

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Cherry

A tree, cherry provides wood, fruit, and attractive blossoms. The cherry straddles three continents. In North America black cherry, *Prunus serotina*, supplies wood. The European sweet and sour cherries, *Prunus avium* and *Prunus cerasus* respectively, provide fruit. The Japanese flowering cherry, now grown in the United States, supplies aesthetically pleasing blooms. Flowering cherries include the species *Prunus serrulata*, *Prunus aedoensis*, *Prunus subhirtella*, and *Prunus incisa*. Europe boasts only 5 species of cherry, North America 6, Japan 13, and China 23. China holds a position of prominence because the last glaciation was less severe in China than elsewhere, and so more species of cherry, and other plants as well, survived. A member of the genus *Prunus*, cherry is related to almond, apricot, nectarine, peach, and plum. In the family Rosaceae, cherry counts among its relatives the rose, apple, pear, strawberry, raspberry, and blackberry. One hundred grams of cherry contain 1 milligram of sodium, 210 milligrams of potassium, 13 milligrams of calcium, 0.2 milligram of iron, a trace of beta-carotene, 0.1 milligram of vitamin E, 0.03 milligram of vitamin B1, 0.03 milligram of vitamin B2, 11 milligrams of vitamin C, and 5 milligrams of folic acid.

Cherries (Corel)

Sweet and Sour Cherries

Cherry trees have long grown wild in Europe, northern Turkey, the Caucasus Mountains, and Transcaucasia. By one account, humans first cultivated the cherry tree 10,000 years ago, making it among the earliest domesticates. Another school of thought places the origin of cherry culture between 5000 and 4000 BCE. A third line of reasoning seeks the origin of cherry cultivation in classical Greece. In the fourth century BCE, Greek botanist Theophrastus mentioned the cherry tree, allowing one to infer that the Greeks cultivated it then. The Greeks may have grown the cherry tree first for wood and second for fruit. The Romans, perhaps imitating the Greeks, planted cherry trees. In the first century BCE, Roman agricultural writer Varro described the grafting of cherry trees. In the first century CE, Roman encyclopedist Pliny the Elder asserted that the Romans grew 10 varieties in Italy, though some scholars believe that the number must have been larger because Pliny could not have been familiar with all cultivars. Pliny remarked that farmers grew cherry trees in Britain, Germany, Belgium, and Portugal. True to Pliny's word, the Romans first planted cherry trees in Britain between 40 and 60 CE. Rome's withdrawal from the province may have caused cherry cultivation to decline. One authority, supposing that Britain ceased to grow cherries during the Middle Ages, credits Richard Harris, gardener to King Henry VIII, with reintroducing the cherry tree in the 16th century, though others place this reintroduction in the 15th century or perhaps earlier. The Romans may have introduced the cherry tree to Gaul (now France). Another account pinpoints cherry cultivation in France to the eighth century, well after the decline of the Roman Empire. In Italy, the cherry tree was fused with religious imagery. Renaissance artists, Sandro Botticelli among them, painted cherries with religious figures.

Of the two types of fruit tree, the sour cherry tree stands 15 feet tall compared to the 25 or 30 feet of the sweet cherry tree. The flowers of a sour cherry tree will self- or cross-pollinate. A sweet cherry tree will not self-pollinate. The sour cherry is tart because it contains more malic acid than a sweet cherry. The 19th-century French botanist Alphonse de Candolle asserted that the sour cherry originated in land near the Caspian Sea, though others have argued that the sour cherry may have originated between Switzerland and the Adriatic Sea in the west and the Caspian Sea in the east. Michigan, Utah, New York, and Washington raise sour cherries. Cherries comprise four classes: bigarreaux, dukes, hearts, and sour. Dukes and hearts, being too soft for shipment, are seldom grown in commercial orchards. Bigarreaux, known as blacks, dominate the fresh market. Among its cultivars are Bing, Royal Ann, and Rainier. Dark cherries dominate the sweet cherry market because the darker the color the sweeter the fruit.

The sweet cherry originated in land between the Caspian and Black Seas. Birds and animals spread seeds to Transcaucasia, Turkey, and northern India. Farmers in the Netherlands, Belgium, and Germany sold fresh cherries as early as the 14th century. Merchants bought cherries to make wine. In the 15th century, the Dutch made jelly from cherries. In 1491, one German herbalist mentioned sweet and sour cherries, evidence that both types were in cultivation. The residents of Hamburg, Germany, celebrate the annual Feast of Cherries to commemorate a victory over the Hussites. In 1432, a Hussite army threatening the city, its authorities sent children to beg the invaders to spare Hamburg. The Hussites not only complied, but they gave the children cherries. In the 18th century, the Germans, doubtless aware of the beauty of cherry trees, planted them alongside roads. By then the more enterprising farmers were eager for new varieties of cherry. An association of growers selected several varieties, including Knorpel, which is still grown in Hungary. In 1819, a nobleman from Battenbourg catalogued 75 varieties of cherry. The list grew to 149 varieties by 1866 and 252 cultivars by 1877. In the 19th and 20th centuries, German growers planted large orchards near the cities in an attempt to access the urban market.

In England, the cherry flourished in the 16th century when prices were high. The decline in prices in the 18th century convinced farmers to remove land from cultivation. Those who could not profit from selling their cherries fresh distilled them into cherry wine. In the 1820s, cherries were profitable again, leading British farmers to intercrop them with strawberries.

The English introduced cherries, perhaps both sweet and sour cultivars, to the America colonies in 1629. The French imported the sour cultivar Early Richmond into the Saint Lawrence River valley and Virginia in the 17th century. More generally, the French planted cherry trees in Nova Scotia, Cape Breton, and Prince Edward Island. The Yellow Spanish sour cherry cultivar, grown since Roman times, was imported to America about 1770. New Englanders grew varieties of both sweet and sour cherries. As was true of the apple, farmers in America first propagated cherry trees from seeds. The Dutch, for example, grew cherry trees from seeds in New York. The practice of grafting must have become common in the 18th century because one nurseryman on Long Island offered grafts for sale that century.

The 18th century was the era of George Washington, and his mythic relationship to the sour cherry tree is well known. His father had imported a sour cherry tree from Great Britain. The father must have pampered the tree, but his son, perhaps in a reckless moment, chopped it down. When confronted young Washington admitted the deed, surely vexing his father. Although an interesting story, the event probably never occurred. The story dates to an 1806 biography of Washington. By then the former president had been dead seven years and so could not verify or debunk the story, which is among the most popular anecdotes from early American history.

In 1804, one nursery listed more than 20 varieties of cherry. In addition to Canada, New England, Virginia, and New York, farmers cultivated cherries in Pennsylvania, New Jersey, Delaware, and North Carolina. As early as 1676, travelers remarked at the abundance of Virginia's cherry trees. In the interior of the new United States, the French planted cherry trees in Detroit, Michigan, Vincennes, Indiana, St. Louis, Missouri, and Florida. In the 18th century, the Franciscans introduced cherry trees into California. The influx of settlers during the Gold Rush of the mid-19th century stimulated the cultivation of cherries in California. In the 1840s, Oregon began raising cherry trees. Until the 20th century, the cherry was a garden crop, raised for home use. It did not enter the market because the fruit did not store well and transit was poor. Today, the United States harvests sour cherries, most of them in Michigan. In addition to the United States, farmers grow sour cherries in Russia, Germany, and Eastern Europe. Three-quarters of the U.S. sour cherry crop goes to make pastries and pies. Sour cherries are cooked, canned, and frozen. Other uses include the making of juice, liquor, and jam. Fewer than 1 million pounds of sour cherries are sold fresh in the United States. Where disease is problematic, farmers plant sour cherries, which are more disease resistant than sweet cultivars. Farmers in the United States, Germany, Russia, Italy, Switzerland, France, and Spain raise sweet cherries, whose uses are the same as those of sour cherries with the exception that sweet cherries are more successful than sour cherries in the fresh market. Laborers pick sweet cherries whereas machines harvest sour cherries. Among sweet cultivars is Bing, which Chinese laborer Ah Bing discovered on an Oregon farm in 1875. Bing is today the leading sweet cultivar.

Competition to enter the fresh market is intense. By airplane, U.S. cherries enter the market in Japan and Hong Kong, where they command 10 times the price of fresh cherries in the United States. Growers want an early harvest to beat their competitors to Asian and American markets. In the Pacific Northwest, the Bing harvest is mid-June, but those who can harvest their crop in mid-May profit the most. Warm regions like the San Joaquin Valley in California yield early cherries; yet cultivation in this region is problematic because cherries need a cold winter to initiate dormancy. Moreover, California's wet winters may yield spring cherries that split from excess moisture. California growers have sought to solve these problems by cultivating a new variety, Brooks. In 1988, the University of California released Brooks, a cross between Rainier and the early variety Burlat. Brooks ripens 10 to 14 days earlier than Bing, giving California growers early enter into the fresh market. Perhaps because of Brooks, California has grown as a cherry producer. In the 1980s, the state ranked third behind Washington and Oregon. Between 1992 and 2002, however, cherry acreage more than doubled in California. Production surely kept pace with acreage, so that by 2002 California produced more cherries than any other state. California growers now harvest more than one-third of U.S. cherries, whereas the fraction had been one-quarter in 1992. Washington also posted gains. Between 1992 and 2002, the state's acreage increased 50 percent. The eastern plains are the area of cultivation in Washington. Washington growers aim for a late harvest, capturing a portion of the market when the supply of cherries has dwindled. In Oregon, farmers grow cherries in the Willamette and Columbia river valleys. Oregon and Michigan grow maraschino cherries. Traverse City, Michigan, promotes itself as the "cherry capital of the world." Led by gains in Washington and California, U.S. cherry acreage increased between 1992 and 2003.

In 2007, Turkey was the leading producer of sweet and sour cherries. The United States ranked second, Iran third, Italy fourth, and Russia fifth.

Black Cherry

Humans derive wood from black cherry, also known as wild black cherry, wild cherry, rum cherry, chockecherry, and cabinet cherry. In Canada, black cherry grows from Nova Scotia to southern Manitoba. In the United States, black cherry stretches from Maine to central Florida, though the climate of the southern edge of its range may be warm enough to interfere with the initiation of winter dormancy. From Maine, black cherry has migrated west to eastern North Dakota and western Texas. Bears and birds ate the fruit of black cherry, and it is likely that they spread the species to the regions of Canada and the United States. Black cherry grows best in moist, well-drained fertile soil and moderate climate. The Allegheny Mountains from Pennsylvania to Tennessee come close to approximating these conditions. Black cherry grows in 30 states, with the densest population of trees in the Appalachian Mountain, of which the Allegheny Mountains are a part, of New York, Pennsylvania, and West Virginia. Loggers have depleted many regions of the United States and Canada. Woodworkers use cherry to make furniture, coffins, railroad ties, and gunstock. It is also burned for heat and cooking. Black cherry lives 150 to 200 years and may reach a height of 100 feet. During the first half of the 20th century, the popularity of black cherry declined as Americans used mahogany and walnut. The fruit of black cherry is about one-quarter the size of the sweet or sour cherry. Humans do not prefer the taste of black cherry to sweet cherry despite the popularity of "black cherry" colas, though black cherry is used to make the beverages cherry bounce and cherry cordial. During the Columbian Exchange, North America exported black cherry cultivars to Europe, which grew them to make up for the continent's declining stock of timber.

Black cherry has recently regained popularity. The current generation of woodworkers and consumers value it because cherry is darker than the oak and ash of their parents' generation and lighter than the mahogany of their grandparents' generation. U.S. president George Washington grew black cherry trees in the 18th century, though the story about his cutting down his father's cherry tree likely concerns a sour cherry cultivar. One admirer of black cherry characterized the grain as "intricate and exciting." Black cherry is an ideal wood because it does not shrink or warp with the passage of time.

Flowering Cherry

The Japanese, who claim to have first cultivated the flowering cherry, have grown it at least since 800 CE. In the 1940s, however, Koreans asserted that the culture of the flowering cherry tree began in the Korean Peninsula. Among flowering cultivars, Yoshinco, a descendant of *Prunus yedoensis*, is popular in Japan and the United States. A second variety, Kwanzan, is a cultivar of *Prunus serrulata*. One legend holds that a cherry blossom blew into the sake cup of first-century CE Japanese emperor Richi while he admired the cherry trees in his garden. From this incident arose the tradition of imbibing sake while viewing cherry trees. The Japanese tell the myth of a maiden whose breath caused a cherry tree to blossom in 712 CE. According to one account, she gave birth to the first Japanese emperor. Her father made him mortal by giving the emperor a life span of "the blossoming of the trees." These early accounts are surely fiction. The origin of the cultivation of the flowering cherry tree is a later event, dating to 794 CE, when a Japanese emperor planted them in his garden. In the 18th century, the town of Koganie near Tokyo boasted three to four miles of 1,500 cherry trees. Rather than black cherry, the Japanese use flowering cherry trees for wood. The flowering cherry trees in Shotokeum Park in Seoul, South Korea, attract thousands of people per day when they are in bloom.

U.S. interest in Japan's flowering cherries dates to the 19th century. In 1853 and 1854, Commodore Matthew Perry collected flowering cultivars from Japan. Japanese gardener Magoemon Tagaki grew trees along the Arokewa River near Tokyo, whose descendants Japan would give the United States. In 1908, American schoolchildren planted flowering cherry trees from Japan on Arbor Day. President William Howard Taft's wife, Frances, envisioned Washington, D.C., as a city of flowering cherry trees, which had been planted in the city as early as 1846. Japan gave the United States 2,000 cherry trees in 1910, but when a U.S. Department of Agriculture entomologist found two scale insects in the shipment, the government burned the trees for fear that the scales would injure fruit trees. In 1912, Japan sent the United States another 3,020 trees, this time screening them for insects. These trees are the basis of the collection in Washington, D.C., though entomologists have claimed that the 1912 shipment contained the oriental fruit moth, costing U.S. farmers millions of dollars per year. In 1982, Japan and the United States began exchanging seeds in an effort to increase the genetic diversity of plant genomes on both sides of the Pacific Ocean. In this exchange, known as Friendship in Flowers, Japanese children sent seeds from flowering cherry trees to the United States while American children sent dogwood seeds to Japan. Some

600,000 people visit Washington, D.C., each spring to see the cherry trees in bloom. Befitting George Washington's role as a cultivator of cherry trees, the grounds of the Washington Monument have 3,700 cherry trees.

The Nanking Cherry

Also known as the Manchu cherry, downy cherry, mountain cherry, Mongolian cherry, and Chinese bush cherry, the Nanking cherry, *Prunus tomentosa*, is native to the cold arid regions of Central Asia and is the most common bush in the gardens of eastern Russia. Nanking cherry will grow wherever it has sunlight and well-drained soil. The gardener may prune the bush in late winter to stimulate new growth. Those who wish to harvest the fruit and who are in no hurry may grow the Nanking cherry from seeds, anticipating a yield in three years. About 98 percent of seeds germinate, giving the gardener every prospect of success. The Nanking cherry does not bear fruit for the market because it is too soft to transport and does not store well. The plant has had many uses over time. In Manchuria, people grow the Nanking cherry as a hedge and a windbreak in addition to harvesting its fruit. In 1882, the U.S. Department of Agriculture collected specimens from China. In the early 20th century, U.S. Department of Agriculture plant explorer Frank Meyer sent 42,000 seeds from China to the United States. In 1915, New York Agricultural Experiment Station horticulturist Ulysses Hendrick remarked that the Nanking cherry was ideal for "small gardens and cold regions." Other scientists praised it. Today, gardeners plant the bush, usually as an ornamental. Gardeners grow the Nanking cherry from Japan and Korea in East Asia to Turkestan and the Himalayas in Central Asia. The bush—one might call it a small tree—reaches between 9 and 15 feet tall. Like the apricot, the Nanking cherry bears its flowers in early spring, though unlike apricot flowers, Nanking cherry blooms tolerate frost. Like the sweet cherry, the Nanking cherry cross-pollinates, bearing fruit in early summer.

Since the early 20th century, Russian scientists have bred new varieties of Nanking cherry. Others have hybridized it with the apricot, plum, and other cherry cultivars. Canadian scientists have also instituted programs to breed new varieties. Interest in deriving new cultivars has been strong in the northern United States. The Minnesota Agricultural Experiment Station, for example, has bred new varieties of Nanking cherry.

Christopher Cumo

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Chestnut

For millennia, humans have derived wood, tannin, and nuts from the chestnut tree. The chestnut is a member of the genus *Castanea*, which derives from Kastanea, the region of Turkey where in the Bronze Age humans may have first cultivated the tree. *Castanea* has seven species. The European species *Castanea sativa* arose in the Caucasus Mountains. Asia is home to the Japanese chestnut *Castanea crenata*, the Chinese chestnut *Castanea mollissima*, the dwarf Chinese chestnut *Castanea seguini*, and the Chinese chinquapin *Castanea henryi*. The Allegheny chinquapin *Castanea pumila* and the American chestnut tree *Castanea dentate* are native to North America. Humans have long eaten chestnuts with good reason because they contain fiber, protein, vitamin C, carbohydrates, and little fat.

Mythology and History

The Iroquois told the myth of Hadadenon and the chestnut tree. A luckless man, Hadadenon lost his immediate family to the seven witches who killed its members. Having little family left, he went to live with an uncle. The two were poor, having only chestnuts to eat. At every meal, the uncle drew chestnuts from a barrel that magically replenished its supply after each use. One day Hadadenon, in a rash moment, destroyed the chestnuts, leaving the two nothing to eat. Fearing starvation, Hadadenon agreed to steal chestnuts from a tree guarded by the seven witches. The theft accomplished, Hadadenon broke the curse of the witches. His family was restored, and in gratitude they planted chestnut trees wherever they went. For this reason, the Iroquois planted chestnuts throughout North America.

The people of Europe and Asia appear not have associated the chestnut with myth. The absence of a chestnut mythology does not mean that they did not appreciate its value. The Romans esteemed the chestnut with the olive, grape, and wheat and planted chestnut trees in the provinces. Since the Middle Ages, people have eaten the nuts of *Castanea sativa* in Europe and *Castanea mollissima* and *Castanea crenata* in Asia. Peasants harvested and dried the nuts, eating them year-round. The Japanese and Chinese long cultivated the chestnut. Peasants raised chestnuts for foods and planted trees where grain would not grow. In Miyun County, China—the land of chestnuts in China—people may have begun cultivating the chestnut before the time of Christ. Miyun County is today the chief chestnut growing region of Beijing. The cultivation of chestnuts is the leading agricultural activity in Miyun. The Miyun chestnut is high in sugar and protein and has little starch. The county's three chestnut factories process chestnuts. Miyun farmers export the majority of their harvest to Japan, Southeast Asia, South Korea, Europe, and the United States, selling the remainder to China's urbanites. Today, China is the world's leading producer of chestnuts, followed by Korea, Turkey, Italy, Japan, Spain, Portugal, France, and Germany. The Japanese and Koreans cultivate the Japanese chestnut. Home owners in Asia and Europe adorn their property with chestnut trees for their aesthetic appeal. Environmentalists are interested in the chestnut tree's ability, like all plants, to remove carbon dioxide from the atmosphere. *Castanea mollissima*, *Castanea sativa*, and *Castanea crenata* produce large nuts and are cultivated for this purpose. People eat nuts with vegetables, in pastries, and as a dessert and snack. Nuts may be made into flour, fermented into beer, or distilled into liquor. A tree of the Northern Hemisphere, the chestnut has been introduced to Chile, Australia, and New Zealand in the Southern Hemisphere.

In North America, the Allegheny chinquapin and the American chestnut tree were so numerous that one account held that in the pre-Columbian era, a squirrel could travel from chestnut tree to chestnut tree between Maine and Georgia without ever touching the ground. The Cherokee made chestnut orchards by killing other species of tree in an area. Compared to European and Asia species, the American trees produced small nuts, and perhaps for this reason the Europeans who settled the New World planted Old World chestnuts. An accomplished gardener, Thomas Jefferson imported European chestnut trees for his orchard. Plant breeder Luther Burbank used Japanese rather than American cultivars in his breeding program.

Despite this neglect, the American chestnuts were a valuable source of food. Because they flowered late, the American chestnuts were not vulnerable to spring frost and so could be counted on to bear nuts every year. A single tree might yield thousands of nuts per year. These nuts sustained the biota of North America. Bear, elk, deer, squirrel, raccoon, mouse, turkey, and passenger pigeon before its demise depended on chestnuts for sustenance. In Appalachia, chestnut trees grew abundantly, comprising one-quarter of the forest. Because chestnut was light, easy to work, and durable, the pioneers built their homes of it. The trees they chopped down resprouted from the roots, obviating the need to replant. Families gathered nuts in autumn, eating them during the lean months of winter. Autumn frost aided people in the task of harvesting nuts by causing chestnut burs to open, depositing nuts on the ground. Nuts were also useful for feeding livestock. Stockmen let their animals, especially pigs, forage in the forest until they were old enough to butcher. The farmers of Appalachia needed no pastureland because the chestnut forests provided all the forage their animals could want.

The chestnuts that did not feed farmers, and livestock generated cash that families needed for school supplies, sugar, shoes, and underwear. A pound of chestnuts fetched 5 to 10 cents, though the price dipped to 1 to 2 cents when the market was saturated. Retailers must have made money because they inflated the price 10-fold over what they paid farmers. Sometimes money never entered the equation. In these cases, families traded chestnuts for coffee, flour, or other desiderata. As in Asia, American urbanites were eager to buy chestnuts. In some areas of Appalachia, chestnuts yielded more income than cattle. In 1910 Patrick County, Virginia, harvested more chestnuts than any other county in the state. Patrick County and its four neighboring counties totaled nearly half of Virginia's chestnut crop in 1910.

In addition to being a source of nuts, the chestnut tree supplied wood. In Europe, *Castanea sativa* serves this purpose. France, Spain, Portugal, and Italy rely on old forests for lumber and nuts. Worldwide, the demand for chestnut wood exceeds the supply. In the 1880s, lumbermen began to fell the chestnut trees of the eastern United States. Because of its lightness, chestnut was cheap to transport. Because the tree grew straight, telegraph and telephone companies valued it as poles, and railroad companies made it into ties. Chestnut beams upheld mine shafts. Chestnut wood formed the frame and shingles of homes. Woodworkers made chestnut furniture, and mortuary firms made chestnut coffins. In southern Appalachia, chestnut supplied one-quarter of all U.S. hardwood. The tannin was likewise valuable. Chestnut wood contains 6–11 percent tannin, which hide workers use to tan leather. A cord of wood has some 700 pounds of tannin. By 1915, chestnut trees supplied two-thirds of the tannin harvested in the United States. In the early 20th century, chestnut was used to make paper. In addition, chestnut was suitable as firewood because it ignited easily.

In 1899, Connecticut produced the most chestnut lumber in the United States. Pennsylvania ranked second and Massachusetts third. In 1904, Pennsylvania overtook Connecticut. West Virginia claimed second place and Connecticut third. In 1908, Pennsylvania ceded leadership to West Virginia. In 1937, North Carolina surpassed West Virginia. Between 1934 and 1943, West Virginia and North Carolina totaled more than half of U.S. chestnut lumber. In 1943, North Carolina, West Virginia, and Virginia totaled three-quarters of the country's chestnut wood.

Yet the American chestnuts did not enjoy a long tenure. Production fell in the 1930s, and even the end of the Great Depression did little to revive their fortunes.

Chestnut Blight

The decline of the chestnut was more than an artifact of the Great Depression. The great threat was a new disease. In 1904 Hermann Markel, chief forester of the New York Zoological Park (now the Bronx Zoo), identified a sickly chestnut tree in the park. Unsure what was wrong, he inspected his trees and in the coming months others ailed. Examining the bark, Markel tentatively identified a fungus of an unknown species. In 1905, with nearly every tree in the park infected, the forester asked the U.S. Department of Agriculture (USDA) for help. The mycologist on staff thought the fungus a common affliction and recommended the spraying of the fungicide Bordeaux mixture. Markel complied but also sought the opinion of New York Botanical Garden mycologist William Murrill. Dissatisfied with the USDA's diagnosis of a common fungus, Murrill proved a new fungus the causative agent and was the first to use the term "blight" in describing the disease. Scientists know the fungus as *Cryphonectria parasitica*.

As is common of fungi, chestnut blight spread in warm, wet weather, and by 1908 it had killed more than 1,000 trees in Prospect Park in Brooklyn, New York. The New York Zoological Park likewise suffered. By 1911, only 2 of its original 1,500 trees were alive. Penetrating cuts and cracks in a tree, the fungus killed it by destroying the bark. A dead tree was therefore suitable as lumber provided it was harvested before rot and insects rendered it useless. Between 1904 and 1954, blight spread from Canada to the Gulf of Mexico, destroying millions of acres of forest. Spores, spread by wind, drifted west to Michigan, Wisconsin, Illinois, Iowa, Missouri, California, Oregon, and Washington. American and European species were susceptible to the fungus, whereas Asia species, notably Chinese chestnuts, were largely resistant, a phenomenon explained by the likelihood that the disease had arisen in Asia. Coevolving with the disease, native chestnut trees had built up resistance to the fungus over millennia. Others thought blight native to the Americas, a supposition that seemed to explain why damage had been confined to the New World. In 1912, USDA plant explorer Frank Meyer discovered a blight-infected tree in northern China. Yet he did not find any dead trees. The discovery of blight in China and in 1916 in Japan led pathologists to confirm an Asian origin of the disease. Chestnut blight had probably reached the United States through the importation of an infected tree, likely from Japan. In the late 19th century, the United States had imported chestnut trees from Japan. In 1886, Luther Burbank had planted nuts from Japanese chestnuts in California and had as many as 10,000 Japanese chestnut trees in his nursery.

Once in the United States, the disease was remorseless. By the 1910s, New Jersey could count only 25 living chestnut trees in the entire state and all were infected. Connecticut, once known as the chestnut state, had so few trees that it had to import nuts from North Carolina. In Pennsylvania, a 300-year-old specimen, the most ancient in the United States, succumbed to the disease. Blight may have cost Virginia millions of dollars per year in revenues from lumbering. Lumbering companies had no sympathy for the afflicted trees. Their pace quickened, determined as they were to harvest as many trees as they could, dead or alive. It is possible that a blight-resistant tree may have been logged before scientists identified it. In this case, lumbering must have hampered the effort to save the chestnut. Today, scientists can count only a few hundred resistant trees in the entire United States. In total, blight killed 3 to 4 billion trees in Canada and the United States. Where chestnuts died, opportunistic maple and oak trees repopulated New England. In Pennsylvania, black cherry and hickory colonized land formerly held by chestnut. In southern Appalachia, oak and hickory gained ground. These newcomers were one-third less productive in nuts than chestnut trees and surely caused a decline in the population of wildlife.

As early as the 1910s, U.S. scientists took the obvious step of crossbreeding susceptible American species with resistant Asian chestnuts in the hope of deriving resistant progeny. To further this effort the USDA sent scientists to scout China and Japan in 1920s for specimens suitable for breeding and for transplantation in the United States. Because the offspring of this breeding program were hybrids, they grew vigorously and in their early years gave scientists hope of having bred a resistant tree. As they aged, however, many succumbed to blight. Others, less tolerant of cold weather than the American species, died during frigid winters. Those that survived were often disappointing. They did not grow as straight as American chestnuts and so were not as useful commercially. They were also shorter and so did not compete well with oak and poplar for sunlight. If hybrids were not the answer, then scientists were willing to look elsewhere. Convinced that American chestnuts must have genes for resistance to blight, University of Virginia geneticist Ralph Singleton began irradiating chestnuts in the 1950s in hopes of causing mutations in the seeds' genome. Another approach was to find an organism that devoured the fungus in much the way that the bacterium *Bacillus thuringiensis* kills some species of insect. In 1965, French agronomist Jean Grenta discovered a virus that diminished the fungus's virulence. These approaches have not superseded efforts to breed a resistant tree. A breeding program with American chestnut trees as the parent to which offspring are backcrossed may offer the best prospect of deriving a tree with blight resistance and the desirable characteristics of the American trees.

Christopher Cumo

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Chickpea

A legume, chickpea (*Cicer arietinum*) is in the family Fabaceae or Leguminosae and the genus *Cicer. Cicer* has some 40 species, many of them perennial, but the cultivated chickpea is an annual. Of *Cicer*'s species, only *Cicer arietinum* is cultivated. Chickpea is of two types. Kabuli has large, light-colored seeds whereas desi contains small, dark seeds. Kabuli is native to the Mediterranean Basin and western Asia. Desi is native to India and eastern Asia. Despite its name, the chickpea is not a pea, though it shares with peas a round shape. The chickpea may be more closely related to beans than peas. One account holds that chickpea derives its name from the seed's resemblance to a chicken's head. Chickpea is also known as garbanzo bean. The word "chickpea" may derive from the Italian *ceci*. The Arabs know chickpea as *hamaz*, Ethiopians as *shimbra*, Turks as *nohund* or *lablebi*, Indians as *chana*, and the people of Latin America *garbanzo*, from which garbanzo bean must derive. Chickpea is related to beans, soybeans, peas, lentils, clover, lupine, vetch, peanuts, and alfalfa.

Origin and History

A crop of the temperate zone and subtropics, chickpea was first eaten in Syria in the eighth millennium BCE and in Turkey about 7500 BCE. These dates may represent the gathering of chickpeas from the wild rather than their culture. The discovery of chickpeas in Damascus, Syria, dating from the seventh millennium BCE, in an area apart from the geography of wild chickpea, implies that Syrians brought chickpea to Damascus, cultivating it there. This early date of cultivation makes chickpea among the oldest crops. Humans domesticated it about the time that they began cultivating wheat and barley. From an early date, chickpea must have been an important source of protein given the relative paucity of the nutrient in grains. One authority believes, however, that southwestern Turkey rather than Syria was the site of chickpea domestication. The chickpea was abundant during the Bronze Age (fourth to second millennium BCE). In Bronze Age Israel, Jordan, and Jericho, the presence of large seeds suggests human selection and cultivation. By the Bronze Age, people in Greece including Crete, Egypt, Ethiopia, Iraq, India, and Pakistan grew chickpea. By the third millennium BCE, the people of what is today southern France were growing chickpea.

In the ninth century BCE, Greek poet Homer regarded chickpea as food and medicine. In ancient Rome and India, chickpea was likewise food and medicine. The ancients ate chickpea after dinner as a snack, taking it with a beverage. In this context Plato, the Greek philosopher of the fifth and fourth centuries BCE, mentioned chickpea in the *Republic* as a snack. First-century CE Roman encyclopedist Pliny the Elder called chickpea the "pea of Venus," perhaps a reference to its aphrodisiac properties. Perhaps in this context Galen, physician to second-century Roman emperor Marcus Aurelius, asserted that chickpea increased sperm production. Galen thought that chickpea was more nutritious than beans and caused less flatulence. Galen mentioned that the ancients ate chickpea in soup and with milk and ground it into flour. The ancients salted and added dried cheese to whole chickpeas. They ate chickpea raw or roasted, much as Americans eat roasted peanuts. The Romans regarded chickpea as a food of the poor. To call someone a "buyer of roasted chickpeas" was to say that he was poor.

In the Middle Ages, Europeans retained the ancient conviction that chickpea was food and medicine. Italian and Spanish cookbooks included recipes for chickpea. On Fridays, Jews cooked a stew with chickpea, eating it on the Sabbath. After 1492, the Spanish Inquisition, intent on apprehending Jews, took the consumption of chickpea as evidence of Jewishness. In the eastern Mediterranean Basin, people ground chickpea into flour, making it into flat cakes. The French made a type of pancake from chickpea.

In the 16th century, the Spanish and Portuguese brought chickpea to the Americas. In the 18th century, merchants carried kabuli chickpeas along the Silk Road from the Mediterranean to India. In the 19th century, Indians brought desi chickpeas to Kenya. Today, the United States grows kabuli for export to Europe. Mexico also harvests kabuli, much of it for export. Afghanistan grows chickpea in the provinces of Takhar, Kunduz, Herat, Badakhshan, Mazar-Sharif, Smangan, Ghazni, and Zabal. Afghans grow kabuli and desi without irrigation, rotating them with wheat. The Chinese cultivate chickpea in the provinces of Xianjiang, Gansu, Qinghai, Inner Mongolia, Yunnan, Shanxi, Ninjxia, Hebei, and Heilongjiang. In India, farmers plant chickpea on one-quarter of land devoted to legumes. Chickpea totals nearly half of India's legume harvest. After beans, chickpea is the most widely grown legume for human consumption. Ideal for semiarid regions, chickpea tolerates drought better than do soybean and pea. Today, nearly 50 nations cultivate chickpea. By one estimate, the Mediterranean Basin including North Africa, the Middle East, and India produce two-thirds of the global harvest of chickpea. Another estimate holds that India produces four-fifths of the world's chickpeas.

Nutrition and Consumption

Although people in the developed world eat only the seed, in the developing world people eat the seed and leaves. The seed contains protein, fiber, calcium, potassium, phosphorus, iron, and magnesium. Chickpea leaves contain more calcium, phosphorus, and potassium than spinach or cabbage. The leaves also have iron, zinc, and magnesium. In the temperate zone, people couple chickpea with grain, and in the tropics chickpea with roots and tubers, to pair protein and carbohydrates. The combination of chickpeas (and other similar beans) with a grain (or rice) provides a complete protein with all the essential amino acids. Vegetarians, those who do not want to eat the fat from some meat, or those who cannot afford meat, like this combination.

Worldwide, the Turks eat the most chickpeas. Whereas chickpea consumption has declined in Pakistan, it has risen in Myanmar, Jordan, and Iran. The people of India, Pakistan, and Bangladesh grind chickpea into flour known as besan, combining it with wheat flour to make roti or chapatti. The people of the Indian subcontinent eat chickpea leaves in addition to the seeds. They eat young chickpea pods the way Westerners eat young pea pods. Stockmen in this region of Asia feed chickpea to their animals. Growing desi, India imports kabuli from Mexico, Australia, Iran, and Turkey and desi from Myanmar. In India, the chief regions of chickpea consumption are Punjab, Harayana, Rajasthan, and western Utter Pradesh.

Of the chickpeas that Americans eat, half is whole chickpea, much of it canned. Americans consume 30 percent of their chickpeas in soup. Mexicans consume whole chickpeas from cans. In the United States and Mexico, people eat whole chickpeas in salad and stew. Peruvians eat chickpea with rice or vegetables. The faithful of the Ethiopian Coptic Church eat chickpea as a substitute for fish during the months of fasting. Ethiopians combine chickpea with soybean and wheat to make faffa, a food of children. The people of Sudan and Egypt eat chickpea during Ramadan, combining it with sesame oil, salt, onion, chili pepper, garlic, and baking powder. Tunisians boil chickpea, adding salt and pepper. In the Middle East, people eat hummus, a dish of mashed chickpea, and also consume chickpea in salad and soup. Israelis prefer kabuli to desi. They eat chickpea with rice and meat or roast it as a snack. Iraqis boil and roast chickpea, add it to soup, and eat it raw. Syrians consume three-quarters of their chickpeas as hummus. Iranians cook kabuli with rice. Afghans combine chickpea and meat and eat roasted chickpea with dried fruit. Like Israelis, Afghans prefer kabuli. The Chinese fry chickpea, salt it, and eat it as a snack. They also bake and boil chickpea, serving it with rice. The people of Myanmar substitute chickpea for soybean, making a kind of tofu.

Christopher Cumo

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Chicory

Chicory (*Chicorium intybus L.*, of the Asteracea family) is a perennial plant with bright blue flowers. It can be found growing in fields and marginal areas such as roadsides in its native Europe and in North America, where it likely escaped from cultivation. Chicory is mostly grown for its roots, which are used as coffee substitute and as a source of inulin, a sugar polymer of relevance for the food industry. Domesticated varieties of this species produce heads of leaves that are known as Belgian endive and radicchio. Chicory roots are tap roots. The roots are very strong and woody in wild plants. Selection during cultivation has led to softer and bigger roots in cultivated varieties. The cultivation of root chicory is similar to that of sugar beet. The plants are grown from seed and develop slowly. Root chicory is best harvested late in the season, as cold fall temperatures lead to a substantial yield increase through weight gain in the roots. It is important to remove the whole root from the soil, since pieces of root that have been overlooked can establish as weeds in the next crop.

History

Chicorium intybus originated in Europe and portions of Asia. It has been speculated that the green leaves of the wild plants were used as a salad green by the ancient Egyptians. Both Roman and ancient Greek sources mention chicory, although it is unclear whether the plant was cultivated or harvested from the wild. In addition to its continued use in salads and herbal teas, chicory was believed to have magic properties during the Middle Ages, both as a protection against attacks during battle and for use in love potions. Various European folk stories tell of a maid turned into a chicory flower after waiting in vain for the return of her beloved who had died far away from her. Chicory was one of the plants that Swedish naturalist Carl Linnaeus used in his famous flower clock, designed to make it possible to read the time of day from the opening and closing of the flowers of selected plant species. Chicory follows a very regular pattern, opening its flowers early in the morning and closing them in the early afternoon.

Chicory Roots as a Coffee Substitute

Roasted, ground chicory roots are used as coffee additives or even substitutes. "Chicory coffee" was made popular by French Emperor Napoleon's attempt to introduce the Continental System in Europe, which was to make Europe independent from British sea trade and the commodities shipped from the colonies. Napoleon hoped to thereby destroy the British economy, which largely relied on foreign trade. A sea blockade of the Great Britain and a ban on British ships in European harbors led to a collapse in coffee imports. Coffee drinkers thus had to look for alternatives. While chicory contains no caffeine, its ground roasted root produces a bitter-tasting dark drink when mixed with hot water.

At the time of the Continental System, chicory as a coffee substitute had been in use in Prussia for some time. Prussian King Frederick the Great had started a campaign against the excessive drinking of coffee in Germany some years earlier. Frederick had been worried about the large amounts of money even poor families spent on this luxury as well as on the effects of large doses of caffeine taken in by the wealthy, who now drank coffee in the same quantities in which they had earlier consumed beer. The king introduced a heavy tax on coffee, making the drink largely unaffordable to people of low or average income. Chicory became the most popular of an unpopular class of substitutes, which also contained various grains. This led to the rise of systematic chicory cultivation.

During the American Civil War, the Union's blockade of New Orleans, which had been the main port of entry for imported coffee into the southern United States, led to a shortage of coffee in the Confederate States and prompted southerners to add ground roasted chicory root to stretch the limited supply of coffee. Even today, chicory is still used as an additive to coffee in the southern United States, particularly in Louisiana, and in parts of Europe.

Production of Inulin in Chicory Roots

Chicory roots are naturally rich in inulin, a fructan sugar that some plants, mostly from the Asteracea family, accumulate as energy reserve instead of the more commonly stored starch. Inulin cannot be digested by the enzymes of the human digestive tract and is therefore a fiber rather than a major source of energy. As such, it has a positive effect on the gastrointestinal functions. Inulin also serves as a prebiotic; that is, it stimulates the growth of certain beneficial bacteria in the intestine. Inulin and its products are used as food additives. Inulin is also used for industrial purposes, mostly by breaking it down into the fructose units the polymer is composed of. This procedure is used to produce fructose syrups. As inulin is easily hydrolyzed and can then be fermented, chicory could also serve as a source of bioethanol in the future.

Kerstin Müller

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Chrysanthemum

Chrysanthemum genus (*Chrysanthemum cinerariaefolium* and *Chrysanthemum indicum L.*) are gardening herbs as well as pyrethrum-yielding plants. Europe, Asia, and Africa played a role in the history of chrysanthemum. Chrysanthemum may have medicinal value.

The 18th-century Swedish naturalist Carl Linnaeus, founder of science of classification of plant kingdom, gave the name *Chrysanthemum*, combining two Greek words—*chrysos* (gold) and *anthemon* (flower). Chrysanthemums are annual or perennial herbs of the genus *Chrysanthemum* of the division Magnoliophyta, class Magnoliopsida, order Asterales, and family Asteraceae. The naming of the genus was disputed until the directive of International Code of Botanical Nomenclature in 1999. Presently, the genus *Chrysanthemum* constitutes about 30 species, such as: *Chrysanthemum indicum*, *Chrysanthemum cinerariaefolium*, *Chrysanthemum segetum*, *Chrysanthemum sinense*, *Chrysanthemum morifolium*, *Chrysanthemum balsamita*, *Chrysanthemum parthenium*, *Chrysanthemum japonense*, *Chrysanthemum aphrodite*, and others. In China alone, there are 17 different species of *Chrysanthemum* with varied colors of flowers grown in Anhui, Henan, Sichuan, and Zhejiang provinces.

Origin and History

The history of chrysanthemum's cultivation is ancient. It was the Chinese who produced it as a flowering plant dating from the 15th century BCE. A city was named Ju-Xian, meaning "chrysanthemum city." Legends are woven in Chinese folklore around chrysanthemum, and it has a special place in the Double Ninth

Festival. The plant is also indigenous to North Africa and southeastern Europe. Around the eighth century CE, it arrived in Japan and became embedded in Japanese culture. The Order of the Chrysanthemum is the highest Order of Chivalry, and National Chrysanthemum Day is designated as a festival of happiness in Japan. The official seal of the Japanese monarchy is a single-flowered chrysanthemum. It arrived in northwestern Europe during the 17th century. The plant was introduced in England around the later part of the 18th century. Its popularity in the United States had been in place since colonial times, and it is known as the "Queen of the Fall Flowers." Presently, the propagation of chrysanthemums with a variety of colors occurs in the United States, China, Japan, France, England, India, and others. Some species of chrysanthemums yield the insecticide pyrethrum. The *Chrysanthemum cinerariaefolium* has been grown for more than a century, and Kenya is the largest producer, accounting for 83 percent of pyrethrum. It also exports to the United States in bulk.

Attribute and Cultivation

The herbaceous perennial chrysanthemums, with lobed as well as glabrous leaves and white, yellow, or pink flowers, grow between 20 and 60 inches tall. The alternate leaves of the plant are generally aromatic. Flowers of the cultivated species produce large flower heads, whereas the wild ones possess smaller ones. The flowers of chrysanthemums are florets as both male and female exist on each flower. All the species possess two types of florets: ray florets and disc florets. In some of the *Chrysanthemum* species, the latter are hidden. These disc florets are marked by scissors for pollination purposes as well as growing new varieties. It is very easy to grow chrysanthemums. Flowers are produced in plenty and in full sunshine. Good results are obtained if the plants are spaced 18 to 30 inches apart and manure is provided each fortnight. The site of cultivation is changed every three years to prevent diseases. Some of the species are grown to beautify the garden: *Chrysanthemum morifolium* (florists' chrysanthemum), *Chrysanthemum parthenium* (feverfew), and others. *Chrysanthemum coronarium* and *Garland chrysanthemum* are used as pot herbs and are harvested when the plants are four to six inches in height. The plants are best grown in fertile and well-drained soil. Fertilizer must be applied to the plants during the growing season.

Chrysanthemums have been used for their medicinal value, decorative quality, and insecticidal property. The Chinese were using them since antiquity as a panacea for sundry ailments. Chrysanthemum may prevent dizziness. The Chinese traditionally recommend it for curing diseases of the eye. It may be applied as a remedy for fever, common cold, migraine, and hypertension. For treating sore throats, yellow chrysanthemum flower may be effective. Modern research has proven the potential of chrysanthemum in treating HIV and heart diseases. (See, for example, "A New Anti-HIV Flavonoid Glucoronide from Chrysanthemum morifolium," 2003, http://www.ncbi.nlm.nih.gov/pubmed/14598216.) It may be anti-inflammatory and fever reducing. A wine made from rice and flavored with chrysanthemum is taken by the Koreans. The Chinese sometimes drink it as a refreshing beverage called *tisane*. In southern China, it is a summertime tea also. Wine made from Chrysanthemum flower is an age-old industry in China since the period of the Han rulers. Pyrethrum (*Chrysanthemum cinerariaefolium*) is a good source of insecticide. Pyrethrins or rethrins isolated from the seed cases of flowers are responsible for the insecticidal property of commercially profitable pyrethrum. Apart from being an insect repellent, pyrethrins have a debilitating effect on the nervous system of various kinds of insects. Chrysanthemum adds beauty to landscape architecture, and its ornamental use makes it one of the prized plants. The yellow, white, purple, and red colors of the flowers add to the ornamental use of the plant. Chrysanthemums are grown in gardens as well as parks. The Longwood Gardens and Cypress Gardens in Pennsylvania and Florida respectively hold annual exhibition of chrysanthemums. In China, a chrysanthemum festival is celebrated annually in Tongxiang. The Nihonmatsu Chrysanthemum Dolls exhibition is held every autumn in the city of Nihonmatsu, Japan. The plant also is used in a kitchen garden when there is a lack of space. The chrysanthemums are planted on causeways and entrance paths also. On Mother's Day, the Australians present their mothers bouquet of chrysanthemums. The flowers also have some commemorative use in funerals or placed on graves in Croatia, France, Italy, Poland, and Spain.

Patit Paban Mishra

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Cinchona

In the family Rubiaceae, the genus *Cinchona* contains roughly 70 species, most of them of little value. The tree is small enough that one authority considers it a shrub, though at 75 to 80 feet tall one may assert that it is too large to be a shrub.

Cinchona bark (Heikerau/Dreamstime.com)

Cinchona is a tree of the tropics that grows at elevation and does not withstand the heat and humidity of the lowlands. The bark of cinchona contains several medicinal compounds, the most important being quinine. Although quinine does not cure malaria, it reduces the parasite's rate of reproduction, thereby reducing the often fatal fever. Cinchona derives its name from the countess of Chinchon, who the bark of a cinchona tree saved from the approach of death. The 18th-century Swedish naturalist Carl Linnaeus dropped the first "h" and added an "a," rendering chinchon "cinchona," the name it has had since. Cinchona bark is known as Countess's bark, Peruvian bark, quinquina, and quinina, from which the name quinine derives. Because the Jesuits, a religious order of Catholics, organized the collection of bark in Peru, Bolivia, and Ecuador, it also became known as Jesuits' bark.

History

The mythology of the countess of Chinchon, Spain, is bound up with the history of the cinchona tree. She accompanied her husband, the count of Chinchon, to Lima, Peru, where he was Spain's viceroy. Peru and all of South America may have been free from malaria until the Spanish brought the *Anopheles* mosquito, the vector of the disease, to the continent. In 1638, the countess contracted malaria. The intermittent fevers prostrated her and worsened day by day. The court physician tried numerous remedies, but nothing worked. At his wit's end, he tried an Amerindian folk remedy. Acquiring bark from a cinchona tree 500 miles distant, he pulverized it and apparently put it in a liquid so the countess could drink it. The flavor was bitter, but she managed to swallow the potion. Her fever abated, and her physician pronounced her cured. The countess was the first European rescued from death by cinchona. So impressed was she with cinchona bark that she returned to Spain in the 1640s with it, administering it to the laborers on her estate who suffered from malaria.

As with many good stories, this one has not been immune from criticism. In 1941, A. W. Haggis, probably a British historian, countered that the countess never had malaria. Her husband alone suffered from it, but he was not given cinchona bark because the people of Lima knew nothing about it. The countess did not return to Spain with cinchona bark because she never set foot again in her homeland but instead died in Lima. The fabrication had duped Linnaeus into naming the tree after a countess who played no role in the discovery that cinchona bark could save the lives of malaria's victims. Botanical nomenclature was not always an exact science.

The medical value of cinchona bark was likely well established by the Amerindians of the Andes Mountains centuries before the Spanish conquest. Curiously, the Inca of Peru were ignorant of cinchona's value. The 16th-century Spanish conquistador Francisco Pizarro apparently showed no interest in the tree and may have known nothing about it. One of his soldiers, Gracilaso de la Vega, collected folk remedies from the Amerindians but did not mention cinchona. A Spanish priest who wrote a natural history of Peru likewise omitted cinchona from his account. About 1630, eight years before the countess's putative cure, Jesuit priests living among the Peruvians first learned about cinchona bark's antimalarial properties. The priests may have learned this fact from their Peruvian hosts.

The discovery was momentous because malaria was an ancient disease that killed more people than any other disease according to one authority. The fact that malaria is a disease of humans and monkeys suggests that humans suffered from it early in their evolution. The disease was established by the Neolithic era. Wherever the climate was warm and wet, the *Anopheles* mosquito brought death. Malaria has been reported as far north as Archangel, Russia (64° north) and as far south as Cordoba, Argentina (32° south). Cities and armies have long suffered its ravages. A disease of the Old World, it plagued Africa, Asia, and Europe. As we have seen, the Spanish likely brought it to the New World. India suffered acutely. In the 19th century, the subcontinent had a population of 150 million. Malaria held this population in check, killing 1 million children under age 1, another 1 million aged 1 to 10, and plagued yet another 2 million with recurrent fever per year. In Europe, malaria may have killed fourth-century BCE Greek conqueror Alexander the Great and hastened the deaths of German artist Albrecht Durer (1471–1528) and 17th-century English Lord Protector Oliver Cromwell.

In the 17th century, as at other times, the world badly needed cinchona bark. In 1648 Juan de Vega, the countess's physician, brought cinchona bark to Seville, Spain, selling it for $75 per ounce, a price that a poor laborer could not hope to afford. Cinchona bark was thus initially a medicine of the affluent. Cinchona has, however, an earlier origin in Europe, though it is unclear who first brought the bark to the continent. Belgian author Herman van der Hayden in 1643 was the first European to mention cinchona, if one considers the story of the countess a fabrication. In 1677, the British Pharmacopoeia added cinchona bark to its list of remedies. The Jesuits sent cinchona bark to Spain and the Vatican in Rome, Italy. Its ties to ecclesiastical authorities made cinchona bark a medicine distributed by priests as much as by physicians. Because of its connection with Catholicism, Protestants were suspicious of cinchona bark. Oliver Cromwell called it "the powder of the devil" (Hobhouse 2005, 14). Because of Protestant prejudice against Jesuits' bark, English self-appointed physician Robert Talbor changed its name, masked the bark's bitterness by mixing it with wine, and established a pharmacy in Essex, England, to sell it. So popular was Talbor's potion that King Charles II summoned Talbor to treat him. The remedy a success, Charles II knighted Talbor. Called to France, Talbor treated King Louis XIV and his son. Other successes followed in Vienna, Austria, and Madrid, Spain. Imitating the French and flush with success, Talbor changed his name to Talbot.

Initially, Europeans paid the Amerindians to collect bark for them. Trees bereft of bark died, shrinking the supply. The Jesuits tried to recoup these loses by requiring that a new tree be planted for every one destroyed. The situation was bleak by 1795, when German naturalist Alexander von Humboldt noted that in Loxa, Peru, alone the Amerindians felled 25,000 trees per year to satisfy European demand. By the 1840s, more than 1 million pounds of cinchona bark were shipped to Europe every year. By 1850, many Europeans doubted that South America could continue to supply such vast quantities of cinchona bark. It would be better for Europe to establish cinchona plantations in their tropical colonies, as they had sugarcane, coffee, and tea. For the British, India was an obvious choice for a cinchona plantation economy. British naturalist Sir Joseph Banks suggested that an expedition collect all known species of cinchona from the Andes Mountains. South American nations, wishing to retain a monopoly on cinchona bark, outlawed the export of seeds and seedlings. These laws were grounded in the fact that ounce for ounce, cinchona bark was more valuable than any other commodity except gold and silver. If Europeans were to collect seeds and seedlings, they would need to use deception. In 1852, amateur naturalist Clemens Markham persuaded the Royal Botanic Garden at Kew, England, and the British India Office to fund an expedition to South America. When a German newspaper publicized the impending expedition, Markham changed his name so that South American officials would not suspect the arrival of a cinchona-hunting expedition. Markham's seeds and seedlings went to Kew and the Botanical Garden in Calcutta, India. The British government decided to plant cinchona in India's Nilgiri Hills. It selected an elevation to match the trees' natural elevation in the Andes and with a temperature of 45°F to 70°F. Trees stripped of bark were covered with moss so that they regenerated their bark and did not die.

In 1820, French scientists Joseph Pelletier and Joseph Caventou isolated the alkaloid quinine. The isolation of quinine made it possible to determine the amount of quinine in the bark of various species of cinchona and so appraise its value. Physicians, knowing the amount of quinine they had, could prescribe the proper dose. Quinine could be extracted from the bark and so a patient could evade the bitterness of the bark.

Parallel to the United Kingdom's work in India was the Netherlands' transfer of cinchona to the Indonesian island of Java. The Netherlands sent botanist J. C. Hasskarl to Peru and Bolivia to collect seeds and seedlings. Dutch diplomats in Peru likewise collected seeds. The venture was not a success. The trees that germinated from these seeds contained little quinine. In desperation, the Netherlands bought one pound of seeds from British farmer Charles Ledger. The plants that germinated from these seeds at last produced appreciable quantities of quinine. In 1856, the Dutch created an agricultural experiment station to use science to perfect the culture of cinchona. By the 1880s, India and Java outproduced South America in cinchona bark. So productive were India and Java that pulverized cinchona bark cost only half a farthing per dose and was available at any post office in Bengal, the district of India most afflicted by malaria. India produced enough cinchona bark to treat 10 million people per day (Hobhouse 2005, 28). Because of the high incidence of malaria in India, Indian production went to local needs. By contrast, the Dutch shipped cinchona bark to Europe. By 1914, Java accounted for 60 percent of the world's production of cinchona bark (Hobhouse 2005, 30). By 1939, the figure topped 80 percent. Yet not everyone had access to cinchona bark. As late 1895, it was available in Egypt only in Alexandria and Cairo. By 1939, Java had 110 plantations on 42,000 acres producing 12,391 tons of bark (Taylor 1945, 7). In 1941, the world consumed 1,017 tons of quinine. It seems unlikely that South America alone could have kept pace with this demand. In 1942, the Japanese occupied Java, cutting off the Allies' supply of cinchona bark. The Allies turned to South America, hoping for more production, and to chemistry. In 1944, scientists synthesized quinine. The world no longer needed to rely exclusively on cinchona for quinine, though cinchona's quinine has fewer side effects than synthetic quinine. Today, Africa is the world's leading producer of cinchona bark. Among African nations, Congo is a large producer of cinchona bark.

Attributes and Cultivation

Cinchona is indigenous to South America from Bolivia to Colombia and to Venezuela. Cinchona is related to coffee, ipecac, gardenia, and ixora. It grows on the slopes of the Andes Mountains between 10° north and 19° south. Cinchona does not grow lower than 2,500 feet in elevation or higher than 9,000 feet in South America. For a tropical tree cinchona, in its higher ranges, grows remarkably close to the frost line. An old, established tree can withstand an occasional light frost, but frost kills seedlings and young trees.

In Java, cinchona grows between 2,500 feet and 10,000 feet. Cinchona grows to 30 feet with an 8-inch trunk in 14 years. It enlarges to 75 to 80 feet and a 14- to 16-inch trunk in 45 years. The bark, on which lichens live, is brown. Flowers may be white, pink, or yellow. They cannot self-pollinate and so depend on insects to cross them. Flowers are fragrant and resemble lilac flowers. Each cinchona flower is one-and-a-half inches long. Seeds are tiny and light. A single ounce contains 98,000 seeds. *Cinchona ledgeriana*, named after its discoverer Charles Ledger, has the most quinine of any species of cinchona and so is cultivated intensively. *Cinchona ledgeriana* favors an elevation of 3,000 to 7,000 feet, a lower elevation than many other species prefer. Below 3,000 feet, *Cinchona ledgeriana* appears to thrive, growing vigorously only to die before maturing. Above 7,000 feet, it grows so slowly that it attains the status of a mere shrub. Cinchona needs 125 inches of rain per year. In parts of Java, cinchona benefits from even more rain. A tree's health deteriorates with fewer than 90 inches of rain per year. Unable to tolerate more than one month of dry weather, cinchona needs rainfall uniformly distributed throughout the year. In parts of Central and South America, aridity between November and April disqualifies the regions for cinchona culture. In this respect, Java is ideal because no part of the island is bereft of rain more than one month. Young trees are more susceptible to aridity than mature trees, probably because mature trees have had time to establish a long taproot. Daytime temperatures should be 53°F to 86°F and nighttime temperatures between 46°F and 59°F.

Cinchona prefers virgin land cleared of forest and rich in organic matter. Densely populated regions in the tropics, however, offer no virgin land for planting. The best soils in Java are the volcanic northern slopes of the Preanger Regency Mountains of western Java. Indonesians have made the mountains into terraces to minimize erosion. Bandung, the principal town of this region, was once the quinine capital of the world. The soil should be loose and deep to permit the taproot to penetrate to great depth. A tough subsoil or hardpan does not allow penetration and so is unsuitable for cinchona. The soil should drain well because cinchona does not tolerate waterlogged soil.

Cinchona ledgeriana flowers in the eighth, nineth, or 10th year. Premature flowering signals unhealthy growth and was once problematic in Java and Latin America. Windy conditions appear to correlate with premature flowering. Because cinchona cross-pollinates, the characteristics of progeny vary. It is possible for a tree with a high yield of quinine to outcross with an unsuitable mate, producing offspring that yield little quinine. Thus the reliance on seeds does not guarantee the perpetuation of high quinine yields. Growers therefore propagate the best trees from cuttings. Offspring are a clone of the parent and will yield the same amount of quinine given a constant environment. Growers also plant stands of similar trees in isolation from other cinchona trees to minimize outcrossing. Cinchona planted on land that has been in cultivation to cinchona yields poorly. The solution to poor yield lies in grafting *Cinchona ledgeriana* onto rootstock of *Cinchona succirubra*, a vigorous tree that produces little quinine and so is not cultivated in its own right.

The seeds of cinchona are so small that when planted they must be sprayed with no more than a fine mist of water. Anything more risks washing the seeds out of the soil. Too much water promotes the growth of fungi that cause damping off disease, which may kill hundreds of seedlings in a single day. Seeds planted evenly in humus germinate in 12 to 14 days. Slow germination may point to an unhealthy seedling or poor care. The latter is more probable given the care with which seeds are selected. Seeds germinate at a rate of 80–90 percent of seeds germinate. At four months, seedlings may be 2 to 3.5 inches tall and are ready for transplantation, though they will not be planted in their permanent location until two years old, when they may be 18 to 24 inches tall. Cinchona is often interplanted with legumes, which enrich the soil with nitrogen. An average plantation has a density of more than 2,700 trees per acre. By the fourth or fifth year, trees have sufficient quinine to harvest, though they will not be taken until 16 to 18 years old, when quinine content has peaked. About the fourth or fifth year, a planter thins his trees to give the remaining specimens room to grow. A planter uproots an entire tree. Harvested trees are sawed into logs, from which bark is stripped. Fresh bark is 70 percent water. Drying in the sun a few days reduces water to 13 percent of the bark. A furnace removes the remaining water. Once dried, bark is ready for sale.

In years when production is too high, the price for bark declines and some planters switch to tea or coffee. The Dutch have sold cinchona seeds to Australia, New Caledonia, Hawaii, California, Fiji, the Berlin Botanical Garden, the countries of East Africa, Madagascar, Congo, the U.S. Department of Agriculture, Mexico, Brazil, Jamaica, Trinidad, Martinique, Japan, Malaysia, Sao Tome, China, and India. Cinchona is also grown in the Philippines, Myanmar, Sri Lanka, and Mauritius.

Christopher Cumo

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Cinnamon

An ancient spice, cinnamon has been coveted throughout its long history. The spice is added to rolls, cookies, pudding, pie, quick bread, chutney, stew, and curry. In sales, cinnamon ranks second only to pepper in the United States and Europe. People have called cinnamon the "spice of life" because of its widespread use and popularity. In the family Lauraceae, cinnamon is the dried inner bark of the tree *Cinnamomum verum*.

Because of its long association with Sri Lanka, the spice is known as Ceylon cinnamon (the island of Ceylon is today Sri Lanka) or Sri Lankan cinnamon. The genus *Cinnamomum* derives from the Greek *kinnamon* or *kinnamomon*, meaning "sweet wood," an appropriate name given cinnamon's origin in the bark of the cinnamon tree. The Greek terms may in turn derive from the Hebrew *quinamom*. The Malayan and Indonesian *kayamanis* likewise means "sweet wood," and it is possible that *kayamanis* may be the source of the Greek and Hebrew words. The Dutch *kaneel*, the French and Italian *canella*, and the Spanish *canela* trace their lineage to the Latin *canella*, meaning "small tube" or "pipe," a reference to cinnamon quills. Because of its antiquity and ubiquity, the word "cinnamon" appears in a large number of languages.

Origin and History

The genus *Cinnamomum* originated in the mountains of Western Ghats and southern India. From an early date, the people of Sri Lanka cultivated cinnamon, and the tree has been synonymous with the island. Its trade was early a part of Indian Ocean commerce. The Egyptians used it in embalming the dead. About 1500 BCE, Pharaoh Hatshepsut dispatched five ships to Punt, land along the coast of the Red Sea, to acquire spices. The ships returned with cinnamon and other spices. Cinnamon trees may not have been grown in Punt, leading one to speculate that this region of Africa obtained the spice from Asia. As early as the second millennium BCE, the people of China and Southeast Asia may have exported cinnamon from Indonesia to Madagascar along what one authority terms the "cinnamon route." It seems possible that from Madagascar cinnamon was traded along the eastern coast of Africa, arriving in Punt and from there to Egypt.

In addition to the Egyptians, the Hebrews valued cinnamon. It may be possible that the Hebrews learned about cinnamon during their captivity in Egypt. So important was the spice that, according to the author of Exodus, God told Moses to prepare "an oil of holy anointment" from cinnamon, cassia, and myrrh. The Song of Solomon mentions cinnamon as being among "the chief spices." The early Christians also knew about cinnamon, its being mentioned in the book of Revelation.

One authority believes that cinnamon was more valuable than gold in antiquity. Certainly it was a luxury that only the wealthy could afford in Greece and Rome. First-century Greek physician Dioscorides regarded cinnamon as a medicine, recommending it as a diuretic. According to him, it improved sight, digestion, and the function of the intestines and kidneys, freshened breath, aided women during menses, rendered snakebites harmless, and soothed the stomach. Dioscorides recommended a mixture of cinnamon and honey to remove blemishes from the skin. Given its cost, one wonders how widely it was used as medicine.

The Greeks did not acquire cinnamon directly from Asia but instead relied on the Phoenicians. More generally, the people of the Mediterranean Basin depended on the Phoenicians and Arabs to supply cinnamon from India and presumably Sri Lanka. Also active in the cinnamon trade were the Sabians of Arabia, who might have supplied cinnamon to Egypt. If this is true, Hatshepsut must have gotten cinnamon from Arabia rather than Punt. In the fourth century BCE, Greek botanist Theophrastus confirmed the availability of cinnamon in Arabia. According to Greek geographer Strabo (64 BCE–23 CE), cinnamon trees were so numerous in Arabia that people used their wood as fuel.

At first, the Romans relied on the Arabs for cinnamon, but it must have remained costly. First-century CE Roman emperor Nero flaunted his wealth by burning a year's supply of cinnamon at his wife's funeral. One authority doubts this story. Nero would not have burned cinnamon wood because it yields no fragrance. Rather, he might have burned *Cinnamosma fragrans*, a tree of the eastern coast of Africa and Madagascar. Building a maritime empire, the Romans bypassed the Phoenicians and Arabs, trading for cinnamon directly with India. In the Late Empire, Constantinople (now Istanbul) acquired cinnamon from Sri Lanka. With the decline of Rome, the Arabs reasserted control of the cinnamon trade.

In antiquity, the people of the Mediterranean Basin appear to have been unsure of the location of cinnamon trees. The Arabs told the story of the Phoenix, a bird from "a distant land" that made its nest in a cinnamon tree. Flapping its wings fast it ignited the tree. The fire consumed the bird, but it was reborn in the flames. Apparently because the Phoenix consumed cinnamon trees in fire, the spice was rare and expensive. In this way the Arabs, by referring to "a distant land," concealed the location of cinnamon trees.

Intent on uncovering the location of cinnamon trees, European explorers searched Asia. Italian adventurer Marco Polo (1254–1324) found cinnamon trees on the Malabar coast of India. By the 13th century, the East Indies emerged as the center of the cinnamon trade. In Asia, the Chinese traded cinnamon much as the Phoenicians and Arabs had in the Mediterranean. In the Middle Ages, physicians used cinnamon to treat cough, chest pain, headache, poor digestion, and flatulence.

By discovering an oceanic route to India in 1498, Portuguese explorer Vasco da Gama enabled Europeans to obtain cinnamon directly from Asia. Eclipsed, Arab trade in cinnamon declined. In place of the Arabs arose the Portuguese, who monopolized the cinnamon trade in the 16th century. Yet the Portuguese had no interest in reducing the price of cinnamon, leading other Europeans to resent them. In an effort to break Portugal's monopoly, Dutch explorer Cornelius van Hartman arrived in the East Indies in 1596. In time, the Dutch wrested control of the cinnamon trade from Portugal. In 1658, the Netherlands conquered Sri Lanka, gaining control of the source of cinnamon. Although the Dutch promoted the cultivation of cinnamon, they were no more eager than the Portuguese to reduce prices. The Netherlands exported only a portion of the harvest. In years of surplus, the Dutch destroyed cinnamon to keep it off the market. In 1796, Britain took Sri Lanka, and with it the cinnamon trade, from the Netherlands. Britain established large plantations on Sri Lanka, cultivating 40,000 acres by 1850. The British planted cinnamon trees in India as early as 1798. Additional plantings followed on the Seychelles Islands, in Madagascar, and in the Caribbean. By 1867, Sri Lanka exported nearly 1 million pounds of cinnamon per year. During World War II, Japan occupied the Dutch East Indies, causing a decline in the cinnamon trade.

Production, Cultivation, and Commerce

Today, cinnamon production is concentrated in western and southwestern Sri Lanka. The island is the leading producer of cinnamon. Also important as producers are the Seychelles Islands, Madagascar, and India. In Sri Lanka, cinnamon is a crop of small farmers. Harvested in their second or third year, cinnamon trees remain productive 30 or 40 years. Farmers harvest cinnamon two or three times per year. A tree of the tropics, cinnamon grows in many soil types. In Sri Lanka, it does well in the sandy soil in Kadirana, Ekola, and Ja-ela and in the loam and lateritic soil in Kalutara, Galle, and Matara. The best quality comes from trees grown in the sandy soil of the Negambo district. The tree flourishes between 68°F and 86°F with 50 to 100 inches of rain. Sri Lankan farmers grow eight cultivars, a number that seems small compared to the large number of cultivars of strawberries and several other plants.

The Department of Export Agriculture of Sri Lanka recommends the application of urea for nitrogen, rock phosphate for phosphorus, and muriate of potash for potassium to the soil. In a tree's first year, it should receive 175 pounds of fertilizer per acre, in its second year 350 pounds per acre, and in its third 525 pounds per acre. Where magnesium is deficient, the farmer should apply dolomite at 440 pounds per acre. Farmers fertilize cinnamon trees every six months. Sri Lanka yields 300 pounds of cinnamon per acre whereas Madagascar yields 210 to 250 pounds per acre.

The quintessential export commodity, 94 percent of the cinnamon crop is exported. London, Amsterdam, and Rotterdam are the centers of the cinnamon trade. Japan, Australia, India, Mexico, the United States, Britain, Germany, the Netherlands, and Colombia among other nations import cinnamon. The United States is the world's leading importer followed by India. Japan, the United States, and Australia import cinnamon from Sri Lanka. Mexico imports more cinnamon than any other spice.

Christopher Cumo

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Clover

A member of the Fabaceae or Leguminosae family, clover is an annual, biennial, or perennial legume. Related to the pea, chickpea, bean, lentil, lupine, peanut, alfalfa, vetch, cowpea, and soybean, clover shares in common with them the ability to fix nitrogen from the air into the soil, enriching the land. A member of the genus *Trifolium*, clover numbers more than 200 species, only 16 of which are cultivated to feed livestock. *Trifolium* is Latin for "three leaves." Anyone who has seen a three-leaved clover in the yard will recognize a *Trifolium*. Despite its genus name, a few clovers have five to nine leaves. Although one writer classified alfalfa a clover, it is not a member of *Trifolium* and so is not a true clover. *Tiltan* is Hebrew for clover and is mentioned in the *Mishna*.

Origin, Geography, and Biology

Clover may predate the Neogene period, 23 million years ago. Clover may have arisen in the Mediterranean Basin, from which it spread to Europe, Asia, and North Africa. From the Mediterranean clover may have penetrated Ethiopia and

Clover (D-flo/Dreamstime.com)

Eritrea. It is also possible that clover originated not in the Mediterranean but in the highlands of East Africa. During the late Tertiary period, clover crossed the Bering Strait into North America. From North America, clover migrated to South America, perhaps soon after the continents fused. Farmers first cultivated clover about the fourth century BCE. An adaptable plant, clover may be grown from sea level to mountains and in wet soil and arid land. A temperate crop, clover grows in the tropics at elevation, where it is cool. Clover is grown in temperate locals and the subtropics. In the tropics of West Africa and South America, farmers cultivate clover in the highlands. Today, farmers cultivate clover in West, North, and East Africa; North America from British Columbia to Baja California; the Rocky Mountains; the eastern United States; Mexico; South America from Peru to Chile, Argentina, and southern Brazil; Europe; and Asia. Because Europe was an early adopter of clover, most cultivated clover has roots in the continent. Of clover's 237 species, 110 are native to the Mediterranean. California is a second center of speciation. Mediterranean Turkey has more than 100 species whereas Mediterranean Egypt has few. In tropical Africa and the Americas and in North America and Europe, farmers grow clover in highland meadows, which they allow livestock to graze.

Fourth-century BCE Greek botanist Theophrastus was familiar with clover, leading to the inference that it had been cultivated no later than that century and perhaps earlier. First-century CE Greek physician Dioscorides knew of clover. First-century CE Roman encyclopedist Pliny the Elder observed that clover improved soil fertility. For this reason, the Romans prized it. The medical writers of antiquity praised clover as a forage crop. In the 16th century, English herbalist John Gerard described 21 species, but only 10 were true clovers. Flemish-French physician Carolus Clusius (1526–1609) knew only 7 species. French physician Jean Pitton de Tournefort (1656–1708) listed 44species, almost all of them true clovers. In the 18th century, Swedish naturalist Carl Linnaeus classified 41 species, grouping them into five units. A more recent classification divides clovers into eight units. Lotoidea is native to the Americas, Africa, Europe, and Asia. Paramesus, Vesicaria, Chronosemium, and Trichocephalum are indigenous to Europe and Asia. Misty Uns claims land in Europe, Asia, and Africa. Confusing is the subunit Trifolium in the genus *Trifolium*. It is native to Europe, Asia, and South Africa. Involusrarium sinks roots in the Americas.

Although most clovers are native to the Mediterranean Basin, 59 percent of species are indigenous to Mediterranean Europe and Asia. Eurasian species grew as far north as Sweden and Norway and have migrated east to Central Asia. One species is found in East Asia. Africa is home to 15 percent of clover species. A number of species grow along the Mediterranean coast of North Africa. Several species are cultivated in Ethiopia, Sudan, Eritrea, Kenya, and Uganda. Ethiopia has 10 species and Kenya, Uganda, and Cameroon claim 1 each. A small number of species are grown in the Congo and Nigeria. Two species are native to the Atlas Mountains. Twenty-six percent of species are indigenous to the Americas, with representatives in Canada, the United States, Mexico, and South America. The West Coast of the United States and the Rocky Mountains have 65 percent of American species. Eastern North America has only 8 percent of American clover species. California totals 9 species, Oregon 2, and Washington 1. South America has 13 species, many in Peru and Bolivia. Chile claims 4 species, with Argentina, Uruguay, and Brazil totaling a small number.

A few annuals self-pollinate, though most clover, dependent on insects to shuttle pollen from flower to flower, cross-pollinates. Perhaps to attract insects, flowers are scarlet, crimson, pink, blue, yellow, and white. Honeybees, bumblebees, and moths are the chief pollinators. Pollen needs humidity to remain viable. In one study, 60 percent of *Trifolium bejariense* self-pollinated, whereas only 22 percent of *Trifolium glomeratum* self-pollinated. Despite clover's preference for cross-fertilization, it rarely hybridizes in nature.

Agriculture and an Introduction to the Species

In the early 20th century, the British cultivated 20 species of clover and Americans 12 species, a larger number than farmers today grow. Most U.S. species were introduced from Europe. The principal cultivated species were medium red clover

(*Trifolium pratense*), alsike clover (*Trifolium hybridum*), mammoth clover (*Trifolium magnum*), crimson clover (*Trifolium incarnatum*), and small white clover (*Trifolium repens*). Medium red, mammoth, alsike, and small white clover are planted in pasture. Medium red and alsike are ideal as a hay crop. Farmers prize medium red, mammoth, alsike, and crimson because of their superiority in fixing nitrogen in the soil. Crimson is an annual; medium red and mammoth are biennial; and small white and alsike are perennial. Clover is attractive as fodder because of its high protein, though too much clover in the diet causes livestock to bloat, leading to the practice of feeding timothy or another grass with clover. Clover is palatable to livestock.

In North America, clover may be grown throughout the United States and Canada. Medium red and mammoth clover grew between 37° and 49° north. Hardy alsike grew as far south as red and mammoth but even farther north. Farmers cultivated crimson east of the Allegheny Mountains, west of the Cascade Mountains, and in the central region of the South. Alsike needed abundant rain. Farmers grew small white clover wherever rain was abundant in the United States and Canada. Soil requirements varied. Medium red and mammoth favored upland clay loam and volcanic soil. Alsike and small white did well on clay loam rich in organic matter. Crimson preferred sandy loam into which its roots easily penetrated.

Medium red, mammoth, and crimson were ideal for rotation. Adding nitrogen to the soil, clover preceded small grain, corn, sorghum, millet, and cotton. A popular rotation in the early 20th century featured grain the first year, clover the second and corn, and potatoes or vegetables the third. In the early 20th century, farmers grew clover for hay and secondarily as pasture. Some farmers grew clover, especially medium red and crimson, in orchards to add nitrogen to the soil. Farmers grew medium red and crimson as catch crops. In some instances they cultivated red clover with grain, harvesting the grain and plowing under the clover as green manure in autumn. Crimson clover was often planted after the harvest of the main crop in late summer and plowed under next spring. Farmers fertilized sandy soil that had been repeatedly cropped before planting clover. In the early 20th century, manure was the all-purpose fertilizer and was applied to the soil in autumn and winter. Once clover was established, the farmers needed not to apply more manure. The application of potash, a source of potassium, was necessary, however, when cloverleaves turned blue green, the yield declined, and young plants died. In these instances, one might have applied potash or replanted clover only after five to eight years of growing other crops.

In the early 20th century, clover was planted in spring as soon as the snow melted. Between 35° and 40° north, farmers planted clover anytime between spring and early fall, though spring planting yielded the best. In the South, farmers planted clover in early spring or autumn. One recommendation urged farmers to plant clover seeds two to three inches deep in light soil, one inch deep on loam, and less than one inch deep on clay. The farmer planted clover more deeply in arid soil than in wet soil. Farmers combined medium red and mammoth with timothy in pasture and medium red, mammoth, and alsike with timothy for hay. Timothy prevented clover from lodging as well as fed livestock in a clover-timothy mixture. The growing of clover with a grass made a more palatable and nutritious hay for livestock. Sometimes clover was intercropped with rye, barley, wheat, and oats, the grains shading young clover plants and improving the nutrition of a clover grain mixture. Farmers planted clover densely—about 12 pounds of seeds per acre—when intending it to be a pasture, to fix nitrogen in the soil, and to be plowed under as green manure. Medium red and mammoth were the chief clovers for this purpose. Farmers often grew crimson to fix nitrogen in the soil. Farmers planted six pounds of seeds per acre of alsike and four pounds of seeds per acre of small white to fix nitrogen in the soil. When intercropped with a grain, smaller amounts of seeds—four to five pounds per acre—were planted. Farmers planted six to eight pounds of seeds per acre when cultivating medium red and mammoth with a grass for hay. For this purpose, farmers planted five pounds of seeds per acre of alsike. When combined with a grass, clover totaled one-third of seeds sown. One authority urged farmers to plant more seeds where soil and climate were not ideal.

Whereas young animals might suffer bloat, mature animals could be fed clover exclusively without cutting corners on nutrition. Some stockmen thought clover inferior to timothy as horse feed, though when cured clover might have been the better choice. Because of its high protein, clover was ideal for lactating livestock. Dairymen fed cows clover in preference to other plants. A mixture of clover and corn was a popular feed because clover had protein and corn carbohydrates.

Species in Detail

Medium red clover is known best as red clover. It is also known as common red clover, broad-leaved clover, and meadow trefoil. The qualifier medium refers to the fact that red clover is intermediate between mammoth and small white and alsike. Red clover is native to Europe. In the 17th century, the English cultivated it. Colonists introduced red early to North America. A biennial, red may be a perennial under certain conditions. In the lands near the Mississippi River and in Ontario, Ohio, Michigan, Wisconsin, and Indiana, red is biennial whereas in the Pacific Northwest it is perennial. Medium red, growing rapidly, yielded a crop of hay 120 days after planting. It bloomed in May in the South and in June in the North. Red clover is ideal for lactating livestock, young animals, and pigs. Some stockmen did not recommend it for horses, but this may be because red is sometimes improperly cured. Because of its rapid growth, medium red may yield two cuttings per year. Farmers often harvested the first crop and plowed under the second. A temperate plant, medium red grew as far north as 50°, though plantings in

Alaska were reported. It may be grown as far south as Tennessee. Where it is cultivated on sandy soil, medium red must have abundant rain. Farmers grew the best crops in Michigan, Ohio, Indiana, Illinois, Kentucky, Missouri, Iowa, Wisconsin, and Minnesota. Medium red was also cultivated in New York and Pennsylvania. Canadian farmers grew medium red in Ontario, Quebec, and British Columbia.

Alsike clover derived its name from Alsike, Sweden, from where farmers introduced it to Britain. Alsike is also known as Swedish, white Swedish, Alsace, hybrid, perennial hybrid, elegant, and pod clover. Linnaeus thought it a hybrid between red and small white, though botanists have since abandoned the idea. A perennial, alsike reached its maximum size of five feet in the second year. Growing less rapidly than medium red, alsike yielded only one cutting per year. The leaves are slightly bitter, though this does not appear to distress livestock. Despite its flavor, alsike has a pleasing aroma when cured. Stockmen fed alsike primarily to sheep and secondarily to horses and cattle.

Grown in Europe, North Africa, and western Asia, alsike yields best in Northern Europe. Britain or Scandinavia introduced alsike to the United States. The crop is suited to a cool, humid climate. In the Americas, alsike yields well in the northern United States and southern Canada. Grown in Michigan, Wisconsin, and northeastern Minnesota, alsike was cultivated as far south as Kentucky, Tennessee, and Missouri. In British Columbia farmers raise a respectable crop, but alsike does less well in Manitoba, Alberta, and Saskatchewan. Grown in rotation, alsike followed corn, potato, and beans in the North and cowpea, soybean, and sorghum in the South. Hardy, alsike did not succumb to spring frost and so was planted early. Farmers often intercropped alsike with rye, barley, wheat, or oats.

Mammoth clover is known as large, tall, sapling, giant, meadow, perennial red, red perennial meadow, pea vine, zigzag, wavy stemmed, soiling, cow clover, and cow grass. A biennial or perennial, mammoth flowers early in the South and in July in the North. Stockmen fed hay to cattle and less often to horses and sheep. Grown in Europe, western Asia, and North America, mammoth is more drought tolerant and hardy than medium red. Farmers grew mammoth in Michigan, Wisconsin, Minnesota, New York, Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska. Canadian farmers cultivated mammoth in Ontario. The farmer rotated mammoth with corn, potato, sorghum, beans, soybean, and cowpea. Mammoth often preceded small grain, corn, sorghum, rape, vegetables, and strawberries. In Wisconsin, a popular three-year rotation featured clover the first year, corn or potatoes the second, and small grain the third. East of the Mississippi River, farmers planted mammoth in spring. In the Pacific Northwest, farmers sowed it in early autumn. In the South, mammoth was planted in spring or autumn and in Canada in spring.

Crimson clover is known as Egyptian clover, a name that suggested cultivation in Egypt. The crop is also called French, German, German mammoth, Italian, carnation, and winter clover. Native to Southern Europe, crimson was cultivated in France, Germany, and Italy. Introduced to the United States in the 19th century, crimson had a small following by the early 20th century. An annual crimson grew in cool weather, not stopping growth until the ground froze. Livestock relished crimson, which was used as pasture, silage, and hay. Farmers fed it to chickens and planted it in orchards. Crimson was grown primarily to fix nitrogen in the soil. Not hardy, crimson fared poorly north of the Ohio and Potomac rivers. Cold winters limited its culture in New York, Pennsylvania, Ohio, and Michigan. Canada was too cold for crimson. Growing poorly on infertile soil, crimson yielded best on sandy loam.

Known as Dutch and white Dutch, small white clover was grown extensively in the Netherlands. Small white was also known as white trefoil, creeping *Trifolium*, and honeysuckle clover. The Irish called small white clover shamrock. Indigenous to Europe, western Asia, and the northern United States, small white was a cool-weather crop that preferred humidity. Frost intolerant, small white flowered in May and June. In Europe, Great Britain and the Netherlands were the leading producers of small white clover. In the Americas, farmers grew small white as far south as the mountains of Mexico. The crop yields well in Minnesota, Wisconsin, Michigan, Ohio, New York, and the Pacific Northwest. Canadian farmers grew small white north of Lakes Erie and Ontario and on both sides of the Saint Lawrence River. In rotation, small white preceded corn, flax, oats, potato, or rape.

During the 20th century, clover diminished in importance. Nitrogenous fertilizers replaced clover's role in fixing nitrogen in the soil. Moreover, soybeans supplanted clover as the dominant legume, and corn replaced clover in feeding livestock. Once an important crop, clover is now marginal.

Christopher Cumo

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Cloves

Clove (*Syzygium aromaticum* or *Eugenia caryophyllata*) is a dried flower bud that resembles a nail. It is classified in the division Magnoliophyta, class Magnoliopsida, order Myrtales, and family Myrtaceae. An essential ingredient in cuisines all over the world, the name clove has originated from Latin *clavus* meaning "nail." Indigenous to the Maluku islands of Indonesia, it is cultivated in the Philippines, Malaysia, South Asian nations, Mauritius, the West Indies, Brazil, Madagascar, and the Pemba Islands of Tanzania. Clove has been interwoven with human history from early times. The beginning of the trade in cloves is hinted in Egyptian hieroglyphic inscriptions, which had mentioned the clove trade around 3,600 years ago. Cargoes of spices were sent to neighboring regions. The Chinese were aware of this spice beginning in the fifth century BCE. Visitors to the imperial court of the Han dynasty (207 BCE–220 CE) kept cloves in their mouths so as not to offend the emperor when they spoke to him. The Chinese called cloves the "chicken-tongue spice." Arab traders who had acquired cloves from Southeast Asia brought them into Europe around the fourth century CE. The seafaring nations of Asia and Europe valued cloves as an important trade commodity. Cloves originated in Indonesia and parts of Malaysia and then crossed the Indian Ocean to arrive in eastern Africa. From Egypt, they arrived in the markets of Europe. There was fierce rivalry among European colonial powers over the control of the clove trade beginning from 16th century. The advent of colonialism prevented the local merchants and mariners of Southeast Asia from taking an active part in the spice trade. But after gaining independence in the 1960s, the Association of Southeast Asian Nations sought to regulate the trade in cloves. In the contemporary world, cloves remain an important item of trade with Indonesia playing a pivotal role.

The evergreen, pyramid-shaped myrtaceous tree is about 45 feet long with large ovate-shaped leaves having a dark green color. It is grown best near the sea and with rainfall of 60 inches. The tree produces a fairly large number of crimson flowers that grow in clusters of three terminating on the branches. The buds of the flowers are cloves of rust brown color. A bud measures about one-half to five-eighths of an inch in length. Cloves are harvested in the dry season. The flower buds are picked twice a year and afterward dried by the sun on palm mats. A flower bud contains oil, and stems as well as leaves are also distilled for oil. The eugenol compound, comprising 60–90 percent of oil, imparts aromatic fragrance to cloves. The clove oil also includes acetyl eugenol, crategolic acid, tannins, gallotannic acid, methyl salicylate, eugenitin, campesterol, and other items. An excess of clove oil is harmful to the human body, and a fatal dose is about 3.8 grams per kilogram of a person's weight. The clove oil should not be used to bathe as it is harmful to mucus membranes. A very good quality of clove will provide a little quantity of oil if squeezed by a fingernail. It will also float on a glass of water. Cloves should not be exposed to moisture. It is advised to buy whole cloves and not the powdered ones. The latter lose their aroma soon.

Cloves have become an essential ingredient in spice blends of most of the countries in the world. Clove is used in recipes such as smoked eggplant, saffron prawn risotto, ice creams, asparagus, and Indian curries. Clove and clove powder are used in preparing meat dishes, salad dressings, ketchups, and desserts in the United States. In the kitchens of South Asian countries, the addition of cloves increases the taste of *biriyanis*, curries, and pickles. In India, Bangladesh, Pakistan, Nepal, Indonesia, Thailand, Laos, and Singapore, cloves are put inside the betel leaf or *pan* to be chewed after meals. Without cloves, the flavor of special type of Indian spiced tea called *massala chai* is not complete. A pinch of clove powder enhances the taste of different kind of soups. Cloves are also used in cheese. Due to influence from its former colony Indonesia, the Dutch kitchen preparation uses clove frequently. Clove cigarettes (*kretek*) are popular in Indonesia, having 60 percent tobacco and 40 percent cloves. Cloves have nonculinary use as a material in perfumes and incense sticks. In some houses during Christmas, cloves and oranges are kept in a container to put inside rooms so that a sweet smell pervades the house. The people of the Maluku Islands plant a clove tree in the house at the birth of a child.

Modern research has proven the disease-preventing and health-enhancing property of cloves. As a mouth care, clove oil has been used from earlier days. It has been used as an antidote for toothache. In dental hygiene, it freshens the mouth. Clove oil has been used by some for treating rheumatism, ulcers, scabies, tuberculosis, acne, nausea, flatulence, dyspepsia, diarrhea, and wound infections. Putting cloves inside the mouth is said by some to lessen the desire for alcohol. Traditionally, cloves have been used to treat malaria and cholera in tropical Asian countries. As a folk medicine, it has been used to stop vomiting. Clove has also been used to treat digestive problems as some believe that it keeps the digestive tract in good order. Clove oil also repels insects. Some believe it to improve memory. Clove also is used as an aphrodisiac.

Patit Paban Mishra

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Coca

Coca or cuca is the name given to several species of cultivated plant belonging to the family Erythroxylaceae. The plant is native to the Andes, in South America, and known for its sweet flavor and most of all for its stimulant properties. Coca is the source of cocaine. Coca is a high-altitude shrub, and the species most frequently cultivated are *Erythroxylum coca* and *Erythroxylum novagranatense*. The coca plant is not to be confused with its homonym, the cocoa or cacao plant, which is used to make and flavor chocolate or hot cocoa.

Today, coca is recognized mainly for its role as the key ingredient in cocaine, and for this reason it is not cultivated on a regular basis in the United States. Furthermore, of the 240 species of the genus *Erythroxylum*, only 1 is of any horticultural interest. Coca plants exist for show in botanical gardens, but it is illegal to grow them in the home or garden. Legal cultivation of coca is rare, and sale of the coca plant is regulated in the United States; obtaining it requires a Drug Enforcement Administration license or prescription.

Attributes

The coca plant is a shrub that grows two to three feet high, with branches on short stalks that bear divided toothed leaves. The leaves of the coca plant have a green hue and are thin and opaque. The flowers of the coca plant are small and are produced in little clusters. The pistil comprises three carpels, which are united to form a three-chambered ovary. The flowers of the coca plant mature into red berries and are sometimes eaten by larvae of the moth species *Eloria noyesi*. Occasionally, the coca plant can be used ornamentally and for decorations, because some coca plants boast yellowish flowers and tall slender branches.

Coca crop (AP/Wide World Photos)

The primary difference between the two species cited above, each of which is cultivated in two subspecies, is that *Erythroxylum novagranatense* has a relatively higher concentration of alkaloids than what is considered the parent variety (*Erythroxylum coca*), whose leaves are less powerful. As well as thriving at higher altitudes, the coca plant also does better in hotter, more humid climates and must be cultivated in weeded soil. The coca plant is ready to be plucked from the ground when the stalk is bent. After they are plucked, the moist green leaves are packed in sacks and kept dry to prevent moth larvae from eating them. The months when the coca plant is most abundant are March, after the rainy season, and June, October, and November.

Cocaine

Coca is classified as a stimulant, and leaves of the plant are the basis of the drug cocaine. The coca plant is renowned worldwide for the alkaloids it contains; these are the active ingredients in the illegal drug. Coca is a powerful plant, with a lot of applications, including medicinal uses. The first European research on coca's effects was undertaken by Eduard Frederich Poeppig, a German botanist and zoologist. Poeppig documented the benefits of the coca leaf in the early 19th century.

Pharmacologically, the most well-known and sought-after alkaloid of the coca plant is cocaine, which is found in only a small percentage in coca leaves (0.3–1.5 percent). The average presence of cocaine in the coca leaves is only 0.8 percent but nonetheless is still one of the most dangerous aspects of this cultivated plant. Although cocaine is an illegal drug that is used as a narcotic, it still has its own practical uses in medicine, such as being utilized as an anesthetic.

The mental effects of the coca plant are extensive, and it is known for greatly stimulating the imagination and the nervous system. When chewed, coca has varying effects, including appetite suppression and the reduction of pain and fatigue. In fact, the chewing of the coca leaves was the most popular way to feel its effects, and they are still chewed in countries like Peru. Where it is native, coca is most commonly used in medicine and religion. The coca plant has also been used as an anesthetic in treatments for malaria, indigestion, and stomach ulcers. Because of its anesthetic properties, it has also been used as a numbing agent in dental procedures.

Although it has been proven that there are some benefits of the coca plant, it cannot be predicted how the substance affects each individual or what the concentrations of active agents are in any given plants. The negative effects that have been reported from ingesting the leaves of this plant range from extreme fatigue to problems with digestion. In the 19th century, the substance cocaine was actually commonly prescribed by druggists to treat ailments and was the main ingredient of Coca-Cola. In 1880, Coca-Cola was laced with cocaine-based syrup for its flavor and caffeine, but obviously, it is no longer used in those products today, and the cocaine-based syrup was removed from the recipe in 1901.

Cocaine, the highly dangerous drug produced by the coca leaf, has a range of detrimental effects and also possesses addictive qualities, which is one of the main reasons why it is illegal. The substance cocaine is extracted from the coca leaf by turning the leaves into a paste and extracting the cocaine using both solvent and acid extraction techniques. Since the production of cocaine is illegal in most places, it is usually done only in illicit laboratories. The manufacturing of it encompasses three steps: the extraction of cocaine from the coca leaf, the purification of the substance, and the conversion of the coke base to cocaine hydrochloride. Because of their notoriety and concerns about being discovered by law enforcement, these labs are usually located in very remote places, and those who manufacture the substance usually have extensive knowledge of chemistry and engineering. There is no one method for extracting the paste out of the coca leaf. Although it is illegal, the production of this illicit substance has become a cottage industry, especially in some places in South America such as Peru.

Although cocaine provides this temporary high, there is a long list of disruptive medical repercussions due to the use of cocaine, such as constricted blood vessels, increased body temperature, elevated heart rate, and a high blood pressure. The long-term effects of cocaine can include a constant irregular heartbeat and palpitations, stroke, respiratory failure, and seizures. The prolonged abuse of cocaine can, as well as having its physical consequences, also cause lingering mental afflictions for the individual who uses on a regular basis. Cocaine shares some of the same qualities as an opiate as it activates certain areas in the brain that control rewards. Cocaine stimulates these areas and brings about positive reinforcement for certain behaviors, which are most likely to be repeated along with the stimulation of the drug, with the positive reward being a temporary but very strong euphoric state, which is one of the main reasons that cocaine is so habit forming.

Cocaine has a very powerful effect on the brain and brain chemistry; neurological studies have found that cocaine blocks norephenephrine and noradregeneric synapses and blocks the reuptake mechanism, which is the reabsorption of a neurotransmitter by a neurotransmitter transporter, which, in turn, is what decreases the level of dopamine to the brain. As a result of cocaine's extreme transformation and some of the decrease in functions in the nuerotransmitters, those who become increasingly dependent on cocaine, if exposed to the drug for a long enough period of time, will eventually need it to feel any pleasure at all. In fact, very shortly after the immediate rush of cocaine is felt, the individual will still have very strong cravings and desire more and more of the dangerous substance. The drug produces highs that are very brief and fleeting, resulting in the desire for more cocaine. This is another reason why the use of cocaine is so detrimental to a person's psyche and physical health, is extremely habit forming, and can be potentially lethal.

On the other hand, no matter what kind of temporary rush cocaine can produce, there is also the parallel dysphoria, which is the opposite effect brought on by cocaine withdrawal. There are some misconceptions that cocaine is less addictive or less dangerous than some other street drugs, but these notions are false, as cocaine is just as highly addictive as, if not more than, other hard drugs like heroin or crack.

Cocaine also has a remarkable effect on brain chemistry and has been known to cause in some cases insomnia for an extended period of time or an extreme depressive state. Those who come off cocaine also experience very severe and debilitating withdrawal symptoms (often referred to as a crash), which can last for days at a time and include extreme fatigue, itching, irritability, nausea and vomiting, paranoia, violent mood swings, insomnia, and an increased appetite (as opposed to the dramatically reduced appetite that individuals experience when using). People who are withdrawing from the drug often experience lethargy and weight gain, as a result of the change in their appetite when they are coming off the drug.

Cocaine withdrawal also comes with a drastic level of depression, pain, and dysphoria. Some individuals also suffer from very vivid dreams and nightmares during their withdrawal. Individuals with a cocaine addiction cannot simply stop using the substance without having some type of replacement, due to the incredibly strong cravings that cocaine causes. The cravings will increase significantly during the withdrawal period. Sometimes withdrawal from cocaine can last for months; however, with treatment, these problems can be addressed, and recovery can be possible for those who were dependent on the drug.

There are also different ailments, which can be brought about depending on the way cocaine is ingested and absorbed into the body. There are a multitude of additional problems that can be brought upon by snorting, ingesting, and injecting cocaine. Each method in which someone intakes cocaine has a different set of physical and mental consequences. Snorting cocaine can cause chronic nosebleeds, loss of smell, and hoarseness, while ingesting the drug can lead to gangrene in the bowels and also an increased chance of contracting HIV, hepatitis, or other diseases associated with sharing needles. The continual use of cocaine can have lifelong consequences, and its abuse has become an epidemic in some parts of the United States.

History and Current Status

Coca leaves have become an especially important commerce for some countries in South America including Bolivia, Colombia, Ecuador, and Peru, as well as having a deep cultural significance. The coca plant was limited to the Andes under the Incas, and because of its rarity the plant was distributed only to nobles and the higher classes. Before chemical refinement techniques made it the basis of such a dangerous drug, the coca plant developed a rich history and has cultural significance for many indigenous groups in the Andes. Persons called coqueros were a specific group of coca leaf users, who understood how to use the coca plant and the principles of its medicine. The coca plant was used and was effective in treating ailments like toothaches and altitude sickness. Cocaine, which is produced by the plant and is mainly known as a notorious narcotic drug, also has its own powerful medicinal purposes. Cocaine can be used medically as an anesthetic for some surgical procedures.

The Spanish conquistadors were not long in discovering that the leaves of the coca plant were especially potent and powerful. When soldiers chewed the leaves of the plant, they altered their mood, allowing them to accomplish feats of incredible strength, plus the leaves allowed them to fast for extended periods of time. Chewing of coca leaves is still popular in Peru and Bolivia. Although the coca plant is most likely most well known for being the foundation for the notorious drug cocaine, it still has a broader range of uses other than being the root of this illicit drug.

Cocaine abuse was particularly prevalent in the 1980s, when cocaine addiction was known historically as cocainism. Often referred to as "the caviar of street drugs," cocaine is an extremely costly method of getting high and can have terrible effects on the body and the nervous system. Though it poses so many health risks, cocaine is still, most likely, one of the most exhilarating drugs on the market. The health problems that can be induced by this drug are caused by how cocaine interferes with the neurotransmitter transporter dopamine. Dopamine is the chemical in the brain that controls pleasure and movement and can cause a false sense of euphoria or extreme pleasure for a brief time.

Bonnie Ellman

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Cocklebur

Cocklebur (*Xanthium strumarium*) is an annual that belongs to the Asteraceae family. Originating in California, *Xanthium strumarium* has spread throughout the country and has also set foot into Europe and Asia due to its hitchhiking ability. It competes for nutrients in agricultural areas along with crops such as corn, cotton, and soybeans and can also be hazardous in children's play areas and parks. Cocklebur is grown for its medicinal value and for the production of yellow dye.

Botany

Xanthium strumarium is considered to be the predecessor of the many subspecies and variations of cocklebur found around the United States. It grows in different kinds of soils of varying pH concentrations from 5.5 to 8, and also in different types of habitats such as plains, dry lands, wetlands, in ditches, along roadsides and fences, in fields along with other crops, and on slopes of mountains even to an elevation of 1,640 feet. Although cocklebur grows in different types of soil, it grows best in soil that is compact and sandy, where organic matter is minimal, and where the soil just below the surface is considerably moist. *Xanthium* can tolerate flooding and even saline conditions at times.

The plant is an annual that spreads and propagates only by seeds. In healthy and moist conditions, cocklebur grows to a height of three feet, while in drier areas it is a very short bush. It possesses a strong and stout, woody taproot. Stems are stout, rigid, and with many branches. It is green, has many oil glands, and emits a peculiar smell. The plant is identified by its alternate, broad, lobed, and triangular to heart-shaped leaves, which, depending on the subspecies, may or may not contain spines. Leaves are rough to the touch and may vary in length from two to six inches. The leaves are also three-veined and have serrated or toothed edges. The inflorescence is an axillary raceme, where the male flowers are on the uppermost, longest stalks and the female flowers are on the short stalks. Flowers are described as imperfect, with either the male or female reproductive part of the flower lacking, and also as dioecious, where both types of flowers, male and female, are found on the same plant. The male flowers are yellow. In Greek, *xanthium* means "yellow." The female flower is pale green to white. The fruit is a bur or a spine-encased dry fruit that measures approximately three-quarters of an inch in length and is more of a flattened oval in shape with a pointed end. The fruit is two chambered, containing a seed in each, and rich in oil. Numerous curved or hooked spines encase the bur. In Bell County, Texas, it has been observed that a subspecies of *Xanthium strumarium* possesses as many as 25 seeds per bur. This is an exception from the usual 2 seeds per bur. A single cocklebur plant can yield from 500 to 1,500 burs per flowering season.

Many have been fascinated by the way this plant has sprouted in areas that have been cocklebur free for over a decade. The seeds of cocklebur are peculiar. They can lie dormant in the soil for as long as 16 years when buried at a depth of eight inches. Usually this happens when farmers have tilled the land and have removed the plants, burying the seeds deep into the earth in the hope of depriving them of oxygen, which is necessary for the germination process. However, when the land has been retilled for cultivation years later, it has been observed that entire fields of cocklebur sprout suddenly, having risen to the surface soil.

Another peculiar feature about cocklebur is its hooked spines. These spines are short and latch onto susceptible target surfaces such as shoes, clothing, and animals. By latching on, they hitchhike to many places where they spread, fall off, or are discarded and take root. Since they are not particular about any specific soil type, they germinate and sprout in no time. A single plant in an area can give rise to an entire field of cocklebur within a couple of years. Swiss engineer Georges de Mestral in 1941 invented Velcro based on the principle of the burs clinging onto looped fibers of wool and fabric. With this began the use of Velcro not only in clothing but also in medical applications such as heart valves.

Toxicity

The flowers and seeds of cocklebur are highly toxic. The plant may be fatal in farm and grazing animals. The most susceptible of all farm animals is the pig, which is an omnivore and feeds on anything and everything within its area. Humans consuming the flesh of sickly or dead pigs can also be affected with serious illnesses. Many times these illnesses can trigger the death of the individual. While it has been proven that the burs of cocklebur are toxic to animals, there has been an occurrence of deaths related to humans in a poverty-stricken area of Bangladesh, where a group of people consumed a lot of burs to avert starvation. Contrary to its toxic nature, the pharmaceutical industry has found promising results that can indicate its application in the world of medicine.

Research

From a scientific point of view, studies on cocklebur have led to insights on a property in plants known as photoperiodism. Cocklebur—unlike most plants, which require the long days of spring and summer to bloom—flowers and fruits best in short days. Hence its flowering season extends from late summer to late fall in most areas of the United States. This feature that is observed, namely photoperiodism, has also led to the studies of how plants respond to light and of the plant organs that are involved with this phenomenon. Cocklebur is a subject for physiological studies opening new doors to scientific research and discoveries in the plant world.

Amanda Mittra

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Coconut

A palm tree, coconut (*Cocos nucifera*) is grown in Asia, the Pacific Islands, Africa, and Latin America. A member of the Palmae family, coconut is widely cultivated between 20° north and 20° south. Near the equator, farmers grow coconut up to 3,000 feet of elevation, though they rarely plant it in large numbers above 900 feet. In Jamaica, coconut is planted no higher than 350 feet. A coconut palm may live more than 100 years, remaining productive for 60 years. Traditional varieties begin flowering in their fifth or sixth year. Ripening on the palm, a coconut requires 1 year to mature. The word "coconut" derives from the Portuguese term for monkey because the Portuguese thought a coconut resembled a monkey's head. Because of its importance, the coconut is known as the Tree of Life, the Tree of Abundance, and the Tree of Heaven. Eighty grams of coconut contain 283 calories, 37.6 grams of water, 2.7 grams of protein, 12.2 grams of carbohydrates, 7.2 grams of fiber, 285 milligrams of potassium, 90.4 milligrams of phosphorus, 25.6 milligrams of magnesium, and 11.2 milligrams of calcium. Coconut milk and coconut water also provide nutrients. Coconut oil, having only calories, is devoid of nutrients.

Origin and Diffusion

One scholar admits that the origin of the coconut is unknown, though scientists are eager to put forward hypotheses. In the 19th century, scholars proposed an origin in Central or South America. Hypotheses that place the origin of the coconut in the Old World appear to be the current fashion. One authority favors Malaysia or Indonesia. Various authorities have proposed India and Melanesia. A coconut-like fossil dating between 15 million and 40 million years ago may point to the desert of Rajasthan, India, as the place of origin. Nevertheless, several scientists dispute an Indian origin of the coconut. Melanesia is a candidate because, according to one scientist, it supports a large population of insects that feed on coconut, implying that it has long been part of the flora of the islands. The coconut dates to 3400 BCE in Melanesia, predating human settlement. If the coconut did not originate in Melanesia, some mechanism must be invoked to explain its transit to the islands. New Zealand is also a candidate for the origin of the coconut, bearing a 15-million-year-old fossil. The Malaysian hypothesis makes clear that the coconut may have originated in Southeast Asia. An Eocene fossil of a coconut, *Cocos sahnii*, places the putative origin in the western Indian Ocean. Fossils along the northern coast of Papua New Guinea may place the origin of the coconut there. Archaeologists have found one fossil of a coconut with a human skull, permitting the inference that humans used the coconut in Papua New Guinea by 4500 BCE, a date that likely preceded cultivation. One scholar puts the origin of the coconut at the Lord Howe Rise-Norfolk Island Ridge of Gondwanaland 15 million years ago.

Wherever its origin, the coconut has dispersed as far west as the Seychelles Islands and as far east as the Line Islands. The question of how the coconut got to these regions has not been answered. One authority asserts that ocean currents could not have taken the coconut far because it will not germinate if it has been in water more than a few days. In the absence of diffusion by ocean currents, humans must have carried the coconut wherever they went. According to this hypothesis, Polynesians, Tamils, and Arabs spread the coconut throughout the tropics of the Old World. When Europeans migrated into the tropics, they became agents of diffusion. Between 1499 and 1549, the Portuguese carried the coconut from the Indian Ocean around the Cape of Good Hope to the Cape Verde Islands and from there to the Caribbean and Brazil. After 1650, the Spanish took the coconut from the Philippines to Central and South America.

Another authority invokes ocean currents as the mechanism of diffusion, noting that saltwater, absorbed by the husk, must induce dormancy. The coconut germinates slowly when placed in saltwater and more rapidly when immersed in freshwater. Thick-husked coconuts float best and so must have drifted great distances in the Pacific and Indian Oceans. Assuming that the coconut originated in Asia or the

Pacific Islands, it spread, possibly by ocean currents, to Australia, Africa, and the Americas, though these vast distances appear to have been difficult to traverse without human aid.

Coconut Agriculture and the Uses of the Coconut

Early humans must have prized the coconut as a source of water that required no tools or digging to obtain. As coconuts washed ashore, humans who dwelled along the coast must have gathered them, an action that surely predated cultivation. As early as 1000 BCE, humans cultivated the coconut on the Malabar Coast (now Kerala) of India, a region that is known as the Land of the Coconut. By the time of Christ, the people of Sri Lanka grew coconut. The beginning of coconut agriculture therefore postdated the rise of agriculture in the Old and New World. Among tropical nations, the Philippines, India, Sri Lanka, Malaysia, Indonesia, and the Pacific Islands, all within 1,000 miles of the equator, produce the majority of coconuts.

In many regions of the tropics, coconut has long been a crop of small farmers, who planted the palm near homes and in gardens. Small farmers account for more than 80 percent of acreage in the Philippines, where the average coconut farm is five acres. In India the average size is less than one acre. Minimizing their reliance on a single crop, farmers plant coconut with sweet potato, cassava, corn, sunflower, and pumpkin. In Jamaica, farmers grow coconut and banana, and in the Seychelles Islands coconut, cinnamon, and vanilla. The small farmer relies on coconut as a cash crop and as sustenance. Every part of the palm has value. Coconut leaves are used to construct roofs, walls, mats, and mattresses. The trunk yields furniture. Coconut meat yields food, feed, and oil. Coconut cake, the portion of copra, the dried kernel of a coconut, left after the oil has been extracted, is fed to cattle and chickens. Coconut sap yields a sugary substance and vinegar. The husks are made into rope and the shell into charcoal. The roots are used as dye and medicine. Coconut oil yields lubricant, soap, laundry detergent, margarine, and nondairy creamer and is burned for light and fuel. Most coconut oil is used in cooking. In the 19th century, the United States and Europe derived oil and soap from coconut. By 1900, the coconut was used to make margarine. The demand for copra spurred exports, which rose from 385,000 to 800,000 tons between 1910 and 1925. Exports exceeded 1 million tons in 1935 but slowed thereafter, reaching 1.5 million tons only in 1975. Coconut is popular as food and oil in the Philippines, Indonesia, Papua New Guinea, Sri Lanka, India, and Malaysia.

Important as coconut oil is, it faces competition from soybean and palm oils. The rapid expansion in soybean acreage in the United States and South America in the 20th century increased the supply and decreased the price of soybean oil. The same dynamic occurred with palm oil because the cultivation of the oil palm increased in Malaysia and Indonesia in the 20th century. According to the World Bank, the production of one ton of coconut oil costs \$320 to \$400 in the Philippines whereas the production of one ton of palm oil costs \$200 to \$220 in Indonesia. Faced with this reality, consumers use vegetable oils in preference to coconut oil, resulting in stagnant demand for the latter. Since 1980, the consumption of coconut oil has grown less than 1 percent per year. What demand there is the Philippines meet, exporting 75 percent of the world's coconut oil. The Philippines are the largest producer of copra and oil. One-third of the islands' population, 18 million people, depends on the coconut for income.

Cultivation and Science

A tropical crop, coconut grows best between 80°F and 90°F with 40 to 100 inches of rainfall per year. The temperature should vary little between day and night and throughout the year. Rainfall should be evenly distributed throughout the year. In hindering transpiration, humidity may injure palms. Because leaves are enormous, the coconut transpires a large amount of water and so roots must have water in the soil to replace these losses. Although soil moisture is important, the coconut cannot survive in waterlogged soil. When water is in shortage lower leaves die, female flowers reduce their number, and palms shed unripe nuts. In the worst cases, the coconut suffers from bronze leaf wilt, a condition in which old leaves fall from a palm, young leaves wilt, and the terminal bud dies. Prolonged water shortage dwarfs palms. Although a healthy palm may reach 100 feet, a palm deprived of water may be only 5 feet tall. Tolerating a range of soils, coconut is cultivated in sand, peat, and acidic swamp. Farmers obtain the best yields on alluvial and volcanic soil. Whatever the soil, the farmer must fertilize it for the best yield. Coconut hybrids, crosses between dwarf and tall cultivars, require large amounts of fertilizer to yield well. Because poor farmers cannot afford fertilizer, scientists feared that the yield of hybrids would decline to the level of traditional varieties without fertilizer, yet their performance has exceeded expectations. In one study, scientists compared the hybrid Khira I with local varieties in South Sulawasi, Indonesia. Over seven years Khira I averaged 2.3 tons of copra per acre with fertilizer whereas local varieties yielded 700 pounds per acre. In the absence of fertilizer, Khira I retained its advantage, yielding 1.2 tons of copra per acre whereas local varieties yielded 150 pounds per acre.

Dwarfs bear coconuts at an early age and produce a large number of small nuts, though the quality of copra is poor. Tall varieties bear a small number of large nuts that are rich in oil and easy to dry. Hybrids combine the early maturation of nuts and the short stature of dwarfs and the large nuts and copra quality of tall varieties. In many instances, scientists have derived hybrids from a cross of the Malayan yellow dwarf as the female parent and a tall variety as the male parent. The Malayan yellow dwarf is a desirable parent because it is partially resistant to the disease lethal yellowing. Among hybrids, Port Bouet 121, a cross between Malayan yellow dwarf and West African tall, is planted worldwide. The hybrid bears coconuts at three-and-a-half to five years compared to five-and-a-half to seven years for traditional cultivars. It yields twice as many coconuts by weight as its parents. Hybrids are as much as 10 times more productive than tall varieties, especially in the early years.

The World Bank and the Consultative Group on International Agricultural Research urge tropical nations to fund research on the improvement of coconut. Yet the hope for gains from research may be only partly realized given that many of the nations that grow coconut are poor. Nevertheless, several nations have instituted programs to breed new varieties. Cote d'Ivoire, the Philippines, the Solomon Islands, Benin, Madagascar, Mozambique, Nigeria, Tanzania, Togo, India, Indonesia, Sri Lanka, Thailand, Fiji, Papua New Guinea, Malaysia, Vietnam, Samoa, and Vanuatu have established breeding programs. Around 1900, India established the world's first coconut research program. In 1908, the College of Agriculture in the Philippines began research on the improvement of coconut. In 1929 Sri Lanka founded the Coconut Research Institute. The next year Indonesia established a coconut research center. In Jamaica, the Coconut Industry Board has collected exotic varieties in hopes of identifying the genes for resistance to lethal yellowing, though inadequate funding has slowed progress since 1981. The desiderata of these programs include high yield, drought tolerance, and disease resistance. Drought tolerance is prized in Benin, Nigeria, East Africa, India, Mexico, and Brazil, where coconut may suffer from inadequate rainfall. Traditional breeding programs may remain more promising than genetic engineering, at least in the near term.

The coconut is a heavy feeder. In one study, 14,770 pounds of copra removed from the soil 238 pounds of nitrogen, 33 pounds of phosphorus, 425 pounds of potassium, 20 pounds of calcium, 33 pounds of magnesium, 44 pounds of sodium, 275 pounds of chlorine, and 20 pounds of sulfur. To repair the loss of potassium, which turns leaves yellow, farmers add muriate of potash to the soil. Unlike many plants, the coconut needs chlorine and in this respect muriate of potash is useful because it supplies both potassium and chlorine. To redress the loss of nitrogen, farmers add sulfate of ammonia to the soil. The fertilizer is valuable because it adds both nitrogen and sulfur to the soil. Where nitrogen is in shortage, coconut leaves are pale. Too much nitrogen or too little potassium may leave coconut palms vulnerable to disease. Less often is phosphorus deficient, though sandy loam, loam, or clay loam may be deficient in the element. Calcareous or coralline soils or shale may benefit from the addition of phosphorus, iron, manganese, and organic matter. Alkaline soils may be deficient in boron. Magnesium is often in shortage in soil that is deficient in potassium. In cases where rainfall is limited, coconut grows slowly and so needs less fertilizer. As a rule, farmers who can afford fertilizer apply it once per year, though these applications are far from inexpensive. On large estates, fertilizer may total half the cost of production. Although the large farms apply fertilizer once or twice per year, in lean years fertilizer is likely to be the first input sacrificed in the name of economy. The jettisoning of fertilizer may be a false economy because it has the potential to more than double yield. Because the husk totals 67 percent of the palm's absorption of potassium and 85 percent of its absorption of chlorine, the frugal farmer may leave it on the land, where it will decay, returning nutrients to the soil. The soil in Cote d'Ivoire lacks potassium and magnesium. In one study, Port Bouet 121 yielded 1,000 pounds of copra per acre without fertilizer. The application of 6 pounds of muriate of potash and 1.6 pounds of kieserite per palm per year boosted the yield to 1.6 tons per acre. The farmer who invests $1 in fertilizer may reap $4 in increased yield. In one study, the application of chlorine in the form of sodium chloride increased the yield from 17 to 26 per palm. Muriate of potash alone increased the yield to 34 pounds per palm. The application of both muriate of potash and sodium chloride raised the yield to 53 pounds per palm. The farmer who interplants coconut with a legume need not apply nitrogenous fertilizer because a legume fixes nitrogen in the soil. One study in Indonesia revealed that nitrogenous fertilizer increased the yield of Port Bouet only 1.8–2 percent. In Cote d'Ivoire, the application of phosphorus increased the yield of Port Bouet by 5 or 6 percent.

Young palms grow poorly in shade and do not compete well against weeds. Coconuts that languish in shade or struggle against weeds benefit little from fertilizer. Young palms need nitrogen for vigorous growth. One scientist recommends the addition of nine-tenths of a pound of sulfate of ammonia per palm per year to age five. Young palms respond better to the removal of weeds than to the addition of fertilizer.

Christopher Cumo

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Coffee

Today, more than 100 countries in the tropics and subtropics grow coffee. Coffee generates more revenue than any commodity other than petroleum. Coffee grows in partial shade or full sun, and needs moderate rainfall evenly distributed throughout the year, altitudes no higher than 6,000 feet, temperatures between 60°F and 70°F, and the absence of frost. Because it is a crop of the tropics and subtropics, coffee must be grown at altitude to achieve moderate temperatures.

Although there are more than 20 species of coffee, 2 are cultivated above all others: *Coffea arabica* and *Coffea canephara* var. *robusta*. Of the two, arabica has superior flavor and aroma and so commands a higher price. Arabica grows best at altitudes of 1,500 to 6,000 feet, whereas robusta is grown from sea level to 3,200 feet. Worldwide, 70 percent of the coffee harvest is arabica and the rest robusta. Comparatively cheap and with twice the caffeine of arabica, robusta has found its way into instant coffee and blends whereas arabica is marketed in specialty coffees. Arabica is more susceptible to disease and more intolerant of poor soils. Robusta tolerates higher temperatures and humidity but suffers more acutely from frost. Farmers have grown arabica at least since the 16th century and robusta since roughly 1850. Arabica is widely grown in East Africa and Central and South America, whereas robusta, an indigene of Uganda, has sunk roots in West Africa and Southeast Asia. Brazil is the world's largest arabica producer, whereas

Coffee beans (AP/Wide World Photos)

An illustration of the largest coffee-producing regions. (ABC-CLIO)

Vietnam is the largest grower of robusta. Robusta claims half the coffee market in the United Kingdom, one-third in Italy, and one-quarter in the United States.

Today, Brazil, Vietnam, Indonesia, Colombia, and Mexico are the leading coffee growers. Worldwide, farmers plant 25 million acres to coffee. At 9.7 million acres, South America claims a plurality of this land. Coffee occupies 5.5 million acres in Asia, 5.1 million acres in Africa, and 4.7 million acres in Central and North America.

Origin and Diffusion in the Old World

The ancients celebrated coffee's origins in myth. The Oromo of Ethiopia believed, perhaps presaging the sorrow of slavery, that coffee came from the tears of the sky god Waqa. One story credits a goatherd with the discovery of coffee. On one occasion, he observed the excitement of his goats after they had eaten coffee berries and leaves. His curiosity aroused, the goatherd likewise ate the berries, presumably spitting out the beans (seeds), deriving such energy from them that he began dancing with his goats. A monk, observing this spectacle, also ate the berries with similar effect. He returned to his monastery with coffee and boiled the berries to derive a beverage that all the monks drank to help them stay awake during night prayers. The success of coffee at this monastery led other monasteries and ultimately secular society to adopt coffee. Some scholars believe that a coffee tree was the Tree of Knowledge of Good and Evil in Genesis. Eating the forbidden fruit (coffee berries), the first humans heightened their state of awareness derived from the caffeine in coffee. Some authorities claimed that passages in the Old Testament refer to coffee. Others believe that they have found reference to it in Homer. According to another account, the angel Gabriel presented coffee to Mohammed in a dream, telling him that the beans had medicinal properties and the power to stimulate the faithful to greater zeal in prayer.

Coffee is indigenous to Ethiopia, though in antiquity Ethiopians probably did not drink coffee because Egypt, which would likely have known about such a beverage, did not mention coffee. Instead, Ethiopian warriors chewed coffee berries, coated in butter or another fat, for energy. High in protein, although protein is absent from the beverage, coffee would have been nourishing in this context. The emphasis on warriors and the focus on men in the mythology of coffee suggest that men rather than women were the first to consume coffee in some form.

As early as the sixth century CE, the people of Yemen were the first to cultivate coffee. A later date comes from a literary source that credits the king of Yemen with importing the first coffee trees in the 13th century. This source may not be accurate, for a list of plants compiled in Yemen in 1271 does not mention coffee. First consumed as food between the sixth and ninth centuries, coffee was eaten as porridge. It was transformed into a beverage between 1000 and 1300, possibly as wine fermented from the berries before it was a nonalcoholic drink. Some scholars believe that in the 10th century, physician Rhazes was the first to write about coffee, using the Arabic word *bunchum*, meaning "berry," for it. In the 11th century, physician and philosopher Avicenna wrote of a beverage that "fortifies the members, cleanses the skin and dries up the humidities that are under it, and gives an excellent smell to all the body."

The people of Yemen invented the beverage coffee by pulverizing the beans and stirring them in hot water, drinking the concoction to stay awake during night prayers. They seasoned the first coffee with salt, butter, and spices. In the 15th century, coffee was a popular drink, and into the 16th century, Yemen grew most of the world's coffee, though about 1500 CE the island of Ceylon (now Sri Lanka) also produced coffee. In addition to devising the beverage, Yemenis invented the coffeehouse, a venue where men took coffee and exchanged news and opinions, evidence that coffee had a secular as well as religious purpose. Men frequented coffeehouses whereas women took their coffee at home. In the 16th century, coffeehouses were fashionable in Istanbul, Cairo, and Mecca.

Coffee derives from the Arabic *quhwah*, a word for liquor, which the Koran forbade. No evidence, however, suggests that Muslims shrank from drinking coffee. Rather, so enthusiastic were they about coffee that they spread it east to India and Indonesia, west to West Africa, and north to Istanbul and the Balkans. In the Ottoman Empire, coffee stimulated soldiers and eased the labor pains of women. In Turkey, a wife could seek a divorce if her husband refused her coffee. Wishing to retain a monopoly on coffee, Arabs prohibited foreigners from visiting coffee farms and exported beans only after they had been heated to destroy their ability to germinate. Around 1600 an Indian, Baba Buden, was the first to smuggle viable beans to India. In 1606, the Dutch smuggled coffee seedlings for planting in their colonies. In the early 17th century, the Venetians introduced the beverage coffee to the people of Western and Northern Europe. In 1655, students at Oxford University formed the Oxford Coffee Club, which evolved into the prestigious Royal Society of London. In 1669, the Turkish ambassador to the court of King Louis XIV made coffee a sensation in Paris by hosting lavish coffee parties for the nobility.

The coffeehouse was likewise popular in Europe. A coffee drinker, Johann Sebastian Bach debuted several compositions at Zimmermann's coffeehouse in Leipzig. So great was Bach's enthusiasm for coffee that he wrote a cantata to it. In the "Coffee Cantata," a father frets over his daughter's coffee habit. Zimmermann's was not the only coffeehouse to attract eminent men. In 1773, the plotters of the Boston Tea Party met in a coffeehouse to finalize their plans. In 1775, patriots met in a New York coffeehouse to debate independence after the battles of Lexington and Concord. In 1789, activist Camille Desmoulins led a mob from a coffeehouse to the Bastille, beginning the French Revolution. An Ethiopian tree had fomented revolution in the American colonies and Europe.

Yet not everyone was enthusiastic about coffee. As early as the 16th century, some Muslims thought that the faithful spent too much time in coffeehouses and not enough time in mosques. In 1511, the governor of Mecca, annoyed at the condemnations of him that circulated through the city's coffeehouses, closed them. The sultan of Cairo, an avid coffee drinker, heard of the ban and promptly reversed it. In Istanbul the penalty for drinking coffee was death. The guilty were sewn into leather bags and deposited in the Bosporus. Even this draconian punishment did not stop people from drinking coffee, and the authorities lifted the prohibition. In the 16th century, priests petitioned the pope to prohibit coffee in the belief that it had come from Satan. Tasting the beverage and finding it agreeable, the pope thought that anything so tasty could not be the work of Satan. In Europe, wives lamented that their husbands spent their free hours at coffeehouses rather than at home. Their resentment may have stemmed from the fact that coffeehouses then barred women from admission. In 1675, King Charles II of England, perceiving coffeehouses as venues for the frank exchange of political opinions, issued a proclamation banning them. The cacophony of protest forced Charles to capitulate. He rescinded the proclamation only days after issuing it. In 1777, Frederick the Great of Prussia, annoyed that his subjects spent their money on a foreign beverage when they should have been drinking German beer, told them "His Majesty was brought up on beer, and so were his ancestors and his officers" (Luttinger and Dicum 2006, 23). Perhaps Frederick, envious of England, France, and the Netherlands, was upset that Prussia had no colonies in which to grow coffee.

He had reason to be jealous as these nations planted coffee in their tropical colonies. In 1616, the Dutch took coffee seedlings from Mocha to plant in Ceylon (now Sri Lanka), which they had taken from Portugal. By the end of the 17th century, the Dutch had introduced coffee, in addition to Ceylon, to Java, Sumatra, Bali, Timor, Celebes (now Sulawesi), and Dutch Guiana (now Suriname). The Dutch East India Company became wealthy growing coffee. In 1714, the burgermeister of Amsterdam gave Louis XIV a coffee seedling, which the king directed to be planted in Paris's Jardin des Plantes. From the progeny of this tree, the French populated Africa, the Caribbean, and South America with coffee. The Portuguese grew coffee in Brazil, in parts of Indonesia, and in Africa. The British cultivated the tree in the Caribbean and India. In the 1860s, the United Kingdom took Ceylon from the Netherlands, retaining the coffee plantations.

The British planters, cutting down 176,000 acres of forest on Ceylon to make room for coffee, endangered the environment. The absence of forest that had once covered the land, left the soil vulnerable to erosion. The topsoil lost from coffee farms polluted rivers and the ocean. In the 1860s, the frail arabica trees came under attack. Coffee rust, a fungal disease that spread rapidly in the humid tropics, swept through the coffee estates on Ceylon. Catastrophic losses were also reported in India, Java, Sumatra, and Malaysia. Some planters responded by replanting their land to robusta. Others rejected coffee altogether, instead planting tea. Coffee rust thereby caused tea to replace coffee as the national drink in the United Kingdom.

Coffee in Tropical America

Coffee and romance may be linked in the origin of coffee in Brazil. One account holds that the wife of the governor of French Guiana had an affair with Francisco de Mello Palheto, a Brazilian diplomat who had been dispatched to French Guiana to settle a dispute. Upon its resolution, he returned to Brazil, but not before his lover had given him a bouquet of flowers, which contained coffee berries. The trees from these berries, so the story goes, populated all Brazil. A more prosaic report credited Portugal with introducing coffee to Brazil in 1727. Yet another account claimed that only in 1774 did Franciscan friar Jose Moriano da Conceicao Veloso plant coffee in Brazil. Whoever introduced coffee to Brazil, and when, the tree flourished. By 1800, the Portuguese colony was exporting coffee to Europe. By the 1820s, coffee had spread to the fertile lands around Sao Paulo. By 1850, Brazil produced half the world's coffee, and by 1900, its 750,00 tons of coffee accounted for three-quarters of global production. By 1910, coffee accounted for 90 percent of Brazil's gross domestic product. As large as was its production of coffee, Brazil has been vulnerable to price fluctuations. Low prices in 1906, the 1930s, and the early 1970s caused Brazilian farmers to burn coffee to keep it off the already glutted market.

Coffee may have sunk roots in the Caribbean even earlier though the chronology is unclear. One account holds that the French introduced coffee to Saint Domingue (now Haiti) in 1715, though if this date is correct it is surprising that coffee was not cultivated on Martinique until 1723. According to this version of events, the first coffee seedlings to be planted on Martinique came from the Jardin des Plants. Yet this account leaves unsettled the origin of coffee on Martinique, for the French could have more easily transferred coffee seedlings from Saint Domingue to Martinique rather than from the Jardin. Rather than spreading from Saint Domingue to Martinique, another account holds that the French transplanted coffee from Martinique to Saint Domingue in 1734. In any case, by 1770 planters on Martinique had 18,680 coffee trees, all of them arabica. Martinique seems to have been the source of coffee in Barbados and Jamaica. In 1736, coffee spread, perhaps from Martinique, to Puerto Rico. Coffee trees from Martinique thereby populated the rest of the Caribbean in the 18th and 19th centuries.

In the Caribbean, planters grew coffee between 3,000 and 5,000 feet in comparatively dry, cool air that did not readily give rise to pathogens. New World plantations did not suffer from the coffee rust that devastated Old World estates. Because coffee trees required 4 to 7 years to mature, a planter needed another source of income during these early years. Although a coffee tree may live as long as 50 years, in the 18th century trees rarely survived longer than 30 years, and a longevity of 10 to 12 years may have been the norm. Without manuring, yields declined over time. Indeed, a crop of 560 pounds of beans depleted from the land 30 pounds of nitrogen, 30 pounds of potassium, 6 pounds of phosphorus, and 22 pounds of minerals.

Like their counterparts on the sugar estates, coffee planters resorted to slavery. Although labor was less intensive on a coffee farm than on the sugar estates, slaves on the former could not count their blessings. During slack times coffee planters, eager for additional income, rented their slaves to sugar plantations. Like sugar planters, coffee landowners showed little regard for slaves' welfare. Masters often overworked and underfed their slaves, contributing to the brief life span of slaves.

Even though coffee trees did not produce beans in their first years, planters needed slaves from the outset to clear land in preparation for planting. This may have been the most arduous task that slaves performed. Once land had been denuded, slaves planted seedlings and fertilized them in a single operation, digging a hole and depositing dung and seedling. Thereafter planters may not have been assiduous in manuring their trees because they complained frequently about soil exhaustion. At the peak of operations, slaves worked six days and part of

Sunday in varied tasks. Slaves set out the beans, once picked, in the sun to dry or soaked them in vats of water to soften the flesh. After their immersion in water, coffee was fed into a pulper, which peeled off the flesh. After pulping, beans were sun dried for a week or kiln dried for a day. Because planters were paid according to the weight of their crop, the first method yielded more money but the planter risked the possibility that his coffee might ferment, ruining the flavor and aroma.

The early years were difficult for New World planters. Not only did they have no income from coffee until their trees matured, but they had to pay a tariff, which benefited planters in French Reunion and Ceylon. In the 1730s, France, Great Britain, and the Netherlands finally eliminated the tariff to encourage growers in Brazil and the Caribbean. The tariff gone and coffee prices high, the pace of production accelerated. Jamaica's yield increased from 50,367 pounds of coffee in 1744 to 252,460 pounds in 1764. Production expanded in Martinique after 1734 and in Guadeloupe after 1763. From the 1730s to the 1830s, coffee was Dominica's leading crop. By 1753, the island had 1.6 million coffee trees. On Grenada, Dominica, and Saint Vincent, coffee was second only to sugar in value. By 1789, Saint Domingue had emerged as the world's leading coffee exporter, but the French Revolution truncated the cultivation of coffee. The slaves revolted, destroying the coffee plantations. Between 1791 and 1801, coffee production halved and exports virtually ceased. Coffee rebounded in the 20th century, but it would never again command the large estates. In the 1980s, small farmers grew 67 percent of Haiti's coffee.

Perhaps because Haiti no longer exported so much coffee, supply fell short of demand and prices doubled between 1793 and 1799. Jamaica took advantage of favorable prices to increase coffee production from 2.3 million pounds in 1790 to 34 million pounds in 1814. By the early 19th century, Jamaica exported 30 percent of the world's coffee. In the 1830s and 1840s, supply exceeded demand and prices fell. Some planters responded by uprooting their trees and planting sugarcane instead. In the 19th century, coffee production remained robust in the Dominican Republic. Between 1897 and 1920, coffee yield in Puerto Rico increased from 6,000 to 27,000 tons. The end of slavery in the 19th century transformed coffee from a plantation crop to the sustenance of small farmers. The former slaves were no longer willing to toil on the large estates, but they were eager to own a small parcel of land and to grow coffee as a cash crop. By 1975, small farmers grew four-fifths of Cuba's coffee.

Coffee in the Twenty-First Century

Coffee is today a transaction between rich and poor. Affluent Americans consume coffee grown in the developing world. Whereas the average American imbibed less than 1 pound of coffee in 1800, he or she consumed 13 pounds in 1900. Today, the United States accounts for one-fifth of the world's daily consumption of 1.5 billion cups of coffee (Luttinger and Dicum 2006, ix).

McDonald's, Dunkin' Donuts, and Starbucks all woo customers with the promise of a satisfying cup of coffee. The mid-morning coffee break is a staple in the routine of countless office workers. Yet few people ponder the lives of coffee growers in the developing world.

Their lot is difficult. Of the 125 million coffee growers worldwide, 25 million are small farmers who depend on coffee as the sole source of income and who are vulnerable to price fluctuations. The decline in coffee prices between 2000 and 2002 cost 600,000 people their jobs in Central America alone (Wild 2005, 2).

In New Guinea, the poor, unable to sustain themselves growing coffee, abandoned their farms. In despair, farmers in India and Africa uprooted their coffee trees, so little were they worth. Consumers can scarcely afford to lose these small farmers because farmers with fewer than five acres produce half the world's coffee. Today, small farmers grow the majority of Mexico's coffee. Those who retain their jobs are not fortunate, for working conditions are appalling. Parents keep children home to help on the farm, causing them to forgo a lifetime of education and the prospect of a living wage. In Guatemala children begin picking coffee at age seven or eight. In parts of Guatemala, the descendants of the Maya harvest coffee. Seasonal coffee workers are the poorest and the most vulnerable to layoff. At harvest, they pick beans from dawn to evening. In Costa Rica, for example, coffee harvesters work from 5:30 a.m. to 6 p.m. seven days per week. They are paid a piece rate so low that the whole family must labor just to subsist. A wage of $1 per basket of beans in Costa Rica translates into only a few dollars per day. Even a proficient harvester in Guatemala earns just $8 per day for picking 200 pounds of berries. Coffee workers receive no medical insurance and no food, so they must bring their own nourishment and water. There are no toilets at the coffee farms, forcing laborers to relieve themselves in unpleasant settings. In Madagascar, workers receive no wages, only payment in kind. The poorest in Nicaragua and Panama have only their labor to sell and so journey to Costa Rica to pick coffee. On the large farms in Brazil, growers dispense with labor, using mechanical harvesters to dislodge beans by shaking the trees. These large estates plant trees at a density of 1,500 to 4,000 per acre, quadruple the density possible on small farms. On the large farms, wealth concentrates in few hands. In Brazil one company, Ipanema Agroindustria, produces more coffee and earns more revenue than Jamaica and Hawaii combined.

In the subtropics, coffee trees flower and so set fruit once per year. Because a tree flowers at one time, it bears a uniformly ripe crop, which laborers harvest once per year. In the tropics matters are more complicated. Coffee trees flower year-round so that at any time they have flowers, immature berries, and ripe berries. In this instance, workers must inspect each berry at harvest, taking only those that are ripe. Laborers spread the harvest over several months to be sure of picking all berries as they ripen at different time. Berries ripen over 7 to 11 months, elongating the harvest accordingly.

Coffee and Health

The angel Gabriel was not alone in thinking coffee a medicine. Some European physicians recommended coffee as protection against plague. Sober Puritans extolled coffee as an antidote to drunkenness. In the 17th century, physicians thought coffee cured dropsy, scurvy, gout, nausea, flatulence, and vertigo. In 1785, physician Benjamin Mosely advised opium addicts to drink coffee rather than get high. One physician believed that coffee cured "exhaustion, paralysis and impotence."

Today, medical opinion is divided. The caffeine in coffee can be fatal, but only if taken in large quantities on the order of 100 cups of coffee. (Coffee berries evolved caffeine for the pragmatic purpose of deterring insects, for caffeine is an insecticide.) Coffee can upset the stomach and cause muscle twitches, rambling thoughts, rapid heart rate, restless leg syndrome, hallucinations, urinary problems, and osteoporosis. Too much coffee causes anxiety, irritability, nervousness, lightheadedness, and diarrhea. Habit forming, the withdrawal of coffee causes headache. A diuretic, coffee stimulates urine production and can lead to dehydration. An oil in coffee raises cholesterol, but paper filters absorb this oil, eliminating the risk of elevated cholesterol. Taken at bedtime, coffee may cause insomnia. The birth control pill and some heart and ulcer drugs impede the body's excretion of coffee and so magnify the effects of even small amounts of coffee. Appetite suppressants, asthma drugs, and thyroid medicine also intensify the effects of coffee.

On the other hand, coffee stimulates brain activity by preventing the neurotransmitter adenosine from binding with its receptor in the brain. Two cups of coffee increase brain activity enough to be measurable on an electroencephalograph. Four cups of coffee increase heart rate and breathing by stimulating the sympathetic nervous system, which regulates breathing, heart rate, and digestion. Thirty to 60 minutes after ingestion, coffee takes full effect, lifting a feeling of fatigue, making one more alert, and quickening cognition. Coffee enlarges the blood vessels in the heart and increases blood flow. At the same time, it constricts blood vessels in the brain, thereby lessening the pain of headaches. Coffee also enlarges the bronchioles in the lungs, improving asthma. Coffee may protect one against live cancer, type two diabetes, gallstones, kidney stones, cirrhosis, Alzheimer's disease, and Parkinson's disease. Coffee stimulates the body to burn fat and for this reason endurance athletes rely on it for energy. Curiously, coffee consumption correlates with a low risk of suicide. Two cups of coffee per day may decrease irritability, improve mood, and increase sociability and confidence. In addition to coffee, the stimulant No-Doz and the pain killer Excedrin have caffeine. Mint, chocolate, and some soft drinks contain caffeine.

Christopher Cumo

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Collard

In the Brassicaceae or Cabbage family, collard (*Brassica oleacea* ssp. *acephala*) is a biennial grown as an annual for its edible leaves. Collard produces leaves in its first year and flowers and seeds in the second. The subspecies name *acephala* means "without a head," a reference to the fact that collard, in contrast to cabbage, does not form a head. Collard derives from the Anglo Saxon word "colewort," meaning "cabbage plant," possibly a recognition of the relationship between collard and cabbage. They are after all in the same family. Because collard is widely cultivated, several people have named it. Brazilians know collard as *couve*, the Portuguese as *couve galega*, the Spanish as *berza*, Bosnians and Croatians as *rastike*, the people of Montenegro as *rasten*, Indians as *haak*, and the people of Congo, Tanzania, and Kenya as *sukuma wiki*. Collard is cultivated in the American South, Brazil, Portugal, several nations in Africa, Montenegro, Bosnia and Herzegovina, southern Croatia, Spain, and Kashmir, India. Collard is not popular with some gardeners because of its strong flavor and toughness if picked at the wrong time. Collard develops an unpleasant flavor if exposed to too much heat.

Origin

Collard traces its lineage to a wild cabbage that still grows along the coast of North Africa and Europe. Perhaps for this reason, one author refers to collard as a "primitive cabbage." Another author believes that collard arose in the eastern Mediterranean Basin or Turkey. A third favors Turkey as the homeland of collard. Collard may have been the first member of the Cabbage family to be cultivated. The Greeks grew both collard and kale without distinguishing between them. The Romans cultivated collard and may have planted it in Britain and France. It is also possible that the Celts introduced collard to these regions about 600 BCE, well before the Roman conquest. Collard was mentioned in the American colonies in 1669, though the British may have imported it earlier. Slaves ate it, leading to collard's association with African American culture.

Attributes and Cultivation

Collard may be planted in spring for a summer crop or in midsummer for an autumn harvest. The gardener may prefer the second because autumn frost improves collard's flavor. If the decision is to plant a spring crop, one may start collard seeds indoors four to six weeks before the last frost. Seeds germinate in 3 to 10 days at 68°F to 86°F or in 6 to 12 days depending on whom one consults. According to one writer, the soil must be at least 70°F for seeds to germinate. Seeds should be planted 2 or 3 inches apart in rows 24 to 30 inches distant. Seedlings should be thinned to 10 to 12 inches apart. Before planting one may add a 5-10-10 fertilizer in a ratio of nitrogen to phosphorus to potassium, compost, or well-rotted manure to the soil. One month after planting, the gardener may add a complete fertilizer, compost, or well-rotted manure to the soil. The gardener may add nitrogen to the soil once or twice during the growing season. Collard should be watered weekly. The gardener may space seedlings 8 inches apart, transplanting them in the field after the last frost. Alternatively, one may plant seeds in the field one-quarter to one-half of an inch deep after the last frost.

Collard prefers full sun though it benefits from partial shade in hot weather. Collard grows best between 75°F and 80°F. The crop matures in 60 days, though one writer recommends that young leaves be picked as early as 30 days after planting. Although the plant may grow two or three feet tall, leaves should be picked when they are eight inches long. The soil should be fertile, well-drained loam. The soil pH should be between 6 and 6.5 or 6.8 depending on whom one consults. One may harvest a whole plant or only the young outer leaves. In its second year, we have seen, collard flowers. A cross-pollinator, collard may be crossed with cabbage so close is the relationship between the two. Collard seeds, derived in the second year, remain viable five years. Collard is hardier than other members of the cabbage family, tolerating temperatures as low as 10°F or 20°F depending on whom one reads. Collard tolerates drought better than other cabbage allies. Collard is the most heat-tolerant member of the Cabbage family. In Florida, collard is planted in September or October for a harvest between November and April. If picked during the heat of summer, collard may be refrigerated 2 or 3 days to sweeten it. More generally, collard may be refrigerated 10 days provided the temperature is near freezing and the humidity is more than 95 percent. Plants should be mulched in autumn to permit them to overwinter.

Cuisine

In the American South, collard is often eaten with kale, turnip greens, spinach, and mustard greens. Collard is often paired with ham, bacon, turkey, pork, onion, vinegar, salt, and pepper. Collard is coupled with cowpeas, peas, and cornbread on New Year's Day, a meal that is reputed to guarantee one wealth in the New Year. Brazilians and Portuguese pair collard with fish or meat or in a stew with pork and beans. In Kashmir, Indians eat both collard leaves and roots. They consume a soup with collard leaves, water, salt, oil, and rice. Collard leaves are eaten with meat, fish, or cheese. Collard may be boiled or steamed, though it should not be cooked more than five minutes to preserve the nutrients.

Cultivars

Cultivated since 1880 or perhaps earlier, Georgia is a blue-green variety popular in the American South. The plant grows to three feet and does well in hot or cold weather. Like all varieties of collard, frost improves the flavor of Georgia. The variety tolerates drought and grows in infertile soil. With a mild flavor, Georgia matures in 70 to 80 days. Georgia Southern, known as Creole or True Collard, grows on the Atlantic coast. Suitable for sandy soil, Georgia Southern grows to three feet, yielding blue-green leaves that mature in 75 days. Tolerating heat, Vates does not bolt in hot weather. Frost resistant, Vates matures in 75 days. The blue-green leaves have a mild cabbage flavor.

Nutrition and Health

One hundred grams of collard have 36 calories, 7.1 grams of carbohydrates, fiber, 0.4 gram of fat, 3 grams of protein, 26 milligrams of vitamin C, and 210 milligrams of calcium. This serving yields 593 percent of the recommended daily allowance of vitamin K, 64 percent of beta-carotene, 43 percent of vitamin C, and 21 percent of calcium. In addition to these nutrients, collard has folic acid, vitamin B6, riboflavin, niacin, thiamine, pantothenic acid, vitamin E, manganese, potassium, magnesium, zinc, phosphorus, and omega 3 fatty acids. Collard has 50 percent more folic acid than broccoli, twice that of Brussels sprouts, thrice that of cabbage, and more than seven times more than kale. One cup of collard has more than five grams of fiber. Two hundred calories worth of collard supply the body with 85 percent of the recommended daily allowance of fiber. Juice extracted from the leaves or stalk is reputed to treat gout and bronchitis. One study compared collard, kale, mustard greens, broccoli, Brussels sprouts, and cabbage, finding collard the best at lowering cholesterol. Steamed collard is better than raw collard at lowering cholesterol. The American Cancer Society urges Americans to eat more collard and other members of the cabbage family to reduce the risk of cancer. Collard contains glucoraphenin, sinigrin, gluconasturtiian, diindolylmethane, sulforaphane, and glucotropaeolin, compounds that may protect one against cancer. Diindolylmethane may protect one against viruses and bacteria. Collard may reduce the risk of developing cancer of the bladder, breast, colon, lung, prostate, and ovaries. Collard contains the antioxidants caffeic acid, ferulic acid, quercetin, and kaemferol. Collard may reduce the risk of developing heart disease. So beneficial is collard that one writer recommends its consumption at least two or three times per week. When overcooked, however, collard loses nutrients.

Christopher Cumo

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Columbine

Columbine is the common name for the *Aquilegia* species belonging to the Ranunculaceae, or buttercup, family. It has been suggested that both the Latin name and the common name of these perennial, yet short-lived, plants are inspired by the instantly recognizable shape of the flower, which, from certain angles, appears bird-like. The name *Aquilegia* derives from the Latin word for eagle, *aquilia*, as the spurs of the flowers resemble the talons of a bird of prey. The Latin name may also be a compound of the Latin words *aqua*, meaning "water," and *leger*, meaning "to collect," as water may pool on the flowers and leaves and nectar collects on the spurs. The common name, columbine, derives from the Latin for dove, *columba*, for, looked at from above, the flower head of a short-spurred columbine resembles a dove with an erect tail.

Columbines (Jennifer Holcombe/Dreamstime.com)

Attributes

There are around 70 species of columbine with flowers appearing between April and July. The flowers are held either in loose racemes or singly with colors including shades of pink, purple, lilac, blue, white, yellow, and red or combinations of colors in single, double, and semidouble forms. The columbine Nora Barlow is a spurless, mutated form of *Aquilegia vulgaris*, which is popular for use in ornamental displays as it has pale green and rosy pink blooms in double form. The frilly appearance of Nora Barlow has led to the columbine gaining the familiar name granny's bonnet. Columbine plants are mound shaped, around one foot wide, with lobed green, blue-green, or gray-green leaves. Columbines can reach up to four feet tall, but the average height for a plant is nearer two-and-one-half feet. Columbines prefer full sun or partial shade with plants grown in full sun producing more blooms than shade-dwelling specimens. Columbines are not choosy about soil, growing usually in rich or average to light soil. However, as they grow from long, tough taproots, which make the plant drought resistant, columbines can be found growing in the cracks of walls and paths where both soil and moisture are scant. The length and strength of columbine taproots mean that once a plant is established, it can prove difficult to remove.

Columbines are pollinated by insects such as moths and butterflies and others with a tongue long enough to reach the flower's nectar. Bees that attempt to reach the nectar by scything through the tube holding the nectar find that the tube secretes a bitter liquid intended to discourage such action. The seed capsule of the columbine is less than one inch in length, consists of five sections, and houses numerous small, shiny, black seeds. Columbines can also be propagated easily from seed, and the plants are able to self-sow. Many cultivated varieties of the columbine are derived from the wild columbine *Aquilegia canadensis*, which has red petals and yellow spurs. However, if the cultivar is allowed to run to seed and self-sow, the descendants will revert to the wild *Aquilegia* form and the cultivar will be eradicated from the garden population. In 2002, the columbine's propensity to self-seed led to a ban on the import of *Aquilegia* seeds into the United States as the plant was considered to be too invasive if accidently introduced into the wild.

Uses

The columbine is widely distributed across the Northern Hemisphere, especially in temperate and cold regions at higher altitudes, although *Aquilegia fragrans* and *Aquilegia skinneri* are less tolerant of the cold than some varieties of columbine. In Europe, *Aquilegia vulgaris* proliferates, and wild columbines such as the five-petaled *Aquilegia canadensis* can be found across the United States and

Canada as the species was named during the period when Canada extended across the United States as far south as New Orleans. A western Columbine, the Rocky Mountain Columbine, is officially the state flower of Colorado. Columbine features in Native America cultures. In Iroquois legend, *Aquilegia canadensis* originated when five chiefs were transformed into the flower after having fallen in love with a maiden and neglecting their duties in their haste to find the object of their passion. The red petals of the flower represent the chiefs' shirts and the yellow spurs their moccasins. Different Native American tribes put the columbine to different uses. The men of the Omaha and Ponca Indians spread mashed columbine seeds on to their hands as a love potion, whereas Native Americans of the western United States would boil and eat the roots. However, columbine should not be consumed. Several species of the plant are toxic, and some parts of plant, especially the seeds, are potentially fatal if consumed because they contain cyanogenic glycosides. The columbine may be a carcinogen, so the medicinal or culinary use of the columbine is discouraged.

The Columbine in Literature

The columbine has also achieved significance in European culture. For instance, Columbine is a stock character of *Commedia dell'Arte* as the mistress of Harlequin, and in the traditional English pantomime, Columbine appears as a symbol of feminine beauty. The columbine has made appearances in several works of literature. In William Shakespeare's *Hamlet*, Ophelia speaks of columbines, alluding perhaps to their role in folklore as the flower of abandoned lovers.

Victoria Williams

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Coneflower. *See* Black-Eyed Susan (Rudbeckia)

Corchorus

In the Tiliaceae family, the genus *Corchorus* contains 50 or 60 species. The chief cultivated species are *Corchorus capsularis* and *Corchorus olitorius*. *Corchorus capsularis* is known as jute and white jute. *Corchorus olitorius* is known as molokhia, nalta jute, tosso jute, tusso jute, and Jew's mallow. The term "jute" is used for the plant and the fiber that derives from it. These two species are a source of fiber and food. The fiber is made into bags, carpet, curtains, fabric, and even paper. The leaves of corchorus are edible. Those of *Corchorus capsularis* are bitter and are seldom eaten, but those of *Corchorus olitorius* are sweet and are eaten as a substitute for spinach. Because they are palatable, children prefer them to spinach. A leaf is 18–22 percent protein. One hundred grams of leaves have 77 milligrams of vitamin C and 5 milligrams of beta-carotene. The leaves have more vitamins C and E than spinach. The leaves have calcium, iron, magnesium, and zinc. The term "corchorus" derives from the Greek *khorkhorus*.

Origin and History

Corchorus olitorius originated in Africa with a secondary center of dispersion in India and Myanmar. The 20th-century Russian agronomist Nikolai Vavilov believed that *Corchorus capsularis* originated in India, Myanmar, and southern China. In antiquity, this species was unknown in Africa and Australia. Since antiquity the people of Africa and Asia have used corchorus for fiber and food. Fourth-century BCE Greek botanist Theophrastus referred to the Greeks' cultivation of corchorus. Even today the Greeks consume corchorus leaves. First-century CE Roman encyclopedist Pliny the Elder was aware that the Egyptians grew corchorus.

Fiber

The fiber jute is widely used in the developing world because it is cheaper than synthetic fibers. The developed world, notably the United States and Europe, relies on cotton and synthetic fibers. India and Myanmar have for years been the leading exporters of jute. Corchorus for fiber is grown in northeastern India, Bangladesh, Pakistan, Myanmar, Nepal, China, Malaysia, Sri Lanka, and Brazil. The monsoon climate of these regions is ideal for corchorus. The valleys of the Ganga and Brahmaputra rivers are the chief regions of cultivation in India. Jute from India, Bangladesh, and Pakistan is traded on the world market. The valley of the Amazon River is the principal region of cultivation in Brazil. American farmers have experimented with the cultivation of corchorus, but the United States is not a leading producer.

Of the two species, *Corchorus olitorius* yields a larger crop of quality fiber, yet the species is not as well adapted to as wide a range of soils and climates as is

Corchorus capsularis. *Corchorus olitorius* produces a fine, soft fiber with an attractive sheen. The process of extracting the fiber from the stem is known as retting. To extract the fiber, stems are submerged in water 20 or 30 days. Bacteria in the water dissolve the pectin, gum, and mucilage that bind the fibers together. The addition of ammonium, potassium, calcium, and magnesium ions to the water hastens retting, which proceeds rapidly between 93°F and 95°F. Lower temperatures slow retting.

Food

Corchorus leaves are eaten in the tropics and subtropics. Demand is strong in the Middle East, Africa, Southeast Asia, and Latin America. The United States imports a small amount of leaves to feed Middle Eastern immigrants to the country. The leaves are added to sauce, relish, salad, and soup. In Asia the gathering of leaves is a secondary activity to the growing of corchorus fiber. In Africa, leaves are gathered from corchorus plants that are grown exclusively for food. The leaves are common in the diet of the people of Cameroon. Thirty to 45 days after planting the leaves are harvested for food. The leaves from a single plant may be harvested repeatedly. Plants from which leaves are derived seldom grown more than four-and-one-half feet tall. In Bangladesh and India, corchorus yields two tons per acre. The yield in China and Taiwan is higher but in Brazil lower. The leaves are eaten locally, though a portion enters international trade.

Botany and Cultivation

Corchorus grows to 12 to 18 feet. The stem has a diameter of 0.4 to 0.8 inche. The axil produces one to four flowers. Each flower has five sepals, five petals, and 10 stamens. Roots penetrate to 24 inches. *Corchorus capsularis* is a lowland crop. *Corchorus olitorius* prefers high ground. The plants photosynthetic capacity, as must be true of other plants, varies with leaf area. Early varieties mature in 135 to 160 days, intermediate varieties in 160 to 170 days, and late cultivars in 180 to 200 days. The variety Tanganika, a high yielder in India, matures in only 120 days. Red Swain, Zaoping, Jap green, and Kulkarius are early varieties. JRC-206 and JRC-909 are late cultivars.

In India, *Corchorus capsularis*, rotated with rice, is planted in early March, before the monsoon. In Bangladesh and parts of India, corchorus is sown between March and June. The farmer plants 7 to 13 pounds of seeds per acre. Dense planting yields thin plants with high-quality fiber. If sown too late, the stem branches, frustrating the attempt to derive long fibers. When *Corchorus olitorius* is planted before April, it flowers prematurely. The yield is low and the fiber of poor quality. Most corchorus varieties are sensitive to photoperiod, though the most widely grown cultivars are not. The variety Tanzania is insensitive to photoperiod.

Scientists aim to breed more cultivars insensitive to photoperiod. In the Philippines, spring planting produces a high yield of fiber and seeds.

The soil should be cultivated deeply and drain well. The black soils of India and Bangladesh are ideal. Corchorus benefits from the addition of organic matter to the soil. A crop of the tropics, corchorus needs uniform distribution of rain throughout the year, about 40 to 60 inches per year. Most corchorus is rain fed. Irrigation is uncommon. Corchorus benefits from a complete fertilizer. Nitrogen increases the yield of fiber because it stimulates the stem to grow long and thick. Phosphorus and potassium contribute to yield and make the corchorus plant less susceptible to disease. Calcium, magnesium, sulfur, manganese, zinc, and copper also contribute to yield. The farmer fertilizes corchorus twice during the growing season, once at planting and a second time when the plant is one month old. At the second fertilizatio,n ammonium sulfate is sued because it stimulates growth. Too much nitrogen, however, diminishes the color of the fiber, a circumstance deemed unattractive. Eighty pounds of nitrogen per acre is the maximum application (Maiti 1997, 25). One authority maintains that manure is the best fertilizer. Corchorus is a heavy feeder of potassium. The farmer may apply nitrogen at 72 to 88 pounds per acre (a figure that does not square with a maximum of 80 pounds per acre), phosphorus at 35 pounds per acre, and potassium at 18 pounds per acre. The variety JRO-632 yields best with 26 pounds of nitrogen per acre, 12 pounds of phosphorus per acre, and 88 pounds of potassium per acre.

Yields decline when corchorus is grown on the same land year after year. The yield is constant when the farmer rotates corchorus with rice or wheat. Corchorus is weeded three or four times until the plant is two months old, when it is large enough to crowd out weeds. The harvest is in November and December. When a plant has yielded half its flowers, it is ready to harvest. *Corchorus capsularis* is drought tolerant as a seedling, whereas *Corchorus olitorius* is drought tolerant as a mature plant. The Tropic of Cancer is the primary region of cultivation. Corchorus does well with 70–80 percent humidity. *Corchorus olitorius* is grown in Australia, Algeria, Egypt, Lebanon, Tunisia, Mozambique, the Philippines, Senegal, Thailand, Sudan, Afghanistan, India, Kenya, Nepal, and Zambia.

Christopher Cumo

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Coriander

In the Apiaceae family, coriander (*Coriandrum sativum*) is an annual herb grown for its edible leaves and seeds, which are used as a spice. Some writers refer to the seeds as coriander and the leaves as cilantro. Others use coriander and cilantro as synonyms. To prevent confusion this entry uses the term "coriander" to refer to the entire plant. The term "cilantro" is not used. The English word coriander dates to the 14th century and traces its lineage to the Old French *coriandre*, which in turn derives from the Latin *coriandrum*, the source of the genus name. These words appear to derive ultimately from the Greek *koriannon*. Coriander is known as Chinese or Japanese parsley and dizzy corn. In German, coriander is *Koriander*, in Italian *coriandolo*, in Spanish *cilantro* or *culantro*, in Arabic *kizbara*, in Indonesian *ketumbar*, and in Tamil *kothamilee*. Coriander is related to parsley and carrot.

Origin and History

Coriander may have originated in the Middle East or southern Asia. Archaeologists have dated coriander seeds in Israel to the Neolithic Period (8000–500 BCE). These seeds may be evidence of cultivation, though it is possible that the original inhabitants of Israel gathered them from the wild or got them through trade. The Egyptians placed coriander seeds in the tomb of 14th-century BCE pharaoh Tutankhamen. It is not easy to interpret the significance of this discovery. If coriander does not grow wild in Egypt, as two scientists maintain, then the Egyptians either cultivated coriander or obtained it through trade. If coriander grows wild in Egypt, as one writer asserts, then the seeds in Tutankhamen's tomb may have been gathered from the wild. Cultivation need not be invoked in this case. The author of Exodus likened coriander to manna. The book, telling the story of the Hebrews' flight from Egypt, allows one to infer that they may have encountered coriander in Egypt. If this is so, the Hebrews' cultivation of coriander in Israel may bear no connection to the earlier use of it in Neolithic Israel.

The Greeks cultivated coriander in the second millennium BCE. Greek physician Hippocrates (460–370 BCE) mentioned the spice. In the first century CE, Roman encyclopedist Pliny the Elder called coriander "coriandrum," the word that would later, we have seen, become the genus name. Coriandrum derives from *coris*, Latin for "bug." Pliny apparently thought that coriander had a "buggy smell." Pliny's choice of words underscored the fact that people either liked or disliked coriander's flavor and aroma. There appears to be little middle ground. It is possible that Pliny thought that coriander seeds resembled the bed bug (*Cimex lectularius*), giving rise to the name "coriandrum." Pliny identified Egypt as the source of the best coriander. In the 16th century, English herbalist John Gerard described coriander, which the Romans might have introduced into Britain in antiquity. Europeans widely used coriander until the Renaissance, when spices from the East Indies began to displace it. Coriander and other spices performed the essential function of disguising the flavor of rancid meat in an era before refrigeration and the unpalatability of medicine.

Food and Medicine

One hundred grams of raw coriander leaves have 23 calories, four grams of carbohydrate, three grams of fiber, one-half gram of fat, two grams of protein, and 27 milligrams of vitamin C. This serving size has 37 percent of the recommended daily allowance of beta-carotene and 45 percent of vitamin C. The entire coriander plant may be eaten. Coriander is part of the cuisine of the Middle East, Central Asia, the Mediterranean Basin, India and the rest of southern Asia, Mexico and the rest of Latin America, Texas, China, Southeast Asia, and Africa. The leaves have a flavor akin to citrus. The flavor of the seeds resembles lemon. Because heat lessens the flavor of coriander, the leaves and seeds are eaten raw or added to a cooked dish just before serving it. The people of India and Central Asia prefer a muted flavor and so cook the leaves and seeds. The leaves must be consumed quickly because they spoil soon after picking. The flavor of the seeds diminishes after they have been pulverized and so should be consumed soon after processing. Dried and frozen leaves have no aroma. Mexicans add coriander to salsa and guacamole and eat it as a garnish. Russians eat fresh leaves in salad. The people of Morocco, India, and Australia grow varieties that yield large seeds. Seeds are roasted or otherwise heated before being pulverized to heighten their aroma. Coriander seeds are an ingredient in sausage in Italy, Germany, and South Africa, in curry and garam masala in India, as a substitute for caraway in rye bread in Russia and Central Europe, and in beer in Belgium. Coriander seeds are eaten in soup and stew. Coriander is paired with meat and game. It is added to cake and baked goods. Arabs add coriander to lamb and meat and eat fried coriander and garlic. The Egyptians couple coriander and cumin. Coriander is an addition to ham, pork, fish, chicken, and chili. Coriander is coupled with ginger and is used to flavor tobacco. Peruvians add coriander to several dishes.

Coriander is thought to inhibit flatulence and to stimulate the appetite and digestion. People once believed that coriander lessened the severity of ergotism. Asians used coriander to treat headache, indigestion, diarrhea, inflammation, colic, conjunctivitis, rheumatism, neuralgia, and ulcers of the mouth. Coriander contains a substance that kills bacteria in meat and may prevent wounds from becoming infected. Coriander was once thought to be an aphrodisiac.

Christopher Cumo

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Corn

Also known as maize and Indian corn, corn is an annual grass in the Poaceae or Graminaceae family related to sugarcane, sorghum, teosinte, wheat, rice, rye, oats, triticale, timothy, millet and tripsacum. Teosinte and tripsacum are not cultivated for food. In the 18th century, Swedish naturalist Carl Linnaeus placed corn in the genus *Zea*, meaning "wheat-like grass," and in the species *mays*, a transliteration of "maize." In turn, maize derives from the Taino word *maiz*, meaning "life giver." A world crop grown in more varied climates and soils than any other grain, corn is cultivated in all tropical and temperate locales from 58° north to 40° south. So important is corn to the United States that it is grown in all 50 states. Corn is adapted to a range of growing conditions and can survive

Corn stalks (iStockPhoto)

in areas with as little as 10 inches of rain per year and as much as 400 inches yearly.

Unlike several other crops, corn is not primarily a food for humans. Worldwide, farmers feed three-quarters of their corn to livestock. In the United States, corn growers feed an even larger portion to livestock. One bushel of corn yields 15 pounds of beef, 26 pounds of pork, and 37 pounds of chicken. Humans thus consume corn secondhand.

The corn that livestock and humans do not eat is converted into an astonishing variety of products. Chemists convert corn into syrup, sugar, glue, and ethanol. Mayonnaise, soap, paint, and insecticides contain corn oil. Peanut butter, chewing gum, soft drinks, vegetables, beer, wine, crackers, bread, frozen fish, hot dogs, and corned beef all have corn syrup among their ingredients. Derivatives of corn are found in cough drops, toothpaste, lipstick, shaving cream, shoe polish, detergents, tobacco, rayon, leather, rubber tires, urethane foam, explosives, and latex gloves. A product in baby food and embalming fluid, corn attends life from birth to death. One ear of corn contains 75 calories, 15 grams of carbohydrate, 2 grams of protein, 1 gram of fat, and 2 grams of fiber. Corn is a source of vitamin C, vitamins B1 and B5, folic acid, phosphorus, and manganese.

Origin and Domestication

Despite intensive research, scholars do not agree on where and when corn originated. The outstanding feature of corn is its dependence on humans for survival. No species of corn is wild. Rather, corn perpetuates itself only with human aid. The husk that surrounds corn binds the kernels (seeds) so tightly that they cannot disperse. Were an ear of corn to fall to the ground, the seeds would germinate so close together that they would die from overcrowding. This state of affairs suggests that humans have cultivated corn many millennia.

In the 19th century, French botanist Alphonse de Candolle proposed that corn originated in Colombia, from which it spread to Peru and Mexico. From Peru, de Candolle believed, corn diffused to South America and the Caribbean and from Mexico to North America. In the 1920s, Peruvian archaeologist Julio Tello dismissed the idea that corn originated in Colombia. Rather, the people of Peru and Mexico independently domesticated corn. In 1939, American botanist Paul Mangelsdorf proposed a variety of wild pod corn, now extinct, as corn's ancestor. Pod corn differs from corn in having a husk for each kernel. This early corn hybridized repeatedly with teosinte, a process that increased the size of corn's ears. This hybridization may have been accidental. Humans may have grown corn near fields of teosinte. This hypothesis is most plausible if corn originated in Mexico, where a species of perennial teosinte grows. Because corn cross-pollinates, it might have readily hybridized with teosinte. Alternatively, humans may have purposefully crossed early corn and teosinte to obtain hybrids (a process different from the production of hybrid corn). Mangelsdorf believed that humans first propagated corn in both Mexico and South America. Others propose Central America as the cradle of corn. American agronomist Hugh Iltis thinks that corn derived from a perennial teosinte and that corn evolved rapidly in size, possibly by mutation.

Archaeologists have found the oldest fossilized corncobs in the Tehuacan Valley, suggesting that corn originated in Mexico about 7,000 years ago. Subsequent excavations in New Mexico turned up corncobs as old as 5,600 years. From Mexico, corn must have migrated north throughout North America as de Candolle thought. From Mexico, corn spread to Colombia around 5,000 years ago and to Peru around 4,000 years ago. Mangelsdorf is surely right in supposing that the Amerindians took corn wherever they migrated. Wherever migrants made contact, they likely exchanged varieties of corn, hybridizing them in the process.

Mangelsdorf believed that humans domesticated corn by accident. Harvesting the then extant wild corn, they must have taken the kernels home for processing and consumption. Along the way, they might have dropped seeds into the land surrounding their homes. They must have observed the plants that germinated from these seeds, harvested their ears, and replanted a portion of the seed. By weeding their land, these first farmers would have allowed corn plants to thrive in the absence of competition. In areas of scant rainfall, humans irrigated corn, though as we have seen some varieties of corn survive on only 10 inches of rain per year.

Whatever the place and time of origin, these hypotheses affirm that corn originated in the Americas and came to the Old World only after 1492.

Corn before 1492

Before 1492, the indigenes of the Americas grew corn from Canada to Chile. So important was corn to the Amerindians that it must have come from the gods. The Maya believed that the god Oze Hunahpu, who defeated the Lords of Death, gave them corn. The Inca believed that the god Manco-Poca, the son of the sun, gave humans corn. The Totenae of Central America received corn from the goddess Tzinteatl, the wife of the sun. The Aztecs looked to the goddess Xilonan and the god Quatzalcoatl for corn. The Pawnee believed that the Evening Star gave them corn.

Probably using recurrent selection, the Amerindians developed the principal types of corn: flint, dent, flour, pop, and sweet. Because cob size increased with time, the Amerindians must have selected plants with large ears, though they may have eaten the best corn and saved only the less desirable kernels for planting.

The Amerindians did not plant corn in isolation. The Peruvians grew corn and potatoes. The natives of North America planted the three sisters: corn, beans, and squash. This triad of plants is nourishing and agriculturally sound. Beans provide protein that corn lacks and take full advantage of sunlight by climbing the corn stalks. Squash, covering the ground with its leaves, chokes out weeds and helps soil retain moisture. Despite the absence of knowledge of nutrition, the Amerindians were nonetheless perceptive enough to soak corn in alkali water, which liberates the niacin that is otherwise unavailable for digestion. The Amerindians prized corn for its rapid maturation, its meager demand for labor, and its longevity in storage. The indigenes understood that corn, unlike other crops, need not be harvested when ripe. By one estimate, the Amerindians devoted 20 hours of labor per bushel of corn.

Corn was the staple of New World civilizations. The Maya erected their civilization on a foundation of corn. Human sacrifice was part of corn culture for the Maya, who fertilized their fields with the blood of sacrificial victims. So central to Mayan civilization that its failure was surely catastrophic; the corn crop may have declined sharply in the ninth century CE, abruptly truncating the civilization. One hypothesis holds that a disease spread by insects killed large numbers of corn plants, causing famine. Unable to recover, the Maya abandoned their cities.

Growing potatoes, the people of Peru were less dependent on corn, though it remained the staple grain and held religious significance. The Inca, who built the last pre-Columbian civilization of Peru, worshipped the goddess Mother Corn. Royalty claimed descent from the union between Mother Corn and the sun. Where rainfall was inadequate the Inca irrigated corn. Taking advantage of mountain slopes, they planted corn in terraces. Their skill in retaining the fertility of corn land enabled the Inca to crop the same land year after year without fear of soil exhaustion. At Cuzco and the highlands, Inca farmers fertilized their land with human excrement. Along the southern coast, they used guano. Elsewhere sardines, buried in the soil, were the fertilizer of choice.

In August, Inca farmers turned the soil with hoes. Without the aid of a plow or draft animal, this task must have been arduous. In September, they planted corn, an event the emperor commenced by digging the first hole and planting seed in the royal plot in Cuzco. Planting was a time of celebration analogous to New Year's Day in the Western world. Women weeded the fields and in May harvested corn. Like many cultures, the Incan system of agriculture exploited commoners, who labored on royal land in addition to their own.

Corn was currency with each kernel being a coin. In a transaction, the buyer placed a fistful of kernels on a table. If the seller deemed the number of kernels insufficient, she said nothing but instead stared at the kernels. The buyer, if she still wanted the item, added a small number of kernels to the total until the seller was satisfied. Where barter prevailed, Inca women exchanged garden produce for cornbread.

For millennia, the people of Peru brewed the beer chichi from corn. So widespread is the consumption of chichi that Peruvian Christians use it rather than wine in reenacting the Last Supper. Along with mother's milk, chichi is the first liquid given to babies.

Like the Inca, the Aztecs irrigated corn, cropped year-round, and renewed their soils with human excrement. They also covered their fields with fresh mud, another restorative measure. So large was the surplus that Tenochtitlan had a population of 1.5 million in the 15th century. But times were not always good. The famine of 1450 forced parents to sell their children for corn: a girl fetched 400 ears of corn, whereas a boy was worth 500 ears. As with the Inca, the Aztecs used corn as currency, paying their taxes with it. The goddess Chicome Couatl blessed corn seed before farmers planted it. Planting stretched from March to May. Weeding their fields two or three times, Aztec farmers harvested corn in September, giving a portion to Cintaotl, the god of ripe corn. By one estimate, the Aztecs coaxed 16 bushels per acre from the land, a yield that compares favorably with figures from the early 20th century.

Like other Amerindians, the Hohokam of the American Southwest irrigated corn. The goddess Corn Matron blessed seed before planting. The Hohokam gathered corn in fall, with the first frost signaling the beginning of the harvest. Around 400 CE the Anasazi, irrigating their fields, grew corn in what are now Colorado, Utah, Arizona, and New Mexico. Around 900 CE, the Sioux grew corn in the Dakotas. East of the Mississippi River, the woodlands Indians, and in the Southeast the Mississippian culture, thrived on corn. In many cultures, women shouldered the burden of cultivating corn. The Iroquois appointed one woman to direct the labor of her tribe. Women also dug the pits in which the Iroquois stored corn. The Iroquois collected liquid from corn stalks, using it as a balm. The Hopi rubbed corn meal, a gift to the living and the dead, on the faces of infants and corpses. Corn, finely ground, was the traditional food at Hopi weddings. The Hopi made dumplings, pancakes, and grits from corn. Perhaps for religious reasons, many Amerindians segregated corn by color and type. Among the Hopi, each family was responsible for maintaining the purity of a variety of corn, passing seed down through the generations.

According to a few scholars, corn spread to the Old World before Christopher Columbus reached the Americas. One account holds that the seafaring people of the American West ferried corn across the Pacific to Asia sometime before 1492. Another hypothesis, relying on linguistic and pictorial evidence, proposes that Arabs brought corn to Africa around 900 CE. It is unclear, however, how corn reached Arabia in the first place. This hypothesis also proposes that Arabs brought corn to the Philippines before 1492. These hypotheses share in common their acknowledgment that corn was domesticated in the New World, but they contradict the current understanding by proposing the diffusion of corn prior to the Columbian Exchange.

Corn and the Columbian Exchange

Columbus's discovery of the Americas transformed corn from a hemispheric to a world crop. He may have first seen corn on October 14, 1492, on the Caribbean island of San Salvador. A few days later he saw in the Bahamas what he called *panizo*, Italian for millet. Because millet had not yet been introduced to the New World, Columbus must have been mistaken. Instead, he likely saw corn. On November 5, he dispatched two men to reconnoiter Cuba. They returned with corn, calling it maiz as the indigenes did.

Recognizing its value, Columbus brought corn back to Spain in 1493. Within 25 years, it spread throughout the Mediterranean Basin. Within 50 years it was grown worldwide. So ubiquitous did corn become so quickly that some people forgot that it was a native plant of the Americas. In the 16th century, one French botanist called corn Turkish wheat in the mistaken notion that corn had originated in Turkey. Confusing it with millet, the Portuguese called corn *milho*, which derives from *milhete*, meaning "millet." Because of this confusion, Portuguese writers posited Asia as the home of corn. Later generations of Chinese were sure that corn had originated in China.

Despite its importance, some Europeans did not esteem corn. One smug botanist opined that corn was less nourishing than Old World grains. It was fit for pigs not humans. The Chinese thought of corn as poor people's food and ranked it below rice and millet. Even today the Chinese eat rice rather than corn, exporting 60 percent of their corn crop to Russia and Japan and feeding much of the rest to livestock. Indeed, the Amerindians were astonished that European settlers fed corn to livestock, a practice that continues today.

Despite their ambivalence toward corn, the Chinese grew it in bulk upon their adoption of the crop from the Portuguese in 1516. A surplus of corn made possible the population expansion that began in the 17th century. Thanks to corn, China's population quadrupled in the 18th and 19th centuries. Farmers grew corn in Manchuria, the Yangtze Delta, the mountains of Yunan and Szechwan, and southwestern China. Today, corn totals 22 percent of all crops grown in China.

Perhaps corn had its greatest effect on the United States. From the beginning of European colonization, corn shaped the lives of settlers. The Amerindians brought corn to a harvest festival, inviting the settlers to join in their abundance. Keeping the corn, Europeans transformed the festival to Thanksgiving. In the 19th century, Americans carried corn as they migrated west. The Midwest proved a hospitable locale for corn and in it Americans created the Corn Belt, an area from western Ohio to the Dakotas and south to Texas. By the mid-19th century, the U.S. corn crop was worth five times more than the value of wheat, other grains, and vegetables. American farmers were not as avid as Amerindians in manuring their corn. Consequently, corn culture depleted the soil. Farmers made amends by rotating corn with clover and alfalfa, crops that fixed nitrogen in the soil. After World War II, farmers rotated corn with soybeans, and in the Corn Belt soybean acreage surpassed corn acreage in the 1980s.

In the South, the legacy of corn was mixed. So important was corn that it became the dietary staple. Planters fed corn to their slaves though they dined on bread. As in China, a diet of corn marked a person as low status. Like slaves, poor whites ate corn, though with adverse results. Because whites did not retain the Amerindian practice of soaking corn in alkali water, they did not have sufficient niacin in their diet. Moreover, corn is deficient in amino acids and so is an inadequate source of protein. Consequently, pellagra, a disease of dietary deficiency, was endemic to the South. In an era before the discovery of vitamins, scientists were divided on the cause of pellagra. Because of corn's ubiquity in the diet, some scientists fingered the grain as the culprit. One camp thought that corn must be deficient in some nutrient. Another camp suspected that a disease of corn, transmitted to humans, caused pellagra. The recommendation that people eat fresh corn free from blemish did not improve the health of ailing southerners. In the 10th century, the discovery of niacin and the adoption of a varied diet caused the incidence of pellagra to decline.

Corn Flakes was the original breakfast cereal, and Tony the Tiger, the mascot of Sugar Frosted Flakes, has been a familiar figure on television ads. In the affluent West, corn syrup is an ingredient in many foods. As early as 1733, the Molasses Act, which taxed the sale of molasses, stirred the American colonists to turn instead to corn syrup. In 1806, Napoleon's Continental System, blockading Caribbean sugar, stimulated the French to produced corn syrup to satisfy the nation's sweet tooth. Today, high-fructose corn syrup, cheaper than sugar, is the sweetener of choice.

Stung by the Organization of Petroleum Exporting Countries' oil embargo, the United States began in the 1970s to produce the fuel ethanol. Between 1978 and 1984, U.S. ethanol production leapt from 10 million gallons to 430 million gallons. Today, some exports question the diversion of food to fuel on the grounds that corn should feed the world's burgeoning population rather than combust in car engines.

In the 21st century, corn has emerged as arguably the world's most important crop. In 2007, the United States produced nearly half of the world's total corn yield. Much of the harvest is genetically engineered corn. This corn is resistant to pests and herbicides. China is the world's second-largest corn producer.

Toward a Science of Corn

In the early 20th century, the Corn Show spread throughout the Corn Belt. A yearly contest akin to the county fair, the Corn Show upheld the virtues of rural life and was as much about instilling civic pride as it was about judging corn.

The Corn Show replaced the quest for yield with an appeal to aesthetic sensibilities. Judges favored large ears with straight rows, full and uniform kernels, and no bird or insect damage. Agronomists, eager to share the latest research with farmers, visited the Corn Show. Some praised the event for encouraging farmers to be keen observers of their corn crop. Others thought the Corn Show distracted farmers from the only criterion that really mattered: yield.

In 1905, Illinois agronomist Cyril George Hopkins pioneered the ear-to-row method of breeding corn. Using several ears of corn, he planted seed from each ear in a row, allowing the plants that germinated from these seeds to cross-pollinate. Because all plants in a row were siblings, Hopkins could chart the pedigree of every plant. By keeping seed from only the highest-yielding row and repeating the ear-to-row method over several seasons, he hoped to derive high-yielding corn. Although he was able to select corn with high oil, he made no progress with yield.

Others, seeing that Hopkins's method did not work, turned to genetics for answers. Austrian monk Gregor Mendel had founded the science as a result of his work hybridizing pea plants. The American geneticist George Harrison Shull realized in 1909 that if he inbred corn, a naturally cross-pollinating plant, he could separate it into types. Each type would be similar to a variety of peas, and by crossing them a breeder would hybridize corn as Mendel had hybridized peas. Hybridization allowed breeders to derive corn with heterosis or hybrid vigor. Heterosis was not a new phenomenon. Humans had known for millennia that the mule, a hybrid between the horse and donkey, has greater vigor than its parents. In corn, heterosis might give plants high yield, resistance to diseases, insects, and drought, stalk strength, or some combination of desiderata.

Although simple in concept, the breeding of hybrid corn occupied plant breeders for a generation. The problem lies in the reproduction of corn, a plant that cross-fertilizes rather than self-fertilizes, as do many other grains. The tassel, having the pollen, and the silk, having the ovule, are far apart on corn, and wind wafts pollen from one plant to another. To inbreed corn, the first step in producing a hybrid, a scientist or farmer or someone familiar with the anatomy of a corn plant must cover the tassel and silk to prevent their cross-pollination. When the tassel is full of pollen, a scientist gathers it to place on the silk of the same plant. The process of inbreeding yields homozygous lines of corn that breed true, as does a variety of peas. In perverting the natural process of crossbreeding, inbreeding attenuates corn, producing scrawny ears with little seed. This small sample provides a breeder enough seed to make a cross on a tiny parcel of land but not enough to produce hybrid seed on the scale that farmers needed for their fields. As long as the yield was small, hybrid corn remained an interesting phenomenon rather than a business venture. In 1917, however, Connecticut agronomist Donald F. Jones obtained large amounts of seed by crossing four inbred lines over two generations.

Accustomed to saving a portion of their corn crop for next year's seed, farmers did not buy hybrids in large numbers in the 1920s. The drought of 1934 and 1936, however, proved the superiority of hybrids. In arid lands, farmers saw their varieties of corn wither whereas hybrids survived. This demonstration won over farmers. Between 1933 and 1943, the percentage of corn acreage planted to hybrids leapt from 1 to 90.

Hybrid corn aided the spread of technology. The old varieties of corn were difficult to harvest because they did not stand straight but bowed under the weight of ears. With stronger stalks, hybrids stood erect and were easily harvested by the mechanical corn picker. The mechanical harvester spread throughout the Corn Belt after World War II. Today, almost no corn is harvested by hand.

In the 1940s, scientists discovered genes that made corn produce no pollen. Using these male sterile lines as the female plant, breeders crossed them with normal plants to obtain hybrids. Although the use of male sterile lines simplified the work of breeding corn, scientists did not fully appreciate their susceptibility to disease. The Southern Corn Leaf Blight, a fungal disease, struck the U.S. corn crop in 1970 and 1971. Some farmers along the Mississippi and Ohio rivers lost their entire crop. Science had not been able to save the corn crop from catastrophe.

In the late 20th century, traditional breeding ceded ground to genetic engineering. In the 1970s, scientists learned to extract genes from one organism and insert them into another, an achievement with obvious applications to agriculture. In 1997, the agrochemical company Monsanto inserted into corn genes from the bacterium *Bacillus thuringiensis* (Bt) that code for the production of a toxin to the European Corn Borer, a pest of corn since 1917. Bt corn allowed farmers to use less insecticide, a practice that saved money and the environment. Yet in 1999, scientists at Cornell University charged that Bt corn pollen killed Monarch butterflies, stirring up a debate over the role of genetic engineering in agriculture that continues today. Despite the furor over genetic engineering, the future of corn, as was true of the past, is surely tied to the progress of science.

Christopher Cumo

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Costmary

Tanacetum balsamita, known as *Balsamita major* or costmary, is an old cultivated plant in Europe and in the Mediterranean region. A member of the Asteraceae family, it is a perennial with oval serrated leaves. Under favorable conditions, it can grow to be almost six feet high. During the summer, the small yellow button-shaped flowers appear in clusters. Costmary is easily grown; although it prefers a sunny situation, it thrives in a variety of conditions. All parts of the plant give off a striking scent. Its sweet smell has been likened to that of toothpaste. It is due to this sweet aroma that, in many languages of Europe, names alluding to balsam have been given to it. In many cases, however, the allusion is instead to the Blessed Virgin, perhaps indicating an association with women's diseases. In German, for example, it has been called *Mariamintz*, *Marienblatt*, *Marienblättchen*, *Marienwurzel*, *Frauenbalsam*, and *Frauenkraut*. Its usual English name is Costmary (from "Costus of Saint Mary"). It is known in French as *herbe sainte-Marie* or *Menthe de Notre-Dame* and in Italian as *erba di Santa Maria* or *erba della Madonna*. Some of its Danish names have also alluded to the Virgin. A publication from 1550, for example, refers to the herb as *Vor Frue urt*.

It was widely cultivated in Europe until the late 19th and early 20th centuries, especially for use as a medicine and a spice. Elizabethan knot gardens often featured it. In the 1880s in Norway, it was considered one of the most common garden plants. During the 20th century, however, its cultivation largely ceased. It is rarely found in European home gardens today. Old-fashioned gardens still feature it occasionally as a traditional ornamental plant. It also grows wild in some places, for example along roadsides. It persists as a relic of an earlier time, when it had a series of different uses.

Origin and Spread

Tanacetum balsamita appears to have originated in the eastern Mediterranean, presumably in the Caucasus region. It is not known when it first began to be cultivated. There is debate as to whether the plant referred to as *balsamita* by the Roman author Columella, around the year 70 CE, was the same as the one in question here. The indications, however, are that Costmary first appeared as a cultivated plant during the Migration Period. According to some accounts, including that of the German ethnobotanist Heinrich Marzell, it was first mentioned (under the name of *costum*) in the year 812, in the plant catalogue featured in *Capitulare de villis vel curtis imperii*, an edict decreed by King Charlemagne that regulated the administration of his crown estates.

Costmary was grown quite widely, especially for medicinal purposes at least until the late 19th and early 20th centuries. It still graces old gardens in the

Mediterranean region occasionally. For the most part, however, it has disappeared. Nowadays, it is found only in some traditional home gardens in Europe, but is still widely used in Southwest Asia. It is naturalized as a weed in many parts of the world.

It is as a medicinal herb that it first attracted attention in Northern Europe, and it is likely on account of its striking aroma that curative powers were attributed to it. Christian Pedersen, a canon from Lund, wrote several prescriptions during the 1530s in which costmary figured. The same was true of Henrik Smid, a clergyman from Malmö, who included several prescriptions made from the green leaves of this plant in a publication of his from 1546. Several Scandinavian authors from the 17th century also mention it, indicating its cultivation in domestic gardens. It appears to have been rather common in the gardens of Swedish clergymen in the early 18th century. During the 19th century, it was widely grown on peasant plots. Nowadays, however, it graces few gardens in Northern Europe.

Medicinal Herb

The characteristic scent that costmary emits has drawn the interest of physicians and healers. The herb is mentioned, for example, in many of the herbals published during the early modern period. In 1539, German physician Hieronymus Bock provided not just an exhaustive description of the plant but also a quite thorough account of both its external and its internal uses. Should menstruation be irregular or even cease, these herbals aver, women will do well to keep some dry leaves of costmary near at hand for use in a decoction for bathing the feet.

Books of medicine from the 18th century classify costmary as good for the stomach, as a laxative, and as an astringent. They recommend the flowers for internal use in order to combat melancholy and hysteria. Throughout Europe, the herb was officially commended for medicinal purposes, in some areas up to the early 20th century. Until 1788, for instance, the British Pharmacopeia prescribed it against dysentery. As late as the 1930s, in fact, the German physician Max Stirnadel recommended tea made from its leaves for the treatment of gallbladder disease.

In Southern Europe, costmary has continued to feature in traditional medicine up to our own time. In Northern Europe, it was prescribed during the 19th century against aches of the head, tooth, and ear. In some parts of France, it was known as *herbe de colique*, indicating its medicinal function. In Slovakia, the juices extracted from it were used as healing liquid. It seems to have had a medicinal use in Italy and Spain too; in some parts of these countries, in fact, it still figures in traditional folk remedies. In Turkish and Iranian folk medicine, it has been utilized as a tranquilizer and cardiac tonic.

The herb has also had external uses. Scandinavians, for example, used a decoction of its leaves as an insect repellent for children and cattle. It has also been used as an insecticide in southern Europe. Inflamed breast nipples were treated with a salve produced from costmary and cream.

In recent years, pharmacologists have taken a renewed interest in *Tanacetum balsamita*. One study shows that it contains highly aromatic oil with carvone as its main component, together with smaller quantities of alpha-thujone, beta-thujone, t-dihydrocarvone, c-dihydrocarvone, dihydrocarveol isomer c-carveol, and t-carveol. The leaves are antiseptic, astringent, digestive, and laxative. The herb is mildly toxic.

Spice

In addition to its medicinal functions, costmary has served as a spice. Conrad Gessner, the Swiss naturalist, recorded in the 16th century that its leaves were used to season egg courses and other dishes. From Italy come reports that, up to our own day, it has been used as a spice for omelets. The names *Kuchenkraut* ("cake herb") and *Pfannekuchenkraut* ("pancake herb"), from German-speaking areas in Central Europe, point to its earlier use as a seasoning for pancakes. In England, it was used as a sort of spice for beer. In York, for example, it was called alecost, "because it was frequently put into ale, being an aromatic bitter," according to William Carr, a scholar of dialects, in 1828.

In some parts of Europe, moreover, it was used to counteract bad odors in the home, and to spread a pleasing scent in wardrobes. But its employment for this purpose gradually ceased, as other aromatic substances and methods for protecting clothing gained ground.

In the Church Bouquets of Peasant Women

Yet it was not mainly for its value as a medicinal herb that costmary first drew the interest of the peasantry of Northern Europe. This interest was due, rather, to the scent emitted by the plant, which was inhaled as a sort of invigorating remedy. It was widely grown on peasant plots during the 19th century, and from there it spread to the gardens of private homes. According to a Swedish handbook on cultivated plants from 1893, costmary was widely grown on peasant plots for its aroma, and for its use in imparting a pleasant smell to clothing. It was above all peasant women who took an interest in the herb. Aside from using it to sweeten odors in wardrobes and in homes, they inserted it into their church bouquets (the aromatic nosegays that they brought to services on Sunday). Extant records of the church bouquet mention "costmary" as one of its most prominent components. A Swedish book on gardening methods from 1910 describes the herb: "This plant is very common in our countryside, and few cottages are so small that they do no furnish themselves with one or two stands of it. The custom among older ladies is to take along a couple of leaves—inserted between handkerchief and hymn book—when attending church on Sunday . . . Costmary is important, for it is thought to be helpful in holding sleep at bay." Women in Denmark also brought it to church. In England, it was known as Bible Leaf, for it was used as a bookmark in Bibles. The sermons, after all, were long, and the pleasant scents from the aromatic herbs in the bouquet helped the women stay awake. The church bouquets, in which costmary figured, however, were a feature of the old peasant society. Older women in Scandinavia continued to bear church bouquets up to the early 20th century; with the emergence of new churchgoing customs, however, the practice gradually disappeared.

In Central Europe, costmary was still used as an ornamental plant at gravesides in the mid-20th century. However, due to the increased supply of garden plants that are more beautiful and more interesting, it has been sidelined as a cultivated plant and replaced with others. Yet it has persisted in some older gardens, although documentation is limited. Its remaining stock is a biocultural legacy worth preserving.

Plant for the Future?

In recent years, costmary seeds have turned up once again in the market. With the growing interest in old-fashioned plants, it may be that costmary will enjoy a renaissance as a garden plant. Never again, however, will it serve as an aromatic plant or medicinal herb. The plant functioned in the latter ways in a different society and another time. It may acquire new uses, however, if its chemical traits prove interesting to exploit.

Ingvar Svanberg

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Cotton

Known as white gold, cotton is the world's most widely grown fiber crop. Its primary use is in making clothing. Socks, underwear, and T-shirts derive from cotton. The fiber is also used to make towels, robes, denim, corduroy, bed sheets, and

Cotton (iStockPhoto)

yarn. Manufacturers even fashion cotton into tents, and it is an ingredient in coffee filters, gunpowder, paper, and bookbinding. In addition to the widespread use of cotton fiber, cottonseed has several uses. It is 17 percent oil, 45 percent meal, 10 percent linters, and 28 percent hulls. Cottonseed oil is an important source of vegetable oil and is in margarine, mayonnaise, salad dressing, cooking oils, and shortening. Stockmen feed cottonseed meal to their animals. Cottonseed meal has 1.4 times more protein than soybean meal, 1.8 times more protein than nonfat dry milk, and 2.5 times more protein than hamburger, with 14 times less fat. Cotton may derive from the Sanskrit *karpasa-i* or the Arabic *af-or el-katum*, which has been shortened to *gutum* or *kutum.*

Origin and Diffusion

Cotton is an ancient plant. By 60 million years ago, early cotton species existed in both the Old and New Worlds. At this time a land bridge across the Pacific linked Asia and the Americas. At least 1 million years ago, cotton species *Gossypium herbaceum* from Asia and *Gossypium raimondii* from the Americas spread across the land bridge, hybridizing in Micronesia and Polynesia. Early humans may have brought cotton with them as they migrated across the planet, providing new opportunities for cotton species to crossbreed.

Humans have domesticated four species of cotton, two in the Americas and two in Eurasia and Africa. The most widely grown species, *Gossypium hirsutum*, originated in Mexico's Tehuacan Valley and spread in prehistory throughout Mexico, Central America, the Caribbean, South Florida, the Florida Keys, and southern New Mexico. Humans have cultivated *Gossypium hirsutum* since 6000 BCE. Today, farmers grow it on 90 percent of all cotton acreage. *Gossypium barbadense*, the other New World species, is known as Sea Island cotton because people cultivated it on the islands near South Carolina and Georgia. Sea Island cotton likely spread from South America to the Caribbean and then to North America. European settlers in North America extended its cultivation to the coasts of South Carolina and Georgia, though attempts to grow it inland failed. *Gossypium barbadense* produced long, highly prized fibers and commanded a high price. The two Old World species, *Gossypium herbaceum* and *Gossypium arboreum*, are native to Asia and are today grown in Africa. Indian farmers still grow *Gossypium arboreum* on soils in which other species do poorly.

The people of Mexico were the first to cultivate cotton. In the Old World, cotton was first grown in the Indus River valley about 5000 BCE. Not used initially to make clothing, cotton was first packing material to protect pottery during transit and as dressing for wounds. From the Indus River valley, cotton spread to Africa by 4000 BCE and probably from Africa to Arabia between 3000 and 2500 BCE. In the frost-free zones of Africa and Asia, humans grew cotton as a perennial. By the time of Christ, cotton was grown between 25° south and 20° north. In temperate regions, frost killed cotton plants, requiring annual replanting, so that inhospitable climates led people to treat cotton as an annual. Around 2300 BCE, the people of the Indus River valley were the first to make cotton clothes. Thereafter cotton spread east to China and Burma. From Arabia, cotton spread both west and north. In the New World, cotton migrated from Mexico to Peru, where people made cotton fishing nets between 2500 BCE and 500 BCE. Judging from the content of tombs, the ancient Peruvians were skillful spinners of cotton cloth and tapestries. From southern Mexico and the Yucatan, the Maya may have brought cotton to the Caribbean. The Inca spread cotton to the Amazon River valley. The ancients of India, Egypt, and China wore cotton clothes. In the first century BCE, Arabs found a market for cotton in Italy and Spain. In the ninth century CE, Muslims planted cotton in Spain. In the 14th century, one English writer, ignorant of the anatomy of a cotton plant, thought that each plant produced a tiny sheep whose hair was really cotton fiber that was shorn like wool.

Even though cotton is native to the Americas, as well as to Asia, European settlers in the former brought their own varieties of cotton for planting. The Spanish made the first European planting of cotton in North America in 1556, cultivating cotton in Florida. In 1607, the English planted cotton in Jamestown, Virginia, and since 1621 the American South has exported cotton. Colonists grew cotton as far north as New Jersey and Pennsylvania, though the climate prevented these regions from becoming significant cotton producers. In the early years, the

American colonies did not produce much cotton, being a net importer. The colonies derived much of their cotton from the Caribbean and the Levant. Around 1750, farmers in the Louisiana Territory began growing cotton varieties from China and Thailand.

In the 18th century, the invention of the spinning jenny quickened the production of cotton cloth, and Great Britain became the center of the global cotton trade. Importing raw cotton from India, Egypt, and the Americas, Great Britain exported finished goods to the rest of the world. Those who invested in technology and land became wealthy, but the masses of farm laborers and textile workers were desperately poor.

In the 1780s, farmers imported Sea Island cotton from the Bahamas to Georgia. The next decade Sea Island cotton migrated north to South Carolina. After the War of 1812, cotton moved west, though only upland varieties of cotton proved adaptable to cultivation in the interior of the United States. By 1850, the Gulf Coast was the United States' leading producer of cotton. Its culture sunk roots in the black clays of Alabama and in Arkansas, Louisiana, and Mississippi. The invention of the cotton gin in 1793 automated what had been the time-consuming task of separating lint from seed. Having widened this bottleneck in production, the cotton gin made possible the growing of more cotton. The Panic of 1837 slowed cotton production in the 1840s, but prosperity returned in the 1850s. By 1860, cotton culture had spread from North Carolina to Texas and from Tennessee to Florida.

The Civil War forced Great Britain to look to India and Egypt for cotton. In the 1860s Australia, responding to the shortage of cotton, began growing the shrub on newly cleared land. Since 1900, farmers in Uganda and Malawi have grown cotton, though coffee has rivaled and in some cases replaced it. In Malawi, farmers with fewer than six acres grew cotton. Because cotton is labor intensive, some Malawi farmers have switched to corn. Where large farms predominate, cotton growers spray insecticide by airplane.

In the 20th century, soybeans became an alternative to cotton in the southern United States. Since the 1930s, cotton farmers have planted legumes and sorghum, causing cotton acreage to decline. The oversupply of cotton during the Great Depression depressed prices to new lows. To reduce supply President Franklin D. Roosevelt's New Deal paid farmers to plow under cotton. They had difficulty prodding their mules to pull plows through cotton rows, leading southerners to remark that the mules were smarter than the Washington elites who had ordered this destruction. The Allies' demand for cotton during World War II returned prosperity to the South. In 2009, China was the leading cotton producer, followed by India, the United States, Pakistan, and Brazil. The United States is the world's leading exporter of cotton, followed by India, Uzbekistan, Brazil, and Pakistan.

In the United States, farmers rotate cotton with sorghum, rice, soybeans, corn, safflower, and wheat. In Australia, farmers rotate cotton with wheat and soybeans.

In parts of Africa, cotton is rotated with sorghum, wheat, and groundnuts. In Uganda, farmers rotate cotton with bananas and coffee.

Cotton and Labor

In the New World, the shortage of labor led planters to enslave Africans and their descendants. Cotton, sugarcane, and tobacco estates all used slaves. Thomas Jefferson expected slavery to die out in the South as planters exhausted their soil. The invention of the cotton gin accelerated the pace of production, and the westward migration of settlers opened new lands to cotton. Rather than disappear, slavery was anchored to cotton culture until the Civil War ended it. Slavery was viable only on plantations. Poor whites grew cotton on small farms, relying on the family for labor.

Slaves on plantations and whites on small farms used a mule and plow to break soil in the spring. Depending on latitude, farmers planted cotton between February and June. Several hoeings followed germination, and cotton was picked by hand into the 20th century. Because not all cotton was ready to harvest at the same time, farmers picked it over several months. On average, one worker could tend six to nine acres of cotton. After the harvest, cotton was ginned. Small farmers took their cotton to large estates to be ginned.

After 1865, sharecropping and tenancy replaced slavery, though blacks did not benefit from these arrangements. In this system, a planter divided his land into smaller parcels, renting some to tenants and offering others to sharecroppers, who owed a portion of their crop, usually between one-third and two-thirds, to the landowner. In the case of sharecroppers, the landowner determined what crop to plant, usually cotton to the exclusion of food crops. In theory, a tenant had the freedom to plant whatever he wished, but in reality the need to generate cash to pay rent led him to grow cotton. After the Civil War, therefore, cotton culture intensified in the South. Between 1850 and 1890, the ratio of cotton to corn doubled as cotton production increased at the expense of corn. Because cotton was so central to the southern economy, it pushed corn to the margins of the economy. As it remained a cotton exporter, the South became a food importer in the late 19th century. Cotton prices reflected the crop's importance to the South. Between 1866 and 1900, cotton fetched nearly two times more money per acre than corn in Alabama and nearly three times more in Georgia.

Wage laborers fared little better than sharecroppers and tenants. Into the 20th century, workers in cotton fields in India earned as little as 7 cents per day. Work in a textile mill was no better. Mill owners hired women and children, supervising them closely to ensure a docile labor force and to quicken the pace of work. Thirteen-hour days were common. Management blacklisted those who favored collective bargaining. Reformers lamented these conditions though they persist in the developing world.

The Search for New Varieties

The introduction of new varieties of cotton into the American South was at first a matter of happenstance. A traveler might come upon a vigorous plant, collect seeds, and give them to a farmer or scientist. Planting the seed of a new variety in its own row or parcel of land, a farmer would select the most vigorous progeny for planting the next year. Repeating the process over several years, a farmer would derive a plant suited to the soil and climate of the region. New varieties came from the Caribbean, Mexico, Central America, Brazil, Peru, the Middle East, Southeast Asia, and China.

An important criterion of selection was earliness. Most cotton varieties flowered only when nights grew long and cool in autumn. This time of flowering coincided with fall rains and so was an evolutionary adaptation to changes in rainfall. In the American South, late flowering exposed cotton to the danger of an early frost. Accordingly, farmers judged a variety partly by its date of flowering.

In the Americas, cotton varieties were of two types: long staple (Sea Island cotton) and short staple (upland cotton). As early as the 1780s, farmers grew varieties of Sea Island cotton along the Gulf Coast. Farmers also had success with these varieties in South Carolina and Georgia, but they fared poorly, as we have seen, in the interior of the continent. Instead, farmers planted varieties of upland cotton in the interior. The most popular upland variety in the colonial era was Georgia Green Seed, which a farmer first planted in 1733 near Savannah, Georgia. He had obtained seed of this variety from the botanical garden in Chelsea, England, though Georgia Green Seed, despite its name, had probably originated in Guadeloupe.

That year farmers in the South began to plant Creole Black, an indigene of Siam. Creole Black had higher yields than Sea Island cotton but its fiber was inferior, being difficult to separate from the seed. From the lower Mississippi River valley, Creole Black spread east to the Carolinas around 1800. In 1810, however, the fungal disease cotton rot swept through Mississippi and neighboring states, killing Creole Black. Farmers, understandably dissatisfied with the variety, switched to Georgia Green Seed, which initially appeared to be resistant to the disease, but new races of cotton rot likewise killed Georgia Green Seed. Twice stung by disease, farmers were eager to try a new variety.

The search for a new cultivar had begun in 1806, when Mississippi planter Walter Burling was on a diplomatic mission to Mexico City. There he collected seed from an attractive plant, which he gave to amateur scientist William Duhbar. Duhbar made several plantings, collecting seed over the next decade. Before 1820, Duhbar and other plant breeders had hybridized the Mexican variety with Georgia Green Seed, Creole Black, and varieties of Sea Island cotton. The Mexican hybrids had several desiderata: earliness, uniform flowering, high yield, and resistance to cotton rot. Enthusiastic about these traits, farmers planted these hybrids in South Carolina in 1816, in Alabama in 1826, in Georgia in 1828, and throughout the Mississippi River valley during the 1820s.

In 1857, a man known by the last name Wyche collected seed from a cotton plant in Algeria, which had likely originated in Mexico. He sent the seed to his brother, who planted it on his farm in Oakland, Georgia. Wyche seems not to have grown it on a large scale and may not have appreciated its value. In the 1870s, amateur scientist J. F. Jones and Warren Beggerly collected seed, apparently from Wyche's farm. The two grew the variety, naming it after themselves: Beggerly's Big Boll and Jones Improved. Although having different names, they were likely the same variety. Curiously, only Big Boll seems to have been widely grown. By the 1880s, Big Boll was grown on more acres than was any other variety and was especially popular in Texas and Oklahoma. But Big Boll did not triumph everywhere. On the rich soils of the Mississippi Delta, the variety produced abundant vegetation but few flowers, yielding little cotton.

Science gave farmers more varieties over time. In 1880, farmers planted only a handful of varieties. By 1880, the number had grown to 58. In 1895, farmers could choose among 118 varieties, and in 1907 they had access to more than 600 varieties. The large number of varieties set in motion a competition among them with few winners and many losers. Of the 58 varieties grown in 1880, only 6 were still cultivated in 1895. Farmers grew none of them by the mid-1930s. Of the 118 varieties available in 1895, only 2 were grown in 1925. Since 1950, the number of varieties has decreased as a small number of elite cultivars has captured the market. In 1954 farmers planted 1 variety, Detapine 15, on more than one-quarter of cotton acreage. By then only 10 varieties accounted for nearly 80 percent of U.S. cotton acreage.

In recent years, genetic engineering has given farmers new varieties. In 1996, agrochemical company Monsanto inserted into cotton genes that code for the production of a toxin to several species of insect. Monsanto derived these genes from the bacterium *Bacillus thuringiensis* (Bt). Bt cotton was resistant to a number of species of moth, butterfly, beetle, and fly. Among the insects against which Bt cotton was effective were the cotton bollworm and pink bollworm, both significant pests. Bt cotton was also resistant to the tobacco budworm, which, despite its name, is a pest of cotton. Farmers grew Bt cotton in the West because of its resistance to the pink bollworm and in the Midsouth for its resistance to the tobacco budworm. Farmers who have planted Bt cotton have been able to use less insecticide, saving money and the environment. In Australia, cotton farmers have reduced their use of insecticides by 85 percent between 1996 and 2009. In 1996, Monsanto also engineered a variety of cotton resistant to its herbicide glyphosate, known as Roundup.

Boll Weevil

Although diseases, among them cotton rot, boll rot, Verticillium wilt, Phymatotrichum root rot, Fusarium wilt, and bacterial blight, have at times caused severe losses, cotton suffers more acutely from insects than from disease. By one estimate, more than 1,000 insects feed on cotton. None has caused more havoc than the boll weevil, a native of Mexico and Central America. In the 18th century and much of the 19th century, American farmers had grown cotton with little damage from insects. Matters changed in 1892 when the boll weevil crossed the Rio Grande and entered the United States near Brownsville, Texas. Advancing 40 to 160 miles per year, the weevil infested all of Texas in the 1890s, causing as much as 90 percent losses in the worst infestations.

Cotton farmers had never witnessed such destruction. The female weevil laid a single egg in each boll. Hatchlings devoured parts of the boll, causing it to fall from the plant. Overnight the weevil denuded whole fields of cotton of their bolls. In the morning, astonished farmers saw the ground littered with bolls. Because the weevil reached only as far west as Arizona, California growers were safe from its depredations. Not surprisingly, they achieved the highest yields per acre. In the Southeast, farmers were less fortunate. Sweeping east the weevil reached Georgia in 1911, where damage was even greater than in Texas. Coffee County, Georgia, which grows no coffee, suffered acutely. In desperation, a few farmers switched to peanuts, and their success prompted their neighbors to grow peanuts. By 1917, Coffee County produced more peanuts than any other county in the United States. The county's farmers had turned tragedy into triumph, and, crediting the weevil with this change in fortune, they erected the world's only statue to it.

The weevil did not stop at Coffee County. By 1916, it reached the Atlantic coast. Because weevil populations increase exponentially over time, long-maturing cotton varieties suffer the greatest losses. Sea Island cotton was therefore vulnerable. By 1930 growers, stung by the boll weevil, had abandoned Sea Island cotton. In 1921, the boll weevil turned north to the Carolinas, and by 1922 it had infested the majority of the South's cotton lands. By 1933, it had infested the entire South. Losses were so great in Louisiana and Mississippi that thousands of gins and half the cottonseed oil mills closed. Because so many rural blacks grew cotton, they felt the effects of the weevil. One scholar believes that the weevil precipitated the Great Migration of African Americans from South to North in the 20th century. Causing such suffering the weevil gave rise, according to one writer, to the blues. At least one blues song identifies "Mr. Bo Weevil" as the villain of the South's way of life.

Scientists labored to contain the weevil. Because it fed exclusively on cotton, scientists understood that it could not cross barren land. In 1894, entomologists from the U.S. Department of Agriculture (USDA) advised the governor and legislature of Texas to create a 50-mile-wide swath of land on which no one would plant cotton. Reluctant to compel compliance, however, they refused to act. The next year Assistant Secretary of Agriculture Charles Dabney proposed a similar solution, advocating that farmers not grow cotton between the Nueces and Colorado rivers. This proposal likewise aroused no enthusiasm and so efforts to contain the weevil failed. The USDA also recommended crop rotation, plowing under plant stalks and residue after harvest to prevent the weevil from overwintering in them, and flooding fields. The most promising advice was to plant early-maturing varieties. Because these varieties would produce cotton before weevil populations reached their maximum, they could be grown with fewer losses than late-maturing cotton.

Whereas farmers were reluctant to try many of these measures, they turned to chemists for the latest, most potent insecticides. In the early 20th century, the most effective insecticides were compounds of arsenic. Because they were in the form of powder, their application was a chore. A farmer had to dust each boll on every plant if he hoped to kill all weevils. Farmers and their children inadvertently inhaled the powder and became sick. Physicians condemned these insecticides, but many farmers felt they had no alternative to them. Rain washed the powder from cotton plants into rivers and streams. Fish, small mammals, and birds died.

In the 1940s, cotton farmers added a new insecticide to their arsenal. Whereas arsenic insecticides had to be ingested to be effective, dichlorodiphenyltrichloroethane (DDT) killed on contact. So lethal was DDT that scientists predicted that it would quickly eradicate the weevil. Weevil populations plummeted and success seemed imminent. By the 1950s, however, some weevils had become resistant to DDT. No less alarming was the fact that DDT killed insects indiscriminately. The predators of harmful insects succumbed, and secondary pests afflicted cotton. Cotton farmers responded by spraying other insecticides, and by 1970 half of all insecticides used in the United States were aimed at the weevil.

If insecticides alone were not the answer, perhaps farmers might learn to use them in concert with another strategy. In the 1970s, entomologists began to use pheromone traps to track of population of weevils, reasoning that if they could identify the location of weevils, they could pinpoint insecticides to discrete plots of land. They further restricted insecticides to the fall with the aim of reducing the population that survived until spring. With these conceptual tools in place in the 1970s, entomologists faced the more daunting challenge of persuading all cotton farmers to participate in the program, for if even one refused, weevils would have a sanctuary in which they could feed and reproduce. Making strides in the 1980s, scientists and farmers had eradicated the weevil in Virginia, North Carolina, South Carolina, Georgia, and parts of Alabama by 1993. In addition to these states, the weevil was absent from the rest of Alabama, Kansas, Florida and New Mexico, and from large areas of Texas, Arkansas, Louisiana, Oklahoma, Mississippi, and Tennessee by 2003. Cotton was at last safe from the boll weevil.

Christopher Cumo

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Cottonwood

A tree indigenous to North America, Europe, and Asia, cottonwood is in *Populus*, a genus of roughly 12 species. Of these, only 2—eastern cottonwood (*Populus deltoides*) and black cottonwood (*Populus trichocarpa*)—are commercial species. Of the 2, eastern cottonwood is more important. Cottonwood is a type of poplar. The wood is light in weight and color. The grain is straight and the texture uniform. The wood is not strong, and when in contact with soil and outdoors in the elements it deteriorates quickly. Wet weather hastens decay. Cottonwood is used to make containers. Shippers prefer cottonwood boxes because they do not impart an odor or taste to food. Large crates of cottonwood are also popular with shippers. Cottonwood is used as lumber and veneer, these products being constructed into boxes and crates. Cottonwood is made into agricultural implements, furniture, cutting boards, and matchsticks. Its pulpwood makes high-end paper for books and magazines. Cottonwood is in the Mallow family. The cotton-like substance that surrounds the seeds gives cottonwood its name.

Eastern Cottonwood

Eastern cottonwood is native to North America. Grown as far west as the Great Plains, it is absent in the East from Maine, Massachusetts, and Delaware. A lowland tree that requires abundant moisture, eastern cottonwood grows along rivers and near lakes. It is seldom grown at elevation. Commercial stands are found along the Mississippi River and its tributaries. Eastern cottonwood is the fastest-growing tree native to North America. In the Mississippi River valley, cottonwood trunks average 20 inches in diameter and a tree may grow 130 feet tall by age 35. It may grow to a height of 190 feet with a trunk 4 to 6 feet in diameter by age 65.

The trunk of eastern cottonwood may thicken seven-tenths of an inch to 1 inch in diameter, and the tree may gain 4 or 5 feet in height each year to age 30, when growth begins to taper.

Eastern cottonwood is grown on alluvial soil or well-drained sandy loam. The tree must have abundant rainfall uniformly distributed throughout the year. Most eastern cottonwoods tolerate standing water early in the growing season or when dormant. Trees have survived six feet of standing water for two-and-one-half months. Some cottonwoods, apparently sensitive to flooding, have died on inundated land. In the wild, eastern cottonwood may be found in what foresters term the cottonwood type of forest in stands intermixed with black willow. Regardless of species, cottonwood produces male and female flowers on separate trees. Wind rather than insects cross-pollinates trees. Allergy sufferers complain about cottonwood pollen, but scientists have yet to document an allergic reaction to the pollen. Fertilized female flowers of eastern cottonwood yield seeds that wind disperses between mid-May and late August. Because seeds are light, wind carries them great distances. Seedlings do not compete well with other flora for nutrients, water, and sunlight. On young trees the bark is thin and smooth and may be green or yellow. Older trees have gray or black bark, a circumstance that doubtless gave black cottonwood its name. Eastern cottonwood is known as eastern poplar, southern cottonwood, Carolina poplar, and necklace poplar. Though known as a hardwood tree, eastern cottonwood yields soft wood.

Black Cottonwood

Among the largest species of cottonwood, black cottonwood grows along the Pacific coast as far north as southeastern Alaska and as far south as northern Mexico. It may be found from British Columbia to southern and central Montana, central Idaho, northwestern Wyoming, northern Utah, and Nevada. Like eastern cottonwood, black cottonwood is a lowland tree needing copious amounts of water. Black cottonwood tolerates a range of soils: gravel, sand, humus, and clay. The soil pH should be 6 or 7. The soil must be rich in elements. Preferring lowlands, black cottonwood may nevertheless be grown above 2,000 feet. In British Columbia, black cottonwood has been recorded at 7,000 feet and in California at 9,000 feet. It grows in forests intermixed with willow, water birch, thin leaf alder, box elder, sycamore, Douglas fir, western white pine, western larch, western red cedar, western hemlock, and white fir. A fertile tree, black cottonwood produces numerous seeds for dispersal in late May and early June. The germination rate of these seeds is high. Seedlings, again, compete poorly with other vegetation. The black cottonwood is mature at 60 to 75 years. In Inyo County, California, its trunk may reach 2 feet in diameter and its height may soar to 60 feet at maturity. In Montana, the trunk of black cottonwood reaches only 1 foot in diameter and the tree tops out at 45 feet at maturity. Black cottonwood is known as California poplar, balsam cottonwood, and western balsam poplar.

Cottonwoods of Less Renown

The Wyoming state tree is the plains cottonwood (*Populus sargentii*). A large tree, plains cottonwood may grow 100 feet tall and spread its canopy 100 feet wide. The trunk may be 5 or 6 feet in diameter. The tree may live 100 years. Botanists are unsure whether the plains cottonwood should be its own species, as it is now, or should be lumped together with eastern cottonwood. The pollen is ripe in late March and April. Plains cottonwood is not ideal for urban landscaping because its roots grow so thick that they uplift sidewalks and streets.

The Rio Grande cottonwood, a subspecies of *Populus fremontii*, is known as Fremont cottonwood, common cottonwood, valley cottonwood, march cottonwood, Alamo, alemillo, and the water tree. The tree may grow up to 60 feet tall with a trunk 3 feet in diameter. A mature tree may yield 25 million seeds per year, most of which perish. Rio Grande cottonwood grows in Texas, northern Mexico, New Mexico, Colorado, and California. The tree may grow as high as 7,000 feet in elevation. Despite its name, the water tree, unusual among cottonwoods, tolerates aridity and so grows in the dry regions of New Mexico.

The Fremont cottonwood (*Populus fremontii*) grows in the American Southwest. The plains cottonwood (*Populus deltoides* ssp. *occidentalis*), not to be confused with the plains cottonwood of Wyoming, and the narrow-leaf cottonwood (*Populus angustifolis*) grow in the American South, Alberta, Canada, and the American West, though not in the desert Southwest. Swamp cottonwood (*Populus heterophylla*) grows in the wet soils of the Atlantic coast from Connecticut to Georgia and west to southeastern Missouri, southern Illinois, Indiana, Ohio, and Michigan. Some growers cultivate *Populus* × *camdensis*, a hybrid of eastern and black cottonwoods. Two aspen species—*Populus tremuloides* and *Populus grandidentata*—and the balsam poplar (*Populus balsamifera*) are in the same genus as cottonwoods.

Production

In 1977, the Forest Service estimated that the United States had 4.8 billion board feet of cottonwood. By 1985, the United States had 50,000 acres of cottonwood under cultivation with the prospect of adding 140,000 to 150,000 acres of new land to cottonwood cultivation. Production has been uneven. It peaked in 1899 at more than 421 million board feet. In 1932, perhaps because of the Great Depression, production slumped to a nadir of 49 million board feet. Thereafter production rose to more than 174 million board feet in 1960, declining again to 125 million board feet in 1970. An acre of untended eastern cottonwood may yield 40 cords of pulpwood by age 15. Intensively managed, an acre of cottonwood may produce 5,200 cubic feet by age 15. The yield may be as great as 40,000 board feet per acre by age 55. In the Mississippi River valley, production of eastern cottonwood was 35,000 cords in 1968, 73,000 in 1969, 100,000 in 1970, and 118,000 in 1971. Cottonwood may be harvested as young as 20 years. Cottonwood is not suitable for fuel wood because it dries poorly and tends to rot. The wood may warp as it dries.

Christopher Cumo

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Cowpea

An annual legume of the Fabaceae or Leguminosae family, the cowpea is known as the field pea, southern pea, black-eyed pea, and black-eyed bean. The Greeks knew the cowpea as *phaselos*, from which must derive *Phaseolus*, a genus of beans. Others know the cowpea as *phaseolus*. The Spanish referred to the cowpea as *caups*. Its classification is uncertain. One writer declares the cowpea to be a bean. Another categorizes it as neither a bean nor a pea. Despite its name, the cowpea is more closely related to beans. Cowpea is also related to pea, soybean, alfalfa, clover, vetch, peanut, chickpea, and lupine. Scientists know the cowpea as *Vigna unguiculata*. Half a cup of cowpea contains 286 calories, 9.2 grams of water, 20 grams of protein, 50 grams of carbohydrate, 9 grams of fiber, 1.7 grams of fat, no cholesterol, 71 milligrams of calcium, 8.3 milligrams of iron, 278 milligrams of magnesium, 366 milligrams of phosphorus, 1,148 milligrams of potassium, 48 milligrams of sodium, 5.1 milligrams of zinc, 1.3 milligrams of vitamin C, 0.6 milligram of thiamine, 0.1 milligram of riboflavin, 2.3 milligrams of niacin, 1.3 milligrams of pantothenic acid, 0.3 milligram of vitamin B6, 534 micrograms of folic acid, and 28 international units of beta-carotene.

Origin and Diffusion

The cowpea's origin is open to debate. It may have originated in Asia, but Africa is more probable. Those who support Africa as the ancestral homeland of the cowpea favor West Africa, central Africa, or Ethiopia. About 1200 BCE, the people of Chad began cultivating the cowpea, perhaps intercropping it with millet, a practice that continues today. The Yoruba of Africa offered cowpeas to the gods in return for their protection. The god Obatala, they believed, ate cowpeas with yams, rice flour, and cornmeal. Because corn was unknown in Africa before the 16th century, this belief must be relatively recent. Yamaya, the mother of the gods, ate cowpeas, watermelon, and fried pork. The god Oxun combined cowpeas with shrimp and palm oil. The cowpea was important enough to enter the lexicon of the Yoruba. Their saying, "you do not know what cowpeas are like for dinner," meant that a person was not mindful of the consequences of his actions. Nigerians wrapped cowpeas in banana leaves and ate them with smoked fish, eggs, canned beef, and vegetables.

The Greeks, Romans, and Indians fed cowpeas to livestock. First-century BCE Roman poet Virgil gave instructions on the cultivation of cowpeas. Galen, the second-century CE physician to Emperor Marcus Aurelius, recommended a dish of cowpeas and fish sauce. The Spartans ate cowpeas with figs and beans as dessert. Medieval Europeans had recipes for cowpeas. African slaves, perhaps in the 16th century, brought cowpeas to the Caribbean and North and South America. Another account credits the Spanish with introducing the cowpea to the Caribbean. Ship captains used cowpeas as a provision because slaves would not eat European foods. In the American South, cowpeas became a staple of African Americans. Despite its association with blacks, the cowpea did not have a stigma. African American cooks prepared cowpeas for their white masters. In this way the cowpea crossed racial barriers. Farmers in North Carolina first grew cowpeas in 1714, and they spread thereafter throughout the South. In the 18th century, Thomas Jefferson cultivated the cowpea among the many plants in his garden. In 1824 Mary Randolph, author of *The Virginia House-Wife*, urged cooks to add cowpeas to their cuisine. One recipe advised the housewife to boil cowpeas until tender and then fry them. Hoppin John was a popular southern dish that used cowpeas. As blacks migrated north during and after World War I and World War II, they brought cowpeas with them. Cowpea dishes were ideal for family gatherings and church socials. Poor African Americans ate cowpeas every day, though affluent blacks ate them less often. Some African Americans were eager to distance themselves from the cowpea. Nation of Islam leader Elijah Muhammad rejected cowpeas because of their association with a "slave diet." More recently, some African Americans have embraced cowpeas as authentically black fare. The cowpea has become part of popular culture. The Dixie Chicks recorded a song in which a woman killed her abusive husband by feeding him poisoned cowpeas. One group of musicians named themselves the Black Eyed Peas.

Current Status

Today, Africa produces the majority of the world's cowpeas. Nigeria alone accounts for more than half of all cowpeas. Other leading producers are Burkina Faso, Niger, Mali, and Myanmar. California and Texas produce virtually all U.S. cowpeas. Once grown in the southeastern United States, cowpeas have ceded ground to soybeans, clover, and other legumes. The cowpea's low yield compared to other crops makes it unattractive to commercial growers.

Intolerant of frost, the cowpea grows well in warm, humid conditions, though it has been cultivated as far north as Illinois, Indiana, Ohio, and New Jersey. Tolerating a range of soils, the cowpea grows in clay and sand. The cowpea may be grown in soil with little organic matter and as much as 85 percent sand. Farmers prize the cowpea for its drought tolerance and ability to yield well in infertile soil. In the South, farmers plant cowpeas on soil that is too poor for soybeans. Tolerant of acidic soil, the cowpea does not grow in saline or alkaline soil. A soil that is too fertile causes the cowpea to grow vegetatively rather than to produce seeds. An indeterminate plant, the cowpea grows vegetatively and produces flowers throughout its life. Bearing white or purple flowers the cowpea, like beans and peas, is a self-pollinator. Pods are yellow, brown, or purple.

Farmers may choose among more than 50 cultivars. Oklahoma farmers, for example, favor Chinese Red, an early-maturing dwarf variety. Because the cowpea tolerates shade, it may be intercropped with several plants. Throughout the South, farmers intercrop cowpeas with corn and sorghum. In Florida, farmers grow cowpeas for forage. A rotation with corn, cotton, and cowpeas is popular in the South. Elsewhere farmers rotate cowpeas with oats or wheat. Because the cowpea, like other legumes, fixes nitrogen in the soil, it benefits other crops. The Arkansas Agricultural Experiment Station has demonstrated that oats and cotton yield better when they follow cowpeas rather than corn.

Cowpeas may be planted in spring after the danger of frost has passed. The farmer may sow cowpeas and corn at the same time. In Virginia, farmers may plant cowpeas in May or early June. In California, cowpeas may be sown between May 1 and June 15. Although spring planting is common, cowpeas may be sown as late as August 1 in the South. In the United States, farmers plant cowpeas with a grain drill or corn planter. One authority recommends that farmers plant cowpeas at a rate of 20 to 45 pounds of seed per acre. Cowpeas may be grown for hay or seed. When pods yellow but before they fill, the farmer may harvest cowpeas for hay. In the United States, the yield of hay averages between one and two tons per acre. When one-half to two-thirds of pods have filled, the farmers may harvest cowpeas for their seeds. The commercial grower may use a combine to harvest cowpeas. In addition to its culture with corn, cotton, sorghum, and millet, cowpeas may be grown with Sudan grass or Johnson grass. Because the cowpea is 25 percent protein, it is suitable for feeding livestock, though the cost of producing cowpeas makes them less attractive as feed than corn or soybean meal.

Diseases and Pests

The fungus *Fusarium oxysporum* var. *tracheiphilum* causes Fusarium wilt, a disease of several crops. The fungus causes leaves to yellow and fall from the plant. The stem yellows, though the inside turns brown or black. Defoliating a plant, Fusarium wilt kills it. The disease strikes in midsummer. Resistant varieties offer the best protection against the disease. Nematodes of the genus *Meloidogne* cause cowpea root knot by producing galls on roots. Infected roots turn brown and decay, impairing the ability of cowpea plants to derive nutrients from the soil. The farmer may plant resistant varieties. Also effective is a four- or five-year rotation with winter grains, corn, sorghum, velvet beans, and soybeans. The farmer may also treat cowpea seeds and soil with fungicide.

The cowpea weevil, *Callosobruchus maculates*, and southern cowpea weevil, *Mylobris quadrimaculatus*, lay their eggs on and in pods and on cowpeas in storage. Larvae bore into seeds, where they feed. The farmer may use an insecticide. Fumigation or heat treatment of seeds is also effective. The cowpea curculio, *Chalcodermus aeneus*, also infests seeds. An insecticide may be effective. Other pests include the lygus bug, corn earworm, lima bean pod borer, mites, cowpea aphid, bean thrips, yellow-striped and beet armyworm, and nematodes.

Christopher Cumo

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Cranberry

A perennial vine, cranberry is a member of the Ericaceae family and *Vaccinium* genus. German and Dutch settlers in North America, fancying that the flowers of a cranberry resembled the head of a crane, named the plant craneberry, from which the English word “cranberry” derives. Cranberries are of two species. *Vaccinium macrocorpon*, the principal commercial species, yields a large berry. *Vaccinium oxycoccus* produces a small berry. Cranberry is rich in vitamin C, fiber, and antioxidants. The proanthocyanidns in cranberries are the source of their

Cranberry bog (iStockPhoto)

antioxidant properties. Oxygen radical absorbance capacity, a measure of antioxidant properties, demonstrates that blueberries and cranberries have the same high levels of antioxidants. Cranberries are thought to prevent bacteria from clogging the urinary tract, though studies have proven inconclusive.

History

Vaccinium oxycoccus, spreading to eastern North America during the Ice Ages, grew near *Vaccinium macrocorpon*. The two hybridized, apparently without human aid and possibly before the advent of humans in the New World. Native Americans were the first to recognize the value of cranberry, though when and whether they cultivated it is unclear. They stewed cranberries to make cranberry sauce and combined them with venison and tallow to make pemmican, a type of dried cake. Cranberry was important not only for flavor but also for its acidity, which kept the cakes free from microbes. European settlers were quick to take note of the cranberry. As early as 1614, English captain John Smith described the fruit to a correspondent in Europe. To the extent that Europeans were familiar with Smith's description, the Pilgrims might have known of the cranberry before their arrival in Massachusetts in 1620. In 1677, the American colonists sent 10 barrels of cranberries, along with corn and cod, to English king Charles II. This might have been the first shipment of fruit from the colonies to the mother country. In 1689, New Jersey resident Mahlon Stacy described the uses and preservation of cranberries in a letter to his brother in Yorkshire, England. One horticulturist credits Stacy with being the first to couple cranberry sauce with turkey, a combination that remains popular today. It is possible, however, that the colonists learned this practice from Native Americans and incorporated it into their Thanksgiving at an earlier date.

New Englanders balked at the Native American practice of picking berries by hand, inventing a handheld rake to harvest them. This method still required manual labor, but it was not as laborious as hand picking. Americans were apparently too eager to pick cranberries early, because in 1789 New Jersey outlawed their picking before October 10. Doubtless sometime later, Wisconsin banned this practice before September 20. Not everyone liked cranberries. The long voyage to Europe rendered them insipid. About 1800, British horticulturist Joseph Banks, finding imported cranberries tasteless, vowed to grow his own. Obtaining plants from the United States, Banks, encouraged by the bounty of his first harvest, expanded his planting so that by 1807 he had 326 square feet given to cranberry, harvesting "five dozen bottles of fruit." Banks's success, although not on the large scale of commercial farming, nonetheless attracted admirers. In 1821, British horticulturist Robert Mallett, obtaining specimens from Banks, made his own planting. He observed that manure did not benefit cranberries as it did other crops and asserted that they would grow only in peat. In the early 19th century, British farmers, obtaining *Vaccinium oxycoccus* doubtless from the United States, planted cranberries in Lincolnshire.

Back in the United States Captain Henry Hall, a Revolutionary War veteran, planted cranberries in Massachusetts. Observing that cranberries frequently grew in soil overlain with a layer of sand, he added sand to his planting, and others, seeing his success, copied him. Aware of its role in preventing scurvy, shipping firms bought cranberries to feed sailors. In 1831, farmers planted cranberries near Boston to satisfy urban demand. Some farmers in Massachusetts even grew cranberries on land normally reserved for corn. In 1835, New Jersey farmer Benjamin Thomas began cultivating cranberries, and that century Joseph Josiah White emerged as New Jersey's largest planter. By the mid-19th century, farmers grew cranberries in Massachusetts, New Jersey, Wisconsin, and after 1883 in Washington and Oregon. By 1869, Wisconsin had 1,000 acres of cranberries. By then, cranberry was a widespread addition to American cookery. Americans made cranberries into pie and pudding. Boiling cranberries, straining them, and adding sugar and nutmeg, cooks made tea. Homemakers added cranberry juice to ground rice to make cranberry and rice jelly. The 19th-century American philosopher Henry David Thoreau was fond of cranberries, taking pleasure in picking them in the wild. Today, the cranberry is widely consumed in the United States and Canada, not just for its traditional use in Thanksgiving dinners in both countries but also in juices, cakes, breads, and other foods.

Attributes

Cranberry colonizes bogs and semiaquatic habitats. It grows in sphagnum or peat and must have acidic soil. *Vaccinium macrocorpon* grows close to the ground, where it forms a dense network of vegetation. Its oval leaves are one-quarter to one-third of an inch long and one-eighth of an inch wide. The shiny leaves are pale to dark green and have more than 630 stomata per square millimeter. Young plants are less tolerant of temperature fluctuations than old plants because old plants have built up dense foliage that acts as a buffer against extremes. Leaves turn brown or red during winter. Cranberry flowers in May or June. Each flower has four sepals and four pink petals. Eight stamens surround each stigma. Scientists once thought that the flowers self-pollinated or that wind pollinated them, but pollen is too heavy and sticky to be moved without the aid of insects. Scientists now know that honeybees and bumblebees pollinate cranberry. Berries are pale pink when young, turning deep red or purple as they ripen. Newly ripe berries have a sharp flavor, but they sweeten with age. Many people believe that the cold weather of autumn imparts flavor to cranberries and so wait until November to pick them.

When planted from seeds, cranberry yields fruit in its fourth year. Cranberry roots have a symbiotic relationship with the fungus *Phoma radicis*, just as legume roots have a symbiotic relationship with nitrogen-fixing bacteria. The fungus makes nitrates available for absorption by roots. The fungus may aid roots in preventing the entrance of pathogens and undesirable minerals. In return, the roots give the fungus carbohydrates. The fungus is not found in soil planted to other crops or in fertile soil. The fungus will not tolerate waterlogged or dry soil.

The soil pH must be between 4 and 5.5. The optimal range is 4 to 4.5. Outside the target range, minerals become unavailable for absorption by the roots. Where necessary, the farmer should add sulfur compounds to increase soil acidity. Cranberry has a low requirement for nitrogen, phosphorus, and potassium compared to other crops. Cranberry needs calcium, magnesium, and sulfur in small amounts. Even smaller quantities of boron, chlorine, copper, iron, molybdenum, and zinc are necessary. Where summer is dry, irrigation is important to prevent peat from drying out because dry peat is difficult to rehydrate. Temperatures below 10°F may damage cranberry plants.

Cultivars

In the 1830s and 1840s, farmers began selecting new varieties for cultivation. Among the early successes were Early Black and Howes in Massachusetts and Searles in Wisconsin. Since 1929, the U.S. Department of Agriculture has released seven cultivars: Beckwith, Bergman, Crowley, Franklin, Pilgrim, Stevens, and Wilcox. Breeders aim to derive cultivars that do not bruise easily, and that store well, resist diseases, and are sweet rather than acidic.

In 1845 Harwich, Massachusetts, resident Cyrus Cahoon selected the renowned Early Black from a wild plant. Today, Early Black is the most widely grown cultivar in eastern North America. Its success has led scientists to use Early Black in their breeding programs. Early Black's distinguishing characteristic is its early maturation. Berries are dark red and pear shaped. They store well and do not bruise easily. Early Black is resistant to false blossom disease and tolerates a higher soil pH than many other varieties.

Between 1914 and 1917, Oregon scientist Joseph Stankavitch crossed a wild cranberry from Oregon with McFarlin, a cultivar in the eastern United States. The progeny, named Stankavitch in his honor, matures early, stores well, and yields abundantly. Berries, one-half to three-quarters of an inch in diameter, are deep red. Stankavitch is best grown in cool weather because warmth causes it to flower twice. The second flowering, late in the season, does not bear fruit and impairs next year's harvest. Berries have more sugar and less acid. Stankavitch is resistant to false blossom disease.

In 1930, USDA scientist H. J. Bain crossed Early Black and Howes to obtain Franklin. An early-maturing variety, it is nonetheless a little later than Early Black. Franklin yields more abundantly than its parents. Berries are dark red and store well. Franklin is resistant to false blossom disease.

In 1940, scientist E. L. Easton of Canada's Department of Agriculture Research Station in Kentville selected Beaver, which derived its name from Beaver River in Nova Scotia. Eaton selected Beaver from a wild plant that grew near Beaver River and released the cultivar to farmers in 1956. Beaver produces large fruit that stores well. Beaver ripens one week before Early Black, the standard among early varieties. Beaver, however, is susceptible to false blossom disease.

Christopher Cumo

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Cucumber

Common cucumbers, also known as cowcumbers, cukes, and the Greek *sikuos*, are native to the East Indies between the Himalayas and the Bay of Bengal. They belong to the Cucurbitaceae family, which includes gourds, watermelon, pumpkins, and other edible squashes. Cucumbers are a warm-season tendril annual that have yellow flowers and white fruit with semihard green rind. Most fruits are 2 to 10 inches, but the largest cucumber was recorded at 59 pounds in Australia. There are thousands of varieties, and new varieties are developed yearly.

Heirloom varieties have also been maintained and are gaining popularity. For example, the lemon cucumber heirloom variety was first introduced in 1894 and produces a small, round fruit that is pale yellow in color when mature. However, the Irish-American horticulturalist Bernard M'Mahon (1775–1816) identified in his comprehensive text, *The American Gardener's Calendar: Adapted to the Climates and Seasons of the United States*, eight original varieties in 1806. In the mid-1800s, Fearing Burr's New England horticulture catalogue included 10-foot cucumber vines that were a common length for producing enough fruits to harvest. Most new varieties are grown to produce high-quality properties as slicers, pickles, or diuretics or with disease resistance. Contemporary varieties have been developed to produce smaller more compact fruits per inch of plant.

Often referred to as a vegetable, the fruit of cucumbers is 96 percent water, and its flavor comes from the edible seeds. The internal temperature can remain 20° cooler than the air temperature, giving rise to the common phrase "cool as a cucumber." Pickler cucumbers are paler green than slicer varieties and sometimes have light stripes. They usually have a thinner rind and crunchier texture, which allows them to avoid becoming soggy when pickled. Persian varieties are most commonly sold fresh, although they often have a waxed skin to retain moisture. There are three types of blossoms that are produced, depending on the cucumber variety. Monoecious plants have both male and female flowers; gynodioecious plants produce only female blooms, and parthenocarpic plants do not need pollination and produce seedless fruits. English greenhouse cucumbers are regularly consumed as slicers. These varieties do not self-pollinate, requiring external pollination. They produce a fruit with very small seeds, and so are called seedless cucumbers.

Original varieties of cucumber that are not bred to be "burpless" have a compound called cucubitacin that in large quantities can make the skin bitter and cause burping in humans. However, some people cannot taste the cucubitacin and so have no awareness of bitter cukes. Unfortunately, others are overly sensitive to this compound. The scent of cucubitacin is also responsible for attracting the yellow-and-black-striped cucumber beetle, which is cucumber growers' worst enemy. This pest can destroy plants by eating leaves, flowers, and roots as well as transferring the devastating bacterial wilt that prevents water from distributing through the stems. However, the bitter chemical compound is thought to be a natural insecticide against other insects, so burpless varieties have no problems with aphids and spider mites.

Cucumbers are frequently soaked in vinegar or brine to create pickles. It is thought that this practice gained popularity to overcome the bitterness of the rind of earlier varieties. Egyptians ate brined cucumbers at every meal, and according to one company, 5 million pickles are consumed daily. There are numerous pickle recipes and variations, but a popular variety for pickling, *cucumis anguria*, is a small, oval fruit that is commonly referred to as a gherkin. According to the Food and Agriculture Organization, in 2005 China led the world in the production of gherkins with 60 percent of the global total. Other significant gherkin producers include Turkey, Russia, Iran, and the United States.

History

Wild cucumbers were found to be in the diet of people living along the Burma-Thailand border as long ago as 9750 BCE. Cucumbers were first cultivated in parts of western Asia at least 3,000 years ago and in China in the second century BCE. It was recorded among the foods grown in the ancient city of Ur, along the Euphrates River, and in India, Greece, Italy, and China.

Many well-known leaders of history enjoyed cucumbers. The first-century CE encyclopedist Pliny the Elder wrote that the Romans used greenhouses to supply the Emperor Tiberius with his daily gherkins: "Indeed, he was never without it; for he had raised beds made in frames upon wheels, by means of which the cucumbers were moved and exposed to the full heat of the sun; while, in winter, they were withdrawn, and placed under the protection of frames glazed with mirrorstone." There is a record of cultivation in France in the ninth century when they were popular with the king, Charlemagne. England began cultivating cucumbers in the 14th century, and they were common during Edward III's reign. However, their popularity waned with the war and strife of the time but recrudesced about 250 years later.

Cucumbers have been mentioned in several iconic writings including the Mesopotamian legend, *Epic of Gilgamesh* (27th century BC). Cucumbers were also referenced several times in the Bible. The Israelites complained to Moses that they missed the good parts of their old life, including "cucumbers and melons." The prophet Isaiah referred to Jonah's misery by saying, "The daughter of Zion is left as a cottage in a vineyard, as a lodge in a garden of cucumbers." These historical references may be to wild varieties or other types of gourds.

In 1494, Christopher Columbus and his Spanish fleet brought cucumbers to cultivate in Hispaniola (the island of Haiti and the Dominican Republic). They were thereafter used by Native Americans. The Spanish explorer Hernando De Soto recorded the cultivation of cucumbers in Florida in 1539 as did the first voyagers to Virginia in 1584. In the 17th century in the new United States, raw foods and vegetables lost favor for fear of disease. It was said raw cucumbers were "only fit for cows," thereby giving them the name "cowcumber." In 1630, Reverend Francis Higginson published *New England Plantation*, which included a description of a Boston garden: "The countrie aboundeth naturally with store of roots of great varietie and good to eat. Our turnips, parsnips, and carrots are here both bigger and sweeter than is ordinary to be found in England. Here are store of pompions, cowcumbers, and other things of that nature which I know not."

Medicinal Uses

The Romans used cucumbers to treat scorpion bite and improve eyesight. Women wore them around their waists to increase fertility, while midwives also carried the fruit during labor and threw it away after the birth of the child.

Cucumbers have been used in Chinese medicine since the eighth century, when people used cucumber leaves as a diuretic. Cucumbers are still used as such today due to their high water content. In the 16th century, people used cucumber roots to help ease diarrhea and dysentery. The stems were first used in the 18th century to treat bowel and urinary diseases, dysentery, skin sores, as well as high blood pressure.

The fruit is still used to reduce swelling, detoxify the body, and ease throat pain, and as a laxative. There are some reports that cucurbitans have been found to be an antitumor agent in animals. The cucumber also has ascorbic acids with antioxidant properties and caffeic acids that act as anti-inflammatory and anticancer agents. They are said to eliminate uric acid, thereby helping kidney function and possibly even alleviating the symptoms of arthritis. Cucumbers are often suggested as a key ingredient in weight loss diets because of their low-calorie and high-water characteristics, aiding the body in reducing built-up water retention while still hydrating the system.

A common Chinese home remedy for dry lips and throat or to prevent laryngitis is a soup made from very mature cucumbers. Other medicinal uses around the world include the cucumber as an ingredient in taeniacide, which kills tapeworm, and some have tried to prevent cataracts with cucumber. It has also been used as an astringent.

Cosmetic Uses

Cleopatra used cucumbers on her skin, and records show its cosmetic uses dating back to 19th-century France. In contemporary society, it is very popular in skin and beauty products. Cucumbers' key components of water, vitamin E, and other oils have made them a popular ingredient in skin cosmetics that soften and hydrate the skin as well as in products that add body and moisture to hair. The cucumber also includes the mineral silica, which helps keep the skin's connective tissue healthy and strong. The ascorbic and caffeic acids also prevent water retention, which may explain the cucumber's popular use of placing slices over the eyes during facials or in the morning to reduce puffiness and wrinkles. Cucumbers act as an astringent, tightening the pores and reducing swelling, thereby keeping skin soft and reducing wrinkles. This characteristic also is said to prevent acne and soothe irritated skin. The calm association of "coolness" with cucumbers as well as its subtle scent has made it a popular ingredient in shampoos, lotions, cosmetics, and even aromatherapy.

Erika Stump

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Currant

The name currant can refer to a number of plants, including a small seedless raisin called a zante currant or dried black cornith; a fruit of the genus *Ribes* that grows on shrubs; a type of small tomato species (*Solanum pimpinellifolium*); a tree that is also called a Juneberry or shadblow service berry (*Amelanchier Canadensis*); a type of bush commonly referred to as a conkerberry or bush plum (*Carissa spinarum*); another type of bush (*Miconia calvescens*), sometimes called a velvet tree or miconia; and the wild currant or Currant-of-Texas, whose Latin name is *Mahonia trifoliolata*. When referring to currants, however, most people are speaking of either the zante currant, or grape, used in baked goods, or the tiny berries of the genus *Ribes* that are related to the gooseberry and come in black, red, and white varieties. The black currant is prized for its nutrients. Black currant has four times more vitamin C than the orange, twice the potassium of banana, and twice the antioxidants as blueberry. Black currant is thought to minimize inflammation and other symptoms of arthritis. Black currant may prevent urinary tract infections and kidney stones.

Zante Currants

Zante currant is the name used in the United States (simply "currant" in other English-speaking countries) for a variety of small, sweet black grape that is seedless. Its scientific name is *Vitis vinifera*. Zante currants are so named to distinguish them from members of the *Ribes* genus that are also known as currants. Zante currants are tiny perennials with a high degree of sweetness. They are used in baking. In the United Kingdom, zante currants are popular in scones, buns, Christmas pudding, Christmas cake, and mincemeat filling for pies.

Ribes

Ribes (rib-iz) is a genus of fruit that includes the species blackcurrants, redcurrants, and whitecurrants. These fruits are juicy berries that grow on a shrub and are mainly cooked into jams. There are about 100 species of these currant berries that are native to and grow chiefly in the temperate climates of the Northern Hemisphere and western South America. The earliest species of currants were cultivated sometime before the 17th century in Northern Europe, chiefly the Netherlands, Denmark, and other areas surrounding the Baltic Sea. In the 1600s, the bush was brought to the United States, although many varieties were already growing in the Americas at that time.

The blackcurrant tree (*Ribes nigrum*) is a deciduous shrub that grows to six-and-one-half feet. It is self-fertile and is typically pollinated by bees. Its berry is a glossy, dark violet with a diameter of less than one inch. It is used to make dyes, jams, and jellies. The fruit has high vitamin C content and an omega-6 fatty acid called gamma-linolenic acid. The redcurrant (*Ribes rubrum*) produces a large red berry that is a bit more tart than blackcurrant. This deciduous shrub usually grows to three to five feet in height, although it occasionally can reach six-and-one-half feet. White currant is a sweeter, albino version of *Ribes rubrum*.

Currant Tomatoes

Currant tomatoes—also called wild tomatoes, Wild Florida Everglades Tomatoes, and spoon tomatoes—are related to the garden tomato and are similar to tomatoes that grow wild in Central America, but unlike the others, this variety is tiny. They are called "currant tomatoes" because they grow on indeterminate vines and resemble currants in size, sweetness, quantity, and color. Common hybrids include the Hawaiian currant, White Mexican currant, Matt's Wild Cherry, Golden Rave, Sugar Plum, and Sweet Pea. The currant tomato is related to the common tomato (*Lycopersicon esculentum*). The two are in the same genus, though they are different species.

Trees

The currant tree or Juneberry (*Amelanchier canadensi*) is of the Rosaceae family and is a tightly multistemmed deciduous shrub with a gray trunk. It grows into a dome shape and to a height of about 20 feet. It produces white flowers before the coarse, green leaves come in. The leaves turn red to yellow in the fall. It grows well in both moist and dry and acid or neutral soils. It grows in eastern North America, from Newfoundland in Canada south to Alabama.

Carissa spinarum, as categorized by Swedish naturalist Carl Linnaeus in 1771, is commonly known as the currant bush or conkerberry. This is a large multistemmed shrub of the dogbane family (Apocynaceae) that is grown in tropical regions surrounding the Indian Ocean. Leaves are a glossy green with opposite and narrow ovate, and branches that are thorny. White, star-shaped flowers are produced before the green berries emerge. The bush grows in semiarid coastal regions and typically is found in fine-textured soils, such as clay or clay loams. The sweet berry produced on this bush is edible but only when it is fully ripe. When unripe, the fruit and the bush's milky sap are toxic. They are a popular food with the Australian aborigines.

Not to be confused with the currant bush, the plant known as the bush currant or velvet tree is a perennial, evergreen woody shrub whose scientific name is *Miconia calvescens*. It is an attractive plant with distinctive leaves that are green on top and purple on the bottom with three lighter-colored main veins and a net of smaller veins that run horizontally. It grows to a height of 50 feet in wet areas that get 80 or more inches of rain annually. Introduced to Hawaii in the 1960s, it is now growing wild on two of the Hawaiian islands—Maui and the Hawaii. It has become a terribly invasive plant, sometimes referred to as the green cancer or purple plague, and is a threat to Hawaii's fragile ecosystem. It is fast growing and is spread by birds throughout the islands. After just 50 years in Tahiti, *Miconia calvescens* had replaced over 70 percent of the island's native forests.

Wild Currant

Mahonia trifoliolata, or the wild currant or Currant-of-Texas, is a rounded, medium, evergreen shrub with gray-green foliage resembling holly that contains clusters of fragrant yellow flowers and fruit that is a bright red berry. The sweet berries, which can be made into jam, attract birds and small mammals in the wild. The shrub grows to a height and width of six feet. It also goes by the names agarita, agarito, algerita, agritos, and chaparral berry.

Rosemarie Boucher Leenerts

See also Grapes, Tomato

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Cypress

In the family Cupressaceae, cypress is a tree that comprises 20 to 30 genera, including *Cupressus*, *Chamaecyparis*, and *Thuja*, and 140 species. The subdivisions of these conifers dates to the 26 species that Swedish naturalist Carl Linnaeus assigned in 1753 to 7 genera. In 1841, the 26 species were redistributed among 13 genera.

Cypresses typically are resinous and coniferous evergreen trees and shrubs. The species of the true genus *Cypress* are native to the Northern Hemisphere, namely North America, Europe, and Asia, but are found on all continents. They grow as far south as Antarctica. In the United States, they thrive in the wet, swampy areas of the South and along the Atlantic coast, the Gulf Coast, as well as along the Mississippi River valley.

Description

The cypress has small dark-green leaves that are scale-like. Female cones have woody scales. The cypress can be monoecious, subdioecious, and sometimes dioecious trees or shrubs and can range in height from 3 to 380 feet tall. The stringy bark, which can easily flake or peel, is typically an orange- to a reddish-brown color and is considered a hardwood. Some species have a smoother, scaly bark. The cypress lives a long time. Those growing in Italy today date back hundreds if not thousands of years. One in particular, in Soma, is believed to have been planted in 1 CE. This tree stands 120 feet tall and has a trunk of 23 feet in circumference. The Soma tree has much history: It is said to have been struck by the sword of Francis I after he was defeated in Pavia. And Napoleon so revered the ancient tree that he planned his pass over the Simplon in the Alps around the tree to avoid injuring it.

Leaves of the cypress start out as small needles and grow to be scale-like. They are arranged in a spiral of opposite pairs arranged at 90° angles to the previous pair, or they are arranged in whorls. Most trees are evergreen, although three genera are deciduous. Seed cones can be woody or leathery in texture, with the exception of the juniper cypress, which grows berries. Cones' scales are arranged in spirals and contain small, flat seeds with two narrow wings that appear on each side of the seed. Cypress branches divide repeatedly and form frond-like sprays. Cypress roots are thirsty, and some trees develop pneumatophores. These are growths that come from the roots and resemble knees. They act as a support for the tree and help to provide aeration for the often waterlogged rot system.

Practical Uses of Cypress

Cypress trees produce an essential oil called cypressine that acts as a preservative in the wood, making it extremely resistant to harsh weather conditions as well as to fungi and insects. It is surpassed only by cedar as the most used construction timber of the Mediterranean region and Turkey. The tree does not produce sap and therefore its wood, which is a light- to dark-honey color, easily absorbs stains, paints, and sealers. The close- and straight-grain wood is also lightweight and rarely develops knots. It is easy to glue, sand, and drive nails and screws into. It is resistant to splitting, warping, splintering, and cracking, which makes it an excellent source for exterior products, such as shingles, porches, bridges, greenhouses, and shutters. In colonial times, it was used to manufacture barns, warehouses, boats, docks, and homes. Due to its length, durability, and aroma, the tall species of cypress, especially the juniper, were used to construct roof beams of Mediterranean palaces and temples. Today, the wood is a popular choice in the construction industry to make shingles, decks, beams, flooring, and siding. It is also manufactured into caskets, blinds, furniture, doors, and window frames. The fine-grain variety is used in custom cabinetry. Its water-resistant properties also make the wood good for roof shingles, boat docks, water tanks, vats, railroad cars, and in shipbuilding. The soft and light wood that is derived from the pneumatophores, or knees, is soft, light, and is often turned into vases and other decorative items.

Cypress's Therapeutic Properties

The main components of the essential oil cypressine are a-pinene, camphene, sabinene, b-pinene, d-3carene, myrcene, a-terpinolene, linalool, bornyl acetate, cedrol, and cadinene. The oil is extracted from needles and twigs of young branches by steam distillation. The oil is a natural healing agent. It acts as an astringent, an antiseptic, a deodorant and a diuretic, and has a positive effect on excess fluids in the body on several levels. For example, it is believed to improve circulation, loosen coughs, and reduce the pain of varicose veins. It may be beneficial in instances of excess fluid in the body, such as that which occurs from excess bleeding, excess perspiring, and oil production in the skin. It can be placed in vaporizers and aid with breathing difficulties, such as coughs, asthma, bronchitis, emphysema, and influenza. Native American Navajo women take an infusion of cypress branches after childbirth as a way to regain strength. In aromatherapy, it is believed to remove stress and restore calm, to soothe anger, and to improve overall life balance. It has a woody, spicy, and masculine scent. It is manufactured into many forms, including oils for vaporizers, massage oils, lotions, creams, cold compresses, and bath salts. Cypressine is believed to be nontoxic and a nonirritant but should be avoided in pregnant women and others with sensitivity to topical solutions.

Ritual and Historic Uses

Native Americans have utilized various species of cypress in ceremonies and rituals over the years. The totem poles of the First Nations people of eastern Canada used the western red cedar (*Thuja plicata*) in making totem poles. The Lawson false cypress, or cedar, is used to call in the spirits at ceremonies. The Navajo make necklaces of the cypress's dried fruit. And the cedar represents the gift of music in "The Legend of the Flute," a tale of the Brulé Sioux and Lakota Sioux of the northern plains states. According to the legend, in a dream a young hunter is shown a hollow branch by a red-headed woodpecker. The wind blowing through the holes made by the bird resulted in a haunting tune. This is how the gift of music was introduced to humans, as the legend goes. Both the Native Americans and Europeans used leaves of the Thuja species as a cure for scurvy.

In Old World societies, the cypress was considered a "tree of light." In the Chinese Taoist tradition, the earth spirits of the East live in the cypress tree, and people can absorb some of the cypress's life force by chewing the resin. In various societies, the cypress is used as a graveyard tree as it is associated with divinity, light, and the heavens. The Turks traditionally plant the tree at either end of graves, which stems from an age-old belief that the aroma from the resin will neutralize the stench of the cemetery. The aroma has long been considered a healing force as well. Some doctors in the Far East would send patients with insufficient lung capacity to the isle of Crete, where cypress trees flourish.

The cypress's evergreen leaves represent eternity and are symbolic of a belief in the resurrection. The tree is still often planted in Christian and Muslim countries. Cypress groves are also reported to have been abundant in ancient Greece. A cypress grove in Greece was dedicated to the ancient Greek god of healing, Aesclepius. Serpents that Aesclepius deemed to be sacred were allowed to roam freely in the grove. Another grove in Phlius is said to have been a refuge for those seeking political and judicial asylum. The refugees who took asylum in these groves were protected, and sometimes simply taking a twig from the cypress grove while moving to the next sanctuary would be enough to protect them.

Several monarchs of ancient Persia, Egypt, and Assyria introduced many nonnative plants to the area by planting palatial gardens. The Persian prophet Zoroaster is credited in the epic *The Book of Kings* with planting seeds of the cypress at his Fire Sanctuary in 1000 BCE in what is modern-day Iran. He had brought the seeds from paradise and they became twin trees: the Sun Tree and the Moon Tree. These trees factor into the story of fourth-century BCE Greek conqueror Alexander the Great, who along with his army encountered the trees while being led to a sacred mountain by an old man. After approaching the trees, he kissed both, made an offering, and requested that his fortune be told. He was told by the oracle of the trees that he would one day conquer India, but die soon after returning to Babylon, which is what did occur. In 846 CE, a caliph of Samarra, in what is modern-day Iraq, cut down one of these trees and paid for the deed with his life.

Rosemarie Boucher Leenerts

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D

Daffodil

Daffodil is the collective name for over 60 species and many subspecies and hybrids that belong to the genus *Narcissus* in the Amaryllidaceae family. The daffodil's most striking feature is its flower. Daffodil flowers display a central cup structure called the corona that surrounds the stigma and stamen. The corona is in turn surrounded by six floral leaves, which form the perianth. Depending on the species and cultivar, the perianth and the corona can have the same or different colors. The most prevalent colors are yellow and orange, but whitish, reddish, and pink varieties exist.

Daffodils are geophytic perennial plants and can spread asexually via bulbs or sexually via seeds. During the growing period in late winter and early spring, the plants store starch and nutrients in the bulb, to be used as an energy resource in the next growing season. Daffodils are hardy and are among the first flowers to bloom in spring. In Europe, daffodils are generally associated with the end of winter and with Easter, when they are commonly used for decoration. The German name *Osterglocke* (Easter bell), for instance, reflects this.

In the Alsace region of France, the wild daffodils bloom and the associated festivals draw thousands of tourists each spring. While daffodils are native to Southern and Western Europe, large stands of wild daffodils are rare and it is more usual to see small groups of escaped cultivated daffodils. Wild daffodils are endangered and protected species in many countries.

The name Narcissus has roots in the Greek word for numbness or slumber, *narke*. In Greek mythology, Narcissus was a beautiful but vain young man. Divine punishment made him fall in love with his own reflection in the water. Different versions of the myth have him commit suicide because his love is hopeless, waste away not being able to leave his mirror image, or drown in an attempt to approach his reflection. The myth has it that a daffodil grew from the ground where he died.

Daffodils as Commercial Crops

Daffodils are popular garden flowers and are also appreciated as cut flowers. This has led to the development of over 25,000 cultivars, of which about 20 make up almost two-thirds of the yearly production. The largest commercial growers of daffodils are the Netherlands. In the United States, daffodils are mostly grown in California, Oregon, and Washington. Daffodils are commercially propagated asexually by dividing bulbs into small portions. Growers can regenerate a new bulb and subsequently a flower from each portion. Both the actual flowers and the bulbs are commercially relevant. In order to produce daffodils for market outside the natural growing period of the plant, growers use a method known as forcing. Bulbs can be forced by mimicking the temperature conditions the plant would undergo in winter followed by exposure to warmer spring temperatures. Forcing makes daffodils available from about December until late April, although the time around Easter remains the peak season for daffodil sales.

Few pests and diseases are a threat to daffodils. Most prominent among the few pests that affect daffodil production are the bulb fly, whose larvae live in and consume the daffodil bulbs, and the Narcissus eelworm, a nematode that also targets the bulbs, but can move to the stem and leaves during the growing season.

Freshly cut daffodils exude a sticky sap from their stems, which is incompatible with other flowers in a bouquet in the same vase. Daffodils therefore need to be kept separate and the water discarded before they can be combined with other flowers.

In botanic research, daffodil flowers are used as source tissue for chromoplasts. Chromoplasts are specialized plastids that store the carotenoids that give the flowers their yellow or orange color.

Daffodils contain toxic alkaloids with the highest concentration located in the bulbs. If eaten by humans or animals, they can cause dizziness, abdominal pain, and convulsions, which can in rare cases be fatal. Grazing and digging animals thus avoid daffodils. The sap of the daffodil can cause a skin reaction known as daffodil dermatitis, an itchy rash that develops on contact and usually affects florists or flower cutters.

History

The popularity of daffodils in European gardening can be traced back to the Renaissance, when flowers of oriental or Southern European origin became popular. The breeding of daffodils started in the 19th century and coincides with the growing commercial relevance of the daffodil. The breeding efforts quickly led to marked changes in flower color, shape, and size. Breeding efforts were helped by the high degree of variability in the genus on which improvements could be based, as well as by the crossing compatibility of different Narcissus species.

Daffodils reached Asia via trading routes and were brought to the United States by European settlers. The settlers grew the flowers in their gardens, but some plants soon escaped to the wild. In the 1920s, the U.S. government placed an embargo on the import of Dutch bulbs in order to protect American growers from the bulb fly that had been spreading in the Netherlands. The embargo affected trade in tulips and daffodils most strongly. Some Dutch flower growers emigrated to the United States to keep up their business. The embargo was not lifted until after the World War II.

The great popularity of the daffodil has led to the founding of national and regional daffodil societies in many countries. The Royal Horticultural Society in the United Kingdom organized the first conference devoted to daffodils in 1884. At this conference, the Daffodil and Tulip Committee was founded, which remains active to this day. Today, the Royal Horticultural Society curates the International Daffodil Register and Classified List and associated online databases, which contain all official daffodil cultivars. Today, daffodils are internationally classified into 13 divisions based on the number, measurements, and shape of their flowers. Divisions 1 through 12 contain all known cultivars, whereas division 13 is reserved for wild species. In addition to the division, a color code is used to describe the color of the perianth, followed by a hyphen and the corona's color. Thus a 4 W-Y daffodil would belong to division four and have a white perianth with a yellow corona.

The Daffodil in Art and Culture

The daffodil's beautiful bright color and the fact that it is one of the first flowers of spring contribute to its strong symbolic character and wide popularity with artists. Certainly the most famous use of daffodils is found in English romantic poet William Wordsworth's lyrical poem "I Wandered Lonely as a Cloud" (also known as "Daffodils"). In this poem, the speaker relates his joy at coming across a stand of wild daffodils "dancing in the breeze," praising their beauty the recollection of which inspire and comfort him as he later remembers them.

Various international cancer research agencies and charities have chosen the daffodil as their symbol, seeing it as a symbol of hope and renewal. Many of these organizations regularly organize fund-raising and awareness events called "daffodil days."

The Isles of Scilly before the coast of Cornwall in England are a protected area. The wildlife trust managing the area leases the islands from the Duchy of Cornwall, a traditional source of income for the Prince of Wales. As the cultivation of daffodils is a traditional pursuit on some of the islands, the trust pays a symbolic rent to the Duchy of one daffodil per year.

Kerstin Müller

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Dahlia

An ornamental in the Compositae or Asteraceae family, dahlia's scientific name, *Dahlia × variabilis*, denotes its status as a hybrid. Its parents, *Dahlia coccinea* and *Dahlia pinnate*, grow wild in southern Mexico. Curiously, their habitats overlap, yet they do not hybridize in nature despite the fact that they cross-pollinate, leading to the inference that somewhere along the line someone hybridized the two to produce today's dahlias. In 1791, Spanish worker at the Madrid Botanical Garden Abbe Cavanilles published a description of dahlia, coining the genus name *Dahlia* to honor Andrea Dahl, a student of 18th-century Swedish naturalist Carl Linnaeus. Cavanilles studied the species *Dahlia pinnate*, one of the progenitors of today's hybrid species. In 1793, Cavanilles described two other species, *Dahlia rosea* and *Dahlia coccinea*, the second progenitor of today's hybrid. The species name *variabilis* means the variability of the dahlias that German naturalist Alexander von Humboldt introduced to Europe in 1804.

Origin and History

Dahlia, at least the wild species, originated in Mexico, perhaps in the south. The Aztecs, fond of ornamentals, may have grown it. Lady Bute, wife of the ambassador to the Court of Spain, is intertwined in the mythology of dahlia. On the urging of the Royal Botanic Garden at Kew, she, so the story goes, obtained dahlia seeds, doubtless through her husband, from Spain and sent them to Great Britain. No later than 1813 the garden tended dahlias. That year it published the story of Lady Bute, crediting her work in 1789. But a subsequent researcher discovered that the 8 and 9 had been transposed. Lady Bute really acquired dahlia seeds in 1798. Even this version did not stand scrutiny. Spain probably acquired dahlia from Mexico in 1789. That year Mexican Botanical Garden director Vincenne de Cervantes sent dahlia seeds to Spain, where they were grown in the Madrid Botanic Garden. Only in 1790 did Cervantes increase the seeds, so Lady Bute must have acquired them in that year. Bute obtained seeds of the three species known to Spain. British naturalist Sir Joseph Banks preserved specimens of these species in the Kew herbarium and London's Natural History Museum.

Meanwhile Cavanilles's publications attracted adherents. They corresponded with him and requested seeds. Dahlia began its trek through Europe. In 1802, France acquired Cavanilles's three species, perhaps from Bute or Cavanilles, planting them in the Botanic Garden in Paris. About 1803, Germany acquired dahlias. That year a German professor reclassified dahlia into the genus *Georgina* to honor a Russian botanist. The result was confusion, with the partisans of *Dahlia* at loggerheads with the partisans of *Georgina*. The genus *Georgina* is occasionally still used in Eastern Europe.

Momentous for the history of dahlia, in 1804 von Humboldt sent dahlia seeds from Mexico to France and Germany. These were not the first introductions to these nations, but they were the first semidouble and double flowers with a corresponding increase in the number of petals. One account holds that he harvested dahlia seeds from the wild in Mexico. Another postulates that von Humboldt got seeds from a local gardener because the former was not knowledgeable about Mexico's flora. His dahlias are the basis of today's cultivars.

By the early 19th century, a vigorous trade in dahlias joined Great Britain and France with Great Britain the importer. Breeders must have been busy deriving new varieties because in 1836 the Horticultural Society of London—today the Royal Horticultural Society—counted more than 700 cultivars. The previous year Great Britain held 45 shows for the exhibition of exceptional specimens. Because these ornamentals were elites, they shared many genes in common. The genetic variability of the modern dahlia is consequently small. In the 19th century, because of its status, dahlia was an expensive flower fit for the gentleman or gentle lady gardener. It was not yet a flower for the masses. By the end of World War II, the center of dahlia culture had shifted from Great Britain to the Netherlands.

Botany and Cultivation

The Compositae or Asteraceae family is the largest family of angiosperms with more than 4,000 species. Dahlia is related to lettuce, endive, artichoke, and salsify. Like the potato, dahlia produces tubers, though dahlia does not bulk large in human nutrition. Although dahlias germinate from seeds the first year, in subsequent years they issue forth from tubers, making dahlia a perennial herb. The plant dies in autumn to regerminate from tubers in summer. Dahlias from tubers are sturdier and thicker with more and larger flowers than plants from seeds. Dahlias produce 8 to 15 tons of tubers per acre. Tubers contain inulin, a starch-like compound. The 19th-century French botanist Alphonse de Candolle tried to eat the tubers but never acquired a taste for them. Cattle and horses likewise do not like them. The Connecticut Agricultural Experiment Station recommends the consumption of tubers in salad as a substitute for radish. During World War II the Dutch, short of food, ate the tubers as a substitute for the potato. Mexicans may have eaten tubers in antiquity, though there appear to be no proof.

The genus *Dahlia* contains 27 species, most wild to Mexico and Guatemala. The modern hybrid stands three to six feet with stems one-quarter to one-half of an inch in diameter. Stems are unbranched except where they flower. Leaves are slightly hairy and simple or pinnatisect. Each plant produces two to eight flowers. Double flowers have as many as 300 florets. Flowers are white, lavender, purple, yellow, orange, and scarlet. Roots are fibrous. The thickest penetrate the soil at depth and from them develop tubers. Others are feeder roots near the soil surface. Cultivation can damage them. Each flower produces about 30 seeds, which will germinate as soon as they are ripe. They do not need a period of dormancy. They germinate in 7 to 10 days at 60°F. Because dahlia originated in volcanic, well-drained soils of Mexico, the gardener should approximate these conditions. Dahlia benefits from the addition of organic matter to the soil. The gardener should fertilize the soil, preferably with bonemeal, six weeks before planting. Because dahlia does not tolerate frost, it must be planted after the last frost. Dahlias should be planted two feet apart. Dahlias need full sun and protection from wind.

Christopher Cumo

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Daisy (Bellis)

Bellis is a genus of 15 species of flowering plants belonging to the Asteraceae or Compositae family, the largest family of vascular plants, that is, plants that have lignified tissues enabling the conduction of water, minerals, and photosynthetic products through the plant. Commonly known as the daisy, *Bellis* is a perennial plant that flowers for much of the year across Europe and western Asia, North Africa, and parts of Canada and the United States, especially California, Utah, Idaho, Montana, and Washington. *Bellis* flourishes on all types of grazed, mown, and trampled land, especially that which is wet and on calcareous and neutral soil. Although *Bellis* is perhaps most often thought of as a weed proliferating in lawns, pastures, and roadsides, it grows also on river banks, at the edge of lakes, and on sand dunes. Several *Bellis* cultivars exist that can be used in ornamental displays, while *Bellis perennis* is a useful addition to grasslands grown to support wildlife as the plant attracts small insects.

Attributes

In appearance, though a flower of the *Bellis* genus may look like a single flower, the upturned flower head actually consists of multiple, tiny, individual flower heads known as florets. These flower heads are a type of inflorescence known as captitulum, in which the densely packed florets are surrounded by bracts to create the appearance of a single flower. Typically, the flower of *Bellis perennis* blooms from March to September, opening at sunrise. The flower head is on average around one inch in diameter and is composed of a golden-yellow center of disc florets surrounded by 30 to 80 white ray florets, which are often flushed with pink or red on the underside. The plant has small, hairy, evergreen leaves that are ground-hugging, enabling the plant to evade the blades of lawn mowers when the plant grows in cultivated grass. Growing to around eight inches tall, *Bellis perennis* may form clonal mats originating from short rhizomes with shallow, fibrous roots. *Bellis perennis* may reproduce either vegetatively from rhizomes, as fragments of rhizome can produce new plants, or from seed. *Bellis perennis* seed falls close to the parent plant and is then dispersed as the soil on which it is has fallen is moved though human and animal activity (for example, footfall during walking). The seed, which is only around one-twentieth of an inch long, can also be included, accidentally, as part of a grass seed mixture and thus distributed along with grass seed. However, under field conditions *Bellis* seeds tend to be short lived.

Mythology

There are three romantic stories as to how *Bellis* originated. According to classical mythology, *Bellis* is so named because one day a beautiful Dryad attracted the unwanted amorous attention of the guardian of the orchards. The nymph called on the gods to protect her, which they did by transforming her into a flower that they called *Bellis*, derived from *bellus*, meaning "pretty" in Latin. The English writer Geoffrey Chaucer (ca. 1343–1400) states in *Legende of the Goode Women* that the Greek mythological princess Alcestis was transformed into a daisy, and according to Celtic legend, the daisy is the flower of newborn babies and the innocent. In Christian legend, the daisy is associated with Saint Margaret of the Dragon, with the French and German word for daisy, *marguerite* (meaning "pearl"), being applied to the daisy on account of the whiteness of the flower petals. *Bellis* species have long been associated with purity and female virtue as seen in the Victorian language of flowers in which the white daisy symbolizes innocence and the red daisy unconscious thoughts.

Literature and Medicinal Use

From Chaucer's "day's-eye," so called because the writer believed the flower to open and close with the rising and setting of the sun, to the playwright William Shakespeare (1564–1616) to the British Romantic poets William Wordsworth (1770–1850), Percy Bysshe Shelley (1792–1822), and Robert Burns (1759–1796), who each referred to the daisy in poems, *Bellis* has a rich cultural history with many references to the plants in literature. In the play *Faust* by Johann Wolfgang von Goethe (1749–1832), the composite structure of *Bellis* allows Marguerite to murmur the famous chant "He loves me, he loves me not" as she plucks the petals from a daisy in order to determine the strength of Faust's affection for her. Traditionally, the phrase is repeated until a single petal remains with the last uttered phrase thought to tell the truth of the beloved's affection. This is but one example of the plucking of a daisy enabling divination. Plants in the *Bellis* group have an equally long tradition in homeopathic medicine as they hold many healing properties. Practitioners of the "Doctrine of Signatures," a system going back to the first century CE with the Greek physician Dioscorides, and based on the principle that the appearance of plants indicated which bodily ailments a plant could be used to treat—advocated the use of the eye-like-shaped *Bellis* species to treat eye conditions. Modern herbalists believe the fresh flowers and leaves of the daisy can be used to make ointments and poultices for the treatment of wounds and boils; the flowers can be made into a decoction to ease respiratory tract infections, and the leaves can be made into an ointment to heal bruises and external wounds.

Victoria Williams

See also Black-Eyed Susan (Rudbeckia)

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Dandelion

Dandelions, one of the most common plants in the world, are also one of the oldest cultivated plants. Although widely despised today as a weed, dandelions were once highly valued as a medicinal plant with beautiful yellow flowers. They also served as an important and highly nutritious food.

Origin and History

The dandelion, *Taraxacum officinale*, has Eurasian origins. From its origin, this perennial has spread across every continent except Antarctica because of a combination of toughness and high reproduction. Dandelions are a seral species, hardy

Dandelions (Thingsofnature/Dreamstime.com)

plants that sprout quickly in disturbed soil. Dandelions are quick growers, progressing from bud to seed in a matter of days. Each seed, an achene, is one-eighth of an inch long with miniscule barbs arranged along its edge. A blast of air on a dandelion puffball can spread 200 seeds on the wind. Hanging on its parachute, the pointed seed lands point first on soil. The umbrella-shaped parachute remains erect, spread protectively overhead, while each touch of breeze makes the seed tilt back and forth. The seed penetrates the soil and slowly edges in deeply. With moisture, dandelion seeds germinate quickly. A germination rate of 90 percent is not unusual. Growth begins when the temperature is at least 50°F and maximizes at about 77°F. The rootlets pry the soil particles apart, effectively rototilling the ground. Meanwhile, the plant sends down a taproot that usually reaches 18 inches, although dandelion taproots have been known to stretch down for 15 feet. The leaves lie low in a basal rosette, making a flat circle that is almost immune to grazing, snow, or wind. They grow out from the center like the spokes of a wheel, overlapping as little as possible to maximize absorption of sunshine. The rosette does double duty by catching rainwater in its funnel. The sides of each leaf are slightly tilted toward the midrib, so the water slides down toward the center of the plant and the roots. When the first layer of dandelion leaves decomposes, the plant provides fertilizer. Subsequent plants, some dandelion and some not, benefit from the loosened and fertilized soil. As the region becomes shady, sun-living dandelions settle in a new location.

The ancient Greeks and Romans probably used dandelions for medicinal purposes, but the first clear reference to the plant is found in a medieval Arabic text from around 1100 CE. The common name dandelion comes from Latin, *dens leonis*, meaning "tooth of the lion." Dandelions were common in medicinal gardens, especially those of medieval monasteries. The popularity of the plant undoubtedly owes much to the fact that it is one of the very first plants in the Northern Hemisphere to grow under snow. An ancient spring tradition in many European cultures, and one that came to the New World, urges one to go out early in spring and pick dandelion greens. The leaves served as a food and as tonic to cure people of the diseases that had befallen them during the cold months.

Dandelion is high in vitamin C, with more of the vitamin per pound than tomatoes or oranges. The plant also contains significant amounts of protein, iron, thiamine, riboflavin, calcium, and potassium as well as vitamins D, K, and B-complex. Dandelion, once commonly called "piss-a-beds," has also long been known as a diuretic (promoter of urination). It has been used to treat pulmonary edema, gallbladder problems, kidney stones, gout, and other conditions where it is necessary to remove excess fluid from the body without depleting it of nutrients. The medicinal properties of dandelion gave it a place in many countries' official listings of medicines and drugs. They were in the United States Pharmacopeia from 1831 until 1926 and were listed in the U.S. National Formulary from 1881 until 1965.

Dandelion in the Americas

Dandelion seeds came to the United States in 1620 on the *Mayflower* along with Puritan settlers. Some of the seeds may have been stowaways, resting in the piles of earth used for ballast, but many also came as treasured items. Puritan women transported dandelion seeds as part of their medicine chests. All parts of the dandelion plant—leaf, root, and flower—have been known for millennia as remedies for a host of ailments. The dandelion had the additional advantage of serving as a comforting reminder of England in the alien environment of the New World. In 1672, John Josselyn reported in his botanical survey of New England that dandelions were well established. Meanwhile, the Spanish brought dandelions to their settlements in California and Mexico while the French imported the plants into Canada.

By the 19th century, sharp-tasting dandelions had grown in popularity as a food and remained as a popular medicinal herb. All parts of the dandelion are edible. The stem is very bitter and somewhat sticky. The petals have a bland, slightly sweet flavor. Mostly, people have eaten the leaves and the taproot, which are both quite bitter. Spring greens and leaves after a first frost tend to be sweeter. Horticulturalists developed many varieties of the plant, including the popular French Large-Leaved Dandelion. The Shakers, in particular, were known for selling dandelion products and cultivated acres of the plants. Dandelion wine proved particularly popular as did dandelion tea and salad greens. By the late 20th century, dandelions fell out of favor. The increasing availability of other, less-bitter greens meant that the plant disappeared from grocery store shelves in favor of such greens as iceberg lettuce. Dandelions can still be found in health food stores and, of course, in gardens and lawns throughout the country.

Unlike many other non-native plants, dandelions pose no threat to the environment. As an invasive species, they are a minor one. But they do grow well in the same environment as turf grass. By interrupting the smooth expanse of green that so many home owners covet, dandelions have become one of the most disliked plants.

Caryn E. Neumann

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Date Palm

A palm tree that produces sugary fruit, the date palm (*Phoenix dactylifera*) is among the oldest cultivated trees. The people of Israel and Arabia knew that date palm as *tamar*, from which the Portuguese derive *tamara*. The English "date," the French *datte*, the German *Dattel*, the Spanish *datel*, and the Italian *dattile* derive from the same source. The genus name *Phoenix* may derive from *phoinix*, Greek for "date palm." The Greeks may have associated the date palm with date-producing Phoenicia, from which phoinix may be derived. The species name *dactylifera* is Latin for "finger bearing," an apparent reference to the resemblance of clusters of dates to fingers. The genus *Phoenix* has 12 species. A ripe date is 60 percent sugar. Because of their sugar content, the ancients fermented dates into wine. The date has little protein and fat, just 2 percent of each. The date has iron, magnesium, potassium, phosphorus, calcium, copper, boron, cobalt, fluorine, manganese, selenium, zinc, and small amounts of vitamin A, vitamin B1, vitamin D, vitamin G, and fiber. Date palm leaves were once used to make baskets, roofs, mats, and rope. Egyptians still use date palm leaves to make rope. The wood was used to build houses.

The Basics

The date is a staple in the Middle East and Saharan Africa much as rice, wheat, and the potato are staples in other regions of the world. The date palm is dioecious,

Dates (iStockPhoto)

bearing male and female flowers on separate trees. If a palm is planted from seeds, the offspring, as one might expect, are half male and half female. To the grower this is wasteful because only half the palms, the females, can bear fruit, and the male trees, shedding abundant pollen, are more numerous than is necessary to pollinate the females. In the 1970s, growers planted palms in a ratio of 1 male to 40 or 50 females. Today, the ratio is 1 to 100. Some growers do not plant male trees but rather buy pollen each year to satisfy their needs.

A palm yields small clusters of flowers in spring. Because insects do not pollinate the flowers, they are not showy. Wind pollinates the date palm, though since antiquity humans have hand pollinated it to increase the yield. Having flowered in spring, a palm is ready to harvest in late summer or early autumn. In California, the harvest spans November to February. If planted from a shoot, a palm needs 4 years to bear fruit. If planted from a seed, a palm needs 8 to 10 years to mature. A palm may grow to 100 feet and live 200 years. The grower who wishes to gather shoots must strip a palm of fruit. The grower who wishes to harvest an abundant crop of dates must remove several shoots. (Removing all shoots will prevent a tree from issuing forth new shoots in subsequent years.) A palm will not produce abundant fruit and shoots simultaneously.

A plant of the desert, the date palm is unusual in tolerating saline soil. Rain may damage dates, so an arid climate is best. The date palm needs full sun and arid conditions, but it is not drought tolerant. From antiquity, humans have irrigated date palms, building irrigation canals or digging wells to tap water underground. The requirement of irrigation made the palm a labor-intensive crop from its earliest days. The planting of a palm was also labor intensive. The grower selected a sucker or shoot from an elite tree, a practice that allowed him to be certain of the traits of the new plant and to know its sex. Digging a hole eight feet deep, he added five feet of a mixture of loose soil and manure. Planting the shoot in a hole that was now three feet, he was able to cultivate it in partial shade. As it grew, the grower filled the hole with soil until he reached the surface of the ground.

There are hundreds of varieties of dates, including the medjool, classified as soft, semidry, and dry. A palm tree may yield 100 to 300 pounds of dates per year. Although a tree of the desert, the date palm tolerates temperatures below freezing. Americans and Europeans consider the date a dessert and import it from the Middle East and North Africa. In 2007, the world produced 7.6 million tons of dates. Egypt was the leader with 1.4 million tons. Iran ranked second with 1.1 million tons, Saudi Arabia was third with 1 million tons, the United Arab Emirates placed fourth with 832,000 tons, and Pakistan ranked fifth with 614,000 tons. The United States was not a leading producer.

The ancients attributed health benefits to dates. First-century CE Roman encyclopedist Pliny the Elder believed that the date treated chest pain and cough and strengthened a person weakened by a long illness. Other ancients used the date to treat anxiety, kidney ailments, and stomach problems. Mohammed (570–632 CE), the founder of Islam, counseled nursing women to eat dates in the belief that the fruit helped them lactate. Mohammed believed that dates protected one from "poison and treachery." Other Arabs believed that the date cured fever, impotence, and other maladies. Oil from the seeds is used in soap and cosmetics.

Scripture, Religious Lore, and Proverbs

So important was the date palm to the Hebrews and early Christians that the Bible contains more than 50 references to it. The Song of Songs likened it to a beautiful woman, and the Psalms asserted that good people would flourish like a date palm. The Gospels record that when Jesus entered Jerusalem the crowd hailed him with date palm leaves, a sign that they regarded him a king. The Koran mentions the date palm 10 times. One passage acknowledged that it was "a sustenance for men, thereby giving life to a dead land. Such shall be the Resurrection." The Koran described the practice of flavoring a beverage with date blossoms.

One Arab proverb held that there were as many types of dates as days in a year. According to lore, Mohammed used dates to determine the identity of an enemy. Confronted by an unknown foe, he examined the date pits in camel dung, recognizing the variety and tracing it to the enemy's city of origin. According to Islamic tradition, the Tree of Life in Genesis was a date palm, which furnished Adam and Eve with their primary food. According to this tradition, God commanded Adam to cut his hair and fingernails, burying them in the ground. From this spot in Eden germinated a date palm, one apparently different from the Tree of Life. Satan, seeing God's work in this date palm, wept. His tears fell to the ground, where the roots of the palm absorbed them, causing it to issue forth the spines that grow at the base of the leaves. Mohammed compared the date palm to humans because both palm and humans were male and female.

According to Islamic legend, Mary, pregnant with Jesus, suffered labor pain so intense that she sought rest under a date palm. From the womb, Jesus commanded her to shake the tree. She obeyed, and even though dates were not then in season, the tree nevertheless showered her with dates. She ate one and her labor pain ceased. According to one Christian legend, an angel holding a date palm leaf came to an aged Mary. Giving her the leaf, he announced that death was near and that a date palm would grow on her grave. Before she died, Mary gave the leaf to the apostle Peter, who forgave sinners by touching them with it. At the moment of contact the leaf expunged their sins.

Origin and History

An Old Word domesticate, the date palm has left fossils in the Mediterranean Basin dating to the Eocene Epoch. No wild palm exists, suggesting the antiquity of cultivation. Wild palms once grew in the region of the Dead Sea, inhabiting lands with brackish water where no other plants lived. According to one authority, humans may have first encountered the date palm in the lower Tigris and Euphrates river valleys of ancient Sumer. Its cultivation dates to 4000 BCE in Sumer. Another authority shifts the origin of date cultivation to Arabia around 6000 BCE, from where it spread to Mesopotamia (now Iraq). Ancient Jericho had so many date palms that it was known as the "City of the Palms." In ancient Babylon, landowners leased land with date palms to tenants in exchange for half the harvest. Babylonians planted date palms at a density of 50 per acre. In the 18th century BCE, the law code of Babylonian king Hammurabi set the fine for cutting down a date palm at 15 ounces of silver, surely a prohibitive amount for the average person. The Babylonians interplanted date palms with sesame, grain, and clover. The delta of the Tigris and Euphrates rivers is today home to some 5 million date palms. In warfare the victors, notably the Assyrians, cut down the date palms of the conquered.

From Mesopotamia, the date palm migrated to North Africa. The Egyptians cultivated it by 3000 BCE. In the 18th dynasty, Egyptian art depicted Pharaoh Thutmose I offering dates to the gods. Today, Egypt has some 10 million date palms. Around the time of Christ, North Africans cultivated the date palm in the Sahara Desert, terming the date the "bread of the desert." Travelers across the desert carried a bag of dates as food for both human and camel. In Algeria, farmers intercropped the date palm with the orange, apricot, nuts and vegetables. From Mesopotamia, the date palm spread to Greece and Rome. The Romans planted date palms in Spain 2000 years ago. Under Muslim rule, the date palm became widespread in Spain.

In 1513, the Spanish attempted to plant the date palm in Cuba, but the Amerindians killed them. This act did not deter Spanish soldier Rodrigo de Tamayo, who founded the town of Datil, meaning date, where he planted date palms and tobacco. The palms did not thrive in Cuba, which is today not an important producer. In the 16th century, Spanish explorer Hernando Cortez introduced the date palm to Mexico. The Spanish attempted to grow it in Florida, but the climate was too humid. In the 18th century, Spanish missionaries planted date palms, derived from Mexican stock, near San Diego, California. In the 19th century, farmers tried again to grow the date palm in Florida, but by the 1830s these efforts had failed. In 1857, rancher J. R. Wolfskill planted date palms in the Sacramento River valley in California. These trees began bearing fruit in 1877. In the 1860s, farmers planted date palms in Yuma, Arizona. These trees began to yield dates in the 1880s. In 1890, the U.S. Department of Agriculture gathered shoots from Egypt, Algeria, and Arabia, planting them in New Mexico, Arizona, and California. In 1900, the Agriculture Department made a second introduction of date palms in Arizona. In 1903 and 1907, farmer Bernard Johnson introduced the date palm to the Coachella Valley in California. In 1912, Johnson made additional plantings in Yuma, Arizona. By then, Arizona had more date palms than California. Between 1913 and 1923, U.S. farmers sent plant explorers to the Middle East and North Africa to find the best varieties of date palm. After 1913, plantings in the Coachella Valley made California the leading date producer in the United States. Since 1921, the Coachella Valley has hosted an annual date festival in February, attracting 250,000 visitors from the United States and Canada.

In the 20th century, the date was so popular in California that merchandisers sold date shakes and date ice cream, and some still do, including at roadside stands in the Coachella Valley. In the 1960s, however, some growers sold their land to real estate developers. Other growers planted citrus to diversify their income. The growers who survived capitalized on consumers' desire for natural foods. Growers boasted that they did not spray their trees with insecticide, use synthetic fertilizers, or add preservatives to dates because they keep months if stored at low temperature. By the 1970s, the Coachella Valley had 220,000 date palms on 4,400 acres. The rest of the United States had 260 acres of date palms. In 2004, California totaled 4,500 acres of date palm. The rest of the United States totaled fewer than 450 acres.

Christopher Cumo

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Dill

Dill is an aromatic plant that is still very much used as a seasoning and for medicinal purposes. This plant is an annual umbellifer with slender 12- to 24-inch-long stems and finely divided leaves. The flowers are white to yellow. It has a characteristic flavor. Within the global food industry, dill, especially the seeds, is widely used for making dill pickles with cucumber. In Scandinavia, the Baltic states and parts of Eastern and Central Europe, dill is a commonly used condiment as a fresh herb in the household and in many different kinds of food. It is also used in the Middle East and India. The Indian dill is sometimes regarded as a separate subspecies, *Anethum graveolens* ssp. *sowa* (Roxburgh ex Fleming) Gupta. It is in common use in the Indian subcontinent, Japan, and Southeast Asia.

Dill is easy to grow in gardens, and it prefers full sun, moderate watering, and rich garden soil. It is propagated from seeds without difficulty. The contemporary use of dill is a more geographically restricted remnant of a cultural plant that once was probably much used in food and as medicine. Its common Germanic name dill is of an old word: *dild* in Danish, *dill* in German and Swedish, *dille* in Dutch, and as a Swedish borrowing *tilli* in Finnish, and was probably in use in the Iron Age in the northern parts of Europe. It has many other names in other languages, such as *aneth* in French, *aneto* in Italian, *anet* in Catalan, *eneldo* in Spanish, *endro* in Portuguese, and as a Portuguese borrowing *ender* in Malay and *inondo* in Japanese. The Roman names are derived from the Greek word for anis. The word "dill" is *ukrop* in Russian, *koper* in Polish, kopar *in* Croatian, *kopur* in Bulgarian, *kopra* in Albanian, *kapor* in Hungarian, and *krop* in Yiddish, which probably developed from a plant name in an ancient language of a Mediterranean civilization, and *dereotu* in Turkish. Both the weed and the seed of this annual herb are used.

Origin and History

Dill appears to have originated in the eastern Mediterranean. A wild and weedy kind of dill is still widespread in the Mediterranean Basin and in western Asia. It is not known when it first began to be cultivated, but early remains of dill have been found in late Neolithic lake shore settlements in Switzerland, a finding that suggests that dill was under cultivation 4,000 years ago. There are also findings from ancient Egypt. Twigs of dill were found in the tomb of Amenhotep II of the 18th dynasty, who ruled from 1426 to 1400 BCE. It is also reported from the seventh century BCE from Heraion of Samos. Fourth-century BCE Greek botanist Theophrastus mentions dill in his writings. Dill is also mentioned in the Bible: "Woe to you, teachers of the law and Pharisees, you hypocrites! You give a tenth of your spices, mint, dill and cumin and have neglected the weightier matters of the law: justice and mercy and faith" (Matthew 23:23). This indicates that it was cultivated as a crop because only cultivated plants were tithed. It was used as a medicinal plant by the Romans.

It is referred to as anetum in the list of herbs in *Capitulare de Villis vel Curtis Imperii* from 812, an edict decreed by Frankish king Charlemagne, and it had probably reached Northern Europe around a century later, although archaeological evidence is lacking before the 13th century in Denmark and Sweden. In the 17th century, it had reached the whole of Europe, and was grown also by European peasantry for medicinal purposes or as a condiment. It is reported also from remote places such as the Faroe Islands in the 1780s. Dill was obviously popular in French cuisine in the 18th century, and was thereby introduced among the upper classes in Scandinavia. It became popular in the food culture of the North and it was there to stay. Veal flavored with dill, later also crayfish, were typical dishes, together with fresh potatoes, also always cooked with dill. Although it seems to have disappeared in many national cooking cultures in southwestern Europe, it has survived and is increasingly popular in the northern and eastern parts of the continent.

Medicinal Plant

The leaves, flowers, and seeds have been used for medicinal purposes. Dill has been used both in scholarly medicine and in traditional folk medicine since ancient times. Papyrus Ebers from 1534 BCE recorded its use in ancient Egypt to relieve headaches. Medieval herbals recommend dill for various diseases and disorders: stomach diseases, headaches, chest pains, and hemorrhoids. Eating the seeds was supposed to be an aphrodisiac for a man. Lactating women were supposed to produce more milk if they ate the seed boiled with flax seed. According to the English physician Nicholas Culpeper's *Complete Herbal* (1653), dill is "good to ease swellings and pains; it also stays the belly and stomach for casting." Within scholarly medicine, dill had earlier been applied as antispasmodic, carminative, detersive, digestive, diuretic, laxative, and sedative.

Dill seeds are common in folk medicine from various parts of the world. For instance, Ozark healers advise dill tea for hiccups, and it is still used as an antihypercholesterolaemic plant in Iranian folk medicine. Since the Renaissance, dill water has been used as a cosmetic and to treat insomnia in various parts of Europe. Woodward's Gripe Water, a kind of dill water introduced in the 1850s, has been used to treat infant colic in Great Britain and other parts of the English-speaking world. The plant is also used in complementary and alternative herbal medicine in many parts of the world. Home remedies with the seeds are prescribed for indigestion, colic, and insomnia. Dill was and to some extent still is also used in ethnoveterinarian therapies in many parts of Europe. The oil extracted from the seeds is said to have special antiseptic properties, and nowadays oil manufactured by the seeds has a revival within herbal medicine. The seed oil contains especially carvone, limonene, and many other substances.

Food and Condiment

The main use in many parts of the world is to flavor pickled food such as cucumber, cabbage, and onion. Especially the seeds are used for this. Fresh and dried dill leaves are widely used in Scandinavia, the Baltic states, Eastern and Central Europe, and southwestern Asia for flavoring purposes. It is used in sauces and stews. In Eastern European borscht, a soup made with beetroot, dill is much used to give flavor. It is also still popular in many central and eastern European immigrant communities in North and South America, including religious enclaves like the Mennonites. *Cacık* or tzatziki, a Turkish and Balkan dish made of diluted yogurt and chopped cucumber, is often seasoned with dill. Dill is also very much used in börek, the Turkish pie stuffed with cheese, hence its local name *börek otu* ("pie plant"). In India, dill seed is one ingredient in some curries. Dill seeds are also commonly used to flavor lentils and bean dishes in Indian cooking.

In Scandinavian cooking, dill is utilized in a wide array of dishes, such as veal (dill-fricassee), mutton, chicken, all kind of fish (including cured salmon and pickled herring), new potatoes, egg dishes, stews, sauces, and bread, and as a flavor in several distilled beverages, for example aquavit. Large quantities of the flowers of dill are a must when cooking crayfish, which is traditionally eaten in Finland and Sweden in August. Although many people grow dill in their gardens, most dill leaves consumed are bought fresh, frozen, dried, or cultivated in pots in common grocery stores. Most dill is produced in commercial greenhouses.

Other Uses

The plant has been used for magical purposes in some parts of Europe. For instance in Denmark, the cattle used to receive a slice of bread with dill and honey as a protection against evil forces. Dill is sometimes used for ornamental purposes. When dried the tall stalks with their seed heads can be used in flower arrangements.

Ingvar Svanberg

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Ebony

The "tree of music" as it is famously called, ebony is one of the most expensive wood-yielding group of trees in the world. Famous for its hardwood and inability to float, the name ebony is essentially given to a group of plants with these characteristic features. The most prominent feature, however, is that which is related to its name; the wood is black or the darkest wood in the plant world.

Botany

Ebony consists of tropical shrubs or trees that are deciduous. Most belong to the genus *Diospyros*, which is found primarily in India, Sri Lanka, and Africa. A few ebony plants, such as the Texas ebony or the persimmon, grow in warm temperate regions. Heartwood is most often black, but some can also be dark red, green, and black with shades of yellow or orange. The stem contains tannin cells but lacks milky sap. The main root is long and fleshy. Leaves are alternate, oblong, thick, and leathery. Leaves also contain tannin cells. Several species may contain spines. The inflorescence is most often a cymose. Most often the flowers are unisexual. Flowers are actinomorphic, where they can be cut into halves along any plane. Usually there are more male flowers than female. Floral whorls may contain three to seven members each. There are likewise the same numbers of stamens. Female flowers, however, consist of two to eight carpels. The ovary is superior in position. The fruit is a berry, which may contain one to many seeds.

Species

Diospyros ebenum is considered to be the true ebony. It is found in India, Sri Lanka, Malaysia, the Philippines, and Mauritius. The tree is about 90 feet tall with a trunk length of 27 feet above which the canopy of foliage rests. These trees are propagated via stumps or seeds. The fruit, which is gummy, is used as a famine food. This fruit is also a poison for fish. The timber from this tree is one of the best commercialized ebonies in the world, followed by the African ebony. China imports this wood for the making of furniture.

Diospyros melanoxylem is shorter than *Diospyros ebenum*. This ebony shrub grows to a height of 75 feet. Found extensively in India and Pakistan, this tree tolerates frost, grows well in the tropics and mild temperate areas, and is also not fussy about its soil type. Trees grow on elevated, hilly areas as well as they do on the plains. During the hot months they shed their leaves, whereas when the weather cools they sprout evergreen leathery leaves. Flowers sprout in spring or summer. The best viable seeds are produced every other year. Seeds are dispersed with the help of bats and birds. The leaves of the tree are used for wrapping tobacco as in the Indian bidis. This species of *Diospyros* has multiple uses. It is an excellent fodder crop as the pruning of leaves becomes an ideal source of fodder. The twigs and branches burn well and are very good fuel wood. The timber is black heartwood, which is very heavy. This wood is ideal for carving and for fashioning ornamental items. Seeds of this ebony are used in the making of neurological and psychiatric medication for the treatment of mental disorders and mental breakdown. *Diospyros melanoxylon* is also a major species in Africa. The main areas where ebony is cultivated in Africa are Tanzania and Mozambique. In Swahili, this ebony tree is called Mpingo.

Diospyros dignya is an evergreen, deciduous, temperate shrub with a maximum height of 75 feet and found predominantly in Guatemala and Mexico. This species is locally known as the black persimmon. It does not tolerate frost and can grow from sea level to an altitude of 5,600 feet. The trees are tolerant of floods and are not sensitive to varying soil conditions. Propagation of plant is by seeds. However, seedless varieties are also cultured using techniques such as grafting or budding. The pulp of the fruit is sweet and edible. It can be eaten only when ripe or even blended with other fruits and essence to make refreshing beverages. Owing to its easy-to-use fruit pulp, the fruit is also part of desserts, ice creams, fruit salads, cakes, and puddings. When the fruit is unripe, it is not always agreeable to the digestive track, due to its high tannin properties. The bark is extracted for the purpose of making medicines such as analgesics. Timber is a mixture of black and yellow wood, yellow being more dominant. The wood, however, is very hard and compact and does not float in water. It is ideal for making furniture due to its appealing color for home décor. Black persimmon is regarded as a very nutritious fruit, containing high quantities of vitamin C in the ripe fruit, along with calcium and phosphorus.

Diospyros blancoi grows luxuriously in Taiwan, Malaysia, and the Indonesian islands of Java and Sumatra. Growing at altitudes as high as 2,400 feet, this plant can thrive well in a wet, monsoon climate. It is an evergreen tree that grows to a height of 100 feet and with a conical crown. The plant is most progressive when male and female trees are near to each other, and minimal numbers of agents are required to bring about pollination. The fruit is considered to be exotic, and is eaten when ripe. It is also added to salads. The timber is black and heavy as in most ebony species. The trees are also grown as ornamental plants.

The Japanese persimmon, *Diospyros kaki* an ebony species chiefly found in China, Japan, and Vietnam and also in the mountains of Indonesia. It has been transported to other regions too, where it took root in the United States in 1856, in Australia in 1885, and in Palestine in 1912. It can grow on the plains as well as at very high altitudes. Primarily tropical, it has also adapted to warm temperate conditions. The tree may be propagated from seeds and from root suckers. The ripe fruit is highly edible and used in the making of many delectable dishes such as sweets, pies, and jams. Roasted and powdered seeds are substituted for coffee, while the leaves can be brewed into a persimmon tea. The wood is prized for its close grains. Color may range from black with orange, yellow, brown, and gray. Tannin obtained from the leaves and unripe fruit is used in the preservation of the wood. Many kinds of alcoholic beverages are prepared by the fermentation of the fruit.

The Texas ebony, *Ebanopsis ebano*, is a large, stately tree that grows to a height of 135 feet. It is deciduous and xerophytic in nature, thriving well in arid conditions. Texas ebony, as the name implies, is found in Texas and in other southern states such as Florida. While this plant is desert tolerant, giving it additional water during its juvenile phase will hasten its growth. The crown of foliage is usually heavy and full. Pruning not only helps the tree bloom well but also makes it an ideal ornamental plant. Its fruit is not appealing, and hence it can be more of a fodder plant than one with edible fruit. The color of the heartwood is dark red tinged with purple or black.

Pests

There are many pests known to attack the ebony trees. Some species of ebony are more resistant, while others are highly susceptible. Mites, thrips, and stem borers can cause havoc to the plant by either eating the leaves or fruits or eating through the heartwood and boring tunnels. Mealy bugs can be a menace to young shoots, killing the plant even before it has a chance to reach full maturity. The Palo Verde borer is a menace in the larval form as it lays larvae in the soil that can attack the plant, feeding on its root and nutrients for as long as three years before detection. In most cases, the pests can be controlled by the topical use of organic pesticides. However, for the case of larval infestation of the pest, the best options would be to keep the plant well nourished with organic feeds and fertilizers. Many species of ebony are good at fixing nitrogen and accommodate many economically important plants like cardamom to grow in its shade.

The Need for Conservation

Most species of ebony, especially *Diospyros ebenum* and *Diospyros melanoxylem*, are valued for their timber. With dark heartwood, lustrous in look and figure, fine grained, having a smooth finish, ebony in many places, especially in Africa, is on the verge of extinction. In Africa, it is considered to be one of the most expensive trees and is always in danger of being smuggled out of the country. Trees take a very long time to grow and mature, making it difficult to keep pace with logging.

Ebony is also known to survive more as a solitary plant than as a community forest plant. Owing to its excellent timber qualities, color, and finish, ebony has become synonymous with musical instruments such as the piano.

Amanda Mittra

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Eggplant

A member of the Nightshade family, eggplant is related to tomato, pepper, potato, tobacco, petunia, and the poisonous belladonna. Apparently aware of its relationship to toxic plants, Europeans were initially wary of eggplant. The word "eggplant" has an affinity with the Indian *vatin-ganah*. In Arabic, eggplant is *al-badinjan*, in Persian *badin-gan*, in Spanish *berenjana*, in Catalan *alberginia*, in French *aubergine*, in Sanskrit *vatingana*, in Italian *melanzana*, and in Greek *melitzana*. In the Middle Ages, Europeans called eggplant the "mad apple" in the belief that it caused insanity. Australians called eggplant "egg fruit," perhaps in appreciation of the fact that eggplant is a fruit rather than a vegetable, though at least one vegetable book includes a section on eggplant. In West Africa, people know eggplant as the "garden egg." The people of the Caribbean know eggplant as "brown jolly." The English word "eggplant" derives from the fruit's reception in England. In contrast to the current purple varieties, the standard varieties of eggplant in the early modern era yielded white fruit that resembled eggs. Italian botanists, apparently aware of the eggplant's kinship with belladonna, called it an "evil unhealthy thing." Confusingly, Europeans called eggplant a "love apple," a phrase they also used to describe the tomato. This language may derive from the belief that both eggplant and tomato were aphrodisiacs. Eggplant was also known as "raging apple." In the 18th century, Swedish naturalist Carl Linnaeus named eggplant *Solanum melongena*. Ninety-three percent water, eggplant has fiber, potassium, magnesium, phosphorus, and folic acid. Four ounces of eggplant have 32 calories. Some medical practitioners believe that eggplant may prevent stroke, bleeding, heart disease, and cancer.

Origin and History

Eggplant traces its lineage to the Old World, a curious circumstance given that the other prominent members of the Nightshade family—potato, tomato, pepper, and tobacco—all originated in the Americas. French botanist Alphonse de Candolle was the first to surmise an Old World origin, writing in 1886 that eggplant originated in Asia. In the 20th century, Russian agronomist Nikolai Vavilov sharpened the focus, pointing to India or Myanmar as the homeland of eggplant. Others have identified Southeast Asia as the cradle of the eggplant. One scholar, eschewing the focus on Asia, proposed that eggplant originated in North Africa.

Eggplant must not have been a promising cultigen in its earliest days. One scientist believes that the ancestor of eggplant bore small, bitter fruit. These traits did not deter humans, who selected eggplant for size and the absence of bitterness. The fact that no wild species of eggplant exists suggests that the plant is an old cultigen, though written records of the crop date to only 500 BCE. Even at this date eggplant may have been an ornamental rather than a food. It seems likely that it is not as ancient as corn, potato, sugarcane, wheat, barley, and several other crops. According to one hypothesis, the Chinese first ate eggplant in the sixth century CE. Chinese women used eggplant to polish their teeth. From China, eggplant may have migrated to Japan, where it was one of the five most important vegetables. Another hypothesis holds that the people of India were the first to eat eggplant. Indians may have gathered wild eggplant around the time of Christ. Having originated in India, according to this hypothesis, eggplant migrated to China and then to Arabia in the fourth century CE. The Arabs featured eggplant in their cuisine. One recipe, known as Iman fainted, paired eggplant and olive oil and concerned an Iman who married the daughter of a wealthy olive oil merchant. She presented her husband with a dowry of 12 jars of olive oil. For the first 12 days of their marriage, she prepared a dish of eggplant and olive oil. On the 13th evening, she did not serve eggplant. The surprised husband inquired about this circumstance. When his wife told him that she had no more olive oil he fainted.

The Greeks and Romans may not have known about eggplant. One hypothesis holds that eggplant reached Europe in the Middle Ages, though another holds that only in the 17th century did eggplant arrive in Europe, having come from North Africa. The second hypothesis cannot be true, because in the 16th century English herbalist John Gerard noted that the people of Spain and Africa ate eggplant. Gerard counseled the reader not to eat eggplant. He was suspicious of its "mischievous quality." Another author warned that eggplant caused depression, leprosy, cancer, headache, and bad breath, turned one's skin black or yellow, and harmed the liver and spleen. In contrast to this negativism, 17th-century English herbalist John Parkinson believed that eggplant was safe. About the 17th century, Europeans introduced eggplant into the American colonies. Americans initially disliked the flavor of eggplant and instead grew it as an ornamental. In the 18th century, Thomas Jefferson, who would later serve as the third president, grew eggplant in his garden. In the Americas, eggplant is grown where the climate is warm. The American South and the Caribbean are regions of cultivation. Although a minor crop, eggplant is today grown in California, Florida, Georgia, New York, and North Carolina.

Attributes and Cultivation

A perennial crop in the tropics, eggplant is an annual in the temperate zone because frost kills it. In temperate locales the gardener may plant seeds, which germinate in 1 to 2 weeks at 70°F to 75°F, 8 to 10 weeks before transplantation in the garden, which should occur 1 to 2 weeks after the last frost. Eggplant may be transplanted in the field 2 weeks after transplanting tomato. One gardener believes that eggplant grows best between 75°F and 80°F. Another favors a temperature between 80°F and 90°F. Among the most heat- and drought-tolerant plants, eggplant does not flourish below 60°F. Temperatures below 50°F may injure flowers. When transplanted in the field, seedlings should be spaced two feet apart. The gardener may add well-rotted manure to the soil at the time of transplantation. One month later a second dressing, fish emulsion or a complete fertilizer, may be added to the soil. Thereafter the gardener may fertilize eggplant every 3 or 4 weeks. The gardener may cover the soil with black plastic to absorb heat and retain moisture. Eggplant should not be planted in soil where tomato, pepper, or potato has been grown. Eggplant needs warm, fertile, well-drained sandy loam. The soil should be slightly acidic, with a pH between 5.5 and 6.5. Eggplant matures roughly 50 to 70 days after transplantation. It is ready to harvest when the fruit's skin is shiny. If one can press the skin with a fingernail and the indentation remains, eggplant is ready to pick. When overripe, the skin becomes dull and brown. The fruit is bitter when overripe. A plant produces four to six fruit but yields more if harvested frequently. The fruit may be as large as a watermelon or as small as a marble. Most varieties are purple, though others may be white, yellow, green, red, or lavender. Eggplant does not store well and should be eaten within a few days of harvest. Because the fruit should not be stored below 45°F, it may not be suitable for refrigeration.

Cultivars

Little Spooky has white fruit that must resemble a ghost. The Japanese on Hokkaido Island once grew Little Spooky to banish evil spirits and to ensure a bountiful harvest. Three-foot-tall plants yield fruit 7 inches long and 3 inches wide. The New Hampshire Agricultural Experiment Station released Applegreen in 1964. The fruit is green like the Granny Smith apple, a resemblance that must give the variety its name. Applegreen matures early enough for cultivation in the northern United States. Unusual in tolerating light frost, Thai Green has lime green fruit that elongates to 12 inches. The variety matures in 80 days. Dating to 1902, Black Beauty is among the most popular cultivars. Fruit should be picked when small to ensure the best flavor. As a rough guide, Black Beauty is ready to harvest 74 days after transplantation. Plants grow to three feet. Louisiana Long Green is known as Green Banana because the fruit resembles an unripe banana. Plants reach three feet in height and bear fruit 8 inches long. Plants should be staked to keep fruit off the ground. Rosa Bianca, a variety popular in Italy, bears white fruit with streaks of lavender or purple. The variety matures in 80 days. Casper matures in 70 days and is suitable for a short growing season. Consumers have likened the flavor of Casper to mushroom. Southern Exposure Seed Exchange discovered Turkish Italian Orange, a Turkish variety, in Italy, introducing it into the United States in 1990. Plants reach four feet in height and yield abundantly. Fruit is most flavorful when picked green. When the skin turns red orange, the fruit is overripe.

Seed Savers Exchange introduced Diamond, a Ukrainian variety, into the United States in 1993. Diamond bears purple fruit that matures in 70 to 80 days. Two-foot plants bear nine-inch fruit. Maturing in 72 days, White Egg is named for the color of its unripe skin. When ripe the skin turns yellow. The United Kingdom has grown White Egg since the 16th century.

Christopher Cumo

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Elderberry

Sambucus is a genus of an ornamental and fruit-bearing shrub commonly called elderberry or elder. There are between 5 and 30 species of *Sambucus*, which belongs in the moschatel family, Adoxaceae, according to 18th-century Swedish naturalist Carl Linnaeus. The elderberry is native to both the Northern and Southern Hemispheres with temperate and subtropical climates. The shrub is primarily found in the Northern Hemisphere, however, and is limited to parts of South America and Australasia in the Southern Hemisphere.

Appearance

Some common cultivated species of elderberry include *Sambucus nigra* (black elder), *Sambucus canadensis* (American elder or common elderberry), *Sambucus javanica* (Chinese elder), *Sambucus melancarpa* (blackberry elder), and *Sambucus racemosa* (red-berried elder). The *Sambucus nigra* is found in the temperate zones of North America and Europe. The white flowers of the black elder grow in clusters that are flat topped and produce berries that are a deep blue to black. The shrubs are large—about 10 to 26 feet tall—and have a stem diameter of 12 to 24 inches. The leaves are mainly deciduous and are typically 6 to 10 inches long. The wood of the elder is soft and pithy but becomes hard with age, and the bark is thin and either gray or dark brown.

Elderberries (Jolanta Dabrowska/Dreamstime.com)

Uses

For centuries, the elderberry has been used as a remedy mainly for two types of ailments—wounds and respiratory illnesses. It is used as a cold and flu treatment in many countries today, including in Panama in 1995, where it was distributed to curb a flu epidemic there. Many cultures have praised the ability of elder flowers and berries to reduce mucous membrane swelling, particularly in the sinuses, and to relieve nasal congestion. Elder may also have other healing properties, including as an anti-inflammatory, antiviral, and anticancer treatment. It has also been used to improve vision, lower cholesterol, and aid in heart health and diabetes. Elderberries contain organic pigments, including tannin, amino acids, carotenoids, sugar, rutin, vitamins A, B, and C, and flavonoids, which have antioxidant properties and may help repair cells.

Elderberry's importance as a healing agent has been evident for centuries. In Europe during the Middle Ages, elderberry was considered a "Holy Tree" and known for its capabilities to restore health and prolong life. Germans turned elderberry into a broth for soup, and in England it was made into syrup and used as a diuretic. Native Americans valued elder fruit for food and dye, and the wood of the elder was turned into combs, pegs, baskets, and arrow shafts. The hollow stems of the shrub were fashioned into whistles, flutes, and blowguns. The Native Americans also used the *Sambucus canadensis* as an astringent, laxative, and diuretic, and to promote perspiration. Its leaves were crushed and used to repel insects. The Choctaw, of what is now the southeastern United States, pounded elder leaves and mixed them with salt to use as a headache remedy. The northeastern Mohegans made a tea of elder flowers and gave it to babies to ease colic.

Written evidence of the elder's medicinal benefits include the writings of the English diarist John Evelyn (1620–1706), who labeled the tree as a universal healing agent in *The Anatomie of the Elder*. From 1831 to 1905, the U.S. Pharmacopoeia, the United States nongovernmental agency that sets the standards for prescription and over-the-counter drugs, mentioned the medicinal values of flowers of the sweet and European elder.

Despite its appeal and renown as a folk remedy, elder carries a serious health warning in the United States. Because it contains cyanogenic gludosides, substances that release the poison cyanide, elder has been listed in the American Medical Association's *AMA Handbook of Poisonous Injurious Plants* and carries a warning of the danger associated with its roots, stems, and leaves.

Elderberry in History and Folklore

Evidence that the elder dates back to the Stone Age has surfaced in recent years, and recorded evidence of the elder's existence dates back to 23 to 79 CE, when the Roman encyclopedist Pliny the Elder wrote of the most sonorous horns being made from elder branches. Today, an Italian musical pipe called a *sampogna* is still made from the branches of the elder.

The Central and Eastern Europeans feature the elder in their folklore and superstitions. For one, it was believed to ward off evil and to protect its bearer from witches' spells. As a result, it became part of wedding and funeral ceremonies. It symbolized good luck at weddings, and branches were buried with the dead to protect the deceased from evil spirits. The cross that Jesus carried to his crucifixion is believed to have been made from a giant elder. Possibly because of this, European Gypsies believed in its sanctity and refused to burn elder branches to kindle campfires. In popular culture, the most powerful wand in the Harry Potter series of books by J. K. Rowling is made of elder. The Elder Wand appears prominently in the final installation of the series, *Harry Potter and the Deathly Hallows*.

The Danes believed that the elder had a magical significance. Legend goes that a wood nymph named Hylde-Moer, a tree mother, lived in elder trees and watched over them. If the elder was cut down and used for furniture, Hylde-Moer would remain with the wood and haunt the owners.

The Significance of Elder and Elderberry

Elderberry is valuable as an ornamental shrub and for its fruit. The fruit of *Sambucus nigra* is used in the production of juice, wine, candy, baked goods, jellies, jams, and preservatives. Some elderberry fruit is toxic, such as that of the *Sambucus racemosa*, the red-berried elder, and must be cooked before eating.

Elder is popular as a stream bank stabilizer. Animals also make use of the shrub as a habitat, for protection, and as a nesting place for birds. Squirrels and other rodents also feed on the fruit and leaves. Elderberry is a favorite fruit of bears. While deer, elk, and moose browse the stems and leaves. Browsing especially occurs in the fall when the leaves turn from a sweet spring and summer leaf to one more agreeable to these animals.

Rosemarie Boucher Leenerts

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Elm

A source of timber, elm is an ancient tree, probably having colonized Europe, Asia, and the Americas before the advent of humans. A tree of the temperate and tropical Northern Hemisphere, elm is in the Ulmaceae family and *Ulmus* genus. *Ulmus* is Latin for elm. "Elm" is an Anglo Saxon word, though the Anglo Saxons also used the word "wice" for elm. The Germans named elm *elm* or *wieke*. The people of the Jutland peninsula used the term "elm" to refer to the tree.

Attributes

The elm has colonized large areas of the Northern Hemisphere. The tree appears as far north as Scotland, southern Finland, northern and central Russia, and Central Asia. Farther south one may find the elm in Turkey, Lebanon, Israel, Iran, Afghanistan, the Himalayas, China, Korea, Japan, Malaysia, the Indonesian islands of Sumatra, Sulawesi, and Flores, Algeria, the eastern United States, Mexico, Central America, and Colombia.

Elm flowers are perfect, each bearing anther and stigma. Young branches do not bear flowers. A branch must be seven or eight years old to flower. Wind disperses pollen, cross-pollinating flowers. Because wind can carry pollen great distances, elms may crossbreed in widely separated locales. Because anther and stigma develop at different times, a flower cannot self-pollinate. A flower remains open 4 to 18 days, during which it is receptive to pollen. Honeybees visit elm flowers and may pollinate them, though wind is the principal pollinator. In the subtropics, elms flower in autumn and in the temperate zone in spring. Where the weather is too cold, flowers will not pollinate. In addition to sexual reproduction, elms propagate vegetatively through suckers.

Origin and History

Ulmaceae has genera in the Old and New Worlds. *Ulmus* separated from the related genus *Zelkova* before the Americas broke apart from Eurasia. The elm colonized eastern Asia and Alaska 80 million years ago and was abundant in Europe by 40 million years ago, possibly being more diverse than it is now. The elm has evolved little since the Miocene Epoch, 23 to 5 million years ago. During the ice ages, the elm retreated toward the equator, recolonizing northern latitudes in interglacial periods. As temperatures rose, birch and pine recolonized the north first. Elm, requiring a warmer climate, came later. The elm was widespread in Europe until about 5000 BCE, when its numbers began to dwindle. Humans may have been responsible for this decline, clearing land for farming. Elms may have been vulnerable because they grew on calcareous soil, which humans desired for their crops. Humans may have defoliated trees, feeding the leaves to livestock. Although elm leaves are not particularly nutritious, the practice of feeding them to livestock has a long history.

Fourth-century BCE Greek philosopher Aristotle and Roman agricultural writer Cato the Elder (234–149 BCE) mentioned the practice of feeding elm leaves to livestock. The Chinese, Japanese, and Indians fed elm leaves to livestock. It may be possible that the elm suffered from disease after 5000 BCE, much as it has suffered from Dutch elm disease since the 20th century.

The decline of elm left concentrations of trees in Northern Europe, notably in southern Norway, southern and central Sweden, Denmark, northern Germany, southern Finland, the Baltic, and northern and central Russia. South of this region elm established itself in the Ardennes Forest in Belgium, the Vonges, the Pyrenees Mountains that border France and Spain, the Cantabrian Mountains of northern Spain, Thuringia and the Black Forest in Germany, the Alps, the Carpathian Mountains of Central and Eastern Europe, and the Balkans. The elms that flourish in Great Britain may owe their establishment there to human migration.

Uses

From an early date, humans prized elm for its toughness, resistance to splitting, and elasticity. Elms grown on light, stony soil produced particularly tough wood. Having selected a tree for use, humans traditionally cut it down on November 1, All Saints' Day. The first use of elm was to make bows. Humans preferred yew for this technology but used elm when yew was unavailable. The fashioning of bows from elm was established in the Mesolithic Age (10,000–3000 BCE) in Denmark. Elm was also used to make crude swords, javelins, spears, and shields, though metal supplanted the wood. Humans used elm to make carts, wagons and chariots. Because elm resisted splitting, it was favored in the making of the hub for a spoked wheel. Oak was preferred for the spokes. The rim was elm or ash. Humans have eaten the inner bark of the elm in times of famine. The Norwegians and Russians made elm bark bread. First-century CE Greek physician Dioscorides recommended elm leaves as a vegetable. In Europe, monks ate elm leaves.

Humans also made elm into bowls and containers, though some people claimed that elm, when used as a receptacle for alcohol, tainted the flavor. In the Middle Ages, sycamore replaced elm as a wood for bowls, containers, and receptacles. Since Roman times, humans had made plows of elm. In the 20th century, the United Kingdom used the elm to make the moldboard of a plow. Farmers preferred elm to metal on heavy soil because clay did not stick to elm whereas it clung to metal. The Romans recorded the use of elm branches to beat slaves.

Elm was used as the headstock of a bell because only elm could withstand the stress of a swinging bell. In the Middle Ages, coffins were made of elm. English queen Elizabeth I (1533–1603) was buried in an elm coffin overlaid with oak. In later centuries, the rich preferred oak, though the middle class continued to be buried in elm. In the Middle Ages, elm was used as the gunstock of firearms because the recoil did not damage the wood. In England and France, the military planted elm so it would have sufficient wood for gunstock. Since the Middle Ages, carpenters have used elm to make floors and stairs, though again the wealthy preferred oak. Elm was used to make chairs and tables. Europeans made waterwheels of elm and oak. Water pumps were made of elm. Elm was sometimes used to make boats, though oak was preferred for large ships. The Arikara of the Great Plains used elm as the fuel for firing pottery. Elm was desirable for this purpose because it burned slowly and steadily. The Yule log of Christmas was elm. The Amerindians of the eastern United States used elm bark for the roof of their houses.

Dioscorides recommended the topical use of elm to heal wounds and fractures. The Anglo Saxons boiled elm bark in urine or milk, applying it topically to heal wounds and shingles. The drinking of a concoction of inner bark and wine loosened mucus in the chest, according to Dioscorides. An extract from the gall of an elm tree was used as lotion, he mentioned. Others have thought elm useful in treating sore throat, increasing perspiration and urine, reducing fever, and improving muscle tone. Italians used elm to treat rheumatism, and in Bulgaria it was used to stop bleeding. First-century CE Roman encyclopedist Pliny the Elder recommended the rubbing of elm leaves on the feet to relieve soreness. Rubbed on the head, elm sap was reputed to regrow hair. One Roman author recommended a mixture of inner bark and ocean water to relieve gout. Wine that contained elm leaves was thought to relieve cough. In the 17th century, the English used elm sap to improve the function of the liver.

Dutch Elm Disease

Dutch elm disease has been the most serious threat to the elm in modernity. In the early 20th century, the fungus *Ophiostoma ulmi* caused the first outbreak of the disease. The fungus blocks the xylem vessels, causing trees to wilt. The elm bark beetle transmits the fungus. The disease spread from ailing to healthy trees in Europe, Asia, and North America. The first outbreak began in northwestern Europe, spreading east to southwestern Asia and west to the United Kingdom and North America, where it arrived about 1927 on imported timber. In the 1930s, the disease spread from Europe to central Asia. The first outbreak killed thousands of elm trees in Europe, Asia, and North America, though the disease abated in Europe during the 1940s. In this decade, the fungus *Ophiostoma* *novo-ulmi* caused the second and more virulent outbreak. The second outbreak centered in Eastern Europe and the Great Lakes of North America. In Europe the disease spread west, reaching the Netherlands about 1975 and east into southwestern and Central Asia. In North America, the second outbreak reached the east and west coasts in the 1980s. From North America, a strain of the fungus crossed the Atlantic, infecting elm trees in the United Kingdom, the Netherlands, France, and Spain. The disease killed millions of elms in the United Kingdom alone.

Christopher Cumo

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Endive

Endive belongs to the *Chicoricum* genus of the Asteraceae or Daisy family (formerly called Compositae). Three products used for human consumption are derived from this plant: roots, leafy greens (for example escarole, frisee, and radicchio), and Belgian endive. Two species used in a variety of cuisines are referred to as endive, which can lead to some confusion. *Cichorium intybus* includes the varieties of Belgian endive (also known by its Flemish name *witloof*) as well as radicchio, both of which are eaten raw or cooked. Endives derived from the species *Chicorium endivia*, with the varieties frisee (curly) and escarole (broadleaf), are commonly used as a salad greens. Both species are traditional horticultural crops and very popular vegetables in Europe, where most endive is produced. Belgian endive is particularly appreciated in France, Belgium, and the Netherlands, while radicchio is most popular in Italy, explaining its other popular name, "Italian chicory." The popularity of endive in North America is somewhat smaller. Endive is grown exclusively for human consumption, but can also be fed in small quantities to rodent pets such as rabbits or guinea pigs. Just like lettuce, endives form heads of leaves because of stunted stem growth. The internodes, that is, the parts of the stem between leaf-producing nodes, do not elongate so that the sequential nodes sit very close together.

The two *Chicorium* species from which today's cultivars have been bred are common wild plants in Europe, North Africa, and portions of Asia. It has been speculated that the green leaves of the wild plants were used as a salad green by the ancient Egyptians, Greeks, and Romans. Chicory roots and leaves have also played a role in many different traditions of Asian and European folk medicine. European scholars in the 16th century were the first to describe cultivation of endive.

Belgian Endive

Belgian endive was first grown and bred in Belgium in the 19th century. Whereas the leafy green endives are grown from seeds, Belgian endive is first grown from seed, but then produced by digging up the roots, removing the leaves, and forcing the defoliated roots to produce a head of leaves. This is achieved through a cold treatment. The heads are then grown in darkness, a process referred to as blanching. The roots were traditionally covered in straw to avoid excessive light exposure. Today, roots are mostly planted in dark chambers called forcing chambers in hydroponic culture, that is, without soil. The production of Belgian endive is thus rather labor intensive, as it involves many steps.

This peculiar production method is said to have been discovered by either a Belgian farmer or a gardener in the Brussels Botanic Garden who forgot some chicory roots in the cellar and later found them to have sprouted oval-shaped heads of tightly packed, whitish leaves that could be used for cooking or in salads. This type of head is called a chicon. The white color of the chicons is caused by the lack of light during development, which keeps the plants from synthesizing the green pigment chlorophyll. Growing the plants in darkness also prevents them from producing certain bitter-tasting chemicals, which would spoil their taste and economic value. For storage, the chicons again must be kept in darkness to prevent them from turning bitter. Even then, the core of the chicons, that is the stem region, remains bitter. Cutting out the core is therefore the first step to cook or prepare endive as a salad.

Radicchio and Leafy Green Endives

Radicchio as well as escarole and frisee endive are mostly produced in northern Italy. The growing conditions of escarole and frisee are similar to those of lettuce. The frisee varieties are cold-sensitive and therefore used for summer cropping. The more robust broad-leaved types tolerate cold and grow well in winter. Both forms come in various shades from almost yellow to deep green. Radicchio is usually planted in late spring or early summer to avoid cold spells that would induce early head formation. Growers often plant several cultivars sequentially, to cover a range of cold requirements for head formation. These cultivars will mature and be ready for harvest at different times during late autumn and winter.

Radicchio exists in forcing and nonforcing varieties. Nonforcing radicchio will form a head under normal growing conditions, while forcing varieties must undergo a cold treatment similar to that described for Belgian endive. The plants are covered during head formation to avoid chlorophyll synthesis.

Radicchio leaves are bright red and have a bitter taste. In North America, they are mostly used to add color to mixed salads, while in Italy they are used in cooked dishes such as risotto.

Breeding and Improvement

Traditional endive cultivars were produced by mass selection. That is, farmers propagated plants from a mix of seeds from desirable individuals. Many land varieties therefore exist that have been developed over generations. As endive is not a vegetable of major economic importance, little research is done on its genetic properties. Breeding now mostly happens in seed companies, although there are still some farmers who breed their own endive varieties. For Belgian endive, many hybrid cultivars have been developed. This is possible because *Chicorium intybus* is mostly cross-pollinating. *Chicorium endiva*, on the other hand, has a strong tendency toward self-pollination.

No genetically modified endive is on the market at this time, and it is unlikely that a system to genetically engineer endive will be developed in the near future due to its lack of economic importance. Breeding goals for endive are the goals associated with most agricultural crops: improved yield, marketable taste, and appearance, and disease and stress resistance.

Kerstin Müller

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Eucalyptus

The genus *Eucalyptus*, native to Australia, has more than 800 species. The term *Eucalyptus* derives from two Greek words: *eu*, meaning "well," and *calyptus*, meaning "covered," a reference to the cap that covers the stamens of the *Eucalyptus* flower. A eucalypt is a *Eucalyptus* tree, though the terms "eucalypt" and *Eucalyptus* are sometimes used as synonyms. Having many uses, the *Eucalyptus* tree is cultivated for timber, pulp, fuel, and oil. In the 18th and 19th centuries, *Eucalyptus* oil was used as disinfectant, solvent, and medicine. The oil is used to treat the common cold, cough, congestion, sports injuries, muscle and joint pain, and insect bites. *Eucalyptus* oil is an ingredient in shampoo, soap, lotion, and cleaning products. More than 1 percent of the weight of a *Eucalyptus* leaf is oil in commercial varieties. The most desirable oil is rich in the chemicals cineole, piperitone, and citronellal. The aborigines of Australia used *Eucalyptus* wood and bark to make canoes, spears, boomerangs, bowls, and dishes. They used the roots and leaves as medicine. The European settlers of Australia used *Eucalyptus* wood to make buildings and fences and for fuel. Brazil and South Africa planted *Eucalyptus* trees along railroad lines to provide locomotives with fuel. Indians and Ethiopians used *Eucalyptus* wood for fuel and housing. Indians plant the *Eucalyptus* tree as a windbreak on the border of their property. Indians plant *Eucalyptus tereticornis*, known as *Eucalyptus* hybrid or the Mysore gum tree, for pulp and paper and other species for firewood. The production of *Eucalyptus* oil is a minor activity in India. Today, *Eucalyptus* yields timber, plywood, fiberboard, pulp for paper and rayon, poles, firewood, charcoal, oil, honey, and shade.

Geography, Botany, and Cultivation

Eucalyptus is a tree of the tropics and subtropics. In 1995, farmers worldwide planted millions of acres of *Eucalyptus*. The tropics accounted for more than the largest portion of acreage, with tropical Asia in the lead, followed by the tropical Americas. India and Brazil totaled millions of acres of *Eucalyptus*. Australia, Chile, China, Morocco, Portugal, South Africa, and Spain all had hundreds of thousands of acres of *Eucalyptus*. Thailand and Vietnam have recently planted *Eucalyptus* trees in large numbers. Because *Eucalyptus* grows rapidly, maturing in 5 to 10 years, farmers plant it for a quick profit. Just four species—*Eucalyptus camaldulensis, Eucalyptus globulus, Eucalyptus grandis*, and *Eucalyptus tereticornis*—are the world's chief plantation trees.

The first humans to settle Australia doubtless discovered *Eucalyptus*, though the moment of discovery is lost to history. Neglecting the achievement of the Australian aborigines, Europeans claimed to have discovered the *Eucalyptus* tree. In the 1770s, British captain James Cook and Sir Joseph Banks found *Eucalyptus* in their exploration of Australia. In 1788, the year that Europeans settled Australia, oil was first distilled from *Eucalyptus* leaves. Although more than 100 species of *Eucalyptus* yield oil, only about 12 are cultivated for this purpose. The species *Eucalyptus globulus*, *Eucalyptus exserta*, *Eucalyptus polybrastus*, *Eucalyptus smithii*, *Eucalyptus citriodora*, and *Eucalyptus divas* are the chief oil producers. Of these species, Victoria and Tasmania have cultivated *Eucalyptus globulus*, whose oil contains 60–70 percent cineole, since the late 19th century. In Australia, *Eucalyptus* covers millions of acres from temperate Tasmania to tropical Queensland. *Eucalyptus* is also found in the tropics of Indonesia, Papua New Guinea, and the Philippines. In the 17th century, the Portuguese brought *Eucalyptus* seeds, perhaps from Indonesia, to Brazil.

In 1788, German botanist Joseph Gaertner was the first to classify *Eucalyptus*, though he put it in the genus *Metroideros*. That year French botanist Charles Louis

L'Héitlier de Bratalle of the British Museum of Natural History, working with a specimen from Cook's third voyage, named the genus *Eucalyptus*, the name that is the current genus. Further explorations followed, and by 1867, British botanist George Bentham of the Royal Botanic Garden at Kew, United Kingdom, could count 135 species of *Eucalyptus*. By 1934, Australian botanist William Faris Blakely of the Royal Botanic Garden at Sydney, Australia, could count 606 species.

In 1890, Italy introduced *Eucalyptus* trees into China. Of the more than 300 species brought to China, only one-third have survived. Today, China cultivates fewer than 10 species of *Eucalyptus*. Initially, the Chinese planted *Eucalyptus* as an ornamental and for shade. They planted trees in gardens, near schools and colleges, in pristine spots, and along roads. The Chinese grew *Eucalyptus* because it matured rapidly and tolerated infertile soil. In the 1950s, China established *Eucalyptus* plantations and in 1958 began extracting oil from leaves. Today China, with 1 billion *Eucalyptus* trees, is the world's largest producer of *Eucalyptus* oil. The Chinese have planted *Eucalyptus* in the provinces of Guangdong, Guangxi, Hainan, Fujan, Yunnan, Sichuan, Guizhou, Hunan, Hubei, Jiangxi, Zhajiang, Jiangsu, Shenghai, Anhui, Shenxi, and Gangsu. Ninety percent of China's plantations are in Guangdong, Guangxi, Hainan, and Yunnan. On Hainan Island, farmers interplant *Eucalyptus* and pineapple. In southeastern China, *Eucalyptus* is intercropped with tobacco or sweet potato. The people of Taiwan also plant *Eucalyptus*.

In the late 18th century, Tippu Sultan, the ruler of Mysore, introduced *Eucalyptus* into India. Favoring the tree as an ornamental, he obtained 16 species from France. In the 1950s, a fungal disease swept through *Casuarina* forests, opening land to *Eucalyptus*. In the 1960s, India planted *Eucalyptus tereticornis* in large numbers. Indians prized this species because it grew rapidly, was impervious to the attempts of cattle to feed on it, adapted to varying environments, and was suitable for fuel and housing. So popular is *Eucalyptus* that some Indians fear that farmers may grow it at the expense of crops.

Species

Eucalyptus citriodora is widely planted in Australia and in other countries as a source of oil. A subtropical tree, it flourishes in southern Australia. A tall, straight tree with smooth bark, the species is known as the lemon-scented gum tree because the citronellal in its oil exudes an odor of lemon. The oil is an ingredient in mosquito repellant. China, India, and Brazil cultivate the lemon-scented gum tree. The world's primary source of *Eucalyptus* oil, *Eucalyptus globulus* is known as the southern blue gum tree. Widely cultivated worldwide, the tree grows tall and straight and has smooth bark. The species is native to southeastern Australia, where rainfall is abundant. China, Spain, Portugal, India, Argentina, Brazil, and

Chile cultivate the tree. Known as the blue-leaved mallee, *Eucalyptus polybractus* is the chief oil species in Australia, which is alone in using this tree for oil. A short tree, the species tolerates little rain and infertile soil. With rough bark, the leaves of *Eucalyptus polybractus* are blue or gray green. A plantation tree, the blue-leaved mallee is grown in West Wyalong in western New South Wales and in Inglewood in northern Victoria. Tall and straight, *Eucalyptus smithii*, the gally gum tree, is grown in southeastern Australia, notably in the plains and valleys of New South Wales. South Africa grows the species for timber, though in eastern Transvaal *Eucalyptus smithii* yields oil. A small tree native to the Cape York Peninsula in Queensland, *Eucalyptus staigerriana*, like *Eucalyptus citriodora*, yields lemon-scented oil. Brazil, Guatemala, the Seychelles Islands, and the Congo cultivate the species. The most widespread species in Australia, *Eucalyptus camaldulensis*, the river red gum tree, is cultivated worldwide in the tropics and subtropics. With smooth bark, the leaves of this species are green, blue-green, or yellow-green. Seeds are yellow or yellow-brown. An ornamental cultivated in southern Australia, *Eucalyptus cinerea*, the argyle apple, has red-brown rough bark. Australia once cultivated this species for oil, a practice that is current in Zimbabwe. A small tree native to western Australia, *Eucalyptus kochii*, the oil mallee, has rough bark. Its blue-green leaves in youth turn green as the tree ages. A small tree native to but uncommon in New South Wales, *Eucalyptus olida* has rough bark. The blue-green leaves of youth turn green or gray-green in maturity.

Christopher Cumo

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Fennel

In *Hamlet*, English dramatist William Shakespeare wrote, “There’s fennel for you and columbines,” when Ophelia started handing out flowers and herbs. In Shakespeare’s time, fennel conveyed “flattery,” and Ophelia was flattering King Claudius. Fennel has had a long history, though most of it does not have to do with the theater. The herb has gained fame as a culinary and medicinal plant.

Fennel is native to Southern Europe and is cultivated in North America, Asia, and Egypt. Fennel was grown in colonial New England, and one can view fennel in the gardens of colonial Williamsburg in Virginia. In fact, fennel can grow almost anywhere in a warm, sunny place. It grows rapidly in southern exposures on slopes and terrace, often invading cultivated areas.

The genus is *Foeniculum* and the family Apiaceae (Umbelliferae). There are two types of fennel: *Foeniculum vulgare*, known as common or wild fennel, and *Foeniculum vulgare dulce*, known as sweet fennel, Florence fennel, and finocchio. *Foeniculum vulgare* can grow up to six feet tall with green-blue foliage. In the spring, feathery shoots appear, and in late summer and autumn yellow umbel flowers are produced. Fennel can help landscapers provide privacy because it is used as a screening plant due to its rapid growth. There is, however, a bronze variety of *Foeniculum vulgare*, a smaller, less vigorous type, growing to about three to five feet, which is considered the most ornamental variety. Fennel is also known for its suitability for home and restaurant dining where its stalks and seeds are used.

Florence fennel produces a swollen leaf base, which is eaten as a vegetable. This bulb has overlapping stem bases packed around a small, central core. It can be eaten raw or cooked. Fennel tastes somewhat like anise or licorice. When you bite into it raw, the anise flavor is well defined. When you cook the herb, the flavor is more subdued.

Fennel has a long folklore history. Fennel tea was used to cure colic in babies, as a breath freshener while gargling, and as an eyewash. The Greeks referred to fennel as *marathon* after the celebrated battle of Marathon in 490 BC was fought on a field of fennel. It is said that the Greeks used fennel to treat more than 20 different illnesses. The Romans included fennel seeds in seasoning mixtures of herbs and spices. The Frankish emperor Charlemagne is said to have introduced the herb into Central Europe by ordering it to be planted in the gardens of monasteries. Mediaeval herbalists said that fennel seed “comforteth the stomach.” In those

Fennel (Darko Plohl/Dreamstime.com)

times, people were said to have kept fennel seeds handy to snack on through long church services. On fast days, the seeds were considered appetite suppressants. Yet there is evidence that fennel stimulates the appetite and aids digestion. In the Middle Ages, fennel was a favorite stewing herb and added to food that was not fresh to make it palatable. The Anglo-Saxons used fennel in their cooking and medicinal procedures before the Norman Conquest. According to some sources, the Anglo-Saxons believed fennel gave courage and virility to those who used it. In the 1600s, fennel was eaten along with fish and meat to aid digestion. Fennel was woven into the winners' crowns in athletic events. Early Hindus and Chinese used it as an antidote to snake and scorpion bites, and it was hung over doorways to repel evil spirits. In superstitious times, some people hung branches of fennel in the home to protect from evil spirits. In addition, those who were afraid of ghosts stuffed the keyholes of their doors with fennel seed. Victorian traditions used herbs and flowers to express emotions, and fennel was used as a symbol of praise. Although fennel and aniseeds are similar in appearance and taste, they come from different plants. Seeds from Florence fennel have a mild anise flavor, while those from aniseeds, which come from the parsley family, are native to the Middle East and taste stronger than fennel seeds. In the past, fennel was used in homemade cough syrups.

Medicinal Uses

Hippocrates believed that our health depended on balancing four elements: fire, water, earth, and air contained in our bodies. When the balance was upset, restoring it was through several methods, including using plants such as fennel along with parsley and thyme and celery. Fennel has been used to treat inflammations of the eyelids and conjunctivitis. Fennel has been used as a mild stimulant. Besides antioxidant activity, fennel oil enhances bile secretion and is "diuretic, analgesic, carminative, antipyretic, antibacterial, and antifungal," according to a recent source. Anethole and other terpenoids inhibit spasms in muscles such as those in the intestinal tract and contribute to its reputation as a carminative and a cramp-relieving agent. Fennel was formerly a drug in the United States and was said to be used for indigestion. It has been entered into the pharmacopoeia or the official list of the medicinal plants in many countries because of its volatile oil. There are claims that fennel has a cleansing, toning effect on the skin. Fennel seed infusions are added to facial lotions and moisturizing creams. Modern herbalists use washes with fennel and other ingredients for the eyes. They also recommend a tea of "seed-like fruitlets" to stem hunger pangs. Fennel juice and fennel tea are used to wash out "weakened" or infected eyes. One authority believes "that tea made from the leaves has been shown to produce a significant reduction in arterial blood pressure without affecting the heart or respiratory rate." Some researchers have questioned whether people with an estrogen-dependent cancer (some breast cancers) should avoid fennel in large quantities until the significance of its estrogen-like activity is clarified. In rare cases, fennel can cause allergic reactions of the skin and respiratory tract. Caution is urged before self-medicating with fennel volatile oil as vomiting, seizures, and respiratory problems may result. Excessive use of fennel is believed to cause problems with the eyes. However, fennel is high in potassium, iron, and vitamin C. According to one folk remedy, if you have a cough but do not want to expectorate, make a tea from fennel seed and aniseed to suppress the cough.

Culinary Uses

The fruit, commonly called seeds, is favored in Italian sweet sausage. The foliage and stems are used in recipes, especially those for fish and shellfish. In some Indian restaurants, the seeds are often available for use after meals to prevent gas and indigestion. Chinese five-spice powder, applied to meat and poultry, often includes fennel. One may use fresh leaves in fruit salads and sweet yogurt dressings and in green salads and herb vinegars. The leaves may be used as garnishes, and one may eat the tender stems like celery. Flower heads are added to salads. Fennel seeds are used in many recipes such as chicken, duck, as well as a variety of Italian dishes. Sliced fennel bulbs are often served on antipasto platters. Fennel is said to be rich in antioxidants, and the uses of fennel are not limited to traditional fish or meat dishes. A vegetable soup in *Food & Wine* features a fennel bulb along with a healthy amount of vegetables and Parmigiano-Reggiano cheese rind.

Television and the Internet are quickly changing the ways food enthusiasts can obtain information. Recipes are readily available online from magazines, newspapers, and food blogs. Obtaining information about fennel, for example, can take only minutes and can produce recipes for a summer salad featuring grilled fennel bulbs and oranges and a recipe featuring braised chicken thighs with caramelized fennel. In addition, TV cooking shows are increasing the number of people interested in food and cooking. Viewers can watch chefs compete for money and learn about ingredients like fennel. Many times "home-trained," that is unschooled, cooks win contests, opening up interest in herbs and ingredients.

The essential oil of fennel seeds has been used for flavoring foods and liquors such as anisette. It is also used in perfume, cosmetics, pharmaceuticals, air fresheners, mouthwashes, and toothpaste (Tom's of Maine, for example). Fennel seeds have been used whole or ground as a spice in cooking to season bread, rolls, pastries, pickles, fish dishes, and sauces. For the home cook, roasting fennel seeds may eliminate a bittersweet aftertaste.

Home Gardens

When growing "common fennel," the stalks should be trimmed several times during the growing season to produce leaves for culinary use and to prevent the herb from taking over the garden. You can harvest the licorice-tasting seed heads when they are yellow-green.

When growing Florence fennel, gardeners must keep the bulbs moist and cover the bulbs to blanch them. The gardener should avoid planting fennel near dill, beans, kohlrabi, tomatoes, or cilantro. Fennel can be harmed if planted close to coriander and wormwood. According to gardening lore, fennel should be planted with several ingredients to produce a good harvest: salt, bread, and several silver coins.

You can store fennel seeds by placing them in a paper bag and closing it. After ripening in a cool, dry area, the seeds may be stored in a jar.

Fennel flowers attract beneficial insects such as parasitic wasps and tachinid flies, which prey on insects that cause damage in the garden. They also attract swallowtail butterflies, large colorful butterflies that may delight the gardener.

It has been recommended that culinary herbs just picked from the garden be placed in perforated plastic bags and placed with the top of the bags open in a refrigerator at 41°F. After an hour or so, each bag may be closed with a twist fastener available in supermarkets. The perforations prevent condensation.

Harriet Weinstein

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Fern

A perennial, nonflowering, vascular plant, the fern is a member of Pteridophyte, a large division of flora. Pteridophyte contains 250 genera of some 12,000 species. Among these groups, ferns comprise 240 genera and 10,400 species, making them the dominant members of Pteridophyte. Once the chief plant on Earth, ferns have dwindled to just 2 percent of flora. The word "fern" derives from the Anglo Saxon "fearn," meaning feather because a fern leaf resembles a feather. Similarly, Pteridophyte means "feather plant," an apt appellation given the prominence of ferns in this division.

History and Economic Importance

Among the first plants to colonize the land, ferns are at least 300 million years old. At 200 million years old, *Osmanda claytonione* is the oldest extant fern and is among the most ancient plants. Ferns quickly rose to prominence in the Carboniferous period. Its frost-free tropical climate, warm inland seas, marshes, swamps, and abundant sunshine provided an ideal environment for ferns. Although they now prefer shade, they then reveled in sunlight, a fortunate circumstance because there were few trees to shade them. Among the largest trees, growing to 80 feet tall, were tree ferns. The onset of the ice ages and the evolution of flowering plants challenged the supremacy of ferns, whose numbers declined. The demise of the dinosaurs 65 million years ago opened land to recolonization by ferns and they once more enjoyed prominence among plants. The return of the ice ages imperiled ferns, making them a small but still consequential member of the plant kingdom.

Perverse as it may seem, ferns have had their greatest effect on humans in their death. Over millions of years, incomprehensible numbers of ferns lived and died during the Carboniferous period. Layer upon layer of dead ferns, packed tightly together by gravity, formed Earth's enormous reserves of coal, the fossil fuel that

Ferns (Sever180/Dreamstime.com)

powered the Industrial Revolution. It powered the generation of electricity and fired the manufacture of industrial products, notably iron and steel. Most scientists admit that coal is a dirty fuel. Its burning pollutes the air, causing smog and aggravating respiratory ailments. It releases carbon dioxide into the atmosphere, warming the planet. Scientists predict dire consequences from global warming: flooded coastlines and cities, enlarged habitats for disease-carrying mosquitoes, hurricanes, and drought. The product of ferns, coal, has an ambiguous legacy.

Long after the end of the Carboniferous period arose humans. Sometime in prehistory, the Maori of New Zealand and the indigenes of New Guinea planted ferns along the side of their homes as windbreaks and fences. The deliberate planting of ferns implies that they were cultivated plants. Far from New Zealand and New Guinea, Europeans were curious about ferns. Medieval herbalists believed that ferns had flowers and seeds like other plants but that they were too small to be seen. People who said the right incantation could see fern flowers, medievalists believed. The discovery of these flowers, they believed, would grant their finders magical powers. Some people believed that ferns yielded tiny blue flowers, but on only one day per year, Saint John's Day (June 24). At midnight, the flowers shed seeds. Those fortunate enough to find these seeds acquired "wonder working powers" according to one writer. The person who put these seeds in his or her shoes or who ate them would become invisible. Fern seeds also, some believed, allowed people to see into the past and future and to find unknown treasures. The possessor of fern seeds, it was believed, would remain eternally young. A popular fad swept medieval Europe in which people eager to catch fern seeds spread white sheets beneath ferns on Saint John's Eve. Waving magic wands and reciting prayers, they sought to beseech ferns to put forth their seeds. Of course nothing happened, but seed seekers were apparently not discouraged, returning the next year to repeat their ritual. The most frantic seed seekers invoked demons and witches to help them.

In France the Catholic Church, aware of these incidents, banned the search for fern seeds on Saint John's Day. So widespread was the belief in fern seeds that Shakespeare mentioned them in his play *Henry IV.* Sixteenth-century British botanist Henry Lyte declared, however, that ferns seeds did not exist.

As early as 300 BCE, Greek botanist Theophrastus urged the ailing to ingest fern oil to expel worms from the body. Medieval Europeans and some Amerindians, unaware of Theophrastus's advice, nonetheless believed that ferns expelled worms. The Cherokee believed that ferns could cure rheumatism. In the 17th century, herbalist Nicholas Culpeper believed that ferns could heal "wounds and ulcers." When burned, ferns gave off smoke that repelled insects and snakes, remarked Culpeper. In 1633, British herbalist John Gerard recommended that one soak fern roots in wine to keep it from spoiling. Folk medicine retains the belief that the consumption of ferns expels worms from the stomach and intestines and cures rheumatism and ulcers. Some people also believe that the ailing should eat ferns to relieve constipation, reduce hemorrhages, and alleviate the pain of insect bites and stings. Some recommend rubbing ferns on bruises, burns, and sprains to decrease pain.

Ferns had other powers according to some. Medieval herbalists, seeing that the roots of the Bracken fern formed the letter *C*, believed that it was a symbol of Christ. The Bracken fern must therefore, they believed, protect the faithful from witches and demons. The Scots, coming to a similar conclusion, used the Bracken fern to expel evil spirits from the body. Witches and werewolves, they believed, were afraid of the Bracken fern. For this reason, the Irish named the plant the "Fern of God."

Despite this interest in ferns, Europeans were slow to cultivate them. Only in 1794 did British surgeon John Lindsay, working in Jamaica, succeed in growing ferns from spores. This achievement may have marked the first time anyone had grown ferns from spores. Lindsay sent spores to the Royal Botanic Garden in Kew for culture. That year Sir Joseph Banks reported Lindsay's discovery to a gathering of scientists in England. In 1795, Captain William Bligh brought 37 species of fern from the Caribbean to Britain. Gardeners began raising ferns from spores, and their popularity began to increase. Gardener John Shepherd gained renown by growing 53 species of fern, many of them from the tropics. In the 1830s, British physician Nathaniel B. Ward recommended the culture of ferns in hospitals to cleanse the air, supplying oxygen and removing carbon dioxide. In 1842, Ward demonstrated that it was possible to grow ferns in airtight glass cases, though others may have anticipated this finding. Ward claimed to have grown a fern, in what was called a Wardian case in his honor, for 18 years without adding water or nutrients. Collectors, finding ferns in the tropics, shipped them to Britain in Wardian cases. Household gardeners took to raising ferns in Wardian cases, though because glass was expensive the culture of ferns became an avocation of the middle and upper classes. Affluent women were prominent fern growers. They bought ferns from nurseries and collectors. Others toured the countryside, taking ferns that caught their fancy. By the mid-19th century, the demand for ferns was so great that nurseries hired collectors to pillage the countryside for ferns. So massive were these collecting efforts that in some parts of Britain ferns were in danger of extinction. Ferns had captured the attention of a public eager for something more than flowers. People came to appreciate the beauty of ferns, which in artistic renderings graced glass, china, curtains, and wallpaper. Stonecutters decorated churches and tombstones with carvings of ferns. By the 1880s, fern mania had ebbed, and the late 19th and early 20th centuries were a period of less intense interest in ferns. Since the 1960s, ferns have recouped a portion of their former popularity, and today gardeners once more covet ferns for their beauty and scientists nurture an interest in ferns for their curious method of reproduction.

Peculiar as it may seem, some people consider ferns a delicacy. In parts of the developing world, the Bracken fern is a food. Some Americans eat the Ostrich fern. Norwegians eat the fronds of *Dryopteris filiz-mas*. Gourmands have remarked that the fronds of *Equisetum arvense* taste like asparagus. The people of New Zealand, the Himalayas, Fiji, Malaysia, India, New Guinea, and Celebes all eat fern fronds. Also edible are fern rhizomes, which contain starch. Some Amerindians eat the rhizomes of *Dryopteris austrisca*. The aborigines of Queensland eat the rhizomes of *Blechnum indicum*, and the Eskimos of Alaska consume the rhizomes of *Dryopteris carthusiana*. Some people have baked the rhizomes of the Bracken fern into a low-quality bread. The people of Hawaii, Australia, New Guinea, India, New Zealand, Madagascar, and the Philippines eat the pith, baked or roasted, from the trunk of tree ferns. Stems of the genera *Morettia* and *Angiopteris* are, like rhizomes, rich in starch. The species *Nephrolepis cordifolia* bears tubers that look like small potatoes, which the people of Nepal eat. Some add fronds to boiling water, drinking the brew as one might drink tea. Europeans use the fronds of *Dryopteris fragrins* for this purpose. In the United States, *Pellaea ornithopus* is the species of choice. In India, ferns of the genus *Angiopteris* are fermented into alcohol. Taking the place of hops, the Bracken fern is used to brew beer. Despite the culinary appeal of ferns, they produce carcinogens. The Japanese who eat ferns have the world's highest rate of stomach cancer. The fact that people knowingly consume carcinogenic ferns should not be surprising given the epidemic of cigarette smoking.

In the United States, florists sell ferns in arrangements. Known as the Christmas Fern, *Polystichum acrostichoides* is a popular holiday plant. In Mexico and the United States, species of the genus *Selaginella*, known as resurrection ferns, are novelty items because the fronds roll into brown balls when the soil is dry and unfurl and green when it is wet. The aquatic ferns of the genus *Azolla* contain algae that fix nitrogen in the soil. The fern derives this nitrogen for growth, and the algae derive carbohydrates from the fern, forming a symbiotic relationship. In parts of Asia, farmers plant *Azolla* in their rice paddies to add nitrogen to the soil. At the end of the season, farmers plow under *Azolla* as green manure. In the tropics, people use the scales and hair of tree ferns to stuff pillows and mattresses. Others use ferns to make rope, baskets, hats, fish traps, and mats. Home builders use tree fern trunks to make houses. The natives of New Guinea use the trunks as struts for houses. In parts of Asia, homeowners thatch their homes with ferns. Some use the stems of ferns to scour pots and pans. In Japan, the spores of *Lycopodium clovatum* are used to polish wood.

Attributes and Cultivation

Having evolved in the warm Carboniferous period, many modern ferns retain a preference for hot, wet conditions. Many species are indigenous to the tropics and subtropics and will not tolerate frost. Most species are native to the world's rainforests. In the forest, some ferns live as epiphytes on the trunks and branches of trees, where they have access to light, the circulation of air, and humidity. Other ferns have evolved the capacity to tolerate cold. These ferns survive when covered by snow. Some ferns even tolerate dry conditions. These ferns have scales or hair on their fronds to reduce the transpiration of water. Drought-tolerant ferns become dormant in dry conditions and revive with rain. Most ferns thrive in shade. Although they tolerate sun in the morning and late afternoon, gardeners should not plant them in spots that receive midday sun. Sunlight can kill delicate species and can scorch and discolor fronds, retarding their growth. In the tropics, the winter sun may kill sensitive ferns because the concentration of ultraviolet light is high. The overcast skies of summer protect tropical ferns. In temperate locales, the winter sun is weaker and so less harmful to ferns. A few ferns dwell in full sunlight. Given that ferns arose in an environment of full sun, it seems peculiar that most have evolved a preference for shade. Because ferns may depend on a larger plant for shade, its loss of leaves prior to flowering may expose ferns to too much sun. On the other hand, these leaves serve to mulch ferns, helping retain soil moisture. Ferns need humidity. Accordingly, gardeners should plant them in groups so that the transpiration of many ferns will raise the humidity. Ferns do well in a protected area, where wind will not disperse humid air. Ferns grow best in a warm, sheltered environment and for this reason are often planted in greenhouses. Some gardeners grow ferns along a brick wall, whose dark color absorbs heat. A light-colored background, however, may reflect light onto ferns, aggravating the problem of sun damage.

Scientists term ferns cryptogams, meaning "hidden marriage," because their reproduction is not obvious. The other cryptogams are algae, mosses, and liverworts. Among the cryptogams, only ferns have a vascular system to distribute water, nutrients, and hormones. Some scientists believe that ferns evolved from algae. Originating before the advent of flowering plants, ferns have a unique method of reproduction. Ferns produce spores rather than seeds. Although one might be tempted to link the two, a seed has a complete complement of chromosomes, whereas a spore has only half a parent fern's chromosomes. Having only half the chromosomes of its parent, a spore does not develop into a mature fern. Rather, it germinates into a prothallus, a tiny plant without roots, a stem, leaves, or vascular system. Primitive in comparison to flowering plants, the prothallus has rhizoids, which, resembling roots, anchor it to the soils and absorb water and nutrients. The prothallus produces male and female gametes. The male sex organ produces antherozooides, which resemble sperm in their use of a tail to swim. The female gamete, the archeogonium, emits a chemical that attracts the antherozooides. The antherozooid that first reaches the archeogonium fertilizes the egg. The rest of the antherozooides dies. Fern reproduction is surprisingly akin to human reproduction, and in this sense humans are more like ferns than like flowering plants. Once fertilized, an egg grows into a fern. A new fern may require four months to several years to produce its first frond. Thereafter another one to two years pass before a fern produces spores. Remarkably prolific, one fern may yield 20 million spores. Because spores are viable for only a few months, the gardener who collects them must plant them quickly. A fern may also reproduce vegetatively, generating new ferns from a rhizome. Ferns that arise from a rhizome are identical to the parent. Those that arise from eggs are genetically diverse.

Ferns can grow to 11,500 feet in elevation, though botanists have discovered them as high as 14,500 feet. Able to grow at altitude, ferns have colonized the Andes Mountains, the Himalayas, and the mountains of New Guinea. Ferns have shallow roots and so cannot withstand the desiccation of the uppermost layer of soil. As is true of many plants, ferns die when their roots become dry. Ferns prefer the circulation of air because still air may impedes their ability to transpire water. Nevertheless, ferns will not withstand wind, which may break fronds and disperse humidity. Hot, dry wind may shrivel new plant growth. A cold wind may stunt growth. Near the ocean, air full of brine may cause salt burns on fronds. A few hardy species tolerate brine air. Ferns cease growth when the days shorten and nights grow cold. These ferns, dormant during winter, survive at high latitude. Some ferns are deciduous, shedding fronds when weather cools to conserve moisture. The fronds of the hardiest ferns may freeze without killing the plant.

Although one often encounters ferns in nature in a bog, they will not tolerate waterlogged soils, which have low oxygen content. Rather, ferns need well-drained soils with a large concentration of oxygen. Ferns tolerate a range of soils. Some species thrive in acidic soils. Others prefer basic soils, and still others can live in acidic, basic, or neutral soils, though as a rule ferns do not tolerate extremes of acidity and alkalinity. As do many other plants, ferns grow best in soils rich in organic matter. Ferns take root in both clay and loam, though they do not thrive in sandy soil because it has too few nutrients and does not hold water. Ferns respond well to the addition of manure and bonemeal to the soil. Gardeners may apply inorganic fertilizers to rapid growers like tree ferns. Fertilizer is best applied in spring and early summer when ferns are growing rapidly. Late application of fertilizer may impair a fern's ability to become dormant in cold weather. Where ferns will not grow because the soil is too acidic, gardeners may add calcium carbonate, limestone (which may be pure calcium carbonate), chalk, marl, or eggshells. Ferns that have been adequately fertilized may be less susceptible to pests and diseases than ferns that lack nutrients.

The contentious gardener plants ferns only after preparing the soil by digging it to a depth of 8 to 12 inches to loosen it and to ease the removal of weeds. A loose soil promotes the establishment of fern roots. For optimal growth, ferns need nitrogen, phosphorus, potassium, magnesium, calcium, sulfur, iron, manganese, boron, zinc, copper, molybdenum, chlorine, cobalt, and sodium. Ferns use nitrogen to make amino acids and to form chlorophyll. Most of the atmosphere is nitrogen, but ferns, like other plants, cannot absorb it in this form. Rather, fern roots take up nitrogen in the form of ammonium and nitrate ions. A deficiency of nitrogen stunts ferns and turns them pale or yellow. Phosphorus is necessary for respiration and photosynthesis. It promotes the growth of roots and reproductive parts. A deficiency of phosphorus stunts the growth of both plant and roots and causes fronds to be dark green. Potassium thickens cell walls and aids in the formation of chlorophyll, reproductive parts, and roots. Parts of fronds may die if a fern is deficient in potassium. Calcium aids in the formation of cell walls. It promotes cell division and the formation of protein and roots. Ferns in acidic and sandy soils may be deficient in calcium. Where calcium is deficient, fronds and roots will be small. Magnesium aids in the formation of chlorophyll. Magnesium-deficient ferns display chlorotic patterns on their fronds. Sulfur aids in the formation of chlorophyll and roots. Sulfur-deficient ferns may be pale. Manganese is essential for photosynthesis. It is often deficient in alkaline soils and superabundant in acidic soil. Deficient ferns display chlorotic patterns with green veins.

Pests, Diseases, and Ailments

Ferns are susceptible to several fungi. Fungal diseases may attack roots, rhizomes, or fronds. Warm, humid weather hastens the spread of fungi. Among the fungal diseases that afflict ferns is armillaria root rot. As the name suggests, this disease destroys the roots, interfering with the uptake of water and nutrients. Afflicted ferns appear to lack water, but watering them does not help. Large ferns are particularly vulnerable to armillaria root rot. Phytophthora root rot, a disease of soybeans, also afflicts ferns. Present in the soil, phytophthora fungi penetrate the roots, advancing to the crown. The disease progresses rapidly and is fatal if unchecked. Like armillaria root rot, phytophthora fungi impair the ability of fern roots to absorb water. Gardeners who respond by watering their ferns unwittingly aid the fungi, which grow numerous in wet soil. Poorly drained soils also harbor phytophthora fungi. Ferns in calcium-deficient soil appear to be particularly vulnerable to phytophthora root rot. Rust, a disease of grains, also infects ferns. Rust fungi cause orange blotches on fronds and in the worst cases are fatal. Weak ferns are more susceptible to rust than are vigorous plants. The gardener who wishes to preserve her ferns should destroy rust-infected plants or spray them with the fungicide oxycarboxin. Mold fungi attack ferns where the environment is too humid. They afflict ferns the first cool nights of autumn. Mold is prevalent where a lack of air circulation has allowed too much humidity to accrue. A similar affliction is greenhouse frond rot, a fungal disease that infects ferns where ventilation is nil and humidity in excess. Crown rot fungi stunt ferns and blacken fronds. Rather than kill a fern quickly, as phytophthora root rot does, crown rot lingers for years, sickening ferns. In addition to fungal diseases, bacteria infect ferns. Nematodes, a pest of ferns, may transmit bacteria to them. Aphids and plant hoppers transmit viruses to ferns. Viruses cause mosaic patterns on fronds. The species *Dryopteris erythrosara* and *Woodwardia orientalis* are especially susceptible to viral infections. Whether fungi, bacteria, or viruses, disease may manifest in spots on fronds or rotted tissue. The wilting of ferns indicates a disease of the roots. In an effort to prevent disease, gardeners should buy healthy, vigorous ferns and plant them in an area in which air circulates. Fungal disease may be combated with fungicides, though one must exercise caution because they may damage ferns. The genus *Nephrolepis* is sensitive to fungicide damage, though the species *Asphenium australasicum* is hardy enough to withstand applications of fungicide without damage.

A large number of pests attack ferns. Although ants do not bother ferns, their presence is a sinister sign because they protect aphids, scales, and mealy bugs, all of which prey on ferns. Aphids, attracted to a young fern, suck its sap. The fern aphid is among the most common pests of ferns. Fronds that have grown in misshapen patterns betray aphid damage. Several species of caterpillar and grub feed on ferns. Chewing on fronds, caterpillars and grubs are numerous in spring, summer, and autumn. Caterpillars hide on the underside of fronds, and grubs often feed on the roots. Young ferns attract caterpillars and grubs. The Florida fern caterpillar feeds on fronds at night. The caterpillar of the dyneria butterfly, native to New Guinea, Moluccas, the Aru Islands, and Queensland, also feeds on fronds at night. Active in spring and summer, the caterpillar of the light apple moth feeds on ferns at night. Active in autumn and winter, the caterpillar of the painted apple moth feeds on ferns during the day. Active at night, cutworm grubs feed on the stem of a fern at the level of the soil. Weakened ferns collapse under their own weight. Curl grubs and Japanese beetle grubs feed on roots, causing ferns to wilt. Adult Japanese beetles devour fronds. Cockroaches feed on roots, fronds, and crosiers. Crickets eat the fronds and crosiers of young ferns. Earwigs feed on roots, rhizomes, and fronds. The vine weevil devours a fern from root to frond. It is most abundant in greenhouses and potted ferns. The species *Asphenium scolopendrium* is especially vulnerable to the vine weevil. It causes ferns to wilt, a condition that is often mistaken for lack of water. Certain species of nematode eat the vine weevil grub, and the beleaguered gardener may add them to the soil. The maggot of the fungus gnat feeds on dead tissue and on rhizomes and roots. Young ferns and potted ferns are particularly vulnerable to it. Sucking sap like aphids, mealy bugs feed on greenhouse ferns. As with many other pests, they are attracted to young ferns. The snail *Helix asper*, an indigene of Europe, is a voracious feeder, attacking ferns in the subtropics and temperate locales. The fern slug is also a serious pest of ferns.

An ailment known as sweating afflicts ferns in an environment of too much humidity and too little air circulation. These conditions, we have seen, interfere with a fern's ability to transpire water. The fronds of ailing ferns blacken. In severe cases, sweating is lethal. In moderate cases, sweating weakens a fern so that it is vulnerable to pests or disease. In temperate zones, sweating is a common affliction in autumn. In the subtropics, sweating is common in wet weather. In all climates, sweating may ail greenhouse ferns. Species of the genera *Blechum*, *Doodii*, and *Pteris* are vulnerable to sweating.

Christopher Cumo

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Fig

A tree that produces sugary fruit, the fig (*Ficus carica*) is an ancient cultigen. The tree is ubiquitous in western Asia. Turkey is the world's leading producer. The United States ranks second. California's Central Valley is the principal region of fig culture in the United States. Other producers are Egypt, Algeria, Italy, Greece, Spain, Portugal, and southern France. Most of the harvest is dried and pressed into a paste that flavors cookies, notably the Fig Newton, and other sweets. Only 9 percent of California's harvest is sold fresh, though fresh figs fetch six to seven times the price of dried figs. Fresh figs are fragile and must be consumed soon after their purchase. Fresh figs begin to spoil after only a few hours at room temperature and must be refrigerated. Those that have begun to spoil emit an odor of fermentation. Figs have fiber, potassium, and vitamin B6. Three figs have five grams of fiber, 20 percent of the recommended daily allowance. Three fresh figs have 348 milligrams of potassium, 10 percent of the daily allowance. Three dried figs have 399 milligrams of potassium. Three fresh figs have 0.2 milligram of vitamin B6, 9 percent of the daily allowance. Some health bars, touting the benefits of the fig, contain it as an ingredient. The Latin *Ficus* is the genus name for fig. *Ficus*, the Italian *fica*, the Portuguese *figo*, the Spanish *higo*, the French *figue*, the German *Feigen*, and the Dutch *vijg* derive from the Indian *fag* or the Hebrew *feg*. The English "fig" derives from the Old English "figge" or "fegge." The Greek *erineos* means "wild fig." Sykon means "cultivated fig." Fig is rendered *tena* in Aramaic, *tin* in Arabic, *paggim* in Phoenician, *paggam* in Syrian, and *anjir* in Persian.

Religion and Mythology

An important tree in the Near East and North Africa, the fig is prominent in the Bible. According to Genesis, Adam and Eve covered themselves in fig leaves when they discovered that they were naked. The awareness came to them only after they had eaten the forbidden fruit, which some biblical commentators believe was the fig. One authority has remarked that the Genesis story echoes an earlier practice in which participants in religious rites covered themselves with fig leaves. Another authority believes that the writer of Genesis had in mind a different species of *Ficus*, in which case the fig could not have been the forbidden fruit.

The oldest certain reference to the fig in the Bible may come from Deuteronomy, which records that God gave the Hebrews a land rich in figs and other foods. King Hezekiah of Israel recommended the fig's use to treat boils. The prophet Isaiah's remark that "all the starry host will fall like . . . shriveled figs from the fig tree" may refer to the fact that unpollinated figs turn brown and fall from the tree. The prophet Jeremiah told the story of two baskets of figs placed before the Temple. One basket contained good figs that symbolized those who submitted to the will of Babylonian conqueror King Nebuchadnezzer. The seeds from these figs, Jeremiah foretold, would be planted throughout Israel. The Hebrews would know that these figs were good because they ripened early. The other basket held figs too bad to eat. Jeremiah compared them to King Zebekiah of Judah.

Jesus apparently knew that fig trees put forth their leaves late in spring because he remarked that one would know that summer was near when they yielded leaves. The Gospels record that Jesus uttered only a single curse, directing it at a barren fig tree. He had apparently been disappointed not to find any fruit on it. The tree, wounded by Jesus's words, withered. According to their religious traditions, the British ate fig pies on Fig Sunday during Lent. They observed the custom of eating figs, bread, and nutmeg on Good Friday.

The fig is important to Greek mythology. According to one myth, the chief god Zeus attacked the titans Ge and her son, Sykeus, in the War of the Titans. Fearful that Zeus's lightning bolts might strike her son, Ge turned him into a fig tree. From this account derives the belief that a fig tree protected one from lightning. One myth credited Dionysus, the god of the grapevine, with discovering the fig. An Athenian legend, however, credited goddess Demeter with this discovery. Demeter gave figs to King Phytalus for allowing her to stay in his home. Upon his death, mourners planted a fig tree, known as the Holy Fig Tree, on his grave. Legend held that a priestess could lead a wild bull to his sacrifice by first collaring him with a supple fig branch.

The Greeks told the story of the tree known as the goat fig. An oracle foretold that the Spartans would defeat the Messenians when a goat drank from the Needs River. Fearful of this prophecy, the Messenians drove away all goats, but their efforts came to naught when a goat fig that grew along the bank of the river dipped its branches into the water, drinking from it. The prophecy fulfilled, Sparta emerged victorious. According to legend, thieves stole figs from trees sacred to the gods in Attica. The citizens accused the thieves, from which derives the term "sycophant," meaning literally "to show the fig."

The Romans credited Bacchus, a god similar to Dionysus, with giving the fig to humans. Accordingly, Roman art depicted Bacchus with a crown of fig leaves. So much did he enjoy figs that Bacchus grew fat from eating them. Because of his connection to figs, the Romans offered the first figs of the season to Bacchus. At his festivals, Roman women wore garlands of dried figs. In processions, figs came behind only grapes and ahead of all other fruit.

The people of southwestern Asia, Egypt, Greece, and Italy worshipped fig trees. One ancient people, the Pharmakai, used a black fig to symbolize a man and a white fig to represent a woman. They held fertility rites to ensure the bounty of the harvest. In Asia and the Mediterranean, the fig symbolized fertility. The people of Greece and India made a phallus of fig wood. The Greeks used it in their worship of Dionysus and Indians used it in their fertility rites. Merchants in Kyoto, Japan, once sold candy made from figs and in the shape of a phallus at Shinto festivals.

Origin and Diffusion

Fossils of figs in Italy and France date to the Tertiary (65–2.6 million years ago) and the Quaternary (2.6 million years ago to the present) periods. Fossil figs were smaller than contemporary figs, evidence that humans, through selection, derived large figs. Humans first cultivated the fig in Arabia, where wild figs still grow. From Arabia, its cultivation spread to Iraq, Turkey, Transcaucasia, Armenia, Iran, and Afghanistan. The Assyrians cultivated the fig as early as 3000 BCE. About 2900 BCE, Sumerian king Urukagina emphasized the fig's medicinal value. From western Asia, birds and humans carried the fig west to the Mediterranean. The Egyptians decorated tombs and monuments with carvings of figs. First-century BCE queen Cleopatra preferred the fig to all other fruit. Legend holds that the asp that killed her had hidden in a basket of figs.

As early as the ninth century BCE, the Greeks cultivated the fig. In the ninth century, Greek poet Homer mentioned the fig once in the *Iliad* and thrice in the *Odyssey*. About 700 BCE, Greek poet Archilechus mentioned the cultivation of figs on the island of Paros. In the fifth century, Persian king Xerxes ate figs to remind him that he did not possess the Greece that had grown them. In the fifth century, Greek dramatist Aristophanes warned fig growers to guard against predaceous insects. According to Greek historian Xenophon (430–354 BCE), philosopher Socrates (469–399 BCE) mentioned the fig in a dialogue with pupil Ischomachus. In the fourth century, Greek philosopher Aristotle and his pupil Theophrastus knew of the fig. The inhabitants of Athens were known as *philosykos*, meaning "a friend of the fig." In Attica, elites and commoners ate figs.

The Romans cultivated the fig as early as the eighth century BCE, planting fig trees on the Palatine Hill. They founded the city of Tarentum, where fig trees were alone in bearing fruit. The Romans imported fig seedlings from Syria. Apparently unable to satisfy demand through domestic production, the Romans imported figs from North Africa. The Romans may have planted fig trees in Britain, though no English text referred to them until the 13th century.

By the fifth century CE, the fig had spread to the Atlantic coast of North Africa and to southern France. The Arabs were renowned as skillful fig cultivators. One source holds that Mohammed (570–632 CE), the founder of Islam, said, "If I should wish a fruit brought to Paradise, it would certainly be the fig." The Moors promoted fig culture in North Africa and Spain. One account places the fig in

China in 127 CE, though another holds that China imported fig trees from Iran and India only in the seventh century. In Transcaucasia, farmers grew figs to 3,000 feet of elevation. In 812, Frankish king Charlemagne attempted to grow figs in the Netherlands. In the 12th century, Crusaders introduced the fig to Germany. In 1690, the Portuguese introduced the fig to Japan.

The first planting in the New World came in 1520, when the Spanish introduced the fig to the Caribbean. In 1526, European visitors remarked at the quality of figs on Hispaniola (now the island of Haiti and the Dominican Republic). In 1590, one European traveler noted that figs were abundant in Peru. In 1763, Greek and Minorcan immigrants planted figs in Florida. Around 1769, Spanish missionaries planted figs near San Diego, California. In 1787, statesman Thomas Jefferson, having observed the cultivation of figs in Marseilles and Toulon, France, thought it a suitable crop for slaves. U.S. president George Washington planted fig trees at Mount Vernon. According to one account, fig trees marked the spot of his birth, but when American writer Washington Irving visited the spot he found only two or three decayed trees. In the 19th century, a merchant sold what he claimed were magnolia trees to Texas residents. The specimens were really fig trees and so were known as Magnolia figs. In 1813, farmers planted figs in Hawaii. In 1880, growers planted Smyrna figs in California because of their suitability for drying. California growers made additional plantings in 1886, and in 1890 the U.S. Department of Agriculture imported 10,000 seedlings to California.

Reproduction and Harvest

The fig tree produces separate male and female flowers. Inconspicuous, they are hidden in the syconium. The cultivated fig bears only female flowers and need not be fertilized to yield fruit. The Smyrna group of fig trees and all wild figs yield more female than male flowers. A tiny wasp pollinates these trees. The female wasp lays her eggs in the flowers of a fig. The female wasps that hatch from these flowers, after mating with the males, leave a flower through a small opening at the top of a fig. As they exit, they pass a male flower, picking up pollen, which they use to pollinate a female flower. The wasps cannot linger in a fig, for the enzyme ficin dissolves those that remain too long. In the 19th century, the immigrants who brought fig trees to California were puzzled by the fact that they did not bear fruit. Only when scientists discovered the role of the wasp did they solve the problem of barren fig trees. In 1889, grower George Roeding established the first colony of wasps in California. Today, paper bags hung on fig trees supply wasps.

Laborers harvest figs by hand. They wear gloves and long sleeves because ficin irritates the skin. Because figs do not ripen at once, harvesters must inspect a tree every other day. The harvest may stretch over several months. As a rule, a fig tree bears two crops per year. The first, in late spring and early summer, is small. The main crop comes in late summer and early autumn.

Christopher Cumo

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Fire Lily

Nowadays, this beautiful lily—which blooms at the height of summer and is known in English as the "fire lily" or "orange lily"—is for the most part an ornamental plant. It is still quite common in Scandinavian gardens. In the rest of Europe, however, its place has long been largely taken by other lily species or hybrids. As a cultivated plant it represents an old bio-cultural inheritance. Among Scandinavians, it brings old-fashioned gardening and idyllic rural life to mind. It is a real eye-catcher in a rural garden.

The fire lily is a bulbous perennial, and it grows to be 23 to 46 inches high. The bulb is round, with rose-tinted, white, lanceolate scales. The upper third of the stem is often hairy. The lanceolate leaves, which grow scattered, are up to 4 inches long. Bulbils often form in the upper leaf axil. Sometimes the blossoms grow alone; normally, however, they form clusters of 2 to 5 or up to 50 in a dense multi-flowered umbel. The flowers are bowl-shaped and three-and-a-half to five-and-a-half inches in diameter. The tepals are yellow-orange with brown spots and are usually darker toward the tip. The nectaries are papillous. The stamens have red pollen, and the pistils are red. The fire lily does not produce any scent. Cultivars of the fire lily do not usually produce seeds. It has not been possible, therefore, to backcross cultivars with the wild species.

Origin and History

In its wild state, this species of lily is spread widely over alpine areas in Southern and southeastern Europe: from the Pyrenees in the west, through the Alps in the middle, to Central Europe and Slovenia in the east. However, it has become very rare in many places. In various parts of Europe, it is named for Saint John (e.g., *giglio di San Giovanni* in Italian, *liri 'd San Giuan* in Piedmontese, and *Sankt Hans lilje* in Danish), because it blooms during the second half of June (Saint John's Day is June 24). In certain parts of Italy, it is named for Saint Anthony (*gigliu di 'sant Antòni*), since its blossoms come out in the vicinity of Saint Anthony's Day (June 13).

Two subspecies of the fire lily are known: the main one, *Lilium bulbiferum* ssp. *bulbiferum*; and *Lilium bulbiferum* ssp. *croceum* Chaix, often called the croceum lily or saffron lily. The former, which has a tendency to produce bulbils on the stem, has a more easterly origin (in the eastern Alps); the latter, which does not produce bulbils, originates from the southwestern and western Alps. A giant variety, *Lilium bulbiferum* var. *giganteum* Terracciano, 1906, originates from the vicinity of Vesuvius, Napoli in Italy. The stem of this variety reaches up to 71 inches.

The oldest evidence for the fire lily as a cultivated plant is from the early modern era. It appears to have been cultivated during the 16th century in Germany, where it was known as *Goldlilie* (Golden Lily). German herbals from the mid-1500s also mention it; however, this may have been a question of the wild variant, which could be found in the Alps at the time. The first evidence of its cultivation in Scandinavia is from Norway in the late 1590s. The botanist Simon Paulli included an image of it in *Flora danica* (1648); it was also mentioned in other Danish works of the period. In Sweden too, it was known during the first half of the 17th century: Johannes Franckenius, for instance, mentioned it in 1638. A record from 1658 attests to its cultivation in Uppsala. Gardening manuals from the 18th and 19th centuries in northwestern Europe make frequent mention of it. In North America, finally, it has been cultivated at least since the 1840s.

In Scandinavia, it is *Lilium bulbiferum* ssp. *bulbiferum*, which has been cultivated in particular; by contrast, *Lilium bulbiferum* ssp. *crociferum* arrived in the region in the 19th century, with the modern trade in gardening products. The latter is still found as an ornamental plant in continental gardens south of Scandinavia; the former predominates in the Nordic region. The plant runs wild easily; during the 19th century, in fact, it was regarded as a weed in the Netherlands and Germany. It seems to be an escaped alien on the Isle of Man. It is also found naturalized in eastern Canada and the state of Utah.

In Sweden and other Scandinavian countries, the fire lily has been associated—perhaps more than any other ornamental plant—with old garden plots. During the 17th and 18th centuries, it was found in palace gardens, academic gardens, and the like; in the late 18th and early 19th century, however, it spread to the garden plots of the peasantry. It quickly became very popular. It grew by the doors of crofters' cottages; with its bright blossoms, it imparted beauty to simple surroundings. A very hardy species, it can be cultivated up to the northernmost parts of Scandinavia.

Traditional Ornamental Plant

The fire lily has served as a garden plant in many parts of Europe. During the 19th century, it was still cultivated in rural home gardens in Germany, the Netherlands, Austria, Switzerland, and the Balkans (Bosnia). Today, however, it is rather unusual as an ornamental plant in those countries, although it still exists in some home gardens of Austrian alpine farmers. It was also a common garden plant in England, Scotland, and Ireland; but it is rare there today. In the Nordic region, due to its cultivation in the home gardens of crofters and peasants, the fire lily came to be associated with those segments of the population. It satisfied a growing need for beauty among the peasantry, and it was easily grown besides. Its popularity is evident not least from the many locally known folk names given to it in Sweden, Norway, and Finland.

Due to its hardiness, it can be grown far up in the north—even in such outposts as the Faroe Islands and Iceland. In Norway and Sweden, it continued to be cultivated during industrialization in the gardens kept by workers and by country folk. In some quarters, on the other hand, it has been viewed with a certain disdain over the last century; and it has not been regarded as obviously suitable—notwithstanding its abundant flowering during the summer, and its endurance in the face of tough northerly conditions—for service as an ornamental plant. The fire lily is not often found in more recent modern gardens; in older gardens, however, it has lived on in considerable measure. In the vicinity of many abandoned gardens, moreover, it has survived as a remnant or even run wild. It is still common in gardens found in the Scandinavian countryside.

It has long been difficult to procure the fire lily on the market; those wishing to cultivate it, therefore, have had to preserve their own stock of it, or to acquire it from old gardens. It is therefore mostly passed on from garden to garden. The fire lily is easily propagated by dividing the bulb's scales. Also, the bulbils are capable of producing plants if sown. In recent years, the fire lily has enjoyed a renaissance as an ornamental plant. With the increased interest in traditional or old-fashioned cultivated plants, there has been a renewed appreciation for the plant. It is also available for purchase nowadays at certain specialized nurseries in Europe and North America.

Ethnobotany and Symbolism

No other real use than as an ornamental plant in gardens has ever been ascribed to the fire lily. The bulb is edible, but it has not served traditionally as a food (although there have been occasional reports to that effect from Italy). Children have found it amusing to fool people into sniffing the blossom. If one sticks one's nose far enough into the flower, it turns yellow from the pollen. This prank is known among children both in Scandinavia and in Central Europe (the folk names *snusgubbe* in Swedish, *gulnæser* in Danish, and *Nasenbeschiesser* in German all refer to its capacity to stain the nose). In the plant's original territories in the Alps, it has found some uses in its wild form in traditional medicine and in the production of surrogate coffee. In Italy, the fresh bulbs were used as poultices to treat sores, burns, and several other skin diseases. The bulb has also been carried as a sort of love charm.

In certain parts of Austria, the fire lily was known formerly as *Donnerrosen*, "thunder rose" (in Carinthia), and *Donnerblum*, "thunder flower" (in the Tyrol); it was believed that it drew lightning to itself and therefore should not be brought indoors. This superstition may have arisen from the fact that the intense orange coloring of the blossom calls to mind fire and lightning.

The fire lily has long been recognized as an emblem of the Orange Order in Northern Ireland. It was employed on July 12 annually by this Protestant organization probably for no other reason than that it was the only orange bloom available (it was for that reason probably not grown by Roman Catholic families). Today, however, it would appear to be modern hybrids, such as *Lilium X hollandicum*, that serve in such a manner. The old species is scarcely available in Great Britain or Ireland nowadays, although it certainly lives on in many old gardens. The fire lily has also been used as the basis for many modern lily hybrids.

Ingvar Svanberg

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Flax

An annual, versatile flax (*Linum usitatissimum*) supplies fiber, seed, and inside the seed, oil. The genus *Linum* derives from the Celtic *lin*, meaning "thread," a probable reference to flax fiber. The species name *usitatissimum* derives from the Latin for "most useful," a reference to the many uses of flax. A member of the Linaceae family, flax is of two types: fiber or textile flax and linseed, oilseed, or seed flax. No cultivar yields the highest-quality fiber, oil, and seed. Rather, one class of flax cultivar yields quality fiber, and another class yields quality oil and seed. The fiber is spun into linen. The oil is known as linseed oil and has several uses.

Origin and History

Flax is an ancient crop. It may have originated in India, which has the largest number of wild species. Although the earliest remains of flax, dating to 8000 BCE in Syria, Turkey, and Iran, were probably from wild plants, its cultivation might date to 7000 BCE, making it among the first plants to have been domesticated. Humans first cultivated flax in the valleys of the Tigris and Euphrates rivers in Iraq. Before 6000 BCE, the presence of large flax seeds in Syria and Iraq evidence cultivation and selection. As early as 6000 BCE, the people near the Dead Sea in Syria made linen garments. About 5000 BCE, this practice spread to Egypt and Judea. By 4000 BCE, the Swiss were making linen clothes. These early examples suggest that humans first cultivated flax for fiber and only second for oil and seed, though as early as 3000 BCE the Chinese extracted oil from flax seeds. By 1400 BCE, the Egyptians used linseed oil for embalming and linen for wrapping mummies. By 1000 BCE, the people of Jordan and Greece were making bread from flax seeds. The Ethiopians made flax into stew, porridge, and beverages. In the Iron Age (900 to 400 BCE), Scandinavians spun flax fibers into linen. The Abyssinians of the southern Nile River used flax for oil and the seed for cereal and bread. They grew short cultivars that did not lodge and that bore large seeds. By 500 BCE, the use of flax was common as a laxative and poultice. Around this time, the Phoenicians, trading flax from Egypt, introduced the plant to Flanders and Britain. The Greeks and Romans used flax as fiber, food, and medicine. They made a dish of flaxseed, barley, spices, and salt and made wheat-flax bread. First-century CE Roman encyclopedist Pliny the Elder remarked that flax had so many uses, though he noted that it exhausted the soil. So greatly did

Flax flowers (Elena Elisseeva/Dreamstime.com) it impoverish the soil that the ancients grew flax on the same land only every seventh year.

Around 800 CE, Frankish king Charlemagne ordered farmers to grow flax. By 1000, Flanders had emerged as the center of the linen trade. Around 1600, the French introduced flax into North America.

Linen

Grown in temperate locales and the subtropics, flax is made into cloth, canvas, yarn, carpet, paper, and insulation. Farmers who wish to grow flax for fiber cultivate tall varieties that yield long fibers. These varieties grow between 31.5 and 47.25 inches tall. Farmers plant these cultivars densely to deter them from forming multiple branches and from producing numerous seeds. Densely planted flax expends its energy in elongating its stem rather than in branching or reproducing. The long fibers yield linen, and the short ones are processed into paper. Today, fiber flax is harvested about 100 days after planting. The process of separating the fiber from the rest of the stem is known as retting and is a simple process. To obtain the longest fiber the plant is uprooted rather than cut. The ancients laid flax stalks on the ground or on a rooftop and kept them moist. The morning dew sufficed to moisten flax stalks. Alternatively, the Egyptians submerged them in the Nile River, and the Romans weighted them down in tanks of water. The moisture encouraged the growth of microbes, which dissolved the gum and pectin holding the fibers together. Once microbes had done their work, the ancients peeled off the fibers from the rest of the stalk for spinning into linen. Flax is an ideal fabric for warm climates because the fiber carries sweat away from the body, aiding evaporation.

Depending on the type of fiber they sought, the Egyptians harvested flax in three stages. The first occurred before the plant flowered. These immature stalks yielded the finest, softest fiber, from which the Egyptians made the clothes of the nobility. The second and largest harvest occurred 30 days after flowering, when the fiber was thicker and less soft. Fibers from this harvest made the clothes of commoners. The final harvest occurred several weeks after the second harvest and yielded the coarsest fiber, suitable for making rope and mats. The final harvest yielded seeds for planting next season.

So important was flax to the Egyptians that they believed that the gods had created it for their own use. The Egyptians spun flax fibers into clothes, towels, bed sheets, sails, fishing nets, rope, and funereal textiles. The pharaohs appointed a director of the king's flax to supervise production. They established flax mills in Thebes, Akhmim, and Memphis. As early as 1900 BCE, the Egyptians dyed linen with red and yellow iron oxide. By 1500 BCE, they dyed linen with indigo. The linen trade was lucrative enough to attract the Phoenicians as the principal carriers, supplying the rest of the Mediterranean with Egyptian flax.

So strong was flax fiber that Persian king Xerxes (520–465 BCE), fifth-century BCE Greek historian Herodotus reported, bought some from the Phoenicians to build a bridge across the Hellespont, presumably to invade Greece in the fifth century BCE. The Romans established linen mills in France and Britain. In the 18th century, Scotland and Ireland erected linen factories. Canadians and Americans made a fabric of linen and wool known as linsey-woolsey or winsey. It remained popular until the end of the U.S. Civil War. Today, Russia, Ukraine, Belarus, Canada, the United States, India, China, Argentina, France, Belgium, Britain, Germany, Spain, Egypt, Ethiopia, the Netherlands, Poland, Romania, the Czech Republic, Lithuania, Italy, Mexico, Australia, Argentina, and Sweden grow flax for fiber. In the United States, North Dakota, South Dakota, Minnesota, and Montana are the principal producers. China grows flax for domestic use. The North and Northwest are the principal regions of flax culture. Cultivation has declined in Sweden, where fungi limit yields. Sweden's cool, wet springs hasten the spread of fungi. Production has also diminished in Poland, where the yield dropped from 312,000 tons on 245,000 acres in 1970 to 100,000 tons on 70,000 acres in 1987. Although the United Kingdom produces flax, the yield does not meet demand. To satisfy demand Britain imports 75 percent of its linen from Belgium, the Netherlands, and Egypt.

Medicinal Use, Food, and Oil

Flaxseed is 35–45 percent oil, 22 percent protein, 12 percent fiber, and 10 percent mucilage. Oilseed flax, shorter than fiber flax, grows to a height of 23.5 to 31.5 inches. Farmers plant linseed flax farther apart than fiber flax to encourage linseed flax to produce abundant flowers and seeds. Today, farmers harvest oilseed flax 150 days after planting. Linseed oil is used in the manufacture of paint, stain, varnish, putty, concrete preservatives, glue, ink, and soap. Linseed cake feeds livestock.

The ancients appreciated the value of flax as medicine. Greek physician Hippocrates (460–377 BCE) recommended the consumption of flax seeds as a remedy for intestinal pain. Charlemagne, perhaps aware of Hippocrates's pronouncements, recommended flaxseed as treatment for gastrointestinal trouble. Recent research has heightened awareness of flax's benefits. A study at the University of Toronto has demonstrated that the consumption of flaxseed reduces cholesterol. The *British Journal of Nutrition* reports that four weeks' flaxseed in the diet reduced glucose in the blood 27 percent and cholesterol 7 percent. Another study documents the efficacy of flaxseed in preventing cancer cells from replicating. Others have underscored the effectiveness of flax in alleviating constipation, stomach trouble, high blood pressure, heart disease, and heartburn. Flaxseed contains 75 to 800 times more lignan than wheat bran, oats, millet, rye, soybean, and other legumes. Lignan may prevent heart disease, diabetes, high blood pressure, asthma, and cancers of the breast, prostate, uterus, and colon. Flaxseed helps bacteria reestablish themselves in the intestines after a course of antibiotics. According to one authority, the consumption of flaxseed improves the immune system. Flax is rich in insoluble and soluble fiber. Two-thirds of flax's fiber is insoluble. Aware of these benefits, the Food and Drug Administration has championed flaxseed "as a food for disease prevention."

Flax merits the attention of medical practitioners in part because it contains omega 3 and omega 6 fatty acids, essential lipids that the body needs but that it cannot manufacture on its own. Flax grown in cold climates produces more omega 3 than flax grown in warm climates. Flax grown in warm climates has more omega 6. Linseed oil is 48–64 percent omega 3, the richest plant source of this lipid; 16–34 percent is omega 6; and the rest is omega 9, the fat that is in olive oil. Flaxseed has a higher proportion of these fatty acids than the oil from any other plant. Today, stockmen feed flaxseed to livestock to increase the amount of omega 3 in their tissues, which, when consumed, benefits humans with the accumulation of this fatty acid. Flax oil helps the body metabolize fat. Some people who have ingested flax oil as part of their diet have lost weight. Linseed oil has been used to fry food, illuminate lamps, and preserve paint and flooring. Linseed oil has been the principal oil in many farming communities in China since antiquity. In Europe and North America, farmers grow flax for oil where they cannot grow peanut or olive. So important was linseed oil that the Egyptians anointed themselves with it before they left home. They welcomed guests into the home by anointing them with linseed oil. The Egyptians anointed the statues of their gods with linseed oil. The priests, apparently operating on the principle that if a little oil was good a lot was better, poured linseed oil on their heads. They Egyptians anointed the dead with linseed oil.

Since antiquity, Germans have eaten flax-rye bread. The Flax Council of Canada reports that Germans, as an aggregate, consume more than tons of flaxseed per year in bread and cereal. Some people eat flaxseed in soup and sauce and with vegetables and grain. Today, bakers add flaxseed to bread, bagels, muffins, cookies, buns, and dinner rolls. It is also added to nutrition bars.

Flaxseed is of two types: golden and brown. Golden flax seeds are large, soft, and flavorful. Golden flaxseed is expensive because the yield is low. Golden flax seeds have more protein and less oil than brown flax seeds and are eaten in cereal and bread. Brown flax seeds are small, hard, and less flavorful and have high oil content. Flaxseed has vitamins A, B1, B2, C, D, and E.

Biology, Cultivation, and Science

Flax flowers have blue, white, and red petals. Each flower, having both anthers and stigma, is perfect. Self-fertile, these flowers self-pollinate in most cases, though insects visit them, taking pollen to other flowers, thereby cross-pollinating them. Once fertilized the seeds are, we have seen, either golden or brown. The plant is indeterminate, growing throughout its life. Fax grows well in soil with organic matter. The soil should be loose and well draining. The plant needs 70 to 100 days to mature and prefers humidity and overcast skies. Although planting density varies according to whether the plant will be used for fiber or for oil and seeds, it averages 44 pounds of seeds per acre. India grows flax for both fiber and oil. China cultivates flax in the Loess Plateau, the grassland, the Yellow River valley, Xinjiang, and Quighai Highlands.

In the 17th century, British king Charles I advised the governor of Virginia to encourage farmers to plant flax. That century German immigrants may have been the first to cultivate flax in Pennsylvania. Each family raised two acres of flax to meet its own needs. Colonists were careful to choose fertile, well-drained soil. They avoided the extremes of clay and sand. The farmer was blessed who could count on rainfall evenly distributed throughout the year.

The yield per acre depends on the progress of science and the development of new cultivars. In 2003, Russia yielded hundreds of pounds of fiber and seeds per acre. The cultivars Alexin, A-93, and Lenok have shattered these figures, yielding thousands of pounds of fiber and seeds per acre. The Agriculture and Agri-Food Canada and the Crop Development Center at the University of Saskatchewan breed new varieties. In the United States, North Dakota State University is the leading flax breeder. Belgium grows Regina and Belinks varieties on the coast and Arianne, Natasja, and Viking inland. One authority recommends the rotation of flax with other crops to minimize pathogens and insects. In Russia, farmers rotate flax with potato, grain, and clover. Because grains are heavy feeders, the farmer should apply nitrogen, phosphorus, and potassium to the soil when flax follows them. Flax is less successful when it follows potato because the potato demands large amounts of nitrogen, whose residue causes flax to grow tall, leaving it susceptible to lodging and lowering fiber quality. In North America, farmers rotate flax with wheat, barley, corn, or a legume. Flax does not yield well when it follows potato, sugar beet, or canola. The benefits of rotation are so compelling that flax monoculture is uncommon in North America. Indian farmers rotate flax with corn, sorghum, millet, peanut, cowpea, chickpea, lentil, and safflower. The Chinese rotate flax with millet, barley, wheat, and potato. In Russia, the soil should have 15 milligrams of phosphorus and potassium per one 100 grams of soil. Where zinc is deficient, the farmer should spray a solution with 500 grams of zinc sulfate per hectare when seedlings emerge. In North America, oilseed flax responds well to nitrogen. One authority recommends the addition of 30 to 70 pounds of nitrogen per acre and 13 to 26 pounds of phosphorus per acre to Canadian soils. In China and India, farmers often plant flax on marginal land, rarely with adequate fertilizer. Canadians plant flax in mid-May and Russians in May. In India, farmers plant flax after the monsoon, usually in October or November. Farmers in Kashmir, however, plant in February or March. Argentines plant flax between May 15 and July 1; the later date holds for Buenos Aires in the north and Santa Fe in the south.

Christopher Cumo

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Forget-Me-Not

In the family Boraginaceae, the forget-me-not is a perennial ornamental in the genera *Myosotis* and *Eritrichium*. Myosotis has some 50 species. Flowers, having five petals each, may be blue, white, or pink. Stems and leaves have hairs.

Folklore, Attributes, and Cultivation

Legend holds that in the Middle Ages a knight and his lover walked along the bank of a river. The knight held a bouquet of flowers. During their excursion he stumbled. The knight fell into the water and, weighed down by his armor, drowned. Before perishing, he tossed the flowers to his beloved, telling her to "forget me not." The desire to be remembered by one's lover has led to the designation of November 10 as Forget Me Not Day. On this day, people connect with family and friends. To give someone a forget-me-not is a declaration of friendship or love.

Possibly because of its reputation as the flower of love and friendship, Alaska in 1949 named the alpine forget-me-not (*Myosotis alpestris*) the state flower. Found in meadows, the ornamental is 5 to 12 inches tall. Petals, one-quarter to one-third of an inch wide, are blue. The flower has a yellow center. The alpine forget-me-not blooms between late June and late July. Alaska is also home to the mountain forget-me-not (*Eritrichium aretioda*) and the splendid forget-me-not (*Eritrichium splendens*).

Also popular is the species *Myosotis sylvatica*, which is diminutive at less than 12 inches tall. Like *Myosotis alpestris*, *Myosotis sylvatica* has blue flowers with a yellow center. Planted from seeds, *Myosotis sylvatica* blooms in the second year. It is native to Europe and Asia and may be grown throughout the United States. It needs fertile, moist soil, though some species tolerate infertile soil. It does well in full sun and well as shade, though many species prefer shade. In the wild Myosotis sylvatica grows near streams and in wet woodlands.

May species of forget-me-not are native to New Zealand. European indigenes have spread to Asia and the Americas. One may plant forget-me-not indoors a few weeks before the last frost, transplanting them in the garden after the last frost. Alternatively, one may sow seeds directly in the garden 0.125 inch deep. Some gardeners leave little space between seeds because forget-me-not grows well when crowded. Others space seeds 4 or 5 inches apart, thinning seedlings to 10 inches distant. Forget-me-not benefits from the addition of compost to the soil. The gardener may fertilize the ornamental once or twice during the growing season. One may plant forget-me-not in large numbers for a showy effect. Forget me not is suitable as ground cover beneath tall plants and trees. Treated as an annual, forget-me-not should be removed in late summer with the intentions of sowing new specimens next spring. Treated as a perennial, forget-me-not may be mulched in autumn to permit it to overwinter.

Christopher Cumo

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Christopher Cumo, Editor

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Chestnut
Coconut
Cottonwood
Cypress
Date Palm
Ebony
Elm
Eucalyptus
Fig
Gooseberry
Guava
Hazel
Hickory
Honeysuckle
Hydrangea
Juniper
Khat
Laurel
Lilac
Locust
Mahogany
Mango

Mangrove
Maple
Mulberry
Nectarine
Oak
Orange
Peach
Pear
Pine
Plum
Pomegranate
Quince
Rattan
Redwood
Rubber
Rue
Sage
Sagebrush
Sea Buckthorn
Shea Tree
Southernwood
Spruce
Sycamore (American Sycamore)
Teak
Walnut
Willow
Wintergreen

Vegetables
Artichoke
Asparagus
Brussels Sprouts
Cabbage
Caraway
Celery
Collard
Dandelion
Endive
Fennel
Garden Angelica
Good King Henry
Kale
Kohlrabi
Lettuce
Rhubarb
Spinach
Swiss Chard
Watercress

Vines
Squash
Tomato
White Bryony

G

Garden Angelica

Garden angelica (*Angelica archangelica*), a robust umbelliferus plant, grows wild in Northern Europe, including the Faroes, Iceland, and Greenland, in littoral and mountainous habitats. Named after the archangel, *archangelos* in ancient Greek, the appellation probably reflects its reputation as a medicinal herb. The name "angelica" is used in English, *herbe d'angèlique* in French, *angelica* in Italian, *Engelwurz* in German, and *engelwortel* in Dutch. The Saami reindeer herders in northern Scandinavia have used and still harvest the wild-growing angelica in the mountains for food. Its use among the Saami is known from written sources from the mid-17th century, although it is probably an ancient practice among them. The Saami people have always used wild-growing specimens. Reindeer milk mixed with angelica and sorrel was an important dish that could also be preserved for the winter.

However, among their neighboring Norse people, angelica was cultivated in gardens as a vegetable already during the Viking. Ever since the first settlement of the Faroe Islands and Iceland in the north Atlantic, garden angelica was grown for human consumption. Garden angelica must be categorized as one of the oldest cultivated vegetables in the North. It was probably also used and introduced in the Norse settlements in Greenland. Garden angelica is still known as *kuannit* among the Greenlandic Inuits, a borrowing from Norse settlers. In the Scandinavian languages, it is known as *hvann* in Faroese, *hvönn* in Icelandic, *kvann* in Norwegian, and *kvanne* in Swedish, which all derive from the ancient Germanic *hwanno*. It is still a well-known cultivated plant in certain parts of Europe, although nowadays it is more used as a condiment for beverages and in herbal medicine rather than a vegetable.

Garden angelica is a thick and tall aromatic fragrant herb that grows only leaves during its first year. The plant is biennial, and during its second year its fluted stem can reach a height of six feet. Its leaves are composed of numerous small leaflets, divided into three principal groups. The flowers, which blossom in July and August, are small and numerous, yellowish or greenish in color. These are grouped into large, globular umbels, which bear pale yellow, oblong fruits.

Although many authors regard its importance as a source of vitamin C as the primary explanation for the popularity of the plant in the northern regions of the hemisphere, this must be disputed. In a study by Hans Debes Joensen, it is pointed out that at least the Faroese angelica is very poor in vitamin C and could therefore not have been of any importance as a prophylactic or a therapeutic remedy against scurvy.

History as a Cultivated Plant

When the Vikings began trading expeditions to southwestern Europe in the ninth century, angelica was an important commodity. The *Saga of Olafr Tryggvason* from 1190 recorded that Norse king Olafr "took a large stick of angelica in his hand and went home therewith to the lodging of Queen Tyri" and gave it as a gift to her. Wild harvested angelica is still sold in local markets in southern Greenland. Toponyms from Iceland, Norway, and the Faroes indicate the earlier significance of this plant as a wild-harvested plant.

However, angelica gardens have been known in Norse areas since the 10th century. In Iceland, there are many swathes of angelica, and special angelica gardens were known to exist in the old days. Right from the *landnam*, the time when the first settlers were taking land in the north Atlantic, angelica has been used for human consumption and is also one of the most important medicinal herbs in the history of Iceland. There are a few medieval sources dealing with herbs in Iceland; there are several mentions of angelica in the texts of those times. The ancient Icelandic law book, *Grägäs*, for instance, refers to penalties incurred for the theft of angelica, some as serious as being outlawed or fined heavily if the plant was stolen from someone else's garden. These laws imply that garden angelica was cultivated in Iceland.

Garden angelica continued to be popular as a cultivated plant and vegetable in the Faroes, Iceland, and parts of Norway until the early 20th century, sometime up to World War II. Only the stem was eaten, and it had to be harvested before it became too big and too hard. The use of angelica is described in almost every travelogue and book about the rural life of the Faroes and Iceland before World War II. "The tender shoots of this plant, particularly the Flowering stalks, when stripped of the outer skin, are eaten by the inhabitants," wrote English traveler James Wright in his diary from the Faroe Islands in 1789. Another writer, Jens Christian Svabo, a Faroese-born scientist, wrote in 1783 that the angelica plant was grown in fenced gardens close to the houses. In spring, ashes and seashells were poured on the plants so that they would grow better. The Danish physician Peter Ludvig Panum mentions in 1846 the use of garden angelica in the Faroes. He reported that more-prosperous people consumed it with cream and sugar. Served together with creamy thick sour milk, it was still being offered as a treat to visitors up until the early 20th century. Angelica was also eaten fresh, especially by children. "Most of the children chew pieces of dried saithe or stalks of angelica as they play," wrote the Scottish ethnographer and zoologist Nelson Annandale in 1905. However, one can get skin eruptions, vesicles, and small ulcers on the lips and the skin around the mouth from eating fresh angelica. Well-kept angelica gardens were a source of pride for many households. Although its use as a food is now reduced to a minimum by Faroese and Icelandic households, some magnificent angelica gardens, fenced with stones, still survive as relicts of a garden culture tracing back to the Viking era. Although wild plants have been brought from the mountains and planted in the gardens, also old cultivars obviously exist, for instance in Norway. They are usually sweeter than the plants originating from the wild.

Angelica is one of the very few medicinal plants that has spread from the north to the south. It has actually been cultivated in the United Kingdom since the days of the Tudors. It was still being grown in reasonable large quantities near London for candying in the late 19th century. Angelica plants "are grown by the London gardeners in moist situations, and along the banks of ditches," according to John Claudius Loudon's *An Encyclopaedia of Gardening* (1839). Recipes of candied angelica are given in many British 19th- and 20th-century cookbooks. Nowadays, it is widely cultivated in Central and Western Europe. Candied angelica is still imported to the United Kingdom and the United States from France for professional confectioners, especially around Christmas.

Medicinal Herb

Angelica was considered to be a kind of cure-all as well as being an important way of eking out the household larder in the west Nordic areas. All parts of the plant could be used, the seeds, leaves, stalks, and roots. It has been widely used in Saami and Scandinavian folk medicine, but it was also sought after for scholarly medicinal purposes. The 17th-century physician Nicholas Culpeper wrote in 1653 that angelica stalks "are good preservatives in time of infection; and at other times to warm and comfort a cold stomach. The root also steeped in vinegar, and a little of that vinegar taken sometimes fasting, and the root smelled unto, is good for the same purpose." Among many virtues he also mentions that the root made into powder and made up into a plaster could be laid on the bites of mad dogs, "or any other venomous creature." The root, *radix angelicae*, has been available in the pharmacies. Angelica was described as "being stomachic, cordial, alexipharmic; of great use in malignant pestilential fevers, in all contagious distempers, and the plague itself: it causes perspiration, and drives out all noxious humours through the pores of the skin," according to a British dictionary of trade from 1810. Compounds to be found in the plant are bittering agents, essential oils, flavonoids, tanning agents, resins, silica, coumarins, and terpenes.

In our time, garden angelica is cultivated on a large scale in the Harz Mountains in Germany, and also in Belgium, the Netherlands, Poland, Hungary, Switzerland, and the Marais Poitevin in France for producing herbal medicine and for various alcohol products. Minor commercial production also exists on Iceland. It is cultivated because of its root, which is harvested from the end of September until the middle of October. The world yearly production of angelica essential oil is 2,200 pounds.

Flavoring Agent, Symbolism, and Magic

Nowadays, angelica besides serving as a medicinal herb is mainly used as flavoring in additives, honey, and various beverages. Various alcoholic beverages, like vermouth, Boonekamp, Bénédictine, Chartreuse, and gin, are flavored with angelica. In Iceland nowadays, it has an economic importance in the production of the popular angelica vodka. Essential oil from angelica is used in aroma therapy.

Garden angelica was used as a fertility symbol by Old Icelandic chieftains. According to Norwegian botanist Ove Fosså, it was still being used as a fertility symbol among Norwegian peasants in Voss in the late 19th century. The front riders, including the bride, of a mounted wedding procession carried large angelica stems in their hands. It also had some reputation as an aphrodisiac.

Angelica has been used as a magic plant in the North. It was planted in graveyards to keep away septic viruses in corpses, and angelica plants can actually still be seen growing in Faroese cemeteries. The Saami made a primitive flute of the stem, and their children used the stem for making toys, for instance as smoking pipes. In Norway, the dried root was smoked or chewed by the peasants. Nowadays, it is grown in many gardens as a herb and a spice and also as an ornamental plant. Plants are available through commercial nurseries.

Ingvar Svanberg

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Garden Cress

Garden cress (*Lepidium sativum*), also known as peppergrass, is grown for its green seedlings, which are used in sandwiches, salads, and soups, and as garnish. All aboveground parts of the seedlings are eaten before the plant develops the first true leaves. Garden cress is an annual member of the Brassicaceae, the mustard family. Plants of this family produce compounds called glucosinolates, which deter herbivores and give the plants their characteristic sharp taste.

Garden cress is most likely native to Ethiopia, the Middle East, and western Asia, from where it was brought to Europe via the Mediterranean region. It is not easy to trace cress through written history records, as it appears under many names, some of which are also used for other herbs. Cress was most likely already cultivated and used as a salad green in ancient Iran, from where it reached ancient Greece and the Roman Empire. Records that likely refer to cress, mostly in the context of medicinal use, have also been left by the Muslim conquerors of southern Spain, and cress is believed to have been a common garden herb in Europe during the Middle Ages. The first illustrations of domesticated garden cress date from 16th-century Europe.

Garden cress is a plant with few requirements, although it does not tolerate frost. It can be grown on soil, wet paper towels, or other artificial substrates. Consumers often buy the seeds and grow the cress at home. Little boxes with uncut seedlings ready for consumption are also commercially available. The seedlings neither freeze nor dry well and should be consumed right after cutting. Garden cress seedlings grow very fast and can be harvested less than 10 days after sowing. This makes it an ideal plant for the first gardening experience of children, and it is therefore often used in kindergarten or school projects.

The large robust seedlings of garden cress are used in various fields of plant physiological research and as toxicity indicators. Garden cress is also used as a model system to study seed biology, as it is closely related with the most widely used model system in plant biology, *Arabidopsis thaliana* (thale cress). This close evolutionary relationship makes it possible for researchers to make use of the extensive genetic information available for thale cress, whose genome has been sequenced. The seeds of garden cress are much larger than the tiny seeds of thale cress, which makes them attractive objects for seed-related research.

Kerstin Müller

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Garlic

Among the oldest cultivated plants, garlic produces a bulb made of cloves. The cloves are swollen leaves. Garlic rarely flowers or produces viable seeds, probably because humans selected against these traits. Instead, the farmer or gardener propagates garlic by planting cloves. As a rule, the larger the clove the larger will be the forthcoming bulb. In the 18th century, Swedish naturalist Carl Linnaeus named

Garlic (Yap Kee Chan/Dreamstime.com)

garlic *Allium sativum*. *Allium* is Latin for "garlic," and *sativum* means "cultivated." Garlic derives from two Anglo Saxon words. *Gar* means "lance" and *leac* means "herb." Garlic is therefore the herb with cloves in the shape of a spear or lance. Garlic is related to onion, leek, shallot, and chive. Despite its name, elephant garlic is a leek rather than a true garlic.

Folklore and Mythology

From Romania arose the iconic use of garlic as protection against vampires. In the fictional work *Dracula*, Irish novelist Bram Stoker assigned physician Abraham Van Helsing the task of protecting vulnerable Lucy from Dracula. True to the beliefs of Romanian folklore, Lucy wore a necklace of garlic to deter Dracula. Van Helsing rubbed garlic on the windows and door of Lucy's room to prevent Dracula from entering the room. Lucy might have rested peacefully but for the interference of her mother. Revolted by the odor, she removed the garlic, ensuring Dracula's triumph. Both mother and daughter died, and Van Helsing, convinced that Dracula had made Lucy a vampire, ended her nightly search for blood by packing garlic into her mouth and cutting off her head. Dracula, repulsed by garlic, would have no more power over her. The superstitious in Romania put garlic in the mouth of a corpse suspected of being a vampire to ensure that it would not rise from the grave. Another folk belief recommended the placing of garlic in the coffin of a corpse to ensure that it would decompose and not become a vampire.

Because garlic gives off an odor akin to sulfur, some people have associated it with the fire of hell. In ancient Etruria in Italy, according to one account, people sacrificed boys to the goddess Mania. The magistrate Junius Brutus convinced the Etruscans to spare the boys, sacrificing garlic instead. Mania apparently accepted garlic and did not visit evil on Etruria. One Islamic myth holds that Satan, after having tempted Adam and Eve, left Eden on two feet. Garlic sprouted where his left foot had trod, and onion germinated in the print of his right foot. Having issued from Satan, garlic must not have been a suitable plant for humans. A Hindi myth likewise hints at an unsettling origin of garlic. According to this myth, the demon Rahu stole a vase containing the elixir of immortality. Determined to retrieve the liquid, the god Vishnu captured Rahu but not before he drank it. In anger, Vishnu cut off Rahu's head. From the liquid, perhaps a mixture of blood and the elixir of immortality, that dripped to the ground emerged a garlic plant.

The Greeks, holding a belief similar to Romanian lore, wore necklaces of garlic to fend off evil. They put garlic bulbs at the door to keep demons from entering the home. Ninth-century BCE Greek poet Homer credited garlic with saving Greek king Odysseus from goddess Circe. His shipmates had no garlic to protect them, and so Circe turned them into pigs. The Egyptians believed garlic protected one from harm. Perhaps for this reason Pharaoh Tutankhamun's tomb contained six garlic bulbs. A European folk belief held that a horse fed garlic would not have nightmares. The superstitious put necklaces of garlic around a horse's neck to deter trolls from injuring it. A necklace of garlic likewise protected cows from trolls who wished to steal their milk. The superstitious placed garlic near the opening of a snake's hole to prevent it from exiting. Some believed garlic worn around the neck protected the wearer from witches, werewolves, demons, and the evil eye. Superstitious parents hung garlic over a crib to prevent fairies from stealing their baby. According to tradition, a grandmother gave garlic to a newborn to protect him or her from evil spirits.

Origin and History

Garlic is native to southern central Asia, where it grew wild in the Tien Shan and Pamir-Alai mountains. Originating in an extreme climate, garlic tolerates hot, dry summers and frigid winters. To avoid the worst effects of hot weather, garlic, nourished by water from snowmelt, matures in late spring. Dormant during summer, garlic has thick skin to retain moisture. More than 10,000 years ago nomadic hunter-gatherers may have planted garlic. Because the bulb is light and stores well, it might have been among the provisions of these nomads. From an early date, people used garlic to flavor other foods and to preserve meat and vegetables. Garlic's antimicrobial properties made it possible to store food for long periods. Because garlic has a strong flavor, it disguised the taste of rancid meat and fish. The nomads of central Asia may have traded garlic with India, Egypt, and other parts of the Mediterranean Basin. In this way, these regions may have acquired the habit of cultivating garlic. The Egyptians valued garlic so much that 15 pounds of the plant were worth a slave. The Egyptians made clay models of garlic bulbs more than 5,000 years ago, putting them in tombs. In other instances, the Egyptians put garlic into tombs. The practice was apparently not confined to Tutankhamun. Egyptian overseers fed laborers, including those who built the pyramids, garlic to maintain their strength. Although the Egyptians used garlic as food, as medicine, and in religious rites, it never appeared on tomb paintings. One writer believes this omission was due to the fact that the Egyptians did not regard garlic as a sacred plant. The Romans, who were not fond of garlic's odor, called the Egyptians "the garlic eaters." Similarly, the Hebrews were "the stinking ones."

According to one school of thought, the Chinese began cultivating garlic during the Han dynasty. The 19th-century French botanist Alphonse de Candolle favored an earlier date. The Calendar of Hsia mentioned garlic 4,000 years ago, a reference that may point to the cultivation of the bulb. The Greek dramatist Aristophanes mentioned garlic. The Roman patricians, we have seen, disliked garlic, but soldiers and laborers ate it because it fortified one with strength, stamina, and courage. Archaeologists have found garlic in first-century CE Pompeii, evidence dated to the eruption of Mount Vesuvius of its consumption in this city.

In the 14th century, Alfonso XI, king of Castille and Leon, evidently had a low opinion of garlic because he forbade knights from eating it. In the 15th century, Queen Isabella of Spain (who sent Christopher Columbus to the United States) disliked garlic so intensely that she would not eat plants that had been grown near garlic. The British, unenthusiastic about garlic, thought it a food suitable only for Mediterranean people. Others were not so negative. By the 16th century, the consumption of garlic was so widespread, at least among commoners, that the phrase "garlic eater" referred to an ordinary person. The Finns, Icelanders, Irish, Norse, and Scots flavored butter with garlic.

In Africa, garlic protected one from mosquitoes and crocodiles. Middle Easterners regarded garlic as an aphrodisiac. A groom pinned a clove to his lapel to ensure a productive night with his new bride. The Amerindians of the Pacific Northwest believed that garlic could rid them of an unwanted lover. The person who wished to be free of his or her encumbrance put pins in a garlic bulb, placing it at the intersection of two roads. The unwanted lover who walked over the garlic lost interest in him or her.

Subspecies, Cultivars, and Cultivation

Allium sativum contains two subspecies: *Allium sativum ophioscoradon*, known as ophio garlic, and *Allium sativum sativum*, known as softneck garlic. Ophio garlic likely evolved from the wild *Allium longicuspis*. Ophio garlic produces 4 to 14 cloves per bulb. Although ophio is less widely grown than softneck, it is making converts in North America. Consumers judge ophio superior to softneck in flavor. Because of ophio's flavor, high-end restaurants use it. Ophio does not store as long as softneck and the yield is lower. German, Polish, Russian, Greek, French, and Spanish immigrants to the United States grew ophio. In Italy, ophio is known as Italian Somona, though there is nothing particularly Italian about ophio. Ophio does best at high latitudes because it requires cold winters.

Softneck garlic may have evolved from a population of ophio, perhaps with the aid of human selection. It follows that softneck has not been in cultivation as long as ophio. Softneck is known as Italian, a name that may, we have seen, cause confusion. There is nothing particularly Italian about softneck because Italians grew both ophio and softneck. Perhaps the name originated from the fact that Italians introduced softneck to the United States. In antiquity, people may have grown softneck because it stored and yielded well. Softneck is also attractive because it produces a bigger bulb than ophio, yielding 8 to 40 cloves per bulb. The flavor may be mild or hot, and cold weather intensifies it.

From the two subspecies of garlic have arisen 5 cultivars according to one authority, though another claims that there are more than 300 cultivars. Taking the smaller figure, ophio claims three varieties: Rocambole, Continental, and Asiatic. Softneck has two varieties: Artichoke and Silverskin. Rocambole is the most widely grown ophio in North America. It yields 3 to 14 cloves per bulb, though most gardeners are apt to see bulbs with 6 to 11 cloves. Adapted to cold weather, Rocambole needs a fertile soil to yield abundantly. It stores 3 to 4 months, though in exceptional cases gardeners have stored Rocambole as long as 8 months. Among ophio cultivars, consumers prefer the flavor of Rocambole. Continental yields 3 to 10 cloves per bulb, though 4 to 6 cloves appear to be the norm. It may be stored 4 to 8 months. Continental has a mild flavor that intensifies during curing. It needs a cold climate and fertile soil. Asiatic, as its name implies, appears to be grown in Asia. Artichoke and Silverskin are the two most widely grown cultivars in North America. The Mediterranean climate of central California is ideal for artichoke. Artichoke yields 12 to 24 cloves per bulb, though bulbs with 12 to 18 cloves are common. The flavor may be mild or hot depending on climate. Perhaps the most adaptable garlic variety, artichoke tolerates a range of soils and climates. Artichoke stores 6 to 9 months. Silverskin is known as Italian or Egyptian garlic, names that, we have seen, are more confusing than enlightening. Farmers grow Silverskin in the American West, France, and northern Italy. Silverskin yields as many as 40 cloves per bulb. The flavor may be mild, though some bulbs may overpower the taster. Winters should be mild, the soil rich, and the growing season long. Silverskin stores 6 to 12 months.

In cold regions, the gardener should plant garlic four to six months before the ground freezes. This interval provides enough time for roots to develop but minimizes the production of foliage, which may freeze. In spring and summer, garlic prefers warm, sunny days and cool nights. Garlic grows poorly in temperatures above 95°F. The bulb does well in a semiarid climate with rain in spring and autumn. The soil should be sandy loam with 3–4 percent organic matter. Soils with more than 5 percent organic matter yield large bulbs, but they may not store well. The western United States provides better growing conditions for garlic than the eastern United States because the West has lighter, well-drained soils, less summer rain and humidity, and more intense sunlight. The United States has a large number of small organic farms. Small farmers may produce more than half of all fresh garlic in the United States.

Health

Three cloves of garlic have just 13 calories, no fat or cholesterol, and more than 200 vitamins, amino acids, enzymes, and minerals. With vitamins A, C, and the B complex, garlic also has calcium, magnesium, potassium, zinc, iron, selenium, germanium, and sulfur. Garlic is claimed to have various health benefits, but studies have been inconclusive, according to the National Center for Complementary and Alternative Medicine ("Garlic" 2010). Garlic has been believed to reduce cholesterol amounts in people. Garlic may reduce blood pressure. Because it has antibacterial properties, garlic may protect one from lung infections. Research suggests that garlic may protect against stomach, colon, and skin cancers. Possibly effective against heart disease, garlic may retard the aggregation of platelets in blood vessels.

The Egyptian medical text the *Codex Ebers*, dating to 1550 BCE, listed 20 garlic remedies to treat several ailments, including headache and throat tumors. According to a first-century CE Indian medical text, garlic improved the function of the eyes, heart, joints, and muscles. Fourth-century BCE Greek philosopher Aristotle believed garlic was a stimulant. First-century CE Greek physician Dioscorides thought garlic useful in treating a large number of ailments. Galen, physician to Emperor Marcus Aurelius, praised garlic as a "heal all." During the plague of 1665, people wore garlic necklaces to protect them from contagion. Physicians carried garlic in their pockets in the belief that it counteracted the effect of bad air, the putative cause of plague. In 1772, according to one account, thieves in Marseilles, France, dug up the corpses of plague victims to steal their grave goods. Washing themselves in a mixture of garlic and vinegar and sprinkling the solution around their homes, they never contracted the disease. In 1858, French scientist Louis Pasteur demonstrated the antibacterial properties of garlic. During World War I, physicians put garlic to good use, applying its juice to wounds to prevent infection.

In Nepal, people use garlic oil to treat cough and pneumonia. Indians combine an extract of garlic and honey to treat bronchitis. In Oman, people crush garlic, rubbing it into the scalp to treat dandruff. They use garlic to treat colic, diarrhea, and diabetes. Boiling garlic in water, the people of Oman inhale the steam to treat tuberculosis. Pregnant women in Mexico eat garlic to ease the delivery of their child. The Chinese use garlic to treat bites, boils, the common cold, dysentery, lead poisoning, nosebleed, and whooping cough. The people of Venezuela consume garlic to slow heart palpitations; stimulate the function of the liver, kidneys, and bladder; cure hemorrhoids, headache, neuralgia, depression, hysteria, insomnia, and varicose veins; relieve constipation, rheumatism, and gout; and decrease the amount of uric acid in the body.

Christopher Cumo

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Geranium

Geranium is a beginner's plant because of its ease of cultivation and its resistance to many diseases and pests. A perennial herb, the geranium is grown as an ornamental. The geranium is in the family Geraniaceae, also known as the cranebill family. Geraniaceae has five genera. In 1753, Swedish naturalist Carl Linnaeus, who collected wild geraniums, put the plant in the genus *Geranium*. The genus has some 400 species. The Greek word *geranos*, meaning "crane," is the source of the word "geranium." The geranium, also known as the wild cranebill, has this name because its seed case, protruding out of a fertilized flower, resembles a crane's bill. The geranium also resembles the pelargonium, a related flowering plant. So confused is the relationship between the two that Linnaeus put both in the genus *Geranium*, and today many people think they are cultivating the geranium when they are really growing the pelargonium. The author of one gardening book has made this error.

Although they resemble one another, geranium and pelargonium are not the same plant. Whereas the geranium has petals and sepals of equal size and shape, the pelargonium has these structures of unequal size and shape. The geranium has 10 fertile stamens per flower whereas the pelargonium has 7 fertile stamens per flower. The geranium is unscented whereas the pelargonium is fragrant. The pelargonium is a better houseplant than the geranium. The geranium is hardy whereas the pelargonium succumbs in cold weather. In 1789, a French botanist distinguished between the two, putting pelargonium in its own genus.

Origin and Cultivation

Turkey and China are centers of geranium diversity, leading one to suppose an origin in one of these countries. The geranium is a plant of temperate Europe, North America, South Africa, New Zealand, and Asia. Few species of geranium are native to Australia and New Zealand. An adaptable plant, the geranium tolerates sandy soil as well as clay, acidic as well as alkaline soil. The flowers may be pink, white, blue, or purple. The leaves may be green, brown, burgundy, or variegated in yellow, green, red, or white. The geranium benefits from the addition of compost or manure to the soil. Additional fertilizer may be unnecessary. The geranium may be planted in spring or autumn, but if planted too late, it may rot in winter. The geranium may live 40 years. Many species need full sun, though some tolerate varying degrees of shade. The geranium does not tolerate waterlogged soil. If the plant is too wet, it may succumb to fungi. If the soil is too heavy, the gardener may add sand or gravel to improve drainage.

Pollinated by bees, the geranium flower has five petals and five sepals. At the end of the style is the stigma, which has five parts. Each stamen has an anther, which surrounds the style. As soon as a flower is fertilized, the ovary begins to grow so that the style extends out of the flower, giving it the shape of a crane's bill. Once a flower has been fertilized, the petals fall off because they are no longer needed to attract bees. The ovary has five compartments, each of which houses a seed. The sepals are often hairy.

The geranium may be found as far north as the Arctic Circle and as far south as Antarctica. In the wild, the geranium inhabits mountains with thin, stony soil, alpine meadows, marshes, and woodlands. Most germaniums can survive to 14°F. *Geranium traversii*, however, cannot tolerate temperatures below 20°F, and *Geranium incanum* cannot tolerate frost. *Geranium sanguineum* and *Geranium pratense* tolerate dry conditions. *Geranium soboliferum* prefers moist soil and full sun. *Geranium endressi*, *Geranium wallichianum*, and *Geranium palustre* tolerate shade.

Species

Geranium albanum originated in the southeastern Caucasus Mountains and Iran. It grows between 12 and 16 inches tall and tolerates full sun or partial shade. Its pink flowers have magenta veins. The gardener may propagate the species by division or from seeds. With each flower atop a long, thin stem, the plant tends to sprawl.

The hybrid *Geranium* Ann Folkard derives its last name from Oliver Folkard, the gardener who discovered it in his garden in Lincolnshire, U.K., in 1973. Ann Folkard is the progeny of a cross between *Geranium procurrens* and *Geranium psilostemen*. From *Geranium procurrens*, the hybrid derives its long stem. From *Geranium psilostemen*, it derives its color. Growing to 20 inches tall, the hybrid tolerates sun or partial shade. Flowers are magenta-red. Because it does not seed, Ann Folkard must be propagated by division. Leaves may be yellow-green. The hybrid is not as hardy as some geraniums.

Geranium asphodeloids grows to 18 inches tall. Tolerating full sun or partial shade, the species yields flowers that are white, pink, or lilac with stripes. It may be propagated by division or from seeds. The species has three subspecies. *Geranium asphodeloids* ssp. *asphodeloids* is native to Southern Europe. Its flowers are white or pink with dark veins. *Geranium asphodeloids* ssp. *crenophilum* originated in Lebanon and Syria. Its flowers are pink with dark veins. *Geranium asphodeloids* ssp. *sintenisis* originated in northern Turkey. Tolerating dry conditions, the subspecies yields light pink or dark purple flowers.

The hybrid *Geranium* × *cantabrigiense* is a cross between *Geranium macrorrhizum* and *Geranium dalmaticum*. Named in 1985, the hybrid grows 10 inches tall and does well in sun or shade. Flowers are white, pink, or purple-red. Because the hybrid does not seed, the gardener must propagate it by division of the rhizomes. The leaves and stems are shiny and hairless. The hybrid has eight cultivars. One botanist found the hybrid in southern Dalmatia in Croatia, though curiously neither parent was present.

Growing between four and six inches tall, *Geranium cinereum* needs full sun. Its flowers are white, pink, or magenta. The species may be propagated by division or from seeds. Varieties of the species include Ballerina, Carol, Laurence Flatman, and Purple Pillow. Ballerina produces few seeds. The species has a reputation of being difficult to cultivate.

Originating in the Himalayas, Tibet, or China, *Geranium domianum* grows between 12 and 16 inches tall and needs full sun. Its flowers are pink. The species may be propagated from seeds, which germinate in late spring, producing leaves the first year and leaves and flowers the second. In autumn of the second and subsequent years, the species yields abundant seeds. The plant is hardy but short lived.

Known as the Bloody Cranebill, *Geranium sanguineum* is named for the color of its flowers. Widespread in Europe and Asia, the species tolerates frost and does well in rocky soil, heat, and dry conditions. The gardener may choose among 40 cultivars.

Geranium himalayense, as the name suggests, is native to the Himalayas. Growing between 25 and 45 inches tall, the species tolerates full sun or partial shade. Its flowers are blue-violet and bloom in May, continuing until late summer. The large flowers are easy to cultivate. The species may be propagated by division of the rhizomes or from seeds. Varieties include Baby Blue, Devil's Blue, Gravetye, Irish Blue, and Plenum.

Native to Southern Europe, the Alps, or the Balkans, *Geranium macrorrhizum* grows between 10 and 18 inches tall and tolerates sun or partial shade. Its flowers are white, magenta, or purple-red and are unusual in being fragrant. The species may be propagated by division of the rhizomes or from seeds. Oil from the plant is used in perfume. The species tolerates dry conditions. The species name *macrorrhizum* means "large root" and refers to the fact that stems, when in contact with the soil, root. Varieties include Album, Bevan's Variety, Czakor, Ingwersen's Variety, Pindus, Snow Sprite, Spessart, Variegatum, Velebit, and White Ness.

The hybrid *Geranium* × *oxonianum* grows to a height of 12 to 31 inches and does well in sun or partial shade. Its flowers, blooming in June, are white, pink, or burgundy. The flowers darken as they age. The hybrid must be propagated by division, though some varieties seed. The hybrid has a large number of varieties.

Christopher Cumo

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Gerbera

Gerbera daisies are classified in the Asteraceae family. They are used in borders and beds, containers, flower arranging, and greenhouses, and indoors in sunny locations. Gerberas have been a favorite of flower lovers for centuries. The plant's simple beauty has led to the gerbera becoming one of the most popular varieties in the floral industry. In 2007, 114,583 gerbera bunches (one bunch is 1,000 stems) were shipped in the United States.

The genus *Gerbera* is known as the African daisy because the plant is native to the continent, and grows wild across the entire country. Gerbera should not be confused with the common daisy, *Bellis perennis*. The two are different species. Gerbera daisies were discovered in South Africa in 1884 and are named for two scientists who figure prominently in the plant's discovery and in the science of botany, Robert Jameson and Traugott Gerber.

In the United States, gerbera daisies are sold as florist stock, ornamental perennials, or annuals. They thrive outdoors in U.S. Department of Agriculture hardiness zones 9 through 11 but will also do well in sunny windows in colder climates. Gerbera daisies can grow as tall as 12 to 14 inches at maturity and offer medium to large flowers that range in color from white to deep burgundy. Yellow, red, and orange are the most popular choices for commercial florists, but lavender, white, and shades of peach and pink are often used in arrangements as well.

Types

There are more than 30 types of gerberas. *Gerbera Jamesonii* and *Gerbera Linnaei* are considered the "parent plants" of today's commercial hybrids. Some of the most popular and diverse include those listed in Table 1.

Cultivation

Most gerbera daisies grow on steep rocks with grass, sand, or dolomite. They are desert-type plants, and too much moisture will cause the crown to rot. Gerbera daisies thrive in temperatures between 45°F and 75°F. Soil that is too wet is always fatal to the plant. It is better to let it dry and wilt than to overwater. In their native Southern Hemisphere environments, gerbera daisies bloom during spring and summer, which is autumn and winter in the Northern Hemisphere; however, naturalized gerberas in the North follow northern seasons. Commercial cultivars have been forced into blooming year-round in both hemispheres. Gerbera daisies are propagated from seeds, which are extremely small. For outdoor landscape use, the gardener should purchase nursery stock, as it is generally healthier and hardier. If sowing for pleasure, seeds should be sown in late fall in a greenhouse or warm, dry indoor climate for spring planting. Gardeners should take care and watch for aphids, leaf miners, thrips, mildew, and whiteflies to maintain the health of their gerbera stock.

Symbolism

Depending on the source of information, "gerbera" can mean "innocence," "purity," or "cheerfulness." Since the larger varieties come in many bright colors,

Table 1 Varieties of Gerbera

Cultivar	Geography	Colors
Ambigua	Throughout South Africa	Yellow
Crocea	South African Cape Peninsula east to Montagu and Bredasdorp	Pink or white, mauve, crimson, maroon, cream, red, magenta, purple, white above, red-maroon to copper below, or pink to mauve above, darker below
Jamesonii	Eastern part of Mpumalanga and the southern part of the Limpopo Province in South Africa	Hybridization has produced hundreds of colors
Linnaei	Eastern South Africa	White or white above and purple-maroon or red to red-brown below Tomentosa has yellow rays, noted in *Gerbera Linnaei*, but not in any other type
Serrata	South Africa, along the coast around Swellendam and eastward to Humansdorp	White or white-tinged pink rays; lower part of the plant is often dark red to purple
Viridifolia	South Africa throughout the East African highland from Ethiopia and southern Sudan through Somalia, Uganda, Kenya, Malawi, Zaire, Zambia, Rhodesia, Tanzania, and Mozambique, Cameroon, Transvaal, Natal, Swaziland, Orange Free State, Lesotho, and the eastern cape as far south as Grahamstown	Cream, mauve, or purple
Wrightii	Cape Peninsula, from Table Mountain in the north and southward to Simonstown, South Africa	White

sending them is a delightful way to brighten someone's day. In addition, some people believe gerbera wards away lightning, and they keep a single plant indoors. In England, it is called bruisewort, since the crushed leaves can be used for relieving bruised or chapped skin. Each color of gerbera has a special meaning. Even different shades of pink gerbera have different meanings. Light pink gerbera represent admiration and sympathy, and they are often given as an act of friendship or as a get-well present. Dark pink daisies are often given as a token of thanks. According to an old Celtic legend, the spirits of children who died in childbirth scattered gerbera on Earth to cheer their sorrowing parents.

Deb Carlton

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Ginger

In the Zingiberaceae family, ginger (*Zingiber officinale*) is a perennial herb. The genus *Zingiber* has roughly 100 species. Ginger may derive from the Greek *zingiberis*, which in turn may derive from the Indian *zindschebil*, meaning "root," a possible reference to ginger's rhizome, though a rhizome is an underground stem rather than a root. The species name *officinale* derives from the Latin *officina*, meaning "workshop." *Officinale* came to mean any substance with medicinal properties. Ginger has a long history as a medicine. In Danish, ginger is *ingefaer*, in Dutch *Gember*, in Estonian and German *ingver*, in Finnish *ingivaars*, and in French *gingerbre*.

Origin and History

The genus *Zingiber* is indigenous to tropical Asia. According to one author, ginger may have originated in Southeast Asia. Medieval Europeans thought that ginger had originated in the Garden of Eden. According to another writer, ginger is native to the coast of India. Ginger is grown principally for its rhizome, which is used in medicine, cosmetics, and fragrant decorations and to make bread, beer, and other beverages. The people of India and China may have cultivated ginger in prehistory. Legend holds that a baker on the Island of Rhodes made the first gingerbread about 2400 BCE. The ancient Egyptians and Romans made gingerbread. About 2000 BCE, the *Atharva Veda* in India mentioned ginger as a medicine. Indians used ginger to treat indigestion, gout, and elephantitis. About 1000 BCE, *The Yellow Emperor's Classic of Internal Medicine* in China listed the uses of ginger as an herbal remedy. Indians knew ginger as "the great medicine" and "the universal cure." Ginger was a medicine in Japan. The Japanese used ginger to treat nausea in pregnant women, seasickness and more generally motion sickness, rheumatism, osteoarthritis, and indigestion. Ginger was part of the cuisines of China, Japan, India, and Southeast Asia. The Chinese added ginger to tea, though whether this was a medicinal beverage is unclear. First-century BCE Egyptian pharaoh Cleopatra gave Roman general Mark Antony a beverage of nutmeg, ginger, and mace, possibly as an aphrodisiac rather than a medicine. First-century CE Roman encyclopedist Pliny the Elder enjoyed ginger's fragrance. He noted that the Romans prized the spice.

In the seventh century, the Koran mentioned ginger. In the 10th century, the Germans traded ginger. The British knew of ginger before the 11th century. By 1000 BCE, the Arabs controlled the ginger trade. The Crusaders brought ginger from western Asia to Europe, possibly in the 12th century. Italian adventurer Marco Polo (1254–1324 CE) witnessed the cultivation of ginger in China. In the 13th and 14th centuries, pepper and ginger were the most prevalent spices in Europe. In 14th-century Europe, ginger was sufficiently valuable that one pound of it was worth one sheep. In the Middle Ages, a mixture of syrup and ginger was popular. In the Middle Ages, the British added ginger to beer. In medieval Switzerland, the area where merchants traded spices was known as "ginger alley." In the 16th century, physicians thought that ginger was effective against plague. In 1561, British adventurer John Hawkins traded 300 slaves for ginger and sugar from the island of Hispaniola (now Haiti and the Dominican Republic). The Spanish brought ginger to Jamaica, likely in the 16th century. In 1585, Jamaica began shipping the spice to Europe. Ginger was cultivated on Saint Domingo no later than 1585 and on Barbados no later than 1654. In 1597, British herbalist John Gerard remarked that "ginger is right good with meat in sauces." The British enjoyed gingerbread, a favorite of British queen Elizabeth I (1533–1603) and her court. In the 16th century, the Portuguese presided over an increase in acreage to ginger in India. In 1653, British herbalist Nicholas Culpeper described ginger, wrongly tracing its origin to the East Indies.

The Countries and Cultivation

Today, ginger is the most widely cultivated spice. The principal growers are India, China, Jamaica, Taiwan, Sierra Leone, Nigeria, Fiji, Mauritius, Indonesia, Brazil, Costa Rica, Ghana, Japan, Malaysia, Bangladesh, the Philippines, Sri Lanka, the Solomon Islands, Thailand, Trinidad and Tobago, Uganda, Hawaii, and Guatemala. In 2008, India was the largest producer with 462,000 tons. In 2005, India devoted 191,778 acres to ginger. India accounted for 30–40 percent of global production, and they exported 10–15 percent of the crop to some 50 countries. Kerala and Mayhalaya totaled 40 percent of India's production. In southern India, farmers cultivate ginger as a monsoon crop from April to December. Planted in mid-February in northern and central India, ginger is irrigated.

In 1890, the island of Fiji began cultivating ginger. Farmers produced the spice in Tamarus, Colo-Suva, Tecinua, Sawani, Waihu Nabukaluka, and Virie. Fiji devotes some 2,500 acres to ginger. In 1920 Queensland, Australia, began cultivating ginger, increasing production during World War II. Production is concentrated in Buderim, Nambour, North Arm, and Eumundi. In 1927, Nigeria began to cultivate ginger. Nigeria grows Indian cultivars. In 2008, Nigeria produced 151,800 tons of ginger. Nigeria devoted 43,000 acres to ginger in 2005. In Jamaica, farmers cultivate ginger in the South Central Parish of Manchester and The Christiana Area Land Authority and secondarily in the parishes of Clarendon, Trelawny, Saint Elizabeth, Saint James, Hanover, and Westmoreland. Jamaica grows ginger on 65,000 to 75,000 acres, though in 2005 production slipped below 1,000 tons.

In 1983, the government of Ghana promoted ginger culture. In 1990, the harvest peaked at 80,000 tons. Thereafter the yield declined. In 2005, Ghana harvested fewer than 1,000 tons. In Sierra Leone, farmers cultivate ginger along the railroad lines in Freetown, Bola, Kennama, Pendembo, Njalo, Mayambo, and East Kano. Ginger from Sierra Leone is known as "African ginger."

In East Asia, China is the leading producer of ginger followed by Thailand, Korea, and Vietnam. China has hundreds of thousands of acres given to ginger. Chinese farmers cultivate ginger in the provinces of Shandong, Guangdong, Zhejiang, Anhui, Jiangxi, and Hubei. In 2008, China yielded a few hundred thousand tons of ginger. In China's Yangtze River valley, farmers plant ginger in April or May. In Hubei province, ginger is planted in May. Taiwan grows ginger on several thousand acres, intercropping it with tea. In 2008, Thailand produced tens of thousands of tons of ginger. In 2005, Thailand devoted tens of thousands of acres to ginger. That year South Korea harvested several thousand tons. In 2008, Indonesia harvested hundreds of thousands of tons of ginger. In 2005, Indonesia devoted tens of thousands of acres to ginger. Java and Sumatra are the leading producers. In 2008, the Philippines totaled a few tens of thousands of tons of ginger. In 2005, the Philippines devoted a few tens of thousands of acres to ginger. Filipinos grow ginger in Las Banos, Laguna, Tanawan, Bantages, Silag, and Cerite. In South Asia, Sri Lanka intercrops ginger with turmeric, cacao, coffee, arecanut, coconut, or vegetables. Ginger is grown in the provinces of Yatinurwera, Harisparta, Siamboligada, and Girijama. Most Sri Lankan ginger satisfies local demand, chiefly in the form of ginger beer and ginger ale.

Ginger needs warmth and humidity. It may be grown from sea level to 4,500 feet, though the best elevation is between 900 and 2,700 feet. Farmers cultivate ginger on heavy laterite loam or clay, though the soil should drain well. The soil pH should be between 6 and 6.5. Ginger prefers partial shade. The soil should be above 59°F for ginger to germinate. Ginger matures in 135 to 150 days. The farmer may apply 30 to 48 tons of manure per acre and 660 to 990 pounds of calcium superphosphate per acre to the soil. In summer, ginger produces fragrant yellow-green flowers tinged with purple and yellow. Ginger needs 70 to 79 inches of rain per year. Pieces of rhizome are planted and harvested in the dry season. Once harvested, the rhizome is boiled and then dried in the sun for 5 or 6 days. Ginger may be stored in the refrigerator for two to three months.

Christopher Cumo

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Ginkgo Biloba

Ginkgo biloba is, like ginseng, a plant that is valued in the Asian community for its healing purposes and culinary uses and is cultivated in China, Japan, and Korea. *Ginkgo biloba* comes from the Maidenhead tree and it has no other known relatives. The *Ginkgo biloba* plant is mainly used for food and traditional medicine and has other types of uses, which have been proven to benefit human life and the treatment of diseases.

Attributes

Unlike ginseng, *Ginkgo biloba* is generally not tolerant of shade and does not thrive in dark, shady, and moist conditions. *Ginkgo biloba* is a species of tree, which has been used since early human history, and for many years it was believed that it could not be found in the wild. The *Ginkgo biloba* tree is rare, can be used for many different purposes, and exhibits a versatility and strength.

The *Ginkgo biloba* tree, often called simply the Ginkgo tree, is hardy, though genetically uniform. In addition to being strong and sturdy trees, Ginkgos are also extremely adaptable to many different conditions and can even thrive and survive in urban and metropolitan environments. Ginkgo trees grow between 66 and 115 feet. They are mainly found in deciduous forests. Although the tree was once widely distributed throughout the world, at present the number of trees has declined by 2 million and is now concentrated in a very small area of China. There is little evidence that any native species of the Ginkgo tree exists today, but there is speculation that some can still be found.

Ginkgo biloba has been commonly cultivated in North America for over 200 years. Ginkgo trees are usually deep-rooted, they are strong, and they are generally resistant to diseases and insects. Ginkgo trees are sturdy and sparsely branched; their leaves are fan shaped and sometimes bifurcate or split. Ginkgo trees also have great longevity: one has been documented to be over 2,500 years old. The Ginkgo tree is such a rare and unique cultivated plant because it is a "living fossil" and dates back 270 million years ago. The ancestral group that the Ginkgo tree belongs to is the Pterosperma or "seed ferns." Fossils of *Ginkgo biloba* were found in the Jurassic and Early Cretaceous periods.

Ginkgos are dioecious or "separate sexed." However, instances of monoecious (single-sexed) trees do occur occasionally. Ginkgos produce pollen cones with sporophylls. Female trees occur at a ratio of 1:1, and the ovules on the female plants are produced in short shoots and secrete fluid to capture airborne pollen, which is predominantly how Ginkgos reproduce. Wind pollination of the Ginkgo plant takes place between early April and late May.

The outer layer of *Ginkgo biloba* is called the *sarcotesta*. It is fruit-like and attractive in appearance, being yellow and brown. However, it contains a very strong type of acid, which is known as butyric acid. Although the outer coating of the plant is visually appealing, the acid is extremely unappealing and smells and tastes like rancid butter.

Uses

There are many uses for *Ginkgo biloba*, and it has a rather prominent part in the history and application of Buddhism and Confucianism. The Ginkgo leaf is also the symbolic leaf of the Japanese tea ceremony. *Ginkgo biloba* can be used in place of Bonsai trees, which are widespread in Asian culture. Although *Ginkgo biloba* grows tall, it can be pruned to be kept small and put on display for decorative purposes. *Ginkgo biloba* is also widely used for culinary purposes and in certain foods and delicacies, especially in dishes served during the Chinese New Year.

Ginkgo biloba contains active ingredients that enhance memory but can also be used to improve concentration and acuity. Although clinical trials have shown evidence that *Ginkgo biloba* has been a functional part of memory enhancement, there has been some degree of controversy as to whether the components of Ginkgo actually are effective in memory enhancement or that the plant is even effective in treating Alzheimer's disease or dementia. A study by the National Institute of Aging, published in the *Journal of the American Medical Association* in 2002, stated that the Ginkgo plant provided "no measurable benefit in memory or cognitive related cognitive function to adults" (Solomon 2002).

Despite the controversy about whether the *Ginkgo biloba* is effective, some other studies have shown that the root really does improve memory and attention span in certain groups of adults. A rival study conducted by Liberty University countered the *JAMA* study, making the claim that there was ample evidence that *Ginkgo biloba* enhanced some nueropsychological aspects of the brain and that the plant actually does help improve memory. It has been proven that *Ginkgo biloba* can be used as an antioxidant and can benefit the renal, cardiovascular, and central nervous systems. Certain ingredients in Ginkgo are also platelet-activating substances, and the plant can be used to treat frequent and sharp muscle pain in the calves. It has been used in clinical trials for the treatment of dementia. The Ginkgo plant contains certain chemical compounds (flavonoid glucosides).

Ginkgo biloba can also be taken as a vitamin supplement because it contains both flavonoids and terpenoids, some B vitamins, vitamin C, and other water-soluble vitamins and amino acids. The recommended dose is up to 40 to 200 milligrams a day. Although there is controversy regarding how effective *Ginkgo biloba* is, many believe it to be a useful and natural remedy.

Bonnie Ellman

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Ginseng

In the Araliacaeae family and *Panax* genus, ginseng is a Chinese herb that is used for medicinal purposes and is one of the most sought-after herbs on the market; it is also one of the most costly. Ginseng is an integral part of the practice of Eastern medicine; however, its use is not so prevalent in postindustrialist Western society. The general public is often ignorant about how multifaceted ginseng is and also its wide range of applications, including facets of botany, mythology, and even Taoist philosophy. Ginseng is, in fact, a very important plant.

Attributes

The ginseng plant is a fleshy rooted herb and a perennial plant, most commonly used as an aphrodisiac, that is present in cool, shaded forests and thrives in dark and moist areas. The ginseng plant is a highly valued commodity in Asian communities, and it has been used for centuries for healing purposes. According to Stephen Fulder, an Oxford University-trained doctor of pharmacology and an expert on ginseng, the plant is described as "one that is held in awe by so many people, it is so loved, worshiped and cherished in all the countries of the East" (Fulder 1993, 13). Ginseng is obviously an extremely important plant in Asian society and is a highly valued commodity in Eastern medicine.

The ginseng plant has a rich and extensive history. In mythology, ginseng was called a "Magical Herb" or "Wonder of the World." Ginseng is also referred to as a "spirit vessel," because of the kindly nature spirit that is associated with the plant (Fulder 1993, 13). In 1842, ginseng was renamed *Panax ginseng* by a German botanist, Nees von Esenbeck. *Panax* comes from the Greek word *Panaxos*, which means "healing." It is from the word "panacea," which is literally translated into "cure-all."

Although ginseng is sometimes cultivated outside its natural environment, the Chinese really value only the ginseng that is found in its natural surroundings. Nowadays, it is almost impossible to find instances of wild ginseng in modern society. There are two main types of ginseng: American and Oriental. Oriental ginseng can be found in Korea and China and consists of Red Panax and White Ginseng. American ginseng is native to eastern North America, from Ontario to Wisconsin.

Although ginseng is a slow-growing plant, it is still extremely useful for so many different types of ailments and is also nutritious. Ginseng is a deciduous perennial, and its leafy material dies every autumn. The regrowth of the plant curiously stems from a bud situated at the peak of the root. Ginseng has a fleshy root, which is thick and yellow, has a taste that is slightly bitter, and has an aromatic sweetness. The foliage of the ginseng plant is plain as compared to the fleshy-colored root and is topped by an array of serrated leaves. The soil is a fresh loam, and it flourishes under a cool thatch, although the pale green flowers of ginseng will not appear until the plant reaches three or four feet.

After it ripens in the fall, it produces red berries that contain two or three seeds each. The berries are edible and are ginseng's only form of reproduction. As the ginseng plant gets older, more stems and leaves appear, and there is more foliage with the aging of the plant. Ginseng cannot be expected to mature overnight or have a speedy growth period, so any person who wants to harvest this precious plant should remember that it does take a bit of time to ripen and to be able to reap the benefits of this herb. Ginseng is most prevalent in the summer months. It can be cultivated using fertilizer and pesticides and survives up to five years in cultivation. If one wants to purchase ginseng, one must keep in mind that the plant itself is rather expensive and can be $200 to $500 per pound.

American ginseng grows best in zone 7, though it may be cultivated in zones 2 through 8. Seeds can be planted individually throughout the woods. It is best to cultivate ginseng in its natural environment so it can thrive successfully in the conditions that it is adapted to.

Uses

Ginseng is a versatile plant with many beneficial uses. It also has many scientific applications and is a remedy for so many different types of diseases, ailments, and afflictions that its effectiveness has even been studied at medical institutions. It is of no surprise that it is written about in scientific texts so extensively. Ginseng root has been used by some to treat impotence, neurosis, headache, fatigue, and arthritis. Ginseng may stimulate arousal and speed metabolism. A study was conducted at the University of Korea in Seoul on test animals who were under a great deal of mental and physical stress due to surgery. It was found that ginseng may have made them calmer and more at ease.When these test animals were given ginseng, their white blood cells seemed to regenerate faster than if they had not been administered the ginseng root. There have not been enough studies to prove that ginseng enhances the health of human cells, but the National Center for Complementary and Alternative Medicine is supporting research to study Asian ginseng's effects on cells (Harvard Medical School Special Report 2010). There are also reports that ginseng may be useful in treating cancer, and many believe it displays the benefits of Eastern medicine.

Bonnie Ellman

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Gladiola

Gladiola belongs to the Iris family, Iridaceae, and is native to South Africa, Europe, and Asia but is also found growing at altitudes up to 8,000 feet in South America and in North America in California, Florida, Illinois, and Virginia. The botanical name "gladiola" means "little sword" and is derived from the Latin *gladius*, meaning "sword," possibly because gladiola leaves, which are basal and feature a fan arrangement, tend to be sword shaped. Common names for gladiola include the sword lily and the corn flag, and as a result of the gladiola's association with weaponry, the flower came to symbolize strength of character in the language of flowers.

History

The history of gladiola is long and international, for it is believed that gladiolas were spread across the globe by the ancient Greeks who exported the plants from

South Africa. Europe in the 19th century saw a flurry of activity in terms of gladiola production, for in 1806 interspecific hybrids were produced for the first time, and in 1823 the first commercially available hybrids were created, both in the United Kingdom. Then in 1837, Gandavensis Hybrids were created in Belgium, which led to the development of the modern gladiola. In 1852, the first gladiola hybrids to become popular in the United States were created in France, and other hybrids were developed in Germany in 1877. Later, in 1902, *Gladiolus primulinus* was discovered near Victoria Falls, and these gladiolas were used to create light-colored, large-flowered hybrids. Ever since, new hybrids have continued to be created in Europe, the United States, and India.

Cultivation

There are two types of gladiola available for cultivation, the large-flowered kind and the butterfly and miniature kind, which do not grow as tall as the large-flowered type. Both types of gladiola have early- to late-flowering cultivars, which are much in demand for flower arrangements as the blooms make long-lasting cut flowers and are available in nearly all colors from white to near-black, including pinks, reds, yellows, greens, and lilacs. Some gladiola, such as *Gladiolus callianthus* and *Gladiolus tristis*, are bicolored and fragrant. The cutting of gladiola flowers for arrangements should occur as soon as the lowest flower takes on color, with the spike severed close to the ground in order to preserve the foliage. Gladiola is equally popular with gardeners as it is easy to grow and adds structure and height (up to five feet) to herbaceous beds and borders and also grows well in pots.

Gladiola usually grows from corms, although a few species develop from rhizomes, and go on to produce spikes on which are attached funnel-shaped blooms of six petal-like tepals, which grow either on one side of the spike or in two parallel rows, with the flowers opening in order from the bottom of the spike to the top. Each individual flower comprises one large upper tepal, two winged side tepals, and three small lower tepals, which form a lip. The number of flowers per spike varies depending on the gladiola. For example, the short-growing *Gladiola carneus* produces 3 to 12 flowers, while *Gladiolus communis* and *Gladiolus tristis* have up to 20 blooms per spike and *Gladiolus* × *hortulanus*, the common gladiolus, produces up to 28 flowers per stem.

Gladiolas prefer a site sheltered from strong winds, which could break the plants' stems. Gladiolas thrive in full sun with light soil that is evenly moist and rich in organic matter, though too much organic matter added to the soil will make the gladiola flower spikes grow too tall and spindly to thrive. The corm should be planted in spring, although corms of hardy gladiola, such as *Gladiolus communis*, may also be planted in the fall. Planting corms at three-week intervals will prolong the flowering season. The deep planting of corms reduces the need for the staking of gladiola for support, but the depth at which corms should be planted depends on the size of the corm, with corm size ranging from one-half of an inch to over one inch in diameter. The smallest corms should be planted three inches deep, while the largest should be planted up to eight inches underground. The planting distance between corms also varies depending on the size of the corm, with a distance of six inches being the maximum. Where gladiolas are not planted deeply, the corms may be planted among tall plants, which will offer the gladiola flower spikes support as they grow.

Once a corm has flowered, it should be discarded as it will not produce again. Therefore once the leaves of the gladiola have turned yellow after flowering, the plants should be lifted and any newly developed corms and small cormels should be separated from the old, with the new corms and cormels treated with fungicide and overwintered in a cool, dry place. Gladiola, such as *Gladiolus communis*, spreads via cormlets. Propagation can also be by seed, although plants will not come true to type, and new hybrids may be developed through sexual propagation.

Mythology

Gladiola makes several appearances in classical mythology. In one myth, a gladiola was said to sprout from the corpse of Hyacinthus after he was killed by a discus thrown by Apollo, while another myth tells that Ceres, the Roman goddess of cereals and the harvest, kept a sacred grove, from which an irreligious man repeatedly stole firewood. One day the man beheaded one of Ceres's worshippers and from the disciple's blood sprouted gladiola. Then, when the murderous man became poor, he tried to sell his daughter, who escaped her father by running into the grove whereupon Ceres transformed the girl into a gladiola.

Victoria Williams

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Good King Henry

For the most part, Good King Henry, a robust perennial herb, grows either as a weed or as a relic of cultivation. It is found over large parts of Europe and eastern

North America. It spread originally as a cultivated plant and served in many areas as food and medicine. Southern Europeans used it as animal feed. Today, however, it is among the forgotten cultivated plants of Europe. The reduction in its cultivation as a foodstuff over the last few centuries probably reflects the introduction of spinach. Only in a few places do its former uses as a pot herb persist.

The stalks are upright, and can grow to be more than 20 inches tall. They are furnished with long wavy-edged leaves of a broadly triangular to diamond shape. The leaves are somewhat mealy at first. Good King Henry blooms in June and July. Its small green flowers grow in erect pyramidal leafless spikes, each of which is equipped with five sepals, five stamens, and two to three stigmas. The flower stalks are often somewhat drooping. The species is propagated by seed.

History and Origin

The history of this species, like that of many old cultivated plants, is lost in the mists of time. It likely originated in the mountains of Central and Southern Europe. Since human beings started using it at an early date, their activities have long assisted its spread. It appears to have arrived in Europe during the Iron Age. The details, however, are not known, and the literature of antiquity does not mention the herb. Nowadays, the plant grows wild over large parts of Europe and western Asia, as well as in some parts of North America. This reflects the geographical expanse over which it was once cultivated as a utility plant. Archaeological finds indicate its presence in southern Sweden as early as the 12th century. In addition, several herbals from the late Middle Ages and early modern era attest to its use in Northern Europe.

The common English name for the plant—Good King Henry—is a rendering of the German *Guter Heinrich*. It has also been known in German-speaking areas as *Stoltzer Heinrich*. Both designations are found in German botanist Hieronymus Bock's *New Kreuterbuch* (1530), and in physician Eucharius Rösslin's *Kreuterbuch* (1533). Earlier names were *gut heyris*, in a medicinal handbook by German surgeon Heinrich von Pfolspeundt (1460), and *guet hainrich*, in Bavarian friar Vitus Auslassen's *Herbarius* (1497). Similar renderings are found in a number of European languages: for example, *brave Hendrik* in Dutch, *bon-Henri* in French, *buono Enrico* in Italian, *mar' dobrogo Genricha* in Russian, and *Hyvänheikinsavikka* in Finnish. The Latin name for the species is *bonus-henricus*. The English expression gained currency through British herbalist John Gerard's *Herbal*, from 1597. In Cambridgeshire, the local version of the name was Good King Harry.

Several explanations have been advanced for the reference to Good Henry. One interpretation is that the name reflects the former belief that ingestion of the herb promotes health. The positive connotations of the term would then reflect, presumably, the great popularity enjoyed—at least according to idealized historical accounts—by Henry IV of France among his subjects. Another theory is that the name originated with a little supernatural being, known in German as Heinrich or Heinz, who had the feet of a goose. Indeed, many observers have noted the resemblance of the plant's leaves to the feet of a goose. The Latin name for the herb, in fact, means precisely "goose foot." Local British names include Fat Hen (Berkshire, Kent, Surrey, Cheshire), Johnny O'Neale (Shropshire), Shoemaker's Heels (Shropshire), Mercury (Lincolnshire, Yorkshire, Cumberland), Smear Docken (Scotland), and others.

Good King Henry was grown widely in Europe during the Middle Ages and early modern era. In the 17th and 18th centuries, for example, peasants over large parts of the continent cultivated it. Sources from the period state that it was used as a foodstuff and a medicinal herb. European emigrants also brought it with them to North America. As early as in the 1700s, however, cultivators in many places ceased to grow it. The plant can survive to an advanced age, and so may long remain in the same place. It can spread into its vicinity, but its capacity in that regard is rather limited. It is most often to be found, therefore, close to where it once had been cultivated. Joseph Niessen, a German ethnobotanist, wrote in 1936 that Good King Henry had been cultivated in the past as a vegetable, but that it was no longer to be found in rustic gardens. As a relic of cultivation, however, it still forms part of the landscape. It grows in the vicinity of villages, testifying to the function it once filled as a cultivated plant. At least in the United Kingdom, moreover, it has survived as a cultivated plant up to our own day. In Canada too, it grows in home gardens still.

Medicinal Herb

Our knowledge of the medicinal uses to which Good King Henry was put comes from herbals. Many references thereto are contained, for example, in the German-language literature on herbs and medicines from the early modern era. Among other things, these sources call attention to the role of Good King Henry in the making of balms and salves. Physicians of the 17th century were well acquainted with the plant. Many pharmacopeias from the 18th century and later also mentioned it. A medical work from 1840 states that, mixed with unsalted butter and made into a salve, the herb is suitable for cleansing old ulcers.

Within scholarly medicine, Good King Henry fell out of favor in time. Within traditional medicine, on the other hand, it lived on. Its leaves were used to treat sores, for example. In southern Sweden, it was applied to panaritium (purulent inflammation near the fingernails). In England, practitioners of traditional medicine prescribed it for skin problems, bladder trouble, and scurvy. It was also used for treating swollen legs and feet. An ointment made from the leaves was smeared on chronic sores. Italians applied it topically on skin inflammations caused by stinging nettle.

Scandinavians used the root against livestock diseases, especially diarrhea among cattle, certain diseases among swine, and coughs and lung afflictions among sheep (hence its Swedish name: *lungrot*, meaning "lung root"). The plant has also been used as an ethnoveterinary remedy in Southern Europe.

Food

Good King Henry is rich in vitamin A, iron, and calcium, and recent studies have stressed its high protein content and nutritional value. Its reputation as a vegetable, furthermore, has long been a good one. In fact, one of the Latin names by which it went before Linnaeus classified it was *spinachia sylvatica* (forest spinach). Europeans of many nations grew it as a vegetable. The leaves were used in soups or stews, roughly in the same manner as spinach. Names like *spinacio di monte* ("mountain spinach") in Tuscany, *spinass d'montagna* in Piedmont, and *spinaz salvadech* in Lombardy testify to its use as a vegetable among Italian peasants (something also confirmed by ethnobotanical studies from Bresciano and Lucca). In Piedmont, in fact, many of the inhabitants still eat the fresh young leaves in soups and in omelettes. Spaniards continue to use it as a vegetable in soups, salads, and casseroles. Its Catalan name is *spinachia de montagna*. It is known in Turkey as *yabani ispanak* ("wild spinach"), indicating its use as a foodstuff in that country too.

In 1660, British naturalist John Ray wrote that if a "tender sprout of this plant is put into boiling water, and cooked for a quarter of an hour, and eaten with butter and salt, [it] is a pleasant and health giving dish not unlike ordinary asparagus." People in many parts of England grew it as a vegetable. In Lincolnshire, in fact, it has been cultivated as a vegetable up to our own day. It is known there as mercury or Lincolnshire spinach, or sometimes "poor man's asparagus." According to a newspaper report from 2008, Good King Henry was still often grown in rural communities in that county, in particular among older people, many of whom keep a patch of it in their gardens. It has also drawn attention in the Slow Food movement, as a local Lincolnshire specialty. The nutritious green shoots are picked between mid-April and June. They are cooked for a few minutes and served with butter. The green leaves are harvested in August, and used in soup or served as a vegetable. Canadians too have cultivated the plant up to our own day as a vegetable. Elsewhere there is a growing (if still small) interest in using it once again as a pot herb and vegetable. Seeds can be procured from small nurseries in Europe and North America.

Ingvar Svanberg

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Gooseberry

The gooseberry is a member of the genus *Ribes*. There are two commonly cultivated species of gooseberry, known as European gooseberry (*Ribes grossularia*) and American gooseberry (*Ribes hirtellum*). Related species include the currant, black currant, and buffalo currant. The European gooseberry is considered the pure species. However, while most American gooseberries cultivated today are genetically linked to European gooseberry species, the American gooseberry is a distinct and separate species.

The Gooseberry in the Old World

Gooseberries are native to North Africa and the Caucasus Mountains. Wild, native varieties can be found throughout the temperate regions of Asia, Europe, and North America. They are widely cultivated across the colder, drier regions of Western Europe and are ubiquitous in many parts of France, Germany, and Great Britain. In Scandinavia, gooseberries can be found thriving far north as the Arctic Circle. They thrive in climates that are humid and cool in summer and cold in winter. The gooseberry is a hardy deciduous bush that grows well in many soil types, and its fruit has long been cultivated as a food. It is commonly used in desserts, such as Gooseberry Fool, in which the fruits are stewed and mixed with cream.

Pre-Christian Europeans believed that fairies sought sanctuary in thorny gooseberry bushes when threatened, leading to the early English moniker "fayberry" or "feaberry." By the time of Henry VIII, the gooseberry had earned its place among England's most common garden fruits. Gooseberry cultivation in Western Europe was already under way by the mid-1500s, with Dutch gardeners breeding hybrid varieties.

Initially, gooseberry juice was a prized treatment for fevers and was sometimes used to treat those stricken by the plague. Toward the end of the 18th century, British cottage gardeners began cultivating the plant in large numbers, with an eye toward breeding hybrids that produced larger fruits. At least a dozen common varieties existed at this time; some, such as the blue gooseberry, no longer exist.

The Gooseberry in the New World and Its Current Status

The American gooseberry is indigenous to the northeastern and north-central parts of the United States, southeastern and south-central Canada, and the Mountain

Allegheny range of the Appalachians. Early European settlers brought the European gooseberry to North America in the 1700s, where it was cultivated and widely sold for culinary use. The New World climate, however, overwhelmed many European and English hybrids with its hot summers. Nevertheless, the gooseberry remained widely cultivated in the New World's cooler northern climates for some time; by the 1920s, over 2,700 acres in the state of New York alone were dedicated to the cultivation of gooseberries.

Gooseberries, as well as many species of currants, are host to the fungal disease white pine blister rust (*Cronartium ribicola*). For this reason, cultivation of gooseberries and currants was outlawed in the United States in the early 20th century. The federal ban was lifted in 1966. Some states still prohibit, or restrict, the cultivation of gooseberries. In spite of their history of restricted cultivation, gooseberries are regaining their popularity as a common garden fruit in the United States, and they remain as popular as ever in Great Britain. Today, commercial cultivation of gooseberries occurs mostly in the cool, northern climates of North America and Great Britain.

Marjorie McAtee

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Gourd

Most of its members being vines, the gourd is in the Bignoniaceae and Cucurbitaceae families, the latter having more than 100 genera and roughly 1,000 species, most indigenous to the tropics and subtropics. The vine of a typical gourd has tendrils and sports an alternate arrangement of leaves. A single plant produces male and female flowers, though occasionally it yields only one or the other. Gourd plants bear more male than female flowers. A male flower has five petals, five sepals, and no more than five stamens, though fewer may be found. The fruit, which is called a gourd, is a type of berry known as a pepo. The word "gourd" has had variants over time. In English, "gourdys" prevailed in 1303 and "gourdis" in 1382. About 1440, a Latin-English dictionary used the term "gourde" to mean several types of plant. In the 15th century, the term "gourd" or its equivalent cannot have been used to mean pumpkin or squash because these New World plants had not yet reached Europe. In 1597, British herbalist John Gerard described one type of gourd, the bottle gourd. More often used as a utensil than as food, a gourd nonetheless has nutritional value. With little saturated fat or cholesterol, a gourd has fiber, vitamin C, riboflavin, thiamine, zinc, iron, magnesium, and manganese. The gourd is related to pumpkin and squash.

Mythology and Folklore

The book of Jonah mentioned the gourd, though not all authorities believe the reference was to a true gourd. Other references in the Bible are also open to doubt. According to a Hawaiian myth, an aristocratic woman died before giving birth to a child. Mourners sealed her body in a cave. From her navel germinated a gourd vine, which forced its way out of the cave and grew until it reached the chief's house, where it bore fruit. Inside the gourd were two seeds, which, when planted, germinated into twin girls whose descendants populated that region of Hawaii.

In the folklore of Southeast Asia, the creator spirit gave two gourds to the first two beings. The two ate the gourds, planting the seeds near a rock. From one seed grew a plant that yielded a gourd that held the first humans. From the other seed came the various animals that inhabit Earth. In the meantime the two original beings, having eaten the first gourds, felt aroused to passion. Their sex impregnated the female, who gave birth to a daughter. The parents would marry her only to a man strong enough to split the gourds containing humans and animals. When a suitable man appeared, he split the gourds, out of which came the humans and animals that populated the world.

According to a myth of southern India, a woman gave birth to a gourd. She and her husband were ashamed of this event and told their neighbors that she had given birth to a stillborn child. The parents wrapped the gourd in funereal garb to disguise it. They intended to cremate the gourd, but when the flames reached it, the gourd opened to reveal a baby boy, giving the parents the child they had longed to have.

A creation myth of the Nuer of Africa held that at the beginning of time a large gourd fell from heaven to Earth. From it emerged a man with a spear and animal skins. He was the ancestor of the first Nuer. In a variant of this story, a being known as Yul found a gourd that had fallen from heaven. Yul told his people to take the gourd, but being afraid they fled. Left alone with the gourd, Yul split it open. In the gourd, he found a man and seeds. Yul took the man to his village.

There the man had children with a woman. These children were the ancestors of all Nuers.

Attributes and Geography

Known as the calabash tree, the tree gourd (*Crescentia cujete*) is unique among gourds in lacking vines. Native to the tropical Americas, the gourds produced by this tree are used as containers, musical instruments, and ornamental plants. As tall as 40 feet, the tree gourd yields attractive yellow or pale green flowers with purple streaks. Bats pollinate them. The tree gourd prefers a hot, arid climate but will grow in wet environs. The tree is found in Mexico, the Caribbean, Central America, and South America as far south as Brazil and Peru. Humans likely dispersed the tree in their travels during prehistory. In modernity, humans extended the tree's range to South Florida. Italian-Spanish explorer Christopher Columbus was probably the first European to observe the tree gourd. The people of the Bahamas used the gourds to hold water and the wood to make chairs. The Amerindians drank cocoa from cups made from the gourds. They believed that the pulp of a tree gourd could cure the common cold, asthma, diabetes, and fever.

The loofah gourd comprises two species: *Luffa aegyptiaca*, known as the common loofah, and *Luffa acutangula*, known as the ridged loofah. The common loofah bears large yellow flowers that open in the morning. From the female flowers grow large gourds with black seeds. The ridged loofah has small pale yellow flowers that open in the evening. The fruit is small and harbors black seeds. The principal use of the loofah gourd is as a sponge. The loofah gourd also serves as a potholder, mats for table and door, sandals, and stuffing for mattresses. In the 1890s Japan began to grow loofah gourds, exporting them to the United States before World War II. The people of Southeast Asia eat immature loofah gourds and use an extract from the vine to treat respiratory ailments. The Japanese use the extract to soften skin.

The fruit of the snake gourd (*Trichosanthas cucumerina*) resembles the cucumber and when introduced into Europe caused confusion. The people of India and Southeast Asia eat immature fruit of the snake gourd. If picked late, the fruit is bitter and fibrous. Snake gourd flowers are fragrant, and this odor may attract insect pollinators. The flowers open late at night and close at dawn and so insects active during night must pollinate them.

The wax gourd (*Benincasa hispida*) is indigenous to tropical Asia. The people of India and China cultivate it for food. It may be eaten raw but is usually cooked. It is sometimes coated with sugar or syrup. The Chinese eat the wax gourd in soup. Today, Peru and Cuba grow the wax gourd. The vine was introduced into the United States in 1884 but is not widely grown here, probably because Americans prefer pumpkin and squash. The wax gourd needs a long, warm growing season. An extract from the plant has been used to treat nervous disorders. Indians eat the seeds to expel tapeworms.

Known as the balsam pear, the bitter gourd (*Momordica charantia*) is native to the tropics of Africa and Asia. Today, it is also grown in the Americas, where it is food, medicine, and an ornamental plant. The bitter gourd is also known as the leprosy gourd because of its use in treating the disease. Flowers are yellow and fruit is green when immature and orange or red when mature. When mature it splits open to reveal the seeds. The fruit attracts birds, which disperse the seeds. Slaves introduced the bitter gourd to the Americas. In the United States, it has escaped cultivation and invaded orange groves. Indians eat the fruit. In traditional medicine, various parts of the plant have been used to treat colitis, dysentery, wounds, burns, itching, gout, rheumatism, ailments of the liver and spleen, boils, irregular menses, catarrh, and cough. The people of Mexico and Guatemala make tea from the leaves of bitter gourd, drinking it as an aphrodisiac. Women in the Caribbean use this tea as birth control. Men drink it to aid digestion. Curiously, given these uses, bitter gourd is toxic.

The best-known gourd, the bottle gourd (*Lagenaria siceraris*), may be indigenous to Africa, though it diffused to Asia and the Americas in prehistory, apparently without human aid. The bottle gourd owes its name to its use as a container for holding water and other substances. The flowers of a bottle gourd plant are white, opening at dusk and closing at dawn. Honeybees and bumblebees visit male flowers for nectar but ignore female flowers and so cannot be the pollinators. Beetles, moths, and hummingbirds also visit the flowers, beetles being the most likely pollinators. Among the most ancient cultigens, the bottle gourd has a long history of cultivation in the Old and New Worlds. Despite the thesis of an African origin, the oldest remains of the plant date between 15,000 and 13,000 years ago in Peru. In Mexico the date, between 9,000 and 7,000 years ago, is more recent but still ancient. The oldest remains of the bottle gourd in the Old World come from Thailand rather than Africa and date between 12,000 and 8,000 years ago.

Christopher Cumo

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Grapefruit

A fruit tree, the grapefruit is grown in the tropics and subtropics. Although the grapefruit thrives in warm weather, some varieties tolerate light frost. A cold winter will kill grapefruit trees, and frigid weather has periodically diminished the harvest in the subtropics. Also known as the forbidden fruit, the connection between the grapefruit and the biblical fruit is unclear. Because the grapefruit is native to the New World, it cannot have been known in the lands of the Bible. The grapefruit is also known as the smaller shaddock because of its relation to the shaddock, a citrus fruit called the pomelo. Spaniards call the grapefruit *toronja*. Scientists know the grapefruit as *Citrus* × *paradisi*. The name indicates that the grapefruit is a hybrid. The name grapefruit, an appellation that originated in Jamaica in 1814, derives from the tree's habit of bearing fruit in clusters akin to the grape. The tree stands about 20 feet tall, though some varieties grow to 50 feet. The flesh of grapefruit may be white, pink, or red. Pink and red varieties have more vitamins than white cultivars.

Origin and Diffusion

In 1683 Captain Shaddock, an officer in the British East India Company, gave seeds from the Malaysian grapefruit, which is the pomelo not the true grapefruit, to William Jones, a planter from Mandeville, Jamaica. Apparently because of Shaddock's efforts to obtain seeds of the pomelo, it became known as the

Grapefruits (iStockPhoto)

shaddock. The pomelo spread to other Caribbean islands, and in 1707 British traveler Hans Sloane remarked that pomelos from Barbados tasted better than those from Jamaica. Others thought the pomelo bitter. Sometime in the 18th century, the pomelo hybridized with the sweet orange, evidently without human intervention, to yield the grapefruit. According to another account, Shaddock hybridized the pomelo and sweet orange, though many scientists doubt this story. This hybridization, however it occurred, probably happened in Barbados, where British cleric Griffith Hughes was in 1750 the first to describe the new fruit. It was Hughes who coined the name "forbidden fruit." The grapefruit spread throughout the Caribbean in the 18th and 19th centuries.

According to one account Odette Felipe, a Spanish aristocrat, introduced the grapefruit into Florida in 1809. Another account credits Felipe but dates the event to 1823. He had gotten grapefruit seeds from Jamaica or Cuba. The grapefruit was not an immediate success. There was little market for the fruit in the early 19th century. Some Floridians grew the grapefruit as an ornamental. Others raised it as a curiosity, taking little interest in the fruit, which they allowed to fall from the trees and rot on the ground. Because of its resemblance to the pomelo, even scientists were slow to recognize the grapefruit's uniqueness. In 1814, scientist John Lunan thought the grapefruit was a variant of the pomelo rather than a separate species. Only in 1837 did botanist James MacFayden distinguish the grapefruit from the pomelo, naming the former *Citrus paradisi*. MacFayden thought that the grapefruit was a mutation of the pomelo. In the 1940s, taxonomists discarded this view, recognizing the hybrid origin of the grapefruit. Accordingly, they renamed it *Citrus* × *paradisi*.

Attitudes toward the grapefruit began to change after the Civil War, when Americans came to appreciate its tart flavor. As Americans industrialized, urbanites with disposable incomes were willing to pay for fresh fruit. The railroad made it possible for citrus growers to supply northern markets. In 1870, farmer John MacDonald established what might have been the first commercial grapefruit grove in Orange County, Florida. Demand grew so quickly that Florida was not initially able to satisfy it. As late as 1874, New York City turned to the Caribbean for grapefruit, importing tens of thousands of fruit. By 1880, Florida grapefruit had captured a sizeable portion of the market for fresh grapefruit in New York City and Philadelphia. Profits were not lavish in the early days. In the 19th century, Florida growers netted 50 cents per barrel of grapefruit.

From Florida grapefruit spread in 1898 to Puerto Rico, where it flourished under U.S. occupation. By 1910, farmers were growing grapefruit in the Rio Grande Valley of Texas and in California and Arizona. During the 20th century, the taste for grapefruit expanded beyond fresh produce. In 1940, the United States exported millions of cases of grapefruit juice and hundreds of thousands of cans of grapefruit. By the 1940s, cultivation had spread to South America and Israel.

During the 20th century, the United States emerged as the world's largest producer and exporter of fresh and processed grapefruit. In 1967 and 1968, the United States produced the majority of the world's crop despite a decline in production in Texas because a hard winter had killed a portion of the harvest. So fast did demand rise that between 1967 and 1970 Israel was able to increase production fourfold. In the 1960s and 1970s, Mexico planted grapefruit trees to compensate for its oversupply of oranges. In 1980, Florida exported millions of boxes of grapefruit, making the fruit the state's leading export crop. Canada, Europe, and Japan imported grapefruit and grapefruit juice from the United States. In addition to the United States, South Africa, Italy, Mexico, Argentina, Cyprus, Morocco, and several Caribbean nations emerged as exporters. Cyprus and the Caribbean exported grapefruit to the United Kingdom. Israel exported to Germany. Puerto Rico has declined as an exporter. Cuba exported grapefruit to Russia and Eastern Europe. Curiously, Central America has not emerged as a market for grapefruit. Its people consider the fruit too acidic and so seldom eat it. Costa Rica is an exception. There people cook grapefruit to eliminate its sourness. Stuffing them with caramel, Costa Ricans eat grapefruit for dessert. Currently, a sizeable portion of Americans drink grapefruit juice, often at breakfast.

Varieties

In the United States, most grapefruit varieties trace their lineage to Florida. Among the oldest varieties is Duncan, which may have arisen in the 1830s in Safety Harbor, Florida. Named for A. L. Duncan, the first person to propagate the variety, Duncan tolerates light frost. By the early 20th century, Duncan was the leading cultivar in Florida and Texas and was grown worldwide. Producing abundant seeds, which consumers disliked, Duncan has ceded ground to seedless varieties, the first of which was discovered in the 1860s. Not everyone has jettisoned Duncan. Farmers in India still plant it.

Among the most popular varieties is Marsh. In the 1860s, Mrs. Rushing of Lakeland, Florida, tending three trees, noted that the fruit was seedless. Because it could not be propagated by seed, farmer C. M. Marsh, for whom the variety is named, cultured it by growing budwood from Rushing's trees. Slow to spoil, Marsh appears to be cultivated more widely than any other variety. In Suriname, Marsh is known as Hooghart.

In 1906, farmer M. B. Foster discovered the variety that bears his name. A sport of the Walters cultivar in Ellenton, Florida, Foster was the first grapefruit to display pink pulp. The Royal Palm Nurseries in Bradenton, Florida, propagated Foster, which is still grown, though not in abundance, in Florida, Texas, Arizona, and India.

In 1958, geneticists R. K. Soost and J. W. Cameron of the University of California at Riverside crossed varieties of grapefruit and pomelo to obtain Oroblanco. A seedless variety, hardy Oroblanco tolerates temperatures as low as 30°F. Farmers harvest the variety between December and April in Riverside and between November and February in Landeave, California. Paradise is a navel grapefruit that originated in a citrus grove in Winter Garden, Florida. Seedless, Paradise produces small fruit. In 1913, a Marsh tree in Onaco, Florida, produced a grapefruit with pink pulp. The name derives from the tree's owner, W. R. Thompson. In 1920, farmers in Riverside, California, began growing Thompson, and in 1924 the Royal Palm Nurseries cultured budwood to propagate the variety even though it yields three to five seeds per fruit. Because of its pink pulp, Thompson is sometimes known as pink Marsh. The pulp is pinkest in January and February. In the late 1920s, farmers planted Thompson in Texas.

Ruby Red derived from a Thompson tree in Texas and was renowned for its red pulp. Discovered in 1929, Ruby Red supplanted Thompson, perhaps because of its color and seedlessness. Ruby Red was widely grown in Texas and was the leading red or pink variety in the United States. It was the first grapefruit to be patented. Ruby Red, supplanting other varieties, came to be emblematic of grapefruit culture in Texas and was arguably one of the great successes of Texas agriculture. Ruby Red is part of a larger group of red-pulped varieties known as Redblush. In addition to Ruby Red's prominence in Texas, farmers in Florida grew Redblush varieties in large numbers. Ideal for the consumer of fresh fruit, Redblush varieties do not make an acceptable juice because their liquid turns brown with age. By 1950, farmers in Florida planted 75 percent of acreage to Redblush varieties. By 1958, farmers in India cultivated Redblush. In the 1970s, Ray Ruby, a derivative of Ruby Red, was grown in Florida.

Star Ruby had an inauspicious beginning. The variety descended from a Foster tree in San Benito, Texas. Farmer C. E. Hudson propagated it as Hudson Red, but it had too many seeds to attract consumers. In 1959, the Texas A&M University Citrus Center in Weslaco, Texas, irradiated the variety, naming its progeny Star Ruby. In the 1970s, farmers planted more than 1,000 Star Ruby trees in Texas and more than 65,000 in Florida. In Texas and Florida, Star Ruby manifest its susceptibility to Phytophthora root rot and ringspot virus. In the mid-1970s, Florida farmers destroyed 25,000 diseased trees. In 1977, Florida authorities distributed 200,000 Star Ruby trees to growers. Perhaps because it has more sugar than Ruby Red, Star Ruby has claimed acreage in Texas.

Triumph traces its lineage to a tree near the Orange Grove Hotel in Tampa, Florida. With flavor akin to that of the sweet orange, Triumph might have been more successful but for its production of 30 to 50 seeds per fruit. Once grown in Florida and South Africa, Triumph has ceded ground to seedless varieties. In 1958, scientists at the University of California crossed a tetraploid grapefruit with a pomelo to yield Melogold, a triploid grapefruit. The variety grows well in the interior of California, though it is unsuitable for the desert and the humid coast. The University of California holds the patent to Melogold.

Several of these varieties are widespread. Farmers in Texas, Arizona, and California grow Marsh, Ruby Red, and other Redblush varieties. In addition to these varieties, Florida cultivates Duncan. Trinidad and Tobago, Spain, Cyprus, Israel, Algeria, and Brazil raise Marsh; Suriname, Argentina, and Cuba Duncan and Marsh; Jamaica Duncan, Marsh, and Silver Cluster; Turkey Marsh and Thompson; and Uruguay Duncan, Marsh, Foster, and Thompson.

Cultivation and Production

Adapted to a warm climate, the grapefruit matures more rapidly at high temperature. In Riverside, California, 13 months elapse between flowering and maturity. In the warmer Imperial Valley of California, the grapefruit needs only 7 to 8 months to mature. In cooler locales, the grapefruit bears more acidic fruit, though in warm Indian River, Florida, South Florida, the Rio Grande Valley of Texas, and throughout the tropics the fruit has little acid. Grapefruit needs between 36 and 44 inches of rain per year and does best when rain is evenly distributed throughout the year. In some areas, grapefruit is cheaper to raise than oranges because it needs less irrigation. Grapefruit may be grown in acidic, neutral, or alkaline soils, though basic soil is best. Florida citrus lands tend to be slightly acidic, prompting farmers to add lime (calcium carbonate). In California, Arizona, and Texas, soils are alkaline. Where grapefruit is irrigated, water deposits alkaline salts in the soil, making it basic over time. In Suriname, farmers grow grapefruit on clay soil. Saline soils decrease yields, interfering with the roots' ability to absorb water. Too much nitrogen in the soil deforms the fruit, which have little juice. Copper deficiency causes exanthema, a condition that mimics disease. Zinc deficiency causes mottle leaf, an affliction, like exanthema, that farmers often mistake for disease.

Growers need not harvest grapefruit right away. Fruit that matures in September or October may be left on the tree without loss of quality or flavor for several months. By the end of May, however, fruit begin to fall from the tree and seeds inside the fruit germinate. A late harvest may compromise next year's crop, reducing the yield. Farmers may retard seed germination by spraying the fruit with gibberellic acid and 2, 4 D. To reduce labor costs, California farmers began harvesting grapefruit by machine in 1972. The tree shaker, as the name implies, vigorously shakes the branches to dislodge grapefruit. The tree shaker is more than three times faster than a person, harvesting between 50 and 63 boxes of grapefruit per hour whereas a worker can pick only 15 boxes per hour.

Between the 1930s and 1960s, the truck replaced the railroad in bringing the grapefruit to market. Processed grapefruit has grown in importance in the United States. In 1935, more than half of all grapefruits sold in the United States were fresh, but by 1940 more than half was processed. The demand for grapefruit has been robust since World War II. During the 1970s, the grapefruit diet, popular again in recent years and promising to help overweight Americans shed 10 pounds in 10 days, spurred the sale of grapefruit. The U.S. Department of Agriculture reports that among produce only potatoes, lettuce, oranges, and apples sell better than grapefruit in New York City. The grapefruit is a breakfast staple. Americans slice the fruit into halves, add sugar, and spoon out sections for consumption. Grapefruit is a popular addition to fruit salad, fruit cups, Jell-O, pudding, and tarts. In addition to fresh grapefruit, Americans eat canned sections in grapefruit juice or light syrup. In Australia, manufacturers make grapefruit marmalade and jelly. Oil from the peel is used to flavor soft drinks. Inside the peel is naringin, a chemical that can be made 1,500 times sweeter than sugar.

The production of grapefruit has been important to the agriculture of several Caribbean islands. Grapefruit trees are so widespread in the Caribbean that U.S. Department of Agriculture citrus scientist William Cooper found them wild on several islands. In 2002, Jamaica yielded tens of thousands of tons of grapefruit and pomelo. In 2004, the figure inched up even higher. In the latter year, Dominica produced tens of thousands of tons of grapefruit and the Bahamas a bit less. Cuba has witnessed a decline in production. In 1990, the island yielded hundreds of thousands of tons of grapefruit. In 2002, a hurricane killed numerous trees, and the 2004 harvest was little more than half the 1990 total. In the Caribbean, the rise of the grapefruit and other citrus has accompanied the decline of sugarcane culture so that fructose has replaced sucrose as the sugar of export on many islands. Worldwide, farmers harvested millions of tons of grapefruit and pomelo in 2007. Leading the world was the United States. China ranked second, South Africa third, Mexico fourth, and Syria fifth.

Health

For many people, the grapefruit is a healthy addition to the diet. Rich in vitamin C, fiber, and antioxidants, grapefruit may lower cholesterol. The fruit contains spermidine, a compound that increases the longevity of worms and fruit flies. Researchers hope for the same effect in humans. Research suggests that the chemical limonin in grapefruit may protect one against colon cancer. The consumption of grapefruit lessens the risk of contracting lung cancer, even among smokers. The consumption of grapefruit may lower the risk of developing several other types of cancer. The American Heart Association recommends the consumption of grapefruit to maintain the function of the heart. Adding grapefruit to the diet may help obese people lose weight, though the pounds lost may not rival the claims made by the proponents of the grapefruit diet. The consumption of grapefruit may slow the buildup of plaque in the arteries. Yet some scientists contest the health benefits of grapefruit. A 2007 study reported that the consumption of one-quarter of a grapefruit per day increased the risk of contracting breast cancer 30 percent among postmenopausal women. A 2008 study, in contrast, reported that the consumption of grapefruit actually reduced the risk of developing breast cancer.

The grapefruit diet, popular since the 1930s and known as the Hollywood diet, advises dieters to combine grapefruit with protein-rich foods, claiming that an ingredient in grapefruit triggers the body to burn fat. The grapefruit diet works by starving the body of calories, though results are often temporary. Weight loss may be rapid, but the dieter loses water rather than fat and usually re-gains the weight once off the diet. A crash diet, the grapefruit diet does not have the support of physicians.

Despite the benefits of grapefruit, people on medication should consult their physician or pharmacist before eating grapefruit or drinking grapefruit juice. In the 1990s, reports of grapefruit-induced overdoses and deaths caused grapefruit sales to slump. The consumption of grapefruit interferes with the effectiveness of HIV drugs, antibiotics, and psychotropic medications. Calcium-enriched grapefruit juice interferes with the body's ability to absorb the antibiotic tetracycline. Grapefruit affects the availability of some drugs by reducing the amount of the enzyme CYP3A4 in the intestine. Because this enzyme breaks down medicines, the diminution of it leaves more of a drug available for absorption into the blood. In particular, grapefruit prevents enzymes from breaking down and thus using the components of cholesterol-lowering statin drugs, which can lead to a dangerous accumulation in the body of these components.

Christopher Cumo

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Grapes

A perennial vine, the grapevine is native to the Old and New World. Having various uses, some grapes are consumed fresh. Others are dried to make raisins or

Grape vineyard (iStockPhoto)

used to derive preserves and juice. The largest use of grapes is to make wine. The most widely grown species, *Vitis vinifera*, has been cultivated since antiquity. An American species, *Vitis labrusca*, is used to produce juice in the United States and South America. *Vitis labrusca* is more resistant to pests and diseases than *Vitis vinifera*, though most people prefer the taste of the latter's grapes. Some people believe that *Vitis labrusca* is suitable for preserves, juice, and table grapes, but not for wine. All grapes belong to the family Vitaceae, which contains 12 genera. Grapes contain vitamins C, B1, B2, and B6, beta-carotene, calcium, chlorine, copper, fluorine, iron, magnesium, manganese, phosphorus, potassium, silicon, and sulfur. Raisins and grape juice also contain nutrients. Wine may protect one against heart disease.

Origin and History

Grapes have grown in the wild for millennia. Vines climbed into the canopy of trees, where birds ate the grapes, helping them reproduce by dispersing seeds. Wild grapes must have been an acquired taste in prehistory. Their flavor is strong, the acid content high, and the amount of sugar low. *Vitis vinifera* originated in northwestern Turkey, northern Iraq, Azerbaijan, and Georgia. From this region, humans gathered grapes long before they cultivated them. In antiquity, the people of this area cultivated grapes and carried them to Mesopotamia, Palestine, Syria, Egypt, and other parts of the Mediterranean. By

3000 BCE, the Egyptians were growing grapes for both fresh consumption and wine. Tomb paintings of grapevines and laborers date to 1500 BCE. The Chinese began cultivating *Vitis vinifera* about 2000 BCE, though they may have grown indigenous varieties earlier. The Greeks and Romans grew grapes, and as Rome expanded into Europe it brought grapes to northern Italy, Spain to the Pyrenees Mountains, Portugal, and north into France, Germany, and Britain. In the Middle Ages, Pope Gregory the Great encouraged monasteries to grown grapes, and they became a center of viticulture. Although the Americas had their own species of grapes, Europeans introduced *Vitis vinifera* into North America, Peru, and Chile during the Columbian Exchange. In 1616, the Dutch brought grapes to South Africa. In 1718, the British introduced grapes into Australia and later New Zealand. Today, farmers grow grapes from the tropics to temperate regions.

Uses

The primary use of grapes is to make wine. Humans have consumed wine for 7,000 years, though the first wine may have been made from dates rather than grapes. Wine was an important beverage in antiquity because the alcohol in it killed microbes, making it safe to drink even when drinking water was contaminated. Yeast naturally colonized grapes. In storage, this yeast fermented grapes into wine, suggesting that the discovery of winemaking may have been accidental. About 3000 BCE, the Egyptians and Phoenicians first made wine from grapes. These ancients drank wine with meals and at festivals. The Egyptians placed vessels of wine in royal tombs so that the dead would not be thirsty in the afterlife. In antiquity, the Chinese also made wine, though whether they at first used grapes or rice is unclear. The Chinese traded wine along the Silk Road. About 2000 BCE, the Greeks began to make wine, though it was different than today's vintages. Rather than use fresh grapes, the Greeks preferred raisins, which made a sweet, thick liquid. Perhaps to counter its viscosity, the Greeks diluted wine with water, a practice that spread throughout the Mediterranean. The Greeks may also have diluted wine to sanitize the water, making it safe to drink. So important was wine to the Greeks that they had a god of wine, Dionysus. Dionysus was a god of revelry and represented the irrational drives in Greek society. By 1000 BCE, the Greeks spread wine throughout the Mediterranean, including North Africa, Spain, southern France, Sicily, and Italy. The Romans, heirs to Greek culture, were the first to trellis vines to keep them off the ground. The Romans aged the best vintages more than 100 years. In contrast to the Greeks, Rome used fresh grapes to make wine, as people have ever since. Like the Greeks, the Romans had a god of wine, Bacchus. A Bacchanalia was a wine feast. In the first century CE, Roman encyclopedist Pliny the Elder gave advice on growing more than 90 varieties of wine grapes. In the second century Galen, physician to Emperor Marcus Aurelius, thought that wine, consumed in moderation, had curative powers. Old wines were the most potent, he believed.

Wine was an important beverage to the ancient Hebrews, judging from the more than 150 times they mentioned it in the Old Testament. The Hebrews drank wine at weddings and Passover. True to his Jewish roots, Jesus apparently drank wine. According to the Gospel of John, Jesus performed his first miracle by turning water into wine at a wedding. According to the gospels, Jesus and his disciples drank wine at the Last Supper. Christians reenact this event by drinking wine at religious services. Catholics, following medieval theologian Thomas Aquinas, believe that God miraculously transforms wine into Jesus's blood during the Mass. Apart from his apparent fondness for wine, Jesus, according to the gospels, told the parable of the vineyard. Given the importance of wine to the Church, clerics and monks, encouraged by popes, were Europe's leading winemakers in the Middle Ages. So pervasive were the Church's activities that many vineyards in France, Germany, Italy, and Spain originated as Church lands. Monasteries crushed the grapes of commoners, for which they charged 10 percent of the value of the grapes. As a rule, monasteries made wine superior to that of the peasants, a fact that the latter resented. The rise of secularism in the Renaissance was accompanied by the transition of vineyards and wineries from religious institutions to private citizens between the 15th and 17th centuries. Although Europe remains a center of winemaking, North and South America and Australia have risen as challengers. The vintages of California rival those of Europe in quality and price. Most wine in Chile and Argentina is exported. The demand for wine is strong in Europe, North America, and Asia, though worldwide consumption is declining. In the United States, California vintages must compete with imports from South America and Australia.

After winemaking, the cultivation of grapes for fresh consumption is the second leading use of the fruit. Table grapes must be durable enough to withstand rough handling during harvest and to resist diseases that may afflict them after the harvest. Consumers prize table grapes for their appearance, firmness, and flavor. The distinction between table and wine grapes is sometimes fuzzy. The Zinfandel grape has served both purposes. In the eastern United States, farmers planted it for fresh consumption. Only when pioneers brought it to California did it become a wine grape. In North America, the advent of refrigerated railroad cars in the 19th century allowed grape growers in the West to compete with their counterparts in the East. California growers shipped grapes by railroad to eastern cities. Improvements in transit and storage in the 20th century led to the rise of the cultivation of table grapes in South America and their shipment north.

As in other sectors of agriculture, management paid workers in the vineyards poorly. Working conditions were unsanitary, the workload heavy, and the workday long. Dissatisfied with this state of affairs, workers in the Delano vineyards of

California struck in 1965. Allying with the new United Farm Workers, laborers rallied behind leader Cesar Chavez. Using the nonviolent tactics of Indian nationalist Mohandas Gandhi, Chavez organized a nationwide boycott of Delano grapes. Chavez won widespread sympathy for his cause and a new contract for workers.

Consumer preference has driven the trend toward seedless varieties despite the fact that seeded varieties have a longer shelf life. Among grape exporters, Chile was in 2007 the leader with hundreds of thousands of tons. Italy ranked second with a slightly smaller figure. The United States exported hundreds of thousands of tons of grapes, and South Africa produced a smaller amount for export. In 2008, China produced more table grapes than the next nine producers together. China's table grapes supply domestic demand as well as export.

Farmers also cultivate grapes for raisins and juice. Humans likely encountered raisins in nature before they made them purposefully. Grapes that escaped scavengers may have dried on the vine. Curious humans must have tasted these raisins and, finding them agreeable, endeavored to make them. Raisins were surely attractive because of their sweetness. The Egyptians may have been the first to make raisins. The variety Sultana is the chief raisin cultivar. The United States and Turkey produce 80 percent of the world's raisins. China, Chile, South Africa, Greece, and Australia also produce raisins. Because most raisins are sun dried, their making is confined to sunny, dry regions. Sultana grapes are also used to make juice, wine, and table grapes. Grape juice is both sweet and acidic in a proportion that many people find appealing. In addition to its use as a beverage, grape juice sweetens other drinks. The Concord grape is renowned for its use in making juice, but other varieties are also important, among them Sultana, French Colombard, and Grenacho. Varieties of *Vitis labrusca* make a juice that many people find sweeter than *Vitis vinifera*.

Attributes and Fertilizers

Having originated in a temperate climate, grapes grow well between 50°F and 68°F. Below 50°F grapes are dormant, and in this state can endure cold weather because a dormant vine contains little water and so does not freeze. The Amur grape *Vitis amurensis* is native to northeastern Asia and is particularly hardy. In addition to its use in making wine, scientists have bred the Amur grape with other cultivars to yield cold-tolerant grapes suitable for high latitudes. Some species of grape can survive temperatures as low as –40°F. Less hardy *Vitis vinifera* tolerates temperatures as low as 5°F. In temperate regions, grapes enter a period of hardening before winter. Once a vine has undergone hardening, it tolerates lower temperatures than it is able to endure during the growing season. An early frost impedes the development of hardiness and may leave a vine unable to survive the coldest temperatures. In the tropics, temperatures never become cold enough to limit growth. Because the grapevine is an indeterminate plant, it grows vegetatively even after it flowers. Growing throughout its life, a vine flowers and produces fruit continually in the tropics. Whereas grapes ripen at once at the end of the growing season in temperate locales, they ripen throughout the year in the tropics and so cannot be harvested in the course of a few weeks. Rather, the harvest must be undertaken throughout the year, increasing labor costs where the mechanical harvester is not used. Grapes are challenging to grow in the tropics because pests and pathogens are more numerous than they are in temperate regions. Warm weather is necessary to stimulate a vine to produce fruit and to fill it with carbohydrates. Although a grapevine can survive with little water, it will not fruit during drought. An abundance of water produces vegetative growth at the expense of grape production. When vegetative growth is too lush, the grower must expend time, effort, and money pruning excess foliage. As the atmosphere accumulates carbon dioxide and as the climate warms, farmers will likely grow grapes at higher latitudes. Spring frosts may occur later as the climate warms, impairing the growth of vines and reducing the harvest. As the ozone thins, more ultraviolet light will reach Earth, causing grapevines to produce small leaves, thereby reducing photosynthesis.

One ton of grapes removes from the soil five-and-three-tenths pounds of nitrogen, nine-tenths of a pound of phosphorus, and seven pounds of potassium. When nitrogen is in shortage, grape leaves yellow, impairing photosynthesis. In severe deficiencies, vines cease growth. An excess of nitrogen in the soil stimulates vines to grow abundantly at the expense of fruit production. Where nitrogen is deficient, the farmer may apply the element before the vine buds with a second application at flowering, times when the need for nitrogen is high. Because rain leaches nitrogen from the soil, the farmer should apply the element at intervals rather than in a single dose. Because grapevine roots are efficient absorbers of phosphorus, the element is rarely deficient. Where it is in shortage, old leaves will yellow. In severe deficiencies, leaves redden. Too much phosphorus in the soil may interfere with the ability of grapevine roots to absorb potassium. Where potassium is deficient, leaves display chlorosis. The farmer may remedy potassium deficiency by applying potassium chloride, known as muriate of potash, to the soil. Potassium chloride is an inexpensive soil amendment, but the farmer risks accumulating too much chlorine in the soil. Where chlorine toxicity is a danger, the farmer should add potassium sulfate to the soil, which, although more expensive than potassium chloride, does not amass chlorine in the soil.

Sulfur deficiency is rare. Because grape leaves absorb sulfur as a gas, in addition to the fact that roots absorb sulfur ions, farmers, in spraying on grapevines sulfur compounds to control powdery mildew, supply plants' need for sulfur. Where magnesium is too abundant in the soil, it displaces potassium ions and thereby causes potassium deficiency. Where magnesium is in shortage, the edges of leaves display chlorosis and grapes may be red. Where the soil pH is too low, magnesium is unavailable for absorption. Excess potassium displaces magnesium ions in the soil, causing magnesium deficiency. Where magnesium is deficient, the farmer may add calcium magnesium carbonate, known as dolomite. Calcium deficiency is uncommon. The application of calcium sulfate, known as gypsum, adds calcium to the soil as well as raises soil pH. In the soil, calcium displaces sodium ions, preventing the accumulation of the element in grapevines.

Among the micronutrients are iron, manganese, copper, zinc, and boron. Where iron is deficient, young leaves display chlorosis and are unable to photosynthesize efficiently. Able to take up iron in warm weather, grapevines have difficulty absorbing iron from wet, cold soil. Iron and manganese are unavailable for uptake in alkaline soil. Where manganese is deficient, mature grape leaves display chlorosis. The addition of manganese sulfate to the soil remedies deficiency. Copper is seldom deficient in soil. Applications of copper sulfate combat downy mildew and add copper to the soil. Too much copper in the soil impairs the growth of grapevine roots. Where zinc is in shortage, a grapevine produces small leaves and fruit may not set. The farmer may remedy deficiency by adding zinc sulfate or zinc chelate. Where boron is deficient, fruit may not set and older leaves may die. Dry soil may be boron deficient.

Diseases and Pests

Fungi are the primary pathogens of grapes. Botrytis fungi cause bunch rot, known as gray mold. Botrytis endures cool temperatures but grows and diffuses best in warm, damp weather. Scientists identified botrytis in the 18th century, though it likely plagued grapevines earlier. Fungi rot grapes and ruin the flavor of wine. Botrytis overwinters on shriveled grapes and on the rachis. Water and wind spread fungi. The farmer may prevent botrytis by planting cultivars whose grapes do not cluster tightly and so dry quickly. The farmer may plant early-maturing varieties where the weather is wet in late summer and autumn. The grower may plant rows in a north-south orientation to maximize sun exposure, thereby causing vine and fruit to dry. The vigilant farmers should keep the vineyard clean. In one New Zealand vineyard, the majority of dropped leaves harbored the fungi.

Another fungal disease, powdery mildew, named because it appears as a white powder on grapevines, attacks buds and other new growth. Originating in England, powdery mildew spread to France about 1847, causing severe losses. In 1854, farmers used the first fungicides against the disease. Water and wind spread fungi, which grow and spread between 68°F and 80°F and in dry conditions. Infected leaves are unable to photosynthesize efficiently. Fungi cause grapes not to ripen and to split. The rachis becomes brittle. *Vitis vinifera* is susceptible to powdery mildew, whereas species native to North America are resistant. The farmer may combat the disease by applying gaseous sulfur, fungicides, potassium bicarbonate, and sodium bicarbonate to vines.

Arising in the United States, downy mildew, a third fungal disease, spread to France in 1878. A farmer devised its treatment by chance. Angered that townspeople were stealing his grapes, a farmer near Bordeaux painted leaves and vine with a solution of copper sulfate and lime. Because the mixture turned leaves and vines an ugly blue-green, the farmer assumed that the townspeople would not continue to steal his grapes. Whether he achieved this goal is unclear, though he accomplished something greater. A scientist who came upon the farmer's vineyard observed that it was free from downy mildew. The Bordeaux treatment was success. Downy mildew develops in warm, humid weather. Spread by wind, fungi are active above 52°F.

Among insects, leafhoppers suck sap from leaves. Afflicted leaves develop spots at the point of insertion. Leaves may redden. Leafhoppers excrete honeydew, which, falling onto grapes, ruins their flavor. The farmer may cut off the basal leaves, where leafhoppers lay eggs. Insecticides and the bacterium *Bacillus thuringiensis* are effective against leafhoppers. Borer moths lay eggs in the soil or on the vine. Hatchlings eat roots, canes, and shoots. In the worst infestations, vines die. Some fungi devour borers and may make biological control possible. Spider mites, grape erineum mites, grape rust mites, and false spider mites feed on leaves, which turn brown and fall from the plant. Other mites prey upon these destructive mites. The farmer who uses insecticides must take care not to kill beneficial mites. Sulfur-based insecticides, for example, kill both destructive and beneficial mites.

Christopher Cumo

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Guava

Guava (*Psidium guajava*) is a fruit plant indigenous to Mexico and Central America. From the 16th century, it gradually spread to the Caribbean. Humans, birds, and other animals have distributed it to other parts of world. The Spanish and Portuguese carried guava from South America to the East Indies. As a crop, guava was grown in parts of Asia and Africa. By 1866, half the states in the United

States were cultivating it. In India, its yield was 27,319 tons per annum from 125,327 acres of land. It is planted in home gardens as well as grown for commercial purposes. Guava has different names in most of the languages, such as *guave* in Dutch and German, *goyave* in French, *guyava* in Spanish, *gujawa* in Polish, *goiaba* in Portuguese, *guava* in English and the languages of Scandinavian countries, *guaba* in Japanese, *jwafa* in Arabic, *jambu batu* in Malay, *amrood* in Hindi, *amba* in Nepalese, and *pera* in Sinhalese.

Attributes

Guava, belonging to the Myrtle family, varies from 4 to 30 feet in height with a bony diameter of 10 inches. With a thin and colored bark as well as spreading branches, the aromatic leaves are oval or oblong with a length of about 3 to 6 inches and 1 to 2 inches in width. The white flowers of the guava tree blossom singly or in groups and are 1 inch in width. The round or pear-shaped ripe fruits with a sweet and musky smell have a thin yellow skin covering a sweet granular pulp of one-and-one-half to one-and-eight-tenths inches thickness. The juicy central portion generally contains hard seeds numbering from 112 to 535. Some varieties of guava are either seedless or possess very soft seeds. The ripe fruit is delicious, but many persons prefer raw ones, which are green and hard.

Cultivation

Guava plants flourish with minimal care and can withstand drought and other seasonal changes. Guava grows well in full sun, but in hot areas some shade is required. The cost of guava production is not much as the need of plants for manure and irrigation is low. Although tolerant of different soil conditions, guava trees prosper in rich soil with high organic content. However, salty soils are not conducive to growth. The honeybee is the chief pollinator of guava. When cross-pollinated with another type, the guava tree produces more fruits. The middle of winter in the tropics is the best time for guava production, although it can produce year-round. For a commercial plantation of guava, care is necessary in planting. In summer, the ground is leveled and afterward plowed. Pits are dug to be filled with soil and manure. In the rainy season, planting is done. Seeds should be planted three inches apart depending on the variety of guava, fertility of soil, and availability of irrigation. Although guava survives in the dry season without watering, it is better to water it after the ground has dried. Without moisture, the fruits will not mature fully and will fall to the ground. Pruning is recommended at harvest. It is always advisable to remove water shoots. Pruning does not diminish the growth of next year's crop. The application of fertilizer gives a better yield with good-quality fruits. A mature tree needs about half a pound of nitrogen per year. Guava is picked by hand to be transported to the market for sale. For export or a market at greater distance, half-yellow fruits may be picked. Guava needs delicate handling during harvesting and transporting. Within 2 to 3 years, the guava tree produces fruits. A 10-year-old tree may produce 220 pounds of fruits per annum. The packaging is done in baskets or cardboard boxes filled with straw, paper, and leaves. The boxes should contain small holes to permit air circulation.

Nutrition and Medicine

Guava, whether raw or ripe, may be eaten fresh. It is also canned whole or cut into pieces. The stewed guava shells or *cascos de guayaba* are a dessert of the Spanish-speaking world. The jelly of guava is universally sold. In Hawaii, guava juice prepared by boiling and straining sliced pieces of guava is used in ice cream sodas and punch. Guava syrup is mixed in milkshakes, ice creams, and puddings in South Africa. Guava is an ingredient in recipes for cakes, pies, sauce, jam, marmalade, and butter in many parts of the world. One hundred grams of guava contain 86.1 grams of water, 11.88 grams of carbohydrate, 6.48 grams of sugar, 5.4 grams of fiber content, 183.5 milligrams of vitamin C, 284 milligrams of potassium, 0.82 gram of protein, 0.6 gram of fat, and 51 calories. Sodium, calcium, phosphorous, and vitamin A are also present. Guava not only is part of a healthy diet but may also aid in weight loss.

Guava has been used to treat nosebleed and to heal wounds. In the tropics, guava has traditionally been used for treating gastroenteritis, skin diseases, and diarrhea. The guava leaves are beneficial for treating toothache, inflamed gums, cough, and cerebral ailments. Some researchers have maintained that nutrients in guava are helpful for treating rheumatoid arthritis, cataracts, Alzheimer's disease, epilepsy, cancer, and cardiac problems. Guava tree wood is used in carpentry and engraving. It is also a source of firewood. In Southeast Asia, the leaves of the guava tree are used as a dye. In Central America, the bark is used to tan hides. Cosmetic companies are using guava as a facial wash and for the removal of wrinkles.

Patit Paban Mishra

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Hazel

The hazels (*Corylus L.*) are deciduous small trees and large shrubs that belong to the family Corylaceae, though some botanists place them in the birch family Betulaceae. The botanical name *Corylus* comes from the Greek word *Korys* ("hat" or "helmet"), and it certainly applies to the helmet-like husks of the hazelnuts.

The hazels are native to the temperate Northern Hemisphere. The hazelnuts flourish particularly well around the 45th latitude and southern regions not too far inland. There are about 18 species, mostly found in Eurasia. Commercially, the common hazel or common filbert (*Coryllus avellána L.*) and the giant filbert (*Corylus maxima Mill.*) are most important. The Latin word *avellána* refers to the ancient town of Abella (Avella today). The city lies in the region around the Mount Vesuvius, in Italy, and was already in antiquity famous for its successful cultivation of hazelnuts. The Latin word *maxima* means "greatest" and refers to the big size of the nuts.

Currently, the commercially significant areas of hazelnut production are located in Spain (Tarragona), Italy (Plemont, Viterbo, Sicily), and the Turkish Black Sea coast, as well as in the Willamette Valley in Oregon. Turkey produces 65–70 percent—which is more than half a million tons—of the world's hazelnuts. Italy produces 23 percent of the world's hazelnut harvest, Oregon 5 percent, and Spain 3 percent. Of the hazelnuts consumed in the United States. 99 percent are grown in western Oregon on an area of more than 30,000 acres, where 0.6 ton of nuts per acre are harvested annually. This is two and a half times the amount that is harvested in parts of Spain.

Hazelnuts are commonly used to bake cakes and cookies. They are also used in a variety of fish dishes and salads. Additionally, they can be used to refine desserts and in the production of ice cream and hazelnut spreads, as well as in an assortment of savory and sweets. Nevertheless, they are mainly used as a spice in confectionary.

Mythology and Folklore of the Hazel

The hazel bush is among the oldest plants in Europe and was already a popular nut in prehistoric times. In Asia, the records of the hazelnut go far back; in a Chinese manuscript from the year 2838 BCE, the hazelnut belonged to the five sacred nourishments God gave to human beings as a gift. In ancient times, the hazelnut was used as a medicine and tonic. In the first century CE, for instance, the Greek physician Dioscorides recommended hazelnuts to cure a cold and as a hair-growth medium.

The hazelnut also plays a role in a variety of superstitious practices. In ancient Rome, the hazel was considered a sign of peace. Peace and ceasefire negotiators carried hazel twigs in their hands as a sign of their good intentions. In Germany in historical times, court facilities were marked with the shoots of hazel. Hazel twigs were used as landmarks to mark property borders. The pointing sticks (or indicator rods) of court and forest sovereignty were made of hazel wood. In other areas, bride and groom were showered with hazelnuts at their wedding. This was done in hopes of making the marriage a happy one and with an abundance of children.

At times, it was even believed that witches and snakes could be warded off with a hazel rod. In the fairy tale "Cinderella" by the Brothers Grimm, the protagonist wants a hazel rod to protect the grave of her mother.The hazel shrub is believed to protect against lightning, flood, and storm. Hazels were believed—and by some are still believed—to have the powers of divination and mercurial energy. Therefore hazel rods are used as dowsing rods or divining rods or wands. Magic using hazels was banned by the laws of the Franks, the *Lex Ripuaria* in the seventh century, but remained over centuries. Up to the 17th century, people believed that they could track down treasures and detect water and mineral or ore veins with a hazel rod.

The hazelnut is still regarded as a symbol of fertility, sexuality, and immortality. It serves as a talisman and is a symbol of wealth and prosperity. In Celtic beliefs, the hazelnut gave one inspiration and wisdom. This can be seen in the Gaelic word for nuts, *cno* pronounced "knaw," and the word for wisdom, *cnocach*. Ancient Celtic tales describe a sacred pool that was surrounded by nine hazelnut trees, which dropped their nuts into it. These nuts were eaten by salmon, a fish sacred to Druids. For each nut the salmon had eaten, it got one spot. The tale tells that the wisdom from the pool came to the Druids through their eating of the salmon.

Cultivation and Harvest of the Hazel

The commercial cultivation of hazel is exclusively done by vegetative propagation. In Oregon, flexible branches are bent down in a U-shape and covered with earth, so they grow roots. In Europe, the cultivation is often done by taking basal shoots. Shoots develop into bushes, unless they are cut so that they grow up into 30- to 45-feet-tall trees, as is commonly done in North America and Italy.

In the United States, the nuts are harvested by allowing them to fall to the ground and then picking them up by a kind of street sweeper. In wooden storage bins, the nuts are dried until they contain no more than 6 percent moisture. Afterward, they are sorted by size and appearance. (Shelled nuts are sorted only by size.) Due to the high fat content of nuts, they must be marketed promptly, since they can be preserved for only about one year.

Heidrun Kordholste-Nikander

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Hibiscus

Hibiscus is a flowering plant of the *Hibiscus sabdariffa* species of the Mallow or Malvacae family. The Malvacae family is quite large, possibly one of the largest plant families, encompassing several hundred species. Hibiscus plants can be divided into two categories: the tropical hibiscus and the hardy hibiscus. The tropical hibiscus is confined, in the United States, to areas like Hawaii and Florida, or can be successfully cultivated in a greenhouse or indoors in climates where it is not warm and humid. Hardy hibiscus, on the other hand, can withstand temperatures well below freezing.

Hibiscus (Docters/Dreamstime.com)

Etymology

Other names for the hibiscus plant are flor de Jamaica and the less commonly used Rosemallow. The genus *Hibiscus* includes both annual and perennial herbaceous plants. The name hibiscus derives from the Greek word *hibiskos*, which is the name first-century CE Greek physician Dioscorides gave for marshmallow, another member of the Malvacae family. The Swedish naturalist Carl Linnaeus, who invented the Latin taxonomy of plants, described hibiscus in depth for the first time in his book *Species Plantarum.* Linnaeus gave it the name hibiscus in 1753. Hibiscus is the official state flower of both South Korea and Malaysia, and carries important symbolism in cultures as varied as Chinese and Bengali.

History

While scientists are certain that the tropical species of the hibiscus originated in the Pacific, their earliest home is yet to be determined, although most cite China. Early hybridization by amateurs took place in Hawaii. In the1800s, interest in cultivating this plant grew, and people in different areas of the world wanted to introduce it. Besides Hawaii, another area where the hibiscus plant became prevalent was Australia.

The history of the hibiscus plant is extensive, since the plants were sprinkled all over the globe, unlike many cultivated plants that are native to just one area. The origins of the tropical hibiscus plant are Madagascar, Fiji, and India. The ancestors of the modern hibiscus plant were similar to current species. Marked differences characterizing the original hibiscus, however, include willowing bushes and the ability to form seeds, which modern hybrids lack. Currently, for hibiscus to be harvested successfully, plants must be cross-compatible with at least one ancestral species. There are eight different ancestral hibiscus plants.

Ornamental Use

Hibiscus is one of the most visually appealing of cultivated plants, which make it so favorable for ornamental purposes. Hibiscus is a gorgeous glossy plant, which is desired worldwide for its color and beauty. Flower color varies in each species of hibiscus plant, and there are several factors that contribute to these changes including age. This change in the floral color is present in two of the species, *Hibiscus mutabilis* and *Hibiscus tilaceius*. Hibiscus has colorful flowers and comes in an array of different colors. The flowers are large and shaped like trumpets, with five or more petals. The hibiscus plant has many cultivars from different parts of the world. The leaves are alternate, ovate to lanceolate with a toothed or lobed margin. The petals of the hibiscus flower can range in color from red, purple, yellow, and orange to white. The leaves of hibiscus are alternate, often with a toothed and yellow margin, and are from one-and-six-tenths to seven inches broad. Hibiscus can grow to heights of up to 15 feet. The seeds of the plant are released when the capsule of hibiscus dehisces or splits open.

Many hibiscus plants are grown solely for the purpose of landscaping or to attract certain types of exotic birds like hummingbirds. The birds are attracted to the Rosa Sinesis variety of hibiscus, despite its overbearing size. Rosa Sinesis is considered a giant hibiscus, and its blooms can be six to eight inches. The succession of blooms can last for months. Two of species most constantly attracted are the Sapphire Spangled Emerald and the Striped Breast Star throat.

Herbal Medicine

There are further uses for the hibiscus plant other than as an ornament. The active ingredients in the hibiscus plant that give it its healing properties are mucilage polysaccharides, its pectin's organic acids, as well as citric and malic acids. The fresh calyces are used for herbal remedies. The dried leaves of hibiscus are also edible and considered a delicacy in Mexico. The leaves of the plant can be ground up and used for things like shampoo. The hibiscus flower has historically been used to make different-colored dyes. Many people drink tea made from hibiscus, which is a common reason why it is cultivated. The tea of hibiscus is used as a diuretic and for a variety of ailments in Chinese herbology and Indian ayurvedic medicine. The tea that is drawn from hibiscus is most popular in Jamaica where it is known by the name sorrel, not to be confused with the herb of the same name, *Rumex acetosa*. Hibiscus tea is known by the name bissap in countries like Egypt and Sudan. The herbal tea has a range of health benefits, which include lowering blood pressure and treating mild hypertension. A 2008 U.S. Department of Agriculture study proved that hibiscus is fairly effective in treating blood pressure problems like hypertension; three cups of hibiscus tea actually caused noticeable changes in systolic and diastolic blood pressure readings (Bliss 2008). In Indian medicine, Rosa sinesis is used exclusively to treat medical conditions (Bliss 2008). The roots of hibiscus are also used in a concoction that supposedly treats a range of ailments.

Bonnie Ellman

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Hickory

Edible nuts, attractive shaggy bark, and strong, dense, flexible wood are just some of the attributes that make many species of hickory trees desirable and appreciated in natural and cultivated landscapes. Hickory belongs to the walnut family Juglandaceae and the genus *Carya*. The name *Carya* is Greek for "nut," and while all bear nuts, not all of the nuts are edible. The genus is made up of 23 taxa and nine hybrids. The common name hickory is from the Algonquin Indian word *pawcohiccora*. This is the name the Indians have given to an oily liquid produced from the nuts, and it means something like "sweet hickory milk." The nuts are pounded into a meal and then steeped in boiling water and passed through strainers. The resulting milk is as sweet as cream and was used in making corn cakes and hominy. Hickory trees are deciduous with beautiful yellow foliage in autumn. They are, in general, tall with deep taproots, making them difficult to transplant. However, the taproot anchors the tree, making it wind resistant.

Hickory Wood Has Many Uses

Hickory wood is prized for its strength, density, and aromatic properties. Tool handles and sports equipment, in particular, benefit from its flexibility. The wood tolerates being steam-shaped into skis and was used by settlers for wagon wheel hubs. Strips of the inner bark are pliable when green and can be woven into chair seats. Unfortunately, all hickory species suffer from "ring shake," a characteristic in which the wood can separate along the annual rings, making it sometimes tricky to use, especially as a veneer. Hickory is prized as fuel wood and charcoal. When it is burned in the smokehouse to cure meat or in the barbeque, it imparts a distinctive flavor. The trees tend to mature slowly, bearing quantities of nuts only after many years. Cultivars are chosen based on the best attributes of each species. For example, desired characteristics such as producing the biggest and tastiest nuts while maturing within a few years are highly regarded. These traits are most often obtained by grafting trees with different root stock.

Not all Hickory Is Equal

The range of wild hickory tree species stretches along the eastern regions of the United States into the Midwest and as far south as Texas. The water hickory, *Carya aquatica*, is one of the larger species, recorded as tall as 150 feet. It does best in the wetter parts of the country such as the flatlands, floodplains, and swamps. Water hickory's nuts are bitter but consumed by ducks and other local wildlife. Bitternut hickory, *Carya cordiformis*, as the name would suggest also bears what many would consider inedible nuts. Although a food source for wildlife, early settlers were believed to extract the oil from the nuts and use it for fuel in their lamps. In addition, the oil was used to relieve rheumatism. Bitternut is one of the more common hickories of the East Coast hardwood forests.

Pecan, *Carya illinoinensis*, may be considered among the more commercially valuable and all around useful species of hickory. It prefers warmer climates and cannot tolerate extremely cold temperatures. The pecan tree thrives in moist, well-drained soils such as those found in river floodplains and loam-filled valleys, making it easily accessible to waterways, an important consideration to the industry. It is a slow-growing, tall tree, often reaching heights of 140 feet, and living and bearing nuts for longer than 300 years. There are still pecan trees growing at Monticello and Mount Vernon that were originally planted by Thomas Jefferson and George Washington. The wood is regarded as a fine hardwood for use in furniture building and flooring. Like other hickories, the wood is also a good fuel and imparts a flavor to curing smoked meats.

The name pecan comes from the Algonquin word to describe "nuts requiring a stone to crack." The sweet, high-fat nuts are used in baking either on their own or after being prepared into a kind of milk. The oil extracted from the nuts is also used in cooking. It is believed that the nuts were even made into a fermented, intoxicating drink called *powcohicora*, the Indian name for hickory. In addition, Native Americans had been known to prepare its leaves into a concoction to treat ringworm and have made a medicine from the bark to treat tuberculosis. It was so useful, in fact, that the Native Americans may have been responsible for first cultivating it, and other hickories, in order to extend their range beyond the eastern area of the country. The first documented cultivation of pecans appears to be by the Franciscans and Spanish colonists in northern Mexico in the early 18th century, about 60 years before the first planting by colonists in the United States. By the 19th century, a technique for successfully grafting a superior wild pecan to seedling pecan stocks led to the first planting of improved orchard trees. Because of this technique, orchards could now be propagated commercially, producing nuts with fairly predictable sizes, shapes, shell characteristics, flavor, fruiting ages, and ripening dates.

Hickory Bark

Some hickory species have a shaggy bark, a characteristic that adds interest to the landscape, especially during the winter. One uncommon variety is the shellbark hickory. It is also known as the "big shagbark hickory." The species name, *laciniosa*, is Latin for "with flaps or folds," referring to the way the mature bark curls away from the trunk in long sections attached at the middle. The shellbark hickory is distinguished from the more common shagbark hickory, *Carya ovata*, by its larger leaves, orange twigs, and large, thick-shelled nuts. Both species can reach heights of 100 feet. The nuts are edible and sweet and coveted by humans and animals alike. The size of the nuts also gives the shellbark hickory the name "kingnut hickory." Many cultivars have been made using the shellbark and shagbark species in order to obtain large quantities of the biggest and tastiest nuts. In the wild, the minimum age to produce nuts is 40 years, with the best quantities produced not until ages 75 to 200. Shagbark hickory can live as long as 300 years. It is believed that Native Americans used the bark to make a kind of nutty-tasting syrup, different from the sweet syrup made from maple tree sap. They must have passed the recipe to early settlers, and it is in fact still being made today. Entrepreneurs in Ohio wash and then heat the bark, rendering the extract most likely from the inner layer. It is then cooled and aged and used to add a unique flavor to desserts, sauces, and meats. Pioneers, too, used the inner layer of the bark to make a yellow dye. Certainly, there are obvious advantages to being able to use the bark of these trees. Shagbark hickories shed their bark after about 7 years. It can be collected, stored, and used at any time of the year.

Common Pests Affecting Hickory Trees

Among the more common pests affecting hickory are those that injure the bark, leaves, and twigs of many varieties. Insect pests include the hickory-twig girdler, which chews a ring around twigs, the painted hickory and hickory-bark borers, and the hickory shuck worm. Anthracnose, a fungal disease, and various other leaf spots, blotches, and scabs can affect hickory leaves, making them less vigorous and, in worst cases, weakening the health of the tree by causing defoliation. These symptoms are sometimes called leaf blight and can be passed among hickory species and other hardwoods by spreading spores via the wind, rain, and other mechanical means. In the wild, the extent of fungal disease is dependent on how wet or dry the year has been. Management of these diseases in cultivated trees is based on techniques to increase air circulation, allowing the trees to dry after rainfall. These include appropriate spacing between trees and pruning limbs to let in more sunlight. It is also important to rake up and burn old, dead foliage and potentially affected branches beneath the trees that might harbor spores.

Hickory trees play an important role in our history and continue to make a valuable contribution even to this day. Cultivars of this genus provide not only a beautiful, interesting tree but also a significant practical contribution to human daily life and commerce. Most notable are the nuts, an important food source for both humans and wildlife, and the wood, offering outstanding characteristics that are difficult to improve upon.

Gwendolyn Vesenka

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Hollyhocks

Once standing tall in ancient Chinese gardens of the well-to-do, hollyhocks now populate more rough-and-tumble cottage gardens throughout the West and wherever stately, easy-care plants can decorate a fence or wall. Symbolizing the passage of time, hollyhocks were popular subjects in paintings, were used as medicine, and became the symbol of various jurisdictions. *Alcea rosea* (or *Althea rosea*) is the poetic Latin name for the familiar larkspur. This member of the Mallow or Malvaceae family is related to hibiscus, rose of Sharon, and okra. Also known as St. Joseph's staff, hollyhocks were shown in medieval paintings depicting that saint.

Hollyhocks (A40757/Dreamstime.com)

Description

Most hollyhock varieties are biennials; gardeners must wait until the second summer for their beautiful flowers. Hollyhocks grow a good base of leaves their first year, then the second year the familiar tall, flower-bearing stalk rises high. Some varieties of hollyhocks will live beyond the common two-year life span, designating them as short-lived perennials. Once a patch of hollyhocks is established, they often will perpetuate themselves without the need for reseeding. Annual varieties also exist and will flower the first year. Seeds of these can be started indoors early in spring to get the good start needed to flower in one long growth season.

The bowl-shaped blossoms come in white, yellow, pink, apricot, purple, red, and nearly black, in single, semidouble, and fully double ruffled forms. Depending on the variety, the flowers are three to six inches in size, with five petals. Pistils are thick and yellow. The plants bloom from midsummer to early fall. The leaves are a textured, medium green with a rounded heart shape, also about three to six inches across, with an undulating edge. Some varieties have deeper indentations approaching a maple-leaf shape.

Dwarf varieties mature as short as two feet in height, and taller cultivars can tower over nine feet. Majorette is a dwarf strain with prolific double blossoms. Traditional varieties produce one stalk, but multistem varieties including Pinafore sprout several spires from their base.

When hollyhocks bloom, flowers decorate all sides of the stalk. The ones low on the stalk bloom first, then blossoming progresses to the top with most of the stalk in bloom as the tip is reached.

Both flowers and seed pods will be on the stalk at the same time. After pollination by bees, the flowers form packets of seeds with a papery wrapping surrounding a tight ring of 15 to 20 flat circular seeds like a round basket of crackers set side by side with a towel folded up across the top.

History

These handy natural containers, with the delightful scientific term of "schizocarps," helped spread hollyhocks from the Orient to the Middle East then to Western Europe, where they were reportedly carried home with returning Crusaders.

Beginning in the seventh century or perhaps even earlier, one of the main annual celebrations today in Kyoto, Japan, is the "Aoi Matsuri" or Hollyhock Festival, which involves two ancient shrines and features hollyhock leaves in costumes and as decorations. Early writers with an interest in botany, including Albertus Magnus or Albert the Great, 13th-century philosopher, scientist, translator, theologian, and prodigious writer, mention hollyhocks as "holy mallow." By the 16th century, hollyhocks were mentioned in early botanical and medical books. Hollyhocks were credited with a wide range of maladies they could assuage if not cure. William Turner, the 16th-century naturalist and pioneering botanist, was also a physician and familiar with hollyhocks and their medicinal uses as emollients, laxatives, and anti-inflammatory treatments.

In the United States, Spanish settlers brought hollyhocks to the Southwest. The hot, dry climate, which also has the occasional frost, was not just tolerated by the plants; they thrived while many other transplants could not hold their own. Taos, New Mexico, acknowledges the hollyhock as its unofficial city flower. During Taos's early establishment, a dedicated woman named Teresina Bent Scheurich, the daughter of Charles Bent, territorial New Mexico's first governor, planted and promoted hollyhocks and enlisted other locals to foster the spread and care of hollyhocks in any and all available sites throughout the settlement. The reward was a town with the air of a perpetual floral fiesta. Today's garden club carries on her work despite the proliferation of parking lots and modern development. Hollyhocks showed up on the other side of the continent in the colonial United States in such well-documented gardens as that of Thomas Jefferson's Monticello. Among his plants stood the still popular and striking Nigra, which is nearly black with a dark-purple velvet sheen.

Culture

Hollyhocks are not fussy. Temperatures across all hardiness zones 3 to 10 (–30°F to –40°F are the usual coldest temperatures) suit them. They prefer fairly rich, well-drained soil but thrive in heavy or poor soil too. They tolerate less than full sun. In especially hot, dry areas, they appreciate some afternoon shade. Best of all they are drought tolerant, thanks to their taproots. In regions with a long summer, once the blossoms fade, a second growth and flowering can be encouraged with fertilizer and abundant watering. Hollyhocks are unique in their ability to grow near black walnut trees, which release a toxin into soil that discourages the growth of most other plants, thereby lessening competition.

The major threat to hollyhocks is rust. *Puccinia malvacearum*, with reference to its victim in its name, malva, is a fungus that looks like its common name. Orange bumps appear first on the leaves, then holes. Rain, overhead watering, high humidity, and lack of air circulation spread rust quickly across the leaves, but it does not usually kill the plant or affect the blossoms. Infected leaves should be cut off and thrown away as soon as they are noticed. The gardener should water plants early enough in the day to allow them to dry before nightfall. Tall varieties of hollyhocks should be staked or otherwise supported in windy areas.

Damage is inflicted by slugs, Japanese beetles, and the caterpillars of several butterflies and moths. Commonly available baits, insecticides, and organic control methods usually offer enough protection to allow successful growth and flowering.

To save seeds, the gardener may gather seed pods that are fully developed and dry. Paper envelopes are good places to store clean seeds in a cool, dry place. The gardener should label the envelope with plant variety, color, and year picked, plus any other information, observations, and tips.

Tamara Stromquist

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Honeydew

Honeydew (*Cucumis melo inodorus*) is a summer fruit that is abundant year-round and shipped all over the world. A member of the melon family, Cucurbitaceae, the U.S. Department of Agriculture has earmarked this plant as a noxious weed. It thrives well in warmer zones and can be a threat to agricultural crops if left unchecked. Honeydew, which is a type of the muskmelon, is grown abundantly in California, Arizona, and Texas. It is a commodity of trade.

Honeydew has been native to Asia and Africa, specifically Algeria, since 2400 BCE. By the 15th century CE, it became popular in Europe and a delicacy in France, where it is called the White Antibes. From France, it was introduced into the United States around 1911 as an heirloom variety. The heirloom variety of honeydew is considered to be the original, organic version of the commercially grown hybrid varieties of today.

Botany

Honeydew thrives in warm climates where the temperature averages above 70°F. It requires well-drained soil rich in manure with a pH from 6 to 8. The soil may be sandy, loamy, or heavy clay. The soil should be moist at all times without being waterlogged or excessively dry. Honeydew cannot tolerate shade and requires the warm summer sun for proper growth. Zones 8, 9, 12, 13, and 14 are most suitable for cultivating this summer melon. In the United States, California leads the list with the highest acreage and output of honeydew melon, followed by Texas and Arizona.

The plant is a creeping vine and forb (herb other than grasses) that has a main taproot with branching root system. It is a climbing herb whose stem is five-angled, hairy, and hollow. Leaves are simple and with a definite petiole or leaf stalk. The leaves alternate in arrangement on the stem. Tendrils, the organs of support, are present on the stem. There is no clear description about the tendril origin, as some botanists believe that it is a modification of the leaf, while others believe the tendrils are extended outgrowths (bracteoles) from the stem nodes at the base of the flower stalk.

Flowers are large, independent or solitary, and bright yellow and have both male and female flowers on the same plant (monoecious). Honeydew melons have a cymose type of inflorescence. That is, the main flower stalk ends in a single, definite flower. The flower stalk ends in a structure called the peduncle on which the different parts of the flower are arranged. Each flower has five sepals and five petals. The male flower, which has a long pedicle, can be cut vertically in half from any side (actinomorphic) to give a mirror reflection of each other. In the male flower, the five sepals are fused and form a small funnel. Likewise, the five large petals are also fused together to give the appearance of a larger funnel or bell. There are three to five stamens, which arise from the sepal tube (calyx tube). The female flower consists of sepals and petals similar to the male flower. The ovary is positioned below other floral structures (epigynous). The female flower is identified by its short pedicle and rounded bulge at the base of the sepal tube. Three to five stigmas arise from the ovary.

The fruit is a large pepo. The most common honeydew fruit may first be green and then turn to a pale yellow or off-white once it ripens. It is slightly oval in shape and weighs an average of six pounds. The fruit coat or rind is smooth, waxy, without ridges or dents, and devoid of a musky smell. The main fruit content may be pale green or white, fibrous, sweet, and with high juice content. The fruit contains numerous seeds, which are oblong, flattened, smooth, and pale colored. One variety of honeydew fruit contains pinkish to orange rind with an orange pulp, while another variety is golden yellow in appearance and with white flesh.

Cultivation

Honeydew melons grow from seeds. Seeds must be sown in soil that is 75°F or higher. If seeds are planted in a greenhouse, the gardener should maintain higher temperatures than recommended and sow seeds during the month of March or April. If the seeds are to be sown outdoors, they should be planted in May. Seeds should be spaced out on raised beds in the field and should be planted 4 to 6 inches deep into the soil. If honeydew is to be grown in a pot in the greenhouse, the pot or container should be spacious with enough soil so as not to choke the roots. While warm and humid temperatures are required, it is vital that the soil remains moist. In order for the soil to remain fertile and moist, many farmers fertilize and feed the soil prior to seeding and after the sapling had emerged. If compost is layered 9 to 12 inches below the topsoil, it not only will provide good manure for the plant but also will provide adequate heat for the roots. Compost also helps prevent evaporation of water from the soil by holding moisture. The ground may then be covered with a porous material through which water can be absorbed, at the same time reducing the amount of dryness in the soil. The light material also allows aeration of the soil. If a ground sheet is not used, the gardener should be sure to mulch the soil. Mulching prevents weeds and water loss.

The leaves are the main carbohydrate processors of the plant, giving the fruit its sweetness. Care should be taken to space plants so that the large, broad leaves have room to spread. Seeds should be sown or saplings transplanted 12 inches away from each other in a row. Rows should be four to six feet apart. As the plant grows, it either crawls or twines depending on the availability of support. Should the gardener want the plant to twine, he must provide enough support for the twining stems. Also, additional support should be provided for the fruit as it grows. The ripe fruit is pale green in color with an almost white appearance. Choosing a fruit at the store may be tricky. A good, ripe honeydew is oval in shape, waxy, off-white in color, and slightly soft at the blossom end. While picking it in hand, it should feel almost like a bowling ball. Ripe melons have a pleasing aroma, while unripe melons have little to no aroma. The flesh will be pale green to white. The orange and golden-yellow varieties may be identified by their color when ripe.

Nutrition and Uses

Honeydew is rich in carbohydrates, vitamin C, and potassium. It may be eaten as a fruit by itself, may be cut, diced, cubed, or shaped to fashion, may be added to salads and puddings, may be converted into juice, and may also be a main dessert ingredient. Since it has a long shelf life and can be transported with ease, honeydews have become commodities of trade. A long shelf life also ensures that the fruit may be in supply year-round. While the northern United States may grow the fruit during the warm months of April and May, the southern states of California, Arizona, and Texas are able to grow the plant even during the later months, owing to their warmer temperatures.

Pests and Diseases

Of all the pests that attack honeydew, the sweet potato whitefly (*Bemisia tabaci*) is the most devastating, attacking the leaves and reducing total fruit output by 75 percent. Other pests that attack honeydew are the melon aphid (*Aphis gossypii*), spider mites, thrips (*Frankliniella occidentalis*), and squash bugs (*Anasa tristis*). Apart from these main pests, others attack in minor proportions and in select regions, such as the melon worm (*Diaphania hyalinata*), serpentine leafminer (*Liriomyza brassicae*), and cucumber beetle.

If the soil is poorly fertilized, bacterial and fungal diseases may arise. One of the most common bacterial diseases is brown spot, caused by the bacterium *Pantoea ananatis*. Among fungal diseases, the most common are downy mildew

(*Pseudoperonospora cubensis*), anthracnose (*Colletotrichum obiculare*), alternaria leaf spot (*Alternaria cucumerina*), gummy stem blight (*Didymella bryoniae*), and powdery mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*).

Pest and Disease Management

During harvest, and handling of the fruit during transport, honeydew may be compressed, cut, and bruised, resulting in desiccation, water soaking, discoloration of the rind, or damage to the fruit. Apart from these undesirable effects, bacteria may grow in injured honeydews. Because this is so, the fruit must be handled with care from the time of harvest to the time it reaches the consumer. Before consumption of the fruit, the fruit should be washed thoroughly to remove surface dirt and bacteria that may be part of the rind. Washing minimizes the transmission of bacteria.

Proper composting, mulching, and fertilizing go a long way in preventing many of the bacterial and fungal diseases. Alongside this, many farmers use fertilizers and pesticides that are acknowledged by the respective governing bodies and agricultural departments. In many cases, strong fungicides like fungicide captam must be used.

Amanda Mittra

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Honeysuckle

There are between 150 and 200 species of the shrub honeysuckle belonging to the genus *Lonicera*; because the common name honeysuckle has been applied to a number of unrelated plant species, the exact number of extant *Lonicera* species can be difficult to determine. Indigenous honeysuckle species can be found in the temperate regions of both hemispheres, as well as in South Asia, North Africa, the Himalayan Mountains, Java, and the Philippines.

The dozens of species of honeysuckle are often quite different in appearance. Coral honeysuckle, *Lonicera sempervirens*, sports large, tubular, bright pink flowers. Japanese honeysuckle, *Lonicera japonica*, commonly produces yellow or white flowers. Henry's honeysuckle, *Lonicera henryi*, produces reddish-purple blooms. The fruits, as well as the blooms, vary in size, color, and utility. Ripe fruits may be orange, white, red, black, or blue, depending on the species. Different species of honeysuckle bloom at different times during the season and have different uses. Some species grow as climbing vines, others as deciduous shrubs, and still others as evergreen shrubs.

Many species, such as *Lonicera caprifolium*, have become established in regions where they are not considered native. Members of the genus *Lonicera* are commonly cultivated as ornamental shrubs or vines. Gardeners value these plants for their attractive, fragrant flowers, their hardiness and resistance to disease and pests, their ease of cultivation, and their ability to prevent soil erosion. Species such as the fast-growing Japanese honeysuckle are considered invasive and responsible for ecological problems in some regions.

Mythology

Honeysuckle has long been awarded a place of importance in many world mythologies. In Greek mythology, the lovers Chloe and Daphnis could be together only while the honeysuckle bloomed. Daphnis asked Eros, the god of love, to make the honeysuckle bloom longer; it is for this reason, says the legend, that some species of honeysuckle remain in bloom as long as the weather remains warm. It is also for this reason that, in the Victorian language of flowers, honeysuckle is said to signify devoted love, fidelity, and affection.

In Celtic mythology, the druids considered the honeysuckle one of the lesser sacred trees and assigned it a place in the tree alphabet (Beth-Luis-Nuin). Later, the Scottish protected their cattle from acts of witchcraft by placing honeysuckle garlands around their necks or above the barn door. Even Native Americans revere the honeysuckle in folklore; an Oneida myth speaks of a young maiden, Aliquispo, who sacrificed herself to save her people from their traditional enemy, the Mingo. To reward Aliquispo and honor her memory, the Great Spirit turned her hair and body into a honeysuckle vine.

Medicinal Use

Several species of honeysuckle, most notably the Japanese honeysuckle, have a long history of medicinal use. Traditional Chinese medicine advocated the use of honeysuckle flowers, bark, leaves, and stems to treat a range of ailments, including upper respiratory tract infections, inflammatory skin conditions, laryngitis, fevers, flu, sores, tumors, and dysentery. Practitioners of traditional Chinese medicine espouse the shrub's antibiotic properties; Western medicine has confirmed the plant's antibacterial and antiviral powers. Chinese medicine classifies honeysuckle as an astringent, a hypoglycemic, an anti-inflammatory, an antifungal, a tuberculostatic, a laxative, an expectorant, a diaphoretic, a diuretic, a febrifuge, and a refrigerant. Japanese honeysuckle remains in widespread medicinal use throughout modern Asia. Researchers are currently investigating the plant's cholesterol-lowering properties.

Honeysuckle also found medical uses in medieval Europe. Nicholas Culpeper, the 17th-century British apothecary and physician, prescribed a honeysuckle conserve for the treatment of asthma. He also believed that an ointment made from the plant could treat skin discolorations, including sun spots and freckles. Native Americans and European settlers in the New World smoked dried honeysuckle leaves to treat the symptoms of asthma.

Today, honeysuckle's flowers, bark, leaves, and stems are widely used by herbalists to treat asthma, arthritis, rheumatism, colds, coughs, and fevers. In her book *A–Z of Herbs*, author Margaret Roberts recommends a mixture of honeysuckle flowers steeped in honey. This remedy can be administered in spoonfuls to treat respiratory symptoms, including those accompanied by fever or chills. Roberts describes other simple honeysuckle remedies in *A–Z of Herbs*. A poultice of crushed honeysuckle leaves can promote wound healing. The daily application of honeysuckle leaf infusion helps rashes and skin inflammations. Hot tea of honeysuckle flowers relieves arthritis, rheumatism, and sore throat.

Uses

Honeysuckle remains a popular plant among modern gardeners, who appreciate its plentiful, fragrant blooms and hardiness. Many species of honeysuckle are fast-growing climbing plants, and some gardeners choose honeysuckle vines as an alternative to ivy for decorating fences, banks, arbors, and walls. Honeysuckle shrubs can create privacy screens around lawns and gardens, and are often planted as hedges. Honeysuckle can attract moths, bees, butterflies, and birds to a flower garden. Hawk moths are particularly attracted to honeysuckle blooms, and nesting birds may pull off strips of the plant's tough bark to add to their nests. In fact, one species of bird, the pied flycatcher (*Ficedula hypoleuca*), typically make their nests out of nothing but honeysuckle bark. Rodents, such as dormice, also build nests from the bark of the honeysuckle, and may even eat the plant's flowers.

Japanese Honeysuckle

Japanese honeysuckle is indigenous to East Asia, where it has long-standing medicinal popularity. These climbing honeysuckle vines were introduced to the

United States in 1806, in Long Island, New York. Since then, Japanese honeysuckle has invaded the entire eastern seaboard and is found in 26 states. Japanese honeysuckle presents a problem in other countries, as well; in New Zealand, for instance, Japanese honeysuckle can be found throughout the North Island, where it threatens many protected conservation sites. Japanese honeysuckle was imported for use as an ornamental and erosion-control plant, but enthusiasts hoped that it might also provide cover and food for wildlife. While Japanese honeysuckle does provide erosion control and habitats for many types of wildlife, it is also a fast-growing invasive vine that competes with native flora for light and soil nutrients. In fact, Japanese honeysuckle literally smothers other plants by twining around and over them. While unable to smother tall trees in this manner, Japanese honeysuckle threatens to overrun low-lying shrublands, glades, and ravines. In deciduous forests, Japanese honeysuckle can cause the understory shrub layer to collapse and can sometimes overwhelm small trees. In this way, Japanese honeysuckle damages forest ecosystems by preventing the growth of new, diversified shrub populations. Japanese honeysuckle simplifies the structure of forests it overtakes by making itself the only member of the shrub understory. It inhibits forest growth by competing with native species for soil nitrogen. It can even interfere with forestry operations, by clogging up the space between trees and making it difficult for foresters to manage forests by individual tree selection. Only in old-growth forests do natural processes keep Japanese honeysuckle in check and confined to the area of initial invasion. Shrublands, areas of open scrub, immature forests and forest peripheries, and wetlands are most vulnerable to Japanese honeysuckle invasion.

Japanese honeysuckle is considered by many to be a serious threat to native flora. Japanese honeysuckle spreads by seed, rhizomes, and surface runners, making it difficult to control. Small patches of Japanese honeysuckle can be controlled by mowing. While mowing does little to slow the growth of Japanese honeysuckle vines, it can control the spread of vines beyond their initial area of invasion. Grazing has similar effects, though its outcome is naturally less predictable than that of mowing. Planned burning can decrease both the growth and spread of Japanese honeysuckle for up to two growing seasons. Hand pulling of Japanese honeysuckle vines is effective, as long as all traces of stems are removed; it is, however, tedious and impractical for large areas of invasion.

In North America, herbicides have been widely used to control the spread and growth of Japanese honeysuckle. Glyophosate solution is widely considered the best herbicide for controlling Japanese honeysuckle, because it can be applied late in the season, when surrounding plants have gone dormant but the honeysuckle vines remain active. Herbicides such as bromacil, hexazinone, and picloram have also been used successfully to control Japanese honeysuckle invasions.

Because Japanese honeysuckle grows fast, produces multitudes of fragrant flowers, and is easy to care for, some gardeners may continue to prefer it. Many other species of honeysuckle, however, offer the same fragrance, flowers, and hardiness without the ecological risk. Gardeners are encouraged to choose a native, noninvasive species, such as coral honeysuckle (*Lonicera sempervirens*), in lieu of Japanese honeysuckle. Coral honeysuckle is not only fragrant, attractive, fast-growing, and easy to care for but also prevents soil erosion and offers similar benefits to wildlife.

Marjorie McAtee

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Hops

A member of the Cannabinaceae family, hops (*Humulus lupulus*) are related to cannabis. Used primarily in brewing beer, hops resin imparts bitterness to beer whereas the essential oils impart flavor and aroma. Hops may have been used in brewing initially because they prevented beer from spoiling. Hops fibers may be used to make cloth or paper. An extract from hops leaves may be used to dye wool or tan leather. In the United Kingdom, some people eat the young shoots of hops like asparagus, but the practice is not widespread.

Biology

A dioecious perennial, hops bear male and female flowers on separate plants. Wind pollinates the female flowers. Each male flower has five sepals and five anthers. The perianth of the female flower bears two stigmas and the ovary. Female plants are more numerous than male plants, doubtless an evolutionary adaptation because the pollen from one male may pollinate the flowers of several females. Where the germination rate is low, female plants are much more numerous than male plants, implying that the females are more vigorous than the males. Female plants germinate faster than male plants. As a rule, female plants outnumber male plants two to one, though the ratio is four to one in the Saazer variety. Hops need long days to flower. The variety Fuggle flowers with 16.5 hours of daylight. The variety New York blooms with 15.5 hours of daylight. In Kashmir, India, hops flower in two periods. The first occurs before the maximum hours of daylight but ceases at the summer solstice, whose duration suppresses further flowering. Once past the solstice, flowering resumes.

Lacking tendrils, hops are nevertheless a climbing plant, using hairs on the stem to latch onto a surface. The haploid number of chromosomes is 10. Accordingly, a diploid has 20 chromosomes, a triploid 30, and a tetraploid 40. Triploids are uncommon. Seeds must overwinter at least six weeks at 10°F to 41°F before they will germinate. Seeds dipped in sulfuric acid for nine minutes germinate well. The short days of autumn cause a plant to be dormant, though its treatment with gibberellic acid restores growth. A hops plant is usually dormant by early September. The foliage dies in late October and early November; though, being a perennial, hops will regrow from the roots when warm weather returns. In spring, when growth resumes, photosynthesis suffices both to generate growth and to store carbohydrates in the roots.

History

Although hops may have originated in China, the oldest reference to them comes from a German text in 736 CE. A Finnish oral account of hops is claimed to be 3,000 years old, but because it was written only in the 19th century, its true age is difficult to determine. In the eighth century, at the time the German text was written, Slavs grew hops in Germany. Their word for hops, *hmelj*, may derive from Finnish, suggesting that the oral tradition is indeed old.

These first plantings may have been for medicinal use rather than for brewing. In 1653, British herbalist Nicolas Culpeper asserted that hops benefited the liver, spleen, and stomach, "cleansed the blood," and caused the body to produce urine. Culpeper recommended hops for the treatment of scabs, sores, and breakouts on the skin. Hops were potent enough, he believed, to expel worms and counteract poison. An extract of hops, mixed with sugar, supposedly cured jaundice and alleviated headache. In 1701 one writer, perhaps familiar with Culpeper's work, asserted that hops "purified the blood," benefited the liver and spleen, and cured tumors, flatulence, and skin diseases. In 1887, the American writer known by the surname Longshore-Potts recommended tea made from hops to alleviate pain in women who had given birth.

Even if medicinal use preceded brewing, the interest in using hops to brew beer was never dormant. Referring to the use of hops in brewing beer, British herbalist John Gerard opined in the 17th century that they were nourishing in this context. He also acknowledged the practice of eating hops buds and young leaves in salad but doubted that they were nourishing in this circumstance. Gerard recommended the apparently common practice of adding hops flowers to bread.

Returning to the narrative, between the ninth and 12th centuries farmers cultivated hops in Bohemia, Czech Republic; Slovenia; and Bavaria, Germany. By the 12th century, Bohemia was exporting hops to Hamburg, Germany. German brewers disliked local hops varieties and instead planted those obtained elsewhere in Europe. The foreign cultivars produced hops of superior quality, but the yield was low. As early as 1160, farmers grew hops in the former Yugoslavia, although acreage did not expand until after 1870. In the 14th century, hops spread from Central Europe west to Flanders. Farmers did not raise hops commercially in England until 1524, when Flemish growers demonstrated their farming methods. One authority believes that hops culture in England predated Flemish influence, going back to the period before the Norman Conquest (1066). In support of this thesis, archaeologists discovered the remains of a boat laden with hops along the Kent coast of England, dating it to 950 CE. Hops acreage increased during England's enclosure movement. The Thirty Years' War of the 17th century retarded hops culture in the Czech Republic. In the 17th century, farmers planted hops in Brandenburg, Germany; Silesia, Poland; Bavaria, Germany; Styria, Austria; Baden, Germany; and Russia. In Russia, hops farmers suffered a setback in the 16th century, when Czar Ivan the Terrible passed laws that favored the making of vodka rather than beer. In the 18th century, hops acreage expanded in Poland.

In 1629, the Massachusetts Company introduced hops into North America. By the mid-17th century, farmers cultivated hops in Massachusetts, New York, and Virginia, though they were not an important crop until the early 19th century. In 1808, farmers made the first commercial planting of hops in New York. Plant diseases forced farmers to shift cultivation from New England to the drier climate of the West Coast. As early as 1799, the British tried to plant hops in Australia, though success came only in 1803 and 1804. In the 1880s, Europeans introduced hops into Kashmir, India, and Japan. During World War I Japan, unable to import hops from Europe, concentrated on developing a domestic hops husbandry. In 1921, Japan introduced hops into China. By 1949, the plant had spread to Xingiang, Gansu, Neimeng, Beijing, Shanghai, and Zhejiang, China, though mold and downy mildew forced the abandonment of hops culture in the last three locales.

The Soil and Nutrients

Hops tolerate a range of soils, doing well even on heavy clay and sandy soil. The soil must drain well and be deep enough to support hops' long roots. Although rainfall must be adequate in the absence of irrigation, hops will not tolerate waterlogged soil. The soil pH should be at least 6.5. The farmer should lime acidic soil. More than many other crops, hops are a heavy feeder of soil nutrients. Recognizing this fact, one authority in 1934 recommended the addition of 300 pounds of nitrogen, 200 pounds of phosphorus, 200 pounds of potassium, and 41 tons of manure per acre of hops land.

Much research has focused on nitrogen, but no consensus exists regarding how much to apply to the soil. One authority calls for 264 pounds of nitrogen per acre, whereas others recommend 132 to 200 pounds per acre. The low figure assumes that the farmer applied manure to the soil in previous years. The figure of 200 pounds per acre supposes that the farmer applied no manure. One study found that a crop of hops removes from the soil 105 pounds of nitrogen per acre. Because hops absorb 65 percent of the nitrogen in soil, the farmer, by this calculation, should apply 165 pounds of nitrogen per acre. Other researchers report high yields with 200 pounds per acre. Recent recommendations, however, lower the amount of nitrogen to between 44 and 70 pounds per acre. Complicating these numbers are regional variations. Soil in the Yakima Valley, Washington, should receive 140 pounds of nitrogen per acre. The best soils in the Yakima Valley need no additions of nitrogen. One scientist counsels British farmers to apply 120 pounds per acre, though some get by with less. Large applications of nitrogen make hops vulnerable to the disease verticillium wilt, giving the farmer incentive to reduce the amount of the element. Moreover, the farmer should minimize the amount of nitrogen to dense plantings of hops because nitrogen, in promoting the growth of foliage, causes hops plants to shade one another.

In the United Kingdom, hops land may need as much as 265 pounds of phosphorus per acre, though often only 44 to 88 pounds per acre are necessary. The maximum application of potassium should be 395 pounds per acre, though in many cases 66 to 130 pounds per acre suffice. One authority recommends the application of 200 pounds of phosphorus per acre and 240 pounds of potassium per acre in Germany. Similar amounts suffice in Yakima Valley, though the most fertile land needs neither phosphorus nor potassium. The farmer must not apply too much potassium for fear of causing magnesium deficiency. One scientist counsels the farmers to apply 26 to 88 pounds of magnesium per acre. Causing leaves to curl in a condition easily mistaken for viral disease, zinc deficiency is common in hops lands in Europe and the United States. The soil in the Yakima Valley is often deficient in zinc. A shortage of boron is common in New Zealand and Germany.

In the former Yugoslavia and Willamette Valley, Oregon, hops need 18 to 20 inches of water per year, though the amount rises to 30 inches per year in the Yakima Valley. In the former Yugoslavia, Oregon, and Washington, hops farmers supplement rainfall with irrigation. The arid regions of Xinjiang, China, the Yakima Valley, and Backa in Serbia and Hungary require farmers to irrigate hops.

Varieties and Breeding

In 1901, one writer listed 60 hops varieties grown in Europe. British farmers then grew 20 varieties. In 1905, German farmers also grew 20 varieties, 8 of them maturing early, 7 late, and 5 intermediate. In Germany, Saazer and Hallertauer varieties were popular. Slovenian farmers grew the variety Savinja Golding. Farmers in the former Yugoslavia grew Fuggle, a British import. They called the variety Fuggles Golding, a confusing appellation because it could be mistaken for the variety Golding. The British named varieties—Fuggle and Golding are examples—after the farmer who had selected them.

In the United States, growers hybridized wild hops with European varieties to obtain the Cluster varieties. Early Cluster, for example, was a selection from Oregon, whereas Late Cluster was a hybrid grown in Massachusetts. Oregon farmers grew Fuggle, Bullion, and Brewer's Gold, all British imports, because they were more resistant to downy mildew than were the Cluster varieties. Because downy mildew was less prevalent in Washington and Idaho, farmers in these states grew Cluster varieties. For many years, Oregon farmers grew Cascade, a product of the Oregon Agricultural Experiment Station, though Willamette has supplanted it. Another recent cultivar, Columbia, is less widely grown.

In the late 19th century, scientists began breeding hops. In 1925, the Czech Republic established the Hop Research Institute, and Germany founded the Hans Pfulf Institut for Hop Research. The latter institute bred varieties resistant to downy mildew. In the United States, Prohibition dampened research, but in 1930 the U.S. Department of Agriculture and the Oregon Agricultural Experiment Station began breeding hops resistant to downy mildew. Poland, Russia, South Africa, Australia, New Zealand, and Mexico all fund hops-breeding programs.

Christopher Cumo

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Horseradish

Horseradish, *Armoracia rusticana Gaertn., Mey. & Scherb.* (also known as *Armoracia lapathifolia Gilib., Cochlearia armoracia L.*, and by other names), is one of the few plants of temperate climates cultivated for its value as a spice. When crushed, its root has a highly pungent taste and exudes a strong aroma that may burn the nose and eyes. Japanese wasabi is a different species, much harder to grow, but with similar taste and effect.

Botany

Armoracia rusticana is an herbaceous perennial belonging to the family Brassicaceae (or Cruciferae), which includes cabbages and mustards. The genus *Armoracia* contains only one species, native to Europe and western Asia. The origin of horseradish is uncertain; it is to be found in either western Asia or Eastern Europe. The plant is now found throughout Central and Eastern Europe and is cultivated around the world. In Europe, it encounters the combination of longer growing seasons with cooler temperatures and winter frosts as well as the moist and semishady environments it prefers. It can grow from seed but oftentimes does not produce any of its own. Mainly, horseradish spreads through underground shoots. It is not only being cultivated but is also found in the wild, often growing from pieces of roots left in the ground after cultivation was given up.

Horseradish typically grows two to three feet high, with elongated-elliptical leaves of up to 20 inches in length. Besides the plant cultivated as condiment, there is also a variety with variegated leaves grown as an ornamental. The root of horseradish, the part of the plant that is usually used (young leaves are also usable), is long, thick, and tapered.

Chemistry

The volatile chemicals responsible for horseradish's strong aroma are isothiocyanates, which are the types of chemicals that also give mustard its strong flavor. They form through the combination of precursor chemicals in the root when the cell membranes are torn, such as from biting or grating. The pungency of pepper (black pepper, *Piper nigrum L.*) or peppers (*Capsicum sp.*) is mainly felt in the mouth and especially on the tongue, whereas piperin excites nerve cells responsible for the perception of pain and capsaicin those normally reacting to heat. In contrast, the hot taste of horseradish (as well as wasabi and mustards) stems from volatile oils that have the greatest effect in the nose and also stimulate the flow of tears.

Cultivation

Horseradish is widely grown in Europe; most of the world's production is in the United States, where it is grown as an annual. It is propagated by planting side roots. Horseradish is preferably planted in deep, fertile, and moist soils to ensure good growth of the roots, which can reach three feet in length. However, it grows well in a wide range of conditions.

Horseradish was once employed as a medicine, not surprisingly since the pungent agents work strongly in the sinuses. Cultivation for the root, to be used as a condiment, is a more recent invention. Horseradish sauces were first made in Germany and Denmark, from where the use spread to Great Britain.

Use

Horseradish roots are grated for use as a spice, often alone. British herbalist John Gerard, in his *Herball* of 1597, mentions the use of grated horseradish with a bit of vinegar, rather than of a mustard sauce, as a common German condiment accompanying fish. In Austria, a combination of horseradish and apples is popular with meats. In Central and Eastern Europe, it is also combined with vinegar and cream or with beets. In Great Britain, horseradish sauce developed into a typical accompaniment to roast beef. Horseradish sauces can be kept, but only for a short time; they can also be warmed but should never be boiled. The pungent principles are highly volatile so that fresh grating provides the best aroma. For commercial uses, horseradish flakes are also dried.

The different pathways through which pepper or capsicum, on the one hand, and horseradish (or mustard), on the other hand, feel pungent also translate into a different tolerance for hot foods: Europeans accustomed to the effect of horseradish sauce and mustard in the nose tend to have difficulty handling the "heat" of chili peppers; people accustomed to cuisines that employ chili peppers tend to handle the vapor of horseradish and mustard badly.

Wasabi, Japanese Horseradish

Wasabi, Eutrema *japonica (Miq.) Matsumara*, also belongs to the Brassicaceae but is a different species than horseradish. The part of the plant that is used is not the root but a rhizome, accounting for the green color of the spice. Horseradish, grated and colored by a food-coloring agent, is often used as a replacement for wasabi, especially as true wasabi is harder to grow and loses its aroma quickly. The taste of wasabi is somewhat fresher and purer than that of horseradish, but has similar burning and lachrymatory (tear-causing) effects. It is a typical accompaniment to sushi and sashimi. A little wasabi may be put on the sushi during preparation, but mainly it is mixed—by the customer, as desired—into the soy sauce used as a dip for the fish. The antimicrobial effects of wasabi are thought to protect from the danger that the consumption of raw fish may pose.

Wasabi is much harder to grow than is horseradish, ideally requiring cold flowing water and cool temperatures, but with little or no frost. Successful plantations have been developed in New Zealand and North America. With the rise in popularity not only of Japanese cuisine but also of hot and pungent tastes in general, one can increasingly find wasabi used as a spice, even for potato chips and other snacks. In traditional use, fresh root should be grated shortly before consumption. Wasabi is a peculiar ingredient in Japanese cuisine, indicative of a liking for hot tastes (also asserted by Japanese spice mixtures and sauces using chili peppers) in a culture of cooking otherwise best known for trying to keep the individual flavors of the ingredients as pure as possible.

Gerald Zhang-Schmidt

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Horsetail

In the family Equisetaceae and the genus *Equisetum*, horsetail is a perennial that issues forth from a rhizome in spring. A Northern Hemisphere denizen for the most part, horsetail derives its name from the foliage's resemblance to a horse's tail. The genus name *Equisetum* combines two Latin words, *equus*, meaning "horse," and *seta*, meaning "bristle," a characteristic of the shoots. Known by many names, horsetail is horsetail rush, bottle brush, paddock piper, joint grass, foxtail, scrub grass, slave grass, pewterwort, Dutch rushes, scouring rush, scome scouring rush, mare's tail, meadow pine, devil's guts, horse pipes, horsetail fern, pine grass, foxtail rush, and snake grass. The multiple references to grass are confusing because horsetail is not a grass. On the other hand, the reference to horsetail is a kind of fern seems sensible given the superficial resemblance between horsetail and fern. The allusion to horsetail's use as a scouring agent is also sensible given this function. In Anglo Saxon, horsetail is *equisetia tanseac leac*. In German, horsetail is *Schechtelhaim*, *Zinnkraut*, *Katzenschwanz*, *Hexenbesen*, and *Tannenkraut*. In French, the plant is *prele des champs* and *equiseta*. Italians know horsetail as *coda di cavallo*, *setolini*, and *rasparella*. In Spanish, horsetail is *equiseta* and *cols de caballo*, and in Irish it is *cireaball capatill*. The Japanese know the plant as *tsakushi*. Horsetail claims a range of uses, notably in cuisine, cleaning, and herbal medicine. Herbalists have perhaps made outlandish claims of its efficacy.

Legend and Attributes

One legend holds that a treasure lies beneath the roots of a horsetail plant. Only digging up all of horsetail's extensive roots can retrieve the treasure. This writer does not know anyone who has claimed this reward. Forest sprites can change into horsetail plants to disguise themselves according to Russian, Czech, Slovakian, and German legend.

An ancient plant, horsetail must have evolved before the angiosperms and so lacks flowers. Instead of propagation by seeds, as flowering plants do, horsetail passes its traits to the next generation through spores. Horsetail also propagates by issuing forth a new plant from a rhizome every spring. This new plant is a clone of the parent. Horsetail seems unable to claim the genetic diversity of crossbreeding plants. In addition to lacking flowers, horsetail has no leaves. Some believe the mass of erect foliage resembles a tiny pine tree. The first shoots of spring are pink, but they wilt quickly and turn brown. In May, new shoots emerge. The shoots of the field horsetail (*Equisetum arvense*) may reach two feet in length. *Equisetum giganteum*, a South American indigene, grows taller.

Whatever its size, horsetail is brittle. Children take delight in the ease with which they can pull it apart. With the exception of a few South American species, horsetail is, we have seen, a plant of the Northern Hemisphere. It tolerates sand and loam and must have damp, even wet soil. Marsh horsetail is confined to damp ground and swamps. Field and wood horsetail (*Equisetum sylvaticum*), however, tolerate dry conditions. Horsetail may be found in fields, ditches, and underbrush and along roads and railways. Horsetail can grow at elevation. Horsetail tolerates shade. Gardeners who wish to deter horsetail from spreading may interplant it with marigold, which reputedly inhibits the growth of horsetail. Also, the coverage of soil with black plastic makes it too hot to support horsetail.

Uses

Horsetail is best harvested between May and July. Large horsetails produce edible, starchy tubers. The Romans cooked the foliage as moderns do asparagus. The Romans also fried horsetail. The Japanese eat horsetail as a vegetable. Horsetail has a bitter, salty, gritty flavor. It seems difficult to imagine its consumption in large quantities.

Because the plant has silica, it has been used as an abrasive. In the past, warriors and hunters scoured the shafts of arrows with horsetail. Knights used horsetail to shine armor. Weavers cleaned shuttles with horsetail. Moderns have used horsetail to polish pewter, taking care not to stain it green. Watchmakers have used the plant to smooth watch parts. Dairy farmers have used horsetail to scour milk pails. Homeowners have used horsetail to clean wooden floors and scrub pots and pans.

Made into tea, horsetail is a diuretic. One writer believes it rids the body of impurities. Horsetail tea reduces swollen areas of the face and strengthens nails and hair. Horsetail tea may heal rashes, acne, and blemishes. The tea reputedly improves the function of the kidneys. It is used to treat kidney stones, swollen legs, eczema, heavy perspiration, prostate ailments, rheumatism, gout, nervousness, ulcers, and bleeding of the nose, lungs, and uterus. Horsetail tea works best when consumed two or three times per day for at least four weeks. A rinse of horsetail may reduce the incidence of dandruff and may improve the function of the scalp's glands. Horsetail reputedly coaxes the glands to secrete less oil, reducing greasy hair. A rinse of horsetail reputedly prevents hair loss. Horsetail may be made into a facial mask to cleanse pores and clear acne. A powder made from horsetail is reputedly used traditionally to treat eczema, rashes, fungal diseases, wounds, and genital sores. A bath of horsetail infusion may be used to wash sore feet, sores, and wounds. Gargling with horsetail rinse may strengthen the gums and prevent infections of the mouth and tonsils. Horsetail may prevent infections of the lungs and bronchia. Ash consumed from a burnt plant reputedly neutralizes stomach acid. The Chinese use horsetail to treat redness of the eyes and blurred vision and to stop bleeding. Veterinarians use horsetail to treat rashes and fungal diseases in animals. Despite these uses, horsetail contains a neurotoxin that causes weakness and trembling. Fortunately, horsetail is seldom consumed in toxic quantities. Cattle, sheep, and horses eat horsetail without ill effect.

Christopher Cumo

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Houseleek

Houseleek is a well-known cultivated plant found in almost every rock garden in the Northern Hemisphere. It is frost resistant down to at least –40°F and can therefore be planted in the far north. Houseleek is available in nurseries in many parts of the world, including Australia and South Africa. It is popular as an ornamental. Several cultivars are available in the trade. The genus name *Sempervivum* means "always living," which indicates its hardiness and usefulness. This is also stressed by local names such as live forever and old man and woman.

Although nowadays it is almost purely an ornamental, in earlier times houseleek was used for other purposes as well. It flowers from June to August, with thick, fleshy leaves that grow in dense rosettes. The pink, purple, or red flowers are actinomorphic (like a star) and have 12 petals. Houseleek is perennial or biennial, and reproduces by division. Its special appearance has given it names such as hen-and-chicks, hen-and-chickens, and hens-and-chickens in England and the United States. The leaves contain organic acids, mucilage, tannins, oils, resins, sugars, and traces of alkaloids.

Origin and History

The houseleek, *Sempervivum tectorum*, is probably one of the oldest cultivated nonfood plants in Europe, and even in the Iron Age was spreading toward Northern Europe. The species appears to have originated in the mountains of Southern and Central Europe, but the juicy plant has a long tradition of being grown on roofs as a protection against lightning strikes, hence its name houseleek. Its species name *tectorum* comes from the Latin *tectum* (roof) and means growing on the roof. This protective use has survived until recently in many rural areas of Europe, for instance in mid-20th-century Ireland. The plant is ascribed a protective effect and has been cultivated as a fire protection on roofs since antiquity.

Frankish king Charlemagne decreed in his *Capitulare de villis vel curtis imperii* (812) that the peasants must have it on their roofs as a fire protection. This usage is also reflected in medieval writers such as Conrad von Megenberg (1309–1374) and in Renaissance herbals. Old names that reflect how it was perceived as a protection against lightning include Thunderplant in English, *Donnerkraut* in German, *donderkruid* in Dutch, and *herbe du tonnerre* in French.

It was brought to North America by early settlers. English traveler John Josselyn observed in 1672 in New England that houseleek "prospereth notably." When roofs began to be modernized in Northern Europe in the late 1700s and peat was replaced by other materials in rural areas, houseleek became instead an ornamental garden plant. It now also grows wild, having spread from gardens in several parts of Europe.

Medicinal Plant

Its use as a medicinal plant is mentioned in numerous medicinal works and herbals from medieval times onward. As early as the ninth century, it was mentioned as a remedy plant that could be used against ear diseases, a use that is described in the late Middle Ages and from more recent folk medicine in many Central European and Balkan countries. It also has many locally known names that allude to this use, such as *Ohrpeinkraut* (German), *lus nan cluas* (Gaelic), *oregliàre* (Furlani), *urehita* (Romanian), *uhovnik* (Croatian), and *fülfü* (Hungarian). This use has been recorded recently in Central Europe (Hungary, Slovakia), the Balkans, among the Istro-Romanians in Croatia, in northern Albania, and in Italy. The expressed sap of the plant is instilled drop by drop in the ear. Polyphenols from this species have recently shown antimicrobial activity. It has also been used to cool fevers. "Our ordinary houseleek is good for all inward heats as well as outwards," wrote British botanist Nicholas Culpeper in 1653.

The crushed crude leaves have been put on bruises, swellings, warts, and wounds. A Scottish Gaelic name, *tineas na gealaich* (moon-sick), may be associated with its use for women's diseases. John Cameron wrote in 1888 that it was used in Scotland for various diseases, particularly "those of women and children, and head complaints." From southern Italy it is reported that the juice of the plant was used to calm burns and irritation. It has therefore been shown to be of interest in alternative and complementary medicine, where it has received a similar use as aloe vera, particularly to protect against sunburn and in wound treatment. In Swabia, the juice obtained from the leaves was said to heal bleeding gums. The tender young leaves, which may be used in salad, are sometimes eaten by children in Central Europe.

Ornamental Plant

Although houseleek is still used in home remedies in many parts of Europe, it is today primarily an ornamental plant and is very popular in cemeteries, in rock gardens, and as ground cover on walls. The plant prefers full sun and does not thrive in the shade. There are many named cultivars available on the market, and a number of closely related species, also used as ornamental plants, including hybrids, can be found in well-stocked nurseries.

Other closely related species that are also used as ornamental plants in gardens include *Jovibarba globifera*, which was originally sent from Ruthenia (in southern European Russia) to Swedish naturalist Carl Linnaeus by the German botanist and explorer Johann Georg Gmelin in the 18th century. It flourished in the botanical garden of Uppsala and from there has been distributed over Western Europe, but it also has run wild.

Ingvar Svanberg

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Hyacinth

Hyacinth is known *as Hyacinthus orientalis*. Formerly, it was classified as a member of the Liliaceae family and later as Asparagaceae. However, modern scientists have grouped plants with features similar to the hyacinth under the family Hyacinthaceae.

Mythology and History

Hyacinths are commonly known as Dutch hyacinths. However, they did not originate in the Netherlands and have been cultivated there only in more recent

Water Hyacinth (Corel)

centuries. During the period before the birth of Christ, hyacinth was a popular plant and native to the Turkey-Iran stretch of Anatolia. For quite a while, it became popular with the Greeks and interwoven with Greek mythology. According to one of the Greek stories, hyacinth is the bloom that sprouted from Spartan prince Hyakinthos's death at the hands of the Greek god Apollo. History also has it that hyacinths were famous for their aromatic blooms over 4,000 years ago and were part of ninth-century BCE Greek poet Homer's and first-century BCE Roman poet Virgil's writings. Although native to Turkey and its immediate neighbors, hyacinth spread to the rest of the Mediterranean, Africa, Asia, and now the Americas. For many centuries, this plant lived an obscure life; but by the 16th century, it gained popularity, with the Netherlands propagating and breeding hyacinths, now famous for its 2,000 cultivars. Approximately 25,000 acres of land is set aside for the cultivation of hyacinths in the Netherlands; hence the popularity of the name Dutch hyacinth. During the early 16th century, hyacinths along with tulips were the prized gifts exchanged between Turkey and the Netherlands. The Double Dutch Hyacinths, although originally from Turkey, became very popular in the Netherlands, such that over a century later it was gifted back to Turkey with its interbred and varying cultivars. Hyacinths helped form a diplomatic bond between the two countries that is present even today.

Cultivation

In the United States, hyacinths thrive in zones 3a to 7b. According to the U.S. Department of Agriculture (USDA), hyacinths grow in California, Texas, Kentucky, Pennsylvania, Utah, and Virginia. They require full sun, can tolerate partial shade, and should be protected from the frost. The soil should be loamy with rich compost. Soil pH can vary from slightly acidic (6.1) to slightly alkaline (7.8). Water should be in controlled proportions as excess water can make the bulb rot. Flowering begins at the onset of spring.

Botany

Hyacinthus orientalis is a perennial herb that propagates and spreads with the help of bulbs. These bulbs are underground shoot reserves, which are the main means of propagation during favorable periods, specifically summer and early autumn. Bulbs are most active during the dormant periods, when they work on the stored energy reserves, after the flowers have withered and the plant has lost its leaves. The loss of leaves is a means for the plant to concentrate its energy in the bulb for the very purpose of propagation and sprouting of new bulbs, similar to the case with deadheading of roses and many other flowering plants.

Hyacinth grows to a height of 8 to 12 inches, depending on the cultivar. It has an adventitious root system that sprouts from the base of the bulb. There is no stem as seen in dichotomous plants. Leaves are protrusions from the bulb that look like slightly bent swords. The leaf edges curve inward, numbering four to six leaves per plant, and with a height that is shorter than the flower bloom. Leaves are mucilaginous. The inflorescence is a spike. A single flower bunch sprouts per plant, which may be as long as a foot. The flowers are seen in vibrant colors of blue, purple, yellow, white, and cream and also in shades of pink and orange. The flowers are highly aromatic. The inflorescence may be described as scapiflorous, where the flower stalk emerges from just below the soil or from soil level, and they are also terminal, as the bunch of flowers of the spike bloom toward the upper half of the flower stalk. Each flower is bell shaped, is irregular, and can be cut along any plane (actinomorphic). Sepals and petals are undifferentiated and are present as two whorls called the perianth, with six partially fused tepals each. The tepals give the flower a star-like appearance and are petaloid (resembling petals with vivid colors). The reproductive state of the inflorescence may be termed as polygamomonoecious, where the flowers may be either hermaphrodite or as male or female. There are six stamens. The ovary of the flower is superior in position or hypogynous (where the ovary of the flower is raised above other flower parts). The styles emerge from a slight depression on the top of the ovary. Seeds range from two to many. The fruit is a wingless capsule. The flower is rich in aromatic oil. An abundance of nectar is found in the flower. Pollination takes place with the help of bees.

Toxicity and Uses

Hyacinth is a poisonous plant and can be fatal when consumed. Due to its poisonous properties, it can be grown as hedge bushes to keep unwanted garden predators away, like deer. A plant that is poisonous in nature, there are no notable pests that are known to thrive on this plant. The toxin is concentrated mainly in the bulbs. This plant is of great delight to gardeners for its ease with growing, its aromatic garden fragrance, and its vivid, lively colors. Plants do not often sprout from seeds; instead, the bulbs are the main media for propagation. Hyacinth is economically important for its ornamental value, where it is grown in large numbers of fields for the purpose of trade. In addition, flowers yield aromatic oil that is used by the perfume industry. As much as 12,000 pounds of flowers are used to extract 2.2 pounds of oil. Flowers are also processed for the extraction of dye.

The beauty of this plant is that it can be grown outdoors as well as in partially shady places and likewise well in a flower pot. According to the season or weather conditions, the pot can be transferred to the shade or indoors, especially during frost. When the flower starts to bloom, it may be shifted to a areas of bright sunlight. During the winter, the bulbs require warmth. Hence, just prior to the main winter cold, mulch the area to lock in the warmth around the bulbs.

Amanda Mittra

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Hydrangea

A perennial shrub or climbing plant, a hydrangea can live more than 50 years. All species of hydrangea need a moist, temperate climate. In the family Sexifraceae, hydrangea is in the genus *Hydrangea*. The word "hydrangea" derives from two Greek terms, *hydro*, meaning "water," and *ongeon*, meaning "a vessel for storing a solid or liquid." Perhaps this derivation stems from envisioning the hydrangea's seed capsule as a kind of vessel. Yet one gardener doubts the association between seed capsule and "water vessel." Moreover, hydrangea is not a particularly thirsty plant, causing one to doubt the association with water. Another possibility, according to one gardener, is that hydrangea derives from the Greek monster hydra, whose multiple snakeheads resemble a hydrangea's seed capsules. Despite its attractiveness, the hydrangea does not enjoy the popularity of the rose or even the rhododendron. In the 19th century, French and German texts celebrated the

Hydrangea (iStockPhoto)

shrub, but little was written in English, suggesting a comparative lack of interest. Recent publications may suggest a renewal of interest in hydrangea.

Distribution and Collection

The hydrangea was one of the denizens of the temperate forests in the Tertiary Period (65–2.6 million years ago). In the Eocene Epoch (40–70 million years ago), hydrangea fossils place the shrub in what are today Alaska, California, and Oregon. In the Oligocene Epoch (25–40 million years ago), fossils place hydrangea in Colorado, Oregon, and California. In the Miocene Epoch (12–25 million years ago), fossils place the shrub in Oregon, Washington, and Shantung province in China. Hydrangea is naturalized in eastern Asia, eastern North America, and western Central and South America. In eastern Asia, hydrangea is numerous in Tibet, central and southern China, Japan, the Philippines, Taiwan, and the Indonesian islands of Java and Sumatra. Its existence in the tropics does not mean that hydrangea is a tropical plant, because it grows at elevation, where the climate is cool, in the tropics. North America has two native species: *Hydrangea arborescens* of the Appalachian Mountains and *Hydrangea quercifolia* of the piedmont of the southeastern United States. In Central and South America, hydrangea, unable to tolerate the hot lowlands, is confined to the mountains. *Hydrangea integrifolia* grows in Central and South America, the Philippines, and Taiwan.

Hydrangea may be a comparatively late addition to the many plants that humans cultivate, though one gardener believes that the Chinese and Japanese cultivated hydrangea in prehistory. Only in 1736 did the British import *Hydrangea arborescens* from Pennsylvania, though it may be possible that cultivation of other species may have begun earlier. In 1798, the Royal Botanic Garden at Kew, Great Britain, obtained hydrangea from China. At first the species was known as *Hydrangea bortensis*, but it was renamed Sir Joseph Banks in honor of a British naturalist. In the 17th and 18th centuries, interest in hydrangea heightened in Japan. The Dutch East India Company, establishing a trading post on the island of Deshima in Nagasaki Bay, gave plant collectors access to Japan's flora. In 1775, Swedish physician Carl Peter Thunberg collected Japanese hydrangeas, as did Bavarian eye specialist Philip Franz von Siebold in 1826. Among the finds were *Hydrangea macrophylla*, *Hydrangea involvicrata*, *Hydrangea paniculuata*, and *Hydrangea petiolaris*, all of which made their way to Europe by the late 19th century. About the same time, plant collectors brought *Hydrangea anamala*, *Hydrangea aspera*, and *Hydrangea heteromalla* from Nepal to Europe. In the 20th century, plant hunters brought climbing hydrangeas from Central and South America to the United Kingdom.

Botany and Attributes

Many florets decorate the inflorescence, which has three kinds of flowers. First, tiny fertile flowers may be grouped together in the center of the corymb or arrayed throughout the inflorescence. Nectar from these flowers attracts insects, which pollinate them. The second type of flower is decorative but sterile. These flowers comprise large sepals and may be on the margin of the corymb or distributed throughout the panicle. The third type of flower arose as a mutation and it is the flower that many gardeners envision when they think of a hydrangea. This type of flower is widely cultivated. It may have sterile florets, which intermingle with the few, if any, fertile flowers. The French call this flower hortensis whereas the British refer to it as a mophead.

Fertile flowers may be white, pink, blue, or lilac. Sterile flowers may be these same colors or yellow. The leaves are ovate and opposite. As a rule, a cultivar is more colorful that the species from which it derives. The most widely grown cultivars derive from *Hydrangea macrophylla*. *Hydrangea aspera* and *Hydrangea heteromalla* are large shrubs. *Hydrangea hirta*, *Hydrangea involucrate*, *Hydrangea quercifolia*, and *Hydrangea sikokiana* grow 3 to 7 feet tall. *Hydrangea arborescens* achieves a height of 3 to 14 feet. *Hydrangea arborescens* grows 4 to 5 feet tall. Snow Queen and Snowflake, cultivars of *Hydrangea quercifolia*, also grow to 4 or 5 feet. *Hydrangea aspera*, *Hydrangea halromalla*, *Hydrangea paniculate*, and *Hydrangea scandens* reach 20 feet in height.

Having evolved in woodlands where taller trees shaded it, hydrangea does well in partial shade. The midday sun may bleach or scorch flowers, turning them brown. Sunlight may cause such rapid transpiration that leaves droop even when the soil is moist. A hydrangea whose leaves droop in shade needs water. *Hydrangea paniculate* is unusual in preferring full sun. *Hydrangea macrophylla*, native to the mountains of Japan, prefers shade and a cool climate. *Hydrangea arborescas* tolerates cold, heat, and drought. *Hydrangea petiolaris* and *Hydrangea quercifolia* tolerate temperatures as low as –20°F. Hydrangeas tolerate humidity. Because flower buds are most tender in April and May, cold can kill them. The plant, being hardier than the buds, will survive, but it will not flower until the next year. Hydrangea thrives in loam. Sandy soil is not ideal because it retains water poorly. Clay, sand, and stony soil need compost or manure to improve their ability to retain water.

Hydrangea is unusual in being able to change the color of its flowers. *Hydrangea macrophylla* may produce pink flowers one year, lilac the second, and blue the third. A single shrub may display multiple colors at the same time. In the late 18th century, gardeners first noted this unusual ability. Scientists have connected it to soil pH. Acidic soil yields blue flowers. The lower the pH the more intense is the blueness. The gardener who prizes blue flowers may add sulfur compounds to the soil to lower the pH. Blue flowers also arise from the presence of aluminum in the soil. The sepals of blue flowers have 10 times more aluminum than the sepals of pink flowers. The gardener may add aluminum sulfate or potassium aluminum sulfate to the soil to obtain blue flowers. Too much aluminum, however, injures roots. In addition to having acidic, aluminum-rich soil, the gardener may derive blue flowers by adding to the soil fertilizer rich in potassium, low in phosphorus, and with nitrogen in the form of nitrates rather than ammonium. A fertilizer in a ratio of 25:5:30 of nitrogen to phosphorus to potassium is ideal. Soil with a pH of 7 to 7.5 yields pink or red flowers. The gardener may add lime to the soil to derive pink or red flowers. Too high a pH, however, prevents roots from absorbing iron. Leaves will yellow. The gardener who wishes to obtain pink or red flowers should add to the soil fertilizer in a ratio of 25 to 10 to 10. Curiously, a hydrangea transplanted from a pot to a garden will shift toward red even in acidic soil. Pink flowers will become deep pink or red, and blue flowers will turn pink. The next year, however, the flowers will be blue. *Hydrangea serrate* is an oddity in retaining red flowers in acidic soil.

The gardener may plant hydrangea in spring after the last frost or in autumn. A hydrangea may be fertilized at planting and twice more per year thereafter with a complete fertilizer. Alternatively, one may add liquid fertilizer when hydrangea is watered. The soil should be mulched to retain moisture.

Hydrangea macrophylla, the most popular species, has a large number of cultivars. All Summer Beauty is prized in the United Kingdom and the United States.

The Netherlands sells the variety, though its origin is unknown. When young, sepals are pale blue along the edges and cream in the center. As they age, sepals become light blue throughout. Flowers are blue. Alpengluehen, another variety, has red flowers in soil with a pH of 6.5. The cultivar has three to five sepals per flower. Mature sepals are deep red.

Christopher Cumo

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I

Impatiens

In the family Balsaminaceae and the genus *Impatiens*, impatiens is related to geranium and pelargonium. The name "impatiens" derives from the fact that the seed capsule ejects from a flower when ripe. This action led botanists to suppose that the seeds were impatient to germinate. The contraction of an elastic valve ejects the seed capsule. Because touching a capsule causes its ejection, impatiens is called "touch me not." Another name for impatiens, "balsam" must be a truncation of the family name. Although Swedish naturalist Carl Linnaeus had only 7 species at his disposal in 1753, today the genus has more than 1,000 species.

Attributes

Before 1970 few gardeners grew impatiens, but their popularity has surged to such a degree that the ornamental now adorns pots, window boxes, containers, hanging baskets, parks, and cities. Impatiens are native to temperate, subtropical, and tropical Africa, Madagascar, and Asia, especially India, China, and Southeast Asia. Because many species are found in the subtropics and tropics, it is easy to mistake impatiens as a warm-weather plant. In fact, they do not thrive above 77°F. In the tropics and subtropics, they grow between 1,000 and 3,000 feet in elevation, regions that are cool. A few species are found in temperate Europe and North America. Species are territorial. No Africa species occurs naturally in Asia and no Asian species occurs naturally in Africa.

The genus *Impatiens* has both perennial and annual species, though gardeners in temperate locals grow perennials as annuals because frost kills the plant. Most perennial species are found in Africa, southern India, and the East Indies. The annuals have colonized the Himalayas, northern India, and Nepal, though the eastern Himalayas and China have perennials. Most impatiens prefer damp, shady environs near rivers and streams and among moss and fern. A few species are epiphytes. Others sink roots in the cracks of rocks, where they absorb the minerals from decaying organic matter. Some impatiens are only three or four inches tall whereas others reach three yards in height. Some species are semiaquatic.

The 19th century was the era of the plant hunter. Botanists searched Europe's colonies for new species, including impatiens. Botanists Robert Wight, Richard Henry Beddome, Michael Palenham Edgeworthy, and Nathaniel Wallich collected impatiens throughout the world, discovering hundreds of new species. In 1859, British botanist Joseph Dalton Hooker published the first monograph on impatiens. In 1874 and 1875, Hooker published the *Flora of British India*, describing 120 species of impatiens native to India. Between 1904 and 1906, he published *An Epitome of British Indian Species of Impatiens*, in which he classified still more species. In 1980, botanist Christopher Grey-Wilson published the *Impatiens of Africa*, classifying all known African species.

Impatiens does not tolerate dry conditions and when in distress sheds old leaves to reduce the loss of water through transpiration. Impatiens has two types of flowers, flat and pouched. Only butterflies and moths have noses long enough to pollinate flat flowers. The pouched flowers are easier to access and are pollinated by bees and wasps. Although most species are insect pollinated, a few self-pollinate, especially those at high altitude where insects are scarce. Impatiens may have five petals and five sepals, though many species have only three sepals. Each flower has five anthers and five stamens. These surround the stigma.

Species

One gardener regards *Impatiens walleriana* as the world's most widely grown ornamental. Gardeners worldwide cultivate it. The species has a convoluted history. Native to East Africa, it was discovered on the island of Zanzibar and named *Impatiens sultanii* to honor the island's sultan. In 1896, the species was first cultivated, presumably by Europeans. Others putative species were named *Impatiens holstii* and *Impatiens hopsii*. Only in 1980 did Christopher Grey-Wilson aggregate all these species into the single species *Impatiens walleriana*, named in honor of botanist Horace Waller, who collected impatiens on an expedition to East Africa with Scottish explorer David Livingstone. The species may be found in Kenya, Mozambique, and Malawi. *Impatiens walleriana* has the moniker "busy Lizzie." Because of its popularity, the species serves as a parent in hybrid crosses with other species. *Impatiens walleriana* flowers from May to autumn's frost. Its flowers may be red, pink, orange, salmon, lilac, mauve, or white.

Also popular is *Impatiens hawkeri*, a species native to Papua New Guinea. The natives have grown the species for generations, collecting and trading it. It has been in cultivation, presumably by Europeans, since 1886. In the 1970s botanists, many of them in the United States, crossed *Impatiens hawkeri* with species from the Indonesian islands of Java and Sulawesi to yield New Guinean hybrids, which are popular in their own right. *Impatiens hawkeri* grows one yard tall and has been known variously as *Impatiens herzogii*, *Impatiens mooreana*, and *Impatiens schlecteri*. *Impatiens herzogii* has vermilion flowers. *Impatiens mooreana* has green leaves and pink flowers. *Impatiens schlecteri* has bronze leaves and red flowers. *Impatiens hawkeri*, into which these species were subsumed, characteristically has green leaves and magenta flowers. It may be propagated by seeds or cuttings.

Because impatiens seldom hybridizes in nature, there are few intermediate forms to cause confusion. Rather, the poor state of specimens in herbaria may account for the profusion and confusion of names. On at least one occasion, botanists have given a single species different names. In other cases, botanists have conflated two species into one.

There are no species of impatiens in South America, Australia, or New Zealand. North America has just two species, *Impatiens capensis* and *Impatiens pallida*. *Impatiens capensis* has orange flowers with red spots or yellow or white flowers. *Impatiens pallida* has yellow flowers. Aside from color, the species are difficult to differentiate. These species are popularly known as jewelweed, "spotted touch me not," and "pale touch me not." The moniker "jewelweed" derives from the fact that water, beading on the leaves, resembles gems or jewels. In the United States, the leaves of *Impatiens capensis* and *Impatiens pallida* are used to treat poison ivy. An extract from the flowers is thought to kill bacteria and fungi. Britain has one indigene, *Impatiens noli-tangere*. George Bowles discovered the species in 1632. Linnaeus named the species *Impatiens noli-tangere*, meaning "do not touch." It has yellow flowers and grows one yard in height. The species prefers moist, shady habitat. *Impatiens noli-tangere* is also found in Continental Europe and Asia.

In 1838, Europeans began to cultivate *Impatiens glandulifera* from Nepal. Hooker grew it in his garden. The people of Nepal eat *Impatiens glandulifera* seeds, using oil extracted from them in cooking. The species grows more than two yards tall and bears pink and purple flowers. *Impatiens glandulifera* is easy to cultivate, grows in a range of soils, tolerates sun or shade, and flowers abundantly. The species is known as the "Himalayan balsam" and the "policeman's helmet" because the flower is native to the Himalayas and resembles a helmet. Today, *Impatiens glandulifera* is so widespread in the British countryside that some people regard it a weed.

Impatiens balsamina has pink, red, mauve, lilac, or white flowers. Originating in India, the species is now widespread in Asia. For centuries, the Chinese used *Impatiens balsamina* to counteract snakebite or the ingestion of poison fish. Juice extracted from the stem and added to rice liquor is reputed to reduce swelling and heal bruises. When dried, the stem may be pulverized and made into an ointment to relieve pain. Flowers are made into paste to treat back pain and neuralgia. The Vietnamese wash their hair with an extract of *Impatiens balsamina* in the belief that it stimulates the follicles to grow hair. Filipinos use the leaves of other species as a poultice.

The classification of new species of impatiens is ongoing. Chinese botanists S. H. Huang and Y. L. Chan have described new species in Yunnan and Sichuan provinces. Botanist Eberhard Fischer has classified new species in Africa and Madagascar. Today, the sale of African and New Guinean impatiens is a multimillion-dollar enterprise.

Christopher Cumo

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Indigo

A group of annuals, biennials, and perennials, indigo is not a single species of plant but rather several species that share in common the production of indican in their leaves. Indican is a chemical that may be processed into dye. Once widely grown in the tropics, subtropics, and temperate regions, indigo has ceded ground to synthetic dyes. The Greeks knew indigo as *indikon* and the Romans as *indicum*, in both cases meaning "a substance from India." This language reveals that the Greeks and Romans obtained indigo from India. In the 18th century, Swedish naturalist Carl Linnaeus named only one indigo plant, coining the genus *Indigofera*, meaning indigo bearer, at a time when it was the chief source of the dye. A tropical plant, *Indigofera* could not be grown in Europe.

Genera and Species

The most important source of indigo, *Indigofera* is a legume in the family Fabaceae or Leguminosae. Like other legumes, the roots of *Indigofera* shelter bacteria

Indigo flowers (iStockPhoto)

that fix nitrogen in the soil. Because of its beneficial effect, *Indigofera* was grown in rotation with other crops. A genus of the tropics, *Indigofera* has similar cultural requirements as sugarcane and cotton and was cultivated with these crops. With 800 species, *Indigofera* numbers more than 600 species in Africa, roughly 200 in Asia, 80 in the Americas, and 50 to 60 in Australia. Grown from sea level to 3,000 feet, *Indigofera tinctoria*, the most common species in the genus, is a perennial shrub. Its origin in India, the species spread from the subcontinent east to Southeast Asia and west to the Middle East, Madagascar, Africa, and, with the Columbian Exchange, the Americas. Two other species used for dye, *Indigofera arresta* and *Indigofera articiolate*, are native to Africa. From Africa the species of *Indigofera*, including *Indigofera tinctoria*, migrated to Java in the 19th century, where they were known as netal indigo. Curiously, from the 19th century Indians knew *Indigofera* as Java indigo, suggesting a reintroduction from the island to India. By then farmers grew *Indigofera* throughout Indonesia: Sumatra, Sumba, and Flores in addition to Java. Other centers of cultivation were Vietnam, Laos, the Philippines, and the Near East. The people of northwestern India and West Africa cultivated *Indigofera articulate and Indigofera coerulea*. These species fared better in dry climates than *Indigofera tinctoria*. The Muslims grew several species of *Indigofera* in Malta, Sicily, Cyprus, and Spain. The species *Indigofera suffruticosa* and *Indigofera micheliana* are native to the Americas. Farmers grew the former in North America. The Dutch cultivated it in Southeast Asia. The Chinese and Africans also grew it. The American species of indigo may have originated in Mexico, spreading to Central and South America in both pre-Columbian and postconquest periods. Native to North America, *Indigofera coroliniana* was the basis of the Southern plantations. After 1500, Europeans introduced *Indigofera tinctoria* to the Americas.

Whereas the species of *Indigofera* were confined to regions that did not experience frost, *Isatis tinctoria*, known as *woad* or *pastel* in French, was a temperate plant. A biennial in the Cruciferas family, the species, whose leaves resemble those of spinach, is related to cabbage, mustard, and rape. Native to the Mediterranean Basin and western Asia, *Isatis tinctoria* spread to Britain by the Iron Age. Its range extended as far north as Scandinavia, though it was also grown in the Azores Islands. The Columbian Exchange spread it to North America. At the height of woad's popularity, Turkey cultivated more than 36 species. Since the 16th century, the Chinese cultivated the related species *Isatis indigotica*, which they called *sung lan* or *tien-ching*. The British knew this species of indigo as tea indigo or cabbage blue, the latter name doubtless a reference to the plant's relationship to cabbage and to the color of its dye. Grown in Tibet and Afghanistan, the species of *Isatis* were the basis of medieval Europe's indigo industry.

An annual or biennial, *Polygonum tinctorium* is a member of the Polygonaceae family. Known as dyer's knot wood, Japanese indigo, and Chinese indigo, the plant may be indigenous to China, where it is still grown, though on a tiny scale. The Chinese knew *Polygonum tinctorium* as *liao-len*. A subtropical plant, *Polygonum* was cultivated with *Indigofera* and in regions too cold for the latter. After the fifth century, *Polygonum* diffused from southern China to Japan, where it was known as Ai. The chief indigo of Japan, *Polygonum tinctorium*, was also cultivated in Korea and Vietnam. In the 18th century, Europeans grew the species, but only in areas free from frost.

A perennial shrub in the Acanthaceae family, *Strobilanthes flaccidifolias*, which yields dark shades of blue, was known as Assam indigo. Despite this appellation, its culture in India appears to have constituted only a small part of its range, which included southwestern China, Thailand, Myanmar, Bhutan, Laos, Vietnam, Bangladesh, Malaysia, Taiwan, Japan, and Okinawa. People in remote areas grew *Strobilanthes*, leading one to suppose that it seldom entered the market. In the 19th century, Indians cultivated both *Strobilanthes* and *Indigofera*. Farmers propagated *Strobilanthes* from cuttings and harvested the plant before it seeded.

Farmers in West Africa cultivated *Lonchorarpus cyanescens*, known as Yoruba indigo. Young plants yielded the best dye. A member of the Asclepiadaceae family, the vine *Marsdenia tinctoria* honors British plant collector William Marsden, who identified the species in Sumatra. Although he hoped to spread the plant throughout the British Empire, it was widely grown only in Southeast Asia, Myanmar, and the Himalayas. Farmers grew *Marsdenia* in areas that were too wet for *Indigofera*. A member of the Apocynaceae family *Wrightia tinctoria* was known as dyer's oleander and Manila indigo. Farmers grew the species in central and southern India, Borneo, and Malaysia.

Cultivation

In the second century CE, the Chinese began the practice of sowing indigo, perhaps species of *Indigofera*, in seedbeds, transplanting seedlings in the field. From an early date, farmers triple-cropped indigo and rice. Farmers harvested the best dye with the first cutting. After the third year, the poor quality of the dye necessitated replanting. Farmers added nitrogen to the soil of all species of indigo but *Indigofera*, which, as we have seen, is a legume. *Indigofera* needed the addition of phosphorus to the soil to yield well. A versatile crop, *Indigofera* was grown for dye, to enrich the soil, and to feed livestock. Woad exhausted the soil, a fact that may have contributed to its decline in the late Middle Ages. Although synthetic dyes have made indigo obsolete, small numbers of farmers still grow the plants in southwestern China, northeastern and southern India, and western Asia.

Women had an ambiguous relationship to indigo. The Egyptians blamed crop failure on the presence of menstruating women in indigo fields. The Chinese feared that women with flowers in their hair might contaminate indigo plants. On the Indonesian island of Flores, men insisted that women not use vulgar language when harvesting indigo for fear that crudities would offend the soul of indigo plants. Unwilling to endure this language, offended plants would not yield their dye.

History

Of the major classes of indigo, woad yielded a small amount of dye, which Europeans used to color wool. In contrast, *Indigofera* yielded a large quantity of dye, which people used to color cotton and linen. The people of medieval Europe and Byzantium associated indigo with divinity and humility. In India, indigo was the color of infinity and of the god Krishna. In many cultures, indigo was the color of loyalty. Despite these positive associations, Indonesians and more generally Muslims sometimes connected indigo with black magic. From an early date, royalty associated indigo with status. The wealthy in Europe, Egypt, Palestine, Mali, and Peru were buried in clothes dyed in indigo. The elites of Africa, the Middle East, South America, China, Japan, and Indonesia wore robes dyed in indigo.

The people of Catal Huyuk, Turkey, may have used indigo as early as 6000 BCE, though they may have gathered it from the wild rather than cultivated it. Textiles from the third millennium BCE in Turkey display evidence of having been dyed in indigo. Around 2400 BCE, the Egyptians used indigo to dye burial linen, a choice perhaps dictated by the fact that linen absorbs only indigo well. Before 2000 BCE, the Egyptians began to dye wool. The Egyptians may have traded indigo, importing it up the Red Sea from Punt in Africa or southern Arabia. Alternatively, they may have produced indigo locally from woad. As did others, the ancient Hebrews combined indigo with other dyes. Early adopters of indigo, the Hebrews used it by the end of the second millennium BCE. Archaeological evidence of dyed linen at Masada, Qumran, and the Cave of Letters establishes the use of indigo in these areas by the time of Christ. The devout dyed in indigo the linen in which they wrapped the jars that contained the Dead Sea Scrolls.

As early as the third millennium, the Chinese dyed silk in indigo. In the second millennium, the Babylonians mentioned "garments dyed in blue," a sure reference to indigo. Around this time India, with its long tradition of making textiles, began to use indigo as a dye. By the first millennium BCE, the people of Southeast Asia were cultivating *Indigofera tinctoria*. Indigo-dyed garments found in the Altai Mountains of central Asia date to the fourth and third centuries BCE. The tombs at Palmyra, Syria, yielded burial clothes dyed in indigo dating between the first and third centuries CE. At-Tar, Iraq, a city along the Silk Road, contained indigo-dyed clothes dating between the second and fifth centuries, evidence of the longevity of the indigo trade.

In the New World, the Peruvians dyed cloth with indigo, using it to adorn the dead in Paracas, Nazca, and Chancay by 700 BCE. Inca graves contained indigo-dyed cotton, and the Aztecs used indigo as medicine. The Maya used indigo in murals, sculptures, ceramics, and textiles.

About 700 BCE, Europeans began to dye textiles with indigo. About this time, the Poles buried the dead in indigo-dyed clothes. In the first century CE, Greek physician Dioscorides and Roman encyclopedist Pliny the Elder understood that indigo derived from a plant. Pliny noted the use of indigo in frescoes. In Rome, imported indigo cost 20 denarii per pound, 15 times the average daily wage. This price probably induced the Romans to grow woad as a local source of indigo. Roman Palestine likely grew *Indigofera*, exporting the surplus to Rome. The Vikings grew woad in the Middle Ages, establishing York, Britain, as a center of the indigo trade in Northern Europe. In Viking mythology, blue was the color of the goddess of death, though it is unclear whether this association strengthened or weakened woad culture. In the fifth century, the Japanese began cultivating indigo, probably adopting the plant from China by way of Korean merchants. Like the Chinese, the people of the Sassanian Empire, which stretched from Iraq to central Asia by the sixth century CE, dyed silk in indigo. In Africa, Upper Senegal and Nigeria emerged as centers of indigo culture. Between the 11th and 16th centuries, the Tellem of Africa dyed grave garments in indigo.

In the Middle Ages, Jews and Muslims traded indigo from India, Afghanistan, Iran, Syria, Palestine, Tunisia, and Morocco. The Genoese and Venetians traded indigo in Sicily, Italy, and Marseilles, France. Baghdad, Iraq, emerged in the Middle Ages as a center of the indigo trade. Medieval India grew large quantities of indigo, doubtless cultivating species of *Indigofera*. From the ninth century, the Arab world emerged as a center of indigo cultivation. Farmers in Iran, the Jordan Valley, Upper Egypt, and North Africa to the Droa Valley of southern Morocco grew indigo. The Berbers traded indigo in sub-Saharan Africa. The Muslims grew indigo in Cyprus and Sicily. By the 13th century, farmers grew woad throughout Europe, cultivating it in France, Germany, Italy, England, and Spain. So great was the demand for indigo that Spanish woad production was insufficient to satisfy it. Medieval France was Europe's leading producer of woad, exporting indigo to England and Flanders. Normandy, Picardy, and Languedoc emerged as centers of woad production in France. One contemporary credited woad with making Languedoc the "richest in Europe." The region exported hundreds of thousands of bales of woad per year. In Germany, woad at its apex totaled one-third of the income of Thuringia, where wine, hops, and wheat were also important. Prosperous merchants were known as "gentlemen of woad."

In the 13th century, German and French merchants exported indigo derived from woad to Belgium, England, Hungary, Poland, and Italy. In Italy, Tuscany profited from the cultivation of woad. The British, having long grown woad, were nevertheless an indigo importer until the late 16th century. In the 16th century, the high price of French indigo imports goaded England to increase domestic production. England also turned to the Azores and the Canary Islands for cheaper imports. British farmers cultivated woad as far north as Scotland. In the 1580s, the strong demand for indigo threatened the grain harvest in England as farmers switched from grain to woad, which was six times more profitable than wheat. In the 19th century, farmers grew woad in France, Germany, the Azores Islands, the Canary Islands, Italy, Switzerland, Sweden, Spain, Portugal, and Hungary.

Yet woad, important as it was to Europe, never challenged the supremacy of *Indigofera* in the tropics. In the 16th century the Portuguese, intent on capturing the trade in tropical indigo, purchased the dye in the East Indies. By the 1620s, the Dutch and British emerged to challenge Portugal. The trade was massive. In 1631, seven Dutch ships carried hundreds of thousands of pounds of indigo worth several tons of gold. By the early 17th century, indigo was the British East India Company's most valuable commodity. Indigo produced in tropical Asia and the Americas overwhelmed Europe. In 1598 France, awash in surplus indigo, banned its import to protect domestic woad growers, rescinding the ban only in 1737. The German states likewise fought the importation of tropical indigo, calling it the "devil's dye."

In the Americas, the mania for indigo led planters to import slaves to tend the crop. As with sugarcane, rice, and cotton, indigo made laborers miserable. Caterpillars and locusts could ruin a crop. The aversion to working on indigo plantations stemmed partly from the fact that the fermentation of indigo attracted masses of flies. Requiring nearly one worker per acre, the cultivation of indigo led planters to import large numbers of slaves. Pound for pound indigo was as valuable as a slave. In the mid-16th century, the Spanish introduced *Indigofera tinctoria* to Central America, where it yielded commercial quantities of the dye in Guatemala, El Salvador, Nicaragua, Honduras, and Chiapas. The Spanish exported indigo from Mexico, Venezuela, Ecuador, and Peru. By 1600, indigo was the chief crop in Central America. By the 18th century, the Spanish were exporting millions of pounds of indigo from their American colonies. Great Britain and the Netherlands bought Spanish indigo. Europeans considered indigo from Guatemala the best. Yet trouble befell Guatemala. Facing competition from other sources, Guatemalan production fell in the 19th century. In an attempt to revive the economy, the Spanish introduced cotton. In 1822, Guatemala became independent, but its subsequent war with El Salvador hurt *Indigofera* growers. In the 19th century, indigo occupied the dominant position that coffee would hold in the 20th century in El Salvador.

In the mid-17th century, the British and French established indigo plantations in the Caribbean. Planters no doubt understood that they could operate an indigo plantation more cheaply than a sugarcane estate. By 1672, Jamaica had 60 indigo plantations. In the 18th century, farmers grew indigo in Saint Domingue, Guadeloupe, and Martinique. By 1780, Saint Domingue had thousands of indigo estates.

In the 1750s, Portugal intensified indigo production in Brazil. In the 1770s, the demand for indigo threatened food production in Brazil, leading in the 1780s to food shortages in Rio de Janeiro. In the 1790s, Brazilian exports peaked at hundreds of thousands of pounds of indigo per year.

In North America, the cultivation of indigo dated to 1650, when the Dutch attempted to grow woad in New York. Obtaining seed from the Caribbean, the French planted indigo in Louisiana in the 1720s. In the 18th century, factories near New Orleans processed tens of thousands of pounds of indigo per year. After 1750, Louisiana produced hundreds of thousands of pounds of indigo per year, and by the 1790s the figure reached an even higher plateau. In the 1730s, planters in South Carolina grew indigo and rice. The two were companion crops in the sense that the farmer who cultivated both kept his slaves busy year-round. In addition to Louisiana and South Carolina, Georgia, Virginia, Alabama, and Florida produced indigo in the 18th century. In the American South, farmers harvested 80 pounds per acre, an amount that was lower than the yield in Guatemala and the French Caribbean. The end of slavery truncated the cultivation of indigo in the Americas. By the 20th century, the use of synthetic dyes replaced indigo, which is now seldom grown.

Christopher Cumo

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Iris

Iris is both a common name for a flower and the name of the genus of a species of perennial herbs known for their showy beauty. The genus *Iris* is the largest within the botanical family of Iridacea, which belongs in the Order Asparagales. In 1753, Swedish naturalist Carl Linnaeus named the genus. Linnaeus placed many plants in the genus *Iris* and more were added over the years. By the 19th century, however, botanists had created new genera in which to categorize the many species. These subgenera included *Evansia*, *Hermodactylus*, *Moraea*, *Oncocycus*, and *Xyphion*. In 1913, however, botanist William Rickatson Dykes regrouped some of the species, placing some back into the genus *Iris*. For instance, the Snake's Head Iris, called *Iris tuberosa* by Linnaeus, was left in the genus *Hermodactylus*. Since then, the genus *Iris* was reclassified again by such botanists as Ludwig Diels and G. H. M. Lawrence in 1953, and G. I. Rodionenko in 1961. The genus *Iris* currently encompasses around 280 species, about 34 of which are found in North America, and the flowers grow from either rhizomes or bulbs, as is the case in drier climates. Although there are many varieties, the blooms of the iris share common characteristics that make the flower easily recognizable. In particular are the drooping, curled "falls" and the erect or semierect "crests" of most irises.

The Bearded Iris (*Iris germanica*), whose name derives from the short fuzzy hairs on its falls, and the Siberian Iris (*Iris siberica*), which is native to the colder areas of Europe and Asia, are the two most common species grown. Popular colors include blue or purple, white, and yellow. Irises are cultivated worldwide, but grow naturally in the north temperate zone of North America, Europe, Asia, North Africa, and the Middle East. The iris can be found in various habitats within these zones, including cold regions and deserts, and in meadowlands, flooded grasslands, savannas, prairies, steppes, and alpine meadows. Irises are threatened in some areas of the world (mainly the Middle East) due to human activity. There are at least three species that are extinct: *Iris antilibanotica* and *Iris damascena* in Syria and *Iris westii* in Lebanon.

Description of the Showy Plant

Typical irises have long, erect flowering stems that are either simple or branched. The stems can be solid or hollow and can have a flat or circular cross section. Those that derive from rhizomes typically have 3 to 10 basal, sword-shaped leaves that grow in dense clumps. Those that sprout from bulbs have cylindrical basal leaves. The flower cluster is fan shaped and contains one or more symmetrical fragrant flowers, which are typically made up of three or so petals. The fruits are capsules and contain 4 to 20 seeds. Tepals, the outer whorls of the flower that include the petals and sepals, are either erect or suberect with horizontally displaced or drooping falls. The three sepals spread or droop downward and are often adorned with lines or dots. The petals, typically of which there are three, stand upright and join the sepals at their base. The anatomy of the iris allows for the pollination of the flower by attracting specific insects. Some irises are self-pollinating, while others must be artificially pollinated. The seeds tend to germinate at irregular intervals. Being a perennial, irises are a popular choice for flower beds. When cut and displayed in a bouquet, the flowers tend to last from three to five days without wilting.

History of the Iris

The common word "iris" originated with the Greeks and is the word for "rainbow," presumably due to the wide variety of colors that the iris comes in. "Iris" also means "eye of heaven," and is the name of the colored part of the eye. It is also the name of a Greek goddess, the messenger of love, who was the personification of the rainbow. The goddess acted as a link between Olympus and Earth. As a way to summon the goddess Iris, who was thought to be a guide into the afterlife, purple irises were placed on the graves of women in ancient Greece so that Iris would lead them to the Elysian Fields. The tradition continues to this day, as irises are frequently placed on the graves of young girls.

The iris was also cultivated in ancient Greece and Rome for its value as a perfume. *Iris Florentina*, a white Iris on a red shield, was displayed on the ancient arms of the city of Florence, Italy, and is presumed to be the source of the name for the city. The ancient Egyptians revered the iris for its exotic beauty. When 15th-century BCE pharaoh Thutmose III of Egypt conquered Syria, where irises grew profusely, he vowed to bring back the iris to Egypt. Depictions of the flower have been found in many Egyptian palaces, including on the Sphinx, at the Temple of Amon in Karnak, on a bas-relief from the 18th Egyptian dynasty, and in Egyptian gardens. The ancient Romans, especially first-century CE Roman encyclopedist Pliny the Elder, spoke of the iris's medicinal value.

In Europe during the Middle Ages, the iris was linked to the French monarchy. The flower (the "fleur-de-lis") became the symbol of the ruling class and the national symbol of France when King Clovis I adopted the flower as his emblem following his conversion to Christianity. Other French monarchs following the tradition include King Louis VII, who adopted the purple iris as his emblem in 1147, and King Charles V, who added three fleur-de-lis to his coat of arms in 1376.

The earliest records of irises in the New World date to the 1600s in Virginia, where the plant is believed to have been brought by the English settlers. Past generations in England may have acquired them during England's Moorish conquests. In modern times, the fleur-de-lis is the symbol of the city of New Orleans, Louisiana, and the New Orleans Saints National Football League team. It is also the state flower of Tennessee and is depicted on the flag of the Canadian province of Quebec. "Iris" is a girls' name that was fairly common in the 1920s and 1930s in the United States. In the arts, "Iris" is the title of a famous pop music song by the Goo Goo Dolls that was featured in the 1998 movie *City of Angels*. One of the most recognizable paintings depicting flowers is the painting *Irises* by Dutch post-Impressionist Vincent van Gogh, who lived from 1853 until 1890. While hospitalized in an asylum in Saint-Rémy, France, Van Gogh set out to paint what he viewed from his window. He began work on *Irises* his first week there.

Symbolism

Irises, also called flags, have come to signify a variety of emotions, including eloquence, hope, and friendship, and are also a designation of royalty, especially the deep purple variety. The three petals of the iris are believed to represent faith, wisdom, and valor. The petals also signify the Holy Trinity in Catholicism, and the flower is the special emblem of the Virgin Mary. Different-colored irises designate different meanings. The purple, for instance, is symbolic of wisdom and compliments. The blue stands for royalty, faith, and hope, the yellow symbolizes passion, and the white designates purity.

The Chinese associate the butterfly with the iris, as the flower resembles a butterfly's flapping wings. In China, the iris is called Tze-Hu-tieh, which means "the purple butterfly." Irises play an important role in the Japanese spring festival for boys, as the deep blue or purple color signifies blue blood and represents royalty and heraldry.

The Value of the Iris

Irises are grown for their exotic beauty, but they are also a source of medicinal value. The Cherokee, for instance, pounded the root of the Virginia iris into a paste and used it as a salve for the skin. They also made an infusion from the root that was used to treat liver disorders. The Seminole of the southeastern United States used the iris to prevent shock from alligator bites. Juice made from German Iris, also called the Flag Iris, was mixed with wine and used to cure dropsy—a swelling due to fluid retention. Other Native American groups made a root tea that was used for gastric problems, stomachaches, kidney and bladder disorders, and gonorrhea. As a poultice, Rocky Mountain Iris, or *Iris missouriensis*, aided in the treatment of sores, bruises, aches and pains, and lesions. Pieces of the root were placed inside dental caries to deaden the pain of a toothache. Some shamans added the root to tobacco and smoked the root as a way to ease nausea. Today, essential oils derived from the petals are sometimes used in aromatherapy. Iris root that is dried and aged, as well as iris petals, is used as a flavoring in some gin, including Bombay Sapphire.

Rosemarie Boucher Leenerts

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J

Jasmine

In the family Oleaceae and the genus *Jasminum*, jasmine is prized as an ornamental, perfume, flavoring, tea, and medicine. Of the more than 200 species of jasmine, only 50 are cultivated and of these fewer than 10 are cultivated in the temperate zone. Most species are native to the tropics and subtropics. The family Oleaceae has 28 genera and 900 species. It is found worldwide, chiefly in Southeast Asia. Related to olive, jasmine is a perennial with 10 to 12 years' yield of flowers. In Persian, jasmine is known as *simam*, in Arabic as *yasmin*, and in French as *jasmin*.

Origin, History, and Uses

Probably originating in tropical Asia, jasmine has been cultivated since the time of Christ. Jasmine spread from Asia throughout the Old World by antiquity. In Africa, superstition attended the cultivation of jasmine. Some Africans believed that the species *Jasminum angulare* protected one from lightning. Kenyans made the stems of jasmine plants into rope. In Southeast Asia, women wore jasmine flowers in their hair and as garlands. The Egyptians offered jasmine to the gods. In the fourth century CE, Sri Lankans planted jasmine, offering the harvest to Buddha. Malaysians believed that the fragrance of jasmine attracted spirits that cured disease. Hindus offered jasmine flowers to the gods. The species *Jasminum sambac* was the flower of the god Vishnu. The god Kama Dem used jasmine flowers to kindle love between two people. In India, Indonesia and Pakistan well-wishers offered jasmine flowers to a bride and groom at their wedding. The Chinese gave jasmine flowers as gifts on New Year's Day. The Moors took *Jasminum grandiflorum* through North Africa and into southern Spain in the early Middle Ages. In the 16th century, Portuguese explorer Vasco da Gama may have brought jasmine from India to Europe, though this cannot have been the first introduction of the plant into Europe. In 1659, Sir Thomas Hammer knew *Jasminum grandiflorum* as Spanish or Catalonian jasmine. Jasmine species from Africa introduced into Florida have escaped cultivation and are now weeds. In the 1930s, the Philippines named *Jasminum sambac*, known as sampagnita, as the national flower. In 1990, Indonesia adopted the same species, known as melati, as its national flower. *Jasminum sambac* symbolizes purity, love, and nobility. Pakistan has named the common *Jasminum officinale*, known as chambeli, the national flower.

Jasmine has been used to flavor alcohol, soft drinks, confectionery, desserts, and tobacco. Jasmine tea has been popular in China since the Song Dynasty (960–1279 CE). *Jasminum sambac* and *Jasminum grandiflorum* are the chief species used to make tea. China is the world's largest producer of jasmine tea. To make jasmine tea, jasmine flowers are layered upon tea leaves, allowing the leaves to absorb the flowers' fragrance. The best quality of flowers for tea are picked in May. In France, Spain, Italy, Morocco, Algeria, and Egypt farmers grow *Jasminum grandiflorum* for its essential oil. Bombay, India, grows jasmine for sale to the Middle East. Because of its distinctive fragrance, jasmine is important to the perfume industry. The Romans used jasmine as perfume, probably importing the plant from the Middle East, Egypt, and the eastern Mediterranean Basin. According to first-century Roman encyclopedist Pliny the Elder, Roman orator Lucius Plotius Gallus tried to hide from his enemies but the scent of jasmine, of which he was fond, betrayed him about 43 CE. First-century CE Greek physician Dioscorides mentioned that jasmine was used as perfume in Iran. *Jasminum grandiflorum* is the chief species used to make perfume. The well-known Chanel No. 5 of Parisian couturier Gabrielle Chanel, Eau Sauvage of French company Christian Dior, and Joy of French fashion designer Jean Patou feature jasmine in their perfume. Yet the perfume industry has an ugly side. It hires children to pick flowers early in the morning for little pay. At the harvest, a worker may pick 5,000 flowers per hour. Eight thousand flowers yield one gram—roughly 25 drops—of oil. From the 17th century to the 1930s Grasse, France, emerged as the chief region for the cultivation of jasmine for perfume. As early as 1912, Egypt grew jasmine for perfume. Since the 1930s Algeria, Italy, and Spain have arisen to contest France's leadership. Despite this competition, enthusiasts judge jasmine grown in Grasse as superior for making perfume.

As a constituent of aromatherapy, jasmine is used to treat nervous disorders, respiratory ailments, urinary problems, and muscular conditions. Tibet, China, Thailand, Nepal, Cambodia, Vietnam, Cuba, Fiji, and several countries in Africa use jasmine to treat snakebite, smallpox, depression, tetanus, ringworm, ulcers, insufficient lactation in nursing women, intestinal problems, headache, and heart ailments. Some people believe that jasmine is an antiseptic and an aphrodisiac. Medical practitioners use all parts of the plant: the roots, foliage, flowers, fruit, oil, the bark of woody species, and especially the leaves.

Cultivation, Species, and Cultivars

Most species of jasmine have white flowers and are cultivated for their fragrance. Species with yellow flowers are cultivated as ornamentals. Jasmine includes climbers that need support and shrubs. Jasmine grows in a range of soils as long as they drain well. Jasmine will not tolerate waterlogged or saline soil. The soil should be slightly acidic to slightly alkaline, with a pH between 6 and 8. Although jasmine tolerates partial shade, it must have full sun to flower abundantly. Jasmine requires regular applications of manure or a complete fertilizer. Irrigation lengthens the duration of flowering. A seedling yields flowers in its third year and thereafter, as we have seen, for 10 to 12 years. Jasmine may be propagated from seed or cutting. The most fertile seeds come from cross-pollination. In the temperate zone, a cutting must take root by midsummer if it is to survive winter.

The species of jasmine are found in Asia, Africa, Europe, and Oceania. Specimens have colonized the tropics and temperate locales and are evergreen or deciduous depending on climate. The few hardy species derive from the Himalayas. *Jasminum fructicans* is also hardy. Common jasmine, *Jasminum officinale*, grows in the Caucasus Mountains, Iran, Pakistan, the Himalayas, and southeastern China. *Jasminum officinale* is hardy enough for cultivation in Northern Europe. In 1548, British botanist William Turner wrote that the species "grows commonly in gardens about London." *Jasminum officinale* has two subspecies: *Jasminum officinale* ssp. *aureovariegatum* and *Jasminum officinale* ssp. *argenteavariegatum*. Cultivars of the species include Clotted Cream, known as Devon Cream, Crug's Collection, and Fiona Sunrise, known as Frojas. *Jasminum officinale* seldom sets seeds, though a small cultivar Inverleith is fertile. This cultivar derives its name from the section of Edinburgh, Scotland, where the Royal Botanic Garden grew it. The National Botanic Garden at Glasnevin in Dublin, Ireland, also grew the cultivar. Dublin had obtained it from a French nurseryman, who in turn had gotten Inverleith from southwestern China.

Jasminum polyanthum, native to China, is less hardy than *Jasminum officinale*. Florists sell the former as a potted plant. Gardeners prize it for the fragrance of its white flowers. Danes, the Dutch, and North Americans raise *Jasminum polyanthum* as a houseplant. When exposed to cool weather, the buds and corollas turn red. Less commonly cultivated is *Jasminum dispermum*. Because it is not hardy, the species is grown in greenhouses in Northern Europe. *Jasminum dispermum* is native to the Himalayas, Pakistan, India, Tibet, and Yunnan, China. *Jasminum beesianum* is the only species in the genus with red flowers. Hybridized with *Jasminum officinale*, *Jasminum beesianum* yields *Jasminum* × *stephanense*. About 1920, French company Lemoine and Son of Nantes first sold the hybrid. Curiously, it does not display heterosis or hybrid vigor. The flowers are pink. The hybrid grows wild in China and Tibet, which are home to the parent species, suggesting natural hybridization.

Jasminum didynum is native to Tahiti, the Indonesian island of Java, the Philippines, New Caledonia, the Austral Islands, and Australia. *Jasminum azoricum* arose in the Tertiary Period (65–2 million years ago) and is today rare on Madeira Island. Because it does not tolerate frost, the British have grown it in greenhouses since the 18th century. *Jasminum sambac* has a long history as a cultivated plant. Its species name derives from its Persian name *zambac*. Indigenous to India, *Jasminum sambac* does not tolerate frost. Indians know several varieties, though the West knows only two: Maid of Orleans and Grand Duke of Tuscany. *Jasminum grandiflorum* grows in northern Arabia and, as we have seen, went with the Moors on their conquest of North Africa and Spain.

Christopher Cumo

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Juniper

The genus *Juniperus* refers to a diverse group of conifers that belong to the cypress family. Juniper is the only cypress member containing edible fruits. The fruit of the juniper is technically a cone with a pulpy resin, but is commonly specified as a berry; berries are typically green and then change to blue or purple after they mature, a process that spans two to three years. The Redberry Juniper (*Juniperus pinchotii*), as its name suggests, is one of the varieties whose fruit deviate from the traditional colors.

Most *Juniperus* species inhabit the Northern Hemisphere but are not restricted to a certain elevation; juniper can be found from sea level to above the timberline. Juniper species are amazingly indiscriminate in regard to soil preference; *Juniperus* thrives in limestone, granite, sandstone, and sand dunes. Most of the cypress family species are very water dependent; however, the evergreen junipers have considerable drought tolerance to survive in desert climates. Some varieties, under ideal conditions, can grow into large trees, but the more common shrub is found in harsher arid and alpine environments. General characteristics include thin bark that peels off in strips, narrow branches covered by scaly leaves, and the aforementioned berries.

More than 220 cultivars of *Juniperus* have been identified. Matching cultivars with their wild, or native, counterparts has proven extremely difficult. Even morphology often falls short in resolving identification. American biologist Robert P. Adams contends, however, that linking cultivated junipers with their corresponding indigenous plant is invaluable to determining the ecology of the species, toxicity, allergenic properties, and adaptive parameters.

History of Healing

The invigorating aroma of common juniper (*Juniperus communis*), a bouquet of pine and menthol, have been historically associated with purification. Juniper-infused elixirs were used during the Middle Ages to stave off plague, and the burning of juniper berries was thought to clear the air of pestilence. Native Americans incorporated juniper varieties into ethnopharmacological practice; the berries and leaves were consumed in many forms to fight infection, relieve arthritis, and treat wounds and illness. *Juniperus sabina* (Savine), similar to common juniper but producing smaller fruit, is native to Southern Europe. Savine also prospers in Britain, where it has been cultivated since 1562. The Savine juniper is a stimulant, diaphoretic, diuretic, carminative, and emmenagogic. In large quantities it is also thought to induce abortion. In the colonial United States, colonists used the berries of *Juniperus virginia* (red cedar) to concoct a variety of remedies to treat colic, urinary tract afflictions, and headaches, and even to strengthen vision.

Food and Spirits

Dating to 2800 BCE, Egyptian scrolls mention the distinctive aromas and flavors of juniper leaves and berries. Native Americans gathered the acrid-tasting fruit and either ate them fresh off the shrub or ground them into meal. In Europe, a juniper berry spread is derived from the pulp extract and eaten with bread. Juniper berries, likewise, are often dried before being sold as a popular spice used in European kitchens. Typically used to season meat and cabbage dishes, the berries are removed prior to consumption.

Although the fruit of some juniper species can be roasted and brewed to provide a coffee substitute, the most renowned use of *Juniperus* is the combination of distilled juniper berry extract with grain alcohol to make gin. In the United States, gin gained notoriety during the Prohibition era of the 1920s as an underground cocktail that was easy to make. Because gin requires no aging, unlike whisky, bootleggers could brew it and immediately sell it, making gin popular hooch for illegal distribution. The inconsistent quality of the homemade spirit was somewhat masked by the pungency of the juniper; however, tonic or soda would be used to further dilute the harshness, leading to the advent of the mixed drink.

Piñon-Juniper Woodlands

In the Great Basin territory of the United States, one of the largest collections of juniper exists, spanning more than 17 million acres, in the piñon-juniper woodlands. It is arguably the most important juniper ecosystem on the planet. Ironically because junipers, predominantly the Utah juniper (*Juniperus osteosperma*), vastly outnumber the piñon trees, some ecologists are adamant about renaming the region the juniper-piñon woodlands. However, based on aggressive dominance tendencies of the plant, juniper woodlands are routinely cleared and burned to promote grass recovery to enhance grazing for livestock. Sagebrush, blackbrush, ephedras, saguaro cactus, and Joshua trees also frequently intermingle with stands of juniper.

Juniper in the Twenty-First Century

The practice of converting juniper into a fine, distilled potion of Tanqueray or Bombay Sapphire gin will certainly continue, but the practical applications for juniper resources extend beyond a stiff beverage. Juniper wood is highly resistant to decay, therefore fence posts, shelters, and furniture made from the conifer offer a durable alternative to similar items crafted from more traditional materials. Cedarwood oil is yet another major commercial product derived from *Juniperus*; it is a natural component used in fragrance compounding. Finally, considering the wide variety of juniper cultivars available, almost all of which are extremely soil tolerant, the evergreens continue to serve as an addition to the residential landscape. Irrigation requirements are minimal; in fact most plants fail when the shrubs have been waterlogged. If appropriately spaced, junipers demand little or no pruning. Overall, juniper is a low-maintenance, fragrant addition to a well-tended lawn.

Matthew Alexander

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K

Kale

Kale is a crucifer, a member of the Brassicaceae family, formerly known as the Cruciferae. This family encompasses a wide range of vegetables, from cabbages and broccoli to turnips and cauliflower. Kale is an ancestral member, dating back thousands of years to the times of the Greeks and Romans. The Scottish term derives from the Roman and Greek *coles* or *caulis*. The original usage referred to the whole group of plants resembling cabbage.

A number of varieties of *Brassica oleracea* are referred to as kale, including the varieties *sabellica*, *medullosa*, *costata*, *and viridis*. Older and sometimes current literature refers to kale as *Brassica oleracea* ssp. *acephala*. An overall term for the closely related kales, collards, and borecole is the Acephala group. *Brassica oleracea* was described by Swedish naturalist Carl Linnaeus in 1753 as being a native of Western and Northern Europe.

The term "kale" encompasses a number of different cultivars of this green, leafy vegetable. The word is used to mean plants that do not have a head. In contrast to cabbage or broccoli plants, which have distinctive heads, kale plants have leaves that grow along a stalk. The appearance of the plants can vary greatly, with leaves being flat or crinkled, green, red, or tinged with purple. The plants themselves can be tall and erect or short and squat.

Origin and History

The genus *Brassica* is believed to have first arisen in the Mediterranean Basin or in Turkey. Molecular studies suggest that the *Brassica olereacea* group arose from ancestors that were similar to wild species of kale. The first cultivated plants of this species were thought to be kale, which later gave rise to other cultivars such as cabbages and broccoli. As part of the *Brassica oleracea* group, kale is diploid and thus has two sets of 9 chromosomes totaling 18.

Kale is primarily a crop of cooler areas. Crops that have had a slight touch of frost are considered to have the most appealing taste. Kale plants are biennials, but are normally grown as annuals. The plants flower and produce seed in their second year. This crop is not commonly grown in the United States. Instead, the more heat-loving collard greens are raised in much of the country. The high vitamin content of kale has made it a favorite of Northern Europeans, however. Ironically, as standards of living improve, populations consume fewer kales and

Kale (Jean-francois Guignard/Dreamstime.com)

cabbages, increasing their consumption of more mild-flavored crucifers such as Brussels sprouts and cauliflower.

Uses

In addition to its utility as a vegetable, kale is grown as an ornamental plant, particularly in European gardens. These horticultural plants have the added benefit of being edible, although their flavor is considered very mild compared to those grown specifically for human consumption.

The ease of growth of kale and rich nutrient content of this plant have made it a popular vegetable in many parts of the world. The plant is a good source of iron, calcium, vitamins A and C, and folic acid. It is one of the best cruciferous sources of antioxidants that are soluble in lipids and thus easily absorbed by the body. For instance, kale is very rich in carotenoids. This plant also contains a number of phenolic compounds such as flavonoids that act as antioxidants. Like most crucifers, it has various derivatives of the flavonoid kaempferol, which is a strong antioxidant. Quercetin is another prominent flavonoid in kale. This molecule, which is thought to reduce the incidence of cardiovascular disease, protects against free radicals. Additionally, like other crucifers, kale also has phytochemicals that appear to protect against the development of cancer. Glucosinolates, formerly known as mustard oil, are sulfur-containing secondary plant metabolites that are stored in an inactive form. When the plant tissue is disrupted, such as by insect or pathogen attack, or by human activities such as chopping or chewing, a myrosinase enzyme is activated. This enzyme cleaves the glucosinolate molecule into breakdown products with biological activity.

The two major groups of molecules produced from the breakdown of glucosinolates are isothiocyanates and metabolites of indole glucosinolate. Both types of molecules have been found to exhibit anticancer activity in numerous studies. Kale contains a number of different glucosinolate compounds, among them sinigrin and glucoraphanin. Both of these compounds have been highly studied for their anticarcinogenic effects.

A single crucifer can produce a dozen different glucosinolates, and the pattern produced has been used to help in taxonomic studies of closely related plants. Such studies have been valuable for comparing kale with its close relative Chinese kale,*Brassica oleracea* ssp. *alboglabra*. Chinese kale is often considered the separate species *Brassica alboglbra*. This type of kale also has a diploid genome with 18 chromosomes.

Kale is one of the easiest vegetables to grow and is encouraged for consumption by nutritionists, because of its wealth of minerals, nutrients, and phytochemicals. Once bemoaned by nutritional experts as an inferior source of nutrients, this humble plant has been found to be a powerhouse of nutrients and beneficial phytochemicals.

Helga George

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Khat

Khat (pronounced "cot") is a natural stimulant with pharmacological properties capable of inducing physiological and psychological changes in the user. It is a native of East Africa and the southern Arabian Peninsula derived from the *Catha edulis* plant, belonging to the Celastraceae family. Praised as the "Leaf of Allah" and the "Flower of Paradise" in Arabic writings as early as 1237 BCE, its mild euphoric and stimulating property was known to induce a trance, while it was also thought to cure influenza, various stomach ailments, and chest infections. A source ascribes 501 kinds of cures to khat, equaling the numerical value of its letters in the Arabic name Ga-a-t (400 + 100 + 1). The Arabian chronicles imply that the use of khat predates the use of coffee. With the introduction of coffee, khat tea fell out of favor. Khat was believed to have been extensively cultivated in the mountains of Yemen, where it was introduced from the Harar Mountains of Ethiopia around the sixth century CE.

Distribution, Ecology, and Botany

Originating in Ethiopia, khat is now cultivated extensively in the region extending from eastern to southern Africa and the Arabian Peninsula. Khat is grown in Somalia, Djibouti, Kenya, Malawi, Uganda, Tanzania, Congo, Zambia, Zimbabwe, Afghanistan, Yemen, and Madagascar, between latitudes 18° north and 30° south. Depending on the language of the region, khat is *qat* in Yemen, *tschat* in Ethiopia, *miraa* in Kenya, Abyssinian tea, African salad, Bushman's tea, chat, Somali tea, kat, qadka, kus-es salahin, brown cows, katyne, mlonge, and murungu. Based on the variety and the quality, khat is classified as kaad methani, the finest-quality khat, which comes from the Sabin Mountains; kaad moherah, an inferior quality; or kaad beladi, the wild and least valued khat. The use extends to other Asian countries including Afghanistan and India, and in some Western countries, notably the United States, the United Kingdom, and France, for experimental purposes. Regular use as a stimulant is confined to the Muslim communities of southern Arabia and eastern Africa. Yemen, Ethiopia, and Kenya are the main khat-growing countries, but it is also collected from the wild.

Khat is a large, thornless, green flowering shrub, resembling a tree shrub having branches with small elliptical leaves. Leaves measure around one inch in length and come in various shades of red, purple, and green. Khat can grow to the size of a tree if not pruned at regular intervals. Indigenous to the arid regions, khat can survive temperatures from 41°F to 95°F. It grows well in the submontane or medium-altitude forests usually near the margins or in the woodland, often on rocky slopes at altitudes of 5,000 to 8,000 feet above sea level. The plant grows to a height of 6 to 18 feet and may reach up to 75 feet in height if not pruned. Extensive pruning makes it a small shrub. It might enjoy a life span of up to 40 years. Khat trees are grown between coffee trees. In its area of cultivation, the average daily temperature ranges between 50°F and 70°F. Annual rainfall requirements are 30 to 40 inches over four to six months. Frost and high humidity limit the growth of khat. It can be grown in a wide range of moderately acid to alkaline soils, from sandy loams to heavy clay, sufficiently deep and well drained with high organic matter content in the topsoil. It is not salt tolerant. It is, however, important to keep *Catha edulis* on the dry side as overwatering will harm these plants, and hence any waterlogging will damage the growth of these plants. In certain areas, it is often grown with coffee plants with proper irrigation on the terraces. Cultivation of khat is alluring to the farmers of the arid and drought-prone areas as not only can it withstand poor soils but also because of its ability to survive long periods of drought. *Catha edulis* is a grown as a cash crop, and its attractiveness is enhanced by its resistance to diseases and insects. Khat is grown by the propagation method, which results in qualitative difference among the harvests upon which they are assigned varying prices. It is believed that the leaves harvested in the sixth year are especially valued for their fragrance, taste, and euphoric value.

Consumption

Young leaves and buds are pleasantly odored and when chewed induce mild hallucinations. It derives its pharmacologic properties in the presence of two active ingredients, cathinone and cathine. From the leaves of khat, the Arabs make a kind of tea, which has been in vogue among the countries of the Horn of Africa and the Arabian Peninsula, where it is part of the social and religious milieu. The fresh leaves, twigs, and shoots of khat are chewed and then retained in the cheek and chewed to induce the intoxicating effect. As liquor drinking is prohibited among the Muslims, khat chewing and the use of khat as a beverage has religious and legal sanction in the community. Interestingly, during periods of fasting in the month of Ramadan, khat consumption registers a significant increase as it is known to alleviate fatigue and reduce hunger. However, widespread use of khat lowers productivity.

The Economics of Khat Production

Khat production lubricates the economy of many producer countries. Along with coffee, khat constitutes the biggest cash crop of Yemen and Somalia. As an export crop, Ethiopia's khat earns valuable foreign exchange. According to a report of the United Nations, between 1980 and 2002 Ethiopia earned $10.7 billion from the export of khat. Yemeni khat is highly favored because of its superior quality. The United Nations Development Programme, assessing the importance of khat production and consumption on the economies of Africa and Arabia, concludes that regulation and not prohibition is the solution in view of the critical contribution that khat makes to farmers' livelihoods.

Kawal Deep Kour

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Kohlrabi

A biennial herb grown as an annual, kohlrabi enlarges the bottom of its stem—some people call this enlargement a bulb—the first year and flowers and seeds the second. Unlike turnip, cassava, carrot, sweet potato, and other root crops, kohlrabi's bulb develops aboveground. It is therefore not a root crop. Kohlrabi's classification is a matter of confusion. It has been classified variously as *Brassica oleracea* (Gongylodes Group), *Brassica oleracea* ssp. *gongylodes*, and *Brassica oleracea* ssp. *caulo-rapa*. The word "kohlrabi" derives from the German *Kohl*, meaning "cabbage," and *rube* or *rabi*, meaning "turnip." Kohlrabi is therefore a cabbage turnip, though it is not, as some have supposed, a hybrid of the cross between cabbage and turnip. In the Brassicaceae or Cabbage family, kohlrabi is related to cabbage, broccoli, cauliflower, kale, collard, and Brussels sprouts. Half a cup of raw kohlrabi has just 19 calories, 2.5 grams of fiber, 245 milligrams of potassium, 16.8 milligrams of calcium, 25 international units of vitamin A, 43.4 milligrams of vitamin C, and 11.3 micrograms of folic acid. A full cup of kohlrabi has 140 percent of the recommended daily allowance of vitamin C.

Origin and History

Kohlrabi has an uncertain history. Native to Europe, the Mediterranean Basin including North Africa, and the Canary Islands, kohlrabi might have originated in Northern Europe. The plant may be descended from a wild cabbage. One writer asserts that it was unknown in Europe before the 16th century. Yet in the first century CE, Roman encyclopedist Pliny the Elder mentioned a "Corinthian turnip," which some authorities believe was kohlrabi. First-century CE Roman gourmet Marcus Gavius Apicius may have mentioned kohlrabi. In the ninth century, Frankish king Charlemagne required farmers in his empire to grow the vegetable. Nonetheless, the first botanical description of kohlrabi dates to 1554, 1,500 years after Pliny's reference to a "Corinthian turnip." By the end of the 16th century, farmers cultivated kohlrabi in Germany, England, Italy, Spain, North Africa, and the eastern Mediterranean Basin. The crop was widespread in Ireland by 1734 and in the United Kingdom by 1837. Kohlrabi was popular among the wealthy and commoners of Europe in the early modern era. Thereafter its popularity ebbed. As people ate more broccoli, cauliflower, and asparagus, they ate less kohlrabi. In the 17th century, kohlrabi was cultivated in northern India. Hindus ate it with rice and greens. The people of Kashmir, India, may eat kohlrabi three or four times per week. Introduced into the United States about 1806, kohlrabi remains more widely grown in Europe than the United States. In the United States, southern Texas harvests kohlrabi between March and May and again between October and December. Southerners eat kohlrabi with greens. Kohlrabi is also part of the diet in Israel, China, and Africa. Kohlrabi may be found in the grocery store year-round with a peak in supply in spring and early summer.

Attributes and Cultivation

There are two types of kohlrabi: white and purple. White kohlrabi, really light green, is more widely grown for food, whereas purple kohlrabi is more widely grown as an ornamental, particularly in Europe, though one gardener prefers the taste of the purple type. Kohlrabi flowers are yellow and fragrant. The foliage may be red, purple, green, gray-green, or dark green. Kohlrabi does best in full sun. It matures in 40 to 60 days. Seeds germinate in 3 to 10 days at 68°F to 86°F. Reaching 6 to 8 inches in height, kohlrabi grows best between 60°F and 70°F. Kohlrabi does not grow above 75°F. According to one gardener, kohlrabi should be planted in fertile loam. Another favors sand or loam, and a third touts the superiority of heavy soil. The soil, whatever the type, should be well drained. According to one gardener, the soil pH should be 6 to 7.5. Another favors neutrality (7). A third favors slightly alkaline soil with a pH just above 7.

Kohlrabi may be planted indoors with the aim of transplanting it in the garden as soon as the soil can be worked. One may stagger plantings in two- or three-week intervals for a continuous harvest and to avoid the glut of a single large harvest. Seeds should be planted one-quarter to one-half of an inch deep. Because kohlrabi tolerates frost, it is not necessary to wait until the last frost before planting the vegetable outdoors. In any case, an early planting is desirable so that one can harvest kohlrabi, which does not tolerate heat, before the heat of summer. Yet one must guard against temperatures that are too cold. Temperatures below 50°F for one week cause kohlrabi to bolt. One gardener recommends the planting of kohlrabi about April 1 to avoid the extremes of cold and hot. Alternatively, one may plant kohlrabi in midsummer for an autumn harvest. Because frost improves flavor, the gardener may leave kohlrabi in the ground in cold weather. Yet one must guard against leaving kohlrabi too long in the ground. Large bulbs are too tough to eat. Rather, one should pick a bulb when it is between two and two-and-a-half inches in diameter to capture the peak of flavor. The cultivar Gigante, known as Superschmeltz, is unusual in retaining flavor and not becoming tough when large. A heavy feeder, kohlrabi benefits from the addition of organic matter to the soil. Once germinated, plants should be thinned to three or four inches apart. The harvested bulb is crunchy like an apple, though it is less sweet. One gardener has compared the flavor of kohlrabi to that of a mild turnip. Kohlrabi may be eaten raw, steamed, or boiled and may be refrigerated one month. In addition to the bulb, kohlrabi leaves are edible.

Christopher Cumo

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Kumquat

Once known as "the little gem of the citrus family," kumquat was first a member of *Citrus*, the genus into which Swedish naturalist Carl Peter Thunberg placed it in 1784, making it a relative of the grapefruit, orange, and lemon. Although a kumquat resembles a small orange, there are important differences. Kumquat tolerates temperatures as low as 10°F, much colder than citrus trees can tolerate. Moreover,

Kumquats (Fttsftts/Dreamstime.com)

the kumquat peel is edible whereas the peel of citrus fruits is inedible. Unlike citrus trees, the kumquat tree becomes dormant in winter. In 1915, American botanist Walter Swingle placed kumquat in a new genus *Fortunella*, which he named to honor British plant explorer Robert Fortune, who had done much to bring kumquat to the attention of Europe and the United States. The word "kumquat" derives from the Chinese *kam kwat*. Kumquat is sometimes rendered cumquat or comquot, meaning "gold orange." Brazilians know kumquat as *kumquat*, *kunquot*, or *laranga de ouro*. The fruit is round or oval. The Japanese call round fruit *kin kanar* or *kin kit* and oval fruit *too kin kan*. In Southeast Asia, round fruit is *kin*, *kin kuit*, or *kuit xu*. Oval fruit is *chu tsu* or *chantu*. Kumquat is in the Rutaceae family. One hundred grams of raw kumquat have 274 calories, 3.8 grams of protein, 0.4 gram of fat, 72.1 grams of carbohydrates, 266 milligrams of calcium, 97 milligrams of phosphorus, 1.7 milligrams of iron, 30 milligrams of sodium, 995 milligrams of potassium, 2,530 international units of vitamin A, 0.35 milligram of thiamine, 0.4 milligram of riboflavin, and 151 milligrams of vitamin C.

Origin, History, and Attributes

Kumquat may have originated in China, southern Asia, or the Pacific Islands. A Chinese text first mentioned the fruit in 1178 CE. In 1646, one European traveler wrote that he had learned about kumquat from a Portuguese missionary who had worked in China. In 1712 kumquat was listed, presumably in a European text, as a plant from Japan. Since the mid-19th century, Europeans and Americans have grown kumquat. In the West, it is grown chiefly as an ornamental rather than for its fruit. In the Western Hemisphere, kumquat is cultivated in California, Florida, Texas, Louisiana, Alabama, Puerto Rico, Guatemala, Suriname, Colombia, and Brazil. In Asia, kumquat is grown in southern India at elevation, and in China, Japan, Taiwan, Hong Kong, the Philippines, Southeast Asia, South Korea, North Korea, southern Pakistan, and the Middle East. Kumquat is a minor crop in Australia and South Africa. The Chinese grow kumquat where the climate is too cold for citrus.

Although it tolerates cold, kumquat needs temperatures between 80°F and 100°F to yield the best fruit. Like several fruit crops, kumquat is seldom grown from seeds but is instead grafted onto rootstock. In China, Japan, northern Florida, and California farmers used the trifoliate orange (*Poncirus trifoliate*) as the rootstock. In South Florida, the sour orange or grapefruit is the rootstock. Lemon is seldom used as rootstock. Kumquat trees are spaced 8 to 12 feet apart or in rows 12 feet apart. The tree is short, growing to 15 feet in height, compact, and yields on average 30 to 50 fruits. Kumquat flowers are white and fragrant. The peel is golden yellow to red-orange. Fresh kumquat is eaten raw like an orange or grapefruit, though because the peel is sweet and the fruit sour, some people eat just the peel. Others, preferring the combination of sweet and sour, eat the entire fruit, peel and all. Because the fruit can be as small as an olive, it may be eaten in quantity. The people of Taiwan can kumquat for export. Chinese restaurants serve the fruit as dessert. Kumquat is suitable for making marmalade and jelly. The Chinese preserve kumquat in salt. Having absorbed kumquat juice, the salt is mixed with water to treat sore throat.

Cultivars

The variety Hong Kong is known as Hong Kong Wild. The people of Hong Kong and the Chinese of Kwantung and Zhejiang provinces know the cultivar as "chin chu," "shan chin kan," and "chin tou." The tree has thorns and bears fruit with little pulp. The fruit is round and the peel orange or scarlet when ripe. The Chinese grow Hong Kong on the lower slopes of hills. In the West, Hong Kong is an ornamental.

Known as Round Kumquat, Marumi was unknown in the West until 1784. In 1885, Royal Palm nurseries introduced Marumi from Japan into Florida. The tree grows to nine feet tall, has thorns and small leaves, and tolerates cold. The fruit is round and acidic. The peel is golden yellow and smooth. The pulp yields one to three small seeds. As is true of many varieties of kumquat, the peel of Marumi is sweet and the pulp, being acidic, is sour. Marumi is used to make marmalade and jelly. Marumi symbolizes luck and is a popular New Year's gift.

Meiwa is known as the Large Round Kumquat. The Japanese know it as *ninpo* or *neiha kinkan*. Meiwa may be a hybrid of the cross between Marumi and the variety Nagami. Between 1910 and 1912, the U.S. Department of Agriculture introduced Meiwa from Japan into the United States. The peel is orange-yellow and thick. In contrast to several varieties, the pulp of Meiwa is sweet and either seedless or contains few seeds. The tree lacks thorns. The variety is popular in Zhejiang province, China, and Fukuoka Prefecture, Japan, where it is eaten fresh.

Known as the Oval Kumquat, Nagami grows to 15 feet tall. Native to Southeast Asia and China, Nagami has fragrant white flowers. In 1846, Robert Fortune introduced Nagami from China into London, England. It may have been introduced into North America as early as 1850. In 1885, Royal Palm nurseries introduced Nagami from Japan into Florida. The variety bears fruit between October and January. The fruit contains two to five seeds. Nagami is the leading cultivar in the United States.

Christopher Cumo

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L

Larkspur

Larkspur is the common name of two different, but closely related, genera of plants in the buttercup family (Ranunculaceae). Often used to refer to species of *Delphinium*, the term is technically applied to species of *Consolida*. The latter genus is a group of approximately 40 annual species native to Europe and Asia that have been introduced to most temperate and subtropical areas because of their appealing two-inch flowers, known as larkspurs.

The type species is *Consolida ajacis*, the "rocket larkspur" or "doubtful knight's-spur." It was given its current name in 1853. Earlier synonyms include *Delphinium ajacis*, assigned in 1753, and *Delphinium ambiguum* from 1763. A more current synonym is *Consolida ambigua*. The term "larkspur" derives from the spur that projects from the back of the flower. Rocket larkspur is so named because of its tendency to grow exceedingly quickly, having been compared to a rocket shooting up. The genus name derives from the "consolidation" or healing of wounds, a medieval usage of the larkspur plant.

Larkspur Flowers

Other species of *Consolida* that are commonly grown are *Consolida orientalis* and *Consolida regalis*. Larkspurs are found so widely because of their flower stalks that grow up to four feet high. The flowers are generally blue or purple, but can be found in shades of pink, salmon, or white. Larkspur flowers are grown as ornamentals in gardens and for their cut flowers. The 5 to 20 leaves are deeply lobed, giving a lacey appearance to the plants. They have been compared to crow's feet.

There is a widespread industry for larkspurs as cut flowers, both as fresh flowers and as dried or everlasting bouquets. The cut flowers of *Consolida ajacis* and *Consolida orientalis* are generally short-lived, less than a week, encouraging local floral production. There are a number of hybrid series, with different hybrids adapted to varying climactic areas. *Consolida orientalis* produces the most striking cut flowers.

Cultivation

Larkspurs can be grown in all of the continental United States. They prefer cool, moist conditions, however, so they are grown in different seasons in various parts of the country. The seeds germinate poorly above 65°F, so they are often planted in the fall in the ground in southern states or in greenhouses in northern states. In the South, the plants are placed into production during the cool, winter seasons. In the North, they are often grown over the winter as seedlings. The plants prefer moist conditions with a soil of pH 6.0 to 7.0, although they can tolerate some drought. Flowering during the summer, larkspur plants require 16-hour days to produce blossoms.

Larkspur flowers are unusually sensitive to the gas ethylene, which induces plant tissue to decay. This gas is produced by ripe fruit and decaying plant tissue and can cause the flowers to shatter. Consumers must be careful about placement of their flowers, and growers must take care that the flowers are not shipped with fruit.

Toxicity

Consolida species are often found growing wild in disturbed areas, such as along railroad tracks, in roadsides, in drainage ditches, and on old homesteads. All the foliage and seeds are poisonous. This is particularly the case for young foliage and seeds. Humans are advised to avoid consuming any part of the plants. The initial symptoms are nausea and depression, with larger doses being fatal. While humans can be trained to avoid eating larkspur plants, livestock poisoning persists as a serious issue. This is generally the case with tall *Delphinium* species, but *Consolida ajacis* can also pose a serious problem, particularly in the western part of the United States.

Issues of poisoning by larkspur are especially acute for cattle, which find the larkspur plants palatable. A relatively small amount of larkspur can be lethal, since 0.25 of a pound of larkspur per 100 pounds of bovine can be fatal. The plant remains poisonous after it has dried, so ranchers need to be cautious with the hay they supply to their cattle.

Horses, and particularly sheep, are much less sensitive to larkspur poisoning, and one strategy for preparing an area for cattle to graze is first to have sheep feed on the vegetation. Treatment with herbicide is not advised as the affected plants become more appealing to the livestock before the plants succumb to the effects of the pesticide.

Species of both *Consolida* and *Delphinium* share a complex profile of plant secondary metabolism production. Alkaloids are organic nitrogen-containing compounds that can have highly complex structures, and diterpenoid alkaloids comprise a major class of these compounds. Larkspurs contain a number of different compounds of this type. The most highly studied are ajacine and delphinine—both highly poisonous. The compounds act like arrow poisons and interfere with neuromuscular communication.

These plants contain many other alkaloids in this class. Their complexity makes isolation and identification difficult. The chemical literature of the early

21st century is replete with the identification of new alkaloid compounds from species of *Consolida*.

Uses

Despite the dangers of consuming larkspur, it has had some ethnobotanical usage. Tea made from the plant has been used as a folk medicine to treat heart conditions. Extracts of the plants have been used to treat skin worm infestations in humans as recently as the 1950s, and research into this area continued into the 1990s. Some of the research to discover new *Consolida* alkaloids aims to discover new antiparasitic compounds.

Helga George

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Laurel

Several plants bear the name laurel, the most important being the bay laurel and the mountain laurel. In the Lauraceae family, the bay laurel (*Laurus nobilis*) is known as the bay tree, sweet bay, true laurel, Grecian laurel, laurel tree, or simply laurel. From the term "laurel" derives laureate and baccalaureate. Bay laurel leaves may be used to flavor food, though they are seldom eaten. The ancients used bay laurel in folk medicine and to celebrate people of achievement. In the Ericaceae or Heath family, mountain laurel (*Kalmia latifolia*) derives its name from Peter Kalm, a student of 18th-century Swedish naturalist Carl Linnaeus. The Swedish Academy of Science dispatched Kalm to North America in 1748 to collect new species of plants. He returned to Sweden with mountain laurel among other species. In 1753, Linnaeus named the mountain laurel. Mountain laurel is known as broad leaved laurel, calico buck, spoonwood, ivy, mountain ivy, big leaved ivy, laurel leaves, and calmoun. The mountain laurel is known as a laurel because its foliage resembles that of the bay laurel. Mountain laurel is an ornamental shrub.

Bay Laurel

An ancient tree, the bay laurel grew in the laurisilva forests of the Mediterranean Basin. They thrived in the humid climate of the time. During the Pliocene Epoch (5–2.5 million years ago), the Mediterranean climate dried, forcing the forests, and the bay laurel with them, to retreat, leaving pockets of bay laurel trees in southern Spain, north central Portugal, and northern Morocco.

The bay laurel is an Old World plant celebrated in antiquity. The Greeks crowned the winners of athletic contests with branches and leaves of the bay laurel. The Oracle at Delphi put bay laurel leaves under the tongue to induce trance. The superstitious used bay laurel leaves to banish ghosts, end bad luck, and break evil spells. Because a crown of laurel symbolized achievement, the Roman emperors were depicted wearing it. The Romans believed that a withered laurel tree was a portent of disaster. Although the Old Testament is curiously silent about the bay laurel, the New Testament contains several references. The first-century CE Jew turned Christian Paul of Tarsus mentioned the bay laurel in the context of athletic contests. The letters attributed to the apostle Peter and James the brother of Jesus include references to the bay laurel. The letter attributed to James compared the bay laurel to "the crown of life" (James 1:12).

The bay laurel was part of the mythology of the Greeks and Chinese. In Greek mythology, the god Apollo desired the nymph Daphne. She resisted him as best she could, and when his advances became too aggressive she appealed to her father, Peneus, for aid. Peneus turned his daughter into a bay laurel tree to prevent Apollo from carrying her off. Thereafter Apollo wore a crown of laurel as a sign of his unrequited love for Daphne. The ancient Chinese, who believed that bay laurel trees inhabited the moon, told the story of Wu Gung. Wu appealed to the gods to make him immortal. The gods replied that he must chop down every bay laurel tree in China if he wished to be immortal. Wu began enthusiastically, but to his dismay every tree he cut down regenerated in an instant. Wu was thus condemned to a life of ceaseless and purposeless toil akin to the fate that befell the Greek man Sisyphus.

Bay laurel yields male and female flowers on separate trees. The flowers, opening in spring, are small and green. Fertilized female flowers yield black fruit and seeds in October or November. Although known as a small tree, the bay laurel may surpass 40 feet in height. The gardener who wishes to cultivate a bay laurel tree may plant it in a pot, choosing a soil that drains well. Because bay laurel tolerates heat, it may be grown outdoors in summer. Although it tolerates temperatures as low as 20°F, one gardener recommends that a tree be brought indoors in winter. During winter a tree needs less fertilizer and water. Even in winter a bay laurel tree needs plenty of light.

Bay laurel has a long history of medical use. First-century CE Greek physician Dioscorides believed that bay laurel could treat kidney and liver ailments. An extract of the leaves was used to treat wounds. The essential oil of the leaf was used to treat arthritis and rheumatism. Various parts of the tree were used to treat earache, high blood pressure, poison ivy, poison oak, and insect stings. Bay laurel extract may inhibit the growth of cancer cells in melanoma. A mixture of water and bay laurel leaves may prevent dandruff. A poultice of leaves may treat bronchitis and cough. As a flavoring, bay laurel leaves may be added to stew, soup, tomato sauce, and fish. Customarily, the leaves are dried before use. The cook should add no more than two leaves per dish or the flavor will be too strong. The leaves are removed from the dish before its consumption because ingestion of leaves may irritate the stomach. The home owner may keep bay laurel leaves in the kitchen to deter insects.

Mountain Laurel

Indigenous to the New World, mountain laurel has colonized North America. The genus *Kalmia* has seven species, all native to North America. The earliest identification of mountain laurel may be credited to British captain John Smith, who noted it in Virginia in 1624. The shrub has given its name to cities in Delaware, Florida, Indiana, Iowa, Maryland, Mississippi, Montana, Nebraska, New York, Washington, Tennessee, California, Kentucky, West Virginia, Virginia, Pennsylvania, Texas, North Carolina, New Jersey, and Ohio. The mountain laurel is indigenous to southwestern Canada, the Pacific Northwest, New York, and central Ohio east to southern Maine and south to southern Mississippi, Alabama, Georgia, and northwestern Florida. With a remarkable range, mountain laurel grows as far north as the Arctic Circle and as far south as Cuba. The Columbian Exchange distributed the mountain laurel to England, Japan, New Zealand, Australia and South Korea. In New Zealand, mountain laurel is grown on acidic, well-drained loam derived from igneous rocks. In Australia, mountain laurel does well in Tasmania and the wetter portions of southern Victoria. Mountain laurel needs 50 to 60 inches of rainfall per year. As a rule, light soils are better than clay. Tolerant of shade, mountain laurel prefers full sun. Benefiting from mulch, mountain laurel does not do well in a hot, arid climate with dry winds.

Its partisans consider mountain laurel the most attractive flowering shrub in North America. For this reason, it is a popular ornamental. Mountain laurel is related to rhododendron, azalea, wintergreen, blueberry, and cranberry. Flowers are one-quarter to one inch in diameter. The calyx has five parts and the petals five lobes. Each flower has 10 stamens. The ovary has five cells and sits atop the calyx. The anthers disperse pollen three to six inches from a flower. Early botanists supposed that the flowers self-pollinated, but American botanist William J. Beal, renowned for his work with corn, observed that bumblebees, in the course of feeding, covered their underside with pollen, which they carried to another flower, pollinating it. Curiously, honeybees seldom visit mountain laurel shrubs. On the infrequent occasions when a flower self-pollinates, it does not produce seeds and so is self-incompatible. Flowers open in late spring or early summer.

In the wild, mountain laurel may be found in thickets of dense shrubbery. Mountain laurel grows roughly 12 feet tall. Taller specimens have been found in the Blue Ridge and Allegheny mountains. The largest specimen in cultivation stands 25 feet tall and belongs to the North Carolina Arboretum at the University of North Carolina in Chapel Hill. The foliage is used in Christmas decorations. The wood is occasionally substituted for brier in making pipes. Native Americans fashioned the wood into dishes and spoons. From this use must derive the mountain laurel's alias as spoonwood. The mountain laurel has five subspecies: the willow-leaved mountain laurel (*Kalmia latifolia* ssp. *angustata*), the miniature mountain laurel (*Kalmia latifolia* ssp. *myrtifolia*), the hedge mountain laurel (*Kalmia latifolia* ssp. *obtusata*), the banded mountain laurel (*Kalmia latifolia* ssp. *fascata*), and the feather petal mountain laurel (*Kalmia latifolia* ssp. *polypatala*).

Christopher Cumo

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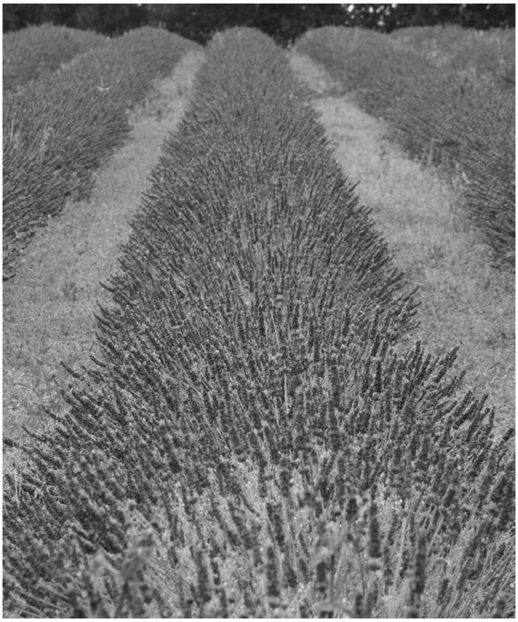
Lavender

In 1826, Swiss botanist Baron Gingins de la Sarraz stressed in his book *Natural History of Lavenders* the need to investigate the families and genera most familiar to us. The genus *Lavandula*, of which lavender is a member, is distributed widely from the Canary Islands, Cape Verde islands, and Madeira, across the Mediterranean Basin, North Africa, Southwest Asia, Arabia, and India.



Lavender (Matthewgore/Dreamstime.com)

The Latin name *Lavandula* comes from the ancient use of this plant to perfume water for bathing. Lavender derives from the Latin word *lavare* meaning to be washed. It is one of the most widely cultivated species, familiar in gardens. Many legends and folklore are associated with these plants. The essential oils, principally harvested from *Lavandula* × *intermedia* and *Lavandula angustifolia*, are of economic importance in the perfumery and fragrance industry; some are widely used in aromatherapy and are known to have antiseptic and antifungal qualities.

Lavandula was known to the earliest botanical writers and can be found in the writings of Greek botanist Theophrastus (ca. 370–285 BCE). Except for the valuable monograph about lavender by Gingins in 1826, Kew Garden botanist Chaytor Dorothy has published a more recent monograph with several descriptions about new species and intraspecific taxa of lavender.

Historical Use of Lavender

The Romans were familiar with many herbs in order to perfume their baths. Lavender was one of the plants used, but it was also referred to as nard, from the Latin Nardus Italica, after the Syrian town Naarda. Lavender has been used as a healing plant and was first mentioned by Greek physician Dioscorides (ca. 40–90 CE) who found what was probably *Lavandula stoechas* growing on the islands of Stoechades (now known as Hyeres); this was used in Roman communal baths. Dioscorides attributed to the plant laxative and invigorating properties and advised its use in a tea-like preparation for chest complaints. The author also recounts that Galen (129–99 CE), physician to Emperor Marcus Aurelius, added lavender to his list of ancient antidotes for poison and bites, and Emperor Nero's physician used it in antipoison pills and for uterine disorders. Lavender in wine was taken for snake bites, stings, stomachache, liver, renal and gall disorders, jaundice, and dropsy. In the first century CE, Roman encyclopedist Pliny the Elder differentiated between *Lavandula stoechas and Lavandula vera*. The latter was apparently used for diluting expensive perfumes. Pliny advocated lavender for bereavement as well as promoting menstruation.

During the Middle Ages, the use of herbs in churches and houses incorporated lavender. Lavender was used in medicines in medieval Wales and England in conjunction with numerous other herbs, including herb robert, valerian, wormwood, elecampagne, parsley, and fennel. English dramatist William Shakespeare mentioned lavender only once, although it was grown in herb gardens, especially knot gardens. It was probably not a common garden plant in his time, though Edmund Spencer (English poet) mentioned it as "the lavender still gray."

Spike lavender was said by some authors to have been mainly used in veterinary practice, as a prophylactic in cases of impending paralysis. It was too camphoraceous and never worth more than one-fifth of true lavender oil, but 16th-century British herbalist John Gerard listed its uses as the main medicinal lavender. Spike oil was also used in the manufacture of fine varnishes and lacquers with oil of turpentine and used for painting on porcelain. Its medicinal value was for promotion of hair growth. Muslim physicians used *Lavandula stoechas*, which they considered to be tonic, to reduce swelling or inflammation, to have the power to clear or open the body's ducts for the secretion of fluids, and to prevent or relieve flatulence, and prescribed it for chest infections and for expelling bilous and phlegmatic humors. Other folk-medicinal Indian writers have accredited *Lavadula stoechas* with cephalic virtues and called it the "broom of the brain" because it sweeps away all phlegmatic impurities, removes obstructions, expels waste, and clarifies intellect.

Cultivation

Katherine Adam, a National Center for Appropriate Technology of United States agriculture specialist, mentioned that lavenders originated around the Mediterranean in poor, rocky soils and mild coastal climates. English lavender (*Lavandula angustifolia*) is the most hardy, but high-camphor lavandin (*Lavandula* × *intermedia*) cultivars are grown in the United States without winterkill under certain circumstances. Bodies of water can greatly moderate otherwise inhospitable climates. For example, *Lavandula angustifolia* can be grown in the British Isles due to the influence of the Gulf Stream. Ukraine produces lavender around the Black Sea. Japan produces several tons a year, and Argentina, Brazil, and East Africa yield lavender. Each location has a climate moderated by a large body of water, which can create microclimates several zones different from those nearby.

Some types of lavender have been grown near Lake Champlain in upstate New York and in the Banana Belt south of Lake Ontario. Illinois, northern Nevada, Idaho, and Minnesota harvest lavender. Elevation, topography, and the severity of winters are other climatic factors that influence lavender farming. Height can significantly influence plant survival, with valleys being less desirable. Heavy mulching of plants is necessary to protect them through severe winters. Continuous snow cover could have much the same effect. Excellent drainage is crucial to the survival of lavender.

Lavandula can be a long-lived perennial, with a typical productive life of about 10 years, although plants have been known to live for 20 years. *Lavandula angustifolia* has the finest fragrance. However, its essential-oil production is much lower than the high-camphor lavandin. Essential oils from lavandin are commonly blended, either with *Lavandula angustifolia* essential oil or with commercially available essential oils, to create a pleasing fragrance. Whole plants in flower can be used for essential oil production. Buds, flower spikes, and flowering tips—both fresh and dried—have a variety of culinary, fragrance, and decorative uses.

Pharmacological Properties

Lavandula compromises a large number of different species, hybrids, and cultivars growing all around the world. The main use of these members is based on their aroma for perfumery and cosmetics reasons. The Abbess Hildegarde (1098–1179) wrote about lavender and its ability to delouse and to clear eyes. Lavender was used in many medicines in medieval Wales and England in conjunction with numerous other herbs.

In vitro pharmacological studies imply that the essential oil or its components of lavender have significant pharmacological actions. Lavender is used in aromatherapy as a holistic relaxant and is said to have carminative, antiflatulence, and anticolic properties. Its sedative nature, on inhalation, has been shown in both animals and humans. The essential oil contains 30–60 percent esters (mainly linalylacetate), limonene, and cineole. Lavender has a spasmolytic activity as was investigated on guinea pig ileum and rat uterus in vitro. The mode of action of linalool, one of lavender's major components, reflected that of the whole oil. The mode of action of lavender oil resembled that of geranium and peppermint oils.

Furthermore, lavender oil and its component, linalool, produce a fall in blood pressure in experimental animals. In addition, a 1921 experiment by scientists David I. Macht and Giu Ching Ting proved that lavender had a slight sedative action, and it was suggested that the vapor from essential oils might be stimulating olfactory sense organs directly.

In addition, it was shown that lavender essence enhanced the hypnotic action of pentobarbitone. Such an effect on barbiturate sleeping time may indicate an effect on the brain but could also be due to inhibition of hepatic enzymes, which metabolize barbiturates. In 1995, scientists Elaine Elisabetsky, Jeanine Marschner, and Diogo Onofre Souza reported that linalool produces a dose-dependent inhibition of the binding of glutamate (an excitatory neurotransmitter of the brain) to its receptors on cellular membranes prepared from the cerebral cortex of the rat, which is a possible explanation for the observed sedative effects. More recently, Elaine Elisabetsky, Silva Brum, and Diogo Onofre Souza (1999) have related this action to an anticonvulsant activity of linalool in rats.

Lavender is one of the few essential oils that has been studied in well-controlled experiments in humans. The aroma of lavender must be one of the best known, and the biological activity of the vapor from the essential oil has been investigated in several species including humans. Until nowadays, lavender was used as an important natural way for keeping insects away from clothes. Many believe that, placed under the pillow, lavender ensures a good night's sleep.

Charalampos Dokos

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Leek

In the Liliaceae or Amaryllis family, leek has two botanical names. The first is *Allium porrum*. The second is a subspecies of *Allium ampeloprosum*, namely *Allium ampeloprosum* ssp. *porrum*. One writer favors the latter. Leek derives from the Anglo Saxon *leac*, meaning "spear," presumably to reflect the shape of the stalk. The Latin for leek is *porrum* or, earlier in Roman history, *aga*. In Hebrew, leek is *hazir*, in German *lauch*, in Dutch *look*, in Russian *luk*, in Turkish *porosa*, in French *poireau*, in Italian *porro*, and in Spanish *puerro*. *Hazir* means "green herb," doubtless a reference to the color of the foliage, which may be blue-green. One gardener refers to leek as a "non-bulbing form of onion." Along with garlic, onion, and scallion, leek is an allium, a monocot like grains, though the relationship between leek and wheat, for example, is not close. The leek differs from its companion alliums in not producing a bulb. Rather, it produces sheaths of leaves, the edible portion of which matures underground. Leeks have a mild and sweet onion taste and are eaten throughout the world. They look like large green onions, or scallions.

History

A temperate plant, leek has no wild forms, suggesting that its cultivation is ancient. Humans must have prized leek from an early date because it bore food in autumn, winter, and early spring, times when other foods were scarce. Perhaps because of its humble station, leek was the food of the poor. One gardener labeled leek "a food of humility."

The Egyptians cultivated leek as early as 3000 BCE. In the first century CE, Egyptian leeks were still prized. First century CE Roman encyclopeidist Pliny the Elder praised Egypt with supplying Rome with the best leeks. Despite their association with poverty, Pliny tells us that first-century CE Roman emperor Nero ate leeks in the belief that they improved his voice, as he fancied himself an orator and singer. After his death, Nero's opponents ridiculed him as *porrophagus*, meaning "the leek eater." The Book of Numbers recounts that the Hebrews, tired of manna, wished to have the leeks and other foods that they had enjoyed in Egypt.

The ancients thought that leeks gave one courage. For this reason, soldiers ate them and wore them, presumably around the neck to guard against misfortune. The Roman legions planted leek in the provinces so that they would not lack courage. The inhabitants of Wales, the Welsh, ate leeks for courage in their fight against the invading Saxons in the sixth century CE. The Welsh placed leeks on their hats and pinned them to their jackets. Using leeks as a marker, the Welsh could differentiate friend from foe. Victorious, the Welsh expelled the Saxons from Wales. Crediting their success to leek, they made it the national flower of Wales. Some Welsh still wear leeks on March 1 to honor Saint David, the patron saint of Wales, in memory of the courageous warriors who had defeated the Saxons. According to another tradition, the wearing of leeks in Wales did not begin until the 12th century, when the Welsh fought the invading English. Again, if the first account is true, the Welsh pinned leeks on their clothes to differentiate comrade from enemy. A third tradition decouples leeks from martial valor. This account claims that the Welsh wore daffodils, not leeks, on their clothing. The two plants might have been confused because the daffodil is known as Saint Peter's leek. Another possibility comes from the pen of British poet Michael Drayton (1563–1631), who reported that when Saint David fasted he ate only leeks and it is this circumstance, rather than the battles with the Saxons and English, that caused the Welsh to wear leeks on Saint David's Day. Around 800 CE, Frankish king Charlemagne listed leek as a suitable crop for his empire. British monks planted leeks in the Middle Ages. In *Henry V*, British playwright

William Shakespeare (1564–1616) has Captain Fluellen punish Pistol, presumably a subordinate, by forcing him to eat a leek. Because Shakespeare regarded this as punishment, he cannot have thought leek imparted courage to soldiers. Before 1775, the Chactaw Indians cultivated leek in the American Southeast. In 1786, the British imported leeks to Australia. British naturalist Sir Joseph Banks recorded that the first British settlers brought 20 bushels of leek seeds and 10 bushels of a variety that he did not specify. Today the people of the United Kingdom, Northern Europe, and parts of Africa and Asia grow leeks.

Attributes and Cultivation

Seeds germinate in 6 to 14 days at 65°F to 70°F, though one gardener favors temperatures between 52°F and 73°F. Below 45°F and above 81°F few seeds germinate. Leek may be planted indoors from seeds, bulbils, corms, sets, and bulbs. Planting from seeds and sets is most common. If started indoors, seeds should be planted 8 to 10 weeks before the last frost and transplanted outdoors in full sun only after the last frost. One gardener, however, plants leeks 2 weeks before the last frost without ill effect. Leeks are ready to transplant when they are half the thickness of a pencil. Leeks prefer damp, fertile, loose, sandy loam. Leeks benefit from the addition to the soil of manure and bone or fishmeal for phosphorus. Leeks grow best between 55°F and 75°F. Temperatures above 77°F diminish the yield. The gardener should mulch the soil to retain moisture and minimize weeds. As leeks grow, soil should be hilled around the base of the plant, covering the stalk below the crown. This practice ensures the production of a long, tender bulb. Leeks grow to eight inches, though the gardener may cut off a portion of the top to coax the plant to put its energy into enlarging the bulb.

As a rule, early varieties mature in 80 to 85 days, mid-season cultivars in 100 days, late varieties in 130 to 135 days, and extra-late cultivars in 150 to 180 days. Extra-late varieties are the most hardy. Because leek has a long growing season, it may be planted in autumn, spring, or summer depending on the climate. Where autumn is cold, an early spring planting is best. Because leek continues to grow throughout cool weather, provided it does not become too cold, the gardener may harvest it whenever it suits her. Leek is ready to harvest when the stalk is one to two inches thick and six to eight inches tall. If leek is to overwinter in the ground, the gardener should mulch it with straw. On the continent of Europe, leek is harvested when the stalk is one inch in diameter. The British and Australians allow leeks to grow larger before the harvest. Where winter is harsh the gardener may harvest leek in autumn, storing it in sand in a cool place. One gardener recommends that leeks be stored between 32°F and 40°F, temperatures that give leek a two- to three-month shelf life.

Leek is a biennial, flowering its second year. Flowers are white, pink, or purple. Gardeners treat leek as an annual by harvesting it at the end of the first growing season. If allowed to flower, the bulb becomes too tough to eat. The seeds gathered from leek in its second year are viable two or three years.

Nutrition, Medicine, and Consumption

Leek has few calories and is a source of vitamins A, C, and E, iron, and fiber. It is an antiseptic. A poultice made from leek leaves may be used to treat hemorrhoids. The ingestion of roasted leak is reputed to remove mucus from the lungs, to stop nosebleed, and to counteract poison mushrooms. Leek is used as an insect repellent and perhaps for this reason is interplanted with carrot, tomato, and rosebush.

People accustomed to the robust flavor of garlic and onion may appreciate the sweet, mild flavor of leek. Typically, only the white portion of the plant is eaten, though the leaves of some cultivars are edible. The best leeks have long, white, thin stalks. A leek should be eaten fresh because flavor deteriorates with age. Since the Romans, people have eaten leek raw in salad. As a rule, leek may be prepared like asparagus, and this connection between leek and asparagus must be the source of the phrase that leek is the "poor man's asparagus." Cooks add leek to curry and stew. Leek is often paired with pork, lamb, and fish. Added to quiche, leek is an ingredient in some sauces. In many recipes, one may substitute leek for onion. Leek is desirable in this context because it has fewer calories than onion. Leek may be boiled, steamed, baked, or fried and served with other vegetables. The cook should cut a leek just before its use because the flavor of a cut leek deteriorates over time. Once cut, leek may be coated with melted butter to retard the loss of flavor.

Christopher Cumo

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Lemon

The word "lemon" refers to both a citrus tree and its fruit. Intolerant of frost, the lemon needs warm summers and mild winters. The tree may grow to 30 feet, though dwarfs stand 15 feet tall. Since antiquity humans, primarily the wealthy, have planted lemon trees for their attractive leaves and fragrant flowers. The lemon tree may have been an ornamental before it was cultivated for fruit. The

Lemons (Olaf Speier/Dreamstime.com)

fruit has a high content of acid and more vitamin C, ounce for ounce, than oranges. In Old French, the word for lemon is *limon*, in Italian *limone*, in Chinese *limong*, and in Arabic and Persian *limun*. The word "lemon" has come to mean a defective product, especially a defective automobile. Scientists know the lemon as *Citrus* × *limon*, the name denoting a hybrid. Many scientists believe that the lemon is a hybrid between the citron and the sour orange. Farmers prize lemon trees because they yield abundantly. Lemons are seldom eaten whole but are instead used to flavor food and drink.

Origin and Diffusion

The lemon tree is indigenous to India, Myanmar, and China. The ancient Indians used the lemon as a food and in beverages. They mixed alcohol with lemon juice, imbibing the tart drink. Archaeologists have dated an earring in the shape of a lemon to 2500 BCE. Recovering it from Mohenjo Daro in the Indus River valley of Pakistan, archaeologists believe this region to have been the cradle of lemon culture. The next two millennia reveal nothing about the lemon. The fruit resurfaced in the fifth century BCE, when the Greeks began to cultivate it. Through its network of trade, Greece had acquired the lemon from Iran. Iran must therefore have first cultivated the lemon sometime between 2500 and 500 BCE. The Greeks referred to the lemon as the Median apple because of its cultivation in Media, now western Iran. The fifth-century BCE Greek dramatist Aristophanes and the fourth-century Greek botanist Theophrastus were familiar with the lemon. The Greeks flavored soup and fish sauce with lemon. Evidently aware that the Greeks had acquired the lemon from Iran, Roman poet Virgil referred to it as the Median apple in the first century BCE. Some scholars, doubting that the Median apple was the lemon, do not believe that Greece and Rome cultivated it and date its arrival to the Mediterranean to the 10th century CE. Others have identified lemon trees in the frescoes of Pompeii and the mosaics of Tusculum. These identifications, if correct, put the lemon in Rome no later than the first century CE. Around the time of Christ, Roman poet Ovid recounted Hercules's theft of the golden apples from the Hesperides. Some scholars believe these apples were lemons, and later authors referred to lemons as Hesperides apples. Because the golden apples grew on a rare tree, the lemon must not have been common in Rome. The fourth-century CE Roman agricultural writer Palladius was reputed to have been the first to plant a lemon tree in Italy, though this date may be too late. The Romans may not have cultivated the lemon tree for fruit. To the extent that they were cultivated for fruit, lemons must have been expensive in antiquity because they were uncommon. The Roman agricultural writers did not mention the lemon, an omission that may imply that the Romans grew the lemon tree more as an ornamental than for fruit. One authority believes that the Romans did not flavor food with lemon juice. The fact that there is no Latin word for lemon suggests that the fruit and perhaps the tree were not important to the Romans.

The fall of the Roman Empire may have plunged the lemon further into obscurity. It appears to have been little cultivated in late antiquity and the early Middle Ages. Acquiring the lemon from the Middle East, the Arabs revived its fortunes. As had the Iranians, the Arabs used lemon juice to flavor mutton. In the eighth century, the Arabs planted lemon trees in the Sahara Desert. These trees were the source of North Africa's lemons. In the eighth century, the Moors planted lemon trees in Spain. Andalusia emerged in the Middle Ages as a lemon exporter. The Chinese, adopting the lemon from the Arabs, may have been the first to make unambiguous reference to the lemon, calling it *limong*, as we have seen, in the early 10th century during the Song dynasty. The Moors introduced the lemon into Sicily, from where it recolonized Italy. Sicilians salted lemon slices and consumed them with cayenne pepper. By the end of the first millennium CE, people tended lemon trees in North Africa, Egypt, Southern Europe, the Near East, the Middle East, and East Asia. In the Middle Ages Morocco, Tunisia, and Algeria emerged as important centers of lemon culture. The Muslims of North Africa used the lemon to flavor a soup that they ate after the fast of Ramadan. They used lemon to flavor sauces, vegetables, and quiche. The Moroccans added lemon to stew. The lemon was part of the cuisine in North Africa, Egypt, Syria, Afghanistan, India, and Pakistan. The Moroccans and Indians pickled lemons. The Egyptians and Syrians added salt and oil to lemon slices. In the 13th century, Crusaders brought the lemon to Northern Europe. In Paris, marchands d'aigrun—merchants of acid—sold lemons, though they were still too expensive for the masses. Perhaps because they were dear, Italian prince Cesare Borgia sent a basket of lemons to his wife in 1494. Renaissance aristocrats grew lemon trees for their beauty. In the 16th century, growers began grafting lemon trees onto dwarf rootstocks. Botanists planted these dwarfs in Italy's Boboli Gardens and the Leiden Botanical Garden in the Netherlands. By the 17th century, the lemon was grown as far north as Brompton Park Nursery in London, England. Ladies at the court of French king Louis XIV bit lemon wedges to keep their lips red.

In the 16th century Libro Novo, chef to the archbishop of Milan in Italy, wrote the first cookbook to include recipes for lemon. Novo was the first to pair lemon juice with fish, a combination that remains popular today. In 1651, French nobleman Pierre Francois de la Varenne recommended the inclusion of lemon juice in sauces. Fearing that the consumption of fresh lemons was unhealthy, the British cooked lemons with sugar and spices. British Queen Elizabeth I drank mead flavored with lemon zest. The British combined brandy, sugar, and lemon juice to make a tart alcoholic beverage. In the mid-17th century, the British ate lemon jelly and consumed a mixture of sliced apples, lemon zest, sugar, and fennel seeds. The British made transparent pudding from almonds, raisins, and candied lemons. Combining lemon juice, water, and sugar in the 17th century, the French invented lemonade, a drink that quickly became popular throughout Europe. In 1788, the British brought lemons from Rio de Janeiro, Brazil, to Australia. Australia began cultivating the Lisbon variety in 1849. In the 19th century, the Victorians made lemon pudding. By the 19th century, India grew more varieties of lemon than any other country. A rare commodity in antiquity, the lemon is today widespread in the cuisines of many people. As a flavoring, lemon is nearly as widespread as salt. The lemon was a subject of art from antiquity, through the Renaissance, and to French painters Georges Braque and Henri Matisse. Iranian paintings depict lovers beneath a lemon tree, a reference to the centuries-old belief that the lemon symbolizes love and courtship.

The Americas

In 1493, Italian-Spanish explorer Christopher Columbus introduced the lemon into the island of Hispaniola (today Haiti and the Dominican Republic). By 1513, lemon trees were plentiful throughout the island. In the 17th century, European travelers remarked that lemon trees were widespread on Guadeloupe. As the Caribbean has moved away from sugarcane monoculture, the cultivation of citrus, including lemons, has become important. In 2002, Jamaica yielded tens of thousands of tons of lemons and limes. In 2004, Dominica produced thousands of tons, and the Bahamas raised a slightly smaller amount of lemons and limes.

In addition to the Caribbean, South and North America are lemon producers. By 1563, the Portuguese had introduced the lemon into Brazil, and the Spanish had planted lemons in Florida. In 1769, Spanish missionaries introduced the lemon into San Diego, California, from where it spread throughout California in the 18th century. In the United States, the Ponderosa variety grows as large as a grapefruit and is often cultivated as an ornamental. Ponderosa yields abundantly from a young age, producing its harvest in winter. The most widely grown varieties in the United States are Lisbon and Eureka. As the name suggests, Lisbon originated in

Portugal, being first grown in California around 1890. Eureka originated in Italy and was first planted near Los Angeles, California, in 1858. Lisbon produces few if any seeds and so is preferred to Eureka. Lisbon is hardier than Eureka and so is grown in Arizona. Neither Lisbon nor Eureka is suited to Florida, where Villefranca, Bearss, and Avon are grown. California and Arizona rather than Florida are the leading producers of lemons in the United States. In 1908, U.S. Department of Agriculture scientist Frank Meyer found a lemon variety near Beijing, China, introducing it to California. Named in his honor, the Meyer lemon was a hybrid between a variety of lemon and the orange or mandarin. Meyer tolerates cooler summers than other varieties and so is grown in northern California. California's Central Valley grows most of the world's Meyer lemons. Florida and Texas raise a portion of the Meyer crop. In these states, Meyer is known as the valley lemon. Farmers harvest Meyer between November and January, though in some years the harvest extends as late as April. Growers in Arizona will not grow Meyer because it may be a host of Citrus tristeza virus. Although Meyer is immune to the virus, other varieties are susceptible. In Florida, Meyer grows as large as a navel orange. The variety, less acidic than other cultivars, is suitable for making lemonade, lemon tart, and lemon granita. Growers in California, Texas, and Hawaii grow the variant Improved Meyer, which yields fruit year-round from a young age. Although Florida emerged as an early center of lemon culture in the United States, it has ceded leadership to California. In the mid-19th century, migrants crowded California in search of gold. Because they suffered from scurvy, these transients were willing to pay $1 per lemon, a price that prompted the state's growers to plant lemon trees. At its peak, California produced one-third of the world's lemon harvest. Florida is not an ideal region for growing lemons. The lemon prefers a dry climate with low humidity. Florida is too wet and humid, a climate that encourages the spread of pathogenic fungi. The freezes of 1886 and 1894 forced farmers to abandon the lemon, though its fortunes revived in the 1950s, when Florida began to process lemons into frozen juice. Lemons are grown as ornamentals in Charleston, South Carolina. In 2007, the United States ranked seventh as a lemon producer. India ranked first, Mexico second, Argentina third, Brazil fourth, Spain fifth, and China sixth. Global production stood at several million tons in 2007. In addition to the United States, Italy, Spain, Argentina, Greece, and Turkey export lemons.

Health

Throughout history humans have ascribed medicinal properties to the lemon. The ancient Egyptians believed that the consumption of lemon juice could counteract poison. This belief may have been widespread. The people of South Asia have long used lemon juice as an antidote for poisoning. Virgil believed that lemon juice was an antidote to poison, and around 300 CE scholar Athenaeus told the story of two criminals who were consigned to a pit full of poisonous snakes. One of the two ate a lemon before being thrown in the pit and so survived snakebite. The other, without protection from a lemon, succumbed to the venom. In antiquity, Indian physicians used the lemon to treat an enlarged spleen. Ibn Jamiya, physician to Sultan Saladin, published *The Treatise of the Lemon*, in which he recommended the lemon as a treatment for fever and weakness. In the 17th century, the British mixed lemon juice with milk, sorrel, and ale to treat kidney stones. For centuries, the people of Southeast Asia had used lemon juice to prevent scurvy. Indeed, the lemon was the first citrus fruit known to prevent scurvy. As early as 1601, the British navy gathered lemons from Madagascar for this purpose, though the Dutch may have been the first Europeans to observe the medicinal use of lemon juice in Southeast Asia. British sailors mixed lemon juice with rum. So effective was it that in 1795, the British issued lemon juice to sailors as part of their daily ration. Between 1795 and 1815, British sailors consumed 1.5 million gallons of lemon juice. After 1850 the parsimonious navy, buying cheap limes from Portugal, replaced lemons with limes though limes have less vitamin C, the nutrient that combats scurvy, than lemons.

Over the centuries, the connection between the lemon and health has strengthened. One authority believes that the consumption of lemon juice reduces nausea. The consumption of lemon juice may improve digestion. Massaging one's feet with lemon juice may reduce aches. Because lemon juice is a sanitizer, it may eliminate athlete's foot. The consumption of lemon juice and water may freshen breath. The imbibing of lemon juice and water may cure bladder infections. Because it is a disinfectant, the application of lemon juice to a cut may help it heal. One writer recommends the consumption of lemon juice, water, and ginger to relieve bronchitis. The consumption of lemon juice and water may relieve constipation. One may prepare cough syrup from lemon juice, honey, and olive oil. It may be possible to treat fever with lemon juice, cod liver oil, and honey. The consumption of lemon juice, water, and salt may relieve heartburn. The person who sucks on lemon wedges may alleviate hiccups. One may rub lemon juice on insect bites to reduce pain and itching. Similarly, lemon juice may diminish itching due to poison ivy. Lemon juice and honey may treat a sore throat. One may rub lemon juice on sunburn to lessen pain. The consumption of lemon juice may improve the function of the liver. Lemons contain pectin, which gives one a sense of fullness and may therefore help the overweight to eat less. The pectin in lemons may prevent colon cancer. The consumption of lemon juice and water may prevent gum disease. One lemon has 52 milligrams of vitamin C, nearly half the recommended daily allowance. The juice from two-and-a-half lemons supplies 100 percent of the recommended daily allowance of vitamin C, though vitamin C content may vary by 60 percent among cultivars. The variety Palestine yields an amount of vitamin C that varies by season. Curiously, the quantity of vitamin C increases during storage. Lemons contain calcium, beta-carotene (the vitamin A precursor), folic acid, thiamine, riboflavin, and niacin. Calcium is abundant in lemon peel, where it is associated with pectin. In lemon peel, calcium combines with pectin to form calcium pectate, a water-insoluble compound. Lemons contain water-soluble potassium compounds. Where the soil is alkaline, lemon trees produce fruit with a high content of chlorine. Some of the chlorine bonds with hydrogen to form hydrochloric acid. The quercetin in lemons may boost the immune system and stimulate the production of insulin.

Attributes and Cultivation

As is true of tomatoes, farmers harvest lemons green, allowing them to ripen in storage. Ripening takes 10 days to four months. Farmers may hasten the process by exposing lemons to ethylene gas. Many farmers do not favor its use because it may cause lemons to decay. Because lemons are sprayed with pesticides and coated with fungicide and wax, the consumer should wash the skin before using a lemon. Some people believe that thin-skinned lemons yield more juice than lemons with a thick peel, but this is not always true. As a rule, the heavier a lemon the more juice it produces. To produce juice commercial growers boil a lemon before squeezing it to increase the production of juice by 50 percent. As a rule, a warm lemon yields more juice than a cold lemon. A typical lemon yields two to three tablespoons of juice. A large lemon may yield four tablespoons of juice and three teaspoons of zest. The best lemons are small and yellow with thin, smooth skin. The greener a lemon the more acid it has. Thick-skinned lemons may have too little pulp and juice. One author uses lemon juice to whiten fingernails, to make hairspray, and to derive a solution that deters fleas. The housewife may prolong the life span of a lemon by storing it at 50°F. A lemon will remain fresh one week at room temperature and two to three weeks if refrigerated. One may derive zest from a lemon by removing the outermost layer of the peel. The person who mistakenly harvests the white pith beneath this layer will derive a bitter portion of the lemon. One may dry or freeze zest to store it.

Lemon trees need full sun to yield well. Susceptible to wind damage, a lemon tree benefits from soil that drains well. Seedlings should be watered twice per week. Older trees, their roots well developed, need to be watered only twice per month. A lemon tree demands plentiful nitrogen to yield abundantly. The farmer may begin fertilizing lemon trees in late winter in anticipation of robust growth. The last feeding should be at the end of summer, when growth slows. A solution of iron, manganese, and zinc, sprayed on trees, hastens growth. As a rule, lemon trees yield in winter and spring, though in the tropics they yield year-round. The yellowing of leaves may signal that the soil has too much water or too little nitrogen, iron, manganese, or zinc.

Christopher Cumo

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Lentils

An annual legume, lentils were among the first plants that humans domesticated. Like all members of the Fabaceae or Leguminosae family, lentils bear their seeds in pods. Like beans, lentils feed the poor, possibly averting famine in years that the grain crop failed. They are high in protein and a good alternative to meat. India is the leading producer of lentils at 800,000 tons per year, a figure that is more than half the world's output. Even so, India is not self-sufficient but must import lentils from Turkey. Although its yield has fallen in recent years, Turkey produces 600,000 tons of lentils per year. Canada is the world's largest exporter, selling 280,000 tons of lentils per year. Lately, Australia has grown as an exporter. The big importers are Colombia, Spain, Belgium, and Italy. One cup of lentils contains 229 calories, molybdenum, manganese, iron, phosphorus, copper, potassium, folic acid, thiamine, protein, tryptophan, and fiber. Lentils are related to chickpea, lupin, peanut, vetch, clover, alfalfa, pea, bean, soybean, and cowpea.

Prehistory and Antiquity

Humans gathered wild lentils of the species *Len orientalis* before domesticating them. As early as 11,000 BCE, Greeks cooked lentils, but they may not yet have cultivated them. Between 9000 and 8000 BCE, the Syrians harvested wild lentils, though again this activity predated their cultivation. Under human aid, wild lentils gave rise to the cultivated species *Lens culinaris*. By one account, about 10,000 years ago women, gathering lentils in the wild in the Near East, saved the largest seeds from the most vigorous plants. They planted these seeds and then, being nomads, followed the caravan routes to various destinations. Upon returning months later, they had lentils ready to harvest. Repeating this process over many generations, humans selected for lentils that did not shatter. Unable to disperse seed, lentils now depended on human intervention for survival. The cultivated lentil also differed from its wild counterpart in having large seeds and a thin seed coat, which made lentils easier to digest. Plant stalks were sturdy, allowing lentils to grow without support. Doubtless humans prized lentils because they yielded well on marginal land. As a winter crop, lentils provided food in spring, when other sources of food were scarce.

As nomads and hunter gathers settled down in the first villages, they came to depend more on lentils and less on meat for protein. In the Fertile Crescent, the likely place of origin of lentils, humans also domesticated wheat and barley, and from an early date may have rotated lentils and grains. The ancients understood that lentils enriched the soil—though they were ignorant of the process of nitrogen fixation—and so followed lentils with a grain. Lentils had a dual use, feeding livestock in addition to humans. Livestock produced manure, further enriching the soil. Lentils and grains provided an adequate diet. They are complementary foods, each supplying amino acids that the other lacks. Lentils and other crops provided more calories per unit of land than did meat from grazing livestock. The surplus of calories fed an expanding population, fueling the growth of cities and the rise of civilization. Humble though they are, lentils helped lay the foundation of Western civilization.

The first evidence of the cultivation of lentils comes from Jarmo, Iraq, where farmers grew the legume as early as 7000 BCE. The Greeks grew lentils by 6500 BCE. Turkey and Iraq traded lentils by 5000 BCE, evidence that they must have relied on agriculture to yield a marketable surplus of lentils. By 5500 BCE, farmers throughout Europe grew lentils. Between 3000 and 1000 BCE, farmers grew lentils in the Danube River valley. By then lentils were cultivated as far north as Britain, as far south as Ethiopia, and as far east as India. Lentils were then unknown in the Americas. Egyptians grew lentils before 3000 BCE. In their religion Horus, the god of lentils, ensured a bountiful harvest. The Egyptians regarded lentils, and probably other plants as well, as a symbol of resurrection. In antiquity, Egypt reputedly grew the best lentils. Some people believe that Egypt still holds this distinction. Alexandria was the center of the lentil trade and the port through which merchants shipped lentils to Rome. As elsewhere Egyptians grew lentils, which do not need irrigation, in arid lands and on marginal soil. Egyptians put lentils in tombs to feed the dead on their journey to the afterlife. Archaeologists have found lentils in predynastic tombs and below Pharaoh Zoser's pyramid. The fact that lentils were among the food in a pharaoh's tomb suggests that the wealthy ate lentils. In Sumeria, where farmers planted lentils, chickpeas, wheat, barley, and millet, the pattern of consumption diverged from that of Egypt. As the gulf between classes widened, the rich confirmed their affluence by consuming meat. Abundant and cheap lentils fed the poor. Given this state of affairs, it is not surprising that ancient cookbooks did not devote much space to lentils. The first written recipe for lentils dates to 1600 BCE. Even then the recipe includes meat, which may have been the main dish. The lentils were to be cooked in beer.

The people of India, many of them vegetarians, cultivated lentils. So important were they that one Indian proverb held that "rice is god, but lentils are my life." The Old Testament makes several references to lentils, the most notable being in Genesis. Brothers Jacob and Esau represented competing lifeways. Esau, the hunter, returned home hungry one day to find Jacob, the farmer, enjoying a bowl of lentil soup. Esau asked for a bowl of soup, but Jacob complied only when Esau agreed to sell him his birthright. Lentils had triumphed over meat. The prophet Ezekiel ate a type of lentil bread, though it is not clear that he enjoyed the bread. Old Testament prophets warned against the unnatural mixture of lentils and grains. This warning taught a larger lesson, reminding the Hebrews not to intermingle with other people to the point of losing their identity and faith.

The Greeks had a low opinion of lentils, regarding them as fit only for the poor. One Greek saying held that "he became a rich man and suddenly he no longer likes lentils." Greek physician Galen believed lentils could cause elephantiasis and liver problems, produce black bile, damage eyesight, and inflame the spleen. Others believed that eating lentils with pickled meat thickened the blood. Yet Greek philosopher Zeno apparently ate lentils. To a degree the Romans shared the Greek distrust of lentils. One Roman medical authority held that lentils were hard to digest and so made one sluggish. In this context, theologian Isidore of Seville suggested in the sixth century that the word "lentil" derived from the Latin *lentus*, meaning "slow." Not all Romans shared this opinion. Consumption of lentils was so great that, as we have seen, Rome had to import them from Egypt. In the second century BCE, agriculturalist Cato the Elder valued lentils as a medicine. All classes ate lentils during the Republic, and only in the Empire did patricians stigmatize them.

The Middle Ages and Modernity

In the Middle Ages, Arab physician Averroes warned that lentils caused depression, weakened vision, and vitiated sexual impulses. Taking a similar view, Arab Haliabbas worried that lentils caused depression, mania, elephantiasis, cancer, and bad dreams. Italian physician Antonius Gazius, having read the Arabs, recommended that people eat lentils only when they had no other food. The absence of lentil recipes from medieval cookbooks suggests that lentils were not an important food in the Middle Ages. It is not certain that lentils did well in cold, wet Northern Europe, leading one to wonder how familiar Europeans were with lentils.

The stigma against lentils persisted in modernity. In the 17th century, one Italian wrote, "In general lentils are only eaten by the lowest of the low." Yet this stigma may have been waning. As early as the 16th century, French surgeon Ambroise Pare believed lentils could cure smallpox. Marie de Sevigne, a friend of King Louis XIV, ate lentil soup, recommending lentils grown in Nantes as the best. Partial to the lentils of Nantes, King Louis XV named them "the queen's lentils" for his wife, Maria Leszczyńska, a native of Poland, where lentils were prized. During the bad harvests of the 1780s, lentils spared many Frenchmen and women from starvation. With the system of food distribution in crisis during the French Revolution, people subsisted on lentils.

In the 18th century, a French priest planted lentils in the Saint Lawrence River valley, teaching the Iroquois to grow them. By 1774, farmers in Virginia cultivated lentils. Thomas Jefferson grew them at Monticello. During World War I, a missionary gave lentils to a farmer in Washington, and by the 1930s they were an important crop in that state and in Idaho. In the 1970s, farmers in western Canada grew lentils for export. Today, the people of India grow and eat more than 50 varieties of lentils. The average Indian eats some five pounds of lentils per year, whereas the average American eats less than one-quarter of a pound of lentils per year. In India, people eat lentils with oil, ginger, chili peppers, cilantro, and cumin. In southern India, people eat lentils, brown sugar, cardamom, coconut milk, and butter during the rice festival of Onam. In northern India, people eat lentils, onions, and chili peppers during the Hindi festival of Holi.

Christopher Cumo

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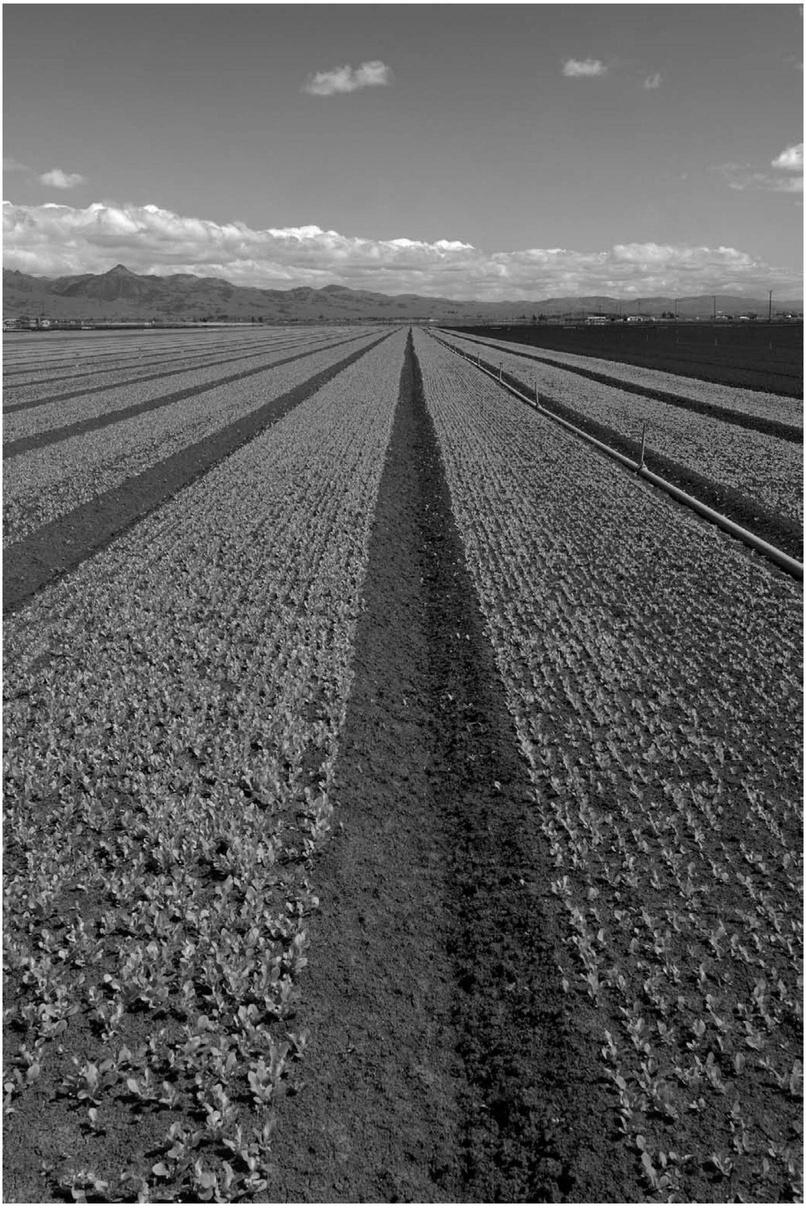
Lettuce

Lettuce (*Lactuca sativa*) is a member of the Asteraceae family, the largest family of dicots. An annual vegetable, lettuce is cultivated for its edible leaves. All classes and ethnic groups eat lettuce, ranking it in importance with the potato, tomato, cabbage, onion, and beans. The most valued salad green, lettuce is consumed raw in salad, though a small portion is cooked in soup. More than 94 percent water, lettuce has fiber, vitamins A and C, calcium, phosphorus, iron, potassium, and a small amount of sodium. Nutrients vary by type. One hundred grams of crisphead lettuce, better known as iceberg, has 22 milligrams of calcium, 26 milligrams of phosphorus, 1.5 milligrams of iron, 166 milligrams of potassium, 470 international units of vitamin A, and 7 milligrams of vitamin C. One hundred grams of butterhead lettuce contains 35 milligrams of calcium, 26 milligrams of phosphorus, 1.8 milligrams of iron, 260 milligrams of potassium, 1,065 international units of vitamin A, and 7 milligrams of vitamin C. One hundred grams of cos lettuce, better known as romaine, has 44 milligrams of calcium,



Lettuce (iStockPhoto)

35 milligrams of phosphorus, 1.3 milligrams of iron, 277 milligrams of potassium, 1,925 international units of vitamin A, and 22 milligrams of vitamin C. One hundred grams of leaf lettuce has 68 milligrams of calcium, 25 milligrams of phosphorus, 1.4 milligrams of iron, 264 milligrams of potassium, 1,900 international

units of vitamin A, and 18 milligrams of vitamin C. The dark outer leaves of head lettuce, of which crisphead and butterhead are types, have more vitamin C than the white inner leaves. One gardener believes that lettuce has the most vitamin C at midday and so picks it then. Because lettuce loses vitamin C in storage, it is best eaten soon after the harvest. The popularity of lettuce is evident in the fact that restaurants, including fast-food enterprises, buy large quantities of the green.

Origin and History

Lettuce may have descended from the wild species *Lactuca serriola*. Alternatively, lettuce may be a hybrid, though its scientific name does not denote hybrid status. Lettuce may have originated in the eastern Mediterranean Basin—Egypt is a possibility—or in Iraq. As early as 2500 BCE, Egyptian tomb paintings included lettuce, leading to the inference that the Egyptians regarded it a sacred plant. The Egyptians may have grown lettuce first for oil and only later as a vegetable. Extracting oil from lettuce seeds, the Egyptians used it for cooking. The Persians esteemed lettuce, serving it to kings as early as the sixth century BCE. About 430 BCE, Greek physician Hippocrates mentioned lettuce, leading to the supposition that the Greeks cultivated it then. He believed that it "breeded the most laudable blood." Syrian and Babylonian hero Tammuz was laid on a bed of lettuce at his death. Lettuce aided Tammuz's descent into the netherworld, the Syrians and Babylonians believed. Mourners carried lettuce in his funeral procession. In the first century CE, Roman agricultural writer Columella knew several varieties of lettuce, though its cultivation in Rome may have begun earlier. In contrast to the current practice of eating lettuce raw, the Romans boiled it, consuming it with oil and vinegar. Some Romans ate lettuce after a meal to aid digestion and promote sleep. Others ate it as an appetizer. In addition to its value as food the Romans believed lettuce was a medicine. Emperor Augustus (63 BCE–14 CE) credited it with restoring him to health after a fever had sickened him. In gratitude, he built an altar and statue to the "noble plant." Third-century emperor Tacitus ate lettuce as a luxury in an otherwise Spartan diet. The Romans planted lettuce in Britain, where it was quickly popular. In the fifth century CE, the Chinese cultivated lettuce.

Interest in lettuce waned in the Middle Ages, though in 1340 British author Geoffrey Chaucer mentioned it with garlic and onion. Renaissance gardeners found space for it in their plot of land. In the 16th century, British herbalist John Gerard, apparently eschewing the Roman habit of boiling lettuce, enthused that it "makes a pleasant salad, served raw with vinegar, oil and a little salt." Not everyone shared Gerard's enthusiasm. The 17th-century British author Robert Burton cautioned against eating lettuce raw in the belief that it caused flatulence.

Popular sentiment appears to have been with Gerard because many people thought that lettuce aided digestion, alleviated thirst, acted as a sedative, prevented hunger, soothed the nerves, and caused nursing mothers to lactate. Whereas some people urged the consumption of lettuce in the belief that it blunted the intensity of lust, others believed that lettuce elevated a couple to love. The British feared that a husband who grew too much lettuce would cause his wife to become sterile. Even a little lettuce, they believed, might diminish fertility.

In 1494, Spanish-Italian explorer Christopher Columbus brought lettuce to the Caribbean island of Isabella. The European settlers in North America planted lettuce in their gardens, though the pilgrims considered it "women's food." An accomplished gardener, Thomas Jefferson planted lettuce in his garden, serving it to guests. Despite Jefferson's efforts on its behalf, one writer believes that lettuce was not widely grown in the 18th and 19th centuries. In the 19th century, journalist and reformer Horace Greeley characterized the diet of the masses in the American West as "bread, bacon and beans." The appetite for lettuce, having ebbed in the 19th century, revived in the 20th century, when interest in nutrition restored it to prominence.

In the early modern era, romaine was the chief lettuce of the Mediterranean whereas butterhead dominated in Northern Europe and, by 1900, the United States. In the early 20th century crisphead, grown in the American West, eclipsed butterhead so that in 1955, crisphead accounted for more than 95 percent of lettuce grown in the United States. After 1980, however, butterhead recrudesced, and leaf lettuce and romaine grew in popularity. Today, 20–30 percent of the U.S. crop is romaine, butterhead, and leaf lettuce. In Europe, crisphead has made converts and is the major type of lettuce grown in the United Kingdom and Scandinavia.

In Europe, the United Kingdom, France, Spain, the Netherlands, Italy, Germany, and Belgium grow lettuce. Other important producers are Australia, Japan, and Israel. Europeans use lettuce seed oil as a sedative. In addition to oil, Europeans use two extracts of lettuce, latucin and lactucopiorin, as sedatives. In the United Kingdom, 75 percent of the lettuce harvest is crisphead, 15 percent is butterhead, and 10 percent is romaine whereas in the 1970s 80–90 percent had been butterhead. Northern England and Wales are the United Kingdom's chief lettuce growers. The French grow butterhead and Batavia lettuce for domestic consumption and crisphead for export. Brittany grows crisphead. Other lettuce producers in France are Provence, Languedoc-Roussillon, and Ile de France. In Germany, two-thirds of the lettuce harvest is butterhead and the rest crisphead. Germany's lettuce producers are Baden-Württemberg, Rhineland-Westphalia, and Palatinate. The Netherlands grows butterhead in greenhouses and outdoors along with crisphead and leaf lettuce outdoors. The Spanish grow lettuce for domestic consumption and export. They raise romaine for domestic consumption.

Murcia, Spain, grows lettuce year-round, yielding one-third of the Spanish crop. Other important producers in Spain are Andalusia, Valencia, and Catalonia. In Italy, butterhead totals half the harvest and romaine one-third. Italians grow small quantities of crisphead and leaf lettuce. In Australia, crisphead is the chief type, though romaine and leaf lettuce are also grown. Japan cultivates lettuce year-round, primarily in Nagano, Ibagi, Kagawa, and Hyogo Prefectures. In Israel, romaine totals two-thirds of the harvest and crisphead the remainder. The Egyptians prefer lettuce with a thick stem. The Chinese cook these stems. In South America, farmers grow a variety of lettuce that yields brown leaves, rolling them into cigarettes. Because lettuce has no nicotine, these cigarettes appear to be less harmful than cigarettes made from tobacco.

California, harvesting 70–75 percent of the nation's crop, is the principal lettuce grower in the United States. By itself, California produces more lettuce than any nation. The state's primary regions for growing lettuce are the Salinas Valley, Santa Maria Valley, Imperial Valley, and San Joaquin Valley. In addition to California, Arizona grows 20 percent of the U.S. crop. Production is concentrated in the southwestern quadrant of the state. Other important producers are Colorado, New Mexico, New York, New Jersey, and Washington. Texas, Michigan, Ohio, and Florida harvest small quantities of lettuce. Americans eat sandwiches with lettuce for lunch as well as salads at lunch and dinner.

Types, Varieties, and Cultivation

We have seen that head lettuce is of two types: crisphead and butterhead. Crisphead has mild, sweet flavor. Yielding smaller heads than crisphead, butterhead has a soft texture and, as the name suggests, a buttery taste. Leaf lettuce has milder flavor than head lettuce. Leaf lettuce is easier than head lettuce to grow. Its rapid maturation makes it a favorite of gardeners. Among varieties of lettuce, Premier Great Lakes tolerates heat and is grown in the South. In the North, farmers and gardeners raise Great Lakes and Ithaca. Among leaf lettuces, popular varieties include Black Seeded Simpson, Oak Leaf, and Ruby Leaf.

Gardeners prize lettuce because it yields abundantly while occupying little space. A cool-weather crop, lettuce does well between 50°F and 60°F. Heat causes it to become bitter. Leaves toughen and the plant goes to seed. Lettuce requires moisture because the large surface area of its leaves transpires water. Its shallow roots cannot withstand drought. One may mulch lettuce to retain soil moisture. Lettuce benefits from shade at midday. Some gardeners grow lettuce with beans, cabbage, asparagus, corn, carrot or tomato for shade. Others interplant lettuce with carrot and onion, harvesting lettuce early to yield space for the latter two. One gardener plants lettuce with ornamentals to showcase its color. The soil should contain organic matter to retain moisture. The gardener should cultivate the soil so that it remains loose. Although the soil should be moist, it should also drain well to prevent lettuce from rotting. One gardener recommends that lettuce be grown in soil with a pH between 6 and 6.5. Another recommends a pH between 6.5 and 7.5. The gardener may use a 5:10:10 or 10:10:10 fertilizer in a ratio of nitrogen to phosphorus to potassium. Nitrogen ranks first in importance because lettuce needs it to yield dark, crisp leaves and to grow rapidly. Phosphorus promotes the development of roots, and potassium helps plants resist diseases. Because it grows so quickly, the gardener may apply fertilizer before planting lettuce. One gardener recommends the application of cottonseed, soybean, or peanut meal to add nitrogen, phosphorus, and potassium to the soil, fertilizing again in midseason. One gardener plants lettuce with radishes in the belief that because radishes sprout so quickly, they attract insects that would otherwise plague lettuce. In addition, lettuce may be interplanted with chive, onion, garlic, and herbs to deter insects.

Because lettuce is hardy, one may plant it four to six weeks before the last frost, planting it as soon as the ground thaws. Alternatively, one may plant lettuce indoors four to six weeks before the ground thaws, transplanting it in the field when the soil is warm enough to cultivate. Because leaf lettuce matures more rapidly than head lettuce, early planting is not essential. The gardener may plant lettuce in midsummer for a fall crop. Whether grown from seeds or seedlings, lettuce is best planted on a cool, overcast day. One may increase the germination rate by freezing seeds the day before planting. One gardener freezes seeds in tea before planting them. One may plant seeds by scattering them on the soil, then tramping on them. Kept dry at room temperature, seeds remain viable five to seven years.

Conditions, Diseases, and Pests

Tipburn, as the name suggests, manifests the first symptoms in the tips of leaves, which yellow. As the condition worsens, leaves turn brown, then die. Tipburn afflicts lettuce where soil moisture is inadequate. The soil should be watered to increase soil moisture and mulched to retain moisture. One should not fertilize lettuce in dry weather because rapidly growing lettuce demands copious amounts of water and so is vulnerable to tipburn. The gardener may plant the tipburn-resistant cultivars Premier Great Lakes, Grand Rapids, Pennlake, Ithaca, and Ballerina.

The viral disease mosaic, known as yellow leaves, deforms and yellows lettuce leaves. The virus stunts plants, which die in severe infections. Aphids, leafhoppers, and ants transmit the virus to lettuce. Resistant varieties include Parris Island Romaine, Valmaine Romaine, and Dark Green Boston. Infected plants should be destroyed and the garden kept free from weeds to deprive insect vectors of sustenance. The fungus *Bemia lactucae* causes downy mildew. Cool, wet weather promotes its spread. The disease causes yellow lesions on leaves. Lesions may turn brown, leading to the death of leaves. Butterhead is particularly vulnerable to downy mildew. Alighting on a leaf, spores germinate between 50°F and 63°F and humidity near 100 percent. Spores germinate in 7 to 9 days. Fungicides, especially metalxyl, may be effective against the disease, though scientists have reported fungi resistant to metalxyl. The fungus *Michrodorochium panattoniana* causes anthracnose, known as shothole disease and ringspot. Anthracnose is most damaging in cool, wet weather, infecting lettuce in early spring. Water from rain or sprinklers spreads the disease. Anthracnose causes small chlorotic lesions on leaves near the base of the plant. Infected leaves desiccate. Symptoms manifest 10 to 17 days after infection. Fungicides may be effective. The variety Salad Bowl is resistant to three of the five races of anthracnose.

Slugs may be the worst pests of lettuce. Because slugs hide under plant debris, the garden must be kept clean. Because of this habit, slugs hide under mulch, though the gardener should exercise caution in removing mulch. Because slugs may plague gardens without mulch, its removal may not protect lettuce from them. Simple remedies may be in order. Wood ashes and ground limestone, scattered around lettuce plants, lacerate the soft bodies of slugs. The attentive gardener may remove slugs by hand, drowning them in kerosene. A transmitter of mosaic disease, aphids also weaken lettuce by sucking sap. Because they feed on the underside of leaves, aphids may evade detection. Simple remedies may control aphids. One may wash them off lettuce with a hose. Also effective is the spraying of lettuce with soap and water. The gardener may release ladybugs and praying mantises to eat aphids. One may plant lettuce with other crops and marigolds to deter aphids. Because cutworms hide in the soil during the day and feed at the base of plants at night, they may escape notice. The garden must be kept free from weeds to deprive cutworm moths of a place to lay eggs. Because onion deters cutworms, it is a good companion plant.

Christopher Cumo

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Licorice

In 1753, Swedish naturalist Carl Linnaeus put licorice in the genus *Glycyrrhiza*. Licorice is a perennial herb that has been used to flavor medicine and food for centuries. It also has been used as a remedy for certain ailments. Also known as sweetwood or sweet root, licorice originates from the Greek word *glyks*, which means "sweet," and *rhyza*, meaning "root." Licorice root contains a compound, glycyrrhizic acid, that is 50 times sweeter than sugar. The underground stems of the licorice plant are used as a flavoring that is derived from a sweet-tasting, aromatic unsaturated compound called anethole, also present in anise, fennel, and similar herbs. *Glycyrrhiza glabra* is the species of plant native to England, where it is known as sweet licorice or sweet wood. *Glycyrrhiza glabra* is also grown in North America, but *Glycyrrhiza lepidota*, or wild licorice, is the common native species of licorice that is grown in North America. *Glycyrrhiza uralensis* is Chinese licorice, which is cultivated in Asia and used in traditional Chinese medicine.

Origin and Description

Licorice is native to the southeastern regions of Europe and the Middle East, where it is a wild plant. Licorice was known in antiquity, having been mentioned by the Greeks in the Hippocratic texts, which date from the fifth century BCE to the second century CE, and turned into an extract by the Romans. As well, herbalists of ancient China used licorice extract by distilling the essence of its roots and preparing it as a remedy for many maladies. Licorice as a confection dates back to 16th-century England, where Dominican monks began the confectionary trade.

Licorice is hard and fibrous and, when dried, resembles pieces of dried wood. The licorice plant grows three to seven feet high. It has pinnate leaves that are about three to six inches long and that contain about 9 to 17 leaflets. The plant's flowers are one-third to one-half of an inch long. They are purple to pale blue in color. Fruit of the licorice plant grows in an oblong seed-containing pod that is one inch in length. Licorice has an extensive branching root system, and the cylindrical roots are about three-eighths of an inch in diameter. They are made up of a brown-skin exterior and are yellow inside. As a spice, licorice is available as the dried woody root, as a powdery substance, and in a concentrated form that is glossy black and sweet. Licorice is highly aromatic and its flavor is similar to that of anise.

Licorice grows well in deep, fertile, and well-drained soils with plenty of sun exposure. When found in the wild, licorice is rarely more than 50 yards from a water source. It will not grow in clay and succeeds only in warm climates. It cannot endure freezing temperatures. The cold inhibits its natural juices and makes the plant woody. Generally speaking, licorice grows well in the types of climates that support the growth of citrus. The plant is harvested in the fall and is ready for harvesting two to three years after planting. After the fourth year, the plant takes on a tough and coarse texture. Typically, the yield is four to five tons per acre.

History and Medicinal Value

Licorice is an ancient multipurpose plant. Throughout history it has served medicinal, culinary, and mystical purposes. It has been chewed to increase passion, and it has been used in spells to ensure a spouse's fidelity. The ancient Egyptians believed licorice root helped the soul pass safely into the afterlife and they therefore placed it inside tombs and caskets, including that of Pharaoh Tutenkhamun, who died in 1323 BCE. Many cultures believed in the curative powers of licorice, including the Egyptians and the Chinese. In fact, in China it is the second most prescribed herb. Its homeopathic use dates back to the first century CE, and its history as a remedy for ailments dates back even further. It was used by the ancient Greeks, who learned of it from the Scythians. As a demulcent, or coating agent, licorice has been known to soothe sore throats and canker sores. Fourth-century BCE Greek botanist Theophrastus, for instance, had mentioned it in his writings as a remedy for dry coughs. The list of other conditions licorice has been used for over the centuries includes athlete's foot, baldness, body odor, bursitis, dandruff, gingivitis and tooth decay, and emphysema.

The Native Americans had many uses for *Glycyrrhiza lepidota*. The Blackfoot of the Great Plains and the Pawnee of the American Midwest used the leaves for making poultices to ease the pain of earaches. Other Natives, such as the Bannock of present-day Idaho, used the most medicinally active part, the roots, for toothaches, fever, and to improve the singing voice. They also made a tea of the root to speed up the delivery of the placenta after childbirth. It also helped relieve a number of symptoms of illness, including diarrhea, cough, stomachache, and chest pain.

The removal of glycyrrhizin from licorice leaves DGL, or deglycyrrhizinated licorice, and it is used to support digestive health and to settle upset stomachs. As an expectorant, it is known to calm coughs associated with the common cold and bronchitis. Licorice also has been used to cure infections caused by viruses. Clinical studies have shown that it prevents the activation of herpes simplex virus type 1 and type 2 and is a treatment for shingles (herpes zoster), a painful, blistering skin rash caused by the varicella-zoster virus.

Although scientific evidence is lacking to support its efficacy and safety, licorice root has been used to treat such disorders as peptic ulcers, osteoarthritis, systemic lupus erythematosis, liver disorders, malaria, tuberculosis, and chronic fatigue syndrome. When combined with other herbs, such as ginseng and *Bupleurum falcatum*, licorice is used as a means of ramping up the function of the adrenal glands and reducing symptoms of stress. As a topical ointment, licorice gel is considered helpful in easing the itching, swelling, and redness of the chronic skin disorder eczema. Some studies have associated licorice with body fat reduction, as well.

Health supplements made from licorice root are found in powdered form, capsules, tablets, creams, lozenges, and tea, and as a liquid extract. Despite its many medicinal uses, licorice with glycyrrhizin can have dangerous side effects and is often limited to six or fewer weeks of use. (DGL products cause fewer problems.) It is known to be toxic to the liver and the cardiovascular system. For this reason, certain people, including those with heart disease, hypertension, headaches, fluid retention, diabetes, kidney disease, liver disease, heart failure, or those taking prescription medicine or are pregnant or nursing, are discouraged from taking licorice. When combined with licorice, many medications can produce serious side effects, as well. Warning signs of an allergic reaction include edema (swelling), lethargy, itchy rash, hives, swelling of the mouth or throat, and shortness of breath.

Edible Value

Licorice flavoring used in foods is produced by boiling the licorice root. After the root is boiled and the water is evaporated, an extract remains. This extract is produced in solid and syrup forms. Licorice flavoring is added to a variety of candies, but aniseed oil, a derivative of the anise plant, is often added to licorice products or used in place of actual licorice to enhance or replicate the flavor. It is believed that the Spanish monks residing at Rievaulx Abbey in Yorkshire, England, were the first to add sugar to licorice to produce a candy. To this day, in Yorkshire and Lancashire, United Kingdom, licorice root is colloquially called "Spanish" in reference to the monks who grew it.

In addition to making candy, licorice flavoring is added to soft drinks and herbal teas, along with liquid medicines. The Dutch make a type of licorice water by adding a few pieces of laurel licorice and a piece of licorice root to bottled water to make a frothy liquid when shaken. Licorice in its natural form is a popular confection in Italy and Spain. There, the root itself is dug from the ground, washed, and chewed. In Italy, small black pieces of unsweetened licorice extract are a popular treat, although the flavor is bitter and strong. In the southern Italian community of Calabria, where, along with Sicily, large quantities of licorice root are grown, a popular liqueur is made from licorice extract. Syrians and Egyptians also enjoy a cold licorice drink called *erk sous*. Licorice is commonly used as a spice in Chinese cooking and is added to broths and foods simmered in soy sauce. It is also added to tobacco products to give them a mellow and sweet flavoring. Glycyrrhizin is thought to open the airways, allowing smokers to inhale more smoke.

Rosemarie Boucher Leenerts

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Lilac

A hardy shrub, lilac is cultivated as an ornamental. A member of the Oleaceae family, lilac is related to olive, forsythia, jasmine, ash, and privet. Lilac is in the genus *Syringa*, named after the Greek nymph Syrinx, who changed herself into a reed to escape the advances of Pan, the god of shepherds. Not willing to concede defeat, Pan selected the reed as his flute. Accordingly, the name *Syringa* refers to the lilac's hollow, reed-like stem. Because of this myth, the lilac is known as the pipe tree. *Syringa* is *sering* in Dutch, *syren* in Danish and Swedish, *syrin* in Norwegian, *siren* in Russian, *serik* in Czech, and *cerini* in Latvian. Lilac may derive from the Persian *lilak* or *lilaf*, meaning "blue." The French know lilac as *lilas*, the Germans as *der Flieder*, the Portuguese as *lilza*, and the Spanish as *lila*. In Old English, lilac is *laylock*, *lilack*, or *lilock*. In the 18th century, Swedish naturalist Carl Linnaeus named the common *Syringa vulgaris*, a native of the Balkans. The French, importing the species about 1500, referred to it as the "French hybrid."

Attributes and Cultivation

The lilac, according to one gardener, evokes memories of the past, perhaps because of its fragrance and brevity of bloom. The shrub is not trendy. It is unlikely to populate upscale neighborhoods but rather old parts of the city, where an older generation appreciates its beauty and fragrance. Lilac appeals more to the sense of smell than to sight. The colors are not spectacular. One gardener regards lilac as "the poor man's flower" because all one need do to obtain a plant at no cost is cut off a shoot and plant it in a suitable spot. Despite lilac's humble station, the United States' first president George Washington grew it.

Indeed, lilac has much to recommend it. Grown from northern Canada to Colorado, lilac tolerates drought, cold, and heat and can be cultivated in a range of soils. Lilac is the state flower of New Hampshire because it symbolizes the hardiness of the state's residents. Lilac is so much a part of the American landscape that one may be surprised to learn that it is not indigenous to the Americas. Rather, it is native to the mountains of Asia, from Afghanistan through China and Japan. Two species are native to Eastern Europe, including the aforementioned *Syringa* *vulgaris*. By the 17th century, lilac was well enough known in England that British herbalist John Parkinson mentioned it. According to British legend, the origin of the white lilac may be traced to the grave of a young woman. Mourners planted a lilac at her grave. When it bloomed, the flowers were miraculously white, perhaps to honor the woman's purity. In the 17th century, immigrants brought lilac to North America.

The mid-18th and 19th centuries were the era of the plant collector. Europeans traveled the world in search of new species and varieties, among them lilacs. In the mid-18th century, plant hunters brought *Syringa peleinensis* from China to Europe. Other finds followed including *Syringa oblata* in 1856, *Syringa pubecens* in 1880, and *Syringa villosa* in 1889. Botanical gardens in Saint Petersburg, Russia, and Paris, France, Harvard University's Arnold Arboretum in Boston, Massachusetts, and the Royal Botanic Garden at Kew, Great Britain, amassed large collections of lilacs. In the United States, credit is due plant collector Ernest Henry Wilson, who brought lilacs from China to the Arnold Arboretum between 1902 and 1926. Plant breeders crossbred these species to yield hybrids and new cultivars. By 1900, the gardener could choose among 300 cultivars. By 1960, the number had climbed to 830, and by 2002 the figure was roughly 4,000. These new cultivars are disease resistant and bear large, double flowers with bright colors and long-lasting blooms.

A lilac floret usually has four petals. Florets aggregate into large clusters known as thyrses but sometimes called panicles or racemes. In addition to their beauty and fragrance, lilac flowers are edible. The gardener who wishes to taste a flower should pick it soon after opening. Flowers may be added to salad or dessert or used as garnish. The Chinese made tea from lilac flowers. In 1629, John Parkinson wrote that Egyptian women used lilac to ease the pain of childbirth.

Native to the temperate zone, lilac must have temperatures below 32°F to initiate dormancy. Hardy, lilac can tolerate temperatures as low as –40°F. Although it is not a plant of the subtropics or tropics, it flowers as far south as Houston, Texas. It has been grown near Gainesville, Florida, but has not flowered at this latitude. Efforts to coax lilac into bloom in Ocala, Florida, have likewise been unsuccessful. We have seen that lilac grows in a range of soils. Sandy loam may be ideal because it drains well. Although sandy loam is a prudent choice, soil that has too much sand lacks organic matter and retains too little water. Clay is likewise a less promising choice because it drains poorly. Whatever the soil, lilac benefits from the addition of organic matter at the time of planting. As a rule, soil that is suitable for corn and potato is good for lilac. Lilac prefers full sun for at least two-thirds of the day.

The Lilac Breeders

In Troyes, France, the Baltet Nursery, founded in 1720, bred lilacs between 1842 and 1900, deriving the renowned Ville de Troyes, DeCroncels, Lucie Baltet, and Blenatre. French plant breeder Pierre Louis Victor Lemoine would use Blenatre in his work. DeCroncels, a dwarf with deep pink flowers, is the parent of Lucie Baltet. The latter remains a popular cultivar. Nurseryman Pierre Cochet of Suisnes, France, selected from *Syringa vulgaris* the cultivars Philemon (1840), a dark purple lilac that won the First Class Award in 1855; Clare Cochet (1855), a pink cultivar; and Scipion Cochet (circa 1872), a purple cultivar. All three remain in cultivation today.

Victor Lemoine is among the luminaries of lilac breeding. Around 1870, he was perhaps the first to hybridize lilacs. Because of poor eyesight, he enlisted the aid of his wife, Marie Louise Anna Lemoine. She did the actual work of transferring pollen from the anthers of one species to the stigma of a second. The pair obtained their first hybrid in 1876, which they named *Syringa hybrida hyacinthiflora plens*. Although a breeder is permitted to name a new cultivar, the Lemoines' name violated Linnaeus's binomial nomenclature and has been renamed *Syringa* × *hyacinthiflora* to reflect its status as a hybrid. The plant has double, blue flowers, which bloom early and are fragrant. Son Emile and grandson Henri continued the work of hybridizing lilacs until the family closed its nursery in 1955. The Lemoine family bred more than 200 cultivars, among them President Grevy (1886), Mme. Lemoine (1890), Belle de Nancy (1891), Charles Joly (1896), Leon Gambetta (1907), Miss Ellen Willmott (1903), and Paul Thirion (1915).

In the 1890s, Scottish immigrant John Dunbar planted a lilac garden in Highland Park in Rochester, New York, now the site of an annual lilac festival. Among Dunbar's successes were the blue-purple President Lincoln (1916), General Sherman (1917), President Roosevelt (1919)—named for Theodore rather than Franklin Roosevelt—Adelaide Dunbar (1916), and Joan Dunbar (1923). Breeder Alvin Grant, working at Highland Park, derived Rochester in 1971. Horticulturist Richard Fenicchia, also at Highland Park, selected Dwight D. Eisenhower and Flower City.

In the 1920s, Isabella Preston, a scientist at the Central Experimental Farm in Ottawa, Canada, was among the first female lilac breeders. She derived what are known as the Preston lilacs in her honor. These include *Syringa* × *prestonia*, a tall, late-flowering, disease-resistant, hardy hybrid, and the cultivars Desdemona and Juliet, named for Shakespearean characters. The Royal Botanical Garden in Ontario, Canada, and the Central Experimental Farm maintain collections of Preston lilacs.

A cattle rancher from Manitoba, Canada, Frank L. Skinner, taught himself to breed plants. Concentrating on lilac, he bred a series of "American lilacs," among them the cultivar Maiden's Blush and hybrids derived from Lemoine's *Syringa* × *hyacinthiflora*. His work earned Skinner the moniker "Luther Burbank of Canada." The Skinner Nursery in Roblin, Manitoba, sells his lilacs, though it will ship only to Canadian gardeners. Skinner's brother-in-law, William Cumming of the Agriculture Canada Experiment Station in Morden, Manitoba, bred the cultivars Minuet and Miss Canada, the latter known as the Pink Lilac.

Christopher Cumo

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Lily

In the Liliaceae family, the lily is a perennial herb, growing a new plant each year from its bulb. The genus *Lilium* has some 100 species of lily. Because of the lily's popularity as an ornamental and its long history of cultivation, this encyclopedia includes, in addition to this general article on lily, separate entries on the fire lily, Turk's cap lily, and lily of the field. The encyclopedia also has an article on the aquatic plant the water lily, though it is not a true lily. Being in a separate family, the water lily is not closely related to lily. Indeed, more than 200 plants bear the name "lily," only half of them being true lilies. The false lilies include, in addition to water lily, calla lily, anum lily, canna lily, Himalayan lily, and daylily. The word "lily" derives from the Latin *Lilium*, from which the genus name comes. *Lilium* in turn derives from the Greek *leirion*. In French, lily is *lis* or *lys*.

Lilies (Nikuwka/Dreamstime.com)

Myth and History

According to myth, the Greek god Zeus wished to make the infant Hercules a god. Zeus's wife, the goddess Hera, objected because the child was not hers. Not to be deterred, Zeus asked Somnus, the god of sleep, to give Hera a sedative. While she slept, Zeus put Hercules to her breast. He sucked so forcefully that Hera's milk flowed faster than he could consume it. The milk that escaped him splashed into the heavens to make the stars, and that which fell to the ground made lilies. Another myth holds that the goddess Aphrodite, jealous of the lily's beauty, put a large pistil in the center of the flower, evidently thinking that it would mar the flower. Legend holds that when expelled from Eden, Eve cried. From her tears germinated lilies.

The Madonna lily (*Lilium candidum*) may be among the oldest domesticates among ornamentals. A painting of this lily, dating to roughly 3000 BCE, adorned the palace of King Minos at Knossos, Crete. This may be the oldest representation of a lily. It is possible, therefore, that the cultivation of the lily may trace to Crete. The flower was sacred to the people of Crete. It was the flower of the Minoan goddess Britamartin, the sweet maiden.

In Iran, King Sargon the Akkadian founded the city of Susa to be the city of lilies. He apparently grew lilies in his garden, and his reference to the lily, dating to 2872 BCE, may be the oldest written record of the ornamental. From Iran, the lily may have spread to Turkey, Egypt, Greece, and Rome, though it seems possible that the lily spread to these regions of the Mediterranean Basin from Crete. Nomads might have spread lilies throughout the Near East because they used the bulbs as food. Uneaten bulbs might have germinated and so formed a new colony of plants. The Chinese and Japanese still eat the bulbs of the tiger lily. The Egyptians believed that the Madonna lily symbolized life. Carvings of what are thought to be white lilies decorated the tombs of the pharaohs. In Greece, the lily was the flower of Hera, and in Rome it was the ornamental of goddess Juno. Representations of lilies decorated Greek vases dating between 1750 and 1600 BCE. The Romans thought that the lily symbolized hope. By one account, the Romans planted the lily in Britain, though according to another writer the flower did not reach Britain until the Crusades. Yet seventh-century CE British cleric Bede the Venerable knew of lilies, leading one to infer that they must have been in cultivation in Britain by then. He thought that the lily symbolized the resurrection of Mary. The white petals symbolized her purity and the golden anthers her soul suffused with light from heaven. Artists depicted the angel Gabriel with lilies in his hands as he told Mary that she would give birth to Jesus. Monks grew lilies in their gardens because of their religious significance. A symbol of goodness and purity, Christians, probably influenced by Bede the Venerable, associated the lily with Mary. In Europe, nobles put the lily on their coat of arms. The University of Aberdeen in Scotland, King's College of the University of Cambridge, Winchester College, and Eton College, all but Aberdeen in the United Kingdom, have the lily on their coat of arms. (By American standards, Winchester and Eton are schools.) The lily was the flower of Saint Anthony, the protector of marriage.

Magic and Medicine

First-century CE Greek physician Dioscorides recommended the use of lily as an ointment as well as a beverage made of lily to treat snakebite. He thought that lily mixed with honey and applied to the skin eliminated wrinkles. Into the 19th century, physicians extolled the lily as a wrinkle remover. One recommended the mixing of two ounces of onion juice, two ounces of the white lily, two ounces of honey, and one ounce of wax. The mixture was applied at night. Similar uses abounded. In the 14th century, physicians used a combination of lily roots, beans, eggs, wine, and water to remove spots on the skin. In the 17th century, one Englishman promoted an extract of lily to improve the complexion. In the 18th century, women washed their hair in a liquid made from lily.

Other uses were known. To heal a burn one boiled a lily in butter, putting the concoction on the tender flesh. Lily was combined with 57 herbs and the "dust of a black snail" to make a "holy salve." The physician to British queen Elizabeth I (1533–1603) recommended a mixture of lily and barley to treat dropsy. One dubious account advised a person to pick lilies when the sun was in the constellation Leo—between July 15 and August 13—combine them with laurel leaves, and bury them under a manure pile. The lily and laurel leaves would breed worms from which a powder could be made. The possessor of this powder dusted it on an enemy, who would be unable to sleep because of the powder. Stirred in milk, the powder would cause an enemy who consumed it to spike a fever. The powder, fed to cows, prevented them from lactating. When a lily grew on the grave of a person executed for a crime, it proved his innocence.

At Greek and Roman weddings, the guests gave lilies to the bride to ensure her fertility. In the 13th century, Dominican priest Albertus Magnus thought that one could use a lily to determine whether a girl was a virgin, though the details of this procedure are unclear. Others believed that one could use a lily and a rose to determine the sex of an unborn child. The procedure was simple. One offered a lily and a rose to a pregnant woman. If she chose a rose, the child would be a girl. If the choice was a lily, the expectant mother carried a boy.

Attributes and Cultivation

The lily is native to the Northern Hemisphere, though it has been introduced to the Southern Hemisphere. It grows near the equator in India and as far north as Siberia. It survives to–40°F in Canada. It may be found in the mountains of Tibet, western China, and Myanmar, throughout the woods of Europe, and in the marshes of the eastern United States. Lilies grow from sea level to nearly 15,000 feet.

A flower has three petals, three sepals, and six stamens that surround the pistil. A flower may be in every color but blue and black. Flowers are widely spaced, though those of hybrids are more tightly clustered. Lily needs cold winters and warm summers. Where winter temperatures do not fall below 40°F, the bulbs should be refrigerated four to six weeks. Lily does poorly in humidity, which encourages the spread of fungal diseases, among them the troublesome *Fusarium* wilt. Lily needs full sun to flower abundantly. It needs well-drained, loose soil. Sandy soil is ideal because it allows roots to expand. Lily does not tolerate heavy soil. Lily benefits from the addition of organic matter to the soil. The gardener may add compost, leaves, grass clippings, pine needles, manure, sawdust, or seaweed to the soil. Sand, dolomite, or gypsum may be added to lighten clay. Soil that is too wet does not provide lily roots enough oxygen. Wet soil also may harbor fungi. Most lily species like neutral or slightly acidic soil, though *Lilium candidum* and the hybrid *Lilium* × *testaceum* prefer alkaline soil. Before planting lilies, the gardener may fertilize the soil with phosphorus and potassium. Too much nitrogen causes lilies to produce foliage at the expense of flowers. The gardener may plant bulbs in late summer or early autumn and as deep as 10 inches. The soil should be mulched to retain moisture, minimize weeds, and insulate the soil from the cycle of freezing and thawing in winter. Once growth resumes in spring, lilies should be treated with a complete fertilizer.

Christopher Cumo

See also Fire Lily, Turk's Cap Lily, Lily of the Field

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Lily of the Field

Lily of the field, or *Lilium chalcedonicum* as categorized by Swedish naturalist Carl Linnaeus in *Species Plantarum* (*The Species of Plants*) in 1753, is a flower, also known as the scarlet martagon, native to Greece and Albania. It is a firm-textured flower that is rare to find in personal landscapes or floral shops, despite its ease of cultivation and its beauty. Its shape resembles a turban, and it is a brilliant red color.

The lily of the field is a hardy flower that has been cultivated for more than 3,000 years. It grows in temperate climates and is an easy plant to grow in a pot, as long as the bulbs are planted just after the flower blooms in soil that drains well. Too much accumulated water will not allow the plant to prosper.

Name's Origin, Myths, and Meaning of the Lily

It is believed that the lily of the field derives its name from the biblical New Testament verse of Matthew 6:28, which reads, "And why do you worry about clothes? See how the lilies of the field grow. They do not labor or spin." Jesus asserted that just as God takes care of the smallest living things, such as the lilies of the field, he will take care of his people as well.

The first images of the lily were discovered in drawings on the Mediterranean island of Crete that are believed to date back to 1580 BCE. One of the first written descriptions of the lily dates to the Middle Ages. Translated, the description reads "the plant flowers until late autumn and there are three types, red, yellow, and purple." The lily has been a part of mythology as well. The ancient Greeks, for instance, called the lily *leiron*, and believed it sprouted from the milk of the queen of the gods Hera, a symbol of purity. In Greek poetry, the lily symbolized tenderness and was referred to as "the voice of the muses."

Lilies are the May birth flower and the flower representing the 30th wedding anniversary. Lilies are associated with the virtues of purity, friendship, devotion, humility, prosperity, and wealth. They also are associated with funerals, symbolizing a restored innocence to the soul after death. Feng shui enthusiasts, believers in the ancient Chinese system of aesthetics and science, consider the lily to be the emblem of summer and its abundance.

Medicinal Purposes

The lily has been used as a remedy for several illnesses and ailments. It has been used as an antitoxin and a cure for depression. It has been believed to be a lucky charm and to avert the power of the evil eye.

Rosemarie Boucher Leenerts

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Lime

The principal species of lime are Key lime (*Citrus aurantifolia*) and Persian lime (*Citrus latifolia*). Of the two, Key lime is the more widely cultivated. Key lime is known as Mexican lime and West Indian lime. In Spanish, the Key lime is *lima acida*, in French *limette* or *limettier acide*, in Italian *limetta*, in German *limett*, and in Dutch *lemmetja* or *limmetje*. In East Africa, Key lime is known as *ndima*, in the Philippines *dalayap* or *dayap*, in Malaysia *limau asam*, in India *nimbu*, in the Netherlands Antilles *lamoantiji*, in Brazil *limao galago* or *lintao miudo*, in Egypt and Sudan *limun baladior* or *baladi*, and in Morocco *doc*. The Persian lime is known as the Tahiti lime. Lime is used to flavor other foods and beverages and as a folk remedy. One hundred grams of lime contain 88.7 to 93.5 grams of water, 0.07 to 0.11 gram of protein, 0.04 to 0.17 gram of fat, 0.1 to 0.5 gram of fiber, 4.5 to 33.3 milligrams of calcium, 9.3 to 21 milligrams of phosphorus, 0.19 to 0.33 milligram of iron, 0.003 to 0.04 milligram of beta carotene, 0.019 to 0.068 milligram of thiamine, 0.011 to 0.023 milligram of riboflavin, 0.14 to 0.25 milligram of niacin, and 30 to 48.7 milligrams of vitamin C. As a source of vitamin C, lime may have saved the lives of innumerable sailors. So closely was the lime associated with British sailors that they were known as limeys. There is doubt that the limes that the British purchased from Portugal were especially high in vitamin C.

Lime (Tom Schmucker/Dreamstime.com)

Origin and History

The Key lime may be native to India or the Malay Archipelago. If so, the names Key lime, Mexican lime, and West Indian lime are all misnomers. In antiquity, the Arabs took the Key lime to the Near East, North Africa and Egypt, Iran, and Palestine. In the Middle Ages, Crusaders brought the Key lime from the Levant to the rest of the Mediterranean Basin. By the mid-13th century, Italy and France cultivated the Key lime, though because it does not tolerate frost it must have been grown in the southern portions of these countries. In the early 16th century, the Spanish introduced the Key lime to Mexico and the Caribbean, where the species likely acquired the monikers Mexican lime and West Indian lime. By 1520, the tree was widespread on the island of Hispaniola (today Haiti and the Dominican Republic).

Although scholars are not sure when and from where, the Key lime was imported to Florida. One thesis holds that the Spanish introduced the Key lime to Florida about 1565. In 1839, one report noted that cultivation of the Key lime was widespread in South Florida. By the 1880s, Floridians grew the Key lime for their own use, with commercial acreage in Orange and Lake Counties. Dissatisfied with the pineapple's tendency to exhaust the soil, and upset that a hurricane had destroyed pineapple groves in 1906, farmers in the Florida Keys turned to the Key lime. The association with the Florida Keys doubtless gave the Key lime its name. Elsewhere in Florida, farmers planted the Key lime on islands off the western coast of Fort Myers. Florida exported Key limes to Boston, whose children ate them as a snack. Key lime culture expanded in Florida between 1913 and 1923, but a hurricane in 1926 arrested this progress. By the 1950s, George D. Fleming Jr., owner of Key Lime Associates of Key Largo, emerged as Florida's chief grower of Key limes. That decade the Upper Florida Keys Chamber of Commerce encouraged Floridians to plant Key lime trees. Outside Florida, California emerged in the 19th century as a lime producer. A bulletin in 1885 did not mention the Key lime by name, but its description of the limes grown in California supports the inference that the Key lime was the species under cultivation. California growers apparently had little experience growing the Key lime, and many of the early plantings succumbed to frost. A large grove at 1,800 feet in Sierra Madre Villa marked the apex of what was otherwise an unsuccessful venture. Cheap Key limes from Mexico drove California's produce from the market. Some Californians grew the Key lime tree as an ornamental, pruning it to the size of a hedge. Outside the United States, India, Egypt, Mexico, the Caribbean, Central and South America, and the tropics of Asia and Africa amassed large acreages of Key lime. Colima, Mexico, alone boasts 2 million trees. The Himalayas grow the Key lime to 4,000 feet. In 1930, Key lime trees were planted on the Pacific island of Niue. In 1979, a hurricane nearly extinguished lime culture on Niue.

The Persian lime may be a hybrid between the Key lime and the citron or lemon, though its scientific name does not denote its status as a hybrid. As its name suggests, the Persian lime is likely indigenous to Iran, from where it spread to the Mediterranean. The Portuguese found the Persian lime on the Tunisian island of Djerba and carried it to Brazil and from Brazil to Australia, the latter migration complete by 1824. On the island of Tahiti, the Persian lime acquired the name Tahiti lime. From Tahiti, the Persian lime was introduced to California between 1850 and 1880 and to Florida by 1883. Although the Persian lime is more cold tolerant than the Key lime, it is doubtful that it was grown in Lake Placid, New York, in 1897. In Florida, the Persian lime competed with and to some extent displaced the Key lime. The popularity of the Persian lime led Florida growers to abandon the lemon for it. Markets for the Persian lime developed after World War I, though Canadians preferred to import the more flavorful Key lime. In the 1930s, Florida citrus growers planted the Persian lime for extra income. After 1949, the use of the Persian lime to make limeade concentrate opened a new niche for the species. By 1954, Floridians planted 1,000 acres to Persian lime. Between 1970 and 1980, the yield of Persian lime increased 60 percent, and by 1979 the Persian crop totaled $9 million, with 1 million bushels sold fresh and another 1 million processed. By 1980, Florida tallied 8,000 acres to Persian lime. In 1985, farmers in Dade County grew Persian lime on 6,500 acres, exporting 110 million pounds of fresh fruit worth $14 million. Today, Florida produces 90 percent of all Persian limes in the United States. In 2007, India was the world's leading producer of limes with 2.2 million tons (Food and Agriculture Organization of the United Nations, http://faostat.fao.org). Mexico ranked second with 2.1 million tons, Argentina third with 1.4 million tons, Brazil fourth with 1.2 million tons, and Spain fifth with 968,000 tons. The United States ranked seventh with 794,000 tons.

Attributes

Known for its tartness, a lime may be sourer than a lemon. The Key lime tree reaches between 6.5 and 13 feet in height. Fragrant, the leaves are purple when young and dark green when mature. Two inches in diameter, a flower has four to six petals. The petals are white with purple streaks. Flowers may or may not be fragrant. Each flower has 20 to 25 white stamens, which house yellow anthers. A tree may bear fruit singly or in clusters like the grapefruit tree. The fruit of a Key lime tree is green when immature and light yellow when ripe. The pulp, organized in 6 to 15 segments, may be green or yellow. Some Key limes are nearly seedless. Others have a large number of seeds.

The Key lime tree prefers a warm, wet climate, with 80 to 150 inches of rain per year. Curiously, given its appetite for water, the Key lime is the most drought tolerant of citrus trees. In fact, too much rain leaves Key lime trees vulnerable to fungal diseases. Key lime trees grow well on the limestone soil of the Florida Keys and Niue. Trees will grow on sandy soil in Florida with the addition of calcium carbonate (lime) to increase the soil pH. Hawaiian farmers grow the Key lime on well-drained sand or gravel. Clay is unsuitable for the Key lime. Unlike many other citrus trees, which are propagated vegetatively, the Key lime may be propagated by seeds. When it is grafted, lemon or sour orange is the rootstock. Hawaiian growers use pummelo as the rootstock. Key lime trees are planted 25 feet apart at a density of 70 trees per acre. Key lime trees are sometimes interplanted with legumes to enrich the soil with nitrogen. Dade County, Florida, farmers use 2-8-10 or 2-10-10 fertilizer in a ratio of nitrogen to phosphorus to potassium. On Niue, farmers apply zinc sulfate to the soil at the time of planting, thereafter fertilizing the soil with nitrogen and potassium.

A young tree bears fruit in 3 to 6 years with a heavy yield in 8 to 10 years. The Key lime is a small fruit, being one-third to one-half the size of a lemon. Fruit ripens five to six months after a tree flowers. In the Florida Keys, the harvest is year-round, though the heaviest yields are in May and June and in November and December. On Niue, farmers harvest Key limes in April and May. Fruit destined for the fresh market should be picked when light green, smooth, and slightly soft. Fruit destined for processing should be harvested when yellow and fully ripe. Some growers allow fruit to fall to the ground, where it is harvested. Fruit may be stored two to three weeks at 48.2°F with 85–90 percent humidity. Refrigeration at 44°F may damage fruit.

In addition to the Key lime, growers may plant varieties of this species. Everglade, a hybrid between the Key lime and grapefruit or pummelo, little resembles the latter parent. In 1922, growers planted Everglade on Trinidad. The Citrus Experiment Station in Riverside, California, likewise planted the variety. The fruit is tart, having 2 to 10 seeds. Everglade bears fruit in clusters. A second variety, Kagzi, is the most popular lime in India.

Larger than the Key lime tree, the Persian lime tree grows 15 to 20 feet tall. Branches bear few thorns. A Persian lime tree flowers intermittently with a large number of blooms in January. Fruit is oval and the peel green when immature and light yellow when ripe. The pulp is green or yellow when ripe and divided into 10 segments. The Persian lime tree lacks the fragrance of the Key lime tree. The fruit of the Persian lime tree is often seedless, though some fruit may have one or a few seeds. Most Persian lime groves are in Dade County, Florida, though because the tree tolerates some cold, it is planted as far north as Winterhaven, Florida. In South Florida, growers plant Persian lime trees on limestone and on sandy soil farther north. The soil must drain well. Because trees that germinate from seeds may not resemble the parents, Persian lime trees are seldom propagated by seeds. Of 114 seedlings at the Agricultural Research and Education Center of the University of Florida at Homestead, only 10 resembled the parents.

Where Persian lime is grafted, lemon, alemow, sweet orange, or grapefruit is the rootstock. Growers plant Persian lime trees closer than Key lime trees. The standard spacing is 10 to 15 feet apart at a density of 150 to 200 trees per acre. Because Persian lime trees bear year-round, they need abundant fertilizer, with applications of nitrogen at least four times per year. Some growers enrich the soil with 4-6-6 fertilizer every 60 days. Potassium may be particularly important in ensuring a high yield of Persian limes. Seventy percent of Persian limes ripen between May and autumn, with the largest yield between July and September. Harvesting fruit 10 to 12 times per year, growers often pick Persian limes by hand to be sure of taking only fruit in an early stage of ripeness. The yield is best on alemow rootstock. Fruit remains edible after six to eight weeks' refrigeration. Not a hardy tree, the Key and Persian limes are less cold tolerant than lemon.

Uses

Most of Mexico's harvest of Key limes is eaten fresh with a minority exported as juice. The peel yields oil for export. The demand for lime oil increased in the 1970s. The island of Dominica grows Key limes for juice. The island's eight factories process Key limes into juice for export to the United Kingdom. Of Dominica's processors, L. Rose and Company produces the renowned Rose's Lime Juice. Soft drink manufacturers buy lime juice. Jamaica, Grenada, Trinidad and Tobago, Guyana, and the Dominican Republic export juice and oil. Montserrat also produces lime juice. Ghana and Gambia are among Africa's leaders in the production of lime juice. Niue exports fresh limes and an even larger quantity of juice and oil. New Zealand is the principal importer of Niue's limes. Lime peel from Niue and elsewhere is made into marmalade, jelly, and jam.

Cooks use lime to flavor fish and meat. Zest from the peel is added to beverages. Lime juice is added to alcoholic beverages and is made into syrup and sauce. As a rule, 2,200 pounds of fruit yield 1,058 pounds of juice. Lime juice is an ingredient in limeade. Floridians combine lime wedges with avocado. Lime juice may substitute for vinegar in dressing and sauce. Lime juice may be used to rinse hair after shampooing. Used as a rinse, lime juice imparts blond streaks to dark hair. Lime juice may be applied to the face as a tonic. Some Floridians clean coffee pots with lime juice and shred a whole lime in a garbage disposal to dissipate odors. Lime may be made into pie, as the renowned Key lime pie attests. As its name suggests, Key lime pie was once made from Key limes, though today the Persian lime is the source of this treat. Florida limes supply the fresh market and are bottled or frozen as lime juice, juice concentrate, or limeade. Malaysians preserve limes in syrup, pickle them, and fry them in coconut oil and add sugar to make an appetizer. Indians pickle limes, sometimes pairing them with chili pepper, turmeric, or ginger. India exports dried limes to Iraq. Indonesians eat minced lime leaves. Filipinos consume the peel with milk and coconut. The people of the Caribbean use lime juice to dye leather. On the island of Saint John, people use a moisturizer made of lime. Some stockmen feed lime peel to their animals. Lime oil is added to perfume. Lime juice soothes mosquito bites. Malaysians drink lime juice to settle an upset stomach. Pickled limes are used as a poultice to treat neuralgia. Indians eat pickled limes to relieve indigestion. Lime juice is an antiseptic and a diuretic and is used to treat hemorrhage, hemorrhoids, heart palpitations, headache, cough, rheumatism, arthritis, hair loss, bad breath, sore throat, and fever. Despite these uses, oil from the peel may irritate skin. Sap from a lime tree may cause a rash on skin.

Christopher Cumo

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Locust

Locust trees, predominantly of two varieties, are native to North America. They grow in the wild, are very hardy, and shed their leaves annually (deciduous). Their sporadic growth and "all-soil-types" nature make locusts a forest tree apart from being grown for ornamental purposes.

The two main varieties of locust are black locust and honey locust. They belong to the family Leguminosae or Fabaceae, otherwise known as the Bean family, and have some basic common features. Both varieties are trees, the former growing to a height of 80 to 100 feet, while the latter is shorter. Both have a branch span of approximately 20 feet. Leaves are pinnately compound, where each leaf consists of many leaflets arranged in pairs on either side of the main leaf stalk called the rachis. Leaves (with leaflets) grow to a length of 18 to 20 inches. Both wild varieties have spines. Flowers are irregular and can be divided into equal halves only along a single plane (zygomorphic). Flowers are also hypogynous, where the sepals and petals are seen below the ovary of the flower. There are five sepals, five petals, 10 stamens, and a single style. The fruit is a legume where the seeds have a thick, leathery coat encased in a pod. The pods open longitudinally along the seams.

Honey Locust (*Gleditsia tricanthos*)

The sweeter variety of the two, honey locust is at times not regarded as the true locust tree. It belongs to the subfamily Caesalpinioideae. This tree generally grows taller than the black locust and has approximately 18 to 20 leaflets on a single rachis. Each leaflet is about one inch long. The plant has wide, spreading branches. Due to the fact that the leaflets are relatively small for a large tree, the canopy does not block sunlight from reaching the terrain below it, and plants growing within its shadow. Flowers bloom in summer and are greenish white. Flowers are also sweet scented and much loved by gardeners for their summer bloom. The wild variety has clustered spines that range from 6 to 10 inches in length. Spine clusters may range from three or more spines. Seed pods are also numerous during the seeding phase. The nursery variety that is sold for home and ornamental purpose is devoid of spines and pods, thereby making it more garden friendly and requiring less cleaning. During fall, the green leaves turn to a pale yellow. Honey locust is hardy and resistant to drought and snow.

The honey locust tree is not a major source of honey. Rather, its name evolved when the Native American tribes began to use the honey locust pods. The pods of this tree are very sweet and have been an ideal substitute for sugar and as a sweetening agent for many generations. Before the refining of sugar from cane, this fruit has also been used for fermenting and sweetening drinks. The spines of the honey locust at times grow up to 20 inches, are soft when young and hard, and are brittle when older. The color of the spine changes from a greenish brown to a deep red or reddish brown as it matures. The spines have been a good carpentry accessory, used as nails in the past.

In the wild, the honey locust is useful to many animals. The honey locust pods are a good source of food for many animals such as deer, opossums, raccoons, hogs, rodents, rabbits, and squirrels. At times, even domestic, foraging animals such as goats and sheep feed on the pods. The tender shoot may be used as food at times, especially during the spring, whereas in the winter, the bark may prove useful to many animals dependent on the locust tree. Apart from being an ideal source of food for animals, the spines of the tree also act as a good defense when animals are preyed upon and hide behind these trees. The honey locust tree yields good timber that is shock resistant. It is also dense and highly appreciated for its excellent finish. The timber is used for making many woodworking items.

One of the most notorious of pests that affect the honey locust is the honey locust plant bug, also known as *Diaphnocoris Chlorionis*. This pest lays eggs during the winter, which hatch in early spring. The young nymphs that emerge are voracious feeders and wreck the plant by eating all the early-spring, fresh leaves. Although fresh leaves may emerge later, the plant growth is stunted for that season. This plant pest does not attack frequently and hence is not necessarily observed during the following year. Another pest of the honey locust is the honey locust spider mite. These mites feed voraciously on tender leaves, living on the undersurface of the leaves and not easily seen. Their infestation and attack cause the leaves to turn brown and prematurely fall off. Other pests of honey locust are eriophyid mites, the cottony maple scale, leafhoppers, and blister beetles. While predators of these insects may help control the infestation, organic or chemical control measures might have to be adopted.

Black Locust (*Robinia pseudoaccacia*)

The black locust is a perennial tree, belongs to the subfamily Papilionoideae (butterfly-like, winged petals), and is found all over the United States, though predominantly in the Appalachian Mountain range. Similar to the general features of the honey locust, this plant is a tall tree, with spines, and is grown as spineless varieties for ornamental purposes. The leaflets too are similar in appearance and arrangement on the rachis. However, the most notable feature of the black locust is its toxicity. The pods, stems, and leaves of this plant are highly toxic and should not be mistaken for the honey locust and how the honey locust pods are used. Grazing animals, especially horses, may die upon consuming parts of the black locust.

The black locust is an ornamental plant with bright green leaves and pale white flowers. The tree is usually shorter than the honey locust and grows to a maximum height of 80 feet. The leaflets too are much smaller and average a length of one-half of an inch. The pods contain black seeds. The bark of the tree is darker than that of the honey locust with furrows. Aromatic flowers bloom in spring. Heavy blooms yield a fairly good amount of pods, which survive even through winter. Spines are generally found in pairs and grow up to a maximum length of three-quarters of an inch.

Like the honey locust, the black locust yields timber that is highly durable and weather resistant. It is especially prized for its water resistance and can last outdoors for up to 50 years. The longevity of black locust wood is one of the main reasons why it is a major resource purchased by the shipping industry. Owing to the fact that it is used for making deck planks and masts and for building ships at large, it is also known by the names Ship Mast Locust and Long Island Locust. Timber may also be used outdoors for posts, for roofing, or for landscaping. Apart from this, woodworking items too may be made from the wood of this plant. Many beekeepers grow black locusts around their beehives since the flowers of this tree are a source of nectar during spring and summer.

It is advisable not to tie horses to black locust trees. As stated earlier, the bark, leaves, and pods can prove fatal to horses if consumed. Even a small amount of black locust leaves or pods can be very dangerous for humans and animals. However, just as digitalis, a poisonous plant, is a major component in cardiac medication, black locust too is used by the pharmaceutical companies for preparing medicines related to ulcers and intestinal problems, and also in analgesics. The flowers of the black locust yield aromatic essential oils that are used in the cosmetic industry, especially in the preparation of perfumes. The bark yields a colorant called Robinetin, which when used with aluminum dyes cotton to a brownish orange. Small amounts of tannin are also a product of the black locust bark. The bark of this plant is highly combustible and is used for fuel. However, care should be taken when using this wood for fuel as the sparks can cause secondary damage. One of the most important uses of the black locust is to minimize soil erosion.

Some of the most notorious of pests to harm the black locust are the leaf miner and the locust borer. The locust borer can prove fatal, while the leaf miner can make the ornamental leaves look very ugly because that the insects eat their way through the leaves. Bark canker and trunk rot affect the tree as diseases and cause widespread damage if left unchecked. Large colonies of locust trees can be damaged by these pests and diseases.

The origin of the black locust's scientific name, *Robinia*, is debatable. While black locust produces a phytotoxin called robin, history has it that the tree is named to honor botanist Jean Robin, who in the early 17th century carried seeds from the United States to France and propagated them there in his attempts at landscaping. From then on, black locust became a popular ornamental plant in Europe too.

Amanda Mittra

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Lotus

A perennial herb, the lotus is an aquatic plant cultivated principally as an ornamental. Botanists have debated the classification of the lotus. Some place it in the Nymphaeceae family with the water lily. Others favor the creation of a new family, Nelumbonaceae, into which the lotus would be placed. Lotus seeds contain vitamin C, other antioxidants, and flavonoids, which may protect one against cancer. The lotus has two species. *Nelumbo lutea* is indigenous to the eastern and central United States. *Nelumbo nucifera* is native to Asia including the Philippines, northern Australia, and Egypt. The lotus should not be confused with *Lotus japonicus*, a legume. The two are not closely related.

Origin and History

Fossils of the genus *Nelumbo* date to the lower Cretaceous Period (145.5 million years ago). Between 145.5 million years ago and 65.5 million years ago, the lotus expanded its habitat and numbers. Fossils dating between 85 and 65 million years ago place the lotus in the Southern Hemisphere in addition to the Northern Hemisphere. Thereafter, as Earth cooled and dried, the lotus's habitat shrank. The ice ages between 1.8 million years ago and 10,000 years ago further contracted the lotus's population.

The species *Nelumbo nucifera* is an indigene of the Old World, growing from Iran in the west to Japan in the east. This species grows as far north as Kashmir, India, and Tibet and south as far as Indonesia and northern Australia. In the Volga River delta, near the Caspian Sea, grows what botanists once termed *Nelumbo caspica*, the species name doubtless a reference to the Caspian Sea. One hundred miles north of Vladivostok, Russia, grows what was once known as *Nelumbo komorovii*, a hardy lotus that tolerates temperatures as low as −44°F. Botanists have subsumed both species into *Nelumbo nucifera*. The Buddhists regarded this species as "the sacred lotus." Legend holds that 2,500 years ago Indian religious reformer Buddha arose from the heart of a lotus bud. Today, lotuses may be found in lagoons near Buddhist temples.

In Egypt, the lotus symbolized fertility, birth, and purity. Egypt may have acquired the lotus from India in the sixth century BCE, though one author favors Iran as the source of Egypt's lotuses. So quickly did the lotus flourish along the Nile River that Egyptians came to think that the plant was indigenous to Egypt. The Greeks cultivated the lotus. In the fourth century BCE, Greek conqueror Alexander the Great observed the lotus in India, being astonished because he thought that the lotus grew no farther east than Egypt. In the fourth century BCE, Greek botanist Theophrastus described the lotus, noting six types. The Phoenicians cultivated the lotus along the coast of the Mediterranean and Aegean seas. The Romans cultivated the lotus, spreading it throughout Southern Europe.

In the first century CE, Roman encyclopedist Pliny the Elder called the plant the "Egyptian bean" or simple the "bean." Pliny evidently associated the lotus with Egypt, though the plant was not indigenous to it. The reference to a bean apparently derives from the resemblance of lotus seeds to beans, though a lotus seed is not a bean. In fact, the lotus and beans are not closely related. Others referred to the lotus as the "Indian bean," though the lotus is not native to India. Pliny noted that the Romans grew the lotus as an ornamental. Pompeii contains mosaics of lotuses. By the fourth century CE, Sicilians were cultivating the lotus, perhaps having acquired it from Rome. The blue lotus of the Nile River and the blue lotus of India are not true lotuses but rather members of the genus *Nymphaea*.

Uses, Attributes, and Cultivation

On festive occasions, decorators add lotus seed pods to bouquets and wreathes. More importantly, the lotus forms tubers, which, like the potato, are edible. Native Americans ate the tubers and seeds of *Nelumbo lutea*. Asians still eat these parts of the lotus. A niche market has developed in the United States for lotus tubers and seeds. Some people eat lotus leaves, wrapping other items in them and baking the food. In Taiwan and China, people eat the rhizome of *Nelumbo nucifera*, which is known as the "edible lotus" for this reason. The people of Taiwan grow this species in well-rotted cow manure.

First-century Greek physician Dioscorides believed that the lotus had medicinal properties. Medical practitioners have used the lotus to calm heart palpitations, induce sleep, and treat Parkinson's disease, erectile dysfunction, bleeding, inflammation, nausea, indigestion, obesity, and mushroom poisoning.

The lotus needs two or three months of temperatures between 75°F and 85°F. The plant may be cultivated in parts of the United States and Canada, southern France, Spain, Portugal, Italy, Greece, western and southern parts of the former Yugoslavia, Egypt, Iran, China, India, and Japan. The American Southwest is too hot for the lotus, whereas the Pacific Northwest, southern Australia, New Zealand, the United Kingdom, and Northern Europe are too cold. In these regions, enthusiasts raise the lotus in greenhouses.

Most lotus varieties bloom during the day, but a few flower at night. Typically, a flower opens early in the morning and closes by mid-afternoon on the first day of flowering. For the next five or six days, it remains open day and night. The cultivar Momo Botan, for example, blooms for nearly one week. Some petals change color during the course of flowering. The cultivar Mrs. Perry D. Slocum has dark pink petals on the first day of flowering. By the third day, the petals have become yellow-pink. *Nelumbo nucifera* has white, pink, and red flowers as well as flowers with two colors. Some flowers are single and others are double.

The gardener may use two or three parts soil and one part well-rotted manure as the cultural medium. Heavy loam is ideal. One may fill a barrel, tub, or container with soil to within three to six inches of the top. To the soil should be added 10-10-5 or 10-14-8 fertilizer in a ratio of nitrogen to phosphorus to potassium. One must guard against applying too much nitrogen, which will burn the roots. Atop the soil should be added one inch of sand and enough water to fill the rest of the container. The lotus prefers full sun but tolerates partial shade.

Beetles and flies cross-pollinate lotus flowers, which often close on these insects, keeping them alive by maintaining a temperature of 90°F. The interior of a flower may be more than 30° warmer than the surrounding air. Lotus seeds may be viable for centuries. Scientists have dated one viable seed to 1,288 years old, the world's second-oldest viable seed, trailing only a date pit discovered in 2005.

Species and Cultivars

Breeders have derived many new cultivars, some of them suitable for Southern Europe. The Chinese grow more than 300 varieties. The Old World species *Nelumbo nucifera* is known as the "Hindu lotus," the "Egyptian lotus," and, as we have seen, the "sacred lotus." It is native to India, China, Japan, the Philippines, northern Australia, Thailand, Vietnam, and the Volga River delta. The deep pink flowers are 9 to 12 inches in diameter, contain 24 petals, and are fragrant. The New World species *Nelumbo lutea* is known as the "American" or "yellow lotus" or the "water chinquapin." The chinquapin is a type of chestnut, suggesting a resemblance between lotus seeds and chestnuts. The American lotus grows as far north as Ontario, Canada, and Maine and as far south as Honduras.

The cultivar Night and Day derives its name from the fact that its flowers remain open around the clock. The variety is a cross between the cultivars Pekinensis Rubra and Momo Botan. Each flower contains 74 to 83 petals and is dark or medium pink with red stripes and 7 to 7.5 inches in diameter. The fragrance is not pronounced. As a cut flower, Night and Day lasts six or seven days. Waltzing Matilda, known as the "tropical lotus," is native to northwestern Australia. Each flower is deep or medium pink, is 8 to 10 inches in diameter, and has 21 petals. The fragrance is strong. New leaves are red or red-purple and turn green as they age. Waltzing Matilda does not form tubers. Strawberry Blond is a hybrid of the cross between the species *Nelumbo lutea* and the cultivar Momo Botan. The flowers, 9 or 10 inches in diameter with 83 to 86 petals per flower, change from deep pink to yellow with pink tips as they age. The cultivar is fragrant.

Christopher Cumo

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Lovage

Lovage (Sheryl Caston/Dreamstime.com)

Lovage is an old cultivated plant, known from peasant gardens in Europe for centuries, but with unclear origins. Lovage is a tall plant growing to a height of 100 inches. A perennial, lovage is a heavily scented plant with small yellow-green flowers produced in globose umbels. The basal leaves are tripinnate with broad triangular to rhomboidal acutely pointed leaflets with a few marginal teeth. The stem leaves are smaller and less divided with few leaflets. Its characteristic odor and taste are sometimes compared to the flavor of celery. Lovage is easily grown and propagated by seeds or through root division.

Nowadays, it is cultivated primarily as a food seasoning and is therefore to be found in European, East Asian, and North American herb gardens. Plants and seeds for home gardens are available through nurseries in Europe and North America. Commercial cultivation exists in Central Europe (Thuringia). Previously, it was very much used as a medicinal plant, especially within folk veterinary practice, but it has also been utilized as a repellent. Lovage has become naturalized in some parts of Europe and North America, and it is often found as a relict of cultivation at deserted farmhouses in rural parts of Europe.

Cultural History

Scholars are not certain where lovage originated, but according to several authors it is native to the Mediterranean region, though its typical form is not known wild anywhere. Maybe it came from Persia where a closely related taxon occurs. Lovage is mentioned as a cultivated plant in antiquity. Greek physicians Dioscorides and Galen of Pergamon and Roman encyclopedist Pliny the Elder were familiar with the plant. It is listed as a cultivated plant in the plant catalogue in Emperor Charlemagne's edict *Capitulare de villis vel curtis imperii* from around 812. Archaeobotanical evidence for its presence in gardens has been found in Central Europe, for instance at various sites in Germany from the Middle Ages. However, the species seems to have reached Scandinavia as a cultivated plant as early as the

Iron Age. It spread northward and was grown also in the front of farmhouses in many parts of northern Scandinavia in the 18th and 19th centuries.

Its Latin name *levisticum* derives from "ligusticum," meaning "that which originates from Liguria." This language might indicate an origin in south-central Europe. However, it is questionable whether lovage ever occurred wild in this part of Europe. Vernacular names in various European languages are folk etymological interpretations of its Latin name, like German *liebstöckel* (Old German *lubestecco*), Swedish *libsticka* (given in medieval Swedish as *libbestikka* or *lybbestikka*), Norwegian *løpstikke*, Danish *løvestikke*, and English lovage (Middle English *loveache*). Romance languages have *livéche* (French), *levistico* (Italian), *levistic* (Catalan), and *ligustico* (Castilian). In Russian, it is known as *lyubistok*, in Polish *lubczyk*, and in Czech *libeček*.

During the early Middle Ages, lovage was cultivated in monastic gardens. It is listed on a plan of the garden of the Abbey of Saint Gall in Switzerland in 820. Trotula of Salerno, a female physician who worked in Salerno in the 11th century, recommended lovage for skin lightening (and it is still used in skin-lightening creams). The Renaissance authors were certainly acquainted with the plant. British botanist Nicholas Culpeper wrote in 1652 that it was usually planted in gardens, where it grew to a great size. Immigrants brought the plant to North America. In New England, the settlers candied the root and used it as a sweet and a breath lozenge. Shaker colonies grew and sold the plant for food as part of their commercial enterprises in the 19th century. Lovage was introduced in China as late as 1957, but is now widely cultivated and used in Chinese medicine and as a food plant.

Medicinal Plant

Lovage has a long history as a medicinal plant. It was used by the Greeks and Romans to aid digestion. According to Dioscorides, its root and the fruit were employed as remedies for internal pains and as an antidote for snake bites, as a diuretic, and to promote menstruation. Lovage root, radix levistici, was available in the early modern pharmacopeias. It was prescribed for hysterical flatulence. It had also a reputation for treating menstrual irregularities. In 1597, English herbalist John Gerard considered lovage to be one of the wonder drugs of the day, and it was used for jaundice, colic, and fever in children. Culpeper wrote: "The distilled water of the herb helps the quinsy in the throat, if the mouth and the throat be gargled and washed therewith, and helps the pleurisy, being drank three or four times. Being dropped into the eyes, it takes away the redness or dimness of them; it likewise taken away spots or freckles in the face."

The fragrant plant was also used in the bath, especially for women, hence the German name *badkraut* ("bath plant") known in the literature from the 16th to 18th centuries. In Bukovina and Silesia, the stems were smoked for sore throat.

Lovage is mentioned as a remedy in medieval medicinal books from Central and Northern Europe, for instance by the German abbess Hildegard of Bingen, who recommended it for sore throat and swollen tonsils. Nowadays, lovage is seen as obsolete in scholarly medicine but survives in complementary and herbal medicine. It is, for instance, assumed that lovage root displays properties that can smooth muscle contractions known to cause menstrual cramping.

In early handbooks from the 16th and 17th centuries on veterinary medicine, lovage is mentioned as an important remedy for many diseases. During the 18th and 19th centuries, it was grown by the peasantry in Northern Europe especially as a medicinal plant for cattle, horses, and sheep. Many animal diseases were believed to be cured by remedies made of this plant. Lovage was also supposed to increase the production of milk. It was therefore also kept in the summer pastures in the mountains in Scandinavia. At the end of the 19th century, it became obsolete, but it still exists as a cultural relict in many old gardens and abandoned places.

Repellent and Spice

As was true of many other strongly scented plants, lovage had a reputation of being a repellent. It was commonly planted in front of the farmhouses in Scandinavia in order to keep snakes away. Also, other pests and evil forces seemed to avoid the plant, according to common folklore in Northern Europe. Lovage was also used to get rid of bedbugs and rats. In Denmark, lovage was planted in several churchyards, although the reason remains unknown.

During recent decades, lovage has again become popular as a garden herb. Now it is cultivated as a spice that can be used especially in various kinds of soups, for instance in tripe soup (made of beef stomach) in the Balkan Peninsula, and in casseroles, stews, and sauces. The leaves are excellent for flavoring almost any fish and meat dish. It can also be used as a salt substitute.

Galen of Pergamon and the Goth Vinidarius from the fifth century both listed lovage seeds as a condiment. Also, during the Renaissance its strong taste made it popular as a spice in many dishes. In preindustrial Sweden, peasant women used to cook meat in a broth made of lovage. In Germany, its aroma is very much connected with maggi, a Swizz food-seasoning sauce, which is popular in many parts of Europe. For this reason, the plant has since the 1920s been known as *maggikraut* ("maggiplant") in German, *maggikruid* in Dutch, and *maggiurt* in Danish. The product does not contain any lovage though. The essential oil in the root has been used in perfumes and for flavoring tobacco. The seed oil has also been used for as a flavoring in confectionery and liqueurs.

It was used in Catholic religious processions and in churches on Assumption Day (August 15) in Luxembourg and the Rhineland. In premodern Europe, it was also believed to have some magical properties. If the plant was placed under the threshold of a stable, it would bring luck to the cattle and protect them from witchcraft, according to Danish folk tradition. In Southern Europe, furthermore, the plant had a reputation as an aphrodisiac.

Ingvar Svanberg

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Lupine

In the Leguminosae or Fabaceae family, lupine, also known as lupin, is a legume related to pea, soybean, lentil, cowpea, peanut, beans, chickpea, lupine, alfalfa, clover, and vetch. Its genus, *Lupinus*, has both annual and perennial species. The name *Lupinus* is Latin for "wolf bean," a possible reference to the fact that lupine grows in wild places. The Greeks called lupine *thermos*, meaning "hot," a possible reference to its bitterness. The greatest concentration of lupine species is in western North America, from Alaska to Mexico, in the Andes Mountains of Peru, and in Brazil, Uruguay, and Argentina. The Old World has 12 species, many of them concentrated in the Mediterranean Basin and East Africa. Lupine endures the subarctic climate of Alaska, the warm climate of the Mediterranean, arid climates, and the subtropical climate of South America and Florida. Lupine does not tolerate shade and prefers light soil with acidic to neutral pH.

Origin and History

The ancestor of lupine may have been Sophoreae, a subfamily of Leguminosae native to the tropics and subtropics. The genus *Lupinus* arose in the mid- to late Tertiary Period (65–2.6 million years ago). In the Quaternary Period (2 million years ago to the present), the ice ages favored lupine, for the retreat of the glaciers left soil poor in nitrogen and organic matter, soil in which lupine competed well against other plants. In interglacial periods, lupine colonized sandy soil bereft of organic matter. Because species of *Lupinus* exist in both the Old and New Worlds, the genus must have arisen when Eurasia and the Americas were connected in some sense. They need not have been joined if it were possible that birds carried lupine seeds both ways across the Atlantic Ocean. The existence of *Lupinus* species in the Old and New Worlds does not tell us where lupine originated, and this is a point of controversy. One hypothesis holds that lupine arose in North America.

Another favors South America, possibly Brazil. One scholar proposes that humans brought lupine from South America to the Mediterranean Basin, though how this would have been possible in the era before the invention of oceangoing ships is unclear. Alternatively, and again this is speculation, humans may have brought lupine from the Mediterranean to South America. Some supporters of an Old World origin point to the possibility that lupine originated in the tropics, later migrating north to the Mediterranean. Various scientists have favored an origin in the Himalayas, China, subtropical Africa, Turkey, or Syria.

According to one scientist, humans might have used lupine first as medicine and only later as food. First-century CE Greek physician Dioscorides recommended a combination of lupine meal and honey or vinegar to expel worms. He touted the value of lupine as a poultice to treat skin ailments and boils. The ancients used lupine cooked in rainwater as lotion. Humans might have eaten lupines in prehistory. Early humans in North and East Africa and the eastern Mediterranean might have been the first to consume lupines. Because lupine contains toxic alkaloids that impart bitterness, humans must have selected seeds low in alkaloids, though this effort must have been only partly successful because first-century BCE Roman poet Virgil acknowledged that lupine was bitter. Fortunately, the alkaloids are water soluble, and humans learned to boil lupine in water or place it in water for an extended time to detoxify it. Despite its bitterness, lupine must have been attractive to early humans. Because lupine readily colonizes disturbed soil, it must have naturally grown in land near human habitation. Early humans cultivated the white lupine, the species *Lupinus albus*, in the Mediterranean and *Lupinus mutabilis* in South America. The Egyptians might have cultivated *Lupinus albus* about 2000 BCE. In the Mediterranean, humans have eaten lupines for at least 3,000 years. In the Mediterranean, cultivation was centered in the Aegean. In the Bronze Age (3000–600 BCE), Cyprus emerged as a site of lupine culture. In the fourth century BCE, Greek physician Hippocrates believed that lupine was a nourishing food and was useful as medicine and cosmetics. In the fourth century BCE, Greek botanist Theophrastus included lupine in his *Enquiry into Plants*, a text that the Romans and medieval Europeans consulted. He recommended that farmers harvest lupine after the rain to minimize shattering, a problem with which first-century CE Roman encyclopedist Pliny the Elder was familiar. Theophrastus, second- and first-centuries BCE Roman agricultural writer Varro, Virgil, and first-century CE Roman agricultural writer Columella all remarked that lupine improved the soil. Scientists confirmed this observation in the 20th century when they discovered that the roots of legumes, including lupine, harbor bacteria that fix nitrogen in the soil. In antiquity, farmers grew lupine for food and forage. In the Mediterranean, people boiled lupine and then soaked it in seawater for a few days. Pliny recommended that people pour water used to boil lupine around fruit trees. The ancients salted lupine and ate it as a snack much as Americans eat salted peanuts. Roman politicians who wished to gain the public's favor distributed lupines to the masses, giving rise to the slogan "lupines for the people." In the Middle Ages, the cultivation of lupines persisted in the Mediterranean, lands along the Black Sea, and the Nile River Valley as far south as Ethiopia.

In the Andes Mountains, the Amerindians consumed lupine as early as 4000 BCE. The Peruvians cultivated lupine in the seventh and sixth centuries BCE. The Nazca rotated lupine with other crops between 100 and 800 CE much as the Romans rotated lupine with grain. The Amerindians washed lupine in mountain streams for weeks to remove the alkaloids, though occasional poisonings indicate that this method did not always work. Where lupine was placed in a container of water, the water was subsequently used as an insecticide. The Amerindians used lupine in their religious rites and believed that the legume treated heart disease, rheumatism, and malaria. The Spanish discouraged the cultivation of lupine in South America, and this agricultural practice retreated to very high altitudes.

In 1781, King Frederick the Great obtained lupine seeds from Italy with the expectation that their planting would improve the poor soil of Prussia. These initial efforts, with *Lupinus albus*, failed because the growing season in Northern Europe was too short. In 1841, a farmer with the surname Borchard grew the yellow lupine, *Lupinus luteus*. By the 1860s, the cultivation of yellow lupine was widespread in the acidic, sandy soil of lands along the Baltic Sea. By then, Brandenburg and Pomerania had up to half their land to yellow lupine as forage or green manure. The death of sheep because of alkaloid toxicity diminished the cultivation of lupine after 1875. By 1900, German farmers grew lupine as green manure or forage on 1.2 million acres. Farmers in Suffolk, U.K., grew the species *Lupinus angustifolius* on light soil. They planted it after grain because it grew into autumn, tolerating frost. After 1900, cheap nitrogenous fertilizers reduced the incentive to grow lupine, which succumbed to cash crops in many places.

During World War I, interest in lupine revived. The Germans ate lupine as a source of protein. In the 20th century, scientists bred low-alkaloid cultivars, presumably obviating the need to detoxify the seeds. The first success came during World War I with the breeding of low-alkaloid white and yellow lupines. After 1954, Australian scientists bred low-alkaloid cultivars of *Lupinus angustifolius*. These new cultivars did not shatter, aiding the harvest. Today Germany, Poland, and Russia grow white and yellow lupine for forage and green manure, though in some regions lupine has not competed well against grain. Western Australia grows *Lupinus angustifolius*. In 1967, Australian scientists released the first low-alkaloid cultivar of this species, Uniwhite. Between 1967 and 1995, production leapt in western Australia.

Nutrition

Lupinus albus is nearly 86 percent water. One kilogram of white lupine has 361 grams of protein, 102.7 grams of fiber, 20 grams of calcium, 14 grams of magnesium, 36 grams of phosphorus, 98 grams of potassium, 24 grams of sulfur, 5 grams of sodium, 5 milligrams of copper, 26 milligrams of iron, 835 milligrams of manganese, 2 milligrams of molybdenum, 30 milligrams of zinc, and 32 milligrams of cobalt. *Lupinus angustifolius* is nearly 85 percent water. One kilogram has 321.6 grams of protein, 149 grams of fiber, 22 grams of calcium, 16 grams of magnesium, 30 grams of phosphorus, 81 grams of potassium, 23 grams of sulfur, 5 grams of sodium, 5 milligrams of copper, 75 milligrams of iron, 17 milligrams of manganese, 2 milligrams of molybdenum, 35 milligrams of zinc, and 112 milligrams of cobalt. *Lupinus luteus* is nearly 95 percent water. One kilogram of yellow lupine has 413.6 grams of protein, 127.2 grams of fiber, 15 grams of calcium, 21 grams of magnesium, 51 grams of phosphorus, 97 grams of potassium, 3 grams of sodium, 9 milligrams of copper, 93 milligrams of iron, 86 milligrams of manganese, 7 milligrams of molybdenum, and 56 milligrams of zinc. *Lupinus mutabilis* is 62 percent water. One kilogram has 447.4 grams of protein, 70.4 grams of fiber, 18 grams of calcium, 21 grams of magnesium, 88 grams of phosphorus, 8 milligrams of copper, 54 milligrams of iron, and 28 milligrams of manganese.

Lupine has more calcium that pea but less than soybean. Lupine has roughly as much phosphorus, magnesium, and potassium as pea but less than soybean. Lupine is roughly 30–40 percent protein. *Lupinus luteus* is 4 percent oil whereas *Lupinus mutabilis* is 15 percent oil. Bread made with 10 percent lupine flour is more nourishing than bread made exclusively from grain. Pasta made with 10 percent lupine flour is more nutritious than pasta made from 100 percent durum flour. Chileans use lupine to make milk. Substituted for soybean, lupine may be made into tofu.

Christopher Cumo

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Magnolia

Magnolia species are members of the Magnoliaceae—an ancient family of trees and shrubs that are native to Asia and the Americas. They comprise a very large family, with over 240 species identified so far. Over half of these species are endangered, with several species having 10 or fewer trees found in the wild. Magnolia trees have been grown for millennia for their large, often white, generally bisexual flowers, although the flowers may also be purple, yellow, pink, or red. Such flowers are the official flowers of several of the United States and North Korea. The trees are also grown for their shade, lumber, and, in Asia, for medicinal uses. They line the streets of many subtropical and tropical cities.

There are fossil records of magnolias dating back at least 36 million years. Molecular DNA analyses of the family suggest that the Magnoliaceae evolved approximately 100 million years ago. Magnolia trees and shrubs have some highly unusual characteristics, because they evolved so early in the development of flowering plants. For instance, they evolved before bees and are not pollinated by these insects. Many species are instead pollinated by beetles, drawn by sweet, fragrant nectar. In some cases, the beetles are trapped in the flowers overnight. The flowers do not have true sepals and petals, instead having structures known as tepals. Also, the flowers are arranged in a spiral structure, rather than in rings.

The majority of the species are found in Asia, ranging from India to New Guinea, with the majority of the world's species being found in China. The remaining one-third of the species are found in the New World, from eastern North America south to Brazil. Fossil records indicate that magnolias were once found in Europe, but were part of forests destroyed by glaciers, unlike those of Asia and North America. A number of genera of plants share an Asian/American distribution.

Magnolias generally are found in moist forests that combine deciduous trees with conifers. The trees usually flower in the late spring or summer and then produce fruit that is eaten by wildlife. Commonly, they are not highly susceptible to insects and diseases. The trees can become infected with fungal leaf spots, which are usually more disfiguring than injurious. Less frequently, fungal heart rot can damage the plants.

Magnolia (iStockPhoto)

Classification of the Magnolias

Although well known by the ancient Chinese on one continent and the Aztecs on another, European botanists were unaware of these traditions when they discovered the first magnolia known to Western science in the 17th century. The genus was named for Pierre Magnol, a French professor of botany and medicine.

Based on the morphology of the plants, derived primarily from herbarium specimens, the magnolias were considered to comprise 11 genera. This system was codified in 1927 by the Magnoliaceae taxonomist James E. Dandy of the British Museum of Natural History. The genera included primarily *Magnolia*, *Manglietia*, *Talauma*, and *Michelia*. Additional genera consisted of *Pachylarnax*, *Kmeria, Alcimandra*, *Aromadendron*, and *Elmerrillia*, with *Tsoongiodendron* and *Paramichelia* added later.

With the advent of molecular biology, DNA sequencing of chloroplasts was employed to provide a more rigorous analysis of the relatedness of the plant species. These techniques were applied to the Magnoliaceae in the late 20th and early 21st centuries. Results of a number of studies indicated that all of the species were closely enough related to comprise one genus: that of *Magnolia*. There are still some taxonomists who follow the traditional 11-genera system, however. At least 1 additional genus has been added in some taxonomic systems.

Horticultural Growth

China is the source of the greatest number of species of magnolias. These trees and shrubs have been cultivated for their flowers, leaves, and sometimes curious fruit in China for millennia and are well represented in ancient Chinese art. An example is the Yunan magnolia, or *Magnolia denudata*, grown in China since 6 or 7 CE and still a popular horticultural plant today. This small, deciduous tree of 30 to 40 feet produces white flowers, although the variety *purpurascens* produces rose-colored flowers. This magnolia was introduced to the United States in 1789. One problem with growing this species is that the tree often blooms during warm spells, only to have the flowers subsequently frozen. The Yunan magnolia is a popular landscape plant in warmer areas and is the parent of many hybrids.

In the United States, magnolias are native to the southeastern coastal plains. This area is the source of the widely grown southern magnolia, *Magnolia grandiflora*, which is grown throughout the United States and world for its large, attractive flowers and leaves, value as a shade tree, and adaptability to varying soils and climates. Growing up to 125 feet, it is considered one of the world's most popular evergreen trees. It is unusually tolerant to sulfur dioxide and can be grown under conditions that other tree species will not tolerate.

While not well adapted to the cold, there are several cultivars that enable this species to be grown in protected areas in the northern United States. The temperature range within its native area is generally between 15°F and 100°F. There are some drawbacks to growing this species. It produces constant litter. The large leaves land with a resounding thump. The roots can lift pavement, and the shade of the tree will prevent a lawn from being grown underneath it.

Magnolia grandiflora naturally grows nears swamps and along streams, so it can tolerate some degree of flooding. The trees are susceptible to winter droughts, however. Older trees can frequently survive fires, but seedlings have a high rate of mortality when subjected to fire.

The white, fragrant flowers are produced in the spring, with the fruit maturing in the fall. Once the fruit matures, seeds up to one-half of an inch hang by a thread before dropping to the ground or being consumed by birds or mammals. The trees produce chemicals that inhibit the germination of their own seeds, so magnolia seedlings rarely grow under the parent tree.

Another method of reproduction is by the production of sprouts from the root and stump of the tree. Limbs that are covered by soil can produce separate trees. This type of layering has been an ancient method of creating new magnolia trees.

Existing magnolia seedlings or trees can be transplanted to desired locations, but this should be done carefully. In general, magnolias are difficult to transplant. It is advised to plant them from containers to lessen the damage to the roots.

The amount of light recommended depends on the maturity of the plant being transplanted. Larger plants can tolerate light shade, but will grow better in the sun. In contrast, it is recommended to grow seedlings in light shade. Soils that are highly alkaline should be avoided.

A Long Tradition of Medicinal Uses

In addition to their desirable horticultural characteristics, magnolias are cultivated for other reasons as well. Over 250 different phytochemicals have been isolated from species of magnolia. Two species in particular have been cultivated for over 1,000 years for their medicinal qualities. *Magnolia officinale* has been widely cultivated in China for the bark of its stems, branches, and roots. This bark is rolled into tight cylinders and sold as Houpo or Houpu, which is used extensively in Chinese traditional medicine. In Japan, the bark of *Magnolia obovata* has been used as a substitute for Houpo, but traditional practitioners consider its properties to be inferior to that of the original Houpo. Magnolia bark extracts are currently used in clinical practice in Japan.

The crude extracts have a long tradition of being used to treat gastrointestinal disorders, anxiety, and depression. The bark of both species of magnolia contains the biphenolic compounds magnolol and honokiol. These phytochemicals have been the source of numerous studies on the treatment of psychiatric disorders, including Alzheimer's disease, Parkinson's disease, various types of cancer, and numerous other types of medical conditions.

Conservation Status of Magnolias

Some types of magnolia are used as a source of lumber, producing furniture and pallets. A large number of magnolia species are rare and threatened with extinction, due to habitat loss, and, in some cases, overharvesting. In 2007, the Botanic Gardens Conservation International (BGCI) and Fauna & Flora International (FFI) published *The Red List of the Magnoliaceae* that identified which species of magnolias were in danger of extinction and reported on their survey of species that were represented in cultivation. They found records for only 37 of the 89 magnolias listed as critically endangered or endangered. Thus the majority of these rare trees were growing solely in the wild, putting them at particular risk for extinction if anything were to happen to their habitat.

The degree of severity of the danger to the endangered and threatened species varied geographically. Chinese scientists have been aggressive about propagating their large number of species of magnolias in botanical gardens. In contrast, the country with the second-largest number of species is Colombia. In this country, a number of species in the very threatened status were found only in the wild. This is a common problem in Latin America and the Caribbean, an area rich in novel magnolia species. Efforts are being made to ameliorate this situation and protect these rare plants.

Helga George

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Mahogany

Mahogany trees are renowned for their resplendent looks and their much prized aromatic wood. One of the finest trees in the plant kingdom, mahogany has played a major role in the development of humanity, especially for those who spanned the oceans in search of new territory, landing at the Americas. Much can be said in favor of mahogany's red wood, which is always described as being intrinsic and beautifully grained. Mahogany is a group of differing tree genera that belong to the family Meliaceae. Each possesses slightly differing features, but has the same family semblance with the main features of red wood, wood grain, and aroma. Medicinal properties too vary, but that is not subject to the similarity in physical features, by which these plants are grouped together as mahogany.

Taxonomy

There are typically three Meliaceae genera that are identified as mahoganies. The first is *Swietenia mahogani*, which is the Latin American (Republic of Suriname) or Caribbean (West Indies) mahogany. It grows to a height of approximately 150 feet, which is the shortest among the mentioned three. The second is *Swietenia macrophylla*, which is also known as the South American mahogany or the Honduran mahogany. The color of the wood has a more orange tint than red, as when compared to *Swietenia mahogani*. It also has the largest leaves and is also called bigleaf mahogany. The third type, which is unrelated to the *Swietenia* genus, is *Khaya ivorensis*, which is native to Africa. The wood of this tree, though red, pales in comparison. This tree is slightly taller than *Swietenia mahogani* and grows to a height of 150 feet.

Attributes

Mahogany trees have similar features. They are deciduous trees with bright to dark evergreen foliage. They require full sunlight and well-drained soil with a pH ranging from mildly acidic to mildly basic (6.1–7.8). While many varieties may be found in the United States, mahogany grows naturally in Florida, with it being introduced into other regions for the purpose of decoration. Mahogany grows best in hardiness zones 10 and 11. These deciduous trees possess a taproot with branching root system. The stem is erect, branching at the terminal end, with the bole reaching a height of approximately 45 to 90 feet, depending on the species. The bark is thick. The color of the bark and sap range from shades of red to brown with tints of orange and even light yellow. Mahogany trees are noted for the way the elements of the tree are arranged in the wood, giving it its fine grain and wood figure. It is this grain that determines the quality of the red-wood mahogany tree. The stem may be described as woody with characteristic aromatic fragrances. Leaves are of the compound pattern, where they are pinnately arranged with many leaves evenly paired on a common leaf stalk called the rachis. The rachis does not end with a terminal leaf. About five to seven or more leaves may be seen on a rachis. In *Swietenia macrophylla*, the leaves are much larger, hence the name. There are no stipules present in the leaves. The inflorescence is a cymose. It may be seen as white patches on the tree. Both male and female flowers are produced. The flowers are symmetrical and can be cut into halves along many planes (actinomorphic), and may be hermaphrodite too. There are four to five sepals and petals each, with stamens ranging from 8 to 10. The stamens are monadelphous, which means that they are united to form a tube-like structure. A remarkable disc may be seen separating the stamens and the ovary. The ovary is superior in position, where the rest of the floral parts are seen arising from its base. The fruit is a capsule, while the seeds are winged.

Mahogany is a winter tree; that is, its growth can best be seen between the months of September and December. New leaves appear during fall, even before it sheds its old ones. Flowers bloom between July and January. The seeding and sprouting period is during the early months of the year. New saplings, although the seeds are windblown, are generally found close to the mother plant.

Harvesting and Conservation

The many mahogany genera are on the list of endangered and threatened species. They are not so much endangered or close to extinction as much as they are threatened by careless and illegal trade. According to the International Union for Conserving Nature (ICUN), all countries that wish to engage in fair trade of mahogany should apply for a permit known as CITES, which protects the rights and controlled usage of endangered and threatened species. Mahogany is prized for its wood, which makes it extremely expensive. Over 120,000 cubic meters of wood is harvested a year from South America, which is very difficult to replace within short period of time. Hence overlogging is one of the main issues related with the careless use of mahogany. Since it is highly expensive, malpractices of illegal trade take place, making it necessary for a governing body to come into place. Hence the position of the ICUN with the issuing of CITES.

Mahogany, as already stated, is prized for its wood, its excellent grain and figure, and its aromatic smell. It is used for making many pieces of art and carpentry such as cabinets, joinery, panels, different types and grades of veneer, musical instruments, arched goods, molding, and many types of household furniture. Because of its close grain, its wood is not easily susceptible to termite attack.

Pests

There are many pests known to attack the mahogany plants. Of these, one of the most important is the mahogany shoot borer (*Hypsipyla gandella*), which is a moth. It is found to attack young shoots of mahogany in Florida, the West Indies, and some of the Latin American countries. First, the moths feed voraciously on the leaves, and then they bore into the shoots, flowers, and fruits, attacking even the seeds. When they attack the shoot, they form hollow tunnels within that aid in the breaking of the stems when acted upon by strong winds, or even induce the death of the plant, due to the attack on the sap. Since this pest first starts by attacking the leaves, the first line of management is to counterattack the pest organism by using organic pesticides. One of the more effective organic pesticides that can be sprayed on leaves for the topical control of the pest is from the Malvaceae family itself. Neem leaf extract has been found to work well in this case as it has against many other plant pests. Another control measure is by cultivating predators to prey on the Mahogany Shoot Borer. Yet a third measure is by cultivating resistant varieties that will hardly be affected by the pest. Mahogany is a plant that many pests find nutritious. Hence one of the main steps to protecting the tree is to identify the attack and pest while it is in the earliest stages.

Amanda Mittra

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Mango

A member of the Amacerdiaceae or Cashew family, mango is in the genus *Mangifera*. The genus has at least 27 edible species, though *Mangifera indica*, meaning "an Indian plant having mangos," is the most widely cultivated (Susser 2001, v). Of these 27 species, most are found in Southeast Asia. Mango has as much as 20 percent sucrose, the sugar in sugarcane and sugar beet. The fruit's sucrose, glucose, and fructose make mango sweet. One enthusiast compares the flavor of mango to that of peach. Mango has amino acids, carbohydrates, fat, minerals, and vitamins, including vitamins C and D, beta-carotene, thiamine, and riboflavin. Mango pulp yields the highest concentration of vitamin C. Mango has as much beta-carotene, the vitamin A precursor, as butter has vitamin A. Mango is *mangga* in Malaysian and Javanese and *manga* in Tamil. Known as the "king of fruits," mango is Asia's principal fruit (Litz 2009, 1).

Origin and History

The ancestor of mango may have arisen in the Quaternary Period (1.8 million years ago to the present). The greatest number of mango species is found in Malaysia, Indonesia, Thailand, Vietnam, Cambodia, Laos, and the Philippines. Species with one fertile stamen occur in northeastern India, Myanmar, Thailand, and Malaysia. These facts have focused attention on southern and Southeast Asia. In 1876, British botanist Joseph Dalton Hooker supposed that India was not the cradle of mango but was a later recipient of the tree. In 1884, French botanist Alphonse de Candolle asserted that mango originated in southern Asia or the Malay Archipelago. One thesis holds, in opposition to Hooker, that mango originated in India, from where it spread to Southeast Asia. This trek must have been slow because seeds remain viable only a few weeks at most and sometimes only a few days and so cannot have been carried long distances. Alternatively, humans may have carried seedlings from place to place, which surely must have accelerated mango's dispersion. Those who hold to a gradual migration believe that the tree was introduced into Indonesia only in modernity. Another hypothesis holds, however, that the Indonesian island of Java cultivated mango as early as 900 CE. According to legend, Buddha meditated beneath a mango tree. If true, mango culture must be ancient, at least in India. Molecular evidence puts the origin of mango in northwestern Myanmar, Bangladesh, and northeastern India.

De Candolle believed that mango cultivation arose first in India, which has tended the tree since 2000 BCE. The first trees produced small fruit with thin flesh, though over many generations Indians selected for size and sweetness. Temples in India dating to 100 BCE bear carvings of mango trees, though these are late artifacts in the history of mango cultivation. Merchants and monks may have taken mango from India to Southeast Asia, though the date is uncertain. In its earliest history, the tree was propagated by seeds. Trees were grafted only in the 15th century with the arrival of the Portuguese in Goa, India. The Moghul rulers of India, having learned from the Portuguese, grafted trees and amassed large groves. The Lach Bagh orchard had 100,000 trees. The Moghuls selected varieties still in cultivation, including Alphonso, Dashehari, Langra, Rani Passand, and Safdar Passand.

From India, mango migrated to China about 645 BCE, to the rest of East Asia in the fifth or fourth century BCE, and to the Philippines between 1400 and 1450. During the 15th and 16th centuries, Europeans distributed mango worldwide, transporting seedlings rather than seeds because of the latter's too brief viability. The Portuguese took mango from India to Africa, though one thesis holds this to be a late introduction, the Iranians or Arabs having brought mango from India to Africa in the 10th century CE. From Mozambique and Angola, the Portuguese took the tree to Brazil. The Spanish carried mango from the Philippines to Mexico and Panama. This heritage is evident in the fact that the most widely grown cultivar in Mexico, Manila, is a Filipino variety. From Brazil, the mango was transported to the Caribbean in the 18th century.

In the early 19th century, mango spread from Mexico to Hawaii, which has also acquired varieties from India, the Philippines, and Jamaica. In 1833, trees were planted in Florida, though they did not survive. A second planting followed in 1861 from Cuban stock and a third in 1889 from India. The winter freeze of 1894 and 1895 killed all mango trees in Florida except those of the Mulgoba cultivar. Mulgoba has oval, smooth fruit weighing 10 to 14 ounces. The skin is bright yellow with red highlights. The flesh is soft, juicy, and sweet with a strong but pleasant aroma. Yet Mulgoba is susceptible to diseases, yields poorly, and the fruit is easily bruised. For these reasons, Mulgoba is no longer in commercial production. Its chief importance is as the parent of Haden. In 1902, Captain F. O. Haden of Coconut Grove, Florida, for whom the variety is named, planted a seed from Mulgoba, recognized the superiority of the new tree, and selected it as a new cultivar. The fruit of Haden is oval and smooth and weighs 24 to 32 ounces. Like its parent, Haden's fruit is bright yellow with red highlights. Fruit is sweet with a pleasing fragrance. Haden is Florida's chief cultivar and is widely grown throughout the Americas. In 1900, railroad baron Henry Flagler established a garden in Miami where the U.S. Department of Agriculture planted mango trees. Today, Florida grows more than 150 cultivars. These varieties are not items of commerce alone. Florida home owners often have a mango tree in their backyard.

Attributes, Production, and Uses

A tree of the tropics and subtropics cultivated primarily in Asia, mango does not tolerate frost. A mango tree may reach 120 feet in height and live hundreds of years. Its leaves, whose petioles may be 0.4 to 5 inches long, are arranged alternately on branches. Its leaves may be lanceolate, oblong, ovate, or a combination of these forms. Its leaves are 5 to 15 inches long and 0.8 to 5 inches wide. Young leaves are copper in color and turn dark green with age. A tree issues forth a long taproot and a large number of feeder roots near the surface of the soil. A single tree yields thousands of flowers. Each flower has four or five petals and sepals. A flower may be male, female, or perfect. Aborting the pistil, a male flower has five stamens, only one or two yielding pollen. Flies cross-pollinate flowers. The fruit is a large drupe. Humans eat the mesocarp of the fruit, which may be elongate, oblong, ovate, or a combination of these shapes. The fruit is 1 to more than 12 inches long.

More than 90 countries grow mangos. More than 96 percent of the crop is consumed locally with less than 4 percent entering world commerce. In 2006, mango was the fifth leading fruit in tonnage worldwide, trailing bananas and plantains, citrus fruits of all types, grapes, and apples. Between 1990 and 2005, the harvest of mangos worldwide rose from 16.9 million tons to 28.2 million tons (Litz 2009, 14). Asia tallies 77 percent of global production of mangos, the Americas 13 percent, and Africa 9 percent. Although India harvested 51 percent of the world's mangos in 1990, the percentage dropped to 38 in 2005 because other nations have increased their share of the total. Production has increased in Mexico, Central America, South America, China, and Africa. Even with this decline relative to other countries, India still ranked first with 10.8 million tons of mangos in 2005, China second with 3.5 million tons, Thailand third with 1.8 million tons, Pakistan fourth with 1.7 million tons, and Mexico fifth with 1.6 million tons. The United States is not a leading producer. Florida, harvesting nearly all U.S. mangos, produced about 3,000 tons of mangos per year. Florida's primary importance lies in its role as the breeder of new cultivars, which are grown worldwide. Mexico, India, and Brazil are the chief mango exporters, and the United States is the largest importer. Canada and the United States buy mangos from Mexico, Brazil, Peru, Ecuador, and Haiti. Western Asia imports mangos from India and Pakistan. The European Union purchases mangos from South America and Asia. The primary fruits of export are red and firm to hold up during long transit. Fruits from the varieties Kent, Tommy Atkins, Haden, and Keitt are the primary export mangos.

Most mangos are eaten fresh. About 1 percent of the harvest goes to juice, nectar, preserves, dried fruit, and frozen pulp, and to flavor bakery products, ice cream, and yogurt. Consumption is rising in the United States, Japan, and China. In 2005, the average American ate 2.2 pounds of mangos, double the intake in 1996. By comparison, Americans ate 24 pounds of bananas and 11 pounds of oranges. The consumer may purchase ripe mangos for use in a few days. Not fully ripe fruit should be stored at room temperature several days. While a mango is ripening, it should not be refrigerated, though once ripe it may be stored in a refrigerator up to one week.

Christopher Cumo

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Mangrove

Mangroves are diversified ecosystems of halophytic plants that can flourish in soil that is in or around salt water. Mangroves may be shrubs, herbs, or trees or any form of plant that can trail or climb. While they fall under different families in the plant kingdom, what these plants have in common is the adaptability to survive despite high concentrations of salt in the water. Most of the mangroves are related to salt water, but there are those that also thrive well in freshwater.

Saline Tolerance

If one looks at the different kinds of mangrove plants, the varying modes of salt adaptability may be seen. Some plants do not allow the salt to enter. In these plants, the roots filter the salt. In some plants, while the salt is taken in with the water, 80–90 percent of it is exuded back into the water during the physiological processes. For a third group, salt may be exuded via the stomata just below the petiole of the leaf and may be observed as salt deposits. In yet another type of adaptation, salt collects in the older leaves, this salt being discarded when the

Mangrove forest (iStockPhoto)

old leaves wither and fall. Mangrove flora may possess two or more of these adaptations. In order to maintain the required amount of nutrient balance devoid of excess salt, the leaves of all plants also have a thick waxy coating on the top to prevent excessive water loss. Moreover, the roots are designed to stay under water, yet partly aerial, so as to facilitate aeration. Prop roots are some of the best root adaptations for mangrove species closest to the sea.

Diversity

Mangroves are some of the most beautiful of all ecosystems that flourish with diversity. Observed most in the tropics, mangrove plays a major role in determining the existence of a number of endangered plants and animals. While about 50 percent of the world's mangroves have already been destroyed, as of today many countries are making an effort to preserve what is left. Colonization along coastlines, inland waterways, and estuaries have accounted for a lot of mangrove deforestation.

The mangroves of Australia are the largest and most diversified of all mangroves found around the world. The Kimberly region mangrove is renowned for its beautiful rivers, estuaries, rugged mountains, and waterfalls, the water of these regions flowing into the sea. Around these water areas are a host of mangroves that are home to a large number of birds, fish, animals, and insects. The saltwater crocodile, which is considered the king of the mangrove, thrives in these areas and feeds on small reptiles, fish, and insects. The Kimberly region mangroves are also home to the noted flying fox, which is a nocturnal, aerial mammal. It feeds voraciously during the night, eating flowers, fruits, seeds, pollen, and nectar, and also dispersing as much as 60,000 seeds in one night.

The mangroves of West Bengal in India are home to the royal Bengal tiger, which is on the brink of extinction. These mangroves, known as the sunderbans (*sunder* means "beautiful" and *bun* means "forests"), are a web of backwaters that can be confusing even for the native human inhabitants.

The Mangroves of Florida

There are approximately 50 genera from 16 different plant families that constitute the world's mangrove population. In the United States, Florida has the largest mangroves, with three main plant species being native to the region. These are the red mangrove (*Rhizophora mangle*), the white mangrove (*Laguncularia racemosa*), and the black mangrove (*Avicennia germinans*).

The mangroves of Florida are seen as different mangrove zones. The red mangrove is found at the shorelines of the ocean, rivers, and inland waterways and is the first line of contact for tides and seawater. It occupies the low-tide levels. The red mangrove has some of the tallest specimens and is characterized by long prop roots from branches extending across the water. Beyond that, inland, is the chain of black mangrove. These mangroves have aerial roots called pneumatophores, which extend out of the main roots and serve as organs of aeration. Moreover, the leaves of the black mangroves are adapted to expel salt, whose deposits are seen on the undersurface of the leaves. They occupy the intertidal zone. The innermost zone of mangroves is the white mangroves, which are comparatively smaller in size than the other two plant species. While they are not directly in contact with the salt water, they inhabit marshy, waterlogged areas, where the water may circulate from the ocean inward or the rivers and waterfalls flowing toward the sea. They are more often than not seen at the high-tide areas. The white mangroves are important to the mangrove ecosystem as they prevent the flow of minerals and nutrients from the soil to the ocean. The red mangroves, on the other hand, deal with the external forces from the sea. They act as wind breakers, tide breakers, and the last line of erosion checks.

Reproduction

The seeds of the mangrove are also adapted for aquatic life. Most are dispersed into the water and are carried from shore to shore, many even traveling vast expanses of seas to reach other countries. The seeds have a thick waxy protective coating that prevents them from getting waterlogged. Many seeds sprout while on the parent plant into small saplings. These saplings may be carried from shore to shore and prop roots at the first available soil grip.

Conservation

The mangrove plays an important role in conserving bird and animal species. It acts as breeding grounds for gulls, black-necked storks, crocodiles, eagles, and fish that breed between the waterlogged roots and also for many reptiles, amphibians, and mammals. The prop roots of many trees, entangled with the lateral roots of others submerged in the ocean or river, form a safe hatchery for fish that come to spawn. With large-scale deforestation, much of the natural mangrove ecosystems have been wiped out, thereby depleting the number of flora and fauna. Oil spillage in the ocean is another factor that greatly affects the survival of mangrove flora and fauna.

Decomposition

Mangroves are known for their peculiar smell, especially those that are nearest the coast and have the thickest forests. The canopy of leaves prevents adequate sunlight from reaching the ground. While the decomposition of leaves and roots takes place by bacteria, not all material gets decomposed fully, due to the absence of sunlight that makes it an abiotic environment. In such cases, the litter that remains converts to peat. Peat is acidic in nature and starts acting on the limestone present in the surrounding area below the roots. These acidic reactions result in the release of sulfur compounds, which are known for their peculiar "rotten egg smell."

Uses

Forest ecosystems have proven to be a good source of naturally obtainable medicines. Different plants have antiviral, antibacterial, antimicrobial, and antifungal properties. For example, *Acanthus illicifolius* and *Avicennia marina* possess analgesic properties, while the bark of *Rhizophora mucronata* and the leaf extracts of *Bruguiera cylindrica* possess antiviral properties suitable for the treatment of hepatitis B. *Acanthus illicifolius* is also used in "bush medicine" to fight ailments related to the skin such as rashes, boils, and wounds and even in the treatment of leprosy. In addition, mangroves are a good source of tannins, terpines, saponins, steroids, flavonoids, and alkaloids. The toxins produced by mangroves work as pesticides, while the ash acts as a soap substitute. The ash is also used in the manufacture of rayon and cosmetics. Tannin and the mangrove sap are used for making dyes. The fruits of many plants are edible, while the leaves are used to feed livestock.

One of the biggest contributions of mangroves to human civilization, although it has been misused, is the large supply of wood from these forests. Wood has been a major source of fuel as well as for construction in colonies near coastlines. Government agencies, the United Nations, and private bodies such as the Programa Reduccion de Vulnerabilidades Ahuachapan-Sonsonate (PRVAS) are working toward building up the mangrove areas in many parts of the world. In

Florida, to conserve the natural mangrove habitat the Florida Department of Environmental Protection has fined those who carry out deforestation activities or tamper with the mangrove forests without a government permit. Only qualified, professional mangrove trimmers are allowed to carry out cutting or trimming of branches, limbs, or foliage. Alteration, removal, or destruction of the mangrove ecosystem is a crime and punishable under law.

Amanda Mittra

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Maple

A hardwood, the maple is an ancient tree. Most maples are deciduous, though *Acer lacarinum*, a tree of the tropics, is evergreen. The maple is a collection of species in the genus *Acer*, which derives from the Indo-European *ac*, meaning "sharp." The name may derive from the pointed leaves of a maple, though there is nothing particularly sharp about them. Nevertheless, the German for "maple," *Spitzblatt*, and the Russian *ostrolistny klejen* mean "sharp leaved." Another possibility is that maple wood is hard and was used to make pikes and lances. In this context, maple wood was indeed sharp. The Dutch *Saanse aak* means "maple."

Maple tree tapped for syrup (Edward Fielding/Dreamstime.com)

Curiously, the word *aak* may be the root of "oak," a tree unrelated to maple. Whatever its origin, the Latin *Acer* is neuter despite the custom of referring to trees as feminine. By the 18th century, *Acer* was the common label for maple, and Swedish naturalist Carl Linnaeus, bowing to tradition, assigned the nine species of maple he knew to its genus. The Greek for maple is *gleinas* or *gleinon*. From it have arisen the Polish *klon*, the Lithuanian *kleveas*, the medieval Latin *clenus*, the Middle High German *linboun* or *linboum*, the Lower High German *lehne*, the Swedish and Norwegian *leonn*, the Danish *lam*, and the Gutnish *leund*.

Origin, Diffusion, and Distribution

One hypothesis holds that the maple originated in Hubei, Sichuan, and Yunnan provinces of China. The oldest fossil of a maple dates to 100 million years ago in Alaska. Had the maple originated in China, it must have migrated to Alaska and so must be older than 100 million years. By 90 million years ago, in addition to Alaska the maple had colonized Greenland, Spitsbergen, and Iceland. Fossils from the Paleocene and Eocene Epochs (65–38 million years ago) place the maple in several regions of North America. Fossils of the Middle Eocene Epoch place the maple in Wyoming. The oldest fossil in Europe, from the species *Acer haselbachensis*, dates to 38 million years ago. The Miocene Epoch (25–5 million years ago) marked the apex of the maple, which was more widely distributed than at any time before or since. The maple even colonized lands near the poles. The warm climate allowed the maple to range far from the equator. The onset of the ice ages in the Pliocene Epoch (5–1.7 million years ago) forced the maple to retreat to what is today the temperate zone. As its geography contracted, the maple's population shrunk. From its putative origin in China, the maple spread west across the Himalayan Mountains to Iran, Afghanistan, Turkey, the Balkans, and Europe; south to Southeast Asia, Malaysia, Indonesia, and the Philippines; and northeast to Manchuria, Korea, Japan, Siberia, and across Beringia to North America, Greenland, Iceland, and Spitsbergen.

Principally a temperate plant of the Northern Hemisphere, the maple tree is found in North America, Europe, Asia, and North Africa, but also in tropical Southeast Asia. Specimens grow in the mountains of the Philippines, Sumatra, Borneo, Sulawesi, and Malaysia. One may find them in the sunny climate of the Mediterranean Basin, including North Africa, and Mediterranean California. The maple tree grows in the Balkans, Lebanon, Turkey, Iraq, Iran, Afghanistan, Pakistan, the Himalayas, China, Japan, Korea, Manchuria, Siberia, and the Kurile Islands. In the United States, the maple has colonized every locale but the southern tip of Florida and southwestern California. It occupies all of temperate Canada.

Uses

The primary use of the maple is to landscape public and private spaces. Landscape architects favor *Acer saccharum* and *Acer rubrum* for their fall colors. *Acer diabolicum* has gained adherents because of its showy flowers. *Acer macrophyllum*, yielding yellow flowers, is especially pretty in spring. Landscapers have planted maples in public parks and gardens in North America, Europe, Asia, and Africa. As late as 1959, 17 percent of trees planted along streets in Berlin, Germany, were the maple. Only the genus *Tilia* claimed a larger percentage. *Acer platanoides* graces the esplanade in Helsinki, Finland. The Netherlands has planted *Acer pseudoplatanus* along its roads, though the tree is ill suited for this purpose. Its roots, growing near the surface of the soil, swell to such a large diameter that they uplift streets and sidewalks. Since the colonial era, Americans have planted the sugar maple along roads. In China, *Acer truncatum* serves this function. *Acer buergerianum* is planted along streets in Japan, Korea, and Pretoria, South Africa. The people of Southeast Asia plant *Acer laurinum* along roadways in Indonesia, Malaysia, and the Philippines.

Because maple wood lacks tannin, it is not naturally weather resistant and so is not ideal for use outdoors. It decomposes when in contact with the soil and when exposed to weather. Nonetheless, its wood has been in demand since antiquity.

According to first-century BCE Roman poet Virgil, the Greeks built the Trojan horse from maple. Today, maple is a popular wood for the floors and walls of homes, bowling alleys, gymnasia, and other structures. The interior beams of buildings are often maple. Woodworkers make maple into furniture. The soft wood of *Acer macrophyllum*, *Acer rubrum*, and *Acer saccharinum* is suitable for making kitchen utensils and wooden tools. Violin makers use the species *Acer pseudoplatanus* to make the back, sidewalls, and pegs of violins.

Several species of maple yield honey, though maple trees are better known as a source of syrup. *Acer saccharinum* (the sugar maple) is the species of choice. Its sap is 1–3 percent sugar, being mostly water. It does not taste especially sweet and may have gone unnoticed but for the fact that Native Americans called attention to it. They taught Europeans to make syrup through the simple process of boiling the sap. By driving off the water, the maker derived syrup. When boiled, eight gallons of sap yielded one gallon of syrup. The colonists, eager for a cheap substitute for sugar, produced maple syrup in quantity. *Acer saccharinum* produces sap in early spring. Sap flows as the temperature rises during the day. The principal producers of maple syrup are Quebec, Canada, and New Hampshire, Vermont, New York, West Virginia, and Ohio in the United States.

The ancients did not regard the maple as a medicine. First-century CE Greek physician Dioscorides did not mention it, and it did not appear in the medical texts of China and Japan. Nonetheless, the species *Acer negundo* yields a drug suitable for chemotherapy. A maple tree also contains glycosides that, while not a medicine, are an insect repellant and insecticide. They protect the wood from termites.

Attributes and Cultivation

Maples grow in all types of soil, though most prefer a pH between 5 and 6.5. *Acer campestre* and *Acer monspessulanum* are atypical in preferring alkaline soil. Where the soil is too basic, the gardener may add compost, leaves, and peat to it. Maples prefer well-drained soil. They will not tolerate waterlogged soil. Japanese maples do poorly in windy conditions. Cold or salty wind is particularly damaging. Other species are more tolerant of wind.

The maple languishes in shade, though where temperatures exceed 90°F, partial shade at midday is desirable. A maple with poor color likely does not receive enough sunlight. Purple-leaf maples especially need full exposure to the sun. A maple tree should be planted when dormant: between late fall and early spring. Where the soil freezes in winter, the gardener should plant a maple tree in early spring. Because a maple tree has shallow roots and cannot tolerate dry conditions, it should not be planted during the rainless days of summer. The gardener should dig a hole twice the size of the root ball so that the roots may expand. Before planting a tree, the gardener should add compost to the hole. Once planted, a tree should be watered where the climate is dry.

Once fertilized, the flowers yield seeds, which have wings that resemble helicopter blades. The wind disperses seeds. The gardener who wishes to propagate a maple tree may gather seeds from the ground, refrigerate them for 60 to 120 days to stratify them, and plant them in potting soil. Growth is not rapid. The gardener must nurse a seedling one to three years before it is ready for transplantation outdoors. A tree grown from seed is unlikely to be as spectacular as one sold by a nursery. A maple tree may also be propagated by a cutting, though weeping maples are difficult to propagate is this fashion.

Species and Varieties

One authority asserts that maples are "trees of perfection." Their palmate leaves have 5 to 9 and sometimes 11 lobes. Not all maples have green leaves in spring and summer. *Acer palmatum*, known as Bloodgood, has dark purple leaves. The variety Orido-nishiki has pink and cream leaves. Beni-kamachi has scarlet leaves. Shi-deshajo has pink leaves. *Acer platanoides*, known as the Crimson King, has, as the name suggests, dark red leaves. *Acer pseudoplatanus*, like the variety Shi-deshajo, has pink leaves. In autumn, this species yields red, golden, crimson, and orange foliage. *Acer japonicum* and *Acer japonica* produce conspicuous flowers, yielding them before they put forth their leaves in spring. Other species, producing leaves and flowers simultaneously, are less showy.

The subspecies *Acer palmatum atropurpureum* is the most widespread red maple. Its leaves are, according to one authority, "black-red." The tree reaches 25 feet in height. The variety Okagami of this subspecies grows only half as tall. Its leaves are dark red in spring and scarlet in autumn. Another variety of this subspecies, Oshio-beni, grows 18 feet tall. In spring, its leaves are orange and red, in the summer red-green, and in autumn scarlet. A third variety, Moonfire, grows 12 to 15 feet tall. Its dark red leaves hold true in spring, summer, and fall. A fourth variety, Suminagashi, grows to 12 feet. It has red leaves in spring, maroon in summer, and crimson in autumn.

Acer buergerianum originated in China, but the work of Japanese horticulturists has led to its renown as a Japanese maple. Atypical of maples, this species tolerates dry conditions. Because it is impervious to pollution, it has been planted in cities. In spring, it bears green leaves, which turn red and orange in autumn. Like *Acer buergerianum*, *Acer griseum* originated in China but is known as a Japanese maple. Called the paperback maple, the tree displays orange-brown bark. The species holds its leaves, which turn red in autumn, until late in the season.

Acer japonicum, known as the full-moon maple, grows to 30 feet. Its purple-red flowers attract admirers. The Asconitifolium variety of this species has leaves that resemble the fronds of a fern. It yields red flowers, and its green leaves turn red, yellow, crimson, and orange in autumn. The variety Vitifolium derives its name for the resemblance of its leaves to grape leaves. Its green leaves turn golden, scarlet, and crimson in fall.

Acer ciriatum—the vine maple of North America—resembles *Acer japonicum* except that the American maple has sticky leaves. One authority characterizes the color of its flowers as "wine and white." The name vine maple derives from the species' way of surviving in shade. When overshadowed by a large conifer in the forest, the vine maple winds its way up the conifer to sunlight. A small tree *Acer ciriatum* grows to 15 feet. The dwarf of this species, Little Gem, grows to only 3 feet. Because of its smallness, Little Gem may be grown in a container.

Christopher Cumo

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Marigold

In the Asteraceae or Compositae family, marigold includes several species in the genus *Tagetes*. The genus has 56 species, apparently not all of them marigolds. *Tagetes* takes its name from Tages, an Etruscan boy who could predict the future. This ability led to his death. The common marigold is sometimes confused with the pot marigold. The common marigold, in the genus *Tagetes*, originated in Mexico, Argentina, or New Mexico, whereas the pot marigold, in the genus *Calendula*, is native to the Old World. Calendula, here I mean the plant not the genus, is treated elsewhere in this encyclopedia. Being in separate genera and having originated on different continents, *Tagetes* and *Calendula* are not closely related. This article preserves the distinction between *Tagetes* and *Calendula* by using the term "marigold" only for those species in the genus *Tagetes* and the term "calendula" for the pot marigold.

Confusion deepens with the almost indiscriminate use of the term "marigold" to apply to ornamentals that are not in the genus *Tagetes*. First-century CE Roman encyclopedist Pliny the Elder confused the marsh marigold with calendula, neither of them true marigolds. The marsh marigold may predate the ice ages, but it is a plant of the wild rather than cultivation. Gardeners have named the cape marigold, which resembles a daisy, the sea marigold with its white branches and flowers, and the corn marigold native to the United Kingdom despite the fact that corn is a New World cultigen. True marigolds, the African marigold is not an indigene of Africa and the French marigold is not native to France. Logic and precision are not the hallmarks of marigold nomenclature. The word "marigold" derives from the phrase "Mary's gold."

Folklore and History

The superstitious once believed that a woman could conjure her lover in a dream by combining marigold petals, marjoram, thyme, wormwood, honey, and white wine, applying the mixture to her stomach, breasts, and lips, and reciting on Saint Luke's Day: "Saint Luke, Saint Luke, be kind to me; in dreams let me my true love see." Others imputed even greater power to marigold, believing that it could treat smallpox and measles.

For most of the marigold's history, only the people of Mesoamerica knew it. It was a favorite of the Aztecs. Aztec women wore marigold in their hair. Men held it in their hands. Known as the "flower of the dead," the Aztecs offered the marigold to the deceased. The Aztecs called marigold *compoalxochitl*, which derived from *compoalli*, meaning "twenty," and *xochitl*, meaning "flower." The marigold was therefore the "twenty flower," presumably because it bore a large number of flowers. *Tagetes erecta*, now known as the African marigold, was a sacred plant. Aztec priests combined it with tobacco. When smoked this combination induced a trance, out of which a priest divined the future. The African marigold has yellow flowers, grows to a height of two to two-and-one-half feet, and bears a large flower. The leaves are fragrant, though some people dislike the odor. In the 18th century, British author William Hanbury wrote of the African marigold that "these flowers stink as bad, or worse, than the French Marygolds." The conquistadors, conquering Mexico, brought the African marigold to Spain, from where it spread to North Africa. Europeans thereafter forgot that it had originated in Mexico. In 1535, soldiers of Holy Roman Emperor Charles V rediscovered the plant in Tunis, Tunisia. Thinking it a new ornamental, Europeans named it the African marigold. In Mexico, the African marigold can be found along roadsides and in fields. Retaining its Aztec association with death, the African marigold decorates graves on the day before All Souls' Day (November 1) and on All Souls' Day (November 2). Because the African marigold blooms in autumn, it is ideal for this purpose. The African marigold is known as the Aztec marigold and the American marigold.

Tagetes patula, now known as the French marigold, is also native to Mexico. Shorter and bushier than the African marigold, the French marigold is as short as six inches and yields one-inch flowers. The flower of the French marigold is golden yellow to red-orange, and the leaves are fragrant. The Aztecs called the French marigold *cempoalxochitl cimarron*, meaning "wild twenty flower." True to its name, the "wild twenty flower" grows wild south of Mexico City.

Uses

The signet marigold (*Tagetes signata*) is edible. The plant yields a large number of small flowers roughly one-half of an inch in diameter. It blooms in summer and autumn. Its spicy flavor reminds one gardener of the flavor of tarragon. The leaves emit a fragrance of lemon, which many people find more appealing than the fragrance of the African and French marigolds. Popular signet varieties include Lemon Gem, Golden Gem, Tangerine Gem, and Starfire, the last having two colors. The signet marigold may be added to salad, potato salad, or pasta salad. It may be steamed or sautéed with zucchini or green beans or cooked with beets. Some cooks add it as a spice to chicken. The signet marigold is a popular addition to the garden because it attracts butterflies.

Tagetes minuta, native to South America, produces an essential oil that is used to make perfume. The essential oil is known as "marigold oil." This species has been introduced into Africa, Hawaii, and Australia. It has escaped cultivation and is so invasive and vigorous that some people regard it as a weed. Europeans use *Tagetes erecta* for its lutein, a food coloring. The United States has not approved it for human consumption, though it has been added to poultry rations. India, Thailand, and Nepal cultivate marigold on a large scale, using it to make garlands and to grace weddings, festivals, and religious rites. Marigolds decorate religious statues and buildings in southern Asia. In India, marigold is a popular New Year's flower. The gardener may interplant marigold with tomato, eggplant, pepper, tobacco, and potato to deter nematodes. Because of its odor, marigold is reputed to repel the tomato hornworm.

Attributes and Cultivation

The African and French marigolds have been hybridized to yield triploids, plants with three sets of chromosomes. The triploids are known as "mule marigolds" because like the mule the triploids are hybrid and sterile. The triploids have red or crimson flowers like the French marigolds. The triploids retain their color longer than the African and French marigolds. Marigold flowers may be single, semidouble, or double and may be white, yellow, orange, gold, or red. Hybrids of the African marigold are larger than the French marigold and have large, double flowers. Hybrids of the French marigold are smaller than the African marigold, usually 6 to 12 inches tall. French hybrids have flowers that are single or semidouble, though a few are double. Single flowers tolerate humidity better than double flowers.

Marigolds may be started from seeds. The gardener may plant seeds indoors one-quarter of an inch deep six to eight weeks before the last frost. One gardener recommends a planting in late March or early April. Alternatively, marigolds may be sown directly in the garden after the last frost. The gardener who plants triploids should sow extra seeds because the germination rate is low. Plants should be thinned to one foot apart. Marigold flowers 45 to 50 days after planting. The soil should be mulched to retain moisture and minimize weeds. Marigold benefits from the addition of compost to the soil. Marigold should be fertilized every four to six weeks, though the gardener must guard against applying too much nitrogen to the soil because it stimulates marigold to produce foliage at the expense of flowers. Suitable fertilizers are calcium and potassium nitrate. The addition of potassium to the soil prolongs flowering. The soil should be cultivated to a depth of five inches. Its pH should be 6 to 6.2. Taller varieties of marigold should be staked to prevent lodging. On commercial farms in India, workers harvest marigolds by hand so as not to injure flowers. Although the odor of marigold may deter some pests, slugs, whiteflies, and mites may be problematic. Marigold prefers full sun and must have at least six hours of light per day to flower.

Christopher Cumo

See also Calendula

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Marshmallow

In the Malvaceae or Mallow family, marshmallow (*Althaea officinalis*) is known as marsh mallow, mallard, mauls, schloss tea, cheeses, mortification root, white mallow, althaea, althaea root, mallow, common marshmallow, malvevisca, hatmi, iviscus, glasul, khitini, khatmah, and usubeni tati aoi. The French know marshmallow as *guimauve*. The family name Malvaceae derives from the Greek *malake*, meaning "soft," leading one writer to speculate that marshmallow has a "softening" effect on the body. The genus name *Althaea* derives from the Greek *althos*, meaning "to cure," a reference to marshmallow's medicinal properties. Marshmallow may derive its name from the fact that it grows in salt marshes. It may also be found near lakes, near rivers, near the ocean, in wet meadows, and alongside ditches. Marshmallow is related to okra, cotton, hibiscus, and hollyhock.

Origin and History

One author asserts that marshmallow originated in Africa, a second in Europe, and a third in Eastern Europe and North Africa. The early use of marshmallow in Egypt fits well with a North African origin. In Europe, marshmallow grows wild as far north as Denmark. The fact that the marshmallow root contains sugar may have attracted the ancients to the plant. Indeed, the Egyptians extracted sap from the root, mixed it with honey, and served it as a confection. The first use of marshmallow therefore appears to have been as a sweet. In the 19th century, physicians followed the Egyptian practice of extracting sap from the root. To it they added egg whites and sugar, whipping this combination into meringue, which they gave to children to sooth a sore throat. In the mid-19th century, gelatin replaced marshmallow sap. Today, the confection marshmallow has no marshmallow, only sugar or corn syrup, gelatin, and gum arabic.

Apart from its use as a confection, marshmallow served as food in antiquity. The Old Testament mentioned it as a famine food, and the poor of Syria appear to have subsisted on it when little else was available. They boiled the root and then fried it with onion and butter. The Romans ate marshmallow as a vegetable, considering it a delicacy. The Romans may have introduced marshmallow into Britain. In the first century BCE, Roman poet Virgil wrote that goats ate marshmallow plants. In antiquity, people decorated graves with the marshmallow plant. In the ninth century, Frankish king Charlemagne required gardeners in his empire to grow it. In 1592, Italian physician and botanist Prosper Alpinus noted that the Egyptians ate marshmallow, though it is not clear whether Alpinus referred to the confection or the vegetable. The Egyptians may have eaten both. The flowers and young leaves are suitable for use in salad, stew, or soup.

Attributes and Cultivation

A perennial herb, marshmallow is slow to germinate, taking as long as eight weeks to poke through the soil. One gardener germinates seeds by placing them in a plastic bag with moist sand. The mixture stands one day at room temperature and is thereafter refrigerated four to six weeks. Shaking the bag periodically, the gardener searches for signs of germination and, upon seeing them, plants the seedlings and sand in a container with potting soil. The seedlings should be kept cool and exposed to sunlight. After the last frost, the seedlings may be transplanted in the garden. As is true in this case, one writer opts for a spring planting. Alternatively, one may plant seeds in autumn, thinning the plants to one foot apart in the first year. That autumn the gardener should mulch the plants to permit them to overwinter. A hardy plant, marshmallow tolerates temperatures as low as –15°F. In the second year, the gardener should thin the plants to two feet apart. The gardener who does not wish to burden himself with the chore of thinning plants may sow seeds two feet apart. Depending on spacing, the seeding rate is three-and-a-half to four-and-four-tenths pounds per acre. Seeds should be planted four-tenths to eight-tenths of an inch deep. One may eschew seeds, rooting a cutting instead. If planted in autumn, a marshmallow plant's leaves will be ready to harvest next spring and the flowers in mid- or late summer. The leaves should be harvested before the plant flowers. The flowers may be picked after they have bloomed and before they wither. The marshmallow flower has five petals, is one-and-a-half inches in diameter, and is white, pale pink, or purple. Depending upon whom one consults, marshmallow flowers sometime between June and October. Marshmallow prefers full sun and light, moist soil. Marshmallow should be cultivated in fertile, loose soil. The plant benefits from the addition of organic matter to the soil. Marshmallow grows in Central and Southern Europe, the United Kingdom, North Africa, and western Asia. Although not native to the New World, marshmallow is naturalized in the United States and Canada. Confined to the East and Midwest, marshmallow grows in Arkansas, Connecticut, Delaware, Kentucky, Massachusetts, Maryland, Michigan, North Dakota, Nebraska, New Jersey, New York, Ohio, Pennsylvania, Virginia, and Wisconsin. Gardeners who grow marshmallow as an ornamental appreciate that it attracts butterflies.

Medicinal Properties

Marshmallow is best known as a medicine, though it appears to be unclear who first identified its medicinal properties. In the first century CE, Greek physician Dioscorides described marshmallow, believing it to have medicinal value. First-century BCE Roman poet Horace and first-century CE Roman poet Martial noted that marshmallow leaves and roots were a laxative. With apparent enthusiasm, first-century CE Roman encyclopedist Pliny the Elder wrote that "whosoever shall take a spoonful of the Mallows shall that day be free from all diseases that may come to him." The Greeks and Romans ate marshmallow flowers in the belief that they prevented cough. The Arabs used marshmallow leaves, apparently topically, to soothe inflammation. The French ate marshmallow tops and leaves in salad, apparently in the belief that these parts of the plant improved the function of the kidneys. In the 16th century, English herbalist John Gerard opined that marshmallow aided digestion. Because of its reputed value, gardeners throughout Europe once grew marshmallow for incorporation in home remedies. One remedy called on the homemaker to pulverize the root and boil it in milk. The resulting brew was thought to treat dysentery. Another remedy called for the boiling of marshmallow, presumably the pulverized root, in wine or milk. The preparation was reputed to treat cough, bronchitis, and whooping cough.

Contemporary claims of marshmallow's efficacy are sweeping. Ingested, marshmallow may be used to treat cough, sore throat, the common cold, influenza, respiratory ailments including bronchitis and pneumonia, gonorrhea, inflammation of the mouth, enteritis, constipation, irritable bowel syndrome, dysentery, diarrhea, sinusitis, laryngitis, Crohn's disease, stomach ulcers, gastritis, colitis, cystitis, bladder infection, inflammation of the bladder, arthritis, tracheal catarrh, and kidney stones. Applied topically, marshmallow has traditionally been used to treat hemorrhoids, burns, scalds, bedsores, varicose veins, abscesses, dental abscesses, boils, eczema, burns, skin ulcers, cuts, wounds, and gingivitis. The proponents of marshmallow believe that the roots, leaves, and flowers all have therapeutic value. Marshmallow leaves have been used to make medicinal tea that is thought to treat cough, sore throat, and even sunburn and dry hair. An extract of marshmallow has been used to treat inflamed eyes and is an ingredient in homemade cough syrup.

Marshmallow roots have 20–30 percent mucilage as well as starch, pectin, asparagines, tannin, and polysaccharides. The root is typically harvested in the third year. The leaves contain 5–10 percent mucilage as well as starch, pectin, coumerin, salicylic acid, phenolic acid, and flavonoids. The flowers contain mucilage and flavonoids. The mucilage in marshmallow is thought to soothe the digestive tract. Marshmallow is used to extract splinters, thorns, prickles, and bee stingers. Marshmallow is thought to prevent a wound from developing gangrene.

Christopher Cumo

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Masterwort

Nowadays, masterwort (*Imperatoria ostruthium*) is a rare cultural relic, surviving only in old gardens in Central and Northern Europe. It was once planted as a cultivated herb by the peasantry and used especially for veterinary purposes. The plant is perennial with large rhizomes and a round stalk that grows 39 inches high. The stalk is erect, hollow, round, leafy, and slightly branched. Lower leaves are on long stalks, twice ternate. The upper leaves are less compound, on shorter stalks, with a sheathing, membranous dilatation at the base. Umbels are broad and flat, of about 40 smooth general rays, 8 or 10 inches wide when in fruit. Flowers are small, white, or pale flesh colored, almost perfectly uniform and regular. In Scandinavia, the plant blooms rarely and often grows in pure vegetative stocks. The fruit is elliptical with an almost smooth surface and wide wing-like edges. The entire plant smells strongly like celery.

Origin and History

Its commanding name arouses interest, and there is a slightly archaic and mysterious aura surrounding this species. Very little is actually known about its history as a cultivated plant. It is native to the mountains of Central Europe, and it grows especially in woodlands and meadows. It was being used as a medicinal plant during the Middle Ages according to German and Danish herbal books. Some authors regard it as a plant spread through monastic herbal gardens. Its medieval Latin name *Imperatoria* (from *imperatoris* meaning "ruler" or "master"), translated into French as *impératoire*, and rendered in English as masterwort, German *meisterwurz*, Danish *mesterrod*, Swedish *mästerrot* and, Slovak *všeliek hojivý*, and Turkish *kral otu*, alludes to its reputation as a plant with superior healing properties. It was known by these names because it was regarded as a divine medicine. Master was once a title for physician. Some local names have been recorded in Great Britain, like felon-grass (Yorkshire and Roxburgshire) and felonwort (Cumberland).

The oldest evidence for masterwort as a cultivated plant is in the early Middle Ages. Archaeological findings show that it had been introduced into the British Isles by the 10th century. Seeds dated about 850 to 950 CE have been found in Antrim, Ireland. It is mentioned in several herbals and medicinal handbooks during the late Middle Ages, for instance in a Danish manuscript by 13th-century canon Henrik Harpestræng at the Roskilde Cathedral as a medicinal plant. It is mentioned as being grown in Danish herbal gardens in the 1530s, Swiss natural historian Conrad Gesner describes it as a cultivated plant in 1560, and it was grown in rural gardens on the island of Bornholm in the 17th century.

It became popular as a cultivated plant in the early modern era, spreading throughout Northern Europe. In the 16th century, German botanist Jakob Tabernaemontanus propagated for its usefulness for making remedies. So did Italian physician Pietro Andrea Matthioli (1501–1577). In the late 18th century, it was planted not only in villages but also at mountain cabins used for summer pastures in northern Scandinavia. William Woodville said in 1810 that it was frequently cultivated in the British Isles. It is still found in villages in the eastern alpine region of Europe. It was introduced into the eastern United States and Canada (Newfoundland) in the 19th century.

Medicinal Use

The rhizomes contain essential oils (sabinene), 4-terpineol, α-humulene oxypeucedanin, ostruthin, and ostruthol. The coumarines give masterwort its characteristic flavor. Masterwort is primarily a medicinal plant. It is mentioned in several medieval and Renaissance herbals for various ailments. Powdered masterwort roots were for instance added to wine as a protection against malaria. English herbalist John Gerard wrote in his herbal from 1597 that "the rootes and leaves stumped, doth dissolve and cure all pestilential carbuncles and botches, and such other apostemetions and swellings."

The rootstock, collected in spring or fall, has been known to hold many medicinal properties such as being antiseptic, diuretic, and emmenagougue. Although regarded as obsolete in scholarly medicine, it was still in the late 20th century available in some pharmacies in Europe as *Radix imperatoriae*. The plant was, and in some circles still is, used for asthma, bronchitis, hepatitis, kidney and bladder stones, as well as flatulence. In Scandinavia, it was used in the 20th century for colic. It was also considered an aphrodisiac by the early authors. Tea made of masterwort is said to reduce migraines and act as a sedative. It has also been used externally against herpes and wounds. Its bitter juice was prized by country people in Kent for toothache. Spirit of the rhizomes was used as medicine in northern Sweden in the 1930s.

Although masterwort has a reputation as a medicinal plant for humans, especially in Germany, it seems to have been planted among the peasantry in England and Scandinavia mainly for veterinary use with cattle and for diseases of swine and horses. French physician Jean Ruel (1479–1537) as well as other Renaissance authors recommended it for horses. It is mentioned as an ingredient in remedies for sheep diseases in the 17th century. Austrian peasants gave a piece of bread with masterwort to a cow after giving birth to a calf. Masterwort was quite common in Scandinavian rural gardens in the 19th century because of its reputation as a medicinal plant for folk veterinary purposes. It happens that Austrian farmers even now use it as a homemade remedy for sick cattle. The fresh root is still used in Italy crushed and mixed with salt as a digestive for cattle and sheep. It can still be found in some rustic gardens.

Food and Ornamental Uses

Masterwort has been and still is used as a condiment in food in various parts of Europe. The whole plant can be used for that purpose, although the leaves and flowers are the mildest. The rhizomes of masterwort are also used as a flavoring for schnapps (known in German as *Meisterwurzbranntwein*), especially in Austria, and for various liqueurs. Masterwort is also used to flavor cheeses. In Tyrol, Austria, and in some parts of Switzerland, the houses were ritually smoked with its rootstocks around Christmas, New Year's Eve, and Epiphany.

The masterwort has been associated with the rural gardens and farmhouses of preindustrial Europe. However, it can still be used as an ornamental plant, which has given it some popularity. A recent variegated cultivar Daphnis from France has increased interest in gardening with masterwort. The species is also used in alpine and rock gardens, and seeds are available through some specialized nurseries.

Ingvar Svanberg

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Millet

An annual grass, millet is a crop of arid and semiarid Africa and Asia. Like other grains, millet is a member of the Gramineae or Poaceae family. Millet is not a single species but rather a complex of species, a group of related grains. Among the types of millet are pearl, proso, and finger, which farmers grow for food and forage; foxtail and Japanese, both of which serve as forage; and several other lesser millets. Farmers in Africa and Asia grow millet primarily for food, whereas their counterparts in Australia and the Americas raise millet principally for forage. In 1753, Swedish naturalist Carl Linnaeus described 2 species of millet. By 1950, botanists had added more than 100 species to this list. Millet is 5.8–20.9 percent protein, a range of figures that compares well with the protein content of other grains. In addition to protein, millet contains fiber, starch, thiamine, calcium, phosphorus, iron, zinc, manganese, phytate, linoleic acid, oleic acid, palmitic acid,

Millet (Venkra/Dreamstime.com)

stearic acid, linolemic acid, palmitoleic acid, riboflavin, and potassium. A nutritious grain, millet nourishes pregnant women and lactating women and children.

The Basics

Where the climate is warm, farmers may plant millet as a spring or autumn crop, though most millet is sown in spring. Having a large root system, millet extracts the maximum water and nutrients from the soil. Millet yields better in light soil than in heavy clay because the roots do not penetrate the latter. Millet even grows well in sandy soil, which is notorious for its lack of water and nutrients. Being more than a good crop for sandy soil, millet does well in infertile soil in which other crops would fail. Of course the best yields are in fertile soil, but good soil goes to higher-value crops like corn and rice. In India and Africa, farmers grow millet on alfisol soil. Tolerating slightly acidic to slightly basic soils, millet grows in soils with a pH between 6.2 and 7.7. Millet will grow with as little as 10 inches of rain per year, whereas sorghum must have at least 14 inches of rain per year. During dry periods millet, closing its stomata periodically, transpires little water. Although millet tolerates low rainfall, sporadic and inconsequential rain that evaporates quickly may form a hard outer layer in the soil. Seeds that germinate in this hard crust may not penetrate it and so may not emerge. As a rule, the harder the crust the fewer millet seedlings emerge. Because millet matures in as little as 45 days, farmers may plant it where another crop has failed. This strategy means that farmers will likely plant millet late, when the weather is hot and dry, conditions that millet tolerates better than many other crops.

Tolerating a range of temperatures between 50°F and 115°F, millet, like sorghum, grows best between 91°F and 93°F. Able to grow in moderately saline soils, millet will not tolerate a high concentration of salt in the soil. Photosensitive, millet needs between 8 and 12 hours of daylight to flower. Although 14 to 16 hours of daylight delay flowering, millet grows best with 16 hours of daylight. Millet needs long days for the formation of tillers and leaves. Because of the requirement for long days, millet grows better in temperate zones than in the tropics.

Needing a warm soil, millet is planted two to three weeks later than corn. In Korea, farmers sow millet about April 30. In Bikaner, India, farmers plant millet in mid-July to coincide with the onset of summer rains. In Coimbatore, India, millet is planted in mid-September. Of the three chief plant nutrients—nitrogen, phosphorus, and potassium—millet generally does not need applications of potassium. Farmers plant and fertilize millet in a single operation, applying all the phosphorus and half the nitrogen in one dose. A second application—the other half of the nitrogen—follows later. Farmers spray the second application of nitrogen on the leaves, a peculiar practice given that nitrogen is absorbed through the roots. Applied alone, phosphorus does not increase yields and so must be applied with nitrogen. Farmers may apply nitrogen up to 185 pounds per acre and phosphorus up to 53 pounds per acre. Higher applications will not increase yields. The application of fertilizer is wise given that so much millet is grown on poor land.

Stockmen grow foxtail millet for hay. Others pasture livestock in millet fields. Like rice, millet will regenerate, so stockmen, removing their animals, may harvest millet after it matures. Millet is not ideal for pasturage, however, because livestock tend to uproot the plant when feeding on it. In addition to its use as livestock feed, farmers feed millet, usually as a corn-millet mix, to chickens. Research has shown that millet nourishes chickens better than do rice and wheat. In the United States, some millet is used as bird feed.

As is true of other crops, scientists worry that millet has become genetically uniform. To promote diversity, scientists have collected wild species and neglected varieties. The International Crops Research Institute for the Semiarid Tropics in Kenya and Niger has collected more than 16,000 varieties of millet. The Tropical Agronomy and Food Crops Research Institute in Burkina Faso has collected germplasm since 1961. The International Crops Research Institute has since 1971 amassed its gene bank, and since 1981 the Food and Agriculture Organization has collected wild and cultivated millets. In 1981, scientists collected 284 samples in Ghana, in 1989 in Togo 555 samples, in 1991 in Nambia 1,270 samples, and in 1992 in Yemen 682 samples.

Origin and Diffusion

Scholars do not agree on the place and time of millet's origin. Even the continent of origin is a matter of dispute, with some authorities pointing to Africa and others to Asia. In the Africa-first camp are those who assert that because Africa has the greatest diversity of wild species, it must be the homeland of millet. Using this reasoning, Russian agronomist Nikolai Vavilov in 1949 and 1950 identified Ethiopia as the place of origin. One school of thought traces the domestication of millet to the Mande of the Niger River valley who first cultivated millet between 5000 and 4000 BCE. Others reject this view because this area then had a wet climate, making it implausible that a drought-tolerant crop would have arisen there. In 1971, American agronomist Jack Harlan proposed the area between western Sudan and Senegal as the region where farmers domesticated millet. Another hypothesis fingers the southern edge of the Saharan highlands as the place where farmers domesticated millet between 3000 and 2000 BCE.

Those who favor Asia as the center of millet culture point to millet's antiquity as an Asian crop. Some scholars believe that farmers in East Asia grew millet as early as 8000 BCE, making it among the oldest cultivated plants. One authority believes that Chinese farmers began growing millet about 8300 BCE. Another writer believes farmers in China began to raise millet around 6500 BCE. Even this comparatively late date may predate the cultivation of rice, barley, and wheat in

East Asia. The priority of millet may mean that people in northern China and Korea ate more millet than rice in prehistory. So important was millet to China that in 2700 BCE, one text listed it among the five sacred grains. As early as 2000 BCE, the Chinese were making noodles from millet. By then, millet had spread to other regions in Asia, being grown in Japan after 4000 BCE and in Korea as early as 3500 BCE.

Given the diversity of locales where farmers grew millet in prehistory and antiquity, it may have been domesticated independently in several areas over time. Whether millet arose in Africa or Asia, it diffused to other regions of the globe. According to the Asia-first school of thought, millet migrated from China to lands along the Black Sea by 5000 BCE. Those who advocate the origin of millet in West Africa trace its spread to East Africa, the Sudan, and India by the time of Christ. By 3000 BCE, Europeans were growing millet, though it became widespread only around 1000 BCE. In the Middle Ages, people ate millet in porridge and flatbread. So popular was it that people may have eaten more millet than wheat. Only in 1849 did U.S. farmers begin to cultivate millet, though never on a large scale. In the United States as in other places, millet had to compete with sorghum for acreage in arid lands. In the United States, North Dakota, South Dakota, Colorado, and Nebraska grow proso and foxtail millet for feeding livestock. In the American Southeast, livestock graze fields of pearl millet.

Today, farmers raise millet from Senegal to Ethiopia and in Spain, northern India, southern Arabia, Pakistan, Bangladesh, Argentina, and the United States. Several countries in southern Asia—southern India, Myanmar, Sri Lanka, Thailand, Laos, Cambodia, the Philippines, and Indonesia—raise millet. Indeed, southern Asia harvests 60 percent of Asia's millet. India produces nearly all of southern Asia's millet. Smaller harvests are recorded in Mexico, northeastern Brazil, and Bolivia. Among the specialty millets is finger millet, which farmers grow in Uganda, Kenya, Ethiopia, Tanzania, Zimbabwe, India, and Nepal.

Of the types of millet, pearl millet totals half the world's production. Farmers grow finger millet at altitude, where the climate is cooler, in Africa and Asia. The people of these continents use finger millet as food and to make beer. The developing world, especially countries in Africa and Asia, produces 94 percent of the world's millet. Small farmers produce almost all the world's millet, consuming it or trading it locally. Millet is therefore a subsistence rather than a market crop. By most measures, millet is a minor crop. Farmers grow it on only a few percent of the world's grain land. Millet accounts for less than a very small portion of the world's grain output.

In 2007, India was the world's leading producer of millet, followed by Nigeria, Niger, China, and Burkina Faso. The United States was not a leading producer. The Chinese eat congee, a millet porridge. The people of Niger eat congee with fried onions. Millet porridge is also popular in Russia and Germany. Kenyans make porridge from millet, milk, banana juice, and sugar, serving it hot for breakfast or lunch. Nigerians eat porridge made from millet, sugar, and salt. In India, people make porridge from millet and buttermilk. They also serve millet with sauce, dhal, pickles, chutneys, buttermilk, curd, and vegetables. A similar recipe calls for millet, pickles, chutneys, dhal, and vegetable sauce. In some countries, Kenya for example, people eat millet with milk as a breakfast cereal. Cooks make millet into thin strips, which they fry. In the United States, muffins and multigrain bread may contain millet. The Russians, Indians, and Kenyans make stew with millet, meat, and vegetables. Ethiopians make stew with meat, a legume, and vegetables. In India, one recipe calls for millet, greens, and lemon or orange slices, and another includes millet, fried onions and garlic, rice, chickpeas, dhal, groundnuts, salt, grated coconut, and coriander. In West Africa, people eat couscous, a dish of millet with ground baobab, peanut paste, okra, and sauce or milk. In Nigeria, a recipe includes millet, bean cake, onion, tomatoes, chili peppers, spinach, salt, and pepper. The Russians eat millet porridge with milk and sugar. In the Sudan, people make millet pancakes, serving them with vegetables, a legume, meat, and soup. The Chinese eat millet with beans, sweet potatoes, and squash. In Taiwan, people brew millet into beer. In Nepal, people distill millet into the liquor rakshi. In Romania and Bulgaria, people ferment millet into the beverage boza. Some people eat millet in tortillas, rice soup, and cookies.

Millet Diseases

Millet is vulnerable to more than 100 diseases. The fungus *Pyriculeria grisea* causes blast, the most serious disease of finger millet. The disease is most destructive in wet weather, causing severe losses. In the worst infections, India has reported nearly total losses. Uganda has recorded nearly total losses, and Kenya has sustained serious losses. Humidity around 90 percent and temperatures between 77°F and 86°F aid the disease's spread. Blast exhibits dark spots that elongate into lesions. When it infects seedlings, mortality is high because seedlings are more susceptible to blast than are mature plants. Wind and rain spread the fungi from plant to plant. Fungi may lurk on nearby weeds, grasses, or crop debris. The disease may also be present on millet seeds. Farmers may combat blast by spraying the fungicides mancozeb and carbendozin once on seedlings and twice more as plants mature. Also effective is the fungicide benlate. Another study credited the fungicide dithera m45 with reducing the incidence of leaf blast by several percent and head blast by nearly as large a factor. Most cultivars are susceptible to blast, making important the derivation of resistant varieties. As a rule, dark-seeded varieties of millet with compact heads are more resistant to blast than are light-seeded cultivars with open heads. Farmers in Uganda plant several resistant cultivars, which have high levels of phenol and tannin, compounds that may retard the growth of fungi. At least one scientist believes that research is important in combating blast and other diseases. He laments the current state of affairs in which too few scientists are working to improve finger millet and to combat its diseases. Uganda, Kenya, and Ethiopia have established research programs but more must be done. Only the International Crops Research Institute maintains a finger millet gene bank, whose varieties scientists may screen for disease resistance.

Afflicting finger millet in India, Japan, and a number of countries in Africa, the fungus *Helminthosporium nodulosum* causes leaf and seedling blight. The disease affects all parts of the millet plant: the base, culm, leaf sheath, leaf, neck, and finger. An aggressive disease, leaf and seedling blight may kill seedlings before they emerge from the soil. The disease manifests in lesions on the leaves, which expand into large patches and which turn brown as it progresses. Lesions form at the juncture of leaf and sheath and on the stem. The parts of the plant above the lesions die as tissue collapses. Infected leaves wither, and seedlings may die within two weeks of infection. Infecting seeds, leaf, and seedling, blight may spread through the soil to other seeds, dooming emerging seedlings to an early death. Crop residue may harbor fungi, which spread in high humidity. Because fungi are seed borne, farmers may treat seeds with fungicide. Farmers may spray healthy plants with fungicide to prevent infection.

Also infecting corn, rice, oats, and wheat, the fungus *Sclerophthora macrospora* causes downy mildew, known as green ear disease. The disease arose in 1930 in Mysore, India. India remains the principal region of infection. Stunting plants, downy mildew turns leaves pale green and causes them to grow close together, giving infected millet the appearance of a bush. Infecting several types of millet, downy mildew is the worst disease of pearl millet. The pathogen *Sclerospora graminicola* causes downy mildew in pearl millet. The fungi kill seedlings within a few weeks of infection. Worldwide, downy mildew reduces millet yields by one-fifth. A 1971 epidemic of downy mildew cost India millions of tons of pearl millet. Downy mildew is a dangerous disease because there are no resistant cultivars and no chemicals to which fungi are vulnerable. The disease is most severe in Africa and Asia. In India, farmers who have planted genetically uniform hybrids have suffered such losses that they have had to switch to other varieties.

The fungus *Soleretium rolfsii* causes wilt, known as foot rot, a soil-borne disease. It spreads during wet weather, infecting the base of a plant, the sheaths, and the culms. Turning plants pale green, foot rot stunts millet. Over time, infected plants turn brown. As the disease progresses, plants wilt, lodge, and wither. Scientists have yet to derive chemicals effective against foot rot. Farmers may combat the disease by deep plowing the soil and rotating millet with a legume or other nongrass. These measures lessen the severity of foot rot by reducing the population of fungi in the soil.

The bacterium *Xanthamones coracana* first infected millet in India in 1937. The disease turns leaves pale green and later brown. Farmers may plant resistant cultivars and apply the antibiotic streptomycin to seedlings. Millet is vulnerable to sugar cane mosaic virus, eleusine mosaic virus, and freckled yellow and stripe disease. Sugar cane mosaic and eleusine mosaic are endemic to India, whereas freckled yellow has taken root in East Africa. Sugar cane mosaic and eleusine mosaic stunt plants, causing mottling and leaf chlorosis. Freckled yellow spreads along the edges of leaves, infecting top leaves the worst. When infection is severe, these diseases may cost farmers their entire crop. Viral diseases are worse in India than in Africa.

Ergot, a disease of several grains, notably rye, infects millet. The fungi of ergot infect millet flowers, causing a cockspur to form where the parts of a flower would ordinarily develop. The disease is not troublesome for causing a loss in yield. Rather, ergot fungi are toxic to humans and livestock, rendering a crop inedible. Hybrids are more vulnerable to ergot than are traditional varieties of millet. Because farmers seldom plant hybrids in Africa, ergot is not a problem there. In India, however, farmers have planted hybrids since the 1980s and have accordingly suffered from ergot.

Christopher Cumo

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Mint

Members of the genus *Mentha* are some of the world's oldest cultivated medicinal plants. They are used in almost every world cuisine to spice and flavor foods and are economically important as a world crop. There are at least 25 species in the genus *Mentha*, all of which are perennial. Three species are commonly cultivated today: spearmint (*Mentha viridis*), peppermint (*Mentha piperita*), and field or Japanese mint (*Mentha arvensis*). These mints are widely cultivated by gardeners, who use them as sweet herbs and as medicinal home remedies. *Mentha arvensis* is of particular world economic importance, since its main extract, menthol, is so widely used in the food, pharmaceutical, perfume, and flavoring industries.

Antiquity

Mint (Videowokart/Dreamstime.com)

Mint has enjoyed popularity as a spice and medicinal herb since antiquity. Mint takes its name from the Latin word *mentha*, derived in turn from the Greek appellation *minthe* or *mintha*. According to Greek legend, Pluto's wife, Persephone, became jealous of her husband's attentions to the nymph Minthe. In a fit of rage, Persephone turned Minthe into an aromatic herb.

The Greeks were among the first to enjoy mint as an herb and to use it medicinally. They added it to milk to keep it fresh, and often would not drink milk that had not been spiced with mint, for fear that the unspiced milk might curdle in their stomachs and cause illness. Ancient Greeks used to wrap swatches of pennyroyal mint (*Mentha pulegium*) in wool and place them under the beds of those stricken with fever as a curative. The citizens of ancient Athens, who typically perfumed each body part with its own prescribed scent, rubbed mint into their arms.

The Romans also appreciated and used mint. In the first century CE, the Roman encyclopedist Pliny the Elder mentioned that mint was a popular treatment for vertigo and that the citizens of Rome wore garlands of mint to treat headaches and protect themselves from diseases of the brain. Both the Greeks and the Romans crowned themselves with peppermint during feasts and used it as a table ornament; they added mint to both wines and sauces for flavor and to stimulate the appetite for meat. Pliny wrote:

> You will not see a husbandman's board in the country, but all the meats from one end to the other, are seasoned with mint. As for the garden mint, the very smell of it alone recovers and refreshes the spirits, as the taste stirs up the appetite for meat, which is the cause that it is so general in our acid sauces, wherein we are accustomed to dip our meat. (Phillips, 343)

To this day, mint sauces are often served with meat, especially lamb.

Medicinal Uses

Mint was used medicinally in the ancient world; many, though not all, species of mint possess medicinal properties. Mint soothes upset stomach, diarrhea, flatulence, colic, and vomiting. As an expectorant, it can help clear respiratory congestion. Pennyroyal mint has been used to treat edema (swelling due to water retention) and jaundice. Wild water mint (*Mentha aquatica*) can be applied to the forehead as a poultice for the treatment of headaches; these poultices may also draw the poison from wasp and bee stings. The smell of mint has long been said to strengthen the brain, improve memory, and remove lethargy. Spearmint, mixed with vinegar, is said to cure hiccups. Peppermint possesses antiseptic properties that, when applied topically, give it the power to relieve toothaches and treat cavities. In fact, peppermint oil remains a common ingredient in today's toothpastes and oral rinses. Peppermint's antispasmodic properties have made it an effective treatment for cholera; infusions of elder flowers and peppermint leaves have long been used to treat common colds and influenza. Peppermint is said to treat heart palpitations, promote relaxation, and relieve anxiety and insomnia. Nicholas Culpeper, the medieval English physician and botanist, named at least 40 medicinal uses for mint; among the ailments Culpeper treated with mint were sore throat, skin sores, and dandruff. In the 18th and 19th centuries, beekeepers applied a mixture of mint and sugar or honey to new beehives to attract bees and attach them to the hives. Mint has long been used to keep mice and rats out of stored food, and on some farms mint has been planted among the crops to protect them from depredation by these pests.

Production

Although many believe that our modern mint species are indigenous to the British Isles, they actually originated in the Mediterranean region. Great Britain, however, was one of the first nations to cultivate mint commercially. Commercial cultivation of *Mentha* species began in Mitchan, Surrey, in 1750. Mint cultivation spread to the Continent in 1771, when the Dutch began to produce it in Utrecht. European settlers brought mint to the New World, where it escaped cultivation and can now be found growing wild in shady, swampy areas. In the late 19th and early 20th centuries, the United States was one of the world's top mint producers; the state of Michigan alone was producing 90 percent of the world's mint by 1900. In the post–World War II era, however, verticillium wilt struck the area so hard that, today, Michigan's commercial mint-farming days are a thing of the past.

India began cultivating mint in 1960 and is now the world's top mint producer; much of the mint grown there is converted into menthol, the main ingredient in many pharmaceutical and over-the-counter drugs. India has 173,000 acres under mint cultivation; it produces 15,000 tons of mint oil (both menthol and the equally useful distillation by-product, dementholated mentha oil) per year, and exports

3,000 tons of mint oil per year. Other top producers of menthol and mentha oil are China, Brazil, the United States, and Japan. Argentina, Brazil, the European Union, Japan, and the United States are the world's major importers of menthol and mentha oil. The annual world consumption of menthol and mentha oil averages about 9,600 tons; India is the world's largest consumer of mentha oils, followed by China, the European Union, and the United States.

Marjorie McAtee

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Mistletoe

Mistletoe, of which there are over 900 species and 73 genera, is generally known in two forms: *Phoradendron flavascens* and *Viscum album* (European mistletoe). It is a parasitic plant native to Europe that grows on other flora, such as oak trees, elms, pines, apples, and firs and other shade trees. It is a "hemiparasite," meaning that although mistletoe sometimes grows off other plants, it is perfectly capable of growing on its own.

Distribution and Attributes

The mistletoe plant is prevalent in the United Kingdom and most of Europe as well as parts of Asia and Australia. The European species has a rubbery texture and small spiked yellow flowers that produce white sticky berries about one-quarter of an inch in diameter. The leaves of the mistletoe plant are pale green and around one inch in length, and the plant is extremely succulent. The seeds of the *phoradendron* consist of the endosperm and the viscin envelope.

The hemiparasite is unique in the world of cultivated plants, because it is exists as a flora that, while thriving on other life forms, can also photosynthesize independently. Mistletoe is what is known as a stem parasite, and many varieties live on the branches of the trees and shrubs they occupy. Mistletoe is also a host plant for the hairstreak caterpillar, which has larvae that can be harmful to humans. The *Phoradendron williamson* species is especially damaging to oak trees, and dwarf mistletoe will attack any coniferous plant or cone-bearing plant.

Mistletoe was discovered in England in 1532. Other names for the mistletoe plant include "Devil's fudge," "all heal," "mysteldene," and "Bird Lyme." Mistletoe is currently best known for its use as a Christmas decoration, which is what gives *Phoradendron serotonim*, or the American species of mistletoe, its visibility. *Phoradendron flavascens* can also be considered Christmas mistletoe and can be identified by its deep green leaves. It differs from other varieties because it is able to complete photosynthesis more readily, and does not rely on its host trees and shrubs as much as other species of the mistletoe plant.

European mistletoe is different from the American form, which does not become visible until winter, whereas the European species is seen year-round. Although the American species is still considered a semiparasite, it often aids its host tree with photosynthesis and the absorption of water and nutrients, meaning that it has more of a symbiotic relationship with its host plant, rather than a parasitic, damaging one. Mistletoe berries have a large quantity of juice and attract birds, which suck these juices. Because of the large number of different species of birds that the mistletoe attracts, it is actually a positive entity ecologically, because its presence encourages greater biodiversity in the area.

Mistletoe has many historic uses, including being harvested for medicinal and religious purposes. Although the berries of the viscum album are known to be poisonous, they are recognized to be dangerous only to domestic animals and other fauna. They have been known to kill pigs, but there has been no clear medical evidence that they are poisonous to humans.

Mythology

The mistletoe plant is known as having an almost magical, mysterious quality to it and so was invoked in many mystical tales and folklore. Celtic Druids and Nordic mythology considered the mistletoe as a symbol of peace as well as of male procreative capacity. The most apparent example of its mystical appeal and its role in traditional practices is the common tradition of kissing under the mistletoe, which is a popular activity for couples during the holiday season.

Uses

Mistletoe is widely known for its use in the treatment of cancer, although there is no reliable medical evidence to show that it has been beneficial in this area. Mistletoe twigs are also used in Europe for treating circulatory and respiratory issues. Randolph Steiner was the first individual to introduce mistletoe in the treatment of cancer. Anthroposophy is a branch of health care based on the use of mistletoe as a substitute for standard medical practices. In Steiner's philosophy of medicine, he saw the mistletoe plant as an integral part of his method and even believed that mistletoe could replace the scalpel. Steiner made a parallel between the behavior of cancer, and he believed that he could use the parasitic plant *Viscum album* to develop a treatment method based around the plant to help cure cancer. Although anthroposophy was often written off as an alternative type of medicine, mistletoe and iscador have been believed by many to be effective as homeopathic remedies.

Overall, the mistletoe plant is special in the world of cultivated plants in that it can be both a friend and a foe to the environment—that is, while sometimes being a parasite, other times it can assume a more useful and beneficial role. Mistletoe has often been introduced to certain areas and has often been a positive addition ecologically because its presence has been known to encourage biodiversity in areas in which it has been cultivated. Mistletoe, acting as a very unique type of flora, although damaging to some forms of shrubbery and flora, has a number of positive uses and contributions to the ecosystem as a whole.

Bonnie Ellman

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Morning Glory

A relative of the sweet potato, morning glory is a perennial in the Convolvulaceae family, which contains 50 genera and more than 1,000 species. Of these genera, *Ipomoea* contains the species of morning glory. The genus name derives from the Greek words *ips* and *homoios*, meaning "worm-like," a probable reference to the plant's vining habit. The morning glory probably derives its name from the fact that its flowers open at dawn. Their moment in the sun is often brief. A cloudy sky causes flowers to shut. Even under ideal circumstances the flowers of most species close by midday. Morning glory may have been first grown as medicine, the ancients noting its power as a laxative. The Japanese may have been the first to grow the morning glory as an ornamental. In the 20th century, recreational drug users consumed morning glory seeds to induce hallucinations. The plant offered a cheap high that attracted the less affluent to it.

History

Species of morning glory are indigenous to the tropics of the Old and New Worlds. In the New World, the Aztecs showed an interest in the plant, whereas the Chinese in the Old World may have been the first to cultivate morning glory for its use as a laxative. In the ninth century CE, the Japanese, acquiring morning glory from China, may have been the first to admire its potential as an ornamental. In Europe, the monks of the Middle Ages, taken by the beauty of morning glory flowers, illustrated manuscripts with drawings of them. Yet morning glory had a less wholesome side. Witches were reputed to cast spells with the plant, which reached its full potency three days before a full moon.

The species *Ipomoea purpurea* was popular in Italy for centuries, and *Ipomoea tricolor* was a garden staple in Spain. England began cultivating these species in 1621. The Victorian era may have witnessed the apex of the morning glory's popularity. Meanwhile, gardeners in the United States began growing morning glory about 1783. One authority holds that Americans planted the flowering vine near outhouses to decorate them. About 1790 Thomas Jefferson, an accomplished gardener, acquired seeds of the species *Ipomoea quamoclit*, known as cypress vine. His daughter Martha planted the species at Monticello, where today's visitor may still see it in bloom. In the 1940s and 1950s, some Americans discovered that the ingestion of morning glory seeds caused hallucinations, and the plant was so popular in this regard that it acquired a bad reputation. Particularly serious was the danger of overdose and death because the seeds are toxic. The drug user risked his or her life to get high.

Cultivation

Because the plant is sensitive to sunlight, it must be grown in full sun. Having originated in the tropics, morning glory does not tolerate a hard frost, though it may survive a light frost. For this reason, whereas morning glory is a perennial in the tropics, it is an annual in temperate locales, where frost ends the plant's life cycle. Before planting, the gardener may soak seeds overnight in water or cut the hard seed coat with a knife to increase germination. These measures may not be necessary given that many seeds germinate in the wild without special treatment. Having prepared seeds, the gardener may start them indoors four to six weeks before the last frost. It is better, however, to plant seeds outdoors because morning glory does not transplant well. The gardener who wishes to plant seeds outdoors must wait until the danger of frost has passed. Early planting risks not only frost but also the possibility that seeds will rot in the cold, damp earth. The soil should be well drained, and although morning glory tolerates poor soil, it does well in soil rich in organic matter. Soil that is too fertile encourages the growth of foliage at the expense of flowers. The flowers may be white, red, and its variants, pink, purple, blue, or more than one color. The flowers cross-pollinate, yielding abundant seeds. The gardener must take care to keep children and pets away from seeds because of their toxicity. Because morning glory produces so many seeds, a planting can get out of hand. The gardener may mulch the soil to decrease the germination of dispersed seeds. Black plastic and newspaper are effective mulches. Because of the tendency to be invasive, Arizona prohibits the culture of morning glory. The gardener may fertilize at planting and monthly thereafter. Where the climate is arid, morning glory must be watered once or twice weekly, the object being to keep the soil moist, not wet. Morning glory may be grown along a fence or other structure for support.

Species, Hybrids, and Cultivars

Italy's *Ipomoea purpurea*, known as Grandpa Ott, has deep purple flowers as its scientific name suggests. The flowers have a pink throat. The vine can grow to 15 feet. The species is popular in the American South, where it tolerates summer's humidity. *Ipomoea alba*, known as Moonflower, was popular during the Victorian era. The large flowers emit the scent of jasmine. Unlike most other species, the flowers of Moonflower open at dusk or when the sky is overcast. The vine can reach 30 feet. First sold in 1884, *Ipomoea alba* may be even older. *Ipomoea nil*, known as Scarlett O'Hara, was especially popular in the 1930s, winning an award in 1939. The white-throated flowers may be red, scarlet, or crimson. The vine, growing vigorously where summer is long and warm, may reach 30 feet. The hybrid *Ipomoea* × *multifida*, known as Cardinal Climber and Hearts and Honey Vine, has red flowers that attract hummingbirds. The vine can stretch to 20 feet long. *Ipomoea quamoclit*, which the Jeffersons had found so attractive, has red flowers that resemble the blooms of Cardinal Climber. One distinguishes the two by their foliage. The foliage of *Ipomoea quamoclit* looks like a fern frond, whereas Cardinal Climber has palmate leaves. Unlike several species, the blooms of *Ipomoea quamoclit* remain open all day.

The species *Ipomoea tricolor* has three varieties. Aptly named Heavenly Blue has blue flowers with a white and yellow throat. The variety was first known as Clarke's Early Heavenly Blue to commemorate its discoverer in 1931, a man with the surname Clarke. The cultivar carries a mutation for earliness and size. The Dutch were eager buyers of Heavenly Blue, and it was popular in the United States. Over time, Clarke lost his claim to the cultivar, which is now known by its truncated name. In 1960, California seedsman Darold Decker bred the variety Flying Saucer, a name that may refer to the shape of the flowers, which are five inches in diameter and bear white and lilac stripes. In 1962, Decker introduced Wedding Bells, whose lavender flowers have a yellow and cream throat.

Christopher Cumo

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Motherwort

Nowadays, motherwort is a relic among cultivated plants, surviving only in old gardens and rural habitats. It was once widely planted as a medicinal and ornamental plant, but this has now largely ceased. Instead, it has become a naturalized plant in Europe. In most parts of Northern and Western Europe, it is regarded as a rare non-native plant. However, when grown in gardens it can spread rapidly. In some parts of North America, it is reported to be a noxious weed. Motherwort is, however, an old cultivated plant and probably originated in central Asia. In Southern Europe, it is still grown in some rural gardens, and it is usually found in modern herbal gardens that include traditional medicinal plants.

Motherwort is an herbaceous perennial that grows from 24 to 60 inches high. It has a square stem and opposite, petiolate, trilobed leaves. The shape of the leaves has given motherwort its alternate English name Lion's tail. The English derives from the Latin-Greek (and now scientific) name *Leonurus* (Liontail). In German, motherwort is *löwenschwanz*, in Norwegian *løvehale*, in French *léonure*, and in Turkish *aslankuyruğu*. Flowers are pink to lilac and appear in leaf axils on the upper part of the plant. Motherwort has a short woody rhizome. The plant is strongly aromatic, and the taste is bitter. Two subspecies exist, *Leonurus cardiaca* ssp. *villosus* (Desfointanes) Hylander, which has long densely hairy stalks, and *Leonurus cardiaca* ssp. *cardiaca*, whose stalk has only short hairs on the edges.

History as a Cultivated Plant

Little is known about the cultural history of motherwort. Scholars do not know whether the ancients knew it. Motherwort has spread over vast areas of Eurasia through cultivation. It reached Northern Europe in the early Middle Ages. Archaeobotanical evidence is found in Sweden and Norway from the 13th century. Its name was known already in Middle English around 1450 as modirwort. Motherwort is mentioned as a medicinal plant in the medieval herbal *Hortus sanitatis* (The Garden of Health) in 1485. Most German Renaissance herbals stressed its usefulness. Motherwort had become naturalized by the early modern era.

It usually was grown in villages and cottages. According to 16th-century English botanist William Turner, motherwort grew "in hedges and about walls."

Today, the species is mostly a naturalized plant found in almost every state in the United States and temperate Canada. It is considered an invasive weed in northeastern and northwestern North America. Motherwort is "an obnoxious foreign weed, totally worthless and unwelcome," wrote an anonymous American author in 1847.

Medicinal Uses

Motherwort has a long tradition as a medicinal plant. English herbalist John Gerard wrote in 1598 that "it is commended for green wounds; it is also a remedy against certain diseases in cattell, as the cough and murreine, and for that cause divers husbandmen oftentimes much desire it." The plant contains oleanolic acid, iridoids (ajugol and ajugoside), flavonoids (quercetin, rutin, quinqueloside, genkwanin, quercetrin, isoquercetrin, hyperoside, apigenin-glucoside, and kaempferol glucoside), the alkaloids stachydrine and leonurine, and oleanolic acid.

Motherwort's species name *cardiac* is derived from the Greek *kardiakos*, meaning "heart," which indicates that since at least the 15th century it was used to treat cardiac disorders. According to the *Kräuterbuch* of 1557, motherwort improves cardiac blood flow and relieves cardiac pain. It is therefore often called heartwort. In the Renaissance, Germans knew it as *herzgespan*. Other German names are *herzheil* ("heart healer") and *herzkraut* ("heart herb"). Similar names are *hartgespan* in Dutch, *hjertespand* in Danish, *hjärtstilla* in Swedish, *srdečník obecný* in Czech, *pust'rnik serdechn'y* in Russian, and *sydämenvahvistusyrtti* in Finnish. English botanist Nicholas Culpeper wrote in 1653 that it "is of use for trembling of the heart, and fainting and swooning. There is no better herb to drive away melancholy vapors from the heart, to strengthen it and make the mind cheerful." There is, however, no proof that it actually alleviates heart diseases.

Motherwort was also widely used as a medicine for women, especially to treat menstrual and uterine conditions. From this usage derives the common English name motherwort. It was regarded as obsolete in scholarly medicine by the beginning of the 19th century, though it seems to have survived as a remedy in the Soviet Union and in some post-Soviet states.

While Western scholarly medicine found it ineffectual, motherwort has survived as a remedy in alternative and folk medicine. In Northern Europe, it has been recommended against intestinal worms and colic. In the Balkans, it has been used against diarrhea and as an emmenagogue. From Romania, it is reported as useful for treating goiter and epilepsy. It was also used as a medicinal plant by the Native Americans in the eastern part of the United States, especially for stomach problems and the diseases of women.

The dried herb is still available through herbal medicine stores and is recommended as tea. The admirers of motherwort recommend it to treat stomach pain and as a sedative. Some modern herbalists recommend it for women who are going through menopause because it stabilizes hormones. In the Baltic states, it is still prescribed as a tincture for many disorders. It is also used within Ayurvedic and Chinese medicine. Commercial cultivation exists in Central and Eastern Europe because of its demand in alternative medicine.

It has also been used in British folk-veterinary medicine. "The farmers of old time esteemed it greatly, when their horned cattle had diseases of the throat, the breast, or lungs; and there are recorded instances of many ages standing, that it has done great cures even in the murrain," wrote Thomas Hale in his *A Compleat Body of Husbandry* (1759). In North America, motherwort is nowadays used for reproductive health in companion animals.

Contemporary Uses

Some people recommend that the leaves be used to flavor vegetable soups. The green parts have also been used for dying woolen cloth. A brown or dark olive-green dye is obtained from the leaves. As a cultural plant, it represents an old biocultural heritage from medieval medicinal gardens. It is sometimes used as an ornamental garden plant and seeds are therefore available from some commercial nurseries in North America and Europe. The species is simple to grow. Motherwort is valuable since it attracts bees, bumblebees, and butterflies. For this and for its ornamental value, motherwort deserves a place in the contemporary garden.

Ingvar Svanberg

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Mulberry

The family Moraceae contains *Morus*, a genus of flowering trees. Humans know the 10 to 16 species of deciduous trees in the genus as mulberries. They are native to warm temperate and subtropical regions of Asia, Africa, Europe, and the Americas, with the majority of the species native to Asia. About 2700 BC, the Chinese began cultivating *Morus alba*, the white mulberry tree, as food for

Mulberries (Saichol Chandee/Dreamstime.com)

silkworms to produce silk. The secret of the art of silk production was kept in China for about 2,000 years, but around 700 BC the practice spread to other countries, including Babylonia, Greece, and Italy.

English poet John Milton (1608–1674) was said to have planted mulberry trees at Cambridge and at Stowmarket, and these same trees still grow in their original locations. English poet and playwright William Shakespeare (1554–1616) is said to have planted a tree that came from the mulberry garden of King James I, though there is no proof that Shakespeare planted the tree. Although the tree, if it existed, was apparently chopped down, a few cuttings of it were reputedly transplanted at various spots around United Kingdom, and the wood was fashioned into countless mementos of the poet and playwright.

Classification and Types

Not all scientists agree on the taxonomy of mulberry. Scientists have published more than 150 species names, and although differing sources may cite different selections of accepted names, only 10 to 16 are generally cited as being accepted by the majority of botanists. Mulberry classification is even further complicated by widespread hybridization, given that some hybrids are fertile. Despite the botanical arguments, mulberry can be divided into three types by color: white, red, and black. White mulberries tolerate cold the best and have the tallest mature height of up to 80 feet. Red mulberries, native to North America, can grow up to

70 feet in height depending on the cultivar and have sweet fruit with a hint of tartness. Black mulberries are the least cold tolerant, hardy only to USDA zone 6. Native to the Middle East, black mulberries were cultivated by the Romans for their sweet and tart fruit. Black mulberries do not grow as tall as other species, generally reaching 30 feet.

The following species are generally accepted: *Morus alba*, the white mulberry of eastern Asia; *Morus australis*, the Chinese mulberry of Southeast Asia; *Morus celtidifolia* of Mexico; *Morus insignis* of South America; *Morus mesozygia*, the African mulberry of southern and central Africa; *Morus microphylla*, the Texas mulberry of Mexico and Texas; *Morus nigra*, the black mulberry of Southwestern Asia; and *Morus rubra*, the red mulberry of eastern North America.

Cultivation

Mulberries can be grown from seeds, which yield healthy trees of good shape; mulberry trees are often planted from large cuttings because these root well. Mulberries need full sun and adequate space. The distance between trees should be at least 15 feet. The trees should not be planted near a sidewalk. The fallen fruit will not only stain the walkway but is likely to be tracked indoors. The trees are quite wind resistant with some cultivars used as windbreaks on the Great Plains.

Mulberries like a warm, well-drained soil, preferably a deep loam. Shallow soils such as those frequently found on chalk or gravel are not recommended. Although somewhat drought resistant, mulberries need to be watered in dry seasons. If the roots become too dry during drought, the fruit is likely to drop before it has fully ripened. Mulberries generally thrive with minimal fertilization. An annual application of a balanced fertilizer such as a 10:10:10 ratio of nitrogen to phosphorus to potassium will maintain satisfactory growth.

The fruit is a multiple fruit, seventy-nine one-hundredths to one-and-two-tenths inch long. Immature fruits are white or green to pale yellow with pink edges. In most species, the fruits are red when they are ripening, turning dark purple to black, and have a sweet flavor. The fruits of the white-fruited cultivar of the white mulberry are green when young and white when ripe; the fruit in this cultivar is also sweet but has a very mild flavor compared with the darker variety. Many consumers prefer the flavor of dark varieties. The fruit may be mixed with raspberries or bananas and eaten as a snack. Mulberry may be made into jam. As a dried fruit, mulberry may be mixed with oatmeal. Mexicans eat mulberry with papaya. Turks dry mulberries for consumption akin to raisins. One hundred grams of mulberry have 61 percent of the recommended daily allowance of vitamin C. Mulberry also contains beta carotene, vitamin K, vitamin E, vitamin B6, niacin, riboflavin, folic acid, iron, potassium, manganese, and magnesium.

Uses, Folklore, and Symbolism

The mulberry has been a tree of utility and part of folklore for thousands of years. In China, the mulberry is used to feed silkworms. Romans used the leaves to treat various diseases. The mulberry is also acknowledged in mythology and folklore. According to a German folklore, the fruits of mulberry trees are associated with evil, as it was believed that the devil uses the roots of this tree to polish his boots. The berries of the mulberry tree are edible, its supple wood is good for carving, and its bark and leaves are used to make paper. So prominent are the uses and attributes of the mulberry tree that, in all of these places, this plant became wrapped in legends, history, and meaning.

Mulberries do not bud until the danger of frost has passed, and so they symbolize patience. When they finally bud, mulberries bud so rapidly that they appear to have budded overnight, symbolizing expediency and wisdom. For all these attributes, the Greeks linked the plant to the goddess of wisdom, Athena. A medical text written by the Japanese Buddhist monk Eisai, in 1211 CE, states that mulberry is excellent for people suffering from thirst. In the contemporary world, this translates into the thirst associated with diabetes. Research has proven that the extract and juices from the mulberry fruit act as a hypoglycemic agent.

The mulberry tree is featured in the works of Roman poet Ovid and in Shakespeare's *A Midsummer Night's Dream* in the tale of Pyramus and Thisbe. The parents of these two lovers forbade them from marrying, so they arranged to meet under a mulberry tree. They both died under the tree in a Romeo-and-Juliet-style death, and their blood is said to have stained the white berries dark red.

According to the Chinese, the three-legged sun bird represents the sun. This bird lives in the eastern sea, atop a mulberry tree. This tree links Earth and the eastern heaven. Depictions of mulberry trees in art are often symbols of this divine tree. The mulberry is also a symbol of the archer, astrologic symbol for the sign of Sagittarius, because legend tells how the first bow was made by Emperor Huang Di to defeat a tiger that had chased him into a mulberry tree.

The Japanese used mulberry paper for offerings in Shinto shrines. Japanese families used mulberries on their family crests, and strips of fiber hung from sacred trees as prayers. Mulberry leaves fed silk worms, which produced the fiber to make kimonos for the aristocracy.

Deb Carlton

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Mullein

There are over 200 species in the genus *Verbascum*, but only 1 (common mullein), *Verbascum thapsus*, is generally cultivated for use. Common mullein has been used medicinally for centuries, and holds a position of importance in the folklore of Europe, Asia, and North America. A native of Europe, this plant can be found in western and central Asia, as far east as the Himalayas. Introduced to the New World by European colonists, mullein quickly gained a foothold with Native American cultures, which adopted it for a number of uses. Physicians and botanists going back to the time of the ancient Greeks recommended mullein for the treatment of a wide range of medical complaints, including tuberculosis, asthma, hemorrhoids, toothaches, inflammations, and earaches. Modern herbalists continue to use mullein to treat a long list of conditions, and modern medical studies have proven that mullein does, in fact, have powerful medicinal properties.

In addition to being known as common mullein, *Verbascum thapsus*, also called great mullein, hag's taper, and bullock's lungwort, is an indigenous European plant. It is believed to have originated on the island of Thapsos, hence its name. Its use as a medicinal herb was well known in antiquity; ancient physicians such as Galen, Hippocrates, Plinius, and Dioscorides wrote about the herb's many medical uses. Galen postulated that mullein cleanses corruption from the tissues and promotes digestion; Plinius and Dioscorides both recorded the common practice of preserving food by wrapping it in mullein leaves.

Since ancient times, mullein has been used to treat spasmodic coughs and respiratory diseases of all types as well as dryness of the mucous membranes, hoarseness, intestinal inflammation, dysentery, hemorrhoids, retained urine, loss of appetite, rheumatism, ulcers, difficult menstruation, gout, edema, convulsions, toothache, earache, and eye inflammation. The leaves, flowers, and stems are used medicinally. The seeds are narcotic and have been used historically as a fish poison. Mullein leaf poultices have been used to treat migraines, burns, and injuries to the skin. Leaves applied topically are said to soften and protect the skin and have been used to remove warts. Root decoctions have been used to treat cramps; a poultice of the seeds and leaves, boiled in hot wine, can remove thorns and splinters buried beneath the skin. Mullein flower oil has long been used to treat earache, soothe ear pain, and clean debris from the ear canal. The flower oil can also relieve neuralgic pain and treat nerve injury; many herbalists believe that mullein can set bones. Some species, notably *Verbascum pulverulentum* and *Verbascum phlomoides*, have been used to expel tapeworm.

During the Middle Ages in Europe, farmers administered mullein leaves to their cattle to treat respiratory complaints, hence its common name, bullock's lungwort or cow's lungwort. Distillation of mullein flower oil for medicinal use began during the Renaissance. The traditional distillation process involved placing mullein flowers and stalks in a corked glass bottle and placing that bottle in the sun or near the heat of a fire; this caused the oil to seep out of the flowers and accumulate in the bottom of the bottle. During Queen Elizabeth's era, mullein leaves were placed in the shoes to warm the feet and promote circulation to the extremities. Mullein leaves worn on the person were said to fend off epilepsy.

Modern medical studies into the properties of mullein have shown that it does, in fact, possess many of the medicinal properties traditionally ascribed to it. Science has shown that mullein contains a number of useful compounds, including saponins, tannins, and mucilage—researchers believe these compounds are largely responsible for mullein's analgesic, topical, and other effects. Mullein has long been known for its expectorant, antispasmodic, anticonvulsant, and antibacterial properties; the herb is also an emollient, a demulcent, and an astringent. Modern scientific research has concluded that mullein does possess expectorant and analgesic properties, making it useful for symptomatic treatment of coughs, colds, and sore throats. Antiviral activity against herpes simplex virus 1, influenza A, and influenza B may be evident. Laboratory studies have confirmed that mullein may be anti-inflammatory, antimicrobial, antiviral, antifungal, and antibacterial; it may even have a future as an antitumor drug. Trials suggest that mullein's efficacy as an earache medication may soon be confirmed as well. Researchers are currently investigating the herb's utility in treating mycobacterial infections, such as tuberculosis and leprosy. Mullein has been used to treat tuberculosis and scrofula (tubercular infection of the lymph nodes in the neck) for centuries, and current research suggests that mullein may provide a promising new weapon in the fight against antibiotic-resistant strains of tuberculosis.

Mullein's uses extend beyond the medicinal. Roman women used the flowers of mullein to make a yellow hair dye. The ashes of mullein leaves, made into soap, have been said to restore gray hair to its natural color. The Romans used the long, dried stalks of the mullein plant, dipped in suet, as funeral torches; the Greeks used the leaves and stalks of the mullein as lamp wicks. Later, in the Middle Ages, Europeans continued the use of mullein stalks during funeral and religious processions. Superstition held that witches used mullein stalks as lamp wicks to cast light upon their dark rituals. Hence, the plant is sometimes known as the candlewick plant or the hag's taper.

Mullein's usefulness as a traditional remedy has given it a place in more than one popular culture. In both European and western Asian cultures, mullein is believed to provide a safeguard against evil spirits and black magic. Ulysses carried mullein to protect himself from the charms of the sorceress Circe. When European colonists introduced this plant to the New World, it caught on quickly among Native Americans; they adopted it for many of the traditional European uses and gave it a special place of significance in many of their sacred ceremonies.

Marjorie McAtee

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Mushrooms

The term "mushroom" derives from the French *mousseron*. In the *Grete Herball* of 1526, scientist Peter Treveris rendered mushroom as "musherom." In the West, scientists and philosophers thought of mushrooms as plants for centuries. The ancients understood that mushrooms lacked roots, but this insight did not stop them from classifying mushrooms as plants. The Greeks and Romans understood that mushrooms lacked seeds, but this knowledge did not dissuade them from characterizing mushrooms as plants. In the fourth century BCE, Greek philosopher Aristotle assigned mushrooms to the plant kingdom. In the 18th century, Swedish naturalist Carl Linnaeus, perhaps misled by Aristotle, categorized mushrooms as plants. In the East, this mistaken view was a tenet of agriculture and science. In 1313, Chinese scholar Weng Cheng devoted a chapter to mushrooms in the *Book of Agriculture*. Not everyone made the connection between mushrooms and plants. The Amerindians of Mochiacan in Mexico understood that mushrooms were not plants, and this view has prevailed. Mushrooms lack roots, stems, leaves, and chlorophyll, making them poor candidates for inclusion in the plant kingdom.

Mushrooms (Elisheva Monasevich/Dreamstime.com)

Scientist now classify mushrooms as fungi and group all fungi in their own kingdom, the Kingdom Myceteae or the Kingdom Fungi. Yet the association between mushrooms and plants has not been abandoned in all quarters. Mushrooms have a cell wall akin to that of plants. Two mycologists consider "mushroom science" to be a branch of agronomy. Indeed, the language of agriculture permeates the culture of mushrooms. The people who tend mushrooms are farmers, and the cultivation of these fungi occurs on farms. More broadly, the fact that humans cultivate mushrooms for food links them to agriculture. As late as 1941, Cornell University horticulturalist Liberty Hyde Bailey listed mushrooms as a cultivated plant. More recently, one scholar has written that fungi and therefore mushrooms are "a large group of plants." Their association with plants makes mushrooms a proper subject of an encyclopedia of cultivated plants.

Folklore, Origin, and History

In Europe, the superstitious have long associated mushrooms with fairies and witches. Europeans referred to mushrooms as fairy clubs, fairy stools, witches' butter, and witches' spittle. In India and Afghanistan, people know the field mushroom as a fairy's cap. European folklore attributed magical powers to mushrooms, perhaps because some of them cause hallucinations. The Talmud mentions mushrooms, though not in a flattering light. In some cultures, people used mushrooms in religious ritual and divination. In the Americas, mushrooms are part of folklore. The people of Belize, Honduras, and Guyana believe that little spirits inhabit the forest. When rain falls at night, these spirits open their umbrellas to avoid getting wet. They disappear in the morning, before any person can detect them, leaving only their miniature umbrellas as a sign of their presence. This story explains why mushrooms are in the shape of tiny umbrellas and why they appear near moisture, and it accounts for the rapidity with which they appear. In parts of Africa, people believed that mushrooms harbor the souls of the dead. The Orotch of Siberia believed that the dead are reborn as mushrooms on the moon. Some Amerindians and Europeans believed that a shooting star created a mushroom on the spot where it fell. The Greeks, Romans, Maya, and Filipinos all believed that lightning created mushrooms on the spot it struck. Like the belief in fairy umbrellas, the notion that shooting stars and lightning created mushrooms accounted for their sudden appearance. According to one Greek myth Sisyphus, the founder of Corinth, populated the city with people who had arisen from mushrooms.

According to one definition, mushrooms are "macrofungi" large enough to be seen and suitable for picking by hand. The ancestor of mushrooms arose 438 million years ago, and mushrooms have been part of the fossil record for 300 million years. Mycologists have identified 14,000 species of mushrooms, though 10 times this number may exist. The fact that in addition to humans gorillas eat mushrooms may suggest that mushroom eating is part of the lifeway of primates. The fact that several Cro-Magnon sites, Lascaux for example, were in areas rich in mushrooms may indicate that humans gathered them, perhaps for several reasons, from an early date. These early humans may have gathered mushrooms for food, for medicine, and as hallucinogens and tinder. Indeed Otzi, the remains of a 5,000-year-old man discovered in the Italian Alps, was carrying bracken mushroom at the time of his death. This mushroom was used to start fires in Europe until the invention of matches. Otzi carried two other types of mushroom, perhaps as medicine.

The Chinese have eaten mushrooms for 7,000 years, and the Japanese have consumed them for 2,000 years. At this time, the people of East Asia gathered wild mushrooms rather than cultivated them. The first written account of mushrooms dates to the third century BCE from China. Around 600 CE, the Chinese were the first to cultivate mushrooms. The Chinese first cultivated the species *Auricularia auricula* on logs. About 800 CE, the Chinese began to cultivate the species *Flammuline velatipe*, and around 1000 *Lentinula edodes*. This third species is today the chief mushroom grown in Asia. China and Japan grow mushrooms for export to the United States and Europe. So enthusiastic are they about mushrooms that the Chinese refer to them as the "elixir of life." In addition to the Chinese, the ancient Greeks, Romans, Egyptians, and Mexicans ate mushrooms as a delicacy and used them as medicine. The Greeks believed that mushrooms gave soldiers strength. The pharaohs prized mushrooms for their flavor and texture. The Romans ate mushrooms on festive occasions. In Rome, the elites ate mushrooms. Emperor Nero proclaimed mushrooms the "food of the gods." One especially prized mushroom was known as "Caesar's mushroom." The Aztecs ate mushrooms, and the people of Central America consumed them for their hallucinogenic effects. The Chinantecs and Masatecs of Mexico grew mushrooms on horse manure. Some Amerindians carved stones in the shape of mushrooms, putting them in tombs. Some Hindus considered mushrooms unwholesome and so did not eat them.

Medieval cookbooks included recipes for mushrooms, though in the 13th century German theologian Albertus Magnus found a new use for the mushroom *Amanita muscaria*, claiming that it could kill flies. Interest in mushrooms grew in the Renaissance, and in 1564 Dutch physician Hadrian de Janghe wrote the first pamphlet, spanning 13 pages, on mushrooms. In 1597, English herbalist John Gerard, perhaps aware that some mushrooms were poisonous, warned against their consumption. "Few of them are good to be eaten," commented Gerard, "and most of them do suffocate and strangle the eater." In 1601, Dutch physician and botanist Carolus Clusius published the first monograph on mushrooms. *A Brief Inquiry into Fungi Found in Pannonia* described 25 types of mushrooms. In the 18th century, Italian scientist Pietro Antonio Micheli discovered that mushrooms arise from spores, a finding that solved the long-standing problem of how mushrooms were propagated. Micheli demonstrated that no mushrooms grew in the absence of spores and that they always grew in the presence of spores. This work was an early critique of spontaneous generation.

Europeans eat mushroom, though according to one authority the British and Dutch are not avid consumers. Italians favor the oyster mushroom. Mushrooms no longer enjoy renown in Greece. The Greeks believe mushrooms are fit only for commoners. The people of Eastern Europe and Russia regard mushrooms as a meat substitute for the poor. Mushrooms are grown in Slovakia, Poland, Hungary, Lithuania, Estonia, Latvia, and Finland. The French and Italians eat mushrooms fried or baked and in soup or stew. Europeans eat canned mushrooms of the species *Gyromitra esculenta*, though this mushroom causes allergy in some. In the West, people use mushrooms to flavor the main dish. In Southeast Asia and Japan, people eat mushrooms every day. Mushrooms are unpopular in some regions of Latin America, perhaps because the descendants of the Spanish and Portuguese dislike them. The Amerindians of these areas, however, eat mushrooms.

In 1993, American scientist Mitchell Sogin created a sensation when he wrote that mushrooms are more closely related to humans than to plants. Both mushrooms and humans depend on plants for sustenance whereas plants manufacture their own food.

Nutrition, Medicine, Toxin, and Ecology

Mushrooms contain protein, lipids, phosphorus, potassium, sodium, calcium, magnesium, copper, zinc, iron, manganese, molybdenum, cadmium, thiamine, riboflavin, vitamin C, and niacin. Mushrooms are between 0.6 and 3.1 percent fat. More than 70 percent of this fat is unsaturated. Mushrooms contain only 1.75 and 3.63 percent protein by weight, a much lower percentage than beans or other legumes and lower even than grains. Yet mushrooms have twice the protein of asparagus and cabbage, 4 times more protein than oranges, and 12 times more protein than apples. What protein mushrooms lack in quantity they have in quality. Many species have all nine essential amino acids. By contrast, most legumes and grains lack at least one essential amino acid.

The Chinese have used mushrooms as medicine for thousands of years. During the Ming dynasty, physician Wu Shui wrote that the donko mushroom, *Lentinula edodes*, increased stamina, cured the common cold, improved circulation, and reduced blood pressure. Some 700 species of mushrooms have medicinal value. The polysaccharides in mushrooms—some 660 species have these compounds—may combat cancer and may stimulate the immune system. *Lentinula edodes* may protect one against influenza. This species may lower cholesterol and may lessen the side effects of chemotherapy and radiation treatment, diminishing pain and reducing hair loss in chemotherapy patients. In 1994, the market for medicinal mushrooms totaled several billion dollars. The figure rose in 1999. In Bohemia, lumberjacks eat mushrooms on the advice that they protect against cancer. Asia and Europe account for nearly the entire market for medicinal mushrooms whereas North America tallies a very small fraction.

Some mushrooms, providing no nutrients, are poisonous. Luckily, very few mushroom species are poisonous. Of these some species are lethal. Greek dramatist Euripides and Greek physician Hippocrates understood that some mushrooms were poisonous. Greek botanist Theophrastus, Roman encyclopedist Pliny the Elder, and Greek physicians Galen and Dioscorides drew a distinction between edible and poisonous mushrooms. The Romans may have used toxic mushrooms to poison people. The emperor Claudius may have died from mushroom poisoning. In the Middle Ages, Arab physician Avicenna mistakenly thought that mushroom poisoning could be cured. People who ignored the dangers of eating toxic mushrooms sometimes lost their lives. In 1767, French organist and harpsichordist Johann Schobert joined a friend and physician in an excursion to collect mushrooms in the countryside. Selecting several specimens, the doctor assured Schobert that they were edible. They took the mushrooms to a chef, asking him to prepare them. The chef refused, saying that the mushrooms were poisonous. A trip to a second restaurant yielded the same result. Growing angry, Schobert and the doctor went to the musician's home to prepare the mushrooms. The chefs were right, however, and the mushroom soup that Schobert prepared killed him, his wife, all their children but one, and the physician.

Mushrooms perform an important ecological role by recycling waste that might otherwise rot in landfills. Among substrates, farmers may grow mushrooms on manure, bagasse, coffee pulp, cottonseed hulls, sunflower seed hulls, sisal waste, sawdust, wood chips, tea leaves, banana leaves, oil palm waste, corncobs, and legume pods and stalks.

Genera, Species, and Production

Because mushrooms do not photosynthesize, they, like animals, must derive nourishment from a source other than the sun. The genus *Agaricus* obtains nutrients from manure; the genera *Lentinula*, *Pleuratus*, *Flammuline*, *Auricularia*, *Pholiota*, *Tremella*, *Agrocybe*, and *Gonoderma* grow on wood; the genera *Volvariella*, *Strepharia*, and *Lomprinus* derive sustenance from compost; and the genera *Lepiota*, *Leptista*, *Morchella*, and *Gyromitra* use soil or humus. Before 1900, farmers cultivated eight species of mushroom, five of which remain popular today.

About 1600, the French began to cultivate the species *Agaricus bisporus*, known as the button mushroom. Since the 17th century, *Agaricus bisporus*, a species that is grown in more than 100 countries on every continent, has been the world's leading cultivar. Between the 17th century and World War II, France was the world's leading producer of *Agaricus*. Between World War II and the 1960s, the United States, France, the Netherlands, and the United Kingdom were the leading producers of *Agaricus*. Thereafter the nations of Asia came to the fore. In 1965, Taiwan emerged as the third leading producer. In 1997, the world produced millions of tons of *Agaricus bisporus*. In 2000, China was the leading producer. The United States ranked second. The Netherlands trailed only China and the United States. France ranked fourth and Poland fifth. The United States and Europe concentrate *Agaricus bisporus*'s production on large estates whereas Asia grows *Agaricus* on small farms. U.S. farmers cultivate the mushroom on horse manure whereas rice straw is the substrate in Asia. Asia cans *Agaricus* for export. Because canned mushrooms from Asia are cheap, farmers in the West, unable to compete in this market, concentrate production for fresh consumption.

Trailing only *Agaricus bisporus* as a cultivated mushroom was *Lentinula edodes*, the most widely grown mushroom in Asia. Chinese legend credits Wu San Kwung with first cultivating *Lentinula edodes* about 1000 CE. Collecting the mushroom in the wild, Kwung noted that it grew on logs. Eager to cultivate it, he discovered that he could increase the number of mushrooms by making several cuts on a log with his knife. When he encountered a log that would not bear mushrooms he became angry, pounding the log with his fist. This treatment, now called the shock method, yielded mushrooms. Because of Kwung's contribution to mushroom culture, China erected two temples to him, and the Chinese countryside has an abundance of Kwung statues, so revered is he by peasants. In the 15th century China—possibly through the action of Buddhists monks—introduced *Lentinula edodes* to Japan. As late as 1983, Japan was the world's leading producer of *Lentinula edodes*, and China totaled only a few percent of production. By 1997, China produced nearly all of the world's tonnage of *Lentinula edodes*. The species is also grown in the United States, Australia, Canada, Brazil, and several countries in Europe.

Popular in Europe and Asia, species of *Pleuratus* are grown in Italy, Germany, the Netherlands, Belgium, China, Japan, Taiwan, India, Singapore, Thailand, Pakistan, and Indonesia. Lesser amounts are raised in Nigeria, Mexico, Brazil, Colombia, Canada, the United States, Namibia, Tanzania, Zambia, and Malawi. *Pleuratus* tolerates high temperatures and so is suitable for cultivation in the tropics and subtropics. Easily cultivated, the genus *Auricularia* may be grown on sawdust. In 1997, the world produced hundreds of thousands of tons, the leaders being China, Taiwan, Thailand, and the Philippines. Known as the winter mushroom, *Flammuline velutipes* tolerates cool temperatures. China, Japan, South Korea, and Taiwan were the leading growers. In 1822, the Chinese began cultivating *Volvariella volvacea*. From this date, Buddhist monks grew the mushroom for their own use and in 1875 began sending it as tribute to the emperor. Around 1935, China introduced *Volvariella* to the Philippines and Malaysia. A fast-growing mushroom, *Volvariella* needs only 8 to 10 days go from spore to harvest. Today, farmers in the tropics and subtropics of Asia cultivate *Volvariella volvacea*. In 1997, the world produced hundreds of thousands of tons of this species with the leaders being Vietnam, China, Taiwan, Thailand, and Indonesia. Production rose swiftly in Vietnam. India, Madagascar, and several countries in Africa also raise *Volvariella volvacea*, though in lesser amounts. In 1997, farmers worldwide raised hundreds of thousands of tons of *Tremella fuciformis*, most of it in China. The Chinese grow it for food and medicine, prizing it as a dessert. Some consumers, especially in the West, consider *Tremella fuciformis* tasteless and this perception may dampen demand for it.

In 1981, the world produced millions of tons of edible mushrooms. East Asia is the world's major producer of edible mushrooms. China, growing 30 species of mushroom, is the world's leading producer, exporter, and consumer. China exports mushrooms to Southeast Asia, Japan, Europe, North America, and Australia. In China, Japan, and Southeast Asia, small family farms grow mushrooms. In the three counties of Lung-Chyan, Qing-Yuan, and Jing-Ning, China, the vast majority of farmers raise mushrooms. In the United States and Europe, agribusiness prevails with large enterprises raising mushrooms. Today, farmers cultivate roughly 100 species of mushroom, though 7,000 species—half of all mushrooms—are edible.

Christopher Cumo

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Mustard

An annual, mustard must be indigenous to the Old World. Known as Indian mustard and mustard greens, mustard may be consumed for its leaves, flowers, seeds, or oil. Mustard is a temperate plant though it grows as near the equator as India. In the Brassicaceae or Mustard family, mustard is of several species. *Sinapis alba*, once known as *Brassica hirta* or *Brassica alba*, monopolizes 60 percent of the world's spice trade. *Sinapis alba* is known as white or yellow mustard. *Brassica juncea*, known as brown or Oriental mustard, totals 40 percent of the global spice trade. There are two types of *Brassica juncea*, the first with brown seeds and the second with golden yellow seeds. *Brassica juncea*, where grown in India, produces flavor unsuitable for making the condiment mustard. *Brassica juncea* tolerates drought better than *Sinapis alba*. Both species prefer neutrality to slight alkalinity, though they tolerate a soil pH as low as 5.6. *Brassica nigra*, known as black mustard, was once grown to make the condiment mustard, but its unsuitability for machine harvest led farmers to switch to *Brassica juncea* in the 1950s. In northeastern Africa, farmers grow *Brassica corinate*, known as Abyssinian mustard, for condiment. One hundred grams of raw mustard greens contain 26 calories, fiber, vitamin C, folic acid, vitamin K, beta-carotene, vitamin E, calcium, iron, magnesium, potassium, zinc, selenium, and manganese.

History

Mustard was first a medicine. As a condiment, mustard was early paired with meat and fish to disguise their rancidity in an era before refrigeration. Sumerian and

Sanskrit texts referred to mustard as early as 3000 BCE, when it was presumably in cultivation. Sanskrit writers distinguished between white and brown mustard. Black mustard was a late import into India. Egyptian texts mentioned mustard by 2000 BCE, and tombs in Thebes, Egypt, contained mustard seeds dating from this time. Again, it seems likely that the Egyptians cultivated mustard by 2000 BCE. The Egyptians buried mustard seeds with the pharaohs. Egyptians ate mustard seeds with a meal, again to disguise the rancid flavor of their food. Ancient dwellings in the Indus River valley contained mustard seeds dating to 2000 BCE. In China, mustard was a plant and a commodity before 1000 BCE. In antiquity, mustard migrated from China to northeastern India to Afghanistan. The 20th-century Russian agronomist Nikolai Vavilov deserves credit for pinpointing part of this migration.

Sixth-century BCE Greek mathematician Pythagoras, fifth- and fourth-centuries Greek physician Hippocrates, fourth-century BCE Greek botanist Theophrastus, fourth-century BCE Greek conqueror Alexander the Great, first-century CE Greek physician Dioscorides, first-century CE Roman encyclopedist Pliny the Elder, and first-century CE Roman gourmet Marcus Gavius Apicius mentioned mustard. The Bible likewise refers to the plant. The gospels tell us that Jesus told a parable of the mustard seed. Eighth- and ninth-centuries Frankish king Charlemagne was familiar with mustard. The Arabs exported mustard seeds from Alexandria, Egypt, presumably to the rest of the Mediterranean Basin. Mustard has been cultivated in Europe since the 13th century. The 13th- and 14th-centuries Italian adventurer Marco Polo traded mustard seeds in Asia. In the 14th century Dijon, France, produced the mustard that bears its name. The 14th-century pope John XXII was so fond of mustard that he elevated his nephew to mustard maker to the pope. The 15th- and 16th-centuries Portuguese navigator Vasco da Gama carried mustard seeds among his provisions. Mustard oil was first isolated in 1660. In the early 19th century, a mustard maker could produce roughly 35 pounds of mustard per day. By 1853, a revolution in mechanization nearly tripled production. Mustard maker Maurice Grey invented the machine that quickened production, receiving a royal commission to make mustard. In 1866, Grey partnered with mustard maker Auguste Poupon. The two sold Grey-Poupon mustard. Mustard maker Francis French developed a mild-flavored mustard, which he sold as French's Cream Salad Brand. The mustard was popular in the United States. One may make mustard by harvesting the seeds when the pods turn yellow. Add seeds to a blender with vinegar, pepper, and salt.

The Canadian provinces of Manitoba, Saskatchewan, and Alberta, and North Dakota and Montana in the United States are the leading producers of mustard seeds. Mustard is also cultivated in Hungary, Poland, Germany, Britain, Argentina, Australia, the Balkans, France, and Italy. Indian farmers grow mustard in Punjab, Bihar, Madhya, Rajasthan, West Bengal, and Orissa. Because India has a warm climate, its farmers grow mustard as a winter crop. In parts of India, mustard follows corn. India feeds mustard seeds to cattle. The principal oilseed mustard is brown mustard, which is grown in India, China, and the southwestern region of the former Soviet Union. Sweden grows white mustard. Mustard has the potential to be grown in the dry regions of western Australia.

Attributes, Cultivation, and Cultivars

Seeds should be planted in fertile, well-drained loam 0.25 to 0.50 of an inch deep and 8 inches apart. Another recommendation calls for the planting of seeds 2 inches apart with the plants to be thinned to 12 inches apart or 18 inches apart for large varieties. Seeds germinate in three to seven days at 68°F to 86°F. Mustard grows best between 60°F and 65°F, though it tolerates heat and drought better than rapeseed. Mustard that receives insufficient water produces the most intense flavor. Because mustard grows best in cool weather, it is frequently planted in spring and fall. Where winter is mild, as in India, the farmer may plant mustard in late summer for a harvest in autumn and winter. Light frost improves flavor. One gardener recommends the harvest at any stage of the plant's growth. Another counsels that the gardener wait until a plant has at least eight leaves. In hot climates, mustard benefits from partial shade, though otherwise exposure to full sun is desirable.

Mustard leaves may be green, chartreuse, purple, or brown. The flower petals may be pale yellow, yellow, or cream. The sepals are green, though they turn yellow before falling from a flower. The flowers open in the morning and remain open three or four days, during which they are presumably receptive to pollen. On the fourth day, a flower sheds petals and sepals. The flowers may self-pollinate. When the wind shakes a flower the anthers shed their pollen onto the stigma. Alternatively, bees cross-pollinate mustard flowers. In one study, bees cross-pollinated 14 percent of flowers; the rest presumably self-fertilized. In most species, the leaves are 6 to 12 inches long. Basal leaves are larger than upper leaves and tend to be hairier than upper leaves. *Brassica nigra* grows to seven feet. The leaves are hairy and 4 to 8 inches long. The flowers are 0.33 to 0.50 of an inch in diameter. The petals are yellow. Insects cross-pollinate the species. The leaves, flowers, and seeds are edible. The younger the leaf the milder is the flavor. In the American South, mustard greens are paired with ham for Sunday dinner, and mustard greens play a large part in traditional African American food. Asians use mustard leaves in stir fries, soup, and dumplings. Some chefs add mustard leaves to ham sandwiches. Others add mustard greens to chicken salad. Mustard leaves may be added to salad or cooked as a vegetable. The use of mustard leaves in salad is common in East and Southeast Asia. Mustard is more than a food. In Europe, mustard is grown as green manure and for fodder. Japanese red mustard makes an attractive addition to the flowerbed. Japanese red mustard has bronze and chartreuse leaves, leading one to wonder how the color red became associated with it. One gardener planted Japanese red mustard among tulips and daffodils.

Cultivars include Fordhook Fancy, which matures in 40 days. It is slow to bolt in hot weather. The variety grows best in fertile loam, planted one-half of an inch deep and eight inches apart. Southern Curled matures in 48 days. An heirloom variety that dates to the 1740s, Southern Curled in a favorite of southern gardeners. Maturing in 45 days, Red Giant has sharp flavor. Its dark green leaves have a tint of purple-red. An heirloom variety, Osaka Purple matures in 45 days. It is a small plant. With mild flavor, Tendergreen matures in 45 days. An heirloom variety, Tendergreen is known as mustard spinach because the flavor combines mustard and spinach. It is slow to bolt in hot weather. Other cultivars include Florida Broadleaf, Green Wave, Purple Wave, Savanna, Southern Giant Curled, and Tokyo Bekana.

Christopher Cumo

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N

Nasturtium

The common garden flower nasturtium, or *Tropaeolum majus*, is a native of Central and South America but is also grown in Europe, Asia, and North America as an annual ornamental. The nasturtium is also grown for the leaves, seeds, buds, and petals, which are edible, with the petals eaten raw in salads or stir-fried and the seed pods pickled in vinegar in the style of capers. Indeed in England, the pickled nasturtium fruit is occasionally known as the capucine caper.

Attributes

The garden nasturtium, *Tropaeolum majus*, was developed from the crossing of *Tropaeolum minus* and *Tropaeolum peltophorum*, and today there are two main types of *Tropaeolum majus*: the flore pleno double-flowered variant and the group of dwarf, nonclimbing nasturtiums. These two variants come in four main hybrids of garden nasturtium: the tall climbing singles, which climb and trail to heights of up to eight feet; the dwarf singles; semidouble gleam, which are semiclimbing and lightly scented; and dwarf double, with many cultivars belonging to each group. Nasturtiums have wiry stems and large flowers, which grow singly on an auxiliary stalk that features a long spur on the calyx. The long spur of the nasturtium flower has inspired the French and Italian names for the nasturtium, *capucine* and *cappucina* respectively, for the spurs are said to resemble the pointed hoods of Capuchin monks. However, while the monks' habits are a dull coffee color, the flowers of the nasturtium are prized for their vibrancy. Growing up to three inches in diameter, nasturtium flowers are available in shades of cream, yellow, orange, and red, which are sometimes bicolored and spotted, as is true of the cultivars Strawberries and Cream and Ladybird. The funnel-shaped flowers consist of five free, unequal petals, which are up to two inches in length. While some cultivars hold their blooms below their foliage, cultivars such as Jewel Mixed hold their flowers above the plant's leaves. Nasturtium leaves can grow up to six inches across and are attractive, rounded, and, in the case of the cultivar Jewel of Africa, variegated. Nasturtiums produce fruit in the form of a three-lobed schizocarp and are very easy to grow from large, pale brown seeds sown in spring. Nasturtiums are unfussy with regard to growing conditions, preferring a sunny or semishady position and dry soil, which should not be very fertile, as too fertile a soil will lead to the overproduction of leaves at the expense of flowers. Nasturtiums are fairly drought resistant and do not enjoy very hot temperatures, nor do they enjoy frost. Although the garden nasturtium is regarded as an annual, *Tropaeolum speciosum*, *Tropaeolum tricolorum*, and *Tropaeolum tuberosum* are perennial cousins of *Tropaeolum majus*. *Tropaeolum tuberosum*, also known as the mashua, produces an edible tuber that is a major food source in parts of the high Andes. In Peru, the nasturtium is known as gold nugget after an Andean legend, which tells that in the days of the conquistadors a Christian convert searched for gold to replace the monies stolen by the Spanish from his village. The man found gold but was attacked by robbers. To stop the thieves from stealing the newfound gold the convert threw the bag of gold into a forest. When the robbers went to search for the bag of gold, all they found was a carpet of golden nasturtium flowers.

A Garden Plant

The diversity of nasturtium types has made the plant a favorite of gardeners as tall-growing nasturtiums can be grown over walls and trees, their grasping petioles twining around supports. Dwarf cultivars, such as Tom Thumb, can be grown in pots and window boxes, and other cultivars may be allowed to trail in among other plants over sunny banks. There are also nontrailing nasturtiums, such as Empress of India, which are more compact. Nasturtium is also popular with flower

Nasturtium (Irina Igumnova/Dreamstime.com) arrangers as nasturtium cultivars such as Whirylbird Cherry make an unusual, long-lasting cut flower, and in areas with colder climates cultivars such as Peach Melba may be grown as an indoor pot plant.

The nasturtium is sometimes called Indian Cress because it is a member of the Brassicaceae mustard family. The genus nasturtium includes watercress, *Nasturtium officianale*, formerly known as rorippa nasturtium-aquaticum. However, despite the similarity in name and the fact that both have peppery-tasting leaves, the garden nasturtium and the nasturtium genus are not related.

Victoria Williams

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Nectarine

A fruit tree, the nectarine (*Prunus persica* var. *nucipersica*) is a subspecies of peach. So close is the relationship between the two that a peach tree occasionally produces a nectarine and a nectarine tree is known to yield a peach. The two fruits are not, however, clones of one another. A nectarine lacks the pubescence, commonly known as fuzz, that a peach has because a nectarine has two copies of a single recessive gene that codes for the absence of fuzz. Where the fruit is heterozygous for this gene it has fuzz and is presumably a peach. This genetic difference has led one authority to classify the nectarine as a "mutant peach." Because the nectarine, without the fuzz that distinguishes it from a peach, resembles a plum, scientists once thought that a nectarine was a hybrid between a peach and a plum. The differences between a nectarine and a peach appear, however, to transcend a single gene. A nectarine is smaller and sweeter than a peach. The former is also more susceptible to mold and peach rot than the peach. Because the nectarine lacks fuzz, it bruises more easily than the peach. A member of the Rosaceae family, the nectarine is related to the rose, almond, apricot, plum, apple, and pear in addition to the peach. A nectarine is 85 percent water, 7.5–8.5 percent sugar, 0.6–1.2 percent protein, 0.3 percent fat, and 1.2 percent fiber. A nectarine has 0.02 milligram of riboflavin per 100 grams of flesh, 0.5 milligram of niacin, 1 to 27 milligrams of vitamin C, 21 milligrams of magnesium, 2 milligrams of sodium, 453 milligrams of potassium, 0.06 milligram of copper, 26 milligrams of sulfur, 15 milligrams of calcium, 41 milligrams of phosphorus, and 2.4 milligrams of iron. A nectarine may be red, white, or yellow. Breeders have derived more than 100 varieties of nectarine.

Origin, Diffusion, and Production

The history of the nectarine appears to be less well documented than that of the peach. Like the peach, the nectarine may have originated in China, where it was cultivated by the time of Christ. Another possibility is that it originated in central Asia, from where it spread to China. From China the nectarine spread to Iran, Greece, and Rome. In the 16th century, Europeans called the nectarine the "nut of Persia," an apparent reference to the belief that it had originated in Persia (now Iran). In the late 16th century, the English cultivated the fruit. In 1616, an English text first referred to the nectarine. According to one account, the Spanish introduced the nectarine into what would become the United States in the 17th century. Another account, however, holds that only in 1906 did the U.S. Department of Agriculture plant the nectarine in the United States. This date must be too late if it is true that American plant breeder Luther Burbank hybridized nectarines in the 19th century. Today, California produces the vast majority of U.S. nectarines. California supplies the U.S. market between April and August. Nectarines from Chile supply the U.S. market between December and March. China rather than the United States is the world's largest producer of nectarines, in 2003 accounting for more than one-third of the global harvest. That year China harvested millions of tons of nectarines and peaches. The United States ranked second, Italy third, Spain fourth, and Greece fifth. France had the highest yield per acre. The United States ranked second whereas China ranked only ninth. Almost all nectarines are consumed fresh. The remainder is eaten in pie and cobbler. In 2003, only a small number of nectarines was processed.

Attributes, Cultivation, and Pruning

Along with the peach, the nectarine is the most important stone fruit grown in temperate locales. The nectarine is known as a stone fruit because the seed is encased in a large, hard pit. Although the nectarine may be grown in the subtropics, the quality of fruit is superior in temperate regions. Like the peach, the nectarine may be freestone or clingstone. The flesh separates easily from the pit in a freestone variety but is much harder to separate in a clingstone variety.

Once fruit is set, growth is initially rapid, though it slows when the pit hardens. After the seed coat has hardened, growth is again vigorous. As the fruit grows it accumulates sucrose, the sugar that is in sugarcane and sugar beet. The nectarine thrives in a climate with hot summers and mild winters. Being only moderately hardy, it is less tolerant of cold weather than apple or pear and requires less cold weather to become dormant. The nectarine will not tolerate humidity. The grower should plant trees on land with a northeastern exposure to prevent them from flowering too early in spring and thereby protecting them from late frost. The grower should choose a location with full exposure to sunlight. Flower buds can endure temperatures as low 20°F. An open flower suffers damage at 26°F, and young fruit dies at 28°F. December and January should be the coldest months in nectarine-growing regions.

The grower should plant a nectarine tree in deep, well-drained soil. A tree will not tolerate waterlogged soil, especially when it is growing vigorously. The farmer cannot, therefore, plant nectarine where the water table is high. Roots die when immersed in water because they produce toxic hydrogen cyanide. The soil pH should be slightly acidic, between 5.8 and 6.8. Nectarines may be propagated by grafting the scion onto the rootstock of a seedling. The rootstock may be a wild nectarine, a cultivar, or a hybrid between an almond and a nectarine. The farmer who wishes to graft a nectarine should do so in December or January. January is the best month in the subtropics. The grower should select a site for planting that was not previously a nectarine or peach orchard and that has good air circulation. Trees, planted 12 to 18 feet apart, should number about 2,500 per acre. Where the climate is cool or arid, dense planting is best. A tree that is one year old is ready to plant in an orchard. The farmer should plant a tree in late winter or early spring. Sometimes nectarine is interplanted with apple, pear, or citrus. A nectarine tree may be intercropped with vegetables to give the farmer income in the years before a tree bears fruit. (A tree typically bears fruit in its second or third year.) In other cases, nectarine is intercropped with soybean, cowpea, turmeric, pineapple, rye, ryegrass, pea, and clover. Intercropping reduces erosion and fertilizer runoff and leaching and increases the amount of organic matter in the soil. A nectarine tree should not be grown in sod, especially in its first two or three years because grass will compete with the tree for water and nutrients. The farmer should not cultivate the soil for fear of damaging feeder roots that lie close to the surface.

Pruning a nectarine tree allows light to penetrate the canopy, improving fruit color, though aggressive pruning in the third, fourth, and fifth years reduces yield. Once dormant, a tree may be pruned in the middle of winter. In temperate locales, the farmer should prune a tree in mid-February to avoid damage from excessive cold.

Nutrients and Water

Nitrogen is the chief element in nectarine nutrition. In some soils, it may be the only element that the farmer need apply. Where nitrogen is in shortage shoots may be small, the yield low, and fruit size small. One recommendation calls for 77 to 121 pounds of nitrogen per acre. Another calls for 48 to 57 pounds of nitrogen and phosphorus and 88 to 120 pounds of potassium per acre. Potassium must be adequate for a tree to produce large fruit and abundant leaves. A leaf should be 1.6 percent potassium. Anything above this amount does not benefit a tree. Nectarine trees seldom need phosphorus, though interplanted crops may benefit from it. Zinc, manganese, and boron may be deficient, in which case the farmer should spray these nutrients. Applications of 0.5 percent zinc sulfate solution increases the yield of nectarines and is as effective as 2.2 pounds of zinc sulfate per tree added to the soil. Chelates and sulfates of iron and zinc improve the health of leaves and the quality of fruit. Zinc may be more important than iron in conferring these benefits. The nectarine is less efficient than citrus and apple in absorbing zinc. Trees one to six years old require progressively more fertilizer with age. After age six, the amount of fertilizer remains constant.

A nectarine tree needs 36 inches of water per year. Irrigation improves fruit quality 20 percent. Irrigated nectarines ripen two to three days earlier than rain-fed nectarines. Irrigated nectarines ripen uniformly, allowing the harvester to pick fruit all at once. Rain-fed fruit does not ripen uniformly, requiring two pickings. Where summers are hot and dry, irrigation is especially important. One report, however, asserts that a one-third reduction in the amount of water supplied to a nectarine tree lessens the necessity of pruning.

Pollination

The reproductive biology of the nectarine is the same as that of the peach. The nectarine tree yields perfect flowers. That is, each flower has both stamens and pistil. Having five petals and clustering on a tree, each flower has 15 to 30 stamens that surround the pistil. The ovary has two ovules, only one of which must be fertilized to yield fruit. Because only one of the two ovules is fertilized, the fruit is asymmetric. Each nectarine develops at the base of the corolla. Several species of insect visit the nectarine tree for nectar and pollen. The pistil is receptive to pollen as soon as the flower opens and remains receptive four to seven days. The flower that is pollinated soon after it opens yields the best fruit. The anthers shed pollen during the time that the stigma is receptive to it. Depending on the variety, the nectarine may be self-sterile or self-fertile. A self-sterile flower must cross-pollinate, whereas self-fertile flowers may be cross-pollinated or self-pollinated. Although once popular, self-sterile varieties are seldom grown today. Because wind does not pollinate the nectarine, insects are necessary even for self-fertile varieties. U.S. growers use honeybees to pollinate nectarine flowers.

Thinning

A tree should not be permitted to yield fruit indiscriminately. Rather, the farmer should thin fruit to enable a tree to produce large nectarines, to reduce the weight on branches, and to maintain a tree's health. The production of too much fruit shortens the life of a tree and results in the production of low-quality fruit. By thinning fruit, the farmer ensures that the remaining nectarines receive enough water and nutrients from the tree. Fruit should be thinned to yield a ratio of 35 leaves to one nectarine. The farmers should thin fruit immediately after it has set. Especially important is the prompt thinning of early-maturing varieties. Fruit may be thinned by hand, by machine, or with chemicals. Chemicals are cheapest and result in the best fruit quality and size. To thin nectarines farmers have used dinitro-o-cresol, naphthaleneacetic acetic acid, 2-3-chlorophenoxy propionamide, 2-3-chloroethylphosphonic propionic acid, naphthylphthalamic acid, and 2-chloroethylphosphonic acid (ethephon). Ethephon and dinitro-o-cresol are the most widely used thinners. Chemicals should be applied one to two days before flowers are in full bloom. One must be cautious in using ethephon because it kills leaves in addition to flowers.

Maturation and Storage

Seventy-eight to 127 days elapse between fruit set and maturity. Roughly 100 days after fruit set a nectarine is at the peak of redness. At this stage, respiration and the production of ethylene peak. Fruit ripens between midsummer and mid-autumn. Nectarines ripen above 59°F. Most nectarines are harvested by hand because machines bruise fruit and cannot distinguish immature from ripe fruit. During storage nectarines lose less moisture than peaches. Nectarines are often stored in 25- or 38-pound boxes, packed either loosely or tightly. A nectarine may spoil 2 or 3 days after picking without refrigeration. In California, as much as one-quarter of the harvest decays before it is sold. Nectarines may be stored two to four weeks at 31°F or 32°F degrees Fahrenheit and 90 percent humidity. The loss of moisture makes nectarines inedible after four weeks' storage. Nectarines shrivel more severely than peaches when they desiccate. Once cut, a nectarine can be stored 2 to 12 days at 32°F and 90–95 percent humidity. When a processor slices nectarines, they have a shelf life of 6 to 8 days at 32°F and 90–95 percent humidity.

Christopher Cumo

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Nettle

An herbaceous annual or perennial, there are about 45 genera and 550 species of nettle within the nettle family, Urticaceae. Nettles are indigenous to Europe, Asia, Australasia, Africa, and North America, growing in thickets on fertile, moist soil in sun or partial shade. Nettles can be monoecious, that is, consisting of male and female reproductive parts on the same plant, or dioecious, that is, having separate male and female plants. Nettles consist of erect simple or branching stems and leaves that are stipulate, petiolate, and opposite. The flowers of the nettle are small and green in auxiliary spike-like cymes. Staminate flowers have a deep four-cleft calyx with four stamens and with a rudimentary ovary. Female flowers have four sepals of which the inner two are larger and house the ovary in fruit. The ovary is superior, the stigma is tufted, and the fruit is a flattened achene. Propagation is by seed or division.

One of the most recognized nettles is the stinging nettle, *Urtica diocica*. The stinging nettle is a rhizomatous perennial plant reaching up to five feet tall and flowering between July and September. The flowers of the stinging nettle are unobtrusive as they are pollinated by wind and so do not need to attract insects. The stinging nettle gained its common name from the stinging hairs with which it is equipped along the stem and underside of the leaves, while the Latin name *diocica* means "two houses." This language refers to the fact that stinging nettles are a dioecious species. The hairs of the stinging nettle feature a hypodermic mechanism that is made up of a capillary tube with a reservoir at its base that is filled with a chemical mixture consisting of formic acid, histamine, acetylchlorine, and other chemicals. While the formic acid causes pain and the histamine reddens the skin, it is the combination of chemicals together rather than the individual components of the venom that causes skin to react. Indeed, the botanical name *Urtica* is derived from the Latin word *uro* meaning "to burn." When skin brushes against the hair, the tip of the hair is detached and the irritant-filled tube is unsheathed. The chemical mixture is then released into the skin as the slim tube is bent and the reservoir is constricted. A traditional folk remedy for the resulting skin reaction is to apply a dock leaf to the affected area. Another nettle, *Urtica ferox*, the tree nettle, is indigenous to New Zealand and has been known to kill humans. The tree nettle has leaves and leaf stalks covered in poisonous bristles. On contact with human skin, the plant injects a toxin that can result in blindness, paralysis, loss of consciousness, and even death.

Stinging nettles are edible, and while the young leaves of the plant may be eaten raw as a salad ingredient, their sting is neutralized when the leaves are steamed or boiled. Young leaves can be used as a substitute for spinach and are a valuable source of vitamins A and C as well as a rare vegetative source of vitamin D. Cystoliths in older leaves may irritate the kidneys. Leaves can be used to curdle milk in cheese preparation, used in beer making, and added to poultry fodder to boost the feed's nutritional value.

Nettles have long been used medicinally with stinging nettles used in ancient Rome in a practice known as urtication in which nettles were slapped against paralyzed limbs in the belief that this would cure the paralysis. Also, the roots of stinging nettles become edible on roasting, and the roasted roots can be made into a tea that is reputed to have an astringent and diuretic effect and that can be used to treat nosebleeds, internal bleeding, stomach disorders, and respiratory conditions. A green dye can be obtained from the fresh stems and leaves of the nettle, while boiling the roots produces a yellow dye; hence the coloring agent E140 can be obtained from *Urtica diocica* for use in medicines and foods. The annual dog nettle, *Urtica urens*, is also edible and is used in homeopathic medicine, for a cream of *Urtica urens* is used to treat urticaria, a skin condition also known as nettle rash.

The word "nettle" is derived either from the Anglo-Saxon *noedl*, meaning "needle," or from the Latin *nere*, meaning "to sew." This reflects the history of the nettle's cultivation as a fiber crop. The history of the use of nettle as a fiber crop dates back to the Bronze Age, and nettles proved a useful source of cloth fibers as recently as World War I when cotton supplies were disrupted in Germany. The roots of *Urtica diocica* become unpalatably tough with age rendering the root inedible, but they may still be used to make strong chords; while *Urtica cannabina*, the hemp nettle, may also be grown as a fiber crop as the plant's fibrous stem may be used to make ropes, nets, yarn, and paper. Although often considered a weed, nettles may benefit the gardener as they are a favorite plant of beneficial insects including members of the Nymphalidae butterfly family such as the Red Admiral, and moths such as the Beautiful Golden Y. An organic fertilizer can be made by stewing nettles in water for three weeks as nettles are rich in nitrogen, silica, chlorophyll, iron, and phosphate. A strained, diluted version of this liquid may also be sprayed to deter aphids and mildew.

Victoria Williams

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Nigella

Nigella, commonly known as the fennel flower or love-in-a-mist, belongs to the buttercup family Ranunculaeae and consists of around 20 species of annuals indigenous to the Mediterranean region of Europe and western Asia. Nigella is a bushy plant growing up to two feet tall and consisting of stems bearing deeply cut, feathery leaves. The leaves are arranged in a spiral formation without stipules. Nigella flowers are either solitary or held in cymes of a few flowers. The plant exhibits a perianth of two whorls.

The flowers are radially symmetrical and made up of five petals and five petal-like sepals, which are larger than the petals. The petals are in the form of clawed nectarines. Some species, such as *Nigella damascena*, exhibit a ruff of green bracts called an involucres, which is the mist of love-in-a-mist. Nigella flowers have many stamens and five carpels, which are joined together. The flowers bloom in the summer and are semidouble, available in shades of lavender, blue, white, yellow, and pink. The flowers of the cultivar Miss Jekyll are particularly popular as they are a striking sky blue shade.

After flowering, nigella develops a large, inflated capsule seed head, which houses a multitude of shiny, black seeds. It is from the black color of the seeds that the name nigella is derived, for *niger* is the Latin word for "black." The seed heads with their horn-like persistent stigmas and dull brown or bronze color are often

Nigella (Mihai-bogdan Lazar/Dreamstime.com) incorporated into dried-flower displays. Deadheading encourages flowering but prevents the formation of the ornamental seed heads, so for continual flowering it may be preferable to sow seed every four weeks throughout the summer. Nigella can be included as a filler plant among perennials in mixed flower beds planted in the informal cottage garden style, where they will self-sow, and where they may be used as a cut flower or dried. Nigella is very easy to grow, requiring a site in full sun and average, well-drained soil. For best results, nigella seeds can be sown outdoors, covered with a very thin layer of soil, before the last spring frost as nigella prefers cool temperatures. Alternatively, outdoor sowing can be carried out in the fall for flowering the following summer. Seeds can be sown indoors six to eight weeks before the last frost at a temperature of 70°F.

Nigella damascena is a widely grown variety of nigella. Naturalized throughout Central Europe, *Nigella damascena* is distributed across Eastern and Southern Europe, and northwestern Africa. Growing up to two feet tall, *Nigella damascena* can be simple or a little branched. The leaves of this species of nigella are finely divided and feature linear segments with three leaves clustered directly underneath each flower. The flowers of *Nigella damascena* come in shades of lavender, purple, blue, white, pink, and red. The Persian Jewels Series of *Nigella damascena* grows to 16 inches in height and is available in a rich array of colors. The oil obtained from the seed of *Nigella damascena* is used in the cosmetics industry in the production of perfume and lipstick. *Nigella hispanica* features deeply cut but nonfeathery leaves. The plant has fragrant blue flowers with maroon stamens but lacks the ruff-like involucres of bracts.

Several species of nigella are edible. Distributed throughout Central and Western Europe, central Asia, the Middle East, and North Africa, both the plant and seeds of *Nigella arvensis* have a long history as a culinary herb. The seeds of *Nigella sativa* have been used in cookery since ancient times. The common names of *Nigella sativa* suggest the plant's long tradition as a spice because alternative names for it include black cumin, onion-seed, black caraway, nutmeg flower, and Roman coriander. The culinary use of *Nigella sativa* seeds was noted by Roman visitors to ancient Egypt, where they were used to flavor bread and sauces, while in Iran *Nigella sativa* was known as royal cumin because it was a favorite spice of the king. The pungent, aromatic seeds are still used in Middle Eastern cooking and in Indian cuisine. In Hindi, the seeds are known as *kalonji* and they are the traditional topping for Peshawari naan bread, while in the Bengali cuisine of northeastern India nigella seeds are an essential element of panch phoron, a traditional ground spice mixture used as an ingredient in cooking or sprinkled as a garnish.

The seeds of *Nigella sativa* were not used extensively in ancient Greek and Roman cuisine, but they were an ingredient in medicinal wines. The seeds of *Nigella sativa*, known as *Upakunchikaa*, are used in ayurvedic medicine, the traditional Eastern Indian medicine. They are considered a diuretic, are taken internally to treat puerperal fever, and are externally applied to ease skin conditions. The seeds were also ingested to counteract purgatives, to cure disorders of the digestive tract, and to fight tumors. Several of the ayurvedic uses of nigella pertain to the needs of women because ayurvedic practitioners believe nigella helps to regulate the menstrual cycle and to stimulate contractions of the uterus, while experiments have shown that feeding nigella seeds to lactating rats results in increased milk production. The seeds are rich in fatty acids including oleic acid and linoleic acid, and may contain antibacterial, antifungal, and anti-inflammatory properties. The essential oil of the seeds, which contains the active ingredient nigellone, is said to have a calming effect and to act as a muscle relaxant.

Victoria Williams

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Nutmeg

Nutmeg, also known as *Myristica fragrans*, originated in the tropical climate of the Moluccas (formerly the Spice Islands) and is the inner seed of the nutmeg tree. Finicky about its volcanic soil and humid climate, the nutmeg tree is difficult to grow and at one time it grew only in the small Banda Islands. However, given optimal circumstances, it can grow to a height of 40 to 50 feet and produce thick shiny green leaves that measure about four inches in length. This evergreen tree is unique in that it produces a yellow fruit that yields two spices: mace and nutmeg.

Mace is a scarlet-colored, net-like covering for the fruit's seed. It is separated from the seed, dried, and sold either whole or ground. The nutmeg is the extremely hard inner seed, covered by the mace, and it is approximately one-half of an inch long. Like the mace, it is dried and sold either whole or grated, but it is never used whole. Before use, nutmeg must be grated. Both mace and nutmeg have an aromatic nutty fragrance and a sweet spicy bite, and both are staples of Indian and Middle Eastern cuisine, but their popularity is global. Nutmeg is often added to hot drinks, such as eggnog and mulled wine, and it makes a flavorful addition to puddings and custards. In Italian cuisine, nutmeg makes a frequent appearance, particularly in dishes with spinach and in cured meats and sausages. Nutmeg oil is widely used not only in perfumes but in the U.S. prepared-foods market, especially in sauces and pickles, and it is rumored to be one of the secret ingredients in the globally consumed Coca-Cola soft drink.

History

The sordid history surrounding nutmeg, however, has more to do with its medicinal benefits, both real and imagined, than its pleasant taste. A health handbook from 15th-century Italy claimed that nutmeg could do everything from freshen one's breath to cure flatulence to improve eyesight. In Elizabethan England, nutmeg pomanders purportedly cured the plague. In India, nutmeg has long been prized as a cure for insomnia, headaches, and incontinence, and in the United States, the Vicks Company adds nutmeg oil to its Vicks VapoRub ointment with the goal of relieving chest and nasal congestion. The spice was often rumored to function also as an aphrodisiac. Perhaps the most disturbing example of nutmeg's sexual uses occurred in Denmark. According to Danish witchcraft trial records from the early 17th century, some Danish men believed that if they swallowed a whole nutmeg and waited for the partially digested nutmeg to appear in their excrement, then they could use it as an aphrodisiac by grating it into an unsuspecting female's glass of beer or wine. Under the influence of this elixir, the woman was supposedly powerless to reject a man's amorous advances. Thus rumored to be a miracle cure for so many ailments, a profitable nutmeg trade developed and many nations jockeyed for control.

Although evidence suggests that nutmeg had reached India before the sixth century, the Arabs located the source of nutmeg around the 13th century and kept it a secret from European purchasers, who paid exorbitant prices for this miracle spice. In the 14th century, for instance, a mere half a kilogram of nutmeg would cost either one cow or three sheep. Eventually, however, the Portuguese discovered that the East Indies were home to many lucrative spices, and by 1526 they dominated the Asian spice trade. In 1595, the Dutch launched their first fleet to attempt the conquest of the Moluccas, effectively broke the Portuguese monopoly on nutmeg, and established the Dutch East India Company in 1602. By the mid-1600s, the Dutch boasted Europe's largest mercantile fleet and a flourishing economy based principally on maritime commerce.

Not to be outdone, in October 1610 the English crown sent merchant navy officer Nathaniel Courthope and a small crew to the Moluccan island of Run. In 1616, the *Swan* and the *Defence*, Courthope's ships, landed on Run, and soon he persuaded the natives to ally themselves with England in exchange for nutmeg. Courthope and his small contingency defended the tiny island against a Dutch siege for four years, but after the death of Courthope in a 1620 Dutch ambush, the English left the island. Tensions between the English and the Dutch continued, however, as the Dutch capitalized on the English Civil War and traded with England's North American colonies. This and other disputes over trade led to the First Anglo-Dutch War (1652–1654). Fought exclusively at sea, the war ended with the Treaty of Westminster, which stipulated that the nutmeg-producing island of Run should be returned to England. Two attempts by the English to take possession of the island were repelled by the Dutch, and in 1665, the Dutch destroyed Run's nutmeg trees, thus launching the Second Anglo-Dutch War (1665–1667). This time the Treaty of Breda ended hostilities, ceding Run to the Dutch and famously granting New Amsterdam (currently New York) to England.

The British occupied the Moluccas from 1776 to 1802, and they successfully broke the Dutch nutmeg monopoly by introducing nutmeg cultivation to several of their other colonies, including Singapore, Penang, and Grenada. This transplanted tree became so significant to the Grenadine economy, in fact, that the country's national flag (adopted in 1974) depicts a yellow nutmeg fruit partially split open to reveal its seed. As these formerly exotic and hard-to-come-by spices became more plentiful and easily accessible, however, and as they proved to be ineffective in many of their advertised uses, they began to fall out of favor with consumers. Likewise, changes in food trends from the heavily spiced medieval foods to the simpler, more natural flavors of Renaissance cuisine reduced demand for many spices, including nutmeg. While the medieval upper class had displayed its affluence and sophistication with the liberal use of spice at the dinner table, the Renaissance aristocracy preferred to flaunt its prosperity and refinement through fine art, jewelry, music, and dress. Thus nutmeg usage throughout Europe diminished but certainly did not disappear.

Nutmeg as Drug

In more recent times, nutmeg has gained recognition among those seeking an artificial high that is both inexpensive and legal. This spice contains myristicin, a natural organic compound that has psychoactive properties at high doses. *Naked Lunch* (1959), the seminal novel by William S. Burroughs, makes reference to nutmeg as a recreational drug, describing it as similar to marijuana with side effects of nausea and headache. Regarding its addictive possibilities, Burroughs wrote: "Death would probably supervene before addiction if such addiction is possible" (231). *The Autobiography of Malcolm X* details his experience with nutmeg: "My cellmate was among at least a hundred nutmeg men, who for money or cigarettes, bought from kitchen-worker inmates penny matchboxes full of stolen nutmeg. I grabbed a box as though it were a pound of heavy drugs. Stirred into a glass of cold water, a penny matchbox full of nutmeg had the kick of three or four reefers" (156). However, this sort of use is relatively unpopular because it can take up to 24 hours for users to experience nutmeg's marijuana-like effect and because of the many troubling health risks that accompany it. In addition to those Burroughs noted, potential side effects of taking large doses of nutmeg include dehydration, body pain, heart palpitations, and even convulsions. There is also an acute psychiatric disorder called nutmeg psychosis that stems from nutmeg abuse and causes hallucinations, agitation, excitement, and thought disorder.

Current Status

In spite of its hallucinogenic properties, however, nutmeg is harmless when used in small cooking quantities, and cooks worldwide maintain that it is a must-have staple in their spice racks. Outside of the kitchen, nutmeg will undoubtedly continue as a popular ingredient in cosmetics and pharmaceuticals as well, so the future of this once rare tree and its fruits remains secure, if still controversial. Although this time it does not pit nation against nation, nutmeg is at the center of a rather heated Grenadian debate over tradition versus technology. Currently producing over one-third of the world's nutmeg supply, Grenada has done little to modernize its nutmeg industry since the mid-1900s when the Grenada Cooperative Nutmeg Association, a farmers co-op created by the Nutmeg Ordinance of 1947, took control. Entrepreneurial politicians and economists in the island nation want to renovate and mechanize the nutmeg industry to cut out the foreign middlemen manufacturers and keep more of the wealth in Grenada, but the members of the cooperative are adamantly resisting such change, fearing the dissolution of the co-op and the loss of control of the industry. Whatever the outcome of this latest controversy, consumers will have their spice.

Dana Nichols

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O

Oak

The oak tree has long been an ornamental and a source of lumber. Few plants match the oak's longevity, which regularly reaches 300 to 400 years. Botanists have reported oaks as ancient as 1,000 years. So beloved is the oak that in 2001 Americans voted it the national tree. The Latin *quercus* gives the oak its genus name. The word "oak" derives from the Old English *ac*. In Dutch, the word for oak is *eik*, in German *eiche*, in Greek *balanus*, and in French *chene*. The Spanish use *roble* to mean deciduous oak and *encine* to mean the type live oak. A member of the Fagaceae family, the oak is related to beech and more distantly to chestnut.

Origin, Diffusion, and Habitat

Some paleobotanists put the origin of the oak tree between 70 and 120 million years ago. One botanist believes these dates are too early and favors the Eocene Epoch (40–56 million years ago) as the period during which the oak arose. One writer favors an origin between 40 and 60 million years ago. The geography of origin has not been identified with unanimity. One authority cites Europe and Asia as the cradle of the oak with a later evolution in North America. Another observes that the Fagaceae family arose in the mountains of southern China and Southeast Asia but that North America is the homeland of the oak. Unfortunately, no fossils from North America document the evolution of the oak, perhaps weakening the continent's claim to be the place where the oak arose. If North America marks the geographical origin of the oak tree, it must have spread across the Atlantic Ocean to Europe and the Mediterranean Basin. This migration would have been eased by the fact that North America and Europe were closer and the Atlantic narrower in the Eocene than today. From North America, the oak must have spread west across the Bering Strait to northern Asia and China. Migrating south, the oak populated the mountains of Mexico, Central America, and northern South America before and during the ice ages.

The white oak, named for the color of its bark, may have been the earliest oak. From a population of white oaks arose the black oak, also named for the color of its bark. Confusingly, however, the white oak may have dark bark, the black oak may have light bark, and the color of both may change as a tree ages. The black oak makes it habitat in the Americas, having never branched out to Europe and Asia. The golden oak, named for the color of the wax that covers its leaves, may

Oak trees (Sborisov/Dreamstime.com)

likewise have evolved from a population of white oaks. The golden oak spread throughout the American Southwest as the climate dried. Deciduous oaks spread throughout temperate Europe whereas evergreen oaks populated tropical Asia. Large groups of deciduous oaks include the English oak (*Quercus robur*), the sessile oak (*Quercus petraea*), and the Turkish oak (Quercus cerris) of Asia and the Mediterranean Basin. As mountains uplifted in California, the northern Mediterranean, and the Himalayas, they provided new habitats for oaks.

Widespread in the Northern Hemisphere, the oak occupies a range of habitats. The oak grows in the rain forests of Malaysia and Borneo, the cool Sierra Madra of Mexico, the tropical coast of Costa Rica, the hardwood forests of China, Japan, and the eastern United States, sunny California and the Mediterranean, the desert mountains of Texas and Arizona, and the mountains of the Pacific Northwest. In Malaysia and other rain forests, the oak must compete with other trees for sunlight and so grows to more than 100 feet. Some oaks reach 150 feet. Despite its range and malleability, the oak is a fragile plant. It will not grow in poor soil, on land that livestock have grazed, or in a polluted environment. Logging, overgrazing, desertification, and erosion threaten the oak. As early as the 19th century Europeans, alert to the danger of logging, began to replant oaks in denuded areas. The large number of popular books on the oak reveals an abiding interest in it and a desire to retain it in the biota.

Taxonomy and Biology

We have seen that the oak is a member of the Fagaceae family. Botanists classify the oak in the subfamily Quercoideae, the genus *Quercus*, and four subgenera: the white oak (*Quercus*), the black oak (*Erythrobalanus*), the golden oak (*Protobalanus*), and the ring-cupped oak (*Cyclobalanopsis*). These subgenera seem to correspond to some unit in nature because the oaks of one subgenus do not crossbreed with the oaks of another subgenus. The genus *Quercus* numbers some 300 to 400 species, though some botanists put the number as high as 600 species.

Numbering more than 100 species, the white oak is abundant in Europe, the Mediterranean Basin, and the mountains of Asia and North America. No species have colonized Southeast Asia. The white oak includes *Quercus alba* of North America, the live oak (*Quercus virginiana*) of the southeastern United States, the English oak, the drought-tolerant cork oak (*Quercus suber*) of Spain and Italy, the Asian cork oak (*Quercus variabilis*), the scrub oak (*Quercus berberidifolia*) of California, and the Garry oak (*Quercus garryona*) of the Pacific Northwest. The white oak has both deciduous and evergreen species.

With about 200 species the black oak, also known as the red oak, derives its Greek name *Erythrobalanus* from the Greek *erythro*, meaning “red,” and *balanus*, meaning “oak.” Most black oaks inhabit North and Central America with a single species in South America. The black oak is numerous in the mountains of Mexico. The black oak includes the deciduous black oak (*Quercus kelloggii*) of California, the evergreen oak (*Quercus humboldtii*) of South America, the scrub oak (*Quercus* *parvula*) of Santa Cruz Island, the silver-leaf oak (*Quercus hypoleucoides*) of Arizona and northern Mexico, the blackjack oak (*Quercus marilandica*) of the southeastern United States, and the scarlet oak (*Quercus coccinea*) of the eastern United States.

Having only six species, the golden oak derives its name *Protobalanus* from the Latin *proto*, meaning "early" or "first." The *Protobalanus* is thus the first oak, a curious appellation given its status as an evolutionary latecomer. The golden oak is also known as the intermediate oak. It is indigenous to western North America—especially California—the American Southwest, and northern Mexico. The species include the golden cup oak (*Quercus chrysolepsis*) of the mountains of the American West, the huckleberry oak (*Quercus vaccinifolia*) of the mountains of California and southwestern Oregon, the relict island oak (*Quercus tomentella*) of California's Channel Islands, and Palmer's oak (*Quercus palmeri*) of the mountains that border the deserts of California.

Numbering about 40 species, the ring-cupped oak derives its name *Cyclobalanopsis* from the Latin *cyclo*, meaning "ring," an apt name given the ring of scales that encircles the acorn cup. With species in the tropics and subtropics, the ring-cupped oak is native to Southeast Asia, Borneo, New Guinea, India, China, and Japan. Species include Elmer's oak (*Quercus elmari*), the golden-haired oak (*Quercus chrysotricha*), the Sarawak oak (*Quercus gotharuensis*), and the keranga oak (*Quercus kerangasensis*). Having evolved in the rain forests of Asia, the ring-cupped oak has leaves whose tips point toward the ground to allow water from a deluge to run off them rather than accumulate.

The oak does not seed in its earliest years but must age 20 years to bear acorns. Once mature the oak is prolific. A single tree may produce 15,000 acorns per year. One acre of forest may yield 700 pounds of acorns. Production is especially large in most years. More than 150 species of bird and mammal depend on the oak for survival, feeding on its acorns. Among these animals are the squirrel, bear, raccoon, turkey, mice, deer, blue jay, woodpecker, pig, chipmunk, pigeon, and several species of insect. Squirrels and blue jays bury acorns for later use. Those that they do not eat may germinate into new trees. Despite their bitter taste, acorns sustained humans during famine. The Irish ate acorns during the Potato Famine of the 1840s. Peasants have even made acorn bread. Like corn, the oak is wind pollinated. Species regularly hybridize, though, as we have seen, the species of different subgenera do not crossbreed.

Folklore, Mythology, and Superstition

According to one myth, the gods created the oak as the first tree and gave humans acorns as their first food. In prehistory humans, the druids among them, worshipped oak trees. The Greeks thought oak a sacred tree, and the Romans associated it with the chief god, Jupiter. One legend holds that a black dove flew from Thebes, Egypt, to the oak grove of Dodona, Greece, apparently endowing the latter with prophetic powers. For this reason, an oracle at the oak grove of Dodona foretold the future according to fifth-century Greek historian Herodotus. Because of the oak's size, lightning must have frequently struck it. The Greeks, thinking that lightning came from the chief god, Zeus, associated the oak with Zeus. The Norse associated the oak with Thor, the god of thunder and sky. According to myth, Thor rode a chariot of oak across the sky. The Celts marked oak trees with a circle that symbolized the four elements of earth, air, fire, and water. The ancients observed that mistletoe grew on oak trees. Identifying the white berries of mistletoe with the gods' sperm, the ancients associated the oak with fertility. So important was the oak tree to the British that it once graced the sides of sixpence and shilling coins. According to legend, the magician Merlin used an oak branch as a wand. The devout associated the oak with Bridget, a fifth-century saint who founded a convent in Kildare, Ireland. Perhaps because of the association with Bridget, the nuns of this convent burned acorns in the winter to keep warm. Edward the Confessor, king of England in the 11th century, preached to his countrymen beneath an oak tree. For this reason, the tree came to be known as the gospel oak.

The oak was a sacred tree of Wicca and witchcraft. Its worshippers thought that the tree had magical properties. The ancients prayed to oak trees for spring rain to nourish their crops. Some people carried oak twigs with them as protection from harm. Two twigs tied together in the form of a cross and hung in a home, the superstitious believed, protected its dwellers from evil. Some people believed that they could protect their home from lightning by placing acorns on the windowsill. Those who were to undertake a journey ensured the safety of their trek by soaking their feet in water that held oak bark and leaves. The person who caught a falling oak leaf would have luck, prosperity, and protection against colds in winter. The superstitious thought that an acorn protected its bearer from illness and pain and guaranteed a long life. Some women used acorns to predict whom they would marry. Placing two acorns in water, a woman would utter a man's name. If the acorns drifted together, she would marry him. If they drifted apart, he would not become her husband.

Uses

Perhaps because of its hardness, early man used oak to make clubs. The Vikings made hammers and longboats of oak. Warriors and workaday people used oak to fashion the handles of daggers and knives. Oak's use as furniture has a long history. One legend holds that England's King Arthur made his round table from a single slice of an oak trunk. Its durability and beauty led to oak's use in the building of secular and religious structures. Churches and cathedrals were made of oak and stone. The roof and beam of the United Kingdom's Westminster Abbey are made of oak. Among secular structures, the United Kingdom's House of Commons has oak paneling. Workmen made the forts and castles of England of oak, leading people to speak of the wooden walls of Britain, referring to the forts along the coast that defended the island from invaders. Oak comprised the ships that defended Britain from the Spanish Armada in 1588. Alert to the importance of oak to the British navy, Spanish king Philip II vowed to destroy the nation's oak forests to deprive them of building material. So important was oak to the navy that Admiral Horatio Nelson, alarmed at the pace of deforestation, asked Parliament to plant oak trees on denuded land. The focal point of a British ship was its oak mast. White oak was particularly suited to maritime needs because it did not rot. Shipbuilders used white oak for the keel, beams, the frame, and ribs. Shipbuilders in the American colonies were no less fond of oak. As early as 1700, Americans were building ships of oak. The *Hancock*, a Revolutionary War privateer, and the USS *Constitution* and USS *Constellation* of the 1790s were oak vessels.

The Europeans who settled North America cleared the oak forests in eastern Canada and the United States to make furniture, homes, and as we have seen, ships. They burned oak logs for heat and cooking. Because oak is a dense wood and gives off abundant heat when burned, it was suited to these purposes. In the United States, oak was the first wood widely used to make furniture. Around 1860, American woodworkers began to use oak. In the 19th century, the invention of the power saw and lathe increased the use of oak in furniture. About 1900, furniture makers began to mass-market their oaken wares. Eager to buy oak furniture, the middle class thought it a status symbol. Nearly every town in the United States had a factory that turned out oak furniture.

Europeans and Americas aged wine, liquor, and spirits in oak barrels and casks. Well suited to this purpose, oak was impervious to the effects of alcohol. Perhaps because of its durability oak was favored for the making of coffins. As was true of furniture, oak was the wood of status. The elite were buried in oak coffins. Many of these coffins were carved from a single large log and were more expensive than commoners could afford. Edward the Confessor, buried in Westminster Abbey, rests in an oak coffin that has resisted the effects of time for nearly 1,000 years. Being 15–20 percent tannin, oak bark has been used to tan leather and make dye. The Scots dyed wool and yarn from the purple extract from oak bark. Native Americans extracted a red dye from oak bark that they used to paint their bodies. Stockmen fed acorns to their animals, especially pigs. In the era of the railroad, people used black oak to make railway ties and carriages. Black oak was also used for fence posts and pulpwood. Today, black oak totals more than one-third of all hardwood used in the United States.

Among its medicinal uses, the water extracted from an oak bud reduces inflammation, some people believe. Oak leaves, placed on the skin, reduce the swelling from cuts and hemorrhoids. Pulverizing oak bark and adding it to water, one may gargle with the concoction to treat a sore throat or bleeding gums.

Christopher Cumo

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Oats

An annual grass in the Poaceae or Gramineae family, oats are the sixth most widely grown crop, trailing corn, rice, wheat, barley, and sorghum, all of them being grasses. In addition to these crops, oats are also related to sugarcane, triticale, bamboo, rye, and timothy. At first people grew oats for food, but their suitability as feed led farmers to raise them principally for livestock. Three-quarters of cultivated oats are of the species *Avena sativa*. These are either white or yellow oats depending on the color of the grain. Farmers plant white oats in April or May, harvesting them in July or August. Farmers in Argentina grew *Avena byzantine*, also known as red oats. Most oats are sown in the spring. Because oats do not tolerate frigid weather, they are a winter crop only where winters are mild. The red oats of Argentina are winter oats. Farmers grow spring oats between 35° and 50° north, though they grow winter oats at lower latitudes, between 20° and 40° north.

Oats (iStockPhoto)

Oats in Antiquity and the Middle Ages

By one account, oats arose as a weed in the wheat and barley fields of northern Germany. Another tradition holds that oats originated in the eastern Mediterranean and Near East, where farmers first grew them about 2000 BCE. A third hypothesis, noting the diversity of oat species, posited the origin of oats in the Canary Islands, the Mediterranean, the Middle East, or the Himalayan Mountains. A fourth hypothesis suggested that oats arose in the islands of the South Pacific, though this idea has fallen out of favor. As early as 8600 BCE, the people of Syria were consuming oats though their cultivation probably came later. The people of southern Jordan ate oats around 7000 BCE and possibly cultivated them as well. In Moldavia and the Ukraine, farmers grew oats as early as 4700 BCE.

By the end of the second millennium, oats had spread throughout Europe as the climate cooled and grew wetter. Sometime in antiquity oats spread to Egypt, surely from other lands of the eastern Mediterranean. From Turkey, oats migrated to Greece in early antiquity. Familiar with oats, Greek physician Hippocrates believed in the fifth century BCE that they had value as a medicine. In the fourth century BCE, Greek botanist Theophrastus characterized oats as "wild or uncultivated," leading one to suppose that he was unaware of its status as a crop. Relying on this evidence, French botanist Alphonse de Candolle asserted in the 19th century that the Greeks did not cultivate oats in antiquity, though others have challenged this view. In the first century CE, Greek physician Dioscorides believed oats relieved coughs and dried oily skin. The Hebrew may not have grown oats in antiquity, for the Bible does not mention them. As late as 1000 BCE, there is little evidence that humans grew oats in Britain, where they may have appeared as a weed in spelt fields. One authority dates the cultivation of oats in Britain to the second century BCE. Another scholar dates the arrival of oats in Britain to the invasion of the Vandals in the fourth century CE, but the historical record does not support this idea. By 100 BCE, farmers were growing oats in Germany, Denmark, and Switzerland, where they cultivated them alongside emmer. In the first century CE, farmers in Northern Europe raised oats alongside beans, barley, and flax.

In the second century BCE, Roman agricultural writer Cato did not list oats as a fodder crop, leading one to wonder whether the Romans took full advantage of the crop. In the first century BCE, Roman poet Virgil referred to oats as a weed, suggesting that the Romans, at least the elites, had a low opinion of the grass. In the first century CE, Roman agriculturalist Columella mentioned oats but did not give them much space. In the first century CE, Roman encylopedist Pliny the Elder recognized the value of oats in feeding livestock. Given to erroneous beliefs, Pliny held that barley could transmute into oats in wet climates and soils. Barley that had been dormant too long in the soil might germinate as oats, believed Pliny.

In the fifth century theologian Jerome, who apparently thought little of oats, denigrated his opponent British scholar Pelagius as an oat eater.

The Romans promoted the cultivation of oats in Britain from the first century CE. Farmers grew oats near encampments of Roman soldiers, suggesting that oats must have fed troops and cavalry horses. This impression gains strength from the fact that in the second century, emperors Trajan and Hadrian imported oats from Northern Europe to Britain to feed the cavalry. Trajan and Hadrian must have taken this step because Britain was not self-sufficient in oats. Nevertheless, Britons grew enough oats to pay the grain tribute to Rome.

In the eighth century, farmers in France grew oats, spelt, and barley. By the 13th century, oats had emerged as a secondary crop in Denmark, trailing rye and barley. The Danes grew oats on unmanured land distant from the village. They regarded oats as suitable only for infertile soils. In Northern Europe, farmers raised oats as a spring crop. As a rule, oats yielded less than rye and barley and, as in Denmark, farmers confined the grain to poor soils, exacerbating the problem of low yields. Oats were nonetheless an important crop. In the 12th century the Count of Flanders, facing famine, forbade the brewing of oats to preserve the crop for human consumption.

In the Middle Ages, by one estimate, oats were the fourth most widely cultivated crop, following wheat, barley, and rye. By the 13th century and probably earlier, oats were the principal crop of Scotland. The Scots fed oats to sheep as well as ate them as food. In northeastern France, farmers grew oats in a three-year rotation, growing oats in the first year, wheat in the second, and fallowing land in the third. Because farmers did not manure their oats, yields were half that of wheat. In medieval Britain, farmers rotated oats with wheat or barley and fallow. In Scotland, farmers grew oats for two years followed by barley. Other fields were sown to oats and pasture grasses for livestock.

From the first century CE, the climate cooled in Northern Europe and soils became more acidic. Farmers who could no longer raise barley and wheat grew oats instead. The wet, cold climate of the ninth and 10th centuries ceded ground to warm summers between 1250 and 1300. After 1300, temperatures gradually declined and in this environment oats thrived. In the 14th century, the estates of Sussex, England, recorded good harvests. Poorer land, for example the Kent Marshes, was fallowed two years between oat crops. On poor land, farmers grew oats in preference to other grains. In the 14th century, oats were the principal crop in Kent and East Anglia. In medieval Britain tenants, as they had under Rome, paid rent in oats. Using oats to feed their horses, landlords kept large stables. The fact that even peasants owned horses made essential the growing of oats.

In medieval Britain, oats may have been the most widely grown crop. Records from isolated estates confirm this impression. In 1211, one manor of the bishop of Winchester yielded thousands of quarters of oats, and lesser amounts of wheat and barley. In 1296, the earl of Lancaster's Great Sutton Manor harvested hundreds of quarters of oats, and lesser quantities of rye and wheat. In other instances, oats produced a harvest much larger than that of wheat, suggesting that oat acreage was large. In the Middle Ages, farmers grew principally yellow oats, whose grain could be easily removed from the husk. Demand for yellow oats must have been strong because they fetched the same price as wheat. The yield of oats was large on the best land. In 1300, Romney Marsh, England, recorded even larger yields, though an estate in East Kent recorded only a small harvest. Between 1370 and 1399 Lullington Manor, England, yielded several bushels per acre, whereas between 1376 and 1393 Alceston Manor recorded a slightly smaller yield per acre.

Oats were not the leading crop everywhere. Between 1283 and 1348, the bishop of Winchester's 14 manors yielded more barley than oats and wheat. Fluctuations in weather appear to have affected oats less than other grains. In 1315 and 1316, the bishop of Winchester saw his wheat yield decline whereas the oat yield held constant. In 1339 and 1346, wet springs and dry summers caused wheat yields to decline but oat yields appear to have been uniform. In the late Middle Ages, oat yields increased and the wheat harvest decreased, evidence that may point to the possibility that farmers grew oats on good soils whereas they had earlier grown them on marginal land. From an early date, the British distinguished oats by color. They thought the black oats of Westmoreland suitable only for horses. Red oats yield the best oatmeal, and white oats were made into bread and pottage.

Yet as the demand for beer increased, some farmers switched from oats to barley. In some instances, clover and other legumes replaced oats in rotation. Nevertheless, oats held their own on the land of Thierry d'Hirecon in Artois, France, where oats were the principal spring crop in the 13th century.

Oats in Modernity

By the 16th century, the Dutchy of Schleswig-Holstein raised oats for cattle and horses. In the 16th century, oats were the chief crop in Hertfordshire, England, whose lords kept many horses. By mid-century, farmers grew oats on more than half the acreage in Tombridge, England. Oats were the principal crop in northern and western England and in Scotland. Oats remained an important crop in Ireland, even as the potato grained ground. So widespread were oats that in parts of England they rather than barley were malted into beer. Oats were sensitive to fluctuations in supply. In 1596, a bad harvest saw the price of oats double whereas wheat prices increased only half as much. The bad harvest of 1771 pushed oat prices up in Germany. Yields in the early modern era were no better than they had been in the Middle Ages. In the 17th century, Devon reaped only several bushels per acre and Cornwall yielded about the same. By comparison wheat, barley, and rye commanded higher yields.

In the 18th century, farmers in Mecklenburg, Denmark, and northern France grew oats in five- and six-year rotations. In the 18th century, one farmer near Lille, France, grew oats in a 10-year rotation, though as was common he did not manure the crop. That century rye replaced oats on some farms, chiefly on infertile land, whereas farmers grew wheat on fecund land.An increase in living standards in the 18th century allowed Europeans to consume more meat. The demand for meat led stockmen to import more oats to feed their animals. Between 1750 and 1850, oats were the principal crop north of the River Trent in England whereas wheat was the chief crop to the south. In the north, farmers grew oats on as much as half of all arable land.

Yet oats were not grown in abundance everywhere. In 1801, farmers grew fewer oats than wheat in England. In Wales, however, oats were grown on more acreage than barley and wheat. In the 18th and 19th centuries, yields inched upward. By one estimate, growers totaled tens of bushels per acre of oats in the 1770s. In the 1790s, the county reports of the Board of Agriculture put Great Britain's oat yield slightly lower. In 1801, the Home Office reported the oat yield in Anglesey at tens of bushels per acre. Dolgella yielded less, and Bala Mold and Bangor even less. Between 1828 and 1835, farmers in northwestern United Kingdom recorded a yield of tens of bushels per acre. The practice of converting marginal land from oats to pasture and growing oats on fertile soils doubtless increased yields.

In the 19th century, Germany was not self-sufficient in oats, its imports increasing fourfold between 1865 and 1900. Even so, oat production rose in Germany between 1880 and 1910. In the 1860s and 1870s, responding to the declining demand for oats, oat acreage fell in England though it remained constant in Scotland and Wales. Farmers in Chiltern Hills, eager to meet the demand of stockmen, replaced wheat with oats. On the estates of the Duke of Cleveland at Brigstock and Sudborough, oats and pasture grasses replaced wheat. Whereas the Brigstock and Sudborough estates produced few oats between 1848 and 1879, they grew oats on one-third of acreage between 1895 and 1899. These years saw an increase in oat production in East Anglia, Kent, Sussex, and Surrey.

The Fate of Oats in the New World and Beyond

In 1516, the Spanish introduced oats to the island of Hispaniola (now Haiti and the Dominican Republic), probably to feed their horses. One scholar believes that English settlers cultivated oats on Roanoke Island in 1585 and 1586. In 1602, traveler Bartholomew Gosnold planted oats on Cuttyhunk Island near Martha's Vineyard. English settlers were growing oats in New Hampshire and Massachusetts in the 1610s. As early as 1622, farmers grew oats in Newfoundland. In 1626, the Dutch in Manhattan exported oats to the Netherlands. By the 1640s, farmers grew oats throughout New England though they were not as important as corn, wheat, barley, peas, and rye. By 1650, oats were widespread in

New England and by 1660 were grown in Maryland and Virginia. In 1682, farmers grew oats along the Ashley River nearly Charleston, South Carolina. Initially a spring crop, by the 1750s American farmers were planting oats in the fall as a winter crop. In 1768, Virginia exported oats to the Caribbean. In the 1780s, the enterprising George Washington grew 400 to 500 acres of oats. In the early 19th century, the Spanish introduced oats to the Pacific coast, though before 1840 most oats were grown east of the Mississippi River. In 1839 Virginia, Kentucky, and Tennessee produced a minority of the U.S. oat crop, and as late as 1860 the South produced an even smaller amount of the nation's oats. In the late 19th century, farmers in the West and western Canada were raising large oat crops.

In the United States, the largest oat producers are Iowa, Minnesota, South Dakota, and Wisconsin. Today, oats are grown in central Asia, Europe, and North America. Smaller amounts of oats are raised in Argentina, Australia, New Zealand, North Africa, and South Africa. Oat production has decreased worldwide in recent years as mechanization has increased. Moreover, the preoccupation with yield has hurt more modestly yielding oats. Once grown in rotation, oats have fared poorly in schemes that emphasize one or a small number of crops. Whereas farmers had in the early 20th century grown oats in the American Midwest, they now prefer corn in rotation with soybeans. Throughout the 20th, century farmers in the United States replaced oats with soybeans. This trend accelerated with the diffusion of the tractor. The tractor made it possible for farmers to forgo the horse. Without the need to keep horses, farmers no longer had to grow oats to feed them. Oat acreage declined accordingly. In Canada, farmers devoted their energy to growing high-value crops of wheat, barley, and canola. They raised oats almost as an afterthought, planting them late because they were too busy to tend to them earlier. Oat production has decreased from 54 million tons in the 1960s to 27 million tons in 2005. Despite this decline, oat production has increased in Russia, Australia, Sweden, and Finland.

Oats as Feed

Oats have long been an important feed crop. Between 1750 and 1850, the number of horses doubled in Great Britain, increasing the demand for oats. As farmers moved to a market economy they tended to raise wheat and barley and to import oats for their horses. In the Fens and East Anglia, farmers grew oats to feed the large number of horses in London. In the 19th century, demand swelled for oats as livestock and horse feed. In the 1930s, horses consumed millions of tons of oats per year in Great Britain. The decline in the number of horses thereafter reduced the demand for oats.

Worldwide the vast majority of the oat crop feeds livestock. Farmers in the United States, Canada, Argentina, Uruguay, and Australia feed most of their oats to livestock. Livestock in Russia, the United States, Canada, Germany, and Poland consume a large percentage of the oats grown for feed. Since the 1960s, oats have declined as feed in the United States and Canada, where stockmen feed corn and soybeans to their herds. The consumption of oats as feed has held steady in Russia and Poland and increased in Germany. In the United States, nearly all the oat crop goes to livestock and horses. In this country, oats feed horses to a greater degree than livestock. In the European Union, the vast majority of the oat crop feeds livestock. In 1991, farmer fed hundreds of thousands of tons of oats to livestock worldwide.

Oats contain more of the amino acid lysine than does wheat and so are suitable for feeding poultry and pigs. In some cases, sheep and cattle graze oat fields when the plants are immature. Removing the livestock, the farmer allows oats to mature for harvest. Yet because a pound of oats has fewer calories than a pound of corn or barley, stockmen prefer the latter grains, particularly corn, as livestock feed. Excluding corn, barley constitutes the vast majority of the grain fed to livestock whereas oats constitute only a few percent.

Oats as Food

In the first century CE, Pliny reported that the people of Germany and of the Oones Islands in the Baltic Sea consumed oats. Oats must have bulked large in the diet in the Middle Ages and modern era. In 1800, 40 percent of Britons did not eat wheat bread and instead subsisted on oats, other grains, and potatoes. Throughout Europe, commoners ate oat or barley bread when wheat bread was expensive. Between 1806 and 1808, the town of Lancaster imported tens of thousands of quarters of oats but far less wheat, leading one to assume that people ate oats in preference to wheat. Some urbanites disdained oats as "vulgar" and "coarse," but their defenders esteemed oats as the food of hardy yeomen and outdoor laborers. Indeed, throughout Wales and Pennine Manor people ate oat bread in preference to wheat bread. Eating up to one stone of oats per week, some Scots ate oatmeal at every meal. In Scotland and Ireland, people ate oat porridge, oatcakes, brewis (oats with broth), biscuits, pudding, muffins, and bread. In the 18th century, the Scots increased their consumption of oats as they decreased their intake of meat. In the 18th century, Scottish economist Adam Smith warned against the consumption of oats, asserting that they produced weaklings and homely people. Yet in Scotland even the gentry ate oats, though the food was more deeply ingrained in the diet of commoners. Throughout Europe, commoners ate oatmeal bread and the poor subsisted on oats in gruel and soup. In 1740 and 1741, oat prices more than doubled after the failure of the potato crop in Ireland. The poor were forced to visit soup kitchens for oatmeal soup. In northern Great Britain, people ate oats, potatoes, and milk. In 1795, the average family in Westmoreland, Great Britain, spent much its income on oatmeal. By contrast, it spent just a few percent of income on meat and a bit more on potatoes. In the

19th century, poor factory workers subsisted on oats, potatoes, wheat bread, and cheese. Even the well-to-do ate oats, but only at breakfast along with fish, eggs, tea or coffee, and toast. During the Potato Famine, English landlords exported oats from Ireland, contributing to the misery of the masses. Whereas oats had sustained them in the 18th-century crisis, the crop was sold abroad during the calamity of the 1840s. In the 19th century, the demand for oats to feed humans declined. Increasingly, urbanites ate wheat bread rather than oats. After 1850, wheat bread was the staple in Wales and northern Britain. After 1875, wheat bread was commonly consumed even in Scotland and Ireland.

In the United States, colonists ate oats with milk and maple syrup. Judging from 19th-century cookbooks, the absence of recipes for oats suggests that they were not a popular food. In 1859, the cookbook *Cookery as It Should Be* advised the sick and frail to eat oats. This advice suggests oats were easier to find in the pharmacy than in the grocery store. This state of affairs began to change in the late 19th century. German immigrant Ferdinand Schumacher, known as the Oatmeal King, promoted the addition of oatmeal to the diet. Manufacturers began to advertise oats as a healthy breakfast cereal. Consumers identified with brand names, the most popular being Quaker Oats. Oatmeal is today the most popular breakfast cereal in the United States. Today, oats are an ingredient in baby foods, pastes, and even pasta. Oat protein is an additive in some beverages. In recent years manufacturers, keen to advertise the health benefits of their products, have added oats to bread. Although oats are comparatively high in protein, they have little gluten, the protein that give dough its stickiness, and so are not ideal for making bread. Oat breads usually contain 20–30 percent oats, whereas multigrain breads have only 5–15 percent oats. In addition to bread and other products, granola bars containing oats are popular in Japan.

Today, nutritionists tout the value of oats. With 15 percent protein, oats exceed barley, wheat, corn, and rice. Oats are a source of the minerals manganese, magnesium, calcium, zinc, and copper. In addition, oats have 14 percent of the recommended daily allowance of thiamine, 10 percent of pantothenic acid, and smaller amounts of other vitamins. Since the 1960s, research has reported that the consumption of oats lowers one's cholesterol. One early study documented an 11 percent decline in cholesterol in people who ate oats for just three weeks (Marshall and Sorrells 1992, 272).

When the study participants returned to their old diet their cholesterol increased, reinforcing the insight that oats should be a regular part of the diet if one is to receive long-lasting benefits from them. Although regular whole-grain oats reduce cholesterol, the greatest benefit derives from the consumption of oat bran. Between 1980 and 1993, scientists conducted 37 studies of the cholesterol-lowering properties of oat bran (Welch 1995, 449). Only 2 of these studies failed to document a reduction in cholesterol. Moreover, oats may reduce the incidence of colon cancer. Diabetics benefit from the consumption of oats because a meal of oatmeal increases glucose levels less than a meal of many other foods. By stabilizing glucose levels, oats help diabetics manage their affliction. The media have made much of these benefits, and health-conscious consumers began to add oats to their diet. Between 1984 and 1988, the Dutch more than doubled their consumption of oats (Welch 1995, 435). In 1988 and 1989, Americans more than doubled their intake of oats.

Christopher Cumo

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Oil Palm

In the Palmae family, oil palm (*Elaeis guineensis*) is a tree whose fruit contains palm oil. The seed or kernel is a nut that has palm kernel oil and palm kernel cake, the last item being fed to livestock. Palm oil and palm kernel oil may be made into soap, candles, margarine, shortening, cooking oil, salad dressing, and creamer for coffee. They may be added to bread, biscuit, confectionary, pastry, ink, and cosmetics. The fruit of the oil palm may be fermented into wine. Oil palm wine is a source of B vitamins. The oil palm has the highest yield of oil of any crop. Palm oil contains fat, vitamin E, and vitamin A, the last an important nutrient given its shortage in the developing world, where oil palm is grown. The oil palm provides leaves for thatching. The petiole and rachis may be used to make fences. The genus name *Elaeis* derives from the Greek *elaion*, meaning "oil." The species name *guineensis* means derived from Guinea, a name that probably derives from the fact that European explorers encountered oil palm in Guinea, Africa. Oil palm is cultivated in the tropics of Africa, Asia, and the Americas.

Origin and History

One authority, noting that all genera related to *Elaeis* originated in Brazil, posited that oil palm had originated in the New World, from where it was dispersed in pre-Columbian times to Africa. This assertion appears to gain strength from the fact that Arab traders and 13th-century Italian adventurer Marco Polo did not mention the oil palm in their travels, suggesting its absence from the Old World. Yet the pre-Columbian people of the Americas did not have ocean-going ships, making it difficult to suppose that they could have crossed the Atlantic Ocean with oil palm seeds to Africa. If oil palm truly originated in the Americas, some other agency must have been responsible for its dispersion. A more satisfactory hypothesis appears to be the conjecture that fossilized pollen, dating to the Miocene Epoch (23–5 million years ago), places the origin of oil palm in Africa's Niger River delta. Cultivation must be ancient because a 5,000-year-old tomb in Egypt yielded a jar with palm oil. Because Egypt is too arid for the cultivation of oil palm, the Egyptians must have obtained palm oil through trade.

In the 15th century, the Portuguese were the first Europeans to witness oil palm cultivation in Africa. Portuguese, Dutch, and English explorers described palm oil and oil palm wine. In 1606, Flemish physician and botanist Carolus Clusius noted that oil palm grew on the Guinea coast and that the Portuguese mixed palm oil with the root of another plant to feed slaves on the island of Sao Tome. This food was a provision for slaves on the transatlantic crossing to the Americas. In 1696, an English writer remarked that oil palms in Jamaica came from Guinea. By the 18th century, it was common knowledge among Europeans that slaves had brought oil palm from Africa to the Americas.

In the late 16th century, England began to import palm oil from Africa. Palm oil was then such a novelty that many Europeans were ignorant of its source. Some thought that it was derived from the roots rather than the fruit. The trade in palm oil was not initially robust. Europeans regarded Africa as a source of slaves rather than palm oil. In an era before the invention of vaccines and the discovery of antibiotics, Europeans could not penetrate Africa's interior to access the oil palm groves. Nevertheless, British imports of palm oil reached 143 tons in 1790 and 1,100 tons in 1810 (Hartley 1988, 9). In the 1830s, West Africa exported as many as 15,000 tons of palm oil per year and in the 1860s as many as 33,000 tons per year (Hartley1988, 10). In the 19th century, Europeans used palm oil and palm kernel oil to make soap and candles and as a lubricant. In the 1870s, palm oil was used to make margarine. By 1905, the United Kingdom's colonies in Africa exported more than 173,000 tons of palm kernel oil, more than two-and-a-half times the export of palm oil. In 1911, the United Kingdom's territories exported more than 96,000 tons of palm oil worth nearly 2 million pounds sterling. So important was Africa as a source of palm oil that in the early 20th century, Nigeria totaled roughly 75 percent of the world's production of palm oil and Sierra Leone contributed another 18 percent. Yet Africa faced competition not only from the tropical United States but also from Southeast Asia. In 1911, Belgium planted oil palm on the Indonesian island of Sumatra. By 1914, the island totaled

6,500 acres of oil palm. A second planting followed in Malaysia. By 1925, Sumatra had 78,000 acres and Malaysia 8,273 acres of oil palms.

Attributes

A tropical tree, the oil palm is cultivated most intensively between 3° north and 7° south. A lowland plant, it is seldom found above 900 feet, though humans have established it at higher elevations, where it survives with adequate rainfall. Africans have planted oil palm as high as 3,000 feet in Guinea and 3,900 feet in Cameroon. Because oil palm languishes in shade, it does not grow in a forest. It requires open space. Human activity in clearing forests must have aided the oil palm's spread, whether by rodent, bird, or human. In Nigeria, oil palm may be grown in areas of standing water, though the roots do not tolerate waterlogged soil.

Oil palm yields male and female flowers, though an occasional tree produces flowers with both female and male parts. Insects pollinate the flowers. In Africa weevils, in Malaysia thrips, and in the tropical United States, beetles pollinate oil palm flowers. A fertilized female flower yields fruit and nut. The nut may contain as many as three kernels, though one is the norm. Oil palm evolved in a climate of abundant rainfall in summer and aridity in winter and so tolerates fluctuations in rainfall. In dry weather, the leaves close their stomata to conserve water. Thanks to this adaptation, oil palm tolerates three months of dry weather. Benin, southern Zaire, and Nigeria experience two to four months of arid conditions. Venezuela has four months and northern Colombia five months with little rain. Despite its tolerance of uneven precipitation, oil palm prefers a uniform distribution of rainfall throughout the year. Oil palm requires at least 80 inches of rain per year.

The maximum temperature should average 85°F to 90°F and the minimum 70°F to 75°F. Oil palm does not grow below 59°F. The tree must have at least five hours of sunlight per day. Throughout Asia, oil palm is frequently grown on clay. In Malaysia, oil palm is grown on volcanic and sedimentary soils. In Indonesia, oil palm is cultivated on latosols from volcanic deposits and on alluvial soil that may contain peat. These soils are rich in elements, especially potassium, but long cultivation has depleted them. The sandy clays of Indonesia on which oil palm is grown are deficient in phosphorus and magnesium. The sandy soils of West Africa drain well, though they become dry when rainfall diminishes. In Zaire, oil palm is grown on latosols that drain well but are deficient in elements. In Ghana, oil palm is planted in soils that are deficient in potassium and magnesium. In Nigeria, oil palm is cultivated on latosol that is shallow in places and has a higher proportion of clay than elsewhere in West Africa. This soil is deficient in calcium, magnesium, and phosphorus, though potassium is adequate. In Benin, farmers grow oil palm on sandy soil atop clay subsoil. Clay may account for 30–60 percent of these soils. The soils on which oil palm is grown in Cote d'Ivoire are deficient in potassium.

Palm Oil in the 21st Century

In 2007 Malaysia, Indonesia, Nigeria, Cote d'Ivoire, Colombia, Thailand, Papua New Guinea, and Ecuador were the leading producers of palm oil. Malaysia and Indonesia totaled 80 percent of global production. Palm oil has surpassed even soybean oil in its use as an edible oil. Acre for acre, oil palm produces 3 times more oil than coconut and 10 times more oil than soybeans. Palm oil is the dietary fat of Africa and Southeast Asia as olive oil is the fat of the Mediterranean Basin.

Once regarded with suspicion because it contains saturated fat, palm oil is today deemed a healthy fat. Palm oil helps the body absorb vitamins D, E, and K and the elements calcium and magnesium. Palm oil contains neither trans fat nor cholesterol. Palm oil may protect one against heart disease and cancer, including breast cancer, and premature aging. It may reduce blood pressure and lower the incidence of arteriosclerosis.

Some alternative health practitioners believe that palm oil improves blood circulation and stabilizes the amount of sugar in the blood, combating diabetes. They believe that palm oil strengthens bones, teeth, lungs, the immune system, the eyes, and the liver and that palm oil may improve the function of the brain. Other scientists are skeptical of these claims. In addition to containing antioxidants, palm oil has more vitamin E and beta-carotene than any other food.

In the 21st century, electric power plants in Southeast Asia turned to palm oil to generate electricity. Results were initially promising. The combustion of palm oil did not pollute the atmosphere with greenhouse gases as does the burning of fossil fuels, but in their enthusiasm to produce more palm oil, farmers in Indonesia, to make room for palm oil trees, have cut down forests and burned peat, polluting the atmosphere with greenhouse gases. Because of these factors, Indonesia ranked third in 2007 in the production of greenhouse gases. The loss of these forests to oil palm monoculture has imperiled wildlife by spoiling their habitat.

Christopher Cumo

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Okra

Okra is the only representative of the Malvaceae or Mallow family that is a food. An annual herb, okra is related to cotton and hibiscus. Once classed as the species *Hibiscus esculentus*, okra is today in the genus *Abelmoschus*. *Abelmoschus* has 10 species, only 2 of which—*Abelmoschus esculentus* and *Abelmoschus caillei*—are cultivated as food. The Bantus of central and southern Africa called okra *ki ngombo* or *ochinggombo*, from which English has derived gumbo, a dish that features okra as an ingredient. In Egyptian and Arabic, okra is known as *bamiah*, in Hindi *bhindi*, in French *gombo*, in Spanish *guino gombo*, and in Portuguese *guibeiro*. Okra is also known as "lady's finger" and "gumbo." One hundred grams of okra have 31 calories, 1.8 grams of protein, 90 milligrams of calcium, 1 milligram of iron, 0.1 milligram of beta-carotene, 0.07 milligram of thiamine, 0.08 milligram of riboflavin and niacin, and 18 milligrams of vitamin C. The leaves are also nourishing, though they are not commonly consumed in the developed world. Okra seeds are 20–24 percent protein and 13–22 percent oil.

Origin and History

Scientists favor Asia or Africa as the cradle of okra. The Asian school points to an origin in India, Pakistan, Myanmar, or tropical Asia in general. If okra did not originate in the tropics of Asia, then it must have been imported. One hypothesis holds that okra was introduced into southern Asia sometime after the second millennium BCE. In 1883, however, French botanist Alphonse de Candolle and in 1951 Russian agronomist Nikolai Vavilov pinpointed Ethiopia as the homeland of okra. If they were correct, it seems odd that the plant did not migrate north to Egypt until the 13th century CE. Ethiopia then included part of Sudan, and in this large territory of East Africa, okra did well in hot, humid lands. From Ethiopia and Sudan okra spread west and south along the caravan routes to the Bantus. Spreading farther west, okra reached West Africa, though some scientists discount this migration, proposing instead that okra originated in West Africa. Whatever the truth of this claim, Europeans encountered okra in West Africa, possibly in the 16th century. Not until the 17th century did okra reach the Americas. In 1658, Angolan slaves brought okra to Brazil, from which it spread to Surinam. From an early date, Europeans branded okra a slave food, though slave owners ate it as they sampled the food prepared by their slave cook. By the late 1680s, slaves in the American South grew okra. The plant was a crop of gardeners and small farmers and seems to have been consumed locally. Certainly, it was not a cash crop. A staple of the slave diet, okra would later be an ingredient in "soul food." In the 18th century, the Cajuns of Louisiana adopted the African dish gumbo, adding to it pulverized bark from the sassafras tree when okra was scarce. When it was plentiful they withheld the bark. Maroon communities in Surinam grew okra along with rice, plantain, banana, yam, pigeon pea, watermelon, and sesame. Jamaican slaves planted okra with oil palm, yam, pigeon pea, banana, plantain, kola, pearl millet, rice, taro, and gourd. From an early date, okra was part of African-based religious rituals in the Americas. In the context of science, African American agricultural scientist George Washington Carver (ca. 1860–1943), though he gained renown for his work with the peanut, also conducted research on okra.

Okra was introduced into Europe in the 17th century. The Spanish and the people of southern France ate it, though it was not universally popular in Europe. In the 1980s Europeans, eating Cajun food, increased their consumption of okra, though it was still a minor part of European cuisine. Okra fared better in the Middle East and southern Asia, where it was an ingredient in stew. In the Middle East, people fried okra coated with cornmeal. Okra has traditionally been paired with fish, corn, tomato, and potato.

In 2001, the world produced about 6 million tons of okra, which totaled only 1.5 percent of total vegetable production. India was the leading producer of okra. In 2001, the country harvested 3.7 million tons on 862,000 acres. India exported okra to Singapore, Mauritius, Malaysia, Sri Lanka, and Bangladesh. Bahrain, Qatar, Kuwait, Saudi Arabia, Muscat, Iran, and Abu Dhabi imported okra. After India the leading producers were Afghanistan, Iran, Pakistan, Turkey, and the former Yugoslavia. In West Africa, the consumption of okra ranks second only to that of tomato among vegetables, though this comparison is valid only if one discounts the fact that tomato is a fruit. In India and the Sahel of Africa, okra is sliced and sun dried to preserve it. The people of Cote d'Ivoire consume the leaves of *Abelmoschus caillei*. In the Americas, okra is cultivated in Central and South America, notably in northeastern Brazil. In the United States, okra is cultivated in Georgia, Florida, Texas, Alabama, and Louisiana.

Attributes and Cultivation

A plant of the tropics, subtropics, and warm temperate regions, okra does not tolerate frost and so must be planted after the last frost in temperate lands. Because okra matures in 50 to 55 days, there is no need to stretch the growing season by planting okra indoors several weeks before the last frost. The farmer should plant six to nine pounds or seeds per acre, spacing them 8 to 16 inches apart. Seeds germinate in 4 to 14 days at 68°F to 86°F. According to one scientist, seeds germinate between 86°F and 95°F. Below 77°F, few seeds germinate. Above 107°F, plants drop their flower buds. Okra grows best between 70°F and 80°F. One scientist, noting that okra prefers heat and humidity, favors a temperature of 77°F and 65–85 percent humidity. Okra benefits from the addition of manure or a complete fertilizer with two or three dressings during the growing season. One scientist recommends the application of four-and-four-tenths tons of manure per acre and 132 pounds of both urea and potassium chloride per acre. Okra does well in fertile, well-drained, light soil. Okra may be planted in clay provided the soil has sufficient organic matter. The correct pH is a matter of debate. One source proposes slightly acidic soil with a pH between 6 and 7. Another favors slight alkalinity with a pH between 7 and 8. A third favors neutrality: a pH of 7. An okra plant needs three-tenths of an inch of water per day. Under irrigation okra should be watered every other day.

In addition to its intolerance of frost, okra does not grow below 68°F and does not tolerate temperatures below 59°F, waterlogged soil, or dry conditions. Given the right conditions, an okra plant flowers 45 to 50 days after planting. The first flowers to open are those from the third to seventh node from the base of the plant. The stigma is receptive to pollen two hours before anthesis and remains receptive three to four hours after anthesis. Each okra flower has both anthers, as many as 100 per flower, and stigma. Flowers, large and yellow, attract insects, which cross-pollinate flowers in instances where they do not self-pollinate. Where the climate is arid, pollen desiccates and does not pollinate the stigma. Flowers open before dawn and close by mid-afternoon. Self-pollination is likely in the morning. Once pollinated, flowers rapidly yield seed pods, which reach two inches three days after fertilization. Pods should be picked at this stage. If pods are allowed to enlarge, they become too tough to eat. The gardener should pick pods every two or three days to avoid the problem of toughness.

West Africans cultivate both *Abelmoschus esculentus* and *Abelmoschus caillei*. The first flowers one or two months after planting. Because this species is planted at the beginning of the rainy season in May, it is known as "rainy season okra." *Abelmoschus caillei* flowers two to four months after planting. It yields its pods during the dry season and is known as "dry season okra." Because *Abelmoschus caillei* is a large plant, seeds should be spaced 30 inches apart. The two species are grown from Guinea to Cameroon.

Christopher Cumo

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Olive

A source of fruit, oil, and wood, the olive tree is an ancient cultigen. In 1764, Swedish naturalist Carl Linnaeus named the cultivated olive *Olea europaea*. *Olea* is Latin for "olive tree" and may derive from the Greek *elaion*, meaning "a plant that produces oil." The species name *europaea* means "of European origin," a reference to the supposition that the olive tree may have been native to the Mediterranean Basin. Indeed, *Olea europaea* is the only species in the genus that may have been indigenous to the Mediterranean. A member of the Oleaceae family, the olive has garnered attention for its health benefits. The olive is rich in antioxidants, among them vitamin E. Its oil is a healthy fat. Perhaps because of the attention on its contributions to health, worldwide consumption of olive oil increased 55 percent between 1992 and 2002.

Mythology and Religion

The olive tree symbolized peace to the ancients because it needed many years to bear fruit. Chaos could not engulf the countryside if the olive was to prosper. The association between the olive and peace may be at the core of the story of the deluge in Genesis. Once the rains subsided, Noah sent a dove to find land. It returned with an olive branch, establishing a covenant of peace between God and humans. The olive branch heralded a new beginning to life after the flood. The olive tree appeared in Deuteronomy, whose writer named it a source of wisdom. The prophet Jeremiah compared the olive tree to a just man. Ecclesiasticus lauded the olive tree for its abundance. The Hebrews used olive branches during the Feast of the Tabernacles. At weddings, couples carried olive branches. Along with wine and grain, the olive was one of the primary foods that God gave the Hebrews. Christianity, true to its Jewish roots, incorporated the

Olives (Chris Hill/Dreamstime.com)

olive in myth and ritual. According to one tradition, Jesus's cross was olive wood. Catholics use olive oil at baptism, confirmation, and the anointing of the sick.

Revering the olive tree as sacred, the Greeks believed that the gods gave it to them. The story of its origin concerns a contest between the god Poseidon and the goddess Athena. The two quarreled over who would be the benefactor of Athens. They agreed to let the other gods judge their offerings to the Athenians. Poseidon pricked the ground in the Acropolis with his trident. From the spot gushed a stream of life-giving water. Athena responded by giving the Athenians a small branch. Although it appeared to be unimportant, the branch, Athena said, would yield a tree that would live centuries, producing food and oil for the preparation of food and for treating wounds, strengthening the body, and producing light when burned. Judging the olive tree more useful than water, the gods named Athena the goddess of Athens. Another account holds that an olive tree germinated spontaneously after a fire swept through the Temple of Athena. Accordingly, the Greeks considered the olive tree a symbol of regeneration. Because of the olive's importance to Greece, parents gave a newborn a small olive branch and adorned the dead with crowns plaited with olive leaves. According to one account Cecrops, the first king of Attica, taught the Greeks to extract oil from olives. Another tradition holds that Aristeo, the god of the Arcadians, taught the Greeks to extract olive oil.

According to tradition Persian king Xerxes, preparing to invade Greece in the fifth century BCE, had a dream in which he wore a crown of olive leaves, from which grew the branches of an olive tree. The tree grew so large that it covered the entire Earth. Despite this story of the olive tree's conquest of the world, Xerxes failed to conquer Greece. Like the Greeks, the Romans believed the olive tree to be sacred. Those that the Romans esteemed heroes wore crowns of olive leaves. The goddess Minerva tended olive trees. The olive symbolized civilization, through which the Romans brought stability and order to the provinces. The olive tree bound city and countryside because urbanites were the consumers of the farmer's olive oil.

Like the Greeks and Romans, the Algerians regarded the olive tree as sacred. It symbolized "the invisible one." The olive tree also symbolized protection and fertility. Women prayed to olive trees that they might become pregnant and achieve robust health. Muslims believed that the olive tree symbolized goodness. Muslims lit a lamp with olive oil at the birth of a child, keeping it aflame for seven days until the parents presented the newborn at the sanctuary. The flame in the lamp symbolized the presence of the soul in the body. The lamp, supplied with olive oil, was a source of illumination and wisdom that lit one's way to the Kingdom of God. The Egyptians assigned goddess Isis the task of tending the olive tree. She taught the Egyptians to extract olive oil. The priests anointed themselves with olive oil as an act of purification.

Origin and History

Scholars have proposed several hypotheses about the olive's origin. A number of scholars pinpoint Asia as the continent of origin. In 1883, French botanist Alphonse de Candolle proposed Syria as the place of origin. In 1949 and 1950, Russian agronomist Nikolai Vavilov asserted that the olive had originated in Syria and Iran. One authority asserts that the cultivated olive descended from the species *Olea cuspidate*, placing its origin in India, Nepal, and Afghanistan. Another maintains that the olive arose as a hybrid with one parent being *Olea ferruginea*, an Asian species. Others favor Turkey. Still others, shifting the focus to Africa, favor Ethiopia or Egypt or both as the olive's homeland. In the Africa-first camp, one expert asserts that the olive descended from *Olea africana*, a species native to Sudan and Egypt. Another proposes a descent from *Olea laperrini*, a species indigenous to the mountains of the Sahara Desert. Those who favor a European origin cite Italy as the homeland of the olive. They point to fossilized olives dating from the Mesolithic and Neolithic Ages (12,000–3000 BCE) in Sicily, Puglia, and Sardinia. The most wide-ranging hypothesis traces the olive's lineage to species native to Africa, Arabia, and Afghanistan.

Scholars likewise debate when and where humans first cultivated the olive. One hypothesis holds that people first cultivated the olive in the eastern Mediterranean and in lands near the Black Sea and Persian Gulf. Another hypothesis places the origin of cultivation in the Canary Islands and northwestern Africa, from which husbandry spread east to Iran and from southern France south to Ethiopia and the Mascarene Islands. A Hamitic-Semitic people who lived south of the Caucasus Mountains may have been the first to cultivate the olive about 6000 BCE. Alternatively, cultivation may have arisen in the Near East in the fourth millennium BCE, spreading west to the Mediterranean. Farmers cultivated the olive as early as 3000 BCE in Lebanon and the island of Crete. Egyptian papyri (2300 BCE) and the Code of Babylonian king Hammurabi (1700 BCE) established the cultivation of the olive in Egypt and Babylon. The Hamitic-Semitic people may have brought the olive to Syria and Turkey in the 15th century BCE. First-century CE Roman encyclopedist Pliny the Elder praised the quality of Syrian olives.

From Syria or Turkey the olive spread to Egypt before 2000 BCE. Some argue for the use of olive oil in Egypt as early as the 21st century BCE. Others favor a date as late as the 15th century BCE. Egyptian tombs contained olive leaves, evidence of the importance of the tree. Pharaoh Ramses III (1198–1166 BCE) planted olive trees around the Temple of Thebes and offered olive oil to the god Ra. The dead in royal tombs from this period wore crown of olive leaves. The Egyptians used olive oil to make perfume and salves. It was a condiment and a source of lighting. Yet the olive was not widespread in Egypt, being confined to lands along the Nile River, and Egypt was not a large producer of olives and oil.

Fourth-century BCE Greek botanist Theophrastus and others did not consider Egyptian olives a good source of oil. An olive oil importer, Egypt must not have produced enough oil to satisfy demand. The Egyptians may have introduced olives to Nubia and Ethiopia sometime between the 21st and 15th centuries BCE. The Phoenicians brought olives from Syria to the island of Cyprus in the 16th and 15th centuries BCE. From Cyprus the olive spread to the islands of Rhodes and Samos.

On the Greek mainland, the cultivation of olives may predate 3500 BCE. So important was the olive tree to the Greeks that they condemned to death anyone who destroyed a tree. Law forbade an owner from cutting more than two feet of wood from a tree per year. In Greece, the winners of athletic contests received olive oil. The winner of one chariot race, for example, received 140 amphoras of olive oil. The Phoenicians and Greeks established the olive tree in Sicily in the seventh century and in Sardinia. The Etruscans imported olive oil from Greece, using it to make perfume and as a source of illumination. They also imported olive oil from the Greek colonies of Campania. Pliny wrote that olive culture was widespread in Italy in the seventh century. In the sixth century BCE and perhaps earlier, the Romans cultivated the olive, though the Po River valley may have been a separate center for the origin of olive culture in Italy. Roman agricultural writers Cato the Elder, Varro, and Columella, and Roman poets Horace and Virgil gave advice on cultivating the olive. The Romans imported olive oil from North Africa and promoted the cultivation of olives there. In the second century, Emperor Trajan compelled North Africans to tend olive trees. Emperor Diocletian (245–316 CE) established three prices for olive oil: 40 denari for virgin oil obtained from the first pressing, 24 denari for second-quality oil, and 12 denari for ordinary oil. The Phoenicians may have brought the olive to Spain, though some scholars believe that the Romans introduced it to Spain in 207 BCE. De Candolle believed that the Arabs brought the olive to Spain. According to him, the Phoenicians introduced the olive to northwestern Africa, Libya, and Tunisia when they founded Carthage in the ninth century BCE. In the eighth and seventh centuries, the Greeks introduced the olive into Cyrenaica. The scale of olive culture there impressed Theophrastus.

Greek philosopher Democritus (460–370 BCE) recommended the rubbing of olive oil on the body to promote longevity. Greek physician Hippocrates (460–377 BCE) recommended olive oil rubs as treatment for a variety of ailments. First-century CE Greek physician Dioscorides believed that olive oil was a laxative. Pliny believed that olive oil could whiten teeth and heal diseased gums. In antiquity, the Phoenicians and Greeks exported olive oil to the rest of the Mediterranean. The Greeks used olive oil in soup and sauce. The average Greek consumed 13 to 15 gallons of olive oil per year. Of this amount they used 4 or 5 gallons in preparing food, 5 gallons in making perfume and cosmetics, 0.50 gallon in performing religious ceremonies, 0.8 gallon in lighting lamps, and 0.13 gallon in preparing medicine.

In the Middle Ages, the kings of France were anointed with olive oil as a declaration of their status. In the 16th century, the Spanish brought the olive tree to the New World, planting it in Argentina in 1556, Peru in 1560, Antilles, Chile, and Mexico by 1697, and California in 1769. In the 18th century, Europeans used olive oil to make soap, to treat wool, and to illuminate lamps. Today, farmers grew olives in California, South Africa, Chile, Peru, Argentina, Australia, New Zealand, Israel, Turkey, and several countries in Europe. In 2009, farmers worldwide harvested 18.2 million tons of olives. Spain was the leader with 6.2 million tons. Italy ranked second with 3.6 million tons. Greece produced 2.4 million tons, Turkey 1.3 million tons, and Syria 886,000 tons. The United States was not a leading producer.

Christopher Cumo

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Onion

A perennial bulb grown as an annual, the onion is a member of the Amaryllis family and is related to garlic, leek, shallot, and chive. The species name, *Allium cepa*, may derive from the Latin *cepa* or *caepa*, meaning "onion." It is also possible that onion derives from the Celtic *cep*, meaning "head," a probable reference to the shape of the bulb. From the Latin or Celtic are derived the Polish *cebula*, the Spanish *cebolla*, the Italian *cipolla*, the Czech *cibula*, and possibly the Scottish *sybo*. In the first century CE, Roman agricultural writer Columella referred to the onion as *unionem*, the source of the French *oigam* and the English onion. The Dutch called the onion *ui*, and the Germans called it *zwiebel*. The Chinese *yang cong* means "foreign onion" and may refer to the fact that the onion is not indigenous to China. The Greeks knew the onion as *bolbos*, from which derives the word "bulb." From *bolbos*, the Romans derived *bulbus*. It appears therefore that the Romans had two words for onion: *unionen* and *bulbus*. The onion is 86 percent water, 11 percent carbohydrates, 1.4 percent protein, 0.8 percent fiber, and 0.2 percent fat and has vitamins A and C, niacin, riboflavin, thiamine, and calcium. As a seasoning, onion trails only butter, salt, and pepper. The onion is grown worldwide in the subtropics and temperate locales. In addition to the common onion, gardeners grow the ever-ready onion, the potato onion, and the tree onion.

Origin and History

The wild ancestor of the onion is extinct, suggesting the antiquity of cultivation. One authority believes that it is no longer possible to pinpoint the origin of the onion. Another places its origin in Iran, western Pakistan, Turkestan, Uzbekistan, and Mongolia. An Islamic legend holds that Satan, after tempting Adam and Eve, left Eden. In the print of his right foot grew an onion. Where his left foot trod grew a garlic bulb. With such a diabolical origin, one wonders whether the onion was fit for consumption. Yet it has a long history as a food plant. Humans may have cultivated the onion as early as 5000 BCE. The Egyptians began growing the onion about 3200 BCE. In the fifth century BCE, Greek historian Herodotus remarked that the Egyptians spent 1,600 silver talents (worth $30,000 today) on onions, garlic, and radishes to feed the pyramid builders. The elites of Egypt included onions in their feasts. Regarding it as a sacred plant, the Egyptians offered the onion to the dead at funerals by 2800 BCE. Placing onions on altars, the Egyptians offered them to the gods during religious rites. They entombed onions with the dead, placing them in the thorax, the pelvis, the ears, near the eyes, and on the soles of the feet. Egyptian tomb paintings included the onion, probably because it was a sacred plant. Egyptian priests did not eat onions during religious festivals, perhaps because they were sacred. It is also possible that religious law forbade priests from eating onions during certain times of the year. The Egyptians believed that onions had a soul, a belief that second-century CE Roman poet Juvenal mocked.

The Hebrews apparently encountered the onion during their captivity in Egypt. Exodus recorded the complaint that the Hebrews had only manna to eat in the wilderness. They yearned for the onions and other vegetables that they had known in Egypt. Greek physician Hippocrates (460–377 BCE) knew of the onion, though his knowledge may have been secondhand if it is true that only in the mid-fourth century did the army of Greek conqueror Alexander the Great introduce the onion from Egypt to Greece. Alexander adopted the Egyptian belief that the onion gave one strength and courage and so he fed it to his soldiers. First-century CE Greek physician Dioscorides and fifth-century Irish cleric Palladius were also familiar with the onion.

In the 1490s, Spanish-Italian explorer Christopher Columbus introduced the onion to the Caribbean island of Isabella. Following the Spanish, European immigrants brought varieties of onion to the New World. In the 17th century, the Iroquois cultivated onions in New York. In 1634, American author William Wood wrote that the people of Massachusetts grew onions. The dehydration of onions, which reached a commercial scale during the U.S. Civil War, made available onion flakes, onion powder, onion salt, onion rings, and onion dip. Manufacturers added onion to instant soup, tomato sauce, and ketchup. The Brazilians used onion as a spice. Hondurans used it as an herb. Outside the Americas, Filipinos, like many other people, used onion to season food. In Africa, people used onion to repel insects, believing it effective against moths and mosquitoes.

Varieties and Cultivation

In the fourth century BCE, Greek botanist Theophrastus was familiar with four varieties of onion. In the first century CE, Roman encyclopedist Pliny the Elder remarked that the Greeks grew seven varieties: Sardinian, Samothracian, Alsodenian, Setonian, Split, Ascalon, and Tuscany. To this list Columella added Pompeian, though it must have been a Roman rather than a Greek variety. Archaeologists have confirmed the presence of onions in Pompeii.

During the 19th century, the number of varieties increased. In 1806, the *American Gardener's Calendar* mentioned 6 varieties in cultivation. In 1863, the *Field and Garden Vegetables of America* listed 14 varieties. In 1883, French nurseryman Pierre Vilmarin totaled 60 varieties, which were presumably grown in France. In 1888, Burpee and Company alone listed 9 varieties: Earliest White Queen, New Golden Queen, Giant Rocca, Silver White Etna, Pale Red Etna, Silver Ball, Tripoli, New Mammoth, and Silver King. The company boasted that Silver King was second in size only to New Mammoth Pompeii, weighing nearly five pounds.

Onion varieties are classified as short, intermediate, or long day depending on their response to the length of day. Short-day cultivars initiate the formation of bulbs when the day is 12 to 13 hours long. Farmers and gardeners grow short-day varieties in the subtropics, which meet the requirement for 12- to 13-hour days. They cultivate intermediate- and long-day cultivars in southern Australia and New Zealand, where most onions are grown in these countries and where 14- to 16-hour days trigger onions to form bulbs. Long summer days make long-day varieties the choice of gardeners and farmers in the United Kingdom, Northern Europe, Canada, and the northern United States. Long-day cultivars popular in the northern United States are Ebenezer, Wetherfield, and Globe. Short-day cultivars suitable for the South include Bermuda, Creole, and Early Grano. Sweet Spanish does well in both North and South. The varieties Bermuda, Spanish, Grano, and Grenex yield large bulbs.

One may raise onions from seeds, sets, or seedlings. Propagation by seeds is the cheapest method of growing onions but is also the most time consuming. A perennial, the onion flowers in the second year and, once pollinated by insects, yields seeds. Needing a temperature between 59°F and 77°F, seeds germinate in 6 to 10 days. Above 81°F, the rate of germination diminishes. One may sow seeds in a seedbed. In 8 to 10 weeks, the gardener will have plants large enough to transplant in the garden. Alternatively, the gardener or farmer may sow seeds directly into the field, planting them one-half to one inch deep. Under ordinary conditions, some seeds may remain viable three years, though it is possible to increase this duration. One study demonstrated that dry seeds sealed in glass remained viable more than 12 years. Warmth and humidity decrease viability. Where the growing season is long, one may plant seeds in late August and September for a second crop. In this case, the gardener may mulch plants with hay to nurse them through the winter. Onions will resume growth in spring.

Where the growing season is short, the gardener may plant onion sets or seedlings. Sets are more expensive than seeds but usually will not suffer from the afflictions of seeds: damping-off disease and poor germination. Planted with the desired spacing, sets require no thinning or transplanting. For this reason, sets require less work than raising onions from seeds. Yet sets may carry nematodes and pathogens from the soil where they were grown as seedlings. Gardeners plant onion sets in the North and Midwest. The varieties Ebenezer and Danvers are often grown from sets. One should plant sets deeper in light soil than in heavy soil. The gardener should plant each set three to four inches from its neighbors. One gardener placed sets atop the soil, then covered them with hay. The sets produced a respectable crop even though they were never planted in the traditional manner.

Alternatively, one may purchase seedlings, transplanting them in the garden. This method yields onions the fastest with the least work, but plants tend to be expensive. Seeds companies distribute seedlings in the South beginning in December and in the North through June. Nevertheless, one must be cautious. Seedlings, like sets, may acquire nematodes and pathogens from the soil in which they were germinated.

Gardeners prize onions because they yield abundantly while occupying little space. Onions will grow in a range of soils, though sandy loam and peat are best. The soil must be fertile, loose, well drained, and cultivated to remove weeds because onions do not compete well against weeds. The soil should contain organic matter. The gardener should fertilize the soil one week before planting onions. The gardener must apply nitrogen, phosphorus, and potassium in quantity for onions to yield well. One gardener recommends a fertilizer with a ratio of 5:10:5 of nitrogen to phosphorus to potassium. Some varieties of onion benefit from extra nitrogen, whereas others will not store well because of their surfeit of nitrogen. One gardener recommends a fertilizer rich in potassium. There is no consensus regarding the proper soil pH for onions. One authority recommends that the pH be between 6 and 8. According to a second, the pH should be above 6.5. A third recommends a pH between 5.8 and 6.5. Onions need cool weather to form the stem and warm weather to develop the bulb. Onion plants grow best between 54°F and 68°F, though bulbs will not form below 60°F. The bulb forms from the leaf base and may be brown, red, yellow, green, and white. Onions tolerate frost, but temperatures below 50°F will cause plants to seed rather than form bulbs. Temperatures above 86°F produce small bulbs. The gardener should plant onions in an area with full exposure to sunlight. A heavy soil yields smaller bulbs than a light soil. As a rule, the larger the plant the larger will be the bulb.

When plants yellow onions are ready to harvest. Some gardeners break the stem to induce a plant to die, but this method may introduce pathogens at the point of breakage. After the harvest the gardener may, if the sky is clear, allow onions to dry in the sun one or two days. An additional two weeks in a dry, ventilated area complete curing. Onions are best stored at 32°F with 60–70 percent humidity. If the temperature is too high, onions may sprout. Temperatures that are too cold may freeze onions. Curiously the onion, although it has a reputation for protecting other plants from insects, is nonetheless susceptible to pests.

Health

A first-century CE Indian medical text, the *Carake-Semihita*, recommended the onion as a diuretic. According to the author, it improved digestion and the function of the eyes and heart and treated rheumatism. Yet Indians thought onions were not a proper food for holy people. Brahmans, Buddhists, Hindu widows, and Jains did not eat onions. The ancients used onions to treat cough, the common cold, croup, wounds, boils, pimples, ulcers, sores, hemorrhoids, rheumatism, gout, epilepsy, worms, asthma, tuberculosis, and other maladies. In the 16th century, British herbalist John Gerard reiterated several of these uses. He believed that onions could treat obesity and baldness. Gerard recommended that a person who was losing his hair should stand in the sun while rubbing onion juice on the scalp to stimulate the hair follicles. In his most enthusiastic vein, Gerard wrote: "It [the onion] is cherished everywhere in kitchen gardens." Yet Gerard tempered his enthusiasm, complaining that onions caused headache and flatulence, injured the eyes, and made one groggy. It is difficult to know what effect his pronouncements had on Britons. Demand apparently exceeded supply in England, which imported onions from Spain. In 1877, the U.S. Dispensatory of Medicine remarked that onion oil aided digestion, treated bronchitis, and functioned as a diuretic.

The Greeks believed that the onion was an aphrodisiac, a belief that persisted in England into the early modern era. In ancient Thrace in southeastern Europe, the guests at a wedding gave onions to the bride and groom to ensure their fertility. Some people believed that onions remove freckles. Chileans believed that the onion was a stimulant. In the Bahamas, people rubbed onion juice on the chest to relieve congestion. Placed in the shoes, onions cured the common cold, they believed. The people of Trinidad boiled an onion in water, inhaling the steam to treat cough, the common cold, and tuberculosis. In the Yucatan, people mashed onions, using them to treat scorpion and spider bites. In Curacao, people put the neck of an onion in an ear to treat earache and ringing in the ears. They used onion peels to disinfect rooms. The Chinese ate peeled onion fried in peanut oil to relieve constipation. They used onion juice to treat spider bites and protect plants from diseases. One herbalist believed that onions stimulated the appetite and helped one fall asleep at night. Herbalists used onions to treat bronchitis. Onion soup was reputed to treat infects of the chest. Home remedies enlisted the onion to treat anemia and infections of the stomach and urinary tract. An onion may be grated and rubbed on joints to treat rheumatism. Rubbed on insect bites, onions reduced pain and inflammation. Despite these putative benefits the onion may cause heartburn.

Christopher Cumo

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Orange

A fruit tree, the orange grows in the tropics and subtropics. An indigene of the Old World, the orange spread throughout Eurasia and Africa in antiquity. Its ubiquity led people in diverse regions of the world to coin their own word for the orange. The Persians referred to the orange as *narang*. In Armenian, the orange is known as *narinj*, in Arabic *naranj*, in Latin *arangia*, in Spanish *naranja*, in Portuguese *laranja*, in Italian *arencia*, and in Old French *oranje*. The English coined the term "orange" in the 14th century. The orange arrived in the New World as part of the Columbian Exchange. Sinking roots in Florida and Brazil, the orange has made

Oranges (Valentyn75/Dreamstime.com)

large growers prosperous. An orange tree may live longer than 50 years, during which it may yield more than 1,000 oranges.

Oranges and orange juice are rich in vitamin C, thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, folic acid, calcium, iron, magnesium, phosphorus, potassium, and zinc. One serving of orange juice has 12 percent of the recommended daily allowance of folic acid. The body that is nourished by oranges and orange juice readily absorbs iron. In addition to vitamins and minerals, oranges contain antioxidants that may protect against cancer. The consumption of oranges and orange juice lowers a person's cholesterol and may reduce the risk of stroke. Yet fresh orange juice loses 70 percent of its vitamin C in seven hours. The freezing of juice to make concentrate destroys some of the antioxidants. Some manufacturers compromise the nutritional value of orange juice by adding corn syrup or beet sugar. These ingredients sweeten orange juice but they also add unwanted calories. The consumption of too much orange juice of this kind may cause obesity.

Taxonomy, Origin, and Diffusion in the Old World

There are three species of orange. The sweet orange is the most familiar to consumers and the most widely grown. Scientists believe the sweet orange to be a hybrid between the mandarin orange and the pomelo. To denote its status as a hybrid they named it *Citrus* × *sinensis*. The mandarin orange, the clementine, and the tangerine, *Citrus reticulate*, are a minor crop, occupying only a few percent of Florida's citrus acreage. In Japan, the mandarin orange is widely cultivated and is also grown in Italy and Australia, though not in large quantities. The sour orange, *Citrus aurantium*, is grown in Southern Europe, especially Spain, where it is known as the Seville orange. The sour orange is an ingredient in marmalade, to which it imparts tartness. The ancients put juice from the sour orange on fish and meat much as moderns use lemons and limes to flavor these dishes.

The origin of the sweet orange is contested. Some scientists believe it arose in China. The term “Chinese orange” or “Chinese apple,” applied to the sweet orange, implies an origin in China. Others favor Southeast Asia as the place of origin. In this camp are those who posit that the sweet orange arose in Malaysia. Still others point to northern India. In antiquity, the orange spread to East Africa and the Levant. In the fourth century BCE, Alexander the Great encountered the orange in India and his troops brought it to the eastern Mediterranean. By the time of Christ, farmers in Italy grew the sweet orange. Mosaics from the fourth century reveal that farmers in the Byzantine Empire grew the orange. In the ninth century the Arabs, conquering Spain, introduced the sour orange to the Iberian Peninsula. During the Crusades, the Arabs introduced it into Sicily and parts of Southern Europe. In 1179, Chinese writer Han Yen Che published a *Treatise on Oranges*, describing the cultivation, breeding, and medicinal uses of the fruit. After Portuguese explorer Vasco da Gama established an oceanic route to India, the Portuguese brought the orange to Southern Europe. This introduction appears to have been one of several attempts to establish the orange in Southern Europe.

Europeans prized the orange. In the Middle Ages, the Byzantine governor of Rome sent a basket of oranges to the king of the Lombards in hopes of enticing him to join the governor in a war against the Byzantine emperor. In a similar incident, the prince of Salerno sent oranges to the duke of Normandy, requesting his help in fending off an Arab attack on Italy. At first Europeans appreciated orange trees and their fruit for their beauty. In Italy, the wealthy planted oranges in their gardens for shade and aesthetics. French king Charles VIII, invading Italy in the 15th century, found orange trees irresistible. He erected a greenhouse for their culture at his castle at Amboise. His wife likewise established a greenhouse for this purpose at her castle in Blois. King Louis XIV planted orange trees at Versailles in 1764. Believing the orange an aphrodisiac, he took it with alcohol and sugar.

Europe’s royalty was not alone in planting orange gardens. In Greek mythology, the goddess Hera grew oranges in her garden. Mortals coveted Hera’s oranges because they made one immortal. Hercules stole the oranges from Hera, but the goddess Athena rescued them, returning the fruit to her. Because the orange is a prolific tree, Europeans thought it a symbol of fertility. In literature, the gathering of orange blossoms was a metaphor for seeking a spouse. Renaissance art featured orange trees, often with biblical scenes, though the ancient Hebrews had not cultivated the orange. Some artists used the orange to symbolize Mary and so placed her in an orange grove. Italian artist Sandro Botticelli featured orange trees in the paintings *Primavera* and the *Birth of Venus*. Artists painted images of oranges on the ceiling of Palazzo Pitti in Florence.

In addition to being the subject of mythology, literature, and art, the orange had a utilitarian value in improving the lives of sailors. Long the bane of sailors, scurvy rendered its victims too weak to work aboard ship. In the 18th century, scientists came to appreciate that citrus fruits protected one against scurvy. With this new understanding of the value of citrus, the Portuguese, Spanish, and Dutch provisioned their ships with oranges and planted orange trees along their trade routes. Physicians believed the orange could cure more than scurvy, prescribing it for stomach ailments, impotence, bubonic plague, and worms and to neutralize poison.

Among varieties, the Shamouri orange grows in Israel. Seedless and sweet, it is exported from Jaffa and for this reason is known as the Jaffa orange. In 1191, English king Richard the Lionhearted spent the winter in a Jaffa orange groves. Perhaps for this reason the English believe the Jaffa orange superior to other varieties. Spain had 35 million orange trees in the 1960s. Harvesting 6 billion oranges per year, one for every person on Earth today, Spain exported more oranges than any other nation that decade. Even the United States trailed Spain as an exporter. That decade Italy yielded 4 billion oranges per year and perhaps many more since then, most of them being grown on parcels of one or two acres. In the 1960s, the Irish ate oranges at the movie theater much as Americans eat popcorn. That decade Icelandic farmers grew, and some gardeners still grow, oranges in greenhouses that derived heat from volcanic springs.

The New World

Christopher Columbus had been an architect of the new trade routes that others exploited. In 1493, during his second voyage, Columbus planted the orange on Hispaniola (now the island of Haiti and the Dominican Republic). In 1513, according to one account, Spanish explorer Ponce de Leon introduced the orange to Florida. Another account holds that the Spanish planted the orange in Saint Augustine, Florida, but not until 1565. A third account credits Spaniard Pedro Menendez with planting the first orange tree in Florida in 1579. In 1707, Spanish missionaries introduced the orange to Arizona. In 1804, Catholic priests planted a large orange grove at the San Gabriel Mission in California. In the 1840s, California made the transition from rangeland to orange grove. After 1850, Los Angeles and Miami used the orange as a symbol of exotic lands where one could enjoy a respite from the workaday world. In the United States, the orange symbolized prosperity.

Among the pioneers of orange culture was Pennsylvania émigré William Wolfskill, who in 1841 planted the first orange grove in California, then part of Mexico. With just two acres in 1841, Wolfskill expanded to more than 100 acres in 1860. By 1862, he owned two-thirds of California's orange trees. So abundant were his harvests that in 1886 Wolfskill loaded an entire train with oranges for shipment east. By then his groves earned thousands of dollars per acre per year. Yet Wolfskill's tenure was brief. In 1888, the family sold part of its land to the Pacific Railroad, and in the 1890s commercial and residential real estate developers bought the rest.

About 1815, the navel orange arose as a sport from a tree near Bahia, Brazil. Another account holds that the navel orange descended from a Portuguese variety, one evidently grown in Brazil. Farmers first grew the navel orange in Australia in 1824, in Florida in 1835, and in California in 1870. Whereas Brazil had been too hot and humid for the navel orange, California had an ideal climate. Between 1873 and 1888, farmers planted more than 1 million navel orange trees near Los Angeles. In 1877, California growers sent the first railroad shipment of oranges to St. Louis, Missouri. That year California's San Gabriel Valley devoted thousands of acres to oranges. Just two years later acreage had expanded. In 1885, blight killed some of the state's orange trees, prompting growers to sell their land to real estate developers. Yet most farmers held their land. By 1889, the farms near Los Angeles totaled tens of thousands of acres to oranges. By then the state produced oranges year-round. Prosperous, California growers adopted the slogan "oranges for health, California for wealth."

In the 1920s and 1930s, California produced more oranges than Florida. The Great Depression left orange growers in crisis. Many families did not have enough income to afford fresh fruit, leaving oranges in oversupply. Unable to sell their oranges, growers burned them, an act that shocked Americans. In the midst of a depression, hungry Americans could not understand why anyone would destroy food. In *The Grapes of Wrath*, American novelist John Steinbeck condemned growers for burning oranges, which could have been used to feed hungry migrants. After the depression, Florida surpassed California in the production of oranges. After Florida and California, Texas and Arizona grow sizable quantities of oranges. Small amounts are grown in Louisiana, Mississippi, Alabama, and Georgia. The United States harvests billions of oranges per year. The vast majority of Florida's oranges are processed into juice, whereas the majority of California's crop is consumed fresh.

Equatorial Brazil produces oranges with little acid because the closer to the equator an orange tree grows, the less acidic is its fruit. In Trinidad and Tobago, street vendors sell oranges. They slice an orange in half, salting the pulp. In 2002, Jamaica produced hundreds of thousands of tons of oranges. In 2004, this figure rose. The latter year Dominica yielded several thousand tons of oranges. In Cuba, however, production held roughly constant. A hurricane killed orange trees in 2002 and lowered yields slightly.

Orange Juice

During the 20th century, orange growers processed an ever larger fraction of their harvest into orange juice. In the early 20th century, pasteurization killed the bacteria that might have otherwise made orange juice unsafe. Trucks brought orange juice to northern and midwestern markets, expanding the reach of orange growers. In the aftermath of the Spanish flu, mothers wanted to give their children food and drink that would ward off contagion. When physicians recommended orange juice, these mothers bought copious quantities of the liquid. Health-conscious Americans appreciated the benefits of orange juice. By the 1920s, orange juice had become a popular breakfast beverage. By then orange juice came chiefly from Florida, which produced the juiciest oranges. California, in contrast, produced oranges with less juice that were sold as fresh produce. In 1950, one-half Florida's orange crop went to juice whereas in California the figure was one-quarter. Whereas the United States processed several percent of oranges into juice in 1934, the figure rose to more than half of all oranges in 1953.

This increase owed much to the baby boom. The post–World War II increase in the birthrate spurred the consumption of orange juice. Parents who had been reared on orange juice fed it to their children in turn. In the 1940s, manufacturers began to make orange juice from frozen concentrate. Between 1945 and 1960, the consumption of orange juice tripled in the United States. In 1999, the average American drank several gallons of orange juice. To keep pace with this consumption a factory can produce several hundred gallons of orange juice per minute. The beverage nets billions of dollars in revenues per year in the United States. Brazil is the world's largest producer of orange juice, totaling the majority of the world's output. Coca Cola buys juice from Brazil, selling it under the Minute Maid label. Anxious to prevent Brazil from gaining too large a share of the market, Florida growers convinced Congress to impose a tariff on Brazilian juice in the early 21st century. The wealthiest Brazilian planter, Jose Cutrale, responded by purchasing orange trees in Florida, thereby circumventing the tariff. With land in Brazil and Florida, Cutrale has millions of orange trees. Florida and São Paulo, Brazil, total nearly all the world's production of orange juice. Brazil grows twice the number of oranges as Florida. Because labor is cheap, growers in São Paulo employ tens of thousands of workers to pick oranges by hand. The mechanical tree shaker is not widespread. São Paulo reaps several billion dollars in revenues from the sale of orange juice. The people of the United States, Denmark, Honduras, the Philippines, Jamaica, and Trinidad and Tobago drink orange juice at breakfast.

Cultivation

As is true of other crops, the orange depends on minerals in the soil for nourishment. The citrus lands of Arizona have calcium, magnesium, sodium, phosphorus, and potassium, though Florida's soils may lack these nutrients, requiring the application of fertilizer. Many citrus soils throughout the United States lack nitrogen. The application of nitrogen increases the number of oranges per tree but may reduce fruit size. The addition of nitrogen to the soil causes oranges to produce a thick peel. Oranges that grow in nitrogen-rich soil produce juice with a high content of acid. Soils deficient in phosphorus yield large, misshapen fruit and a thick peel. The core of an orange is hollow, and the fruit and peel are a dark orange. The addition of phosphorus to the soil decreases the thickness of the peel. Fruit that grows in phosphorus-rich soil is juicy, though the juice has less vitamin C than oranges grown in phosphorus-deficient soil. The addition of potassium to the soil increases the size of fruit and the thickness of the peel. When the soil has a dearth of magnesium, orange trees yield poorly and fruit is small and discolored. The addition of manganese to the soil increases the sugar in oranges. Too much copper in the soil yields oranges with a high acid content. Oranges in this soil mature slowly. A lack of copper decreases the yield, causes the fruit to be small, and reduces the amount of vitamin C. Where zinc is deficient fruit is small. In Florida, zinc-deficient soil produces a thin peel, but in California it yields a thick peel. Too much boron in the soil decreases the content of vitamin C. Citrus soils in California tend to have too much boron. On the other hand, some soils in Florida have too little boron. These soils produce fruit with little juice. Soils deficient in iron produce small fruit and the yield is low. Where molybdenum is in shortage, trees lose their leaves and the yield is small. The addition of arsenic to the soil, necessary in many citrus lands in Florida, reduces the acid content of oranges.

The application of the chemical 2, 4D, although not a nutrient, benefits trees by reducing the loss of oranges by dropping. In the presence of 2, 4D, fruit grow large. Water is as important as any nutrient. When it is in short supply, the fruit grow small. An abundance of water increases the amount of juice in oranges and reduces its acidity. Pollution slows the growth of trees and reduces yield.

Christopher Cumo

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Orange Lily. *See* Fire Lily

Orchid

Belonging to the largest family of perennial angiosperms, the orchid is prized for its flowers. The orchid comprises 800 to 1,400 genera and 17,500 to 35,000 species. Breeders have derived more than 100,000 hybrids, crosses between related species and even between the species of different genera. Although one thinks of the orchid as a tropical plant—and many species are native to the tropics and subtropics—hardy species grow almost from pole to pole. The orchid grows from swamp to desert and from equator to latitudes that support only tundra. A product of the Columbian Exchange, the orchid was carried from Central and South America to North America and Europe and from Asia to the Americas. The 19th century witnessed a quickening of interest in the orchid. The Wardian case made it possible for collectors to ship orchids from the tropics to Europe and North America. Because only the wealthy could afford the inflated prices that collectors charged and because glass for a greenhouse was expensive, the ownership of an orchid announced one's status as an elite. Gentlemen and ladies, wearing orchid flowers on their clothes, attended sumptuous balls and dinner parties. The Greeks

Orchid (Kati Molin/Dreamstime.com)

coined the term *orchis*, from which the English language derives "orchid." *Orchis* means "testes," a name that refers to the fact that the pseudobulbs, sometimes coming in pairs, looked like this part of the male anatomy.

History

From an early date, the people of New Guinea intermingled orchids and the bones of the dead so that the roots attached themselves to the bones. The orchid therefore functioned as a funereal flower. The New Guinean use of it paralleled the Western custom of stationing flowers around the deceased in funeral parlors and beside tombstones. By 500 BCE, Chinese emperors grew orchids, chiefly the genus *Cymbidium*, for their fragrance. Confucius was familiar with orchids and perhaps cultivated them. Gardeners raised orchids throughout China and Japan. The Greeks and Romans grew orchids, though they knew only terrestrial species. The Greeks believed that the roots and pseudobulbs had medicinal value. They believed that the "man orchid," known as *Acerasanthropopharum*, was an aphrodisiac because the lip of the flower resembled the shape of a man. The Aztecs grew the vanilla orchid, which they called Tlilxochid, for its fragrance and for food. Combining the seeds of this orchid with the seeds of cocoa the Aztecs derived a beverage.

In their exploration of the tropics, Europeans discovered many new species of orchid. The orchid trade quickened in the 18th and 19th centuries as Europe's elite developed a fascination for the flower. Alert to the growing demand for orchids, nurserymen sponsored expeditions to the tropics to collect new species. Among those drawn to the orchid was British naturalist Charles Darwin. Studying the Madagascan orchid *Angeracum sesquipadale*, he noted the length of the spur on the back of the flower, supposing its pollinator to be a moth with a long tongue. After his death naturalists discovered this moth, vindicating Darwin. During the Victorian era, of which Darwin was a representative, nurseryman Frederick Sander, the Orchid King, amassing one of the largest collections of orchids in the United Kingdom, boasted that he had an orchid from every region of the world. To maintain such a collection, Sander employed more than 100 orchid hunters who searched the world for new species. One of them, whether he worked for Sander is unclear, found a new species growing among human remains in New Guinea. Undeterred, he bartered for the bones and flowers, selling them on his return to Europe. Sander was not alone in having a large collection of orchids. Amateur scientist James Bateman built up a collection so vast that its sale occupied three days.

Because many orchids issue forth from a rhizome, it was an easy matter to propagate them by division. Gardeners had little success raising orchids from seeds until 1903, when French scientist Noel Bernard discovered that an orchid must have a fungus in its roots to grow and on its seeds to germinate. This insight explained why growers had been unable to germinate seeds in antiseptic conditions. In 1922, Cornell University horticulturalist Lewis Knudson published a paper on growing orchids from seed in an agar medium in an ordinary glass flask. Growing orchids from seeds had the advantage of generating new forms because the plant of each seed is a unique genotype, whereas the culture of new plants by division merely produces clones. In the 1940s, scientist John Watkins succeeded in propagating orchids by tissue culture. These methods made orchids widely available, thereby reducing prices. Gardeners of modest means could afford an orchid.

After World War II, Los Angeles and San Francisco, California, emerged as centers of orchid culture. In these cities, gardeners raised orchids outdoors, whereas the climate of Northern Europe and northern North America compelled growers to cultivate orchids, at least those from the tropics and subtropics, indoors. The growth of suburbs and the middle class opened a new era in the cultivation of orchids. After World War II emerged the hobbyist who wanted to grow an orchid or two by an apartment window and who had neither the money nor the inclination to invest in a greenhouse. In Japan, an exhibition of orchids may attract more than 100,000 people. The competition to raise the prettiest orchid is keen because some contests award a new car to the winner.

Attributes and Cultivation

Orchids are of three types. Epiphytes grow on trees, their roots in a tree's crevices. In the wild, epiphytes have the advantage of being closer to the light than terrestrial plants. Epiphytes derive nourishment from decaying leaves that have fallen from other trees and from bird excrement. Some epiphytes are large enough to encircle a tree and may become so massive that they topple it. Growing in tandem with a tree, an epiphyte, in the case of deciduous orchids, sheds its leaves when the host tree loses its foliage. Often an orchid will shed its leaves at the beginning of the dry season. Because an orchid produces a new pseudobulb to replace a dead one, the plant may live more than 100 years. In cultivation, generations of gardeners have recorded orchids with life spans of 150 years. In the wild, most epiphytes inhabit live trees, though a few—the *Catasetum* orchid is an example—cling to dead trees. As a rule, epiphytes have the most colorful flowers. Most epiphytes are indigenous to the tropics, growing in Australia, New Zealand, Central and South America, Mexico, Malaysia, and the Philippines.

Growing in soil and generally less colorful than epiphytes, terrestrial orchids are hardy, able to endure life in the Australian desert, northern Russia to the Arctic Circle, and the grasslands of North America. Cold-tolerant species have a rhizome that survives the winter. Although the rest of the plant may die during winter, the rhizome issues forth new growth in spring. Some tropical terrestrials likewise have a rhizome, which survives the dry season. Among terrestrial orchids is the genus *Ophryx*. The lip of its flower resembles a bee or spider, tricking a male bee or spider to mount it. In the process, the insect or arachnid acquires pollen, which it deposits on the stamen of another flower, cross-pollinating it. Terrestrial orchids are numerous in Greece, Cyprus, and Turkey. In the wild, they occupy uncultivated land but will not grow on fertilized farmland. Yet where human activity has disturbed land, terrestrial orchids are among the first to recolonize the soil. Orchids in temperate locales are mostly terrestrials.

Lithophytes are among the oddest orchids. Growing on bare rock, they sink their roots into the crevices in rocks, deriving nutrients from decaying matter. They may grow on moss or humus that accumulates on rocks. Relying on rainwater for moisture, they nonetheless are able to endure dry periods.

The orchid has a reputation of being a difficult plant to cultivate, perhaps because many orchids will not grow in soil. Instead, in the early 20th century, gardeners grew orchids in Osmunda fiber and sphagnum moss. The use of fertilizer on an orchid had the unintended effect of killing the moss and leaving the fiber a soggy mess. The need for a better medium led growers to cultivate orchids in shredded bark, often redwood or pine. Because bark decomposes slowly, it may host an orchid for several years before repotting is necessary. Bark will not retain much water, necessitating frequent additions of the liquid. The gardener may add one part sphagnum to three parts bark to obtain a medium that retains water better than an all-bark medium. The grower may add horticultural charcoal—not barbeque charcoal—to keep the medium alkaline. In addition to these organic media, the gardener may use an inorganic substance like pumice, known as rockwool. Pumice and other inorganics, unlike organic media, will not decompose and may be used indefinitely. The grower may choose between two types of pumice, absorbent and nonabsorbent pumice, depending on how much water she wishes to retain in her medium. Another inorganic substance is horticultural foam, which may be combined with pumice or bark. Other inorganics, perlag and perlite, may be mixed or used alone. Whatever the growing medium, it should drain rapidly, exposing orchid roots to air. In the case of inorganics, the gardener must fertilize his orchids because the medium will not decay to supply nutrients. The gardener must wet the medium before planting an orchid.

Like other plants, orchids must have water. One gardener recommends the use of water at room temperature or warmer. An orchid should not be put in a pot and the pot in a saucer of water. Rather, a container of water should be poured into the medium until it flows from the holes at the bottom of the pot. This method may be repeated to ensure a good drenching. Because orchid media hold little water, the gardener should add copious amounts of the liquid. Thereafter an orchid may be watered at intervals to ensure that the medium does not become dry. In spring and summer, when growth is vigorous, the gardener should water her orchid more often than in autumn and winter, when the plant is dormant. Growers should not use soft water, which may contain sodium and calcium, because these elements may harm roots. Rainwater is ideal. As a rule, orchids need watering once or twice per week during the growing season and once every two to three weeks when they are dormant. Orchids may be watered early in the day to allow excess water to evaporate before nighttime. Because temperatures are usually cooler at night, an orchid should not be too wet then because it does not tolerate cold and wet conditions.

The ideal temperature depends on the type of orchid. Orchids from the mountains of Colombia, Ecuador, New Guinea, and Borneo thrive in cool weather. In cultivation, the gardener should maintain a temperature between 50°F and 55°F and should avoid temperatures greater than 80°F. An intermediate grade of orchid should be grown between 58°F and 62°F with a maximum of 85°F. Orchids indigenous to the rain forests of Central and South America tolerate warm temperatures, growing between 60°F and 90°F.

In temperate regions, an orchid should be grown indoors during winter. Indoors, an orchid will do better near a window than in the center of a room. The hobbyist should take care, however, not to put an orchid so close to a window that leaves or flowers touch the glass. The grower should also keep an orchid away from sources of heat, which may dry it. Temperate orchids that tolerate cool weather include the genera *Cymbidium*, *Odontoglossum*, *Coelogyne*, *Encycliae*, and *Dendrobium*. In the temperate zone, orchids may be grown outdoors during warm weather. The gardener may put an orchid in a pot, placing the pot on a table rather than on the ground, where pests may attack the plant. A patio or balcony is also a good location for an orchid. An orchid may be set outdoors in late spring or early summer. Some plants lose their leaves when first placed outside. This is not cause for alarm because it will regrow them when it has adjusted to its new environs. The enthusiast should return an orchid indoors before the first frost. In the tropics, orchids may be grown outdoors year-round. An orchid's roots must be drenched in the dry season. Some orchids grow well in temperate locales and the tropics. The genus *Phalcenopsis*, for example, may be grown indoors in temperate regions and outdoors in the tropics. All orchids need light, but many, having evolved alongside or on trees, do best in shade. The genera *Masdevallia* and *Cattleya* thrive in shade.

Because orchids grow slowly, they will not benefit from large applications of fertilizer. In the early 20th century, gardeners fertilized orchids with manure but it burned their roots. Today, it is possible to buy orchid fertilizers. One may also use ordinary plant fertilizer at half strength. The gardener should not fertilize dormant orchids for fear of harming the roots. It is important, as well, not to allow fertilizer to accumulate in the medium. With this caution in mind, the gardener should water her orchid when she fertilizes it to be sure of flushing excess fertilizer out of the pot. As a rule, an orchid should be fertilized every second or third watering. Because orchids grow more rapidly in summer than in winter, they should be fertilized more in warm weather. The gardener should apply more fertilizer to orchids growing in an inorganic medium because it will not break down to give them nutrients. Nitrogen may be added to the medium in spring when plant growth is most robust. In summer, a phosphorus-rich fertilizer may be used to promote flowering. Although most orchids prefer shade, they tolerate direct sunlight during winter when the intensity of light is low. When the amount of light is insufficient orchids may not flower.

Pests and Diseases

Known as greenflies, whiteflies, and blackflies, aphids, attracted to buds and other new growth, may be numerous in summer. Aphids suck the sap of orchids and may damage flowers to such an extent that they do not open or are disfigured when they open. Aphids cause yellow lesions on buds and new growth. The honeydew that aphids excrete may cause mold to grow on an orchid. Because ants are attracted to an aphid's honeydew, their presence may indicate an aphid infestation. The gardener who detects aphids should wash his plant with water to remove them. Alternatively, one may immerse the affected part of an orchid in insecticide soap to kill the pests.

Eating orchid pollen, mice may congregate in a greenhouse during winter. The gardener may rid herself of these pests by trapping them. Mealy bugs damage buds and flowers, discoloring them. The larvae of moss flies feed on roots. The gardener may immerse an afflicted plant in water to drown flies. One gardener recommends the cultivation of carnivorous plants alongside orchids to capture these flies. Red spider mites, like aphids, suck the sap of orchids. The genera *Dendrobium*, *Lyaste*, *Coelogyne*, and *Cymbidium* are vulnerable to mites, which cause lesions that blacken and may be the site of infection. Mites are active in warm weather and breed in dry conditions. An affected orchid may lose its leaves. One may combat an infestation by spraying the underside of leaves with water to dislodge mites. Alternatively, one may coat an orchid's leaves with insecticide soap, being sure to repeat this treatment after 10 days to kill hatchlings.

Scale insects cut lesions in orchid leaves, which yellow. Scales may hide on the underside of leaves. Active in spring and summer, scales may inhabit a greenhouse year round if it remains warm. Because the honeydew of a scale attracts ants, their presence may indicate an infestation of scale insects. The gardener may wash a beleaguered plant with insecticide soap, using a toothbrush to dislodge scales. This treatment may be repeated to kill new generations of the insect. Slugs and snails may gather in a humid greenhouse. Eating orchid roots the garlic snail is particularly damaging. Slugs and snails may chew the pseudobulb, causing it to rot. These pests may eat new growth. One gardener recommends that the enthusiast keep toads in the greenhouse to eat slugs and snails. Slices of apple in the growing medium will attract the garlic snail.

Caterpillars and weevils eat leaves and flowers. Weevils hide in the growing medium during the day and feed at night. Adult weevils are not alone in harming orchids. Grubs eat roots. Weevils are common in outdoor gardens but also infiltrate greenhouses and the home. Insecticide soap may be rubbed on the leaves to kill weevils and caterpillars. The medium may be saturated with insecticide soap to kill grubs. Woodlice and ants burrow into the medium, causing organic media to break down rapidly, suffocating the roots. Earwigs eat roots. The gardener may use insecticide soap to combat these pests, pouring it into the soil to kill woodlice, ants, and earwigs where they hide.

When an orchid is cold and wet, a condition it dislikes, it is vulnerable to attack from fungi, which can rot new growth, turning it brown. In addition, fungi can cause the tips of leaves to blacken. Fungi can also spot flowers and pseudobulbs. The gardener may combat fungi by increasing the heat during winter, reducing humidity, and watering orchids less frequently to deprive fungi of moisture. Fungi may inhabit dead leaves, making it imperative to clean the greenhouse or garden of debris. One may treat beleaguered plants by cutting diseased parts of an orchid down to the rhizome to be sure of eliminating all the disease and then treating the wound with horticultural sulfur. Viruses cause black spots, streaks, or mottling of leaves. Red spider mites transmit viruses to orchids. The genus *Cymbidium* is vulnerable to viruses. In many cases, lack of air circulation promotes disease.

Genera and Species

With 25 species, the genus *Brassia* is native to Central and South America and the Caribbean. Known as the spider orchid for its long, thin petals, which are often light green and brown, *Brassia* flowers in early summer, its blooms lasting four to five weeks. *Brassia* prefers cool temperatures and so is ideal for the grower in a temperate region. *Brassia* should be grown in bark and should be watered year-round with less water in winter. With 50 species native to Central and South America, the genus *Cattleya* is a tropical epiphyte. The species *Cattleya labiata*, indigenous to Brazil, was first cultivated in 1818. With many species rare in the wild, it falls to the gardener to perpetuate them in cultivation. Retaining its leaves year-round, *Cattleya*'s fragrant flowers are yellow, pink, lavender, mauve, green, and brown. Breeders have derived flowers so large that they must be staked to prevent the stem from collapsing. Thriving in shade, *Cattleya* likes indirect sunlight. Although *Cattleya* should have shade in summer, it does best in direct light in winter. *Cattleya* has a dormant phase but it differs by species. Some species grow in autumn and winter and are dormant in spring and summer. *Cattleya* prefers intermediate temperatures. The genus grows in coarse bark or pumice and should be watered abundantly in summer and less in winter.

Breeders have derived more than 10,000 hybrids of the genus *Cymbidium*. It has 50 species native to Asia. Especially prized are those from India and Nepal. The hybrids of Cymbidium have blooms that last months. Some hybrids flower year-round. Like the flowers of *Cattleya*, some flowers of *Cymbidium* grow so large that they must be staked. *Cymbidium* grows more vigorously in spring and summer than in fall and winter. The gardener may put *Cymbidium* outdoors in summer to promote flowering. Like many orchids, *Cymbidium* prefers to be shaded from the midday sun, though it welcomes sun in the early morning and evening. In California and parts of Australia, *Cymbidium* may be grown outdoors year-round. Preferring cool temperatures, *Cymbidium* does well in coarse bark or pumice. The genus may be watered year-round, but in winter the interval between watering should be lengthened so that the medium dries.

With both deciduous and evergreen species, the genus *Dendrobium* is an indigene of China, India, Malaysia, New Guinea, Australia, and New Zealand. Its 900 species are primarily epiphytes. The flowers are white, yellow, green, pink, purple, and mauve. It tolerates cool to intermediate temperatures. Grown in bark, *Dendrobium* prefers shade in summer and full light in winter. The gardener may water the plants abundantly in spring and summer and then sparingly in autumn and winter, when growth slows. Known as the pansy orchid for its resemblance to the pansy, the genus *Miltoniopsis* is a popular indoor plant because of its ease of cultivation and for its pretty flowers. Its popularity has increased in recent years. *Miltoniopsis* rewards the grower by flowering twice per year, once in summer and a second time in autumn. Gardeners appreciate *Miltoniopsis* for the fragrance of its flowers. Although *Miltoniopsis* has only five species, all native to Colombia, breeders have created more than 1,000 hybrids. Breeders often hybridize the species of *Miltoniopsis* with the species of the genus *Odontoglossum*. Preferring cool temperatures, *Miltoniopsis* grows in fine bark or pumice. The gardener should shade the genus year-round and fertilize between spring and fall.

Odontoglossum, one parent in the hybrid crosses with the species of *Miltoniopsis*, has 60 species of evergreen epiphytes. Known as the Queen of Orchids, *Odontoglossum* originated in the Andes. Collectors have taken so many plants from this genus from the wild that they are nearly extinct and depend on the benevolence of gardeners to perpetuate them. With more than 100 hybrids, *Odontoglossum* flowers year-round. The blooms last several weeks. The gardener must take care not to overheat these orchids, keeping the temperature below 75°F in summer. *Odontoglossum* may be kept outdoors in shade in summer. The leaves redden in the sun, a feature that some gardeners find attractive. In winter, *Odontoglossum* may receive full sun. Growing in fine bark, the genus should be fertilized year-round but less in winter.

Odontoglossum is likewise one parent in the hybrid crosses with the species of the genus *Oncidium*, known as the beginner's plant because of its ease of cultivation. With 400 species of evergreen epiphytes, *Oncidium*'s flowers are often yellow and last three or four weeks. The genus flowers year-round with blooms abundant in autumn. Native to the tropics of the Americas, the species of *Oncidium* that grow at altitude prefer cool temperatures. The rest grow near the rain forest and prefer warm temperatures. Orchids from the rain forest tolerate more light than those that grow at altitude. At high latitude, *Oncidium* may not flower because of insufficient light in winter.

Christopher Cumo

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Oregano

Oregano has uses other than the making of tomato sauces and toppings on pizza. The herb traditionally is used with fish, chicken, and tomato-based foods, often in Italian, French, and Greek dishes. There is a recipe for oregano jam as well. But oregano is not just for culinary purposes. The herb is used for culinary, medicinal, commercial, and ornamental purposes as well. Oregano is native to the Mediterranean, but it is cultivated throughout the world. Its genus name is *Origanum* and there are more than 40 species. The herb, sometimes called wild marjoram, belongs to the mint family (Lamiaceae or Labiatae) and is related to marjoram and thyme, both of which are in the same genus.

History and Folklore

Oregano dates to ancient Greece and Rome. The word "oregano" stems from the Greek word *oros*, which means "mountain," and *ganos*, meaning "joy"—that is, "joy of the mountain." Oregano was sprinkled on church floors at funerals and located in sick rooms because it was considered an antiseptic. Folklore had it that if oregano appeared on a gravestone, the deceased was enjoying the afterlife. At Greek and Roman weddings, the bride and groom wore wild marjoram wreaths to mark the event. The Greeks were to have made tea from fresh leaves for headaches, stomach problems, and nervous complaints. As if to confirm some the folk uses, a reference from a 2006 book, *The Natural Pharmacy*, mentions that the Greeks used oregano for medical conditions like convulsions and heart failure. Folklore credits oregano with being used in treatment for respiratory disorders, coughs, and inflammation of the bronchial mucous membranes.

It is difficult to trace the various names of oregano because marjoram is in the same genus as oregano and it even looks like oregano. British herbalist John Gerard, author of the famous *Herball* in the 16th century, discussed the names of several oreganos to limit his readers' confusion. In current times, botanists have changed the names of genus and species, and as a result many oreganos have botanical and common names that are confusing. For starters, the *Origanum* genus contains herbs that are called both marjoram and oregano. As an example, there is the species *Origanum vulgare*, which is the scientific name for a plant whose common names include wild marjoram and oregano. Additionally, there is the species with the scientific name *Origanum majorana* that also known by the common name sweet marjoram.

It must be noted that plants besides those in the *Origanum* genus are marketed as oregano not because of botanical nomenclature, but because of chemical makeup, giving rise to the odor and flavor of oregano. In fact, although they are known and used as oregano, some experts say they are not true oreganos because they are not members of the *Origanum* genus. Examples are members of the Verbena family, *Lippia graveolens* (Mexican oregano), and *Lippia micromera* (Jamaican oregano) and plants in the mint family: *Poliomintha bustamanta* and *Plectranthus amboinicus* (Cuban oregano). One expert on oregano says, "It is best to think of oregano as a flavor of high carvacrol and low thyme rather than a genus or species."

Oregano Gains in Popularity

Some food historians attribute the initial burst of interest in oregano to the fact that U.S. troops in Italy during World War II ate well-seasoned Italian food. Back home, oregano was popular in ethnic neighborhoods, and eventually Pizza Hut, Dominos, and other chains came to town.

Technology is helping food get noticed. At first, customers were calling in pizza orders from their homes and offices, but with iPhones and other mobile Internet browsers, orders of delivered pizza may be only minutes away. In addition, television and the Internet are creating markets for food consumption.

Googling "oregano recipes" yields recipes for chicken, shrimp, and ravioli, and one by Scott Conant, a New York City restaurateur, features eggplant, farfalle with one teaspoon of finely chopped oregano, basil, tomatoes, two types of oil, and several other ingredients. However, there are many nontraditional uses of oregano in food. A Mario Batali recipe for veal chops with lemon oregano jam uses two tablespoons of chopped oregano leaves with pieces of lemon, sugar, extra-virgin olive oil, and the meat.

Species

Origanum majorana, sweet marjoram, is popular for growing in containers. It is used in traditional Greek and Italian meals with meats, tomato sauces, and soups. Some say it is the sweetest of the culinary origanums. However, its essential oil should not be used by home cooks. Commercially, it is used in beverages, baked goods, condiments, liqueurs, soaps, and hair products and in the process of making perfume. The essential oil shows antimicrobial activity. Dried sweet marjoram is imported into the United States from Egypt, France, and Canada. The chef who cooks with *Origanum majorana* should wait until right before serving before adding the fresh herb. This oregano is said to have a more delicate flavor than *Origanum vulgare*, a popular oregano.

Origanum × majoricum, hardy sweet marjoram, is a hybrid of sweet marjoram (*Origanum majorana)* with wild marjoram (*Origanum vulgare*), and some experts say "it has the spice of oregano and the sweetness of marjoram." An alternate name is Italian Oregano.

Origanum onites, pot marjoram, is native to the Mediterranean. It is particularly favored in Turkey for its "macho" taste, according to one expert. The cultivation of other species of *Origanum* nearby may yield hybrid seed. The oil of pot marjoram is antifungal and antibacterial due to its high carvacrol content. The leaves and flowering stems are ingredients in potpourri and scented items like sachets. An essential oil from the leaves is used in food flavoring and in making perfume.

Origanum syriacum, Lebanese oregano, is indigenous to Syria. It is also known as Syrian hyssop, white oregano, and Bible hyssop. The Arabs call this plant Za'atar, but Za'atar is also known as a Middle Eastern spice mixture with oregano, sesame seeds, and sumac berries. In Lebanon, there is a bread called Za'atar that is spread with crushed Syrian oregano, like pizza is spread with herbs when it is being prepared. The oil of *Origanum syriacum* is antimicrobial and antioxidant because of the high phenol, or carvacrol content. This oregano resembles pot marjoram in appearance.

Origanum vulgare, wild marjoram or oregano, is often used in dried form with tomatoes, onions, olives, and wine. The oil is used in commercial food flavoring, toiletries, and men's perfumes. The herb has been used in folk medicine as an expectorant and has been used in treating respiratory disorders, coughs, and inflammation of the bronchial mucous membranes. Currently, there are commercial essential oil products to treat these maladies, although "substantial clinical evidence proving its efficacy is lacking," according to the Reader's Digest Association (2009, 81). The oil is also used in aromatherapy. Leaves and flowering tops are infused for tea and added to potpourris. The essential oil is fungistatic, or capable of inhibiting the growth of fungi; bacteriostatic, that is, capable of inhibiting the growth or reproduction of bacteria; and active against trypanosomes, a parasite living in the bloodstream of vertebrates. The essential oil and alcoholic extract of the leaves are antioxidant, and two flavonoids in oregano were shown to be antimutagenic in lab tests against a common dietary carcinogen, according to Tucker.

Current Uses of Oregano

Oregano is sold dried and in crumbled forms and combined in packaged Italian seasoning mixes. It is also available fresh in supermarkets and smaller neighborhood markets and is sold in nurseries during planting seasons.

Oregano has a stronger flavor in its dried form. "The commercial dried oregano is most often imported from Turkey, sometimes from Greece or even Morocco," said Tucker (Tucker and DeBaggio 2009, 82). "It is a mixture of *Origanum spp*., most often *Origanum vulgare subsp. hirtum* and *Origanum onites*," he added (Tucker and DeBaggio 2009, 720–21). Little oregano is grown in the United States.

Oregano is a feel-good herb, according to the authors of *Healing Remedies* (Wilen and Wilen 2008). If you stir oregano into a glass of water and drink it, you will feel your spirits lift, the authors believe. Sources have mentioned that the essential oil or the volatile oil from oregano should not be used internally. It was also recommended that women who are pregnant or breast feeding not use the oil. The essential oil is, however, said to contain antimicrobial and antioxidant properties.

The Natural Pharmacy cautions against taking what it terms "oregano volatile oil" internally because of the lack of human research (Lininger et al. 2006, 720). Children less than two years old or people with sensitive skins not use the oil topically.

However, the volatile oils are used commercially. "There are suggestions that the oregano volatile oils used during food processing play a role in preventing the spoilage of food and reducing the risk of ingesting harmful bacterial, fungi and parasites," according to *The Natural Pharmacy* (Lininger et al. 2006, 721).

Landscaping

Ornamental *Origanums* include Dittany of Crete (*Origanum dictamnus*), and cultivars of *Origanum vulgare* ssp. *vulgare* such as Aureum and Golden Creeping are used in landscaping. *Origanum vulgare* has dark purple flowers that are excellent for drying, but the herb lacks flavor for culinary uses. Oregano is attractive to many pollinators, including honeybees and butterflies. The gardener should not plant oregano where it will hang over a walkway because a traveler may have a difficult time getting around the bees.

Harriet Weinstein

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Painted Tongue

Salpiglossis sinuata, also known as the painted tongue, is a beautiful flower belonging to the Nightshade or Potato family. Seen in a host of varying colors, the painted tongue flower is funnel shaped; the ends of the petals are bilobed, shaped like a tongue, and have richly colored streaks that extend outward from the base of the petals. It is more of an ornamental plant owing to the fact that it is highly colorful, disease-free, and a good addition to a florist's catalogue.

Salpiglossis is fairly easy to grow and a delight to look at. The ornamentals are annuals that sprout from seeds. Originating in Chile, they are not widely popular in the United States and are found along the Andes Mountains and by the east coast. They grow well in zones 10 and 11 and at times in zone 9. Salpiglossis requires a slightly acidic soil with a pH ranging from 6.1 to 7.5. An average of 6.5 is ideal. At times the plants thrive even in a pH of 5.5. Growth is best when the soil, in addition to the pH factor, is sandy loam to clay loam. They require full sun and grow best when their main stem is supported with a stake. While they require full sun, they cannot tolerate heat or frost and require mild to medium humidity. The flowering season ranges from early summer to mid-fall with temperatures between 50°F and 75°F.

This plant grows up to a height of two feet and with a width of one foot. The flowers may be as large as three inches wide and may be red, yellow, blue, violet, purple, orange, gold, pink, maroon, lavender, mauve, and magenta. The long-lasting flowers coupled with the wide array of colors are a horticulturalist's delight. With proper care, they may be cultivated well in a greenhouse.

Botany

Salpiglossis sinuata belongs to the family Solanaceae. Other common plants in this family are potato, eggplant, peppers, tobacco, and Atropa belladonna. However, the closest relative to the painted tongue is the petunia. Salpiglossis is a tropical plant and an annual herb. It possesses a taproot system. The leaves tend to be opposite, especially toward the inflorescence end of the stem. Devoid of stipules, the leaves are narrow, sometimes lobed, and are simple. Each leaf is independent and not clustered in groups on the stem. Larger leaves are seen at the base of the plant with shorter or smaller leaves toward the bloom end. The inflorescence is a cymose where three or more flowers branch out from a single flower stalk, the older flower at the center of the axis, and the younger flowers extending from the bract at the base of the older flower. The flowers have a long pedicle or flower stalk, can be cut along any plane (actinomorphic), and are regular and without bracts or bracteoles. There are five sepals at the base of the petals, which are united or fused at the base (gamosepalous). The corolla consists of five petals, which are velvety in texture and are forked or bilobed at the end. The petals are gamopetalous, in that they are fused together at the base to form a funnel. The male part of the flower consists of five stamens. There are two carpels present in the female part of the flower. These two carpels are fused together and are said to be syncarpous. The ovary of the flower is superior in position, where the sepals, petals, and stamens originate from the base of the ovary and not above it. The flowers produce seeds, which are the means of propagation. The seeds dry on the plant and are encased in a seed pod.

Cultivation

The best way to sow and grow salpiglossis plants is to choose seeds that have dried on the mother plant, in the seed case. Many times seeds that are sold in nurseries have been induced, that is, dried on the forceful opening of the seed pod. Such seeds are not very viable and may wither away once the sapling has produced a few leaves. However, there are also nurseries that have a reputation for quality, selling seeds that are completely dried and sprout into healthy plants once sown.

Other than growing in the wild, seeds of the painted tongue must be sown in a container, more or less toward the surface of the soil and covered with newspaper. The soil should be moist with good compost. The container may be kept indoors under room temperature. Once the saplings emerge, the container may be transferred to areas of sparse sunlight where the covering is removed. As true leaves emerge, unlike the two cotyledon leaves, the sapling may be transferred to wider flower pots, one plant per flower pot. Plants require full sunlight as they grow, and the stem ends should be pinched frequently to induce branching. Salpiglossis, as it matures, is a wide, bushy plant with an abundant bloom.

Salpiglossis is not as frost tolerant as it is drought tolerant and should be protected from the cold. The best time, however, to grow plants from seeds is to sow the seeds just prior to the frost period as the saplings can be cultivated indoors. This plant is sensitive to nitrogen and cannot tolerate dryness of the soil. It also requires soil that is rich in compost. Care should be taken to transplant the seedling with a fair amount of the potting soil around its roots.

The painted tongue is fairly disease resistant. If in flooded conditions, it may develop root or stem rot. Apart from that, the only attack on the health of the plant is from pests such as thrips, aphids, spider mites, and mealy bugs. These can be easily controlled with the use of a mild insecticide. At times, rubbing a cotton ball dipped in mild alcohol on the leaves and stem of the plant can prove useful.

Organic pesticides may also be used. The use of an insecticidal soap is another alternative.

Amanda Mittra

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Pansy

The pansy, one of today's most popular bedding flowers, is a relatively recent cultigen. Only about 200 years old, it was hybridized from several species of wild violet. It is therefore a member of the genus *Viola*. The pansy's complex genealogy is based principally on *Viola tricolor* (commonly called the viola, Johnny-jump-up, or heartsease), a small perennial violet with flowers of purple, yellow, and white, which was crossed with *Viola lutea* (a yellow-flowered violet) and other violet species.

The common name pansy, derived from the French word *pensée*, which means "thought," was used for violets in medieval times, and even today is the common name for some *Viola* species. So when English playwright William Shakespeare (1564–1616) has Ophelia say, in *Hamlet*, "Here's pansies; that's for thoughts," she is referring not to today's garden pansy, which had not yet been invented, but to the wild violet or heartsease. However, the name pansy became attached to the new hybrids almost from their beginnings in the early 1800s. The pansy's botanical name, *Viola* × *wittrockiana*, commemorates Swedish botanist Veit Brecher Wittrock (1839–1914).

History

The earliest known experimental crosses of violets were made in the early 19th century in the gardens of two English aristocrats who lived quite close to each other in Buckinghamshire: Lady Mary Bennet, with her gardener William Richard, and James, Lord Gambier, with his gardener William Thompson. Lady Mary directed Richard to plant every kind of wild violet he could find in a bed, allow the flowers to cross-pollinate, and keep breeding the prettiest of the resulting crosses. She produced the first pansies in 1812; a year later, a well-known florist, Mr. Lee of Vineyard Nursery, discovered her collection and saw the potential for profit from further cultivating pansies. He began to market them, and he was soon followed by other breeders, leading to a pansy fervor. The pansy quickly became a favorite in society because of both its aristocratic origins and its wide availability and charm. Breeding continued through the 1820s and 1830s. By 1835, over 400 named varieties of pansy were available in the United Kingdom alone.

Attributes

Pansies have five petals: two slightly overlapping ones at the top, two at the sides, and one at the bottom, slightly indented at its lower edge. Breeders labored to make the petals rounder and have them lie flat, to make a showier blossom than the smaller, more angular and folded viola flower. Breeding also produced a wide range of colors, bicolors, and markings.

Early pansies, like violets, had dark, narrow nectar guides, or "whiskers," on their petals. In the late 1830s, a chance sport was found in Lord Gambier's garden that instead of whiskers had broad, dark blotches on its petals. These came to be called a "face." This blotched variety was released to the public in 1839 as Medora, and it and its descendants soon became popular throughout Europe. Medora is the ancestor of the many pansies with blotched faces that we see today.

By 1840, the pansy had become so popular that it had its own appreciation societies. One of these, the Hammersmith Heartsease Society, put on its first show in 1841, displaying the newest varieties of pansy. The show had strict rules for blossom colors and markings, with only yellow or white backgrounds and perfectly round flowers accepted. French and Belgian breeders, however, increased the range of acceptable colors and markings; they marketed pansies with central blotches covering nearly the entire petal.

By the 1870s, pansies had been transformed from tiny violas with whiskers into big, colorful, spectacularly marked blooms. The Chalon Giants, a strain from a Swiss grower, came in yellow, violet, red, blue, white, and deep purple, with dark brown or black faces. Their petals were ruffled, and some blossoms were fragrant.

Near the end of the 19th century, the Scottish grower Charles Stewart bred a single-colored pansy with no markings at all, thus creating the third major category of pansy coloring. Now pansies were available with whiskers, faces, or "clear."

Since pansies came of age during the Victorian era, it is not surprising that these flower favorites were frequently depicted in the embroidery, painting, and jewelry of the period. Because of the meaning of their name, "thoughts," pansies were interpreted to mean "think of me" in the language of flowers, and they became a popular motif of both love tokens and mourning jewelry.

Pansies increased in popularity through the 20th century, becoming a standard bedding flower. Continued breeding developed new colors, including orange, apricot, bronze, and black (very dark purple). Pansies today are among the top three bedding plants in the United States. Flats of pansies sold in 2005 totaled $111 million. But the drive for bigger and bigger blossoms seems to have ended; now buyers seem more interested in medium-size flowers in the especially popular colors: orange, lavender, and pastel shades. In keeping with the growing interest in heirloom plants, smaller flowers in softer colors that look more like their viola ancestors are now growing in popularity. There is also greater interest in longer-flowering plants that will continue blooming through the heat of summer. Heirloom pansies still available today include Bullion, a 19th-century golden yellow, and Jackanapes, which has red upper petals and yellow lower ones.

Emily Goodman

See also Violet

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Papaya

A tropical herb, papaya (*Carica papaya*) resembles a tree in size and shape to such an extent that the novice is apt to misidentify a papaya plant as a tree. In the family Caricaceae, papaya is known by many names. The Maya named papaya *ababai*, which the Spanish mistook as papaya. Cubans know papaya as *fruta de bomba*. The British, upon encountering the plant in the Caribbean, called it "paw paw," a name common in Australia and parts of the Caribbean, along with "papaw." The people of southern Asia and Indonesia know papaya as *kapaya*, *kepaya*, *lepaya*, or *tapaya*. In French, papaya is *papeye*. Puerto Ricans know papaya as *lechosa*. Germans call papaya *papeja*, *papajabaum*, or *malonenbaum*. Brazilians know papaya as *memoi*. The papaya plant yields several melons that resemble cantaloupes. Alternatively a papaya may resemble a large pear. The principal use of papaya is as food. Secondarily, an enzyme of papaya, papain, reputedly treats dysentery. As a cream, papain cleans, softens, and moisturizes skin. As a powder, papain is used to clean teeth and gums.

Origin and History

A New World cultigen, papaya may have arisen in southern Mexico or Central America. One writer supposed that Italian adventurer Marco Polo (1254–1324) was the first European to encounter papaya, finding it in Asia. This writer believed that Portuguese explorer Vasco da Gama (1469–1524) was familiar with papaya. Another author believed that Polo and da Gama referred to durian, a related plant. Perhaps in the late 15th century, Spanish-Italian explorer Christopher Columbus was the first European to encounter papaya, finding it in the Caribbean and calling it the "fruit of the angels" ("Papaya"). In 1519, Spanish conquistador Hernando Cortez encountered papaya in the Yucatan Peninsula. The Maya of southern Mexico, believing Cortez a god, invited him to a feast, where he and his soldiers first tasted papaya. So intrigued were the soldiers that they asked the Maya to take them to the plants that produced papaya. These they found in the jungle growing to 20 to 30 feet tall. Before 1525, the Spanish planted papaya in Panama and on Hispaniola (today the island of Haiti and the Dominican Republic) and in 1616 on Bermuda. In the Caribbean, cultivation was intensive on Cuba and Jamaica. In Asia, the Spanish planted papaya on the Philippines around 1550. From the Philippines papaya spread to Malaysia and India. A second migration from the Philippines carried papaya to Sri Lanka and from there to East Africa. By the early 20th century, papaya was grown in Uganda, Tanzania, Kenya, and Congo. In Congo, King Leopold II of Belgium (1835–1909) had ordered the cultivation of papaya. In the early 17th century, English captain James Cook planted papaya from Central America on Hawaii. One account holds that papaya was not cultivated on Hawaii until the 1920s. From Hawaii papaya diffused to several Pacific islands. From the Bahamas papaya spread to Florida, where home owners and farmers grew it until the mid-20th century, when insects and diseases crippled the crop. Most papaya is grown between 20° north and 20° south latitudes in Mexico, Central and South America, the Caribbean, islands in the South Pacific, the Philippines, the Mariana islands, Guam, Ponape, Vietnam, Laos, Cambodia, Myanmar, Malaysia, Sri Lanka, Indonesia, India, South Africa, Tanzania, Congo, and Uganda. The largest producers of papaya are the United States, Mexico, and Puerto Rico.

Attributes and Cultivation

As we have seen, papaya resembles a tree, though one without branches. The large leaves issue forth from the stem. Often, papaya yields male and female flowers on separate plants, though a single plant may bear flowers of both sexes or perfect flowers. In the former instances, flies, bees, and wind pollinate the female flowers. Perfect flowers may self-pollinate. Environmental conditions determine whether a plant yields flowers of only one sex or both. Male flowers are small and white. Yellow female flowers are large. Like leaves, flowers issue forth from the stem. The self-pollinators yield a one- to two-pound melon, the fruit with which Americans are familiar. Papaya yields fruit in 4 to 18 months. A plant may live 20 years, bearing a succession of crops. As a rule, farmers consider only the first crop valuable. Subsequent crops are too small to fetch a fair price. Instead of relying on an old plant, farmers cultivate new plants each year to ensure a succession of large harvests. In parts of Africa, however, farmers harvest a second crop from old plants. One prolific plant in Baja California reportedly yielded 250 melons in just 11 months. Papaya is best picked half ripe for local use. Where it will be transported long distances, fruit should be one-quarter ripe to withstand rough handling. As a melon ages, it turns from dark green to red-orange. The flesh is white when immature and golden when mature. The seeds are gray in immature melons and black in mature fruit.

The three varieties of papaya are Cariceae, Leucpremna, and Javille. Of these, Cariceae dominates the market. Although a tropical plant, papaya does best at elevations above 2,000 feet. It grows on rocky hillsides with thin, volcanic soil that is not suitable for other crops. Papaya prefers shallow, well-drained soil. The soil should have nitrogen, calcium, aluminum, and magnesium, though papaya seldom needs fertilizer. Leaves fallen from a plant decompose in the soil, nourishing papaya. Papaya needs abundant rain and high humidity.

Seeds should be planted in loam 4 inches apart in a seedbed. Rows should be 8 inches apart. The farmers may plant two seeds per hole, transplanting seedlings in the field when 6 inches tall. Seedlings should be planted nine feet apart, yielding roughly 425 plants per acre. When first planted in the field, seedlings must be protected from the sun. This practice promotes vigorous root growth. The farmer should irrigate seedlings until 12 to 14 inches tall. Even then the soil should be kept moist. Despite the need for moisture, seedlings do not tolerate waterlogged soil. North of the equator, the tropics may be comparatively dry November to May and in the South May to November, necessitating irrigation. Irrigation is particularly important in East Africa and Sri Lanka. Sri Lanka was an important producer through World War II. After the war, competition from Colombia and diseases hurt production in Sri Lanka. Because roots are shallow, wind may uproot plants. Accordingly, the farmer should divide an estate into 10-acre blocks surrounded by trees to break the wind and minimize damage to plants. The conscientious farmer weeds his land, being careful not to cultivate the soil too near a plant for fear of damaging the roots. In nature, male plants outnumber female plants, but the grower should remove male plants until he achieves a 1:25 ratio of male to female plants. Males should be planted amid populations of female plants to aid pollination.

Uses, Nutrition, and Selection

Some people of the tropics apply papaya juice to the skin to soften and clean it. People consume the seeds to expel worms and prevent conception. Women wrap meat in papaya leaves to tenderize it. People eat the fruit to calm an upset stomach. The leaves, seeds, and fruit are nutritious. Tea made from papaya leaves has beta-carotene, B vitamins, vitamins C and D, potassium, sodium, iron, aluminum, manganese, calcium, and phosphorus. Papaya seeds contain vitamin C, though their bitterness deters people from eating them. One papaya of about 300 grams has 119 calories, 1.9 grams of protein, 30 grams of carbohydrates of which 18 grams are sugar, 5.5 grams of fiber, 0.4 gram of fat, 270 grams of water, 3,326 international units of beta carotene, 0.08 milligram of thiamine, 0.1 milligram of riboflavin, 1 milligram of niacin, 0.06 milligram of vitamin B6, 116 micrograms of folic acid, 0.7 milligram of pantothenic acid, 188 milligrams of vitamin C, 2.2 milligrams of vitamin E, 7.9 micrograms of vitamin K, 73 milligrams of calcium, 0.05 milligram of copper, 0.3 milligram of iron, 30.4 milligrams of magnesium, 0.03 milligram of manganese, 15.2 milligrams of phosphorus, 781.3 milligrams of potassium, 1.8 micrograms of selenium, 9.1 milligrams of sodium, and 0.2 milligram of zinc. Of these nutrients, one papaya has 67 percent of the recommended daily allowance of beta-carotene, 313 percent of vitamin C, 29 percent of folic acid, and 22 percent of potassium. Papaya has more vitamin C than oranges ounce for ounce and ranks second among fruits only to guava in vitamin C content. Papaya loses beta-carotene in storage.

If intending to eat a papaya within a day, one should choose fruit with red-orange skin and soft flesh. Those with spots of yellow require more time to ripen. Yellow papayas ripen in a few days at room temperature. They ripen faster when placed in a container with a banana. Ripe papayas may be refrigerated with the aim of eating them in one or two days. Fully ripe papayas yield the maximum nutrition.

Christopher Cumo

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Papyrus

An annual reed, papyrus (*Cyperus papyrus*) is a member of the Cyperaceae family of sedges. The Cyperaceae resemble grasses. The Latin *papyrus* may derive from the Egyptian *pa-en-peraa*, meaning "material of pharaoh," a possible reference to the fact that the pharaohs regulated the manufacture of papyrus. The Egyptians also called papyrus *mehyt*, which may have meant "marsh plant." The Greek *pap-uros* closely resembles papyrus. The Arabic *bardy* means papyrus. From papyrus derives the word "paper," though papyrus is not paper.

Papyrus (iStockPhoto)

The Plant

The papyrus plant may grow 10 to 15 feet tall. In the first year alone, a plant may reach a height of 12 feet. Because seeds are difficult to germinate, growers propagate papyrus by dividing the roots. The description of papyrus as a marsh plant is apt. An aquatic plant, it grows in the marshes that border shallow lakes and rivers. Despite its association with Egypt, papyrus is probably not native to the country. It may be indigenous to the region near the White Nile River in Sudan. It also grows in Lake Chad, the delta of the Niger River, the Okavango River in Botswana, Lake Bangweula in Zambia, Lake Albert in Uganda, and Morocco. Papyrus must have reached Egypt before 3000 BCE. From Egypt, it spread to Palestine. In the fourth century BCE, the Palestinians cultivated papyrus near Lake Tiberias according to fourth-century BCE Greek botanist Theophrastus. Sometime between 300 and 150 BCE, the Seleucids, heirs to the eastern portion of Greek conqueror Alexander the Great's empire, introduced papyrus into Babylonia. About 250 BCE, Pharaoh Ptolemy Philadelphus brought papyrus to Sicily, though the plant must not have been a success because the Arabs had to reintroduce it into the island in the 10th century. The drainage of swamps to prevent the spread of malaria eliminated papyrus's habitat and it again disappeared, only to be reintroduced a second time. This planting was near Syracuse in the 17th century. In the first century CE, Roman encyclopedist Pliny the Elder remarked that papyrus was cultivated along the Euphrates River. First-century BCE Greek geographer Strabo asserted that India cultivated papyrus. Some ancients asserted that the Greeks and Romans cultivated papyrus though one scholar doubts this.

Despite these varied locales, historians have long associated papyrus with Egypt. Obtaining papyrus from the Egyptians, the Greeks and Romans were convinced that it was native to the region. Cultivation was concentrated in the Nile River Delta. Papyrus fields and the wildlife that they supported were the iconic pastoral scenes in ancient Egyptian art. The Egyptians spread the harvest between March and August. The Nile River's inundation in September limited access to papyrus fields and accordingly hampered the harvest. When the use of papyrus declined, cultivation diminished and the plant disappeared from Egypt after a tenure of nearly 5,000 years. Invading Egypt in 1798, French emperor Napoleon Bonaparte found no trace of the plant, though one authority maintains that it grew in Egypt as late as 1820. Thereafter the drainage of swamps caused papyrus to disappear from Egypt as it had from Sicily. In 1872, the French, who maintained papyrus plants in a botanical garden in Paris, reintroduced the plant to Egypt. The source of the Paris specimens may have been Egypt, though proof is lacking.

Uses

The focus on papyrus's use as a writing medium has overshadowed its other uses. The Egyptians made papyrus, whose stem is buoyant, into boats. These boats allowed fishers and hunters to patrol the Nile Delta for fish and game. Because the Egyptians believed that crocodiles disliked papyrus, the people who used these boats thought that they were safe from this ever-present danger. According to myth, the goddess Isis took a papyrus boat to search for the remains of her dead husband and brother, Osiris. The most spectacular use of a papyrus boat came in 1970, when Norwegian archaeologist Thor Heyerdahl crossed the Atlantic Ocean in one to call attention to his claim that the Egyptians might have sailed to the Americas centuries before Spanish-Italian explorer Christopher Columbus's voyages in the 15th and 16th centuries.

Papyrus was a status symbol. The elites wore papyrus sandals while commoners were barefoot, though one authority believes that ordinary people may have worn inexpensive papyrus sandals that did not command the prestige of the elites' footwear. Law declared that only papyrus was good enough to be made into the sandals of the priests. Because wood was scarce in Egypt, its people used papyrus as a substitute, burning it for fuel according to Theophrastus and for smelting iron and copper according to Pliny. One Greek text mentioned the use of papyrus roots in making tables. First-century CE Greek physician Dioscorides noted that the Egyptians ate papyrus roots. The plant's ubiquity must have made it cheap sustenance. In addition to the roots, the Egyptians ate the lower portion of the stem, which contained starch. Papyrus was eaten raw, baked, or boiled. From an early date, the Egyptians made baskets from papyrus. First-century CE Jewish historian Josephus and second- and third-centuries CE Christian theologian Clement of Alexandria wrote that Moses's parents placed him in a papyrus basket, which they set upon the Nile River. The Egyptians also made mats from papyrus, a practice that the Arabs continued as late as 1796. Sailors used papyrus as rope and sail. The Egyptians made chairs and pillows from papyrus. Papyrus boxes were found in 14th-century BCE Pharaoh Tutankhamun's tomb. Commoners made their huts from papyrus. When burned, papyrus yields a pleasant odor and so was used as incense. Garlands made from papyrus adorned the statues of gods and the tombs or royalty.

A Writing Material

Above all else, papyrus was a writing material in antiquity and the early Middle Ages. The Byzantines, Muslims, Greeks, Romans, Persians, Palestinians, and Syrians all used papyrus, though in Egypt the use of papyrus as a writing material reached its apex. The Egyptians began to write on papyrus before 3000 BCE. Papyrus had the advantage of being durable—some texts have survived thousands of years—and permitting the storage of more information per unit space than clay tablets, wood, or metal. The Egyptians fashioned papyrus into rolls. The book had not yet been invented. Alternatively, pieces of papyrus were used in the composition of letters and were folded rather than rolled.

The pith of the stem of a papyrus plant was used as a writing surface. In some cases, the pith was sliced into thin strips. In other cases, a piece of papyrus was obtained by peeling the pith into a long segment. The maker of a papyrus roll may have attached segments of pith to one another with starch paste with less than one-inch overlap between strips. Pliny remarked, however, that strips were moistened and adjoined without the need for paste. The strips may have been attached to one another by pressing them together or by hammering them. Papyrus strips were bleached in the sun to ensure maximum whiteness.

A single roll contained 20 to 70 strips of papyrus. In Egypt's Middle Kingdom, strips were 15 to 17 inches wide, whereas in the New Kingdom they were 6 to 8 inches wide. Only ceremonial scrolls were taller than one foot because tall scrolls were too large for a scribe to place in his lap while writing. In the Old Kingdom, papyrus scrolls were 8 or 9 inches tall, though in the Middle Kingdom some were as tall as 13 inches. Most Middle Kingdom papyri were 3 to 6 inches tall.

The quality of papyrus was highest in Egypt, with a decline in the Roman and Islamic periods. In antiquity, the manufacture of papyrus was not widespread because only the elites were literate. Egyptian texts do not specify where or how papyrus was manufactured. Greek sources place the manufacture of papyrus in Alexandria, Sais, Tanis, and the Fuyum. Because papyrus must have been fresh when it was fashioned into rolls, its manufacture must have been close to the marshes where it grew. The manufacture of papyrus was a private undertaking, though, as we have seen, one that the pharaohs regulated.

Some scholars, pointing to the fact that papyrus was routinely reused, believe that it was expensive. Another set the price of papyrus at two deben per roll, the price of a small goat. Although this amount must have been too dear for commoners, it would have been little to the elites who were the consumers of papyrus. Still another estimates the price of a papyrus scroll at one to two days' wages for a laborer, an amount that would not have impoverished the elites.

Contrary to current practice, scribes wrote vertically in the Old Kingdom. Scribes began to compose horizontal lines of text in the Middle Kingdom. At the beginning of 19th century BCE, Pharaoh Amenemhat III's 46-year reign, vertical text was the norm, but by the end of it text was composed horizontally. In the New Kingdom, formal treatises contained vertical text. The rest used a horizontal arrangement. When text was first arranged horizontally, scribes wrote from one end of a scroll to the other, requiring the reader to unravel the entire roll to read a line of text. The adoption of blocks of text obviated the need to unravel a scroll to read a section. New Kingdom papyri, the *Book of the Dead* for example, contain blocks of text surrounded by a colored border. Sometimes the border was created first, text being added later to fit the space. The papyrus maker added an extra strip of material two to four inches long to the ends of a scroll. The strips formed a border on which text was not written. The writer left a margin of one to two inches at the top and bottom of a papyrus roll in the expectation that the top and bottom might fray with age. Scribes right-justified text, leaving the left edge ragged. The writer sometimes numbered blocks of text, which came to be conceptualized as pages. Columns were occasionally numbered. At first scribes wrote on only one side of papyrus, but by the second century CE it was common to use both sides. When a writer was short of space, he added an extra sheet of papyrus or wrote on the back.

Letters tended to be short and were seldom longer than a single sheet of papyrus. The sender wrote the name and address of the recipient and sometime the date on the outside of a letter. The sender secured a letter, in one case with a fishhook, in another case with string, and in a third with a seal of hardened mud. Official and legal documents were likewise sealed. In some cases, the seal on a letter was unbroken, indicating that the recipient had never read or perhaps never received it.

Because papyrus was durable, it was possible to moisten it and then erase text without damaging it. In the third and fourth centuries CE, the Greeks used a type of whiteout to cover text so that new material could be inserted. In some instances, corrections were made in the margin of a document or in the space above a line. In some cases, a chief scribe corrected text. The documents of the workaday world reused old papyri. Only official documents were deemed important enough to be committed to new papyri.

Papyrus was unrivaled as a writing medium until late antiquity, when parchment and vellum competed with it. Despite these challengers, papyrus continued in use until the 11th century, when paper replaced it. After 4,000 years, papyrus became obsolete.

Christopher Cumo

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Parsley

In the Umbelliferae family, parsley is in the genera *Petroselinum* and *Cryptotoenia*. There are four species of parsley. Curly-leaf parsley (*Petroselinum crispum*) has a fine texture and can grow 8 to 14 inches tall. Italian flat-leaf parsley (*Petroselinum neapolitanum*) lacks the texture of curly leaf. Italian parsley's smooth leaves are more aromatic and flavorful than curly leaf. For this reason, cooks prize Italian parsley. Italian parsley grows two to three feet tall. Curly leaf has long been more popular than Italian parsley, despite the latter's superior flavor and fragrance, because it resembles fool's parsley, a toxic plant. Since 1900, farmers and gardeners have grown turnip-rooted parsley (*Petroselinum tuberosum*), known as Hamburg parsley. The name turnip root is apt because people consume the roots of Hamburg parsley. Hamburg parsley leaves resemble the fronds of a fern. The fourth species, Japanese parsley (*Cryptotoenia japonica*), resembles Italian parsley but is infrequently cultivated, probably because of its bitter taste. Nonetheless it is part of Asian cuisine. The Greeks called parsley "rock celery," a fitting name given its tendency to grow on rocky hills and its relationship to celery. Worldwide, parsley is an important garnish and vegetable.

Origin, History, Cuisine, and Cultivation

Parsley originated in Mediterranean Europe according to one thesis. As the name suggests, Italian parsley, and likely all parsleys excepting Japanese parsley, may have originated in southern Italy. A third thesis favors an origin in Tunisia and Algeria in North Africa. Humans have cultivated parsley at least 2,000 years, first

Parsley (iStockPhoto)

as medicine and second as food. The Greeks viewed parsley in a religious and ceremonial context rather than as food, giving it to victorious athletes and adorning tombs with it. Mourners placed parsley liberally on corpses to disguise the stench of decomposition. The Romans may have been the first to eat parsley, using it as a garnish, a practice that continues today. In the ninth century CE, Frankish king Charlemagne so valued parsley that he required his subjects to plant it in their gardens.

Parsley may be fresh or dried. Fresh parsley has more flavor. Parsley spied in the supermarket should be dark green and crisp. Yellow or wilted leaves are too old for purchase. Drying, then storing in a cool, dark place best preserves Italian parsley. Curly leaf is best stored frozen. Because parsley loses flavor when cooked too long, a cook should add it to a dish when it is nearly ready for the table to retain flavor and nutrients. The people of the Middle East combine parsley with bulgar wheat, onion, mint, lemon juice, and olive oil. Others combine parsley with garlic, lemon zest, chicken, lamb, or beef. Some people add parsley to tomato soup and sauce, to a salad of fennel, cherry tomato, and pumpkin seeds, and to fish and vegetables.

A biennial, parsley produces leaves the first year and flowers and seeds the second. Parsley puts forth yellow to yellow-green flowers and seeds. The flowers attract bees and seeds attract birds. Once seeds are mature the plant dies. The first year's leaves are more flavorful than those of the second year. At high latitudes, parsley is cultivated as an annual because frost kills it at the end of the growing season. Parsley needs six to eight hours of sunlight per day, though it tolerates partial shade. The soil should drain well, contain organic matter, and have a pH between 6 and 7. Seeds germinate in two to five weeks. Long germination inspired the superstition that the seeds traveled to hell and back before sprouting. For this reason, superstitious farmers and gardeners refused to plant parsley. One may accelerate germination by soaking seeds in warm water 24 hours before planting. The gardener may start seeds indoors six to eight weeks before the last frost or directly in the garden after the last frost. The gardener is in error in planting early because parsley does not tolerate anything more than a light frost. One may plant seeds 0.125 inch deep in moist soil, being vigilant lest the soil dry. Seedlings resemble turf grass and should be thinned when 2 or 3 inches tall so that they are 10 to 12 inches apart. Once seedlings are established, the gardener should water them once weekly and cover the soil with leaves or grass clippings to retain water and minimize weeds. Parsley should be fertilized twice during the growing season with 5-10-5 fertilizer in a ratio of nitrogen to phosphorus to potassium. The gardener should allot three ounces of fertilizer to every 10 feet of row. Alternatively, one may use liquid fertilizer at half potency every three or four weeks for outdoor plantings and every four to six weeks for indoor cultivation. Parsley needs temperatures between 72°F and 86°F. The gardener should harvest stalks near the group, taking the outside leaves first. Frequent harvesting causes the plant to issue forth new leaves.

Nutrition and Health

Two tablespoons of parsley, about 7.6 grams, contain 6.7 grams of water, 2.7 calories, 0.23 gram of protein, 0.48 gram of carbohydrates of which 0.06 gram are sugar, 0.25 gram of fiber, 0.06 gram of fat, no cholesterol, 640.2 international units of beta carotene, 0.01 milligram of thiamine, 0.01 milligram of riboflavin, 0.01 milligram of vitamin B6, 0.01 milligram of copper, 0.01 milligram of manganese, 0.1 milligram of niacin, 10.1 milligrams of vitamin C, 0.06 milligram of vitamin E, 11.6 micrograms of folic acid, 124.6 micrograms of vitamin K, 0.03 milligram of pantothenic acid, 10.5 milligrams of calcium, 0.47 milligram of iron, 3.8 milligrams of magnesium, 4.41 milligrams of phosphorus, 42.1 milligrams of potassium, 0.01 microgram of selenium, 4.3 milligrams of sodium, and 0.08 milligram of zinc. Just 7.6 grams of parley supply 155.8 percent of the recommended daily allowance of vitamin K, 17 percent of the recommended daily allowance of vitamin C, and 12.8 percent of the recommended daily allowance of beta-carotene. Ounce for ounce parsley has thrice the vitamin C of oranges and twice the iron of spinach. Despite this nutritional profile, parsley contains oxalates that retard the absorption of calcium and may aggravate kidney or gallbladder ailments.

Parsley's volatile oils may reduce the growth of tumors, especially in the lungs. Parsley promotes the oxidation of molecules that harm the body. Parsley may make cigarette smoke less carcinogenic. Parsley's flavonoids act as antioxidants. Parsley may protect blood vessels from damage, may reduce the risk of heart attack and stroke, may protect one against colon cancer and women against cervical cancer, and may reduce the incidence of rheumatism.

Christopher Cumo

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Parsnip

Wild parsnips (*Pastinaca sativa*) originated in the area between the western Mediterranean and the Caucasus Mountains of Europe and Asia. Other common names include bird's nest, hart's eye, heeltrot, hockweed, madnip, queen weed, and tank. Parsnips are sometimes also confused with the highly poisonous Water Hemlock (*Sium latifolium*) in the wild since they are similar in appearance. Modern cultivated parsnips include four subspecies of what is now referred to as wild parsnip. *Pastinaca sativa* L. ssp. *sativa* is the commonly cultivated parsnip of the Northern Hemisphere, including the United States and Canada. *Pastinaca sativa* L. ssp. *urens* and *sylvestris* are grown in France, Georgia, Italy, Russia, Switzerland, and Ukraine. *Pastinaca sativa* L. ssp. *latifolia* is found in Corsica.

The cultivated parsnip is an herbaceous plant with an ivory-colored root, which has a sweet aroma and flavor. The leaves are simple, dark green, two feet in length, and often have the distinct characteristic of being hairy; the yellow flowers are in umbels at the end of stems. Wild parsnips are usually about half the size of

Parsnips (iStockPhoto)

cultivated plants and have a much lighter yellow flower. Parsnip is classified as a biennial or monocarpic perennial, meaning it dies after it produces seeds and flowers. It is planted in early spring and has its strongest growth until fall. The leaves die in freezing temperatures but the starches develop into sugars with frost, then growth resumes in late winter or early spring. Flowers bloom in this second spring and disperse their seeds in fall.

History

The Latin name, *Pastinaca*, has been referenced in writings since the time of the Romans. It may have come from the Latin *pastino* meaning "to prepare the ground for planting of the vine" or simply *pastus* meaning "food." It is in the family Apiaceae (Umbelliferae), which also includes carrot, celery, celeriac, fennel, anise, caraway, chervil, coriander, lovage, and parsley. Written identification of the plant is a bit confusing because of the uncertain history of its Latin name (*Pastinaca*), which was also used for carrots. But according to encyclopedist Pliny the Elder, Emperor Tiberius loved the sweet flavor of parsnips so much that he had them imported from where they grew bountifully in the area of Gelduba on the Rhine. While parsnips were eaten and used for medicinal purposes quite commonly until replaced by the potato in the 19th century, they were probably picked from the wild. The first intentional cultivation was recorded when Europeans introduced parsnips upon their arrival in North America.

The first illustrations of parsnips were created by German botanists. Leonhart Fuchs (Fuchsius Leonhartus) identified it in 1542, although he refers to the plant as "*gross zam mosen*." Roeszlin also drew parsnip in 1550, calling it "*pestnachen*." In the same year, Jerome Bock (Hieronymus Tragus) mentioned parsnips and says they are more common in kitchens than fat. Parsnips were a staple food of Europe's poor, providing a sweet starch that included vitamin C, fiber, and potassium. It was recorded as a cultivated crop in the United States in Virginia in 1609 and declared common in Massachusetts by 1630. Native Americans also used parsnips frequently after they were brought to North America, and it was reported by General John Sullivan in 1779 that he destroyed the stores of parsnips of the Iroquois of western New York in his attacks. The most commonly cultivated parsnip used in modern times is the garden variety called the "Student," developed between 1848 and 1850 by Professor James Buckman. Professor Buckman raised this variety from seed originating in the Royal Agricultural College in Cirencester, England. It is still a widely used heirloom seed.

Invasive Wild Parsnip

Cultivated parsnips are popular crops worldwide with 45 of 50 states in the United States producing them (excluding only Alabama, Florida, Georgia, Hawaii, and Missouri), the largest producers being northern California and Michigan. However, wild parsnips are highly invasive and problematic, and it is still debated if they are edible for humans. Wild parsnips are plants that escaped from cultivation soon after they were introduced to North America. In the United States, wild parsnips have been declared noxious in Ohio and an invasive weed in Kentucky, Nebraska, Tennessee, Wisconsin, and Pennsylvania. They are causing problems in other countries across the globe.

While very similar to the cultivated plant, wild parsnips are a bit smaller and do have some chemical differences. All parsnips contain furanocoumarins, which deter herbivores from eating the leaves and can cause phytophotodermatitis (skin redness and blisters from touching sap or ingesting leaves). The symptoms are the most prevalent when the plant is in bloom. However, cultivated varieties have less furanocoumarins than those growing in the wild. This compound does keep many pests from consuming the plant, resulting in some research about the plant's potential use in insecticides. Unfortunately, it also repels honeybees as well as takes over the habitat of flowering plants the bees pollinate, further limiting their resources and causing concern for beekeepers. It is also unfortunate that the only insects that appear to be unaffected by the furanocoumarins are destructive parsnip webworms, which seem to be thriving along with the invasive wild parsnip.

Medicinal and Culinary Uses

Since 968 CE, the class of organic chemical compounds found in parsnips called furanocoumarins has been used to treat skin disorders such as leprosy and leucoderma (white spots and patches on the skin). More recently, furanocoumarins have been used in photochemotherapy to help cure psoriasis and lymphoma of the skin. Research using furanocoumarins is also being done studying DNA structure since they bind to DNA. And due to furanocoumarins' insecticidal properties, parsnip can be used to research plant and herbivore interactions.

Parsnip roots were used by Native Americans to relieve sharp pains, and various written records indicate their value as a cure for fever, jaundice, and gravel and as a diuretic. It is also indicated that parsnip was used in a poultice to help heal skin inflammations and sores. The fruits were known to be used as a tonic, to aid digestion, and to induce menstrual flow.

Parsnips have long been staples in numerous culinary dishes because of their sweet, starchy flavor as well as their timely harvest in late winter or early spring. It is recorded that they were a common companion to salt fish during Lent. In northern Ireland, parsnips sometimes replace hops, are fermented with yeast, and mixed with malt to make beer. Parsnip wine is also often made as well as marmalades, soups, cakes, and even raw salads.

Erika Stump

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Peach

A fruit tree, the peach is a member of the Rosaceae family and is related to the rose, almond, plum, nectarine, apple, and pear. The species name, *Prunus persica*, derives from the old assumption that the peach originated in Persia (now Iran). Because the Romans encountered the peach in Iran, they thought it must have originated there. Many scholars, including 18th-century Swedish naturalist Carl Linnaeus, supposed that the Romans had been correct. Rich in beta-carotene, vitamin C, niacin, potassium, and fiber, peach has little saturated fat, cholesterol, and sodium. One peach has 185 calories.

Mythology, Origin, and Diffusion

Taoist mythology holds that the peach symbolizes immortality. According to tradition, the Queen Mother of the West tended a garden with the peach trees of immortality. The garden had 3,600 peach trees. Some fruit ripened once every 3,000 years. One who ate a peach became immortal. Other fruit ripened every 6,000 years. A man who ate one of these peaches ascended to heaven. Still other peaches ripened every 9,000 years. A man who consumed a peach from one of these trees gained the ability to grow as old as the Earth without aging. The Monkey King, visiting the garden, ate a peach, thereby gaining eternal life.

In the first century BCE, the Romans, acquiring the peach from Iran, brought it to Italy. They were wrong, however, in supposing that the peach originated in Iran, though only in 1885 did French botanist Alphonse de Candolle pinpoint China and the true homeland of the peach, a view that Russian agronomist Nikolai Vavilov confirmed in 1951. In the second or third century BCE, merchants traveling the Silk Road brought the peach from China to Iran. By the first century BCE, farmers cultivated peaches widely in Italy. A second introduction of the peach from Iran brought it to France. From France rather than Italy the peach likely diffused throughout Europe during the Middle Ages. After 1500, the Spanish brought the peach to Central America and later to North America. Around 1850, Chinese immigrants brought the peach, doubtless a second introduction, to the United States.

China

The world's largest producer of peaches, China was the ancestral homeland of the fruit. From an early date wild peaches grew in Tibet, Gansu, eastern Shaanxi, southern Henan, southwestern Sichuan, and western Yunnan. By 6000 BCE, the Chinese were gathering wild peaches, though it is not certain when they began cultivating them. One authority places the origin of peach culture in the Neolithic era. Another believes that the Chinese cultivated the peach before 1000 BCE. In this context, archaeologists have dated the remains of cultivated peaches to 1600 BCE. Whatever the date, Chinese texts refer to the peach more than 1,000 years before Europeans knew of it. One Chinese manual, written between 1100 and 600 BCE, confirmed the antiquity of the peach. So prized was it that a bountiful peach tree has for millennia symbolized a family's prosperity, happiness, and luck.

Eager to improve agricultural methods, a fifth-century BCE Chinese text emphasized the importance of fertile soil, attempting to describe the ideal soil for peach cultivation. By the third century BCE, the Chinese cultivated the peach tree for shade and as an ornamental in addition to its use as a source of food. In the pre-Han era, the Chinese grew the peach principally in southern China. In the Han dynasty, the emperors grew peach trees in the imperial gardens. By the Han, the Chinese cultivated a large number of varieties adapted to local conditions. One Han text recommended the planting or transplanting of peach trees in January, presumably because they were dormant then. The Chinese understood that a tree in bloom should not be transplanted.

Between the third and 10th centuries CE, the Chinese domesticated several wild species of peach and took care to select vigorous seedlings for transplantation. The result was an increase in the number of cultivars. In the fourth century, the Chinese classed peach varieties as being a winter peach, a summer white peach, and an autumn white peach. By then farmers were selecting varieties for early maturation. In the sixth century, a Chinese text noted that some peach trees fruited at age 3 years. Peach trees were then apparently short lived, for the text observed that some trees suffered a decline in production after 7 or 8 years and died in 10 years. The text emphasized the value of manure in improving yields. One Chinese book listed the peach among five species of fruit tree vulnerable to frost when in bloom. Farmers knew that frost was possible when the sky cleared and the wind turned cold. They burned straw and manure to heat the air in peach orchards, a practice that continues in northern China.

Between the 10th and 20th centuries, the Chinese planted peach trees on new land. An 11th-century Chinese manual recorded 30 varieties, including the small peach, the October peach, the winter peach, the flat peach, and the thousand-leaf peach. The peaches grown in southern China derived from these cultivars. Among cultivars, the pink peach, light pink peach, crimson peach, red peach, dark red peach, purple peach, golden peach, silver peach, and white peach were named for the color of the flesh. The May peach, the October peach, the autumn peach, and the winter peach derived their names from the time of maturation. A 14th-century text gave instructions on planting peach trees, recommending the transplanting of seedlings in early spring, when they were still dormant, or in autumn, when they shed their leaves. The text outlined the procedure for grafting branches onto the rootstock of seedlings.

Today, the peach is one of China's five most important fruit trees. Among varieties China has since the 1990s are planted the Kanto 5 and Myoujou varieties from Japan, and NJN and Babygold from the United States. Since 1994, China has been the world's largest peach producer. The majority of the harvest is white-fleshed varieties. Between 1984 and 2006, peach acreage quadrupled in China. By the latter year, China produced millions of tons of peaches. That year China yielded nearly half of the world's peaches. By contrast, the United States totaled just a few percent. The world's five leading producers are China, Italy, Spain, the United States, and Greece. Despite China's leadership, the nation does not boast the largest yield per acre. China's leading peach producers are Shangdong, Hebei, Henan, Hubei, and Jiangsu provinces. Production concentrates in northwestern, northern, central, and eastern China. In some areas of China, the peach is replacing citrus, which is in oversupply. Although consumers prefer a diversity of peaches, growers focus on the white-fleshed peach. Small farmers produce most of China's peaches.

The Nutrients and Water of the Peach Tree

A peach tree needs nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, zinc, boron, iron, manganese, and copper. Peach trees worldwide need applications of nitrogen, though annual fertilizing may not be necessary. It was once common to apply 176 pounds of nitrogen per acre of peach trees, though today 88 pounds per acre are the norm. The amount of nitrogenous fertilizer has declined because farmers are more environmentally aware of the danger nitrate pollution poses to groundwater and rivers. Moreover, a small application of nitrogen is more economical than a large application. Light green or yellow leaves betray nitrogen deficiency. The farmer may also discover leaves with red or brown spots. Nitrogen-deficient trees yield small fruit, which tends to be red and of poor quality. Too much nitrogen produces excessive vegetative growth. The fruit is less red because the large number of leaves shades it. The fruit matures slowly. Because of the growth of branches and leaves, the farmer must spend money and time pruning the excessive growth. When nitrogen is too abundant, a tree is susceptible to pests and diseases. Urea is an efficient source of nitrogen. A tree absorbs the majority of urea applied to the soil. Mature peach trees absorb nearly one pound of nitrogen per acre per day.

Phosphorus deficiency, though uncommon, causes fruit to ripen early. Under normal circumstances earliness is a desideratum, but the early fruit from a phosphorus deficient tree is tasteless. Scientists were alarmed by the prevalence of potassium deficiency in the 1930s and 1940s, though it is less common today. Where potassium is in shortage, leaves curl and turn pale green. A tree bereft of potassium produces few flowers. The yield is accordingly low. One scientist recommends the application of potassium every three to four years. Where the soil has too much potassium, magnesium will be in shortage. Where there is a dearth of calcium, a common occurrence, peach roots grow poorly, being swollen and short. The leaves display chlorosis. Some leaves die, falling from a tree and causing defoliation. The fruit is small and the sugar content low. The peaches are accordingly tasteless. The application of calcium to the soil may retard the decay of peaches, maintain firmness, and improve flavor and fragrance. Magnesium, deficient in sandy or acidic soils, may be leached by rain or irrigation. Where it is in shortage, the tips of old leaves turn pale green and may display yellow chlorosis. Leaves may fall from a tree. A severe deficiency of magnesium decreases yield, producing small fruit that may not ripen. The farmer may need to fertilize his orchard two to three years to restore the proper level of magnesium.

Zinc deficiency is widespread, particularly in Australia and North America. Peach trees are particularly sensitive to a shortage of zinc. The farmer may have difficulty identifying this problem because the symptoms of zinc deficiency are similar to those of manganese deficiency. Where zinc is in shortage, old leaves fall from a tree, which produces small fruit that decays quickly. One scientist recommends the application of zinc sulfate to the soil. Boron deficiency is also common. More than 80 countries have reported it, yet the peach tree tolerates a dearth of boron better than most crops. An excess of boron may be more problematic because the difference between deficiency and toxicity is small. Too much boron causes buds to die. The leaves are small, the bark cracks, and the fruit is deformed. The farmer need apply boron only every three to five years at 8.8 to 26.4 pounds per acre. A dearth of iron is uncommon, though a high soil pH may make the element unavailable for uptake by the roots. Moreover, a peach tree may suffer from an immobility of iron in its cells. In some areas, half the peach trees suffer from iron immobility. Among fruit trees, the peach is particularly sensitive to iron deficiency. Where iron is in shortage, peach leaves yellow, though the veins remain green. Young leaves are especially susceptible to damage. An afflicted tree produces few flowers and accordingly little fruit. Not only is the yield low, but the fruit is small. Iron fertilizers are effective but expensive. Where soil pH is too high the farmer must reduce it, but this too is expensive. Manganese deficiency is common, but the affliction appears not to reduce the yield.

A peach tree needs more water than other fruit trees, possibly because it evolved in an area of high rainfall and humidity. There was apparently no selective pressure to evolve a mechanism to conserve water. High rainfall or irrigation rewards the grower with large fruit that ripens uniformly. Irrigation is common in dry regions. A well-watered tree suffers from few diseases and is hardy. Conversely, too much water may make a tree less hardy. Young trees bear fruit early when irrigated. Although moisture is important, a peach tree will not tolerate waterlogged soil. Soil that is too wet may harbor fungi that cause the disease *Phytophthora* root rot.

Breeding New Cultivars

Scientists have aimed to breed new varieties of peach suitable for cultivation in the subtropics. Because the subtropics are warmer than temperate regions, these new varieties need little cold weather to initiate dormancy in winter. For this reason, scientists call them low-chill cultivars. The effort to breed low-chill varieties is important because peaches grown in the subtropics provide fruit out of season to consumers in temperate zones. Flowering in mid- to late winter, low-chill varieties yield fruit when the supply is small and the price high. As Earth warms, it may become more suitable to the cultivation of low-chill cultivars.

In the 19th century, Chinese immigrants introduced the low-chill cultivars China Flat, Bell's November, Beauty of Booroodabin, and Watt's Early Champion to Australia. In 1869, Australians brought China Flat, now called Australian Saucer, to the United States. In 1907, the University of California Citrus Experiment Station at Riverside began breeding low-chill peaches. In 1933, the station released Babcock, an early-ripening low-chill variety. From Babcock, scientists derived Early Babcock and Giant Babcock. Between 1933 and 1958, the University of California released 23 cultivars. California farmers raised these varieties as late as the 1990s, exporting their fruit to Asia.

In the 20th century, Florida grew the low-chill varieties Angel, Jewel, Bidwell Early, Waldo, and Peen-to. In the 1940s, the University of Florida began breeding low-chill varieties. Among its most promising varieties are Sunred, Sunlite, and Maravilha. Between 1980 and 2004, the University of Florida released more than 100 cultivars. The Floridian varieties Tropic Beauty, Flordaprince, and UFGold are grown in Australia. In 1985, the Centro de Fruiticultura in Chapingo, Mexico, began breeding low-chill cultivars. The program aims to derive varieties resistant to the fungal disease powdery mildew. The Mexican program has cooperated with the University of Florida. In 1989, the two jointly released Oro A, a low-chill variety grown in Australia. Most of the Chapingo varieties yield peaches that are sold fresh.

Since 1950, the Instituto Agronomo has bred low-chill varieties in São Paulo, Brazil. The program has used the U.S. cultivars Jewel, Suber, Hall's Yellow, Lake City, and Angel as breeding stock. Scientists aim to derive peaches for canning and the fresh market. Among the program's objectives are the derivation of varieties that yield early, produce large fruit, and resist diseases and pests. The program has released 58 varieties, which account for 1.2 of 1.9 million peach trees in São Paulo. Since 1953, the Brazilian Agricultural Research Enterprise has released 21 low-chill cultivars.

Although Taiwan planted temperate cultivars from Japan in the highlands, soil erosion turned the island toward low-chill varieties that could be grown in the lowlands. In 1980, the Taiwan Agricultural Research Institute began breeding low-chill varieties. The program aimed to derive white-fleshed peaches that were juicy and had high sugar content. Among its new cultivars are Ing-go, Tainung No. 1, and Spring Honey. The last ripens early.

In the 1990s, the University of Western Sydney and the Queensland Department of Primary Industries and Fisheries began a program to breed low-chill varieties. By deriving suitable cultivars, Australian scientists hope to help farmers export peaches to Southeast Asia from September to December, when few peaches are on the market.

In 1997, the Royal Project Foundation and Kasetsart University began breeding low-chill varieties in Thailand. These varieties are suitable for the highlands, which have a long growing season and high rainfall. The program aims to produce peaches that ripen between March and June, Thailand's dry season. Varieties from Texas A&M University serve as breeding stock.

Christopher Cumo

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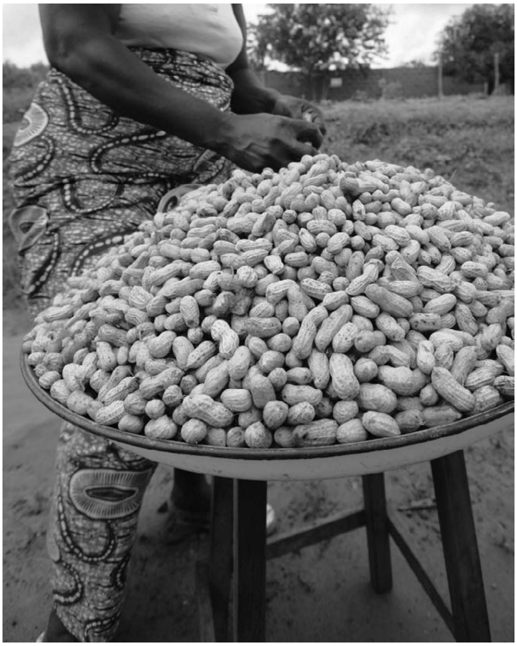
Peanut

Neither a pea nor a nut, the peanut, a perennial legume, has several names. The Inca called the peanut *ynchia* or *inchia*. The Tainos of Hispaniola (now the island of Haiti and the Dominican Republic) referred to the peanut as *mani*, a name the Spanish appropriated. The Gedda of West Africa knew the peanut as *nguba*, from which may have arisen the slang "goober." Another tradition holds that the Bantu word *nguber* is the source of the term "goober." The Aztecs called the peanut *tlalacachuafl*, meaning "the chocolate bean that grows underground." This linkage between the peanut and chocolate implies that the Aztecs combined these foods. The pre-Columbian people of Brazil called the peanut *manobi*. In the 17th century, Dutch physician Willem Piso referred to the peanut as *mandubi*, perhaps borrowing this term from the Amerindians. A member of the Fabaceae or Leguminosae family, the peanut is also known as the pygmy nut, the pig nut, the monkey nut, pinder, pinda, and the Manilla nut. Some people call the peanut the groundnut and the earth nut because the pod matures underground. Finally, scientists know the peanut by the name *Arachia hypogaea*. Peanuts are related to beans, soybeans, lentils, lupine, alfalfa, clover, vetch, chickpea, cowpea, and peas.

Scientists believe that the ancestor of the peanut bore pods above the soil but may have evolved an underground habit to protect peanuts from grasshoppers, locusts, and other predators. The modern peanut plant bears flowers low on the stem. Once fertilized, the flowers produce pods on the stems known as pegs. The pegs hang near the ground and enter the soil, where the pods mature. The peanut is 43–52 percent oil and 25–32 percent protein. A calorie-dense food, one pound of peanuts has as many calories as two pounds of beef, one-and-one-half pounds of cheddar cheese, and 36 eggs. A nutritious food, the peanut has protein, oil, niacin, folic acid, fiber, magnesium, vitamin E, manganese, and phosphorus. It has small amounts of calcium and copper.



Peanuts (iStockPhoto)

Origin and Diffusion

The peanut is indigenous to South America, which has 29 species of the legume. One hypothesis puts its origin in Bolivia, which has the largest number of wild species. Another hypothesis traces the peanut's lineage to the land bounded by Brazil, Bolivia, and Paraguay. About 3000 BCE, the people of Brazil and the Caribbean cultivated the peanut. Between 1800 and 1200 BCE, the Peruvians first grew the peanut. The ancient Peruvians ate peanuts as a snack, just as Americans do today. Around 700 CE, the Chimu of Peru painted images of peanuts on pottery and must have grown the crop earlier. The Nazca of Peru also painted images of peanuts on pottery. The pre-Columbian people of Peru put peanuts in tombs, perhaps intending them as food for the dead. In the second millennium CE, the Inca and the people of the Bahamas grew the peanut. The Aztecs cultivated the peanut and may have used it to treat swollen gums. The peoples of the Americas may have traded the peanut and carried it with them as they migrated throughout Central and South America and Mexico.

In the early 16th century, Spanish priest Bartolomé de las Casas, working in Hispaniola, may have been the first European to encounter the peanut. He wrote the first European description of the plant. In the early 16th century, the Portuguese transferred the peanut from Brazil to Africa. Within a century, the peanut was so widespread that many Africans forgot that it was not an indigene of the continent. In 1530, the Spanish carried the peanut from Peru to Spain and Malaysia. In 1565, the Spanish introduced the peanut to the Philippines. After 1600, African slaves introduced the peanut to North America. Alternatively, the peanut may have migrated from the Caribbean to North America, perhaps without the aid of slaves. In 1690, the Dutch introduced the peanut to Indonesia. In the 17th century, the Chinese adopted the peanut. The peanut must have quickly become a food for the masses, though its success bothered Gonzalo Fernández de Oviedo y Valdés, governor of Hispaniola, who declared it fit only for slaves, children, and commoners. He denigrated its "mediocre taste" and found it suitable for people "who do not have a fine taste."

Types and Varieties

Scientists divide the peanut into four types, large categories of the legume that share common characteristics. Between 1707 and 1725, African slaves brought the runner type, named for its production of long vines, to the American colonies. Alternatively, runner may have migrated from the Caribbean to British North America. Grown in the South, runner was known as Africa, Wilmington, North Carolina, Georgia, and southern runner, perhaps because of the association between runner and these regions. The Spanish type, named because of its association with Spain, originated in Argentina, Paraguay, or southern Brazil. In 1784, Spaniard Don José Campus introduced the Spanish type to Lisbon, Portugal, and may have introduced it to France about 1800. Spaniards grew the Spanish type for oil and for chocolate-covered peanuts. In 1871, Spain introduced the Spanish type to the United States, where its popularity stemmed from the fact that it matured earlier than runner. The Virginia type originated in Bolivia or the Amazon region and was introduced to the United States in 1844 or 1871. Producing a large kernel, the Virginia type may have hybridized with runner, perhaps in the 19th century. The Valencia type, named for its association with Valencia, Spain, originated in Paraguay or central Brazil. In 1911, Spaniards introduced the Valencia type to the United States.

From these four types, scientists have bred more than 8,000 cultivars according to the Southern Regional Plant Introduction Station. In 1960, the varieties derived from the Spanish type totaled 36 percent of U.S. peanut production whereas the runner type tallied 32 percent. Varieties of the Spanish type were the most widely grown peanuts in the United States until the late 1970s. In 1969, the Florida Agricultural Experiment Station developed the variety Florunner, a cross between the varieties early runner and Florispan. The new variety surpassed the Spanish type within a decade. Whereas Spanish varieties occupied 45 percent of U.S. peanut acreage in the late 1960s, Florunner and other runner varieties claimed 44 percent of acreage in 1972. That year Spanish varieties totaled 32 percent of U.S. acreage, Virginia varieties 23 percent, and Valencia varieties just 1 percent. In 1980, varieties derived from runner monopolized 79 percent of U.S. peanut production. Virginia totaled 16 percent and Spanish just 5 percent. Runner varieties were the leading cultivars in Mississippi, Alabama, Florida, Georgia, and South Carolina and were gaining ground in Texas and Oklahoma.

Growing primarily the Valencia type, New Mexico supported research into the development of new varieties. In 1971, the New Mexico Agricultural Experiment Station derived Valencia A from Tennessee red. The Valencia type, including Valencia A, is sweeter than the other types. Vendors sell it in the shell. Virginia varieties produce large kernels, which are sold as salted nuts and peanut butter. In 1990, 55 percent of the runner harvest went to peanut butter and 18 percent to salted nuts. That year 60 percent of the Spanish crop was sold to make peanut butter. In the American Southeast, farmers grow principally Florunner, which is raised from Virginia to New Mexico. In addition to florunner, farmers in the Southeast grow Sunrunner, GK-7, Southern Runner, and Sunrise. The last variety produces kernels more uniform in size than those of florunner. Southern Runner is popular because of its resistance to leaf spot though it does not mature early. Texas and Oklahoma grow the Spanish varieties Tamspan 90, Starr, Spanco, and Pronto.

The United States

In the United States, the peanut sustained slaves, who planted it in their gardens. Eating it as a substitute for meat, the slaves depended on the peanut to help them endure the privations of winter. In the South, stockmen fed peanuts to hogs, turkeys, and chickens. Stockmen let pigs graze in peanut fields. The peanut was suitable for this purpose because livestock can digest the entire plant, not merely the kernels. Yet livestock need a supplemental feed. Because the peanut is comparatively low in minerals, pigs that eat just peanuts develop weak bones. Lactating pigs produce abundant milk, but it is low in calcium. Because Americans associated the peanut with slaves and pigs, they thought it food for the poor. In the antebellum South, farmers cultivated the peanut in Alabama, Georgia, Louisiana, Mississippi, the Carolinas, Florida, Arkansas, Tennessee, and Texas. In the 1840s, farmers in Virginia adopted the peanut. During the Civil War, peanuts nourished soldiers in Union and Confederate armies. For many northern soldiers, the war marked their introduction to the peanut, and, acquiring a taste for it, they returned home with the expectation of being able to enjoy the legume as a regular part of their diet. After the war, demand for the peanut was so robust that the United States tripled its production of the legume between 1865 and 1870. During the 1870s, the peanut emerged as a snack food. In 1871, entertainer P. T. Barnum sold peanuts to circus goers. By 1880, South Carolina produced a surplus large enough to make it a peanut exporter.

After 1892 the boll weevil, forcing growers to seek an alternative to cotton, benefited the peanut. Many farmers in the Carolinas, Georgia, and Alabama switched from cotton to peanuts. Stung by the weevil, farmers in Coffee County, Georgia, abandoned cotton for the peanut. The decision was wise. By 1917, Coffee County produced more peanuts than any other county in the United States. Initially a regional commodity, the peanut became a national crop in the early 20th century. One authority credits the use of peanut butter with accomplishing this transition. Although the Aztecs invented peanut butter in the first century CE, they received no credit for this achievement, and in 1898 physician John Harvey Kellogg, perhaps believing himself the inventor, patented peanut butter. It quickly became a favorite of children, a mainstay of the lunchtime sandwich, and a snack food. In 1901, inventors F. V. Mills and H. S. Mills devised a machine that dispensed roasted peanuts for a penny. So popular was it that by 1910 the United States had 300,000 machines. North Carolina growers cultivated Spanish peanuts for use in these machines. In the early 20th century, confectioners produced peanut candies in large quantities to cater to American tastes. In 1905, the invention of the peanut picker, the first mechanical harvester, made the work of harvesting peanuts less onerous. In 1906, entrepreneurs Amedeo Obici and Mario Peruzzi founded Planters Nut and Chocolate Company in Wilkes-Barre, Pennsylvania, now one of the world's leading peanut sellers. The company's Mr. Peanut is recognizable worldwide.

Before World War I, the United States was a net importer of peanuts. The war, disrupting trade, caused a shortage of peanuts in the United States. American farmers responded by increasing land to peanuts from hundreds of thousands of acres in 1914 to millions of acres in 1918. Texas, Alabama, and Georgia farmed more than 1 million acres apiece, and Florida, Virginia, Arkansas, the Carolinas, Oklahoma, Louisiana, and Mississippi devoted more land to peanuts. Appreciating the legume's importance, the Red Cross declared it one of the four most nourishing foods for soldiers. During the war, the shortage of wheat led bakers to make bread from a combination of peanut and wheat flour. The Red Cross lauded peanut bread, and patriotic Americans added "Victory Peanut Flour" to bread. The National Emergency Board Garden Commission encouraged gardeners to grow peanuts for their own sustenance. One Florida gardener made headlines by living entirely on peanuts during the war. Patriotic organizations urged Americans to observe meatless days and encouraged them to eat peanuts rather than meat. The U.S. Food Administration promoted the use of peanuts as hay and in cosmetics, fuel, fertilizer, packaging material for sardines, roofing shingles, putty, insulation, and linoleum. World War I increased the demand for vegetable oils, peanut oil among them. In 1916, the South produced hundreds of millions of pounds of peanut oil.

The enthusiasm of the peanut produced a crisis. The end of World War I allowed the United States to reestablish the peanut trade with South America, Asia, and Africa. In 1920, imports flooded the United States and peanut prices fell. Anxious peanut growers approached Congress for help. Among the supplicants was Alabama agricultural chemist George Washington Carver, whose testimony helped persuade Congress to pass a tariff on peanut imports. Carver's conversion to the peanut had not been dramatic. He credited a white woman with stimulating his interest in the legume. She had planted thousands of acres to cotton but lost the crop to the boll weevil. She turned to Carver for an alternative and for help marketing peanuts. Turning his attention to the peanut, Carver conducted a series of experiments on peanuts as hog feed. These experiments were not revolutionary. Stockmen had fed peanuts to hogs for many years. Nevertheless, this work marked an important stage in Carver's career for he had shrewdly selected a crop whose importance was dawning on the nation. The South's oil mills that had crushed cottonseed could now derive oil from peanuts. Sharecroppers grew peanuts as a cash crop and as food. Whites employed blacks to pick peanuts and to work in factories that produced peanut butter. The South in general and African Americans in particular would benefit from Carver's work. During a long, productive career, Carver developed more than 300 uses for peanuts, among them flour, cake, feed, shoe polish, pickles, rubber, coffee, vinegar, punch, cough syrup, and face cream. In making his case for the peanut, Carver even touted its use in treating polio. The American Medical Association did not endorse this claim, and Carver admitted that he had not proven the efficacy of the peanut as a treatment for polio. More appropriately, Carver urged farmers to grow the peanut because, as a legume, it fixed nitrogen in the soil and so helped them combat the bugaboo of American agriculture: soil exhaustion.

In addition to these uses, peanuts, in the form of oil, can be made into soap, shaving cream, cosmetics, paint, and explosives. The American market for peanut oil is not large, representing less than 1 percent of vegetable oil produced in the United States. Peanut oil occupies this low position because it is expensive compared to other oils and has a short shelf life. Nuts that are not suitable for wholesale or making into peanut butter go to make oil. Fifteen percent of the U.S. peanut crop is converted into oil. Among vegetable oils, peanut oil ranks sixth in sales in the United States and is suitable for frying. Peanut meal has also not carved out a large niche, totaling less than 1 percent of plant meal in the United States. Peanut meal does not challenge the supremacy of soybean meal in feeding livestock. Ground peanut shells may be used to make wallboard and as roughage in cattle feed. Some brands of kitty litter have peanut hulls.

In 1941, the year that marked the United States' entry into World War II, the federal government declared the peanut an essential crop. In response to wartime demand, the U.S. peanut harvest increased sharply between 1940 and 1945. Under the federal farm program that evolved during the 20th century, farmers sell a portion of their peanuts to the federal government and export much of the crop. The rest satisfied domestic demand. In 1990, Americans consumed the majority of the harvest as peanut butter. They ate one-quarter of the crop as shelled or salted nuts and a little more than one-fifth as candy. Presently, Americans eat the vast majority of the peanut harvest. The rest is crushed into oil or set aside as seed and livestock feed. Today, Georgia grows nearly half of all U.S. peanuts. Three-quarters of Georgia's peanut crop are sold to make peanut butter. Peanuts generate millions of dollars for the state's farmers. Former president Jimmy Carter rose to prominence partly because he used his occupation as a peanut farmer to convince Americans that he embodied the rural values of diligence, thrift, piety, and honesty.

Popular during much of the 20th century, peanuts suffered a setback in the 1990s. The demand for peanuts fell as many Americans branded them fattening. Reports of allergies to peanuts and even of deaths from their consumption led nervous administrators to reduce or eliminate peanuts and peanut butter from school lunches. Between 1982 and 2002, as demand for peanuts ebbed, competition from cheap imports intensified and the trend toward the consolidation of farms in fewer hands caused the number of peanut farmers in the United States to decline by half. Yet the peanut is enjoying a revival. Weight Watchers and the American Diabetic Association tout the nutrition of peanuts. In 2002, the average American ate several pounds of peanuts, a larger quantity than many other nations can boast.

The combination of peanuts and chocolate mixes saltiness and sweetness in a way that many people cannot resist. An early peanut candy, Reese's Peanut Butter Cup, sold for a penny per cup in 1928. Other peanut candies followed, including Baby Ruth and Snickers. In 1991, in the midst of the Gulf War, Mars Incorporated put a Snickers bar in every U.S. soldier's ration for Thanksgiving. Reese's, Baby Ruth, Snickers, and other peanut candies are favorites of children who trick-or-treat on Halloween. In the United States, candy makers use 0.25 percent of the peanut harvest. Today, peanuts are ubiquitous. One may eat them at a baseball game or on a flight to Dallas, Cincinnati, or hundreds of other destinations. Peanut butter is, according to one writer, "America's favorite food." Americans ate hundreds of millions of pounds of peanut butter, more than several pounds per person, in 2002. Jiff was the leading peanut butter in 2002. Skippy ranked second.

Cuisine

As a worldwide crop, the peanut has inspired a multinational cuisine. The people of Peru, Bolivia, and Ecuador make the peanut into a sauce, combining it with eggs, cheese, olives, chili peppers, and spices and using the sauce to flavor potatoes. Brazilians eat chicken stew with a sauce of peanut and coconut milk. In Zimbabwe, as in the United States, people roast peanuts, eating them with salt. Ethiopians make a stew of peanuts and chili peppers, eating it with rice or millet cakes. Kenyans make a stew of peanuts and beans, consuming it with corn pudding. The people of Malawi and Zambia make a dish of peanuts and tomatoes, both American crops. The people of Mali eat fried peanut cakes. The people of Mozambique prepare a dessert of peanuts, egg yolks, and sugar, commonly eaten as pudding. Indonesians combine peanut sauce with meat and rice. They make the sauce from peanuts, ginseng, chili peppers, garlic, lime, shrimp, and shallot. Indonesians also make wafers of chopped peanuts, eat boiled peanuts with chili sauce, and chop peanuts on salad. Malaysians make a sauce of peanuts and coconut milk, pouring it on vegetables. The Thai prepare a salad of roasted peanuts and papaya and use chopped peanuts in several dishes. The Vietnamese combine peanuts and vegetable roots. Vietnamese children eat boiled peanuts at breakfast. The Chinese use peanut oil for frying. They fry peanuts in peanut oil. Alternatively, they boil peanuts, eating them in stir-fries. The Chinese make candy from ground peanuts and sugar. Indians eat a type of trail mix of peanuts and other legumes. They use peanuts in curries, stews, and soups. Americans have recipes for peanut soup, peanut brittle, and peanut crust pies. They boil peanuts in the shell in salt water.

Attributes and Cultivation

The peanut may be grown in tropical, subtropical, and temperate locales. An outstanding attribute of the peanut is its ability to fix nitrogen in the soil. For this purpose, Florida citrus growers plant peanuts between their trees. The peanut's self-sufficiency in nitrogen makes it suitable in rotation with soybeans, another nitrogen-fixing legume, though this coupling may be susceptible to disease. Also popular is a rotation of peanuts and cotton. The peanut restores the nitrogen that cotton removes from the soil. Despite its virtues, the cultivation of peanuts was hard work. Before the mechanization of agriculture, workers had to dig peanuts, pick pods by hand, and spread them on sheets to dry and roast them. The mechanization of agriculture lessened but did not eliminate this drudgery.

The peanut takes minerals from the soil. A 2,000-pound crop of peanuts removes from the soil tens of pounds of nitrogen, though the fact that peanuts fix nitrogen in the soil must lessen the net loss of nitrogen. This crop also takes from the Earth several pounds of phosphorus, potassium, sulfur, and a few pounds of calcium and magnesium. A 2,000-pound crop also removes from the soil micronutrients: zinc, iron, manganese, copper, boron, molybdenum, and chlorine. Rarely is the soil deficient in nitrogen because of the peanut's capacity to fix nitrogen. The exception is sandy soil, which may not retain nitrogen, in which case the farmer should add the element to it. Most lands on which the peanut is grown in the United States do not need applications of phosphorus and potassium, though potassium may be deficient in sandy soil or where a grain was grown before peanuts. In these cases, the farmer should supply the soil with potassium. Unlike nitrogen, phosphorus, and potassium, a dearth of calcium characterizes many lands on which peanuts grow. Although calcium does not play as large a role as nitrogen, phosphorus, or potassium, its shortage makes peanuts susceptible to pod rot. Calcium-deficient plants may bear small or underdeveloped kernels. Plants may germinate poorly. Calcium-deficient peanuts may produce plentiful flowers, but these are often sterile. The farmer may apply calcium sulfate to deficient soils. Farmers who wish to fertilize their peanuts should apply fertilizer before planting, sometimes five or six months in advance. The peanut does best in slightly acidic soils. The pH should be between 5.8 and 6.2 in the American

Southeast and between 6 and 7 in the heavier soils of the Southwest. When the pH falls below 5.5, the peanut may accrue toxic amounts of aluminum, zinc, and manganese. Below 5.5 calcium, potassium, and magnesium become insoluble, starving the peanut of these nutrients. When the pH is too low, farmers should lime the soil. Often grown in sandy loam, the peanut needs 20 to 40 inches of rain per year. New Mexico irrigates its peanuts to reach this threshold.

Production and Consumption

In 2008 and 2009, the world produced tens of millions of tons of peanuts. Among peanut producers, China was the leader. India ranked second, the United States third, Nigeria fourth, and Indonesia fifth. Of these five nations only one, Nigeria, is from Africa, a continent that was once home to a thriving peanut agriculture. The peanut was a cash crop in Africa from the 16th century to the 1970s. The spread of rosette disease after 1975 devastated Africa's peanut fields, forcing many farmers to abandon the crop. Consequently, many African countries are no longer large peanut producers. Scientists have bred rosette-resistant cultivars in hopes of restoring the peanut to prominence in African agriculture.

China and India, the world's largest producers, find a market in Asia, whose people consume the most peanuts. Asia raises the vast majority of peanuts, Africa one-fifth, and the Americas several percent. Difficulties in Africa have led Europeans to turn to Asia for peanuts. In Malawi, where peanuts are still grown, people raise the legume for local consumption. For the masses, peanuts are the chief source of protein and oil, and although weight-conscious Americans fret over the presence of oil in the diet, one must remember that it is essential in allowing the body to absorb vitamin A.

Among producers, Argentina and Brazil are the world's largest exporters of peanut oil. The United States is also an exporter. Producing only several percent of the world's peanuts, the United States is nonetheless the leading exporter of peanuts, followed by China and Argentina. America exports shelled peanuts to Canada, France, and Britain. The United States exports three-fifths of its peanuts to the European Union, with the United Kingdom, the Netherlands, and Germany being the principal buyers. The United States exports peanut butter to Saudi Arabia, Canada, Japan, Germany, and South Korea. Among peanut candies, Snickers is the most popular candy bar in Russia.

Christopher Cumo

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Pear

A tree in the Rosaceae family related to the rose, quince, and apple, the pear (*Pyrus communis*) yields fruit whose appearance one writer has likened to the shape of the female body. The aroma and flavor of a pear some tasters think akin to those of wine. Perhaps in imitation of wine-tasting events, the Filoli estate south of San Francisco, California, holds an annual fall festival at which visitors taste pears. The sensuous qualities of the pear have attracted admirers for centuries. One serving of pear has 100 calories. Pear has fiber, calcium, and vitamin C and lacks fat, cholesterol, and sodium.

Mythology, Folklore, Origin, and History

According to the Greeks Zeus's wife, Hera, favored the pear tree. Worshippers made statues of her from pear wood. In the Balkans and Eastern Europe, people burned pear wood in sacred fires, which they used in rites to ensure the bounty of crops and the health of livestock. The Circassians of southern Russia believed pear trees protected cattle. During the autumn harvest festival, they chopped down young pear trees. Taking them indoors, the Circassians decorated them with candles and topped them with cheese in a ritual that seems similar to the decorations moderns lavish on Christmas trees. According to custom, Europeans planted a pear tree at the birth of a girl. A priest blessed the tree upon the girl's baptism. The parents believed that the spirit of the tree protected the girl as she grew into womanhood.

In cultivation at least 4,000 years ago, the pear tree originated in the southern Caucasus Mountains, northern Iran, or the Middle East, from where it migrated to Egypt and Europe. Slices of dried pear date from the last ice age in Switzerland, though the Swiss may have first gathered pears from the wild and only later cultivated the tree. In the ninth century BCE, Greek poet Homer called the pear "the fruit of the gods." By the fifth century BCE, the elites ate Jargonelle, an ancient variety. By the fourth century BCE, the Greeks knew how to propagate the pear, presumably by grafting. In Rome, the patricians ended a meal with a dessert of grapes, apples, and pears. So successful were they that Roman cultivars were grown in Italy until the Renaissance, when new varieties supplanted them.

By 100 BCE, the Romans knew 6 varieties. In the first century CE, Roman encyclopedist Pliny the Elder listed 40 varieties, none of which has come down to the present. According to Pliny, "pears are harmful to eat raw but good boiled with honey."

In medieval Italy and Mediterranean France, monks grew pears in their gardens and the elite cultivated them in their villas. Regarding the pear as a luxury, the nobility tended orchards of pears and other fruit. France imported pears from Italy, giving them the names by which several are known today. By the 13th century, England imported pears from France. Although England had a native pear tree (*Pyrus nivalis*), its fruit was hard and bitter. Rather than eat them, the English made an alcoholic beverage, perry, from them. The English cultivated the varieties Wild Hedge Pear, Lowsie Wild, Crow Pear, and Great Choke. With evident dissatisfaction with all things French, the English claimed that French pears were tasteless. The English claimed to prefer their native pears, though this preference seems unlikely given their bitterness. In 1629, British herbalist John Parkinson claimed that perry made from Great Choke and aged a few months was "as mild and pleasant as wine."

Monks bred the renowned French and Italian varieties. In the 17th century, Grand Duke of Tuscany Cosimo II served 209 varieties of pear to guests. In the Renaissance, growers began to graft pear onto quince rootstock. The result was a dwarf that yielded earlier than a tree grown from seed. French King Louis XIV (1643–1715) preferred the variety Rousselet de Reims. La Quintinye, the designer of the royal gardens at Versailles, believed that no garden should lack a pear tree. He knew more than 100 varieties and claimed to have raised pears with a weight of more than two pounds each. La Quintinye recommended Bergomotte, Louise Bonne, and Doyenne d'Automne as the best varieties.

In the 18th century, Belgium surpassed France in deriving new varieties. The priest Nicolas Hardenpont bred the Beurre varieties, named for their buttery flavor. A Belgian physician with the surname Van Mons amassed a collection of 400 varieties, among them the Beurre d'Anjou, known today as Anjou, and the Beurre Bosc, now called the Bosc pear. By 1850, the United Kingdom's Royal Horticultural Society had 627 varieties in its garden at Chiswick. The collection included Doyenne du Comice, now known as Comice.

In 1559, the Italians brought the variety White Doyenne to the New World. Immigrants from several nations brought cuttings to the American colonies. Colonists ate pears raw, baked them, and used pear wood to make furniture and the leaves to make yellow dye. Perry was second to cider as an alcoholic drink. Until its cultivation in the American West, the pear was not as abundant as the apple, peach, or cherry. In the United States, the apple was more popular than the pear. The pear did not flourish in the eastern United States, whose climate was extreme. An accomplished gardener, Thomas Jefferson planted more than

1,000 pear, apple, cherry, apricot, and quince trees at Monticello between 1769 and 1814. While minister to France, Jefferson had come to appreciate European pears, planting 17 varieties including Crossane, Beurre Gris, and Saint Germaine.

China, Korea, and Japan cultivated the Asian pear. The Chinese call the pear Li, and the Japanese call it Nashi. In China, the Asian pear is as popular as the apple is in the United States. At a Chinese hotel, the servants leave a pear on the pillow as a dessert for a guest. A Chinese text mentioned the cultivation of pears in 1134 BCE. The Chinese text *The Shiji* mentioned the variety Zengdin Yuli. About 1000 CE, the Chinese adopted the practice of propagating pears by grafting. Today, China grows 34 varieties of pears. Despite the prominence of the pear in China, the Asian pears that farmers cultivate in the western United States originated not in China but in Korea and Japan. The United States, New Zealand, Australia, Argentina, Chile, and France grow Asian pears.

The American West

The Spanish introduced the pear to Mexico, Peru, and Chile, and from these planting missionaries brought it to California, whose coastal valley, with its hot, dry summers and cool winters, was ideal for the pear. According to legend, Spanish priest Junipero Serra planted pear seeds at each mission as he traveled throughout California. In 1786, French naturalist Jean-François de Galaup de La Perouse brought cuttings of pear trees to California's Spanish missions. Native Americans worked these orchards. The Spanish inhabitants of California preserved pears in jam, jelly, and candy. Among their varieties, the Spanish grew Presidents, Bergamota, Pana, and Lechera. As California's population increased during and after the Gold Rush, growers planted large orchards of European varieties. Markets were local, giving consumers access to fresh fruit. After World War II, varieties with large fruit that withstood rough handling replaced many of the older varieties. California shipped pears, Bartlett being the dominant variety, east. California, Oregon, and Washington emerged as the chief regions of pear culture in the United States. These states grew 90 percent of U.S. pears, mostly Bartlett. In the 1950s, processors canned pears in fruit cocktail and as a stand-alone fruit. Today, pear juice flavors other fruit juices, wine, and baby food.

In the West, farmers raised pears from British Columbia to California in the mid-20th century. In the West, irrigation was the norm, though wherever it is not irrigated a pear tree needs at least 35 inches of rain per year. In the United States, farmers cultivated the pear in the valleys and coast of central California, the Rogue River valley of southwestern Oregon, the Hood River valley of central Oregon, central Washington, Idaho, Utah, and Colorado. Roughly half the pear trees in California were clustered in the valleys near the center of the state. In central California, farmers raised pears in the Sacramento River valley, the foothills east and northwest of the valley, the Clear Lake District of Lake County, and the Ukiah District of Mendocino County. Bartlett was the primary variety in these areas.

Between the cities of Sacramento and Isleton, the pear was the most important fruit tree. In this region, farmers planted pear trees on loam. Trees yielded early in the year. The Sacramento River valley shipped the first crop of Bartlett east in early July. Thereafter farmers in valley harvested pears for six weeks. The late harvest was canned. East of the Sacramento River valley were 7,000 acres of pear trees in Placer and El Dorado Counties. Grown to 3,500 feet in elevation, trees produced small fruit on thin soil and large fruit where the soil was deep. Where pears were grown at elevation, the harvest was late. Because these pears reached the market after the summer glut, they commanded a high price. Farmers in these counties planted small numbers of Bosc and Winter Nelis, chiefly to pollinate Bartlett. Most pears in these counties were sold fresh with the remainder being canned. Most of the soil in Placer and El Dorado counties was fertile but lacked organic matter. In El Dorado, farmers planted pears on clay loam. The valleys northwest of the Sacramento River valley, having adequate rain, made little use of irrigation. Bartlett was the principal variety, most of it consumed fresh. In Vaca Valley, the dearth of rainfall limited the yield. In Lake and Mendocino Counties, irrigation was universal. In these counties, trees yielded large fruit. The harvest being late, the pears reached the market after the summer glut and, as we have seen, fetched a high price. Roughly half the harvest in Lake and Mendocino counties went to the fresh market with the rest canned. Lake County was California's chief producer of fresh pears. On the coast of central California, the ocean breeze lowered summer temperatures, resulting in a late harvest. Although Bartlett was the principal cultivar, farmers in this region grew several others, including Hardy, Anjou, Bosc, Winter Nelis, and Comice. In this scheme, farmers canned Bartlett and sold the others fresh. Irrigation was the norm on the coast. Some Bartlett pears grown on the coast, being short and squat, were unsuitable for canning. In the Rogue River valley, Oregon, hot, dry summers hastened ripening. During the dry season, farmers irrigated their pears. Trees grew vigorously in deep soil and slowly in shallow soil. The yield was greater on deep soil than on shallow. Farmers in this region grew Bartlett, Anjou, Bosc, and Comice, selling Bartlett fresh and canning it. In the Hood River valley, Oregon farmers cultivated Bartlett, most of which was canned, and Anjou. Farmers irrigated their trees to compensate for inadequate rainfall. The Hood River valley's cold winters sometimes injured young trees. Because rain fell principally in the winter, farmers in central Washington irrigated their trees in summer.

Cultivation and Cultivars

The pear needs winters colder than 45°F to become dormant. A tree tolerates temperatures as low as −15°F, though the pear is less hardy than the apple.

Nevertheless, the pear is hardier than the peach. Flowering roughly one week before an apple tree, a pear tree may be vulnerable to a late spring frost. Temperatures below 27°F may kill pear flowers, ruining the harvest. Bosc and Bartlett prefer hot weather in the months before harvest, though Anjou, grown in the Pacific Northwest, prefers cool weather.

A pear tree requires eight hours of sunshine per day. The soil must drain well because pear will not tolerate waterlogged ground. Humidity encourages the spread of the bacterial disease fire blight, the most damaging disease of pear. A newly planted tree must be watered every other week. Being drought tolerant, an established tree requires water just once per month. One gardener recommends the application of nitrogenous fertilizer in autumn. Spring application causes a tree to produce new growth that is susceptible to fire blight and pear scab. The cultivation of the soil is important because a pear tree competes poorly against weeds. The farmer or gardener may harvest European varieties when the fruit is still green and hard. A pear that is allowed to ripen on the tree will be mushy and tasteless. Depending on the variety, 105 to 190 days elapse between flowering and harvest. A farmer can expect to harvest pears early in a warm year and late in a cool year. Summer pears—Clapp's Favorite is an example—are ready to harvest in late July. Winter pears—for example Winter Nelis—may be picked in October and November. Asian pears spread the harvest among August, September, and October. Asian pears store well. Pears need to be stored between 34°F and 40°F for at least four weeks. After this period, the gardener or farmer should keep pears at 60°F to 65°F in a dark place for 5 to 14 days to ripen. Refrigeration may degrade the flavor of the varieties Shinseiki and Twentieth Century. Dwarfs need 3 to 5 years to bear fruit, whereas traditional varieties yield after 7 to 10 years.

Among varieties, Bartlett occupies first place. In the late 18th century, a British schoolmaster found a pear seedling in Berkshire, Great Britain. A nurseryman whose surname was Williams thought it resembled the ancient variety Bon Chrétien. For this reason, the variety is known as Williams' Bon Chrétien or simply Williams outside the United States. Farmer Thomas Brewer brought Williams to his estate in Massachusetts. Enoch Bartlett bought the land in 1817, renaming the variety Bartlett. Today, Bartlett is the world's most widely grown cultivar, occupying 70 percent of U.S. pear acreage. In the western United States, farmers harvest Bartlett when still green in late July or early August. When it yellows, Bartlett is at the peak of juiciness and flavor. Left too long on a tree, Bartlett decays. A sport of Bartlett, Red Bartlett, named for the color of its skin, dates to 1934. It has the juiciness and flavor of Bartlett and is harvested in summer.

Anjou is the second most popular pear in the United States because it stores and handles well. Refrigerated, it keeps for six months. Farmers harvest Anjou in late September and consumers can still find it in the supermarket the following spring. Anjou derives its name from a region of France. The flavor is tart, leading some consumers to downgrade it as a dessert pear. A mutant of Anjou, Red d'Anjou, discovered in 1956 on a branch of an Anjou tree, does not store as well as Anjou, though its popularity is increasing.

Another popular pear, Comice is also known as Royal Riviera. In the United States, merrymakers give Comice pears as Christmas gifts. Comice is juicy and, though not the sweetest pear, has enough sugar to satisfy most consumers. The name Comice derives from the Comice Horticola, an agricultural society in Angers, France, where the variety originated in 1848. Susceptible to several diseases, Comice must be grown where pathogens are not numerous. The Pacific Northwest is such a region. Comice is sold in fruit baskets. A sport of Comice, Red Comice, also known as Red Crimson, dates to 1988. Discovered in Medford, Oregon, Red Comice has become popular in recent years even though it does not have the flavor of Comice.

Bosc, known as Kaiser Alexander, dates to 1807 and is widely grown in the United States. It has the highest sugar content of any pear, though when harvested too soon it is woody and tasteless.

Christopher Cumo

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Peas

An annual flowering plant, peas, grown from the subtropics to cold climates, are the most geographically and climatically variable legume. Despite this adaptability, peas yield best in cool weather. Like other legumes, peas are a member of the Fabaceae or Leguminosae family related to beans, soybeans, alfalfa, clover, vetch, lupine, lentils, chickpea, cowpea, and peanut. The word "pea" derives from the Old English *pease*, from which also derives pease porridge. Although *pease* is a singular noun, the English came to think of it as plural because it contained the letter "s." Accordingly, the singular became "pea." "Pease" in turn derives from the Latin *pisum*, from which botanists coined the species name *Pisum sativum*. Farmers and gardeners grow peas for their seeds and sometimes for their pods. From *Pisum sativum*, scientists have bred peas with edible pods. These peas, known in French as *mangetout*, meaning "eat all," may be eaten pods and seeds. Among these peas are snow peas, which are often eaten in stir-fries, and sugar snap peas. Snow peas are picked and eaten when the seeds are immature, whereas


Peas (Peter Gau/Dreamstime.com)

sugar snap peas are eaten when the seeds have matured. In addition to *Pisum sativum*, farmers grow *Pisum arvense*, field peas, as feed for livestock. As a livestock feed, pea protein supplements soy protein.

The flavor of peas deteriorates after picking. The grocery store may claim to have fresh peas, but they are at least three days old and no longer at the peak of flavor. Around 1900, growers began to can peas in an effort to preserve flavor. After cooking peas for 20 minutes, growers canned them, though this method of preservation leaves peas mushy and tasteless. More successful has been the practice of freezing peas, a method that American innovator Clarence Birdseye pioneered in 1920. Because consumers want peas at the peak of flavor, growers freeze them within three to four hours of picking. With this method, peas are boiled briefly to kill parasites and then frozen 0°F. Frozen to peas retain color, texture, and flavor. Between the 1950s and 1970s, demand for frozen peas increased rapidly as Americans craved a convenience food and as they came to own freezers. Growers first froze peas in fish freezers, making the seaports the center of this industry. As frozen peas have become popular, the demand for canned peas has declined, notably since the 1930s. Today, growers freeze 65 percent of peas. Like other legumes, peas are nutritious. Two-thirds of a cup of peas has as much protein as a large egg. In addition to protein, peas contain vitamin A, thiamine, riboflavin, niacin, pantothenic acid, vitamin B6, folic acid, vitamin C, calcium, magnesium, phosphorus, potassium, and zinc.

Origin and Diffusion

Wild peas are native to the Mediterranean Basin and the Near East, though the place of their domestication is contested. One school of thought asserts that farmers first cultivated peas in Central Asia and Ethiopia. A second school of thought points to India as the place of origin. Indian farmers, this line of reasoning holds, domesticated peas from a wild ancestor that is now extinct. A third school of thought believes that farmers began to grow peas in the Near East about 10,000 years ago. If this hypothesis is correct, peas are among the most ancient crops and were domesticated around the same time as lentils, barley, and wheat. This Neolithic Revolution gave people a dependable source of protein in peas and lentils and a source of carbohydrates in barley and wheat.

Farmers in Syria, Turkey, and Jordan were among the first in the Near East to grow peas. Among the earliest finds, archaeologists have discovered peas 11,000 years old in land that borders Myanmar and Thailand, a find that may support the idea that the people of India domesticated peas. From the Near East, peas migrated to the Nile Delta by 4500 BCE and to Upper Egypt by 3500 BCE. Because peas tolerate arid conditions, the Egyptians may not have irrigated them. By the fifth millennium BCE, farmers were growing peas in Georgia. By 2000 BCE, peas had spread to Afghanistan, Pakistan, and northwestern India. From northwestern India peas migrated south during the second millennium. To the west peas reached Europe by 4000 BCE. Archaeologists have discovered peas in prehistoric Switzerland, Britain, northern Greece, and northern France, an area with a cool climate suitable to the cultivation of peas. Farmers grew them in Eastern Europe by 2000 BCE.

Peas were a staple in antiquity and the Middle Ages. In this era—before botanists bred sweet peas—peas made a nourishing but bland diet. Peas were not flavorful in part because people dried them before consumption so that they would store. Commoners, unable to afford meat, derived their protein from peas and lentils. They made peas into soup and porridge. The rhyme "pease porridge hot, pease porridge cold, pease porridge in the pot nine days old" suggests that people ate peas day after day. Their reliance on peas was acute during years when the grain harvest was poor and the price of bread high.

The Romans ate pease porridge. The patrician family Piso (Julius Caesar's wife, Calpurnia, was a Piso) took its name from peas, declaring that its ancestors had been pea farmers. Although it may seem peculiar that a wealthy family would claim a humble origin, one should remember that the Romans prized the virtues of thrift, self-reliance, hard work, and piety and believed that these values originated in the countryside. The Piso family chose to identify with peas as a way of claiming that its members embodied rural values. Roman recipes called for the combination of peas and meat. Because commoners seldom ate meat, these recipes suggest that the affluent ate peas. Gourmet Marcus Apicius devised a recipe for peas, sausage, meatballs, pork, pepper, lovage, oregano, dill, onion, coriander, garum, and wine. Medieval recipes combined peas, almonds, and various spices. Scandinavians ate peas and pork. Pea soup, known as *aertsoppa*, was ubiquitous in Sweden. Pea soup was *gula aerter* in Denmark, *harnekeitto* in Finland, and *arwtensoap* in the Netherlands. Another indication that the affluent ate peas comes from the fact that Eric XIV, king of Sweden, ate pea soup. His brother, John, lacing pea soup with arsenic, killed Eric in 1577.

One writer believes that Charlemagne, king of the Franks, ate fresh peas. The king ordered farmers to plant peas, presumably to feed his army as it marched through the land. Christians ate peas during Lent as a substitute for meat. In Europe, peas were especially prized in England, where the cool climate was ideal for the culture of peas. The earliest written reference to peas in English dates to the 11th century, though farmers cultivated the pea much earlier. In the late Middle Ages, Italian botanists bred the first peas to be eaten fresh rather than dried, though Charlemagne must have eaten some other variety. Rapidly maturing varieties, these *piselli novelli* ("new peas") were suitable for early planting and harvesting. In the late 15th century, the English planted peas in their gardens, ensuring a supply of fresh peas in spring, and by the mid-16th century fresh peas were eaten widely in England. Among other noble families, the wealthy Medicis of Florence ate fresh peas. In 1533, Catherine de Medici, having married King Henry II of France, brought Italy's new peas to France, though the French adopted them slowly. Only in the late 17th century did peas make headway in France. In 1695, a French nobleman, visiting Genoa, returned home with fresh peas. Presenting a basket of peas to King Louis XIV, the nobleman convinced the king to try them. Louis enjoyed them so much that he had his gardener grow them in the royal greenhouse. The masses followed Louis's example, eating fresh peas, which the French called *petits pois*, "little peas." Peas were a ration for English sailors, and soldiers ate peas and bacon during the Franco-Prussian War.

Peas were unknown in the Americas until 1493, when Christopher Columbus introduced them to Hispaniola (now the island of Haiti and the Dominican Republic). In the 16th century, the Spanish brought peas to Mexico and Florida. In 1608, one year after the colony's founding, colonists planted peas in Virginia. In 1629 peas, probably in a separate introduction, were grown in the Massachusetts Bay Colony. In the 1670s, a food shortage in the Carolinas reduced the colonists to subsisting on one pint of peas per person per day. This ration, though it was not generous, averted starvation. Thomas Jefferson declared fresh peas his favorite vegetable and cultivated them as early as 1767 at Monticello. Planting 30 varieties, Jefferson competed with his neighbors to determine who could harvest the earliest peas.

In the 17th century, some Americans ate peas thrice daily. Martha Washington's *Booke of Cookery* included a recipe for pease porridge and pea soup with mint. *The Virginia House-Wife* recommended the cooking of peas with butter and mint. It detailed a recipe for pea soup with celery and for pease pudding with pork. In 1841, Sarah Josephe Hale's *The Good Housekeeper* included a recipe for soup with peas and spinach and for peas and lettuce. New Englanders ate peas with corned beef, thyme, and marjoram. Cooks added pearl ash to old peas to soften their seed coat. Perhaps the most unusual and unappetizing use of peas comes from Amelia Simmons's *American Cookery* (1796), which advises bakers to substitute peas for apples and other fruit in pies.

The science of genetics owes its origin to peas. In the mid-19th century, Austrian monk Gregor Mendel, screening several plants for crossbreeding experiments, selected the pea plant because it does not yield gradations of traits. A cross between a tall pea plant and a short one produces either tall or short progeny, not plants intermediate in height. Crossbreeding peas, normally a self-fertilizing plant, over several years, Mendel published his results in 1866, establishing the laws of dominance, segregation, and independent assortment. Although Mendel made few converts during his lifetime, the rediscovery of his paper on pea hybridization in 1900 marked the founding of genetics. In the early 20th century agronomists, following Mendel's method of hybridizing different varieties of peas, bred hybrid corn, an achievement of applied genetics.

Peas are a favorite of gardeners, who may choose among varieties that mature early and have high sugar content and edible pods. Gardeners may also choose either determinate or indeterminate plants. Determinate plants cease vegetative growth when they flower. They flower at the same time and so produce pods all at once. Determinate peas ripen about the same time and so may be picked in a short interval. Indeterminate plants grow vegetatively throughout their lives, yielding flowers and pods over a longer interval of time. The harvest is accordingly spread over several weeks. Thomas Jefferson probably planted indeterminate peas because his harvest extended from May to July. This range of time also suggests staggered planting.

Today, the French eat peas with lettuce, onions, and butter. Cooks add peas to stir-fries and Thai curries, often combining them with shrimp. Spaniards eat peas, meat, and baked eggs. The Portuguese eat peas with eggs. In Iran, people eat peas with lamb. The Germans make a stew with peas, bacon, carrots, and celery. In Denmark, the Netherlands, and the United States, pea soup remains popular. In Peru, people eat a stew of peas and shrimp. Brazilians eat peas and chicken. In India, people eat peas with potatoes, or alternatively they consume peas with paneer cheese. The people of Japan, China, Taiwan, Thailand, and Malaysia eat roasted, salted peas as a snack much as Americans snack on roasted peanuts. The Chinese consider pea leaves a delicacy, and the people of Greece, Turkey, and Cyprus eat a stew of peas, meat, and potatoes.

Pest and Diseases

Peas are vulnerable to a number of pests and diseases. The pea weevil attacks early peas. Adults feed on pea leaves, defoliating young plants, and larvae feed on roots. Damaged roots are vulnerable to soil borne fungi, which compound the havoc that pea weevils cause. Because larvae feed on root nodules, they decrease the amount of nitrogen available to the plant. The larvae rather than the adults are the more serious threat to peas. Adults overwinter in nearby grasses or in ditches, emerging in spring. They lay eggs on pea plants. Rain washes the eggs into the soil, where larvae hatch, burrowing into the soil. Among the most widespread pea pest, the weevil afflicts peas in the United States, Europe, Asia, and Australia, reducing yields as much as 25 percent. Because early peas are susceptible to attack, farmers who plant peas late may reduce infestations. Insecticides are also effective.

Slugs and snails may be ubiquitous in pea fields in wet weather. One authority judges that slugs are the most common pea pest. Slugs may be numerous in clay soil and in soil covered by crop debris. In wet weather, slugs are active in the day, feeding both day and night on pea plants. Snails may be abundant in calcium-rich soil. Slugs and snails devour pea seedlings, feeding so voraciously that plants die. Slugs and snails breed throughout the year, laying a large number of eggs in autumn. Slugs overwinter in crop residue, whereas snails overwinter in uncultivated land on the edge of a pea field. Farmers may cultivate a strip of land six feet wide around the perimeter of a field to discourage the migration of slugs and snails to pea plants.

Active in temperate locales, the pea midge assails peas in the United Kingdom, France, the Netherlands, Germany, Switzerland, Austria, Scandinavia, and Russia. Larvae feed on pea flowers, reducing the formation of pods. Midges may cause severe losses in determinate peas because they flower at the same time, providing midges a large supply of food. Indeterminate peas, flowering over a longer duration, suffer less damage. Where infestations are large, farmers may lose as much as half their pea crop. The female midge deposits eggs on flower buds. Larvae hatch in four to five days, burrowing into buds. After five to seven days of feeding, larvae drop to the soil and form a cocoon from which adults emerge, ready to repeat the reproductive cycle. The insecticide lambda-cyhalorthrin is effective against the midge. Also useful is crop rotation, though because the midge breeds a large population and colonizes a vast area, rotation is effective only when several farmers in an affected area coordinate their efforts.

The fungal disease pea leaf and pod spot, as the name suggests, causes brown spots on leaves and pods. The fungi live in the soil and can survive on crop residue. The disease is worst in wet weather, and seedlings are especially vulnerable. Irrigated peas may suffer losses. Fungi may infect seeds, which will not germinate when infection is severe. Afflicted plants that germinate may lodge. Fungi produce spores, which spread in wet weather. Fungi penetrate pods, thereby infecting seeds. Because fungi may persist in the soil for years, farmers must grow other crops for four or five years before replanting peas. Fungicides, notably chlorothalonil, azoxystrobin, vinclozolin, and cyproaonazole, may be effective.

Powdery mildew, another fungal disease of peas, spreads when days are warm and nights cool and humid. Late peas are vulnerable to infection. Fungi appear as mildew on leaves at the bottom of pea plants and spread upward, covering the stem. Infecting pods, fungi may cause them to fall to the ground or to be barren.

Powdery mildew reduces the weight and yield of pods. Fungi may slow the growth of pea plants and retard the formation of pods and seeds. Fungi overwinter in crop residue and in other legumes, notably vetch. Farmers may plant one of several cultivars with two recessive genes that confer resistance. Fungicides are also effective.

The fungal disease pea foot rot is among the more serious diseases, causing as much as 75 percent losses. Soil-borne fungi attack peas during and after flowering, causing stunting and the formation of small leaves. The fungi shrivel lower leaves on pea plants. From there the disease spreads upward. Beset by foot rot, pea plants form only small pods or no pods at all. In some cases, plants die before pods form seeds. The disease may turn stems brown or black. Roots form few nodules and those that exist decay, depriving plants of nitrogen and compounding the problems caused by the disease. Pea root rot is among the most common afflictions of peas. Fungi are prevalent in compacted, waterlogged soil and may live for years in it. Because there are no resistant cultivars, farmers must turn to other means of control. Farmers may plant a grain or other nonlegume for at least five years before replanting peas to reduce fungi populations in the soil. Alternatively, farms may treat pea seeds with the fungicides fludioxynil or thiabendazole to decrease fungi populations.

Peas that have suffered damage from pests, cultivating tools and machines, or hail or frost are vulnerable to pea bacterial blight. Brown lesions appear on infected the leaves and stems of infected plants. The pathogenic bacteria penetrate pods, infecting seeds. The disease spreads rapidly in wet weather, rotting plants so that they die. In dry weather, pea bacterial blight shrivels leaves but plants may survive. Peas planted in autumn are particularly vulnerable to an early frost and to the opportunistic infection by bacterial blight. Losses may be severe in Europe and New Zealand, where autumn planting is common. Overwintering in crop residue, bacterial blight propagates itself by infecting pea seeds, which may show no symptoms until the plants flower. Scientists have identified seven races of pathogenic bacteria. Race 2 is prevalent in spring peas, whereas races 4 and 6 are common in autumn peas. In the United States, however, race 4 afflicts spring peas. Some cultivars are resistant to races 2 and 4, though none is resistant to all seven races. Chemicals are of no avail, making bacterial blight difficult to control. Farmers may test pea seeds for the presence of the bacteria, planting only those free from infection. Rotation may be effective in reducing bacterial populations.

Christopher Cumo

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Peony

In the family Paeoniaeae, the genus *Paeonia* has about 30 species and 3,000 cultivars. The peony is of two types. Tree peonies are shrubs with deciduous leaves that they shed in autumn. Tree peonies grow to 10 feet. Herbaceous peonies die back in winter, sending forth new shoots next spring. Herbaceous peonies may be as tall as 4 feet. Tree peonies bloom earlier than herbaceous peonies.

Origin and History

The peony may have originated in Europe during the Pleistocene Period (2.6 million–12,000 years ago). The peony is native to the Mediterranean Basin, central Asia, the western Himalayas, East Asia, the Pacific Northwest, and California. Today, peonies may be found in the Kola peninsula in Russia, the land between the Ural Mountains and Siberia, Tibet, southwestern China, Manchuria, Japan, France, Spain, Portugal, Switzerland, Central and Eastern Europe, the Mediterranean, Turkey, and the Caucasus Mountains. A few species are native to California, but the peony is not native to the Southern Hemisphere.

China may have been the first to cultivate the peony. A fourth-century CE painting of peonies suggests that they were then in cultivation. The Chinese first cultivated the peony because they believed that the root had medicinal properties. As early as the first century CE, the Chinese believed that the root of the tree peony prevented blood clots. In some instances, the Chinese ate herbaceous roots as early as the sixth century, though one gardener finds the flavor unpalatable. By the sixth century, the Chinese grew the peony as an ornamental. The wealthy, civil servants, and merchants grew peonies. The tree peony was China's national flower. The Chinese called the tree peony "Hue Wang," meaning "the king of flowers." They called herbaceous peonies "Hue Liang," meaning "the king's ministers," suggesting a preference for the tree peony. Another name for the tree peony was "Fu Gui," meaning "wealthy and honorable." In turn, herbaceous peonies were also known as "Shaoyao," meaning "medicinal herb plant," but it can also mean "wealthy and honorable" or "charming and beautiful." Perhaps herbaceous peonies were not second-rate plants after all. Today, the Chinese use the word *Mudan* to mean either "tree peony" or "herbaceous peony."

The Sui dynasty (581–618 CE), although not the first to cultivate the peony, took pride in its tree peonies. In the seventh century, Empress Wu Zetien named the peony her favorite flower. Wu planted thousands of tree peonies. As a decorative motif, peonies adorned buildings and ceramics. The price of peonies followed demand, and at one point a single peony sold for 100 ounces of gold. Luoyang, Wu's city, remains China's center of peony culture. The 11th-century scholar Ouyand Xiu, who knew more than 90 varieties, wrote the first treatise on the tree peony. In the 20th century, the peony suffered setbacks in China. In 1933, a flood of the Yellow River washed away innumerable peonies. China's increasing population led farmers to plant crops rather than peonies. During the Cultural Revolution of 1966 and 1967, Chinese leader Mao Zedong forbade the cultivation of flowers. The peony could be grown only as medicine. After 1980, however, interest revived in China. In the eighth century, Japan imported tree peonies from China as a medicinal plant. The Japanese named the tree peony "Botan."

Europe had native peonies and may have cultivated them in antiquity. Fourth-century BCE Greek botanist Theophrastus and first-century CE Roman encyclopedist Pliny the Elder thought that the peony was dangerous and should not be touched, an attitude that leads one to wonder whether it was cultivated then. One who wished to obtain a peony had to tie a string around the plant at night, fastening the other end around a dog's neck. Prodding the dog to move, it would uproot the peony. The attempt to obtain a peony during the day risked the loss of sight.

Another myth concerns the god Apollo, his mother, Leto, his son Aesculapius, and Aesculapius's student Paeon. Aesculapius was the first physician and passed his skills to Paeon. Leto gave Paeon a peony, which he used to heal a wound that the god Hades had received from Hercules. Paeon also healed the god Ares. In gratitude, Ares turned him into a peony, though one might question the depth of this gratitude.

Europeans grew peonies in the Middle Ages. In the 12th century, Augustinian monk Alexander Neckham listed the peony as an essential garden plant in his *De Naturis Rerum*. In 1597, English herbalist John Gerard valued the peony as medicine. He believed that eating peony seeds prevented nightmares. He compared the beauty of the peony to the rose. Gerard reported the superstitions of the Greeks and Romans, and then dismissed them as silly. He knew the species that 18th-century Swedish naturalist Carl Linnaeus would name *Paeonia officinalis*, a species that grew wild in Portugal, southern France, Switzerland, northern Italy, Hungary, Croatia, Romania, and Albania. The species name *Paeonia officinalis* means "of the [apothecary's] shop," a reference to its use as medicine.

The 16th-century physician Leonhart Fuchs noted that the peony was widespread in Germany. In 1656, a member of the Dutch East India Company may have been the first European to glimpse peonies in Canton and Peking (now Beijing), China. As we gave seen, Linnaeus classified all the peonies he knew into the single species *Paeonia officinalis*. Today, botanists have divided his species into three: *Paeonia officinalis*, *Paeonia muscule*, and *Paeonia clusii*. In 1789, British naturalist Sir Joseph Banks obtained the first specimen, presumably from China, planting it in the Royal Botanic Garden at Kew, Great Britain. In 1794 and 1797, the garden obtained two more tree peonies. By 1808, one nurseryman in the United Kingdom sold herbaceous peonies to the public. In the 19th century, plant collectors brought peonies from China to Europe and the United States. The Saint Petersburg Botanical Garden in Russia and the Arnold Arboretum at Harvard University were avid collectors. Plant hunter Joseph Rock (1884–1962) obtained tree peonies from China and southeastern Tibet, distributing seeds to the United States and Europe. Collectors also found tree peonies in Japan. By the end of the 18th century, Empress Josephine Bonaparte grew peonies in her garden at Malmaison in France. By 1810, Malmaison had acquired a peony from Siberia. The next year the garden boasted both single and double flowers. Its three double flowers were white, yellow, or white and pink.

Paeonia officinalis was the first species cultivated in the United States. Third U.S. president Thomas Jefferson grew it at Monticello. In 1807, nurseryman John Bartram of Philadelphia, Pennsylvania, offered a handful of varieties for sale. In 1829, nurseryman William Prince of Flushing, New York, offered 40 cultivars, boasting that he had specimens from Europe and China. In the United States, the market for cut flowers boosted peony sales. Since World War II, the United States has led the effort to breed hybrids. Since 1895, American nurseries have sold peonies to Canadian growers. One marveled at the ability of peonies to tolerate temperatures as low as –50°F. In the 19th century, Australia and New Zealand began growing peonies.

Attributes and Cultivation

The peony flowers between April and July in the Northern Hemisphere depending on climate. Peonies imported into the Southern Hemisphere flower between September and December. Flowers may be crimson through several shades of pink, salmon, yellow, cream, and white. The peony is a temperate plant though a few species tolerate a warm climate. The southernmost latitude of the peony is 35° north in northwestern Africa. The northernmost latitude is 67° north in the Kola Peninsula. *Paeonia anamala* grows near the Arctic Circle.

The soil should be fertile and well draining. Most peonies prefer alkaline soil, but a few favor neutral or acidic soil. *Paeonia luten* and *Paeonia delavayi* prefer acidic soil, whereas herbaceous peonies favor alkalinity. Peony may be grown in soils ranging from clay to sand. Clay may be acceptable, but it must drain well. *Paeonia anomala*, *Paeonia lactiflora*, *Paeonia mlokosewitschii*, *Paeonia veitchii*, and *Paeonia wittmanniana* grow well in clay. Peony is a heavy feeder of phosphorus and potassium. Some growers favor a balanced fertilizer with a ratio of nitrogen to phosphorus to potassium of 10:10:10 or 12:12:12. Others favor a fertilizer low in nitrogen and high in phosphorus and potassium, for example a ratio of

5:10:5, 5:8:7, or 10:30:20. Some authorities favor autumnal applications of fertilizer. Others apply fertilizer in spring. Still others feed their peonies in spring and autumn.

Peonies do not tolerate waterlogged soil. *Paeonia brownii*, *Paeonia corsica*, and *Paeonia coriaceo* do not tolerate abundant rain. *Paeonia obovata* ssp. *japonica* and *Paeonia obovata* ssp. *obovata* tolerate shade, but some species flower poorly if not exposed to full sun. Young plants should have shade. Most peonies need some shade or their flowers will be short lived.

Christopher Cumo

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Pepper

Pepper usually refers to the fruit of the plant *Piper nigrum L.* (or to the plant itself). Some other species also belonging to the genus *Piperaceae* produce seeds or leaves that are used as spices. Long pepper, the fruit of *Piper longum L.*, is particularly noteworthy because it was traded earlier and was once more highly prized than black pepper. Other spices labeled as pepper are not related, except for a somewhat similar look or taste, for example the pink peppercorn that is the fruit of *Schinus molle* or *Schinus terebinthifolium*, Sichuan pepper (*Zanthoxylum piperitum*), or the red or chile pepper or peppers that belong to the genus *Capsicum*. The fruit of *Piper nigrum L.* is easily the most commonplace spice in the contemporary world. Depending on harvest stage and preparation, it can take the form of green, black, white, or red pepper. Among cultivated plants, pepper holds a special place as one of the few plants producing a spice with a pungent flavor, for its historical role, and for its continuing economic importance.

Botany

Piperaceae are a subtropical and tropical family of plants. The genus *Piper* contains over 1,000 species, several of which are used as spices, flavoring, or medicine. The species *Piper nigrum L.* has its origin in the Western Ghats mountain range of southeastern India, in the state of Kerala, which is still an important and well-known pepper-producing region. As a distinctly tropical plant, it requires high temperatures and humidity, as well as well-drained moist soil. *Piper nigrum* is a perennial climbing vine that can reach heights of 30 feet. Its lower parts turn woody over time. Originally an inhabitant of tropical forests' understory, pepper is somewhat sensitive to wind and strong sunshine.

In cultivation, pepper is usually propagated from cuttings, which enable earlier harvests from the new plants than growing from seed. Shade trees or poles give the pepper plants a place to climb on. Cultivated varieties of pepper must not stand in strong shade.

Cultivation of *P. nigrum L.* and Economic Importance

Black pepper is now grown around the equator, from India to continental and insular Southeast Asia, in Madagascar and Brazil. The largest producers of pepper in 2007 were Vietnam, Brazil, Indonesia, India, and China.

World pepper (*Piper sp.*) production in 2008 amounted to 433,283 metric tons, and 303,697 metric tons with a value of slightly over $1 billion were exported in 2007 (FAOSTAT). Trade value fluctuates strongly.

Forms of Pepper

Depending on the stage of ripening and preparation, *Piper nigrum L.* alone gives different kinds of pepper: green, black, white, or red. Green pepper is the unripe corns, harvested while fully grown but before ripening, taken off the stalk, and preserved by pickling in brine. This form of preservation keeps the aroma intact, but results in lower pungency. Red pepper is preserved in the same way. Here, however, the berries are harvested only when fully ripened. To produce the common black pepper, semiripened berries are collected, immersed in hot water, and then dried. This results in the well-known peppercorns with a dimpled, uniformly black surface and high pungency. Harvesting ripened red berries and removing the fruit pulp (in a process called retting where the berries are first immersed in water for about a week and then rubbed against each other) gives white pepper. This treatment keeps the essential oils and therefore the aroma intact, but removes much of the piperin that is concentrated in the fruit pulp.

Pepper, especially black, is also differentiated by region of origin. Tellichery/Thalassery and Malabar pepper are two well-known types from the Malabar Coast of India; Sarawak pepper hails from Borneo; Lampong pepper is grown on Sumatra, Indonesia; Muntok pepper is a white pepper also from Indonesia.

Uses and Flavors

The main use of pepper is simply as spice, of course. Piperin is the chemical giving pepper its pungency; various essential oils give it further flavor. Little attention is currently paid to differences in flavors. Rather, one tends to encounter already-ground black pepper that is of comparatively little flavor as the essential oils are released from the broken seeds. Even mixtures of white and black pepper with pink peppercorns (seeds of *Schinus sp.*), chosen more for their attractive looks than aroma, have recently become popular. In fact, however, different kinds and origins of pepper have different pungency and aroma, especially when freshly ground. White pepper is more pungent and less flavorful than black pepper; Indian peppers are considered to be both more pungent and more aromatic than other types, but there are differences among those as well.

Other Types of Pepper

Piper longum L., long pepper, produces smaller seeds, which form flower spikes that are one to two inches long. In the Roman Empire, it was already traded between India and Europe and valued highly. Long pepper is still grown in India and Southeast Asia, but traded only in low volumes, is sold as a specialty pepper. Its aroma is similar to that of black pepper, but with higher pungency.

Piper cubeba L., cubeb or tailed pepper, has fruits that grow similar to those of black pepper, but with a small stalk that remains firmly on each of the pepper corns. Its origin lies on the Sunda Islands of Indonesia; there are also plantations on Sri Lanka and in West India. Cubeb pepper's flavor is pungent with a bitter note. It is used medicinally rather than as a spice and has very little economic importance.

Piper guineense Schumach. et Thonn., guinea pepper, is a pepper species similar to *Piper cubeba L.* from the West African coastal region. It is bigger and the flavor is much less strong than that of black pepper, but was used as a replacement in times of crisis.

Piper betle L., betel pepper, is an outsider in this list because it is one of the peppers grown for its leaves. They form a part of the betel bite, wrapped around a piece of betel nut and some chalk. This concoction is a popular recreational drug (similar to the Euro-American use of coffee as stimulant) in many countries from India to Southeast Asia.

Gerald Zhang-Schmidt

See also Peppers

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Peppermint. *See* Mint

Peppers

Peppers refer to various species of *Capsicum*, a genus of the Solanaceae family. They go by various names, most prominently chile peppers, chiles, or chilles (sometimes chili, but that spelling is less popular because the word stands for the Tex-Mex stew made with peppers). The pungent types are among the most prominent representatives of this group for the important role their fruits play in many, especially tropical, cuisines and the pungency they impart to them. Bell peppers, the best-known and most widely traded nonpungent *Capsicum* fruits, are relatively recent cultivated varieties. The origin of *Capsicum* lies in southern and Central America, from where they were spread globally only after 1492. They spread quickly and widely, however, and became integral parts of cooking the world over. In the last decades, sauces made from chile peppers (i.e., salsas) have overtaken ketchup as the favorite American condiment, testifying to the increasing popularity of this spice in much of European and American cooking, where it was formerly shunned.

Botany and Cultivation

As part of the family Solanaceae (also known as Nightshade), peppers are relatives of potatoes, tomatoes and tobacco. Some 30 wild and 5 domesticated species of *Capsicum* have been described. The vast majority of wild species occurs in South America, with two branches in the Andean countries and the Brazilian lowlands.

Noteworthy among wild *Capsicums* is the Central American chiltepin, *Capsicum annuum* var. *glabriusculum Dunal*, the fruits of which look like ripe red fruits of black pepper (*Piper nigrum L.*). The Central American chiltepin may be the wild ancestor of the domesticated *Capsicums annuum L.* As one of a very few wild ancestors of domesticated species, it continues to be harvested in the wild and sold commercially. It is highly prized for its flavor and pungency, which is described as *arrebatado* (“hasty”) for the speed and strength with which it kicks in. Chiltepins are also interesting because their northern range reaches into southern Texas and Arizona, areas where frosts can occur. Cold spells kill off most growth, but if not too strong chiltepin will regenerate from lower buds; the bushes can thus grow for years. A “Wild Chile Protected Area” has been established in the Coronado National Forest near Tucson, Arizona, and chiltepin is included in Slow Food USA’s “Ark of Taste” initiative.

The cultivated *Capsicums* are rather short-lived perennial plants, with stems that turn woody, native to tropical and subtropical regions of the Americas. Domesticated peppers are often grown as annuals, however. In temperate regions, this is necessary because they cannot survive low temperatures; cultivation as an annual also reduces disease and pest pressure. *Capsicum* cultivars grow as bushes up to six feet or as low as a few inches, depending on the variety and conditions. One factor responsible for the wide spread of the *Capsicums* is the ease with which they can be grown. In subtropical regions, peppers often emerge as volunteer plants growing on the edge of rice fields. They also produce well in temperate regions with summers that are sufficiently long and hot to allow for fruit maturation, and can be grown either as field crops, in greenhouses, or as pot plants.

Cultivated peppers predominantly belong to the species *Capsicum annuum L.* Its region of origin lies in Central America, from where this species of peppers was spread around the world and developed into even greater diversity. Both sweet bell peppers and a large number of hot chile pepper varieties belong to this species. Jalapeño, New Mexico, and Cayenne peppers are representatives with well-recognized names. Poblano/Ancho, Pasilla, and Mulato are typical Mexican *Capsicum annuum* varieties used for moles (Mexican sauces). Nonpungent bell peppers were developed out of natural mutants producing no capsaicin (the chemical responsible for the chile pepper's pungency).

Capsicum frutescens L. and *Capsicum chinense Jacqu.* are of less commercial importance and contain far fewer domesticated varieties. Tabasco peppers are easily the best known *Capsicum frutescens L.* due to the sauce of the same name; so-called Bird's Eye peppers also tend to belong to this species but may also be *Capsicum annuum L. Habaneros*, which are often treated as one variety, show some diversity, and are the most prominent representatives of *Capsicum chinense Jacqu.*, infamous for their strong aroma and extreme pungency. In fact, the chile pepper in the current *Guinness Book of World Records* for the highest pungency ever measured belongs to the Bhut Jolokia pepper from Nagaland, India, a *Capsicum chinense Jacqu.* (The former world record also belonged to a habanero pepper.) There are also nonpungent varieties of *Capsicum chinense*; however, both traditional cultivars, such as Venezuela's *ají dulce*, and modern developments, for example the "NuMex Suave" varieties created by New Mexico State University's Chile Pepper Institute. *Capsicum frutescens* originated in Central America; *Capsicum chinense*'s origins lie in the Caribbean.

The differences among *Capsicum annuum*, *frutescens*, and *chinense* are small enough that their status as distinct species has often been questioned; they are sometimes argued to belong to species complexes or even a single complex. Their ranges in Central and South America also overlap considerably. *Capsicum pubescens Ruiz & Pav.*, commonly called *rocoto* or *locoto* in the Andes where they originated and *manzano* or *canario* in Mexico, and *Capsicum baccatum* var.

pendulum (Willd.) Eshb., commonly called *ají* in South American Spanish, are also cultivated species, but of only regional importance in South and Central America. *Rocoto* is notable for its purple flowers and black seeds, as well as because no direct wild ancestor of this species is known.

Chemistry

Chile pepper's pungency is mainly caused by capsaicin. This amide is produced in the placental tissue and internal membranes of the fruit of most varieties and species of *Capsicum*. Other capsaicinoids also contribute to the pungency and flavor of peppers, but are of less importance. Capsaicin excites mammals' sensory apparatus responsible for the perception of heat. Its content, and therefore pepper's pungency, is measured on the Scoville scale ranging from 0 Scoville heat units (SHU) for the nonpungent bell peppers to about 200,000 for habanero peppers. Record measurements for peppers such as the Bhut Jolokia or Naga Jolokia exceed 1 million SHU.

Especially for the hotter peppers, the Scoville Organoleptic Test, in which human subjects would be used to detect the heat in dilute samples, has been superseded by high-performance liquid chromatography (HPLC). A notorious problem in the search for ever-hotter pepper varieties, aside from the cost of HPLC, is the strong dependency of capsaicin content not only on variety but also on growing conditions.

Allure

Why humans acquired a liking for the sensation of pain that the ingestion of capsaicin causes is still hotly debated. What is known is that the pungency evolved as a form of deterrence. That is, capsicums produce pungent fruit to keep mammals from eating the pods and thus destroying the seeds. Birds, on the other hand, cannot sense pungency as their nerve cells are different, and passage through their digestive tract does not destroy the seeds. Humans, unique among mammals, can learn to overcome their initial repulsion to peppers and acquire a taste for them.

Explanations center on health effects: Hot chile pepper is combined with meat and used in tropical climates as a protection against spoiled meat. Another popular suggestion is that eating hot and spicy food causes profuse sweating, which helps cool down the body in the hot climates where most peppers are consumed. On the other hand, however, are suggestions that chile peppers are popular in winter, for the warming sensation one gets after eating a hot and pungent meal. Other hypotheses for the popularity of chile peppers range from use of the pungent flavor to cover the taste of spoiled meat to a human fascination with thrill seeking satisfied by the endorphin rush that follows the consumption of extremely spicy foods.

Origin and History

Whatever the initial appeal of peppers to humans was, they were among the first domesticated plants. Archaeological remains in the Tehuacán Valley in Puebla, excavated by Richard S. MacNeish, show that chile peppers were already used in Mexico around 7000 BCE; recent research into starch fossils showed chile peppers to have been domesticated and used from southern Peru to the Bahamas, starting 6,000 years before the present. The Tello Stela in Chavín de Huantar, Peru, from 900 BCE depicts caimans holding plants from their home range in the Amazonian lowlands, including chile peppers. Mesoamerican documents from before the Spanish conquest of Mexico were largely destroyed, but the extant Codex Mendoza shows a punishment that was used in the Aztec upper levels of society, by holding the unruly child over the smoke of burning peppers. Chile peppers are also mentioned as a part of tribute payments. The Codex Florentino (or *Historia General de las Cosas de la Nueva España*) created under Bernardino de Sahagún mentioned chile pepper, for example naming the wares of the chile pepper seller, listed as one of the traditional occupations.

The worldwide spread of chile peppers began with Christopher Columbus's journeys. Chile peppers were among the plants brought back to Spain, where they were first grown in monastery gardens. Presumably, *Capsicum* was soon spread along the various trade routes established during the following age of navigation and colonization, spreading to Africa, India, Southeast Asia, and East Asia. In many cases, the chile peppers traveled so quickly that early botanists thought they were native plants. Leonhart Fuchs in 1542, for example, labeled some of his pepper drawings as Indian or Calecutian pepper, that is from Calcutta, India; Nikolaus von Jacquin similarly named *Capsicum chinense* because he thought China its country of origin. Even the Blue Beryll, a Tibetan description of medicinal plants created between 1750 and 1800, included chile pepper. Mainstream European and American cooking developed a dislike for pungent tastes. In recent decades, however, chile peppers and condiments with them have found increasing popularity.

Diversity

Chile peppers are easily among the most diverse of cultivated species. There are not only different species of peppers, but there is also the Babel of names for peppers in general, and a real biological diversity within varieties. The habaneros or jalapeños so often talked about as varieties are actually so-called pod types, typical forms of peppers. Within these, varieties should be further classified and named. In cultivation, however, some diversity is found within the peppers grown in particular regions. Often one even finds mixtures of small-fruited *Capsicum annuum L.* and *Capsicum frutescens L.* grown together. Peppers, especially within *Capsicum annuum L.*, also readily cross-pollinate. Local names, on the other hand, tend not to differentiate between different origins of peppers, labeling them only as green or red, hot or not hot.

Economic Importance

The leading producers in 2007 were China, Mexico, Turkey, Indonesia, Spain, the United States, Nigeria, Egypt, the Republic of Korea, and the Netherlands for green peppers, and India, China, Peru, Bangladesh, Pakistan, Ethiopia, Ghana, Vietnam, Myanmar, and Mexico for dried peppers. Total world production of green peppers amounted to 27.9 million metric tons and an export value of $3.7 billion. The world produced 2.8 million metric tons of dried peppers with an export value of $871 million.

Products and Uses

Peppers are among the most diversely used of cultivated plants. Peppers with upright fruit maturing through various colors are even grown as ornamentals. Bell peppers and larger, less pungent chile peppers are used as a vegetable, either green or ripe. They are eaten raw or in various preparations, for example stuffed and baked, braised, or pickled. Hot chile peppers can also be used green, but are predominantly used when ripe. Typically, they ripen to red, though varieties maturing to yellow, orange, or reddish-black also exist. Chile peppers are typical of many cuisines, for example Mexican, where they are used in a great variety of ways, from cooked to baked, or Chinese, whereas Hunan cuisine uses them in rather pure flavors, and Sichuan cuisine in combination with Sichuan pepper (*Zanthoxylum piperitum*). South and Southeast Asian cuisines are also well known for their use of peppers, for example in some Indian as well as Thai curries; North and East African cooks use harissa (chile pepper paste) or dry spice mixtures with chile pepper.

Aside from dishes using fresh peppers, a large range of chile pepper sauces is made: Mexican moles and salsas, Chinese La Jiao Jiang, but also the Tabasco sauce found in many supermarkets around the world. For the burgeoning scene of chileheads, people who enjoy growing and consuming hot and spicy peppers and pepper products, various kinds of hot sauces have been invented. These often use capsaicin extract to reach extreme levels of pungency and typically have equally extreme names, for example Kiss of Fire, Satan's Blood, and Death Rain. With the rise of peppers, there has also been a notable trend toward sweet heat, products such as wine gums or, most importantly, chocolate employing some chile pepper to impart a combination of sweetness and pungency. The case of chocolate is noteworthy because it is something of a return to the original Mesoamerican preparation, which took the form of a drink often heavily flavored. Chile peppers are also dried and ground into pepper powder such as Hungarian paprika, Basque Piment d'Espelette from the Pyrenees region of France, or Spanish Pimentón de la

Vera from the Extremadura region, which are among the few peppers and pepper products with controlled designation of origin status. More commonly, as in much of cooking, such chile pepper powders are made without much explanation of origin and kind of pepper used. It is mainly in Mexican cooking that certain varieties of peppers are associated with certain uses, even though some differences in taste are notable. This is most obvious with the habanero peppers, which are typically extremely pungent with a tropical fruity aroma that is employed well in Jamaican jerk used to barbecue meats, for example, but would not fit in other uses where pungency with little aroma is desired.

Gerald Zhang-Schmidt

See also Pepper

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Petunia

Unlike many plants with multiple, sometimes confusing, common names and with visual similarities to other unrelated plant families, the petunia remains recognizable in all its versions. Everyone, gardener or not, already knows the botanical name for the petunia because the genus name is *Petunia*. From the term for tobacco, *petun*, in the Tupi-Guarani language of Brazil, petunias are in the Solanaceae or Nightshade family. Other members include tobacco, potato, tomato, deadly nightshade, eggplant, chili pepper, and the garden plant, nicotiana, whose name reflects its kinship with tobacco. Its blossoms look like small, more tubular petunias.

The *Petunia* genus has 35 species of annuals, perennials, and shrubs. The plant we know and use is a tender perennial for zones 9 to 11 but is treated generally as an annual everywhere a sunny gardening site has a need for color. As one of the most popular, widely used, prolific blooming of all garden plants, petunias are a summer staple. This flowering favorite with its wide spectrum of colors has a place in every yard—even if it is a porch container, window box, or the hanging baskets that many cities and towns use to dress up their more popular pedestrian areas. Whether on public or private land, they serve as a reliable, trouble-free tonic to jazz up a walkway or green space.

Native to South America, wild petunias were brought to Europe in the early 19th century. *Petunia axillaris*, with white flowers, and *Petunia violacea* and *Petunia integrifolia*, with purple blooms, were the progenitors of today's petunias. The resulting crossbreeds were named *Petunia* × *hybrida*. That designation remains in use for the hundreds of current petunia varieties.

British and German plant breeders did the early work to improve and adapt the petunia. Coincidentally, a French botanist named Petun also did early breeding and helped popularize the plant in Europe. The plants easily crossbred but results were inconsistent. Seeds from one plant would yield both single and double blooms. In the United States, Theodosia Shepherd (1845–1906) of Ventura, California, started swapping seeds and progressed into hybridizing petunias. Superbissima, one of her California Giants, had flowers of five to six inches, larger even than today's grandiflora blooms. Superbissima was introduced in 1880 and had a lot to do with creating an industry for petunia seeds and plants. In the 20th century, Japanese plant breeders produced reliably double petunias. Their All Double Victorious mix was the 1934 All-American Selection and is still a fine example of a grandiflora with fringed petals.

Judges from the nonprofit All-American Selection Organization evaluate new plants for their outstanding characteristics and contributions to the plant market. Once the gene for doubleness was recognized as dominant, production began on a modern scale. In the 1950s, the petunia bedding plant industry grew to provide home owners with ready-made plants to buy rather than deal with the tiny seeds. With more than a quarter of a million seeds per ounce, some varieties have been pelleted, which adds a coating to the seeds to make them a little easier to handle. Mixing seeds with sand also distributes them more evenly.

Petunia seeds should not be covered, but just firmed into preferably slightly acidic soil (5.5 to 6 pH) or planting mix and kept moist. With temperatures over 70°F, plants germinate in 10 to 14 days. After about a month, the seedlings will be large enough to transplant and acclimate to a cooler temperature. Their location should provide at least five hours of daily sunlight with full sun being ideal in all but the hottest regions.

Reliable F1-designated petunias continue to win All-American Selection awards. F1 (first filial generation) is the term that indicates the uniform result of a first crossing of two different varieties. F1 parent plants must be crossbred every year to get the desired offspring. Most seeds of those offspring will not breed true in the second generation.

Petunias were initially divided into grandiflora, with blooms up to 5 inches, and multiflora, with 2- to 3-inch blooms in abundance. The multifloras are the workhorses of mass plantings and stand up to weather better than the grandifloras. Now there are also milliflora, which cover the plants with 1.5-inch flowers, and hedgiflora, which spread over 4 inches as a quick-growing groundcover, with heights from 3 to 18 inches. The spreading varieties are ideal for hanging baskets.

The F1 Wave series is a popular spreading variety and includes Double Wave, Easy Wave, Shock Wave, and Tidal Wave. Purple Wave, bred in Japan, was the first spreading variety, available in 1995, and won the All-American Selection award. Waves grow a large root system, which can be a problem in baskets and containers. Production of Waves is generally from seeds while Surfina is grown only from cuttings. Surfina is preferred in Europe and commands 85 percent of the petunia market. In 1996, the F1 Fantasy series of milliflora was introduced. As miniatures, milliflora are ideal for edging flowerbeds and tucking into containers. Supertunia is another dependable mini-series with a smaller root system that does not outgrow containers.

Petunia blossoms include about every color in solid, bi- and tricolored, starred, striped, edged or picotee, speckled, veined, and combinations on fringed, ruffled, single, double, giant, or dwarf blooms. Hybridizers continue to work to combine disease resistance, hardiness, consistent and better growth habit of foliage, and earlier, more prolific blooms with all the colors and combinations that can be derived genetically. Blossoms both large and small grow well in single and double varieties on tall, short, and spreading plants.

Although generally trouble-free, petunias have fuzzy stems that break easily and the blooms tend to water-spot. Without deadheading and pinching back, many varieties will get scraggly. Caterpillars dine on the about-to-open blooms and young leaves. Aphids can harm young buds.

Aside from the profusion of new petunia varieties, the original wild species remain available and popular. They reseed readily—in fact they are naturalizing in some states—and have a wider range of tolerance for heat, humidity, and cold than the hybrids. *Petunia integrifolia* with its bright magenta two-inch flowers blooms throughout the season and fills in around its neighbors. *Petunia axillaris* is similar with large white blooms that are fragrant at night.

The year 1997 was the Year of the Petunia as designated by the National Garden Bureau. But its popularity and easy nature make every year a good year to add the petunia to a garden or city landscape.

Tamara Stromquist

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Phlox

No garden is complete without the inclusion of the colorful, old-fashioned phlox flower. Phlox was at the apex of its popularity in Victorian gardens, but even today it is a garden staple for its dependability and easy maintenance. A member of the family Polemoniaceae, *Phlox* is a genus of 67 species, all native to North America except for one found in Siberia (*Phlox sibirica*). They thrive in such diverse habitats as the alpine tundra, prairies, and open woodland. As a result, they are hardy and highly cultivated. In fact, these days many varieties found in the wild are actually cultivated versions that have escaped. The name phlox is Greek for "flame," and phlox is often called "flame flower," referring either to the clusters of bright blooms or perhaps to the shape of the flower, which resembles a torch. Phlox given as a gift during the Victorian period was meant to acknowledge love. The fragrant phlox also served to wish someone sweet dreams. Colors range from pale blue, pink, violet, and red to white. Most cultivated phlox are perennial and, unlike many hybrids, maintain their fragrance. In addition to the color they add to the garden, butterflies and other insects are attracted to their nectar.

There Is a Phlox Variety for Nearly Every Garden

Garden, or summer, phlox, *Phlox paniculata*, is one of the more common and most cultivated species of phlox. The wildflower grows naturally in both open woods and thickets ranging from New York to Iowa. The plant in general does better in northern than southern climates. Although phlox thrives in full sun, the flower colors will bleach out if temperatures are extremely hot. Garden phlox grows to a height of two to six feet. Its flowers form a pyramidal cluster on top of a smooth, erect stem. In order to propagate the flowers and retain the parent colors, it is best to take cuttings or split existing clumps of plants. Flowers tend toward an uncertain, unattractive, purplish pink when raised from seed or as volunteers. Although not commonly thought of for herbal uses, it has been noted that phlox has been widely used as a medicinal herb. An extract made from the leaves has been used to treat boils and as a laxative. Garden phlox is also edible. The flowers have a mild spicy taste and are a good addition to salads.

While most phlox are perennial, one species found growing along roadsides and in fields as far south as Florida and Texas is annual. Annual phlox or Drummond phlox, *Phlox drummondi*, gets its name from British naturalist Thomas Drummond, who in 1835 sent seeds from Texas to England to be cultivated. The British created several cultivars and then reintroduced them to North America. This phlox has bright red, pink, or white flowers, some with a contrasting eye. They grow in tight clusters at the end of 8- to 18-inch stems, in full sun and rich loam.

In northern climates, one of the first flowers to bloom in spring is the moss pink, *Phlox subulata*. This plant has evergreen, needle-like leaves on creeping stems that form wide mounds six inches high. This phlox thrives in dryer habitats and rocky slopes. Colors range from white through bright pinks and lavenders. The effect in a rock garden is like a sheet of brilliant color. Native Americans have been known to call the full moon in April the "full pink moon" because it often occurred at the same time as the moss pink bloomed.

Phlox Is a Valuable Addition to All Gardens

The variety of colors, the open, trumpet-shaped flowers, and the sweet fragrance of all phlox species are irresistible to pollinators. An assortment of butterflies, bees, and hummingbirds is drawn to the area and, in turn, visits other plants. By choosing different species, a garden can be filled with blooms from early spring to fall. Early-blooming phlox play an important role alongside wildflowers such as dandelions in providing nectar for the first pollinators of the season. Some varieties of phlox have clusters of pale white flowers along with fragrances that are especially attractive to hawk moths and others that forage in the early evening and at night.

Common Pests and Diseases

Because of the popularity of phlox, it has been cultivated not only for different color variations but also for disease resistance. Powdery mildew resistance is a desired trait due to the plant's susceptibility to the fungal disease. Phlox is also prone to rust, another fungal infection. In most cases, some cultivars are resistant longer than others, but can still be plagued by the disease. It weakens the plant by affecting the foliage and sometimes results in death. Besides using resistant varieties, gardening practices that increase air circulation, such as splitting large plants and cleaning up affected foliage, are suggested. It is also important to properly dispose of infected plants away from the garden and compost area. Drip watering at the roots instead of overhead keeps the plant drier.

Other ills include spider mites, stem canker, Southern blight, stem nematodes, leaf spots, leaf miners, and caterpillars. Standard garden management and preventative procedures may be successful against many of these pests. In general, phlox is fairly hardy and requires little special maintenance except to split the plant clump every three years or so.

Given the popularity of phlox, it is no wonder that it has been highly cultivated. As a native of North America, the genus is already adapted to many habitats, from those that are hot and dry to more northern climates. Cultivation of different species has introduced a wider range of colors and has given gardeners plants that remain healthier longer into the season.

Gwendolyn Vesenka

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Pine

Since 810 CE Venice, Italy, has stood strong with its clock tower and St. Marks square. However, few people know that "the city of Venice rests on the hearts of larch." In the ninth century, the name "pine" had yet to be coined, so today if you translate that saying, you get "The city of Venice rests on the hearts of pine."

Pine trees throughout the world, have, since an early period, been a key factor in the development of humankind. When early humans discovered fire, they faced the problem of keeping it burning throughout the night. To solve this problem, they collected pine cones from the forests of towering pine trees and placed them on the smoldering embers. The resin, acting with the moisture of the pine cones, burned for hours.

Botany

Pines are evergreen, coniferous trees found in all the parts of the world. There are approximately 120 species of pine. Pine trees have green to bluish-gray needles arranged in bundles of two to five or six to eight, depending on the species. The cones of pine trees range in size from 0.5 inch to 12 inches. The longleaf pine, *Pinus paulustris*, bears one of the largest cones at up to 10 inches, and the mugo pine, *Pinus mugo*, has one of the smallest cones at 0.75 inch to 2 inches. Pine trees, such as the longleaf pine, can reach 130 feet high, or, like the mugo pine, grow to a shrubby 8 feet high.

Pine trees cross-pollinate to form hybrids. This is the case with the sonderegger pine of the American Southeast. A hybrid between the longleaf pine and the loblolly pine, it has the best qualities of both species: long pine needles and fat cones with fast growth, resulting in a mature tree in a short time. The stems of most pine trees branch freely in apparent whorls, having a racemose arrangement, so that, especially when the trees are young, they have one main shoot, which elongates rapidly and gives the whole tree the outline of an attenuated cone. At a certain age, however, the tree ceases to increase in height. Instead, the last-formed branches lengthen while the lower ones frequently decay, give the tree a spreading, flat-topped, or parasol-like outline. This is seen to a limited extent in the yew, the cedar of Lebanon, and the sequoia, and in the scots fir (*Pinus sylvestris*) at an advanced age. It is especially characteristic of the stone pine of Southern Europe (*Pinus pinea*). The stone pine may be a native of China, where it is plentiful. In Southern Europe, it is seldom seen far removed from human habitations. It occurs in the south of France, Spain, Greece, and Barbary, but it is most closely associated with Italy.

Uses

Pine trees are the leading source of paper products and building materials in the world. Loblolly pine is one of the leading timber species in the United States. The timbers of this species are very compact and are suitable for flooring. In the 19th century, growers noticed that the sap from pine trees could be collected and boiled down with several by-products that could be marketed, creating the tree sap boom. Resin oil could be taken for a cough or a scratchy throat, and some soaps and glues were processed with turpentine as the primary by-product. Pine trees also began to be harvested around this time on a commercial level to make paper and build houses.

Pine trees are known throughout the outdoor world as a survival plant. The cambium, or sub-bark, is moist and almost sweet and is rich in vitamins A and C. In the winter, the Swedes often make tea from the needles and tiny baby pine cones of *Pinus nigra:* the European black pine tree or Austrian pine. Pine tree cultivars recommended for the United States are loblolly pine, longleaf pine, mugo pine, slash pine (*Pinus elliottii*), sonderegger pine, and white pine (*Pinus strobes*).

Therapeutics

The steam-distilled essential oil from the balsam of *Pinus densiflora* is part of Chinese and Japanese pharmacopeias. Song-jie (the Chinese name) was first mentioned in Chinese medical literature around 500 CE as an antiarthritic and analgesic drug. Today, it is used in the traditional medicines of China, Japan, and Korea, administered as a topical ointment to treat rheumatism. The Micmac of Canada prepare an aqueous infusion of the needles and twigs of white pine for oral ingestion as a medicine for colds.

In Germany, pine needle oil is part of the German pharmacopoeia and the standard licenses for finished-drug monographs, and it is also approved by Commission E. Drops of the essential oil of pine are added to boiling water for the inhalation of steam vapor as a treatment for catarrhal diseases of the respiratory tract. The drops are also applied topically by carefully rubbing into the skin for rheumatic complaints. The Germans also prepare an aqueous infusion of pine shoots for oral ingestion for the same treatments as the oil. In German pediatric practice, pumilio pine oil is widely used as a component of inhalation. The composition of pumilio pine oil is 45 percent eucalyptus oil, 45 percent pumilio pine oil, and 10 percent peppermint oil. This oil is intended for acute cold symptoms, nasal inflammation, and nasal catarrh in children. In the United States, pine needle oil, distilled from the leaves of dwarf pine (*Pinus mugo* and *Pinus pumilio*), is part of the national formulary. It is used as a component in cough and cold medicines, vaporizer fluids, nasal decongestants, and analgesic ointments. The essential oil of Scots pine is also used for aromatherapy purposes. This plant, used in homeopathic remedies, is available in natural-foods stores and herb shops.

The approved modern therapeutic applications for pine needle oil are based on its history of use in well-established systems of traditional and conventional medicines and on phytochemical investigations and pharmacological studies. German pharmacopeia-grade pine needle oil is the steam-distilled essential oil extracted from the fresh needles, branch tips or the combined fresh branches with needles and branch tips of *Pinus sylvestris* or other essential oil-containing species of *Pinus*.

Charalampos Dokos

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Pineapple

A perennial herb, pineapple is a crop of the tropics and subtropics. Americans associate the fruit with Hawaii, though the islands are past their heyday in pineapple production. The Tupi-Guarani of South America called pineapple *nana*, meaning "excellent fruit." *Nana* is the root of the genus *Ananas* and the Spanish word *anana*. A member of the Bromeliaceae family, all species of pineapple are in one of two genera: *Ananas* and *Pseudonanas*. *Ananas* contains the five species *Ananas bracteatus*, *Ananas fritzmuelleri*, *Ananas comosus*, *Ananas eretifolius*, and *Ananas ananassoides*. *Pseudonanas* has only the species *Pseudonanas sagenarius*. Pineapple is 80–85 percent water, 0.4 percent protein, 0.5 percent ash, 0.1 percent fat, and 12–15 percent sugar, of which 5.9–12 percent is sucrose, 1–3.2 percent glucose, and 0.6–2.3 percent fructose. One hundred grams of pineapple contain 2.5 to 4.8 milligrams of folic acid, 200 to 280 milligrams of niacin, 75 to 165 milligrams of pantothenic acid, 69 to 125 milligrams of thiamine, 20 to 88 milligrams of riboflavin, 10 to 140 milligrams of vitamin B6, 0.02 to 0.04 milligram of vitamin A, and 10 to 25 milligrams of vitamin C. In addition to nutrients, pineapple contains the enzyme bromelaia, which reduces inflammation.

Origin and History

One authority places the origin of pineapple in southern Brazil. Another, remarking that the fruit is almost surely an American indigene, believes that it originated between the Parana and Paraguay rivers, where Argentina, Brazil, and Paraguay meet. The area is home to three wild species of pineapple. Wild pineapples contain numerous seeds the size of rice grains and are difficult and unpleasant

Pineapple (iStockPhoto)

to eat. The cultivated pineapple, by contrast, is seedless and is propagated by suckers. Humans selected pineapple for size, quality, and seedlessness. Humans, probably the Tupi-Guarani, cultivated pineapple as early as 3300 BCE from the coast of Ecuador to Peru. In addition to the Tupi-Guarani, the Aruak and Caribs took an interest in pineapple, diffusing it throughout tropical America: the Atlantic and Pacific coasts of South America, Central America, and the Caribbean. The Amerindians may have initially reserved pineapple for the elites. As a luxury good, it was an item of trade. Those who ate pineapple relished its flavor and believed that it stimulated the appetite and aided digestion.

In 1493, the Callinago of Guadeloupe gave pineapple to Spanish-Italian explorer Christopher Columbus, who carried it back to Spain, where King Ferdinand delighted in its flavor. Columbus called pineapple "the most delicious fruit in the world." On his third voyage (1498–1500), Columbus found the indigenes of Panama cultivating pineapple, banana, and coconut. These people derived a beverage from pineapple. The Spanish encountered the pineapple in the Caribbean, from Panama to Mexico, and in Brazil, Guiana, and Colombia. Spanish-Italian historian Pietro Martire d'Anghiera thought that pineapple resembled artichoke. The fruit had many admirers. In the 16th century, French cleric Jean de Lery declared it to be "the finest fruit in America." In 1519 one European, encountering pineapple in Brazil, praised it as "the finest fruit in existence." In 1535, Spanish historian Gonzalo Fernandéz de Ovieda Valdés esteemed pineapple "the prince of all fruits." His *General and Natural History of the Indies* contained the first published illustration of pineapple. In 1596, English nobleman Walter Raleigh, in contrast to Valdés, referred to pineapple as a female, calling it "the princess of fruits." Because pineapple was uncommon in Europe in the 16th century, it was the preserve of the wealthy, though sailors in the tropics ate pineapple to ward off scurvy.

In the 16th century, the Portuguese introduced pineapple into Africa, Madagascar, India, and perhaps China. From China pineapple migrated to the Philippines. In 1614, pineapple spread from the Caribbean to Virginia, though frost killed it. Between 1616 and 1619, pineapple was introduced into Bermuda, from where it was reintroduced to Virginia in 1621. About 1660, the Dutch brought the pineapple to South Africa and later to Java, Surinam, and Curacao. From these areas, the Dutch exported pineapple to Amsterdam, the Netherlands. Around 1690 the Dutch grew pineapple, doubtless in greenhouses, in the Netherlands. In the 1710s German philosopher, scientist, and mathematician Gottfried Leibniz took an interest in pineapple, though he apparently did not grow it himself. About 1720, the British grew pineapple in greenhouses. In 1822, Scottish writer John Claudius Loudon published *The Different Modes of Cultivating the Pineapple from Its Introduction into Europe to the Late Improvements of T. A. Knight, Esq.*, in which he offered advice on cultivation and the construction of greenhouses.

By then, Loudon reported that the British imported pineapple from Bermuda in such quantity that the fruit's price diminished, presumably allowing the masses to afford it. The British ate pineapple grown in its tropical empire. It was a popular holiday fruit, being consumed especially on Christmas. Because Europeans could get pineapple cheaply from the tropics, there was no longer a need to grow them in greenhouses. Now widely consumed, pineapple became a symbol of the fecundity and luxury of the tropics.

By then pineapple had ensconced itself as a dessert fruit in the United States, where American president George Washington had had a high opinion of it. The principal species that Americans enjoyed was *Ananas comosus*, the Cayenne pineapple. The Maipure first cultivated this species in the Orinoco River valley. They called this pineapple Mai-pouri perhaps because it originated in Maipures, a village at the junction of the Triparro and Orinoco rivers or because they wished to memorize themselves. French explorer Samuel Perrottet discovered Cayenne in Cayenne, the capital of French Guiana, giving the species its name. Perrottet brought Cayenne to a botanical garden in Versailles, France. From French Guiana, Cayenne migrated to Great Britain, possibly in the early 19th century, to Australia in 1858, and to Jamaica in 1870. Sometime earlier farmers grew it in Florida, from where it spread to Hawaii in 1885. British explorer Captain James Cook had introduced pineapple to Hawaii in 1779, though the cultivar may not have been Cayenne. In addition to Hawaii, Cook planted pineapple in Easter Island, Tonga, Saint Helena, and the Society Islands. Hawaii was the site of multiple introductions. In 1886, Jamaica exported Cayenne to Hawaii. In the 1890s, Australians brought Cayenne to Hawaii. By the late 19th century, Hawaii grew pineapple varieties imported from Algeria, Australia, the Bahamas, Florida, Jamaica, Mexico, Puerto Rico, Samoa, Singapore, and Trinidad. From Hawaii pineapple spread to several Pacific islands in the 20th century. Hawaiians labeled pineapple a foreign crop, though some dissenters on the islands of Maui and Hawaii thought it indigenous to the islands. It is possible, believes one authority, that the Polynesians introduced pineapple into Hawaii long before the advent of Europeans. If this is true, then the pineapple's long tenure in Hawaii may have led people to assume that it was native to the islands. In 1901, entrepreneur James Drummond Dole settled in Hawaii. Initially interested in coffee, he determined to invest in pineapple and that year incorporated the Hawaiian Pineapple Company. Having learned from his predecessors, Dole established a cannery in Wabiewa so he could export pineapple worldwide. Determined to minimize costs, he paid laborers only $12 per month at a time when Ford Motor Company paid workers $5 per day. By paying so little, Dole undercut the cost of growing pineapple in Florida. By 1921, Dole was the largest and wealthiest landowner in Hawaii, though when labor costs rose he transferred operations to the Philippines. By 2000 Hawaii, no longer the center of pineapple culture, totaled just 2 percent of global output. Today, farmers grew pineapple throughout the tropics and subtropics: Thailand, the Philippines, China, Brazil, India, the United States, Vietnam, Mexico, Indonesia, South Africa, Colombia, Malaysia, Kenya, Costa Rica, Singapore, Ghana, Cote d'Ivoire, Taiwan, and Zaire. Thailand, the Philippines, and Brazil are the leading producers.

Attributes, Cultivation, Harvest, Storage, and Cultivars

A dessert fruit, pineapple is canned as slices or rings, made into juice and jam, and eaten in fruit salad. Most pineapple is sliced, for example as chunks. Other pineapples go to make dried fruit. Still others are processed into syrup. From pineapple derives alcohol, calcium citrate, citric acid, and vinegar. The plant grows to a height of 35 to 40 inches. The first harvest is the main crop. Subsequent harvests are ratoon crops. The farmer harvests one or two ratoon crops before replanting. Although it has shallow roots, pineapple is drought tolerant because, like its epiphytic relatives in the Bromeliaceae family, it stores water in its leaves as a reserve against dry conditions. To conserve water, pineapple's stomata close during the hottest part of the day. Because pineapple is native to the tropics, where the amount of daylight is roughly constant year-round, it has not evolved a response to changes in the length of day. As a rule, pineapple is cultivated from 25° north and south, though in India it is grown as far north as 30°, and in South Africa it is cultivated as far south as 33°. Pineapple leaves grow best at 90°F, and the roots develop best at 84°F. One authority recommends a temperature of 81°F, with little change in daytime and nighttime temperatures, as best for raising pineapple. The fruit will not grow below 68°F or above 97°F. In Guinea and Hawaii, pineapple ripens at 77°F.

In Kenya, farmers grow pineapple at elevations up to 5,400 feet. Pineapple needs exposure to full sun. Yields decrease with a diminution in sunlight. Pineapple grows best with 59 to 98 inches of rain per year. Pineapple grows in a range of soils, though clay is not ideal. Better media are sandy loam, alluvial soil, and lateritic soil. Soil pH should be slightly acidic, between 5.5 and 6. The farmer should add six-and-six-tenths to eight-and-eight-tenths tons of compost or manure per acre. Plowing to a depth of 8 to 10 inches, the farmer should apply two-and-six-tenths pounds of nitrogen per 100 plants. One-third of the nitrogen should be applied at 3 months' growth, one-third at 6 months' growth, and one-third at 12 months' growth. Fertilized adequately, a pineapple plant should contain one-and-four-tenths grams of nitrogen and three-and-seven-tenths grams of potassium. The farmer may apply four-and-four-tenths pounds of the herbicides bromacil and diuron per hectare to kill weeds.

From flowering to harvest, four-and-one-half to five-and-one-half months must elapse. The pineapple harvest is still chiefly by hand. The local market absorbs pineapple too large or too small for other uses. Ripe pineapple is canned. Pineapple destined for export is harvested before it is fully ripe. Fruit that is half ripe may be stored two weeks at 47°F to 55°F. Green pineapple deteriorates at temperatures below 50°F. Pineapples from South Africa store well at 47°F. Pineapple may be stored four weeks at 45°F. Each 10° drop in temperature adds one week of additional storage. At room temperature, pineapple juice retains 80–85 percent of its vitamin C but only 38–47 percent at 99°F. Color deteriorates at high temperature. Canned juice may be stored 12 to 15 months without loss of quality and nutrition.

The varieties Cayenne, Giant Kew, Valeva, Balenca, and Espinola Roja are canned. Americans consume pineapple of the cultivars Cayenne and Hilo. The Spanish and Portuguese eat Saint Michael. Other Europeans consume Monte Lirio, Charlotte Rothschild, Mauritius, and Congo Red. The chief cultivars in Hawaii are Cayenne and Hilo. In the Philippines, Taiwan, Kenya, and Mexico, the principal variety is Cayenne. In Malaysia, farmers grow Singapore Spanish, in Cuba and Australia Cayenne and Red Spanish, in Brazil Red Spanish and Abacaxi, and in India Giant Kew and Queen Mauritius.

Christopher Cumo

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Pistachio

The pistachio is an edible nut produced by the tree *Pistacia vera*. It has a long, royal history, having been beloved by kings and queens. One of the oldest edible nuts, archaeological findings date the pistachio to 7000 BCE in the area that is now Afghanistan. These nuts are atypical in remaining intact within a shell that splits open. They are consumed raw—a favorite at Middle Eastern wedding parties—and as components of pastries, ice cream, and bagged meats such as sausages. Most of the world's pistachio nuts are supplied by Iran and the United States, and these nuts are imported by over 90 countries. The trees can grow in arid regions with alkaline or saline soils and are currently being used in reforestation programs and to provide new sources of income to poverty-stricken societies.

The name "pistachio" is thought to derive from the Persian *pista-pitak* or *piste*. A member of the Anacardiaceae or Sumac family, the pistachio is 1 of 11 species

Pistachio nuts (Chrisimages/Dreamstime.com)

in the genus *Pistacia*. All of these species produce a resin similar to turpentine. Other members of this family include the cashew and poison ivy, and some people have an allergic reaction to pistachio nuts.

Archaeological findings indicate that the pistachio has been consumed for nearly 10,000 years. Remains dating back to the Neolithic Era have been found in biblical regions. Anecdotal references to the nut abound in ancient literature. During her visit to Assyria, the Queen of Sheba decreed that all pistachios under her domain were to be transmitted to her, where she shared them with favorites in her court. The Christian Bible states that Jacob sent pistachios to the pharaoh as a gift. Approximately 1800 BCE, such trees were cultivated by the Babylonian king Merodach-Baladan.

The pistachio is such an integral part of the Middle Eastern and Mediterranean cultures that there is even a Sicilian proverb comparing the inseparable state of two people with a pistachio tree grafted onto its rootstock. It translates to "Be close together, as is the pistachio grafted on a terebinthus."

Pistachios are an important part of hospitality in a number of countries, particularly at weddings, such as in Syria. In Tunisia, rozata—a syrup made from pistachios—is consumed at wedding parties. Israel has the world's greatest consumption of nuts per person, because it is a traditional gesture of cordiality to offer pistachios to guests. In Syria, small bags of the nuts are often given as guests leave.

Biology of the Pistachio Tree

The tree can grow to 33 feet tall and live to be over 1,000 years old, still producing edible nuts. The pistachio tree is dioecious: it has separate male and female plants. The flowers on the female plants do not attract bees and are pollinated by the wind. Thus it is necessary to have a male plant in the vicinity for pollination and subsequent nut production to occur. The standard ratio in orchards is to have one male plant for every eight female plants.

The flowers, and thus the fruits that produce the nuts, are produced in panicles at the ends of one-year-old branches. The fruit produced by the pistachio is a drupe, the same type of fruit as a cherry, plum, or almond. These fruit all have an outer exocarp, a fleshy mesocarp, and a seed enclosed by an endocarp. The difference is that with a plum, the mesocarp is fleshy and edible, while with pistachios and almonds, it is the seed that is consumed.

Pistachio trees have a long juvenile period during which they bear few nuts. Typically, trees do not begin producing until 6 years of age and do not bear fully until they are 7 to 12 years old. The pistachio tree requires moderate winters and hot, dry summers for trees to produce a high volume of nuts. The trees produce more nuts at lower elevations, where the temperatures are likely to be hot enough for a prolonged period, so the fruit can ripen. Humid areas are ill suited to pistachio production because they facilitate the spread of fungal diseases. This is a problem in some areas of the Mediterranean.

The root system is of a type known as a phreatophyte. This is an extensive root system that can spread deeply to take advantage of scarce water resources. It enables the tree to grow in arid regions in which few types of vegetation can survive. The tolerance of pistachio trees to saline or alkaline soils, or soil containing lime, enables them to be grown in areas in which most vegetation has a hard time flourishing. Examples include the formerly barren regions around Mount Etna in Italy and the dry deserts of Afghanistan. Groves of pistachios are being established both to benefit the environment by helping to mitigate the spread of desertification in the Middle East and North Africa and to provide food and income for the economically deprived inhabitants of such areas.

Commercial Pistachio Production

Pistachio nuts are unique in that they remain intact within a split endocarp. The color of the nut can greatly affect its market price. Green nuts are in high demand and fetch the highest prices. For instance, the pistachio nuts of Sicily are renowned for their green color and receive double the price of standard pistachios. Nuts are sometimes dyed to hide blemishes, which is partly why pistachios were traditionally stained red. The marketing of California pistachios features the "natural pistachio"—a large nut with a naturally colored shell.

Having a blemished shell can be more than a cosmetic issue since it can indicate fungal or insect damage to the crop. Such damage can be a precursor to contamination with aflatoxins, carcinogenic fungal toxins. Nuts that are processed within 24 hours will not be contaminated with these toxins, and this is the standard process for commercially produced nuts from California.

While a number of countries grow pistachios, only a few countries are major exporters of these nuts. Iran and the United States provide 75 percent of the world's pistachio exports, with virtually all of the United States' nuts being grown in the Central Valley of California. Of the two, the United States is the leading exporter. The other leading exporting countries include Turkey, Syria, and China.

Pistachios were not introduced into the United States until the mid-1800s. In 1890, the U.S. Department of Agriculture introduced a number of cultivars from the Middle East to California. One was the female Kerman—named after its original location in Iran—which now comprises the nut-bearing portion of the California pistachio industry. It is complemented by the male variety Peters, named after the grower who first selected it to pollinate Kerman.

One intrinsic negative feature of the crop is its tendency toward alternate bearing. Production of a heavy crop one year will be followed by negligible amounts of nuts being born the following year. Heavy pruning of three-year-old wood will mitigate this costly trait for up to six years.

The high cost of establishing a pistachio grove in the United States has led to primarily corporate ownership of the groves. Several reasons make it highly expensive to introduce and maintain a grove of this type. In areas like the San Joaquin Valley of California, the trees transpire at a high rate due to their type of stomata. Despite their having evolved in arid regions, such commercial pistachio groves require substantial amounts of irrigation compared to those of other nuts to produce at high levels. The lack of nut production for years after the trees are planted requires a large initial capital investment that will not be repaid for quite some time.

In their native regions, pistachio trees are generally grown as seedlings, since they are stronger than those of other species. In much of the world, however, the desirable nut bearing tree is grafted onto the rootstock of one of its wild relatives. The type of rootstock used varies, depending on the local needs of the orchards. In some cases, resistance to *Verticillium* wilt is of paramount concern, while other orchard managers are more concerned about tolerance to salinity. In the United States, rootstocks include the species *Pistacia terebintus*, *Pistacia atlantica*, *Pistacia integerrima*, and a hybrid of *Pistacia atlantica* and *Pistacia integerrima*. These particular grafts provide enhanced disease resistance. Iranian orchards tend to utilize rootstocks of *Pistacia mutica* and *Pistacia khinjuk*.

The nuts are generally harvested by shaking the trees. In much of the world, the trees are manually shaken. Large, commercial groves often utilize mechanical shakers to release the nuts from the trees. Frequently, the nuts are subsequently sun dried.

California's commercial pistachio industry did not produce enough nuts to be competitive on the world market until 1976. In just 31 years, California's industry grew to produce 207,810 tons of pistachios. The total value of the U.S. crop for 2007, which was produced almost entirely in California, was $557 million. Despite having produced over half a billion dollars' worth of pistachio nuts, the United States is not the world's leading exporter of this delicacy. That title belongs to Iran.

Unlike the United States' monoculture of female pistachio trees, Iran is a center of genetic diversity for this species. The most important area of nut production in this country is the Kernan Province, where over 70 cultivars are in production. Despite this industry's location in the region of origin of the pistachio, their cultivation was economically unimportant until the 1930s. There is currently a rapidly expanding profusion of orchards, with major cultivars including Ouhadi, Kalleh-ghouchi, Ahmad Aghaii, Akbari, and Badami Zarand.

Health Effects of Pistachios

In general, tree nuts are considered a healthy food that contain large amounts of protein and fiber, and are good for heart health. Pistachios are a nut of particular interest. Several epidemiological studies have found that subjects who consumed 15–20 percent of their daily caloric intake in the form of pistachios for several weeks experienced statistically significant reductions in levels of harmful cholesterol without changes in the amount of beneficial LDL cholesterol.

Pistachios have been compared to berries, due to anthocyanins in the skin of the nuts. They contain a number of phtyochemicals thought to be beneficial to health, including resveratrol, phytosterols, and the carotenoid lutein. The fat of the nuts has a high proportion of monounsaturated fatty acids, which are considered one of the more healthy forms of fats to include in one's diet. Like avocados, pistachios have a high concentration of oleic acid.

Additional Uses of the Pistachio Tree

The tree has strong bark and is the source of quality furniture and agricultural tools. Unfortunately, in many areas pistachio groves are the only source of firewood, leading to the large-scale destruction of such orchards. This has been the case in Afghanistan during the war years.

Infestations of mites can lead to the production of galls on the trees. These have been the source of several useful items. In the country of Georgia, such galls were the source of material for high-quality paints. They have also been used to produce tannins in Algeria, which have been used to tan goat wool. This wool is then used to produce a traditional cloth to cover water jugs.

Helga George

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Pitcher Plant

A carnivorous plant, the pitcher plant has leaves in the shape of a container for the trapping of invertebrates and occasionally small vertebrates. Its genera populate both the Old and New Worlds. Many pitcher plants inhabit the tropics and subtropics, though at least one species makes its home in Canada. Relics of the ice ages, several species tolerate cold weather. A flowering plant, the pitcher plant attracts bees to cross-pollinate it. Because it cross-pollinates, it forms hybrids with other species of pitcher plant. These hybrids are exceptional in being fertile. Because these hybrids are fertile, taxonomists sometimes have trouble distinguishing a hybrid from its parent species. The fact that different species of pitcher plant flower at different times seems to be a barrier against hybridization, though hybrids are common enough to prove an overlap in the time of flowering of some species. The fact that hybrids do not swamp their parent species may mean that they do not possess a selective advantage over their parents.

Known for its carnivorous habit, the capture and digestion of insects are not essential to a pitcher plant's survival. Like all flora, a pitcher plant derives energy from sunlight. Its roots absorb nutrients and water, all of which are necessary for survival. At least one specimen of pitcher plant discovered in the wild does not, however, have roots. In any case, the roots of a pitcher plant do not store water, leading it to derive at least some of its water from its trap, which holds rainwater in addition, in some instances, to its own digestive juices. Although a pitcher plant does not need to trap insects for survival, the plants that do catch insects grow more vigorously than those that capture no prey. The carnivorous habit is an evolutionary adaptation to life in nutrient-poor soils. By digesting insects, a pitcher plant thrives in soils deficient in nitrogen and phosphorus because it absorbs these nutrients from insects. Because other plants do poorly in these soils, a pitcher plant does not need to compete with them for space and sunlight. By digesting insects, pitcher plants have carved out their own niche in marginal soils. Although they may seem weird to the casual observer, pitcher plants are an evolutionary success.

Pitcher plants (Suemack/Dreamstime.com)

Origin, Diversity, Discovery, and Cultivation

The progenitor of pitcher plants may have arisen in Laurasia or southern Gondwanaland. The progenitor did not eat insects. In fact, all pitcher plants derive from at least two species of noncarnivore. The carnivorous habit must therefore have evolved at least twice. From their origin, pitcher plants colonized the Old and New Worlds long before humans arose.

All 148 species of pitcher plant belong to one of three families. Having just one species of carnivorous plant, the Old World family Cephalotaceae is native to southwestern Australia. A family of Old World pitcher plants, Nepenthaceae, is the largest of all families, holding 90 species. The single genus within Nepenthaceae, the well-known *Nepenthes*, inhabits Southeast Asia, Madagascar, the Seychelles Islands, northern India, Sri Lanka, China, and northern Australia. The New World family, Sarraceniaceae, has three genera: *Heliamphora*, *Darlingtonia*, and *Sarracenia*. *Heliamphora*—the sun pitcher plant—is native to South America. *Darlingtonia* inhabits northern California and southern Oregon. *Sarracenia*, the best known of American pitcher plants, may be found in the southeastern United States. One species lives as far north as Canada.

Given the antiquity of Old and New World pitcher plants, it seems strange that they escaped notice so long. The Amerindians appear not to have taken an interest in them, and only in 1576 did the Spanish collect pitcher plants in Florida. In the late 16th and early 17th centuries, several botany texts had illustrations of pitcher plants, though mystery surrounded them. In the 16th century, botanist Carolus

Clusius was among the first to describe a pitcher plant, though he did not have a live specimen to inform his work. In 1637, the British imported the first live pitcher plants for cultivation and study. In 1640, British botanist John Tradescant grew pitcher plants in his garden, though he may not have known of their carnivorous habit. Meanwhile, a continent away Étienne de Flacourt, the French governor of Madagascar, described the first species of *Nepenthes* in 1658. In 1700, French botanist Joseph Pitton de Tournefort named the genus *Sarracenia* after physician and botanist Michel Sarrazin, who had sent him a specimen. Swedish naturalist Carl Linnaeus retained the genus name in 1731, though he dismissed the idea that pitcher plants ate insects. Such a supposition contradicted the divine order of nature, he believed. Animals ate plants, not the other way around. Given Linnaeus's eminence, few had the courage to challenge him.

Linnaeus supposed that a pitcher plant was shaped like a container to collect rainwater to hydrate the plant during dry spells, a supposition that appears to be correct, at least for some species. In 1737, he chose the genus name *Nepenthes* for the specimen that Flacourt had described.

Apparently following Linnaeus, American naturalist Mark Catseby dismissed the claim that the pitcher plant was a carnivore. Rather, insects hid in pitcher plants to escape predators. In 1791, American naturalist William Bartram observed that pitcher plants trapped insects and that captured insects decayed in them. Unwilling to admit that pitcher plants were carnivores, Bartram doubted that they derived nourishment from decaying insects. In 1874, British botanist Joseph Hooker proposed that the pitcher plant digested insects just as the human stomach digested food. The next year British naturalist Charles Darwin marshaled the evidence that the pitcher plant and several other plants were carnivores. Journalists and religious leaders, taking up Linnaeus's objections anew, ridiculed Darwin. With Darwin dead in 1882, the task of defending the assertion that the pitcher plant ate insects fell to physician Joseph Mellichamp, who in 1887 demonstrated that a pitcher plant could digest a piece of venison. Despite the critics, Hooker and Darwin had been right.

In the 19th century, botanists had been the first to cultivate the pitcher plant, though they did so to advance their studies rather than to derive pleasure from its culture. Yet gardeners found pitcher plants alluring and grew them for purely aesthetic reasons. *Sarracenia* found admirers. Easy to cultivate, *Sarracenia* was grown for its beauty (it was attractive in floral arrangements) and its carnivorous habit. Gardeners have grown *Sarracenia* outdoors in Michigan in temperatures as low as –16°F and in the United Kingdom with temperatures as low as 5°F. Not only does *Sarracenia* tolerate cold, it needs at least six weeks of temperatures below 50°F to initiate dormancy. Gardeners give *Sarracenia* soft water with a low salt concentration or distilled water. Because *Sarracenia* is a bog plant, gardeners must give it copious amounts of water, though the approach of winter should signal a reduction in water so that roots will not freeze. By reducing the amount of water in the soil, the gardener allows air, which insulates roots, to protect them from freezing.

Having evolved with a minimum of competition from other plants, pitcher plants do best in full sun. They prefer at least six hours of sunlight per day, though they will do well with as few as three hours of sunlight per day. The gardener, mindful of a pitcher plant's need for sunlight, should nonetheless shade it in hot, dry weather so that the sun will not dry them. The gardener who puts a pitcher plant in a pot by a sunny window must keep the soil wet to encourage growth and keep the humidity high. Because pitcher plants do well in nutrient-poor soils, there is no need to add fertilizer. Water and sunlight are all they need. The gardener who keeps a pitcher plant indoors and away from insects may fertilize with nitrogen, phosphorus, and potassium in a 10:10:10 ratio. The gardener who wishes to fertilize *Darlingtonia* should use a fertilizer of nitrogen, phosphorus, and potassium in a 30:10:10 ratio, though we have seen that pitcher plants will do well without any fertilizer.

The gardener must take care in preparing the soil. One gardener believes that peat is the best soil. Others use fine sandy soil, secure in the knowledge that sandy soil is nutrient poor and so suited to pitcher plants. Still others use sphagnum moss, vermiculite, or perlite. *Darlingtonia* prefers a soil of one part sphagnum to one part perlite or two parts perlite, lava rock, or pumice to one part peat. *Heliamphora* prefers a soil with one part sphagnum, one part perlite, and one part lava rock or pumice. The West Australian pitcher plant likes a soil of one part peat and two parts sand or perlite. *Nepenthes* will grow in a soil of one part sphagnum, one part peat, one part perlite, and one part pumice, lava rock, vermiculite, orchid bark, or charcoal. Alternatively, the gardener may prepare a soil of one part peat or sphagnum, one part orchid bark, one part perlite, and one part vermiculite. A third option is a soil of one part sphagnum and two parts osmunda fiber.

So popular has the pitcher plant become that a market has developed for the addition of cut pitcher plants to floral arrangements in the United States and Honduras. In the United States, florists sell several million pitcher plants per year in floral arrangements. Their aesthetic appeal is not hard to understand. The buyer who wants something other than green foliage will find pitcher plants in red, yellow, white, and black. At least one species of *Sarracenia* has an attractive combination of yellow leaves with red veins. A light frost enhances its beauty, imparting white crystals to the leaves and making them sparkle like jewels.

Gardeners who wish to raise pitcher plants may turn to a nursery for plants and guidance, but they must exercise caution. Unscrupulous nurserymen take pitcher plants from the wild. Although this practice is illegal, it nonetheless appears to flourish. Reputable dealers raise their pitcher plants from seed, and the gardener who has established a colony of pitcher plants at home may also propagate by seed. If kept outdoors, pitcher plants will attract bees. Indeed, they flower before the traps open in spring, ensuring that they do not devour their pollinators. *Sarracenia rubra* produces red flowers with an aroma similar to that of roses. Others describe the odor as akin to that given off by cherry Kool Aid. Once pollinated, the flowers shed their petals and seeds form, ready for harvest in summer and autumn. Pitcher plant seeds need a period of dormancy, six to eight weeks of temperatures below 41°F. This requirement may be satisfied in temperate locales by planting seeds in fall. They will be dormant during winter and germinate in spring two to four weeks after the onset of warm weather. It is neither necessary nor desirable to plant seeds beneath the soil's surface because they need sunlight to germinate. Instead, the gardener may sprinkle them atop the soil. As a rule 70–90 percent of seeds will germinate, giving the gardener plenty of seedlings. Pitcher plant seeds remain viable up to five years. One gardener recommends that enthusiasts put old seeds in gibberellic acid to stimulate germination. Another trick involves freezing seeds in water for 48 hours to stimulate germination.

In addition to growing pitcher plants from seeds, the gardener may propagate them by division. In this method, the gardener digs up part of a rhizome, replanting it where she wishes to establish a new colony. The section of rhizome will generate new plants. Whether cultivated by seed or division, seedlings require five to eight years to mature, though their care is not arduous. The gardener may allow them to mature, taking care to keep the soil wet. Otherwise they will fend for themselves. They will attract insects without the gardener's intervention, though some gardeners feed their plants crickets and other insects. Fertilizer, we have seen, is not necessary. Pitcher plants remain erect even when laden with insects and do not need staking. They are hardy perennials, requiring less labor than many other garden plants.

Insect Capture

The fact that gardeners and the public find pitcher plants fascinating stems from their ability to capture insects. Evolution has equipped them with an efficient trapping mechanism. So efficient are pitcher plants that scientists have discovered a single specimen with some 6,000 insects in various stages of decomposition. Some pitcher plants specialize in the capture of ants, termites, and other crawlers, whereas others are adept at imprisoning flying insects. Pitcher plants have glands that secrete nectar to attract insects. These glands are numerous along the mouth of the trap and sometimes on the underside of the lid. An insect drawn to the nectar may feed on it without incident. In the case of ants and termites, the escape of a potential prey is not a catastrophe because it will likely return to the colony to recruit others to trek to the pitcher plant en masse. As ants or termites crowd onto a pitcher plant, they jostle one another. Unlucky ants or termites on the edge of the mouth lose their footing from being knocked about and fall into the trap. New ants or termites replace their fallen kind and suffer the same fate.

Insects that do not topple into the trap may crawl into a pitcher plant at their peril. *Sarracenia* and many other species have hairs in its interior that point downward. Insects that climb down these bristles find too late that they impede their retreat. Once past the first patch of bristles, insects find more nectar, so much that it wets the interior of the plant, making it slippery. Those that lose their foothold topple to the bottom of the trap. The tube of the trap of some species narrows, preventing flying insects from spreading their wings to escape. At the bottom of the trap, a luckless insect again encounters hairs that prevent its climbing back out. In any case, the nectar the insect had eaten contains chemicals that stun and immobilize it and these act on it to prevent escape. An insect that falls to the bottom lands in a liquid, which drowns many. Others starve or die from exhaustion as they struggle for freedom. Many species of pitcher plant secrete digestive juices that dissolve an insect, freeing its nutrients for assimilation. Glands in the interior of the trap absorb these nutrients. The odor of decay attracts carrion feeders and these too succumb to the trap. The digestive juices may contain acids, which diminish the liquid's pH to as low as 2.5. The juices are strong enough to dissolve even snail shells. All but the hardest parts of the exoskeleton dissolve. A survey of the contents of a pitcher plant revealed little more than beetle legs, the rest having been devoured. The juices are potent enough to be diluted by rainwater without much loss of strength.

A species of *Sarracenia*, the purple pitcher plant, which grows as far north as Canada and as far south as the Gulf of Mexico, has weak digestive juices and relies on the bacteria in an insect to decompose it. *Sarracenia* attracts a diversity of insects: moths, wasps, beetles, treehoppers, and leafhoppers. Because ants are avid collectors of nectar, they are common prey. Species of *Sarracenia*, the hooded pitcher plant and the sweet pitcher plant may have evolved as ant traps. *Sarracenia* also captures blowflies, which are carrion feeders. Spiders, attempting to trap the insects that feed on a pitcher plant's nectar, also are among the prey. Curiously, grasshoppers and June beetles are seldom caught.

The lid of *Sarracenia flava*, a popular garden plant, minimizes the ingress of rainwater and so retains its digestive juices at full strength. Known as the yellow trumpet, *Sarracenia flava* may capture so many insects that it topples over from their weight. *Sarracenia minor* has a translucent back leaf. Flying insects equate the light with an escape route and slam into the back of the trap. Stunned, they fall to the bottom. Crawling insects, intent on escape, try to reach the back wall but, losing their footing on the slick surface, topple into the trap. The parrot pitcher plant has a bright interior that attracts insects. As with other species of *Sarracenia*, the trap has hairs that permit entrance but block exit. Insects, unable to back out, crawl to the trap's bottom and death. The cobra pitcher plant, a species of *Darlingtonia*, combines nectar and hairs to immobilize and imprison insects. The plant secretes water rather than digestive juices. Drowning insects, the cobra pitcher plant relies on their bacteria to decompose them. Inhabiting an area of high rainfall, *Heliamphora* has a slit along its side out of which rainwater flows. This adaptation keeps the level of liquid in the trap constant. Like *Darlingtonia*, *Heliamphora* produces no digestive juices, relying on an insect's bacteria to decay it.

Nepenthes secretes nectar that intoxicates insects, contributing to their demise. The digestive fluid is initially neutral, being neither acid nor base, but as insects accumulate *Nepenthes* secretes acids strong enough to digest a fly in just two days. Small flies may last only hours until decomposition is complete. The exoskeletons of decayed insects sink to the bottom of the trap, which is a kind of graveyard. As pitcher plants age, they may dry up. Now safe, carrion feeders invade the trap to carry away dead insects. In *Nepenthes*, the bottom of the trap is wider than the mouth, ensuring that insects fall unimpeded to their death. Once at the bottom, an insect is unable to free itself. The surface tension of the liquid holds an insect in place. In other cases, the liquid has low surface tension, and an insect, surrounded by a heavy exoskeleton, sinks to the bottom, where it drowns. In youth *Nepenthes* has a low pH, but as it ages the pH approaches neutrality. An old *Nepenthes* depends on microorganisms to aid it in decomposing insects. Bacteria, yeast, and protozoa inhabit the trap and help digest insects. Some pitcher plants line the bottom of the trap with a viscous liquid in which insects stick. Even when overturned by rain, the trap holds its insects because of this liquid. *Nepenthes* has a varied diet: ants, bees, beetles, butterflies, centipedes, cockroaches, craneflies, earwigs, flies, midges, millipedes, mites, moths, spiders, termites, wasps, and even scorpions. In one study, the average pitcher plant had 140 insects in various stages of decomposition. The bright colors of *Nepenthes* and *Sarracenia* attract insects. Some *Nepenthes* coat the interior of the trap with a sticky liquid. Insects that land on the side of these plants get stuck just as insects get stuck on the tentacles of a sundew. These insects slide to the bottom, where they drown. Because these *Nepenthes* and the sundew have a similar method of capture, they may share a common ancestor.

Nepenthes has the largest traps of any pitcher plants and so captures the largest prey. Because *Nepenthes*'s traps are so large—the biggest holds nearly one gallon of liquid—they have even trapped tadpoles, frogs, rats and other rodents, and small birds. *Nepenthes attenboroughii*, *Nepenthes deaniana*, *Nepenthes insignis*, *Nepenthes merrilliana*, *Nepenthes mira*, *Nepenthes peltata*, and *Nepenthes rafflesiana* are all large enough to trap small vertebrates in addition to insects. The nectar and the smell of decaying insects may attract rodents. Amphibians may be attracted to a pitcher plant because it has a pool of standing water in which they may lay their eggs. Lizards and frogs station themselves at a pitcher plant to eat the insects that it attracts. All may fall to their death.

In *Nepenthes aristolochioide* and *Nepenthes klossis*, as with several other species, the underside of the lid secretes nectar. Insects must hang upside down to harvest this nectar, placing them in a precarious position. The light interior of these pitcher plants lures insects to their death. The majority of the victims of these species are small flies, which react to light by rushing toward it. *Nepenthes alba*, *Nepenthes gracillima*, *Nepenthes ramispina*, and *Nepenthes spectabilis* have a dark exterior and a light interior, a contrast that draws insects inside them. The shape of pitcher plant leaves may have evolved to deter carrion feeders from stealing insects. *Nepenthes altomarginate* specializes in capturing termites. Its white rim attracts termites, which feed on the white trachoma along the rim. In one study, a *Nepenthes altomarginate* trapped 22 termites per minute. The largest trap had some 6,000 dead termites. With colonies of 500,000 members, termites are a plentiful supply of food. Some pitcher plants attract frogs and birds, which sit atop the mouth as they await insects. They may defecate in the trap, giving the pitcher plant another source of nourishment. Occasionally, leaves from nearby trees may fall into a pitcher plant, but these, like insects, decay and appear to nourish a plant. A study calculated that one pitcher plant derived 35.7 percent of its nitrogen from fallen leaves.

Cephalotus folliculoris is similar to *Nepenthes* in having a dark exterior and a light interior to attract insects. The species has projections that gird the mouth of the trap and on which insects try to tread. The projections are slippery, sending many to their death. Some *Cephalotus* are so successful that their traps fill two-thirds full with insects. *Cephalotus* attracts ants, beetles, flies, and snails.

In addition to trapping insects, some pitcher plants are home to other organisms. In one study of pitcher plants in Malaysia, infauna inhabited more than 90 percent of them. Scientists first believed that these organisms competed with the plants for food, but they now classify the relationship between plant and infauna as mutualism in many cases. The pitcher plant gives these organisms a home and food to eat. In return, these organisms excrete waste on which a pitcher plant feeds. As early as 1747, one German botanist discovered a shrimp living in a pitcher plant. In 1898, naturalist Reginald Pocock discovered that a crab spider inhabited a species of *Nepenthes*. In 1928, naturalist Cedric Dover discovered that tadpoles inhabit some pitcher plants. Mosquitoes sometimes lay their eggs in pitcher plants. Even when digestive juices are strong, they seem not to injure these inhabitants. Infauna may not have special adaptations to a pitcher plant's digestive juices. They are simply adapted to aquatic life. As long as an organism does not die, it is not digested. The digestive juices are not lethal. Rather, captives die from drowning, starvation, or exhaustion and are only then digested. Mosquito, fly, and midge larvae all live in pitcher plants. Some mosquito larvae are so adapted to life in a pitcher plant that in the winter they freeze along with the fluid. In spring, they emerge unharmed. In some cases, however, organisms take advantage of a pitcher plant. One species of spider spins a web in the trap, catching mosquitoes, flies, and midges as they emerge from the fluid as adults. This spider also snatches insects that fall into the trap, depriving a pitcher plant of food. The flesh fly lays its eggs in a pitcher plant. The maggots that hatch feed on the decaying insects. When they are ready to pupate, they bore a hole in the side of the wall and fall to their ground, where they emerge as adults. One species of wasp deposits grass into a pitcher plant, to which it adds dead grasshoppers or crickets. The wasp lays its eggs in this mix. Larvae eat the grasshoppers or crickets. By adding this material to a pitcher plant, the wasp deprives it of its means of trapping insects. Some species of moth lay eggs in the interior of a pitcher plant. Hatchlings feed on the plant. Caterpillars of the genus *Tortrix* feed on pitcher plant flowers. Other insects feed on the rhizomes of a pitcher plant. Gardeners may spray insecticides at half strength against these predators, but even dilute insecticide may damage a pitcher plant. Moreover, insects that have invaded the rhizome are safe from insecticides.

Christopher Cumo

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Plantain

The plantain and banana are not, as one writer seems to imply, the same plant. Both are in the family Musaceae and the genus *Musa*, but the plantain, unlike the banana, is a cross between the species *Musa acuminata*, which has what scientists call the A genome, and *Musa bulbhisiana*, which has the B genome to yield the triploid with A, A, and B genomes. A triploid is an organism, in this case a plant, with three sets of chromosomes, in this case A, A, and B. Being a hybrid and a triploid, the plantain, like the banana is sterile, producing no seeds. Without seeds, vegetative propagation is necessary, in this case from suckers that develop from the corm (the rhizome). The propagation of plantain by sucker yields a clone of the parent since there is no recombination of chromosomes that is the hallmark of sex. In rough terms, a plantain is a starchy food, often cooked, that is eaten in the main course, whereas a banana is a sweet fruit eaten for dessert. A plantain only slowly converts starch to sugar, a process that is rapid in the banana. There is confusion over the meaning of the term "plantain." In French-speaking Africa, the word "plantain" refers to the cultivars French and Horn. In the Spanish-speaking areas of the Canary Islands and Central and South America, only Horn is considered a true plantain. In the French-speaking Caribbean, the term *corne* means Horn and *banana blancho* means French. The plantain is often served at restaurants fried and with sour cream. This practice imparts too much fat for an otherwise healthy food. Plantains contain fiber and potassium and are one of a handful of plants to have plenty of both beta carotene and vitamin C. One cup, roughly 150 grams, of plantain has 1 gram of protein, 179 calories, no fat, 48 grams of carbohydrates, 4 grams of fiber, 20 percent of the recommended daily allowance of potassium, 28 percent each of beta carotene and vitamin C, 18 percent of vitamin B6, and 12 percent each of folic acid and magnesium.

Origin and History

The plantain might have originated in Malaysia, from where it spread throughout Southeast Asia. Alternatively, the plantain might have originated in Oceania, whose people gathered it from the wild. Papua New Guinea appears to have been the center of this activity, which spread to other islands in the Pacific Ocean. In the first millennium CE, Polynesians who migrated to Southeast Asia brought the plantain to this region. The plantain, often thought to be a tree though it is a perennial herb, provided humans with the fiber they used to make fishing nets and homes. The first use of the plantain may therefore have been for fiber rather than food. Legend holds that humans first ate plantain after seeing birds do so. When plantains spread from Southeast Asia to India and the Philippines they hybridized, possibly in India, to yield the triploids. Although triploids are sterile, humans favored them because they are more vigorous and yield more food than their diploid progenitors. From India plantain, perhaps with the assistance of Arab merchants, spread to the Middle East and North Africa. By the 12th and 13th centuries, farmers grew plantain in Egypt, Tunisia, and Spain. In addition to these areas, sometime after the birth of Christ the plantain migrated to sub-Saharan Africa. In sub-Saharan Africa, the cultivation of plantain caused the population to increase. Giving up nomadism, people settled the land. The clearing of forest for plantain may have diminished the incidence of malaria. In the 15th century, Europeans noted the plantain's cultivation in West Africa. In the meantime, the plantain may have arrived in Madagascar from Indonesia. After the 14th century, the people of the Mediterranean Basin or Africa introduced plantain into the Canary Islands to feed the slaves who toiled on the sugarcane estates. In the 16th century, the Portuguese and Spanish introduced plantain into the New World. Portugal, for example, introduced plantain into Brazil. By 1607, plantain was the most important fruit in Panama.

Growing more than 70 percent of the world's plantains, Africa is the primary region of cultivation. Small farmers grow most plantains, 85 percent of which are consumed locally, though in some regions the advent of a market economy has led some farmers to sell plantains for cash. In some Nigerian households, for example, 80 percent of plantains are sold. In Africa, plantain fills the role of a starchy staple that the potato occupies in the temperate zone. In East Africa and Bangladesh, the average plantain grower has one-and-two-tenths acres. In Nigeria he has up to four-and-four-tenths acres, in Malaysia two-and-five-tenths to five acres, and in Costa Rica less than two-and-one-half acres. Subsistence farmers rely on dung to fertilize plantains. In some regions, plantain is among the first crops planted after clearing land. In Polynesia, farmers plant plantain after yam and aroids. In parts of Asia and Africa, plantain follows corn, yam or cassava, and beans. Plantain provides shade to young coffee and cacao trees and so is intercropped with them in Africa, Asia, and Latin America. Plantain provides food and income while coffee and cacao mature. Farmers favor plantain because of ease of care and because it yields year-round in the tropics. In Cameroon and West Africa, plantain is boiled or fried. Africans favor it because it yields more food than yam.

Attributes and Cultivation

In Africa, the plantain is cultivated in the rain forest. In the Caribbean and Central America, plantain may be grown in monoculture. Elsewhere, as we have seen, it may be intercropped with coffee, cacao, cassava, cocoyam, tannia, corn, haricot beans, and peanut. In parts of the Caribbean, farmers grow plantains for their own sustenance. In other parts of the Caribbean and in Central America, growers export plantains to the U.S. South.

From the corm develops roots. Roots may be six to nine feet long, though many are only 12 to 20 inches in length. When a plantain puts forth leaves, the corm yields a terminal bud from which flowers develop. The so-named female flowers have both female and male parts though the female organs are larger. From a flower emerges a bunch of plantains. Plantain has 60 cultivars classed as giant, medium, and small. The French variety has 6 to 10 hands per bunch and a large number of small fingers. The giant French has more than 10 hands and needs 15 to 18 months to produce a crop. A bunch may weigh as much as 100 pounds. The medium French plantain needs 12 to 15 months to yield a crop. Its bunch may weigh as much as 66 pounds. The false Horn plantain yields 3 to 6 hands with a small number of long, swollen fingers. A crop matures in 12 or fewer months. Its bunch may weigh as much as 33 pounds. The true Horn plantain usually yields 1 to 3 hands, though occasionally as many as 10 hands may be produced. This cultivar produces long, swollen fingers, usually fewer than 10.

A plantain should have five or six inches of rain per month with rainfall evenly distributed throughout the year. A plantain does not tolerate a dry season longer than three or four months. Plantain grows best at 82°F and poorly below 61°F and above 100°F. Because the roots tend to be shallow, wind may topple plants. Plantain prefers full sun and light, deep soil free from rocks. Sandy soil is ideal because it permits roots to expand. Plantain does not tolerate heavy soil with poor drainage. Too much water in the soil suffocates the roots. Plantain benefits from a soil rich in organic matter and a soil pH between 5 and 6.5.

As do all plants, plantain removes nutrients from the soil. In producing one-and-one-tenth tons of food, the cultivar French Sombre removes from the soil 13.9 pounds of nitrogen, 1.5 pounds of phosphorus, 75.2 pounds of potassium, 7.7 pounds of calcium, 2.6 pounds of magnesium, and 1.3 pounds of sulfur. The variety Njoch Kon takes from the soil 8.6 pounds of nitrogen, 0.9 pounds of phosphorus, 45.3 pounds of potassium, 4.4 pounds of calcium, 1.8 pounds of magnesium, and 0.7 pound of sulfur. The cultivar Popoula removes from the soil 18.5 pounds of nitrogen, 2.2 pounds of phosphorus, 101 pounds of potassium, 9 pounds of calcium, 3.5 pounds of magnesium, and 1.5 pounds of sulfur.

Because tropical soil often lacks organic matter, its addition may be more important than the use of fertilizer. Even with the use of fertilizer, the soil may become deficient in one or more elements. One scientist recommends that the grower add 32 tons of manure and 24 to 32 tons of compost per acre of plantain. Where the soil is too acidic, plantain benefits from the addition to the soil of 0.8 to 4 tons of dolomite per acre. Where nitrogen is in shortage, plantain benefits from the application to the soil of 66 to 264 pounds of nitrogen per acre. Ammonium sulfate and urea are good sources of nitrogen. Ammonium sulfate has the benefit of supplying plantain both nitrogen and sulfur, though urea is cheaper and does not acidify the soil. Plantain absorbs nitrogen best in four to six doses over the course of a year. The grower should not apply nitrogen during the dry season and at the peak of the rainy season. Where potassium is deficient, plantain benefits from the addition of 220 to 526 pounds of potassium per acre. Plantain increases its need for potassium when it flowers. The farmer should apply potassium two or three months before flowering. Where magnesium is in shortage, plantain benefits from the addition of 44 to 88 pounds of magnesium sulfate per acre. Where sulfur is deficient, plantain benefits from the addition of three-and-one-half ounces of ammonium sulfate per plant at the beginning of the growing season. Sulfur deficiency is common in lands where plantain is grown. Among trace elements, zinc, manganese, and boron are often deficient. In these cases, plantain benefits from the addition of seven-tenths of an ounce of borax and five-tenths to one ounce of zinc sulfate per plant and 35 pounds of manganese sulfate per acre.

Christopher Cumo

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Plum

A fruit tree grown in temperate locales, the plum is a member of the Rosaceae family and is related to the rose, apple, pear, apricot, and almond. A member of the genus *Prunus*, the plum contains more than 100 species, 30 of them native to North America. A plum is 86–88 percent water, 0.4–0.8 percent protein, 0.1 percent fat, 1.3–2.4 percent fiber, and 6.7–9.9 percent sugar, of which 1–4.2 percent is sucrose, 0.9–3.4 percent fructose, and 1.7–5.2 percent glucose. The content of sucrose, the sugar in sugarcane and sugar beet, increases as a plum ripens. One hundred grams of plum contain 120 to 190 milligrams of potassium, 0 to 3 milligrams of sodium, 6 to 8 milligrams of calcium, 4 to 7 milligrams of magnesium, 0.1 to 0.4 milligram of iron, 0.1 milligram of zinc, 4 to 11 milligrams of vitamin C, 0.02 to 0.05 milligram of thiamine, 0.04 to 0.05 milligram of riboflavin, and 0.2 to 0.9 milligram of niacin.

Origin, Production, Types, Categories, and Cultivars

Humans have cultivated the plum tree since prehistory. One authority believes that among fruit trees only the apple is a more ancient cultigen. Europeans have grown the plum tree since the time of Christ and perhaps earlier. In 2003, the world produced tens of millions of tons of plums. Producing a near majority of the world's crop that year, China harvested millions of tons of plums. Romania ranked second, the United States third, Serbia and Montenegro fourth, and Germany fifth. China totaled the majority of the world's plum acreage in 2003, but tallied a low yield, nearly a sixfold reduction compared to Chile's yield, the world's highest yield per acre.

Plums are of three types: European, Japanese, and American. Most European plums are in the species *Prunus domestica* and originated in Eastern Europe or western Asia. The majority of the world's cultivars are of this species. A hexaploid, the European plum arose from the hybridization of the diploid *Prunus arasifera* and the tetraploid *Prunus spinosa*. The progeny were a triploid, but the chromosomes doubled, apparently in a mutation, to produce a hexaploid. The skin of the European plum may be red, blue, or intermediate colors.

Scientists group the European plum into four categories: Prunes, Raine Claude, Yellow Egg, and Lombard. The category Prune may cause confusion because it applies not only to a class of plum but also to the dried fruit of any plum. Prunes are oval, firm, thick, and freestone. The skin may be blue or purple. With a high sugar content, prunes are usually dried, a circumstance that gives this category its name. Prune cultivars include Agen, also known as French. Other cultivars are Stanley, Sugar, Imperial Epineuse, Italian, German, Giant, and Tragedy. The category Raine Claude, also known as Green Gage, is round with green-yellow or red skin. Raine Claude boasts sweet, juicy flesh. Plums of this category supply the fresh market and are canned. Cultivars include Raine Claude, a confusing name that applies to both category and cultivar. Other varieties are Bavay, Jefferson, Washington, Imperial Gage, and Hand. Yellow Egg is canned. Fruit is large, long, and oval, with yellow skin and flesh. Varieties include the confusing appellation Yellow Egg, Red Magnum, Bonum, and Golden Drop. A large plum, Lombard is oval with red or pink skin. Cultivars include Lombard, Pond, and Bradshaw.

Another European plum, *Prunus insititia*, yields small fruit. *Prunus insititia* cultivars include Damson, Bullecea, and Mirabelles. Damson has purple skin whereas Mirabelles has yellow skin. Seldom eaten fresh, Damson is processed into preserves and jam.

The Japanese plum, *Prunus salicina*, may have arisen in China, from where it spread to Japan between 1600 and 1800 CE. The islands gave this species its name and the impetus to spread worldwide. The tree has rough bark, which distinguishes the Japanese plum from its European counterparts. Because the Japanese plum tree flowers, early in spring it is susceptible to late frost.

The American plum comprises several species. *Prunus americana* has yellow or orange flesh. Cultivars include Desota, Hawkeye, Wyant, Weaver, and Terry. Made into jam and marmalade, *Prunus hortulena* is resistant to brown rot. Cultivars include Wayland and Golden Beauty. Also resistant to brown rot, *Prunus munsoniana* tolerates frost. Farmers plant Wild Goose, the chief variety of this species, in the lower Mississippi River valley. *Prunus bessayi* is not cultivated for its fruit but as rootstock for other varieties. Native to northeastern California, *Prunus subordata* is made into preserves and jelly.

Attributes and Cultivation

When a plum tree is in bloom, it will not tolerate cold, wet soil, or wind. The Japanese plum needs less cold weather than the European plums to initiate dormancy in winter. One authority recommends an orientation toward the north, especially for the Japanese plum, to delay flowering in spring and thereby to reduce the risk of frost injury. Where possible the farmer should plant plum trees near large expanses of water to moderate the temperature. It is better to plant plum trees on a gentle slope rather than on flat land. The farmer should plant plum trees in spring to give them time to grow roots and branches before the onset of winter. Where winter is mild, the farmer may plant plum trees in autumn and winter. Dwarfs may be planted at a density of 320 to 480 trees per acre. Full-size trees are planted less densely. The farmers should choose a well-draining, deep loam, though European plums prefer clay and the Japanese plum does well in sand.

The farmer may graft a plum scion onto a plum, peach, Japanese apricot, or almond rootstock. In India, wild apricot is the rootstock of choice. During its first two years, a plum tree competes poorly against weeds. Irrigation should supplement rainfall. During its first year, a plum tree should be irrigated every two to three weeks. Because honeybees pollinate plum trees, the grower should rent beehives, placing them at a density of one hive per acre. When a plum tree is young, it needs little pruning. The European plum species remain attractive even when they are not pruned. By pruning, the farmer aims to let light penetrate the canopy. Where the climate is dry, a plum tree should be pruned heavily to encourage it to produce a small number of large fruit. Because the Japanese plum tree yields fruit more heavily than European plum trees, its limbs may break under the weight of its bounty. Accordingly, the farmer should prune the Japanese plum tree more heavily than European plum trees. In addition to pruning a tree, the farmer should thin fruit to encourage it to produce fewer but larger plums with uniform color. The farmer may thin by hand, machine, or chemicals. The third method is cheapest and yields the best fruit size and quality. The farmer should thin flowers when they are in full bloom and up to four weeks after the petals have fallen from them. A plum tree may be grown in sod because it competes against grass better than peach or cherry trees. The plum tree is sometimes intercropped with vegetables or other fruit. Where irrigation is unavailable, the farmer should not intercrop because the other plants compete against plum trees for water. Where irrigation is available, the farmer may interplant plum trees with rye grass, clover, peas, alfalfa, or other legumes. Soil near the tree may be cultivated to eliminate weeds, but one must be careful not to damage feeder roots near the surface. Since the 1950s, farmers have used herbicides to kill weeds. Effective are atrazine, simazine, diuron, oxyfluorfan, and glyphosate. A tree younger than one year should not be exposed to herbicides for fear of injuring it. One may eliminate weeds with a mulch of grass clippings, sawdust, pine needles, or black plastic. Mulch is desirable because it minimizes erosion and water runoff.

Soil Nutrients

In 1928 scientists, focusing on the importance of potassium in plum nutrition, first documented its deficiency in soil in which plum was grown. Research on other elements followed. The amount of a nutrient in plum leaves may indicate the adequacy or inadequacy of that nutrient in the soil. A plum leaf should have 2.3–2.5 percent nitrogen and 3.2–3.4 percent potassium. The coupling of these elements is important because applications of nitrogen and potassium to the soil are more effective than either alone. A plum leaf has the highest concentration of nitrogen and phosphorus early in the season. The concentration declines as the season wanes. A plum leaf should have 0.14–0.25 percent phosphorus, 1.5–3 percent calcium, 0.3–0.8 percent magnesium, 0.02 percent sodium, and 0.3 percent chlorine. A plum leaf should have 6 to 16 parts per million (ppm) of copper, 40 to 160 ppm of manganese, 100 to 250 ppm of iron, 20 to 50 ppm of zinc, and 25 to 60 ppm of boron.

A plum tree removes from the soil 21.6 to 55 pounds of nitrogen per acre, 4 to 11.5 pounds of phosphorus per acre, 20.5 to 54.4 pounds of potassium per acre, 3.4 to 10.2 pounds of calcium per acre, and 1.8 to 5.9 pounds of magnesium per acre. One recommendation calls for 0.2 pound of superphosphate and 0.1 pound of muriate of potash per plum tree multiplied by its age in years. Another recommendation calls for the application of 197 to 295 pounds of a fertilizer with nitrogen, phosphorus, and potassium per acre. Various recommendations set the ratio of nitrogen to phosphorus to potassium at 45:45:45, 120:60:60, 120:30:15, and 200:240:300. Alternatively, the farmer may apply 60 to 105 pounds of nitrogen, 70 to 105 pounds of phosphorus, and 140 to 190 pounds of potassium per acre. Another variant calls for the application of 130 pounds of manure, 1.1 pounds of nitrogen, 0.55 pound of phosphorus, and 1.3 pounds of potassium per tree. A large application of potassium is important for trees that bear fruit heavily. The farmer should apply all phosphorus, potassium, and manure in December and January. Half the nitrogen should be applied before a tree flowers and the other half after fruit set. The farmer who applies aqueous nitrogen by drip irrigation may halve the amount with no loss in yield. Drip irrigation is also an effective method of apply aqueous potassium, though a plum tree is less efficient than apple or citrus trees in absorbing aqueous fertilizers. Water is commonly applied by drip irrigation. A plum tree needs as many as 36 inches of water per year.

Harvest, Storage and Uses

A plum that will be shipped far should be picked when firm. The Santa Rosa variety should be picked about 94 days after flowering. In California, French needs 158 days after flowering to mature. Plums often ripen unevenly, requiring two or three pickings. Plums that will be canned may be harvested all at once. Most plums are picked by hand because machines damage them. Once harvested, a plum should not be exposed to sunlight. Machines are used, however, to harvest plums that will be dried.

Plums stored at 31°F or 32°F and 85–90 percent humidity may remain fresh 12 days. As a rule, plums cannot be stored longer than four weeks, though the plums of a few cultivars may be stored three months. Some plums deteriorate if kept too cold, in which case the temperature should be raised to 45°F after 7 to 10 days. Plums may shrivel during storage, losing 1.4–2.3 percent of their weight. Storage in an atmosphere of 1 percent oxygen and less than 0.2 percent carbon dioxide may increase the storage of a plum of the Victorian variety as much as four weeks. Santa Rosa and Sangold varieties may be stored two weeks at 33°F, 4 percent oxygen, and 5–7 percent carbon dioxide.

Late-ripening plums are made into jam because of their high sugar content and dry matter. Prune juice, a source of minerals and a laxative, is extracted from plums and is a popular breakfast beverage in the United States. Some prune juice is marketed as frozen concentrate. When the harvest is too large, the surplus goes to make prune juice. Plums are canned in several countries including the United Kingdom. Fewer plums are canned than peaches and pears. Italian plums are often canned. Plums that will be canned are picked before fully ripe. California and the Pacific Northwest produce 75 percent of the world's prunes. The French and Imperial varieties are the plums of choice for drying. Prunes were once sun dried, but now machines do the work. Prunes are dried to 4 percent moisture. Some prunes are pulverized into powder, which flavors wheat and rye bread. Plums may be made into wine. Plum wine is popular in Germany and the Pacific coast. The Santa Rosa variety yields the best wine. Plums may also be made into vermouth and brandy. Plum brandy is popular in Romania, Hungary, and the former Yugoslavia. The Alsace region of France produces plum brandy.

Christopher Cumo

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Poinsettia

In the family Euphoebiaceae, poinsettia, once considered a weed, is now a Christmas plant. The family has more than 8,000 species of herb, shrub, tree, perennial, annual, biennial, and succulent. Euphoebiaceae arose in East Africa 800 million years ago. In the 18th century, Swedish naturalist Carl Linnaeus named the genus *Euphorbia*, which originated in hot, dry South America 30 million years ago. In 1833, German botanist Karl Ludwig Wilenow named poinsettia *Euphorbia pulcherima*, meaning "very beautiful." All *Euphorbia* exude sap, perhaps as a source of liquid given the harsh conditions of South America. *Euphorbia* derives its name from Euphorbus, the first-century CE Greek physician to Numidian king Juba II, who used the sap as medicine. *Euphorbia* has 1,600 species. The Aztecs called poinsettia *euetaxochitle*. Euphoebiaceae and Euphorbia acquired the slang "spurge," a derivation of the word "expurgate," meaning to "purge". This name derives from the fact that the plants of this family and genus were powerful laxatives.

Legend

Poinsettias (iStockPhoto)

According to one account, magic transformed poinsettia from a green shrub into the red flower we known today. Another account holds that the poinsettia turned red, the color of love, because a woman, separated from her beloved on Christmas Eve, died of a broken heart. Yet another legend holds that when the Star of Bethlehem pierced the sky the night of Jesus's birth, it made poinsettia bracts the color of fire. According to another tale Pepita, a poor girl, cried in anguish. An angel, hearing her distress, appeared before the girl to inquire about her trouble. The girl replied that she was sad because she could not afford a gift for Jesus on Christmas morning. The angel instructed her to pick a weed along the road. When her tears fell on its the bracts turned red. Yet another tale has it that a boy, too poor to afford a gift for Jesus on Christmas, knelt before the altar of a church, praying for guidance. When he got up to leave a poinsettia germinated from the spot where he had knelt.

History

The Aztecs of Mexico may have been the first to cultivate poinsettia. The plant was at its peak between the 14th and 16th centuries. Aztec physicians used sap from poinsettia to treat fever. Aztec merchants dyed cotton with the bracts of poinsettia. Aztec priests used it in their rituals because the redness of the bracts symbolized purity. Because poinsettia did not grow well at the elevation of Tenochtitlan (what is today Mexico City), Aztec leaders Nexahuelaoyotl (1410–1472) and Montezuma (1480–1520) imported the plant. Every day some 50,000 people gathered to trade beans, corn, and poinsettias. In the 17th century, a Franciscan priest near Texco, Mexico, added a poinsettia to the nativity.

Poinsettias came to the attention of the United States when Joel Poinsett, the first U.S. ambassador to Mexico and an amateur botanist, came upon the flower in December 1828 while touring the countryside. Taken by its beauty, he shipped cutting to his greenhouse in South Carolina and to friends, among them botanist John Bartram in Philadelphia, Pennsylvania. The husband of Bartram's granddaughter, Colonel Carr, entered a poinsettia in the 1829 Exposition of the Pennsylvania Horticultural Society, where the public greeted it enthusiastically. Bartram sent a poinsettia to Philadelphia nurseryman Robert Buist, who sold the progeny in New York City and Philadelphia. Nurseries throughout the United States and Europe, especially in Scotland and England, eagerly bought the flower. By the late 1830s, poinsettia challenged holly and mistletoe as a Christmas plant. Because of Poinsett's role in bringing the poinsettia to prominence, historian William H. Prescott named the flower after him.

In the early 20th century, rumor circulated that poinsettia was poisonous. Mothers feared that their children might eat the plant out of curiosity and die. In 1919, a false report was issued that a boy in Hawaii died after eating a single bract. The belief that poinsettia is poisonous persists to the present even though the Ohio State University, at the request of the Society of American Florists, debunked it in the 1970s. The university concluded that a 50-pound boy could eat 500 poinsettia bracts and suffer only an upset stomach.

In 1902, German immigrant Albert Ecke established a nursery in Hollywood, California. In December 1906, his son Paul picked several poinsettias, which must have grown wild there. Albert increased them, offering the progeny for sale to people throughout Southern California. The Ecke family bred new cultivars, naming many of them after kin: Henrietta Ecke in 1927, Mrs. Paul Ecke in 1929, Ruth Ecke in 1931, Albert Ecke in 1938, Ecke White in 1945, Barbara Ecke Supreme in 1949, and Elizabeth Ecke in 1960. Today, the Eckes have 35 acres of greenhouses in the United States and Denmark. The family produces 90 percent of all poinsettias sold in the United States and Europe. Poinsettias are grown in all 50 states. In 1994, California was the leading producer with 7.8 million poinsettias, followed by Ohio with 4.2 million, North Carolina with 4.1 million, and Pennsylvania and Florida with 3.4 million each.

Attributes and Cultivation

Poinsettia does not tolerate temperatures below 50°F. The flower grows best between 60°F and 70°F and with 6 hours of sunlight per day. The plant must have 14 hours of darkness per day between late September and early October to flower. The gardener should apply a mist of water every other day and nitrogenous fertilizer every other week to her specimen. Poinsettia should receive little water when it loses its bracts. In winter, the gardener may place poinsettia near a shady window, watering it once per month. In late winter, the plant should be repotted in two parts loam, two parts sand, and one part peat and placed by a sunny window.

The gardener should water it frugally. After the last frost, the gardener may put the flower outdoors in full sun, bringing it indoors once more in September.

Christopher Cumo

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Pomegranate

The family Punicaceae has a single genus, *Punica*. The two species of *Punica* include *Punica granetum*, the pomegranate, a fruit tree. The other species is a small tree. A pomegranate tree may live more than 200 years, though fruit production diminishes after 15 years. A tree may reach a height of 30 feet, though between 12 and 16 feet is the norm. Some farmers plant dwarfs. A tree may yield fruit within a few months of planting. Others may not bear fruit until age three. A hot climate yields the sweetest fruit. The pomegranate does well in a semiarid climate. The climate may be mild or subtropical. Humidity should be low and summer hot. Winter should be no colder than 12°F. Pomegranate flowers are chiefly orange, though they may also be red, pink, or white. Flowers may self-pollinate. Alternatively, insects may pollinate them. The fruit is two-and-a-half to five inches in diameter. It may be the size of a large apple at roughly 7 ounces or a small rugby ball at 25 to 32 ounces. Northern Israel grows the largest pomegranates. The rind of a pomegranate may be yellow, pink, or red. An average fruit may have between 200 and 800 seeds. About 18 percent of a seed is oil. Pomegranate juice has all the essential amino acids in small amounts. The juice has fructose, glucose, and sucrose, the sugar in sugarcane and sugar beet. Seven ounces of pomegranate have 105 calories, 1.5 grams of protein, 26.4 grams of carbohydrates, 0.5 gram of fat, 5 grams of fiber if the seeds are eaten and less than 1 gram if one does not eat the seeds, and nine-and-four-tenths milligrams of vitamin C—15 percent of the recommended daily allowance.

Mythology, Religion, and Medicine

The Greek goddess Persephone divided her time between the surface of the Earth and the underworld, bringing spring and summer when she visited Earth and autumn and winter when she departed. The god of the underworld, Hades, knew that Persephone, despite her longing for Earth, would remain faithful to him because she had eaten pomegranate seeds as a pledge of fidelity. The ancients likened pomegranate juice to blood and thereby to the life force. It is not surprising that the pomegranate was thought to have medicinal properties in this context. Throughout history, medical associations in Europe have featured the image of a pomegranate on their coats of arms. The simplistic doctrine of signatures, which maintained that a plant that resembles a part of the body may be used to treat diseases of that part, comparing the pomegranate's color, shape and size to the heart, held that the fruit benefited it. Although the research on pomegranate is controversial, two ounces of pomegranate juice per day may benefit the cardiovascular system. Pomegranate stimulates the body to produce nitric acid, which keeps the arteries open. Pomegranate juice may prevent the buildup of plaque in the arteries. Pomegranate juice may reduce blood pressure. Pomegranate seed oil may lower cholesterol.

Several religions regarded the pomegranate as sacred. The Chinese believed that pomegranate juice symbolized immortality. Muslims know pomegranate as the Paradise Fruit. The Koran thrice mentioned it. The Hebrews esteemed pomegranate as the fruit of "sanctity, fertility, and abundance." According to tradition a pomegranate had 613 seeds that corresponded to the Old Testament's 613 commandments. King Solomon decorated the pillars of his temple with bas-reliefs of pomegranates. The Song of Solomon likened a bride's cheeks to the two halves of a pomegranate. Jewish priests wore robes decorated with pomegranate motifs. Christians believed that the pomegranate symbolized the resurrection and eternal life. A pomegranate symbolized the incarnation of Jesus. Several paintings of Mary and the infant Jesus include pomegranate trees. The Buddhists regarded pomegranate as one of three blessed fruits, the others being citrus and peach. According to legend, Buddha cured a goddess from eating children by giving her a pomegranate. Like the fruit, she became a symbol of fertility. Japanese Buddhist women pray to this goddess of pomegranate to conceive a child. In the Middle Ages, pagan tradition associated the pomegranate tree with fertility and the hunt for a unicorn. Once tamed, a unicorn was to be chained to a pomegranate tree.

Origin and History

According to one hypothesis, the pomegranate originated in the Middle East. Others favor an origin in Iran or Turkey. In antiquity, the pomegranate was a fruit of the Mediterranean Basin. The people of western Asia esteemed the pomegranate with the grape and fig. The Babylonians believed that a warrior who ate pomegranate seeds became invincible. The Egyptians buried pomegranates with the pharaohs. Holy Roman Emperor Maximilian I (1459–1519) declared pomegranate a royal fruit. The city of Granada, Spain, and the island of Grenada in the Caribbean derive their names from the Spanish and French words for pomegranate. A picture of a pomegranate is a popular wedding gift in China. In a Middle Eastern wedding among Bedouins, the groom splits a pomegranate as he and his wife enter their home. If the fruit has many seeds and the bride and groom eat them, then they will have many children. In parts of the world, visitors give a new home owner a pomegranate to guarantee his abundance, fertility, and luck.

The Pomegranate in the Contemporary World

The pomegranate is widely cultivated in Iran, India, Afghanistan, Israel, Spain, Morocco, Egypt, and Turkey and on lesser scale in Tajikistan, Pakistan, the United States, China, Georgia, Greece, Cyprus, France, Japan, Lebanon, Armenia, and Bangladesh. In addition to these regions, the pomegranate may be found in the Himalayas.

So numerous are pomegranate trees that they grow wild in Israel. In 2002, the Gene Bank for Agricultural Crops in the Agricultural Research Organization in Israel amassed a collection of pomegranate trees in an effort to derive new varieties. Scientists compared the established cultivars Wonderful and Moller de Elcha with the new accessions. Among the new cultivars derived from this work, Shani-Yanai and PG 128-29 ripen at the end of August. They are notable for the sweetness of their fruit. Of some 600 seedlings, scientists identified 30 promising selections.

Worldwide, Iran ranks first in area, production, and export. Iran exports pomegranates to nearly 50 nations, including Afghanistan, Armenia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Bosnia and Herzegovina, Bulgaria, Canada, China, Denmark, Britain, France, Georgia, Germany, Greece, Hungary, Iraq, Italy, Japan, Kazakhstan, Kuwait, Malaysia, Moldova, the Netherlands, New Zealand, North Korea, Oman, Pakistan, Poland, Qatar, Romania, Russia, Saudi Arabia, Singapore, South Korea, Sri Lanka, Sweden, Switzerland, Thailand, Turkey, Turkmenistan, Ukraine, the United Arab Emirates, and Uzbekistan. Pomegranate is grown throughout Iran except in Hamedan Province. Iranians eat pomegranate fresh as well as consume juice, sauce made from pomegranate, and dried seeds. Among the varieties that Iranians cultivate are Malas, which appears to be the most widely cultivated variety, Naderi, Ravandi, Shahvar, Zagh, Shirin, Galou Barik, Ghojagh, Arousak, Shisheh-cap, Bajestani, Khazar, Ardestani, Ghand, Leili, Dousti, Meykhash, Syah, Sorkhak, Sangani, Rabab, Bereit, Farough, Kadrou, Ahr, Shahpasand, Keyvani, Kolbad, Shekar, Lamsari, Agha Mohammad Ali, Alak, Gel, Togh, Garden, and Souski.

The Turks eat pomegranate fresh. The fruit is also used for juice, citric acid, and livestock feed. The hot, dry summers of Mediterranean Turkey are suitable for pomegranate. Most of the harvest is consumed locally, though in 2005 Turkey exported a few thousand tons of pomegranates, with Russia, Germany, Ukraine, the Netherlands, Moldova, and Latvia being the principal buyers. Other importers of Turkey's pomegranates are Greece, Romania, Britain, Belarus, and Bosnia and Herzegovina. Hicaznar is the chief cultivar for domestic consumption and export. Hicaznar is known as "the Turkish pomegranate." Turkey grows 43 varieties. In 2005, Turkey processed tens of thousands of pounds of pomegranates into juice. The harvest spans August to November.

In India, farmers cultivate pomegranate in dry lands, including Karnataka State. The principal cultivars are Genesh, Mridula, Ruby, and Bhagwa. India devotes hundreds of thousands of acres to pomegranate. Most pomegranates are consumed locally with only a small amount of the harvest exported. Europe buys Indian pomegranates out of season. Himachal Pradesh, India, grows pomegranate because the tree is hardy, yields are high, and fruit stores well. In the Kullu Valley, pomegranate trees are irrigated.

Christopher Cumo

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Poppy

In the Papaveraceae family, poppy, known as opium poppy and drowsy poppy, is an annual flowering plant. Its scientific name, *Papaver somniferum*, means "the poppy that brings sleep" (Hodgson 1999, 11). The genus *Papaver* has about 110 species, but only *Papaver somniferum* yields appreciable quantities of opium. For much of its history, poppy has been best known as a source of opium, but this is not its only product. Morphine may be derived from poppy. In 1817, French chemist Pierre Jean Robiquet isolated codeine from poppy sap. In the late 19th century several scientists, including those at Bayer, used morphine to synthesis heroin. Although poppy seeds may be eaten as a source of protein, poppy is seldom grown today as a food crop. Its uses are medicinal, recreational, and occasionally ornamental.

Attributes and Cultivation

The stem of a poppy plant is cylindrical and stout, and the roots are thick. A poppy plant, growing three or four feet tall, yields a single flower. A flower bears four white or purple petals and yields a large quantity of yellow seeds. By 18th-century Swedish naturalist Carl Linnaeus's count, a single seed pod contained 32,000 seeds. One flower yields three to five seed pods. In India, where cultivation was once intensive, farmers planted poppy seeds in November, irrigating the plants during the three-month growing season. When petals fell from a flower, it was ready to harvest. Workers slit open a seed pod, which exuded sap. The sap may be more than 10 percent morphine. A single pod may yield 20 to 100 milligrams of opium. In the first century BCE, Roman poet Virgil warned that poppy exhausted the soil. He recommended its planting after the autumn equinox. Perhaps because of its effect on the soil, the Romans appear to have grown little poppy, preferring to import opium from Greece and Egypt.

Origin and History

Indians seek the origin of poppy in myth. A holy man shared a hut with a mouse. The mouse wished to be transformed into a variety of creatures. The man granted each request, turning the mouse into a cat, a dog, a monkey, an elephant, and a beautiful woman. In this last incarnation, the mouse married a prince in a nearby kingdom, but she fell to her death in a well. The distraught prince sought the holy man's guidance. He advised the prince to let the body remain undisturbed in the well. From the body germinated the first poppy plant. Its seeds populated all India.

One thesis holds that poppy originated in the Mediterranean Basin. A second focuses on the western Mediterranean, citing an origin in Italy, North Africa, Spain, Mediterranean France, and the Canary Islands. A third concentrates on the eastern Mediterranean, preferring an origin in Turkey. As early as 5500 BCE, the inhabitants of Belgium, France, Central Europe, and Ukraine began growing poppy with wheat, flax, lentils, and peas. At the dawn of poppy culture, humans may have grown the plant for food, fodder, and oil. Its use as food and fodder seems puzzling given that an overdose of poppy is lethal to humans and livestock. Poppy must have been the fodder of last resort because livestock dislike its bitterness. People may have used poppy in their fertility cults given its fecundity. Its use as a drug may have come later. A competing hypothesis holds that poppy sap was used as a drug from the earliest days of cultivation and that poppy may be the world's oldest medicinal plant. The presence of large seeds in Switzerland, dating before 4000 BCE, implies cultivation. The Swiss may have used poppy as fodder. The inhabitants of Britain began cultivating poppy about 3700 BCE. Prehistoric Italians may have grown poppy for food, oil, medicine, and religious purposes.

In western Asia the Sumerians of Iraq, cultivating poppy around 3000 BCE, wrote the first account of it. Aware of its powers, they called poppy *gil hul*, meaning "the joy plant" (Kapoor 1995, 2). The Assyrians, Iranians, and Arabs took up the cultivation of poppy in turn. In Africa, the Egyptians cultivated poppy before the mid-second millennium BCE. The Ebers Papyrus of 1552 BCE listed poppy as a medicinal plant. According to their mythology, the god Thoth taught the Egyptians to grow poppy. As early as 1400 BCE, the Hittites began cultivating


Poppy flowers (Swetlana Wall/Dreamstime.com)

poppy. The Greeks probably imported poppy from Turkey. In the eighth century BCE, Greek poet Hesoid named a Greek city Poppy town because of its cultivation of the plant. In the fourth century BCE, Greek philosopher Aristotle was familiar with poppy. His pupil, Greek botanist Theophrastus, described its cultivation.

One account holds that Greek conqueror Alexander the Great introduced poppy into India in the fourth century BCE. Another account maintains that only in the seventh century CE did the Arabs introduce poppy into India. European traveler Duarte Barbosa witnessed the cultivation of poppy in India in 1511. Cultivation was then more intensive along the coasts than in the interior. The Moghuls cultivated poppy on a large scale in India and sold opium to China. Moghul ruler Akbar (1542–1605) declared poppy culture a government monopoly. In 1757, Great Britain's East India Company took charge of the cultivation of poppy. By the late 20th century, poppy was grown in India, China, Egypt, France, the Netherlands, Hungary, Greece, Spain, Portugal, Italy, Turkey, Australia, Russia, the former Yugoslavia, Japan, Bulgaria, Thailand, Myanmar, Laos, Afghanistan, Pakistan, Iran, Austria, the Czech Republic, Germany, Poland, and Romania.

Uses

The uses of poppy are the source of myth. According to one account, God gave Adam opium to induce sleep so that he could extract one of Adam's ribs, from which he made Eve. Another account holds that the Romans gave Jesus a liquid with opium to ease his suffering on the cross.

Aside from this lore, the medicinal properties of poppy attracted the attention of many commentators. As do physicians today, Greek physician Hippocrates (460–370 BCE) classified opium a narcotic. Roman poet Ovid (43–17 BCE) knew of opium's power to induce sleep. Although he recommended opium to treat headache, arthritis, and wounds, first-century CE Roman encyclopedist Pliny the Elder was not pollyannaish about the drug. He noted that suicides used opium to end their lives. Galen, physician to second-century Roman emperor Marcus Aurelius, prescribed opium to treat poisoning, snakebite, headache, vertigo, deafness, epilepsy, apoplexy, poor eyesight, laryngitis, asthma, cough, spitting blood, colic, fever, dropsy, leprosy, and depression. Galen prescribed opium to Marcus Aurelius, perhaps because of his gloomy disposition. The emperor became so dependent on opium that he could not sleep without it. Kurdish hermeticist Thabit ibn Quarra advised the sick to consume opium to treat the common cold. Islamic physician Abn Bakr al-Raza (865–930) advocated opium's use as a sedative and an anesthetic to be taken before surgery. Islamic physician and philosopher Avicenna (980–1037) wrote a treatise on opium. He used it as a recreational drug and may have died from an overdose. In ayurvedic medicine, Indians used opium to treat diarrhea and insomnia. In the 19th century, opium was added to medicines, even those given to babies. In the 1850s, Chinese immigrants brought the habit of smoking opium to Europe and the United States, where it attracted writers, artists, the elite, sailors, and prostitutes.

Poppy has sustained writers. British poet Samuel Taylor Coleridge (1772–1834) began using opium at Cambridge University, apparently to treat neuralgia and toothache. This usage grew into an addiction. Coleridge apparently needed the drug to stimulate his imagination. He remarked that an opium-induced dream allowed him to compose the poem "Kubla Khan." As American author Edgar Allan Poe would in the 19th century, Coleridge took opium in the form of laudanum, a mixture of alcohol and opium. At age 15, 19th-century British poet Elizabeth Barrett Browning, suffering from fatigue, consulted a physician who prescribed laudanum and morphine. As had befallen Coleridge, Browning became an addict, though she denied any attachment. Nevertheless, she became so dependent on laudanum that she could not sleep without it. Perhaps betraying her dependency, Browning called morphine "my elixir" (Filan 2011, 148). Her attachment to morphine grew after her third miscarriage. In 1857, she took laudanum, perhaps in a renewal of an earlier habit, to lessen the grief of her father's death. In American dramatist Eugene O'Neill's *Long Day's Journey into Night*, the female character Mary Tyrone is addicted to morphine as was O'Neill's mother. Mary Tyrone's husband and sons alternate between hope of recovery and fear of relapse.

Christopher Cumo

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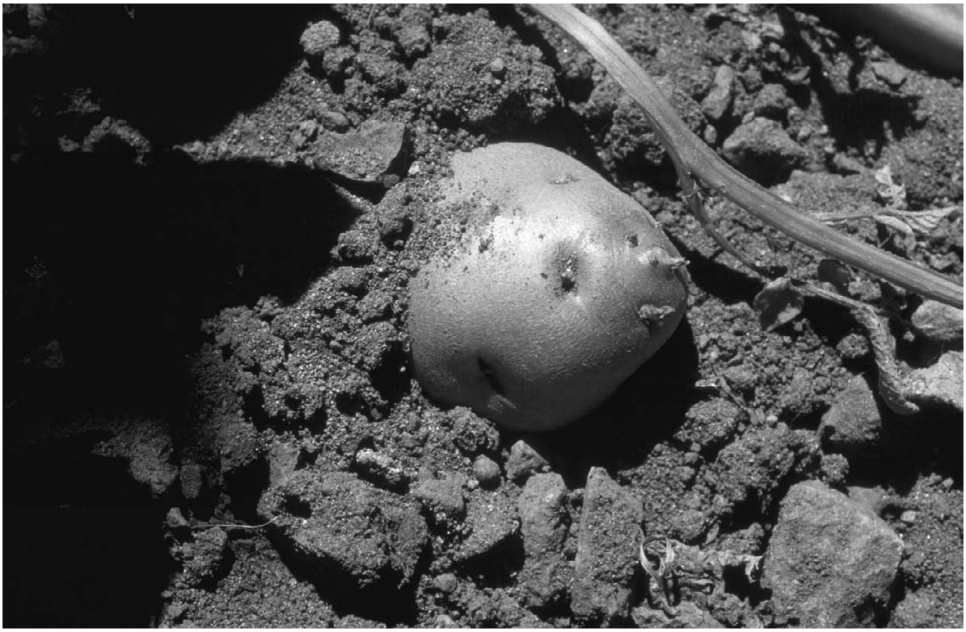
Potato

People in the English-speaking world call the potato, a perennial grown as an annual, the white potato or Irish potato to distinguish it from the sweet potato. Although superficially similar, the two are only distantly related. The Peruvians called the potato *papa* or *papus*, meaning "root," in the mistaken belief that the tuber is a swollen root. In fact, the potato is an enlarged stem. The Spanish confused the term *papa* with the word *batata*, meaning "sweet potato," yielding the word *patata* or "potato" in English. The term "potato" refers to both plant and tuber. The potato excited the curiosity of Europeans because, unlike grain, it produced its edible parts underground, similar to the production of turnips and carrots. Europeans were right to focus on the production of tubers because the potato is an efficient converter of sunlight into biomass, yielding more than three-quarters of its biomass in tubers. By contrast, grain yields only about one-third of their biomass in edible seeds.

A member of the Nightshade family, the potato plant produces toxic foliage. For this reason, its vegetation cannot be fed to humans or livestock. Some wild potato plants produce poisonous tubers, an evolutionary adaptation that deters predators. Tubers exposed to sunlight turn green, producing the toxin solanine. A cook must peel away the green flesh if people are to eat sun-exposed potatoes. As a member of the Nightshade family, the potato is related to the tomato, peppers, tobacco, petunia, and the poisonous belladonna.

Most farmers propagate potatoes by planting sections of potatoes, known as seed potatoes. The eyes in each section germinate to form a new plant. A section of potato is a clone of the parent plant, and so propagated in this way the potato is genetically uniform. Potatoes may also be propagated by seed. The potato flower, esteemed for its beauty, is white, pink, red, blue, or purple. The flower attracts insects, especially bumblebees, which cross-pollinate it with other flowers. Because anther and stigma are close together in each flower, the potato is also a self-pollinator.

Some people believe that the potato is fattening. The french fry and potato chip, prepared in oil, are high in fat, but the unadulterated potato contains little fat. Moreover, it is rich in nutrients. Seventy-nine percent water, the potato has carbohydrates, mostly in the form of starch. Although some nutritionists denigrate starch, the body converts it into energy at a gradual rate, providing hours of energy. Starch may be a better source of calories than sugar and fat. The potato also contains protein. Although it has less protein than grains, the potato yields



Potato (Corel)

high-quality protein with all the essential amino acids. The quality of potato protein ranks second only to the protein in egg whites. Potato protein is even superior to soy protein and much better than the protein in corn and wheat. One medium potato has nearly half the recommended daily allowance of vitamin C, 18 percent of potassium, 10 percent of vitamin B6, and thiamine, riboflavin, folic acid, niacin, magnesium, phosphorus, iron, zinc, and fiber. Potato fiber may reduce the risk of colon cancer and diabetes and does lower cholesterol and triglycerides.

Origin and Diffusion

Unknown in the Old World, the potato is native to the Americas. The ancestor of the potato lived 40 million years ago in the American Southwest, Mexico, and Guatemala. Predating humans by millions of years, this proto-potato migrated to South America roughly 3.5 million years ago. Evolving into more than 5,000 varieties, wild potatoes grow today in the southwestern United States, Mexico, Guatemala, Honduras, Costa Rica, Panama, Venezuela, Colombia, Ecuador, Peru, Bolivia, Argentina, Chile, Paraguay, Uruguay, and Brazil. About 12,500 years ago, the people of Monte Verde, Costa Rica, ate potatoes though they did not cultivate them. One authority believes that the ancient Peruvians domesticated the potato as early as 10,000 years ago. These early potatoes crossed with a wild potato yielding the modern species *Solanum tuberonum*. Others favor a later date. Around 8,000 years ago, they assert, the Amerindians who lived near Titicaca on the border of Peru and Bolivia began to select potatoes for size and flavor. The Tiwanaku of Bolivia grew potatoes in raised fields that trapped heat, creating an ideal environment for the culture of potatoes. With a population of 100,000 the Tiwanaku, by one estimate, grew enough potatoes to fed more than 500,000 people, trading the surplus as far away as Mocha, Ecuador. Amassing a large empire, the Inca grew potatoes in rotation with quinoa and kanihua. They fertilized potato fields with dung from llama and alpaca. At low altitudes, they grew both potatoes and corn, though because corn will not grow above 2,500 meters the Inca raised only potatoes at high altitude. Adding potatoes to soup and stew, the Inca ate them with corn, beans, and peppers. Before the Spanish conquest, the potato had not migrated far from the Andes. The Maya and Aztecs did not know the potato, and the people of North America and the Caribbean did not grow the tuber.

Spanish conquistador Francisco Pizarro's invasion of South America in 1532 marked the beginning of Europe's relationship with the potato. In 1537, the Spanish came across Amerindians growing potatoes. The Spanish liked their flavor, though they were determined to find gold rather than tubers and so neglected the potato. Even when the Spanish turned to agriculture, they focused their efforts on transplanting European crops in the Americas rather than on developing the potential of indigenous crops. One Spaniard who took an interest in the potato, Pedro Ciaze de León, described it as an "earth nut."

How and when the potato reached Europe is unclear. One account holds that English adventurer Francis Drake encountered the potato on an island off the coast of Chile in 1578, but he may not have taken it back to England. Botanist Carolus Clusius visited Drake in England, though Clusius did not mention that Drake had found the potato. Another account holds that Drake gave the potato to a friend, presumably in England, in 1580. The man grew it in his garden, but, treating it like a grain, he ate the seeds rather than the tuber. Finding them unpalatable, he had his gardener destroy the plants. The gardener fed the plants into a fire, but by chance a potato emerged baked but unscathed. The gardener ate it and, finding it agreeable, saved the rest of the potatoes from destruction.

A more prosaic account holds that the Spanish provisioned their ships with potatoes to feed the crew on their transatlantic crossings. Leftover potatoes from these voyages might have been planted in 16th-century Spain. Once established in Spain, the potato spread to other parts of Europe in the following centuries. Yet another tradition holds that the Spanish brought the potato to the Canary Islands in 1567 and only later transplanted it to Spain. Another account credits Sir Walter Raleigh with introducing the potato to Europe. Tradition holds that Raleigh served a plate of boiled potatoes to Queen Elizabeth I, but scholars, pointing out that he never went to the region of the Americas where he was to have gotten the potato, have discredited this legend. Economist Earl Hamilton, combing through archival documents, discovered that a hospital in Seville, Spain, first bought potatoes for its patients in 1573, establishing this date as the latest when the potato could have been cultivated in Spain. Geneticist Redcliffe Salaman believed that Spain grew the potato as early as 1570, establishing this date as the year of transfer of the potato to the Old World.

Botanists took an interest in the potato from an early date. In 1596, botanist Gaspard Bauhin named the potato *Solanum tuberonum*, an appellation that Swedish naturalist Carl Linnaeus retained in his taxonomy in the 18th century. In 1597, botanist John Gerard published a botany text in which he described and illustrated the potato. Gerard may have grown the potato in his garden and so had firsthand knowledge of it. His geography, however, was fuzzy. He claimed to have derived his potatoes from Virginia, but they were then unknown in the colony. In 1601, Carolus Clusius cleared up the confusion, identifying the potato as an indigene of the Andes Mountains. As early as 1588, he had obtained potatoes from Belgium, though how they came to be grown in Belgium is unclear. Like Gerard, Clusius grew potatoes in his garden. Clusius wrote that the potato was common in Germany and Italy and that Italian stockmen fed it to pigs.

In the 17th century, many people believed that the potato was an aphrodisiac. Demographers understood that wherever people raised the potato population increased. Some took this circumstance as evidence that the potato made people eager for sex. In the 18th century, herbalist William Salman pursued this line of thought, asserting that the potato increased sperm production in men who ate it. As early as 1622, physician Tobias Venner, going beyond the claim that potatoes were an aphrodisiac, intimated its nutritional value, writing that they "nourish and strengthen the bodie."

Not everyone was enthusiastic about the potato. In the early 18th century, clergymen warned against it, reasoning that if the potato had value the Bible would have mentioned it. Of course the writers of the Bible could not have known about the potato because they did not know about the existence of the Americas. Into the 19th century, the potato was not widely consumed in some areas of Europe. Because the potato came in strange shapes, some people feared that it might cause leprosy, arguably the most frightening disease in the early modern era. In the early 17th century Burgundy, a region of France, outlawed the consumption of the potato because its leaders feared the spread of leprosy.

Yet the potato transcended these fears. As early as 1640 farmers in Belgium, recognizing its value, grew the potato for their own use. Farmers quickly appreciated that the potato yielded four times more food per unit of land than grains. Its abundance made the potato "dangerously cheap" in the words of one physician. The poor, hard-pressed to afford bread, subsisted on the potato, and virtually everywhere in Northern Europe it became the staple of the masses. Moreover, the potato saved farmers from the depredations of war. In the early modern era, armies did not worry about maintaining supply lines. They lived off the land, carrying off the year's grain harvest. Before the arrival of the potato, luckless farmers starved when soldiers stole their crops. Yet armies seldom made the effort to dig up potato fields, so farmers who lost their grain still had potatoes to keep them from starvation.

Attending to military matters, King Frederick the Great understood that the potato could cheaply feed his army. This realization led him to appreciate the potato's role in preserving Prussia's security. In 1744, he distributed free seed potatoes to farmers throughout Prussia, ordering them to grow the tuber. Austria, Russia, and France, witnessing Prussia's success, likewise encouraged farmers to grow potatoes. In 1765, Russian Empress Catherine the Great followed Frederick's example, urging farmers to cultivate the tuber. By the 1770s, farmers grew potatoes in Germany and Central Europe. By 1800, the potato was grown from the Alps to Russia. Instrumental in the success of the potato was French soldier and druggist Antoine-Augustin Parmantier. Captured by the Prussians during the Seven Years' War, Parmantier spent three years in jail. His captors fed him potatoes, and Parmantier, at last free, credited his survival to the potato. Returning to France, he popularized the potato's nutritional value and encouraged farmers to grow it. He took his crusade to Versailles, presenting King Louis XVI and Queen Marie Antoinette with a bouquet of potato flowers. Taken by their beauty, Marie wore them in her hair and the king pinned a flower to his lapel. The nobility had images of potato flowers painted on china. Suddenly the potato was a fashionable food. Thomas Jefferson may have attended a dinner party hosted by Parmantier. From his stay in France, Jefferson acquired a liking for french fries. Congratulating Parmantier, Louis declared, "France will thank you some day for having found bread for the poor." A convert to the cause of potato culture, the kind required all priests to sermonize on the potato's merits in an effort to convince farmers to grow it.

The Potato Famine

No sermons were necessary in Ireland. The cool climate was ideal for the potato. Equally important was the economic and social system. The English perceived the Irish as an inferior grade of human and exploited them without scruples. The Irish had no title to the land. Instead, English gentry claimed the land as their own. Like the sugar planters in the Caribbean, English landlords lived in style in England, taking no interest in the lives of the Irish. Charged high rent, the Irish tenant could hope to pay his obligations only by planting most of the land to grain or converting it to pasture. The tenant could afford to set aside only two or three acres for his own needs and on this land he planted potatoes. The poorest Irish could afford to rent only a few acres and on these they likewise planted potatoes. The potato was thus the only food that stood between the masses and starvation.

Dysfunctional though it was, the system worked initially. Two or three acres were enough to feed even a large family with potatoes left over to feed a pig.

By one account, the potato enabled the Irish peasant to eat better than his counterpart on the continent who subsisted on bread. One historian estimated that the average adult Irishman ate 10 pounds of potatoes per day. Supplementing this monotonous fare with cabbage, turnips, and milk, he consumed some 4,000 calories per day, a high figure by contemporary standards. Nourished on potatoes, Ireland's population rose swiftly. In 1600, Ireland had at most 1.5 million people. In 1700, the population reached 2 million, in 1800 5 million, and in 1845 8.5 million.

The first evidence that the system could not be sustained came in 1740 and 1741 when a long frigid winter killed the potato crop. By one estimate, hundreds of thousands of people starved, and only the apparent willingness of British landlords to let the peasants keep some of the grains, notably oats, prevented the famine from killing more. From this disaster and others like it, British clergyman Thomas Malthus concluded that population tends to outrun its food supply. He understood that the potato had allowed the population to increase in Ireland and throughout Northern Europe. Ireland and other countries did not have jobs for all these extra people, so wages decreased. Many people had no alternative to an existence as landless laborers. The potato had not improved living standards. It had only allowed more people to live in a state of misery. Between 1800 and 1845, 114 commissions reported that Ireland's poor were on the verge of starvation, yet the United Kingdom did nothing to ameliorate conditions. The final precondition to disaster came in the early 19th century when scientists derived a new potato variety, the Lumper. It had little to recommend it beyond high yield. It was insipid, less nourishing than the old varieties, and vulnerable to disease. Because the Irish planted the Lumper to the exclusion of other varieties, they had a genetically uniform crop. A disease that killed one plant would likely kill many more.

Warning came in 1843 when a fungus struck potato plants near Philadelphia, Pennsylvania. In 1844, the fungus spread to lands near Lakes Erie and Ontario. In 1845, it reached the Mississippi River. By that year it had spread in Europe to Belgium, Denmark, England, Wales, France, northern Italy, Spain, Norway, and Sweden. The fungus and the damage it caused were not therefore a local event. The fungus was an epidemic that attacked a vulnerable crop.

In Ireland, the year 1845 seemed promising at the outset. The Irish planted a few million acres to potatoes, a 6 percent increase over the previous year, and expected a harvest of tens of millions of tons. Summer bathed the potato plants in sun, but in September the rains and overcast skies brought a fungus to Ireland. As one might have expected of a genetically uniform crop, the fungus swept through the potato fields, killing the entire crop in only weeks. The fungus turned a potato plant black and withered it. When an anxious farmer dug up the tubers, he found them rotten. In cases where a farmer had an intact potato, he celebrated his luck but it too rotted. The entire crop was lost. In 1846 the fungus returned, repeating the tragedy. Bereft of their potatoes, the poor had nothing to eat. Some were reduced to eating acorns and tree bark in an attempt to satiate hunger.

The masses might have eaten some of the grain that they had grown but the British landlords took it all as rent. Acting selfishly, they worsened the crisis. Great Britain's Parliament was slow to act. Its members did nothing to help the Irish in 1845. Reformers, roused at last, targeted the Corn Laws as part of the problem. The laws placed a duty on grain imported to the British Isles, raising its price. Because imported grain was costly, domestic growers could keep prices above market value, ensuring that the poor could not afford bread. Repealing the Corn Laws in 1846, Parliament made possible the importation of cheaper grain to Ireland. Parliament even sent a shipment of corn from the United States to Ireland to feed the poor, but these measures were not enough. Between 1845 and 1849, 1 million died and 1.5 million left Ireland for the United States and Canada.

Scientists could not initially agree on the cause of this catastrophe. In 1845, Belgian clergyman and amateur scientist Edouard van dan Hecke made a promising start, using a microscope to identify a fungus on the leaves of diseased plants. Botanist Rene van Oye, using Hecke's discovery, asserted that the fungus had killed the potato plants. British surgeon Alfred Smee disagreed, countering that the fungus had arisen from putrefying plants. The fungus was therefore a result not a cause of the malady. Others thought that excess water in the soil rather than a fungus had rotted the potatoes. These attacks did not put the supporters of the fungal hypothesis off the track. In 1846, clergyman and amateur scientist Miles Joseph Berkeley published a detailed study of the fungus, once more fingering it as the culprit. Finally, in 1861 German botanist Anton de Bary took the decisive step, putting the fungus on healthy plants. They all succumbed, proving the fungal hypothesis. De Bary named the fungus *Phytophthora infestans*, a moniker it retains today. De Bary's work marked the foundation of the new science of plant pathology. Through the perverse agents of disease and death, the potato had advanced science.

New and Old Varieties

As with other crops, scientists, most of them amateurs, labored to breed new varieties of potato. In 1853, New York clergyman and amateur scientist Chauncey Goodrich derived the variety Garnet Chile, a potato, one might suppose, that traced its lineage to Chile. From Garnet Chile, others derived the variety Early Rose. Early Rose was peculiar in producing no flowers, so scientists thought. In 1872, however, American plant breeder Luther Burbank found one Early Rose plant with flowers. Seizing this discovery, he crossed this plant with another variety, creating the Russet-Burbank potato, now known as the Idaho potato, arguably the world's most famous plant variety. The long smooth flesh was ideal for making fries and chips and so feed the growth of this industry.

Some breeders were unscrupulous. Merchant Archibald Findlay passed other people's varieties off as his own in hopes of getting rich. In 1891, he established a reputation as a capable breeder with the variety Up to Date. Its popularity led Findlay to brag of having derived an even better variety, Northern Star. About 1900, he sold 12 pounds of Northern Star seed potatoes for 6 pounds sterling to a customer who reported a profit from growing the variety. The claim that anyone who grew Northern Star would profit from its sale allowed Findlay to charge as much as 1,000 pounds sterling per ton. Findlay claimed to have developed yet a third variety, Eldorado, which he also sold at inflated prices. Inspection revealed, however, that Eldorado was not very productive. In fact, it was not even a new variety. Findlay had recycled an old, poor variety, Evergood.

In the United Kingdom, one scientist dubbed a variety Victoria, in honor of Queen Victoria. One account holds that the queen served this variety for dinner. Other varieties claimed a royal connection. The Prince Albert, British Queen, Irish Queen, Prince of Wales, King Edward VII, Majestic, Red King, and Purple Eyed King Edward all displayed the predilection of their creators to link the ordinary spud to royalty.

A Worldwide Crop

In the 18th century, Buddhist monks grew potatoes in Bhutan and Nepal, and in the 1770s people first raised potatoes in South Africa. In 1772, the French planted the potato in New Zealand, though the native Maori credited Captain James Cook with introducing the potato in 1773. By another tradition, the crew of a U.S. whaling vessel gave the Maori potatoes. The indigenes regarded the potato as a gift from the ancestors. A family retained the cultivation of a single variety for generations, preserving a link to the ancestors. Today, the potato is New Zealand's leading export crop. In 1794, the Dutch introduced the potato to Java, where it was known as the Dutch potato. In the 1830s, farmers first grew the potato in Lesotho and in the 1830s in East Africa. In 1897, the French planted the potato in Vietnam, where it was known as the French tuber. Sometime in the 19th century, the British East India Company introduced the potato to the Himalayas, where it was called the English potato.

In China, people have increased their consumption of potatoes as they have eaten more french fries. A purveyor of french fries, McDonald's opened its first restaurant in Beijing in 1992. In the 1990s, McDonald's and Kentucky Fried Chicken imported 70 percent of their potatoes because Chinese growers did not produce potatoes of sufficient quality. By 2002, China had a large number of

McDonald's restaurants. Whereas the consumption of potatoes increased only a few percent worldwide between 2002 and 2007, it increased by nearly half in China during these years. By 2009, the average Chinese ate less than half the American average of potatoes per year. In 1982, China planted millions acres of potatoes and harvested a few tons per acre. Whereas China produced only one-twentieth of the world's potato crop in 1961, it raised one-quarter of the crop in 2005. Today, China and India produce one-third of the world's potatoes.

One tradition holds, sensibly enough, that the French invented french fries. As we have seen, Thomas Jefferson ate them in Paris, an encounter that stimulated his lifelong interest in the potato. Jefferson grew potatoes in his garden at Monticello. Another tradition holds that the Belgians invented the french fry. American and British soldiers stationed in Belgium during World War I mistakenly called the food french fries because the Belgian soldiers, from whom they acquired the habit of eating fries, spoke French.

The potato chip is an American invention. In 1853, the customers at a restaurant in Saratoga Springs, New York, dissatisfied that their slices of potato were so thick, complained to the cook. Irritated, he sliced potatoes into paper-thin segments, frying them. To his surprise the customers relished potatoes made in this fashion. The thin slices of potato were first known as the Saratoga chip and later as the potato chip. In 1920, businessman Herman Lay began selling potato chips. So successful was Lay that he founded the H. W. Lay Company, one of the world's largest sellers of potato chips. In 200,5 the potato chip totaled more than one-third of all snacks sold worldwide and generated billions of dollars in sales.

Christopher Cumo

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Pumpkin

An annual vine, pumpkin, like potato, corn, peanuts, beans, and several other cultigens, is native to the Americas. Botanists classify pumpkin a fruit, yet one writer, apparently equivocating between fruit and vegetable, termed pumpkin a "fruiting vegetable," and at least one vegetable book contains a section on it. A member of the Cucurbitaceae family, pumpkin is related to squash and gourd. One writer doubts that pumpkin and squash differ botanically. By convention, people use color and roundness to differentiate the two. All pumpkins are members of either *Cucurbita pepo* or *Cucurbita maxima*. The second species contains the giants that enthusiasts raise for cash and bragging rights. The genus *Cucurbita* has 20 to 27 species. Pumpkin derives from the Greek *pepon*, meaning "large melon," though it is not a melon. The French *pumpion* likewise translates as "pumpkin." Pumpkin has vitamins A, C, and E, potassium, starch, and little fat. It is a laxative and diuretic. Pumpkin seeds are 45 percent unsaturated fat and 25 percent protein. They have zinc, iron, and B vitamins.

Origin, History, and Folklore

One authority believes that pumpkin originated in South America, though the oldest archaeological remains of seeds, dating to 7000 BCE, place the origin of pumpkin in northeastern Mexico, though it is unclear whether pumpkin had been domesticated this early. According to one authority, pumpkin was cultivated in Africa as far south as Zimbabwe, and in China and India as early as the sixth century BCE, though it is unclear how pumpkin traveled from Mexico to Africa and Asia in an era before the invention of oceangoing ships. The Amerindians roasted pumpkin for food and wove strips into mats. The Europeans who settled the Americas adopted pumpkins along with other indigenous crops. In the 17th century, explorers and settlers brought pumpkin to Europe. By 1621, the British settlers of North America stuffed pumpkin with honey, milk, and spices, baking them. In 1623, the Pilgrims ate pumpkin pie at the second Thanksgiving. In 1629, British herbalist John Parkinson praised pumpkin as "very sweet and pleasant." The colonists made soup and beer from pumpkin. In the 16th century, English herbalist John Gerard recommended that those suffering from kidney stones consume pumpkin seeds. In the 18th century, people used an extract from pumpkin to make tea, which they imbibed as a diuretic. This tea, they believed, had the power to expel tapeworms. The people of Central Europe believed that pumpkin caused the body to manufacture testosterone. In the 19th century, pumpkin fell out of favor. In the United Kingdom, cooks seldom used pumpkin, and knowledge of its origins was so poor that one writer could suppose that the United Kingdom had only recently imported it from Iran.

Europeans absorbed pumpkin into their folk traditions. The Irish, who had used candlelit turnip, gourd, rutabaga, beet, and potato to banish evil spirits, turned to the more widely available and easily carved pumpkin for this purpose when they came to the United States in the 19th century. The Irish thereby invented the jack-o-lantern, a staple of Halloween. The superstitious placed jack-o-lanterns on the windowsills to prevent evil spirits from entering their homes. Perhaps the most widely known folk tradition derives from 17th-century French writer Charles Perrault's story of Cinderella, who went to the ball in a pumpkin carriage, a story that 20th-century American entertainer Walt Disney popularized. From a pumpkin derives all the world's water, fish, and whales according to an Indian myth. Other tales identify the pumpkin as the source of petroleum, a year's supply of rice, silver, and gold. In Africa and Asia, pumpkin symbolizes rebirth. According to this tradition, a pumpkin vine germinates on the spot where a person died or was buried. Native Americans told of pumpkin vines so large that they stretched into the sky, like Jack's beanstalk, or across rivers. The 20th-century American cartoonist Charles Schulz contributed to these folk traditions with his story of the Great Pumpkin. Every Halloween Linus, staking out a pumpkin patch, awaited the Great Pumpkin, who was to distribute gifts to children, but the pumpkin, like Godot, never comes. According to one tradition Peter, Peter, pumpkin eater killed his adulterous wife, stuffing her inside a giant pumpkin. One wonders whether he ate this grisly pumpkin.

Cultivars

A Halloween favorite because it resembles a ghost, Casper is blue-white. Often cooked and eaten like winter squash, Casper is suitable for making pie. It matures 100 days after planting. Amish Pie was first grown in the mountains of Maryland. The variety may be processed or frozen and makes an admirable pie. Its moist flesh is five inches thick. Amish Pie can reach 80 pounds. Connecticut Field is also known as Big Tom. In the 17th century, New Englanders observed Native Americans interplanting Big Tom with corn. A round pumpkin that weighs up to 25 pounds, Connecticut Field may be eaten fresh or canned. Stockmen have fed it to their animals. In 1883, Burpee bred Rouge vif D'Etampes, a member of *Cucurbita maxima*. Rouge vif means "vivid red," and the skin, ranging from "neon orange to burnt orange," almost lives up to this name. A flat rather than round pumpkin, Rouge inspired the artist who illustrated the pumpkin carriage in Disney's *Cinderella*. For this reason, Rouge is known as Cinderella or Cinderella's Carriage. Its sweet, mild flavor has led cooks to praise Rouge as the "gourmet's pumpkin." One gardener disagrees, however, calling it "insipid and watery." A popular variety in Europe, Rouge does not yield many seeds. Having recorded some of the world's largest pumpkins, Atlantic Giant, also known as Dill's Atlantic Giant, has yielded a pumpkin weighing 1,060 pounds. Although large pumpkins are sometimes unappealing, Atlantic Giant is attractive in the garden and is ideal for making pie. Tended by the enthusiast, Prize Winner grows to more than 400 pounds. King Mammoth Gold, a Kentucky variety, is not as large as its name implies, though pumpkins may weigh 50 pounds. Big Max, a competitor at county fairs, is another large pumpkin. A variety bred by seed company W. Atlee Burpee in 1887, Small Sugar resembles a miniature version of Big Tom. With dark orange skin and meaty flesh, Small Sugar weights 5 to 8 pounds. It matures in 80 to 100 days. Also small are Baby Bear, Becky, and Jack Be Little. Burpee's Triple Treat, weighing 6 to 8 pounds, is ideal for the gardener with a small plot. The aptly named Halloween is popular as a jack-o-lantern. With blue-gray skin, Crown Prince grows to one foot in diameter. The flesh is golden orange, flavorful, and stores longer than the flesh of large cultivars.

Cultivation

A heavy feeder, pumpkin requires abundant water and nutrients. Accordingly, the soil must be fertile and well draining, though it must have organic matter to retain moisture. The soil must not dry out when a plant is producing fruit. The soil should be 20 percent organic matter, and the gardener may dig a hole 18 inches deep and 24 inches in length and width, filling it half full with manure, grass clippings, leaves, or compost, before planting seeds. Alternatively, one may cover a compost pile with a layer of soil, planting seeds in it. The role of nitrogenous fertilizers is open to debate. One gardener prefers to add manure to the soil rather than nitrogenous fertilizers. He prefers cow and horse manure, which has less nitrogen than chicken and sheep manure. Too much nitrogen causes pumpkin to produce vines at the expense of fruit. One should apply less nitrogen and more calcium to yield pumpkins in quantity and quality. The gardener may apply aqueous potassium every two weeks. As a rule, the more frequent the application of fertilizer the larger will be the pumpkin. The gardener may also add fish emulsion, kelp meal, and seaweed to the soil. The soil should be slightly acidic, between 5.5 and 6.8. Because the soil must be between 68°F and 86°F for germination, the gardener should plant pumpkin in late spring in the north. The gardener may soak seeds in water overnight to increase germination. In the north, the gardener may plant seeds indoors three to four weeks before the last frost or outdoors in hills with four or five seeds per hill. Five to 10 feet should separate hills to give vines room to sprawl. Pumpkins should be thinned to three seedlings per hill. Miniature varieties may be planted 2 feet apart. One may wait until mid- to late July to plant pumpkin in the south to ensure a harvest by Halloween. To coax a plant into putting its energies into the fruit, the gardener may thin pumpkins to one to three per vine. One authority recommends thinning pumpkins to two per vine and then removing the smaller of the two so that the plant concentrates its energy on a single fruit. One authority recommends that the gardener cover the soil with black plastic to conserve moisture, eliminate weeds, and keep pumpkins off the soil, where they can rot or be attacked by insects. When a pumpkin is fully orange, the vines die and the rind hardens it is ready to harvest. In most areas, the harvest occurs in late September and early October. The gardener should harvest pumpkins before the first frost, which will damage them. After the harvest, the gardener may leave pumpkins in the field to cure for 10 days. Ideally, the temperature should be 77°F for curing. Pumpkin should be stored in a dry place between 50°F and 55°F. Because pumpkin cross-pollinates with zucchini and squash, the gardener may not wish to save seeds of these crosses. In October and November, after the harvest, the gardener adds compost or manure to the soil so that it will be ready in spring.

Giant Pumpkins

At the juncture of gardening and sport is the avocation of growing giant pumpkins. One writer likens the attempt to grow the largest pumpkin to the quest for an Olympic gold medal. The avocation tests the limits of gardener and pumpkin. The giant pumpkin has none of the romance of the quaint pumpkin patch. In some respects, a giant pumpkin does not resemble a traditional, modest pumpkin. Rather than orange, many giants are an unappealing gray, white, or pink, and they are not round. The tyranny of gravity tugs them into misshapen lumps that would have been at home in a painting by 20th-century surrealist Salvador Dali. One writer likens a giant pumpkin to “a huge, cancerous tumor.”

Despite the image of giant pumpkin as outcast, gardeners have long competed to harvest the biggest behemoth. In 1903, the St. Louis World’s Fair crowned gardener William Warnock Pumpkin King for his world record 403-pound pumpkin. The mark stood until 1979, when a 438.5-pound pumpkin eclipsed Warnock’s giant. The new record marked the ascent of Atlantic Giant. In 1992, the world record climbed to 827 pounds. Two years later four farmers, two in Canada and two in the United States, harvested pumpkins weighing more than 900 pounds apiece. In 1996, two pumpkins surpassed 1,000 pounds and measured 14 feet in circumference. In 2002, the world’s largest pumpkin tallied 1,337.6 pounds. In 2010, the heaviest pumpkin weighed 1,810.5 pounds.

As the records have climbed, so has the quest for the perfect seed. In the early 20th century, 21 percent of the world’s pumpkins weighing more than 700 pounds traced their lineage to the seeds of just three pumpkins. To competitors these seeds are invaluable. One seed has fetched hundreds of dollars. Giant pumpkin seeds are the size of a large almond and may be brown, gold, or white. Bobier, named after New York gardener Bill Bobier, is renowned for yielding giant pumpkins. The top five Bobier pumpkins averaged 1,208.5 pounds each, more than the pumpkins from any other seeds. By 2006, Wallace had emerged to challenge Bobier. At auction, one Wallace seed fetched $410.

As is true of many endeavors, the quest for a giant pumpkin is sometimes fraught with disappointment. As big as they are, giants may succumb to microscopic bacteria and fungi. These pathogens rot pumpkins. Because the microbes destroy pumpkins from the inside out, by the time the gardener detects trouble he is too late. One gardener lost a pumpkin only days before a competition. Fortunately for him, there is always next year.

Christopher Cumo

See also Squash

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Purslane

Purslane (*Portulaca oleracea*), is a member of the Portulacaceae family. This annual is a succulent that is prolific at reproducing itself. Because of this trait, it is considered a weed in some parts of the world, such as several U.S. states. In many parts of the world, the plant is consumed as an herb added to salads or as a cooked dish. Purslane has been found to produce large quantities of the omega-3 fatty acid alpha-linolenic acid, making it a highly nutritious plant. The plants also contain a high level of protein and numerous antioxidants. Due to the presence of large quantities of oxalic acid, purslane should be consumed in moderation. It has also been used as a medicine, for animal feed, and to cleanse wastewater in many parts of the world.

History

Despite being considered a scourge in many gardens, fields, and orchards, purslane has a long history of being cultivated as a human food. The Latin name of the plant derives from its use as a food. The species name *oleracea* is derived from the word *olera*, meaning "vegetable." The genus name *Portulaca* derives from *portula*, meaning "little door." This is thought to be attributed to the manner in which the seeds separate from the plant. The common name of the plant is thought to have originated from the Italian name *porcellana*. In Spanish, purslane is known as *verdolaga*. The wide variety of popular names for the plant in different cultures is considered to be a testament to the widespread utility of the plant as a food.

Purslane was mentioned in the first century CE by both Roman encyclopedist Pliny the Elder and Greek physician Dioscorides. It was widely used in the Middle Ages and was grown in monasteries. Its history in Italy has been highly studied, since seeds of the plant have been identified from archaeological sites from a number of different eras. It was not clear whether the seeds were those produced by weeds or those of cultivated plants. Italian researchers Giovanna Bosi, Paolo Maria Guarrera, and Rosella Rinaldi associated with the department of palaeobiology and the Botanic Garden Museum at the University of Modena, and Reggio Emilia, along with Marta Bandini Mazzanti of the National Museum of Folk Traditions in Rome, analyzed a number of such sites to try to assess whether the purslane seeds found at these sites were present as a consequence of cultivation of the plant or merely the offspring of weeds. Due to the presence of the seeds in the remains of garbage dumps, the researchers concluded that the plants were "almost certainly" cultivated in Italy during the late Middle Ages onward.

Nutrition

All parts of the plant are edible. Purslane has been receiving attention in the popular press as a potential "Power Food" (Palaniswamy et al. 2002, 453; Bosi et al. 2009, 136), and it is sold in Europe, eastern Asia, Mexico, and the United States. The plants taste sweet and slightly acidic and have been found to contain high quantities of the fatty acid alpha-linolenic acid. This compound is one of the omega-3 fatty acids more commonly known as fish oil that are thought to have broadly beneficial effects on the human body. Its concentration in purslane led to this plant having been designated as having higher concentrations of this essential fatty acid than many highly touted food plants. Such compounds cannot be manufactured by humans and must be obtained from dietary sources.

Purslane also produces a number of antioxidant compounds, ranging from ascorbic acid (vitamin C) and beta-carotene to the flavonoid quercetin. It also has high levels of protein. Despite this plant's high nutritive content, there is some concern that the consumption of large amounts of purslane might be unhealthy. This is because the plant also contains the organic acid oxalic acid. Usha R.

Palaniswamy, Bernard B. Bible, and Richard J. McAvoy at the University of Connecticut have found that it is possible to mitigate the amounts of this compound by adjusting the type of fertilizer used in the production of this plant. These researchers varied the ammonium content of the nitrogen source applied to hydroponically grown plants to cause a decrease in the amount of oxalic acid produced. This treatment also resulted in higher concentrations of omega-3 fatty acid in the plants (Palaniswamy et al. 2002, 453–55).

The Invasive Nature of Purslane

This common plant grows close to the ground, frequently resulting in a dense mat. Seeds of this annual succulent will germinate in soils when the soil temperature has reached 60°F. While they prefer moist, sunny conditions, these plants are tolerant of a wide range of climates. Their habitats range from moist, fertile soils to strips of hot gravel. The plants exhibit a great deal of drought tolerance. A single plant can produce up to 10,000 seeds, and these seeds can remain viable in the soil for up to 40 years. Such adaptability has led purslane to be considered a weed in parts of the United States.

The control of this plant can be difficult, since cultivation frequently results in seeds that were buried in the soil being brought to the surface to germinate and produce even more purslane plants. Also, hoeing the plants or tilling the soil often causes bits of the plants to break off. These fragments frequently root and produce more plants. Even hand weeding of the plants can result in further growth. If fragments of the purslane plants are not removed from the ground, they can root, producing even more undesirable growth. Also, plants that have been pulled can continue to flower and produce seeds for up to a week.

Mulching can be a way of controlling the growth of purslane, as can solar sterilization of the soil to kill any seeds present in the ground. Various herbicides have also been recommended as a control measure. One place in which herbicides are not generally considered necessary is the growth of purslane in turf grass. Healthy grass will usually crowd out these plants, so the emphasis is put on ensuring vigorous grass growth to combat the spread of purslane.

Several biological control agents that feed on this plant have been identified. The most prominent is the purslane sawfly, *Schicerella pilicornis*. In some parts of the United States, this insect is not an efficacious agent to control purslane. In parts of California, however, it can provide excellent control of excessive growths of this plant.

Helga George

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Encyclopedia of Cultivated Plants

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Volume 3: Q–Z

Christopher Cumo, Editor

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Q

Quince

Cultivation of the common quince (*Cydonia oblonga*), a member of the Roseaceae family, began in Mesopotamia, a region that is now northern Iraq. Between 200 and 100 BCE, the Greeks cultivated this golden "apple." The quince was cultivated prior to the true apple and reached the Levant by 100 BCE. Reference to an apple in the Song of Solomon may have been to a quince instead. On March 16, 1629, the Massachusetts Bay Colony requested quince seeds from England. By 1720, quince was thriving in Virginia. Many home gardens throughout the colonies were reaping a fall harvest from their quince trees; however, apples overtook quinces in popularity. In the Middle East, quince is a common food, and, though it is sour, is eaten raw as well as cooked. Quince is also popular in Germany and South Africa, where cuisines tend to have higher fat content. The acidic quince counteracts the fat of certain foods, and it is served as a sauce like applesauce.

The beautiful flowers produced by quince last for only a couple of weeks; most of the year the plant is a scraggly, shrubby tangle of thorny branches and unremarkable foliage. Because of the denseness of the twigs, a quince plant may even collect windblown debris that will be difficult to remove. The branches have long thorns, which are very sharp. The plant puts up shoots from the ground.

The popularity of the quince is waning in the United States. In 1908, 14 varieties of common quince were important in the United States, and at the start of the 21st century, only four or five cultivars remain more widely planted.

Quince (Softdreams/Dreamstime.com)

Types

The common quince produces fruit based on shape: oblong (Portugal), apple shaped, and pear shaped. The oblong, or Portugal, quince is a taller and more vigorous shrub than the others and has large, fine fruit. The apple-shaped quince, which is sometimes considered to taste better, has round fruit, is more productive, and ripens under less favorable conditions than either of the others.

Cultivar names of common quince trees often become confusing, as some cultivars are referred to with different names within the same country or region. For example, the cultivar Portugal is also known as Lusitanica, while the Orange cultivar is also called Apple by some quince growers. Four other species previously included in the genus *Cydonia* are now classified in separate genera. These include *Pseudocydonia sinensis*, a native of China, and the three flowering quinces of eastern Asia, now being in the genus *Chaenomeles*. Another unrelated fruit, the bael, is identified as the Bengal quince, though it is not a quince. Flowering quince is a group of three hardy, deciduous shrubs: *Chaenomeles cathayensis*, *Chaenomeles japonica*, and *Chaenomeles speciosa*. Japonica is used by many to refer to flowering Chinese and Japanese quince, regardless of species.

The quince trees that bear the aromatic golden yellow fruits measuring about three inches in diameter bear the scientific name of *Cydonia oblonga*. For clarification, horticulturists sometimes refer to them as common quinces to differentiate them from the Chinese quince (*Pseudocydonia sinensis*) and the low, shrubby flowering quince (*Chaenomeles* spp.). These two other quinces bear fruits that are edible, but are not of the sweeter, more delicious flavor or quality of those produced on the common quince's branches. The flowering quince is a deciduous broad-leafed shrub native to eastern Asia. Flowering quince is a food plant to the larvae of some butterflies, and the flowers attract bees. Flowering quince is also an important food for hummingbirds because it blooms so early in the spring.

Cultivation

Quince is an easy-to-grow, drought-tolerant shrub that does well in shady spots as well as sun. (More sunlight will produce better flowers.) It adapts to many soils and grows in heavy clay as long as the pH is not too high. It is an extremely tough plant that persists for years without pruning or serious insect or disease problems.

Quince is cultivated on all continents in warm-temperate to temperate climates. Quince is hardy and requires a cold period below 44.6°F to flower properly. The gardener should grow quince in a sunny location and water regularly, though the mature shrub is drought tolerant. Quince is one of the most popular species for creating deciduous bonsai specimens. Quince may be planted in U.S. Department of Agriculture zones 4 through 9.

Propagation is generally by cuttings or layers. The better plants come from cuttings, though they take longer to mature than layers. The species can be propagated by seed, but named cultivars are propagated by cuttings or layers grafted onto the rootstock of the species. Quince forms a thick bush and is generally not pruned, unless required to form standard fruit-bearing trees, when it should be trained up to a single stem until a height of five or six feet is attained.

Quince is much used as a dwarfing stock for certain kinds of pears, and for this purpose the young plants when bedded out in the quarters should be shortened back to about 18 to 20 inches. The effect is to restrain the growth of the tree, increase its fruitfulness, and enable it to withstand cold. The tree is self-fertile; however, its yield is higher when cross-fertilized. The fruit can remain on the tree to ripen fully. When ripe, the fruit becomes soft to the point where the consumer can eat it raw in warmer climates. The harvest occurs before the first frost in cooler climates.

Most varieties of quince are too hard and sour to eat raw unless softened by frost and subsequent decay. They are used to make jam, jelly, and quince pudding, or they may be peeled, then roasted, baked, or stewed. The flesh of the fruit turns red after a long cooking time. The cook can add quince in small quantities to apple pies and jam to enhance the flavor. The term "marmalade," originally meaning "a quince jam," derives from *marmelo*, the Portuguese word for this fruit. One can make wine from quince. Because of its high acidity, these wines are sweet dessert wines high in alcohol.

Although quince is a hardy shrub, it may develop fungal diseases in hot weather, resulting in early defoliation; often only a few leaves remain by August. The suckers that come up around the main plant are not appealing. Most gardeners consider the thorns to be ugly and dangerous, as well.

Folklore, Medicine and Cuisine

Aphrodite, the Greek goddess of love, considered apples sacred. Historians believe the apple favored by Aphrodite was really a quince, though others hold it to have been an apple. The legendary golden apple of Hesperides that Paris gave to Aphrodite may have been a quince or an apple. The ancient Greeks considered quinces to symbolize fertility and dedicated them to Aphrodite. In an ancient Greek tradition, friends and family tossed quinces into the bridal chariot as the groom escorted his bride to their new home. Once they arrived, the bride was given a quince to guarantee fertility.

The rabbinical traditions of the Jews date quince back to the Garden of Eden, where it tempted Eve to commit her first disobedience. Several other fruits are candidates for this infamy, but the apple was unknown to the Near East when Genesis was composed. In the Middle Ages, Europeans thought quince aided digestion and prepared it frequently along with meats. The English called the combination *chardeqynce*, meaning “flesh of quince.” In Iran and other parts of the Middle East, the dried pits of the fruit are still used to treat sore throat and cough. The pits are soaked in water and the juice is taken like cough medicine. It is commonly used for children, since it has no alcohol. In Slavonia, Croatia, when a baby is born, the parents plant a quince tree to symbolize fertility, love, and life. In Malta, a jam is made from the fruit. According to local tradition, a teaspoon of the jam dissolved in a cup of boiling water relieves intestinal problems. In Lebanon, quince is called *sfarjel* and also used to make jam. In Syria, quince is cooked in pomegranate paste with shank meat and kibbeh (a Middle Eeastern meat pie with burghul and mincemeat) and is called *kibbeh safarjalieh*. In Iran, quince is called *beh* and is used raw or in stews and jam, and the seeds are used as a remedy for pneumonia and lung disease. In parts of Afghanistan, quince seeds are collected and boiled and then ingested to combat pneumonia. In Pakistan, quinces are stewed together with sugar until they turn bright red. The resulting stewed quince, called *muraba* is then preserved in jars and eaten like jam. Ninety-two grams of quince have 52 calories, 23 percent of the recommended daily allowance of vitamin C, 4 percent of iron, 1 percent of beta carotene, and 1 percent of calcium.

Deb Carlton

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Quinoa

Quinoa (pronounced keen-wah) is an annual herb, *Chenopodium quinoa*, of the goosefoot family to which spinach and Swiss chard also belong. Quinoa grows between three and six feet tall and produces thousands of edible, small, black, white, cream, or yellow seeds held tightly packed at the end of the plant's stalks. It is cultivated as a highly nutritious food crop rather than as an ornamental plant. Although often referred to as a grain, quinoa is technically classed as a pseudocereal. The quinoa plant enjoys the cold temperatures, little rainfall, and poor soils of high-altitude regions. At altitudes above 9,800 feet, quinoa is often planted to shelter more weather-sensitive crops, such as corn and potatoes, from harsh mountain environments.

Quinoa (iStockPhoto)

Quinoa has a long history of cultivation as a food crop in the mountains of South America, having been cultivated in the high Andes since 3000 BCE. There are around 2,000 varieties of quinoa, including Apelawa, which is named after a Bolivian village. Quinoa now grows in Peru, Bolivia, Columbia, Ecuador, and Chile. Quinoa is also cultivated in areas of North America, principally in Colorado, where it has been grown since 1984, and in California and New Mexico. Quinoa is also grown in Canada and occasionally in Europe and Asia.

The Inca revered quinoa, calling it *chisiya mama*, or "mother grain," as Incan legend held quinoa to be the remains of a celestial feast. Each year a ceremony was held in which the Incan ruler planted the first seeds of the year's quinoa using a golden spade, and each solstice the Inca made an offering of quinoa seeds to their sun god, Inti. The Inca also fashioned idols made from the quinoa flour. The Inca prized quinoa for its high nutritional content. The Inca fed a sustaining mixture of quinoa and fat to their soldiers and included quinoa in a variety of foodstuffs including flour, bread, cakes, and beer. Indeed, so vital was quinoa to the Incan way of life that when the Spanish invaded South America they decided that the best way to destroy the Inca was to prevent the cultivation of quinoa. To this end the Spanish made it illegal for Incas to grow the crop. The disobedient faced death. Unsurprisingly, quinoa cultivation began to decline with the Spanish invasion, for not only was quinoa outlawed, but the Spanish also introduced the cultivation of non-native crops such as barley and wheat to Bolivia and Peru. Quinoa cultivation was labor intensive when compared with the farming of such imported grains and so quinoa production fell. Modern crop breeders seek to reduce the labor-intensive aspect of quinoa cultivation. Industry aims to do this by introducing sterile male plants into the breeding of hybrids as this would make unnecessary the labor-intensive removal of anthers from plants. In 1994, a patent was issued in the United States for cytoplasmic male sterile quinoa. However, a reliable system of cytoplasmic male sterility has yet to be developed and so sterile male plants are still unavailable commercially.

Ancient Andeans use every part of the quinoa plant. The water in which quinoa was washed was used to cure fevers, and the ashes created by burning the stalks were mixed with coca leaves and chewed. The Andeans ate the leaves in stews and soups and ate quinoa seeds as a replacement for animal protein in their diets. Today, nutritionists consider quinoa to be a complete protein, for quinoa contains twice as much protein as rice, barley, or corn. Quinoa is also rich in calcium, iron, soluble and insoluble fiber, manganese, magnesium, copper, phosphorous, and polyunsaturated fats. Quinoa is also particularly high in vitamin E and the B vitamins, especially folic acid and riboflavin. This extremely rich nutritional content has led to quinoa becoming increasingly celebrated globally. For example, where once quinoa was the preserve of health-food shops, it is now to be found on U.S. and European supermarket shelves, and a range of quinoa-based products are available including breakfast cereals, salads, cakes, chips, and breads, all aimed at the health-conscious shopper and those following low-GI (glycemic index) diets, because quinoa is a whole-grain food that releases energy slowly. It is also a complete protein, having the essential amino acids necessary. Quinoa can be incorporated in the diet in a number of ways, either ground as flour or kept whole, for cooking softens the hard exterior coating of the quinoa seed so that the grain becomes palatably soft yet crunchy. One problem with its newfound popularity in the world is that it has become more expensive for poor people who originated its use in the Andean regions of South America.

Untreated quinoa seeds are coated in a bitter-tasting toxic glycoside called saponin, which acts as a deterrent to birds and insects. Saponin should be removed from untreated quinoa before cooking as saponin acts as an antinutrient, reducing the absorption of nutrients by the body and potentially leading to damage of the small intestine. While modern manufacturing processes remove saponin by either abrasion or washing, untreated quinoa should be rinsed well under running water to remove the toxin. Andean Indians used saponin to create antiseptics and laundry detergent. Yellow-seeded quinoa is still used in the creation of detergents as well as to create makeup, soap, and shampoo. Yellow seeds are also used to develop a disparate range of products including fire extinguishers, photographic chemicals, and beer. The seeds of both yellow-seeded quinoa and white-seeded quinoa are used in the pharmaceutical industry to develop steroids.

Victoria Williams

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R

Radish

A member of the Brassicaceae or Cabbage family, radish (*Raphanus sativa*) was more popular in the 19th century than it is today, though the Japanese continue to cultivate it in quantity. So popular was radish in the 19th century that seed company W. Atlee Burpee urged Americans in 1888 to eat it "for breakfast, dinner and supper, three times a day." Those Americans who eat radish today often consume it as a garnish with salad or as an appetizer. Having little saturated fat or cholesterol, radish contains fiber vitamin C, folic acid, riboflavin, vitamin B6, potassium, calcium, magnesium, copper, and manganese.

Origin and History

The radish may have originated in China, where philosopher Confucius mentioned it about 479 BCE. In the fifth century BCE, Greek historian Herodotus reported that Egypt's pyramid builders had eaten radish, onion, and garlic. The Egyptians cooked with radish seed oil much as the people of the rest of the Mediterranean Basin cooked with olive oil. So much did the Greeks esteem the radish that they offered it on gold platters to the gods. First-century CE Roman encyclopedist Pliny the Elder, however, had a low opinion of the radish, describing it as "a vulgar article of the diet . . . showing a remarkable power of causing flatulence and eructation." By the mid-16th century, the British planted radish. In 1597, English herbalist John Gerard counted four varieties and one wild radish. He recommended the radish as a treatment for the common cold and cough. Gerard thought the radish stimulated the appetite.

Attributes and Cultivation

Once a radish seed is planted the root develops first, but it does not begin to swell until the leaves have formed. If a radish is planted in spring, it flowers in summer. Planted in autumn, radish will not flower until the following spring. Insects pollinate the flowers. Once fertilized, the flowers yield seeds, which remain viable five years. The earliest vegetables, most varieties of radish mature in 22 to 55 days. Once the soil temperature has reached 45°F, radish seeds may be planted. Seeds germinate in four to six days at 45°F to 55°F. The gardener may grow radish with carrot, beet, parsley, and parsnip. The fast-growing radish marks the spot where its slower kin will germinate. Radish roots loosen the soil for other root crops.

Harvested early, radish opens space in the garden for its slow compatriots to develop. In summer, radish breaks the soil crust, easing the growth of other crops. Radish grows best at 70°F. Plants reach a height of four to six inches.

Early radish, known as spring radish, is the most common type at the grocer and in the garden. Growing rapidly, early radish matures in three or four weeks. The gardener may sow seeds every 7 to 10 days from early spring to extend the harvest. Early radish may be planted one month before frost for an autumn crop. Early radish should be planted near the surface of the soil unless one wants long roots, in which case deep planting is desirable. In mild climate, early radish may be planted from autumn to spring. Early varieties are suitable for the greenhouse in winter. Because early radish is small, it may be grown in a container or window box.

All-season radish matures in roughly 45 days. The root is long and white. The all-season radish tolerates heat better than other types, growing well in summer. Planted in late summer, it is suitable for an autumn and winter crop. Asians grow autumn and winter radish, which needs cool weather at the end of the growing season. Autumn and winter varieties should be planted in late summer. Autumn and winter radish cannot be planted in spring because it will bolt in warm weather.

The gardener should cultivate the soil thoroughly to a depth of at least four inches, being sure to remove stones that might otherwise impede the root. Loam is best. If radish is planted in a raised bed, the gardener should space plants two inches apart. Elsewhere the standard is six inches apart with one foot between rows. Seeds should be planted one-quarter to one-half of an inch deep. Because radish does not transplant well, the gardener should sow it where she intends to grow it. Preferring full sun, radish tolerates partial shade. A thirsty crop, radish should be watered frequently. A radish that receives insufficient moisture becomes tough. The flavor becomes hot. Radish left too long in the soil becomes tough and bitter. The core may be hollow. Subject to few diseases, radish is susceptible to the flea beetle and cabbage root maggot. Radish should be picked within a few days of maturity. Round varieties should be picked when they are the size of a large marble. The gardener should pick French varieties when they are young and tender. One may sample a radish to determine whether its neighbors are ready to harvest.

Cultivars

A small, red, round radish, Cherry Belle matures in 30 days. Popular with children, Easter Egg matures in 25 days. Each packet of Easter Egg has seeds that yield pink, red, white, or lavender roots. When the gardener picks an Easter Egg radish, she is invariably surprised by the color. Black Spanish dates to the Middle Ages, when Spaniards ate it. The variety matures in 60 days, late for a radish. Hardy, Black Spanish may be planted in late summer for an autumn and winter crop. The skin, as the name suggests, is deep purple to black, beneath which is white flesh. Bred about 1824, Round Black Spanish resembles a large turnip.

The flavor is hot. Round Black Spanish may be eaten raw or boiled. It stores well. Rat's Tail, known as Rat Tailed Radish or Purple Podded Radish, is a Japanese variety introduced into the United States in the 1860s. The name did not appeal to consumers. Bred in 1879, French Breakfast yields a scarlet root with a white tip. An early radish, it matures in 24 days. In 1899, Child's seed catalogue recommended its "delicately flavored flesh, free from coarseness or any biting quality." The French dip the variety in butter, add salt, and eat it with bread for breakfast. Early French Breakfast matures in 25 days. D'Avignon matures in 21 days, the earliest of the French varieties. As the name suggests, Plum Purple has a purple root. A large radish, Plum Purple may be eaten with butter, garlic, thyme, salt, and pepper. A French variety, Plum Purple matures in 25 days. The French seed company Vilmorin Andrieux listed Violet de Gourney in its catalogue before 1885. Named for the French town of Gourney, the variety has purple skin and sweet, white flesh. Hardy Violet de Gourney tolerates severe frost. It matures in 65 to 70 days. In the 1880s, seed company Landeth and Sons released Philadelphia White Box, a mild, crisp variety. The small root resembles that of the turnip and is white. The variety may be grown in a cold frame. Bred about 1896 White Icicle, known as Lady Finger, matures in 28 days. As the name suggests, the root is white. The white roots bear a vague resemblance to icicles. The flesh is crisp. The root swells to four or five inches in diameter, but the flavor is best when White Icicle is young. The root grows four to six inches long, tapering to a point like a carrot or an icicle. The variety is not suitable for heavy soil, which truncates the root. The gardener may add sand to the soil to lighten it, giving the root space to grow. White Icicle tolerates hot weather.

An autumn radish, Misato Rose is a large radish with the dimensions of a small turnip. The root grows two to four inches in diameter. The top is green, the root pink, and the tip white. One may add white wine or rice vinegar to slices of Misato Rose to darken the pinkness. The Chinese eat slices of Misato Rose as a snack. German beer, known as Munchen Bier, has long roots with pungent flavor. One may slice German Beer on black bread, adding salt or sugar. By tradition, it is consumed with beer.

Christopher Cumo

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Raffia

Raffia palm (*Raphia farinifera*) is a monocotyledonous plant found in Africa. Native to Madagascar and grown in the tropical regions of Africa, it is found in forests near lakes and rivers, especially on the east coast and also along the River Sonso of the Congo. It is a plant that has been poorly studied. It is not because of the lack of interest from the part of the botanists over the ages, but rather the inconvenience one is faced when trying to collect and assimilate plant material. There are neither stems nor twigs, nor are the leaves of convenient herbarium sizes that can be pressed and dried with ease for the purpose of research. One of the main factors in its lack of publicity is also its limited access and selective habitat.

Botany

Raphia farinifera belongs to the family Aracaceae. It thrives in mangroves, marshes, wetlands, and swamps, prefering rich, moist soil for its germination and survival. Also grouped as one of the 30 species of *Raphia* or wine palms, raffia is a large tree with fibrous and adventituous roots that arise from the base of the stem. The stem or tree trunk is 30 feet in height, without branches but with a thick bark and containing rings of scale leaves at the nodal rings. The trunk terminates in a cluster of leaves. The leaves are twice as long as the stem and may contain as many as 80 to 100 leaflets. In fact, raffia palm is recorded for having the largest and longest leaves in the plant kingdom. Each leaf has a fan-like appearance, with the leaflets arranged on either side of the rachis in a palmately compound fashion. The base of the leaf stalk or rachis is broad and forms a sheath around the tree stem. Veins of the leaflets are parallel and not in a network pattern as seen in dicotyledonous plants. The rachis is thick, fibrous, and tough, and does not easily snap. The petiole of each leaflet is long and strong. The inflorescence is a large spike. Flowers are unisexual and trimerous where the members of the flowers are arranged in sets of threes. Flowers are also actinimorphic and can be cut into two equal halves along any plane of its cross section. The calyx (sepals) and corolla (petals) are undifferentiated and are called tepals. There are six tepals arranged in two whorls. In male flowers, there are also six stamens in two whorls of three each. The stamen filaments are short, and with a two-celled anther each. When mature, the anthers dehisce or open along vertical slits. The ovary of the female flowers consist of three carpels (tricarpellary), fused and with a superior position, where the tepals are arranged below the ovary of the flower.There are three stigmas per flower where each style is extremely short. Flowers are wind pollinated. The fruit is a berry, which has a rough scaly exocarp, and inner fleshy mesocarp and an inner hard and oval endocarp or seed. Fresh seeds are easier to germinate while older seeds lose their viability with time.

Raffia palms are not easy to grow. They are selective in their habitat and can fluctuate their preferences for soil pH. While it has been noted that in some areas, acidic soil has helped them thrive, it has also been observed that soil rich in lime also favors growth. Smoke from nearby fires is known to help fruits germinate faster. Each spike can give rise to as many as 500 raffia fruits.

Uses

Raffia is a plant with immense possibilites and uses. To begin with, the entire leaves, when interwoven together, provide thick and cooling thatch roof material, which is widely used in African villages. They also function as ideal material for walls. The petioles of each leaflet, when stripped off the leaf laminae, are ideal for making brooms for sweeping the floor indoors and the yards outdoors. Many decorative items can be made using the leaflet petioles or leaflet stalks. The main leaf stalk or the rachis is widely collected by tobacco farmers. They use this for the curing and drying of tobacco leaves, where the raffia leaf stalks are inserted through the big tobacco leaves. It is a huge business, which requires a lot of raffia leaves to be used. This has brought about the restrictions by the forest departments, and most people, if they do not cultivate it at their homes, must obtain a permit to harvest raffia trees. The leaf stalks are also used for making furniture and as poles for fences or in weapons of attack or defence. The leaflet laminae, which are stripped off the petiole or stalk, are used for making mats, baskets, and hats. They are also used as a binding and fastening material for tying things together, thus serving the purpose of a rope. The trunk of raffia provides a drink, the raffia palm wine, which has many uses. Unlike the drink of many palms, this beverage grows sweeter with age and fermentation. It is also used in the treatment of hair, and also for the marination of fish. Owing to the difficulty in growing raffia, and its need to be conserved, raffia palms are also looked upon as ornamental plants. The dried fruits of raffia (ankop) are stringed together to form long hanging curtains.

Ecology

Pests and diseases are known to affect the raffia palm on a large scale. The palm beetle eats its way through the trunk and lays its larvae inside. This way it infects and takes control of the plant's metabolic functions, leading to the death of the palm within two months of attack. Likewise, the *Fusarium* fungus causes leaf blight, which can result in the deterioration of the leaves causing death or stunted plant growth.

Raffia forests are home to large chimpanzee populations, especially seen around the River Sonso. As many as 75 chimpanzees are known to inhabit the raffia forests, which are under threat due to the reduction of the forest for the tobacco business. Efforts are being taken by the African forest departments conserve wildlife and the raffia palm.

Amanda Mittra

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Raspberry

Most raspberries are biennial, fruiting in their second year. Some, however, bear fruit the first year, fruiting in autumn and again next summer. These raspberries are known as everbearing or primocene raspberries. Because they fruit in autumn, the first year their berries are marketed after the summer glut and command a high price. Raspberries are in the genus *Rubus* and most of them are members of the subgenus *Idaeobatus*. In the 18th century, Swedish naturalist Carl Linnaeus derived the genus name *Rubus* from the Latin *ruber*, meaning "red" because many raspberries are red. He coined the species name *idaeus* for the European and North American red raspberries because first-century CE Roman encyclopedist Pliny the Elder had remarked that the Greeks called the raspberry *ida* because the people of Mount Ida gathered it. The word "raspberry" may derive from the Anglo-Saxon *resp*, meaning "shoot" or "sucker." Another possibility is that "raspberry" derives from what one authority calls its "rasping" flavor.

The subgenus *Idaeobatus* contains 200 species, which are native to Asia, eastern and southern Africa, Europe, and North America. The subgenus includes the subspecies *Rubus idaeus* ssp. *vulgatus*, the European red raspberry, and *Rubus idaeus* ssp. *strigosus*, the North American red raspberry. *Rubus occidentalis*, the black raspberry, and *Rubus neglectus*, the purple raspberry, a hybrid between red and black raspberries, are members of the subgenus *Idaeobatus*. The greatest diversity of *Idaeobatus* species exists in temperate and subtropical Asia. The subgenus *Cylactis* contains the species *Rubus arcticus* and *Rubus stellatus*, the arctic raspberries, which grow in the arctic regions of Europe and North America. A member of the Rosaceae family, raspberry is related to the rose, apple, pear, strawberry, apricot, almond, and blackberry. One hundred grams of raspberry contain 87 grams of water, 49 calories, 12 grams of carbohydrates, 0.9 gram of protein, 0.6 gram of fat, 3 grams of fiber, 0.4 gram of ash, 22 milligrams of calcium, 0.6 milligram of iron, 18 milligrams of magnesium, 12 milligrams of phosphorus, 152 milligrams of potassium, no sodium, 0.5 milligram of zinc, 0.1 milligram of copper, 1 milligram of manganese, 25 milligrams of vitamin C, 0.03 milligram of thiamine, 0.09 milligram of riboflavin, 0.9 milligram of niacin, 0.2 milligram of pantothenic acid, 0.1 milligram of vitamin B6, and 130 international units of vitamin A.

History

The ancients of Turkey may have been the first to eat raspberries. One authority believes that the Greeks were early cultivators of the raspberry. Roman agricultural writer Cato the Elder (234–149 BCE) was the first to mention the raspberry. Pliny's account that the people of Mount Ida gathered raspberries, presumably from the wild, may not be reliable because botanists have found no trace of raspberries near the mountain. Some believe that the raspberry originated near the Ide Mountains of Turkey. Perhaps Pliny confused the two. The raspberry was first a medicine and only second a food. The flowers were used to make an eye ointment. First-century CE Greek physician Dioscorides valued raspberry as medicine.

Despite the interest of Cato and Pliny, the Romans may not have cultivated the raspberry during the High Empire. It may have been an inconsequential plant then because third-century BCE Greek poet Theocrites, first-century BCE Roman poet Virgil, and third-century CE Greek grammarian Athenaeus do not mention it. By the fourth century, attitudes toward the raspberry had changed because Roman agricultural writer Palladius mentioned it as a crop. Archaeologists have found raspberry seeds at Roman forts in Britain, evidence of the plant's status as a cultigen.

There appears to be little evidence of the raspberry's cultivation in the Middle Ages. Perhaps interest in the crop waned with the decline of Rome. In the 13th century, English king Henry III may have eaten raspberries. In the 16th century, Italian herbalist Pietro Matthioli wrote that Bohemians harvested raspberries, possibly wild ones, in the woods. That century French physician Jean Ruel remarked that the fruit was cultivated everywhere. In 1548, English writer William Turner opined that the raspberry was sour. In the 16th century, German scholar Joachim Camerarius and, in 1601, Flemish physician and botanist Charles Clusius observed yellow raspberries. In 1629, British herbalist John Parkinson classified raspberries as red, white and thornless. By then, gardeners in Chiswick and Brentford grew raspberries for sale in London. Despite Ruellius's observation, one authority believes that farmers have widely cultivated the raspberry only since the late 19th century, when migration to the cities increased urban demand for the fruit. Today, farmers grow raspberries in the United Kingdom, continental Europe, Canada, the United States, Chile, New Zealand, and Australia. Sweden, Finland, Italy, and California grow small amounts of raspberries.

Attributes

Wild specimens have colonized temperate locales and the subtropics, though they are absent from the tropics. Wild raspberries produce about 70 canes per plant with as many as 130 canes per plant. By contrast, cultivated species may bear 70 canes per plant but only about 20 mature. Cultivated raspberries yield long, thick canes compared to the canes of wild raspberries. Cultivated species yield berries twice and thrice the size of the fruit of wild raspberries. Some botanists consider the flavor of cultivated raspberries superior to that of wild specimens, though others have found wild raspberries in Finland and the former Yugoslavia with excellent flavor. Wild raspberries are valuable because those that grow at elevation are often mildew resistant and are thus a source of genetic resistance that scientists incorporate in their breeding programs.

The red raspberry is the most widely cultivated raspberry. The American red raspberry is cultivated in the mountains and lowlands of North America. Its canes are hardier than the canes of the European red raspberry. The American red raspberry bears round fruit, whereas the European red raspberry has conical berries. The black raspberry is neither as hardy not as disease resistant as the red raspberry and the yield is lower. Farmers in the Pacific Northwest, especially Oregon, grow black raspberries. The purple raspberry has large fruit. Berries are juicier and the yield is higher than those of the black raspberry. Farmers grow the purple raspberry in northeastern and central United States. The yellow raspberry resembles the red raspberry in appearance, except for color and flavor, though it is less popular than other species and is grown only for niche markets.

The United States, South America, the United Kingdom, and New Zealand export fresh raspberries. Scotland, Eastern Europe, New Zealand, and the Pacific Northwest process raspberries. Some berries are packed in sugar and frozen. Raspberries are made into jam, jelly, pie filling, yogurt, ice cream, juice, and wine. Only a small amount is canned.

Cultivars

The development of new cultivars must have been a slow process for much of history. In the 17th century, English naturalist John Tradescant mentioned four varieties. In 1829, British author George Johnston counted 23 varieties, though three years later American writer W. R. Prince named only 20. The first cultivar to gain renown was Red Antwerp, discovered about 1800, a variety that produced large berries. In 1820, Fostoff was discovered near the castle of Sir John Fostoff, after whom the variety was named. Fostoff was likely a variant of Red Antwerp. In 1888, the variety Superlative was discovered near Dover, England. A gardener with the surname Laxtons derived the varieties Bountiful, Prolific, Renown, Reward, and Yellow Hammer. Pyne's Royal, derived in 1913, had higher yield, larger fruit, and better flavor than Lloyd George, a variety derived in 1919. These varieties were selections from the wild or from other cultivars. Only in 1922 did European scientists begin breeding new varieties.

Before 1800, the varieties cultivated in North America were European introductions. Of the 20 cultivars that Prince listed, only 3 were native to North America. In 1853, all 4 cultivars that the American Pomological Society recommended were European indigenes. In 1891, 14 of the 20 cultivars recommended by the society were European varieties. Despite the dominance of European varieties, they were not as well adapted to North America's climate as were American indigenes. Red Antwerp was for generations the most popular European cultivar grown in the United States. In the 1930s, Cuthbert was the chief variety in the Pacific Northwest. Thereafter Willamette and Mecker, which produced large fruit and yielded abundantly, supplanted Cuthbert. Willamette and Mecker were machine harvested and processed. The new cultivars Chilliwack and Tulameen compete with Willamette and Mecker for acreage. Chilliwack, Tulameen, Chilcotin, Skeena, Centennial, and Comex are suitable for the fresh market, are firm, and are resistant to insects and diseases. Among black raspberries, Munger is popular and Bristol has large fruit and high yield. Farmers grow Heritage and Willamette along the coast of north-central California. These cultivars supply the fresh market and are shipped by airplane. In California, Willamette yields crops in summer and autumn. Autumn Bliss is gaining ground in California because of its high yield and large fruit. In the Midwest, northern United States, and eastern Canada, red raspberry cultivars dominate because they are hardier than black or purple cultivars. Latham, a red raspberry, is the chief cultivar because it is hardy and adaptable to a range of soils and climates. Boyne is even hardier and is challenging Latham in northern latitudes. Other popular cultivars include Milton, Taylor, Newburgh, Titan, Nova, Hilton, Festival, Killarney, and Nordic.

Christopher Cumo

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Rattan

The old wicker chair on the porch, the rattan furniture throughout the lobby of a colonial Hong Kong hotel where famous authors and explorers lounged between—or during—intrigues and adventures, or a handcrafted basket that is both utilitarian and beautiful all trace their origin to a jungle vine.

The Calmoideae family of vining palms populates the tropics of Southeast Asia, principally Indonesia as well as China, India, and regions with similar climates in Australia and Africa. Stems, generally about one inch in diameter, grow to prodigious lengths of 65 to 600 feet. Hooked thorns on the bark and long tendrils on the ends of frond-like leaves attach to whatever they come across.

Uses

Rattan's many uses include the making of mats and baskets. Rattan may be eaten as food, and its leaves are suitable for thatching and bindings used to hold building material together. Of the 600 species of rattan, *Calamus* is the largest genus, with more than 370 members. *Calamus caesius* is the principal cultivated species. Other domesticated species, most of which have multiple stems and therefore can be harvested periodically, are *Calamus trachycoleus*, *Calamus pinisillatus*, and *Daemonorops crinita*. Wild rattans are *Calamus manan*, which has a single stem but is fast growing enough to be considered for commercial planting, and *Calamus scipionum*. The African species is *Calamus deerratus*. About 20 percent of rattan species are useful enough to be marketable. Rattan is farmed along with village crops in a variety of soils and moisture levels, especially areas of periodic flooding, and also in commercial plots.

Rattan is perennial and dioecious, each plant bearing both male and female flowers, which are small and pollinated by insects and wind. The vines produce nearly round, slow-ripening fruit with slightly tapering ends and one seed. Birds, such as the hornbill, and various animals enjoy the fruit, which is used in traditional medicine and as a red dye. The seeds sprout easily, growing readily alongside a rice crop on river banks and climbing among various types of trees. Six to 10 years are needed before harvesting, but some varieties are very long-lived, with harvesting possible beyond the 30th year. Fibrous roots anchor clumps of vines and send up shoots as they spread. Unlike hollow bamboo, rattan canes are solid.

Harvesting is simple. Most rattan still grows in the wild, where the vines are pulled from their supports by hand. To begin the processing, the thorns and bark are removed by pulling the vines through a notch. The stripped vines are cut for transport into lengths called poles. From warehouses, the bundles are shipped to major transit centers such as Singapore and Hong Kong. The Philippines, Java, and China have large rattan furniture-manufacturing industries.

To further process the rattan, the hard, shiny outer layer is split off the inner core. The hardness prevents dyeing the "chair cane" with regular cloth dyes that are used to color the softer inner layer. Paint and wood stains can be used to color the outer layer. As chair cane, it is cut into narrow widths of one-fifth of an inch or less and lengths of 10 to 20 feet. Sizes are indicated with the numbers zero through six by U.K. standards, but are given more whimsical designations including "superfine" and "fine fine" in the United States.

The softer center or pith of the vines, also split lengthwise, is cut into flat, half oval, or round shapes. For the craftsperson, center cane can be managed after being soaked in warm water. The porous strips will absorb enough moisture after several minutes to be easily manipulated. The strips neither should be left in the water nor should more than the amount needed for one session of work be soaked or the grain will become rough.

Besides the well-known uses in furniture and crafts, rattan has a musical application: it provides excellent mallets for keyboard percussion instruments such as the marimba and xylophone. For their strength, durability, and lightness, the staves or bastons of martial arts are rattan canes. Rattan also is the cane of the corporal punishment still practiced in some East Asian countries.

Commerce

Rattan became an important item of trade during the rule of the Dutch East India Company in the early 19th century. By the late 1980s, as much as 300,000 tons were exported from Indonesia, which provides most of the world's commercial rattan. Double that amount was reached in 2009. As other forest products became less valuable—such as tree resins and gums that were replaced by synthetics or rubber—rattan increased in importance as a cash crop. In the villages most active in growing rattan, it produces about 85 percent of the per capita income.

In 1986, Indonesia banned the export of raw rattan, with other bans and export taxes added in the following years. Although the situation improved for finishing industries, the prices growers and harvesters received declined. A trade regulation of 2009 further restricted the export quota and caused consternation among rattan farmers, gatherers, traders, members of the manufacturing, crafts and furniture industries, and exporters of raw rattan. In Jakarta in July 2010, representatives of all phases of rattan production from raw through finished goods as well as nongovernmental organizations and provincial governments met to discuss the effects of these restrictions. Issues included forest protection and crop sustainability, fair trade regulations based on all interests, registration of exporters, the promotion and strengthening of bargaining positions, government use of rattan, the establishment of forums, and the control of smuggling.

Furthermore, serious pressure is being exerted on rattan gardens by the oil palm industry, which has replaced former rattan-growing areas. To make matters worse, land on which rattan was grown was lost to drought, arson, and wildfires and in continuing land squabbles. As an agricultural export, rattan faces the same issues as some other crops. Rattan is a renewable resource and potentially eco-friendly, but it still can result in ecological imbalances or can cause harm during harvest in the wild. With proper husbandry and efficiency, rattan can continue to provide material for long-lasting, durable, and beautiful products while contributing a valuable source of income on a local level as well as internationally.

Tamara Stromquist

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Redwood

Redwoods are a type of mainly coniferous tree of the families Taxodiaceae and Cupressaceae and are comprised of three genera: *Metasequoia*, *Sequoia*, and *Sequoiadendron*. Although most redwoods are considered coniferous, the *Metasequoia* are unusually deciduous. The oldest of the redwoods—the Dawn Redwood (*Metasequoia glyptosroboides*)—has been traced back to the time of the Cretaceous Period (136 million years ago) and extending into the Tertiary Period of 26 million years ago. It was originally discovered in China and is native to the remote Sichuan-Hubei Valley region. Its seeds were brought to the United States in the mid-20th century. The seeds were cultivated in 1948 in Boston, Massachusetts, and today the tree is found in temperate climates. The Dawn Redwood is a hardy, fast-growing variety and can reach 66 feet, which makes it the shortest of the redwoods.

World's Tallest Trees

The coast redwood (*Sequoia sempervirens*), also known as the California redwood, is considered to be the tallest tree in the world. It is also considered the fastest growing of the conifers. Redwood trees are native to the northern California coast and are mainly contained in Redwood National Park near Eureka. The area's climate, longitude, and elevation place limits on the expanse of the redwoods' range, which are contained in an area of a few hundred coastal miles.

Coast redwoods do not grow well in urban environments due to their intolerance of pollution. The tallest of the giant sequoias was discovered in 2010 by a team of California researchers, which has found and measured more than 135 redwoods that soar to 350 feet or more—the height of a 35-story building. The tallest of the redwoods has been named Hyperion and measures 378.1 feet. The next in line by height are named Helios, which stands 376.3 feet, and Icarus, which is 371.2 feet. These three trees have replaced the Stratosphere Giant, which was discovered in 1963 by the National Geographic Society on the banks of Redwood Creek, as the tallest known tree. The coast redwood contains more than 25 named varieties.

Coast redwoods derive from seeds similar to the size of tomato seeds. They have leaves of dark green needles that are arranged in ranks along their stems. The smallest of the coast redwoods is a slow-growing dwarf variety. But even though a dwarf, Adpressa can still reach 90 feet. The coast redwood is also an ancient tree. Records of fossils in the area where today's coast redwoods soar have been dated to the Jurassic period of 160 million years ago.

The sierra redwood (*Sequoiadendron giganteum*) is nicknamed the giant sequoia and is the sole living species of *Sequoiadendron*. The sierra redwood grows naturally in only one place on earth: the western slopes of the Sierra Nevada mountain range in California. Whereas the coast redwood is the tallest tree, the sierra redwood is the largest tree in volume. It grows to an average height of 160 to 279 feet and an average diameter of 20 to 26 feet. The oldest known recorded sierra redwood is 3,500 years old. The sierra redwood has a soft, reddish-brown bark, very large stems, and enormous height. Its branches are massive and if left to grow wild, will often touch the ground and then curve back upward. These branches can produce a complete ring of new trees. Forest fires, however, tend to keep the low branches in check. The sierra redwood has dense foliage that consists of overlapping pointed scales.

Trees That Thrive

Redwoods are considered the largest living objects on the planet, and they are also one of the oldest. Ancient redwoods are believed to have existed at the time of the dinosaurs and to have covered the earth. Now they grow naturally in just three areas: China (dawn redwood), the northern California coast (coast redwood), and a strip on the western side of the Sierra Nevada range (sierra redwood). They are cultivated in other parts of the world, however, including the countries of New Zealand, the United Kingdom, Italy, Portugal, and Mexico, as well as the state of Hawaii and parts of the southeastern United States, from Texas to Maryland.

Why redwoods have grown for millions of years remains a mystery. One theory suggests that the impressive life span is due to the trees' inborn defense mechanisms and the natural environments in which they grow. Complex soils on the forest floors, for instance, contribute to the redwoods' growth. The soils also contribute to the growth of other similar verdant plants and fungi, such as ferns, mosses, and mushrooms, as well as other, smaller trees such as Douglas firs, western hemlocks, Pacific madrone, and tanoaks. Coast redwoods also pull moisture from fog drip and the cool coastal air into their needles at the tops of the trees, where the tree's naturally occurring circulation system would not typically reach. The coast redwood's reddish-brown, thick, fibrous, and spongy bark, which can grow to as much as one foot thick, protects the tree, even acting as a heat barrier in forest fires. Fires can harm these trees, of course, but the coast redwood stands require the heat produced by forest fires to begin the process of opening the cones in order for the seeds to disperse. U.S. Forest Service efforts to limit fires may even harm this tree by not allowing it to reproduce.

Natural Predators

The redwood may survive so long because it is not susceptible to many pests. In fact, some pests find the chemical composition of the tree to be distasteful, and it is even poisonous to some. Another contribution to the tree's long life is its resistance to disease. Diseases of redwoods are virtually unknown. Also, the redwood does not rely solely on sexual reproduction to spawn new trees. New sprouts can grow asexually—directly from a downed tree's root system or from a stump. Basal burls, which are hard and knotty growths that form from dormant seedlings on a living tree, can produce a new tree.

Redwoods mature around 10 to 15 years of age, when they can begin producing seeds. Seed viability is low—some estimates measure it at about 15 percent—and this too may protect trees from predators searching for edible seeds from a majority of chaff. Seed dispersal is from wind, and the seeds usually land about 200 to 400 feet from the parent. A typical coast redwood's growth, like most redwoods, is rapid, with most trees reaching 65 feet tall by the 20th year.

Uses, Mythology and Modern Times

Coast redwood is an extremely valuable timber for a number of reasons, including its light weight, its resistance to fire and decay, and its beauty. Because of its durability and decay-preventive properties, redwood is turned into furniture, especially outdoor furniture, roofing, decking, house siding, gazebos, pergolas and other outdoor structures, as well as railroad ties and trestles.

West Coast Native Americans have long revered the majestic redwood. The Mono are a Native American people who inhabit the Sierra Nevada Mountains in northern California, near today's Mono Lake. A Paiute legend of the Mono claims that the California redwoods are *who-who-nau*, or sacred, and protected by the owl. The Mono believe that bad luck will come to those who cut down the enormous trees or who shoot at or in the presence of an owl. The Mono dissuaded the non-Native settlers from cutting down the trees; those who cut down the trees were believed to be forever cursed by an owl.

Because of their height and size, redwoods have become a part of some unusual practices over the years. In the late 1990s, for instance, a redwood tree was used by an environmental activist in a newsworthy protest. Julia Butterfly Hill spent two years living in the canopy of a thousand-year-old redwood tree. Sitting 180 feet from the ground, Hill staged a sit-in to protest deforestation. Following the sit-in, the tree and the ones around it were spared and are currently maintained by the nonprofit Sanctuary Forest land trust.

A less-serious pastime concerning redwoods involves making them into recreational features, such as drive-through trees, trees whose bases have been carved out in order to allow a vehicle to pass through. Currently, there are just three drive-through trees left in California. They are Chandelier Tree in Leggett, Shine Drive-Thru Tree in Myers Flat, and Klamath Tour Thru Tree in Klamath. All are privately owned and charge a fee to drive through. Also in northern California is the World Famous Tree House in Piercy, in which the rotted-out hollow lower portion of a still-living coast redwood has been turned into what is billed as "the world's tallest single room." Other redwood attractions include the Famous One Log House, a redwood log turned on its side and furnished, and the Living Chimney Tree in Philippsville, similar to the house in Piercy.

Rosemarie Boucher Leenerts

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Rhubarb

In the Polygonaceae family, rhubarb (*Rheum rhaponticum*) is a perennial herb that remains productive as long as 20 years. Rhubarb is a compound of two Latin words. *Rhu* meant the river along which rhubarb grew. Today, this river is known as the Volga in Russia. *Barbarum* meant "foreign" because Russia was a foreign land to the Latin-speaking Romans. Rhubarb's status is uncertain. In 1947, a New York court ruled that it was a fruit, and its use in pie, pastry, and cobbler reinforces that notion that, if not a fruit, rhubarb is at least a fruit substitute. In this context, rhubarb is known as "the pie plant." On the other hand, at least one gardening book lists it as a vegetable. One hundred grams of rhubarb have 21 calories, 4.5 grams of carbohydrate of which 1.1 grams are sugar, 1.8 grams of fiber, 0.2 gram of fat, 0.9 gram of protein, 93.6 grams of water, 7 micrograms of folic acid, 8 milligrams of vitamin C, 0.3 milligram of vitamin E, 29.3 micrograms of vitamin K, 86 milligrams of calcium, 0.2 milligram of iron, 288 milligrams of potassium, 4 milligrams of sodium, and 0.1 milligram of zinc. The calcium in rhubarb is in the form of calcium oxalate and so is not absorbed by the body.

Origin and History

One writer asserts that rhubarb originated in Siberia, from where it spread to Europe about 1700 CE. Another author favors an origin elsewhere in Asia, perhaps in northern China. A Chinese medical text, the *Pen-king*, dating to 2700 BCE, suggests that rhubarb was first a medicine. The root was reputed to have medicinal value, and the Chinese and later the Romans used it to treat constipation and digestive ailments. In the first century CE, Greek physician Dioscorides mentioned a root that may have been rhubarb. In the Middle Ages, the secular community called on monks to heal the ailing and so they grew rhubarb in their gardens. If this is true, then rhubarb must have spread to Europe well before 1700. In the 13th century, Italian adventurer Marco Polo observed the cultivation of rhubarb in China. The extensiveness of its export impressed him. In the 13th century, Arab writer Ibn el-Beither remarked that rhubarb was "common in Syria and Persia." (Persia is now Iran.) Under Islamic rule, merchants carried rhubarb along the Silk Road through Central Asia to Europe. Rhubarb obtained along the Silk Road was known as Turkish rhubarb. Because of the long distances that rhubarb traveled, it was more expensive than exotic cinnamon, opium, and saffron in Europe. Because of its value, governments tried to monopolize rhubarb commerce. In 1772, Russia contracted a company in Lanzhou, China, to supply it with rhubarb root. Russians then sold rhubarb roots to Europe as "royal rhubarb." Many Europeans knew this rhubarb as "Russian rhubarb."

Aside from the root, humans must have eaten other parts of the plant. The leaves, however, contain the toxin calcium oxalate. The people who sampled the leaves must have become sick, though death must have been uncommon because one must eat 11 pounds of leaves to consume a lethal dose. It is possible, however, that the bad experience of eating rhubarb leaves may have discouraged the consumption of other parts of the rhubarb plant. According to one author, only about 1800 did people realize that the stems were edible, and it is this use that has led to the addition of rhubarb to the dessert cuisine of several nations. According to one writer, a gardener in Maine obtained rhubarb seeds from Europe about 1800. Pleased with his crop, he introduced rhubarb into Massachusetts. By 1822, Massachusetts gardeners were selling rhubarb to their neighbors. Another writer, however, asserts that only in the 1820s did Europe introduce rhubarb into Maine and Massachusetts. Canada and the United States cultivate rhubarb, though it is a minor crop. The leading U.S. producers are Washington, Oregon, and Michigan. Poland, Russia, and Britain also cultivate rhubarb.

Uses

Rhubarb that will be sold fresh is packed into 15- to 20-pound cartoons. Workers do not wash the stems because water may encourage the growth of harmful microbes. The grocer displays rhubarb from these packages for consumers. Red stems reputedly are sweetest. Consumers prefer the flavor of rhubarb grown in greenhouses rather than outdoors. Rhubarb that will be processed is washed, chopped, and frozen. This rhubarb is made into pie and other treats. Rhubarb is often paired with strawberries in pie, gelatin, pudding, soufflé, and jam. The tartness of rhubarb lends it to these uses. British restaurants serve mackerel with white sauce, rhubarb, and sugar. Rhubarb is sometimes dipped in butter, fried, and topped with sugar. Rhubarb may be fermented into wine. The people of Iceland make soup and pudding from rhubarb. Both recipes combine rhubarb, water, sugar, and potato flour. The Poles cook rhubarb with potato, onion, and mushroom as a side dish to meat. The oxalic acid in rhubarb leaves may be used as an insecticide against aphids. The oxalic acid also breaks down the chlorofluorocarbons that destroy the ozone layer.

Attributes and Cultivation

Rhubarb grows 18 to 36 inches tall. It does well in full sun or partial shade. Seeds germinate in 7 to 21 days at 68°F to 86°F. Commercial growers seldom uses seeds because, being the product of sex, plants that germinate from seeds are not clones of elite parents. Rather, growers propagate rhubarb by dividing the roots, each of which must contain a bud, known as a crown. Propagated in this way, these plants are clones of the parent. Growers plant crowns two or three inches deep and two or three feet apart in rows four or five feet distant. Another gardener recommends a spacing of three to four feet. Where winters are cold, rhubarb should be planted in early spring. Where they are mild, rhubarb should be planted in autumn. Rhubarb tolerates a range of soils: peat, sand, and clay. Sandy loam is best. The soil should be fertile, well drained, and contain organic matter. Rhubarb prefers acidic soil. One writer recommends the addition of manure or compost to the soil at the time of planting. Another recommends the application of 1,500 pounds of 10-10-10 fertilizer in a ratio of nitrogen to phosphorus to potassium per acre before planting. One may plant a legume or green manure in the year before planting rhubarb. With this method, one need add only 1,200 pounds of 5-10-10 fertilizer per acre at the time of planting. Rhubarb benefits from annual applications of fertilizer. One author recommends the application of 400 pounds of ammonium nitrate and 200 pounds of muriate of potash per acre before rhubarb resumes growth in spring. In late June and early July, the grower may add 60 pounds of nitrogen per acre. Rhubarb should be watered when it is fertilized. The gardener should give rhubarb copious amounts of water during dry weather.

Rhubarb does not tolerate heat. It grows poorly above 75°F and does not grow above 90°F. Rhubarb must have a cold winter to initiate dormancy. The winter mean must be no higher than 40°F. Without sufficient cold, rhubarb does not grow new stems the next spring. So inimical is hot weather that rhubarb survives only a few months in the American South. In greenhouses, rhubarb grows best at 56°F. Lower temperatures cause stems to darken, but their growth slows. Below 50°F, they cease growth. Above 60°F, stems become pale, though growth accelerates. Above 65°F, the yield decreases. Rhubarb prefers humidity.

The grower should remove flowers so that the rhubarb plant concentrates its energy on growing stems. In the 1970s, growers in Washington and Michigan began to apply gibbereillic acid to rhubarb to increase the yield. Gibbereillic acid reduces a plant's requirement for cold, though it still must have cold weather, allowing it to break dormancy earlier in spring. Rhubarb should not be harvested in the first year. In the second, rhubarb may be picked for one or two weeks. Thereafter the grower may harvest stems twice per week for two or three months. Stems are ready to pick when they reach 12 to 20 inches. Rhubarb is ready to harvest in April or May, earlier than many other crops.

Christopher Cumo

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Rice

Today, half the world's population eats rice as the primary source of nourishment. Because so much rice is grown, it supplies more calories than any other food. Several percent of all farmland is planted to rice, a larger percentage than to any other crop. Unlike corn, farmers grow rice principally for human consumption. So important is rice that the ancients believed it to have been a divine gift. Probably because women did much of the work of growing rice, the rice deity was thought to be a goddess: the Rice Goddess or Rice Mother. The ancients believed that rice sustained the body like no other food can. Because humans ate rice, it must be a component of body and soul. Like humans, the rice plant, people conjectured, had a soul. Rice growers elaborated rituals to propitiate rice spirits, thereby ensuring an abundant harvest. Rice contains carbohydrate, thiamine, riboflavin, niacin, vitamin D, calcium, iron, and fiber. Rice has little fat and sodium and no cholesterol or gluten. Rice fiber may protect one against cancer. Rice contains eight of the nine essential amino acids. In the family Poaceae or Gramineae, rice is related to corn, wheat, barley, sorghum, rye, sugarcane, bamboo, oats, triticale, and timothy.


Brown rice (Hlphoto/Dreamstime.com)

Origin and Domestication

Scientists have traced the ancestry of rice to a grass that thrived on the supercontinent Gondwana 130 million years ago. When the continent broke up, the proto rices evolved separately in what became Asia and Africa. Around 12,000 years ago, the climate warmed and glaciers, and with them large mammals, retreated toward higher latitudes. Humans, then hunter-gatherers, shifted their energies from hunting to the collection of edible plants. Among these plants was wild rice, which some humans harvested from antiquity until the 19th century. The decisive step in domestication occurred when humans, likely women, saved seed from the harvest for planting on their own land. These first farmers grew rice in swamps near their homes, taking care to weed it and to keep animals away. Humans selected plants with a high grain to straw ratio, plants that were shorter than wild rice. Repeated seed selection yielded large grains. Through these actions, humans isolated the species *Oryza sativa* from its wild progenitor in Asia and *Oryza glaberrima* in Africa. Of these, Asian rice yields more grain than does African rice.

Asian rice also resists shattering during milling better than does African rice. These advantages may account for the fact that *Oryza sativa* is more widely grown than *Oryza glaberrima*. Scientists recognize two types of Asian rice: the short sticky grain of Japonica and the long dry grain of Indica.

Asia

Authorities disagree about when and where humans domesticated rice. One scholar believes that humans first domesticated rice in the Yellow River valley about 8000 BCE. Alternatively, humans may have first domesticated rice in northeastern India and southwestern China, perhaps along what is now the border between India and China, about 7000 BCE. Another account identifies the Yangtze River valley around the same time as the cradle of rice culture. One account dates the origin of rice farming in India to 6500 BCE, whereas another points to 4000 BCE as the proper date. By 5000 BCE, according to one scholar, rice was grown in China, India, and Southeast Asia. The earliest efforts to grow rice were on rain-fed lands. Before farmers grew rice in paddies, dryland agriculture prevailed in Thailand, Laos, Vietnam, and southwestern China. As people migrated along the Mekong and Chao Phraya rivers, they brought rice to Indochina. From the Brahmaputra and Ganges rivers, people brought rice into the heartland of India. From India, rice was taken across the Bay of Bengal to Malaysia and Indonesia. From Indonesia, rice spread to the Philippines and from there to Taiwan and Japan. Rice is the staff of life in Asia and is grown from India and Sri Lanka in the west to Southeast Asia and the islands of South Asia and to China, Korea, and Japan in the north. By 1000 CE, farmers were growing rice in all these areas. In Japan, farmers took great pride in their rice fields, earning the islands the moniker "the land of vigorous rice plants."

In Asia and elsewhere, water serves two purposes in rice culture. First, plant roots take up water. Although all plants use water, rice requires more water than any other grain. The second purpose of water is to flood land, suffocating weeds. Farmers in Asia cultivated both rain-fed and paddy rice. A minority of farmers in Laos and Borneo and half the farmers in India rely on rain. The rest of the farmland is paddy. In some cases, throughout India for example, irrigation supplements the water rice plants derive from rain.

Because rice is a labor-intensive crop, it required the effort of an entire community to grow it. The need for labor led communities to centralize their leadership, for someone had to determine when to plant, weed, and harvest rice. The aggregation of communities into larger units led to the creation of civilization and in China to dynastic rule. Rice therefore made possible the organization of Asia into hierarchical states. Curiously, in China rice culture took root in the south whereas the dynasties flourished in the north. Consequently, the first Chinese states did not elevate rice culture to the status of a quasi-religious activity. Nonetheless, the empire could not have survived without abundant harvests of rice, which fed people in both south and north.

In South China, farmers from an early date put fish eggs in rice paddies. The fish that developed from these eggs ate insect larvae, lessening the damage insects did rice. Because of this practice, people throughout Asia referred to South China as "the land of rice and fish."

Innovations in China and Vietnam intensified the growing of rice. In the second century CE, the Chinese began raising seedlings in nursery beds, transplanting them into the field as they matured. Although this practice demanded more labor than simply seeding the land, it increased yields. Sometime in antiquity, farmers in Vietnam derived a rapidly maturing cultivar that made possible the growing of more than one crop per year in temperate climates. In the 11th century, Chinese farmers adopted this cultivar, the Champas variety. Along the Guangong-Vietnam border, farmers raised two crops of rice per year and one crop of sweet potatoes. In the lower Yangtze River valley, farmers rotated rice with wheat. In parts of Cambodia, farmers raised as many as four rice crops per year, and even temperate locales could produce two or three crops of rice in a year. Over the millennia, Asian farmers have grown more than 120,000 varieties of rice, each with its own characteristics. The fast-maturing varieties ripen in as little as two-and-one-half months, whereas the full season varieties take nine months to mature.

In Asia as elsewhere, women have figured prominently in the growing of rice. In the earliest efforts at cultivation, men used a stick to make holes in the ground. Women then inserted seeds into the holes. Women's role in planting expanded when farmers adopted transplantation of seedlings in the field. Women were responsible for the initial nursery planting and for the transplanting of seedlings. They also weeded rice, often twice a season for paddy rice. Because women were responsible for weeding, a well-tended field was a vivid demonstration of their industry. Bringing the agricultural cycle to a close, women harvested rice with small knives, painstaking work. Women did not use a sickle for fear of injuring a rice plant's spirit.

Because of their importance, women performed the rituals that ensured a bountiful harvest. In the mythology of many Asians, a female guardian of rice fashioned a wooden structure with an opening to symbolize the vagina and a phallus to symbolize the penis. The union of vagina and penis represented conception, presaging an abundant harvest. In Bali, the female head of each household blessed the field before harvest and cut the first stalk of grain. Senior women had the responsibility of selecting the seed to be planted next season, ensuring continuity between one season and the next. Bali farmers prayed to the Rice Goddess after the harvest. In Vietnam, married women who had many children and who therefore symbolized abundance planted the season's first rice in a sacred plot of land. Vietnamese farmers prayed to the Rice Goddess at harvest. In Thailand, only women may enter the family granary to retrieve rice for cooking. Because of Thai women's importance, farmland is commonly inherited along the maternal line. In Thailand, time has a gender and planting time is female. Indian farmers called the Rice Goddess Annapurna. Unusual in Asia, they also had a rice god Annadevata. Women throughout Asia made straw representations of the Rice Goddess to guard rice fields from evil.

Ritual and celebration attended the growing of rice. In many Asian countries, for example Vietnam, the New Year falls between last season's harvest and next season's planting. New Year's celebrations therefore mark the renewal of the agricultural calendar. Agricultural festivals, weddings, and other social events often follow the harvest. In Bali, the calendar derives its six months of 35 days from the 210 days necessary for rice to ripen. In Bali, the ancients built temples near irrigation works. In these temples, they prayed to the rice spirits to ensure a bountiful harvest. The temples, Bali farmers believed, purified the water that nourished rice. After the harvest, farmers in Bali offered the Rice Goddess prayers of thanks. In Borneo, farmers performed elaborate rituals to propitiate the spirits that protected newly planted rice. In Japan, planting songs had a sexual component, linking human fertility with a bountiful harvest. Dances between boys and girls emphasized sexuality and fertility. The Harva Gurai ritual emphasized the link between human sexuality and a bountiful harvest. In Java, farmers performed rituals to expel evil spirits from a field. In Thailand and Bali, farmers performed pregnancy rites when rice began to head. In northern Thailand, where rainfall is erratic and irrigation is absent, farmers held rainmaking ceremonies. Monks led processions to a local pond or forest, where the rain spirits were thought to live, to recite prayers for rain. The ritual concluded with a communal bath. Throughout Thailand, farmers offered food to the Rice Goddess to ensure the survival of seedlings upon transplant. In addition, farmers gave part of the harvest to a Buddhist monastery as a holy offering. In Terai, a lowland region along the Himalayan Mountains and the Ganges River, farmers recited prayers at planting to protect seedlings from disease and to rid fields of evil spirits. In India, families offered rice, flowers, and sweets to the household gods before planting and recited prayers at harvest to banish insects from a field. Other prayers guarded against caterpillars, fire, and swarms of bees. Throughout Asia, rice is the first food that parents give their children, and it is the first food that a wife offers her new husband at their wedding. Rice is the last item of food that the dead take with them to the afterlife.

The community that tended rice cared for its weakest members. At season's end, the poor could claim a share of the harvest by helping to reap the grain. This way of life is receding into the past. Since the 1960s, the Green Revolution has transformed rice growing throughout Asia and in the rest of the world. The new high-yielding varieties of rice are capital rather than labor intensive. The use of fertilizers, herbicides, and pesticides made rice farming expensive. Large corporate farmers took the place of small family farms. The family granary fell into disuse as commercial farmers stored rice in warehouses. The poor were no longer entitled to a portion of the harvest as commercial growers relied on hired help, who received wages rather than a portion of the harvest. The high-yielding cultivars could be grown in succession year-round, blurring the distinction between one season and the next. In the process, rice festivals lost much of their purpose. As high-yielding, genetically uniform cultivars spread throughout Asia, they displaced traditional varieties. The result has been a loss of genetic diversity, though the International Rice Research Institute has labored to preserve this diversity by collecting more than 100,000 varieties of rice.

Gains have balanced these losses. India has the largest area planted to rice in the world, and the majority of its people rely on rice as their staple food. In the past, famine killed millions. By 1977, however, high-yielding cultivars made India self-sufficient in rice production, possibly for the first time in its history. Yields doubled and in some cases tripled. Between 1964 and 1991, rice yields doubled throughout Asia. In 1970, Bali farmers planted half their land to high-yielding cultivars. By 1977, this amount had increased. Today, high-yielding cultivars account for nearly all rice grown in Asia. Also important has been the cultivation of large amounts of land. Whereas in the 1850s farmers in Myanmar planted more than 1 million acres to rice, by 1990 the figure had increased 12-fold. In Thailand, rice acreage increased 10-fold between the 1880s and 1990.

Thailand is now the world's largest rice exporter. Nine of the world's 10 largest exporters are in Asia. (Brazil claimed the 10th spot.) In 2000, the U.S. Department of Agriculture estimated that China produced one-third of the world's rice crop. Today, rice remains a staple in Asia. Health-conscious consumers eat brown rice as well as ginseng rice: brown rice with ginseng powder. Supermarkets sell several brands of rice cakes.

Africa

Some Africans believe that the rain god gave them rice in the mythic past. The Niger River valley may have been the center of rice cultivation in West Africa, where farmers domesticated rice between 4500 and 3000 BCE. Another account puts the origin of rice culture in West Africa at 1500 BCE. From the Niger River valley, rice spread to Senegal, if the first dates are correct, between 1700 and 800 BCE and to East Africa in the ninth century CE. In addition to the Niger River valley, farmers independently domesticated rice along the Guinea coast between 1000 and 1200 CE.

As early as 1000 BCE, merchants may have brought varieties of Asian rice to Madagascar, from which they spread to East Africa. Alternatively, merchants in East Africa may have imported rice from South Asia. According to one account, Arabs brought Asian rice to Africa between the sixth and 11th centuries. Another source holds that Africans did not know about *Oryza sativa* until the era of the slave trade. Despite its advantages, Asian rice did not supplant African rice, at least not everywhere, because Asian rice does not compete well with African weeds. Nevertheless, where farmers irrigated their land, Asian rice yielded well and displaced indigenous varieties. Yet Asian rice spread only slowly. Only in the 19th century did Asian rice spread from Mozambique to the Congo. Farmers cultivated rice, likely African varieties, in deep water basins, in water holes, in hydromorphic soils in the forest, on drylands in the hills of West Africa, and in mangrove swamps along the Guinea coast. In the 16th century, African farmers began to grow rice on the Cape Verde islands. Farmers grew rice as far north as Morocco.

In West Africa, farmers practiced three systems of cultivation: rain-fed agriculture, paddy agriculture in inland swamps, and floodplain agriculture. In the last, farmers along the Guinea coast took advantage of the fact that the tide pushes freshwater upriver ahead of saltwater. They used this source of freshwater to flood lowlands on which they had planted rice. The advent of the slave trade opened a new market for African rice: ship captains bought it to feed slaves on the Middle Passage. Because it was cheap, slavers bought unmilled rice, which female slaves milled and cooked aboard ship to feed the rest of the slaves.

As in Asia, African women traditionally tended rice fields whereas men grew corn. Because corn is less labor intensive than rice, one wonders whether this division of labor was fair. To reduce the intensity of labor, women planted rice at intervals of time to ensure that it would not all ripen at once. In this way, women spread the harvest over months. In the floodplain, both women and men worked to ensure an abundant harvest. Men built embankments and canals and women planted, weeded, harvested, and prepared rice for eating.

The Green Revolution has been tardy in coming to Africa. Whereas parts of Asia are self-sufficient in rice production, Africa imports a near majority of its rice. African countries buy one-third of the rice traded on the world market. Aware of the continent's deficiency in rice production, scientists have labored to breed high-yielding varieties suitable for Africa. Some of these new cultivars yield well on rain-fed land and therefore promise to raise yields. Between 1985 and 2005, rice production in West Africa more than doubled. In the early 21st century, yields increased in Ghana, Mali, Benin, the Ivory Coast, Uganda, and Nigeria. The African Rice Center believes that Africa may become a rice exporter if its farmers bring more land into cultivation. Rice-for-Africa believes that West Africa has the potential to feed the entire continent.

The Americas

As in Asia and Africa, when and from where rice came to the Americas are matters of controversy. Around 1570, a Portuguese writer noted the cultivation of rice in Brazil, though how it got there is unclear. One tradition holds that a slave woman smuggled rice into Brazil by hiding it in her hair. In 1579, a Spanish writer observed that rice was grown along the Gulf coast of Mexico. Again, the origin of this rice and the year of its introduction are unknown. According to one account, slaves in South Carolina grew rice as early as 1680. Another account holds that a ship's captain introduced rice from Madagascar to South Carolina in 1685. If this account is true and if Asian rice was then grown in Madagascar, then this rice may have been either African or Asian rice. If, on the other hand, rice came to South Carolina aboard a slave ship, perhaps as leftover provision, then it surely did not originate in Madagascar.

Whatever its origin, rice depended on slave labor in the Americas. By 1698, slaves from the Caribbean grew rice in South Carolina, though the colony turned to imports from Africa to meet its needs in the 18th century. In the 18th century, a near majority of slaves imported to South Carolina came from rice-growing regions of Africa. Slavers understood the value of these slaves, announcing in newspapers that they intended to sell slaves skilled in growing rice. As rice production soared in South Carolina and Georgia, so did the number of slaves. As in Africa and Asia, women did much of the work in the Americas. They imported not only the technology of cultivation but also the culture or rice production. Their field songs, for example, originated in Africa.

By 1690, rice had emerged as a cash crop. In the 18th century, rice made South Carolina the wealthiest plantation economy in North America. Planters in South Carolina and Georgia sent their rice to Great Britain, which reexported it to the Continent and India. Planters enjoyed strong demand for rice in Europe, where it was used to make beer and paper. Catholics ate it as an accompaniment of fish on meatless Fridays and during Lent. South Carolina met this demand. By 1763, rice accounted for the vast majority of American exports to Great Britain. As production increased, so did the yield per acre. Between the early 1700s and 1800, yields rose from hundreds of pounds per acre to thousands of pounds per acre.

Until 1720, farmers in South Carolina depended on rainfall to sustain their crop. Around 1720, they began using water from ponds and streams for irrigation. About 1750 planter McKewn Johnstone, probably using the knowledge of his slaves, introduced the tidal flow system to South Carolina. He used a gate to capture water from rivers, whose water the tide had pushed upstream. The gate opened to receive water and then closed when the tide receded to prevent water from flowing downriver.

So important in the 18th century, South Carolina lost its preeminence after the Civil War. Whereas South Carolina and Georgia produced the vast majority of rice in the United States in 1860, they produced only a few percent in 1900 and none in 1929. The two states had been unable to compete with rice growers in Cuba and South America and in the American Southwest. After experimenting with sugarcane and cotton, the Southwest turned to rice. By the mid-19th century, farmers in lands along the Mississippi River were irrigating their rice fields with the river's water. Production moved farther west to western Louisiana and Texas. By 1903, these two states produced almost all the U.S. rice crop. In the early 20th century, rice culture migrated west to California and north to Arkansas and Missouri.

Drought in the Soviet Union in 1972 led the region to purchase U.S. wheat and rice, expanding U.S. rice exports. Since its inception, the United States has exported a large share of its rice crop. Louisiana, Mississippi, Missouri, Texas, California, Florida, and Arkansas are the major rice producers in the United States. In Louisiana, farmers rotate rice with soybeans in the same way that midwestern farmers rotate corn with soybeans. In the upper Mississippi River valley, farmers follow rice with two years of soybeans. California farmers rotate rice with sunflowers, beans, Sugar Beet, vegetables, or tomatoes. In Florida, farmers rotate rice with sugarcane or vegetables. Farmers in Louisiana and Texas, taking advantage of the fact that rice regenerates new seed after harvest, reap a ratoon crop.

Christopher Cumo

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Ricinus. *See* Castor Bean

Rosebush

A perennial shrub, the rosebush is among the world's most popular ornamentals. With exceptional longevity, it can live hundreds of years. The specimen at Hildesheim Cathedral in Hildesheim, Germany, is 600 years old. Probably native to

Roses (Zhanghaobeibei/Dreamstime.com)

China, the rosebush has spread throughout the world. In the family Rosaceae, the rosebush is related to the apple, pear, cherry, plum, peach, strawberry, raspberry, and blackberry. The genus *Rosa* contains more than 100 species. Today, the gardener may choose among thousands of cultivars, though these have a narrow genetic base, having been derived from no more than a dozen wild roses. The term "rose" may derive from the Greek *rhodon*, meaning "rose tree." Alternatively, the Greek *roton*, meaning "wheel," may be the source of the word "rose" because the flower is shaped like a wheel according to one authority. Another possibility is that "rose" derives from the Greek *rheim*, meaning "to flow," an appellation that may refer to the belief that the fragrance of a rose flows through the air. Despite common usage the rosebush does not have thorns, which are difficult to detach from a plant, but rather prickles, which are easy to remove.

Origin and History

The rosebush traces its lineage 30 million years into the past. The Tertiary Period has yielded fossilized leaves, spines, and twigs. Because no flowers have been found, some botanists remain unsure that the fossils represent the rosebush. By one estimate, the fossil record holds 25 species of rosebush. The Chinese may have been the first to cultivate the ornamental, planting it about 2700 BCE. Around 500 BCE, Confucius wrote that the emperor grew roses in Beijing. In the first millennium CE, the Chinese crossbred roses to derive new varieties.

Europeans in turn used Chinese varieties in their breeding programs. In the 18th century, Europeans knew only a few dozen varieties. By 1815, the number had increased to 250 varieties and by 1828 to more than 2,500 cultivars.

In ancient Iran, the rosebush was so ubiquitous that the words for rose and flower were identical. From Iran, the rosebush spread to Turkey, Greece, Iraq, Syria, and Palestine and in the seventh century CE to Arabia. A fresco on Crete dating to 1500 BCE contains images of roses, possibly the species *Rosa gallica*. In the eighth century BCE, Greek poet Homer stated that mourners anointed Achilles's corpse with rose oil. In the seventh century BCE, Greek poet Sappho called the rose the "queen of flowers." About 500 BCE, the poet Pindar noted that Athenians wore wreathes of roses. In the fifth century, Greek historian Herodotus observed that King Midas's roses were more fragrant that other varieties. One authority holds that Midas's roses may have been the hybrid *Rosa* × *alba*. The fourth-century BCE Greek botanist Theophrastus was familiar with two species of rose. Herodotus and Theophrastus knew roses with 100 petals. In the 18th century, Swedish naturalist Carl Linnaeus would name a species with 100 petals *Rosa centifolia*. About 300 BCE, Greek philosopher Epicurus tended the rosebush. In antiquity, its cultivation was widespread on the Greek island of Rhodes.

The Romans were no less enthusiastic about the rosebush, growing some 50 species. In the first century, Emperor Nero lavished roses on his guests. For just one banquet he spent millions of sesterces, worth hundreds of thousands of dollars today, on roses. Later emperors were equally prodigal. In the third century, Emperor Heliogabalus ordered so many rose petals to be dropped from the ceiling of his palace that they covered some of his guests, suffocating them. So strong was the demand for roses that horticulturists cultivated them at the expense of food. About 25 miles south of Naples, Paestum emerged as the center of rose culture. Another important site of rose cultivation was Praenesta (modern Palestrina), 19 miles southeast of Rome. Gardeners grew principally *Rosa gallica*. Even with this land in production, demand surpassed supply, causing Rome to import roses from Egypt. Egyptian roses must have been durable to withstand the six-day voyage to Rome. The Egyptians painted frescos and embroidered cloth with images of roses. They put the species *Rosa richardii*, the rose of death, in tombs. It was known as the Holy Rose from Abyssinia. In the first century BCE, Roman poet Virgil praised the beauty of the roses of Paestum. According to him, these roses flowered twice per year. The people of Herculaneum and Pompeii grew roses. In Pompeii, the walls of elite homes were painted with images of roses.

Perhaps because the Romans associated the rose with decadence, its popularity diminished in the Early Middle Ages, when it was grown chiefly as a medicinal plant. Desiring the rose to be planted on a wider basis, Frankish king Charlemagne issued a decree in 794 CE urging people to cultivate the flower. This edict may not have succeeded. As late as the 13th century, German theologian Albertus Magnus listed just four species in cultivation, fewer than the Romans had known. Yet Europeans were eager for new varieties. The Crusaders brought the hybrid *Rosa* × *damascena*, named for Damascus, Syria, to Europe. Europeans considered this species the most fragrant of any rose. So impressed were the Crusaders with the territory that they called Syria the "land of the roses." Having been on crusade Thibaut IV, king of Navarra, brought a variant of *Rosa gallica* to Europe. Known as the Apothecary Rose, it was grown in Provins near Paris, France. In the 11th century, Arab physician Avicenna noted that the Syrians grew the rosebush for rose water and medicine. He was familiar with the Autumn Damask, the hybrid *Rosa* × *bifera*. In the 12th century, the Arabs cultivated this rose in Spain, though the Romans may have grown it a millennium earlier. At the end of the Middle Ages, doubled roses spread from the Near East, China, and India to Europe. Apparently viewing rose water as a cleansing agent, Saladin, sultan of Egypt and Syria, applied it to the Omar Mosque in Jerusalem upon its conquest from the Crusaders in 1187. Sultan Mohammed II likewise cleansed a mosque in Istanbul, Turkey, with rose water upon its conquest in 1453.

Thibaut's rose may have been the Red Rose of England. The 15th-century War of the Roses derived its name from the roses of the competing claimants to the English throne. The House of York took the white rose, possibly *Rosa* × *alba*, as its symbol. The House of Lancaster had the red Apothecary Rose as its symbol. The House of Tudor emerged from this war with the crown. Unifying England, the Tudors took as their symbol a small white rose atop a large red rose. England's royalty were not alone in coveting the rose. In the 19th century Empress Josephine, Napoleon Bonaparte's wife, had a garden with all the cultivars known to Europe. Her garden may have been the largest collection of roses at that time.

Mythology, Religion, and Art

According to one tradition, the rose is a symbol of love. A woman who wore a single rose on her dress declared her love for her betrothed. A single red rose marked its recipient as the beloved. A white rose symbolized passion, a yellow rose jealousy, and a pink rose youth. If a rose could kindle love, it could also enflame lust. It may not be an accident that rose and eros contain the same letters. The symbol of Aphrodite and Venus, the rose had erotic overtones. Some people find the fragrance of a rose arousing. In some cultures, the rose symbolizes the female libido. A rose garden is the place where lovers meet to consummate their passion. The Roman Feast of the Flowers, in which the rose was prominent, celebrated eroticism. A rose garden is a city's red-light district. Prostitutes in Germany once wore a rose to advertise themselves to men.

According to Roman myth Venus, in going to meet her lover Adonis, stepped on a thorn. Her blood seeped into the ground, from which grew a red rosebush.

Another myth holds that Roman god of war Mars, jealous of Adonis, killed him. From his blood sprang a rosebush. Venus's tears for her dead lover soaked the soil, yielding a white rosebush. The white rosebush became red when it blushed at the sight of Sappho's breasts.

The rose was the flower of the Greek god Dionysus and the Egyptian goddess Isis. Priests heaped rose petals on their altars. According to one myth, the gods turned mortal Lucius into a donkey for his sins. Worried that he would never regain his humanity, Lucius slept fitfully. Fortunately he did sleep, and while asleep Isis appeared to him in a dream, commanding Lucius to eat rose petals. He obeyed and was once more a man.

One tradition holds that a rose is a symbol of secrecy because one must be silent about Venus's trysts. Hebraic tradition associates the pink rose with paradise. The Turks believed that the rosebush germinated from prophet Mohammed's sweat. Muslims accordingly revere the rosebush. According to a Cherokee account, the warrior Tuswanaha returned from a hunt to find his village destroyed and his beloved Dowansa missing. The Nannshi tribe had saved her from her enemies by turning her into a white rosebush. Marauders and even Tuswanaha trampled Dowansa, causing her to beg the Nannshi to give her prickles. In the 12th century, Iranian poet Nizami told of two physicians who hated one another. One tried to poison the other without success. The other retaliated by casting a spell on a rose. His opponent took in its fragrance and fell dead.

In the Middle Ages, Christians revered the rose as a symbol of Mary. Theologians conceived of her as the new Eve and Jesus as the new Adam, placing them in the new Eden, a rose garden. Artists steeped in Christian tradition used a rose garden to symbolize paradise. Possibly inspired by the rose window in the mosque of Ibna Tulum in Cairo, Egypt, European architects added it to Gothic cathedrals. Some contemporary churches, modeled on their predecessors, retain the rose window. Absorbing the pagan association of the rose with Venus, 15th-century Italian artist Sandro Botticelli painted images of roses in *The Birth of Venus*. His *Primavera* likewise contains images of roses. Flemish and Dutch artists excelled in painting images of roses. The rose, painted in a glass vase, came to symbolize the transitoriness of life. In the 19th century, French artist Pierre-Joseph Rudouté made a reputation as a painter of roses.

Types, Species, Cultivars, and Flowering Habit

All wild roses have five petals and five sepals, excepting the species *Rosa sericea*, which has four of each. Humans have taken advantage of the fact that in some roses the stamens enlarged into petals. By selecting these roses for cultivation, gardeners have acquired roses with numerous petals. The semidouble flower has between 10 and 19 petals, the double flower totals between 20 and 39 petals, and the very double rose tallies at least 40 petals.

As its name implies, the once-flowering rose blooms one time per year. The flowers may last as long as five weeks. The spring rose flowers once per year in May. The remontant rose blooms twice per year, once in June and again in August and September, though the second flowering is less spectacular. The repeat rose may bloom several times per year. In the United States, repeat roses usually bloom twice, once in June and a second time in August. Some repeat roses flower continually between June and August. Other repeat roses flower later, making it possible, by planting cultivars with different flowering dates, to enjoy roses in bloom throughout the growing season.

The hybrid tea rose, renowned for its beauty, produces a long stem atop which is a single double rose. This rose traces its lineage to the Chinese tea rose. In 1867, French gardener Jean Baptist Guillet bred the first hybrid tea rose, the cultivar La France. Because it is hardy, gardeners plant the hybrid tea rose rather than the Chinese tea rose. In contrast to the hybrid tea rose, cluster varieties have multiple blooms per stem. The popular English rose has a very doubled flower and is expensive. As a rule, the more doubled the flower the longer it remains in bloom.

Roses are noted for their fragrance. The scent attracts pollinating insects, especially bees and bumblebees. Most intense in the morning, the fragrance may repel some fungi and insects that chew rosebushes. The scent depends on soil type, location, the time of day, and the maturity of a rosebush. In nature, about one-quarter of rose species are fragrant. Because breeders have retained primarily fragrant roses, the gardener may have the impression that all roses are scented. The genes for fragrance are recessive, so a scented rose must have a homozygous coupling of them. Because these genes are recessive, the progeny of a scented parent and an unscented parent may lack fragrance. The offspring of two fragrant parents is scented. The genes for fragrance and color appear to be on the same chromosome because lilac roses are almost always fragrant, though they may be susceptible to pathogenic fungi. Yellow roses are often fragrant, though they may not be hardy. Red roses, many people know, are often scented.

In addition to their beauty and fragrance, roses are used for oil. The hybrid *Rosa* × *damascena*, known as the Kazanlik rose, produces oil in respectable quantities. The Ukraine produces half the world's rose oil and Bulgaria yields one-quarter. Turkey and Morocco produce the rest. The yield of oil is not high. About 3,000 pounds of roses yield one pound of oil. The effort of extracting oil is worthwhile because it fetches twice the price of gold by weight.

Gardeners use the date 1867, the year of the first hybrid tea rose, to differentiate old from new varieties. Old varieties tend to be susceptible to the fungal diseases powdery mildew and spot anthracnose. In the 19th century, breeders on the island of Reunion in the Indian Ocean crossed the Kazanlik rose with a Chinese variety to yield the Bourbon rose. Some gardeners considered the variety Souvenir de la

Maimaison the most beautiful rose. The variety Louise Odier was a favorite during the Victorian era. Gardeners may choose between two types of Damask Rose. The first is an offspring of the cross between *Rosa gallica* and *Rosa phoenicia*. It blooms in summer. The second is known as the Fall Damask Rose because it blooms in summer and autumn. It is a cross between *Rosa gallica* and *Rosa moschara*. Both Damask Roses are fragrant.

The variety Rosa de Rescht is hardy, has a strong fragrance, and flowers repeatedly. Gardeners consider it a beginner's rose because of its ease of cultivation. Growing to six-and-one-half feet, *Rosa centifolia* has a strong fragrance. The monks grew it in Europe. Flemish artist favored it as a subject in their paintings. More compact is the Moss Rose, a variant of *Rosa centifolia*. *Rosa* × *alba* is known as the Alba Rose. Among the oldest garden roses, it found a home in ancient Greece and Rome. The Alba Rose is hardy and fragrant. Varieties of miniature rose, growing only one foot, may have originated in China. Derived from the Rouletti Rose, also known as Pompon de Paris, miniature roses gained popularity in the 20th century. In 1929, plant breeder Georg Abrendo imported miniature roses from the United Kingdom to Germany, breeding them in large quantities. Because they are vulnerable to fungi, miniature roses must be kept dry. Splashing rain may transfer spot anthracnose to miniature roses. They should have at least eight hours of sunlight per day to ensure that they remain dry and healthy.

In addition to flowers, many varieties of rosebush produce hips, the fruit that contains seeds. Because the rosebush must expend energy in producing hips, the second blooming will be less spectacular than the first. The gardener may wish to remove the hips from a repeat flower to ensure a vivid display of blooms throughout the growing season. People have eaten hips for centuries. Hips are high in vitamin C, containing more of the nutrient than even lemons. The gardener who wishes to eat hips should do so soon after the harvest to retain the most nutrients. The species *Rosa pendulina* and *Rosa jundzilli* are rich in vitamin C. Some roses, however, do not produce hips. The varieties Alba Meidiland and Magic Meidiland, for example, lack hips.

Since antiquity, humans have regarded the rosebush as a medicinal plant. In the first century CE, Roman encyclopedist Pliny the Elder thought it could cure 32 ailments. People used the roots, flowers, hips, and leaves for medicine. In antiquity, physicians used the rosebush to cure stomachache, headache, toothache, and pain from wounds. The rosebush could, physicians thought, cure mental illness and help insomniacs sleep. Rose petals, placed on irritated eyes and burns, reduced swelling. Renaissance physicians had additional uses for the rosebush, believing it effective in healing ulcers of the mouth. Europeans believed that the Apothecary Rose was a cure-all. The French shipped medicine derived from this rose to the rest of the world. As late as 1860, France exported six tons of rose petals to the

United States as medicine. Not everyone celebrated the rosebush's curative powers. In the Middle Ages, Arab physicians feared that the rosebush caused constipation.

Cultivation

The gardener should deeply cultivate the soil to provide space for the roots to grow. The soil should be sandy loam with 3–8 percent organic matter. Soils with too much sand will not hold water and nutrients. Organic matter helps the soil retain water, and as it decays, it nourishes the rosebush. The soil should be cultivated to a depth of 24 to 32 inches. Roses sometimes do poorly when planted where another Rosaceae species had been grown, probably because the soil has accumulated too much bacteria and too many nematodes. Soils with organic matter tend not to produce this condition. The gardener who faces this problem should remove the soil to a depth of 20 inches, inserting new soil in its place. Once the hole has been dug, the gardener may add well-rotted manure before planting. In the Northern Hemisphere, the rosebush should be planted between mid-October and mid-November. Alternatively, one may plant it in spring, as soon as the ground has thawed.

The principal nutrients of the rosebush are nitrogen, phosphorus, potassium, magnesium, and iron. Nitrogen promotes robust growth. When it is in shortage, leaves turn light green. The flowers are few and small and the canes are thin and frail. Too much nitrogen softens canes, leaving them vulnerable to frost. For this reason, one gardener cautions against applying nitrogenous fertilizers to the soil after July 1. Phosphorus is seldom deficient. When it is in shortage, the leaves are small, blue-green, and fall from the bush. The flowers form late and the hips turn bronze. Where potassium is in shortage, the gardener may apply one-and-three-quarters ounces of fertilizer per 11 square feet of soil at the end of August or the beginning of September. Where potassium is adequate, the rosebush is less susceptible to frost and to spot anthracnose. The addition of calcium carbonate, known as lime, to the soil promotes the uptake of potassium. Where magnesium is deficient, leaves yellow. Older leaves turn brown and fall from the bush. Like phosphorus, iron is rarely in shortage, though it is unavailable to the roots if the soil pH is too far below or too far above 6.5. The leaves and hips of iron-deficient rosebushes display chlorosis. Too much water in the soil impairs the roots' ability to absorb iron. Where iron is deficient, the gardener may add Sequestren or Fertrilon, iron-rich fertilizers, to the soil. The gardener who wishes to apply an all-purpose fertilizer to the rosebush may choose one in a 20:20:20 ratio of nitrogen to phosphorus to potassium. The gardener need apply only one-and-three-quarters to three ounces of fertilizer per 11 square feet of soil. An inorganic fertilizer should not be sprayed on young bushes because it may add too many salts to the soil, injuring roots.

Diseases and Pests

Pathogenic fungi may threaten rosebushes. Powdery mildew appears as a white powder on the leaves, calyx, and canes. Fungi spread when the humidity exceeds 90 percent. Heavy rains may suppress the disease, but they may further the spread of spot anthracnose. The rosebush that receives too much nitrogen may be vulnerable to powdery mildew. The gardener who wishes to avoid this disease should plant a rosebush where air circulates. Because leaves may harbor the fungi, the gardener should not compost infected leaves. The fungicides triadimefom, triforim, and thiophenate methyl may be effective against powdery mildew.

Downy mildew, another fungal disease, is a white-gray mold on the underside of leaves. Infected leaves develop dark spots, wither, and fall from the rosebush. Its symptoms similar to those of spot anthracnose, the two diseases are difficult to differentiate. Young rose leaves are especially vulnerable to downy mildew, which is prevalent in late summer and autumn. The cool nights of fall allow water to condense on rosebushes, providing an environment for fungi. The gardener should cut off infected leaves and canes, taking care not to compost these materials. Fungicides with copper, manganese, or zinc may be effective.

Spot anthracnose manifests as star-shaped violet-brown or black spots on rose leaves or canes. Infected leaves fall from the bush. The disease weakens a rosebush, leaving it less hardy. Infections begin at the bottom of a rosebush and progress upward. Although the disease may occur as early as June, it usually attacks rosebushes in late summer and autumn. To avoid the disease a rosebush should be planted in an area with plenty of sunshine and air circulation. The leaves should not remain wet for several hours because spores germinate rapidly in damp conditions. Rose rust, a fourth fungal disease, appears as an orange powder on rose leaves. In autumn, the powder is dark brown. Fungi spread in humid weather. Leaves should not remain wet because of the danger of an infection. Fungicides may be effective.

Among pests, aphids suck sap from rosebushes. Roses that receive too much nitrogen or too little water are vulnerable to aphids. Insecticide soap or a solution with onion or garlic may be effective against aphids. The Japanese beetle eats foliage and flowers. Numerous in the eastern United States, the beetle is active from midsummer to autumn. The gardener may spray an insecticide to kill beetles. The red spider mite sucks sap from the underside of leaves. Damaged leaves may fall from a bush. Infecting roses as early as May, the mite thrives in dry, hot weather. The rose leaf roller wasp deposits eggs on the edge of leaves, causing them to curl. The wasp infests rosebushes in May. Larvae feed on leaves until July, when they fall from a rosebush to pupate in the soil. The gardener may cut off infested leaves and use an insecticide to kill wasps.

Christopher Cumo

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Rosemary

Rosemary (*Rosmarinus officinalis*), also known as garden rosemary, is native to the Mediterranean Basin. A member of the mint family (Lamiaceae), it is an evergreen shrub related to basil, marjoram, and oregano. It is usually found growing by the ocean. The name "rosemary" derives from the Latin word *rosmarinus*, which is a compound of "dew" (*ros*) and "sea" (*marinus*), meaning "dew of the sea" because in many locations it needs no other water than the humidity carried by the sea breeze to live. *Rosmarinus officinalis* is one of only two species in the genus *Rosmarinus*. The other species is the closely related but less commercially viable *Rosmarinus eriocalyx*, of the Maghreb of Africa and Iberia. Since Swedish naturalist Carl Linnaeus named rosemary in the 18th century, it has not undergone much taxonomical change.

History

Rosemary is an herb with a long history. In fact, it is one of the oldest recorded herbs in the history of botany. References to rosemary were found written in on stone tablets dating from the fifth millennium BCE. First-century CE Greek physician Dioscorides recommended it for its "warming faculty." Ancient Greek students wore garlands of rosemary to improve their memory. Rosemary became associated in ancient Rome with Venus, the goddess of love who was supposed to have sprung from the sea foam. Because of that legend, it became the symbol

Rosemary (Photoeuphoria/Dreamstime.com)

of fidelity in love and was used at weddings and funerals. In place of more costly incense, the ancients used rosemary in their religious ceremonies. An old French name for it was *incensier.*

Christians called rosemary the holy herb and associated it with Mary, who, according to Spanish legend, draped her cloak over a rosemary bush on the Holy Family's flight to Egypt, turning the color of the blossoms from white to blue. In addition rosemary, along with juniper and thyme, was burned in medieval hospitals as an antiseptic. It was widely grown in kitchen gardens in England at that time; an old folk saying was that "where rosemary flourishes, the woman rules."

Rosemary was the main ingredient of Hungary water, prepared for the Queen of Hungary to "renovate vitality of paralyzed limbs" and to treat gout. It was used externally and prepared by mixing fresh rosemary tops into spirits of wine. In English dramatist William Shakespeare's *Hamlet*, Ophelia says, "There's rosemary, that's for remembrance." The colonists brought rosemary to the United States. The herb was highly prized in the first settlements because it could be stored during the cold New England winters. Don Quixote (chap. 17, vol. 1) mixes it in his recipe of the miraculous balm of Fierabras with revolting results.

Rosemary has been used as a symbol for remembrance during weddings, war commemorations, and funerals in Europe and Australia. In addition, mourners place it on graves as a symbol of remembrance for the dead. Especially in the Middle Ages, rosemary was associated with wedding ceremonies. The bride wore a rosemary headpiece, and the groom and wedding guests wore a sprig of rosemary. From this association with weddings, rosemary evolved into a love charm. New couples planted a branch of rosemary on their wedding day. If the branch grew, it was a good omen for the union and family.

Rosemary was also stuffed into poppets (cloth dolls) in order to attract a lover or attract curative vibrations for illness. It was believed that placing a sprig of rosemary under a pillow before sleep would repel nightmares, and if placed outside the home it would repel witches. Rosemary leaves were burned in ancient Greece in order to protect the user from illnesses and evil.

Cultivation

Rosemary evolved in a Mediterranean climate. Since it is attractive and tolerates some degree of drought, it is used in landscaping. It is considered easy to grow for beginner gardeners and is pest resistant. Rosemary grows on friable loam soil with good drainage in an open sunny location. However, it will not withstand waterlogged soil, and some varieties may be susceptible to frost. It grows best in neutral to alkaline conditions with a soil pH of 7 to 7.8. The soil may have average fertility.

Pharmacology

Rosemary is a common household plant grown in many parts of the world. It is used for flavoring foods and beverages. It is also used in cosmetics; in folk medicine it is used as an antispasmodic in renal colic and dysmenorrhoea. Other medical uses include the treatment of respiratory disorders and the stimulation of hair growth. In traditional medicine, rosemary is used to treat different diseases including depression, gout, insomnia, and arthritis.

Rosemary oil was first extracted about 1330 CE by Majorcan writer and philosopher Raymundus Lullus. Rosemary leaves contain the volatile oil *Rosmarini aetheroleum* with *a*- and *ß*-pinene, cineole, borneol, and camphor. The extract of rosemary relaxes the smooth muscles of the trachea and intestine, and has choleretic, hepatoprotective, and antitumerogenic activity. The most important constituents of rosemary are caffeic acid and its derivatives, such as rosmarinic acid. Both have antioxidant properties. Antioxidant properties of rosemary are important in the management of aging and ultraviolet photo-aging.

Relatively large-scale production of rosmarinic acid can be obtained from the cell culture of *Coleus blumei* when supplied with phenylalanine and tyrosine. Rosmarinic acid is well absorbed by the gastrointestinal tract and through the skin. It increases the production of prostaglandin E2 and reduces the production of leukotriene B4 in human leucocytes, and inhibits the complement system of immunity. The antimicrobial effects of rosemary essential oil can be attributed to the monoterpens combination and in particular α-Pinene. In addition, rosemary oil is effective against opportunistic infections like *Cryptococcus neoformans*.

Rosemary and its constituents, especially caffeic acid derivatives such as rosmarinic acid, may have a therapeutic potential in the treatment or prevention of bronchial asthma, spasmogenic disorders, peptic ulcer, inflammatory diseases, hepatotoxicity, atherosclerosis, ischaemic heart disease, cataract, cancer, and poor sperm motility. Rosemary oil as well as its bornyl acetate and cineole are antispasmodic on smooth muscle and cardiac muscle. In smooth muscle, borneol is considered the most active, by antagonizing acetylcholine. The antispasmodic action of rosemary as preceded by contractile action, due to pinenes, which are spasmogenic on smooth muscle, inactive on cardiac muscle. Rosemary oil relaxes the Oddi's sphincter of small intestine contracted by morphine.

Rosemary in Culinary and Other Uses

Rosemary remains one of the most popular herbs. It is used in a variety of dishes such as soups, salads, vegetables, fish, and lamb. Rosemary is a staple ingredient for those on a low-sodium diet. Rosemary is low not only in sodium but also in cholesterol. It is a good source of vitamin A, thiamin, magnesium, fiber, vitamin C, vitamin B6, folic acid, calcium, iron, and manganese.

The tender leaves, stems, and flowers are used for flavoring stews, fish, and meat sauces but are not widely popular in the United States. In France large quantities, both cultivated and wild, are used for distilling the oil of rosemary, a colorless or yellowish liquid suggesting camphor, but even more pleasant. Rosemary extract was used in toilettes until the last century as an antiodor and antibacterial. It is also one of the ingredients used in the preparation of eau de cologne.

Charalampos Dokos

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Rubber

Also known as white gold, rubber is a tree of the tropics. The native Omagua of Brazil called rubber, in the family Euphorbiaceae, *heve*, a word at the root of rubber's scientific name, *Hevea brasiliensis*. Scientist and adventurer Charles Marie

Rubber trees (Toa555/Dreamstime.com)

de la Condeminus named the genus *Hevea* in 1736, and German botanist Konrad Wildener coined the species name in 1801. Condeminus also coined the term "latex," meaning "milk," for the secretion of the rubber tree. The indigenous Mainas of South America called rubber the "tree that weeps" because of its liquid secretion. From the phrase derives the French *caoutchous* for rubber and the Spanish *caucho*. An early use of rubber in Europe was to rub out pencil marks, leading British chemist Joseph Priestly in 1770 to coin the term "rubber."

The rubber tree lives about 30 years, though production declines with age. Although one does not think of rubber as food, the seeds, if boiled to break down toxins, are edible and may be fed to humans and livestock. Nourishing, the seed is 30 percent protein, an amount that compares favorably with the protein content of grains. People in the tropics also use rubber seeds as fish bait. Although *Hevea brasiliensis* is the primary source of natural rubber, rubber may also be obtained from the Castille tree, *Manihot glasiovii* (a relative of cassava), the Bombay rubber plant, and the India rubber plant. In the developing world, policy makers debate whether rubber can provide small farmers with a living wage. If it cannot, farmers will cut down the trees and put the land to other uses. In parts of Brazil, ranchers have cut down rubber trees so their cattle may graze on grass. Since the 1980s, manufacturers have used wood from rubber trees to make furniture. So brisk is the demand for furniture that India, Malaysia, Sri Lanka, and Thailand are short of rubber wood.

The Basics

The progenitor of rubber lived 60 million years ago in what is today Germany. Because rubber grows only in the tropics, Germany must then have been warm. Over the millennia, rubber migrated to South America. It is indigenous to the Amazon, with most wild trees having taken root just south of the equator. Today, farmers cultivate rubber chiefly between 10° north and 10° south with the most intensive cultivation between 6° north and 6° south. Despite this narrow range of latitudes, Bangladesh grows rubber as far north as 24°, and Brazil cultivates rubber as far south as 21°. In Bangladesh, temperatures can drop to 64°F between December and February, a temperature that slows the growth of rubber. Because of cool weather, rubber trees in Bangladesh require seven years before farmers can tap them, whereas trees in warmer Malaysia need only five years to mature. The average temperature in this belt is 82°F. Rubber requires abundant rainfall, between 80 and 160 inches per year. Trees produce the best rubber when rainfall is uniform throughout the year. Rain falls 100 to 150 days per year in the tropics where rubber is grown. Rubber grows best in acidic soils with a pH between 3.8 and 6. The ideal pH occupies a more narrow range between 4 and 5.5. Rubber is usually grown below 660 feet. Higher elevations are cooler and rubber will not grow above 2,640 feet. Rubber trees grow best when humidity ranges between 65 and 90 percent. Rubber requires 1,800 to 2,800 hours of sunlight per year. The tree grows better on a slight slope than on flat terrain because water drains better on a slope. Trees yield 24 percent more rubber in deep soils than in shallow ground. Enterprising farmers plant legumes between rows of trees to fix nitrogen in the soil.

Although rubber trees do best in high humidity, this environment supports large populations of pathogens. The most serious disease of rubber is South American Leaf Blight. As the name suggests, the blight is native to South America. The fungus that causes this disease feeds on rubber leaves, defoliating trees. Unable to photosynthesize without leaves, the trees die. So severe is the blight that it restricts rubber trees to a narrow band of land in the Amazon. The blight has frustrated attempts to grow rubber outside the Amazon. In 1934, American automaker Henry Ford, intent on deriving his own source of rubber, bought 1,000 square miles of land in Brazil, planting 4 million trees. Naming the settlement Fordlandia, Ford intended it to be a plantation and model city but blight wiped out his trees. A second attempt, Fordlandia 2, met the same fate.

Rubber is vulnerable to other diseases that thrive in the tropics. Powdery mildew afflicts trees in Sri Lanka, Vietnam, and Malaysia. Black stripe is a disease of rubber trees in India and Central America. The diseases *Colletotrichum gloeosporioides*, *Oiduim heveae*, *Phytophthora botryosa*, and *Phytophthora mendii* attack young leaves. Phytophthora botryose is widespread in Malaysia and

Thailand. Trees in India and Sri Lanka suffer from *Phytophthora mendii*. Both species of *Phytophthora* afflict trees in Brazil. The disease *Dreschlera hevea* is widespread in Asia, West Africa, and Central America. Target leaf spot and black crust assail trees in South and Central America. Pink disease infects trees in Africa, the Americas, and Asia. Infestations are severe in wet weather. Moldy rot and white root disease afflict trees in Malaysia. In addition to diseases, rubber is vulnerable to termites and cockchafers. Feeding on the wood, termites kill trees when unchecked. Cockchafers weaken trees by feeding on roots. Affected trees may uproot in storms.

Rubber is vulnerable to diseases and pests because it is genetically uniform. A disease or pest that kills one tree is likely to kill many more. Rubber is genetically uniform because only a small number of genotypes contributed to the current population. Aware of the degree of homogeneity, research institutes have labored to increase diversity. In the 1970s, the Rubber Research Institute of Malaysia (RRI) collected 330 seedlings from Belem, Brazil, to increase its genetic reserve. In 1981, the International Rubber Research and Development Board collected 8,900 seedlings in Brazil. In 1995, the RRI and the Forest Research Institute of Malaysia, in what may have been the largest effort to date, collected more than 400,000 seedlings in Brazil.

The narrow genetic base of rubber has led research institutes to create gene banks with a wealth of genotypes. Because rubber seeds will not keep, these gene banks are not seed collections but rather forests of trees. This type of gene bank is expensive to create and maintain because a research institute must amass lots of land on which to grow the trees. Land far from the city is cheapest, but it is difficult to entice scientists to take a job in the hinterland. Brazil's gene bank has 2 million square miles of land and 1,300 genotypes. In 1988, Brazil halted its collection of genotypes because officials could not agree on where to plant new trees. Malaysia also has a large gene bank, having derived its trees from Brazil. China, India, Indonesia, parts of Africa, Thailand, Costa Rica, Guatemala, and Panama have also established gene banks.

These research institutes have worked to breed trees with high yield and disease resistance. These efforts are nearly a century old. In 1919, the Dutch created the first breeding program in Indonesia. In 1928, scientist L. E. Morris inaugurated a breeding program in Malaysia. By 1980, 11 countries had a national research institute and private firms had established six research stations. Presently, the RRI funds three-quarters of rubber research. Some 12 countries operate research programs. In addition to yield and disease resistance, desiderata include adaptation to a range of soils, drought tolerance, short stature to minimize storm damage, soft bark that can be more easily tapped, and tolerance of cool weather. Drought tolerance is important in China, India, and Vietnam. Adaptation to cool weather may become an important trait as farmers seek to grow rubber at higher latitudes in China and Vietnam. Several breeding programs seek to incorporate genes from wild species into cultivated trees. Scientists have identified wild species with genes that code for resistance to leaf blight and other diseases, but breeding programs have had limited success incorporating these genes into cultivated varieties of trees. Crosses between blight-resistant wild species and susceptible cultivars have yielded blight-resistant progeny, but yields have not been high.

The breeding of high-yielding trees has benefited growers. Between 1910 and the 1940s, rubber output in Southeast Asia increased fivefold. In the 1970s, some trees in Asia yielded hundreds of pounds of rubber per acre, 17 times greater than production in 1910. Between 1955 and 1988, new high-yielding varieties increased production of rubber per acre per year. Few crops have witnessed such gains in yield.

Rubber and Its Uses

In the early days of rubber, demand was small and its uses were limited. Among the first uses of rubber was recreation. The Aztecs and the natives of the Caribbean made rubber balls, with which they played games. Because the rubber tree is not native to the Caribbean, islanders must have traded for it. In 1492, Christopher Columbus observed the natives of Hispaniola (today the island of Haiti and the Dominican Republic) playing with rubber balls. In 1519, Spanish conquistador Hernando Cortés witnessed a ball game at Tenoctitlan. In 1530, writer Pietro d'Anghiera published the first account of the rubber tree. In 1615, Spanish writer Torquemada described the making of rubber shoes and bottles in South America. In 1653, Spanish priest Bernabe Cobo coated socks with rubber to create rubber stockings, which protected people's legs while they walked through jungle. In the 18th and 19th centuries, the Omagua made rubber bottles, boots, and elastic bands. In Africa the indigenes, tapping their own rubber plants, used rubber to fasten arrowheads to shafts.

The demand for rubber in Europe was initially small. In 1523, Spanish priest Bartolemé de las Casas asserted that Columbus had brought rubber balls to Spain. By then, Columbus was dead and so could not have confirmed this story. None of his letter, mention rubber, leading one to wonder whether las Casas was wrong. Few accounts from the 16th and 17th centuries mention rubber, though by the 18th century it had become an important item. In 1755, the king of Portugal ordered rubber boots from a Paris manufacturer. In 1769, Prussian king Frederick the Great purchased a pair of rubber riding boots. By then, rubber was not just for royalty. In 1770, a one-half-inch cube of rubber for erasing pencil marks sold for three shillings in Great Britain. More important, the Industrial Revolution increased the demand for rubber, which was used to make the gaskets on steam engines.

If it was not yet a household good, rubber had nonetheless become an item of commerce by the 19th century. By 1820, the United States imported hundreds of thousands of pairs of rubber shoes per year. In 1832, the Roxbury India Rubber Company, seeking to capitalize on demand, began making rubber shoes in the United States. By 1839, the United States imported millions of rubber shoes per year, leading one to suspect that Roxbury met only a fraction of the demand for them. That year American inventor Charles Goodyear took a decisive step in the evolution of rubber. Almost by accident, he invented the process of vulcanization, a method of heat-treating rubber to make it durable and able to withstand extremes in temperature without a loss in consistency.

From South America to Asia and Africa

Demand for rubber now quickened. The rubber boom initially centered in South America, especially Brazil. By 1853, tens of thousands of people collected rubber in Belem. Methods were primitive. Men penetrated the forest, living off the land as they tapped trees. Seeking to impose order on this system, men with money carved out rubber plantations in the jungle. The Vanderbilts and Morgans invested in rubber estates in Bolivia. One plantation owner amassed several million hectares of rubber trees and commanded a labor force of tens of thousands of workers. Brazil took the early lead in producing rubber. In the 1850s, Brazil's output of rubber was thousands of tons per year. The figure rose to tens of thousands of tons. The latter amount equaled the value of Brazil's coffee exports so that rubber and coffee totaled the vast majority of the country's exports. By 1870, Britain imported hundreds of thousands of tons or rubber per year from the Amazon. By 1890, hundreds of thousands of men worked the rubber estates of Purus valley Bolivia. Those who profited from rubber outdid one another in building ornate mansions. They transformed the jungle into cities with electricity, roads, and public transportation. The wealthiest rubber planters often diversified by growing sugarcane and raising cattle.

By creating its own plantations, the United Kingdom could profit from the rubber trade. If it could plant rubber in its tropical colonies, the United Kingdom could wrest control of the rubber trade from the Amazon. As early as 1851, Scottish explorer Richard Spruce made the first attempt to collect rubber seeds but they turned rancid, leading him to give up the idea. In the 1860s, Brazilian planter Martins da Silva Coutinho and James Collins, curator of the Pharmaceutical Society museum, remarked that rubber could in principle be grown outside South America. In 1865, naval officer Clement Mikham urged the United Kingdom to establish plantations in India to meet the demand for rubber. In 1871, British adventurer Henry Wickham, writing about his exploits in Brazil, suggested that rubber seeds might be planted in the United Kingdom's tropical holdings. This suggestion intrigued Joseph Hooker, curator of the Royal Botanic

Garden at Kew, who agreed in 1873 to fund Wickham's search for rubber seeds in Brazil. Brazilian authorities forbade the export of rubber seeds, fearing competition for the Old World should it establish rubber plantations. The prohibition deterred no one. In 1873 Charles Farris, a friend of Collins, delivered thousands of seeds to London. The British East India Company bought them but only a few germinated. In 1875, collector Ricardo Chavez sold the company hundreds of pounds of seeds. It shipped them to India to no avail. None germinated. The problem lay with rubber, whose seeds, as we have seen, will not keep. Having high sugar content, rubber seeds ferment in storage. Wickham had better success because of the volume of his collection. He delivered tens of thousands of seeds to Hooker in 1876. Of these, thousands germinated. Because Wickham had collected his seeds from just a few trees, the genetic base of Old World rubber was astonishingly narrow.

Hooker acted quickly to found a rubber dynasty in British Asia. He sent thousands of seedlings to Sri Lanka and in 1877 an additional shipment of seedlings to the Singapore Botanic Garden. From these seedlings derived the plantations of Southeast Asia. In the 19th century, Africa emerged as a secondary center of rubber. On the pretext of ending slavery in Africa, King Ludwig II of Belgium took the Congo as his own property. Valuing money more than lives, he established rubber plantations in the most ruthless manner. His agents kidnapped women and children, requiring husbands and fathers to pay rubber as ransom. While the men labored to extract rubber from the trees, agents raped the women. The men returned home to find their wives and children dead from disease or starvation. Agents executed men who did not collect enough rubber, taking heads and hands as trophies. In the late 19th and early 20th centuries, millions of Congolese died at the hands of Belgian officials. These atrocities provided Polish novelist Joseph Conrad with the material for his novella *Heart of Darkness*. Brutal, Ludwig's methods yielded results.

The expansion of rubber in Asia and Africa satisfied rising demand in Europe and the United States. In 1885, entrepreneur John Dunlop invented the pneumatic tire, which provided a more comfortable ride than the solid rubber tire. Manufacturers fitted the pneumatic tire on the bicycle, for which demand increased during the bicycle craze of the 1890s. For example, the French witnessed an increase in the number of bicycles into the 20th century. Whereas France had hundreds of thousands of bicycles in 1894, the number swelled to several million in 1914. The automobile stimulated even greater demand for rubber. In the 20th century, rubber went to make automobile and airplane tires. Today, the vast majority of rubber is used to make tires. Presently, not all rubber comes from trees. Since the 1950s, chemists and engineers have synthesized rubber from petroleum. In 1959, the production of synthetic rubber surpassed the output of natural rubber. In 1960, farmers harvested millions of tons of rubber from trees and manufacturers made a slightly larger tonnage of synthetic rubber. In 1980, the ratio was more than two to one in favor of synthetic tires. Thereafter natural rubber staged a comeback. As petroleum prices have increased, so has the cost of deriving synthetic rubber, making natural rubber attractive again. The demand for natural rubber has increased as automakers have made radial tires standard on some models. Radial tires are nearly half natural rubber. Truck and airplane tires also have a large proportion of natural rubber.

Natural rubber has emerged as a green alternative to synthetic rubber. Rubber estates do more than secrete latex. They are forests that sequester carbon dioxide, a greenhouse gas. By one estimate, the world's billions of rubber trees absorb tens of millions of tons of carbon in the form of carbon dioxide per year. By contrast, the manufacture of synthetic rubber depletes the world's store of petroleum, making direr the energy crisis. Natural rubber is not, of course, perfect. Plantation owners have denuded forests so they could establish their own forests of rubber trees. The destruction of forest to replant a different type of forest may provide no net environmental benefit. Small growers may farm more responsibly by growing rubber along with other tree species in a system called "jungle rubber." Unlike uniform stands of rubber trees in plantations, jungle rubber preserves a diversity of tree species. Evidence suggested that jungle rubber, because it spaces rubber trees farther apart than do traditional plantations, may be less vulnerable to epidemics.

Asia

From the Singapore Botanic Garden, trees were sent to Myanmar and Indonesia. In 1895, the British planted rubber seedlings in Malaysia. In the 1890s, coffee rust swept through the coffee estates of Sri Lanka and Malaysia, forcing planters to choose an alternate crop. Some planted tea but others grew rubber, leading to a rapid expansion of acreage. By 1900, the plantations in Malaysia had grown so swiftly that planters, unable to satisfy the demand for labor with local workers, imported Chinese laborers. By 1908, Malaysia had millions of rubber trees. Because Malaysian rubber was abundant, it was cheap, costing only one-fifth the price of Brazilian rubber. By then, Malaysia produced nine times more rubber than did Brazil. By 1912, Malaysia and Sumatra produced thousands of tons of rubber. Just two years later, output reached tens of thousands of tons.

Rubber claims several million acres in Southeast Asia, where small farmers produce two-thirds of the region's rubber. In Thailand, small farmers produce virtually all the nation's rubber. Rubber is central to the economies of Malaysia, Indonesia, Thailand, and Sri Lanka. Rubber is also an important crop in China, which, like Thailand, is expanding acreage. So important is rubber production in Asia that the United States, losing access to Asian rubber during World War II, sought to create its own plantations. As early as 1897, President William McKinley had urged that the United States establish its own rubber estates, presumably in the Philippines and Hawaii. In 1943 and 1944, botanist

Russel J. Seibert collected hundreds seedlings from Brazil and botanist Richard Evans Schultz collected hundreds more in Colombia and Brazil, but these collections did not revolutionize rubber production. At war's end, trade resumed with Asia and interest in the United States having its own source of rubber evaporated.

Jungle rubber is the principal system of cultivation among Indonesia's small farmers. Rubber employs millions of people, many of them small farmers, in Indonesia. In Indonesia, small farmers produce the vast majority of the nation's rubber and hold the vast majority of rubber land. In addition to rubber, small farmers grow rice for their own needs. In many instances, they do not grow enough rice for subsistence and must use part of their income from rubber to buy rice. Small farmers often take second jobs in oil palm plantations and gold mines to increase income, particularly when they work on old, unproductive rubber farms. Some work as many as 10 months per year off farm, though they earn only a small percentage of their income from a second job. Rubber remains the primary source of income.

Yet rubber faces competition from oil palm in Indonesia. Some farmers grow both rubber and oil palm. Others have converted from rubber to oil palm. Northern Sumatra was once Indonesia's rubber belt but has since the 1990s transitioned to oil palm, leaving southern Sumatra as the heart of rubber production. Rubber has also suffered from calamity. In 1997 and 1998, fire engulfed rubber trees in Sumatra and Kalimantan. At the same times small farmers have felt the squeeze from low rubber prices and the high price of food and consumer goods. These years form part of a long-term trend in which rubber incomes have declined since 1985 as rubber prices have fallen. The period between 1994 and 1996 offered farmers hope as China increased its consumption of rubber and car sales surged in the United States. Since 1996, however, prices resumed their downward trend as the supply of rubber has expanded faster than demand. In addition to declining prices, rubber has fallen victim to ethnic conflict in Indonesia. In 1999, the Dayak and Madura squared off against one another in West Kalimantan. Many of the Madura fled the region, leaving rubber farms short of labor. Without sufficient labor rubber output fell substantially in West Kalimantan in 1999.

Christopher Cumo

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Rudbeckia. *See* Black-Eyed Susan

Rue

In the Rutacea family, rue (*Ruta graveolens*) is a perennial evergreen shrub grown in gardens and was once highly esteemed, especially among women. The ramified stem reaches to around 20 inches high. The bluish-green leaves are bipinnate alternate with a feathery appearance, and the small fringed flowers are yellow, with four or five petals. The fruit is a four-lobed capsule, which contains numerous seeds. The plant has a characteristic strong and for many people unpleasant smell; its taste is hot and bitter. Sensitive persons can get allergic symptoms from the plant. Rue is cultivated as a household spice and remedy and for economic purposes, because of its volatile oil, in many parts of the world. It is increasingly popular as an ornamental plant, especially because of its nicely colored foliage, but also for its tolerance of hot and dry soil conditions.

The species has been used in various rituals, and rue has therefore also a symbolic significance reflected in European folk songs, old quotes, and sayings. It has been important as a home remedy and love potion for women globally. Rue plays for instance an important role in Lithuanian traditional folklore and contemporary popular culture, and is nowadays considered as a national flower of that country.

Rue is derived from the ancient Greek name of the plant, *rhyte*, with an unclear meaning. The plant actually has similar vernacular names derived from the same root in many languages, for instance *Raute* in German, *ruit* in Dutch, *rude* in Danish, *arruda* in Portuguese, *ruda* in Catalan and Castilian Spanish, *rue* in French, *routa* in Czech, *rūta* in Lithuanian, *arroda* in Basque, and interestingly enough *aruda* in Sinhala, probably indicating that it was brought there by European colonists or traders. In southwest and central Asia, it is otherwise known under its Persian name *sadab* rendered as *sedef otu* in Turkish, *sädo* in Azeri, *sädäp otu* in Tatar, *suzap* in Kazak and Uighur, and *sudab* in Kurdish.

Other closely related taxa are also used for the same purposes as rue, but they are seldom cultivated. In particular the fringe rue, *Ruta chalapensis*, is hard to distinguish from *Ruta graveolens*. When harvesting rue, caution must be taken against getting the plant juice on the skin, because the oil can cause blistering.

History as a Cultivated Plant

The species appears to have originated in the eastern Mediterranean region, and it still grows wild from the Balkan Peninsula and reaches eastward to the Crimea. It has also escaped from gardens and become naturalized in many areas, for instance in southwestern Europe and eastern North America and also in Texas and California.

Common rue was already being cultivated during antiquity. The plant is mentioned in the Bible: "But woe unto you, Pharisees! For ye tithe mint and rue and all manner of herbs" (Luke 11:42). The classical authors recommended rue to heal the stings of bees, wasps, and scorpions. Rue is mentioned by Greek and Roman writers like Greek physician Hippocrates (460–370 BCE), first-century CE Greek physician Dioscorides, and first-century CE Roman encyclopedist Pliny the Elder.

The Romans brought it to northwestern Europe. Carbonized seeds have been found in a Roman site at Dutch Valkenburg. It probably came farther north with the monastic garden culture. It is referred to as "rutam" in the list of herbs in *Capitulare de villis vel curtis imperii* from 812, an edict decreed by Frankish king Charlemagne. Remnants of the plant are known in archaeological material from 12th- to 14th-century Scandinavia. It is also mentioned in medieval medical literature, and more frequently from the early 17th century. It is sometimes said that it was introduced into England as late as 1562, when it was first mentioned by physician William Turner in his *A New Herball*. The plant was referred to as "herb of grace," the common name of the species at that time, on several occasions by English playwright William Shakespeare (1564–1616). It has been a common garden plant in many European rustic gardens until today.

Nowadays, it is cultivated in many parts of the world and still plays an important role as a spice and folk remedy over a wide area that includes South Asia, Taiwan, the Middle East, Ethiopia, South Africa, the United Kingdom, Scandinavia, the Baltic states, North America, Central America, and South America.

Medicinal Herb

Common rue contains essential oil, alkaloids, rutine, resin, and bitter substances. In premodern Western scholarly medicine, it has been used as a treatment for many disorders and diseases, including epilepsy, ergot poisoning, flatulent colic (in hysterical females), headaches, insomnia, psoriasis, and vermifuge. In external application, it was used for headache, rheumatism, and warts, and as an ointment. It has also been recommended for bad eyes. Pliny the Elder in 69 CE prescribed rue for the "clouds in the eyes," but as physician and botanical writer Robert John Thornton wrote in his *A New Family Herbal* in 1814: "The author of this work has several times, with himself and others, cured the most violent inflammations of the eyes by the vapour of boiling water alone: so much for the probability of this practice with rue."

Its usages in folk medicine are many. The whole plant is used. Rue tea was recommended in Britain for improving the appetite and for the relief of coughs. The juice of the plant has been applied for earache in Mexico, while the Diegueño Indians or Kumeyaay in Southern California used to put a sprig in the ear for the same disorder. In South America, rue is used to treat migraine. The Afro-Creoles of Trinidad are treating rheumatism with it, while in Jordan and Sri Lankan local folk medicine rue has been used as a diuretic. In Taiwan, it is used in treating palpitation and heart protection. In Spain, Mexico, the Caribbean, and many other parts of the world, the plant is supposed to ease childbirth and relieve menstrual pain.

Dioscorides warned in the first century that rue "kills the creature in the womb." An infusion of the plant has been used in many parts of the world to induce abortion. Rue was actually known as *herbe à la belle fille* ("herb of a beautiful girl") in the vicinity of Saint Lubin during the 19th century because of this usage. It has also been used as a contraceptive. The plant contains pilocarpine, a substance given to horses in order to induce abortion.

Rue has also been used for ethnoveterinary purposes in order to treat disorders in horses, swine and cattle. Spanish farmers still make use of rue to ease delivery and afterbirth expulsion in goats, sheep, and cows. Country people in the British Isles used the leaves to cure croup in poultry. Its popularity as a folk remedy has decreased in recent years because of its phototoxity and its being an abortifecant.

Spice and Food Plant

Ancient Roman recipes, as given in *Apicius*, a cookbook compiled in the late fourth or early fifth century CE, contains several dishes with rue as a spice. This plant is still used in Mediterranean cooking. In other parts of Europe, it is commonly used in vinegars and sometimes also to flavor beer. It has also been utilized as a spice in mutton, egg dishes, and bread. Essential oil of rue is used not only in food but also in perfume industries.

Locally made grappa, the fragrant grape-based alcoholic beverage made in Italy and Istria, is sometimes flavored with rue. Ethiopian cuisine uses both rue leaves and the dried berries extensively. The fresh leaves are also used to enrich the taste of Ethiopian coffee (also *Ruta chalapensis* is used for the same purpose). It is also used to flavor local milk products, such as cheese and yogurt. The local name for rue in Amharic is *tena addam*, which can be translated as "Health for Adam," that is, health for humankind.

Other Uses

According to a record from Herefordshire rendered by British antiquary Thomas Dudley Fosbroke in his *Compantion to the Wye Tour* (1821), nosegays of rue, "enclosing a piece of half-eaten bread and butter, were dropt in the church path and porch by a deserted woman, to denote an unhappy wedding." In Austria and elsewhere in German-speaking areas, a corpse was covered with rue branches, hence its folk name *Totenkraut*, "plant of death."

Rue has been used as a repellent to keep noxious insects and other dangerous organisms away. Sprigs of rue used to be placed on judges' benches in English courts of justice in the 17th and 18th centuries. The reason was to protect against epidemic typhus infection ("jail-fever"), which could be brought into the courtroom by the prisoners. This practice is also known from New England. The renowned *Four Thives Vinegar*, which was believed to protect against plague, is said to contain rue, among other plants.

Bundles of rue were hung in the roof of the kitchens in Central Europe in order to keep ants away. In southwestern Europe, the bundles were said to protect against the evil eye. Rue water has been recommended to be sprinkled in houses to get rid of fleas. As an insect repellent, it is also planted between other ornamental plants in order to protect them from beetles and other bugs. The plant has also been used in hospitals in order to get rid of bad odors. Dogs and cats are supposed to dislike the odor of the plant.

It is also a widespread notion in Europe, North Africa, and Asia that the sharp odor of the leaves promotes sexual desire in women. Maybe this is the reason why it is a popular garden plant in many areas. It is also probably why Shakespeare in *Hamlet* let Ophelia give the lovesick queen a rue and address her: "There's rue for you; and here's some for me: we may call it herb-grace o' Sundays: O you must wear your rue with a difference."

Rue is apparently a useful plant that should be planted in sunny open places. The species is easily propagated through division, tip cuttings, and seeds. Rue has a long history as a cultivated plant and is likely to be found in human care in the future.

Ingvar Svanberg

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Rutabaga

Rutabaga, also known by the names root bag, Swede, and yellow turnip, is a cross between the turnip and wild cabbage. An important member of the Brassicaceae or Mustard family, rutabaga is grown as a crop, for both human and animal consumption. Rutabaga grows in the colder zones of Europe, primarily in Sweden and Russia, and in North America and Australia. It is a winter crop and has a long shelf life, once stored. In the United States, it is grown extensively, although it is believed to have originated in Bohemia in the 17th century.

Rutabaga (*Brassica napobrassica*) can best be described as a small, turnip-like, strong-tasting root, with a peculiar bite to it depending on where it is grown. At times, when it is grown along with undesirable companion crops, the taste of the vegetable can be greatly affected, making it even more pungent. The outer coat of the vegetable is thick and dark, the inner flesh is white, and the rutabaga is best harvested when it has reached a diameter of no more than six inches. Beyond that, and the vegetable is bound to change texture and taste.

Rutabaga requires heavy clay, loam, or mixed soil with a pH ranging from 5.5 to 7. The ideal pH would be an acidic value of 6, which allows the root to lock boron within. The acidic soil prevents the rutabaga from facing boron deficiencies and in turn club-root disease. It will grow in soil of higher pH. However, the quality of the vegetable will decrease with a rise in pH, more so with its added exposure to the dreaded club-root disease. One serving of rutabaga, about 170 grams, contains 66 calories and no fat or cholesterol. One serving of rutabaga has 15 grams of carbohydrates, 2 grams of protein, and 34 milligrams of sodium. One serving has 53 percent of the recommended daily allowance of vitamin C, 8 percent of calcium, 4 percent of iron, and no beta carotene.

Botany

Rutabaga possesses features similar to other members of the Brassicaceae family. This plant is a biennial with a pungent watery sap. It belongs to the herb category and has unicellular hairs. It possesses a taproot, which swells as it stores food and takes on a napiform shape, that is, a round bulge, as in a turnip, at the stem end. Leaves are simple, alternate in arrangement, possess fine hairs, and form a rosette. The inflorescence of this root vegetable is a raceme. Flowers are without bracts and bracteoles, are complete, and can be cut into two equal halves along any plane (actinomorphic). The flowers are also hypogynous, where the ovary of the flower is raised above all other parts of the flower, such as the sepals, petals, and stamens. There are four sepals, arranged in two whorls, of two sepals each. Likewise, there are also four petals, except these petals are arranged in a single whorl in a cross-like manner: hence the name crucifers. These petals alternate between sepals. There are six stamens arranged in two whorls. The outer whorl has two short stamens while the inner whorl has four stamens, which are comparatively longer. There are two carpels with many ovules. The fruit is a siliqua, while the seeds contain oil, which is characteristic of its family.

Rutabaga is propagated via seeds. Seeds may be planted in the fall. Since it is a biennial plant, it does not produce seeds the first year. Rather, it matures through the cooler months, growing very slowly during the summer. Although they are winter hardy, young saplings have to be protected from frost, preferably by using row covers. Row covers are fine, water-permeable material that protects the sapling from frost, at the same time preventing insects from reaching the young sprouts.

Even though rutabaga is grown as a food crop, it is not a popular vegetable of choice and is often regarded as the inferior of most vegetables. However, this vegetable was an important part of the diet for many during the world wars owing to its long shelf life and the ability to be cooked in many forms, or to be shipped. It is grown extensively in the American Midwest and in cooler zones and is farmed mainly for commercial purpose. It is not a very popular home garden vegetable.

When planting rutabaga as part of crop rotation with other plants, care should be taken that it is not rotated with plants that use similar nutrients. On the other hand, it may be planted with plants that require different and varying amounts of nutrients that do not lead to soil nutrient starvation. Some ideal crops to rotate with rutabaga are cabbage, Chinese spinach, cauliflower, broccoli, Brussels sprout, turnip, kohlrabi, and mustard greens.

Swedes can be grown with other companion plants. However, they do not tolerate shade and require a rich supply of organic matter. The land should be tilled well prior to the sowing of seed or the transplant of the sapling. Untilled land can give rise to deformed rutabagas. Once harvested, rutabaga may be dipped in paraffin wax, cooled, and stored for many months. Or rutabagas may be stored in clamps, where they are heaped in a pile, and covered with hay and soil, to store through winter. If storing in a clamp, the farmer must make sure the clamp is rodent free to prevent contamination. The clamp should face the poles so that the direction of the sun does not affect the vegetable. Since rutabaga has a long storage life, it is not necessary to store it in a refrigerator.

Rutabaga may also be packed and stored as a frozen vegetable for commercial purposes. For this, tender roots are the most desirable. These have to be cut and blanched in hot water for 3 minutes. After that, the rutabaga pieces have to be immersed in chilled water for another 3 minutes, removed, drained, and frozen for at least 30 minutes. Once they freeze for a little while, they can be removed, packed into containers or storage bags (with the air removed), and then stored in the freezer for up to six months. While the uses of rutabaga are not numerous, it may be cooked in a similar way as other root vegetables in its family. In the United States, southerners add this vegetable to stews, while the tender leaves are used in salads.

Amanda Mittra

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Rye

An annual grass, rye is a member of the Gramineae or Poaceae family and is related to other grains, prominent among them corn, rice, wheat, oats, and barley. Rye is also related to sugarcane and bamboo. Among the grains, rye has the eighth-largest yield, trailing wheat, corn, rice, barley, sorghum, oats, and millet. Humans consume rye as bread and whiskey, though some of the harvest feeds livestock. Most varieties of cultivated rye are members of the species *Secale cereale*, though farmers in southwestern Asia grow some *Secale fragile*, a species of rye related to *Secale cereale*. American author J. D. Salinger derived the title for his novel *The Catcher in the Rye* from protagonist Holden Caulfield's image of children playing in a rye field. Caulfield imagined the field near a cliff and made it his duty to catch the children before they fell.

Rye (iStockPhoto)

Origin and Diffusion

The wild annual grass *Secale vavilovii* may be the progenitor of cultivated rye. Alternatively, the perennial grass *Secale montanum* may be the ancestor of domesticated rye. Whereas *Secale vavilovii* is native to southwestern Asia, *Secale montanum* is indigenous to Southern Europe and Central Asia. Because rye appears to have originated in southwestern Asia, *Secale vavilovii* may be the better candidate as progenitor. Rye retains two features of its wild relatives. First, like corn, it cross-pollinates. Most other grains, wheat, barley, and oats for example, self-pollinate. Second, rye shatters. That is, the grain disperses its seed when mature. The dispersal of seed is basic to the survival of a plant in the absence of human intervention.

Like oats, rye may have arisen as a weed in barley and wheat fields. Like these grains, humans probably harvested stands of wild rye before they domesticated it. Domestication may have followed from the observation that rye tolerates extreme cold and poor soils better than do wheat and barley. Into modernity, farmers grew rye in fields of wheat or barley, creating a mixture of crops. The sowing or rye ensured the harvest of a crop even if wheat or barley failed. In this context, rye was a famine crop. In Syria, Iraq, Iran, the Balkans, Turkey, Caucasia, and Transcaucasia, farmers planted rye with wheat for fear that cold or dry weather might claim their wheat. The practice of intercropping rye and wheat persisted in Europe, where farmers named the mixture maslin, meaning "mixed." Between the 14th and 17th centuries, maslin was the most common crop in Europe.

Rye may have originated in eastern Turkey and Armenia, though the earliest evidence of rye comes from northern Syria, where scientists have dated rye grains to 8500 BCE, a date that may be too early for the cultivation of rye. These kernels were found with einkorn wheat, suggesting that people harvested both grains and that wild rye and wheat grew together. Scientists have dated rye to 6600 BCE in Turkey, though these carbonized grains likely derived from wild rye. Humans domesticated rye comparatively late, possibly in the fourth millennium, when farmers grew it in Poland and Romania. Farmers then grew more wheat and barley than rye, raising the latter as a minor crop. About 2000 BCE, humans domesticated rye in Turkey, an event that may have been independent of the domestication of rye in Poland and Romania. Between 1800 and 1500 BCE, rye culture spread to the Czech Republic and Slovakia. At the end of the second millennium, farmers grew rye in Iran. Later, farmers grew admixtures of rye and wheat in Moldavia, Ukraine, Germany, Denmark, and the Crimea. The Romans grew rye along the Rhine and Danube rivers and in Gaul and Britain. Roman encyclopedist Pliny the Elder knew of rye but he had a low opinion of it. Rye was suitable only as a famine food and had a bitter taste, he believed.

Despite its prevalence in western Asia and Northern Europe, rye was unknown in ancient Egypt, the Aegean, Greece, Bulgaria, and Yugoslavia. Its absence in Southern Europe leads one to suspect that rye must not have come to Europe from the Mediterranean but instead across the Caucasus Mountains. From Turkey, rye may have migrated north to Russia and then west to Poland and Germany. By another route, rye may have spread from Turkey to the Balkans and then into Northern and Central Europe.

If rye was a minor crop in antiquity, its popularity grew in the Middle Ages. In medieval Europe and western Asia, farmers planted 40 percent of their grain land to rye, a much larger proportion than is common today. Rye bread was the staple of peasants and the poor. In the early modern era, peasants ate as much as three pounds of rye per day. In contrast, prosperous urbanites ate wheat bread. In the 16th and 17th centuries, Europeans introduced rye into North America. In the 17th century for example, the French planted rye in Nova Scotia. In New England and Virginia, farmers intercropped rye with oats, barley, or corn. The 16th and 17th centuries witnessed the migration of rye from Russia to Siberia. In the 19th and 20th centuries, farmers grew rye in Argentina, southern Brazil, Uruguay, Australia, and South Africa.

In modernity, the production of rye has declined as farmers have grown corn for feed and wheat for bread. Today, rye is a minor crop, being grown on 1 acre for every 20 acres of wheat, rice, and corn. Production has fallen worldwide and in the United States. Production also declined in Russia in 2005. Despite these discouraging numbers, one authority predicts an increase in the number of acres to rye in the northern Great Plains, an area in which farmers now grow wheat and barley. Among the states, the leading producers are Oklahoma, Georgia, North Dakota, and South Dakota, though farmers grow rye in all 50 states. In Oregon, farmers grow rye for forage. As a forage crop, rye is often grown with vetch and clover. Rye is planted for forage in Argentina and to decrease erosion in Australia. In some cases, farmers permit livestock to graze immature fields. Removing the animals, farmers then allow the rye to mature, harvesting it in spring or summer.

Because rye is a minor crop, scientists have devoted less attention to it than to other crops, though the countries of northwestern Europe are at the forefront of rye science. Accordingly, scientists have developed fewer varieties of rye. Despite this lack of attention, there have been notable achievements. The success of hybrid corn in the early 20th century focused efforts on breeding rye. Scientists concentrated on rye because of its reproductive similarity to corn. As with corn, scientists inbred varieties of rye. Crosses of inbred lines yielded heterosis or hybrid vigor. Many farmers in Europe now grow hybrid rye just as American farmers grow hybrid corn. Scientists have discovered the genes that code for resistance to several diseases and have incorporated these genes into elite lines. Scientist have bred rye cultivars for yield, seed size, winter hardiness, plant height, and lodging resistance. The result of this work has been an increase in yield per acre. Farmers have achieved these gains by planting high-yielding varieties, rotating crops, and using fertilizers and good land. Curiously, given the infamy of ergot, scientists have made no progress in deriving ergot-resistant cultivars. Rye appears not to have any genes that would lessen its susceptibility to ergot.

Northern Europe grows the vast majority of the world's rye. Especially important is the land between the Ural Mountains and Nordic Sea, which produces nearly all the world's rye. In Poland, farmers grow more rye than wheat, and in Germany rye constitutes a sizable portion of the grain crop, the majority of acres going to wheat. Switzerland and northwestern Europe recorded the highest yield per acre. In 2005, the worldwide rye yield totaled tens of millions of tons. The leading rye producers were Russia, Poland, Germany, Belarus, and Ukraine. These five countries produced the vast majority of the world's rye crop. The largest producers are also the largest consumers of rye. No longer an important producer, the United States yielded only hundreds of thousands of tons of rye in 2005.

With one exception, the leading rye producers are the largest exporters. In 1996, Germany, Russia, Canada, Ukraine, and Belarus were the leading rye exporters in 1996. Japan, where consumers have come to appreciate the taste of rye bread, was the leading importer of rye in 1996. The Czech Republic ranked second, Poland third, and the United States fourth. Despite its status as a leading producer and exporter, Russia nonetheless imported rye in 1996. Even though it is an importer, Russia is a net exporter of rye. Its farmers therefore must produce enough rye to satisfy domestic demand. In big producers and small, most rye is consumed locally. In the 1990s, only a few percent of the world's rye crop was exported compared to a sizable amount of the wheat crop.

Attributes

Rye's importance derives from its hardiness. The most cold tolerant of the grains, rye can endure temperatures as low as –40°F. Cold tolerant, rye will germinate when the temperature is near 32°F. In fact, rye needs temperatures between 32°F and 43°F for a few weeks so that it will become dormant. The addition of phosphorus and potassium to the soil increases rye's tolerance to cold. The cultivar Dankowskie Zielonkowe is particularly cold tolerant. Because rye grows at low temperatures, it is the last grain to cease growth in autumn and the first to resume growth in spring. Grown as either a winter or spring crop, most rye is sown in fall because the plant is winter hardy. Because of its cold tolerance, farmers grow rye as far north as Canada, Scandinavia, and Siberia. Winter-hardy varieties of rye will not grow at low latitudes because the weather is not cold enough to make it dormant. Its ideal temperature between 55°F and 65°F, rye is a temperate crop, though it is sometimes grown in the subtropics as fodder. Although it can be grown in the subtropics, rye is less tolerant of heat and will not grow above

86°F. Yields are low at high temperatures. Growing where wheat fails, rye will survive in sandy soils devoid of nutrients and in acidic soils. In South America and Australia, farmers grow rye in preference to wheat on acidic soils. Adapted to a range of conditions, rye will grow in several types of soils. The tendency to grow rye in poor soils because higher priced crops command good land has led to the perception that rye is a low yielder. In fact, however, rye yields on fertile soil may surpass those of wheat and barley. For optimal yields, rye needs phosphorus, potassium, calcium, magnesium, boron, zinc, and cobalt in the soil. Rye yields best in fertile, well-drained loams.

The most drought-tolerant grain, rye may be grown in arid regions. Rye requires less water than does wheat. Only corn is a more efficient converter of water to biomass. During drought, rye forms smaller leaves and so transpires less water. Tolerant of drought, rye may be grown near deserts and at altitude. When rye heads, however, its need for water is acute. Rye has roots as long as three-and-one-half feet, allowing it to absorb water and nutrients deep in soils. Its thick root structure explains rye's ability to grow in poor soils. Because rye has a fibrous root system, it extracts the maximum in nutrients and water from the soil and so needs less fertilizer than the other grains. Especially tolerant of leaf diseases, rye is the most disease-resistant grain, though it is susceptible to several pathogens. Because of its disease resistance, scientists have crossed rye with wheat to derive resistant wheat cultivars. Farmers sometimes grow rye in rotation as a green manure. It is suitable for this purpose because rye competes well against weeds.

Because of its low price, rye is sometimes favored as livestock feed. Stockmen prefer to feed animals corn, soybean meal, or barley, but when the price of rye falls below the price of barley stockmen will switch to rye, often feeding it as a mixture with barley. Some farmers feed rye to horses. By one calculation, a few acres of rye can feed 40 pigs. Rye is suitable for fattening hogs, though it is not ideal for poultry and young animals because it interferes with the absorption of nutrients in them. As livestock feed, rye has low conversion into biomass. More rye than barley is necessary to prod pigs to gain an equivalent weight. Because rye has less the feed value of corn, stockmen prefer the latter. Its low price may make rye suitable as a biofuel, though in the United States corn serves this purpose. Rye may one day be an ingredient in fish and pet food. Manufacturers make rye into glue and adhesives. It is used, for example, in wallpaper glue.

By weight, rye is 80 percent carbohydrate. Of this amount, 55–65 percent is starch. The chemical composition of rye starch is similar to those of wheat and triticale. Fifteen percent of the rye kernel is protein, a percentage that compares favorably with other grains. The application of nitrogenous fertilizers increases the amount of protein in rye. Two percent of the kernel is fat and 2 percent ash. Rye may improve health. A study of Finnish men suggested that rye fiber might protect against heart disease. In Finland, the average person ingests 43 grams of rye per day, from which he or she derives 7.7 grams of fiber per day. Rye bran lowers cholesterol in hamsters, leading researchers to hope for a similar effect in humans. The lignans in rye may protect one from cancer. Nutritious, rye contains thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, and vitamin B6. Rye has a better balance of amino acids than do wheat or triticale.

Humans consume rye primarily as bread. Rye is second only to wheat for making bread. Rye bread remains popular in Northern and Eastern Europe and western Asia. Rye proteins do not form gluten, a protein that gives dough its stickiness, as they do in wheat. Rather, other proteins give rye dough its adhesive quality, making it suitable for making bread. Because of the absence of gluten, some bakers regard rye bread as inferior to wheat bread, though rye bread has a shelf life two to four weeks longer than wheat bread. In Europe, rye and pumpernickel breads contain 100 percent rye, though in the United States rye bread may have as little as 15 percent rye. U.S. recipes call for no more than 40 percent rye in rye bread. In the United States, pumpernickel bread may have as little as 10 percent rye. Whatever the claims of manufacturers, wheat is the primary ingredient in American rye and pumpernickel breads. In Europe, bread may contain a mixture of rye and wheat. In Germany, roughly one-third of the rye harvest goes to make bread. Some of the remainder makes rye pasta. In Germany, some rye is brewed into beer. In the Netherlands, bakers make a type of cake from rye.

Diseases and Pests

Although rye is more disease resistant than other grains, it is vulnerable to several fungi. The fungi that cause snow mold afflict rye in winter. The worst infestations occur where snow covers the soil for long periods, often more than 100 days per year. Alternatively, snow mold may infest rye where the soil does not freeze during winter. Severe infestations occur in Scandinavia and parts of Central Europe. Infected seeds may germinate but seedlings will be frail. The leaves of young plants die, contributing to their attenuated condition. The stricken parts of a rye plant appear white or pink. In some fields, snow mold may cause as much as a 50 percent loss. Since 1974, scientists have bred resistant varieties. The cultivars Eusi, Buranskia, Lunganer Taueru, and Vyatka are partially resistant to snow mold. Some hybrids are 50 percent more resistant to the disease than are traditional varieties.

In addition to rye, spot blotch afflicts barley, wheat, oats, and triticale. It spreads in areas of humidity and high rainfall. Infecting seeds, spot blotch causes root and foot rot in seedlings. Leaving dark spots on leaves, it kills them, weakening rye's ability to photosynthesize. Symptoms are most severe when rye heads. Farmers in afflicted fields rotate crops to minimize pathogen populations. Farmers may treat plants with fungicide to combat the disease. The fungi *Helminthosporium* and *Fusarium* cause seedling blight and root rot. *Helminthosporium* infects rye in warm, dry soils, and *Fusarium* is most severe in cool, moist, acidic soils. Infecting seedlings, these fungi usually kill them soon after germination. Seedlings that survive are attenuated. The diseases are more common to winter than spring rye. A few rye cultivars are resistant to *Fusarium*.

Infecting rye, powdery mildew is a common disease of grasses, also affecting barley and wheat. The disease is most severe in cool, arid lands. Dense populations of rye encourage the disease to spread. Infecting the lower leaves, it moves up a plant, discoloring leaves. Deep plowing destroys soil-borne pathogens. Farmers may also spray their crop with fungicide. The fungicides tradimofon, diclobutrozol, and fenpropimorph are particularly effective. Another alternative is to plant resistant cultivars. Notable for their resistance to powdery mildew are 12 hybrids and the variety Rossiyanka. Farmers who limit the amount of nitrogenous fertilizers usually suffer little damage from powdery mildew.

The worst disease of rye is ergot, not for the damage it does rye but for its toxicity to humans and livestock. Ergot, caused by the fungus *Claviceps purpuru*, afflicts about 170 species of grasses, including triticale, wheat, and barley, but it is most common and most severe in rye. Ergot settles inside the flowers of these plants. Because wheat and many other grasses self-pollinate, their flowers do not open to receive ergot spores. Their infection rate is accordingly low. Rye flowers, however, open to pollinate and so are a target of ergot fungi. Once ergot has infiltrated one flower, insects feeding on the flower get ergot fungi on their legs and so transmit them to other flowers. In one study, hybrid rye was more susceptible to ergot than were traditional varieties. In this study, ergot afflicted one-third of hybrids in a field. Having hijacked a flower for their own use, ergot fungi grow in place of the kernel. The result is a purple cockspur that is easily identifiable.

Ergot is a disease of cool locales and so was prevalent in Northern Europe, probably since antiquity. Before people connected the ingestion of contaminated rye with the onset of ergotism, they were helpless against the disease. Ergotism impairs the circulatory system, causing gangrene. Other symptoms include hallucinations, insanity, and convulsions. The worst cases are fatal.

Because people did not know the cause of ergotism, they called it Holy Fire, apparently believing that it was God's punishment for sin. The first mention of Holy Fire dates to the eighth century CE, though the disease is surely older. In the Rhine Valley, an outbreak of ergotism, possibly the first epidemic, killed thousands in 857 CE. In the 11th century, the Order of Saint Anthony established hospitals to treat the victims of ergotism and so the disease came to be known as Saint Anthony's Fire. In 1581, the first case of ergotism arose in Germany. In 1722, ergotism killed tens of thousands of men and cavalry horses in Russian Czar Peter the Great's army, halting his invasion of Turkey.

In 1670, a French physician made the connection between contaminated rye and ergotism. Intrigued by the fact that affluent urbanites did not contract the disease but that the poor and rural folk fell victim to it, he visited the homes of several families in the countryside. Noting the presence of loaves of rye bread in their homes, he focused on the rye grown in farmers' fields. Observing purple cockspurs in some of the plants, the doctor, in a flash of insight, drew the connection between ergotism and contaminated rye. In 1676, Frenchman Denis Dodert published the first medical report on the disease, but the first American reference to it came only in 1807. In the United States in the 17th century, as in Europe, some people ascribed ergotism to the malevolence of witches. One scholar believes that the witchcraft hysteria in Salem, Massachusetts, derived from ergotism.

From 1640, rye was a common crop in New England. The warm, rainy spring and summer of 1691 were ideal for the onset and spread of ergot in rye fields. The colonists planted spring rather than winter rye, an important circumstance because ergot infects spring rye more readily than winter rye. Moreover, the curious circumstance that ergotism appears to have afflicted more women than men throughout history may explain why the accusers in Salem were eight girls. Their behavior—incoherent speech, strange posture and gestures, and convulsions—mimicked the symptoms of ergotism. The girls reported sensations of chocking, biting, pinching, and pricking, all symptoms in accord with ergotism. The rye that they must have eaten had probably been threshed in November 1691 and consumed thereafter, a chronology that fits with the onset of the girls' behavior in December. At the witchcraft trials, witnesses testified to having had hallucinations, another symptom of ergotism. The connection between ergotism and witchcraft must have been close. In the 17th century, French officials and physicians puzzled over the question of whether one might cause the other, and German clerics wondered whether ergotism might be mistaken for witchcraft. Other scholars, however, doubt that ergotism was at the root of the witchcraft trials in Salem. They note that whole families did not display the symptoms of ergotism, though one should have expected this circumstance because a family would have shared the same contaminated loaf of bread.

Even the 20th century was not free from ergotism. In 1951, the disease recrudesced in France, sickening hundreds of people, causing cases of insanity, and killing a small number of its victims. The tragedy could have been averted. The farmer who sold the rye knew it was contaminated, and the miller who bought it likewise knew of its toxicity. From ergot, one scientist derived LSD, whose use increased during the psychedelic 1960s.

Rye is also vulnerable to nematodes, which feed on roots, and to insects, which, in addition to feeding on plants, may transmit viral diseases. Aphids, for example, transmit barley yellow dwarf virus, a pathogen of rye, barley, and other grains. By feeding on rye, aphids cause kernels to shrink. The cereal leaf beetle may in severe cases infest half the rye in a field. The fruit fly afflicts winter rye. The Hessian fly, which may be the worst pest of rye, lays its eggs on the stem of plants. Hatchlings suck sap from plants, stunting them, reducing yield, and causing lodging. Mites may transmit wheat streak mosaic virus to rye. Stem maggots, grasshoppers, chinch bugs, jointworms, sawflies, and thrips also feed on rye. Grasshoppers often lay their eggs on winter rye.

Christopher Cumo

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Safflower

Safflower, *Carthamus tinctorius* L., is currently planted chiefly for its nonvolatile, commercially important oil. Standing from 12 to 60 inches, the plant has many branches, which each hold a globular red, yellow, or orange flower head. Related to the sunflower, it is one of the oldest cultivated crops. Grown for centuries from China to the Mediterranean region and along the Nile Valley for use as a dye, safflower probably grew as far north as southern Russia. The use of safflower as primarily an oil crop came only in the 20th century, although the ancient Egyptians did occasionally use it as a milder substitute for castor oil.

History

Safflower has a very long history as a cultivated plant. The many names for the plant give an indication of how it has been used: false saffron, bastard saffron, thistle saffron, and dyer's saffron. The Egyptians used the brilliantly colored flowers of safflower as a source of red-yellow and orange dye for cotton and silk. Mummies found in Egyptian tombs had their bindings dyed with safflower. It was also used to color the ceremonial ointment to anoint the mummies prior to binding and in other religious ceremonies. Safflower seeds can be identified in Egyptian temple collections, and the flower is seen in wall paintings. In ancient India, Sanskrit writers describe safflower being used as a purgative, similar to castor oil. In ancient North Africa, people used safflower to dye the wool used in the carpet-weaving industry. The crop apparently came to China in the second century BCE, possibly from Afghanistan along the Silk Road. The Chinese used it chiefly as a cosmetic and as a substitute for saffron in food dishes. Meanwhile, as Muslims moved westward in the seventh and eighth centuries, they spread the cultivation of safflower along the North African coast and into Europe via the Iberian Peninsula. The Spanish and Portuguese used safflower to dye cloth and in soups and rice dishes. It is still commonly used as a food coloring in the region. Safflower probably came to North America through the Spanish via Mexico. Safflower came to England in the 16th century for use as a food coloring for sausages and cheeses as well as a textile dye. A red dye, carthamin, extracted from the flowers was still in extensive use in the 19th century to color cotton and silk. While the yellow dye is water soluble, carthamin is insoluble in water. Most Europeans, including the Germans and French, grew safflower for use in the textile industry. Communities of Jews in Poland, however, used safflower extensively as food coloring, particularly for breads.

Attributes and Current Uses

Safflower, no longer much used as dye, is still a minor oilseed in terms of total production and world trade. It has never caught on with gardeners because of the long, sharp spines on its prickly foliage, though it can be used to good effect when planted as a dense hedge. As a commercial crop, safflower long suffered from the specialized uses of the oil, the relatively low oil content of the seed, and the high fiber content of the cake. The breeding of high-oil-content types with thin seed hulls has greatly reduced the disadvantages of growing safflower, and the number of acres in cultivation has jumped since the mid-20th century. Safflower is grown commercially mostly in Mexico, the United States, and India, though crops also come from Russia, Australia, Canada, Argentina, Kazakhstan, Ethiopia, and China. Vegetable oil users prefer to purchase in 1,000-ton lots, effectively shutting out smaller farmers.

Safflower, an annual, can be grown in a wide range of climates, although it is susceptible to frost damage. The long tap root of the plant, which commonly sinks six to nine feet into the ground, helps it survive in dry areas. Safflower is generally not self- or wind-pollinated, instead relying on insects such as bees for fertilization. A safflower plant takes 10 days to progress from seedling to the development of the first leaves beyond the initial ones. The leaves are dark green and deciduous with short spines scattered along the margin and a pronounced midrib. Main stem branching begins to occur after 21 days. After 46 days, floral buds begin to appear. It takes about 14 hours of sunlight to initiate flowering, but this period can be modified by temperature during growth. Flowering can also be accelerated artificially by chemical means. After 97 days, the ray petals on the flowers begin to drop and the plants have reached maturity. The safflower kernel, which looks like a small, triangular sunflower seed, is ripe when it has a moisture level less than 8 percent. The seed is usually white or cream in color. Safflower seed is usually crushed whole so the proportion of oil in the kernel and hull is of little importance. However, the kernel generally contains about 98 percent of the oil.

Until the mid-century, safflower grown in the United States wound up in industrial uses such as paints and resins. Since about 1960, the plant has been used chiefly for oil. Safflower oil is flavorless and colorless with similar properties to sunflower oil. As a relatively unsaturated vegetable oil, it is regarded as less likely to produce heart disease than more fatty oils. Safflower oil comes in two forms. Monounsaturated safflower oil is used as heat-stable cooking oil. High in oleic acid, it is regarded as more healthful than some fats but not ideal.Polyunsaturated safflower oil is quite nutritious since it is high in linoleic acid. However, it is not heat-stable and can be used only in such products as salad dressings. Monounsaturated safflower oil is very shelf-stable, but polyunsaturated oil is prone to going rancid. Safflower is being tested as a source of insulin for diabetics but it is likely to remain as mostly a source of oil.

Caryn E. Neumann

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Sage

Sage (*Salvia Officinalis*) is an herb in the mint family that is native to the Atlantic and the Mediterranean coasts of Europe. Sage is a fairly popular herb with a lot of versatility, including medical and culinary uses. Sage plants are evergreen perennials, annuals, or biennials, depending on the species. The Arabic name for sage is *Marymiah*, and some common varieties of the sage plant including broad-leaved sage, common sage, clary sage, garden sage, and narrow-leaved white sage, belong to the *Salvia dorinius* species. There are about 900 known species of the *Salvia* genus, excluding a number of hybrids that are cultivated by gardeners. Sage is also an ornamental plant and has been put on display in many botanical gardens and herbariums throughout the world. The United Kingdom has three special gardens devoted just to different types of sage, including the Royal Botanical Garden at Kew and the Royal Horticultural Society's garden.

Attributes

Sage belongs to the family Lamicae. It is a silvery green shrub with fragrant leaves and a strong, bitter odor. *Salvia officinalis* is one of the hardiest species in the sage family, whereas other sage cultivars need protection from thawing. Garden sage adapts to and is grown in many different types of habitats, all with varying temperatures and climatic factors. The plant (*Salvia Officinalis*) was first written about by Swedish naturalist Carl Linnaeus in 1753 and has been grown for centuries in the Old World. *Salvia officinalis* has often been described as a shrub and has been harvested for hundreds of years in France, England, Germany, Spain, and Italy.

The propagation of sage is by seed. Plants in the *Salvia* genus do not require specific fauna to pollinate them; rather, various insects and aviary species can release the pollen. There are a number of cultivars of the sage plant. The major ones include Alba, a white flower, Aurea, and Tricolor, all of different textures and colors. The large leaves of the sage plant grow off a main stalk, which bends with the weight of the flowers.

Sage blossoms in the summer and has a pale green color and a slight peppery flavor, which makes it ideal in certain types of cuisines. The Old World sage differs from the common sage in both length and width. The Old World sage plant is approximately two feet tall, smaller than the three-foot average for New World plants, and is most commonly seen with lavender flowers, which are large and whorled. The stalks are rounded at the ends, with a visible network of veins on each side, both grayish in color. The strong scent of the sage plant can be attributed to the powerful oils that it possesses.

History

Sage is a holiday favorite and is used frequently for Christmas and holiday decorations. Sage was frequently used by Emperor Charlemagne of the Holy Roman Empire in the ninth century, during his reign. Charlemagne ordered that the sage plant be grown in all of his medical gardens, because at the time it was considered an almost indispensable medicine. In the 19th century, the herb was considered a controlled substance and kept under very stringent guidelines, because of constituents of the plant that can make it a dangerous and potent psychoactive drug, which means that the sage plant has leaves that produce a liquid substance called salvia, which is a lesser known but nonetheless potent drug with a number of mental and physical repercussions. Although it is considered a psychoactive drug, it is legal in the United States and Mexico. When used as a drug, the leaves of sage can be either ingested or smoked. Sage is popular because of its noted psychological and psychedelic effects.

Culinary Uses

Sage also has culinary uses and can be vital in the distinct flavoring of certain types of cuisine. *Salvia officinalis* is widely used in cooking and for culinary purposes because of its peppery flavor and sharp taste. Sage can be used alone, but it can also be combined with other herbs or spices like thyme and can also be combined with certain types of cheeses. Sage is also used as a flavoring in many British recipes, including delicacies like Lincolnshire sausage and Sage Derby cheese. It is also used in Italian and American cooking, usually with meats like pork or poultry.

Medicinal Uses

It is perhaps not surprising that the sage plant is popular for medicinal purposes, as the *salva* in *salvia* literally translates “to save.” Traditionally, sage is known for a number of mystical properties attributed by folklore, such as being a panacea for immortality, as well as being used as a remedy for muscle pains and aches. In the Middle Ages, sage was often referred to as an herb of longevity. Sage oil, which contains rosmarinic acid, tannins, and flavonoids, can be used sparingly for some health conditions, but it can be dangerous if too much is applied. It has been used for centuries to heal the mind and the body and has soothing qualities. It has been used as a remedy for sore throats, as a remedy for the common cold, and as an appetite stimulant, and some women have found it helpful with their menopausal symptoms. Sage is a commonly used diuretic and can be seen as an anesthetic. The ancient Egyptians used sage as a fertility drug in some cases, but its use should be avoided during pregnancy. Other medical uses for sage include as an astringent and an antibacterial, due to the antioxidants in the plant. Some believe that sage improves memory and cognitive function. It is no wonder that sage was so sought after in the past and today; it certainly is a versatile plant, with many useful applications.

Bonnie Ellman

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Sagebrush

The cultivars and wild varieties known as sagebrush are full of misconceptions. First, sagebrush is a generic term used to classify or describe a variety of species that belongs to the genus *Artemisia*, named after the Greek goddess of wilderness. Also confusing the designation, sagebrush is often mistaken for sage; however, true sages belong to the genus *Salvia*, part of the mint family. It is widely accepted that sagebrush originated in Eurasia, but is now more closely associated with the American West. The most common western shrub, big sagebrush (*Artemisia tridentata*), dominates the Intermountain West territory of North America including the Great Basin and Colorado Plateau, although other sagebrush species can also be found. Two of the more familiar Old World sagebrush cousins include: *Artemisia absinthium* (wormwood), used to flavor absinthe, and *Artemisia dracunculus* (French tarragon), used as a culinary herb with a variety of purposes, often to season vinegar.

Native Americans are generally recognized as being the first humans to incorporate sagebrush into their culture. They found an impressive number of applications for the western weed. Uintah Utes and Shoshoni Indians wove fibers of sagebrush bark into clothing and blankets. Shoshoni women were so adept at designing sagebrush fashions that other tribes referred to them as the "sagebrushers." Torches were frequently constructed from bound pieces of sagebrush, and many American Indians burned piles of the shrub to herd bison and antelope off cliffs during hunts. Sagebrush usefulness extended to medicinal practice. Due to the appealing but pungent fragrance of the plant's leaves, Cheyenne and Utes placed sagebrush bark in sweat lodges to create an aroma-therapeutic purification sauna; they believed the scent cleansed the mind and body and could ward off evil spirits. Other Native American medicinal uses for sagebrush included remedies for reducing fever, treating indigestion and colds, and relieving arthritis.

Presently, varieties of sagebrush such as *Artemisia frigida* (fringed sagebrush) serve as a valuable source of natural feed for livestock, particularly sheep and goats. To some ranchers, however, sagebrush is a nuisance due to its aggressive growth and spread, which choke out grasses needed for cattle grazing. Sagebrush has become a favorite of the western garden, and although it is not a true desert species, it has proven resilient in arid-climate landscaping due to its drought adaptations: the shrubs have both deep roots to access soil reservoirs and shallow roots to collect surface moisture. Sagebrush can flourish in myriad environments, attributable to a broad soil tolerance and need for little water. It excels in deep, sandy soils with full sun. The popularity of sagebrush as a cultivar in the United States likely stems from the romantic, frontier nostalgia that the fragrant North American *Artemisias* inspire. So tight is the association with the American West that Nevada has adopted sagebrush as the official state plant, incorporated the shrub on the state flag, and referenced the iconic cultivar in the state song.

Matthew Alexander

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Sago Palm

Sago palm is the name given to four types of tree: a true palm whose scientific name is *Metroxylon sagu* and that belongs to the order Arecales and the family Arecaceae, and three types of cycads—*Cycas revoluta*, *Cycas rumphii*, and *Cycas circinalis*. The *Cycas revoluta* is also known as the sago cycad, the Japanese sago, or the king sago palm. *Cycas revoluta* and *Cycas rumphii* are both commonly referred to as queen sago palms. All three cycads belong to the genus *Cycas*, the order Cyacadales, and the family Cycadaceae. Cycads are related to conifer and Gingko trees and are ancient plants that date back 200 million years.

Metroxylon sagu

Metroxylon sagu is native to the tropical climates of Southeast Asia, specifically Indonesia, Malaysia, and the Philippines, although it may have been introduced in the Philippines from the other areas. The tree is extremely useful in a number of ways, but the main significance of the sago palm is its production of sago, which is a starch extracted from the pith of the sago palm stems and used in cooking. The sago is a staple of the foods of the lowland civilizations of Papua New Guinea and the Moluccas. Sago is eaten in a number of ways, including as a noodle, a pancake, a rolled-up ball, and a paste made with boiling water. Sago is also sold in the form of small pearls that are typically boiled in water and mixed with milk and sugar and made into a custard or pudding.

Description

The sago palm tree is a perennial that is medium size and reaches from 23 to 82 feet tall. Its trunk diameter is about 1 to 2 feet. A palm typically produces 18 to 24 leaves that are 16.5 to 23 feet in length. The tree mainly grows at sea level in the lowland freshwater swamps and burned-clearing gardens in lowland rain forests of Southeast Asia. It can grow in a variety of soils and can live to be 15 years old. *Metroxylon sagu* is fast growing, exceeding 5 feet in a year, eventually reaching 20 to 108 feet before being harvested at around year 8. By then, one tree will typically have yielded about 330 to 661 pounds of starch, with the female plants producing more starch than the male. In addition to providing sago, this palm also is a good source of thatching for roofs, walls, ceilings, and fences. The leaves are made into mats, baskets, and cord. The sago starch can be turned into alcohol and used as a biofuel, and it is also used as an adhesive and a sizing paste for paper and cloth. The pith, its refuse, and the trunks of the sago palm can be fed to animals. And the outer layers of the trunk can be burned as fuel.

Extracting the flour from the plant necessitates cutting the palm and pulverizing the pith, which is then washed in order to separate the starch from the fiber. After numerous washings, the starch floats to the top. It is then removed, dried, and stored for use. The starch is used in the baking of bread, crackers, and noodles. Bread baked with sago has a much longer shelf life than that made with wheat flour.

Cycas revoluta

Sago is also the name of the starch that is extracted from the other specimen known as a sago palm, *Cycas revoluta*, which is sometimes called the cycad sago palm. It is native to southern Japan. Unlike *Metroxylon sagu*, *Cycas revoluta* is poisonous, making extraction of the sago difficult and rare. It is used as a food only by some groups of people of the Pacific and Indian oceans. *Cycas revoluta*'s main benefit is not its starch. It is instead valued as an ornamental plant. In fact, *Cycas revoluta* is one of the most widely cultivated cycads and is a popular landscape tree in temperate and subtropical climates. It is also popular in bonsai arrangements and container gardens. It is not tolerant of cold weather and rarely grows in Northern Europe or the northeastern United States. It requires good drainage to prevent rotting. It also requires hot summers, in the mid-80s to mid-90s degrees Fahrenheit.

Deadly Sago

All parts of *Cycas revoluta* are toxic to animals, including humans. Most parts contain the neurotoxins cycasin and beta-methylamino L-anine, or BMAA. Unfortunately, pets can find the sago to be palatable, but ingestion can prove fatal. Especially dangerous are the seeds, or nuts. Ingesting just one or two seeds can result in serious side effects, including vomiting, diarrhea, drooling, rapid heartbeat, seizures, and coma. Pet fatality from ingestion of parts of sago palms is estimated at a rate of 50–75 percent. First signs of discomfort include nosebleed, bloody stools, and blood in the joints.

Description

Cycas revoluta has dark-green pinnate leaves, similar to a palm's, that are about 3 to 4 feet long and arranged in a circular pattern. Its trunk is cylindrical and pineapple shaped in young specimens. Unlike the true sago palm, *Metroxylon sagu*, *Cycas revoluta* is slow growing. The rough trunks are 1 to 2 feet in diameter and the tree is approximately 6 feet tall, although some can reach about 20 feet. Instead of growing new leaves, *Cycas revoluta* produces a periodic flush of new leaves, which is called a break. The trunks can branch a number of times, producing multiple heads of leaves. Basal offsets, commonly known as suckers or pups, grow at the base of the cycad's main trunk. Propagation can develop from seed or from the basal offsets. Sagos produce either female or male cones. The male cones protrude and are torpedo shaped, while female cones resemble gold or tan cabbages. Generally, the male cones appear in May.

The Queen Sago Palms

Cycas rumphii and *Cycas circinalis* are commonly called queen sagos in deference to the king sago, *Cycas revoluta*. Like *Cycas revoluta*, these cycads resemble palms. *Cycas circinalis* is a native of the Old World tropics. Along with "queen palm," it is also called "false sago" or "fern palm." It is the fastest-growing species of cycad. The trunks reach 20 feet in height and the dark-green pinnate leaves can grow as long as 8 feet. Individual narrow leaflets (the "palms") can grow to be 12 inches long. *Cycas circinalis* is dieocious, having both male and female cones that sprout from the center of the plant. Female plants produce large orange seeds, which is the tree's source of propagation. This queen sago is native to equatorial Africa, but is now grown around the world. It is easy to grow and offers a tropical appearance. As with *Cycas revoluta*, this sago produces a starch that contains neurotoxins that can paralyze or even kill.

Cycas rumphii is native to eastern Indonesia, in an area that is centered in the Moluccan island group of Maluku, or the Spice Islands, and extends east into Papua New Guinea, north to Sulawesi, and as far west as southern Borneo and northeastern Java. It currently is cultivated in Fiji and Vanuatu. The tree is a source of edible starch, which can be prepared by drying, grinding, and washing. The seeds do contain a toxic glucoside, which can be removed with careful, repeated washings followed by cooking of the starch. The tree's bark, seeds, and sap are used to make poultices for skin sores.

The name *rumphii* refers to the German-born Dutch naturalist Georg Eberhard Rumphius (1628–1702), who was a military officer with the Dutch East India Company, and who later authored a well-known catalogue of plants that contributed to the binomial classification system employed by 18th-century Swedish naturalist Carl Linnaeus. *Cycas rumphii* is a small cydad and reaches a height of only 10 feet. The bright-green, glossy leaves are 5 to 8 feet long and grow from the crown. *Cycas rumphii* is threatened, as it had undergone habitat loss across its native range.

Rosemarie Boucher Leenerts

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Saint John's Wort

In the family Hypericaceae, Saint John's wort (*Hypericum perforatum*) has been used as medicine since 500 BCE. Part of its name, "wort," derives from the Old English for "plant." The other part of its name, "Saint John's," derives from the Christian era. The plant's flowers are most abundant about June 24, the putative birthday of Saint John the Baptist. In August, the flowers display red spots, which

Saint John's Wort (iStockPhoto)

Christians associated with the blood of Saint John, whose beheading was thought to have occurred then. The superstitious placed a sprig of the plant under their pillow on Saint John's Eve in the belief that he would appear to them in a dream, offering protection against death in the ensuing year. The superstitious believed that Saint John's wort had supernatural powers. It could protect one from evil spirits and from the terrors of the dark. The genus name *Hypericum* derives from the Greek words *hyper*, meaning "above," and *eikon*, meaning "image," a reference to the practice of placing a portion of the plant above a picture to protect the one in it from evil spirits and demons. Saint John's wort was known as *fuga demonum*, meaning "the devil's scourge." The species name *perforatum* derives from the Latin *perforatus*, meaning "perforated with small holes," a reference to the oil glands that cover the leaves and petals. These glands may produce medicinal chemicals.

History

Humans have used the flowers, buds, seeds, and leaves of Saint John's wort as medicine since antiquity. Greek physician Hippocrates (460–370 BCE) mentioned the plant. In the first century CE, Greek physician Dioscorides thought it effective against sciatica, burns and fever. First-century CE Roman encyclopedist Pliny the Elder recommended a mixture of Saint John's wort and wine to counteract snakebite venom. In 1597, British herbalist John Gerard recommended the plant as a diuretic and believed it effective against bladder ailments. He recommended a mixture of leaves, flowers, seeds, and olive oil, presumably applied topically, to treat wounds. Europeans used Saint John's wort to treat bronchitis, other infections, hemorrhoids, burns, ulcers, and inflammation of the urogenital tract. Russians used Saint John's wort to treat rheumatism, boils, cough, and bleeding. The Iroquois used the plant to treat fever. They believed that it helped women conceive. The Cherokee used Saint John's wort to treat fever, diarrhea, venereal disease, cuts, and snakebite. They believed that it aided women during menses. Other uses included the treatment of anxiety, fatigue, mania, and depression. The rise of pharmaceuticals at the end of the 19th century caused Saint John's wort, and many other herbs, to decline in popularity. In the 1970s, the plant regained a portion of its former prominence as German physicians began to prescribe it for depression.

Current Status

A perennial herb, Saint John's wort is native to Europe, western Asia, North Africa, Madeira Island, and the Azores Islands. It is naturalized in North America and Australia. The plant has golden yellow flowers with five petals. Today, Saint John's wort is cultivated worldwide. In the United States, California, Oregon, and Washington are the chief producers. The plant has escaped cultivation, colonizing sandy and rocky soil to grow wild in the countryside and along roads. Some people regard Saint John's wort as nothing more than a weed. Indeed, it is known as Klamath weed. Ranchers in the American West have a low opinion of the plant, wishing to eradicate it because their livestock, grazing on it, become sick when exposed to sunlight. Ranchers have imported the Australian flea beetle, *Chrysolina quadrigemina*, to devour the plant.

Despite its critics, Saint John's wort appears to have a range of medical uses, at least according to its advocates. It has been used to treat insomnia, inflammation, burns, shock, concussion, hysteria, gastritis, hemorrhoids, kidney ailments, scabies, and wounds. The plant is best known for its use against depression. Germany has been a leader in the use of Saint John's wort. German physicians may prescribe the plant to treat depression, anxiety, and insomnia, and insurance companies pay for the use of Saint John's wort for these purposes. Saint John's wort is also available over the counter in Germany, as it is in the United States, but 80 percent of sales are by prescription so that the patient need not pay for it. In Germany, a physician tries Saint John's wort first, turning to antidepressants only when it fails. In Germany, Saint John's wort is the most prescribed antidepressant. In Germany, the sale of Saint John's wort eclipsed the aggregate sale of all other antidepressants. Saint John's wort outsold Prozac more than seven to one. In the United States, 7.3 million people took Saint John's wort in 1997, though sales were not as robust as in Germany. U.S. drug companies, unable to patent Saint John's wort, show little interest in developing its potential. Because it is not a drug in the United States, it may be sold only as a dietary supplement. The Food and Drug Administration forbids marketers from ascribing medical benefits to a dietary supplement, so Saint John's wort does not enjoy the status in the United States that it does in Germany.

Despite its status as a dietary supplement, researchers have identified chemicals in Saint John's wort that may have medicinal value. Naphthadianthrones may kill viruses and may improve mild depression. According to reports from the National

Center for Complementary and Alternative Medicine at the National Institutes of Health (2012), the usefulness of St. John's wort for depression has been disappointing. It worked no better than a placebo for treating major depression of moderate severity. It may, however, be useful for mild depression and mild anxiety. Flavonols are thought to reduce inflammation, kill viruses, prevent cancer, and dilate the arteries. Flavonols are diuretic, sedative, and astringent. Xanthones kill microbes, improve depression, stimulate the production of urine, and improve the function of the heart. Phlaroglucinol kills bacteria and improves depression. The essential oils kill microbes and reduce inflammation. The n-alkanols stimulate the metabolism, a curious effect give Saint John's wort's reputation as a sedative. Gamma aminobutyric acid, 13,118-biapigenin, and 2 methyl-butenol are sedatives. Hyperforin kills bacteria and may treat wounds and cancer. Hypericin kills viruses and may have the potential to treat cancer. Proanthocyanidins are antidepressants. They kill microbes and "relax blood vessels." Pseudohypericin kills viruses. Quercitrin improves depression. Amentoflavone may be used to treat ulcers and inflammation.

Not all clinical studies have been conclusive, though some have identified the medical value of Saint John's wort. In one study, researchers combined 5 grams of the plant's flowers with 100 grams of olive oil, allowing the mixture to stand 10 days at room temperature. Using it to treat first-, second-, and third-degree burns, researchers documented that the mixture healed first-degree burns in two days. Second- and third-degree burns healed three times faster than burns treated conventionally. The mixture minimized the formation of scars. The consumption of Saint John's wort may hasten the healing of wounds, though this claim appears to be undocumented. According to one writer, Saint John's wort is a more powerful antibiotic than sulfanilamide and has been used to treat staph infections. Enthusiasts claim that Saint John's wort may be effective against herpes, influenza, and the human immunodeficiency virus. An extract of Saint John's wort added to blood killed the microbes in it according to one author, making it safe for transfusion. Hypericin may be effective against glioma, a type of brain cancer, and against melanoma. Saint John's wort may cause the pineal gland to secrete melatonin, which helps a person fall asleep.

Initial investigation focused on hypericin as the antidepressant in Saint John's wort. Researchers found that the amount of hypericin prepared as liquid or powder decreased 14 percent in one year. When stored at 86°F, the amount of hypericin decreased 33 percent when prepared as powder or tablet and 47 percent when suspended in a liquid. Drying a harvested plant in sunlight diminishes hypericin content 80 percent. Despite the attention on hypericin, recent research suggests that the hyperforin in Saint John's wort may be a more effective antidepressant than hypericin. Hyperforin may work by maintaining high levels of the chemicals serotonin, norepinaphrine, and dopamine in the brain.

Enthusiasts tout the safety of Saint John's wort. No one, they note, has died from an overdose, and the side effects—upset stomach, dizziness, confusion, and fatigue—are no more severe, and perhaps less so, than the side effects of antidepressants. Saint John's wort does not appear to interact with medicine.

Christopher Cumo

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Salpiglossis. *See* Painted Tongue

Sea Buckthorn

In the last few decades, sea buckthorn (*Hippophae rhamnoides*) berries have become an increasingly popular commercial product not only in the Baltic Rim and Russia, but also in Central and East Asia and Canada. Since the shrub is an undemanding and hardy plant (it is both frost resistant and heat resistant), it is especially suitable for cultivation in the colder northern parts of these regions. The berries are made into juice, jam, mash, marmalade, sweets, parfaits, and ice cream. They are also used to flavor liqueurs and in commercial yogurt production. Medicinal and cosmetic products also contain substances from sea buckthorn berries. The berries are becoming increasingly popular in many parts of Europe, used by some of the more innovative chefs, as well as in current research on health matters. In western Finland and the Åland Islands, whose inhabitants have access to wild plants in the coastal areas, sea buckthorn dishes are nowadays considered regional specialties. Sea buckthorn is also used as an ornamental shrub in gardens because of its decorative foliage and colored berries. It has a great potential in modern landscaping.

Sea buckthorn is a thorny, silver-leaved shrub, usually 40 to 150 inches high, although it can grow into 50-foot-tall trees in East Asia. The thorns are 1 to 3.5 inches long. The plant has male and female flowers. Male flowers are in short spikes near the base of the branches, while female flowers are single. In the fall, the plant carries yellow or reddish fleshy fruits.

The wild shrub is found in coastal areas in Northern Europe, the eastern Baltic, and the British Isles, but also above the tree line in mountainous areas of Central Europe, Russia, and China. In Central Asia, it also grows in semidesert areas. The Germans call it *Sanddorn*, *Seedorn*, and *Stranddorn*, the English Sea buckthorn, the Danes *havtidse*, *havtorn*, or *sandtorn*, the Norwegians *tindved*, the Swedes *havtorn*, the Finns *tyrni*, and the Estonians *astelpaju*.

Several subspecies are known from inner Asia: *Hippophae rhamnoides turkestanica* Rousi 1971 is found in Xinjiang, Mongolia, and Afghanistan; *Hippophae rhamnoides gyantsensis* Rousi 1971 in Tibet; *Hippophae rhamnoides yunnanensis* Rousi 1971 in the Chinese provinces Sichuan and Yunnan; and *Hippophae rhamnoides sinensis* Rousi 1971 in Gansu, Hebei, Qinghai, Shangxi, Sichuan, and Inner Mongolia as well as in Mongolia and eastern Russia. Other closely related species exist in China.

Traditional Uses

In general, this thorny shrub has been left untouched by humans and animals. According to observations from the Åland Islands in the Baltic Sea from the beginning of the last century, only crows ate the berries in late fall, although the islanders also observed that even small birds sometimes ate the berries. It is now well known that fieldfares (*Turdus pilaris*) eat the berries.

The wild berries were nevertheless here and there used along the coastal areas of Northern Europe. In the 18th century, fishermen in the Bothnian Sea used the astringent berries as a sauce for fish dishes. The berries must be picked after they are frost-bitten; otherwise they were very unpleasant to eat. Thus the berries were regarded as delicious and eaten also by children. In northwestern Jutland in Denmark, the peasants made porridge of the berries. Around 1900, the berries became popular when sugar became easily available. Because of thorns, the berries are difficult to pick. In Finland, the use of any instruments for picking or breaking branches is forbidden, and the berries can be picked only by hand. From Siberia, there are some reports that the Tatars made jam of the berries and ate it with milk and cheese.

There are also some reports of berries being used in traditional folk medicine, for instance from Norway. However, in China, the bark and leaves have been widely used in folk medicine. Some medicinal uses are reported, for instance for abdominal pain, rashes, lung diseases, diarrhea, and scurvy, and as a hemostatic agent.

The leaves and shoots were traditionally given to horses as fodder in some parts of coastal Europe. The tough, hard wood has been used for rake teeth (Norway, Austria) and also for small boxes and small tools. Twigs from the wild bushes have also had some ornamental use. In the 1930s, there was a demand for them in Scandinavia as they fit the décor ideal of functionalism. They immediately became very popular as decorations in shop windows and homes in Denmark and Sweden.

Planting Sea Buckthorn Shrubs

The shrub has a long history as binding dunes along the coastal areas of Northern Europe, and its planting has therefore been promoted by authorities for centuries. Nowadays, it is used for soil erosion control in Central and East Asia. The thorny branches also make it an excellent hedge plant. Since it grows fast, it quickly makes an impenetrable barrier protecting the garden from unwanted visitors. It also provides shelter for birds and other animals. The plant is easily propagated with cuttings, and it is salt tolerant. It can actually grow in a wide variety of soils, making it very useful also in rough gardens. Sea buckthorn is also an ornamental shrub with its silvery leaves and orange berries, and has therefore been cultivated as a garden plant in Europe and North America. Among cultivars for ornamental use is Sprite, a dwarf that does not produce berries.

Sea buckthorn has been cultivated in Russia since the 1930s and it is now popular in Finland, northern Germany, Estonia, and Sweden; it is increasingly popular also in Canada. The bush is easy to cultivate and thrives on sandy and meager soil. Cultivars with large berries have been developed. Many of these Russian, Siberian, and even Belarusian cultivars are now available in nurseries in Europe and Canada, for instance *Botanicheskaya* (Botanica), *Otradnaya* (Russian Orange), *Prevoshodnaya* (Siberian Splendor), and *Trofimovskaya* (Titan). Others, like Fergana and Hergo, originated in Germany. Thornless shrubs from Finland are increasingly popular in the market.

Sea Buckthorn Products and Uses

One reason the berries were overlooked for a long time is the fact that due to the thorny character of the shrub harvesting is difficult. The branches had to be removed and frozen. The berries could then be shaken off. Nowadays, various harvesting techniques exist. There are mechanical berry shakers that do not damage the plant.

The soft and juicy berries are very rich in vitamins C, A, and E, and they also contain a variety of bioflavonoids. Their fruit is said to be one of the most enriched plant sources of vitamin C that exists, and the juice is therefore very popular, although expensive, among health-conscious Germans and Scandinavians. A beer flavored with the berry has been marketed in Finland. Some make wine of the sea buckthorn juice, although this practice is done more as a hobby than to make a commercial product. The flavonoids are extracted from the fruit pulp for medicinal use.

An ornamental shrub, sea buckthorn is cultivated as a garden plant and branches have been used for decoration. Young leaves are dried and used as tea. The bark has been used for dying wool yellow-brown. The kernels are rich in vitamin E and the oil is used for cosmetics (especially skin creams) and in the medical industry. According to one report, the Russian cosmonauts used the cream for protection from cosmic radiation. Its medicinal potential is under development in China. The leaves and young branches are used as animal fodder.

Sea buckthorn is the provincial flower of Satakunta, Finland. The shrub is becoming an increasingly important crop in many countries, and especially in China, Mongolia, and Siberia huge areas in the north are planted with the shrub. Research and product development is promoted in many countries. The shrub has a high commercial potential and is seen as a plant for the future. An International Seabuckthorn Association (ISA) was founded in Beijing in 1995 for the promotion of awareness regarding sea buckthorn. Starting with 9 countries as members, now over 30 countries participate in their biannual conferences. Also, the European Commission funded an international cooperation network, EAN-Seabuck, in 2005, between Europe and Asia, including Russia and the newly independent states, to improve technical knowledge and know-how on sea buckthorn production.

Ingvar Svanberg

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Sesame

Known as "til," "gingelly," "simsim," and "gergelin," sesame is cultivated for its oil. Sesame is in the family Pedaliaceae, which has 16 genera and 60 species, several of which are interfertile with sesame. Greek physician Hippocrates (460–370 BCE) named sesame "sesamum," the name 18th-century CE Swedish naturalist Carl Linnaeus adopted. Linnaeus divided sesame into two species: *Sesamum* *indicum* and *Sesamum orientale*. In the 19th century, French botanist Alphonse de Candolle regarded *Sesamum orientale* as a variety of *Sesamum indicum*, restoring unity to the species. In Sanskrit, *tila* means "sesame seeds" and *taila* means "sesame oil." In Persian, "sesame" is *kunjut*. In Hebrew, "sesame" is *sum-sum* or *sem-sem*. The magic words "open sesame" may derive from the opening of the sesame seed capsule. Sesame seeds contain iron, copper, manganese, magnesium, vitamin E, and thiamine. One hundred grams of sesame seeds contain 26 grams of carbohydrates, 48 grams of fat, and 17 grams of protein.

Origin and History

Along with coconut, sesame may be the oldest oil crop. Competing hypotheses hold that sesame originated in Africa, India, Iran and Afghanistan, Southeast Asia and Malaysia, and China. Because Africa has a large number of wild species, it may be the homeland of sesame. Those who posit an African origin favor Ethiopia. If sesame originated in Ethiopia, it may have taken a circuitous route to Egypt. The Babylonians may have given sesame to Egypt. De Candolle believed that Semites brought sesame to Egypt, perhaps from the Near East and perhaps no earlier than the fourth century BCE. He believed that ancient papyri were silent about sesame, though one scholar believes that the Medical Papyrus of Thebes, dating to 1550 BCE, mentions sesame as a medicine. About 1230 BCE, a painting from the tomb of Pharaoh Ramses II (1304–1227 BCE) depicts a mixture of sesame seeds and flour. Even today, Egyptians have preserved this recipe. Yet it is possible that the seeds in the painting are caraway or poppy. If this is true, de Candolle may have been right to propose a late introduction of sesame into Egypt. It is possible that the Semites introduced sesame to Egypt after the exodus. In the first century CE, Greek physician Dioscorides noted that the Egyptians used sesame oil, but he thought that sesame seeds harmed the stomach and by sticking to the teeth caused bad breath. First-century CE Roman encyclopedist Pliny the Elder remarked that Egypt exported sesame oil from Pakistan to Europe. From Africa, sesame spread east to India, China, Southeast Asia, and Japan and west to Afghanistan, Iran, Turkey, and the rest of the Mediterranean Basin. After the Columbian Exchange, Africans often preferred peanut oil to sesame oil. Moreover, sesame oil competed poorly with castor oil for lighting because sesame oil burned quickly and was expensive. Sesame was little cultivated south of Ethiopia until the 19th century, when Arab and Indian demand spurred Africans to raise sesame for export.

In 1951, Russian agronomist Nikolai Vavilov proposed an origin in India, though it is possible that sesame, originating in Africa, crossed the Indian Ocean to India so early that Indians though sesame an indigene of the subcontinent. One authority remarked that the cultivation of sesame was as old as the rice culture in India. Yet earlier, de Candolle had proposed that India had received sesame from Malaysia or Indonesia and so could not have been the cradle of sesame. Another hypothesis holds that sesame, first cultivated in the Euphrates River valley and Uzbekistan, migrated from this region to India and from India to Egypt and Europe. This hypothesis makes India a doubtful homeland of sesame. Alternatively, the Aryans may have brought sesame to India. Indians may have been the first to derive oil from sesame seeds. They ate sesame seeds with sugar or ground them into meal. Sesame was part of Hindu religious rites. Sesame was the sacrificial plant. A devoted daughter, for example, offered it to her deceased father. The 13th- and 14th-centuries Italian adventurer Marco Polo remarked that Indians on the Malabar Coast extracted oil from sesame seeds. He also reported the extraction of sesame oil in Abyssinia and Sri Lanka and observed the process in Iran. He wrote that sesame oil was flavorful.

The earliest written record of sesame comes not from Africa or India but from Sumeria about 2350 BCE. By 2000 BCE, the Babylonians employed oil mills to extract sesame oil. In the fifth century BCE, Greek historian Herodotus noted that the Babylonians used virtually no oil other than sesame oil. The Babylonians used sesame as medicine and food, and in making wine and brandy. The Assyrians believed that the gods drank sesame wine and gave the crop to them. In the eighth century BCE, Assyrian king Sargon II caped the price of sesame oil. Perhaps because of his efforts, the price held constant during the first millennium BCE. In Assyria, sesame was so valuable that a debtor could repay a loan with sesame seeds or silver.

Herodotus wrote that sesame saved Greek boys from castration. The tyrant of Corinth, Periander (665–585 BCE) abducted 300 boys, sending them to Sardis, Turkey, to become eunuchs. En route to Sardis, the ship stopped at the island of Samos. Learning of the boys' fate, the inhabitants of Samos took them to the temple of the goddess Diana. The Corinthian guards, unable to enter the temple, determined to starve the boys into submission. The residents of Samos responded to this crisis by declaring a festival to Diana in which a choir of boys and girls entered the temple with sesame cakes, which they gave the famished boys. The guards gave up, allowing the inhabitants of the island to return the boys to their parents. In the fourth century BCE, Greek conqueror Alexander the Great encountered sesame, possibly in India, and Greek botanist Theophrastus described the plant. Greek soldiers carried sesame seeds as ration. De Candolle may have been the first to note that sesame is absent from the Old Testament, leading to the supposition that the Hebrews were latecomers to its cultivation. One hypothesis holds that the Hebrews did not grow sesame until the second century CE. Unlike the Old Testament, the Talmud refers to sesame.

The Romans cultivated sesame. First-century CE Roman agricultural writer Columella described its cultivation, including recommendations on soil, cultural methods, the harvest, and the uses of sesame seeds and oil. Pliny believed that sesame oil counteracted lizard bites and could be applied topically to inflamed ears and burns. Sesame has been cultivated in Russia since the end of the 17th century. The Portuguese brought sesame to Brazil, possibly in the 16th century. Slaves brought sesame to the American colonies at the end of the 17th century, growing it in South Carolina.

In the sixth century BCE, China used sesame seeds as currency. De Candolle believed, however, that sesame was not cultivated in China until the time of Christ. In 702 CE, a Japanese text noted that priests used sesame oil for lighting. By 928, Japanese farmers raised sesame, though it was not an important crop until the 18th century. In the 11th century, the people of Myanmar began cultivating sesame. Sri Lankan woman used sesame leaves and roots to darken their hair. Sesame grown in Kyrgyzstan in Central Asia yielded high-quality oil. Sesame was widely cultivated in India, Myanmar, Southeast Asia, China, Japan and the hot dry regions of Africa and the Mediterranean.

Attributes

Sesame roots are extensive and include a taproot. A large number of roots are only two or three inches deep and may be damaged by cultivation. As a rule, the later the maturity of a cultivar the more extensive is the root system. Roots are more numerous in sand than clay. Roots do not tolerate waterlogged or saline soil. A plant with a large root system usually produces seeds with high oil content. The farmer should not interplant sesame with corn or castor because the roots of the latter crops grow more quickly than sesame roots and so compete for water and nutrients. Crops following sesame yield well because sesame roots improve soil structure.

The stem is erect, growing up to two yards in height, though a few cultivars top out at three yards. Leaves are palmate and dull green. Flowers are pale or red. Each flower has four fertile stamens and often one sterile stamen. Stamens are green white. Each flower has five petals. The corolla is often white or pale pink but may be nearly as dark as purple. Flowers with a dark corolla were common in India, where it may be violet, white with a tint of violet, white with a violet border, or white. Flowers with a light corolla were common in Myanmar. Dark flowers bear dark seeds. Sesame flowers are self-fertile, though insects may pollinate them. Bees of the species *Megachile umbrapennis, Aphis dorsata*, and *Aphis florea* are frequent pollinators. The flowers open in the morning and wilt after midday. The stamens release pollen shortly after a flower opens. The stigma is receptive to pollen one day before a flower opens and on the day it opens.

Christopher Cumo

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Shea tree (Djembe/Dreamstime.com)

Shea Tree

The shea tree, known in the plant kingdom as *Vitellaria paradoxa* and *Butyrospermum parkii*, is a plant belonging to the Sapotaceae family. It is native to Africa and widely grown in Burkina Faso, Cameroon, Ghana, Cote d'Ivoire, Nigeria, Sudan, and Uganda. Although many of the exports of its products are part of the U.S. export-import business, this tree has failed to take root in the United States on a commercial level. Economically, especially in Africa, this plant has gained considerable significance since the 14th century CE. An explorer, Mungo Park, is believed to have mentioned the significance of the shea tree in his botanical writings of 1779 with an attempt at classifying and naming the plant.

Attributes

Shea grows well in dry conditions. Seen mostly in the savannah belts and in areas where water is scarce, shea can go through half the year with very little water. It cannot tolerate moist loamy soil, waterlogging or flooding, and areas that are swampy or saline. It grows at mild elevations up to a height of 900 feet above sea level.

Shea may be identified as a tree with dense foliage, a wide round crown, and a tree trunk the height of approximately 12 feet. The tree grows to a height of 42 feet. A late bloomer, attaining maturity when it averages 10 to 15 years, this perennial can live for over 200 years, producing shea nuts up to that time. Consistently abundant produce begins when the plant is almost 30 years old. The root is a strong, deep taproot with an extensive branching root system. The bark of the tree has numerous fissures, which may extend both horizontally and vertically. Due to its thick, corky bark, the shea tree is able to withstand and outlive forest fires. When the bark is peeled off, the wood below it is pale pink and with latex-secreting organs. The leaves, like most members of the Sapotaceae family, are long and oval and arranged at the end of the stalk in a clustered, spiral pattern. The leaf stalks or twigs holding the cluster of leaves have a thick bark covering them. The younger leaves grow in the center of the cluster while the older leaves are outside. The young leaves have a distinct rust-brown or brownish-red color and are flimsy, while the older leaves are a lush to dark green and with numerous oil-secreting glands. The leaf coat may also feel waxy or leathery to the touch. The inflorescence, which happens at the end of the twigs, is a dichasial cyme with many clusters of flowers, each cluster possessing about 40 flowers. In some cases, twice the number of flowers per inflorescence may be noted. Each flower is perfect, has both reproductive organs, and is self-pollinating, although much pollination is brought about by bees and other pollinating insects. The fruit, called the shea nut, is a berry that has a thin, shelled outer covering, a buttery, fleshy, pulpy middle layer, and a fairly large seed inside. The base of the fruit on the outside has a broad sheath.

Uses

From an economic point of view, shea has impacted the global market in a tremendous way with its products and fruit extracts. Every part of the tree is used in some form or another. The main product of the shea tree is its fruit, the shea nut. The nut has a pulpy flesh that is rich in oil, proteins, carbohydrates, ascorbic acid, iron, calcium, the vitamin B complex, and vitamins A and E. The oil or fat that is extracted from the nut is the main reason why this plant is cultivated on a large scale. The oil and buttery pulp are extracted as the most affordable means of cooking fat. In the unrefined form, the fruit extract is sold as loaves, while in the refined condition it is sold as butter that has a consistency similar to cocoa and is an ideal replacement for cocoa in pastries and dough. The fruit can be eaten raw, although it is best when it is slightly ripened. When ripe it is sweet to the taste. The flowers can be used in pastries and in making shea fritters. Shea butter has also been used by the African communities for skin treatment, as a skin nourisher, and as an antiaging cream for the past six centuries. The leaves and roots of the shea tree possess medicinal properties and are taken advantage of by pharmaceutical companies, especially in Europe and Japan. The leaves are also a source of African spice, a means for healing headaches through their vapor-inhalant properties, and an eye-cleaning solution when soaked in water. The bark of the tree, when boiled, transforms into a much appetizing beverage. The bark infusions are also used in sheep for the treatment of worm infestations. Shea butter has healing properties that are ideal for use as a balm for ulcers, cuts, and wounds.

Apart from its edible and medicinal contributions to human society, the tree yields latex, which is an important ingredient in the making of glue when mixed with palm oil. The by-product of refining shea nut is a residue that is reddish brown and not always used for consumption. This has an oily nature and is mixed with clay to strengthen the mud that is used for building. The residue, which is also rich in proteins and other nutrients, is an ideal animal feed. Likewise, it is also good as mulch and a fertilizer for the soil. Owing to the fact that shea has an abundance of clustered flowers, this tree becomes an ideal spot for setting up beehives for the culture of honey in apiculture.

While this plant is considerably sturdy and dry-weather tolerant for desert conditions spanning a few centuries, it is also susceptible to *Pestalotia heterospora*, which causes leaf mosaic disease. The larvae of *Ceratiris silvestrii* affect the fruit pulp, rendering it useless and contaminated. When detected in time, these diseases and pests can be controlled by the use of organic pesticides, which in turn affect neither the nutrient composition of the fruit nor the viability of the seed.

Amanda Mittra

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Snapdragon

There are 30 to 40 species of snapdragons, the most common of which is *Antirrhinum majus*. The name comes from the Greek, *antirrinon*, meaning "nose-like." The snapdragon has been a popular ornamental flower for centuries, and it has a rich history in folklore. Cooking oil can be made from its seeds, and the snapdragon plant also has medicinal uses. Indigenous species can be found in Europe, North America, and North Africa. The plant is of minor economic importance as an ornamental cultivar. *Antirrhinum majus* is native to southern Spain, from where it spread throughout the Roman Empire, and wild varieties can still be found growing freely in the ruins of ancient Greece and Rome. Native species in North America are not as showy and have not been cultivated for ornamental use.

The snapdragon was a well-known flower in the ancient world. The Greeks knew it by the common name *kynokephelon*, meaning "dog-headed." The Romans called it *leonis ora*, or "lion's mouth." The Old French word for Snapdragon was *muflier*, or "snout"; the Italians called the flower *bocca de leone*, and the Germans *Lowenmaul*, which both mean "lion's mouth." In English, common names for Snapdragon include dragon's snout, dog's mouth, calf's snout, and toad's mouth. All of these names reflect the unique, muzzle-like shape of the snapdragon bloom. If one gently squeezes the sides of the flower together rhythmically, it will pop open and closed, like a snapping jaw. For this reason, only larger insects, such as the bumblebee, can pollinate snapdragons; smaller insects are not strong enough to separate the flower's petals and reach its interior. Snapdragons are most commonly grown as an annual, but they are, in fact, perennial plants. Snapdragons are not particularly resistant to cold weather, but they can live through the winter, especially when properly seeded. Gardeners are advised to seed large swaths of soil in both the spring and fall if they want to grow these flowers as perennials. Biannual seeding helps replace plants that do not survive cold weather, and these plants are generally hardier when cultivated in larger groups.

Antirrhinum majus holds a significant place in European folklore. Snapdragons have been considered, since antiquity, to possess magical qualities. They have been said to protect against charms and enchantments. Both the first-century CE Greek physician Dioscorides and Roman encyclopedist Pliny advised wearing a bracelet of the flowers to stave off illness and protect against poisoning. During the Renaissance, snapdragons were believed to bring charisma, glory, honor, and social status; wearing them on one's sleeve was believed to lead to favorable receptions at court and among one's betters. Pliny recorded that rubbing oneself with snapdragon could improve one's appearance. Ancient Greek magicians believed that, by holding a snapdragon flower beneath one's tongue during sleep, and reciting a magical incantation upon rising, invisibility could be achieved.

In addition to serving as charms against witchcraft, snapdragons were said to provide special shelter to elves. A German folktale tells of a woman who is placed under magical enchantment by an elf. The elf kidnaps the woman and, as she follows him from her home, he warns her to lift her skirt so as not to damage the snapdragons growing underfoot. The woman, spotting a chance to escape, crushes the snapdragons under her feet and releases herself from the elf's magic spell.

The snapdragon retains its importance among modern practitioners of magic and Wicca. Modern practitioners celebrate the snapdragon's traditional protective powers against charms, curses, and magic. Any part of the plant, when worn on the body, is said to offer a charm against deception and lies. A seed of the plant, when hung around the neck, prevents bewitchment. Stepping on a snapdragon, or holding one of its blooms, is said to drive away evil influences. Modern Wiccans place fresh snapdragons on their altars when casting protective charms, and may plant protective borders of snapdragons around their gardens or homes.

Snapdragons placed in front of a mirror are said to dispel negative energy and reflect curses back to the person who sent them.

While mostly valuable for their showy and fragrant blooms, snapdragons do possess some limited medicinal value. As early as the first century, Dioscorides recommended pounding the seeds in lily oil to make a restorative facial lotion. The leaves of the snapdragon have bitter and stimulant properties, and have been used to treat stomach ulcers. An infusion made from the flowers of the snapdragon can be used to treat jaundice, though it is not as effective as other herbal remedies. The leaves and flowers of snapdragon can be made into an ointment for rashes and sunburns. Crushed flowers, mixed with almond oil and warmed, can be applied to the skin to treat sprains, strains, hemorrhoids, rashes, redness, and inflammation. This same concoction can provide relief for stiff muscles and aching backs. An infusion of the flowers and leaves can be gargled to treat sores and ulcers of the mouth. Snapdragon tea has been used as a remedy for sore throat. The leaves and flowers contain the soothing and softening agent mucilage as well as gallic acid, pectin, and resin. These components are believed responsible for the plant's limited medicinal uses.

The oil of snapdragon leaves is edible and is said to be just as healthy as olive oil. It has been extracted in Russia for culinary use since the 15th century. Russian legend tells of a poor farmer who lived amongst a vast field of wild snapdragons. One day, a stranger appeared, asking for something to eat. The poor farmer did not have much, but he invited the stranger to share his last loaf of bread. The farmer apologized that he had no butter to share with the stranger, and the stranger replied that he could offer an alternative; he went outside and plucked the ripe flowers from several wild snapdragons. He removed their seeds and squeezed the seed oil onto the farmer's bread. Afterward, the poor farmer began harvesting the snapdragon seeds around his home, expressing the oil himself and selling it at market. Thanks to the stranger's kindness, the farmer eventually prospered.

For the most part, snapdragons are considered an ornamental plant. They have long enjoyed popularity as such. Modern breeding of hybrid varieties, which began in the early 20th century, has made them more popular by removing the plant's one ornamental defect, namely, that the blooms of unhybridized plants fall off after being pollinated. As early as 1629, English herbalist John Parkinson, in his *Paradisi de Sole*, wrote of the many colors and varieties of snapdragon flowers. European settlers brought their snapdragon cultivars with them to the New World, and seeds were available for sale in the colonies as early as 1760. Despite its popularity, snapdragon was considered a "rustic" flower, not appropriate for planting among the more elegant flowers of the garden. Gardeners have been advised for centuries to seed snapdragons as background plants, among shrubs and on banks. Snapdragons are also highly recommended as a bedding plant, and can be used to bring liveliness to swaths of monotonous ground cover. Snapdragons grow well in most temperate regions of the Northern Hemisphere. The many varieties of snapdragon produce blooms in an astounding range of colors; they can be found in orange, scarlet, crimson, coral, amber, yellow, and white. The wide range of colors makes these flowers easy to match with others in the garden. Dwarf snapdragons may reach heights of about 10 inches, but larger varieties may grow as tall as three feet. The larger varieties especially make excellent cut flowers. They may be cultivated in beds or used as borders; they make attractive accent plants for ground cover beds and can bring late-season color to early-blooming gardens.

Snapdragons are not considered economically important in the modern world; their cultivation is restricted to greenhouses, where they are offered as annuals for flower gardening and landscaping. Though these plants can survive the winter to come back in the spring, they are nevertheless somewhat delicate, such that gardeners are advised to treat them as annuals, pulling them up at the end of the growing season, and replanting in the spring.

Snapdragons have been of some importance to science, which has used them as a model for molecular leaf development. Study of snapdragon rust has led scientists to a closer understanding of fungal rusts and how they affect plants. Science textbooks use the self-pollinating nature of the snapdragon to illustrate how botanists can create new hybrids by crossbreeding. Like many flowers, the snapdragon carries both pollen and egg cells within each bloom, meaning that it does not require the presence of other snapdragons for pollination. Self-pollinating flowers such as the snapdragon can be crossbred by removing the pollen-carrying structures from the blooms and then artificially pollinating these flowers from another plant.

Marjorie McAtee

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Sorghum

A perennial grass in the Poaceae or Gramineae family, sorghum is grown as an annual in lands that are too hot and dry for corn. Worldwide sorghum is the fourth most widely grown crop, trailing corn, rice, and wheat. Sorghum competes with millet for dry-land acreage in Africa and Asia, though in the United States farmers prefer sorghum to millet. The people of Africa and Asia eat much of the sorghum they grow, whereas in the United States sorghum feeds cattle, pigs, and poultry. Rich in starch, sorghum has nearly all the feed value of corn. In the United States,

Sorghum (Corel)

only corn surpasses sorghum as a livestock feed. U.S. farmers grow sorghum, a versatile crop, for hay and pasturage in addition to feed. Despite its importance, sorghum has in the United States always been in the shadow of corn. Corn, the American indigene, has resisted the encroachment of alien sorghum. One cup of sorghum has 2,370 calories, 25 grams of protein, 118 grams of carbohydrate, 18.5 grams of water, 3.4 grams of ash, 24.7 grams of fiber, 24.7 grams of starch, 4.2 grams of fat, 18.6 international units of beta-carotene, 0.5 milligram of thiamine, 0.4 milligram of riboflavin, 7.2 grams of niacin, 0.5 milligram of vitamin B6, 2.2 milligrams of vitamin E, 101 micrograms of folic acid, 10 micrograms of vitamin K, 2.5 milligrams of pantothenic acid, 55.8 milligrams of calcium, 0.8 milligram of copper, 4.5 milligrams of iron, 204 milligrams of magnesium, 4.5 milligrams of manganese, 632 milligrams of phosphorus, 446 milligrams of potassium, 60 milligrams of selenium, 10 milligrams of sodium, and 6.3 milligrams of zinc.

Origin and Diffusion in the Old World

The progenitor of sorghum may have arisen in southern Asia, but sorghum arose as a cultivated plant in Africa. Russian agronomist Nikolai Vavilov placed the early cultivation of sorghum in northeastern Africa. The Wadi Kubbaniya of Sudan may have been among the first to grow sorghum, planting it in damp beds that retained floodwater from the Nile River. Migrants, they planted sorghum, leaving it to mature while they wandered and returning in time to harvest it. The Mande of the Niger River valley may have planted sorghum as early as 5000 BCE. The Mande may have borrowed sorghum or at least agriculture from others. One school of thought holds that agriculture arose in western Asia and through human migration spread to Africa between 12,000 and 7000 BCE. Once in Africa, agriculture moved west between 10,000 and 6000 BCE, when the climate was wet in the Sahara and Sahel. Thereafter the climate dried. The Sahara Desert expanded, forcing farmers south, where they encountered the Mande, who, borrowing agriculture from them, began to cultivate sorghum. If, as one hypothesis holds, Africans grew sorghum in the Saharan Fertile Crescent as early as 6100 BCE, then the Mande cannot have been the first to cultivate the grain. Alternatively, Ethiopians may have been among the early cultivators of sorghum. From Ethiopia, sorghum spread west to Lake Chad and then to the Niger River, where the Mande presumably adopted it. Other early cultivators may have been the Hamites, a Caucasian people who migrated into northeastern Africa around 7000 BCE. Harvesting wild sorghum that grew in this region, the Hamites domesticated the grain before 1000 BCE. In the process of domestication, the mutation of two genes transformed sorghum from a shattering to a nonshattering plant. Because sorghum could no longer disperse seeds on its own, it held its seeds until humans harvested them. Benefiting from the nonshattering habit, humans selected for this mutation. By 1000 BCE, the Hamites had spread sorghum south to Kenya and Tanzania. About the time of Christ the Bantu, who must have adopted sorghum earlier, migrated to the Congo and then farther south, taking sorghum with them. By 500 CE, they reached East Africa. As they migrated, they established the culture of sorghum in central and southern Africa. By the 10th century, the Bantu carried sorghum to Botswana and by the 14th century to Zimbabwe.

From Africa, sorghum spread to Asia. India may have cultivated sorghum as early as 1500 BCE, though the source of this early introduction is unknown. The Arabs, who had established trade between Africa and Indian across the Indian Ocean, provisioned their ships with sorghum. From these stores may have come the introduction of sorghum into India 2,000 years ago. One authority dates the cultivation of sorghum in India to the first century CE. Another scholar believes that humans independently domesticated sorghum in India and Africa. From Africa, sorghum migrated to western Asia. A carving of a sorghum plant dates its cultivation in Assyria no later than 700 BCE. From India, sorghum spread to Iran, though the date of this transfer is unclear. About 600 CE, China adopted sorghum from Arabia or India. The people of Africa, India, and Arabia traded sorghum, certainly by the first millennium CE. Around 60 CE, the Romans grew sorghum, and first-century Roman encyclopedist Pliny the Elder wrote the first description of the plant.

Attributes

Sorghum's outstanding attribute is its drought tolerance. With a root system twice as extensive as that of corn, sorghum extracts 90 percent of the water, and nutrients, available from the soil. Some sorghum roots penetrate to a depth of six feet, deriving water at depth. Most sorghum roots are shorter than 10 inches and derive water from the upper layer of soil. During drought, sorghum becomes dormant, resuming growth when the rains return. When rain is scarce, sorghum leaves curl up, exposing less surface area to transpiration. Moreover, the leaves and stalk have a waxy coating that minimizes the loss of water. Sorghum tolerates drought best between 20 and 40 days after planting. During flowering, the need for water is greater and a sorghum plant may absorb 0.2 inch of rain per day. Overall sorghum survives with as little as 15 inches of rain per year. Of the grains, only millet can cope with less rain, though sorghum better tolerates a prolonged drought. Sorghum's drought tolerance makes it a crop of the arid regions of Texas and Oklahoma.

A tropical crop sorghum will not tolerate frost. Photosensitive, sorghum flowers need 12 hours of daylight. Sorghum will grow from sea level to 9,800 feet. It germinates between 50°F and 95°F. The optimal growing temperature is 86°F, though sorghum can tolerate temperatures above 100°F. Sorghum needs at least 130 days to mature and so cannot be grown at latitudes higher than 45° north or south.

Adapted to both acidic and basic soils, sorghum will tolerate a pH between 6.2 and 7.8. Throughout much of the world, farmers grow sorghum in soils with a pH between 7 and 8.3, that is, in slightly alkaline soils. Where farmers irrigate sorghum, the soil may become too saline. Like sugarcane, rice, and millet, sorghum will regenerate after the harvest, though the second crop will yield only half the grain of the first crop.

Sorghum is a tall plant. African cultivars exceed eight feet, and early American varieties were also tall. Because early sorghum varieties were so tall, they sometimes lodged. One account holds that U.S. sorghum growers could harvest their plants only by standing on a wagon. Because of its height sorghum is still harvested by hand in much of Africa. In the United States, tall cultivars persisted so long because, grown in the South, sorghum did not benefit from the mechanization of agriculture in the North and West in the 19th century. The desire to mechanize the harvest prompted scientists to breed short cultivars suitable for machine harvest. Farmers began to adopt these varieties in the 1940s. Texas farmers harvested all sorghum by combine in 1945.

Sorghum extracts nitrogen, phosphorus, potassium, sulfur, calcium, magnesium, iron, zinc, manganese, copper, boron, molybdenum, and chlorine from the soil. Sorghum absorbs more nitrogen, phosphorus, and zinc than corn but less potassium and iron. Sorghum growers add potassium and phosphorus to the soil before planting. Farmers plant and fertilize with nitrogen in a single operation. As a rule, they apply half the nitrogen at planting and the other half 10 to 25 days later. Sorghum is so efficient at extracting nutrients from the soil that when grown in rotation farmers must fertilize their soil before the next crop so that it has enough nutrients.

In the United States, many farmers rotate sorghum with other crops. On the Great Plains, farmers let land lie fallow after a sorghum crop and then rotate with wheat. In other instances, farmers do not fallow land but instead alternate sorghum and wheat in a two-year rotation. In the South, farmers rotate sorghum with cotton. A sorghum-cotton rotation is common in Texas. Sorghum is suitable for this rotation because it reduces the population of the pathogens that cause cotton root rot and verticillium wilt. In some regions, farmers rotate sorghum with vegetables and Sugar Beet. In arid regions, farmers alternate sorghum and fallow. In the North, farmers rotate winter wheat and sorghum. In the Southeast, farmers double-crop sorghum and a winter grain. In other instances, farmers in the Southeast rotate sorghum and soybeans, cotton, or peanuts. In the Midwest, farmers rotate sorghum with soybeans, though they are more apt to rotate corn and soybeans. In some cases, farmers flood their sorghum fields, raising crawfish in the muck.

Sorghum is a self-pollinator, though 4–8 percent of pollen fertilizes another flower. Each panicle has more than 20 million pollen grains, more than enough to pollinate an entire field were sorghum a crossbreeder. Excessive heat reduces the rate of pollination, though we have seen that sorghum tolerates high temperatures. The discovery that some sorghum produced no pollen led to its use as the female line in hybrid crosses and so made hybrid sorghum a reality. Although farmers rapidly adopted hybrid sorghum, early hybrids were vulnerable to insects and diseases. In the 1970s, scientists incorporated insect and disease resistance into elite lines. Curiously, this decade witnessed a retreat from sorghum. In western Ohio, where farmers had grown sorghum for decades, they switched to soybeans.

In Sudan, Ethiopia, Yemen, and Nigeria, people eat sorghum as a type of bread known as injere in Ethiopia, rison in Yemen, and masa in Nigeria. In Ethiopia, people roast and eat immature sorghum grains. In India, Bangladesh, China, Ethiopia, Kenya, Botswana, and Nigeria, people boil and eat sorghum, which has the consistency of boiled rice. Indians eat popped sorghum as a snack much as Americans eat popcorn. The people of India, Botswana, Uganda, and Nigeria make sorghum into porridge. In India, people eat boiled sorghum with meat and vegetables. Indians eat popped sorghum with syrup, butter, milk, and sugar.

By 1920, U.S. farmers grew sorghum on several million acres. Acreage declined during the 1930s as machines replaced draft animals, reducing the demand for sorghum as feed. After 1940, sorghum rebounded and in the 1950s was cultivated on a larger number of acres. By the 1980s, farmers grew sorghum on even more acres, but thereafter acreage fell during the 1990s. In paying farmers not to plant crops on marginal land, the federal government inadvertently caused sorghum acreage to decline. Moreover, the derivation of drought-tolerant corn hybrids gave dry-land farmers an alternative to sorghum.

As early as 1935 Kansas, Oklahoma, and Texas produced the vast majority of all U.S. sorghum. By 1998, these states plus Nebraska and Missouri yielded nearly all sorghum grown in the United States. Kansas was the leading producer, followed by Texas and Nebraska. Farmers grew sorghum from Georgia to California and from Texas to South Dakota. In 2000, the United States was the world's leading producer of sorghum. In addition to the United States, El Salvador, Mexico, and Nicaragua produce hundreds of thousands of tons of sorghum. In South America, Argentina produced the most sorghum in 2000, followed by Brazil. In Africa, Nigeria was the leading producer in 2000, followed by Sudan, Burkina Faso, and Ethiopia. In Asia, China and India totaled more than 90 percent of the continent's sorghum production in 2000. Other Asian producers are Pakistan, Saudi Arabia, Thailand, and Yemen.

Conscious of sorghum's importance, the townspeople of Butler County, Kansas, held an annual Butler County, Kansas, Kafir Corn Carnival in 1911 and for several years thereafter. Carnival organizers sponsored an essay contest, soliciting the best prose about the value of kafir to the local economy. The carnival featured a kafirville arch, which was ablaze in electric lights. The information booth had a telephone, which was a novelty in the rural United States. The carnival featured a parade with floats and automobiles. Analogous to the corn shows of the Midwest, the Kafir Corn Carnival promoted civic pride and the virtues of rural living.

Races, Varieties, and Hybrids

In prehistory and antiquity, humans segregated sorghum into five races: bicolor, guinea, caudatum, kafir, and durra. Biocolor appears to be the oldest of the five. The ancients grew bicolor in Africa, India, China, and Indonesia. West of Lake Chad, Africans selected guinea from bicolor. True to its ancestral homeland, guinea is today grown primarily in West Africa. A second selection from bicolor was caudatum, which the Chari of the Nile River Valley derived. South of the Congo humans selected kafir, though its parent is unknown. The fifth race, durra, evolved in India before 1000 BCE. Around 500 CE, Arabs planted durra in Arabia and parts of Africa. In 615 CE, Arabs introduced durra into Ethiopia.

From these races, farmers and scientists selected all the varieties grown throughout the world. The origin and adoption of these varieties were tied to the development of European agriculture in the New World. During the slave trade, Africans introduced guinea into the Americas. Known as chicken corn, guinea must have fed poultry. Curious was its association with corn, for a sorghum plant looks superficially like a corn plant. The association with corn may simply have meant that guinea was a grain. Because Americans associated sorghum with slavery, they disparaged it as poor people's food. Fit only for animals, many thought, sorghum was fed to livestock. In the 18th century, Benjamin Franklin may have introduced the first variety of sorghum into the United States, though if this is true it seems strange that no farmer grew sorghum until 1853, when William Prince of New York cultivated it. The French adopted Chinese amber, a variety, as its name suggests, from China in 1851, and Americans adopted it in 1853. In 1857, the U.S. Patent Office (Congress would not create the U.S. Department of Agriculture until 1862) began distributing sorghum seeds to farmers. That year farmers began cultivating sorgo, a variety ideal for making syrup. Americans called sorgo sweet sorghum or cane, though it was not a variety of sugarcane. The same was true of Chinese sugarcane, which despite its name was a variety of sorghum. In 1874, U.S. farmers began growing durra, known as gyp. According to one account, farmers called durra gyp in the erroneous belief that it had originated in Egypt. Another account holds, however, that Egypt was the source of America's durra and that farmers grew gyp, an early grain, sorghum, in Georgia and California before 1874. In 1876, U.S. farmers obtained kafir seeds from South Africa. The Centennial Exposition of 1876 exhibited white and red kafirs and may have alerted farmers to their value. In 1879, African missionary H. B. Pratt returned to South Carolina with maiz milo, which may have been the source of the milo introduction of 1880. Kafir and milo were the sources of other cultivars. In the

1880s, Kansan farmers began to cultivate the variety white durra. In 1881, U.S. farmers began to raise collier, a variety from South Africa. In 1888, they began cultivating planter, a variety from Australia.

In the 19th century Leonard Wray, a British sugar planter, introduced 16 sorghum varieties to the United States. Farmers grew them in South Carolina and Georgia. In 1890, the Louisiana Agricultural Experiment Station began growing shallu, a cross between guinea and kafir from India. Known as Egyptian wheat, shallu was neither a variety of wheat nor an Egyptian cultivar. That year farmers began to cultivate blackhull kafir, which by 1936 was the leading cultivar in the United States. Known as African millet, blackhull was not a millet, though it was suited, like all sorghum and millet, to dry lands. In 1890, the Texas Agricultural Experiment Station recorded the availability of 23 cultivars. Doubtless many of them were imports. In 1891, U.S. farmers began growing mclean, a variety from Australia. In 1904, they began to raise the South African variety Pink Kafir. In 1905, scientists derived the variety Dawn Kafir from Blackhull. Thereafter farmers and scientists selected Buff Kafir, Header Mill, Dwarf Duallo, and Dorso from Blackhull. Dorso was cinch bug resistant. In 1906, the United States adopted Feterita, a cross between durra and caudatum, from Sudan. That year the United States imported Hageri, a variety derived from caudatum from Sudan. Also in 1906, farmers in Oklahoma and Texas began to grow Dwarf Yellow Milo, a short cultivar. That year A. H. Leidigh, director of the Amarillo Cereal Field Station, selected Sunrise Kafir, apparently from a field of Blackhull. An early-maturing variety, Sunrise was grown in 12 states by 1936. In 1909, U.S. farmers began to raise sudan grass, a type of sorghum suitable for pasturage. By 1918, sudan grass was valued at several million dollars in the United States. In 1914, crop breeders crossed Feterita with Blackhull to derive Chiltex and Premo. Bonito was in turn a cross between Chiltex and Hegari. Quadroon was a cross between milo and kafir. In 1928, scientists derived Beaver, which was likewise a cross between milo and kafir. A short cultivar, Beaver was suitable for machine harvest. In 1931, scientists made a third cross between milo and kafir to derive Wheatland, so named because the type of combine used to harvest wheat was also used to harvest wheatland. In 1941, W. P. Martin selected Martin's milo from a field of Wheatland. Martin's milo, named after W. P. Martin, was resistant to root and stalk rot. It was the leading cultivar until the advent of hybrids.

In the 1910s, sorghum breeders made the first hybrid crosses of sorghum, a plant that normally self-pollinates. These efforts overlapped with the crossing of corn inbreds, though hybrid corn predated and anticipated the development of hybrid sorghum. DeKalb, an agricultural company that was an early innovator of hybrid corn, sold the first hybrid sorghum in 1956. Farmers adopted hybrid sorghum more rapidly than they had hybrid corn. Today, all sorghum in the United States is hybrid. Between 1956 and 1985, sorghum yields tripled in the United

States. Hybrid vigor accounted for one-third of this increase. The use of fertilizers, herbicides, and irrigation accounted for the other two-thirds. The promise of high yields that hybrids offered may have persuaded farmers to grow sorghum.

Insects and Diseases

Among the insects that feed on sorghum is the red imported fire ant, a species that has replaced indigenous ants in many places where sorghum is grown. Aggregating in colonies of hundreds of thousands of ants, the red imported fire ant may benefit farmers because it eats other insects but it also eats sorghum seeds. Chewing through the seed coat, it removes the embryo, leaving nothing to germinate. In some cases, the ants will eat the roots of seedlings. Seeds that germinate rapidly offer the best control against the ants because rapid germination reduces the time that seeds are vulnerable to attack. Farmers may also treat seeds with insecticide. Moreover, they may pack down the soil to make it difficult for ants to penetrate to seeds. Conventional tillage seems to reduce ant populations. Ants are more numerous in no-till fields.

A beetle, larvae of the white grub feed on sorghum roots. They overwinter in the soil as larvae and so are ready to feed when seeds are planted. Destroying seedlings before they reach a height of six inches, white grubs kill plants 7 to 10 days after germination. Larvae stunt plants that survive to maturity though these may not bear grain. Due to the feeding of the white grub, sorghum plants may have such poor root systems that they lodge. Farmers may combat the white grub by planting sorghum where a grain was not grown the previous year. Furthermore, they may apply insecticide to the soil before they plant sorghum. Once the crop is planted, however, it is too late to combat the grub by other means.

A moth, larvae of the cutworm overwinter as larvae and emerge in spring to menace sorghum. Emerging from the soil, cutworms feed on the base of sorghum plants. Some larvae climb plants to devour leaves, and others remain in the soil to feed on roots. Root feeders are so damaging that they kill seedlings and stunt older plants. Because cutworms are most abundant in weedy fields, farmers must take care to minimize weeds. They may cultivate field in autumn to destroy weeds so that their fields are clean in spring. Farmers may apply insecticide in the evening to kill larvae as they emerge to feed at night. In addition, farmers may apply insecticide to the soil before planting to kill larvae before they have an opportunity to strike.

Particularly damaging in the American South, the sorghum midge may be the most widespread pest of sorghum. The midge has spread to all regions of the world where sorghum is grown except Southeast Asia. A female midge lays some 50 eggs on a sorghum plant. Hatchlings feed on flowers, preventing grain from forming. Because midge populations increase over the summer, farmers may plant sorghum early to avoid heavy infestations. Farmers may addition spray herbicides to kill Johnson grass, on which midges also feed, to reduce their population. Moreover, farmers may deep-plow the soil to kill overwintering larvae. Resistant cultivars, which sustain only 20 percent as much damage as susceptible varieties, are also an option. Insecticides, sprayed every five days, may keep midge populations low.

The pathogen *Sporiserium reilianum* causes head smut, which has spread to many regions of Africa, including western Kenya, Niger, and southern Africa. It is also present in the United States, Mexico, and China. The susceptibility of early hybrids to head smut precipitated an epidemic in Texas in 1958. Chastened, the U.S. Department of Agriculture began research to control smut in the late 1950s. Alert to the dangers of smut, the Texas Agricultural Experiment Station bred the first resistant hybrids in 1963. Newly evolved smut, however, undermined this resistance by 1968. In addition to planting a new generation of resistant hybrids, farmers benefit from dry winters, following which head smut is less severe.

Also infecting corn and several other grains, the fungus *Peronosclerospora sorghi* causes downy mildew. The disease first appeared in India in 1907, spreading to the Americas in the 1950s. In 1958, it invaded Panama and in 1961 Texas. In the United States, it has spread east to Georgia, north to southern Indiana and Illinois, and west to Kansas, Nebraska, and New Mexico. Downy mildew threatens sorghum in all regions of Latin America. The fungicide metalexly is effective against downy mildew. In addition, farmers may rotate sorghum with a nongrass, soybeans or cotton for example.

In Asia, the fungus *Claviceps sorghi* causes ergot, a disease of several grains, notably rye. In Africa, the fungus *Claviceps africana* transmits ergot to sorghum. Ergot reduces yields. More importantly, the fungus is toxic to humans and livestock, rendering a crop inedible. The fungus infects sorghum flowers before they are pollinated. Because male sterile lines do not produce pollen, their use in producing hybrids leaves them susceptible to ergot. The disease has accordingly become serious since the advent of hybrid sorghum in the 1950s. In 1995, *Claviceps Africana* spread from Africa to Brazil and thereafter throughout the Americas. About the same time, it spread to Australia. Farmers may spray fungicides to limit damage from ergot.

Christopher Cumo

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Southernwood

A bushy shrub, southernwood is a perennial with highly aromatic leaves. It is also a very old cultivated plant, known since antiquity. The highly slender leaves, which resemble those of dill, grow along the stiff stems of the plant. Southernwood can grow to be 40 to 60 inches high and 12 to 24 inches wide. When touched, it gives off a scent recalling that of lemon. The blossoms, which are small and yellowish, appear during autumn. In Northern Europe, however, they never have the time to open fully. The plant can easily be propagated from cuttings or by dividing the roots.

Southernwood was once cultivated as a medicinal herb, as well as for use as a spice. Nowadays, however, it is not used much for either purpose. Peasants in Northern Europe long grew it for its scent. It is still used to spice bread in certain parts of southwestern Europe. One often encounters it today in historical herb gardens that have been established for educational purposes. In Europe and North America, moreover, it is sometimes grown as a hedge plant. In this form it is quite decorative, with its fine, feathery gray-green foliage and its strong smell of lemon. A variant found on the American market is silver in color, which increases its ornamental value. Southernwood can fill difficult spaces in the garden (dry rocky slopes, for example), and it is resistant to drought. In a dried form, moreover, it is still a good way to spread a pleasant smell in the home.

History and Origin

Southernwood grows wild in the eastern Mediterranean, and probably has its origins in western Asia. Its common English name comes from the Anglo-Saxon *sutherne wudu*, meaning "native to Southern Europe." It is also found in Armenia, Ukraine, southern Russia, the Caucasus, and the Balkan Peninsula. References to its use as a medicinal herb are found in the literature of antiquity. It is also mentioned as abrotanum in the plant catalogue featured in *Capitulare de villis vel* *curtis imperii*, the edict issued by Frankish king Charlemagne in 812. The edict indicates southernwood's range as a cultivated plant. It seems to have spread during the Middle Ages with the expansion of monastic gardens and to have figured within monastic medicine.

Many of the names for this plant in Southern, Western, and Northern Europe are loan words based on the Latin *abrotanum* and remade through folk etymology: for example *abrodd* (Norwegian), *åbrodd* (Swedish), *abrotone* (French), and *broida* (Catalan). This may indicate that southernwood spread with the monasteries. Its presence in Northern Europe and England is attested from the mid-16th century. "It was formerly a common garden plant in London, as it will live even in the densest parts," wrote British author Elizabeth Kent in 1823. European immigrants brought it to North America around 1600. It has also been introduced into Australian and South African gardens.

People in modernity started using southernwood as a kitchen spice too, especially for rich dishes like pork, duck, and goose. Germans used it as a seasoning in soup. Applications of this kind seem to have ceased, however, and cookbooks now rarely mention them. In addition, physicians advise today against using the herb in food preparation because the alkaloid abrotanin, which is what gives the plant its bitterness, is mildly toxic.

Southernwood is not often cultivated today. Its significance is primarily historical. As a relic of cultivation or in naturalized form, however, it can still be found here and there in Europe.

Medicinal Plant

With its fresh lemon-like scent, southernwood has long served as a medicinal plant. Greek physicians Hippocrates and Dioscorides mentioned it. Physicians in ancient Greece endorsed it as a diuretic and recommended its use for menstrual pains, coughs, and snake bites. European herbals from the Middle Ages averred that, if mixed with wine or taken as an extract, southernwood could ease chest pains, breathing difficulties, and coughs, and that it was an antidote against poison. German botanist Leonhart Fuchs recommended in the mid-16th century that its flowers or seeds be boiled in a mixture of water and wine, and that the resulting solution be ingested or rubbed onto painful joints. Other herbals state that it killed parasitic worms, that it could be applied to sores, and that it was used "against unchastity." According to one handbook from the 18th century, moreover, southernwood slowed the decomposition of corpses if placed among them and hindered the spread of gangrene if applied to the skin.

Pharmacopeias in many parts of Europe long recommended the use of southernwood. It was particularly prized as a diaphoretic; but it was used as well to treat liver, spleen, and stomach problems. It had a wide use within traditional medicine too. According to reports from Sweden, the inhabitants of that country minced the plant and applied it to sores. Indeed, southernwood has continued to feature in household remedies up to our own day. Dried and boiled in water, for instance, it serves as a diaphoretic, as well as a remedy for diarrhea, bronchitis, kidney disorders, and lack of appetite. It is also an ingredient in certain factory-made cough medicines.

Country folks also used it as an ethnoveterinary medicine. According to reports from Denmark, for example, 19th-century peasants in that country used the root of southernwood to combat various horse diseases. They also sought, by spreading smoke from the burning root within their barns, to prevent cows from aborting their calves. When shearing sheep in the spring they would dry the animals' muzzles with a bundle of southernwood and then recite the doggerel "In a year daughter and son again," in the hope that the sheep would lamb again the following year.

Southernwood contains up to 1.4 percent essential oil, chiefly absinthol. Minor components include fenchene, sabinene, alpha-caryophyllene, and beta-caryophyllene. The plant also contains abrotanin, a bitter alkaloid that is active against bacteria.

Folk Uses

Up to the latter half of the 19th century, peasants throughout Northern Europe evinced great appreciation for this aromatic herb, and cultivated it extensively. Reports from the British Isles tell of its use within courting and as a love potion; thus it has also been known as Lad's Love. In Cambridgeshire before the World War I, for example, young men would sport it in a buttonhole, in the hope of attracting women. Other names are Boy's Love and Lady's Love. In Scandinavia, young women were known to carry a bouquet of southernwood at times, such as when calling upon their suitors' parents for the first time.

The herb was also used to spread a pleasing fragrance in the home. Many of its folk names thus refer to its characteristic smell. Names for it include *citronella maior* in Portuguese, *Armoise citronnelle* in French, and *bálsamo verde* in Spanish. In Denmark, Sweden, and northern Germany, it was used in church bouquets or as a bookmark in hymn books. Women sitting in the church pews would spread its fragrance during the long sermons; the striking scent may have helped them to stay awake. In northern Germany, accordingly, it went by such names as *Riechblume*, *Rukelbloem*, *Rückelbusch*, and *Schmecker*. On the Danish island of Bornholm, it was known as *lugtegodt* ("smell good"). Names like Sweet Benjamin, Old Man, and Old Woman have been recorded in the United States. "A sprig of it was carrying to Meeting each summer Sundays by many old ladies," wrote American historian Alice Morse Earle about the local customs in Massachusetts in the 1850s. Merrymakers also strewed it on the floor in preparation for parties. Old branches of southernwood could be used as brooms for sweeping the floor. In Denmark, the plant had a reputation as an aphrodisiac.

In Southern and Western Europe, worshippers burned it as an incense in churches. English botanist Nicholas Culpeper wrote in 1653 that it "drives away serpents and other venomous creatures." Well-dried seeds of the plant were used as a vermifuge, as noted by German botanist Jacobus Theodorus Tabernaemontanus in 1588. Even today, in fact, rural people in some parts of Europe use southernwood to repel moths and fleas. Children have also made perfume from the leaves. The plant is known in Lithuanian as *diemedis* and in Latvian as *ievakoks*, meaning "God's Tree." It is also called God's Tree in several Slavic languages (for example, *božo dravče* in Bulgarian) as well as Romanian (lemnul domnului). In Slavic regions, finally, it has been used for purposes of divination.

According to Culpeper in 1653, oil made from southernwood "put among the ointments that are used against the French disease, is very effectual, and likewise kills lice in the head." People of later periods were also aware of the plant's virtues as an insect repellent. They often placed it in wardrobes, both to keep moths away and to impart a pleasing smell to clothing. There is evidence for this as early as the 17th century in Scandinavia. Southernwood also deterred flies. In the United States, for example, it was once used in this way. Hanging bundles of the plant on doors and windowsills kept flies from coming into the home. The plant also enabled beekeepers, due to its powerful aroma, to entice swarming bees into beehives. Its branches, finally, were used to dye wool yellow.

Since seeds very seldom reach maturity, one must find cuttings of the plant in order to propagate it. These root easily. They can be procured from older gardens, where old specimens of the plant are still to be found.

Ingvar Svanberg

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Soybeans

Also known as soya bean, soja bean, Chinese pea, Manchurian bean, Japan pea, Japan bean, and Japanese fodder plant, the cultivated soybean is an annual legume in the family Leguminosae or Fabaceae. The appellation "soya bean" derives from *show-ya* or *so-ya* in Japanese, which in turn derives from the Chinese *Chiang-yia*, meaning "soy sauce." To the term "soya" the British added the noun "bean."

Soybeans (Sarahgen/Dreamstime.com)

In 1737, Swedish naturalist Carl Linnaeus put cultivated soybeans in the genus *Glycine*, Greek for "sweet." He termed the species *max*, meaning "large" because the nodules on soybean roots are large. Soybeans in the species *Glycine glycine* and *Glycine soja* are not cultivated but are perennial legumes. Soybeans are related to chickpea, peas, alfalfa, clover, vetch, beans, cowpea, lentils, and lupine.

Soybeans are of two types. Indeterminate plants produce new stems and leaves throughout their lives and are as tall as eight feet. Determinate plants virtually cease vegetative growth after flowering. Determinate soybeans may be only one foot tall. Among these short plants are semidwarfs, which are determinate plants. Unlike semidwarf wheat and rice, semidwarf soybeans are not widely grown. Their pods hang low to the ground and so are difficult to harvest by machine. Determinate soybeans flower later than indeterminate plants and are suitable for cultivation in the American South. Seldom are determinate soybeans grown in the northern United States.

Soybeans are photosensitive. Different varieties flower at different day lengths. Because soybean cultivars are anchored to specific day lengths, they must be planted at precise latitudes. As a rule, a cultivar cannot be grown more than 100 miles north or south of its ideal latitude without suffering a decrease in yield. Because cultivars have such a narrow range of adaptation, scientists have bred a large number, more than 20,000, designer cultivars, each tailored to a specific latitude.

Origin and Diffusion in the Old World

The wild species *Glycine soja* may have given rise to *Glycine max* sometime in antiquity. *Glycine soja* grows wild in parts of China, Taiwan, Japan, Korea, and Russia. This transformation from perennial to annual occurred without human intervention. Compared with the grains, soybeans were domesticated late, about 2800 BCE in northern China. In 2207 BCE a Chinese agriculturalist wrote a treatise on, among other topics, the cultivation of soybeans. During the Shang and Chou dynasties (1700–700 BCE) farmers spread soybeans throughout China. In the 11th century BCE, a Chinese book of verse mentioned the soybean and its uses. One poem noted that people boiled soybeans before eating them. Another poem implied that the Chinese ate soybean leaves as a vegetable and fed them to livestock. A fifth-century BCE Chinese text classed the soybean as one of five grains, though it is really a legume. Despite this textual evidence, one archaeological site dates soybean culture to only 700 BCE. A second site dates soybeans even later to 300 BCE.

In the first century CE, the soybean migrated to Manchuria and Korea. Following land and oceanic trade routes, soybeans spread to Japan, Indonesia, the Philippines, Vietnam, Thailand, Malaysia, Myanmar, Nepal, and India between the first and 15th centuries. In Asia, farmers planted soybeans with rice, a nutritious combination. Whereas rice provided carbohydrates, soybeans nourished humans with a balance of amino acids and oil. Farmers repeated this combination of a grain and a legume in Eurasia, where they planted wheat and peas, and in the Americas, where they planted corn and beans.

In the 17th century, Europe imported soy sauce and likely the bean from Asia. Textual evidence dates the cultivation of soybeans in Indonesia to the 17th century. One British governor noted the growing of soybeans in Java in the 1810s. In 1712, botanist Englebert Kaempfer introduced the soybean to Europe, though it must not have been widely grown because Europe continued to import soybeans into the 21st century. As we have seen, Linnaeus was familiar with the soybean in the early 18th century, demonstrating that it had reached Sweden by then. In 1739, missionaries in China sent soybeans to the Jardin des Plantes in Paris, France, where it was planted, though farmers seldom grew them before 1855. In 1790, the Royal Botanic Garden in Kew, Great Britain, planted soybeans. Two 18th-century texts mention the cultivation of soybeans in Vietnam. Soybeans were a popular crop because they stored well. After the harvest, Vietnamese farmers bound soybeans in sheaves, which they hung in the kitchen. The women of the household prepared these soybeans for consumption. As early as 1804, farmers in Yugoslavia fed soybeans to chickens. After 1804, Japanese farmers used soybean meal as fertilizer. In 1894 and 1895 Japan, in preparation for the Russo-Japanese War, stationed 200,000 troops in northern China, increasing the demand for soybeans for human consumption. Manchuria met this demand, expanding soy acreage. In 1895 Japan, evidently unable to satisfy domestic demand, began importing soybeans from Manchuria.

In 1908, British farmers began growing soybeans for oil to make soap and to feed livestock. By 1910, Germany, Denmark, and the Netherlands were importing soybeans from Manchuria. Production declining amid competition, Manchurian farmers ceded these markets to European and American soybean growers in the 1930s. In 1935 Germany, preparing for World War II, offered farmers in Romania and Bulgaria a guaranteed price for soybeans. Between 1934 and 1941, soybean production in these nations, responding to favorable prices from Germany, increased from 375,000 to 5.5 million bushels.

Only in the 19th century did African farmers begin growing soybeans. The French introduced the soybean to Algeria that century, though its cultivation was not widespread. In 1908, Nigerian farmers grew their first soybean crop, and in 1909 soybeans were first grown in Gambia and Ghana. Only in 1981 did farmers in Guinea-Bissau begin to grow soybeans. European colonists, primarily the British and French, began the cultivation of soybeans in Africa, importing varieties from northeastern China. Colonists hoped to export soybean oil to Europe, where demand was strong. With the end of colonialism, efforts at growing soybeans stalled. By the 1950s, most African farmers were unfamiliar with soybeans. In many places, farmers had no incentive to grow soybeans. Farmers in Cote d'Ivoire, for example, complained of low yields and prices.

In Bangladesh, farmers consume much of the soybeans they grow. In 2003, Bangladeshi farmers grew thousands of tons of soybeans, feeding most of them to chickens. Bangladesh exports no soybeans but instead imports soybean meal from India and oil from South America. Farmers plant soybeans where rice will not grow. The people of Bangladesh eat biscuits made from soybeans as well as roasted beans. The largest concentration of soybean acreage is in southern Bangladesh.

Soybeans in America

The soybean was not part of the initial exchange of crops that followed Christopher Columbus's discovery of the New World. Rather, soybeans crossed the Atlantic Ocean roughly 250 years after the first crop transfers. Soybeans were thus a late arrival to the United States. In 1765, Samuel Bowen, a sailor with the British East India Company, gave soybeans to surveyor Henry Yonge, who planted them on his farm in Georgia. The next year Bowen planted them on his farm near Savannah, Georgia, growing them for sauce and noodles (vermicelli). In 1769, the American Philosophical Society mentioned soybeans, though their cultivation must not have been widespread. In 1770, Benjamin Franklin sent soybeans from Great Britain to botanist John Bertrum, who planted them in his garden near Philadelphia, Pennsylvania. In 1804, physician James Mease reported the cultivation of soybeans in Pennsylvania, a circumstance that is not surprising given Bertrum's planting of them in 1770. The botanical garden in Cambridge, Massachusetts, planted soybeans in 1829, though farmers were reluctant to grow them, thinking of them as a luxury crop suitable only for making sauce.

The rise of soybeans as an American crop dates to the late 19th century. In 1851, farmers first grew soybeans in Illinois, from which they spread to Iowa and Ohio in 1852 and thereafter to the rest of the Corn Belt. In 1854, the Commissioner of Patents began distributing soybeans to farmers. In 1873, missionaries in China collected the variety Mammoth Yellow, the first cultivar widely grown in the United States. Farmers grew it in the South, especially in North Carolina. Other cultivars followed that were suitable for growing in New Jersey, Kansas, and Massachusetts. In 1898, the U.S. Department of Agriculture began collecting soybean varieties, sending them to farmers who requested a sample. By 1907, the Department of Agriculture had amassed 20 varieties and by 1937 the number had grown to 2,500 cultivars from China, Manchuria, Japan, Korea, Indonesia, and India. In the early 20th century, a German scientist discovered that legumes, including soybeans, fix nitrogen in the soil. Responding to this news, the Massachusetts Agricultural Experiment Station urged farmers to grow soybeans to increase soil fertility.

In 1915 the boll weevil, widespread in the southern United States, destroyed the cotton crop, causing a shortage of cottonseed oil and prompting farmers to grow soybeans for oil. In the 1920s the tractor, spreading throughout the rural United States, freed farmers from their reliance on horses. Farmers who substituted tractors for horses found that they no longer needed to grow oats. In many instances, they converted land from oats to soybeans. In these early years, Americans did not think soybeans suitable for human consumption, and before 1930 Americans ate less than one-fourth of the soybean crop.

The Great Depression, deleterious in so many respects, marked a turning point for soybeans. The drought of 1934 hurt corn growers, who scrambled to find another crop. Their corn withered, enterprising farmers discovered that soybeans tolerated drought better than did corn. Moreover, the New Deal, hoping to increase farm incomes by raising commodity prices, limited acreage of several crops, among them corn. Because soybeans were not among these crops, farmers in the Corn Belt grew soybeans on land that they would have planted to corn. Between 1934 and 1939, soybean acreage increased 40 percent in the United States, with much of the increase centered in the Corn Belt. The Corn Belt was an ideal location for soybean culture. Whereas corn depleted the soil of nitrogen, soybeans fixed nitrogen in the soil. Soybeans thereby complemented the growing of corn, and farmers, appreciating this fact, rotated the two. In the 1930s, scientists in the United States and Canada, responding to farmers' interest in the soybean, began breeding new varieties. Between 1939 and 1988, American scientists bred 274 new cultivars.

Before World War II, farmers grew soybeans chiefly to feed livestock. In other cases, farmers grew soybeans simply to improve soil fertility and made no use of the bean, instead plowing under the crop. The wartime shortage of vegetable oil, however, led Americans to consume soybean oil, and by 1944 72 percent of the soybean crop nourished them, most of it in the form of oil. World War II also invigorated the culture of soybeans by cutting off Asian imports. U.S. farmers found that they could meet domestic demand on their own and planted ever more acreage to soybeans. Whereas American farmers grew 78 million bushels of soybeans in 1940, they raised 192 million bushels in 1945. During the war, soybean acreage grew rapidly in the central Corn Belt: Illinois, Indiana, Ohio, Iowa, and Missouri. Agricultural scientists identified yellow-seeded soybeans as high in oil as well as suitable for making tofu. Farmers grew black-seeded varieties for oil and fodder.

After the war, production increased at a brisk clip. American farmers grew hundreds of millions of bushels of soybeans in 1949, and billions of bushels in 1979. Production has since held constant. Part of the gain in production came from higher yields. Between the 1940s and today, yields have nearly doubled. Although these figures lagged behind corn yield, they compared favorably with wheat yield. In 1956, the United States became the world's largest soybean producer, tallying more soybeans than all of Asia combined. In 1973, soybeans eclipsed wheat and corn as the leading generator of farm income in the United States. In the 1980s, soybean acreage eclipsed that of corn in parts of the Corn Belt. In 1990, Illinois was the leading producer of soybeans in the United States. Following Illinois were Iowa, Minnesota, Indiana, Ohio, and Missouri. These six states raised two-thirds of all soybeans grown in the United States. By 1991, soybeans generated billions of dollars in the United States, more money than did any other crop. Because soybeans mature rapidly, farmers often grew them along with a second crop in a single season, a practice known as double-cropping. In this system, soybeans often followed winter wheat, oats or barley. In 1991, farmers in Delaware double-cropped half their soybeans.

In the United States, farmers grow soybeans east to North Carolina, west to the Dakotas, Nebraska, and Kansas and south to Oklahoma and Texas. Since 1985, soybean culture has concentrated in the Corn Belt, with a decline in the South except in Arkansas and Oklahoma. In 2002, the Corn Belt produced the majority of the U.S. soybean crop. Increases in production and acreage in South Dakota, Iowa, Nebraska, Minnesota, and Illinois offset declines in the South.

A World Crop

In the 20th century, soybeans emerged as a world crop. Since the 1960s, soybeans have yielded more oil than any other crop. Soybean oil totals a sizable portion of the world's production of plant oil. By contrast, olives tally just a few percent of the world's oil crop. Manufacturers use soybean oil in making margarine, cooking oil, shortening, salad dressing, paint, and plastic. Soybean protein is found in infant formulas, soymilk, and veggie burgers. Soybeans are an additive in a bewildering array of products: hospital meals, vegetarian foods, sports drinks, pizza toppings, seafood, diet aids, frozen foods, canned foods, dietary supplements, cookies, pet food, peanut butter, chicken nuggets, and ravioli. Billions of people have eaten soybeans in one form or another. Worldwide, soybeans are a chief source of protein for livestock.

Some 50 countries grow soybeans. In 2001, the United States, the world's leading producer and exporter of soybeans, produced nearly half the world's soybeans and the majority of exports. In North America, farmers grow soybeans from the Gulf of Mexico to southern Canada. Following the United States, Brazil and Argentina are the second- and third-largest soybean producers. In Argentina, farmers double-crop soybeans with wheat and rotate them with corn, pasture grass, peanuts, sunflowers, oats, and flax. The United States, Brazil, and Argentina together produce the majority of the world's soybeans. In India, soybeans follow wheat or chickpea. In some cases, Indian farmers intercrop soybeans with corn, sorghum, sugarcane, millet, and cotton. In India, the vast majority of the soybean crop is processed into oil. The country exports soybean meal.

Europe and Asia are the principal soybean importers. In Asia, China and Thailand are large importers. Thailand's rise as an importer has been sudden and swift. In 1985, the country imported no soybeans. In 2002, Thailand imported millions of tons of soybeans. In the Western Hemisphere, Mexico is the largest soybean importer with millions of tons of soybeans in 2000. Argentina is the world's largest exporter of soybean oil whereas the United States ranks third. China, India, and Iran are the chief importers of soybean oil. In Africa, Egypt, Morocco, and Tunisia are the primary importers of soybean oil.

From the beginning, Asian cuisine has had a place for soybeans, which are foreign to the American palate. As a rule, Americans do not eat tofu or other soybean foods. Instead, they ingest soybeans as an additive in processed foods.

Genetically Engineered Soybeans

Genetic engineering has arguably had its greatest effect on the culture of soybeans. Chemical company Dupont has bioengineered a soybean variety with oil that is healthier for humans than oil from conventionally bred soybeans. The company is working to engineer soybeans with better flavor. Agrochemical company Monsanto and hybrid seed corn company Pioneer Hi-Bred International aim to engineer nematode-resistant soybeans. This achievement would be an important breakthrough because nematodes are the worst pest of soybeans in the United States and South America. Farmers planted genetically engineered soybeans on more than half of U.S. soybean acreage in 2000 and on three-quarters in 2002. Worldwide farmers planted genetically engineered soybeans on more than half their acreage in 2005 and on three-fifths of acreage in 2006. Genetically engineered soybeans are grown on more acres than are any other crop. Genetically engineered corn, the second-leading bioengineered crop, totals just one-fourth of corn acreage. Farmers may choose from more than 1,000 genetically engineered soybean cultivars.

The greatest success to date is Roundup-ready soybeans. One expert hailed this soybean as "the most rapidly adopted agricultural technology in history." Scientists engineered Roundup-ready soybeans by inserting genes from the microbe *Agrobacterium* that cause soybeans to break down the herbicide glyphosate into harmless chemicals. Monsanto, the creator of Roundup-ready soybeans, also markets glyphosate under the label Roundup. Because Roundup is not toxic to Roundup-ready soybeans, farmers can spray the herbicide on their fields without fear of killing their crop. Because Roundup is a broad-spectrum herbicide, it kills all weeds, giving farmers clean fields. In the absence of competition from weeds, Roundup-ready soybeans grow vigorously.

Because Monsanto owns both Roundup and Roundup-ready soybeans, farmers initially feared that seed and herbicide prices would increase. In the absence of competition, these fears might have been justified. Instead, other agrochemical companies derived their own herbicides for use with Roundup-ready soybeans, and herbicide prices fell. Other benefits accrued to farmers. Because the use of Roundup sufficed to kill weeds, farmers no longer needed to plow under weeds and to cultivate their fields to remove weeds. The rise of no-till agriculture, by one estimate, might save tens of millions of tons of soil from erosion by 2020. Not needing to plow or cultivate, farmers might save several gallons of fuel per acre by 2020, preventing the generation of hundreds of thousands of tons of carbon dioxide.

In 2006, U.S. soybean growers planted the vast majority of their acreage to Roundup-ready soybeans. In Argentina, nearly all soybean acreage is planted to Roundup-ready soybeans. In 2005 and 2006, Brazil's acreage to Roundup-ready soybeans increased meteorically; these soybeans now account for two-fifths of soybean acreage in Brazil.

Despite their success, farmers worried that Roundup-ready soybeans yielded fewer bushels per acre than conventional soybean varieties. Monsanto has remedied this fear and now markets a second-generation Roundup-ready soybean with higher yields. Nutritionists initially feared that oil from Roundup-ready soybeans would contain proteins synthesized by the *Agrobacterium* genes. The food supply might therefore be unsafe. This fear was groundless: Roundup-ready soybean oil is indistinguishable from conventional soybean oil. Detractors feared that Roundup-ready soybeans might cause illness or allergy. Yet in the 14 years that Roundup-ready soybeans have been on the market, no one has become sick or developed an allergy. Rather than imperil health, genetically engineered soybeans may improve it. Should Dupont succeed in engineering soybeans with better taste, consumers might eat more soy foods.

Environmentalists worry that Roundup-ready soybeans may create a new generation of super weeds. They assert that Roundup-ready soybeans might cross-pollinate with weeds. The progeny of these crosses might be resistant to Roundup and so might reproduce with impunity. This scenario is implausible in the United States and South America, whose weeds are not close relatives of soybeans and so cannot crossbreed with them. Only in China do such weeds exist, and even there such a cross is unlikely because soybeans self-pollinate. Anthers and stigma are in the same flower, facilitating self-pollination. The anthers shed their pollen before the flower opens. The flowers are barren of pollen by the time bees visit them. The few remaining pollen grains are infertile. In fact, soybeans cross-pollinate less than 1 percent of the time. Moreover, Roundup-resistant weeds are a risk of soybean culture in general, not of the cultivation of Roundup-ready soybeans in particular. A chance mutation might confer Roundup resistance on a weed. Even should such a weed arise, it would still be vulnerable to other herbicides.

A legitimate concern is the effect of Roundup-ready soybeans on insects and birds. The growing of Roundup-ready soybeans has increased the use of Roundup. Because it strips fields of weeds, it leaves nothing on which insects might feed. A decrease in insect populations might likewise reduce the number of birds that feed on insects. In a similar vein, genetically engineered soybeans resistant to nematodes might kill even beneficial nematodes that would have preyed upon insects.

The debate over genetically engineered soybeans has not affected Brazil, where schools offer children soymilk made from genetically engineered soybeans. Although some European countries have banned the import of genetically engineered corn, much of Europe imports genetically engineered soybeans from Brazil, feeding them to livestock.

A tension, one not easy to resolve, concerns the assertion of intellectual property rights. Companies invest money and intellectual capital in engineering new soybean cultivars. They require farmers to sign contracts promising not to save genetically engineered seed for planting next year. In the case of corn, second-generation seed does not yield well, a deterrent to the practice of saving seed. Because soybeans self-pollinate and so breed true, unscrupulous farmers can save seed in violation of their contract. In some cases, they have sold this seed to others. Monsanto is alert to this behavior and has sued violators of their contracts.

Health and Disease

As early as 450 CE, one text recommended the consumption of soybeans as a curative for ailments of the heart, liver, kidneys, stomach, bowels, and lungs. Soybeans, it was thought, were good for complexion and improved lung function. Farmers fed soybeans to horses in the belief that they increased strength and lung capacity.

In modernity, soybeans have arisen as the leading source of plant protein and oil. Soybeans are 90 percent protein by weight, 19 percent oil, 5 percent ash, and 30–40 percent carbohydrates. Because soybean oil is unsaturated, it is healthier for humans than is fat derived from animal products. Unlike the protein of some other plants, soybean protein has the nine essential amino acids needed to create a complete protein. The consumption of soybean protein decreases blood pressure and cholesterol and reduces the risk of developing arteriosclerosis. As early as 1967, research documented a reduction in cholesterol and triglycerides with a diet rich in soybean foods. One study credited the consumption of soybeans with a 50 percent decrease in the risk for developing heart disease and a 20 percent reduction in cholesterol. Recent research credits the isoflavons that soybean contain with lowering cholesterol.

The consumption of soybeans may reduce the incidence of osteoporosis. Some studies attribute the low rate of hip fractures in many Asian countries to the fact that soybeans are a dietary staple throughout the continent. Soybeans are not merely rich in calcium, a constituent of bone, they promote the retention of calcium in the body. Recent research credits soybean isoflavons with stimulating the formation of new bone. Indeed, rats fed soybeans had greater bone density than rats that lacked soybeans in their rations.

The consumption of soybeans may also decrease the incidence of cancer. In Japan, where soybeans are part of the diet, prostate cancer is less common than in the United States, where soybeans are largely absent from the diet. People who ate tofu regularly in Hong Kong and Hawaii had lower rates of prostate cancer than did Americans who did not eat tofu. Perhaps because they eat soybean foods, Japanese men are 10 to 15 times less likely to develop prostate cancer than are American men. The rate of lung cancer is lower for Chinese who eat tofu than it is for Chinese who do not consume tofu. Japanese women who eat tofu at least three times per week have a lower risk of breast cancer than Japanese women who consume tofu fewer than thrice per week. The consumption of tofu at least once per week may lower the risk of developing lung, colon, rectal, breast, stomach, and prostate cancers.

Christopher Cumo

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Spinach

In the Chenopodiaceae or Goosefoot family, spinach (*Spinacia oleracea*) is a leafy vegetable. Native to the Old World, spinach is a cool-weather crop. The Iranians called spinach *esfenaleh*, *aspanakh*, and *asfannk*. Spinach may derive from the Spanish *hispania*.

Origin, History, and Consumption

One authority believes that spinach originated in southwestern Asia. Another points to Iran as the cradle of spinach. Spinach grew wild in Iran at the time of Christ. One hypothesis holds that the Arabs rather than Iranians were the first to cultivate spinach. Travelers, liking Iranian cuisine, took spinach seeds with them to plant elsewhere in Asia. The people of Nepal grew spinach in late antiquity. Iranian merchants brought spinach to China, where it was grown during the Tang dynasty. According to one authority, the Chinese have cultivated spinach since the seventh century CE. In the early Middle Ages, Arabs introduced spinach into Sicily and Spain. From Sicily, the plant migrated to Malta and Greece. Italian merchants introduced spinach into France, from where it spread to Britain, Germany, and other parts of Northern Europe. By the 16th century, spinach was widely cultivated throughout Europe. The Spanish planted spinach in the New World, presumably during the 16th century. During World War I, the French gave wounded soldiers wine and spinach juice to increase the production of hemoglobin.

In the United States, the cartoon character Popeye the Sailor brought spinach to the attention of Americans. Perhaps because of his influence, U.S. spinach consumption increased by one-third during the 1930s. Certain of the link between Popeye and spinach, Crystal City, Texas, erected a statue of him and christened itself the Spinach Capital of the World. It is possible, however, that the increase in spinach consumption resulted from the Great Depression, when people could afford spinach more readily than meat. In the northern United States, farmers and gardeners grow spinach as a spring or fall crop. In the South, spinach is cultivated in late fall, winter, and early spring. Pacific coast spinach is canned. In the United States, Asian Americans had the highest per person consumption of spinach in 2002. Considered by gender, women over age 39 had the highest per person consumption of spinach in 2002 and teenage girls the lowest. Americans eat spinach in salad and cook it as a vegetable. Between 1972 and 2002, spinach consumption increased fivefold in the United States. Between 2000 and 2002, the average American ate a few pounds of spinach per year. During these years, aggregate consumption totaled hundreds of millions of pounds. The majority of spinach consumed during these years was fresh. In 2002, the United States ranked third as a spinach producer, yielding a few percent of the global crop and trailing China and the United Arab Emirates. California produces the majority of U.S. spinach, followed by Texas and Arizona. In 2002, spinach generated hundreds of millions of dollars in sales. In the United States, spinach generated more income than garlic, peas, pumpkin, chili peppers, and artichoke. As the demand for fresh spinach has increased, the consumption of canned spinach has declined. The consumption of young leaves—“baby spinach”—has contributed to the strong demand for spinach in the United States. On an average day, a few percent of Americans eat spinach.

Attributes and Cultivation

Spinach seeds should be soaked in warm water a few hours before planting them to improve germination. The farmer may plant spinach at a rate of 25pounds per acre. Seeds should be planted at a depth of one-and-one-half inches. Rows should be eight or nine inches apart. Seeds germinate in one to three weeks at 59°F. Plants grow best at 75°F and mature in 40 to 50 days. Long hours of daylight and heat distress spinach. Under these conditions, flavor deteriorates and plants bolt. The gardener may plant the heat-tolerant varieties Avon Hybrid and Bloomsdale Long Standing. One gardener believes that the soil pH should be between 6 and 7. One scientist puts the value between 7 and 10.5. Spinach grows best in sandy loam or alluvial soil. The gardener should water spinach every 4 to 6 days in summer and every 10 to 12 days in winter. One gardener recommends the addition of fertilizer when spinach is one-third grown. One scientist recommends the addition of 10 cartloads of manure per acre. During the growing season, the farmer should thrice apply 100 pounds of ammonium sulfate per acre. Another recommendation calls for 10 cartloads of manure, 44 to 150 pounds of nitrogen, and 77 pounds of phosphorus and potassium per acre. The farmer should apply all the manure, phosphorus, and potassium and one-third of the nitrogen before planting with two applications of nitrogen to follow during the growing season. In addition, the farmer may apply urea 15 days after germination and thereafter at every cutting. When a plant has five or six leaves, it may be harvested. The harvest may continue until spinach seeds. When spinach is used fresh, the whole plant is harvested. When processed, leaves are cut one inch above the ground. The farmer or gardener should not harvest spinach after rain because wet leaves break easily.

Nutrition, Health, and Storage

One hundred grams of spinach have 140 milligrams of sodium, 500 milligrams of potassium, 170 milligrams of calcium, 54 milligrams of magnesium, 45 milligrams of phosphorus, 2.1 milligrams of iron, 0.04 milligram of copper, 0.7 milligram of zinc, 20 milligrams of sulfur, 98 milligrams of chlorine, 0.6 milligram of manganese, 1.71 milligrams of vitamin E, 25 milligrams of vitamin K, 0.07 milligram of thiamine, 0.09 milligram of riboflavin, 1.2 milligrams of niacin, 0.27 milligram of vitamin B6 and pantothenic acid, 26 milligrams of vitamin C, and smaller amounts of beta carotene and folic acid. The initial efforts to gauge spinach's nutrition were flawed. In 1870, German chemist Erich von Wolf miscalculated the amount of iron in spinach, inflating the value 10-fold. This number led to exaggerated claims of the plant's nutrition. Only in 1937 was the error corrected. Although the oxalic acid in spinach is a mild laxative and diuretic, it impairs the body's absorption of the iron and calcium in spinach. According to one study, the body absorbs only 2.8 percent of the iron in spinach. One remedy for this drawback is to eat spinach with lemon juice or tomato because the vitamin C in these foods helps the body absorb iron. Old plants have more vitamin C than young plants. Spinach leaves lose vitamin C when they wilt. The addition of nitrogen to the soil increases the amount of thiamine and riboflavin in spinach. The application of nitrogen and potassium to the soil lowers the amount of vitamin E in spinach. Spinach has antioxidants that may prevent cancer. Women who eat spinach lower their risk of breast cancer. Men who consume the vegetable reduce their risk of prostate cancer. Spinach may help prevent osteoporosis, heart disease, colon cancer, asthma, arthritis, mental ailments, macular degeneration, and cataracts. Despite these benefits, spinach may aggravate thyroid problems, kidney stones, and gout.

Refrigeration at 32°F from packaging to the grocer maximizes spinach's shelf life. At 35°F spinach may be stored 24 days, at 50°F 7 days, and at 70°F just 2 to 2.5 days. The content of beta-carotene and vitamin C decreases during storage. After 3 days at 68°F, spinach loses 83 percent of its vitamin C. Sun-dried spinach loses less vitamin C than oven-dried spinach. More than 20 percent of beta-carotene is lost after 2 days' storage. Dried spinach has only one-quarter the beta-carotene of fresh spinach. Boiled spinach has 38 percent as much beta-carotene as fresh spinach. Spinach soaked in water loses almost half its beta-carotene. Exposure to ultraviolet light reduces the amount of beta-carotene in spinach as much as 65 percent. By contrast, the amount of thiamine increases during storage. Cooking converts 20 percent of the calcium in spinach into calcium oxalate, which the body cannot absorb. One hour's cooking reduces the amount of beta-carotene 25 percent. Processed spinach loses vitamin C. The simple act of washing spinach reduces the content of vitamin C 10 percent. Cutting spinach with a knife lowers vitamin C content 35 percent. Cutting and washing spinach diminishes vitamin C content 54 percent. Cooking spinach in a pot with a lid for two minutes reduces the amount of vitamin C by half. Cooking without a lid reduces vitamin C content by two-thirds. Canned spinach has only half the folic acid of fresh spinach. Stored three months, canned spinach has only 40 percent as much folic acid as fresh spinach. Stored three months, frozen spinach loses 28 percent of its folic acid. As much as 65 percent of folic acid leaches into the water in which spinach is cooked. Spinach cooked in a microwave oven loses less folic acid than spinach cooked by conventional methods.

Christopher Cumo

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Spruce

Spruce trees (from the genus *Picea* and the pine family Pinaceae) are straight and single-stemmed conifers that often grow extremely tall and in dense forests. They have rough shoots that are covered in sharp pegs called pulvinus. The leaves are a broad evergreen needle. *Picea* contains from 35 to 40 that grow throughout the continents of North America, Europe, and Asia. Seven of the species can be found in North America. Those growing in the northern climates are typically found in dense and extensive forests, while those growing in the more southern regions, specifically in the southwestern United States, tend to be scattered and mixed with other montane conifers. The name spruce is believed to have derived from the Old French word *Pruce*, which means "Prussia." The English word "spruce" derived from *Pruce* and was used to mean any items brought to England from the Prussian region, including the tree that now bears its name.

Native spruce trees grow best in climates with moist winters and hot, dry summers or cold and snow-filled winters and warm summers that range from moist to dry. Spruce can grow in, and almost seems to prefer, nutrient-poor soils. Most species are shade tolerant.

Spruce is one of the oldest trees. A Norway spruce was discovered on Fulu Mountain in western Sweden that is believed to be 9,550 years old.

Description

Spruces can grow to a mature height of 66 to 200 feet tall. They are distinguishable from other evergreens by their whorled branches and the conical form in which they grow. The sharp, pointy, one-inch-long needles are attached in a spiral fashion on the pulvinus and are shed when they reach 4 to 10 years old. The remaining pegs give the branches a rough appearance. Cones grow at the ends of the upper branches and are colored according to the soil in which the tree grows. Cones can be dark red, purple, pink, or yellow.

Spruces are used as food by the caterpillars of several *Lepidoptera*, including the autumnal moth, the grey pug, the gypsy moth, the winter moth, and the turnip moth. Budworms are a common predator of some spruce trees, including Blue Spruce and Engelmann Spruce. Spruce is also susceptible to a number of other pests, including aphids, bark beetles, mealy bugs, and scale.

The Multiple Uses of Spruce

Spruce trees are commercially valued for the timber they produce. The wood is used in construction and as pulp. In fact, spruce is an important wood in paper manufacturing due to its long fibers. The leading Canadian pulpwood and lumber tree, for example, is the White Spruce. In construction, spruce is turned into wooden aircraft, including gliders, and musical instruments, such as guitars, cellos, and piano soundboards, because of the wood's resonance. Wilbur and Orville Wright's first plane, the Wright Flyer, contained spruce. Today, gliders still use spruce. (Ironically, Howard Hughes's famous Spruce Goose was made of birch and not spruce.)

Native Americans of North America also made use of spruce roots for weaving and sewing. They used the resin for medicinal purposes, mainly as a poultice to treat rheumatic joints and wounds. As a skin treatment, resin was used on burns and as aid in healing of foot sores induced by the cold. The Chippewa of the northern Midwest applied the resin to eyes affected by snow blindness. Native Americans as well as the greater population also used the resin of spruce to make pitch. The pitch served as a waterproof seal for wood products, such as boats, prior to the use of petrochemicals.

Native Americans chewed the resin as a gum and drank a tea concoction made from the boughs and needles. The chewing of spruce resin was picked up by the colonists, who mixed it with beeswax. The first chewing gum, in fact, was made from spruce resin and called "State of Maine Pure Spruce Gum." The colonists also adapted the Native Americans' practice of drinking spruce-derived beverages when they concocted spruce beer. The spruce beer provided therapeutic ascorbic acid and was used to prevent and cure scurvy.

The Paiute who live in the western states of California, Arizona, Oregon, Idaho, Nevada, and Utah use spruce boughs as flooring in sweat lodges, while the Malecite of Maine and northeastern Canada and the Micmac of New England and the Atlantic provinces of Canada use the boughs as camping bedding and the wood to make toys, paddles, frames for tents, cabins, and cabin roofs. The Algonquin of northeastern North America make cords and ropes out of shredded and pounded roots.

Spruce trees are also valuable in their natural environments. They are commonly planted in reforestation projects, as they can easily grow from seed, such as the Black Spruce, and are valuable as landscape specimen trees and as windscreens. As a result, forest animals use their thermal and protective covers as shelter and also look to spruce seeds as a food source.

Christmas tree farms also produce many spruce trees and a spruce has symbolized Christmas for many Americans. In 1978, a 30-foot blue spruce was planted as the National Christmas Tree on the Ellipse in Washington, D.C. It had been transplanted from a farm in York, Pennsylvania, and was lighted by six presidents and their families for every holiday season since then. On February 19, 2011, however, the 32-year-old tree, which stood 42 feet at the time, was felled by gusty winds reaching speeds of 50 miles per hour.

Medicinal and Spiritual Value

The resin and essential oils in spruce make it a natural healing agent. Since ancient times, it has been used in this manner to treat gout, rheumatism, and upper-respiratory infections. Bathing in a bath of boiled spruce needles is known to stimulate the circulatory system. The Native Americans have used spruce to cure a number of ailments, including those associated with the skin, gynecology, coughs, and tuberculosis.

Native peoples also place great sacred value in the spruce. The First Nations people of southern Canada, for instance, call it the Peace Tree and believe it teaches the values of cooperation, joy, and tranquility, and that it solidifies connections between humans and the heavens. It is also a tree that plays a role in Native American traditions. The Sitka spruce, for one, is part of many tribes' coming-of-age ceremonies, and sitka boughs are used by shamans, hunters, and fishermen in purification and preparation ceremonies.

North American Varieties

The following species of spruce grow in North America: Brewer spruce, or Weeping spruce (*Picea breweiana*); Engelmann spruce (also called mountain spruce and Columbia spruce; *Picea enelmanii*); white spruce (also called Canadian spruce, skunk spruce, and cat spruce; *Picea glauca*); black spruce (also known as bog spruce or swamp spruce; *Picea mariana*); Colorado spruce (also called blue spruce or silver spruce; *Picea pungens*); red spruce (also known as eastern spruce, yellow spruce, or Hebalsam; *Picea rubens*); and Sitka spruce (also known as coast spruce or tideland spruce; *Picea sitchensis*).

Rosemarie Boucher Leenerts

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Squash

A vine, squash is an American indigene. Gardeners classify it as summer or winter squash. One gardener has added the category "autumn squash" to encompass late-maturing squash that keeps no longer than two months. Some people classify pumpkin as winter squash, though gardeners have long differentiated pumpkin from squash on the basis of color, size, and shape. The word "squash" may derive from the Amerindian word *asq* in the singular and *asquash* in the plural. The Algonquin of New England called squash *askutasquash*, a possible origin of the word "squash" and meaning "green things that may be eaten raw." If this rendering is correct, humans may have first eaten squash young, green, and immature. Indeed summer squashes, zucchini among them, are still picked immature. Squash once referred to a pea pod or a disreputable person. A member of the Cucurbitaceae family and *Cucurbita* genus, squash is related to pumpkin, gourd, and melon. A fresh squash is 90 percent water, though it loses water in storage. One hundred grams of summer squash have only 20 calories. One hundred grams of winter squash contain 37 calories. Having little saturated fat, cholesterol, and sodium, squash contains fiber, vitamin C, vitamin B6, riboflavin, folic acid, beta-carotene, vitamin K, thiamine, niacin, phosphorus, copper, manganese, magnesium, potassium, and protein.

Origin, History, Attributes, and Cultivation

Humans first grew squash some 4,000 years ago in the highlands of Mexico. In what is today the United States, Amerindians from the Zuni of the Southwest to the Wampago of the Northeast interplanted squash and corn. The Maya and Aztecs grew squash, calling it *ayotli*. In the pre-Columbian era, the Amerindians cultivated squash in North, Central, and South America and the Caribbean. One tradition holds that the Babylonians grew squash, though it is unclear how squash could have migrated from the Americas to Asia before the invention of ocean-going ships.

One gardener believes that the enthusiast can never lavish too much compost and manure on squash. These substances benefit squash by adding organic matter to the soil. But this gardener is less sanguine about the value of fertilizer, pointing out that too much nitrogen and phosphorus may decrease the yield and quality of squash. Too much nitrogen causes squash plants to produce few female flowers. Dense planting has the same effect. Although squash consumes copious amounts of water, it does not tolerate waterlogged soil. The soil should drain well and be fertile. The gardener should water squash deeply. Squash does not do well in clay. The soil pH should be slightly acidic, between 6 and 6.8. A warm-weather crop, squash may suffer injury below 50°F. Daytime temperatures should be in the 80s degrees Fahrenheit, and nighttime temperatures should be in the 60s degrees Fahrenheit. According to one gardener, plants grow best between 70°F and 85°F. The gardener may start seeds indoors three to four weeks before the last frost, though because squash does not tolerate cold, he should wait until one week after the last frost before transplanting squash in the field. The soil should be at least 70°F before transplantation. Alternatively, the gardener may plant seeds directly into the field one-half to one inch deep one week after the last frost. As a rough guide, squash may be planted about the time lima beans are sown. The gardener may plant seeds outdoors in hills 4 feet apart, thinning each hill to two or three plants. Seeds germinate in four to seven days at 68°F to 86°F. Because squash vines may grow longer than 10 feet, the gardener should give them room to sprawl, spacing seeds 6 to 8 feet apart. Bush varieties may be planted more densely. Because squash is a thirsty crop, the gardener may use black plastic to retain moisture. The plastic is also valuable because it heats the soil and keeps squash off the soil and away from soil borne pathogens.

Each squash plant yields male and female flowers. Male flowers are produced first and are more numerous than female flowers, an evolutionary oddity given that the pollen from one male flower should suffice to fertilize several female flowers. Bees cross-pollinate squash. Species and cultivars readily hybridize, making it inadvisable to save seeds where two varieties have crossed. In the 19th century, Americans made squash into pudding and pie. Squash was eaten with milk, eggs, cinnamon, nutmeg, mace, ginger, lemon, and molasses. Americans stewed squash, adding it to bread. These uses may have derived from the Iroquois.

Species, Types, and Cultivars

There are four species of squash. Native to South America, *Cucurbita maxima* has mild flavor and orange flesh. *Cucurbita moschate* is native to Central and South America. Native to Mexico and the United States, *Cucurbita pepo* includes the scallop squash, summer crookneck, acorn squash, and zucchini. Native to Mexico, *Cucurbita argyrosperma* includes the Japanese pie squash, a curious name for an American indigene. *Cucurbita argyrosperma* has a dark-green and orange rind.

Summer squash is the species *Cucurbita pepo*. Summer squash, maturing in 50 to 60 days, is earlier than winter squash. The fact that it matures in summer must lend summer squash its name. Summer squash does not store as long as winter squash and may be kept in the refrigerator 7 to 10 days. Summer squash has thinner skin than winter squash. Summer squash bears so heavily that two or three plants yield more than enough food for a family. The gardener may fertilize summer squash twice during the growing season with a balanced fertilizer or well-rotted manure. Summer squash may be picked when four inches long. If allowed to exceed eight inches, summer squash becomes tough. Varieties of summer squash include Aristocrat Hybrid, Pale Green Hybrid, Golden Zucchini, Golden Summer Yellow Crookneck, Saint Pat Scallop Hybrid, Seneca Butterbar, and Straightneck Yellow Buttercup. Many summer squashes are bush varieties, whereas winter squashes vine. Summer squash has softer flesh than winter squash.

Winter squash (*Cucurbita maxima*) is eaten, in contrast to summer squash, when fully mature. It is ready to harvest when the rind becomes hard, in roughly 80 to 120 days. In contrast to summer squash, winter squash may be stored as long as two years, though in a desiccated state it is unappealing. Winter squash includes butternut, buttercup (a word that seems to be used interchangeably between summer and winter squashes), acorn, hubbard, and spaghetti types. Some people believe that the flavor of winter squash improves with frost. Acorn squash, a type of winter squash, is ready to harvest when the spot touching the ground turns yellow-orange. The gardener should cure winter squash for one to two weeks at 75°F to 80°F, then store in a dry place at 50°F to 55°F. Spaghetti squash, which grows to 8 to 10 inches and three to six pounds, is ready to harvest when it turns from green to yellow. Spaghetti squash should be cured in a sunny spot for a week, and then stored in a cool, dry place. Winter squash is larger and heavier than summer squash. Varieties of winter squash include Buttercup, Blue Hubbard, Waltham Butternut, Golden Nugget, and Table Queen. The Arikara of North Dakota may have been the first to cultivate Table Queen.

Among the cultivars of *Cucurbita maxima* is Queensland Blue, which derives its name from its blue-green skin and from its origin in Australia. Maturing in 110 days, Queensland Blue yields 8- to 15-pound squashes. With thick skin and orange flesh, Queensland Blue stores well. Also known as Autumnal Marrow, Boston Marrow, maturing in 95 days, is an early-winter squash. The Iroquois may have been the first to cultivate this variety, which was also grown in Chile in the 18th century. In 1834, a gardening exhibition in Boston, Massachusetts, showcased the variety and it may have been at this venue that Boston Marrow acquired its name. The variety is suitable for making pie. Among cultivars of *Cucurbita moschate* is Butternut, an oblong variety with tan skin and golden flesh. Among the most popular winter squashes, Butternut matures in 90 to 100 days. Among varieties of *Cucurbita pepo* is Summer Crookneck, which U.S. president Thomas Jefferson grew in his garden as early as 1781. Jefferson believed it native to Virginia or perhaps farther south, reaching Virginia through trade in pre-Columbian times. Summer Crookneck has yellow skin that becomes orange as it ages. The white flesh may be baked, steamed, fried, or sautéed. Jefferson sent squash seeds, perhaps of this variety, to correspondents in France, recommending them for the garden. Seed company W. Atlee Burpee bred Mammoth Chili, a variety that a farmer in Weaver, Minnesota, grew to 231 pounds. Small Cocoanut and Perfect Gem were popular in the 19th century.

Christopher Cumo

See also Pumpkin

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Strawberry

A perennial fruit, the strawberry may derive its name from the practice of stringing berries onto pieces of straw as a way of conveying them from the woods to home. This practice may imply the gathering of strawberries from the wild. The name may also derive from *strawberige*, a reference to the fact that the plant's runners spread in all directions. From this habit derives the strawberry preacher, the name of a cleric who traveled in all directions from the parish. The Roman poets Ovid and Virgil and Roman encyclopedist Pliny the Elder termed the strawberry *fraga*, the root of the genus *Fragaria*.

The French called *Fragaria vesca*, the species native to Europe, *froise des bois*. In 1766, French botanist Antoine Nicholas Duchesne named the modern dessert strawberry *Fragaria* × *ananassa*, the name denoting that the species was a hybrid

Strawberries (iStockPhoto)

between the Chilean strawberry *Fragaria chiloensis* and the North American strawberry *Fragaria virginiana*. The species name *ananassa* derives from *ananas*, meaning "pineapple," because *Fragaria* × *ananassa* smells like a pineapple. A French engineer gave *Fragaria chiloensis* its name.

Origin and History

Humans likely gathered strawberries from the wild long before they cultivated them. The gathering of wild strawberries may have continued during the era of cultivation. The earliest evidence of cultivation dates from the Iron Age, when the Swiss grew strawberries. The Egyptians and Greeks did not mention the strawberry, though one horticulturist believes that the Greeks grew it in their gardens. The Latin *fraga* resembles Frigga, the Norse goddess of matrimony. The strawberry was her fruit. She gave berries to the spirits of infants who had died. Embedded in a strawberry, they ascended to heaven.

Europeans knew only the small woodland berry *Fragaria vesca*. Initially eaten by farm families, the strawberry came to the attention of religious and secular leaders. In the Middle Ages, it symbolized perfection and righteousness. Artists painted it with Mary. Masons chiseled strawberries on the altars and pillars of churches and cathedrals. The gift of a strawberry plant was a sign of respect, but it announced that the giver did not love the recipient. In the 12th century, abbess Saint Hildegard von Bingen knew of the strawberry, though she had a low opinion of it, believing it unhealthy because the fruit grew near the ground, where the air was stale. Her opinion does not appear to have been widespread. In the 14th century, French king Charles V planted more than 1,000 strawberry plants in the royal garden of the Louvre in Paris. The Duke of Burgundy likewise grew strawberries. In 1484, Peter Schoffer first illustrated the strawberry in a botanical text. Contrary to von Bingen, Schoffer thought that the strawberry promoted health. Others shared his opinion, and Europeans used the strawberry to make medicinal tea, syrup, tincture, and ointment. Physicians used the strawberry to treat breakouts on the skin, bruises, bad breath, throat infections, kidney stones, and even broken bones. Because the strawberry yielded numerous seeds, Europeans thought it was an aphrodisiac. In France, a wedding breakfast included a soup of strawberries, sour cream, borage, and powdered sugar. By the 15th century, the strawberry was a common item in spring and summer markets. By the 16th century, Europeans widely planted the strawberry. As a dessert, people ate strawberries with cream, soaked in wine, or covered in powdered sugar. In the 17th century, Europeans began to make jelly from strawberries. In Britain cultivation peaked in the United Kingdom, when one farmer in Kent tended 2,000 acres of strawberries. Workers picked them at night so that the strawberries would be ready for the morning sale at Covent Garden. One grower claimed to make jam on the day he picked strawberries and to sell it that afternoon.

The Americas had two indigenous species of strawberry. In South America, the Mapuches of Chile cultivated *Fragaria chiloensis* more than 1,000 years ago. The Mapuches ate the strawberry fresh and dried, drank it as juice, and used it as medicine to treat indigestion, diarrhea, and bleeding. The harsh treatment by the Spanish provoked the Mapuches to use the strawberry against their oppressors. They planted strawberries to trick the Spanish into picking them. In this defenseless state, the Spanish were vulnerable to a Mapuche attack. The Spanish, conquering the Mapuches, planted strawberries throughout South America in the 16th century. Production clustered near Cuzco, Peru, Bogota, Colombia, and Ambato, Ecuador. Ecuador boasted thousands of acres between the late 18th century and 1970. In the 18th century, one Spanish priest remarked that *Fragaria chiloensis* yielded fruit thrice the size of *Fragaria vesca*. In the warm climate of South America, *Fragaria chiloensis* produced fruit year-round. In 1716, French soldier Captain Amodee Frazier brought the Chilean strawberry to Marseilles. Antoine de Jussieu, director of the Jardin de Plants in Paris, obtained a plant for the garden. Within a few years, botanical gardens throughout Europe had a specimen. In Brittany, France, *Fragaria chiloensis* thrived. By the mid-19th century, Brittany boasted thousands of acres of the species. By then, France may have grown more Chilean strawberries than Chile.

The North American strawberry, *Fragaria virginiana*, is native to the lands between Canada and Virginia. The Native Americans called it the heart seed berry because of the large number of tiny seeds. They put strawberries in cornbread, but they do not appear to have cultivated them, at least not widely. The Europeans who settled North America remarked at the abundant growth of *Fragaria virginiana*. They prized it for its large fruit and sweet taste, judging it superior to *Fragaria vesca*. The North American strawberry made converts in Europe. In the late 16th century, the British and French planted it, and in the 17th century it began to supplant *Fragaria vesca*. In the early 17th century, English herbalists John Tradescant and John Parkinson grew the North American species. In 1636, Guy de La Brosse, physician to French king Louis XIII, grew it in his extensive gardens. In 1652, Belgian apothecary Jean Hermans grew the species in his garden in Brussels. In the early 19th century, farmers grew strawberries, surely *Fragaria virginiana*, near Boston, New York City, Philadelphia, and Baltimore to meet urban demand.

Cultivation and Nutrition

In North America the strawberry, suited to all climates of the continent, flowers in late spring and early summer and yields fruit from early summer to autumn. Its fruit is among the earliest to ripen. Strawberries are classified as June bearing or ever bearing. June-bearing varieties yield one crop per year. Many consumers judge them to be more flavorful than ever-bearing varieties. June-bearing strawberries yield a larger crop than ever-bearing varieties. Ever-bearing strawberries yield fruit from early summer to autumn.

The gardener or farmer should plant strawberries in well-drained loam in full sun. The soil should contain organic matter and be slightly acidic. As long as it has organic matter, any type of soil supports strawberries. The gardener should mulch the soil to retain moisture. One gardener recommends the removal of the first flowers of a new plant to encourage it to bear more heavily the following year. Where winters are cold, strawberries should be planted in spring. In mild climates, one may plant them between late summer and early winter to yield berries the following summer. In mild weather, berries ripen 30 days after fruit sets. Warmth encourages strawberries to ripen quicker. Strawberries have the best flavor when grown during warm days and cool nights. Cloudy skies, humidity, and warm nights diminish flavor. Where the climate is cold, the gardener may cover plants in straw to protect them. Some gardeners cut off the runners to prod a plant to produce a small number of large strawberries. If left to root, the runners yield a large number of small berries. As a rule, the gardener should water strawberries once per week, being careful not to water so much that mold grows on the fruit. Strawberries should be fertilized in spring and late summer. One gardener recommends the application of two bushels of manure per 100 square feet of land. One-quarter of an acre of strawberries may take one to two tons of hog or chicken manure or four to eight tons of horse or cow manure. One may replant every third year in a new patch of soil to avoid depleting the nutrients. Some home owners grow strawberries in pots. These may need more water than those cultivated in the ground. Some gardeners practice companion planting, growing strawberries with pyrethrum (the painted daisy) to deter insects. Lavender planted with strawberries drives off birds. Some people think that plants yield large fruit when planted with borage. Others plant strawberries with beans, lettuce, and spinach, but not with cabbage. One gardener cautions against planting strawberries with rosemary, mint, and thyme. According to her, strawberry plants die when planted near gladiola. Because berries soften after three days, they must be picked often.

Gardeners prize home-grown strawberries because of their earliness, ease of cultivation, and superior flavor over those from the grocer. Strawberries are also prized as a nutritious fruit. One serving of strawberries exceeds the recommended daily allowance of vitamin C. A cup of strawberries has more vitamin C than an orange or half a grapefruit. The vitamin C content is highest in fresh strawberries. Processed or frozen berries lose up to half their vitamin C. Not all varieties contain the same amount of vitamin C. Catskill and Sparkle ware especially rich in the vitamin.

Production

The Northern Hemisphere grows nearly all strawberries. With a sizable portion of the world's crop in 2008, the United States was the leading producer, followed by Spain, Mexico, Poland, Egypt, and Italy. In 2008, the United States yielded millions of tons of strawberries. In the United States, California is the leading producer followed by Florida and Oregon. In the mid-2000s, California totaled the majority of U.S. strawberries, Florida tallied a small portion, Oregon accounted for less, and Washington supplied only a few percent. In California, strawberries are grown in the central coast, the Santa Maria Valley, and the Oxnard Plain. Fewer strawberries are cultivated in the southern coast and the Central Valley. In Florida, farmers grow most strawberries near Plant City, east of Tampa. Most of the produce is eaten fresh. Other southern producers are North Carolina and Louisiana. In the east, farmers grow strawberries in New York, Michigan, and Pennsylvania. Mexicans cultivate strawberries in Michoacan and Gunanajuanto states northwest of Mexico City. Guatemala and Costa Rica also produce strawberries. Most fruit is frozen and exported to the United States. In Canada, Quebec and Ontario are the leading producers. British Columbia ranks third.

In Europe, Poland has the largest acreage and Spain the highest yield per acre. Spain, Europe's leading producer, exports strawberries to France, the United Kingdom, and Germany. Campania is Italy's leading region of strawberry culture. In Africa, Egypt and Morocco are the leading producers. Egypt has thousands of small farmers who produce strawberries for local consumption and a small portion for export to Europe.

In western Asia, Israel and Turkey are the leading producers. Turkey processes strawberries to make jam and marmalade. Large berries are sold fresh, and small ones are processed. In Turkey, strawberries are grown on small farms. In Japan, the strawberry is the principal fruit crop. In Japan, the leading producers are Kanto, Chubia, and Kyuchu. Most Japanese strawberries are consumed fresh. In addition to domestic production, Japan imports strawberries from California, New Zealand, Taiwan, and South Korea. The strawberry is gaining popularity in Southeast Asia and South Korea. South Korean farmers grow most strawberries south of 37° north. Most strawberries are eaten fresh in South Korea. Chinese farmers grow strawberries in Hebei, Liaoning, Shandong, Jilia, Heilongjiang, Zhejiang, and Hubei provinces. Most strawberry farms in China are small, and 80 percent of the produce is consumed fresh.

In the Southern Hemisphere, Australia, Colombia, Peru, Argentina, and Chile produce strawberries. In Australia, almost all berries are consumed domestically. In the Southern Hemisphere, half the harvest is sold fresh and the rest is processed. These countries export fresh strawberries to the United States and Canada.

Cultivars

The University of California derived Camarosa, the world's most widely planted variety. Farmers in Florida and the rest of the southern United States, Australia, Italy, New Zealand, South America, South Africa, Mexico, and Spain raise it. Also widespread in these regions are Selva, Chandler, Oso Grande, and Pajaro. In addition to Camarosa, Floridians grow Sweet Charlie and Key Largo. Elsewhere in the South, Chandler and Sweet Charlie are popular. In the Midwest and northeastern

United States, farmers grow Honeoye, Kent, and Earliglow. In eastern Canada and the upper Midwest Veestar, Kent, Glooscap, and Bounty are popular. Totem is the chief cultivar in the Pacific Northwest, with Redcrest and Hoodare grown on a minor scale. Mexico, Guatemala, and Costa Rica plant Californian cultivars.

In southern Italy, Pajaro, a Californian variety, is the chief cultivar. Also popular are Camarosa, Chandler, Tudla, Eris, Tethis, Clea, and Miranda. In the Po Valley of northern Italy, Marmolada is the principal cultivar, followed by Idea, Addie, and Miss. In the northern mountains, farmers raise Elsanta, Selva, Marmolada, and Seascape. In Spain, Camarosa is the primary variety. Also widely grown are Tudla, Oso Grande, and Pajaro. Spanish farmers grow Sanchez and Eguialde on a small scale. In France, Elsanta and Gariguette are the leading varieties. In southwestern France, DerSelect and Eros command acreage. In the southeast, farmers grow Pajaro and in the Loire Valley Chandler. The French devote comparatively few acres to Seascape and Selva. In the United Kingdom, Elsanta is the primary cultivar. Symphony and Pegasus are widely grown, and Honeoyo and Florence are gaining adherents. Also popular are Evita, Bolero, and Tango. In Germany, the Netherlands, and Belgium, Elsanta is the chief cultivar. Farmers devote fewer acres to Selva, Korma, and Elvira. In Poland and Scandinavia, Senga Sengana is the principal variety. Also grown in Scandinavia are Karona, Honeoye, Zefyr, Bounty, and Dania. Senga Sengana is the leading variety in Eastern Europe, where farmers also plant Gorella and Elsanta. In Russia, farmers grow Kolinskaja Rannaja, Festivalnaja, Ramashka, Zorya, Zenit, Nadezhda, Lurck VIRa, Rannyayo Plotnoya, Istachnik, Desna, and Senga Sengana.

Between 1998 and 2008, Japanese scientists released a large number of new varieties, most of which occupy only a small acreage. Japan's leading cultivars are Toyanako and Nyoho. In the west, farmers grow Toyanako, and in the east and south Nyoho. Also popular are Sachinoka and Tochionona. Hokowase, once grown throughout Japan, is now confined to Hokkaido. In South Korea, the leading cultivars are Suhong, Reiko, and Nyoho. In Israel, Rachel has supplanted Douglas, Tufts, and Chandler. Turkey raises the Californian varieties Douglas, Pajaro, and Cruz. Senga Sengana claims acreage in northwestern Turkey. Turkey's Cukurova University is breeding new varieties. Egypt raises the Californian varieties Chandler, Oso Grande, Selva, Douglas, Pajaro, and Sequoia, the Floridian variety Sweet Charlie, and the Israeli varieties Sharon and Ofira. Australians cultivate Chandler, Pajaro, Selva, Oso Grande, Sweet Charlie, and Tudla.

Christopher Cumo

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Sugar Beet

A biennial, sugar beet (*Beta vulgaris*) enlarges its storage root the first year and produces seeds the second. The farmer who cultivates sugar beet for sugar treats it as an annual. Humans derive sugar, sucrose, from only two plants: sugar beet and sugarcane. The former is grown in temperate locales whereas the latter is a tropical and subtropical plant. The production of sugar from sugar beet rose rapidly during the 19th century, so by 1862 Austria no longer needed to import sugar from the tropics. By 1920, sugar beet accounted for more than half the world's production of sugar, though the proportion today is only one-quarter as sugar beet production has lagged behind that of sugarcane. This change is not due to consumer preference because, the sugar produced by sugar beet is indistinguishable from the sugar that cane yields. Rather, beet sugar is more expensive to produce than cane sugar. The Greek *tentlon* was the generic term for beet, though fourth-century BCE Greek botanist Theophrastus used the word *sicula* to refer to the beet from Sicily in the apparent belief that it originated on the island. The Arabic *selg*, the Nabataean *silg*, and the Assyrian *silga* derive from *sicula*. The Latin *Beta* is the genus name for sugar beet. The plant is related to spinach, Swiss chard, beet, and fodder beet.

Origin and History

The sugar beet is a recent domesticate, but its ancestor grew wild in Asia in prehistory. The proto-sugar beet may not have been especially sweet and may have come to the attention of humans because its leaves made a suitable vegetable. The Egyptians may have grown this beet as early as 7000 BCE. From Egypt, it spread to the rest of the Mediterranean Basin. The Greeks adopted the proto-sugar beet in antiquity. Around 420, BCE Greek dramatist Aristophanes mentioned it, evidence that it was in cultivation in the fifth century BCE. Greek physician Hippocrates (460 BCE–370 BCE) recommended a broth of proto sugar beet as medicine. Its leaves were immersed in wine to treat wounds. The ancients believed that beet juice, when rubbed on the scalp, stimulated hair follicles. It cleaned the teeth and flavored sour wine. In the first century CE, Greek physician Dioscorides described the medicinal uses of the proto sugar beet. Roman agricultural writers Cato the Elder, Varro, and Columella, Roman orator Cicero, and Roman encyclopedist Pliny the Elder mentioned the plant.

During the Middle Ages, farmers in France and Germany grew this beet for both leaves and its sweet root. From the Middle Ages, it seems fair to refer to this beet as the sugar beet. In the ninth century, Frankish king Charlemagne grew the sugar beet in his gardens. Monks and peasants alike cultivated the sugar beet. In 1420, an English text mentioned the cultivation of the sugar beet. By the end of the 15th century, its cultivation was widespread in Europe. In the 17th century, the Spanish grew the sugar beet on a large scale. Around 1700, the Mennonites cultivated it in Germany. Stockmen in France and Germany fed sugar beets to cattle.

In 1747, the sugar beet came to widespread attention when German chemist Andreas Marggraf isolated sucrose in the root and noted that it was identical to cane sugar. In the early years of sugar beet chemistry, scientists labored to extract large amounts of sugar from the root. Marggraf succeeded in extracting sugar equivalent to only 1.6 percent of the root's weight. Even with this yield, he presented loaves of sugar to the King of Prussia in 1761. Marggraf's pupil Franz Achard extracted a larger proportion of sugar from the root and calculated that he could produce sugar at a cost of only 6 cents per pound. The French Institute of Science, however, revised the cost to 18 cents per pound.

The sugar beet had come to the attention of scientists at a fortuitous moment. Aware that sugar came from slave plantations, Europeans were eager for another source of the sweetener. The danger of the slave system of sugar production became apparent in 1791, when slaves on the French possession Saint Domingue (now Haiti) revolted, destroying the sugar estates. The Napoleonic Wars that followed only worsened matters. Great Britain blockaded France, forcing its citizens to do without Caribbean sugar. The price of sugar throughout Europe leapt during these wars.

Frederick William III, king of Prussia, reacted to this crisis by opening the world's first sugar beet factory in Cunern, Silesia, in 1802. The French followed with factories at Saint-Ouen and Chelles, but they were not profitable. Others thought that scientists should extract sugar from grapes, France's national fruit. These efforts did not succeed either, and in 1811 Benjamin Delessant built a factory for extracting sugar from sugar beet in Passy, France. Napoleon was so impressed with Delessant's success that he bestowed the Cross of Honor on him. That year Napoleon set aside tens of thousands of acres to sugar beet and established six experiment stations to conduct research on the crop, appropriating money for this purpose. In 1812 and 1813, France established hundreds of sugar beet factories. In 1812, Germany established a school to teach students that most efficient methods of growing sugar beet and extracting sugar from its root.

Napoleon's downfall marked a temporary reversal of the sugar beet's fortunes. With Great Britain and France no longer enemies, commerce resumed between Europe and the Caribbean. Abundant, cheap cane sugar gorged the European market and the price of sugar fell. Unable to profit, all sugar factories in Germany and Austria closed. By 1816, France could count only a single sugar beet factory, at Arras. Given the suddenness of this reversal, it seems remarkable that the sugar beet recovered so quickly. The emancipation of slaves in the 19th century doubtless benefited the sugar beet. Many former slaves refused to toil on the sugar estates, and sugar production declined in Haiti. In the 1830s, Germany began building new sugar beet factories. In 1832, the United Kingdom opened its first sugar beet factory. By 1856, Austria boasted more than 100 factories. In 1870, one writer asserted that the sugar beet had the potential to revitalize British agriculture, giving rural people work and thereby reducing their emigration to already overcrowded cities. By 1889, Russia processed hundreds of thousands of tons of beet sugar per year. By then Russia, France, Germany, and Austria had emerged as Europe's largest beet sugar producers.

The Amerindians may have extracted sugar from a beet native to central California, though they apparently collected this beet from the wild rather than cultivated it. Alert to developments in Europe and the Caribbean, James Ronaldson, president of the Franklin Society, organized the Beet Sugar Society of Philadelphia. In 1836, the society sent James Pedder to Europe to study the culture of sugar beet. He returned with several hundred pounds of seeds, but these were planted too late in the year to yield sugar and so were fed to cattle. In 1837, farmers in White Pigeon, Michigan, established the Beet Sugar Company, the next year building a factory for which they received a loan from the Michigan legislature, though the factory failed. In 1838, Edward Chase and David Lee Child, who had witnessed sugar beet production in France, established a factory in Northampton, Massachusetts. Producing thousands of pounds of sugar, the factory was nonetheless a failure, closing in 1841. The Mormons, paying a high price for sugar in remote Utah, decided to grow and process sugar beets. Missionary John Taylor studied the sugar beet while in France. In 1852, he established the Deseret Manufacturing Company. Buying the materials for a factory, he made the arduous journey from the Gulf of Mexico to Utah, but like the other ventures it too failed. Between 1838 and 1879, businessmen built and then abandoned sugar beet factories in Maine, Massachusetts, Delaware, Michigan, Illinois, Wisconsin, Utah, and California. Success finally rewarded the efforts of California farmers and entrepreneurs in 1879 and 1888. In the late 19th and early 20th centuries, U.S. Department of Agriculture chemist Harvey Wiley and Secretary of Agriculture James Wilson championed the culture of sugar beet. It was valuable not only as a source of sugar, they believed, but also as feed for cattle and sheep.

Uses, Cultivation, and Production

In addition to its value in producing sugar and feeding livestock, sugar beet improves the soil. As the roots enlarge, the beet loosens the soil. Sugar beet roots are six to seven feet long. When the beet is harvested most of the roots remain in the soil to decay, adding humus to it. Because it improves the soil, sugar beet is valuable in crop rotation. Wheat that follows sugar beet yields more grain than wheat grown in monoculture according to one estimate. Other crops report gains.

In the 18th century, scientists identified the white-rooted beet from Silesia as a rich source of sugar and used it to breed new varieties. Breeding has raised the sugar content of the root. The work of extracting this sugar falls to the factory. In Europe, a modern factory can process tens of thousands of tons of beet sugar per day. In 2000, farmers planted millions of acres to sugar beet. Adaptable, the sugar beet may be grown in clay, silt, or sand, though the pH must be close to neutral. The leader, the European Union produces three-quarters of the world's beet sugar. The United States produces several percent of the world's beet sugar, though in the United States beet sugar must compete against high-fructose corn syrup. Sugar beet remains viable despite competition from cane sugar and high-fructose corn syrup where mechanization has reduced labor costs. After Europe and the United States, Asia produces several percent of the world's beet sugar, and Africa and South America a few percent. In 2004, Europe planted several million acres to sugar beet, achieving a respectable yield. The short growing season limits the yield in the Great Lakes, the upper Midwest, and the Great Plains. Idaho and California boast larger yields because of their longer growing season and irrigation. In the United States, farmers grow sugar beet in California, from Montana to Texas, and in the Red River Valley of North Dakota and the Great Lakes region of Michigan and Ohio.

Around 1880, farmers in Japan adopted sugar beet. In 1881, farmers in Quebec and in the early 20th century in Ontario began growing sugar beet. In the 20th century, Uruguay and Chile began cultivating sugar beet. Since the 1920s, farmers have grown sugar beet in Turkey and after World War II in Pakistan, Syria, China, Iran, Iraq, Egypt, Algeria, Morocco, and Tunisia. Today, 50 countries—among them Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Slovakia, Spain, Sweden, the United Kingdom, Moldavia, Romania, Russia, Serbia, Switzerland, Turkey, Ukraine, Egypt, Morocco, Canada, the United States, Chile, China, Iran, Japan, Pakistan, and Syria—grow sugar beet. The crop is cultivated on every continent but Australia and Antarctica. Most sugar beets are grown between 30° and 60° north.

Nutrients

Nitrogen is the most important element in determining the quantity and quality of sugar beet. The crop needs 1,100 to 1,375 pounds of nitrogen per acre. Even the best soil supplies only 330 pounds of nitrogen per acre, necessitating the application of nitrogenous fertilizer. The leaf of a young sugar beet plant contains 5 percent nitrogen, and the root has 3 percent nitrogen. The leaf of a mature plant is 3 percent nitrogen, and the root is 0.8 percent nitrogen. Of the nitrogen applied to the soil, sugar beet absorbs 50 percent, leaving the rest to leach or remain in the soil. Where nitrogen is in shortage, the yield may halve. Under these conditions, leaves turn light green and then yellow. Nitrogen-deprived leaves are inefficient photosynthesizers. Old leaves may wilt and die. Where nitrogen is adequate, sugar beet produces large, abundant foliage, large roots, and high sugar content. In the United Kingdom, sugar beet farmers apply ammonium nitrate, which is 34 percent nitrogen, to the soil. Elsewhere in Europe, urea (46% nitrogen) and sodium nitrate (16% nitrogen) are common on sugar beet lands. Manure, applied as a source of nitrogen, should be added to the soil before planting sugar beet, though it may reduce the quantity of sugar in the root.

Sugar beet contains half its phosphorus in the root and the other half in the leaves. Sugar beet takes up 550 pounds of phosphorus per acre. Because phosphorus does not leach from the soil, deficiency is uncommon. Where it is deficient, leaves are dark green and the plant is stunted. Where the deficiency is severe, leaves turn purple-red or brown. A plant bereft of phosphorus produces a large number of small roots rather than a long taproot.

A sugar beet plant absorbs potassium rapidly between June and August in the Northern Hemisphere. At harvest, sugar beet roots contain 550 pounds of potassium per acre. The amount of potassium in the leaves is greatest in late September and early October. The leaf of a sugar beet plant is 7 percent potassium and the root 6 percent potassium in April. The leaf is 3 percent potassium and the root 1 percent potassium in August. Where potassium is adequate, a plant produces abundant leaves, photosynthesizes efficiently, and yields roots rich in sugar. Sugar beet farmers apply potassium, often as muriate of potash, kainite, or sylvinite, before planting. Since the 1970s, farmers have applied potassium in autumn or winter. In the United Kingdom, half the sugar beet soils are deficient in potassium. Where potassium is in shortage, leaves turn olive-green. Where the deficiency is severe, leaves turn bronze.

Sugar beet is unusual among crops in requiring sodium. A crop of sugar beets absorbs nearly 550 pounds of sodium per acre. The leaves absorb 468 pounds of sodium per acre, and the roots take up 66 pounds of sodium per acre. The root is 0.04–0.11 percent sodium and the leaf contains 0.9–1.7 percent sodium. Like nitrogen and potassium, sodium aids sugar beet in producing leaves, photosynthesizing, and filling roots with sugar. Sodium also increases the efficiency with which a sugar beet plant absorbs water. Soils in Northern Europe may lack sodium, necessitating the addition of 825 pounds of sodium per acre. Sandy soil on which sugar beet is planted should receive 1,100 pounds of sodium per acre. The sugar beet farmer should apply sodium to the soil every third year before planting. The application of sodium reduces the severity of potassium-deficiency symptoms.

Sugar beet absorbs more calcium than phosphorus or magnesium but less than nitrogen or potassium. Calcium plays an important role in regulating soil pH. Sugar beet, we have seen, must have a pH near 7. At low pH, phosphorus is unavailable for absorption, and aluminum, manganese, and hydrogen reach toxic levels. At a pH below 5, seedlings die. Where pH is low, leaves yellow and die due to manganese toxicity. At high pH magnesium, boron, and manganese are unavailable for absorption. Sugar beet absorbs 550 pounds of calcium per acre, though the farmer must apply thrice this amount to compensate for leaching. The farmer should apply calcium at least 18 months before planting sugar beet.

Magnesium is often deficient in arid lands. Sugar beet leaves deficient in magnesium turn pale yellow in July or August, often following dry weather. Where magnesium is deficient, photosynthesis is inefficient and the yield low. The leaf of a young sugar beet plant is 0.6 percent magnesium and 0.2 percent when mature. Sugar beets grown on sand or sandy loam may need applications of magnesium. The application of magnesium to the soil may increase the yield of sugar beet 6–20 percent.

The leaf of a sugar beet plant is 0.5–1.4 percent sulfur. Where sulfur is in shortage, leaves yellow. Sulfur-deficient leaves may display brown spots. The sugar beet farmer may apply sulfur in the form of calcium sulfate in late summer.

Christopher Cumo

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Sugarcane

A perennial grass grown in many countries, sugarcane yields falernum, molasses, rum, ethanol, and, of course, sugar, a sweetener coveted for millennia. Botanists have noted that sugarcane is related to corn, sorghum, and rice, an insight that French geneticist Angelique D'Hont confirmed in 1998. In 1999, scientists worldwide began to sequence the sugarcane genome in hopes of identifying genes that code for agronomic traits. Unlike successes in the bioengineering of soybeans and corn, the cultivation of genetically engineered sugarcane is not widespread. Agrochemical company Monsanto aims to engineer a herbicide resistant variety of sugarcane. Given the success of herbicide-resistant soybeans, farmers would likely plant this genetically engineered sugarcane cultivar.

Sugarcane (Photosoup/Dreamstime.com)

The Columbian Exchange made sugarcane, which had spread throughout the Old World in antiquity and the Middle Ages, a world crop. From an early date, landowners coerced workers, with slavery being the worst exploitation, to toil on sugar estates. Misery thus attended the cultivation of sugarcane. Even with competition from sugar beets, high-fructose corn syrup, and artificial sweeteners, sugarcane remains important, yielding several million tons in 2007. Despite competition from these sweeteners, rising living standards may benefit cane growers. People who earn a living wage spend a portion of their earnings on sweetened food and beverages, though this does not necessarily guarantee the consumption of more sugar, a portion that rises with incomes. At the same time, affluent people eat more meat, causing stockmen to rear more livestock. Because molasses is a livestock feed, its use should increase with an improvement in living standards.

The Basics

A crop of the tropics and subtropics, most sugarcane is grown between 20° north and 20° south. The presence of frost above 31° latitude may preclude its cultivation farther north or south; for instance, farmers have grown sugarcane as far north as Iran and Spain. Frost not only damages or kills cane plants, but it makes the stalk, which contains the sugar, unsuitable for crushing. In the United States, the need for warm weather confines sugarcane to southern Louisiana, Texas, and Florida, though Texas has never produced large amounts of the crop. Temperatures must be high—between 86°F and 93°F is ideal—with little fluctuation during the year. Sugarcane will not grow below 60°F or above 100°F. Sugarcane needs at least 60 inches of rain per year. That is, sugarcane needs 260 gallons of water to yield one pound of sugar. The quicker a variety of sugarcane matures the more water it needs. The need for copious amounts of water raises the possibility that soils will become saline, though sugarcane has evolved tolerance to modest salinity. Sugarcane stores sugar throughout the plant's life, except when it flowers. Accordingly, scientists have labored to breed cultivars that produce few flowers.

Sugarcane has a long growing season, between 12 and 14 months on average, though some varieties have a 48-month life cycle. Because it is a perennial, sugarcane produces additional crops after harvest. These ratoon crops require less labor since one need not toil to replant, but the yield declines as much as half. After 1680 planters in Barbados, concerned about the decrease in yield, replanted every year, whereas Jamaican landowners harvested two or three ratoon crops before replanting.

Origin and Diffusion in the Old World

Sugarcane is celebrated in myth. One Polynesian story holds that a fisherman caught a piece of cane stalk in his net. Disappointed that he had caught no fish, he threw the cane back into the ocean. A second cast yielded the same result. Surprised at this happening, he nonetheless tossed the piece of stalk again into the water. A third cast fetched the same piece of cane, and this time the man understood that the gods intended him to keep it. Returning home, he planted it in his garden, where a large and vigorous sugarcane plant grew. One day a beautiful woman emerged from the plant. So entranced was the fisherman that he asked her to marry him. The two wed and their children populated the world. A single cane plant had generated all the races of humanity.

A second story, originating in India, tells of a king who awoke one morning to find a sugarcane plant growing in his bedroom. Unsure what to think of this circumstance, the king consulted his ministers, who regarded the plant as a good omen. Taking their advice, he nurtured the plant as it grew. One day the plant split apart, revealing a baby. The queen claimed the boy as her own, and when he reached maturity he had many children, the 100th of whom was the Buddha. From a sugarcane plant had come the holiest man in India.

Whatever the merits of these accounts, sugarcane originated in prehistory and is among the oldest cultivated plants. At first, sugarcane was not a crop. Rather, the people of Papua New Guinea used the wild species *Saccharum robustum* to thatch their huts. Sometime before 8000 BCE, *Saccharum robustum* hybridized with the grass *Erianthus arundinaccus* to yield the now familiar Creole cane. In turn, Creole crossed with another wild species, *Saccharum spontaneum*, to yield other sugarcane species including a wild cane variety extant in India.

Around 8000 BCE, sugarcane, probably Creole, spread to Melanesia and Polynesia. Among these islands, sugarcane spread to Fiji, Tonga, Samoa, the Cook Islands, Marquesas, and Easter Island. About 6000 BCE, the people of New Guinea brought Creole to India where it hybridized to yield *Saccharum barberi*, a species adapted to marginal environments. In India, people first learned to crystallize sugar by boiling cane juice. In China, Creole hybridized again, this time yielding *Saccharum sinense*, meaning "Chinese cane." Between 4000 and 3000 BCE, sugarcane was cultivated in Indonesia and the Philippines in addition to New Guinea, several Pacific Islands, and India. By 7000 BCE, the people of Southeast Asia, evidently excluding Cambodia, grew sugarcane. By 2000 BCE, sugarcane culture was widespread in China and Cambodia. The latter paid sugarcane as tribute to China. By 100 BCE, sugarcane had reached Africa and perhaps Oman and Arabia. By 600 CE, the people of Iran cultivated sugarcane.

The rise of Islam coincided with the expansion of sugarcane culture. The Koran prohibited the consumption of alcohol, though it permitted the taking of sweet beverages. This pronouncement must have aided sugarcane in its spread. Muslims carried sugarcane from China west to the Atlantic coast. In the seventh century, they spread sugarcane to Syria, Palestine, and Egypt, though one account credits one of Alexander the Great's generals with taking cane from India to Egypt in 325 BCE. By 700 CE, farmers were growing sugarcane in Cyprus, Sicily, and North Africa. In 755, Buddhists took sugarcane from India to Japan. Muslims brought sugarcane to Spain in the eighth century and to Crete and Malta in the ninth century. The crop was tended in lands along the southern shore of the Caspian Sea and in Damascus and Jordan by the 10th century. Around 1100, Crusaders returned to Europe with sugar from the Holy Land, though Northern and Western Europe were too cold to sustain the plant. Around 1285, Italian adventurer Marco Polo reported the growing of sugarcane in China, India, and East Africa, though he did not observe all these lands firsthand. In the 14th century, sugarcane culture shifted from Palestine, Egypt, and Syria to Cyprus, Crete, and the western Mediterranean. By the end of the 16th century, sugarcane cultivation in the Mediterranean had faltered as the Little Ice Age made the region inhospitable for the tropical crop. Moreover, cheap sugar from Brazil and the Caribbean undercut the price of Mediterranean sugar.

In 1432, the Portuguese planted sugarcane on Madeira. By 1500 the island, the largest producer in the West, yielded nearly 2,000 tons of sugar per year. By 1550, the Portuguese island of São Tomé off the coast of West Africa had replaced Madeira, yielding more than 2,200 tons of sugar per year. In 1788, the British introduced sugarcane to Australia, though it would not be an important crop until the 20th century. In Australia, planters grew sugarcane in New South Wales and Queensland. Today, sugar is Australia's second most valuable export, wheat being first.

Sugarcane in the New World

In 1493, Christopher Columbus introduced sugarcane to the Caribbean island of Hispaniola (today Haiti and the Dominican Republic). By 1550, sugar totaled the majority of the island's exports. In 1500, the Portuguese began growing sugarcane in Brazil, with exports to Europe after 1519. Production kept pace with demand for sugar. Despite an increase in production, competition, chiefly from Caribbean plantations, was cutting into Brazil's success. In the 17th century, Brazilian sugar lost much of its share of the European market. By 1690, Brazilian sugar accounted for just a few percent of sugar produced worldwide.

Not content to let Spain and Portugal have all the profits from sugarcane, the British, French, Dutch, and Danes carved out sugar estates in the Caribbean islands that Spain could not protect from interlopers. In the 17th and 18th centuries, the European powers established sugar plantations on Barbados, Jamaica, the Leeward Islands, Martinique, Guadeloupe, Saint Domingue (today Haiti), and the Danish West Indies (today the U.S. Virgin Islands). Landowners planted sugarcane to the exclusion of other crops, creating monoculture on several islands. The most successful planters amassed hundreds of acres. The expense of buying land and slaves and building a mill priced the small farmer out of the enterprise of growing sugarcane. By the 18th century, sugar totaled half the value of all French colonial exports and was worth more than all other colonial products in Great Britain.

Preferring the comforts of home, prosperous landowners returned to the mother country to live as gentry. They entrusted the running of the sugar estates to overseers. Paid little, overseers had few incentives to do a good job. Some cheated landowners. Other allowed the property and mill to dilapidate.

By the 18th century, Saint Domingue was the jewel in France's crown. In 1789, on the eve of the French Revolution, the colony produced much of the world's sugar, an amount greater than the yield of the entire British Caribbean. Taking the ideals of the French Revolution to heart, the slaves on Saint Domingue revolted in 1791, destroying the sugar estates. The era of French supremacy in sugar production had passed. Between 1820 and 1824, Haiti averaged only several hundred tons of sugar per year, much less than the production before the French Revolution. Sugarcane retains on Haiti the stigma of slavery. Its people may engage in many occupations but field hand is not among them.

The failure of sugarcane culture in Haiti did not doom the crop elsewhere. In the 19th century, planters in Cuba expanded cane acreage at the expense of coffee, tobacco, and ranchland. Before nationalist Fidel Castro seized power, the United States was the largest importer of Cuban sugar. An avid supporter of the sugar industry, Castro set production quotas, though growers never achieved them. In 1980, Cuba produced three-quarters of all Caribbean sugar. Cane occupied millions of acres, two-thirds of the island's arable land. Grenada and Puerto Rico achieved a better balance, growing sugarcane, coffee, and cocoa. Into the 21st century, the United States has been the principal purchaser of Puerto Rican sugar.

The perception that the Caribbean has diversified beyond sugarcane is not entirely accurate. Whereas the islands averaged several million tons of sugar between 1934 and 1938, the amount grew between 1976 and 1980. In the 1980s Cuba, Barbados, Guadeloupe, and Saint Kitts exported the majority of their sugar, with the United States and Europe being ready buyers. In the 21st century, sugarcane remained a leading crop in the Dominican Republic, though exports fell between 1981 and 2003.

In 1750, Jesuit missionaries introduced sugarcane to California and the Louisiana Territory. California has never been a large sugar producer. In Louisiana, however, sugar plantations played a leading role in the economy and society. The United States bought the Louisiana Territory from France in 1803, opening the plantations to U.S. investment. In Louisiana, planters grew sugarcane along the Mississippi River and in the bayous. The culture of sugarcane along the Mississippi River spurred the building of levees to prevent flooding. The largest planters were among the wealthiest Americans in the antebellum period. In the 19th century, sugarcane was Louisiana's principal crop. By 1860, Louisiana produced the vast majority of U.S. sugar. Because frost damaged cane, landowners replanted the crop every third year. Since World War II, the trend toward aggregation of land has accelerated. Consequently, the number of plantations has diminished through consolidation. Whereas Louisiana had tens of thousands of sugar estates in 1957, it counted only several hundred in 1995.

Oxen or horses powered the first mills, but in 1822 the first steam mill began to operate in Louisiana. By 1854, more than three-quarters of mills in the state were steam powered. Then a mill cost much to build, a price that barred small farmers from cultivating sugarcane unless they could use a neighbor's mill. In the antebellum United States, internal markets absorbed all the supply. Attentive to planters' wishes, Congress placed a tariff on sugar to keep cheap Caribbean sugar off the market. Since 1950, the trend toward large plantations has accelerated in the United States. Small and medium-size farms have declined precipitously.

Hawaii, another region of the United States suitable for sugarcane culture, has the world's largest yield per acre. Yields are so good that landowners may harvest two or three ratoon crops without much loss in productivity. The high wages of sugarcane workers have cut profits in recent decades. Farmers have responded by diversifying agriculture, growing macadamia nuts, ginger, papaya, and cacao in addition to sugarcane. In other cases landowners, alert to the profits to be made in tourism, have converted sugar estates to resorts.

Since 1920, sugarcane has emerged as an important crop in Florida. Planters grow sugarcane on the rich soils south of Lake Okeechobee, relying on the local African American population and Jamaican immigrants for labor. The embargo on Cuban sugar has benefited Florida growers. Today, the state produces a sizable portion of U.S. sugar, and the white crystal is second in value only to citrus in the sunshine state. In Florida, planters fallow a portion of cane land and rotate much of the rest with vegetables or rice. As in Louisiana, large plantations are the rule in Florida with most cane grown on parcels of several hundred acres.

Labor

Sugarcane is a labor-intensive crop. Free labor may have sufficed in antiquity and the Middle Ages, but the early modern era adapted an old institution, slavery, to the New World. The planters initially tried to press the indigenes into service, but they were susceptible to European diseases and died in large numbers. Indentured servants from Europe fared little better, leading landowners to turn to slavery to meet the demand for labor. In 1444, the Portuguese imported the first African slaves to work the plantations on Madeira, an island in the Atlantic Ocean. The use of slaves became the norm in Brazil, the Caribbean, and the Louisiana Territory, all regions in which sugarcane dominated. By 1810 New World plantations, many of them devoted to sugarcane, had imported millions of slaves. Sugar planters drove their slaves to an early death. In the Caribbean, the average slave lived only 10 years after importation. Eager to maximize profits, slave owners cut corners by underfeeding and overworking slaves. In the Danish West Indies, where sugarcane was the cash crop, slaves on the verge of starvation in 1733 had little alternative but to revolt. The planters tortured and executed the rebellion's survivors.

Australia may have been the first European colony to produce sugar without slaves, instead using convicts and indentured servants from the Pacific islands. In the 19th century and in the absence of slavery, planters paid wages, but these decreased with the decline in sugar prices. When labor was scarce, they imported workers from China, Japan, and India. In the 20th century, sugarcane workers unionized in Hawaii and are now the world's highest paid farm laborers. In some areas, machines now harvest cane, but in South Florida, where the land is too soft for mechanical harvesters, workers harvest cane by hand as they have for generation.

The crop cycle began with planting, between October and December in much of the tropics, to coincide with the rainy season. Because sugarcane will germinate vegetatively, workers planted pieces of stem in "holes," which were really squares roughly one-and-one-half yards long and six inches deep. In other instances laborers dug trenches, laying pieces of cane end to end. In either case, seedlings sprouted from the joints in cane stems. Using only hand tools, 30 laborers could plant two acres per day. Despite its use for millennia elsewhere, the plow was absent from Caribbean sugar plantations. According to one historian, planters refrained from using the plow to keep slaves, who had to use hoes to break ground, in a state of near exhaustion, too busy and too tired to foment rebellion. When plants were one to two feet tall, workers weeded and manured them. One recommendation called for 30 loads of dung per acres. In the parts of the tropics where slavery was entrenched, slaves carried manure in buckets on their heads. The contents often ran down the sides of a container, smearing the head and face of a slave. Understandably, slaves resented this chore above all else. Overseers who were too zealous in goading slave to perform this task risked being poisoned. Laborers harvested cane between January and May, the driest months. Traditionally, landowners set their fields ablaze before harvest to burn off cane leaves and to kill vermin. Cane cutters used a curved knife known as a bill.

New Opportunities and Problems

In 1768, French sailor Louis Antonin de Bougainville discovered a new variety of sugarcane in Tahiti. This new cultivar, Otecheita, yielded one-third more sugar than the widespread Creole and soon supplanted it in Java, Burma, Mexico, the Philippines, Hawaii, Jamaica, the French Caribbean, Puerto Rico, and British Guiana. Otecheita's tenure was brief. In the 19th century the fungal disease red rot struck, destroying Otecheita fields in Mauritius, the Caribbean, and South America.

In the late 18th century, farmers planted a new cultivar, Cheribon, in Louisiana and Georgia. Popular and widely grown, Cheribon remained the standard cultivar in the United States into the 20th century. After 1840, Cuban planters grew Cheribon. In 1796, surgeon James Duncan of the British East India Company discovered a new variety in Canton, China. Botanist William Roxburgh named it *Saccharum sinense*. Later another scientist traced Chinese cane to India, though others insist that the variety is indigenous to China.

The tendency of farmers to propagate sugarcane vegetatively obscured the obvious fact that it is a sexually reproducing plant. Only in 1888 did amateur scientist John Bovell publicize this finding, leading scientists to breed new varieties. By hybridizing different species of sugarcane, scientists exploited the phenomenon of heterosis or hybrid vigor. In Barbados alone, sugarcane hybrids increased sugar production 76 percent between 1930 and 1939. In Puerto Rico, hybrids generated more than $10 million.

Since the 19th century, scientists have focused on deriving ethanol from sugarcane to power automobiles. The plant is a good candidate for this function because it converts a few percent of sunlight into biomass. Although this may appear to be a small amount, it is larger than the conversion rate of most other plants. In the 19th century, nascent automakers in the United States used sugarcane ethanol, and India and Brazil now use it in automobiles. In the United States, ethanol derived from corn replaced sugarcane ethanol in the 20th and early 21st centuries. In addition to its role in producing ethanol, sugarcane may be used to generate electricity. Power stations in the tropics burn bagasse, the plant residue that remains after the extraction of cane juice, to produce electricity. The island of Hawaii generates a sizable portion of its electricity from burning bagasse. Containing cellulose, bagasse is also used to make paper and cardboard.

Positive though these aspects are, sugarcane culture depletes soil of nutrients. Planters in Brazil, reckless in exploiting the soil, moved to new land when they had exhausted old land by monoculture. Caribbean planters followed this policy until they ran out of land. The use of manure to fertilize cane lands led planters to keep livestock. To feed livestock and slaves, planters set aside land for corn, a welcome practice that diversified agriculture, though soil exhaustion remains troublesome on many sugarcane estates.

Moreover, the cultivation of sugarcane threatens the environment. In Queensland, sugarcane growers have denuded hundreds of millions of acres. Without the protective cover of forest, soil erodes, washing into wetlands, rivers, and the ocean. By one estimate, the growing of sugarcane costs Australia several hundred tons of soil per hectare per year. In addition to the loss of soil, fertilizer runoff pollutes wetlands, rivers, and the ocean. In the Caribbean, sugarcane growers have removed vast tracts of forest, hastening erosion. In South Florida, sugarcane occupies the majority of land in the Everglades Agricultural Area. This region accounts for more than half of all sugarcane grown in Florida. The runoff of nitrates and phosphates endangers the Everglades, a region of rich biodiversity. Erosion and fertilizer runoff imperil mangrove swamps, sea grass beds, and coral reefs in Florida, the Caribbean, Australia, and Mauritius.

Sugar

A cane stalk is 75 percent water, 25 percent sugar, and 10 percent fiber. Sugar is pure sucrose, a disaccharide carbohydrate with 110 calories per ounce. In prehistory, the Polynesians chewed the pith of cane stalks to derive sugar. According to legend, the first food Buddha took after a fast was sugar. In accord with this belief, Buddhist monks drank sugar water while fasting. Evidently thinking of sugar as a medicine, Buddha counseled physicians not to withhold it from the sick. The ancients thought that sugar protected one against several diseases, aided digestion, promoted cheerfulness, improved complexion, and increased sperm production. Roman encyclopedist Pliny the Elder recommended sugar as a medicine, and Catholic saint Thomas Aquinas, apparently sensitive to its medicinal properties, thought it unwise to deprive the faithful of sugar during Lent. Inspecting the species of sugarcane commonly known as Creole, Swedish naturalist Carl Linnaeus termed it *Saccharum officinarum*, the species name meaning “of the apothecaries’ shop.”

Not everyone was enthusiastic about sugar. In 1606, French physician Joseph Du Cherne assailed sugar as being unhealthy. In 1647, English writer Theophilus Garencieres speculated that sugar caused tuberculosis. In 1674, English physician Thomas Willis fingered sugar as the cause of scurvy. In the 19th century, British writer William Duffy claimed that sugar caused insanity. Modern opinion is not charitable. Dental caries are rare in people who do not consume sugar, but their incidence rises with its ingestion. Nutritionists charge that sugar, devoid of protein, vitamins, and minerals, is empty calories. Too much sugar makes one fat. Sugar is surely to blame, at least partly, for the epidemic of obesity in the developed world.

In its early days, sugar was too expensive for commoners, but by the 13th century it had become what one scholar termed “a luxurious necessity.” Between 1700 and 1800, the British increased their consumption of sugar fivefold. Whereas people in Europe and the United States derived a few percent of their calories from sugar in 1800, the number has leapt to a sizable portion today. Once a medicine of doubtful utility, sugar has become an addiction.

Christopher Cumo

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Sundew

A carnivorous plant, the sundew is in the genus *Drosera*, Greek for "dewy." The sundew acquired this name because each tentacle has mucilage at its end that forms a globule with the appearance of dew. Insects may mistake this substance for dew, but it is really an adhesive that binds an insect to a tentacle. Also known as the catch-fly and the flypaper trap, the sundew functions superficially like flypaper, though its trapping mechanism is much more active than the passive character of flypaper. A remarkably diverse plant, the sundew has roughly 160 species that inhabit the Americas, Europe, Africa, Asia, Australia, and New Zealand. The smallest sundews are only one inch long, whereas the largest are the size of a bush. The dimensions of a sundew determine the size of insects that it can catch.

History, Carnivorous Habit, and Cultivation

Medieval Europeans knew the sundew but were unaware of its carnivorous habit. Instead, they thought of it as a medicinal plant, believing that it cured coughs and respiratory ailments. Even today, a few people are convinced that it has medicinal value, thinking that an extract of sundew improves the function of the heart. Some sundews, like the potato, form tubers, and the aborigines of Australia have long eaten them. In the Renaissance, botanists paid renewed attention to the plant. In 1578, British botanist Henry Lyte may have been the first to call *Drosera* the sundew because in sunlight its mucilage sparkled like dew. Lyte included a description of the sundew in his *New Herbal*. In 1633, English herbalist John Gerard included the sundew in his *New Herbal*, the name apparently being a popular title for botanical texts. Adhering to the medical lore that surrounded the sundew, he recommended it as a cure for tuberculosis. Others believed that the sundew was an aphrodisiac. Female sheep and cattle that ate it desired sex, they believed. Still others held that the juice from the sundew removed warts and freckles and soothed sunburn.

In 1779, German botanist A. W. Roth discovered that the tentacles of a sundew move. Roth witnessed them entomb an insect, though he may have been unaware of the sundew's carnivorous habit. In 1791, American naturalist William Bartram observed that a sundew captured insects, but he was not sure why. That year Erasmus Darwin, physician and grandfather of English naturalist Charles Darwin, perhaps unaware of Bartram's work, supposed that the sundew's mucilage protected it from predators. The insight that the sundew was a carnivore may have eluded Swedish naturalist Carl Linnaeus. He believed that God had ordered nature from the most primitive organism to the most exulted humans. Because fauna was more advanced than flora, it was appropriate for animals to eat plants. Plants did not, however, eat animals and so plants could not be carnivores. Linnaeus's eminence may have discouraged others from challenging him, and only in 1875 did Charles Darwin amass the evidence that the sundew ate insects. Darwin demonstrated that the sundew was sensitive to touch and that in addition to insects it digested egg white and several solutions that contained nitrogen.

The sundew's carnivorous habit is likely an adaptation to its having evolved in nutrient poor soil. Because the soil in which the sundew grows is deficient in nitrogen and phosphorus, the plant obtains these nutrients from insects. The carnivorous habit gives the sundew an advantage over noncarnivorous plants, which, having no means of obtaining nutrients aside from mining the soil, grow poorly in marginal land. In its native habitat, therefore, the sundew faces little competition from other plants. Rather, the sundew may be found growing among other carnivores: Venus's Fly Trap and the pitcher plant. Like other carnivorous plants, the sundew prefers acidic soil. A few sundews grow in bogs, their soils perpetually wet. Others grow in climates with a dry season and go dormant when rainfall is scant. Some sundews are dormant in winter and are able to survive in frozen soil. Others endure hot days and cold nights.

The sundew's carnivorous habit has excited the curiosity of gardeners for more than a century. The plant must appear innocuous to insects, which alight on a globule of mucilage in anticipation of drinking dew or perhaps nectar. It is also possible that insects perceive a sundew as a landing pad and so alight on it. Whatever the reason, an insect soon discovers its error and endeavors to escape. Large, strong insects do occasionally escape, but smaller ones are doomed. As an insect struggles to free itself, it inadvertently contacts other tentacles, finding itself hopelessly entangled. An insect may thrash about so violently that it loses a leg or wing, but its struggles are futile. Within minutes of initial contact, tentacles move to ensnare prey in ever greater secretions of mucilage. An ant may struggle 15 minutes before dying, but a larger insect may writhe in agony for hours before succumbing. Covered in mucilage from several tentacles, an insect either drowns or suffocates in the secretions. Some insects are particularly unfortunate. A cranefly whose legs get stuck on a sundew may hang helplessly from the plant, dying of exhaustion or starvation. While it lives, a sundew digests its legs, a process that must pain the insect. Some sundews specialize in the capture of certain categories of insect. The diet of the European species *Drosera anglica*, *Drosera intermedia*, and *Drosera rotundifolia* is 90 percent flying insects, whereas more than 70 percent of the Australian sundew *Drosera erythrorhiza*'s prey is crawlers, notably springtails.

Digestion begins at once. The glands that secrete mucilage also secrete digestive juices that break down the innards of an insect. Once an insect has been reduced to liquid, a process that takes hours or at most days, the digestive glands absorb it. Among the juices is chitinase, a chemical strong enough to dissolve the exoskeleton. A sundew must not secrete much chitinase because the exoskeleton invariably remains intact even when the rest of the insect is digested. The juices also include acids, which are effective in dissolving an insect. Once a sundew has digested an insect, its tentacles unfold, and its leaves, if they have enveloped an insect, uncurl to reveal an empty exoskeleton. The exoskeleton may remain stuck on the mucilage, it may break apart, or it may dissolve in rain. A sundew may attract spiders, which spin a web near it to capture escapees. Occasionally, a spider may approach a sundew to poach an insect and is ensnared in turn. So effective is a sundew that it may capture more than a dozen insects at roughly the same time. A sundew is a selective trap. It will not respond to a pine needle, but it will eat chocolate, cheese, and other items of food.

In cultivation, one should aim to replicate a sundew's native habitat. Because sundews inhabit a diversity of ecosystems, one must know the requirements of each species in order to cultivate it. A few generic guidelines may inform the gardener. The soil should have some proportion of peat and sand, though other amendments may be suitable. Some sundews do best in a soil that is predominantly sand, whereas others like sphagnum. Temperate species should be grown in a soil of more than 50 percent peat, whereas tropical and subtropical species do well in a soil of roughly 75 percent sand. Some sundews need waterlogged soil, whereas others are content with their soil in a pot and the pot immersed in a tray of water. In the latter case, the soil absorbs water by capillary action. Although the soil should be wet during the growing season, sundews that go dormant should receive less water during dormancy. In some cases, the soil of dormant plants should be dry. The gardener should use rainwater or distilled water. Tap water may have too many minerals, soft water may have too much calcium or chlorine, and bottled water is likely to contain salt. Some sundews are dormant in winter when freezing temperatures lock up groundwater. Others are dormant in summer, when rainfall is scant. As a rule, sundews prefer abundant sunshine. They need sunlight to photosynthesize the energy necessary to maintain their trapping equipment. A few species, having evolved in forest, thrive in shade. Most sundews do well between 60°F and 77°F. Tropical sundews should not be exposed to temperatures below 68°F. During dormancy temperate species should be kept just above 32°F. Sundews grow more vigorously when they have insects to eat. Gnats, fruit flies, and ants are all-purpose foods. Large sundews may eat flies, spiders, and moths. Some gardeners give their plants dried insects, hardboiled egg, cheese, chocolate, or powdered milk. Fertilizer is unnecessary when a sundew feeds on insects, though the gardener may fertilize a plant bereft of insects with a solution at one-quarter strength sprayed on the leaves. The gardener must take care not to saturate the soil with fertilizer because it may injure the roots. Many sundews do well in a pot placed by a sunny window. The gardener should keep the humidity high, being careful to circulate the air so fungi do not attack the plant.

Although some species of sundew will not flower in cultivation, many will produce flowers in abundance. As a rule, the flowers of sundews self-pollinate, yielding a bounty of seed. The gardener who wishes to propagate a sundew may collect seeds, planting them immediately or storing them in a refrigerator to prolong viability. Seeds may be planted in a mix of peat and sand, taking care not to bury them because seeds need sunlight to germinate. Because many sundews seed in late winter and early spring, the gardener should keep the soil in a seedbed cool. The humidity should be high. Seeds germinate in four to eight weeks. After germination, seedlings should not be exposed to frost. In addition to propagating by seed, several species of sundew produce gammae. These may be collected and planted like seeds. Despite their resemblance to seeds, gammae are clones of the parent plant, whereas seeds are a unique arrangement of genes that they have inherited from both mother and father. In the case of self-pollinating sundews, a single plant serves as both mother and father. In addition, the gardener may propagate sundews by leaf and root cuttings.

In the wild, the sundew occupies a diversity of habitats, growing as far north as the Arctic Circle and as far south as the Clarence Islands near Antarctica. Sundews grow from sea level to 10,000 feet. They grow atop Neblina Tepui, Brazil's highest mountain. Australia, the center of sundew diversity, has some 70 species. As a rule, sundews in the Northern Hemisphere have a greater range than those in the Southern Hemisphere. Despite the perception of carnivorous plants as bog flora, most sundews do not inhabit a bog but rather sandy soil that dries during periods of meager rainfall.

The Diversity of Sundews

Of the roughly 160 species of sundew, several are favorites of gardeners. Because of its ease of cultivation and the beauty of its flowers, the cape sundew of South Africa is ideal for the beginner. Tolerating frost and temperatures as high as 100°F, though only for brief durations, the cape sundew does best between 40°F and 80°F. It does not go dormant and so may be cultivated year-round. Temperatures below freezing cause the crown to die, but the return of warm weather signals the plant to regenerate from the roots. The cape sundew has survived temperatures as low as 10°F. It flowers between spring and autumn. Each stalk bears dozens of flowers. Self-pollinating, flowers yield abundant seed, which may be planted in wet peat. The gardener may also propagate the cape sundew by leaf and root cuttings.

Subtropical sundews encompass several species and a diversity of ecosystems. Small plants, these sundews are only one to three inches tall and therefore capture only tiny insects. Perennials, the leaves of these plants die after several years, necessitating their propagation by seed. Easy to cultivate, subtropical sundews do not have a period of dormancy. Some subtropical sundews will tolerate temperatures as low as 20°F. Although the leaves will die at this temperature, the return of warm weather signals the roots to produce new leaves. Because they are subtropical plants, these sundews are best grown, where they are cultivated outdoors, in frost-free locales. Some subtropical sundews will not seed in cultivation and must be propagated by root cuttings. They thrive in unheated and heated greenhouses. The gardener may pot these plants and place them by a sunny window. The humidity should be high. Popular subtropical species include *Drosera alicise*, *Drosera slackii*, *Drosera cueifolia*, *Drosera dielsiana*, *Drosera collinriae*, *Drosera glabripes*, *and Drosera venusta* from South Africa. Of these, *Drosera slackii* seldom seeds and must be propagated by root cuttings. Other subtropical sundews include *Drosera spatulate* from Japan, *Drosera capillaries* from the southeastern United States and Central and South America, *Drosera brevifolia* from the southeastern United States, *Drosera montana* and *Drosera villosa* from South America, *Drosera hamiltonii* from Australia, *Drosera burmanni* from Australia and Southeast Asia, and *Drosera roraimae* from Venezuela. Of these, *Drosera hamiltonii* does not seed and must be propagated by root cuttings. *Drosera burmanni* dies after flowering and must be propagated by seed. Hardy seeds, they remain viable when exposed to light frost.

Temperate sundews survive cold weather, during which they die down to buds known as hibernacula, meaning “hibernate.” The return of warm weather stimulates the roots to issue forth new leaves. Of temperate sundews, *Drosera intermedia* grows from Canada to South America and the Caribbean. One member of this species is native to Wisconsin. Temperate sundews can survive temperatures below 0°F. In northern latitudes, they may be dormant six or seven months each year. When cultivated in warm climates, the buds and roots should be refrigerated to initiate dormancy. Species native to Cuba, on the other hand, do not have a dormant period and will not tolerate frost. The temperate sundew *Drosera rotundifolia* is renowned as the plant that Darwin chose for his experiments. This species grows in North America, Europe, and Asia. *Drosera anglica*—the English sundew—is rare in England but plentiful in Scotland, Japan, North America, continental Europe, and Hawaii.

Forked-leaf sundews are native to Australia and New Zealand. Popular during the Victorian era, these sundews need wet soils, several hours of sunlight per day, and high humidity. Hardy plants, they tolerate frost. The gardener may grow them in greenhouses with or without heat. The soil should be a mix of peat and sand. Alternatively, they may be grown in sphagnum. Despite their name, a few tropical sundews tolerate frost. The gardener should grow them above 50°F in a warm greenhouse. Three species from the rainforest of Australia do well in shade. Tropical sundews seldom seed and must be propagated from root cuttings. The gardener should not fertilize these sundews.

The wooly sundews of northern Australia may be grown in waterlogged soil. In the wild, they experience six months of rain followed by six months of arid conditions, when they are dormant. Their native soil is sandy. In cultivation, they do well in two parts sand and one part peat. The gardener may grow them in a terrarium or greenhouse in full sun and with temperatures between 60°F and 90°F. Among the smallest of their kind, pygmy sundews, native to southwestern Australia, grow in the winter, when rainfall is abundant, and are dormant during the dry summer. Growing in sandy soil, pygmy sundews reproduce by gammae. These plants also produce seed, though the yield in cultivation is poor. During winter, gammae germinate and seedlings grow vigorously in winter and spring. In late spring, pygmy sundews flower, producing seed in summer. These germinate only in autumn, when rains return. In cultivation, the gardener need not initiate dormancy. The plants do well in two parts sand and one part peat. Pygmy sundews need abundant sunlight and may be grown in a greenhouse. They prefer a frost-free environment but survive temperatures as low as 20°F.

Tuberous sundews of western Australia are adapted to wet winters and dry summers, when the plants are dormant. These sundews produce tubers that range from the size of a pea to the dimensions of a walnut and that are between a few inches to two feet underground. Atop each tuber is an eye. From an eye, a tuber issues forth a stolon in autumn. The nutrients stored in a tuber sustain the stolon in its growth. The stolon produces a new plant. In cultivation, the gardener may store tubers at room temperature in a dark place. The soil should be two parts sand and one part peat. Tuberous sundews grow between 40°F and 75°F. In addition to producing tubers, these sundews yield flowers, either at the beginning of a plant's life or before it becomes dormant. Many gardeners appreciate the fragrance of these flowers. Among tuberous sundews, *Drosera peltata*, native to western Australia, New Zealand, India, and Southeast Asia, is easy to cultivate. Among the largest sundews, *Drosera gigantea* grows to three feet. Even larger at five feet is *Drosera macrantha*. In cultivation, it does not produce seed and must be propagated by tuber.

Christopher Cumo

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Sunflower

An annual, the cultivated sunflower (*Helianthus annuus*) is an American indigene. In 1752, Swedish naturalist Carl Linnaeus created the genus *Helianthus*, into which he placed sunflower. *Helios* means "sun" and *anthos* means "flower," giving the plant the literal name sunflower. Fond of it, Linnaeus asked: "Who can see this plant in flower, whose great golden blossoms send out rays in every direction from the circular disk, without admiring the handsome flower modeled after the sun's shape?" Linnaeus, who grew sunflower in the botanical garden at Uppsala, Sweden, knew 11 species, all perennial except the cultivated species. The genus *Helianthus* has more than 50 species. Sunflower is a member of the Asteraceae family, which has more than 20,000 species. The 19th-century Dutch artist Vincent van Gogh painted sunflowers, considering them a symbol of gratitude. When the Mormons migrated from Missouri to Utah, they left a trail of sunflower seeds for others to follow. Sunflower seeds have oil, protein, thiamine, and iron. Pound for pound, sunflower seeds contain more calories than corn. Today, homeopaths use sunflower to treat fever, nosebleed, nausea, and vomiting. Sunflower is today one of the four most important oil crops, the other three being soybean, peanut, and rapeseed.

Attributes, Cultivation, and Cultivars

Young plants are heliotropes, tracking the sun as it journeys across the sky. Mature plants face east, absorbing the morning sun. The large head of sunflower is not a single flower but a composite of many flowers. Many people think that a sunflower has one head per plant, but some varieties have multiple heads per plant. The gardener should not start sunflower indoors because it does not transplant well. Seeds should be sown one-half of an inch deep in the garden after the last frost. Sunflower is hardy enough to tolerate light frost, though it languishes in shade. When flowering, the plant consumes copious amounts of water. Because they are tall, some varieties benefit from being staked so they will not lodge. When a flower drops its petals, its seeds are ready to harvest. The gardener should store seeds, which may remain viable seven years, in a cool, dark place. The sunflower has anthers and stigmas in each flower, making possible self-pollination, though in most cases insects cross-pollinate flowers.

More than 2,000 varieties of sunflower exist. Russian scientists have bred numerous varieties, among them Russian Mammoth, also known as Russian Giant, Tall Russian, and Russian Greystripe. Growing to a height of 9 to 12 feet, the cultivar produces large heads, each of which yields up to 5,000 plump seeds that are gray-black with white stripes. Seeds are ready to harvest 80 days after planting. Tarahumara matures in 85 to 100 days. The attractive heads are golden with a green center. Seeds are gray and white. In the 1930s, Mennonites introduced Tarahumara into Canada. The Tarahumara Indians of Chihuahua, Mexico, adopted the variety, giving it its name. In 1804, American explorers Meriwether Lewis and William Clark found the Arikara Indians of North Dakota cultivating the variety that bears their name. The head, 12 to 16 inches in diameter, is yellow-orange. Arikara may yield more than one head per plant. Maturing in 100 days, the seeds are black and white. Today, Arikara is difficult to find.

Origin

Originating in what is today the southern United States or southern Mexico, sunflower predated the arrival of humans in the Americas. As the climate cooled and dried in North America, sunflower expanded its habitat at the expense of trees. Buffalo may have been the original dispersers of sunflower seeds, enabling the plant to colonize North America. Between 8000 and 6000 BCE, humans began eating wild sunflower seeds. Between 3000 and 1000 BCE, humans domesticated the sunflower. One authority believes that the Amerindians of Arizona and New Mexico began to cultivate sunflower about 3000 BCE, though this date may be too early. Another authority believes that Native Americans domesticated sunflower before corn. Archaeologists have dated fossilized sunflower seeds in Tennessee to 2200 BCE. Because the seeds are large, they must have been the product of selection and cultivation. This find may mark the origin of sunflower culture in the Americas. Fossilized sunflower pollen found in Amerindian settlements in Kentucky, Ohio, and Texas suggests that the plant was widespread in prehistory. Humans may have first cultivated sunflower at the edge of their campsites. Sunflower seeds were a leading source of calories for Native Americans. In what is today the United States, sunflower was one of only six cultigens, the others being chenopod, sump weed, may grass, erect knotwood, and little barley. Of these, only sunflower remains a crop today.

The conviction that the sunflower was a domesticate in what is today the United States received a blow when a recent find dated sunflower seeds in southern Mexico to 2800 BCE, 600 years older than the Tennessee seeds. If this date is accurate, the sunflower originated in Mexico rather than the United States. The sunflower, and with it agriculture, may not have arisen independently in the United States but may have been an offshoot of developments in Mexico. It is possible, of course, that agriculture arose independently in the United States and Mexico, but it seems probable that it arose first in Mexico and diffused to the United States. Yet not everyone accepts the Mexican find. One authority believes that the Mexican seeds were really from squash, not sunflower. If this were true, Tennessee would remain the cradle of sunflower culture. If one assumes the validity of the Mexican find, then the Americans cultivated sunflower from southern Mexico to Canada in prehistory. At its height, sunflower was cultivated from the Arctic Circle to the tropics and from the Missouri River to the Pacific Ocean.

The Amerindians ate sunflower seeds raw, roasted, or ground into meal or bread. By 1000 BCE, the Amerindians extracted oil from sunflower seeds for cooking. In the 19th century, Buffalo Bird Woman, a Hidatsa Indian in North Dakota, told how tribal women pounded seeds into meal that they wrapped in skin, giving it to men to eat for quick energy. Doubtless, this was an ancient practice. The Amerindians pulverized sunflower seeds into powder, which they mixed with water to make gruel. Native Americans ate sunflower flower buds. They used sunflower in cosmetics and to treat kidney ailments, snakebite, cough, whooping cough, and the common cold. They used sunflower to remove warts, to rid the body of excess water, and to loosen mucus in the chest. The Amerindians planted sunflower around their homes in the belief that it would shield them from malaria. They used sunflower stalks to make their homes.

By the 13th century, the Hopi cultivated sunflower and corn. They made sunflower seeds into piki, a type of bread. They believed that goddess Kuwanlelenta was the guardian of sunflower. They wore sunflowers in their hair during the worship of Kuwanlelenta. According to myth, the Spider Grandmother taught the Hopi to sing to sunflowers. As long as they sang, the plants grew. When they stopped singing, the plants ceased growth. Because they were trapped in the underworld, the Hopi sang to sunflowers in hopes that they would grow tall. They then aimed to climb up the plant and out of the underworld. This attempt failed, leading the Hopi to climb up a pine tree to escape the underworld.

The Mandan cultivated sunflower in North Dakota, and the Pueblo grew sunflower in the Rio Grande Valley. Other tribes made sunflower seed cakes. The Amerindians of North Dakota combined sunflower with beans, squash, and cornmeal. Warriors carried balls of sunflower seeds for a Spartan meal. The Iroquois grew sunflower, beans, and corn. The Amerindians of Virginia used sunflower oil in making bread.

A World Crop

In 1510, the Spanish acquired sunflower seeds from New Mexico, growing them in a botanical garden in Madrid. In 1568, Flemish herbalist Rembertus Dodonaeus published the first description of sunflower. From Spain, the plant migrated to Italy and France. By the late 16th century, botanists grew sunflower in Belgium, the Netherlands, Switzerland, Germany, and Britain. Cultivating it in his garden, in the 16th-century English herbalist John Gerard obtained 14-foot-tall specimens. He declared the seeds "exceeding[ly] pleasant." By 1664, sunflower was grown as an ornamental in Hungary. In the 17th and early 18th centuries, sunflower was a symbol of French king Louis XIV's reign. In the 18th century, Europeans ate sunflower seeds as a snack. In this capacity, sunflower seeds competed with nuts. Europeans prepared sunflower petioles like asparagus. In Europe, sunflower seeds were used to treat wounds and kidney ailments. Europeans regarded them as a diuretic and planted them in marshes in the belief that they retarded the spread of malaria. In the 18th century, Europeans extracted oil from sunflower seeds. In 1794, Romanians cultivated sunflower for its oil. Romanians grew sunflower in preference to rapeseed on sandy soil. Czar Peter the Great (1672–1725) introduced sunflower from the Netherlands into Russia. In Eastern Europe and Russia sunflower oil was the chief dietary fat. By 1854 Veronezh, Russia, produced many tons of sunflower oil per year. By 1880, sunflower had spread to Ukraine and Kuban. By then, the plant occupied hundreds of thousands of acres in Russia. By the end of the 19th century, sunflower was the principal oilseed crop in Hungary. By then, Hungary exported sunflower oil to Western and Northern Europe and the United States. France exported sunflower oil to the United Kingdom.

In the 19th century, Mennonites introduced sunflower from Russia to Canada. In 1893, the American consul in Saint Petersburg, Russia, sent sunflower seeds back to the United States. In the 1890s, U.S. farmers grew sunflower to feed seeds to chickens and for silage. They cultivated it where the climate was too cold and too dry for corn. By 1914, farmers in Missouri and Arkansas raised sunflower in quantity. Between 1919 and 1947, the United States harvested an average of several million pounds of sunflower seeds per year. In the 1930s Canada, eager to reduce its import of vegetable oils, cultivated sunflower. After World War II, affluent Americans and Europeans turned to sunflower seeds as a snack food.

In 1875, India began extracting oil from sunflower seeds for use as a lubricant and in paint. In the 20th century, farmers grew sunflower in the Philippines and China. Filipinos rotated the crop with rice. In the 20th century, Australians grew sunflower to feed seeds to chickens. During World War II Australia, like Canada eager to reduce the import of vegetable oils, extracted oil from sunflower seeds.

During the war, vegetable oil was scarce in Germany, leading the Nazis to invade Russia for its sunflower oil according to one writer. Sunflower oil lubricated Nazi and Soviet rifles. In Africa, South Africa was the leading producer. As elsewhere, sunflower seed was first a feed for chickens in South Africa. In the 1920s, South Africans used sunflower oil to make soap. European immigrants may have introduced sunflower into Argentina, South America's leading grower. In Argentina, sunflower competes with peanut as a source of oil. Other South American producers include Uruguay, Chile, and Brazil. In 2010, Ukraine was the world's leading producer of sunflower oil. The European Union ranked second. Russia ranked third, Argentina fourth, and Turkey fifth. The United States ranked seventh.

Christopher Cumo

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Sweet Flag

Nowadays sweet flag (*Acorus calamus*), a highly aromatic plant originally from East Asian, is not only cultivated but also naturalized in many parts of the world. As a cultural relict, it reminds us that it was once widely planted and used for many purposes. It has few equivalents among flowering plants in gaining such widespread use in so many cultures. The plant occurs in Eurasia, Africa, and North America. It is a stout grass-like and hairless erect perennial plant with long, sword-shaped, slightly crinkled, sweet-scented leaves that grows to almost five feet tall. It thrives in wet places and shallow habitats, like ditches, farm ponds, and rivers. The plant rarely flowers or produces fruit.

Several of its English and American English names include sweet, beside its now generally accepted name sweet flag—for instance, sweet rush, sweet root, sweet cane, sweet myrtle, and sweet seg (southern England), sweet grass, sweet flagroot, and sweet caramel, with corresponding names in French (*acore odorant*, *roseau aromatique*, and *canne aromatique*), Italian (*Acoro aromatico* and *Acoro odoroso*), and other languages. "Sweet" refers to the pleasant aromatic flavor of the plant when crushed and especially of the rhizomes. The scent reminds of tangerines, or as the British 20th-century author Geoffrey Grigson writes, it "is like orange peel, warm and pungent, and unexpected."

Botanists distinguish chromosome numbers of sweet flag that exist in nature: triploid, which is sterile (var. *calamus*); tetraploid, which is fertile (var. *angustata*); and hexaploid. The sterile triploid seems to have originated in the Himalayas but exists throughout Europe and India, while the tetraploid originated in eastern and tropical Southeast Asia, including Japan and Taiwan. The hexaploid is found in some parts of the Kashmir Valley. The species never fruits in Europe. It prefers full sunshine and is easily propagated by dividing the plant. The fertile diploid variety of North America is now regarded as its own taxon, *Acorus americanus* Rafinesque, 1828.

Cultural History

Sweet flag has a long but little known history as a cultivated plant. The plant is hardy and easy to grow. Although it originated somewhere in eastern or southeastern Asia, it was obviously under cultivation from early times and traded westward. It is known from ancient China and India and has a long history within Chinese and ayurvedic medicine. However, it probably quite early also reached some parts of the eastern Mediterranean Basin. Its mention in the Bible is disputed, and according to several authors the plant in the text actually refers to another taxon. Some have suggested that sweet flag was brought to southeastern Europe through the Ottoman Empire from India with itinerant groups of Romani people (gypsies). It is also believed that it was brought by the Mongols to Eastern Europe during medieval times. They seem to have used it as a water purifier, and were planting it in places where their horses were drinking.

According to some records, it was introduced into Central Europe (Baltic area, Poland, and Ukraine) with the Mongol invasion in the 13th century. It is known in late medieval and early modern medical works. For instance, the Danish canon Henrik Smid suggested in 1546 using the pickled rhizomes to prevent stomachache and malaria. We have a record of its presence in Prague in 1565, to where it was imported from the Ottoman Empire. In 1574, Flemish physician and botanist Carolus Clusius cultivated it in the imperial medical garden in Vienna. When English herbalist and physician John Gerard grew it in his garden in the 1590s, it was treated as a newcomer, recently introduced by him into the British Isles. He received his specimens from Anthony Coline, an apothecary in Lyons. Gerard wrote that it "prospereth well in moiste medowes . . . brinkes of riuers, ponds, and standing lakes."

Interestingly enough, it seems to have reached North America with the native Indians, either through trade in the north Pacific region or with early Stone Age settlers. Many Native American tribes used it as a folk medicine, and for other purposes. Lakota warriors made a paste by chewing the rhizomes, and rubbed it on their faces. When the European settlers arrived, it was already there. Candied rhizomes were early used as a confection among these settlers, in the same way as it was used back in Europe. The Shaker communities in New England used to sell the candied flag root as sweet. It is said to have been a favorite plant of 19th-century American philosopher Henry David Thoreau. He remembered it as a food plant in his childhood and he loved it.

It was of course also widely used all over Eurasia. For instance, explorer Johan Peter Falck, employed by Russian Academy of Sciences, reported in the mid-1780s from central Asia that the Bokharans used the fresh roots as a drug for all kind of chest diseases, including phthisis. It was made by laying the roots on the warm ashes, after which the skin can be removed and the rhizome mashed to a drug.

Food and Medicine

The almost four-feet-long rhizome is sharp and bitter tasting and contains 1.5–3.5 percent volatile fragrance oils (e.g., asarylaldehyd, methyleugenol, shyobyone, asarone), the bitter glycoside acorine, resin, starch, tannin, and cholin. It was and still is primarily used as an aromatic bitter substance. Interestingly, the proportions of each chemical compounds in the essential oil varies among the varieties of the species.

Sweet flag's medicinal properties are many. It has been used widely in folk medicine, and there are many records from Native American tribes. They used it for both internal and external diseases. Some tribes, like the Cheyenne and Chippewa, used it as a charm to keep evil spirits and rattlesnakes away. However, it has been used in Western scholarly medicine and in folk remedies. In northeastern European folk medicine, it was used for treating a wide spectrum of diseases, including rheumatic, scurvy, skin conditions, stomach conditions, toothache, and cough, and as an appetizer. John Stephenson and James Morss Churchill wrote in their medical botany handbook of 1831 that

> The country people in America cure themselves of ague by a free use of the tincture, and asserts, that it has proved energetically beneficial in that distressing complaint to which sailors are so frequently subject from the nature of their life and diet, well known, particularly to naval surgeons, by the name of wind colic; given in hot decoctions in the manner of ginger-tea, it quickly relieves the distressing swelling of the abdomen.

It was widely used as a stimulating aromatic tonic. According to American author John C. Gunn in his *Gunn's New Domestic Physician* (1861), it was preferably used in cases of flatulent colic, and given to children in tea. In the Balkan Peninsula, the peasantry has been using it to induce abortion. Sweet flag has also been used for treating animal diseases.

Sweet flag has also been utilized as food. London-based physician Nicholas Culpeper suggested in his 1653 *Complete Herbal* using it as seasoning because it was "having a very grateful flavor" and were "by some nice cooks put into sauce for fish." The root has also been used in order to flavor cordials, liquor, wine, and other alcoholic beverages. Country people in the United States and Canada used it earlier as an ingredient to make wine bitter. Still in the World War I, Northern European soldiers used to chew the root, and also children gathered the bittersweet rhizomes in wet places just for the pleasure of chewing them. In the Netherlands, children used to chew the rhizome like a gum and made popgun projectiles of them. Local anglers in the United Kingdom still pull up the rhizomes and chew on them. The taste of the rhizomes is sharp and bitter. It has therefore been given names like bitter-pepper root, cinnamon sedge, and Deutscher Ingber (German ginger).

Since 1968, sweet flag and products derived from it (oil) have been banned as a food additive and in medicines by the U.S. Food and Drug Administration, because it was believed that some substances in were carcinogens. Nevertheless, it is still used in folk and herbal medicine in many parts of the world. Its modern reputation as a hallucinogenic drug is false, but seems to be believed in some circles.

Other Uses

Peasants in various parts of Europe once used the fresh root, spread in pieces over the barn floor, to repel rats and mice and protect the harvest, and also to keep away unpleasant insects. They were also used to give homes a nice fragrant aroma. Smoke of the plant has been used for the same purposes. Mixed with ammonia Danish villagers used the chopped rhizomes to drive away ants. This use is also known in Malaysia. In India, powdered rhizomes are used to get rid of lice from pet birds. Due to its insecticidal activities, it is still used for repellents. Its oil (asarone) is also being employed as antifungal and antibacterial agents, making possible its use as an organic pesticide in the future. In some parts of North America, it has also been used for tanning leather. In China and in modern Egypt, it has a long reputation as an aphrodisiac.

Sweet flag is cultivated for its oil in Poland, Ukraine, Russia, Hungary, Sri Lanka, and India. As an economic plant, sweet flag is today used mostly in perfumes. It can also be used as a decorative plant for garden ponds. There are several varieties with variegated leaves with highly ornamental value available from nurseries. Also, varieties with purple leaves are available.

Ingvar Svanberg

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Sweet Pea

The history, character, and uses of sweet peas are similar to that of another popular plant that endures as a mainstay of gardens everywhere—the rose. While not as praised in song and poem as the rose, sweet peas steadfastly provide color, fragrance, and versatility. Although the sweet pea is a legume, like the garden peas, beans, soybeans, lentil and several other food plants, I cannot find any evidence that sweet pea was used in any other capacity than as an ornamental. As a legume, sweet pea is in the Leguminosae or Fabaceae family.Today's sweet peas sprang from a hardy, fragrant native species with small blue and purple blooms. Simple, old varieties still thrive along with hybridized modern versions with more colors, larger and more abundant blossoms, longer stems, and earlier and later varieties to extend the bloom season. The typical plant size of six-foot vines now is joined by dwarf bush types. Because of their popularity, varieties are again being bred with a strong emphasis on fragrance, which can be lost when focus is put on improving other characteristics.

History

A Sicilian named Franciscus Cuprani, a member of the order of St. Francis, catalogued plants on the island of Sicily. He is credited with sending sweet pea seeds to botanists in England and Holland at the end of the 17th century. Probable recipients of those seeds and often mentioned as growers of sweet peas around 1699 include Dr. Robert Uvedele, a teacher in Enfield, Middlesex, England, and noted botanist Leonard Plukenet, who chronicled and had drawings made of thousands of plants and published *Phytographia*. Specimens of his were exhibited in the Natural History Museum in London. Sweet peas show up in *Species plantarum*, the definitive plant catalogue of 1753 by Swedish naturalist Carl Linnaeus. Under his landmark system of naming plants, sweet peas are designated with the Latin *Lathyrus odoratus*.

An even earlier work, *Thesaurus Zeylanicus*, by the Dutch physician and professor of botany Johannes Burmann in 1737, includes sweet peas. *Zeylanicus* indicating Ceylon, now Sri Lanka, gives rise to consideration of that island being the original home of sweet peas as well as, or rather than Sicily. The earliest credited illustration of them is by Jan Mominckx of Amsterdam in Jan and Caspar Commelin's *Horti Medici Amstelodamensis* of 1701.

Species and early varieties had two or three blooms per stem. Modern varieties triple that and then some. The larger-blossomed grandiflora types were hybridized in the second half of the 19th century. Henry Eckford created the Spencer varieties, which display wavier flower petals, named in honor of the Countess Spencer. Painted Lady, a white and rose-pink variety from the early 18th century, remains a popular classic. In the United States, early and multiflora varieties hybridized include Early Multiflora Gigantea, Mammoth, Winter Elegance, and Winter Sunshine. David Lemon of California contributed the Solstice series and developed nontendril varieties. In the 1890s, a dwarf series was developed and given the charming names of Cupid, Sweetie, Pinocchio, and Cherub.

Sweet peas now are grown commercially as a cut flower. Thanks to modern shipping, they serve as a major floral crop. The long-lasting blooms fly worldwide from markets supplied by producers principally in the Netherlands, Japan, Australia, and California.

Culture

Sweet peas are not fussy. They prefer slightly alkaline soil and moist, cool locations. Their possible origin in the Mediterranean region makes them partial to wet winters and low-humidity summers. The mild sunny summers with cool nights in the Pacific Northwest and the United Kingdom are ideal environments for sweet peas. In such suitable climates, the blooming season can extend all the way into fall. But normally, sweet peas fade as the hot, dry summer sets in. New heat-tolerant varieties also extend the season.

To maintain a continuing supply of blooms, sweet peas need to be deadheaded on a consistent basis. Letting the flowers fade and start to set seed will impede new buds. This means that it is a good idea to have a constant supply of sweet pea bouquets around the house. Early fall rains help plants rally. However, rain or overhead watering late in the day brings on the main scourge of sweet peas—mildew. The blossoms will remain largely undamaged, but the leaves will be splotched with white. Slugs and snails will dine on young plants so baits or other measures must be taken to keep them away.

The large seeds are easy to handle. To assist the hard, pea-size seeds to germinate, the gardener may cut a nick in the hull and soak the seeds overnight in water. Seeds can be planted directly in the soil in the spring or fall or started indoors or in a cold frame. Sweet pea blossoms age into pods with seeds that spring off the plant after the pod dries and pops opens. The tan halves of the pod form spirals that add interest to dried bouquets.

Uses in the Landscape

Versatility is the mainstay of sweet peas both as a cut flower and as a landscape feature. The vines ramble across the ground with light to medium green, Y-shaped bamboo-like leaves with whimsical tendrils curling from their tops. Soon sprays of flower buds rise above the foliage and tendrils, and then splashes of color begin to decorate the vines. The bloom stems sprout from the leaf bases and progress toward the ends of the vines. Given the opportunity, the vines climb pillars, trellises, teepee-type frames, and trees and other plants within their reach. To enjoy sweet peas without a large flower bed or even any yard at all, dwarf bush types that do not require support will happily live in containers, hanging baskets, or window boxes with proper care.

Sweet pea flowers come in many colors, combinations of colors, and patterns, in single or double forms. Gardeners may choose varieties to match or contrast other plants in the landscape. Colors include cream, all manner of pinks, mauve, burgundy, lavender, blues, reds, white, peach, orange, and dark, nearly black purple, and chocolate-maroon. Patterns include shades of one color, bicolor, striped, or picotee, which is a white or lighter edge. The blossoms float on strong stems and make long-lasting bouquets. As the bouquets age, petals of some varieties will lighten in color, changing a vase of fuchsia mauve to shades of pink and lavender. Whether several sprays of sweet peas are tucked into an ornate little perfume bottle or an armload forms a mound in a big bowl centerpiece, whether long vines wander among other plants in a flower bed or climb up an arbor, or whether a dwarf variety fills a porch container, sweet pea, like the rose, continues its contributions to horticulture, both commercial and personal.

The year 2005 was designated the Year of the Sweet Pea by professional growers. For 300 years, this plant has been a favorite and will continue to be a solid choice for many gardeners.

Tamara Stromquist

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Sweet Potato

The term "sweet potato" refers to both the perennial vine and the swollen root. Despite its name, the sweet potato is not a potato. It does not develop from an underground stem, as does the potato, but from a root. The tendency to refer to the sweet potato as a yam is also incorrect. The two are in different genera and are not closely related despite superficial similarities. Yet southerners persist in calling the sweet potato a yam. The U.S. Department of Agriculture has further complicated matters by allowing farmers to market their crop as sweet potato yams. In the Arawak language of the Caribbean, *batatas* means sweet potato, giving the roots its species name. The indigenes of Peru called the sweet potato *apichu* or *kumara* depending on its moisture content. The people of Paraguay know the sweet potato as *yety*. The sweet potato is known as *chaco* in Venezuela, *camote* in Bolivia, Chile, and Ecuador, *boniato* in Uruguay, and *batata-douce* in Brazil. In China, the sweet potato is known as the red potato, red creeper, white potato,

Sweet potatoes (iStockPhoto)

mountain taro, red taro, ground melon, and foreign potato. Africans call the sweet potato the local potato or the traditional potato. A member of the Convolvulaceae family, the sweet potato is related to morning glory. Scientists know the sweet potato as *Ipomoea batatas*.

The sweet potato is 70 percent water and 30 percent dry matter. It has a greater proportion of dry matter than other crops. Seventy-five to 90 percent of the dry matter is carbohydrate. An ideal food for health-conscious consumers, the sweet potato has only 0.4 percent fat. It has beta-carotene, the vitamin A precursor, vitamin C, riboflavin, vitamin B6, vitamin E, potassium, copper, manganese, and iron. Orange-flesh varieties have more beta-carotene than white-flesh cultivars. With 1.5–2.5 percent protein, the sweet potato compares favorably to vegetables and fruits but poorly to grains and legumes. The sweet potato is low in sulfur-bearing amino acids. In Southeast Asia, people eat leaves, petioles, and stem tips as greens. These parts of the plant have vitamins A and C and more protein than the roots. Compared with the potato, the sweet potato has more dry matter, starch, sugar, fiber, and fat but less protein.

Origin and Diffusion

The genus *Ipomoea* has 400 species, most of them diploids, though the sweet potato is a hexaploid. Scientists are not certain of the steps that transformed a diploid ancestor into a hexaploid sweet potato. A New World crop, the sweet potato may have originated between the Yucatan Peninsula and the Orinoco River in Venezuela and Colombia. Panama, northern South America, and the Caribbean have all been proposed as the place of origin. Central America has the greatest diversity of sweet potato varieties and so may be the site of origin. The closest relative of the sweet potato, *Ipomoea trifida*, grows wild in Mexico, making it a possible location of origin. Another relative, *Ipomoea tiliacea*, is native to the Caribbean, strengthening the assertion that it may be the ancestral homeland of the sweet potato. The remains of the sweet potato date to 6000 BCE in a Peruvian cave, though scientists do not know whether the ancient Peruvians had domesticated the plant by this date. The people of tropical America domesticated the sweet potato at least 5,000 years ago. In pre-Columbian America, the Maya grew the sweet potato in Central America and the Inca cultivated it in Peru.

By one account, farmers grew the sweet potato in New Zealand as early as 1000 CE, having gotten the root possibly from Peru or Polynesia. From Central America, the sweet potato reached Oceania, though humans may not have been involved in this transfer. The sweet potato of Papua New Guinea differs from that of Peru, ruling out the latter as the source of the root in the former. In 1492, Spanish explorer Christopher Columbus brought the sweet potato from the Caribbean to Spain. Around 1600, the Portuguese introduced the sweet potato to West Africa, Southeast Asia, and the East Indies. Later, the root migrated to India, China, and Japan, though not everyone supports a late date for China. It is possible that farmers in the Philippines and Polynesia grew the sweet potato before European contact. One authority believes that the sweet potato may have originated in the Philippines and Polynesia, though this school of thought is difficult to reconcile with the antiquity of cultivation in the Americas. Alternatively, migrants or ocean currents may have spread the sweet potato from Central America and Mexico to the Philippines and from Peru to Pacific islands before the arrival of Europeans. Differences between the sweet potato in the Caribbean and in the Philippines and Polynesia rule out the West Indies as the source of the root in these islands. Another possibility is that the Spanish brought the sweet potato from Mexico to the Philippines in the 16th century.

Attributes

The roots of a sweet potato plant swell with water and carbohydrates to form sweet potatoes. About 15 percent of the roots of a sweet potato plant enlarge, a process that may take as little as two months in the tropics and 90 to 150 days in temperate locales. The average plant bears 4 to 10 sweet potatoes, each weighing 3.5 to 14 ounces. The flesh may be white, yellow, orange, red, or purple. The flowers are pink with a red, lavender, or purple throat. Not surprisingly, sweet potato flowers look like the flowers of the related morning glory. Insects pollinate flowers, which bear seeds. Sweet potato plants flower in the tropics but seldom in temperate regions. Sweet potato plants flower with 11 or fewer hours of daylight. Farmers do not usually raise sweet potatoes from seeds, though scientist use seeds in their breeding programs.

In the tropics, farmers propagate the sweet potato by planting pieces of stem and vine shoot tip. It is also possible to propagate sweet potatoes by burying sections of roots much as one propagates potatoes by cuttings. The farmer may plant at a density of 100 sections, stems, or tips per square yard. Eleven hundred to 1,500 pounds of roots are enough to plant two-and-a-half acres. Sweet potato plants yield the largest roots when planted at widely spaced intervals. Large sweet potatoes are used by food processors. Closer spacing yields small sweet potatoes with which consumers are familiar.

Raised in the tropics, subtropics, and temperate regions, the sweet potato is grown as far north and south as 40° latitude. The plant grows best with warm days and nights. The long days of temperate regions favor vine growth at the expense of root enlargement. As a rule, the larger the vine the lower is the yield. The soil should be a sandy loam that drains well. The plant tolerates a soil pH between 4.5 and 7.5, though between 6 and 7.5 is best. Below a pH of 5.2, the sweet potato is susceptible to pox and scurf diseases. The sweet potato tolerates saline soil. Roots enlarge with one to one-and-two-tenths inches of water per week. With roots up to six feet long, the sweet potato plant is able to tap water from deep within the soil and so tolerates drought. Unable to tolerate waterlogged soil or frost, the sweet potato yields reasonably well in infertile soil. Farmers often grow sweet potato as a secondary crop to capture fertilizer that the primary crop did not use. A crop of sweet potatoes removes from the soil 87 pounds per acre of nitrogen, 23.6 pounds per acre of phosphorus, 246.8 pounds per acre of potassium, 50 pounds per acre of calcium, and 16 pounds per acre of magnesium. Most sweet potato cultivars yield poorly in shade, though shade-tolerant varieties yield an acceptable crop.

The sweet potato has three stages of growth. In the first, roots penetrate the soil. In the second, vines grow and roots begin to swell. In the third stage, root enlargement accelerates and vine growth slows. Thirty to 35 days after planting, roots fill rapidly. The sweet potato grows best with daytime temperatures of 84°F and nighttime temperatures of 70°F. Above 86°F yields decline. The plant will not grow below 59°F. Temperatures below 50°F injure plants.

Most sweet potatoes are grown for home use and so never enter the market. Most farmers who grow sweet potatoes are poor and have little access to capital and technology. They plant and harvest by hand. In Papua New Guinea, farmers harvest the sweet potato while the plant is still growing because old sweet potatoes lack flavor. These farmers spread the harvest over months. In the developing world, people may derive many of their calories from the sweet potato. In the United States, consumers prefer sweet potatoes with high sugar content. In the developing world, people prefer sweet potatoes rich in starch. In both developed and developing worlds, stockmen feed sweet potatoes, both vine and root, to animals, especially pigs. In China, the majority of the harvest feeds livestock. In Vietnam, the Philippines, India, Kenya, Taiwan, Indonesia, and Papua New Guinea stockmen feed sweet potatoes to pigs. In Latin America and parts of Africa, a smaller amount of sweet potatoes feeds livestock. In the United States, most sweet potatoes are canned. Other sweet potatoes go to make chips, noodles, flour, and candy. In Japan and Taiwan, farmers process sweet potatoes into starch and alcohol.

The developing world yields virtually all the world's sweet potatoes. In the developing world, farmers devote several percent of land set aside for roots and tubers to sweet potatoes, which account for a sizable portion of the yield of roots and tubers. Asia accounts for the vast majority of the world's sweet potatoes. China alone raises the majority of the world's sweet potatoes on several million acres. Throughout the developing world, acreage has decreased in recent years as farmers have switched to corn, other grains, legumes, and vegetables. Worldwide the sweet potato ranks ninth by the size of the harvest. The average yield worldwide is more than several tons per acre. In Africa, yields are lower. Breeders have derived high-yielding varieties, but farmers are reluctant to plant them because of their vulnerability to weevils. In the developing world, the sweet potato is the fifth most important crop. Between 2000 and 2003, production averaged hundreds of millions of tons worldwide. The leading producers were China, Uganda, Nigeria, Indonesia, and Vietnam. Between 2000 and 2003, farmers devoted an average of several million acres to sweet potatoes with an average yield of tens of thousands of pounds per acre. In 2006, China totaled the majority of the world's acreage. The rest of Asia tallied several percent of acreage, Africa less, Latin America still less, and the United States the least. After China, Vietnam is the leader in acreage to sweet potato. Portugal, Europe's leading producer, totals only a tiny fraction of world production. Throughout the developing world, the sweet potato is a famine food. In East Africa, the sweet potato is "the protector of children" because of its use as a subsistence crop. The sweet potato must save countless lives by supplying people with vitamin A. Using it as a famine food, the Japanese have planted the sweet potato in rice fields after typhoons.

The farmer who wishes to fertilize sweet potatoes may add a soil amendment with nitrogen, phosphorus, and potassium. Too much nitrogen stimulates the growth of vines at the expense of roots. The farmer may apply half the nitrogen before planting and the other half when vines elongate. Sweet potatoes are often rotated with corn, cotton, potatoes, and legumes. After the harvest, the sweet potato is cured for a week at 85°F to 90°F and 80–90 percent humidity. Sweet potatoes deteriorate below 50°F. Twenty to 40 percent of the harvest may be lost during storage as roots lose water and sugar oxidizes. The sweet potato may be boiled, steamed, baked, roasted, or fried. Cooks use sweet potatoes to make pie, pudding, biscuits, cake, and desserts. Large sweet potatoes are used to make baby food. Sweet potatoes are often eaten at Thanksgiving, Christmas, and Easter. Sweet potato flour may substitute for wheat flour in making bread.

The United States

Explorers in Mexico and the Caribbean brought the sweet potato to the American colonies. As early as 1648, farmers grew the sweet potato in Virginia, in 1723 in Carolina, and in 1764 in New England. A crop of the South, sweet potatoes were grown for home use. In the 18th century, farmers grew the sweet potato in eastern North Carolina, South Carolina, and Georgia. The yield was then 100 to 200 bushels per acre, though farmers reported up to 1,000 bushels per acre. The sweet potato was a staple during the American Revolution and Civil War. Slaves ate the root. By 1909, Delaware, Maryland, Virginia, and New Jersey emerged as the center of sweet potato culture. Per person consumption was 31 pounds in 1920. During the Great Depression, the sweet potato emerged as a subsistence crop. Between 1930 and 1937, the land planted to the crop increased 200,000 acres, but the yield decreased because farmers had little money for fertilizer. Because the price of sweet potatoes halved during the Depression, per person consumption hovered at 25 pounds per year. In the 1930s, Louisiana established a program to breed improved varieties. After World War II, scientists in North Carolina, Maryland, South Carolina, Georgia, Mississippi, Virginia, and Oklahoma began breeding sweet potatoes. With the return of prosperity after World War II, the production and consumption of sweet potatoes declined as Americans spent money on meat and milk rather than sweet potatoes. In the 1960s, Louisiana and California emerged as important producers. Since the 1970s, per person consumption of sweet potatoes lingered at 4.5 pounds per year, a steep reduction from the amount early in the century. Between 2000 and 2003, the United States averaged hundreds of thousands of tons of sweet potatoes on tens of thousands of acres for a yield of tens of thousands of pounds per acre. In 2007, the leading producers were North Carolina, Louisiana, Mississippi, California, Alabama, Arkansas, New Jersey, and Texas. In the United States, the majority of sweet potatoes are eaten fresh with the rest to chips, fries, canned products, and feed. Cookies and pet food contain sweet potato flour. In the United States, farmers harvest sweet potatoes in August in the South, in September in New Jersey, and in October in California. The harvest occurs before or immediately after the first frost. Although most of the world depends on rainfall, California irrigates virtually all its sweet potato crop. Farmers grow the sweet potato from Florida to southern Ontario.

China

According to one account, Chinese businessman Zhenlong Chen brought the sweet potato from Luzon in the Philippines to Fujian, China, sometime in the

16th century. The date remains unknown because the merchants of Zhangzhon, the port of Fujian, kept this information secret. Chen's son presented the sweet potato to the governor of Fujian, and either father or son introduced the root to Zhejiang, Shandong, and Henan provinces. The introduction of the sweet potato must have occurred before 1594 because the governor of Fujian, familiar with the crop, ordered peasants to plant it to avert famine that year. One account holds that the peasants of Myanmar introduced the sweet potato to Tali, China, in 1563. Another account maintains that the sweet potato spread from Vietnam to Dongyuan, China, in 1582. Another possibility is that the sweet potato migrated from India to China. From the south of China, the sweet potato spread to Quanzhou, Putian, and Changle counties.

In the 1950s and 1960s, farmers increased the production of sweet potatoes to feed a growing population. In 1961, farmers planted sweet potatoes on record acreage. By 1985, the area had fallen as farmers switched to rice, wheat, and corn. Since 1985, the land planted to sweet potato has steadied at several million acres. In China, the sweet potato ranks fifth behind rice, wheat, corn, and soybeans in the size of the harvest. Farmers grow sweet potatoes from Hainan in the south to Inner Mongolia in the north and from Zhejiang in the east to Tibet in the west. The Yellow and Yangtze river valleys are the centers of sweet potato culture. The leading producers are Sichuan, Hanan, Chengzing, Anhui, Guangdong, and Shandong provinces. Stockmen feed sweet potato stems and leaves to pigs, cows, and goats. China's soils are often deficient in phosphorus, leading farmers to fertilize their sweet potatoes to ensure an abundant harvest.

Africa

During the era of the slave trade, the Portuguese brought the sweet potato to Africa. Farmers first grew sweet potatoes in West Africa about 1520. By the end of the 17th century, the sweet potato was widely cultivated in the region. There farmers grow sweet potatoes with cassava and yams. The sweet potato is not the most important crop in West Africa because farmers prefer to grow yams, cassava, rice, cowpeas, cocoyams, and acha. West Africa and East Africa account for the majority of Africa's sweet potato harvest. In Ghana, sweet potatoes rank third in acreage, trailing cassava and yams. The people of Ghana boil, fry, or roast sweet potatoes.

In sub-Saharan Africa, farmers adopted the crop from an early date, often planting it in preference to yams. So long has the sweet potato been in cultivation that some Africans erroneously assume it to be a native crop. In 2001 and 2002, Africa yielded a few tons of sweet potato per acre. The poor grow sweet potatoes, a subsistence crop, on small farms. With little investment in fertilizer and technology, these farmers have nonetheless managed to increase production of sweet potato at a faster rate than other crops. African farmers grow the sweet potato from sea level to 7,500 feet. The sweet potato is an important crop in Africa because it requires less labor and fertilizer than other crops. The root has made gains where cassava and banana disease have limited these crops, especially in land near Lake Victoria. Farmers often plant sweet potato and cassava on adjoining plots. Where cassava fails, farmers plant sweet potato. Where the size of farms has decreased, farmers have increased the proportion of land planted to sweet potato in order to derive the maximum calories and nutrients from the soil.

Government policies have favored the cultivation of sweet potato in Africa. At the end of colonialism, governments subsidized corn growers to encourage subsistence agriculture. These subsidies have proven too costly, and in the early 21st century governments, especially in southern Africa, have ended them, leading corn growers to plant sweet potatoes for subsistence. The AIDS epidemic, in depopulating the countryside, has led single-parent households, seeking to minimize labor and costs, to plant sweet potatoes. Where farmers have opted for a less capital-intensive agriculture, they have switched from coffee and banana to sweet potato. In Africa sweet potatoes, planted where other crops have failed, are a famine food.

In sub-Saharan Africa, 23 countries produce virtually all the region's sweet potatoes. Uganda and Nigeria total one-third of sub-Saharan Africa's sweet potato yield. In Uganda and Nigeria, the most densely populated areas produce the most sweet potatoes. Uganda, Rwanda, Burundi, and Malawi harvest hundreds of pounds of sweet potato per person. The lowest producers are the Congo, Ethiopia, South Africa, Cote d'Ivoire, Niger, and Burkina Faso. Not as productive as the United States and China, sub-Saharan Africa yields 1.8 tons of sweet potatoes per acre. In South Africa, prosperous farmers use irrigation and fertilizers to produce several tons of sweet potatoes per acre. In eastern and parts of southern Africa, farmers grow sweet potatoes as a secondary crop with corn, banana, and plantain being the primary crop. In parts of Africa, sweet potatoes are planted after a grain or cash crop. In Uganda, farmers dry sweet potatoes so they can be stored for five months. Ugandans grind sweet potatoes to make a porridge known as atapa. Throughout Africa, women tend sweet potatoes, giving rise to the association among the root, women, and poverty.

India

In India, the sweet potato ranks third among tuber and root crops, trailing the potato and cassava. The sweet potato is cultivated everywhere in India except Jammu, Kashmir, Himachal Pradesh, and Sikkim. In comparison with other countries, India ranks fifth in the yield of sweet potatoes per acre, eighth in sweet potato production, and 12th in acreage to sweet potatoes. The sweet potato is a rainfed crop in Orissa, West Bengal, Uttar Pradesh, Bihar, and Jharkhand. These states account for the majority of India's sweet potato acreage and a large fraction of production. In India, the average farm has only a few acres of sweet potatoes. In Bihar, farmers cultivate sweet potatoes year round. Elsewhere, sweet potatoes are grown in the rainy season between September and January and in summer. The yield in Bihar is modest. In Orissa and Jharkhand, where the soil is poor, the yield is meager.

As incomes have risen in India, as in the United States, people have eaten fewer sweet potatoes. Accordingly, farmers have switched from sweet potatoes to grain. In India, the majority of sweet potatoes are eaten fresh. Indians roast, bake, or boil the root. Many Indians believe that sweet potatoes and milk are a healthy addition to the diet but that sweet potatoes alone are unwholesome. Stockmen feed the vast majority of sweet potato vines to animals, saving the rest for next year's planting. In Bihar, farmers rotate sweet potatoes with corn, wheat, and onions. In Orissa, sweet potato follows corn or rice. In West Bengal, farmers rotate moong, taro, and sweet potatoes. In Andhra Pradesh, sweet potatoes follow corn and precede vegetables. In Chhattigarh, Uttar Pradesh, and Maharashtra farmers rotate sweet potatoes with cowpeas.

South America

In South America, the sweet potato ranks third among tubers and roots, trailing cassava and potato. Between 2005 and 2007 Brazil, ranking first among South American countries, averaged hundreds of thousands of tons of sweet potatoes. Argentina ranked second, Peru third, and Paraguay fourth. Among South American nations, Brazil devotes the greatest acreage to sweet potatoes. Argentina ranks second, Paraguay third, and Peru fourth. Peru recorded the greatest yield. Guyana ranked last in yield per acre. In Guyana, farmers intercrop sweet potatoes with coffee, citrus, and avocado. Unlike much of the developing world, farmers in South America grew sweet potatoes for the market. In South America, most sweet potatoes are eaten fresh. Smaller amounts produce starch, flour, canned products, and chips. In 2007, South American farmers harvested millions of tons of sweet potatoes. South America yields half the New World's sweet potatoes. In South America, farmers favor the sweet potato because it requires little labor or cost, yields well in infertile soils, and tolerates heat and drought. In the central coast of Peru, which has little ranchland, stockmen feed roots and vines to animals. In Argentina and Uruguay, manufacturers make sweet potatoes into sweets.

Brazil, Argentina, Peru, Paraguay, and Uruguay produce virtually all South America's sweet potatoes. In Argentina, Uruguay, and Chile the sweet potato ranks behind only the potato as a tuber or root crop. In Paraguay and Guyana, it trails only cassava. The continent's largest exporter, Brazil sends little of its crop to foreign buyers. In South America, per person consumption of sweet potato trails that of Asia, Africa, Oceania, and the Caribbean. Paraguay and Uruguay have the continent's highest per person consumption of sweet potato. In Paraguay, sweet potato rivals cassava as a staple. In Uruguay and Argentina, people eat sweet potatoes primarily during winter. Brazilians eat sweet potatoes when other crops fail. In the Yungas region of Peru, sweet potato rivals potato as a staple. People in the countryside eat more sweet potatoes than do urbanites.

Christopher Cumo

See also Yam

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Swiss Chard

Chard (*Beta vulgaris*), also known as Swiss chard, is a cool-season leafy vegetable, and is one of the cultivated descendants of the sea beet, *Beta vulgaris* ssp. *maritima*. The species name means "common beet." The subspecies name, *Beta vulgaris* ssp. *cicla,* means "chard." Other names include silver beet, perpetual spinach, spinach beet, crab beet, bright lights (due to Swiss chard's bright and vivid colors), seakale beet, and mangold. Although the leaves are eaten, it is in the same group and subfamily as beetroot (garden beet), which is usually grown for its edible roots. Seed catalogues of the 19th century used the word "Swiss" distinguish chard from French spinach varieties.

History

Chard may have been grown in the Hanging Gardens of Babylon, 604–562 BCE, near Baghdad. The Chinese grew Swiss chard in the seventh century BCE. The plant remains popular, particular as a winter crop in southern China. The Arabs used Swiss chard in several dishes, and the Spanish dish of chard leaves with nuts and raisins harkens back to its Moorish origins. The name chard derives from Latin and French for "thistle," even though it has no connection to a thistle. Swiss chard got its name from Swiss botanist W. D. J. Koch, who in the 19th century classified and named the vegetable in honor of his homeland—even though it originally hails from the Mediterranean region.

Swiss chards with broad stalks are recorded in 1596, and 17th-century English herbalist John Gerard grew a red-stemmed variety in England at the same time. John Evelyn, English scholar, connoisseur, bibliophile, and horticulturalist, called it "white beet" in 1699, but noted that it was called "chard" by the French. Chard continues to be popular among Mediterranean cooks, making its first appearance in English gardens and kitchens in 1620, when it was imported from Portugal. This white-rooted beet is cultivated for its leaves, which are put into soups, or used as spinach, and in France are often mixed with sorrel, to lessen their acidity. Swiss chard is also largely used as a decorative plant for its large handsome leaves, blood red or variegated in color. Its root, though containing almost as much sugar as the red garden beet, is not as visually appealing or tasty.

Types

There are three types of chard: white, colored, and perpetual. White-stemmed chard varieties have white stems, with green leaves, and tend to produce more leaves and to be more tolerant of both cold and heat than colored varieties. Varieties include Fordhook Giant, Lucullus, and Silverado. Colored-stemmed chard is favored as an ornamental. Tall pink- and red-stemmed varieties such as Pink Passion or Burgundy often grow quite tall and tend to be productive. Red varieties may bolt if planted too early. Varieties include Pink Passion, Burgundy, Orange Fantasia, Golden Sunrise, Bright Lights, and Rhubarb. Perpetual varieties produce more leaves with continual pruning. Popular in Europe, green perpetual chard bears greens with mild flavor over a long season. Varieties include Perpetual and Verde da Taglio.

Cultivation

Seeds propagate Swiss chard and are best sown in early spring when the ground is suitable for tilling. In home gardens, successive plantings may be made every 10 to 14 days until three or four plantings are in, to ensure a continuing supply of fresh tender beets. Seedlings need to be thinned, as the seed is actually a dried berry that contains two seeds per berry. The main crop, grown for processing or for fall and winter marketing, especially in cooler climates, should be planted in May or June. Seed is drilled at intervals of 1.5 to 2 inches in rows 12 to 15 inches apart, and covered about 0.5 inch deep. The beet ball (seed) varies in size and the seeds germinate irregularly, so that a uniform crop is difficult to attain. Screening the seeds enhances the chance of getting a more uniform crop. When the beets are large enough to eat as beet greens with the small beets attached, rows should be thinned so that the remaining plants stand about 6 to 8 inches apart. Shallow cultivation should be given to control the weeds. Most cultivation is done by hand weeding, hand cultivators, or small tractor cultivators, as the lateral roots are very shallow and are easily damaged. Beet seeds retain their viability for five to six years under average storage conditions. They should be treated to prevent damp-off and seed rot. Germination is best at 65°F to 75°F. Seed stalks are likely to be produced after temperatures of 40°F to 50°F for 15 days or longer. After a soil test, commercial fertilizers containing nitrogen, phosphorus, and potassium may be added. Fertilizer may also be added as green manures, crop residues, animal manure, and compost.

Folklore and Medicine

A decoction from the seeds is a folk remedy for intestinal cancer. Seeds boiled in water are reputed to cure genital tumors. The juice or other parts of the plant are claimed to cure tumors, leukemia, and other forms of cancer including cancers of the breast, esophagus, glands, head, intestines, leg, lip, lung, prostate, rectum, spleen, stomach, and uterus. South Africans use Swiss chard to treat hemorrhoids. Swiss chard juice has been applied to ulcers. Leaves and roots are thought to stimulate blood flow in the pelvis and uterus; some stimulate menstruation.

The leaves may be effective against feline ascariasis (roundworms). In the past, beet juice was a treatment for anemia and yellow jaundice, and was put into the nostrils to purge the head, clear ringing ears, and soothe toothache. Beet juice in vinegar was said to eliminate dandruff and was recommended to prevent hair loss. Juice from the white beet was said to clear obstructions of the liver and spleen. English herbalist Nicholas Culpeper claimed Swiss chard effective against headache and vertigo as well as “affections of the brain” in 1653.

Chard is grown for its leaves, which have thick and fleshy midribs that are used as a vegetable. Some cultivars are also grown ornamentally for their colored midribs. The thickened midribs are thought to have arisen from the spinach beet by mutation. Swiss chard is a cool-season vegetable of the goosefoot family and is closely related to beets and spinach. Swiss chard is actually a beet that has been bred for its leafy greens instead of a swollen root. The stems and midribs come in a variety of different colors including pink, yellow, and orange. Swiss chard has appreciable quantities of beta carotene, vitamins K and C, protein, and fiber.

Deb Carlton

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Sycamore (American Sycamore)

The tree known as the American sycamore, American plane, Occidental plane, and the Buttonwood is a deciduous hardwood tree that grows in the eastern parts of North America. It was classified by Swedish naturalist Carl Linnaeus as *Platanus occidentalis*. Although it is similarly named, this tree is not related to the other trees also known as sycamores and grouped in the genera *Acer* and *Ficus*.

Description

The American sycamore is a tall, fast-growing tree. It can grow to be 500 years old, although a hollowing effect begins inside the trunks after about 200 to 300 years. The tree ranges from about 60 feet to 130 feet in height, and its straight trunk is about 4 feet in diameter, making it the American hardwood tree with the largest diameter. Its shape is pyramidal while young and then takes on a rounded shape with a spreading crown as it matures. The branches of the American sycamore are large, crooked, and widely spread, and they begin to droop as the tree ages. The branches produce thin, green, jagged twigs. The bark of the American sycamore is smooth and pale and flakes off in patches of various sizes, revealing a lighter, splotchy bark of brown, gray, and green beneath. The coarse leaves of the American sycamore are about four inches to eight-and-one-half inches wide. They contain three to five lobes with ridges along the edges. When young, the palmate leaves are felted on both sides, but as the leaves age the felt is limited to the veins on the underside of the leaf.

The American sycamore's tiny flowers, which change from green to red and appear in May, are clustered together. The dry, round fruit of the American sycamore is small at about one inch in size. The brown fruit tends to grow singularly while hanging on a stalk. Some of the seedballs, which are sometimes called buttonballs, stay on the tree throughout winter, while others fall to the ground. Inside each ball are tightly packed, fuzzy seeds known as achenes. The seeds are disseminated at irregular intervals from the late fall to May and are dispersed by the wind and can travel on water. They are also dispersed through the feces of birds and small animals that eat the seeds.

The younger, softer sapwood of *Platanus occidentalis* is white to light yellow in color and can sometimes reach a pink hue. The inner heartwood of the tree is a dark brown or reddish brown.

Habitat

American sycamores typically grow in forests and prefer the moist soil around water sources, such as ponds, swamps, lakes, and streams. They can be planted in areas where space is sufficient and are used as landscaping in yards and along highways and city streets. They are popular as a shade tree.

The natural range of the sycamore is from Maine south to the northern Florida border and from the lower Midwest east to the Atlantic coast. It grows well on flat land and can be found in elevations up to 2,500 feet in the southern Appalachian Mountain range.

A Functional Tree

As American sycamores age, they tend to become hollow, which makes a good nesting spot for animals such as raccoons, and birds like the barred owl and pileated woodpecker.

American sycamore is a durable wood. It is used in homes for flooring and other often-used surfaces, such as cutting blocks and cabinets. Sycamore wood is a common type used in the production of musical instruments and food containers, and in the past it was manufactured into barber poles and washing machines.

The American Sycamore History

The Native Americans used the barks and leaves of the sycamore for numerous medicinal purposes, including as a cold and cough remedy, as a dermatological aid, and for the treatment of respiratory, gastrointestinal, and gynecological ailments. They also hollowed out the trunks to use as canoes. The Cherokee in particular have a spiritual connection to the tree, believing that the first fire came to Earth when lightning struck a sycamore. European settlers made use of the sycamore's ability to grow quickly and produce a strong wood, which they used as wagon wheels, crates, boxes, and chopping blocks. The wood was manufactured into buttons, a practice that gave *Platanus occidentalis* its appellation as the Buttonwood. It also lent its name to an historical accord known as the Buttonwood Agreement, which laid out the terms of the founding of the New York Stock Exchange and was signed under a Buttonwood tree on Wall Street.

Over the years, the sycamore has come to represent protection, divinity, eternal life, and strength. A sycamore that shielded both General George Washington and the French Marquis de Lafayette during the Revolutionary War still stands in Brandywine Battlefield Park in Pennsylvania. It is now known as the Lafayette Sycamore in honor of the French nobleman who came to the aid of the colonists in their fight for independence. In later years, the sycamore still symbolized protection when a jagged stump of one was discovered in front of the intact Trinity Church chapel after the bombing of New York's World Trade Center on September 11, 2001.

The tree also has been a part of less-heroic historical events. For one, in colonial times men would cram themselves into sycamore trunks as a stunt, and some hollowed-out trees with extraordinarily expansive trunks have been used as temporary homes.

Because of their size, shade capacity, and appearance, sycamore trees were planted in New York City's Central Park by designer Frederick Law Olmsted, some of which survive to the present day. Philadelphia also planted the tree.

The Sycamore's Enemies

The leaves of the sycamore are food for numerous insects; however, none causes significant damage. Lace bug infestations can be a problem in the fall, and the infestations by the insects can cause leaf drop. The tree is a victim of several diseases, particularly anthracnose, which can form in wet, cool springs. Anthracnose causes defoliation and is a reason the tree must be uprooted from city landscapes annually. *Diplodia theobromae* and *Ceratocystis fimbriata* produce dieback and canker, which can reduce the growth rate of the tree as well as diminish the wood's quality and possibly kill the specimen. Bacterial leaf scorch is another infectious disease that can kill American sycamores. Forest fires also pose a problem for sycamores, but the wet bottomlands that sycamores prefer often make them less susceptible to fire danger than those growing in upland forests.

Sycamores can be a threat as well. Because they grow rapidly and large, they can pose a problem to concrete sidewalks and sewer drains, which they can clog. Their broad leaves and seed balls also can be a hazard to high-traffic areas.

Rosemarie Boucher Leenerts

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Tansy

Tansy is a robust, scented perennial herb with a long history as a cultivated plant. It has dark-green, deeply cleft, and pinnatifid fern-like leaves and characteristic yellow, button-like flower heads. It flowers in July and August. The stem is stout and grows from 20 to 60 inches tall. It is native to temperate Europe. Through cultivation, this hardy plant has become widespread, and its distribution as a naturalized plant now covers a large part of Eurasia, including distant places such as Iceland and the Faroe Islands to where it was once brought as a cultivated medicinal plant. It seems to be absent from the southern Balkans and some of the Mediterranean islands. It is also established in North America, where it is sometimes regarded as an invasive, even noxious weed. The species is very drought tolerate. Tansy is easily grown. It prefers full sun and dry soil.

Tansy was widely cultivated in Europe and North America until the early 20th century, especially for use as a medicine and a repellent, but also as an ornamental plant, in rural gardens. As an ornamental plant, it still grows not only in Europe and North America but also in South African gardens. An old garden cultivar, which is very much connected with rustic gardens, tansy is sometimes called curled tansy, parsley fern, or scented fern in English, and is known as *Tanacetum vulgare* var. *crispum*. It has typically bright green, finely cut, feathery leaves. Scientists do not know how old this cultivar is, but it is mentioned in a Swedish source from the 1640s. The variety is mentioned by Philip Miller, head gardener at the Chelsea Physic Garden, in his *The Gardeners Dictionary* as "curled or double tansy" in 1731. Several British botanical reference books mention curled tansy as a common garden plant in the early 19th century. In Swedish, it is known as *gubbskägg* ("old man's beard") or nowadays more commonly as *munkrenfana* ("monk's tancy"). This cultural variety is regarded as less invasive than the typical species. Its ornamental foliage makes it more popular as a garden plant in Northern Europe, the British Isles, and North America. A more recent golden-leaved form available in nurseries in Europe and North America is the gold leaf tansy "isla gold."

Cultural History

This old-fashioned strong-smelling plant, nowadays also known as "golden buttons" in English, has a long cultural history, although it is uncertain if it was grown by the ancient Greeks or Romans. However, tansy was known to the

Germanic tribes in the early Middle Ages as a garden plant, and it is mentioned as tanazitam in Emperor Charlemagne's edict *Capitulare de villis vel curtis imperii* of around 812. About this time, tansy was among the plants grown in the herbal garden of the Benedictine monastery in Saint Gall, Switzerland. It was known as *reinefane* by the German Benedictine abbess Hildegard of Bingen in 1160. Tansy has been grown mostly as a medicinal (vermifuge, emmenagouge, stimulant) and ornamental plant in Europe but has other virtues. Especially the crispy variety has been a typical plant in rustic gardens in Northern Europe and Scandinavia until recently.

Settlers in North America used tansy as a medicinal plant. It is known that John Winthrop the Younger, who later became governor of Connecticut, transferred seeds of the species to the Plymouth colony in 1631, and it is mentioned as flourishing in East Coast gardens by English traveler John Josselyn in his *New-England Rarities* (1672).

It has escaped and become naturalized in roadsides and waste places in many parts of the world, including Australia, New Zealand, and North America. Many of its Germanic names refer to its preference for roadsides, like German *rainfarn*, Swedish *renfana* (known since 1538), Danish *rejnfan* (known since 1633), and Icelandic *reinfáni*. It is regarded as a nuisance weed in some areas.

Repellent and Insecticide

Tansy has a long reputation as a remedy to expel intestinal worms. According to physician Thomas Cogan of Manchester in 1584, there was a good cause for eating tansy with fried eggs at Easter, since it purged the phlegm "engendered of fish in the Lent season" and killed the worms to which this phlegm gave rise. From the Faroese folk medicine, it is said that the flower buds could be chewed or swallowed in whole pieces or an infusion of water could be drunk. Some boiled the buds in milk and drank it to rid themselves of worms. Old German and Italian names for the plant are *wurmkraut* (mentioned by German physician Leonhart Fuchs in 1542) and *erba vermicolare* ("worm herb"), respectively. Tansy tea is still available in herbal stores and is recommended for various purposes, especially for treating pinworm.

Tansy has also been widely used as a repellent in Great Britain and Scandinavia to keep away various insects and mice. From Great Britain, it is recorded that bunches of the plant were placed at windows in order to keep away flies. At the end of the 19th century, the Scandinavian peasantry used it to repel moths from their clothes chests. It is still used in Australian gardens to keep away ants. Some recommend it as well suited to interplanting with potatoes because of its pest-repellent properties. It is, for instance, planted alongside potatoes in order to repel the Colorado potato bug, obviously with some success.

It has been investigated in order to be used to repel ticks. Some people once deterred fleas by rubbing the fresh leaves into a pet's coat. Tansy has commercial potential as a cultivated plant, and powder of the plant is still sold on the market as insecticide. The plant itself is still sometimes used in landscaping because of its insect-repellent qualities.

Medicinal Uses

Tansy has a long history as a medical plant. The characteristic camphoraceous odor that the species emits has drawn the interest of physicians and healers. Its use as a medicinal plant is mentioned in numerous medicinal works and herbals from medieval times onward. In 1533, Danish canon Christian Pedersen recommended it as a remedy for malaria. Wine flavored with the buds has been used as children's medicine.

However, it was regarded as obsolete in scholarly medicine in the 19th century but has survived as folk medicine and house remedy in Europe. "Let those Women that desire Children love this Herb, it is their best Companion, their Husband excepted," wrote British botanist Nicholas Culpeper in 1653. "It is also very profitable to dissolve and expel wind in the stomach, belly, or bowels, to procure women's courses," he continued. More recent records from Cambridgeshire in England urge married couples eager to have children to eat salads containing tansy. In Norway and Great Britain, it has been used against hepatitis, probably according to the archaic Doctrine of Signature because of its yellow flower buds. Danes used to gather tansy for medicinal purposes on Saint Bartholomaeus day (August 24). From Belarus, it is reported that frightened children were bathed in a solution with tansy.

As Swedish naturalist Carl Linnaeus observed in Lappland in 1732, tansy promotes menstruation. This is also known in the Turkish countryside. Also, some Native American tribes seem to have appreciated the medicinal virtues of tansy. Cherokee women wore the plant around the waist and in their shoes to prevent miscarriages and abortions.

Other Use

The buds and the green parts of tansy have been used to flavor spirits. It has also been used together with hops when brewing beer, for instance in Denmark. Among rural people in certain parts of Scandinavia and in North America, tansy was long used for preparing corpses for burial.

Dried plants have an ornamental value and are still used in floral arrangements. The buds as well as the leaves, which contain flavonoids, have been used as dye. They impart a yellow or green color to wool. Tansy puddings, made of tansy leaves, eggs, milk, and flour, have been eaten on Palm Sunday and Easter in Great Britain. According to a British encyclopedia from 1816, food flavored with tansy is good for warming and strengthening the stomach. The leaves have a slightly bitter flavor, though tansy has been used as a spice in Irish sausage. Leaves of the curly variant are still sometimes employed for garnishing dishes.

Ingvar Svanberg

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Taro

Taro, *Colocasia esculenta*, of the Araceae family, has a long history, especially in tropical regions where it is propagated widely. Native people recognized its value early on for many uses in daily life. Out of necessity, they learned to grow it successfully. Today, approximately 10 percent of the world's population depends on the plant as a major food source. Taro is closely associated with Hawaiian culture but is well known in most Pacific countries, including tropical Africa, India, Polynesia, China, and Japan. In fact, it is most likely one of the oldest cultivated plants. At one time there were over 300 varieties in Hawaii alone due to popularity and demand. Today, the main differences in cultivars are the color or shape of the leaves and stems and slight differences in root types. Some varieties have large, one- to three-yard leaves referred to by landscapers as "elephant ears." They are primarily ornamentals. The true value of taro is a cultural one, for much of the entire plant is edible and its history consists of stories supporting its usefulness. It is grown successfully in the warm, humid conditions of the tropics as a semidry land cultivar with the aid of mulch and high moisture or, as a wetland plant, directly irrigated by moving water.

The Cultivation of Taro Passed from Country to Country as People Came to Depend on It as a Food

Taro is considered one of the first truly cultivated plants. Natives, originating most likely from Malaysia, learned to dig and harvest most of the root (corm), which can grow up to a foot long. They then learned to replant the shoot end so that in approximately 10 months they could return and harvest the corm again. From Malaysia, the plant was brought to India, Egypt, and Greece. Due to its popularity and ease of cultivation, it was also distributed toward the other direction, to Indonesia and China. One of the common names for taro is *dasheen*, which probably comes from the word *de Chine*, meaning "China" in French. This is thought to be where its use as a food and information about its cultivation were first documented. Polynesians introduced the plant to Polynesia and New Zealand and then onward to the Hawaiian Islands by 450 CE, where it is still known today as *kalo*.

In Antiquity, Hawaiians Placed the Value of Taro above Man, and Today, Taro Remains a Central Part of Hawaiian Culture

In Hawaiian stories, taro was said to be the product of the union between mother Earth and father sky. The child was stillborn and out of its body grew the *kalo* (taro) plant. It was also known as *haloa*, which means "everlasting breath." Because of this rich cultural history and the people's dependence on it as a food, it was considered *the* most important food source. It is said that when British Captain James Cook arrived at the Hawaiian Islands in 1778, he found the local population living mostly on taro and sweet potatoes, supplemented by food from the sea, such as seaweed and fish. In fact, Hawaiians often referred to taro simply as *ai*, the word for "food." The ritual of eating the sticky paste made from taro, *poi*, in a circle with elders and other members of the community, continues to be an important way that Hawaiians pass their stories from one generation to another. This ritual is called the *lu'au*, the name also given to the taro leaf, and includes many other aspects of Hawaiian life and history. Tourists are encouraged to experience a *lu'au* to learn more about Hawaiian culture, to speak with local farmers about the lore, and to gather tips for cultivating various cultivars of taro.

Taro Has a Lot to Offer as a Food Source

Through the ages, taro is beloved because in the Southern Hemisphere it grows well, is easily propagated, and in addition to being almost entirely edible, has been found to have many medicinal and decorative uses. Taro is well known as the plant with the root that is made into the thick mash called *poi*. *Poi* is made by skinning and pounding the taro corm into a thick paste. Locals know which cultivar's roots have the degree of glutinosity to make the best *poi* and which variety grows most successfully in its environment. Once mashed, *poi* is dried, diluted with water, kneaded, and eaten fresh or aged. In some cultures, *poi* is fermented to add a distinctively sour, but not alcoholic, flavor. Alternatively, the root can be baked, steamed, or boiled, depending on preference and the variety of taro. These plants are distinguished from each other not only by the quality of the *poi* but also by the flavor of the corm and leaves. The leaves, desirable in their own right, are steamed and eaten as a vegetable similar to spinach or other greens.

In fact, taro would be considered the perfect edible plant except that, because of a certain amount of toxicity, it must be fully cooked before it is eaten. The cellular structure of the root, stem, and leaves contains microscopic needle-like crystals of calcium oxalate, which is known to contribute to kidney stones. When taro is eaten raw, people experience a burning sensation in the lining of their mouth and throat. It is not known whether this is due to the calcium oxalate or to other chemicals that irritate the tissue in conjunction with the crystals. The leaves must be boiled at least 45 minutes and the root for over an hour until soft. Cooking taro destroys the toxins but unfortunately also removes some vitamins and other nutrients. Slow cooking, or steaming under pressure, can help preserve them. Nevertheless, taro is a good source of carbohydrates, calcium, and iron. It is digested easily and is often used as an additive in the form of taro flour and given to babies and people with allergies. Taro is also an excellent source of vitamins A, B complex, and C, as well as phosphorus, thiamine, and riboflavin.

Taro Has Been Used Medicinally and Has Also Contributed to Cultural Art

It is not surprising that people use what they have on hand to treat various ailments. The boiled parts of taro, since edible, were not harmful and were often used alone and in conjunction with other plants medicinally. Sometimes parts of the plant were applied raw. As a paste, *poi* was often useful as a poultice on infected sores, or mixed with salt, applied to an injury, and wrapped with a taro leaf. *Poi* was also eaten to settle the stomach or mixed with arrowroot starch as a treatment for diarrhea. A slice of taro stem could be rubbed on cuts to stop bleeding and on insect bites to diminish itching and pain. It is difficult to say whether the popularity of taro stemmed more from its edibility, from its ease of propagation, or from these additional uses, but taro definitely had an important place in the history of tropical people.

One might not be surprised, then, that the people, perhaps in showing a sense of gratitude, used taro in some forms of cultural art. Or, possibly, taro was used simply because it was common and available. The Polynesians who settled in Hawaii brought, along with taro, shoots and roots of the paper mulberry tree known as *wauke*. This is the principal plant that was used to make *kapa*, or *tapa*, cloth. *Kapa* means "beaten" and was made from the inner bark of the *wauke* tree. Because it also thrives in warm, moist conditions, *wauke* was often cultivated near the field ponds of taro. The rich, dark mud of the taro pond yielded a black dye, and the *kapa* cloth would be laid in the mud to color it black. Some cultivars of taro produced a red dye from the stems. They could be used to apply geometric patterns using the carved stem as a stamp. Diluted *poi* was even used to glue pieces of the beaten fabric together. Because at the time these people had no other source of fiber to make fabric, *kapa* cloth was used in most aspects of life, from everyday needs to burial and other ceremonial rituals.

Growth Conditions and Pests and Diseases

Challenges are plentiful when a community is dependent upon a specific agricultural product. There are diseases and pests, adapted to the same environment, that diminish the propagation and yield of taro. While there is limited information about the relative resistance of different taro cultivars, the effect on economic outcome is motivation to justify research into discovering potential resistance. Similarly, research into the causes of diseases is justifiable. Those diseases that affect the corm are especially detrimental. In addition to ruining the prominent product of the crop, root problems seriously affect plant health.

In moist growing conditions, fungal infections are a constant threat. *Pythium* "soft rot" is an especially serious fungal disease that causes the corm to turn into a soft, smelly, rotten mass. The leaves turn yellow, crinkled, and spotted, and the plant is essentially useless. This problem is especially a concern in acidic, low-calcium soils, suggesting that soil amendment might be part of the solution. Taro pocket rot results in small to medium-size holes in the corm as a result of *Phytophythora* infection. Research has shown that spores of *Phytophythora* survive a long time in the taro field and, in fact, can accumulate over time. Scientists recommend that farmers fallow, or not seed, some of their fields for a season in order to reduce the likelihood of some of the spores surviving. Other fungal diseases cause more minimal but unsightly problems such as leaf blight and stunted growth. Clearly, while much has been learned, it is important that farmers continue to strive to determine the best conditions for growing taro.

In addition to problems caused by fungi, other pests affect taro both directly and indirectly. For example, the dasheen mosaic potyvirus is transmitted when aphids are attracted to the plant. The virus causes an unattractive pattern to form on the leaves, but the corm is not affected and the aphids do not appear to do much harm. However, root aphids, *Patchellia reaumuri*, have a serious effect directly on the developing roots of dryland taro. They consume the corm until the plant eventually dies. Another pest, the apple snail, was brought from South America by the aquarium trade. Believing the snail to be popular with hobbyists, it was introduced to wetland taro ponds in order to supplement the income of farmers. Unfortunately, the apple snail population did quite well and has flourished by decimating all parts of the taro plant. Efforts are now under way to find a method to eradicate the apple snail population from the taro fields.

From Past to Present, Taro Represents Cultivation at Its Finest

Hundreds of years have passed since taro was first recognized as a useful plant, completely edible once its toxicity was neutralized. Native people were quick to take the initiative to learn to grow this plant efficiently. It was not long before it was introduced to countries throughout the Southern Hemisphere far from its source. Stories and documentation have shown that people of many different cultures chose cultivars based on how well they grew or tasted under various environmental conditions. Modern-day farmers have learned to increase the yield of their crop by understanding and counteracting pests and diseases that harm the plant. Current growing methods are much different from those present when the plant was first discovered and cultivated. Modern technology and knowledge have even permitted taro to be introduced to the Northern Hemisphere for use as an ornamental. It is likely that its cultivation will continue to be refined for many years to come.

Gwendolyn Vesenka

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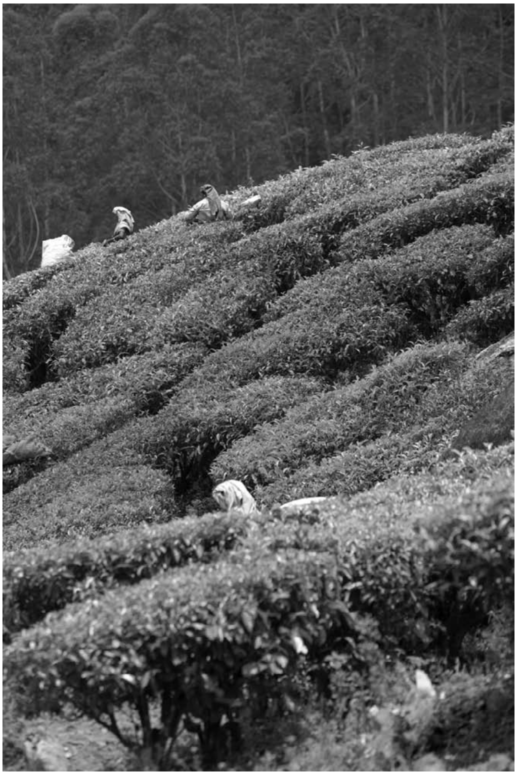
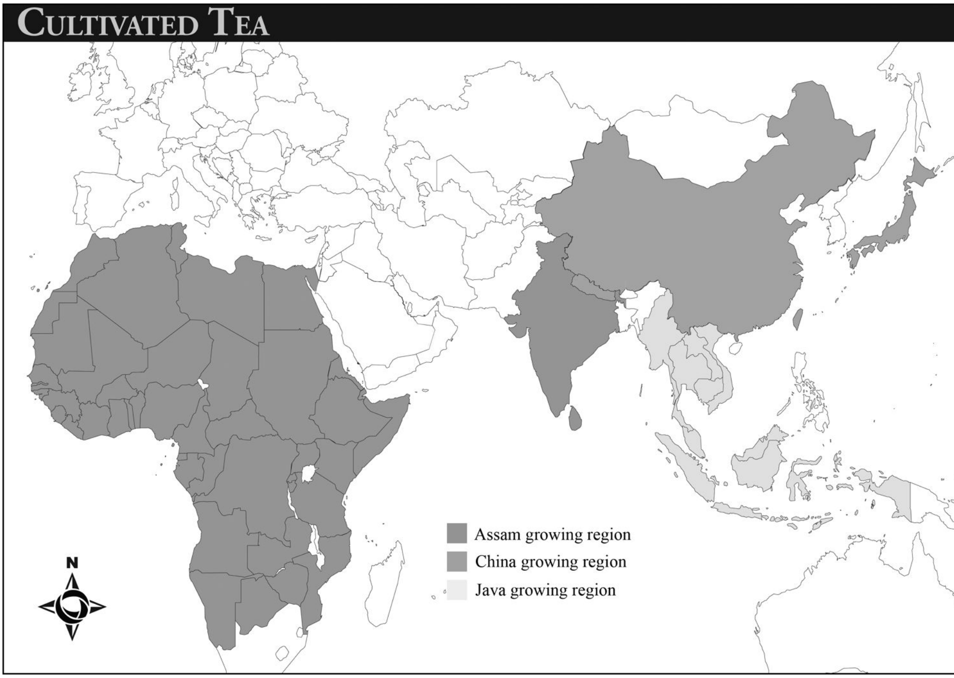
Tea

A perennial tree, tea is an ancient plant. *Homo erectus*, the forbearer of modern humans, may have encountered tea in Asia 500,000 years ago. Like several other crops, tea is grown in developing countries for consumption in the developed world. Tea is adapted to a range of climates and may be grown in the tropics and in temperate locales. Known by many names, tea is *te* in Catalan, Latvian, Malay, Norwegian, Danish, Hebrew, Italian, Spanish, and Swedish; *tee* in Afrikaans, Finnish, German, and Korean; *the* in French, Icelandic, Indonesian, and Tamil; *thee* in Dutch; *cha* in Greek, Hindi, Japanese, Persian, and Portuguese; *chai* in Russian; *chey* in Albanian, Arabic, Bulgarian, Croatian, Czech, Serbian, and Turkish; and "tea" in English and Hungarian. In the parlance of science, Swedish naturalist Carl Linneaus placed tea in the genus *Thea* in 1753, though second thoughts led him to assign it instead to the genus *Camellia*. In 1905, the International Code of Botanical Nomenclature named cultivated tea



Tea plants (iStockPhoto)



An illustration of Assam, China, and Java tea-growing regions. (ABC-CLIO)

Camellia sinensis, an appellation it retains today. Linneaus believed that there were two species of tea, one that yielded green tea and the other black tea. This is incorrect. The method of preparation yields either green or black tea. British adventurer Robert Fortune, visiting China in disguise in the 19th century, learned that only one species of tea is capable of producing green or black tea.

The Basics

The genus *Camellia* encompasses 82 species, but humans have domesticated only *Camellia sinensis*. A variable species, it tolerates temperatures between 21°F and 95°F, rainfall between 40 and 200 inches, and day length between 9 and 15 hours. Cultivated in Argentina as far south as 27° latitude and in Georgia as far as 43°, tea is adapted to range of altitudes, growing from sea level to 10,000 feet. Above the tropics or at altitude, tea trees are dormant 90 to 180 days during winter. Perhaps unique among trees, tea is harvested for its leaves rather than its fruit, timber, or secretions. In the tropics, tea grows year-round and may be harvested many times. Workers harvest tea throughout the year in East Africa, southern India, and Indonesia and for 150 to 270 days per year in Argentina, the Caucasus, China, Japan, Kazakhstan, northern India, and Tadzhikistan.

Tea converts 7 percent of sunlight into biomass, of which 10 percent is leaves. Needing acidic soils, tea prefers a soil pH between 4.5 and 5, though some varieties tolerate slightly less acidity, favoring a pH between 6 and 6.5. Tea needs soils rich in silicon and aluminum. Indeed, an average tea tree is 1.7 percent aluminum, though this metal's role in physiology is little understood. Tea tolerates soils with a low concentration of calcium. Adapted to a range of soils, farmers grow tea on alluvial soil in Assam, India, and Malawi; peat in Cachar, India; red soil in Dooars, India, and China; sedimentary soil in Darjeeling, India; lateritic soil in southern India, Sri Lanka, and parts of East Africa; volcanic soil in Kenya, Tanzania, and Japan; podzol in the Caucasus; andosol in Indonesia; and yellow soil in Taiwan. Where the soil is deficient, farmers supply tea with nitrogen and sulfur. Long lived, a tea tree will yield leaves for 50 years, though some trees are thought to be centuries old. In the first years of cultivation, a farmers needs another source of income because a tea seedling requires three years to mature.

Cultivated tea is of three classes. The China bush grows at 6,500 to 9,800 feet, where the climate is comparatively cool. It will tolerate a light frost and is adapted to a short growing season. Harvested four to five times per year, the China bush grows 3 to 10 feet tall. Its leaf produces high-quality green tea. Farmers grow the China bush in China, Japan, Taiwan, parts of Southeast Asia, and the Himalayas. The China bush grows on the northern and southern fringes of the subtropics. It is pruned and fertilized, if at all, after the last harvest and before frost. Between March and May, the China bush resumes growth in the Northern Hemisphere and between September and November in the Southern Hemisphere. The first harvest of spring is usually of the highest quality. Named for a region in northeastern India, the Assam bush grows in rich loams that are light, well drained, and acidic. An indigene of the tropics, it prefers temperatures of 85°F, high humidity, and 100 inches of rain per year. The Assam bush can grow above 6,500 feet, but only where the climate is warm. Workers prune the bush; otherwise it would grow to 50 feet. Leaves resemble those of the orange tree, though tea and oranges are not closely related. A prolific tree, workers harvest leaves every 10 days throughout the year. The Assam bush produces the black tea of northeastern India, Sri Lanka, and Africa. The bush also produces white tea. Tolerant of heat, the bush cannot endure cold weather or frost. Needing high humidity and heat, the Java bush is adapted to a tropical climate. It derives its name from the fact that the Dutch planted it on Java. Closely related to the Assam bush, the Java bush is grown in Southeast Asia, especially in Indonesia. Connoisseurs judge Java tea to be of low quality. Accordingly, the demand for export is weak and most Java tea is consumed locally. Both Assam and Java bushes prefer humidity in the form of morning fog with the sky giving way to sunshine in the afternoon.

Origin and Diffusion in Asia

Tea may have originated in Southeast Asia, where most of the 82 extant species reside. Alternatively, tea may have arisen in Central Asia or in the land that is the border between India and China. Some varieties of tea may have originated in southern China, Indonesia, and Assam. According to one authority, tea may have originated in the region where southwestern China, Myanmar, and Laos meet. Wild tea still grows in Yunnan, China. Tea must have been among the earliest plants to elicit the curiosity of humans if the conjecture is correct that *Homo erectus* came across tea in what is today Yunnan, China. *Homo erectus* mastered fire and may have been adept at boiling water. Into this water, he may have placed tea leaves, consuming the beverage, perhaps for its caffeine. One account of the origin of tea concerns Emperor Shen Nung, who ruled China between 2737 and 2697 BCE. Boiling water, Nung used the branches from a tea tree to stoke the fire. By chance, a gust of wind blew a tea leaf into the water. Nung tasted the brew, finding it flavorful. Committing this discovery to paper, he wrote the *Pen Ts'ao*, a book on medicinal herbs in which Nung extolled tea. He supposedly wrote that tea "quenches the thirst, lessens the desire for sleep and gladdens and cheers the heart." Yet the earliest edition of the *Pen Ts'ao* dates to the first century CE, long after Nung had died. Moreover, this edition is silent about tea. Only in the seventh century did someone add a reference to tea. According to one legend, tea originated in a gruesome way. In 520 CE the monk Bodhidharma, traveling from India to China, sought refuge in a cave, where he vowed to stay awake in mediation for nine years. Despite his resolve, he fell asleep. When he awoke, Bodhidharma was so angry with himself that he cut off his eyelids and cast them to the ground. From this spot grew the first tea tree. Thereafter monks have consumed tea to stay awake so that they would not suffer Bodhidharma's fate. This story explains why tea leaves are shaped like eyelids.

The accounts of *Homo erectus*, Shen Nung, and Bodhidharma seem fanciful because humans did not first drink tea. Instead, they consumed tea leaves as food. In prehistory, people consumed tea leaves in Assam, Yunnan, northern Myanmar, Laos, Vietnam, and Thailand. People chewed tea leaves for energy and rubbed them on wounds. The Chinese ate tea leaves chopped with shallot and ginger. The Thai boiled leaves, rolled them into balls, and ate them with salt, oil, garlic, and fish. The people of Myanmar have long eaten pickled tea leaves as a salad. The first people to drink tea may have been Buddhist and Taoist monks who drank it while meditating. They found, as Shen Nung was to have recorded, that tea, because of its caffeine, lessened fatigue and increased concentration. Lao-tzu, the founder of Taoism, was a tea drinker.

The book *Working Rules of Servants*, dating to the first century BCE, gave advice on buying and preparing tea. By this time, tea was a popular beverage in China. By the fourth century CE, the demand for tea outstripped the harvest of wild tea. The Chinese responded by cultivating tea, perhaps for the first time in history. By the seventh century, tea had become China's national drink. So popular was it that in some districts the Chinese used tea as money. In turn, the merchants who traded tea invented paper currency for this purpose. The Chinese emperors understood that tea generated wealth, and in 780 CE the emperor first taxed tea. Also, in 780 poet Lu Yu wrote *The Classic of Tea* in which he described the culture and preparation of tea. Yu made tea synonymous with refinement and sophistication. The Mongol conquest of China marked a setback for tea. Unfamiliar with the drink, the Mongols had a low opinion of its. So unimportant was tea during the Mongol reign that Italian adventurer Marco Polo, visiting China, was unaware of its cultivation. The expulsion of the Mongols returned tea to prominence.

At first, the Chinese dried and charred tea leaves. Between the third and sixth centuries CE, the Chinese steamed leaves, after which they dried and compressed them into small cakes. Tea makers then baked the cakes to keep them from spoiling. Drinkers took chips from these cakes, boiling them in water. According to one Chinese writer, tea drinkers took the beverage with onions and ginger. In 641 CE Chinese princess Wen Cheng, marrying Tibet's king Songtsan Gambo, introduced tea to Tibet. China exported tea to Tibet in exchange for horses, which the cavalry used.

In the Song dynasty (960–1279), people added plum juice to tea to sweeten it. During these centuries, tea in the form of powder replaced tea cakes. The teahouse became common during this time. It offered a forum for social and economic interaction. People cemented business alliances, listened to poetry, and gossiped at the teahouse. During the Ming dynasty (1368–1644) the Chinese learned to oxidize tea leaves, creating black tea, though many people regarded it as inferior to green tea. Imperial China controlled every facet of the tea harvest, assigning the work to young women, who wore their names on their jackets so that officials could measure each girl's production. Officials required harvesters to grow long fingernails because only the nail and not the skin could touch a tea leaf. One emperor decreed that only virgins were pure enough to harvest tea. Careful not to pull a leaf from a tree, they used golden scissors to cut off each leaf.

Tea was also a coveted beverage in Japan. According to one story, a Japanese priest who had lived in China returned to Japan with tea in 815 CE. Legend holds that when shogun Minamato Sametomo fell ill in 1191, Buddhist monk Myoan Eisai cured him with tea. Sametomo credited his recovery to tea and became its advocate. This tradition holds that Eisai planted tea seedlings on the island of Kyushu.

A Global Crop

Europeans came to know tea only in the Renaissance. To be sure the Turks had imported tea as early as 479 CE. Since the 15th century, tea has been a popular beverage in Egypt, but Europeans apparently did not learn about these developments. We have seen that Marco Polo did not learn about tea in his trip to China. Only in the 1550s did tea come to the attention of Europeans. In 1559, Gaimbattista Ramusio, secretary to Venice's Council of Ten, wrote *Voyages and Travels*, the first European account of tea. In 1606, the Dutch began importing tea from China to the Netherlands. In 1618, Chinese ambassadors gave Russian Czar Alexis several chests of tea. Thereafter China began to export tea to Russia. By 1635, the Dutch were supplying tea to London and Paris in addition to Amsterdam. In 1650, the Dutch exported tea to Germany, in 1672 to New York City, in 1982 to Philadelphia, and in 1723 to Scandinavia. In 1878, the Dutch transplanted tea trees from Assam to Java. Dutch merchants favored black tea because it survived the ocean crossing without rotting. The Dutch took their tea with milk because they supposed that the Chinese emperor did the same. The French nobility likewise took tea with milk. As early as 1660, the British added milk to tea in the belief that this concoction prevented tuberculosis. Later, the British imbibed tea with cream and sugar. One British observer remarked in the early 19th century that tea and sugar were cheaper than beer.

Yet in the 17th century, tea was more expensive than coffee and so was not consumed in bulk. Rather, tea was a luxury and a medicine. Among the nobility Catherine of Braganza, wife of England's King Charles II, popularized tea. She made tea fashionable for the aristocracy. Tea was not then a beverage of commoners. In the 1660s, the East India Company began importing tea to England. In 1669, Indonesia became a source of English tea. In 1699, Britain England 6 tons of tea per year, though the fact that tea was five times more expensive than coffee held down imports. In the early 18th century, the East India Company began importing tea from China, and as imports grew the price of tea fell. In the 18th century, tea prices declined 20 times, and tea replaced coffee as the national beverage. By 1718, tea was Great Britain's chief import from China. By 1721 imports reached 5,000 tons per year. At the peak of the tea trade, tea totaled 60 percent of the East India Company's commerce. In 1799, Great Britain imported 11,000 tons of tea. In the 18th century, Great Britain's factory workers drank tea. Factory owners encourage this practice, giving their workers tea breaks. They understood that tea kept workers sharp as they performed long, monotonous tasks that were otherwise mind numbing. Eager to profit from tea's popularity Thomas Twining, owner of a London coffeehouse, opened a teashop in 1717, possibly Europe's first teahouse. In contrast to the men-only policy of coffeehouses, the teashop welcomed women. Eager consumers, women hosted tea parties, as did the Chinese and Japanese.

In the American colonies, tea intensified resentment against Great Britain. The mother country placed a duty on tea, reasoning that the money helped defray the cost of defending the colonies from the French and Indians. The colonists avoided this tax by smuggling tea from the Netherlands. Determined to stamp out smuggling, Parliament passed the Tea Act in 1773, granting the East India Company the exclusive right to import tea from China to the American colonies. Because the company priced tea below the price smugglers charged, Great Britain expected them to exit the tea trade. The colonists, enjoying low tea prices, would celebrate the Tea Act. Unfortunately for Great Britain, Parliament and the East India Company had miscalculated. Rather than gratitude, the colonists resented Great Britain's intrusion into their affairs. They expected that the East India Company, monopolizing the tea trade, would eventually raise prices. Stiffening their resolve, the colonists boycotted British tea and refused to pay taxes. Defying the company, the colonists refused to let its ships unload tea. As tensions mounted, a group of colonists dressed as Mohawk Indians boarded three company ships, dumping every chest of tea into Boston's harbor. In March 1774 Parliament retaliated, closing Boston's harbor until the colonists had repaid the company for its losses. Benjamin Franklin urged repayment but many other colonists took a hard line. The Tea Party was one of a series of events that led to the American Revolution.

Even though the American colonists turned against British tea, Great Britain had other buyers. So brisk was trade in the 18th century that Great Britain had trouble mining enough silver to buy tea from China. The solution lay in fueling China's opium habit. Growing opium in India, Great Britain traded it with China for tea. The fact that opium destroyed lives seems not to have troubled British and Chinese officials so long as it sustained the tea trade. While fostering this trade, Great Britain looked for an alternative to Chinese tea. Recognizing that India grew small amounts of tea, the British turned in the 1820s to raising tea in the subcontinent. In 1834, the British acquired more than 1,000 tea seeds from China, planting them in Calcutta. Initial results were not encouraging. The British attempted to transplant the China bush into an area that was too hot for it. Only when they used the native Assam bush did their fortunes change. Much of the credit for this insight goes to British official George Williamson, who in the early 19th century came to understand that tea cultivation would flourish in India only when the British used the native Assam bush. In 1838 the East India Company imported its first shipment of tea from India to the United Kingdom. The next year the company planted the Assam bush in Sri Lanka but, the island having been planted to coffee, tea made little headway until the 1860s, when the fungal disease coffee rust swept through the coffee estates. Facing ruination, many planters switched to tea, and in 1872 Sri Lanka exported its first shipment of tea to the United Kingdom. By the 1880s, tea had replaced coffee as the leading crop on Sri Lanka.

By the mid-19th century, India was at the center of a tea mania. Whereas in 1872 the cost of producing one ton of tea was the same in India and China, by 1913 the cost of producing tea in India had fallen 75 percent so that Indian tea cost roughly one-fourth the price of Chinese tea. This dynamic favored India at the expense of China. Whereas the United Kingdom imported 31,000 tons of tea from China in 1859, it imported only 7,000 tons from China in 1899. In 1669, the East

India Company imported 150 pounds of tea to the United Kingdom, in 1705 400 tons, in the 1850s 40,000 tons, and in 1899 100,000 tons of tea from India. Then the United Kingdom imported just 5 percent of its tea from China and much of the rest from India. In the 19th century, the Portuguese, Dutch, and British established tea estates in Africa. Since the 1880s, farmers have grown tea in Malawi. In 1903, the British introduced tea to Kenya and in the 1930s to Tanzania.

Grown in Africa, Asia, South America, and the Pacific, tea is more widely consumed than any other beverage except water. Today, India is the leading tea producer and consumer, China ranks second, and the United Kingdom third. England, Ireland, Australia, and New Zealand are among the leading consumers of tea (Tanui et al. 2012). The Koran's prohibition against alcohol has aided tea in becoming an important beverage in Islamic countries. In contrast, the United States, France, and Germany drink less tea and more coffee. Contrary to popular belief, Americans did not stop drinking tea because of the Tea Act. In the 1780s, tea remained the most popular beverage in America. In 1832, however, the U.S. Congress abolished the tariff on coffee, making it cheaper than tea. By 1850, coffee had surpassed tea in popularity in the United States. The trend in immigration contributed to tea's declining popularity. In the late 19th century, few immigrants came from the United Kingdom where the consumption of tea was a habit. Instead immigrants came from Southern and Eastern Europe, areas without a tradition of drinking tea.

Tea and Health

The Japanese shogun Minamato Sametomo credited tea with his recovery from illness. He must have had many believers because Asians had a long-standing conviction that tea improved health. As early as 780, poet Lu Yu asserted that tea could cure headache, pain throughout the body, constipation, and depression. The 12th-century Buddhist monk Myoan Eisai believed that tea stimulated appetite and prevented waterborne diseases, paralysis, and beriberi. Europeans were divided about tea. In the early 17th century, Italian writer Matteo Rici remarked that the Chinese lived long lives because they drank tea. In 1635, German physician Simon Pauli warned that tea was toxic to the body, but in 1641 Dutch physician Nikolas Dirx believed that tea promoted longevity and protected one from illness. Another Dutch physician was equally enthusiastic, recommending that people drink up to 50 cups of tea per day. (The 17th-century teacup was small.) Doubtless to the dismay of sugarcane planters, however, he warned against the ill effects of adding sugar to tea.

Tea may have improved the health of people in the early modern era. One account holds that after 1730 the incidence of dysentery diminished in Great Britain, and in 1796 one commentator remarked that waterborne diseases were rare in London. In the early 19th century, physicians attributed this improvement in public health to tea, which is an abiotic drink. The tannic acid in it kills the bacteria that cause cholera, typhoid, and dysentery, though it is also true that the boiling of water to make tea would have killed microbes. Because tea was free of pathogens, it was safer to drink than water or beer. Because tannic acid passes into breast milk, it may have protected infants from diseases and so lowered infant mortality. One writer believes tea increased longevity in early modern Europe and Asia. Because of tea's antimicrobial properties, one army physician urged solders in 1923 to fill their canteens with tea to prevent typhoid. By killing pathogens, tea reduced the incidence of diarrhea and lessened the rate of infection from influenza. Tea combated the growth of bacteria in the mouth and so improved oral health.

A tea leaf is 75–80 percent water and has no calories. The solid portion of a tea leaf contains amino acids, vitamin B2, vitamin K, vitamin D, and vitamin C. One gram of green tea has two milligrams of vitamin C, 10 times the amount of vitamin C in black tea. Tea has the minerals chromium, calcium, magnesium, manganese, iron, copper, zinc, molybdenum, phosphorus, strontium, cobalt, nickel, and potassium. Improving the function of the circulatory system, tea may protect one from cardiovascular disease. In one study, women who drank tea had only one-fourth the number of strokes than women who did not drink tea. Tea may also lower cholesterol and blood pressure. Increasing the amount of antioxidants in the body, tea may protect against cancer. Green tea has more antioxidants than black tea. In one study, tea-drinking women had one-third fewer cancers than women who did not drink tea. In a study of Iowa women, those who drank the most tea had 10 percent fewer cancers than non-tea drinkers. According to one study, Japanese women who drank 10 cups of tea per day had lower cholesterol than women who did not drink tea. Overall, the consumption of at least 2 cups of tea per day appears to lower the risk of getting cancer by 10 percent. Research suggests that tea may sharpen the mind, detoxify the body, strengthen the immune system, preserve the skin's elasticity, aid digestion, and lessen fatigue.

Christopher Cumo

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Teak

Teak is a type of large, hardwood, deciduous tree native to the tropical forests of southern and Southeast Asia, especially India, Laos, Malaysia, and Myanmar. In the 18th century, Swedish naturalist Carl Linnaeus named teak *Tectona grandis*. *Tectona grandis* belongs to the order Lamiales and the family Verbenaceae. There are two other species in the *Tectona* genus: *Tectona philippinensis* and *Tectona hamiltoniana*. Teak is cultivated worldwide in warm climates such as in Central America, South America, Africa, the Pacific Islands (Australia, Fiji, and the U.S. Pacific Islands), and the Caribbean islands. Teak can grow in a variety of habitats and climate conditions, from arid to moist, but the typical annual rainfall in areas where teak grows is around 57 inches. *Tectona grandis*'s common name derives from the Malayalam (southern Indian) word *theka*, or *tekka*. It is sometimes referred to by its Hindi name of *Sagon*, or *Sagwan*.

Appearance

Tectona grandis can grow rapidly and can become up to 130 feet tall. It has gray or grayish-brown branches and shallow longitudinal grooves. The papery leaves are a simple elliptical or ovate shape and contain small glandular dots and fuzz on the underside. The flowers are fragrant and white and primarily are pollinated by bees, bumblebees, and wasps, but they can also be pollinated by wind. The seeds are white and ovate and ripen November through January, then fall gradually from the tree. If cultivated, the seedlings are planted when they are four to six weeks old. *Tectona grandis* prefers porous, well-drained soils.

Common Uses

Teak is a long-lasting, durable hardwood with high-quality grain, a desirable hue, and weather resistance. It holds up well outdoors even without being treated with oil or varnish. Teak timber is much sought after, and the forests of southern and Southeast Asia have had difficulty keeping up with demand for the wood in other Asian countries as well as in North America and Europe. As a result, it is now one of the most widely planted forest species worldwide. The wood is especially useful in outdoor applications and is made into ships, lifeboats, yachts, construction poles, frames, railway ties, harbor piles, bridges, window frames, siding, door sills, transmission poles, shingles, tanks, vats, decks, and furniture, especially patio furniture. It is also used to produce weaving looms, scaffolding, pallets, brushes, cutlery, toys, musical instruments, wooden serving pieces, sports equipment, cabinets, wardrobes, dowels, picture frames, ceilings, shoes, hat racks, chests, beds, wood carvings, and firewood. (It is a hot-burning wood.) *Tectona grandis* is a stable wood, meaning it does not warp and is resistant to variations in humidity and temperature. The leaves of teak produce a dye that is used for dyeing silk, cotton, and wool. The roots are also used for dyeing mats a yellowish-brown color.

History of Teak

Teak was introduced in Indonesia from seeds brought by Hindu monks from India in the 14th century. The Dutch discovered teak in Indonesia some 300 years later and quickly began logging the wood and shipping it. In the early 1700s, the British Empire demanded teak for use in naval ships. The wood was also a staple of bridges throughout Europe and Asia and some still stand to this day. In the late 19th century, the reclaimed lumber from floors and ships was used to make outdoor benches in England. Outdoor leisure was taking hold in the country, and durable, weather-resistant teak was the perfect wood to manufacture into tables, chairs, and garden storage facilities. By this time, logging restrictions were put in place in Asia to manage distribution and protect the species. Man-made forests were added to the natural distribution areas to increase capacity. Half the distribution in the world still comes from the four areas where teak is indigenous (India, Myanmar, Laos, and Malaysia). Myanmar is the only country of the four that still exports teak grown in natural forests. Ten percent of the world's plantations are currently found in North and South America, where teak was introduced in 1913 in Trinidad, and Africa, where teak was introduced in the 19th century.

Teak's Natural Enemies

Teak is a hardy tree that can withstand the elements as well as insect infestations; however, it is susceptible to some diseases and insects. Diseases that affect teak include rust stem and leaf, mildew, leaf spot, pink disease, and root, butt, and heart rot. Insect enemies include white grubs, sapling borers, trunk borers, hole borers, shoot borers, and termites. *Hyblaea puera*, whose common name is the teak defoliator, is a moth native to Southeast Asia and India that feeds on *Tectona grandis*.

Medicinal Uses and Cookery

Teak has medicinal value, and many parts of the tree are useful. Teak has been used to treat inflammation, burning sensation, skin diseases, diabetes, urinary retention, kidney diseases, and arthritis. It is used as a laxative and for the treatment of piles, vitiligo, and dysentery. Its oil is useful in treating scabies, and the wood can be used to relieve headaches and burning sensation. The bark has been used as a cooling agent to bring down fevers and is also an astringent. It has been employed to improve bronchitis, hyperacidity, leprosy, and other skin diseases. It has been tested on laboratory animals to heal wounds. Teak also contains tannin, which is an anti-inflammatory.

In southern India, teak leaves are used to make jackfruit dumpling (pellakai gatti), a pastry in which batter is poured into a teak leaf that is then steamed. Gudeg, or green jackfruit stew, is another dish made with jackfruit and teak leaves. It is cooked with palm sugar and is extremely sweet. Teak leaves are added to change the color to a reddish brown. Gudeg is popular in Indonesia.

Rosemarie Boucher Leenerts

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Teff

An annual grass in the Poaceae family, teff (*Eragrostis tef*) has a number of names. Teff surely derives from "tef," which in turn may derive from the Amharic term *teffa*, which means "lost." This meaning doubtless refers to the small size of teff grains, which dropped to the ground become lost in the soil. It is also possible that teff or tef derives from the Arabic term *tahf*, the preferred word in southern Arabia. Other variants of teff are ttheff, tteff, thaff, tcheff, and thaft. In Ethiopian, teff is rendered *tafi* or *taf*. In French, teff is *mil enthiopien*. Further afield are the monikers "lovegrass," "annual bunch grass," and "warm season annual bunch grass." Only recently have botanists settled on *Eragrostis tef* as the scientific name. At one time or another scientists named teff *Eragrostis pitosa*, *Cynodon abyssinicocus*, *Poa cerealis*, *Poa abyssinica*, and *Poa tef*, the last three designations surely favored because teff is in the Poaceae family. The genus *Eragrostis* has more than 50 species, only a few of which are cultivated. Of these teff is the most valuable.

Value as Food and Feed and in Human Nutrition

The teff plant produces grain for human and animal nourishment. The grain is ground into flour and used to make the flat bread injera or enjera. Injera resembles a soggy pancake, and its detractors, among them a British diplomat in the 19th century, think the flavor sour. This perception may derive from the fact that the fermentation of teff produces sourness. Others are much more enthusiastic, deeming the flavor akin to molasses, though not as sweet. Much depends on the grain sampled. Light-colored grain yields a comparatively bland flavor, one akin to chestnut. Darker grains are more robust in flavor, tasting like hazelnuts. Despite its blandness, light-colored grain fetches the higher price, and throughout history the elites ate it, relegating dark grains to commoners. Teff is also eaten as porridge or fermented into alcohol. Some recipes substitute teff for sesame seeds. Because teff grains are so small, one cup of them substitutes for two cups of sesame seeds. Cooks and bakers add teff to pudding, pie, soup, stew, gravy, biscuits, cookies, cake, stir-fry preparations, casseroles, and pancakes that are apparently different from injera. Teff may be combined with herbs, seeds, or other crops, beans, tofu, garlic, and onion to make a meatless teff burger. Sprouts a few days old may be added to salad and sandwiches. Uncooked seeds should be kept in a cool, dry, dark place. Once cooked teff may be refrigerated, though it should be eaten in a few days. Ethiopians eat teff as often as thrice daily and may rely on it for two-thirds of their protein. Injera is a food of the well-to-do. The poor usually cannot afford it.

Nutritionists value teff, which has all eight essential amino acids and is 9.6 percent protein. Teff has more of the amino acid lysine than do wheat and barley but less than rice and oats. Having little gluten, teff is ideal for people allergic to it. In addition to protein, 100 grams of teff have 11 grams of water, 336 calories, 73 grams of carbohydrates, 2 grams of fat, 0.3 milligram of thiamine, 0.18 milligram of riboflavin, 2.5 milligrams of niacin, and 88 milligrams of vitamin C. Minerals include 159 milligrams of calcium, 13 milligrams of chlorine, 0.7 milligram of copper, 5.8 milligrams of iron, 170 milligrams of magnesium, 6.4 milligrams of manganese, 378 milligrams of phosphorus, 401 milligrams of potassium, 47 milligrams of sodium, and 2 milligrams of zinc. Because teff grains are so small they are mostly bran and germ, the structures packed with nutrients.

Beyond its value in human sustenance, teff has for centuries fed livestock, which relish both seeds and straw. Ethiopians rank teff straw above the straw of other grains in feed value. South Africans prefer teff straw for cattle, sheep, and horses. Teff is a livestock feed elsewhere in Africa, India, and South America.

Origin and Attributes

Teff originated in Ethiopia, where it was domesticated between 4000 and 1000 BCE. Given the long tenure of humans in Africa, it seems surprising that teff was not domesticated earlier. By one account, teff migrated to classical Egypt, where it was found in a pyramid 5,300 years old. Recent scholarship doubts the Egyptian thesis. The seeds found in the pyramid may be only *Eragrostis aegyptiaca*, a wild grass widespread in Egypt and related to teff. It seems probable therefore that teff did not wander from Ethiopia in its early history. In addition to Ethiopia and South Africa, teff spread to Eritrea, Malawi, Kenya, Yemen, Pakistan, Nepal, and, during the Columbian Exchange, the United States, Mexico, Bolivia, Peru, and Ecuador. Teff's tolerance of cold weather may make it attractive to Canada, Alaska, Russia, and northern China. U.S. farmers have made small plantings in Montana, Idaho, Kansas, Oklahoma, Minnesota, and South Dakota to serve a niche market. Restaurants that serve Ethiopian Americans buy U.S. teff to make their cuisine. Teff is also a specialty item in health food stores. Minnesota farmers feed teff to livestock. Despite its cultivation in both the Old and New Worlds, teff is primarily an Ethiopian crop. Elsewhere acreage is small.

Teff tolerates a range of conditions, coping with drought and waterlogged soil on which most other grains, except for rice, will not grow. The roots are shallow but numerous and hold the soil in place, lessening erosion. A teff plant may reach nine-and-eight-tenths inches to four-and-four-tenths feet in height, and, like many other grains, it self-pollinates. Seeds are so small that 1,000 weigh only three-tenths to four-tenths of a gram. One hundred and fifty grains of teff tip the scale at the weight of just one grain of wheat. Teff grows best at 5,400 to 6,300 feet in elevation. Rainfall should be between 17 and 22 inches per year and the temperature between 50°F and 80°F, though teff can tolerate temperatures above 95°F. The plant is photosensitive and must have 12-hour days to flower. In the Northern Hemisphere, teff is planted in late May about the time one would sow millet. A late planting gives the farmer time to plow the soil repeatedly to destroy weeds. It is important to plant teff in weed-free soil because seedlings compete poorly with weeds for water and nutrients. The red root pigweed may be the most serious threat to young plants. The farmer prepares the soil for teff as he would for alfalfa. Seeds may be broadcast at 4 to 8 pounds per acre. Seeds should be sown at a depth of less than an inch. Teff germinates rapidly. Once established, mature plants are better able to cope with weeds. The farmer should fertilize with nitrogen and phosphorus to prevent lodging. On rain-fed lands in the United States, the yield is 600 pounds per acre. On irrigated land in Montana, the yield doubles to 1,200 pounds per acre. Ethiopians plant 3.5 million acres to teff per year, reaping one ton of grain. In Ethiopia, teff yields almost as much grain per acre as does wheat. Because teff yields even in poor years, it is a famine food. Teff is also valuable because few pests and diseases attack it. Yet it is a labor-intensive crop, a fact that dissuades some farmers from growing it. Ethiopians plant teff where corn, sorghum or wheat has failed. Able to grow in acidic soil, teff tolerates a soil pH below 5.

Christopher Cumo

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Thyme

Thyme is a member of the genus *Thymus*, of which the most commonly used and cultivated species is *Thymus vulgaris* or common thyme. Thyme is one of our oldest culinary spices, having been used to season stews of barley and vegetables as early as 6000 BCE, when the domestication of animals and the cultivation of grains became widespread among early communities. The essential oil of thyme, thymol, has documented medicinal properties; thyme has been used since antiquity as an antiseptic, antifungal, and antibiotic, and its essential oil is still used today as a commercial disinfectant. Thyme is native to the Mediterranean and central regions of Europe, Asia Minor, and North Africa. Folklore credits thyme with magical powers, and its culinary use is central to both French and Creole cuisines.

Antiquity

Though thyme was not widely used as a culinary spice in ancient times, the Romans did use this herb to flavor cheese and wines. In antiquity, thyme was appreciated mostly for its medicinal qualities and was used in spiritual rites. The earliest recorded use of thyme was in Sumeria in 3000 BCE. The ancient Egyptians included essential oil of thyme in their embalming recipe, and from this use likely comes the belief that the souls of the dead rest in thyme blooms on their way to the afterlife. The ancient Greeks burnt thyme as incense and considered it a sacred herb. The English word "thyme" comes from the Greek *thymon* or *thumus*, meaning "courage" or "strength," which is derived in turn from the Indo-European root word *dheu*, which means "to rise into flames" or "to smoke." The ancient Greeks expressed their reverence for thyme in their language; the altar-like platform found in the center of the orchestra in Greek theaters was known as a *thymele*; the ceremonial censer used during religious rites was known as a *thymiaterion*; and to say that someone "smells of thyme" was a compliment to that person's elegance, grace, and courage. The Greeks believed that the best honey in the world came from Mount Hymettus near Athens, where the honeybees feasted on the flowers of the wild thyme that grew rampant there.

To the Greeks, and to many others since, thyme was the herb of courage. The Greeks believed thyme was strengthening and invigorating; later, Roman soldiers bathed in thyme to enhance their strength and courage on the battlefield. In the Middle Ages, ladies embroidered handkerchiefs with thyme and then gave them to their knights to inspire courage; many knights carried these tokens to war in the Crusades.

The Middle Ages

The Middle Ages attached a strong magical folklore to thyme. According to Christian mythology, the baby Jesus slumbered on a bed of the herb. Thyme was believed to bestow a lifelong blessing onto children who touch it during their first trip into an herb garden. Some believed that bringing wild thyme into the house was bad luck, and would result in illness and even death of a family member; others believed that thyme, with its connections to death and the afterlife, should be brought into the house after a death and kept there until after the funeral. This practice hinged on the ancient belief that thyme's flowers provide a resting place for the souls of the dead and an easier passage to the afterlife. In Wales, thyme was planted on graves.

Fairies were said to hide in thyme flowers, which made them invisible to humans. Those who wished to see fairies were told to sleep on a fairy mound with sprigs of thyme placed over their closed eyes. Thyme scattered on windowsills and thresholds invited fairies into the home. Thyme's magical powers extended to love divination, as well. Girls in the Middle Ages tried to find out who they would one day marry by placing a sprig of thyme in one shoe and a sprig of rosemary in the other on St. Agnes Eve. Alternatively, on St. Luke's Day, girls could anoint themselves with a decoction of thyme, marigold, marjoram, and wormwood, boiled in honey and white vinegar, to bring themselves visions of their true loves. Pillows of thyme were said to prevent nightmares and promote restful sleep.

Medicinal Use

Medicinal use of thyme dates back to the ancient Greeks, if not earlier. Greek physician Dioscorides (40–90 CE) recommended thyme as a treatment for nervous conditions, convulsions, and spasms. Thyme was employed in ancient Greece to clean wounds and promote healing, to bring relief from asthma and to ease stomach cramps. The first-century CE Roman encyclopedist Pliny documented the use of thyme to treat headaches and draw the poison from snakebites and marine animal stings. Thyme was used to treat flatulence and colic and, when administered at the onset of a fever or cold, could promote perspiration and facilitate a faster recovery. Thyme was commonly cultivated in English cottage gardens by the 16th century. English herbalist Nicolas Culpeper (1616–1654) recommended thyme for the treatment of whooping cough; when administered at the first sign of the disease, one-and one-half to six ounces of thyme per day could, he believed, alleviate symptoms within three days and cure the disease entirely within two weeks. Culpeper advocated the regular use of thyme tea to treat shortness of breath, and believed, correctly, that it was a powerful antibiotic for infections of the upper respiratory tract. Fellow English herbalist John Gerard (1545–1611/12) believed that thyme was an effective treatment for headaches, sciatica, leprosy, and epilepsy. Ointment of thyme was used to treat acne, warts, gout, and inflammation. Thyme was even believed to improve poor vision and support spleen health.

In 1725, the apothecary to the Court of Berlin discovered camphor of thyme, the plant's essential oil, which is called thymol. Thymol has the same antiseptic properties as phenol but is less toxic and less irritating to wounds and skin. Thymol has been employed as a topical antiseptic, a deodorant, and a local anesthetic since its discovery. As an antifungal, it treats ringworm, eczema, chilblains, burns, and psoriasis in external usage; taken internally, thymol can treat bronchitis, asthma, whooping cough, and the septic sore throat associated with scarlet fever. Thymol has been used internally to treat infestations of hookworms, roundworms, and threadworms.

Common thyme is sometimes known as mother thyme because of its usefulness in supporting uterine health. Thyme tea can be used to treat menstrual cramps and support healthy menstruation; taken at bedtime, the tea is said to fight insomnia; as a general health tonic, the tea fights off infection. One may place thyme leaves in boiling water and inhale the fumes to clear congested nasal passages. A hot poultice of thyme treats boils, abscesses, and other swollen inflammations of the skin. Recent research shows that thyme may have powerful antioxidant properties, and it has long been attributed the ability to dissolve and remove tumors. As an antifungal, thyme can treat athlete's foot and similar infections. Oil of thyme has been used successfully to treat crabs, lice, and scabies.

Thymol's antiseptic and antibacterial properties made it invaluable for medicating the gauze used in surgical dressings. Germany was the world's top manufacturer of thymol prior to World War I; this led to thymol shortages for surgical dressings throughout the war. Thymol was nevertheless used during World War I, when available, to sterilize wounds and deodorize hospital wards. Today, thymol is still widely used in soaps, mouthwashes, cough syrups, aftershaves, perfumes, and cosmetics; it forms one of the main active ingredients in Listerine. A sachet of dried thyme flowers can keep moths out of linens. Thymol is even still used as an embalming agent, often to preserve botanical and anatomical specimens.

Current Use

Today, thyme is most widely known as a culinary spice. Meats can be rubbed with thyme as a preservative as well as a spice; thyme's savory flavor enhances almost any dish, whether soup, salad, or roast. Thyme is considered an ideal seasoning for vegetables, meats, cheeses, and cream sauces. Fresh sprigs of thyme can be served as garnish. Much of thyme's popularity as a culinary herb stems from its long shelf life. The dried leaves retain their fragrance and flavor for a long time in storage, and their flavor holds up well under long cooking times. As an added benefit, thyme used in cooking aids digestion. Thyme has long been central to French cuisine, and its culinary importance also extends into Creole cooking.

Thymus vulgaris is considered a world crop of minor importance. Annual thyme production averages 20 to 30 tons per year. Spain, France, Germany, Italy, Portugal, North Africa, Canada, the United Kingdom, and the United States all cultivate thyme for its dried leaves and oil. Thyme production involves both commercial cultivation and wild harvesting; much of the world's thyme, especially that produced in poorer nations, is still harvested from the wild, due to the expense associated with cultivation.

Marjorie McAtee

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Timothy

Timothy (*Phleum pretense*), also known as herd grass and meadow cat's tail, was named after two pioneers in the field of agriculture: John Herd and Timothy Hanson of United States. It is believed that the early settlers of the 16th century CE brought Timothy grass with them from Europe. However, it was not until 1711, when John Herd introduced this crop in New Hampshire for the purpose of agriculture, that it gained exposure. It became more popular when Timothy Hanson, in 1720, encouraged its cultivation and expanded its field base from the northeastern states to the south, especially to the Carolinas. They were instrumental in propagating and spreading this crop in the United States in the early 18th century, when it was brought from Europe. Except for Turkey, this grass is found all over Europe and is native to North Africa, Europe, and western Asia. According to the U.S. Department of Agriculture's plant database, timothy grows all over the Unites States. History has it that the United States was the first to recognize this plant as an agricultural crop.

Timothy grass, a perennial graminoid, is grown for its use in the farming industry as fodder for cattle and horses. This grass averages a height of two or three feet, and thrives in well-drained, fertile, and acidic soil. It does not tolerate droughts and poorly drained soil. Usual habitats include pastures, fields, roadsides, vacant spaces, and alongside rail tracks. It grows as thick clumps of weed with short fibrous roots that do not hold the plant well under extreme conditions of drought, shock and erosion.

Botany

Timothy is found abundantly all over the United States and eastern part of Canada. Timothy grass grows well in loamy and clay soils, and in cooler temperatures. It thrives in snow and can withstand a dry climate for a fairly tolerant period. Yield is best in the colder geographical zones. It is a perennial graminoid that grows best in soil with a pH from 5 to 7.8. Timothy grows vigorously in spring and summer. It is intolerant of shade. The roots are adventitious and fibrous and also shallow in ground depth ranging from 10 to 20 inches deep. The stem, known as culm, is erect and in clumps or bunches. Internodes are long with conspicuous nodes. The leaves of timothy consist of two parts, namely the sheath and leaf blade (lamina). The sheath is the part of the leaf that is wrapped around the stem. Leaves are a rich green in color. The inflorescence of timothy grass is a cluster of spikelets, which are arranged on a central axis called the rachis. Each spikelet may consist of a number of florets or flowers connected at the rachilla. Each flower is yellow in color and is devoid of a stalk (sessile). It is connected to the rachilla at the base. There are numerous hairy bracts present below the flower. Each flower is also unisexual, in that there are either stamens or pistils, not both. The petals that are seen in this flower are not all alike (irregular) and can be cut in half along a single plane only to create a mirror reflection (zygomorphic). A flower has three stamens. Stamens have free, long, and slender filaments with versatile anthers; that is, the anthers are attached to the stamen in the middle, allowing them to swing on the stamen axis. The anthers, which are two-celled, split open or dehisce longitudinally. While the pistil is tricarpellary, only one carpel is functional. The ovary is raised above the level of all other flower parts (hypogynous) and contains only one compartment (unilocular). The style is short, while the stigma is feathery and seen to arise from the wall of the carpel. The fruit is a caryopsis.

Seeding and Uses

Timothy is a fodder crop that can be fermented and maintained in a silo as a high-fiber feed for cattle and livestock, especially for horses, when grazing pastures are dry. While timothy grass is high in fiber it is low in protein. Although many farmers grow this grass along with other grass varieties, it should be noted that the timing of growth and maturity may vary and hence not result in the perfect, desirable yield. Palatability and management requirements too will vary with mixed crops, bringing about changes in the quality of the overall product.

Seeding of timothy may be done in either early spring or early fall. An average of 10 pounds of seed per acre is recommended. If mixed with other varieties of grass or other plants, an average of 4 pounds per acre should be ideal. Seeds should be sown one-quarter of an inch deep. The farmer must make sure that the soil is not dry or the seeds may not germinate evenly. Liming and testing of soil should be done prior to seeding, after competing vegetation has been cleared or suppressed.

Horticulturalists have used timothy grass to intensify landscaping. Timothy may be used in lawns or grown in patches in select areas of the garden to give it a rustic look. While this may be for landscaping and horticultural uses, it is mainly used as a pasture grass for grazing animals. Timothy may be harvested twice or thrice a year, depending on the seeding period. It yields about five to seven tons per acre of good, fine-quality hay.

Diseases

Stem rust is one of the most common of all diseases known to affect timothy. Lesions that are formed on the stem have a rust-like appearance or are reddish in color. Lesions may be oval or round or be striped about one-half of a millimeter in width. Lengths of the lesions vary from one to two millimeters. The causative organism of stem rust is a fungus known as *Puccinia graminis*. Lesions are at first localized and small, but when they increase, they spread, fuse, and rupture, discharging small spores.

Brown leaf blight is a fungal disease known to affect only timothy. It is caused by the fungus *Dreschslera phlei*. This blight occurs during spring and may eat its way into the leaves of timothy. Starting from the leaf tip, most of the leaf will ultimately turn from green to yellow to brown.

The fungus *Ovularia pussila* causes bird's eye spot. It starts at the end of summer and thrives through autumn if unchecked. The disease causes lesions in the leaves, which are brown in color and generally oval in shape. A yellow ring surrounds the lesion, giving it an appearance of a bird's eye.

Ergot is a very common disease of grasses and cereal crops. Ergot can be a devastating disease, decreasing yield to a considerable degree and causing secondary infection through consumption of flower heads or grain. It is caused by the fungus *Claviceps purpurea*. If infected grain or hay is consumed, this fungus can cause ergotism in livestock. Ergot can be identified by the dark purple, cattle horn-like sclerotia that affect the flower head or grain of the plant in question. If left unchecked, it can decrease the yield 10 percent or more, eating its way through the seeds.

The fungus *Cercosporidium graminis* causes leaf streak, a disease that is widespread in wet and damp periods rather than in the drier climates. In this fungal disease, the leaves are initially affected by brown, rust-looking spots. If left unchecked, these spots may elongate and extend to cover the entire leaf with a brown appearance. As the leaf dries, white stripes emerge, even reaching to the base of the leaf into the leaf sheath. These leaves are ultimately lost before the plant matures and cause a decrease in the yield of hay and silage. Affected leaves look streaked with green to brown patches; the green a remainder of the once healthy leaf and the brown as an infection taking over the leaf.

Choke is caused by the fungus *Epichloe typhina* and is compared to the effect of choking. Flower heads are the part of the plant that are affected where the flowers are choked and prevented from maturing and producing seeds. Mycelia in the form of a white ring develop around the flower stalk and suppress the flowering growth of the plant. Eventually, the mycelia cover the entire, underdeveloped flower head, giving it an orange appearance.

Purple spot is caused by the fungus *Cladosporium phlei*. This disease is characterized by purple spots appearing on the leaf that may turn brown in appearance with gray centers. Unaffected areas of the leaf turn from green to yellow, indicating nutritional deficiency. Ultimately, the leaf rolls up from the leaf tip and falls off due to withering. Defoliation of leaves in a severe infection can cause massive loss to the crop yield and seed production.

Sclerotonia snow blight is a blight disease affecting timothy grass where there are regions of prolonged snow. Wet and cold, the soil can harbor the fungus *Myriosclerotinia borealis*. When infected, the plant appears to rot, changing colors from a healthy green to a dark green and then a rotting, brown appearance. Black spots that resemble rodent excreat appear on the stem.

Disease Management

As most of the diseases that affect timothy grass are fungal, chemical treatment is ineffective. Most agriculturalists adopt the methods of crop rotation and burning of affected grass to control and minimize the spread of these fungal diseases. Mycelia of the affecting fungus tend to stay in the soil for long periods of time if the conditions are right. It is therefore necessary to weed out the soil and till the land where infections of the grass has been high. Sowing highly resistant varieties of the crop too is an effective way to control the diseases. Spraying the plants with organic pesticides can control pests like grasshoppers, which may eat their way through the leaves and spread the fungal spores from one area of the field to another. In some cases, the addition of organic nitrogen fertilizers to the soil can help tide over the disease, as fungi consume nitrogen from the plants indicating blights, spots and nutritional deficiencies.

Amanda Mittra

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Tobacco

A perennial, tobacco is grown as an annual in temperate locales. The word "tobacco" derives from the Spanish term *tobaco*, which in turn derives from the Taino language of the island of Hispaniola (now Haiti and the Dominican Republic). Except for cotton, farmers grow tobacco on more acres than any other nonfood crop. A member of the Nightshade family, tobacco is related to tomatoes, potatoes, and peppers. A self-pollinator, tobacco cross-pollinates less than 5 percent of the time. Remarkably fertile, one tobacco plant produces 1 million seeds, enough to plant more than 12 acres.

Tobacco (PhotoDisc, Inc.)

Origin and Diffusion

Tobacco may be native to Virginia, though one writer believes it originated in Peru. Assuming Virginia to be the cradle of tobacco, in prehistory it spread to Central and South America. About 8,000 years ago, the Amerindians began cultivating two species of tobacco: *Nicotina rustica* in North America and *Nicotina tabacum* in Central and South America. *Nicotina rustica* has a harsh flavor and is today grown only in the former Soviet Union, China, India, Pakistan, and North Africa. Consumers prefer *Nicotina tabacum* for its pleasant aroma and mellow flavor. Because tobacco will not tolerate wet soils, farmers worldwide grew it on well-drained soils.

Tobacco was part of the Columbian Exchange. In 1492, Christopher Columbus observed its cultivation on Hispaniola and brought seed back to Europe. The demand for tobacco in Europe led Brazil and the Caribbean to cultivate the weed in the 16th century. The American colonies followed their lead in the 17th century. As early as 1610, the Amerindians gave the English colonists at Jamestown *Nicotina rustica*. Dissatisfied with its bitterness, colonist John Rolfe began in 1612 to grow a variety of Spanish tobacco that had originated in Trinidad or Venezuela. Approving Rolfe's selection of this variety, one contemporary termed it "pleasant, sweet and strong." Back home the British agreed and were willing to pay a higher price for the Spanish leaf than for *rustica*. Having floundered in its early years, the Jamestown colony found prosperity in tobacco. Although colonial officials were uncertain of its merits, strong demand in Europe swept aside reservations, and by 1617 colonists were devoting every spare acre to tobacco, even planting it in churchyards. In 1627, Virginia exported several hundred thousand pounds of tobacco, in the late 1660s tens of millions of pounds, and in 1770 hundreds of millions of pounds worth millions of dollars. The Roanoke River valley was the center of Virginia's tobacco economy. There the vast majority of farmers, most of them holding only eight or nine acres, grew tobacco. In Charlotte County, on the other hand, tobacco growers owned large estates.

From an early date, production outpaced demand. By 1630, tobacco farmers had glutted the market. Prices collapsed from 12 cents per pound in the mid-1620s to less than a penny per pound in 1630. Low prices plagued growers throughout the 17th century. In an effort to steady prices, the Virginia legislature passed minimum price laws in 1632, 1633, 1639, and 1640. The fact that legislators revisited this issue several times suggests that the laws were ineffective. Unable to gain satisfaction from the law, farmers took matters into their own hands. Desperate to reduce supply, they destroyed 750,000 pounds of tobacco in 1682 to keep it off the market.

The American Revolution, by severing trade with Europe, hurt tobacco farmers, dependent as they were on exports. The Embargo Act of 1807 had the same effect. Prices likewise fell during the War of 1812 and during the Panic of 1819. Tobacco prices recovered and were favorable during the early 1830s. The Panic of 1837, however, depressed prices through the 1840s. Prices rebounded in the 1850s, and by the Civil War the largest tobacco barons were among the wealthiest Americans.

After the American Revolution, the former colonists migrated west, taking tobacco with them. Tobacco sunk roots in western Virginia and North Carolina, where it was grown on sandy soils. By the Civil War, this region had emerged as the center of tobacco culture. By 1860, Tennessee and Kentucky produced more tobacco than any other state except for Virginia. The Civil War, in causing turmoil in Virginia, Maryland, and North Carolina, cost farmers in these states a portion of their crop and Kentucky emerged as the leading tobacco state. By then, tobacco had emerged as an important crop southern Ohio and in the Connecticut River valley, an area that specialized in the growing of cigar leaf. Now a corn and soybean state, Ohio had thriving tobacco farms in the 19th century. Whereas Ohio produced hundreds of thousands of pounds of tobacco in 1840, the Buckeye State yielded millions of pounds in 1860. In the 19th century, farmers grew little tobacco in the tidewater as the crop spread to southern Virginia, northern North Carolina, and western Maryland. Whereas farmers in the 17th and 18th centuries exported most of their tobacco, domestic consumption grew in the 19th century so that by 1859 half the tobacco crop went to satisfy domestic demand.

Tobacco was notorious for exhausting soils. Farmers planted it in monoculture for 3 to 5 years or until yields declined, then planted new land. They fallowed exhausted land as long as 20 years before replanting to tobacco. In this way, they rotated land rather than crops, a curious circumstance given that agricultural scientists almost universally recommended crop rotation. One observer of tobacco culture remarked that "agriculture in the South does not consist so much in cultivating lands as in killing it." Tobacco had a curious relationship to fertilizer. Farmers understood that several varieties did well in infertile soils, and in some cases the application of fertilizer was likely to make the flavor of tobacco too strong. Yet fertilizer quickened the maturation of tobacco, a desideratum given the short growing season in the North. As early as 1840, German chemist Justus von Liebig had called attention to the value of fertilizers, and his prestige gave his pronouncements an almost hypnotic effect on American scientists. By the 1870s, the tide had turned in favor of fertilizers. Between 1879 and 1919, North Carolina tobacco growers increased their use of fertilizers 10-fold. The trend toward the use of fertilizers was strongest among growers of cigar leaf, whereas growers of tobacco suitable for cigarettes understood that they could get by with less fertilizer.

World War I saw a surge in demand for tobacco. The catastrophic fall in price in the 1920s ruined tobacco growers. In 1931, tobacco prices plummeted to their nadir. By one estimate, farmers lost many dollars per acre of tobacco because prices were so low. President Franklin Roosevelt's New Deal sought to stabilize prices. Recognizing that prices were low because supply was too large, the New Deal attempted to limit production. Resurrecting the old idea of a minimum price, the New Deal guaranteed a minimum for farmers who reduced acreage. In 1933, Congress guaranteed a minimum price.

Since the 16th century, Europeans have grown tobacco in their colonies. As we have seen, from an early date the Portuguese grew tobacco in Brazil. In the 19th century, the French raised tobacco in Algeria, which exported the crop to the mother country. Tobacco spread south, and in 1912 all of Africa produced tens of millions of pounds. In the 20th and 21st centuries, Zimbabwe, Malawi, and South Africa have been the leading producers. In 1905, Zimbabwe raised its first crop of tobacco, and during much of the 20th century it was the cheapest producer of tobacco because wages were so low. The enactment of a minimum wage law in 1980, however, raised the cost of production. Zimbabwe exports the vast majority of its harvest. Tobacco is the country's largest source of foreign exchange and the largest employer. In Zimbabwe, farmers rotate tobacco with corn, cotton, and groudnuts. In Asia, India was in the 19th century the largest tobacco producer. Even as production increased from hundreds of millions of pounds in 1884 to billions of pounds in 1984, India ceded leadership to China in the 1930s. By 1984, China produced half Asia's tobacco. Today, farmers grow tobacco in more than 120 countries in tropical and temperate regions. By continent, Asia produces the majority of the world's tobacco, Europe several percent, North America slightly less percent, South America less still percent, and Africa the least.

Labor

Before the machine age, tobacco was a labor-intensive crop and, even with advances in technology and chemistry, remains so today. In spring, farmers burned vegetation to eliminate weeds and planted tobacco in seedbeds, transplanting them to the field in late spring. Because weeds can lower yields, farmers hoed tobacco fields repeatedly. Breaking the top of the stalk—a practice known as topping—farmers prevented the plant from going to seed, thereby concentrating biomass in the leaves. To put the matter another way, farmers encouraged tobacco to grow vegetatively rather than reproductively. Similarly, farmers cut off suckers and small leaves to encourage the growth of large leaves. Throughout the growing season, farmers removed tobacco worms by hand, a time consuming and tedious task. Farmers harvested tobacco either by cutting down the entire plant or by removing leaves one at a time. In the first case, farmers still needed to cut leaves from the stalk to prepare them for curing. To cure tobacco, farmers hung leaves in barns either to air dry or to dry over a fire. In some instances, tobacco was cured over a hickory fire to impart flavor to it. In the 19th century, North Carolina slave Stephen Slade discovered by serendipity the use of charcoal in curing tobacco. Tending a wood fire one night, Slade fell asleep. Upon awakening, he found the fire nearly extinguished. Having no wood on hand, Slade turned to charcoal and discovered that it turned the tobacco leaves a deep yellow. Charcoal-cured tobacco became popular, selling for several dollars per pound, four times the average price for wood cured tobacco.

In the 16th century, small farmers grew tobacco in the Caribbean, relying on their family for labor. In many areas, sugarcane replaced tobacco in the 17th century, and in any case production shifted to North America. Planters in the American colonies relied on indentured servants for labor until the mid-17th century. By then, slaves were cheaper than indentured servants and, labor being scarce, planters imported slaves to toil on their farms. Tobacco farmers were thus the first in the American colonies to use slaves. From the 17th century, a chasm separated slave and free. As a rule, large planters used slaves whereas small farmers, as had their counterparts in the Caribbean, used free labor.

Tobacco planters bought slaves in small amounts, usually one or two per year though big planters bought as many as a dozen slaves in prosperous years. As one might guess, slaves were reluctant laborers. They resisted their masters as best they could, working slowly, breaking tools, feigning illness, and disregarding instructions. Masters responded by closely supervising every phase of tobacco culture, appointing 1 overseer per 10 slaves. They also made slaves fend for themselves. After working long hours in tobacco fields, slaves had to labor at producing their own food. They could expect no sustenance from their owner, and some slaves, failing to grow enough food, died of malnutrition. Corn was the principal sustenance crop, though slaves also grew vegetables and tended pigs.

Working from sunrise to sunset in tobacco fields, slaves in the 17th century could count on a respite during the heat of midday. They were off Saturday afternoon and holidays. During winter, labor was less intensive. In the late 17th century, however, working conditions worsened as labor became more strenuous. Planters required a full day's work on Saturday and limited the number of holidays to Christmas, Easter, and Whitsuntide. Malnutrition and overwork contributed to the early death of slaves. Slaves felt the burden of their lot at an early age. Girls as young as 12 worked in the fields. Slave women worked as hard as men. With hoes, they broke ground in spring. Only in the 1790s did planters begin using the plow, and men had charge of it. Women did the onerous chores of building fences, grubbing swamps, winnowing grain, cleaning stables, and spreading manure.

The Civil War ended slavery. Planters adjusted to the new environment by renting land to tenants. Although in theory he was free to grow whatever he wished, the need to pay rent forced a tenant to grow a cash crop, in this case tobacco. After the Civil War, tenants worked the majority of tobacco land in parts of North Carolina. As planters divided their land among tenants, the average size of tobacco farms decreased and the family came to be the unit of labor.

In 1910, the U.S. Department of Agriculture (USDA) estimated that farmers expended hundreds of hours of labor for every acre of tobacco. Rather than decrease, labor requirements rose by 1950. By contrast, farmers expended only a few hours per acre of wheat in 1950. Although tobacco remained a labor-intensive crop, in the 1940s the largest farmers began to substitute capital for labor, using fertilizer, pesticide, herbicide, irrigation, and chemicals to inhibit the formation of suckers. In the 1950s, landowners shed tenants as they relied on chemicals and machines to cultivate tobacco. Between 1964 and 1974, the number of tenants decreased sixfold in one North Carolina county. In the 1970s, farmers began harvesting tobacco by machine.

New Varieties

The development of new varieties of tobacco increased the plant's biodiversity and usefulness. In the 17th century, the American colonists grew two varieties of tobacco. They cultivated Orinoco, whose name suggests an origin in the Orinoco River valley of South America, for its strong flavor. They also raised Sweet Scented for its mild aroma and flavor. Around 1635, farmers first grew tobacco in Maryland, initially cultivating Orinoco. By the late 17th century, however, they had switched to Maryland Broadleaf, a derivative of Sweet Scented. Farmers cured Orinoco and its derivate Pryor over a fire. Several other varieties were air cured. These varieties were suitable for making snuff and plug tobacco. Around 1650 planter Edward Digges, growing tobacco on sandy loams, derived the E. Dees variety of yellow tobacco, whose sweet smell and pleasant taste commanded a high price. E. Dees and other varieties yielded a better-quality leaf on light rather than heavy soils.

On fertile lowlands, farmers grew Orinoco and Pryor. In Louisiana, farmers grew Perique, a variety with strong flavor and dark leaves. By 1820, growers in Kentucky and Ohio planted Red Burley, a derivative of Maryland Broadleaf that was used in making plug tobacco. After 1820, the demand for cigars increasing, farmers in the Connecticut River valley grew the variety Shoestring for this purpose. Other farmers in this region grew Maryland Broadleaf on sandy soils, discovering that it did well in relatively infertile soils. Soil with low nitrogen content imparted a mild flavor to Maryland Broadleaf. By the mid-19th century, Maryland Broadleaf had supplanted Shoestring. By then, farmers in Pennsylvania and Ohio grew Connecticut Broadleaf, whose cultivation spread to Wisconsin in the 1870s. By mid-century farmers grew Havana, whose name suggests an origin in Cuba, for cigar leaf. Around 1850, brothers Eli and Elisha Slade of North Carolina, bred a new variety, Bright Yellow, apparently named for its color. Its leaves used as wrapper for plug tobacco, the variety fetched a good price. After the Civil War, manufacturers used Bright Yellow in cigarettes. Farmers in North Carolina and southwestern Virginia grew Bright Leaf, the major constituent of cigarettes. The rapid increase in the consumption of cigarettes after 1890 made Bright Leaf one of the world's most widely grown varieties.

In 1864 George Webb and Joseph Fore, tenants in Brown County, Ohio, discovered a new variety by chance. Acquiring seed of the variety Little Burley from a Kentucky grower, they planted it in a seedbed. Some of the plants that germinated were pale. Webb and Fore concluded that the strange plants must have been diseased. Leaving them in the seedbed, they planted the others in the field, but when they ran short of seedlings they transplanted the putatively diseased plants. Contrary to their expectation, the plants thrived and the two tenants realized that the plants were not diseased but were a new variety, which they christened White Burley. The variety fetched a good price in Cincinnati and became a staple of tobacco culture in the Ohio River valley. By 1880, farmers in the east planted the majority of their acreage to White Burley. From long use, farmers shortened the name to Burley, the moniker that is known today.

Although rice and cotton were the staple of South Carolina in the 18th and 19th centuries, farmers grew tobacco in the 19th and early 20th centuries. In 1884, South Carolina planter Frank Rogers experimented with Orinoco before switching to Bright Leaf. Rogers gave lectures to farmers, alerting them to the value of Bright Leaf. In 1886, the state commissioner of agriculture offered a prize for the best tobacco. Rogers won though he seems to have faced little competition. The commissioner judged two-thirds of entrants as poor. Those who did not cultivate Bright Leaf grew Cuban varieties for cigar leaf.

In 1896, the USDA experimented with the variety Sumatra, though how it derived this name is unclear, in Florida. Like Burley, Sumatra was suitable as a cigar wrapper. Yielding poorly in direct sunlight, Sumatra was grown in the shade of large stands of trees. The USDA tried to introduce Sumatra to the Connecticut River valley but it yielded poorly, perhaps because the latitude was farther north than Sumatra's zone of adaptation. By 1919, farmers grew Bright Leaf on a sizable portion of acreage. Kentucky and Tennessee, which produced nearly half of U.S. tobacco in the early 20th century, grew Burley.

Several varieties were susceptible to diseases. As early as 1881, the bacterial disease Granville Wilt arose in Granville County, North Carolina. As the name suggests, the disease wilted plants, killing them. The bacterium infested soils, where plant roots absorbed it. In the worst infestations, farmers had to abandon land, fallowing it many years. Sandy soils were the most susceptible to infestation. In 1893, the fungal disease Black Shank arose in Java and by 1915 had reached Florida. By 1930, it had spread throughout the United States. As the name suggested, the disease blackened the stalks of plants, stunting them and thereby reducing yields. A second fungal disease, Blue Mold, arose in 1921 in Florida, spreading in 1931 to Louisiana and Virginia, in 1932 to Maryland, in 1933 to Pennsylvania and Tennessee, and in 1937 to Connecticut. By the 1930s, disease killed roughly 15 percent of the tobacco crop per year. Because seedlings were most vulnerable to these diseases, farmers adopted the practice of heating the soil of seedbeds to 212°F to sterilize it before planting.

Tobacco and Health

Given what scientists and physicians now know about tobacco, it seems surprising that the Amerindians valued it so highly. They believed that tobacco protected them from evil winds and poisonous snakes. The Amerindians chewed and ate tobacco leaves, used their extract as eye drops, and took tobacco as an enema. Chieftains blew tobacco dust in the faces of warriors to give them courage. Men dusted women with tobacco before sex. The Amerindians understood that tobacco is an insecticide and used it on crops and fruit trees. In this vein, people rubbed tobacco leaves on the skin to kill lice. Tobacco presaged the transition from adolescence to adulthood. The Tucano of South America gave teen boys snuff before their initiation. As a medicine, tobacco had many uses in pre-Columbian America. Medicine men packed tobacco leaves around an ailing tooth and rubbed the juice of tobacco leaves into wounds to cleanse them. The Aztecs believed that tobacco cured gout. The woodlands Indians of North America believed that tobacco cleaned the lungs and healed snake bites. The use of tobacco was a quasi-religious experience. The exhaled smoke carried prayers to the gods. Used in large quantities, tobacco was a hallucinogen. Shamans used it to alter their consciousness, deriving new insights for their tribe.

Not everyone esteemed tobacco. King James I of England, calling tobacco "that stincking weede," had no illusions about the harm it could cause. Another Englishman labeled tobacco a "filthie weede," and a third termed it a "noxious weede." Many otherwise sensible people ignored these warnings. The consumption of tobacco has increased at a relentless pace since the 17th century, making cigar and cigarette manufacturers wealthy. Eager to maintain profits, tobacco executives denied tobacco's deleterious effects. Despite this subterfuge, scientific and medical evidence accumulated against tobacco, and in 1964 the U.S. Surgeon General issued the first of many warnings against the use of tobacco.

The evidence against tobacco now seems irrefutable. The litany of diseases that tobacco causes is extensive. Cigarette smoking is the chief cause of lung cancer and the pulmonary disease emphysema and chronic bronchitis. In the United States, smokers account for the majority of all lung cancers and the vast majority of deaths from lung cancer. Smokers are many times more likely than nonsmokers to develop lung cancer and 22 times more likely to die from the disease. As women have taken up smoking, their risk of developing lung cancer has increased, and in 1988 lung cancer surpassed breast cancer as the leading killer of women. Smoking causes virtually all cases of emphysema and chronic bronchitis. Smokers are many times more likely than nonsmokers to die from these diseases. Tens of thousands of smokers die each year from diseases of the lungs.

Smoking is the chief cause of cancers of the esophagus, larynx, tongue, salivary glands, lips, mouth, and pharynx. Smokers account for the majority of cases of esophageal cancer. Smokers are many times more likely than nonsmokers to develop esophageal cancer and are many times more likely to develop cancer of the larynx. Indeed, smoking accounts for the majority of all cases of larynx cancer. Smokers total one-third of all deaths from pancreatic and cervical cancers. In the aggregate, smokers are several times more likely than nonsmokers to die from cancers of all types. Smoking causes one-third of all cancer fatalities.

Smoking also injures the heart and circulatory system. Once in the bloodstream tobacco constricts blood vessels, forcing the heart to work harder to pump blood. Tobacco smoke puts carbon monoxide into the blood. Red blood cells absorb carbon monoxide rather than oxygen, causing the heart to work harder to supply oxygen to the body. Within minutes of its inhalation, tobacco raises blood pressure and over time causes hypertension. Tobacco causes platelets in the blood to stick together, increasing the risk of heart attack and stroke.

On average, women who smoke are nearly one-third less fertile than nonsmoking women. Tobacco harms a woman's eggs and fertility hormones. Tobacco causes spontaneous abortions by expelling fertilized eggs from the body. In other cases, tobacco may cause an egg to implant in a fallopian tube, endangering the mother's life. Women who smoke are several times more likely than nonsmoking women to miscarry a child and are more likely to give birth to premature babies. The fetus suffers as well. Tobacco raises its blood pressure and lessens its ability to mimic the action of breathing.

Tobacco costs the U.S. economy several hundred billion dollars per year and smokers their lives. The average man who smokes lives fewer years than a nonsmoker and the average woman fewer years. Tobacco causes more deaths than the aggregate of deaths from AIDS, alcoholism, illegal drugs, car crashes, murder, suicide, and fire.

Christopher Cumo

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Tomato

Tomatoes (Joe Klune/Dreamstime.com)

A perennial vine grown as an annual in temperate locales, the tomato is a member of the Nightshade family. Related to the potato, peppers, tobacco, and the poisonous belladonna, the tomato has toxic foliage that cannot be fed to humans or livestock. The fruit, however, is safe for consumption. Far from dangerous, the tomato is nutritious. One hundred milligrams of tomato supply 40 percent of the recommended daily allowance of vitamin C, 30 percent of vitamin A, and smaller amounts of potassium, calcium, iron, thiamine, and riboflavin. Controversy has attended the debate over whether the tomato is a fruit or vegetable. Botanists have been consistent in classifying it a fruit. In the 1890s, however, the U.S. government designated the tomato a vegetable. At the time, the tariff placed a duty on imported vegetables. By classifying the tomato a vegetable, the tariff protected domestic growers from competition from Mexico and Cuba. One merchant, eager to import tomatoes into the United States, sued the government, charging that the tomato was really a fruit and so should not be subject to the tariff. The case reached the U.S. Supreme Court, which, though noting that botanists designated the tomato a fruit, decided that it was a vegetable because people consumed it with the main course rather than as a dessert, when fruit was customarily consumed. Since this decision, historians have suspected that the Court acted to protect American tomato growers. Economics rather than science shaped this ruling. In 1981, the controversy once more erupted. President Ronald Reagan's budget called for a reduction in spending for school lunches. Nutritionists feared that schools would skimp on vegetables, an expensive item. Determined to preserve the claim that school lunches were nutritious, the U.S. Department of Agriculture classified ketchup a vegetable because it was made from tomatoes. French fries and ketchup were nutritious after all.

In the 20th century, the tomato emerged as the most popular item in the vegetable garden. Gardening books, with advice on how to grow tomatoes, proliferated. Gardeners spent as much as 25 cents per tomato seed for a variety of heirloom tomato, some of which traced their linage to the 19th century. One gardener facetiously wrote that it cost him $64 to grow a single tomato. Others, spade in hand, enriched their soil with leaves, grass clippings, and compost. All this effort and expense was worthwhile because the harvest was so tasty. Perhaps no other food tastes so flavorful when home grown and so insipid when store bought. The problem lies in how commercial growers produce tomatoes. Needing a tough fruit that resists spoilage, growers pick tomatoes green, well before they reach the peak of flavor and nutrition. They then spray tomatoes with ethylene gas to cause them to redden, though whether this redness constitutes ripeness is debatable. The result is a hard, compact, tasteless fruit.

Tomatoes may be red, yellow, pink, green, white, black, purple, or orange when ripe. Plants may be indeterminate or determinate. Indeterminate plants grow throughout their life, sometimes reaching several feet. Gardeners stake them or grow them in metal cages to prevent their sprawling across the ground. Because indeterminate plants flower throughout their life, the harvest may extend over months. Of course in temperate locales, cold weather truncates the harvest. In contrast to indeterminate plants, determinate tomato plants grow little after they flower. They are therefore shorter than indeterminate plants and may not need to be staked or caged. Because determinate plants flower at the same time, they restrict the harvest to two or three weeks. Cultivated tomato plants self-pollinate 95 percent of the time. Because the stigma is short, it receives pollen from adjacent anthers in the same flower. In contrast, wild species cross-pollinate with the aid of insects. In these instances, pollen cannot reach the long stigmas and so cannot pollinate them without assistance. In domesticating the tomato, Amerindians must have selected for short-stigma plants. Containing few calories and little fat, the tomato has fiber, potassium, folic acid, iron, calcium, and manganese. One hundred grams of tomato contain 21 percent of the recommended daily allowance of vitamin C.

Origin and Diffusion in the Old World

Because the tomato grows wild in Peru, Ecuador, Bolivia, Chile, and Colombia, botanists believe it originated in South America. The first tomatoes likely bore small fruit akin to cherry tomatoes. The people of South America may have neither eaten nor cultivated the tomato because the indigenous languages of South America had no word for tomato. Their art and pottery were bereft of tomatoes. Possibly through the aid of animals, the tomato spread from its South American homeland. Sea turtles may have taken the tomato from South America to the Galapagos Islands. Birds and other migrators may have carried tomato seed to Central America and from there to Mesoamerica. Sometime in antiquity the Maya domesticated the tomato, naming it *xtomatl* or *tomatl*. They selected tomatoes for size and flavor and are responsible for the range of fruit sizes. They cleared forest, burned vegetation, and planted seed in nutrient-rich soil. The Maya also raised tomatoes in small gardens with each family responsible for the propagation of seed generation after generation. With tomatoes, the Maya grew chili peppers and herbs. The descendants of the Maya traded yellow tomatoes with the Aztecs and in this way the latter came to cultivate the tomato. They grew tomatoes on farms called *chinampas* in Tenochtitlan. With tomatoes, they raised squash, potatoes, and corn.

In 1519, Spanish conquistador Hernando Cortez came across the tomato in Tenochtitlan. Returning to Spain, he gave the king seed from large yellow tomatoes grown by the Aztecs. Perhaps borrowing from the Aztec language, the Spanish called the tomato *tomate*. From Mesoamerica, the Spanish introduced the tomato to the Caribbean and the Philippines. From Spain, the tomato migrated to Italy. In 1544, Italian botanist Pietro Andrea Matthioli, studying a yellow tomato, called it a "golden apple." Matthioli's terminology may refer to the myth of the golden apples. According to this Greek myth, the nymphs Hesperides gave gold apples, symbols of fertility and eternal life, to the goddess Hera upon her marriage to Zeus. Hercules stole the apples from Hera, presumably keeping for himself the secret of immortality. Italians still call tomatoes golden apples. Matthioli's account was the first European description of the tomato, though it must have been cultivated in Italy earlier because he noted the practice of frying it in oil with salt and pepper and because cultivation must predate cookery. Matthioli grouped the tomato with mandrake, a plant to which the Bible may have referred as an aphrodisiac. Because mandrake was reputedly an aphrodisiac and was supposedly related to the tomato, Matthioli reasoned that the latter must also stimulate lust. In 1554, he announced that tomatoes may be red in addition to yellow.

Although Matthioli offered the first European description of the tomato, some scholars sought earlier references in the works of Greek physician Dioscordes and Roman physician Galen. In particular, these scholars thought Galen's account of the North Africa plant lycopersicum was a description of the tomato, but this is not possible because he cannot have known about the Americas. Perpetuating Matthioli's belief that the tomato was an aphrodisiac, Swiss naturalist Konrad Gesner termed it a "love apple." In the 16th century, Italian botanist Luca Ghini called the tomato *amatula*, meaning "aphrodisiac." Perhaps because of interest in Galen's putative reference to the tomato and in the myth of the golden apples, some Renaissance authorities believed that it had originated in the Mediterranean Basin. German botanist Joachim Camerarius thought the tomato had originated in Asia. These guesses were wide of the mark, but Luigi Squalermo of the Padua Botanical Garden in Italy hit the target by positing an origin in South America. In 1608 and possibly earlier, the inhabitants of Seville, Spain, made tomatoes and cucumbers in a salad. In 1692, the first European cookbook with recipes for the tomato was published in Italy. These recipes derived from Spain. In the 18th century, Italian and Spanish cookbooks included tomato recipes.

From the 1540s, Europeans grew the tomato north of Italy. In the 1590s, the tomato reached England. In 1597, English botanist John Gerard described the tomato in his *Herball*. Gerard grew the tomato in his garden and so had firsthand knowledge of it. Gerard had a low opinion of the tomato, finding its odor offensive. He must not have eaten it, regarding the tomato as poisonous even though he should have known that Italians and Spaniards consumed it. Because he obtained his seed from Spain and Italy, he must have been aware of cultural and culinary practices. Botanist John Parkinson observed that people in "hot countries," by which he may have meant the Mediterranean Basin, ate tomatoes whereas the English grew them as ornamentals. Reinforcing this idea, botanist William Salmon wrote in 1710 that that people of North Africa, Egypt, Italy, Spain, and other "hot countries" consumed tomatoes. In 1719, botanist Joseph Pitton de Tournefort declared that the tomato, though devoid of nutrients, was a suitable medicine for several maladies. In 1728, botanist Richard Bradley admired the beauty of tomatoes but considered them "dangerous," by which he may have meant poisonous, a repetition of Gerard's charge. Despite this warning, the British were eating tomatoes in soup by 1752.

The Tomato in North America

Curiously, the tomato did not migrate north from Mesoamerica to North America. Rather, like the potato, the tomato made two transatlantic crossings: east to Europe and west from Europe to British and Spanish North America. In 1710, William Salmon noted the cultivation of the tomato in the Carolinas. Salmon's account is the first reference to the tomato in North America. Thomas Jefferson credited physician John de Sequeyra with planting the first tomato in America in the mid-18th century, but this claim does not square with Salmon's report that the people of Carolina grew the tomato as early as 1710. No more credible is the assertion of Mary E. Cutler, a member of the Massachusetts Horticultural Society, that a man from Bermuda planted the first tomato in the United States in 1802. This is certainly too late. Spanish Florida must have grown the tomato earlier. Archaeologists have dated seeds recovered from Florida to the 1740s, establishing the decade as the latest when the Spanish could have introduced the tomato. In the Caribbean, slaves grew the tomato and added it to their cuisine. Female slaves from the Caribbean, taken to the American colonies, often served as cooks and in this capacity brought the tomato to the attention of their masters. Tomato cookery implies of course that Americans grew the tomato in the colonial era. The Caribbean may have been an important center for the diffusion of the tomato. Undoubtedly, migrants from Europe, especially Southern Europe, brought the tomato with them to the United States, but another source must have been Jamaica, whose people coined the term "tomato." Because Americans adopted this word, they likely adopted Jamaican tomatoes as well.

The French may have planted the tomato in Alabama and Louisiana and the Spanish in California in the 18th century. In the 1760s, prominent rice planter and slave owner Henry Laurens grew tomatoes on his plantation in South Carolina. Gardeners and farmers raised the tomato in Georgia in the late 18th century. In the 1780s Thomas Jefferson, then a diplomat in Paris, France, sent seeds to an acquaintance, who grew them in Berkeley County, Virginia. As early as the 1780s, Jefferson may have grown the tomato in his garden at Monticello. By another account, only in 1809 did he cultivate it in his garden.

Established in the South in the 18th century, the tomato spread north in the late 18th and early 19th centuries. In the 1790s, Haitian immigrants introduced the tomato to New York. In 1797, gardener George Logan, having obtained seed from South Carolina, raised tomatoes in Salem, Massachusetts. Before 1803, gardeners and farmers grew the tomato in Delaware. In 1804, physician James Meese reported that the tomato was widely grown in Pennsylvania. In 1806, the Manhattan Botanic Garden raised the tomato, though it is unclear whether it was the Haitian variety. In the early 19th century, farmers grew enough tomatoes in Alabama to support the manufacture of ketchup. In the early 19th century, the Spanish introduced the tomato in Texas. After 1815, gardeners grew it in the suburbs of Boston to satisfy the demand of immigrants for fresh and processed tomatoes. In 1816, immigrants brought the tomato from Cuba to New York, marking the second Caribbean introduction to the state. In 1817, one physician planted the tomato in Plymouth, Massachusetts. In 1819, the residents of Ogdensburg, New York, raised tomatoes. Sometime between 1820 and 1840, farmers first grew tomatoes in Camden, South Carolina. In 1824, Thomas Jefferson planted a tomato variety from Mexico and may also have grown cherry tomatoes at Monticello. In 1829, farmers planted the tomato in Morristown, New Jersey, the same year the tomato may have been introduced to Salem, New Jersey. By the 1830s, farmers grew the tomato throughout the Delaware River valley. The Spanish introduced the tomato to Hawaii in the 1830s. In 1833, farmers raised the tomato in Salem, North Carolina. In some households, people ate tomatoes in some form at every meal, taking them with eggs, meat, poultry, and fish. Tomatoes were made into pastries, pies, tarts, marmalades, jams, and jellies. Farmers even fed tomatoes to cattle and hogs. By the 1850s, grocers sold more tomatoes than any vegetable.

The belief that the tomato was toxic may have slowed its migration, though it is difficult to know how prevalent this belief was. However widespread, it gave rise to two legends. The first was to have occurred in 1819, when Jefferson was traveling to his summer home. On this trek he passed through Lynchburg, Virginia, where he came across a garden with ripe tomatoes. Finding a girl at home, he asked her whether anyone would eat them. Recoiling in horror, she replied that no one would eat them because they were poisonous. Jefferson, determining to allay her fears, asked her to bring him a tomato, which he ate in her presence. Her astonishment gave way to wonder, as Jefferson showed no sign of illness. Having made a convert, he resumed his trip.

The next year Colonel Robert Gibbon Johnson, a veteran of the American Revolution, determined to persuade skeptics that the tomato was wholesome. Buying seed from South America, he announced to friends and neighbors his intent to grow tomatoes and to eat a basketful on the steps of the Salem, New Jersey, courthouse. On the appointed day, a large crowd gathered in Salem. Expecting to witness death, they instead beheld a hale Johnson, who, true to his word, ate several tomatoes. His survival elicited surprise from the crowd. Yet at least one historian doubts this story. Johnson's escapade, passed down from generation to generation, may not be true. The Salem *Messenger* did not record the feat in any of its 1820 issues. By one account, nobody in Salem grew tomatoes until 1829, making it impossible for Johnson to have grown them in 1820. The legend, however, refuses to die. Since 1987, Salem's inhabitants have held an annual Robert Gibbon Johnson day, on which they reenact the story. In 1988, ABC's *Good Morning America* declared that Johnson was the first person in the United States to eat a tomato. This cannot be true of course if Jefferson ate a tomato in 1819, as his legend claims. It also must be false if slaves from the Caribbean ate tomatoes in the 18th century.

In the 19th century, the demand for tomatoes stimulated the rise of specialty farms near cities. Farmers in New Jersey supplied New York City with tomatoes. Greenhouse growers in northeastern Ohio produced tomatoes for Cleveland. Wherever immigrants gathered they hankered for tomatoes. In contrast, farmers in the countryside were slower to adopt the tomato, partly because they were conservative but also because there was little rural demand for tomatoes. Improvements in transportation made it possible for farmers to ship tomatoes great distances. The completion of the transcontinental railroad in 1869 enabled California growers to supply tomatoes to New York City. By the 1870s, Florida emerged as a competitor of California, shipping tomatoes to Chicago and other northern cities. Tomatoes were, however, a perishable crop and before the invention of the refrigerated car, many growers must have made limited use of railroads. Farmers were eager to produce tomatoes in early summer, when supply was small and demand and prices high. In the 19th century, the most successful growers reported sales of several thousand dollars. The high prices of early summer justified transportation costs, allowing growers in the South to ship tomatoes to northern cities. By midsummer, tomatoes glutted the market. With supply outrunning demand, prices fell and farmers who had not cashed in early made little money. When prices declined in midsummer southern growers, unable to recoup the cost of transportation, exited the market.

In the 18th century, gardeners' and farmers' demand for tomatoes was strong enough to support the existence of at least one seed company, Landreth Seed Company, which may have been the first in United States to sell tomato seed. As early as 1800, seedsmen sold tomato seed to farmers near Philadelphia, in 1807 to farmers near New York City, in 1810 to farmers near Baltimore, and in 1827 to farmers near Boston. By the 1830s, tomato seeds were sold throughout the United States. The popularity of the tomato in the 1830s and 1840s benefited seedsmen. In 1833, Boston had a single seed store, which sold only 1 pound of tomato seed. In 1851, Boston seedsmen sold more than 1,000 pounds of tomato seed.

American manufacturers began making ketchup in the 1830s. (Ketchup may have originated in Malaysia and China.) In 1876, H. J. Heinz Company began selling ketchup. In 2007, the company sold 650 million bottles of ketchup worldwide. In the 1850s, manufacturers first canned tomatoes, making it possible for consumers to enjoy them year-round. In the 1880s, Italian immigrants brought tomato cuisine to the United States, increasing the tomato's popularity. In the late 1890s, Campbell Soup Company first made tomato soup. During the Great Depression, Americans ate more tomato soup than any other food. That decade a can of tomato soup cost 12 cents. Today, Campbell's sells more than 300 million cans of tomato soup per year.

By the Civil War, Southern farmers supplied Northern cities with tomatoes. The war, however, destroyed many of these farms, leaving Northern farmers to supply their cities. During the war, Bermuda sold tomatoes to the United States. Soldiers in the North and South ate tomatoes as part of their rations. In the North, canning factories supplied the troops with tomatoes. Many soldiers ate canned vegetables and tomatoes for the first time, acquired a liking for them, and returned to civilian life to share their newfound taste for tomatoes with their families. After the Civil War, the Bahamas emerged as a tomato supplier, shipping more than 8,000 boxes of tomatoes to the United States in 1879. By the 1870s tomatoes, peas, and corn were the leading canned foods. By 1879, manufacturers sold several million cans of tomatoes per year, generating millions of dollars in sales.

The Tomato Pill

The belief that the tomato was toxic lingered into the 19th century, though some physicians found other reasons for eschewing it. In Europe, some physicians in the early modern era declared that the tomato was a food of Southern Europe. Because the tomato plant was ill adapted to the north, the tomato was not a suitable food for Northern Europeans. Others believed that the tomato contained no nutrients. Some physicians believed that the tomato caused apoplexy, fainting, and stomachache. Others believed that the acid in tomatoes could harm the body. The tomato, they believed, caused the gums to bleed and teeth to loosen. Yet not everyone discredited its value. Renaissance pharmacists recommended tomato juice for cataracts and eye inflammation. William Salmon encouraged the ailing to drink tomato juice as a cure for inflammations of various parts of the body, bladder obstructions, headache, gout, and sciatica. He urged people to rub tomato oil into burns.

In the United States, the enthusiasm for the tomato's health benefits peaked in the 19th century. Physician Constantine Rafinesque believed that the tomato could cure tuberculosis. Dr. Sequeyra declared that longevity would bless those who ate tomatoes. His long life seemed to support this claim. Editor and journalist David Thomas asserted that the tomato decreased fever. In 1831, journalist Horatio Spafford wrote that the tomato cured headache and improved digestion. The most indefatigable apostle of the tomato was physician John Cook Bennett, who, in a series of newspaper and journal articles promoted the tomato as a cure for diarrhea and dyspepsia and a safeguard against cholera. Bennett speculated that an extract of tomato had these curative powers, though the chemical composition of this extract appears to have been unknown.

Perhaps guided by Bennett, physician A. J. Holcombe advertised a pill containing tomato extract. His venture was apparently unsuccessful, though the idea of a tomato pill persisted. Selling the American Hygiene Pill, merchant Archibald Miles met Bennett in 1837. Following his counsel, Miles changed the name of his pill to Extract of Tomato. The pill was, Miles advertised, effective against fever, the common cold, inflammation of the chest, rheumatism, pleurisy, and "acute diseases." Miles boasted that it could even cure syphilis. Amassing endorsements from physicians and journalists, Miles distributed Extract of Tomato nationwide. In 1837, demand was so strong that he ran short of pills.

Predictably, competitors arose, the most successful of them Guy Phelps. Whereas Miles claimed to have derived his extract from the fruit, Phelps purported to have obtained his from the leaves and stalks. The two traded insults. Their charges were probably justified. If Phelps's pill really had ground-up leaves and stalks, it should have made people sick rather than cured them. An inquiry into Extract of Tomato revealed no tomato. Miles had duped the public. Demand for tomato pills collapsed in 1840, leading Miles and Phelps to pursue other schemes.

The Tomato in the Modern World

The tomato is part of Middle Eastern and Mediterranean cuisine. The Spanish add it to bread, and Italians use tomato sauce to flavor meat, pasta, pizza, poultry, fish, and vegetables. Manufactures make tomatoes into juice, soup, paste, and ketchup. The tomato is the world's leading processed fruit, surpassing even oranges. More than 25 percent of the tomato harvest is processed into juice and other products. Worldwide, farmers produced hundreds of millions of tons of tomatoes in 2008. China, producing the most tomatoes, yielded millions of tons. Trailing only China, the United States produced several million tons. Other leading growers were Turkey, India, and Italy. These figures omit the large but incalculable quantity that home gardeners grow. In the United States, as many as 40 million home gardeners grow tomatoes. The leading state, California produces the vast majority of U.S. tomatoes. Both a tomato importer and exporter, the United States imports hundreds of thousands of tons of tomatoes per year, most of them from Mexico. U.S. farmers gross billions of dollars per year in the sale of tomatoes.

Since 1975, Seed Savers Exchange has collected more than 1,000 tomato varieties. The Tomato Genetics Resource Center has several thousand varieties. The National Seed Storage Laboratory has amassed an equally impressive collection of varieties. In 1984, the National Aeronautics and Space Administration launched several million tomato seeds into orbit around Earth. In 1990, astronauts from the space shuttle *Columbia* retrieved the seeds, distributing them to millions of schoolchildren in all 50 states. Critics feared that the seeds, having been exposed to all types of electromagnetic waves in space, would produce mutant plants, but the tomato plants that germinated from these seeds were normal. In 1994, Calgene Fresh Incorporated derived the first genetically engineered tomato by suppressing the gene that controls how rapidly a tomato softens after picking. This Flavr Savr tomato had longer shelf life than conventionally bred tomatoes.

Christopher Cumo

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Triticale

A human construct, triticale (*Triticale hexaploide*) is a hybrid between wheat and rye. Wheat, providing the ovum, is the female line, and rye, supplying the pollen, is the male line. The initial crosses used bread wheat, though the most successful triticales have durum wheat as the female line. Triticale is thus a cross between durum wheat (*Triticum durum*) and rye (*Secale cereal*). Triticale is a contraction of the parental genera *Triticum* and *Secale*. Ideally, triticale combines the best traits of both parents. From wheat, triticale derives the attributes of making pasta, bread, and pastries. From rye, triticale derives resistance to several diseases, drought tolerance, hardiness, and suitability for infertile soil. Triticale resembles wheat more than rye. From a distance, a field of triticale looks like a wheat field. A grass in the Poaceae or Gramineae family, triticale is related to barley, bamboo, sugarcane, and oats, in addition, of course, to its relation to wheat and rye.

Origin

Humans selected the crops we know more than 3,000 years ago in the Neolithic Revolution. Since then, few new crops have emerged. (Sugar beet is an example.) Triticale is the first new grain since the beginning of agriculture. In 1876, Scottish botanist Alexander Stephen Wilson crossbred rye and bread wheat. Like many hybrids, however, triticale was sterile and so of no benefit to farmers. The chromosomes of triticale did not pair up as they must in all but haploid organisms, and so even though the hybrid yielded pollen and ovum, they were not viable. The initial interest in triticale, therefore, was confined to scientists rather than farmers. In 1891, German botanist Wilhelm Rimpan partially solved the problem of sterility by breeding a partly fertile triticale. In 1937, botanists discovered that the chemical colchicine doubled the number of chromosomes in a plant. The next year Swedish plant geneticist Arna Muentizing applied colchicine to triticale. By doubling the number of chromosomes in the pollen and ovum, colchicine enabled them to pair, restoring their viability. Triticale treated with the chemical was fully fertile. Because the first triticales were made with bread wheat, they were octoploids, having eight pairs of chromosomes, six pairs from wheat and two pairs from rye. In 1948, scientist Joseph G. O'Mara crossbred durum wheat with rye, producing a hexaploid with six pairs of chromosomes, four pairs from durum and two pairs from rye.

Hard Times

When it was created, one scientist called triticale "a modern miracle." By the 1960s, farmers grew the grain on thousands of acres, chiefly in Europe. By 1969, farmers in Hungary planted triticale on hundreds of thousands of acres, feeding the harvest to livestock, but the golden age of triticale was brief. The Canadian research program, a leader in triticale improvement, produced unsuitable specimens with low yield, susceptibility to several diseases, and lodging, shriveled seeds, and only partial fertility. Seedsmen worsened matters by inflating claims of triticale's performance. When farmers obtained poor yield and other undesirable agronomic traits, they felt deceived. Triticale acquired a poor reputation. Researchers backcrossed triticale with wheat to obtain desirable progeny. The result was triticale with more protein and more of the amino acid lysine than wheat. Yet the old problems persisted. In field trials, triticale yielded half the grain of wheat. Some triticale flowers were still sterile. The grain was shriveled rather than plump. Triticale was not adaptable to a range of soils and climates. Tall with weak stalks, triticale was susceptible to lodging. Grains sprouted in humidity. Seeds germinated poorly. Triticale was susceptible to stripe rust, a disease common in cool, wet areas. The Canadian varieties, derived during the long days of Canada's summers, matured late and so were unsuitable to areas with short days. Triticale, derived from durum wheat, did not make bread as well as bread wheat did.

The 1960s and 1970s were initially unkind to triticale. In many respects, the crop was premature and had problems to resolve. In the 1970s agriculture, fueled by the Green Revolution, entered a period of prodigious growth. Wheat was in surplus worldwide. There seemed to be no need for yet another grain to deflate prices by exacerbating the problem of oversupply. Universities canceled research on triticale and might have truncated its history.

The Renewal of Hope

But the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, determining that triticale could ease hunger in Africa, Asia, and Latin America, the targets of the Green Revolution, continued its breeding program. In 1967, a chance pollen grain from a dwarf wheat blew onto the stigma of a triticale flower. This is known as a backcross, although in this case it was accidental. This new variety, the renowned Armadillo, had high yield, set seeds well, could be grown at varying day lengths, was a dwarf with a stout stalk to resist lodging, and matured early, though grain was still slightly shriveled. So promising was Armadillo that breeders backcrossed it with wheat and rye to derive new varieties. By 1970, nearly every variety released by CIMMYT had Armadillo in its lineage. Some of these varieties had suitable levels of the protein gluten for making bread.

By 1988, 32 countries grew triticale. Most of the harvest fed livestock. Triticale was still not ideal for making bread because it produced sticky dough that clung to the mixer and so must be mixed with wheat flour to achieve dough that rolled easily off the mixer. Shriveled seeds persisted when triticale was grown on marginal land. When it and wheat were grown on infertile soil, triticale yielded more grain. Herein lies its virtue. On the marginal lands in the developing world, triticale may provide a yield advantage and thus stave off hunger. Global warming may subject agriculture to fluctuating conditions, and triticale may be adaptable enough to meet these conditions better than other grains. Triticale required less fertilizer, lime, and pesticides than wheat. On fertile land, triticale and wheat had comparable yields. Triticale was more resistant than wheat to leaf blotch, powdery mildew, smut, and bunt. Like rye, it was, however, susceptible to ergot, a fungal disease that has caused much misery throughout history. Birds did not afflict triticale because of its seed husks and awns. Of all the grains, only oats are more nutritious than triticale. Triticale is 19.7 percent protein compared to 12.6 percent protein for wheat. About 90 percent of triticale protein is digestible, a percentage similar to wheat and better than rye. Triticale has 3.1 percent fiber, 1.6 percent fat, 0.12 percent calcium, and 0.44 percent phosphorus. Triticale has more potassium, phosphorus, sodium, manganese, iron, and zinc than wheat. Triticale has as much thiamine, biotin, folic acid, pantothenic acid, and vitamin B6 as wheat but less riboflavin and niacin. Triticale has more thiamine, niacin, biotin, folic acid, pantothenic acid, and vitamin B6 than rye but less riboflavin. Triticale has about the same number of calories as wheat. Triticale is more suitable than wheat for dry conditions, sandy soil, acidic or alkaline soil, mineral-deficient soil, and soil with too much boron. On acidic soil in Poland, Kenya, Ethiopia, India, Ecuador, Brazil, and Mexico, triticale yielded more grain than wheat. Oregon farmers grew Flora, a variety suitable for alkaline soil. In Australia, triticale was grown on soil deficient in copper, manganese, and zinc. In Australia, triticale outyielded wheat on soil with excessive boron.

Triticale may be a substitute for soft wheat for making cookies, cake, biscuits, waffles, pancakes, pasta, and tortillas. Triticale may be used to produce unleavened chapattis, a staple flatbread of southern Asia. The people of Michoacan, Mexico, used triticale to make tortillas. Triticale may be used to make conchia, a bread with molasses, in Mexico. Ethiopians used triticale as a substitute for teff and buckwheat in making the flatbread enjera.

In the 1960s, the United States planted hundreds of thousands of acres to triticale, but little demand developed, particularly for food. In the United States, much of the harvest fed livestock. The American West grew most triticale, though the South planted winter triticale for pasture. The leading producers were Washington, Texas, California, and Kansas. In 2009, the world produced millions of tons of triticale. The leading producers were Poland, Germany, France, Belarus, and Australia. Triticale may find a market as pizza dough, breakfast cereal, and biofuel. It may be fed to cattle, sheep, pigs, goats, and chickens.

Christopher Cumo

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Tulip

A perennial bulb, the tulip acquired its name by accident. In the 1550s, Austrian diplomat Ogier Ghiselion de Busbecq, stationed in Turkey, came across a tulip. Struck by its beauty, he asked his interpreter the name of the flower. The interpreter likened it to a turban. Because the Turkish word for turban is *tulbend*, Busbecq mistakenly thought it was the flower's name, rendering it in Latin *tulipa*. According to a variant of this account, Busbecq overheard someone compare a tulip to a turban and assumed the name to be *tulipa*. The Portuguese retain *tulipa* as the name for the tulip. In French, *tulipe* means "tulip." In Italian, the word is *tulipano*, in Spanish and Danish *tulipan*, in Dutch and German *tulpe*, in Swiss *tulpan*, and in English "tulip." In 1753, Swedish naturalist Carl Linnaeus classified three species of tulip: *Tulipa gesneriam* in honor of Swiss physician and botanist Conrad Gesner, *Tulipa sylvestris*, and *Tulipa breyniana*. Others classified three additional species in the 18th century, with many more to follow in the 19th and 20th centuries. At least one early enthusiast mistook the tulip, a member of the Liliaceae family, for a lily.

Origin and Cultivation in Turkey

So close is the association between the tulip and the Netherlands that many people erroneously assume that the ornamental originated there. A plant of the mountains, the tulip more likely originated in the Pamir-Altai Mountains of Uzbekistan, Kyrgyztan, and Tajikistan. A second center of genetic diversity, the Caucasus

Mountains must have been an early site of tulip colonization. Of the 120 species of wild tulip, three-quarters are native to central Asia. From central Asia the tulip spread, probably without human aid, east to western China, Kashmir, India, and the Himalayan Mountains and west to the Atlas Mountains of northwestern Africa and to Israel, Syria, Iraq, and Lebanon. In the wild, tulips may be found about 40° north, from Ankara, Turkey, to China. Today, wild tulips may be found in Spain, the North African, European, and Asia coasts of the Mediterranean, Turkey, the Middle East, Iran, central Asia, China, and the Himalayas. In the wild, tulips grow as far north as southern Siberia. The wild tulip *Tulipa schrenkii*, native to the Crimea, the Caucasus Mountains, and Kurdistan, may be the ancestor of cultivated tulips.

The Turks appear to have been the first people to cultivate the tulip. Before the 11th century CE, the Turks knew only 1 species, but it may not have been cultivated this early. Perhaps 4 species are indigenous to Turkey, though the country now has 14 species. Cultivation must have begun before the 16th century, when Europeans became aware of Turkey's passion for the ornamental. The Turks called the tulip *lale*, whose letters form the name Allah in Turkish. Accordingly, the Turks believed the tulip to be a divine plant. The tulip was the official flower of 16th-century sultan Suleiman the Magnificent and is today the national flower of Turkey. In the 16th century, Sultan Murad IV's historian collected 7 tulip species from Iran, planting them in Istanbul. In 1574, Sultan Mohammad Babur brought tulips to India. The sultan planted hundreds of thousands of bulbs in the royal gardens in Kefe, which is today in the Ukraine. The tulip trade must have been vigorous in Istanbul, whose mayor published a list of prices in the 16th century. Merchants who sold tulips above these prices risked exile. During the 17th century, the Turks began breeding tulips to derive new varieties. The people of Turkey favored tulips with thin, spiked petals whereas Europeans preferred round, wide petals. The tulip may have reached the apex of popularity in the early 18th century, during the reign of Sultan Ahmed III, who hosted lavish parties in which tulips enhanced the festive atmosphere. So enormous was Ahmed's desire for tulips that it outstripped domestic supply. The sultan imported millions of bulbs from the Netherlands. In the early 18th century, Turkey's Grand Vizier, who had several hundred thousand bulbs in his garden, was known as Lalizari, meaning "tulip lover." The Turks held tulip festivals during a full moon. By one account, the Turks cultivated thousands of varieties. After Ahmed's death in 1730, Turkey's passion for the tulip subsided though it remains strong today.

The Tulip in Europe

By one account, ship captain Lopez Sampayo introduced the tulip to Portugal in 1530, giving it to the king. From Portugal, the tulip spread to Flanders, perhaps in the 1530s, and to France by 1546. That year French traveler Pierre Belon observed tulips in Turkish gardens. He may have been confused about the ornamental, which he called red lily. Belon remarked that the flowers were fragrant, though he apparently did not take them back to Europe. In 1554 Busbecq, sure that tulips would grow well in Europe, sent bulbs and seeds to Dutch botanist Carolus Clusius. Packing them in sugar, Clusius ate tulip bulbs with oil and vinegar. During World War II the Dutch, short of food, would eat tulip bulbs. By 1593, Clusius had established a garden in Leiden, Netherlands, in which he grew tulips. The garden may have been the finest in Europe, though Clusius rejected repeated requests to sell some of his tulips. At last he named a price so high that no one could afford his tulips. Perhaps resenting Clusius's garden, thieves stole his tulips one night. Using seeds to increase the population of tulips, the thieves sold them throughout the Netherlands. When Busbecq returned to Austria, he planted tulips in Vienna's royal garden.

Once introduced to Europe, the tulip spread rapidly. In Augsburg, Germany, in 1559, the tulip migrated to Antwerp, Belgium, in 1562; throughout Belgium by 1583; to Middleburg and Lucerne, Switzerland, by 1596; and to Montpellier, France, by 1598. In 1561, Conrad Gesner published the first European description and illustration of the tulip. Gesner established Turkey as the source of Europe's tulips. In these early years, confusion arose over the tulip. In 1565, Italian physician and botanist Pier Andrea Matthioli mistook the tulip for narcissus.

As in Turkey, the tulip emerged as a marker of status in Europe. Aristocrats cultivated it. The Margrave of Baden-Durlash spent thousands of florins on tulips per year, 50 times the annual wages of a washerwoman. In the 17th century, Italy's Duke of Sermoneta counted tens of thousands of tulips in his garden. Perhaps because the tulip was a status symbol, it commanded high prices. In the, century, in an incident separate from tulip mania in the Netherlands, a French beer maker traded his brewery worth tens of thousands of francs for a single bulb. Underscoring the high status of the tulip, scholar Charles de la Chesnes-Monstereul remarked that it stood at the apex of plants as humans were at the pinnacle of animals and diamonds occupied the zenith of gems. As had royalty in Turkey, French king Louis XIV grew tulips, though his successor Louis XV preferred exotic plants.

In the 1540s, migrants from Flanders and France may have introduced the tulip into England. Another possibility is that Flemish botanist Matthias de l'Obel brought the tulip to England in 1570. In 1582, writer Richard Hakluyt asserted that Vienna was the source of England's tulips. Despite the possible Flemish and French origins of England's tulips, English herbalist John Gerard supposed that Greece and lands near Istanbul were the source of England's tulips. Gerard noted in 1597 that a friend had grown tulips for 20 years, implying that the cultivation of the tulip in England was at least this old. Gerard remarked that the consumption of tulip bulbs with sugar was "good and nourishing." English gardeners prized tulips for their variety of colors. In the 17th century, English apothecary John Parkinson remarked that some people mistook tulip bulbs for onions and, finding tulip bulbs agreeable, ate them in stew and soup. Like Clusius, Parkinson ate tulip bulbs with sugar. Parkinson described hundreds of varieties of tulip. Evidently believing France to have been the source of England's tulips, English nurseryman John Rea referred to tulips as "French flowers" in the 17th century. Rea catalogued hundreds of varieties of tulip, dividing them into early, mid-season, and late-blooming, a practice that continues today. In the 17th century, John Tradescant, gardener to English king Charles I, grew several varieties in his garden. The ascension of William of Orange to England's throne in 1688 furthered trade between England and the Netherlands. Tulips were part of this trade. In the 18th century, the tulip became a decorative motif on furniture, clothes, silver, and ceramics.

The Netherlands and Tulip Mania

The origin of the tulip in the Netherlands, the bastion of its cultivation, is unclear. One account holds that Amsterdam imported the tulip from Istanbul in 1562. Another tradition accords France the honor of introducing the tulip to the Netherlands sometime earlier. That fact that Dutch florists bought bulbs from Flanders and France may strengthen the assertion that France was the source of the Netherlands' tulips. As in England, the tulip was a decorative motif in the Netherlands, gracing furniture, clothes, and tile. In the 17th century, the Netherlands Royal General Bulbgrowers' Association listed thousands of cultivars.

Dutch fascination with the tulip centered on the phenomenon of breaking, whereby a single-colored flower germinated the next year with more than one color. No one knew what caused tulips to behave this way, leading to speculation. Hucksters sold fertilizer that supposedly caused tulips to break. Others sold pulverized plaster from old walls for this purpose. Still others thought water from dung heaps caused tulips to break. Yet others fertilized the soil with powdered paint in the hope that roots could absorb color. In desperation, some gardeners cut a red tulip in half, doing the same to a white tulip and fastening red and white halves together in the expectation that next year's flower would be red and white. None of these remedies worked, mystifying gardeners and leading to a speculative boom in which one could buy an ordinary tulip cheap with the expectation that if it broke the owner could sell it for a profit.

Why this speculative mania descended on the Netherlands is uncertain. Other nations, notably France, had witnessed steep increases in the price of tulips, but events in the Netherlands were of a different magnitude. Perhaps the Netherlands fell victim to tulip mania partly because Clusius had amassed the finest collection of tulips, leading the Dutch to pay exorbitant prices for the progeny. Moreover, plague had depopulated the Netherlands between 1633 and 1635. With a dearth of labor, wages rose, giving the ordinary worker a surplus income to spend on luxuries like the tulip, though at the apex of prices, workers surely could not have afforded even a single bulb.

Historians date tulip mania to 1634, though the increase in tulip prices began earlier. In 1623, the sought-after Semper Augustus variety fetched 1,000 florins per bulb at a time when the average Dutch worker earned 150 florins per year. By 1633, a single bulb of Semper Augustus commanded 5,500 florins. In a single month, the average price of one variety rose from 46 guilders to 515 guilders. A second variety leapt from 60 to 1,800 guilders. By 1637, the average bulb cost 16,000 stuivers, and Semper Augustus sold for 260,000 stuivers per bulb. In 1638, tulip mania having run its course, a single bulb of Semper Augustus cost 13,000 florins, more than the price of a house in the center of Amsterdam. These prices shut out the gardener, leaving speculators to enter the market. Because one did not know whether a flower would break, speculators bought bulbs without bothering to examine them. Hoping that next year's flower would be broken, allowing them to sell it for a profit, speculators traded on the future rather than on the reality of the present. When sellers outnumbered buyers in 1637, prices tumbled, though we have seen that Semper Augustus held its value. After 1637, many Dutch professed to loathe tulips. A botany professor at the University of Leiden hacked them to the ground with his cane. Lavish paintings of tulips gave way to illustrations that juxtaposed tulips and skulls. The tulip, once a marker of prosperity, now symbolized the transitoriness of life.

The mystery of what caused tulips to break lingered after the demise of tulip mania. In the 18th century, Dutch nurseryman Nicholas van Kampers noted that broken tulips were less vigorous than single-colored tulips. Supposing that infertile soil caused tulips to break, he advised gardeners to plant tulips in poor soil. He also urged the gardener to change a tulip's soil to encourage it to break and to plant tulips in different parts of the garden. The fact that broken tulips were not vigorous was a clue, though only in the 20th century would scientists understand its importance. In the 1920s, the invention of the electron microscope opened a new era in the study of plant pathology. For the first time, scientists could see viruses, and that decade they isolated a virus in broken tulips. Infecting tulips, it attenuated them, causing them to be less vigorous than healthy tulips. By suppressing the primary color of a flower, the virus allowed the underlying white or yellow to become evident. The virus, by weakening tulips, decreased their production of seeds. Because this was so, broken tulips were less common than healthy tulips, keeping their price high. Scientists having identified the virus, botanist E. J. Collins discovered in the 1920s that a species of aphid transmitted it from tulip to tulip. Because this aphid was numerous in orchards, scientists understood why broken tulips were abundant near fruit trees. This virus is the only example of a pathogen that increases the value of a plant. In the early 20th century, the mono-colored Darwin tulip, named for English naturalist Charles Darwin, became popular, supplanting broken tulips.

The Netherlands remains a center of the tulip trade. One Dutch firm exports tulips to the United States, Canada, the United Kingdom, Ireland, Germany, Austria, Hungary, Czechoslovakia, France, Belgium, Luxembourg, Switzerland, Italy, Spain, Portugal, Romania, Yugoslavia, Bulgaria, Greece, Turkey, Russia, Poland, Sweden, Norway, Denmark, Finland, the countries of Africa and South America, Australia, and New Zealand. Today, the Netherlands exports two-thirds of its tulips. This trade, is perched atop a narrow genetic base. Only 20 varieties dominate the trade and just 10 account for half of all tulips grown in the Netherlands.

The New World

The tulip was unknown in pre-Columbian America. The Dutch brought the tulip to North America in the 17th century. In 1624, the American colonists grew tulips on Manhattan Island. New York governor Peter Stuyvesant cultivated tulips. The city fathers of colonial Williamsburg decorated their gardens with tulips. In the 17th century, tulips were grown in Pennsylvania. In 1760, Boston newspapers advertised the sale of 50 varieties of tulip. In the 18th century, Thomas Jefferson and George Washington grew tulips. In the 19th century, the Vanderbilts planted tulips in Biltmore Gardens, North Carolina. The Dutch, migrating west, introduced the tulip to the Midwest. The Dutch Reformed Church planted tulips in Holland, Michigan, and Pella, Iowa. During the 19th century the United States, apparently unable to meet the domestic demand for tulips, began importing them from the Netherlands. By 1910, the United States imported millions of dollars of tulips per year from the Netherlands. The Netherlands reciprocated by buying U.S. wheat and corn. Americans preferred the tulip to several other flowers, and in the early 20th century gardeners bought three times more tulips than hyacinths or daffodils. In 1920, the United States imported tens of millions of tulip bulbs, in 1925 hundreds of millions, and in 1930 still more. Americans were especially interested in tulips that bloomed in late spring. In Germany and Scandinavia, by contrast, gardeners preferred early tulips.

Attributes and Cultivation

Having evolved in the mountains, the tulip tolerates cold winters. The species *Tulipa saxatilis* from Crete survives to 20°F. Others endure temperatures as cold as –20°F. Able to tolerate drought, the tulip flowers in early spring before the onset of hot, dry weather. Needing moisture to flower, the tulip should be supplied with water in spring. When it has ceased flowering, the tulip may receive less water. As the amount of water is restricted, the gardener should let the soil dry before rewatering it. In summer, the gardener may cease watering tulips. The soil should drain well. If it retains too much water, bulbs may rot. To avoid excessive moisture, the gardener may add sand and organic matter to heavy soil. Sand is valuable for its capacity to shed water. Peat is not an ideal growing medium for tulips because it is difficult to rewet when it dries. Tulips prefer alkaline soil, full sunlight, and air circulation to disperse pathogenic fungi. Many wild tulips are diploids. Many of the tulips that humans have domesticated are polyploids, which are large and vigorous but which produce few seeds.

Christopher Cumo

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Turk's Cap Lily

Lilium martagon, in the family Lilacea, is an old-fashioned lily—known in English as the Turk's cap lily or martagon lily—a classic plant from archaic manor parks, cemeteries, and traditional rustic gardens. This robust, but fascinating, species is an old, cultivated ornamental plant and is still common in many gardens. Turk's cap lily is also long living; 50-year-old plants are known, and it can adapt to shade and humidity in gardens and parks. The species has been grown in gardens since the early modern period in Northern and Western Europe. Since it is very hardy, it is suitable for northern climates. It can be found in subarctic gardens in northernmost Scandinavia, as well as in the Faroe Islands. It is widespread as a garden plant over the Northern Hemisphere, but is also found in Australia, New Zealand, South Africa, and many other countries in the south. It has also escaped and became established in meadows in Scandinavia, northern Germany, the United Kingdom, northeastern Canada, and elsewhere.

The erect plant reaches a high of 36 to 50 inches, sometimes even taller in cultivation. Leaves are in a whorl in the middle part of the stem, seldom scattered, lanceolate, and 4 to 6 inches long. Flowers are in a raceme, each 1.5 to 2 inches across, with six oblong, strongly curved back, red-purple perianth segments, shining, nodding, and with a strong but rather unpleasant scent. Tepals are strongly revolute, with a typical Turk's cap shape, hence its English name Turk's cap lily and German *Türkenbundlilie*. The plant name martagon lily is derived from the *martagan*, which refers to the kind of turban (Ottoman

Turkish *martagān*) introduced into the Ottoman Empire by Sultan Mehmed I Çelebi in the early 15th century. It is also called turban lily. However, the shape also caused the Dutch name *krullelie*, which is borrowed as *krollilja* in Swedish and *krøll-lilje* in Norwegian. The gold-yellow pigment of the bulb has given it many locally known German folk names such as *Goldapfel*, *Goldbölla*, *Goldlilie*, *Goldpfandl*, *Goldvorza*, *Goldwürze*, *Goldwurz Goldrübe*, and *Goldzwifl*. It was also earlier known as *guldløg* ("gold bulb") in Denmark. A French name is *Poms d'or.* The 16th-century Italian herbalist Pietro Andrea Matthioli in 1563 gave it the name *Goldwürtz* because of its reputation of having the power to transform metal into gold and therefore being used by alchemists. The bulbs were held in high regard for this quality. It was still in 19th-century handbooks called *alkymistløg* ("alchemist's bulb") in Danish.

Numerous varieties and cultivars exist. Varieties with white, mauve, red, or pink flowers are common in cultivation. Some local wild varieties are also available through nurseries. It is easily grown and survives for generations in gardens. It can be propagated by dividing rhizomes, by bulbs, and from seed.

Cultural History

In its wild state, this plant is widely distributed over a huge area extending from the mountainous areas of Portugal over Central and Eastern Europe through Turkey and the Caucasus Mountains to western China, Mongolia, and Siberia. It is regarded as the most widely distributed lily in the world. The lilies in the eastern part of its distribution (northern Xinjiang and Mongolia) belong to the subspecies *Lilium martagon* ssp. *pilosiusculum.*

The Turk's cap lily has been naturalized in the United Kingdom and has escaped from gardens or is standing as relic of cultivation in meadows and parks in Northern Europe. It was known as a wild plant in continental Europe, and it was referred to as *martagon* in *Codex Bellunensis*, a Venetian herbal, from around 1415. As a medicinal plant, the wild variety was mentioned in various continental herbals in the Middle Ages.

The date of its introduction into garden culture as an ornamental plant has long been disputed, but according to a recent in-depth study from Sweden it was introduced into Scandinavia at the very end of the 16th century and the first half of the 17th century. It seems also to have reached gardens in England in the 16th century. English botanist Henry Lyte wrote in his *A Niewe Herball, or, History of Plantes* (1578) that the species "groweth in some places of Almaigne, as in the woodes, & medowez whose situation or standing is upon Mountaynes; but in this countrey they plante them in gardens." British garden historian John H. Harvey concluded that it was introduced to the British Isles simply as an ornamental plant "after 1548 but shortly before 1568." English herbalist John Gerard mentioned two different kinds of the species in *The Herball* (1597), and in 1629 English herbalist

John Parkinson was acquainted with five different kinds of *Lilium martagon*. The species became very popular in the 18th century, when few other lilies were available in garden culture. It was later introduced into North America as a garden plant with European immigrants in the early 18th century, and it is recorded from Canada in the early 19th century.

Use

This lily has been grown first and foremost for ornamental purposes. It is still common in Scandinavian, Baltic, and British gardens. A lot of cultivars are available in the trade. Among them are Backhouse, Harzmärchen, High and Low, Netherhall Pink, Plenum, Red Russian, Townhill, and Wood Nymph. Many hybrids with other lilies are used in gardens as well. Nearly 220 hybrids were once registered in the martagon section of the now defunct Online Lily Register by 2010.

However, it has had some other uses as well, as recorded in the ethnographic literature. This is mostly true for lily specimens harvested in the wild rather than for those growing in garden. For instance, in the alpine areas of Central Europe it was said that if the cows were fed with the bulbs, they would produce nice yellow butter. It has had some medicinal use in some parts of Western and Southern Europe but also in Asia. The Irish, and they must have taken it from their gardens, made a remedy of the bulbs for boils and swellings. The Germans have used it to treat hemorrhoids. In Styria, it was once used to treat colic. The Albanians used the bulbs of the plant, known locally as the *bar thamti*, "herb of the liver," to treat liver diseases, since the color of the flowers resembles that of the liver. According to some reports, the bulbs possess cardiotonic properties and are used externally in the treatment of ulcers.

In Russia, Siberia, and Mongolia the bulbs, which are rich in starch, were gathered by the locals as food. Known as *sarana* in Kazakh and Russian, they were collected in the wild state with a digging stick or by harvesting them from rodents' nests. The plundered nests contained large amounts of bulbs and they were of very good quality. The bulbs were eaten with meat or cooked separately in milk or water. It is a well-known plant in the Altaic area and therefore also used in folklore, for instance in riddles.

Due to its beauty, hardiness, and ease of growth, Turk's cap lily has remained popular as an ornamental plant in traditional cottage and woodland gardens, especially in northern regions. Bulbs from many cultivars are available through nurseries. However, its popularity is now often superseded by many more colorful and striking hybrids, and they will certainly replace it in more modern gardens.

Ingvar Svanberg

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Turnip

In the Brassicaceae or Cabbage family, turnip (*Brassica rapa* ssp. *rapitera*) is related to rutabaga, which is a hybrid between turnip and cabbage. A biennial grown as an annual, turnip fills its hypocotyl, what many people mistake as a root, in the first year and flowers and seeds in the second. The hypocotyl has vitamin C, calcium, and iron. The leaves have beta-carotene, the precursor of vitamin A, and several B vitamins.

Origin and History

The turnip may have arisen independently in the Mediterranean Basin and eastern Afghanistan and Pakistan. One writer posits an origin in Europe or western Asia about 2000 BCE. A third pinpoints northeastern Europe or Asia as the cradle of the turnip. Turkey, Iran, and Transcaucasia may have been a secondary center of origin. Wild species may be found in Russia, Siberia, and Scandinavia. The Celts and Germans may have been the first to cultivate turnip. By the time of Christ, the Greeks and Romans grew turnip. The Romans preferred the flavor of turnip to that of carrot. Legend holds that a Roman general refused to give his meal of turnips to the enemy in exchange for a bag of gold. The Romans introduced the turnip into Britain and France. Before the Columbian Exchange brought the potato to Europe, turnip was the staple, especially in the Middle Ages. Because the masses ate turnips, the wealthy thought them fit only for commoners. Although many aristocrats refused to eat turnips, the Duke of Orleans, France, served them to his guests in 1690. The advent of the potato in Europe left turnip a famine food. Because of its association with hard times and poverty, turnip was known as "poor man's food."

The 18th-century British agriculturalist Charles "Turnip" Townshend was not ready to jettison the turnip. He turned a critical eye to stockmen. Because hay was expensive, stockmen could afford to keep few animals through winter. Consequently, they butchered much of the herd in autumn, leaving them with a glut of meat, much of which spoiled in an era before refrigeration. Townshend thought this practice wasteful and proposed to feed turnips to livestock through winter.

His idea gained adherents and a new role for the turnip. Today, stockmen still feed turnips to their animals. British stockmen feed turnips to sheep and pigs. Moreover, turnip has not ceased to be food. People still eat it in the United Kingdom, Germany, Poland, Russia, and the Czech Republic. They eat turnip with potatoes or add it to soup and stew. In addition, turnip is used in roasts, casseroles, and salad or cooked as a side dish.

Just as the Columbian Exchange brought the potato to Europe, it carried turnip to the Americas. Canada received the turnip in 1540, Mexico in 1586, Virginia in 1610, and New England in 1628. Admittedly, the turnip is not popular in the United States, though southerners still prize it for its leaves. The United States, the United Kingdom, and Japan have amassed collections of turnip varieties, but these countries are making little effort to breed new cultivars. Japan plants hybrids, but the United States has been slow to adopt them. Hybrids yield large hypocotyls and a large number of leaves.

Attributes and Cultivation

In its second year, we have seen, turnip flowers. These flowers attract insect pollinators. Each flower has two stamens, an ovary, and two nectaries to draw insects to it. When reproduction is imminent, flowers open around 8 a.m. and anthers shed pollen between 10 a.m. and noon. Pollen is most fertile at and one day before anthesis. The stigma is receptive to pollen two days before and two days after anthesis. Breeders aim to derive cultivars with high yield, earliness, slowness to bolt, and resistance to white rust, phyllody, club root, powdery mildew, turnip mosaic virus, cabbage root fly, turnip root fly, and aphids.

Preferring full sun, turnip matures between 35 and 70 days. Seeds germinate in 3 to 7 days at 68°F to 86°F. The plant grows best between 70°F and 80°F. Leaves grow 10 to 12 inches tall. The tops of some varieties are even larger. Turnip may be grown in a range of soils as long as they are deeply cultivated. The gardener should apply potassium to the soil because turnip is a heavy feeder of this element. The soil should be slightly acidic, with a pH between 5.5 and 7. A thirsty crop, turnip should be watered frequently. The gardener may plant turnip in spring, late summer, or autumn. A planting in late summer or autumn yields the best flavor. Autumn turnips store longer than spring turnips. Seeds should be planted 0.50 inch deep in rows one to two feet or 16 inches apart depending on whom one consults. The gardener who desires only greens may plant seeds close together. Otherwise, seedlings should be thinned so that plants are 6 inches apart. Some gardeners interplant turnip with corn. The gardener may pick leaves when they are 4 inches long. Those who grew turnip for the hypocotyl may harvest only as much as they need for a meal, leaving the rest in the ground for later picking. White turnips usually grow fastest, though they do not store as well as yellow turnips. White turnips are less hardy than yellow turnips.

Cultivars

Bred in the 1780s, Waldoboro Greenneck is named after Waldoboro, Maine, although it may have originated in France. Legend holds that seeds of this variety washed ashore, presumably in Maine and presumably from a French shipwreck. Waldoboro Greenneck has a large, white hypocotyl and blue-gray leaves. The variety matures in 50 days. Today, it is difficult to find.

Seven Top, known as Foliage Turnip or Southern Prize, was bred in 1845. One may harvest the leaves several times. The leaves, growing between 16 and 22 inches, regrow after each harvest. Leaves mature in 45 to 50 days. The hypocotyl is tough at any age and unsuitable for consumption. Perhaps because the variety is grown for its leaves, Seven Top is popular in the South. Because winter is mild in the South, gardeners cultivate the variety in winter and early spring. Southern Exposure Seed Exchange counsels chicken growers to plant Seven Top. The leaves attract harlequin bugs, which chickens will eat.

Tokyo Cross Hybrid matures in 35 days and should be picked when the hypocotyl is two inches in diameter. In 1855, Americans imported Golden Ball from a London, England, seed company. Farmers grew it with 26 other varieties, judging Golden Ball the best. Maturing in 45 to 65 days, Golden Ball yields a golden yellow hypocotyl. The flesh is claimed to be sweet, tender, and mild. It may be mashed. The variety is ready to harvest when the hypocotyl is three to four inches in diameter. It stores well.

Dating before 1865 Snowball, with its round, white hypocotyl, resembles a snowball. Maturing in 50 days, Snowball is ready to pick when the hypocotyl is three or four inches in diameter. The flesh is reputed to be juicy and crisp. If left in the ground too long, the hypocotyl becomes tough.

Gilfeather is named for its late-19th-century creator, John Gilfeather of Wardsboro, Vermont. The hypocotyl is egg shaped and white. The variety matures in 70 to 85 days. The gardener should pick it before the hypocotyl becomes large and tough. Picked early, Gilfeather is sweet. The tops, prized for their flavor, should also be picked early.

Purple Top White Globe, known as Veitch's Red Globe, has been cultivated since 1880. It remains popular today. The round hypocotyl has a purple to purple-red top and a white bottom. The gardener may pick the hypocotyl, which has mild flavor, when it is 3 or 4 inches in diameter. It may be eaten fresh or mashed. Purple Top White Globe matures in 45 to 65 days. Leaves should be picked when they are 14 to 22 inches long. Purple Top White Globe stores well. Cultivated since the 1880s, White Egg, with a round, white hypocotyl, resembles an egg. Maturing in 48 days, White Egg is said to have tender, sweet flesh.

Christopher Cumo

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V

Vanilla

The only fruit-bearing orchid among thousands of species, vanilla is widely used in cooking and for its scent. The Aztec name for the vanilla bean is *tlilixoxchiti*, which means "black flower" and refers to the vanilla bean pods' thin black wisps. The primary name for vanilla comes from the word *vainilla*, derived from the Spanish diminutive, which literally means "little sheath."

History

The first recorded instance of its cultivation was found in Mesoamerica (Pamplanta, Mexico). The Spanish conquistador Hernán Cortés is credited with introducing vanilla and chocolate to Europe in 1520. In fact, vanilla was first presented to Europeans when the Spaniards found the Aztecs using it to flavor chocolate. In the last century, there has been a burgeoning demand for this plant since it does have a very distinctive taste and is used so widely all around the world. The vanilla plant is one of the more expensive cultivated plants available, but although the plant remains expensive, vanillin can also be synthesized cheaply from petroleum and paper mill wastes. However, the vanilla made by this process has a distinctly different taste and quality from natural vanilla.

The vanillin substance is what makes this orchid such a desirable cultivated plant and why it is sought out for use in cooking. Vanillin is what gives the plant the characteristic fragrance that it is most noted for. The vanillin is not produced by the seeds of the vanilla plant, but by the microscopic hairs that exist within the fruit wall.

Attributes

Although the vanilla plant belongs to the orchid family, it has confused taxonomists for years because, while easily categorized among primitive orchids in many respects, the vanilla plant shares one characteristic possessed only by advanced orchids, which is a single fertile anther (the pollen-bearing part of the plant) that is incumbent. Also, although the stems of the vanilla plant are bent, they are not bent in the usual way, but hyperincumbent, meaning they bend downward and continue to curve a full 180°.

The pollination of the vanilla plant is also unique, as certain insects and birds are needed to pollinate it. However, the vanilla plant has what could be called a "backup" plan in case its flowers are not pollinated. Unlike many other plants in

Vanilla beans (iStockPhoto)

the orchid family, many of the flowers of the vanilla plant do not wither and fall away even after they develop into seed-bearing fruits. The sepals (the leaves of the flower) will eventually disappear after instances of pollination from insects and birds.

The several species of the vanilla plant include *Vanilla planifolia*, "Oreja de Burro," literally meaning "donkey ears," which has yellow leaves with green stripes. The *Vanilla planifolia* species is the most common and typical in plant cultivation; *Vanilla pomplona*, *Vanilla grandifolia*, and *Vanilla tanehensis* all contain varying amounts of vanillin, which is a crystalline substance that functions as an enzyme working on a glucoside (sugar-producing substance) in the pods.

Each species of the vanilla plant has different features, depending on the stem morphology. There are four different leafless species of the vanilla plant found in the Caribbean and southern Florida, including *Vanilla barbellata*, *Vanilla dillonia*, *Vanilla clavicatula*, and *Vanilla poetaie*. Leaves grow initially in these species, but then they eventually rescind and break off. Although *Vanilla poetaie* is considered leafless, it exists in between a leaved and leafless state.

Vanilla planifolia is the species of vanilla most widely demanded on the consumer market, because of the flavor it offers. However, fresh vanilla lacks the desirable aroma and taste that cultivated vanilla possesses. The cultivated vanilla is expensive, and its price is mainly due to the vanillin extract.

Vanilla is most widely grown in the subtropics of Asia, Northern Europe, and Canada. Currently, Madagascar is the world's largest producer of the vanilla flower. Vanilla is a vine flower or *epiphyte*, meaning it is a tree climber, and grows on tall branches. The vanilla vine is formally known as a hemiephyite, a plant that begins as an epiphyte but later grows roots in the ground. The vines of the *Vanilla planifolia* plant can reach heights of up to 20 feet. The vanilla plant bears many thick leaves with distinct parallel veins. Some vanilla plants have a rough, warty texture. The Mansa cultivar of the vanilla plant is the most commonly grown of the vanilla vine and has been widely cultivated since the 19th century. The leaves of the Mansa plant are glossy, green, and straight.

The discernible characteristics of each species of vanilla plant lie in the different textures and colors of the leaves. The Caribbean species of the plant often has an orange color when grown in the full sunlight. Since it is a climber, if left unattended, the vanilla plant will grow on existing poles or branches and can reach a staggering height of over 80 feet. Sometimes the vanilla plant can be found in multicolored blotches, because of parasitic lichens and epiphyllous bryophytes (a kind of moss that grows on leaves).

In leafless species in Africa and Asia, the stems and roots are the primary photosynthetic organs. The leaves of the vanilla plant contain sticky, liquid mucilage, which is composed of chemicals such as carbonate and calcium oxalate. Although this sticky substance is mainly harmless, those who work around it can develop skin rashes, called *vanilinitis*, because of its active ingredients.

The length and width of the stems also vary among the different species of the vanilla plant. Some species have thin stems (*Vanilla bicolor*), while the stems of other species like *Vanilla grandiflora*, the species most well known for its appealing and beautiful foliage, and *Vanilla pomplana* can be as thick as a baby's arm. In most species, the stem is smooth and green.

The vanilla flower is a hermaphroditic flower, meaning that it has both female and male stems. The vanilla flower carries anther flowers (male) and stigma (female), which are separated by a membrane. The stems of the vanilla flower are dark green and are fleshy and veinless. They are an alternating oval and sessile and have a framework, which supports the entire plant. Vanilla has aerial roots, which cling to trees and occur in thin reams of 20 or more blossoms. The vanilla bean is linear and flattened with narrow and wrinkled aerials.

For successful integration in the home, a vanilla plant must be potted in a soil rich with nutrients and, ideally, with compost. Vanilla plants are heavy feeders and require a great deal of care.

Nutritional Value

The vanilla plant has many nutritional and health benefits, although it is more commonly known as being used for flavoring in cooking. The plant can be a remedy for many health concerns and can even enhance sexual pleasure. There are several beneficial attributes of the vanilla plant, and vanillin has a great deal of nutritional value. The vanilla extract is comprised of many essential vitamins, minerals, and complex sugars, including small amounts of niacin, riboflavin, and vitamin B6.

These nutrients help with enzyme synthesis, enhance the nervous system, and regulate the body's metabolism. In addition to nutrients that vanilla contains in the B-complex group, vanilla also contains the minerals iron, zinc, calcium, magnesium, potassium, and manganese. Vanilla oil is also a rich and excellent source of nutrients. This essential oil can work as an antioxidant, antidepressant, and aphrodisiac (it has been said to be effective in helping with erectile dysfunction). Vanilla may increase sexual arousal and sexual performance and has been known as a powerful aphrodisiac throughout history and in folklore. Xanat, the Mexican goddess in a Mesoamerican mythical tale, turned herself into a vanilla plant because she was unable to marry a man; thus for centuries, the vanilla plant has been acknowledged as being a plant related to lust and desire.

The vanilla plant can also act as a febrifuge or fever reducer, because it contains elements like eugenol and *vanillin* hydroxybenzaldehyde, which are compounds present in vanilla oil. These chemicals may reduce fever, lessen inflammation, and build up the body's immune system. Vanilla oil may also have a positive effect on brain chemistry.

Surprisingly, the sweet aroma of the vanilla plant can elevate mood and treat depressive illness simply because of its pleasant and satisfying smell. Synthetic vanilla or natural vanillin can both be used for this purpose, and any individual can benefit from how its sweet smell elevates mood. Vanilla also has another range of mood-altering effects such as bringing about calmness, relaxation, and the regulation of unstable moods. Investigative studies may show benefits of vanilla on a control group that was experiencing symptoms of depression. A greater percentage of the participants who used the essential vanilla oil reported an elevation in mood and a great sense of relaxation, as a result of using the healing oils.

All of these may control certain functions of the body and may improve several aspects of functioning, such as maintaining heart rate and blood pressure. Another benefit of using vanilla is that it can be used as a substitute for sugar. Because of its chemical and flavoring properties, vanilla is an acceptable substitute and has a distinct flavor. Using vanilla as a substitute may be healthier, because it has the potential to replace sugar completely.

Some researchers believe that vanilla may work against the possible development of cancer and other degenerative diseases by preventing the damage to cells by oxidants or free radicals, and may act to destroy cancerous tissue and prevent it from spreading. As well as the oil and extract, the vanilla bean may also act as a factor in preventing diseases as well. A 2004 study in the *British Journal of*

Hematology, led by research hematologist Toshio Asakura, found that vanilla extract may treat sickle cell anemia because vanillin may protect red blood cells.

Bonnie Ellman

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Venus's Fly Trap

Arguably the best-known carnivorous plant, Venus's Fly Trap has long excited the curiosity of hobbyists. One gardener credits it with stimulating a lifelong interest in carnivorous plants. Thomas Jefferson, an accomplished gardener, grew the Fly Trap and gave seeds to friends. Declaring it "one of the most wonderful plants in the world," English naturalist Charles Darwin despaired over his inability to cultivate it. The fault may have lain with England's cool climate, though he may have fed his plants too much meat and cheese.

Along with the sundew, Venus's Fly Trap is in the Droseraceae family. The Fly Trap got its name by a circuitous route. In 1768 John Ellis, a fellow of the Royal Society of London, asserted that the Cherokee or Catawba referred to the Fly Trap as *tipitiwitchet*. The meaning of the word is obscure, though the Amerindians of Guiana used a similar world, *tipiti*, to mean a "cassava squeezer." This usage may be analogous to the Fly Trap's ability to squeeze a captured insect. If this link is valid, one historian speculates that African slaves gave the words *tipiti* and *tipitiwitchet* to the Amerindians of the Carolinas and Guiana. *Tipitiwitchet* may instead derive from a twitch-up, a trap for catching small game, especially rabbits. Venus's Fly Trap, of course, catches the smallest game in trapping insects. Another historian offers a lascivious interpretation of the origin of tipitiwitchet. He asserts not only that it is not an Amerindian word but that Ellis or one of his associates coined the term as a euphemism for the vagina, noting the similarity in shape and color between the trap and this part of the female anatomy. In this context, *tipitiwitchet* may mean "toothed vagina." The teeth were apparently the spikes or cilia along the outside of the trap.

Venus's Fly Trap's scientific name, *Dionaea muscipula*, appears to have no connection to the term *tipitiwitchet*. About 1770, American physician Daniel Solander assigned the Fly Trap to the genus *Dionaea*. In Greek mythology, Dione

Venus's Fly Trap (Jordan Tan/Dreamstime.com)

was the goddess of love and beauty. Dione bore Zeus a daughter, Aphrodite, whose beauty was renowned, and the genus name *Dionaea*, meaning "daughter of Dione," refers to Aphrodite, a fitting name given Venus's aesthetic appeal. Solander offered the species name *crinita*, an odd term meaning "tuft of long hair," but this name did not catch on. To the genus name Ellis appended the species name *muscipula*, a word that derives from *mus*, meaning "mouse," and *capio*, meaning

"I capture." The name *Dionaea muscipula* means Aphrodite's mousetrap. Yet Venus's Fly Trap is not known as Aphrodite's mousetrap, surely because Venus was the Roman equivalent of Aphrodite and because it was literally a flytrap rather than a mousetrap. Ellis evidently coined the name Venus's Fly Trap, though the fact that he chose to name it a flytrap is curious because it attracts more ants and other crawlers than flies. Less commonly, Venus's Fly Trap is known as the meadow clam, the flycatcher, and the catch fly sensitive. There are many variants of Venus's Fly Trap, including Venus Fly Trap, Venus Flytrap, Venus flytrap, Venus' Flytrap, and other iterations of these forms. Although he never saw a live Fly Trap in action, Swedish naturalist Carl Linnaeus was so impressed by the nonliving specimen he received (Ellis send him a live Fly Trap but it died before reaching the taxonomist) and the description that Ellis sent him that he named it *miraculum naturae*, the miracle of nature. In 1771, Linnaeus included Venus's Fly Trap in his *Mantissa Plantanum*. The Fly Trap is the only species in the genus *Dionaea*.

History and Cultivation

Its origins unclear, Venus's Fly Trap is native to the American Southeast. Its range remarkably restricted, the Fly Trap inhabits 11 counties in North Carolina and 1 county in South Carolina, though reports hold that its range once extended to 18 counties in North Carolina and 3 in South Carolina. Even the latter range is small. One can survey Venus's habitat by driving 100 miles in any direction from Wilmington, North Carolina. In the wild, Venus's Fly Trap grows in sandy peats on the edge of swamps, fens, and pocosins. Because it grows in nutrient-poor soils, it faces little competition from other plants. In this context, the carnivorous habit give the Fly Trap a selective advantage over plants that need plenty of nutrients from the soil and that consequently languish in marginal land. Venus's Fly Trap may be found in open areas where grasses are more numerous than trees. Growing in the open, the Fly Trap receives abundant sunlight, an important factor given the plant's need to photosynthesize the energy necessary to maintain its trapping equipment. The soil that supports Venus's Fly Trap is wet, bathing the roots in water. In its natural habitat, the Fly Trap receives rain year-round. This water leaches minerals, contributing to the poor quality of the soil. Venus's Fly Trap likes humidity and warmth, inhabiting a region with hot days and warm nights during summer. Snow is infrequent during winter, and temperatures are occasionally low enough to trigger frost. In addition to its native habitat, enthusiasts have introduced Venus's Fly Trap to New Jersey, Alabama, Arkansas, Delaware, Pennsylvania, Virginia, California, the Florida Panhandle, and Jamaica. It is among the flora of the Apalachicola National Forest in Florida. These introductions may prove to be important given the degradation of the Fly Trap's habitat. Farmers have claimed a portion of this habitat for their crops. Developers have pushed

Venus's Fly Trap aside in the rush to build homes, retirement communities, and golf courses. In the name of progress, these people drain wetlands, depriving the Fly Trap of its home. Understandably but shortsightedly, they suppress fires. Fire, when it is allowed to burn, clears the land of vegetation. Because Venus's Fly Trap grows from underground rhizomes, it will regrow unscathed after a fire. Because fire burns other vegetation, Venus's Fly Trap has little competition from other plants. Without periodic fires, trees and brush grow dense, casting this sun-loving plant in shadow. Under threat, Venus's Fly Trap, according to one estimate, numbered little more than 35,000 specimens in the wild in 1992.

The Fly Trap is much more numerous in cultivation, numbering between 3 and 6 million specimens by one estimate. Cultivation is an important means of perpetuating an endangered species. The first efforts to cultivate the Fly Trap date to the 18th century. That century American naturalist John Bartram grew it in his garden, distributing seeds to friends. We have seen that Jefferson cultivated it and shared seeds with friends. In the late 18th century, the French grew the Fly Trap. In the late 18th and early 19th centuries, the Fly Trap was a popular subject for illustrators. Many illustrations depict it in action, a fly ensnared in a trap. In the early 19th century gardeners, fascinated by exotic plants, grew Venus's Fly Trap. Botanical gardens and universities grew it in their greenhouses. The use of the Wardian case in the 19th century made it possible for American enthusiasts to ship Venus's Fly Trap overseas. Because the supply of cultivated plants was small and the price of glass expensive, only the middle and upper classes could afford to cultivate the Fly Trap. As did Darwin, gardeners in Great Britain, having imported the first specimen in 1768, had trouble growing it. The cultivation of the plant suffered during World War I in northern latitudes, when a shortage of fuel prevented many gardeners from heating their greenhouses. In the 1950s interest revived, though nurserymen did not then propagate by seed. Rather, they dug up specimens from the wild for sale to enthusiasts. Law now prohibits this practice, though it apparently continues.

As is true of any plant, the key to cultivating Venus's Fly Trap is the replication of its natural habitat. The gardener, appreciating the fact that the Fly Trap grows in a sandy peat, may cultivate the plant in a soil of one part peat and one part sand. Alternatively, the gardener may make a soil from sphagnum, peat, and sand. A third option is to make a soil of three parts peat and one part sand or vermiculite. To this soil one gardener adds live sphagnum moss, which will stay green when the soil is appropriately wet. Moss that turns brown betrays a soil that is too dry. One must take care to keep the moss within bounds, trimming it as it grows to prevent it from overwhelming the Fly Trap. Overwhelming it, moss may cause the Fly Trap to rot. A small plant, Venus's Fly Trap should not suffer the stress of competing against moss, or against other plants, for space. Nevertheless, sphagnum is ideal because its pH of 3 to 5 gives the Fly Trap the acidic soil it prefers.

Sphagnum is also valuable because it holds 10 times its weight in water, keeping the plant hydrated. Acknowledging the importance of water, the gardener, avoiding the extremes of dry soil and waterlogged soil, should keep the soil wet. To keep the soil in this condition, the gardener may place a potted plant in a saucer of water, taking care to keep the saucer full of water. The quality of water is as important as the quantity. Tap water may contain too many minerals for Venus's sensitive roots, causing them to rot. Soft water is likely to contain salts. Bottled water, even if it claims to be spring water, may have too much sodium. Rainwater is ideal and may be collected from a downspout. In the absence of rainwater, the gardener may use distilled water. As in the wild, a cultivated Venus's Fly Trap needs abundant sunlight. One gardener believes that a deficiency in sunlight leads to the death of more Fly Traps than die from any other cause. One gardener recommends the culture of Venus's Fly Trap in a pot by a sunny window as a way of maximizing its exposure to sunlight. The Fly Trap prefers a comparatively cool morning sun. Afternoon sun, by contrast, may be too hot. In summer, Venus's Fly Trap may receive up to 15 hours of sunlight per day in temperate locales. In winter, the amount of sunlight may diminish to 9 hours per day and may, along with cool temperatures, trigger dormancy. The most valuable light is in the visible spectrum between blue and orange. Blue light energizes vegetative growth, whereas orange light supports the growth of flowers.

Venus's Fly Trap cannot be grown year-round. Growers in the tropics and subtropics find that their efforts at year-round cultivation yield sickly plants that eventually die. A temperate plant, Venus's Fly Trap must be allowed to initiate dormancy. In temperate regions, it may be possible to grow Venus's Fly Trap outdoors as long as the winter is not severe. Despite this cautionary note, the Fly Trap tolerates brief cold snaps. One gardener in Dallas, Texas, grew Venus's Fly Trap outdoors despite winter temperatures below 10°F. The Atlanta Botanical Garden in Atlanta, Georgia, has grown the Fly Trap outdoors in winters with temperatures as low as 0°F. Gardeners have raised the plant outdoors as far north as Vermont. The plant tolerates a range of temperatures, from 14°F to 104°F. The ideal temperature ranges from 68°F to 95°F.

Venus's Fly Trap produces traps throughout the growing season in a cycle of death and rebirth. When a trap blackens and dies, the gardener should remove it so that it does not attract pests. The plant will grow slowly, a process the gardener may aid by repotting it every year or two. The use of fertilizer is debatable. One school of thought holds that because Venus's Fly Trap grows in nutrient-poor soil, the addition of fertilizer may injure it. According to this line of reasoning, the Fly Trap derives its nourishment from sunlight, water, and insects and needs nothing extra. Even Fly Traps that do not catch insects may survive, underscoring the fact that they have frugal needs. Another school of thought holds that Venus's Fly Trap should be fertilized if it receives no insects. To avoid saturating the soil with fertilizer, this line of reasoning urges the gardener to spray fertilizer at one-quarter to half strength on the leaves, which, like the roots, will assimilate nutrients.

Every May or June a Fly Trap flowers. The flowers grow one foot above the traps, ensuring that they are conspicuous to insect pollinators and that the low-growing traps will not eat their pollinators. The gardener who does not wish to propagate his plant may remove the flowers because their production taxes its reserves. On the other hand, the gardener eager for seed may rub two flowers together to pollinate them, use a brush to transfer pollen from one flower to another, or use tweezers to remove a stamen from one flower and rub its pollen on the pistil of another flower. More simply, one may allow insects to accomplish this task. About six weeks after pollination, a flower will yield small black seeds. The gardener may plant these on a mix of peat and sand. It is neither necessary nor desirable to bury seeds because they need light to germinate. The gardener should keep the humidity high and the soil temperature between 54°F and 86°F. Above 68°F, seeds germinate quickly. Seedlings will emerge in a few weeks. The gardener may transplant them when they are one year old. Another three or four years must pass before a plant is mature. The gardener who wishes to propagate Venus's Fly Trap by seed but who has had no success generating his own seed may obtain it from the International Carnivorous Plant Society in Fullerton, California, the Bay Area Carnivorous Plant Society in Freemont, California, the Tampa Bay Carnivorous Plant Club in Tampa, Florida, or the Los Angeles Carnivorous Plant Society in Glendale, California. Societies in other countries likewise offer seed to gardeners. Seeds are viable for only a short time. Less than 30 percent of year-old seeds can be germinated. One may also propagate Venus's Fly Trap by division. Because it grows from a rhizome, the gardener may dig up part of a rhizome and replant it. The cut rhizome will grow a new plant. Alternatively, the gardener may propagate the plant by peeling a leaf from a rhizome. Replanted in soil of its own, the leaf will send forth new roots and leaves. In spring, leaves are close to the ground, growing horizontally. In summer, leaves are thin, erect, and comparatively large. In autumn, leaves revert to a horizontal arrangement.

One gardener recommends feeding live insects to the Fly Trap. The gardener may place one in a trap with tweezers, waiting until it closes to release the insect. Alternatively, one may refrigerate insects. Because they, like cold-blooded animals, are less active in cool weather, one may easily place a refrigerated insect in a trap. As it warms to room temperature, it will slowly become more active; but in moving around, it is likely to stimulate a trap to close. One gardener fed a live caterpillar to a Fly Trap, only to have it chew through the trap and then climb up a second Fly Trap to devour a portion of a leaf. Chastened by the experience, he thereafter decapitated insects before feeding them to his plants. The gardener who is squeamish about the use of live insects may buy dead insects from a reptile and amphibian store, being certain to stimulate a trap manually to close.

Among cultivated Fly Traps, the red dragon, a cultivar bred by the Atlanta Botanical Garden, is an attractive deep red. Also popular is the cultivar Justine Davis, a purely green Fly Trap named for Justine Davis, the wife of Arthur Dobbs, governor of North Carolina and an amateur botanist. Excepting Justine Davis, the interior of a trap will redden with exposure to sunlight.

Insect Capture

In the 18th century, many botanists understood that Venus's Fly Trap was a carnivore. In 1763, Dobbs christened it the "Fly Trap Sensitive," and John Ellis was even more explicit in referring to the plant as a "machine to catch food." This insight into Venus's Fly Trap's carnivorous habit eluded Linnaeus, perhaps because he did not have a live specimen and so could not observe it in action. Although he was aware of Ellis's opinion, Linnaeus believed that the Fly Trap did not really eat insects but rather released them once they became calm. The idea that plants could eat insects contradicted the divine order of nature, Linnaeus believed. Plants did not eat animals but were eaten by them. Linnaeus's pronouncements may have deterred others from entering the fray. Only in 1875 did Darwin prove the Fly Trap's carnivorous habit by demonstrating that it digested pieces of meat and cheese. Perhaps this diet explains why Darwin had such difficulty raising the plant, for meat and cheese impart microbes to the Fly Trap, sickening it. Despite the care with which he worked, people, resurrecting Linnaeus's objections, ridiculed Darwin's conclusions. Presently, at least one gardener, perhaps emulating Darwin, feeds the Fly Trap chocolate with the same pitiable result.

Although science fiction writers have envisioned Venus's Fly Traps large enough to eat humans, the plant is only several inches long with traps just an inch or two. Large insects may be strong enough to escape, and small fry climb free. Only insects of an intermediary size may meet an unpleasant end. Venus's Fly Trap attracts its prey partly by its appearance. The traps absorb ultraviolet light whereas the rest of the plant reflects it. This contrast may lure insects to investigate. The red hue of the interior of a trap, so colored by the digestive glands, may also attract insects. Moreover, the Fly Trap secretes nectar from cells on the edge of the traps. Inside a trap are three or four trigger hairs. Erasmus Darwin, a physician, naturalist, and grandfather of Charles Darwin, supposed that the hairs impaled a trapped insect, killing it. In truth, the hairs trigger a trap to close. An insect that moves about a trap in search of nectar almost surely contacts a hair. In hot weather, a single such stimulation may be enough to shut a trap. More often an insect must contact a trigger hair twice or two hairs in succession within 20 seconds to stimulate a trap. This mechanism prevents rain or other random events from triggering a trap to close. In preventing a trap from closing on such occasions, this mechanism saves a trap from wasting energy. A trap that closes accidentally or at the instigation of a curious child will reopen in one to two days.

The movement of a trigger hair causes cells within a trap to accumulate calcium ions. Because a trap either shuts or does not shut in an all-or -nothing response, the buildup of calcium must surpass a threshold for a trap to close. As early as 1873, Sir John Scott Burdon-Sanderson demonstrated that the triggering of a hair produces an electric charge within a trap. The idea that a plant could produce electricity disturbed German botanist Julius von Sachs, who in 1887 suggested that only nerves could produce electricity. Because plants do not have nervous tissue, they cannot emit electricity, Sachs believed. Plant physiologists now believe that the buildup of calcium ions stimulates a trap's endodermal cells to fire an electric charge, creating an action potential along the length of a trap and causing it to close. The concave surface of a trap becomes convex as it snaps shut. Young traps are the fastest, closing in as little as three-tenths of a second, quick enough to capture a fly. As the two halves of a trap come together, the spikes or cilia that line the rim mesh, much the way fingers interlock when two hands are clasped, imprisoning an insect in a kind of cage.

In the initial moments of closure, a trap does not seal shut. Charles Darwin hypothesized, probably correctly, that the incomplete closure of a trap allowed a tiny insect, which would not be worth the expenditure of digestive juices, to escape. An appropriately sized insect is unable to escape. As it struggles, it contacts the trigger hair repeatedly, stimulating a trap to seal shut. Moreover, an insect may defecate in a trap, releasing urea or sodium or ammonium ions, which stimulate a trap to seal. Once a trap has closed completely, it secretes digestive juices. These may drown an insect. Alternatively, a trap may close so tightly that it crushes an insect. A third possibility is that an insect suffocates inside a trap. Whatever the cause of death, digestion is a slow process, ranging from 4 to more than 30 days. Acidic, digestive juices have a pH of 2.5 to 3.5. A trap also produces chitinase, a chemical strong enough to break down the exoskeleton. A trap must not produce much of this chemical because the exoskeleton of most insects remains intact after digestion. The innards of an insect are dissolved, supplying Venus's Fly Trap with nutrients, especially the nitrogen and phosphorus its soil lacks.

Once digestion is complete most traps reopen, though they remain insensitive to insects for several days. This respite may allow wind or rain to remove the exoskeleton. Spiders, attracted to the carcass of an insect, may in turn succumb to a trap. A few traps remain shut, perhaps because the digestive juices stimulate them to remain closed. A trap can capture only three or four insects before it dies, implying that the mechanism of capture must exhaust some cellular process. An old trap may die after only a single meal. Venus's Fly Trap has a varied diet, including wasps, ants, flies, grasshoppers, springtails, beetles, butterflies, and spiders. In addition to insects, some Fly Traps in California have captured Pacific tree frogs, reducing them to skeletons.

Christopher Cumo

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Verbena

Verbena (*Verbena hybrida*) is a garden standard that has been available since the early 19th century when it was derived from the intercrossing of *Verbena peruviana*, *Verbena melindres*, *Verbema tweediana*, *Verbena incisa*, and other species of South American origin. It is generally a creeping plant, although many different cultivars are available. It typically has square stems, opposite, often hairy, leaves, and flat clusters of phlox-like, fragrant flowers that can be found in a wide range of colors. Best noted are variations of purple, blue, and red, but whites and some yellows can be found. For centuries, garden designers have chosen different verbena species for their reputation as colorful and long-lived bedding plants. They attract bumblebees and other important insect pollinators and are a favorite in butterfly gardens. Verbena plants prefer well-drained soil and good air circulation. Although verbena is a perennial, gardeners usually treat it as an annual in the North.

Parent Species of Verbena Have a Rich History

While *Verbena hybrida* (garden verbena) is more widely grown, the genus *Verbena* actually includes about 250 species. Many found in the United States are low-growing, small-flowered, somewhat weedy plants more commonly called vervain (*Verbena officinalis*). The name verbena comes from the Latin for "sacred boughs." Vervain, also known as "herb of grace," is an ancient verbena and is believed to have been sacred to many people in history including the Egyptians, the Romans, the Persians, and the Druids. The name vervain comes from the Celtic *ferfaen*, which means "to throw a stone." This most likely refers to its use in those times for treating kidney stones and bladder problems. Reportedly, the herb was also pressed on Christ's wounds to stop bleeding during the crucifixion. Furthermore, the Egyptians believed vervain actually originated from the goddess Isis's tears as she mourned the dead god Osiris.

Medieval physicians used vervain to heal many common ailments, believing it to be an astringent, antispasmodic, diaphoretic, emmenagogue, anti-inflammatory, and many others. Those believing in the Doctrine of Signatures supposed that the bright flowers of some species indicated the plant could cure problems of the eyes. Modern physicians have not found any evidence supporting any of these claims. They do caution, however, that vervain induces vomiting, most likely due to the glycosides verbenalin and verbenin, which can also cause photosensitivity and uterine contractions. In addition, verbenin is thought to be the constituent that can stimulate milk production in lactating women. Vervain was clearly used to cure many problems. More than likely people did not use it lightly for it is described as having a bitter and astringent taste.

Some Verbenas Are Important Commercially

Lemon verbena (*Aloysia triphylla*) is also a member of the Verbenaceae family, which together with the *Verbena* genus and about 75 others includes around 3,000 species mostly of tropical and warm temperate regions. Unlike vervain, lemon verbena had no importance medicinally in the medieval period because it was first discovered in the New World and then brought back to Europe at a later time period. Folk historians report that parts of lemon verbena have been used to aid digestion, as a sedative, and to reduce fevers. These days, its leaves are most often steeped to produce a delicately flavored tea. In fact, they can be used whenever a light lemon flavor is desired, for example in marinades, salad dressings, jams, and beverages. Commercially, the oil is extracted and added to bath products and perfumes. Lemon verbena is not known for extravagant flowers, which are lavender colored but tiny. The leaves, however, are attractive, and the entire plant is a welcome addition to a fragrance garden. Since it is native to Chile and Argentina, more northern gardeners tend to grow this deciduous woody shrub in pots that can be brought indoors during the cooler part of the year.

Garden Verbena Is Susceptible to the Usual Diseases and Pests of Cultivated Flowers

Over the years, garden verbena has come in and out of favor because of its susceptibility to the so-called verbena disease. Many gardeners pushed the plant to its limit by unknowingly overcrowding and underfeeding it in an attempt to subjugate it to the current desired look of a thick and brightly colored bedding plant. When it did not thrive under these conditions, the plant became less popular until it was used in different ways and as less of a strong focal point. Essentially ignored and under less stressful conditions, verbena again grew heartily and rose in popularity to encourage the derivation and availability of new cultivars. Most are susceptible to powdery mildew and various other fungal diseases. As a result, they prefer good air circulation and well-drained soil. Common pests in some species include spider mites, whiteflies, and leaf miners. Typical control methods such as insecticidal soap spray, insect predators, and chemical insecticides can be effective.

Garden verbena has a rich and varied family tree. From being considered an ancient sacred herb effective in healing many ailments of the time, to one of its present roles as a flowering plant prized for adding color, fragrance, and pollinators to our gardens, Verbenaceae have played a role in human history for hundreds of years.

Gwendolyn Vesenka

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Vetch

In the family Fabaceae or Leguminosae and the genus *Vicia*, vetch is an annual or biennial legume related to chickpea, soybean, alfalfa, clover, lentil, pea, cowpea, peanut, and beans. Vetch was used for green manure and pasture when it was not harvested and as hay or silage when harvested. Vetch seeds were added to chicken feed. The chief use of vetch was for green manure, a circumstance suited to the legume. Because the plant harbored nitrogen-fixing bacteria in the roots, it added nitrogen to the soil. When the farmer plowed under vetch the plant decomposed, liberating nutrients to be absorbed by the crop following it.

Attributes and Cultivation

A temperate crop, vetch preferred cool temperatures, though it has been grown as far south as southern Alabama and Georgia. Some vetches tolerated temperatures below 0°F when covered by snow. Without snow cover, no vetch could endure 0°F. Willamette variety tolerated temperatures as low as 10°F. Bitter vetch, purple vetch, monantha vetch, and narrowleaf vetch suffered injury below 15°F. Plants on poorly drained land were susceptible to winter injury. In the South, hairy vetch and common vetch served as green manure and a cover crop. Alternatively, vetch has been interplanted with small grains, particularly oats or ryegrass on which livestock graze in winter and early spring. The combination of vetch and grain was ideal because, as a vine, vetch was susceptible to lodging without the support of grains stalks. Vetch was suitable as livestock feed because it was as nourishing as clover, alfalfa, or another legume. Vetch hay was 12–20 percent protein.

Hairy vetch, the hardiest vetch, was planted in autumn in the northern United States, where it overwintered. In the South and on the Pacific coast, vetch was usually planted in autumn because it did not suffer injury in the mild winter. Excepting hairy vetch, spring sowing was common in the northern United States. Because of the need for cool weather, vetch planted in autumn in the South, as we have seen, matured in late spring or early summer. The vetch vine grew two to five feet long. Vetch prefers fertile loam. Hairy vetch, woollypod vetch, and monantha vetch grew on sandy soil. Hungarian vetch did well in heavy, wet soil. Vetch did not tolerate drought. Vetch was more tolerant of acidic soil than other legumes and could be grown throughout the United States without the addition of lime to raise the soil pH.

In the South, vetch followed or preceded cotton. It also followed soybean, cowpea, and peanut. In the Pacific Northwest, vetch followed a small grain. Corn often followed vetch. Cotton and corn that followed vetch yielded more biomass than these crops grown in monoculture. Two to three weeks elapsed between plowing under vetch and planting a new crop to give vetch time to decompose. In the southeastern United States, corn, cotton, and soybean followed vetch. In the North, vetch was sometimes rotated with millet. In the Southwest vetch, was rotated with grain. In the Pacific Northwest, vetch was rotated with a small grain. In Oklahoma, Texas, and Arkansas, farmers interplanted vetch with oats or rye. In Michigan, vetch was intercropped with rye. Elsewhere, vetch was intercropped with oats, wheat, rye, and barley. Where vetch was interplanted with a small grain, farmers used only three-quarters as much seed as they would have used if planting vetch alone. Similarly, the seeding of small grain was halved. Hairy vetch was seeded at 20 to 30 pounds per acre in the South and 30 to 40 pounds per acre in the North and West. The figures for common and Hungarian vetches were 40 to 50 pounds per acre in the South and 60 to 80 pounds per acre in the North and West. Monantha vetch was seeded at 30 to 40 pounds per acre in the South and 60 to 70 pounds per acre in the North and West. Narrowleaf vetch was seeded at 20 to 30 pounds per acre in the South. Purple and bart vetches were seeded at 60 to 70 pounds per acre in the North and West. Woollypod vetch was seeded at 25 to 35 pounds per acre in the South and 40 to 50 pounds per acre in the North and West. When grain and vetch were interplanted, more grain was sown when the hay was destined for horses rather than cattle or sheep. On poorly drained land, vetch was broadcast. On well-drained soil, a grain drill planted vetch. The farmer sowed vetch seeds four inches deep on loam.

Fertilizer was unnecessary on the Pacific coast. In Oregon, farmers applied the mineral gypsum to the soil at 75 to 150 pounds per acre. In the South, additions of phosphorus and potassium were often necessary. Because vetch roots harbor nitrogen-fixing bacteria, the addition of nitrogenous fertilizer was unnecessary in most cases. On infertile soil in the South, nitrogenous fertilizer was applied at 15 pounds per acre. Fertilizer was added before or at the time of planting. In the process of inoculation, the farmer added nitrogen-fixing bacteria to the soil, a practice that was unnecessary on the Pacific coast but necessary in the eastern United States.

Oregon and Washington dairy farmers used common and Hungarian vetches for pasture during winter, spring, and early summer. The nutritional value of oats and vetch was more than double that of oats alone. Common and Hungarian vetches were often used as hay. Vetch was cut for hay when it formed seedpods. Vetch that was more mature was a better horse than cattle or sheep forage. Vetch yielded one-and-one-half to three-and-one-half tons of hay per acre. Common, Hungarian, monantha, and purple vetches yielded 10 to 12 bushels of seeds per acre. Hairy and woollypod vetches yielded 6 or 7 bushels of seeds per acre. Vetch seeds remained viable five years. Moist seeds remained viable only a short time. Oregon, Oklahoma, Texas, Arkansas, and western Washington were the leading producers of hairy vetch seeds. Oregon and western Washington produced common and Hungarian vetch seeds. Western Oregon, western Washington, and northwestern California produced monantha and purple vetch seeds. Western Oregon produced woollypod vetch seeds.

Types

Hairy, common, and purple vetches were the chief vetches in the United States. Hairy vetch was grown worldwide in temperate locales. Oklahoma, Texas, Arkansas, and western Oregon grew hairy vetch for seeds. Woollypod vetch resembled hairy vetch, though the former had less pubescence on stem and leaf. Woollypod flowers were smaller than the flowers of hairy vetch. Woollypod vetch was grown as far north as Washington, D.C., without winter injury. Auburn, Oregon, and Lana were varieties of woollypod. Common vetch was less hardy than hairy vetch. The former was grown on the coast of Washington and Oregon without fear of winter injury. In the northern Cotton Belt, however, the farmer risked winter injury by planting common vetch. On the Pacific coast, common vetch was grown for hay, seeds, green manure, silage, and pasture. In the American Southeast, common vetch was grown for green manure. Willamette was a hardy variety of common vetch grown in the Southeast. Pearl vetch was another variety of common vetch grown in western Oregon. A third variety, Warrior, was used for green manure and grazing. Purple vetch was native to Southern Europe, from which it was introduced into the United States. The legume was among the most susceptible to winter injury. Western Oregon, western Washington, and northwestern California grew purple vetch for seeds. Elsewhere in California it has been used for green manure and hay. Hungarian vetch was native to Central Europe. It was less widely grown in Europe than hairy and common vetches. Western Oregon grew Hungarian vetch, which could be grown as far north as Washington, D.C., without winter injury. Hungarian vetch did well on wet clay, though it fared poorly on sandy soil. In the Pacific Northwest, Hungarian vetch was cultivated for hay, silage, green manure, pasture, and seeds.

In Europe, hairy vetch was grown in lands near the Baltic Sea and south to Hungary. Common vetch was grown in Southern Europe and Great Britain. Bitter vetch was cultivated in the Mediterranean Basin, where it fed livestock. Hungarian and monantha vetches were grown in Southern Europe.

Christopher Cumo

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Violet

The genus *Viola* contains nearly 500 species of flowering plants distributed on every continent except Antarctica, though most live in the temperate parts of the Northern Hemisphere. Their common name is violet. Most violets are perennial plants four to eight inches tall, with palmate or heart-shaped leaves and small purple, yellow, or white flowers. There are a few annual and biennial species found in Europe, and a few woody-stemmed shrubs found in Southern Europe and South America.

Today, violet is the common name most often used for the small wildflower and its cultivated varieties; pansy refers to the larger garden flower first bred from wild violets in the early 19th century, and viola and violetta are common names for cultivated flowers intermediate in size between pansies and violets. However, in the past, all of these names were used as common names for the wild violet, and some species of violet today are commonly called pansies. African violets and dogtooth violets are members of other plant families and not related to *Viola* species.

History

The violet's importance in history and literature stems mostly from the lovely, strong fragrance found in the blossoms of several European species. Chief among the scented violets is *Viola odorata*, the sweet violet, a soft-stemmed plant four inches tall with purple, lavender, or white flowers. Native to Europe, North Africa, and Asia, sweet violets were among the first flowers ever grown commercially. They were sold in markets in Athens as early as 400 BCE and were so valued that the violet became the city's symbol. Violets were used in cooking and to make wine, perfume, purple dye, garlands (Aphrodite is described as "violet-crowned"), and medicines. Mentioned by ninth-century BCE Greek poet Homer, seventh- and sixth-centuries BCE Greek poet Sappho, fourth-century BCE Greek botanist Theophrastus, first-century BCE Roman poet Virgil, and first-century CE Roman encyclopedist Pliny, the violet was second among flowers only to the rose.

As a medicine, the ancients believed that violets could "comfort and strengthen the heart," and this may be the source of another of the plant's common names, heartsease. Violets were also thought to moderate anger, aid in sleeping, and cure gout and stomach complaints. The Romans made a wine from violets that was thought to prevent epileptic fits. Violets were also highly esteemed among Islamic cultures. They were cultivated in Iran and Arabia in antiquity. A treatise from 904 CE, probably translated from an earlier text, describes how to care for and propagate violets. A Muslim proverb proclaims, "The excellence of the violet is as the excellence of Islam above all other religions." The Middle East may be the place of origin of the so-called Parma violets, whose double flowers are renowned for their fragrance. Once thought to be a strain of *Viola odorata*, Parma violets are now often considered to derive from a different species.

In Europe, violets were used in cooking, cosmetics, and medicine, and as a strewing herb. Again, it was the flowers' sweet scent that made the plant so valuable. English herbalist John Gerard's *Herball* (1597) declares, "The mind conceiveth a certain pleasure and recreation by smelling and handling those most odoriferous flowers," and says that they cure inflammation and comfort the heart. English herbalist John Parkinson wrote in 1629, "Violets are Spring's chiefe flowers for beauty, smell and use."

Before sugar was readily available from the New World plantations, violet blossoms were used to sweeten foods, including meat. The dried and crystallized flowers have been used as a cake decoration and sweetmeat since medieval times, and in France, violets were also made into a syrup used in cooking. Violet plants were frequently grown in pots on windowsills, as well as in monastery and cottage gardens. The flowers were not the only part of the plant used: the entire plant can be eaten cooked or raw; its leaves contain vitamins A and C and other antioxidants. In early medicine, violets were most often used as a soporific or soothing medicine, a laxative and diuretic, a treatment for skin inflammations, or an expectorant.

The flower's dusky color (most species have purple flowers, though there are also yellow and white violets), the plant's small size and lowness, and the fact that the blossoms often "nod," or turn their faces down, made the violet frequently a symbol of modesty or shyness and gave rise to the expression "shrinking violet." The 16th-century French saint Francis de Sales used the violet as an image for a widow: "A true widow is in the church as a March Violet, shedding around an exquisite perfume by the fragrance of her devotion and always hidden under ample leaves of her lowliness and by her subdued coloring, showing the spirit of her mortification. She seeks untrodden and solitary places."

William Shakespeare (1564–1616), on the other hand, mentioned the violet several times but never described it as modest. Instead, he sometimes described a peculiar trait of the violet's perfume: the way it appears to come and go. Actually, the scent does not disappear, but it contains a substance that desensitizes the nose's scent receptors: after the first burst, the nose grows numb to the fragrance, then recovers and is able to register the scent again. Shakespeare referred to this phenomenon in *Twelfth Night*, describing a strain of music by saying, "It came o'er my ear like the sweet sound / That breathes upon a bank of violets, / Stealing and giving odor." And in *Hamlet*, "A violet in the youth of primy nature, / Forward, not permanent; sweet, not lasting, / The perfume and suppliance of a minute; / No more." Shakespeare also honored the violet's fragrance in these famous lines: "To guild refined gold, to paint the lily, / To throw perfume on the violet, / Is wasteful and ridiculous excess."

French emperor Napoleon Bonaparte (1769–1821) chose *Viola odorata* as the emblem of the House of Bonaparte; it was also a favorite flower of the Empress Josephine, who raised violets at Malmaison. After being banished to Elba, Napoleon pledged to return to France when the violets blossomed again, and his followers wore violets in their buttonholes to show their support. When Josephine died, sweet violets were planted on her grave. Napoleon plucked some of these flowers and wore them in a locket, which was found around his neck after his death.

Napoleon's second wife, Marie Louise, established the commercial culture of the supremely fragrant double violets near Parma, in northern Italy, where she moved in 1817. The mild climate there suits these flowers and gave them the nickname "Parma violets." In 1819, British poet John Keats wrote about them to his wife: "I hope you have a good store of double violets—I think they are the

Princesses of flowers, and in a shower of rain almost as fine as barley-sugar drops are to a schoolboy's tongue."

The United States

In contrast to the high esteem in which violets have been held in Europe and the Middle East, Americans seem on the whole to have been less impressed by violets. Perhaps this is because our native species are mostly scentless. However, many Indian tribes used violets in cooking and medicine, and four states have chosen the violet as their state flower. The violet's modest popularity exploded when Parma violets were introduced to the United States in the 19th century. By the end of the century, they had become an essential flower for corsages. They were raised outdoors in fields near San Francisco, California, and indoors in greenhouses in the Hudson River valley, where the cultivation of Parma violets became a small industry. By 1920, there were 138 such greenhouses, shipping violets to every city east of the Mississippi. They were worn first at the waist of a woman's gown, and later, when styles changed, at the shoulder. One writer, whose father owned such a greenhouse in the 1920s, remembers,

> Throughout the country, no evening function was complete without fine gowns displaying a bunch of fragrant, rich-colored violets. It was only after three decades of this fashion that women changed styles and took to gardenias and then to orchids. Thus Rhinebeck, in 1976, had but one grower with a few houses of a nonfragrant single violet. . . . This rise and fall of an industry tells nothing of the flowers that were grown. . . . The fragrance of a bouquet of fifty Parma violets was ineffable.

Today, while pansies are an extremely important garden plant, they are the only member of the genus *Viola* of any real commercial significance in the United States. Our native wild violets are often considered weeds, and the cultivation of sweet and Parma violets is limited mainly to specialists in heirloom plants. In Europe, violets retain some of their earlier commercial importance. But climate change and overharvesting have caused populations of many wild species, including *Viola odorata*, to shrink. They are still raised for specialty culinary uses, especially around Toulouse in southern France, and for the perfume industry. Violet scent is an ingredient in such modern perfumes as L'Interdit and Xeryus, though today much violet scent is produced synthetically.

Emily Goodman

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Walnut

The walnut is a nut-bearing tree in the genus *Juglan* in the family Juglandaceae. Two main species are found in temperate regions around the world. The Persian or English walnut, *Juglans regia*, is grown commercially for its fruit—nuts that have a sweet taste and are used in a variety of foods. There are a number of scientific studies on the nuts that indicate that they are beneficial to heart health and possibly improve cognitive function. These fruit have a high concentration of the fatty acid alpha-linolenic acid, also known as fish oil. China is the largest producer of these nuts in the early 21st century, with a large number also being grown in the United States, almost entirely in California. The black walnut tree, *Juglans nigra*, sometimes grown as an ornamental, is native to the United States and is found in forests in the eastern half of the country. Both tree species are prized for their lumber, which is used in making furniture and gunstocks. The trees can be problematic for gardeners, since they produce chemicals known as juglones that inhibit the growth of many other plants underneath them. The name of these trees derives from Roman terminology. The Romans thought that the nuts looked like testicles and named them "glands of Jupiter" or *Juglans*, for short. Jupiter was the king of the gods worshipped by the Romans. *Juglans regia* translates to "royal nut of Jupiter." The species name of the black walnut is more pedestrian, with the species name of *nigra* indicating the blackness of the fruit and bark. Walnut trees were designated *Juglans* by Swedish naturalist Carl Linnaeus in 1753.

History

Walnuts have a long and storied history in human civilization. There is evidence that they were consumed up to 17,000 years ago, and they were considered of great medicinal value during ancient Mediterranean times. The physicians Dioscorides and Galen both extolled the virtues of walnuts as a medicine.

Persian walnut trees were disseminated around the world by English traders, leading to the alternate name of English walnut. They are thought to be native to central Asia. The trees were introduced to California in 1867 from Chilean trees that originated in Spain. Black walnuts are native to the eastern United States.

Plant Culture

The trees grow best in deep soil that is fertile and moist. Walnut trees have deep taproots, along with a lateral network of more shallow roots. The degree of lateral

Walnuts (Ghettog76/Dreamstime.com)

root production depends on the soil type. More fibrous roots are produced in sandy soils. This root system enables walnut trees to tolerate drought, although the deep taproot can hamper transplantation of them. This type of tree can tolerate some degree of flooding, although the trees usually succumb if they are flooded for 90 days or more. High temperatures can damage fruit production, although varieties differ greatly in their degree of heat resistance. Commercial growers in California have applied reflective materials to the tops of the trees to protect against the deleterious heat from sun rays. Such treatment can reduce temperatures by about 10 percent.

Walnut breeders are constantly creating new varieties. There were more than 400 varieties of black walnut introduced over a 100-year period. The trees have a great degree of genetic variability, and new growers of walnuts are advised to select varieties that grow well in their area. Persian walnuts are frequently grafted onto rootstocks that are better suited for the geographic area in which they are grown. In the 21st century, black walnuts were primarily used as rootstocks upon which to graft Persian walnuts.

Left to grow to their full potential, the trees commonly reach 75 to 100 feet. Individuals in forest settings can grow to 150 feet. Black walnut trees in the eastern United States have been found with trunks as wide as 5 feet. In their natural setting, walnut trees are frequently found on stream banks or slopes that face north or east. The seedlings do not tolerate shade and generally grow in clearings in the forest.

The trees have flowers that are monoecious, with each tree having both male and female flowers. The male flowers are greenish-yellow, hairy catkins that develop on growth from the previous year. Female flowers are spikes of up to eight flowers that produced on the current year's growth. They generally appear before the male flowers. The flowers are produced in the mid- to late spring concurrently with leaf production. Normally, another walnut tree is required to pollinate the flowers, so that fruit is produced. Walnut trees are self-fertile to some degree and will not produce a large crop of fruit unless at least one other tree is nearby.

Nuts ripen in the fall and drop to the ground after the leaves have fallen. With black walnuts, optimal nut production begins when the trees have reached 30 years old. They generally produce large amounts for another century. In commercial orchards, tree shakers are used to remove the nuts from the trees. With the fruit of wild trees, people compete with squirrels to gather them from the ground. New black walnut trees in the wild commonly grow from fruit that have been buried by squirrels and left behind.

When the trees are grown as landscape specimens, the fruit production can be considered undesirable, since its fall creates a mess underneath the trees. Home owners are generally advised against growing walnut trees. They are deemed best for parks and campuses, which have plenty of space for the trees to spread. Their use as street trees is also usually not recommended.

Properties of the Nuts

Walnuts are grown commercially for their edible fruit—nuts contained within a dark, hard husk. In the late 20th and early 21st centuries, there was a plethora of scientific studies on health benefits of the nuts. Walnuts were the first food for which the U.S. Food and Drug Administration (FDA) allowed a health claim to be made. Supportive but not conclusive research indicated that a diet containing one-and-one-half ounces daily, as part of a diet low in saturated fats and cholesterol, might reduce the risk of coronary heart disease. The European Union's European Food Safety Authority has also made a health claim about walnuts.

One ounce of walnuts is about 14 walnut halves. Nutrition information is presented as amount per one-ounce serving. The nuts from Persian walnuts contain 18 grams of fat with 13 grams of it being polyunsaturated fat. This high concentration of polyunsaturated fats rather than monounsaturated fat makes walnuts unique among nuts. These nuts possess a high concentration of alpha-linolenic acid compared to other plants. Persian walnuts contain 2.5 grams of this compound per serving, while black walnuts have only one-fifth as much alpha-linolenic acid. This polyunsaturated fatty acid is more commonly known as fish oil. Humans are incapable of synthesizing this type of fatty acid, and such essential fatty acids must be obtained from food. There is evidence that this type of oil is broadly beneficial to human health. The nuts are also high in protein and have been found to contain 4 grams per ounce of protein along with 2 grams of fiber.

Studies with walnuts as a component of human diets have indicated that they help to regulate cholesterol levels, resulting in a cholesterol profile that is more beneficial to human health. In people with type 2 diabetes, a diet rich in walnuts was found to improve the flow of blood. These nuts have also been studied for their anticarcinogenic functions and their ability to promote cognitive function. When consumed in moderation as part of a so-called Mediterranean diet, the nuts were found not to cause weight gain in the people studied. Some people have an allergy to walnuts and should avoid their consumption. Contact with the leaves can cause dermatitis of the skin.

Additional Economic Uses of Walnut Trees

Walnut trees can be the source of high-quality lumber. The wood is hard, attractive, and easy to manipulate. It has been widely used in cabinets and other furniture and as veneer. The wood is also prized for gunstocks. It has been used in building ships and, in earlier days, airplanes. The desirability of the wood has led to the frequent destruction of natural walnut groves in the United States.

The nuts have a number of uses aside from their use as food. Ground shells have been used to clean airplane pistons and jet engines. They are also used in oil-drilling operations, as a component of dynamite, and in the manufacture of automobile tires. The husks of the green fruit have been used as a source of yellow dye, while the husks of the ripe fruit, leaves, and nuts can provide a brown dye. In previous eras, the whole fruit were used in streams to kill fish. This practice was declared illegal in the United States in the late 20th century.

Toxicity to Other Plants

These trees produce a series of toxic compounds known as juglones that interfere with the respiration of a number of types of plants and prevent them from growing under or near walnut trees. This type of inhibition is known as allelopathy. These compounds are secreted by the roots and are also found in the nut husks, leaves, and bark of the trees, although at a lower concentration than in the roots. The toxicity can persist for years after a tree is removed, since decaying walnut tree roots continue releasing juglones.

Plants in the Solanaceae family such as tomatoes and potatoes are especially susceptible. Many evergreens will not grow under walnut trees, and apple trees are particularly susceptible to ill effects from juglone production. Some plants are resistant to this compound, and there is evidence that it improves the growth of the widely grown turf grass bluegrass (species of *Poa*).

Helga George

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Watercress

Watercress, *Nasturtium officinale*, is one of the oldest leaf vegetables eaten by humans. It is a hardy plant of the mustard family that grows in temperate climates in wet soil along and inside spring brooks, ditches, and pond edges. A low, trailing plant of European origin with small, pinnately compound leaves that have a sharp, peppery taste, watercress is cultivated for use as a garnish and as a salad ingredient. Its white flowers are not edible. As a fast-growing perennial, it can be produced continuously and harvested throughout the growing season. It has been used in sustainable aquaculture as a plant that is commercially viable yet can be grown in a manner that respects the ecosystem.

A World Crop

Plants known as cress are grown throughout the world, though watercress is the only one that is sold in food stores. Watercress is a popular edible because it is rich in iron, iodine, folic acid, vitamin C, and calcium. The leaves and stems of the plant contain so much iron that they oxidize and turn purple if they are in the air too long. The aggressive character of watercress means that it goes well with rich foods. Smaller leaves are not as strongly flavored. Watercress is difficult to market commercially because the leaves are so tender, but advances in packaging have made it more common on supermarket shelves. The sprouts are also sold.

While *Nasturtium officinale* is the most common commercial type of cress, many countries have indigenous species of cress. Indian cress, *Tropaeolum majus*, is a native of Chile and Peru that has found considerably popularity in Latin America. Mainly grown for its pink flowers, the leaves and blossoms can also be eaten as salad, and the immature seeds can be pickled like capers. Garden cress, *Lepidium sativum*, is an annual that originated in Asia but has enjoyed much popularity in Europe for its peppery flavor. Upland or winter cress, *Barbarea vernapraecox*, is a hardy European biennial that is naturalized in many parts of the United States. Bitter cress, *Cardamine pratenis*, is a small, spring-blooming perennial that is sometimes grown in rock gardens. Its leaves are used for salads in Europe.

Attributes

Although *Nasturtium officinale* is easily grown from seed, it is usually propagated by bits of stem, which readily take root in wet soil and need no further attention. If grown from seed, propagation is more successful in ambient controlled temperature conditions, such as greenhouses and poly tunnels. The densities at which the watercress is planted can vary greatly. Intensive production operates on a 1:10 ratio, meaning that 1 square meter (10.76 feet) of seedlings is planted in 10 square meters (107.6 feet) of growing area. The plants do not do well if totally submerged in water, so water levels must be monitored. The hollow stems of watercress normally float upon the water, which should be somewhat alkaline. If plants are growing closely together, they are under considerable stress and are more vulnerable to disease. Intensive production, therefore, requires chemicals to protect the watercress from disease and to provide extra nutrition. Ecologically minded growers typically plant at half the density indicated for intensive cultivation. Doing so avoids the need for adding chemicals.

The season of *Nasturtium officinale* runs from mid-autumn until spring. Water temperature will inhibit plant growth during the winter months in temperate climates. Watercress, particularly the root structure, is also sensitive to freezing. Once watercress has grown to four or five inches, it can be harvested on a continuous cropping basis. It is normally cut this way under standard production. After its flower buds appear, the leaves generally become too rank in flavor to be edible, though some people tolerate the strong, peppery taste.

Cultivation

Watercress can be taken out of beds at the end of every growing season and replanted with some other aquatic plant species or more watercress, but this is not necessary. The beds do not need to be regenerated for cultivation. In standard production, the watercress is removed at the end of each season, but green farmers often leave the plants. Green growers who take out watercress yearly are often also growing fish and are removing the plants to facilitate the fish harvest. Ecologically minded growers generally clean, replant, and rejuvenate the watercress beds every two or three years when the water temperatures are low and the stress generated by human intervention has minimal impact on the aquatic environment. When watercress is removed from a pond, the plants release organic detritus known as particulate organic matter (POM). This material is retained within the site by organic farmers who use it as an important food source for macrobiota.

Growers who are focused upon ecological aquaculture often raise fish alongside watercress. The fish provide nutrients for watercress, thereby reducing the need for farmers to add nutrients to the water. Watercress is extremely efficient at taking up nutrients from water. Ducks and other waterfowl, wild or domesticated, can naturally supply some nutrients, but the numbers of the birds have to be controlled to balance the ecosystem. The birds also need to be kept away from the edible growing plants to avoid direct fouling. Organic farmers often utilize water from a separate waterfowl pond to add nutrients to the plant pond. Watercress that is not grown in water suitable for drinking should be cooked before it is eaten as a protection against possible liver fluke.

Caryn E. Neumann

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Water Lily

The family Nymphaeaceae has nine genera, one of which, *Nymphaea*, is the genus of the water lily. Fourth-century BCE Greek botanist Theophrastus coined the genus name. An aquatic plant, water lily inhabits pools of fresh, still water. The water lily does not tolerate flowing water.

Water lilies (iStockPhoto)

Origin, History, and Attributes

Fossils date the water lily to the Jurassic Period (200–145 million years ago). Later fossils date to the Tertiary Period (65–2 million years ago). Before the climate cooled, the water lily colonized the planet from the Arctic Circle to Australasia. From an early date, humans ate the tubers and seeds, which contain starch and sugar. The Egyptians, among the earliest to cultivate the water lily, made a kind of bread from its seeds. Because the water lily has tubers, it is able to endure the dry season. The plant dies during dry spells, but a tuber issues forth a new plant when the rains return. The Egyptians, observing this phenomenon, thought of the water lily as a resurrection plant. To the Egyptians the plant symbolized immortality and purity.

Among the earliest evidence for the cultivation of the water lily comes from the tombs of Beni Hassan, a village along the Nile River. A tomb painting, dating between 3000 and 2500 BCE, at this village depicts two gardeners tending a pool of water lilies. By 2000 BCE, the Egyptians were burying the nobility and priests with wreaths made of water lily petals. The blue petals of *Nymphaea coerulea* were favored for royal burials. The white petals of *Nymphaea lotus* were used in religious rites. Petals from both species adorned the tombs of 18th-dynasty pharaoh Amenhotep I (reign 1526–1506 BCE) and 19th-dynasty pharaoh Ramses II reign (1279–1212 BCE). The 14th-century BCE pharaoh Amenhotep IV, better known as Akhenaten, grew water lilies in his gardens at Ikhnaton. The tomb of 14th-century BCE pharaoh Tutankhamen, Akhenaten's son, contained water lily petals. The Egyptians offered water lilies to the dead.

Among the Greeks, Theophrastus and first-century CE Greek physician Dioscorides mentioned the water lily. The Chinese grew the white-petaled *Nymphaea tetragona*. The 11th-century CE Chinese writer Chou Tun wrote that the water lily symbolized purity and truth. The Japanese likewise grew water lilies. Some people believed that the water lily root calmed nervousness and aided digestion. The 17th-century English herbalist Nicholas Culpeper wrote that the water lily "settles the brain of nervous persons." Others thought of the water lily as an aphrodisiac. Water lily roots were used as dye. The 19th- and 20th-centuries French impressionist Claude Monet painted some 250 scenes of water lilies. The painting have garnered praise worldwide.

The water lily prefers neutral or slightly alkaline water and becomes weak in acidic water. Hardy species of water lily bloom during the day, opening at noon and closing at sunset. Tropical day-blooming species open their flowers in the late morning and close them at sunset. Tropical night bloomers open their flowers from sunset to sunrise. Their flowers may remain open on overcast days. A flower may last five days in warm, sunny weather. Rainfall diminishes the period of flowering. The water lily needs full sun.

Pests and Diseases

Beset by pests and diseases, the water lily may challenge the ability of the gardener to control them with chemicals because chemicals may injure the other aquatic life in the pool. The presence of fish is particularly important to the health of water lilies because fish eat the larvae of insects that might otherwise plague the plants. The water lily aphid (*Rhapalosiphum nymphaeae*) is one such pest. The black insect, one of several species of aphid that feeds on water lilies, can be particularly damaging. Breeding large populations, the water lily aphid feeds on water lily leaves. Aphids lay their eggs on nearby plum or cherry trees, in which they overwinter. The gardener assailed by aphids should spray water lily leaves with water to dislodge them. When they fall into the pond, fish will eat them. If fish are not present, the gardener may spray the leaves with insecticide soap.

The water lily beetle (*Galerucella nymphaeae*) is a brown beetle twice the size of a ladybug. It alights on water lily leaves in June, laying eggs that hatch in one week. The larvae feed on leaves. Once more the gardener may spray leaves with water, allowing fish to eat the dislodged larvae. The gardener should cut back the foliage in winter to deprive the beetle of a place to overwinter. One might also spray the leaves with powder containing the bacterium *Bacillus thuringiensis*, which will devour the larvae. The brown china mark moth (*Nymphula nymphaeata*) chews holes in water lily leaves. The female lays eggs on the underside of leaves. The larvae are more damaging than the adults. In severe infestations, the gardener should remove damaged leaves.

The fungal disease water lily crown rot is a species of *Phytophthora*, a widespread genus of fungi that attacks, among other plants, soybean roots. As the name suggests, the fungus blackens and rots the crown and stem. The foliage will yellow. The gardener must destroy infected plants. The most susceptible varieties of water lily are Laydekeri, Fulgens, Marliacea Ignes, Ellisiana, and Rose Arey.

Some gardeners introduce snails into a pool of water lilies to eat algae. The ramshorn snail (*Planorbis corneum*) and the Japanese snail (*Viviparis malleatus*) are useful in this regard. Yet the pond snail (*Limnaea stagnalis*) will eat water lily leaves. The gardener who wishes to eliminate snails may place a piece of cabbage or lettuce in the pool, removing it once it has attracted snails.

Species and Cultivars

A tropical day bloomer, *Nymphaea gigantea*, known as Blue Gigantea, is native to Australia and New Guinea. Its flowers rise one foot above the water. The inner petals are pale blue violet. Outer petals are deep blue violet. The sepals are violet-purple. Anthers and stamens are deep yellow. Each flower has 24 petals and four sepals and is 10 to 12 inches in diameter. Flowers are not very fragrant. The top of a leaf is green and the underside purple.

A tropical day bloomer, *Nymphaea ampla* is native to southern Texas, Mexico, Central America, Brazil, and the Caribbean. The petals are white, though the outermost petals may be yellow-green. The sepals are white. The anthers and stamens are yellow with white tips. The flowers, strongly fragrant, are four to five-and-one-half inches in diameter. Each flower has 7 to 21 petals and four sepals. Young leaves are bronze, turning green with age. The underside of a leaf is red-purple.

A tropical night bloomer, the cultivar Brazos White has bright white petals, though the outermost petals may be green. The sepals are white, though again the outermost sepals may be green. The anthers and stamens are soft yellow. Each flower, being 6 to 8 inches in diameter, has 19 or 20 petals and four sepals. The fragrance is strong. Young leaves are light green, the color darkening with age. The leaves may be 12 to 14 inches long. One gardener judges Brazos White ideal for large pools.

The fragrant, hardy species *Nymphaea odoretis* is indigenous to eastern North America from Newfoundland to Florida, and west to Texas, Kansas, Michigan, and Indiana. The species may also be found in Mexico and the Caribbean. The petals are white, though the outermost petals may be pink-blue. Sepals are white or pale pink. The anthers and stamens are yellow. Each flower has 24 to 32 petals and four or five sepals. The top of leaves may be green and the underside bronze, pink, purple, or red. The stem may be green or green-purple.

The hardy *Nymphaea tuberosa* is native to Ontario and Quebec, Canada, ranging from Lake Champlain to Minnesota and south to Arkansas. The species may also be found in New Jersey and Maryland. The petals and sepals are white. The anthers and stamens are yellow. Each flower, having 27 to 31 petals and four sepals, is four to nine inches in diameter. Young leaves are purple and turn green with age.

Christopher Cumo

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Watermelon

An annual vine, the aptly named watermelon (*Citrullus lanatus*) is 92 percent water. In addition to containing water, watermelon is 6 percent sugar; 14 percent vitamin C; 4 percent pantothenic acid; 3 percent vitamin A, thiamine, vitamin B6, and magnesium; 2 percent iron, phosphorus, and potassium; and 1 percent riboflavin, niacin, folic acid, calcium, and zinc. One hundred grams of watermelon contain only 30 calories, 0.4 gram of fiber, 0.15 gram of fat, and 0.61 gram of protein. Watermelon has more lycopene, an antioxidant that may prevent cancer, than any other fruit or vegetable, including the tomato. The Bushmen of the Kalahari Desert in southern Africa called watermelon *tsamma*. Watermelon is a cucurbit or gourd. Controversy attends the question of whether watermelon is a fruit or vegetable. In 2007, Oklahoma adopted watermelon as the state vegetable, provoking a debate about its status. Indeed, several vegetable books include a section on watermelon. In the United States, 44 states produce watermelon. Georgia, Florida, Texas, California, and Arizona are the leading producers. The Chinese roast and salt watermelon seeds, eating them as a snack much as Americans eat peanuts. The Vietnamese eat watermelon seeds during Tet, their New Year.

Origin and History

In the 1850s, British explorer David Livingstone discovered wild watermelons in the Kalahari Desert. He found them to be less sweet than the cultivated watermelon, but this discovery nonetheless led others to suppose that watermelon originated in this inhospitable land. It may seem strange that a plant so dependent on water might have originated in a desert, but the vine is adept at absorbing even small amounts of water, and the thick rind minimizes evaporation. In 1882, French botanist Alphonse de Candolle, perhaps incredulous at the suggestion that a water-loving plant could have originated in the desert, proposed tropical Africa as the homeland of watermelon. From the tropics, if this hypothesis is correct, watermelon spread both north and south. French explorers proposed yet a third possibility. Because they found Native Americans growing watermelon in the Mississippi River valley, they supposed that it had originated in the New World. Another possibility, of course, is that watermelon spread throughout the New World ahead of European settlement, in which case the Native Americans were cultivating an African rather than American indigene.

The Egyptians may have been the first to cultivate watermelon, a possibility that accords with the hypothesis that it originated in the tropics and migrated north. Alternatively, a northern migration from the Kalahari Desert was also possible. It is much harder to envision a migration from the New World to Egypt in antiquity. The date of cultivation is open to debate. One hypothesis holds that the Egyptians cultivated watermelon as early as 3000 BCE. Another pinpoints

2000 BCE as the earliest date of cultivation, whereas a third proposal points to the second millennium BCE, of which 2000 BCE would have marked the beginning. This range of dates may stem from the difficulty in identifying the ancient remains of watermelon. One authority notes that ancient watermelon seeds resembled cucumber seeds, complicating their identification. Some scholars believe that the Egyptians put watermelon seeds in 14th-century BCE pharaoh Tutankhamun's tomb. Others suspect that those seeds belonged to cucumber.

From Egypt, watermelon spread to the Middle East, Greece, Rome, India, and China, though in the latter two locales it was not widely cultivated until 800 CE and 1000 CE respectively. The identification of Greece and Rome as early adopters may be problematic. The ancient Greek and Latin sources are silent about watermelon, and it does not appear to have spread throughout the Mediterranean Basin in antiquity, a fact that is surprising given the supposition that Rome had cultivated watermelon. The Arabs and Berbers in North Africa and the Moors in Spain cultivated watermelon, having doubtless acquired it from Egypt. From Spain watermelon spread throughout the Mediterranean during the Middle Ages.

The introduction of watermelon into the New World owes much to the efforts of the Spanish, English, and Africans. The Spanish may have been the first to act, bringing watermelon to the Americas, probably in the 16th century. The slaves who populated the New World brought watermelon with them, possibly around the time of the Spanish introduction. In 1628, the English brought watermelon to the Massachusetts Bay Colony, from where it spread to Virginia and Florida. In the 18th century, Spanish missionary Francisco Garces introduced watermelon to the Amerindians of the lower Colorado River valley. We have seen that Native Americans were eager adopters of watermelon and they spread it from the Colorado River valley to the Pacific coast. In the 19th century, watermelon crossed the Pacific Ocean to Hawaii.

In the American South, African Americans made watermelon a part of their cuisine. Malevolent whites denigrated blacks as watermelon eaters, but the fruit's popularity did not wane. Today, African Americans near Lake Okeechobee, Florida, still sell watermelon at roadside stands. This brand of culinary racism permeates Russia, whose inhabitants mock the people of central Asia for eating watermelon. Despite this prejudice, Russia imports watermelon from central Asia. Russians make beer from watermelon.

Varieties and Breeding

A watermelon may be a diploid, having two sets of chromosomes, a triploid, having three, or a tetraploid, having four. The cross between a tetraploid female flower and a diploid male flower yielded a sterile triploid plant. The sterile plant had fertile female flowers but lacked pollen so that a plant could not pollinate itself. (A watermelon plant has male and female flowers on the same plant in a ratio of 13 male flowers to 1 female flower, but it does not have perfect flowers that can self-pollinate.) The sterile plant is desirable because it produces seedless watermelon, which consumers prefer to watermelon with seeds. Because the sterile triploid does not produce pollen, a traditional pollen-bearing cultivar must fertilize it to yield fruit. Accordingly, the farmer or gardener must plant a triploid and either a diploid or a tetraploid to obtain seedless watermelon. The ratio of fertile to sterile plants should be one to three to ensure the production of enough pollen. Honeybees and bumblebees are the principal pollinators. Raised in the United States since the late 1980s, Tri-X-313 is a triploid with a tough rind, small fruit, a vigorous vine, disease resistance, and slow spoilage. Tri-X-313 is now grown throughout North America, Europe, and Israel.

An open-pollinated variety, Moon and Stars, has a mysterious origin. Mennonite immigrants from Russia may have introduced it into the United States, possibly in the 19th century. It was apparently poorly known, and in 1926 Peter Henderson seed company of New York claimed to have bred the variety. It was not popular in the early 20th century because, being round, it did not stack well. It was well enough known and at the same time rare enough that Seed Savers Exchange determined to find it, tracing a handful of seeds to gardener Merle Van Doren of Macon, Missouri. The exchange maintains the variety, which derived its name from its exterior being speckled with small spots akin to stars and a large yellow blotch akin to the moon.

Another open-pollinated variety, Rattlesnake is known as Southern Rattlesnake and Gypsy Oblong. As the last appellation suggests, Rattlesnake is oblong and easily stacked in truck and railroad cars. Dating to the 1830s in Georgia, the variety has dark green lines along its exterior that some gardeners liken to the outlines of rattlesnakes. Others think the lines resemble a tiger's stripes. Maturing 90 days after planting, a ripe melon may weigh as much as 45 pounds.

In 1881, seed company W. Atlee Burpee introduced the open-pollinated variety Cuban Queen. It produces long vines, a trait that it shares with many watermelon varieties. Melons, containing red flesh, grow larger than 70 pounds.

A 19th-century open-pollinated variety, Ice Cream is named because its white seeds and white flesh resemble vanilla ice cream. Maturing in 82 days, it is suitable for the short growing seasons of the North, though as a rule watermelon grown in the North is not as sweet as watermelon grown in warm locales. In 1876, Americans ate a variety of watermelon known as Ice Cream during the centennial celebration. Having pink flesh and black seeds, however, it was not the real Ice Cream, whose seeds are today difficult to obtain.

About 1940, U.S. Department of Agriculture horticulturist Charles Andrus bred the popular Charleston Gray, a variety that was disease resistant, did not wilt, bruise, or crack, and was slow to spoil. Being oblong rather than round, it was easy to stack. A number of varieties trace their lineage to Charleston Gray.

As the family has gotten smaller, Americans have come to prefer a small watermelon and breeders complied. Burpee markets the Fordhook Hybrid, which produces 12- to 14-pound melons. At 6 to 8 pounds, Burpee's Sugar Bush yields even smaller melons. Grocers have also adjusted to the desire for small melons, selling melons by the half, quarter, or even slice.

Within the past 25 years, hybrids have supplanted open-pollinated varieties, leaving the cultivation of the latter to heirloom enthusiasts. Although hybrid seed is more expensive than open-pollinated seed, farmers found that the high yield of hybrids justified their cost. The adoption of hybrids changed farming practices. Because open-pollinated seed was cheap, farmers did not worry about a late frost. If frost killed their plants, they simply replanted. Hybrid seed, however, was too expensive to risk a late frost. Farmers turned to germinating hybrid seed not in the field, where it was at the mercy of the weather, but in a greenhouse, transplanting seedlings in the field only when the danger of frost had passed. Hybrids yield 40–60 percent more fruit than open-pollinated varieties and produce more uniform fruit. China plants nearly all of its 5 million acres to hybrids, and the figure is also high in Japan and Korea. U.S. breeding programs focus almost exclusively on hybrids.

Cultivation

To get the most out of their varieties, some farmers began grafting watermelon plants on gourd rootstock, a practice common in Japan and Korea since the 1920s. Today, Japanese and Korean farmers graft 95 percent of their watermelon plants. In 1992, Japan cultivated 59,000 acres of grafted watermelons. Taiwan and Egypt also graft watermelon. The people of Southeast Asia use citron as rootstock. Grafted plants yield large melons, are resistant to soil-borne pathogens, grow well at low temperature, tolerate saline or waterlogged soil, absorb nutrients efficiently, and offer farmers a long harvest.

Where the growing season is short, the gardener should plant watermelon indoors three to four weeks before the last frost. Watermelon needs the soil to be 75°F to 85°F to germinate. Where summers are cool, the gardener may cover the soil with black plastic to absorb the sun's heat. In the South, the gardener may plant watermelon outdoors from seeds after the last frost. Planting will coincide with the sowing of corn and beans. The gardener may plant watermelon in hills, with each seed about one inch deep. Hills should be spaced four to six feet apart to give vines space to sprawl. Vines should be thinned to one or two per hill and melons to three or four per vine to produce large, sweet fruit. Melons closest to the base of a plant will ripen first. A melon is ripe when thumping it produces a "dull plunk." It is important to thump a melon in the morning because by afternoon all melons, ripe and unripe alike, sound the same. One may also gauge the ripeness of a watermelon by rolling it over to reveal a white or pale yellow patch.

Christopher Cumo

See also Gourd

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Wheat

An annual grass in the genus *Triticum*, wheat, along with barley, may have been the first plant that humans cultivated. It spread throughout the Old World in antiquity and the New World between the 15th and 19th centuries. Farmers, millers, and scientists recognize eight categories of wheat: hard red winter, hard red spring, hard white winter, hard white spring, soft red winter, soft white winter, soft white spring, and durum. The color red or white refers to the kernel (seed). As a rule, hard wheat has much protein and soft wheat much starch. From an early date, scientists touted the nutritional value of wheat. Among hard wheats, 12.6 percent

Wheat (PhotoDisc, Inc.)

by weight is protein, 1.5 percent fat, 71 percent carbohydrates in the form of starch, and 12.2 percent fiber. A small fraction, 0.0032 percent, is the mineral iron. In the family Poaceae or Gramineae, wheat is related to oats, barley, rye, timothy, bamboo, sugarcane, triticale, and sorghum.

Farmers plant winter wheat in fall. It germinates then, is dormant in winter, resumes growth in spring, and is harvested in late spring. A cold-adapted plant, winter wheat can tolerate temperatures as low as –30°F, though for only short durations before suffering damage or death. Having a long dormancy, winter wheat yields fewer bushels per acre than spring wheat. Farmers plant spring wheat after the last frost, when the soil is at least 40°F. It germinates between 55°F and 75°F. Early planting is important because yield decreases when wheat is sown late.

The genetics of wheat may seem formidable to the neophyte. Here only brief treatment is necessary. Wheat has 7 chromosomes in the haploid state. That is, each of the 7 is unpaired. Although there are some species of haploid insect, no haploid wheat exists. Diploid wheat has twice the number of chromosomes (14) as a haploid because each chromosome has a partner. Diploid wheat is therefore seven pairs of chromosomes. Unlike haploids, diploid wheat exists. Einkorn, one of the first wheats to be cultivated, is a diploid. In antiquity and without human aid, einkorn crossbred with a wild goat grass to yield tetraploid wheat, which has four pairs of 7 chromosomes or 28 chromosomes. Emmer, one of the earliest cultivated wheats, and durum are tetraploids. Today, durum is the most widely grown tetraploid with little acreage to emmer. In turn, tetraploid wheat hybridized with another wild goat grass to yield hexaploid wheat around 8,000 years ago. Because no wild hexaploids exist, this hybridization must have occurred in farmers' fields. Hexaploid wheat has six pairs of 7 chromosomes or 42 chromosomes. The bread wheats are hexaploids and, as one might expect, most acreage worldwide is planted to hexaploids. Wheat with larger numbers of chromosomes does not exist.

Wheat is a variable plant. Some varieties grow as tall as seven feet, though fewer than four feet is the norm. The semidwarfs of the Green Revolution are shorter than three feet. Scientists have bred more than 50,000 cultivars, giving farmers varieties for a range of soils and climates in temperate locales.

Origin and Domestication

The ancients believed that wheat, given its importance, must have been a gift from the gods. The Egyptians believed that sibling deities Isis and Osiris gave humans wheat. The Greeks attributed this beneficence to the goddess Demeter, and the Romans, borrowing from the Greeks, thought the goddess Ceres the giver of wheat. Some biblical scholars believe that the Tree of Knowledge of Good and Evil in Genesis was a wheat plant. In eating the forbidden fruit, the first humans sought to learn how to grow wheat. The story of Adam and Eve thus symbolized the transition from hunting and gathering to agriculture, with wheat being the first cultivated plant.

In modernity, scientists have not been content with these origin myths. In 1873, German botanist Friedrich Kornicke discovered a wild emmer plant in the herbarium of the National Museum of Vienna, heralding it the progenitor of cultivated wheat. In 1886, French botanist Alphonse de Candolle asserted that wheat arose in the Near East, pointing out that a Chaldean priest had mentioned the cultivation of wheat in Mesopotamia as early as 2,700 years ago and that archaeologists had discovered fossilized wheat grains in northwestern Iran and the Euphrates River valley. In 1910, Israeli agronomist Aaron Aaronsohn discovered wild emmer near the Lake of Galilee. Perhaps for patriotic as well as scientific reasons, Aaronsohn posited that wheat originated in Israel.

Building on this work, scientists and historians appear to be close to consensus. Although a minority of scholars dates the cultivation of wheat to 16,000 years ago, most favor a later date. Most scholars credit the Natufians, a people of the Near East, with first cultivating wheat. Between 13,000 and 10,300 years ago the Natufians, fashioning the first sickles, harvested stands of wild wheat and barley. As population increased, they depleted their source of food and devised a new way of obtaining food: agriculture. Between 10,300 and 9,500 years ago, the Neolithic people of Turkey, southwestern Iran, the Tigris and Euphrates river valleys, Syria, Israel, and Jordan—the Fertile Crescent—began to grow einkorn and emmer. These first farmers may have been women, who likely had the responsibility of planting wheat. Around 9,500 years ago, Neolithic people selected wheat whose grain no longer separated easily into individual spikelets, impeding wheat's ability to disperse seed. The loss of this ability altogether made cultivated wheat, though wild varieties continued to exist, dependent on humans for propagation. Moreover, humans selected wheat with seeds that did not have a dormant phase, at least not in warm weather, and so could be planted anytime.

It is unclear whether humans first grew einkorn or emmer, though their cultivation appears not to have overlapped. Neolithic people first grew emmer in Jordan and Syria. The cultivation of einkorn arose in Turkey. Einkorn was grown farther north than emmer because it better tolerated cold weather. Because wheat evolved in an area with mild winters and hot, dry summers, it grew in winter and went to seed before the advent of hot weather. Growing in winter, it was naturally cold tolerant, a trait for which humans selected. Despite einkorn's advantages, many farmers in antiquity grew emmer in preference to einkorn. Today, durum and bread wheat have supplanted emmer and einkorn. Einkorn is grown only in the mountains of Turkey, Yugoslavia, and southern Italy as fodder. Emmer is confined to remote regions of Ethiopia, India, Iran, Turkey, and the Balkans.

Migrating about 3,000 feet per year, wheat spread south from the Fertile Crescent to the lowlands of Mesopotamia and west to Anatolia in the eighth millennium BCE. In the sixth millennium, farmers in Egypt, central Asia, and India began growing wheat. Around 3000 BCE, wheat was cultivated in Ethiopia. In the third millennium durum, first grown between 7,500 and 6,200 years ago, began to replace emmer. Egypt and the Levant emerged as the center of durum culture, though elsewhere in the Mediterranean Basin farmers retained emmer. The hardest of wheats, durum has 1 percent more protein than bread wheat. Durum, however, has less of the protein gluten, which causes wheat to clump together, than bread wheat. Originating in Abyssinia or the Mediterranean Basin, durum was first cultivated, as we have seen in the southeastern Mediterranean. Intent on conquest, the Muslims brought durum with their soldiers, spreading the grain to the Middle East, North Africa, and Spain during the Middle Ages. So enthusiastic were farmers for durum that in some parts of the Mediterranean Basin, they grew it as the only species of wheat. Active in Sicily and southern Italy, Muslims established durum as a staple crop in these regions. Arabs used durum in soup, gruel, pudding, pastries, bread, couscous, a dish of durum and meat, and the cereal bulgar. In the Middle East and North Africa, only 15 percent of durum is converted into pasta. Half the durum crop in the Middle East goes to make bread. In Europe, durum is the main ingredient in pizza dough. As early as the 10th century, the Egyptians used durum to make noodles, though another tradition credits China with this innovation. Either from Egypt or China, Europeans derived the practice of making pasta from durum. Millers ground the grain into a coarse flour known as semolina. Most varieties of durum have a yellow endosperm that gives pasta its distinctive color. Some varieties of durum have a red endosperm, but these types feed livestock rather than humans. Farmers grow durum profitably in areas of low rainfall, because in this environment it yields better than bread wheat. Until roughly 1950, farmers in the Soviet Union grew durum, though in recent decades they have been unable to compete with cheaper durum from the United States and Canada. The latter exports much of its durum to Italy, where it is made into pasta.

Eight thousand years ago wheat migrated from Anatolia to Greece, Italy, southern France, and by 5000 BCE, Spain. From Greece, wheat moved into the Balkans, through the Danube River valley, and to the Rhine River valley about 5000 BCE. From the Rhine River valley, wheat spread to Central, Western, and Northern Europe as far as the Netherlands by 4000 BCE. One thousand years later, wheat had reached Scandinavia and England. About this date, farmers in Russia began growing wheat. At the same time, wheat migrated south from Egypt to Sudan and Ethiopia and west to Libya. From southern Italy, wheat spread to Sicily, Tunisia, Algeria, and Morocco. By the time of the Roman conquest of North Africa and Egypt, wheat was the principal crop. The Romans depended on Sicily, North Africa, and Egypt for wheat. So important was Egypt in this respect that the emperors declared it their personal possession. In Africa, farmers grew chiefly emmer. Einkorn was absent from Egypt, Ethiopia, and North Africa with the exception of Morocco. From Iran, wheat migrated east throughout Asia, reaching Pakistan 6,500 years ago and India 5,000 years ago. Two routes led to China. To the north wheat spread from Turkestan to Sinkiang. To the south wheat moved from Pakistan to Afghanistan, India, Burma, and the Yangtze River valley. By 2000 BCE, farmers throughout China were growing wheat. The grain reached Japan about 3000 CE.

Wheat in the New World

In 1493, Christopher Columbus brought wheat to the Caribbean, though the islands have never been large wheat producers. In 1521, the Spanish introduced wheat to Mexico, which by 1735 was exporting the cereal to the West Indies. In the 17th century, the Spanish brought wheat to Texas and the American South. In 1620, the Pilgrims introduced wheat to Massachusetts, though the colony, like the Caribbean, was ill suited to its culture. In the 1620s and 1630s, colonists grew spring wheat, and by 1624 they harvested a surplus of grain. In 1644, however, disease claimed the crop, spurring colonists to try winter wheat instead. The experiment failed when disease struck again, this time in 1664. Similar problems in Connecticut left wheat a minor crop in New England.

Elsewhere wheat fared better. Colonists imported varieties from Sweden and the Netherlands into New York, New Jersey, and Delaware around 1638. American farmers could count more than 470 varieties by 1892. Before 1860, U.S. farmers grew primarily soft red winter and soft white winter wheats because their yield was higher than those of hard wheats and because millers preferred them. In 1842, one farmer planted hard white winter wheat in Canada, marking the genesis of hard wheat on the northern plains. After 1860, U.S. farmers on the Great Plains adopted this Canadian variety. As early as 1841, farmers grew durum in Montana, and in 1864 Russian immigrants introduced it to North Dakota, where it remains an important crop. In 1872, Russian Mennonites planted in the United States hard red winter wheat that had originated near the Black Sea. In 1900, farmers in Nebraska planted 40 percent of acreage to hard red winter wheat. In 1919, one variety of hard red winter wheat, Turkey, claimed 83 percent of wheat acreage in Nebraska. From the Cornhusker State, Turkey spread to Texas, Oklahoma, and Kansas. Among Turkey's progeny was Norin 10, a variety that scientists used to breed the high-yielding semidwarfs of the Green Revolution.

Wheat in the Modern World

In the West and several other regions, people consume wheat in the form of bread. Simply by adding yeast to wheat flour and water, bread makers fashion a dough that rises, giving bread its light texture. For millennia, bakers made a coarse flour of wheat, one with the bran intact. This whole wheat bread is nutritious, containing protein, vitamins, and fiber. In recent decades, consumers have come to prefer white bread, which lacks bran. This bread is far less nourishing than whole wheat bread. Indeed, bread makers have had to add to white bread the vitamins that they had stripped away in removing the husk. Never an advocate of white bread, American writer James Baldwin likened it to Styrofoam and blamed it for causing many of the ills that afflict modern life. Nutritionists have found little more than empty calories in white bread. Worse, research has linked the consumption of white bread to obesity in children and adults. Even whole wheat bread is not immune from criticism. The advocates of a low-carbohydrate diet deem all types of bread too rich in starch. Moreover, although wheat contains protein, it does not have all the essential amino acids, requiring humans to derive them from some other source, fish or chicken for example. Nevertheless, as early as the sixth century, the Chinese identified the gluten in wheat as an important source of nourishment and learned to separate gluten from the rest of wheat flour. Gluten fed monks on a vegetarian diet throughout Asia. Today, health-conscious people consume wheat germ as a source of protein, oil, and fiber.

Wheat has not always enjoyed its current popularity. In Northern and Western Europe, the cultivation of wheat declined in the Middle Ages. In France and parts of the Holy Roman Empire, farmers grew rye rather than wheat and rye bread became peasant fare. In the 17th century, New Englanders grew rye where wheat had failed. Potatoes fed commoners in Ireland and Northern Europe. Yet during the Industrial Revolution, wheat returned to prominence, feeding the mass of factory workers. In the United States, the cornfields of the Midwest yielded to the wheat farms of the Great Plains. An arid region, the Great Plains were suitable for the cultivation of wheat, and American industrial workers, like their counterparts in Europe, ate wheat bread.

In India and Pakistan, wheat remains an important crop. In the 1960s, farmers in these countries adopted the semidwarfs of the Green Revolution. With adequate fertilizer and irrigation, these new cultivars yielded as much as four times more grain than traditional varieties. In less than a generation, these cultivars made India a wheat exporter rather than an importer. That is, yield gains have outpaced the rate of population growth. These new wheats have driven down the price of bread and thereby improved living standards. Yet these wheats have not been an unqualified success. Farmers in India, and throughout much of the world, grow a small number of genetically uniform cultivars where they had once grown a large number of traditional varieties. The result has been a loss of genetic diversity.

Genetic uniformity leaves wheat vulnerable to insects and diseases. The chief pest of wheat is the Hessian fly. In the United States, it is widespread in the East, the Southeast, the Great Plains, and the Pacific Northwest. Attacking both spring and winter wheat, the fly is most damaging in the Southeast. The female lays more than 200 eggs on wheat leaves. Hatchlings migrate to the stem, on which they feed. In the Southeast, summers are long enough to accommodate six generations of Hessian fly. It is particularly predacious in fall, attacking newly germinated winter wheat. Scientists have yet to derive wheat immune to the Hessian fly. In Georgia, alone the fly costs wheat growers $20 million per year. The best farmers can do is plant winter wheat in late fall, after the last brood of flies has died. Another approach is to reduce the population of Hessian flies by rotating wheat with other crops. In the Southeast, farmers rotate wheat with soybeans, corn, or sorghum. On the Great Plains, farmers fallow land for 9 to 14 months before again planting wheat. Less successful but increasing in popularity is no-till farming in which growers leave wheat stubble and other plant residue on the land. These remains may harbor Hessian flies or pathogens.

The Green Revolution underscored the importance of fertilizers in improving wheat yields. In the early 19th century, farmers seldom fertilized their wheat, or other crops for that matter, causing soil exhaustion. Throughout the century, scientists urged farmers to manure their wheat though there is little evidence that farmers did so. In 1840, German chemist Justus von Liebig called attention to the importance of nitrogenous fertilizers. Since then, scientists have confirmed that a farmer must supply the soil with 120 pounds of nitrogen to produce 100 bushels of wheat. The advent of anhydrous ammonia, a source of nitrogen, after World War II boosted wheat yields. Whereas farmers in North Dakota reaped 15 bushels per acre of wheat in 1940, the yield more than doubled to 34 bushels per acre in 1990. In addition to nitrogen, wheat needs phosphorus, potassium, and micronutrients. Of these, phosphorus may be the most important because it promotes the growth of roots and of the plant itself, particularly when it is young.

Worldwide, farmers produce tens of billions of bushels (hundreds of millions of tons) of wheat, making it the third leading crop in tonnage behind only corn and rice. Of these bushels, the United States produces a few billion bushels, second only to its yield of corn. In wheat production, the United States trails only China and India. In 1866, the United States grew hundreds of millions of bushels of wheat on several million acres, exporting a portion of the crop. Today, the United States produces its surplus on millions of acres, exporting a sizable portion of its wheat. Among the states, Kansas and North Dakota are the leading wheat producers.

Wheat consumption varies by region. Consumption is high in North Africa and the Near East. In Asia, people prefer rice to wheat and the indigenes of the Americas prefer corn. Wheat consumption remains high in Pakistan, India, parts of Europe, Australia, and North America. Worldwide, the profitability of McDonald's depends partly on the consumption of wheat. The uses of wheat are also varied. Europeans eat wheat in the form of bread, rolls, pastries, pasta, and cereal. In Asia, people consume the grain in chapatti, noodles, rolls, and steam bread. Africans eat flat bread and injera. Americans consume bread, cookies, biscuits, pastries, crackers, and cereal.

The iconic land of rice, China is the world's largest consumer of wheat as well as being, as we have seen, the world's largest wheat producer. China also devotes the most acreage to wheat worldwide. In China, wheat is second in acreage only to rice. A major exporter, Argentina has grown wheat since 1527. Argentine farmers grow wheat between 31° and 40° south. They rely on rainfall, irrigating only a small portion of their land. After 1880, wheat acreage expanded as population increased and as railroads opened new land. Between 1880 and 1908, exports grew from a few hundred thousand tons to a few million tons. Production has followed yield per acre. On the best land, farmers grow several tons of wheat per acre. In 1999, Argentina produced tens of millions of tons of wheat. Almost the entire crop is hard red spring wheat for making bread, though a small percentage is durum. Argentine farmers rotate wheat with soybeans, sorghum, sunflower, potatoes, or alfalfa, though acreage to alfalfa has declined in recent years.

Hybrid Wheat

The discovery of heterosis or hybrid vigor in corn in the early 20th century led scientists to wonder whether they could achieve similar success with other crops. Progress with wheat was slow. Unlike corn, wheat naturally self-pollinates and so does not readily form hybrids. The anthers are small and their removal is a delicate task, making impractical and costly the emasculation of numerous wheat plants. Scientists must then collect the pollen from other wheat plants to fertilize the emasculated plants. Because this work was only on a small scale, it could not produce enough wheat seed to meet the needs of farmers. More promising was the discovery of genes that caused wheat to produce no pollen. These plants served as the females in hybrid crosses.

U.S. hybrid seed corn company DeKalb marketed the first hybrid wheat in 1974. Its competitor Pioneer Hi-Bred International followed with its own variety of hybrid wheat in 1975. After a lag of 10 years, French firm Rohm and Haas derived its first hybrid wheat, though the cultivar sold poorly. Today, companies in the United States, France, Australia, and South Africa sell hybrid wheat. The United Kingdom, Denmark, Belgium, Germany, China, and India aim to breed their own hybrids. Today, the United States and France are the largest growers of hybrid wheat. In the United States, only a fraction of acreage is planted to hybrids. France tallies a larger amount, but it is still not on an ambitious scale.

Though these numbers are only a small percentage of acreage, hybrid wheat has the potential to feed the planet's burgeoning population. The progeny of hybrid crosses yield as much more than the parents. These crosses are between wheats in different categories: a cross between a hard red winter wheat and a soft white winter wheat for example. Crosses within a category yield a small gain in grain over what the parents yielded, an appreciable if unspectacular gain.

Toward the Future

Because of the Green Revolution, wheat production has doubled between 1960 and 2000. Further increases should be possible. One scientist projects a wheat yield of several hundred million tons in 2030. This increase may result partly from a rise in land to wheat and partly from the breeding of high-yielding cultivars. Yet the rate of increase may slow, leading experts to wonder whether wheat production can keep pace with population growth. Yield gains may slow because water for irrigation may become more costly and because wheat cultivars may be near the maximum yield. Scientists may find it harder to squeeze gains from already elite cultivars. Moreover, globalization and the attendant decrease in government subsidies to farmers may make wheat a less attractive crop.

Despite these worrisome signs, one scientist expects wheat production in Pakistan and India to more than double between 1995 and 2030. Wheat production in the Near East and North Africa may nearly double between 1995 and 2030. The trend is less certain in China, where increasing demand for meat may cause some farmers to switch from wheat to corn. In the developing world, the demand for wheat will likely grow as population expands and as people increase their intake of calories. By 2030, the consumption of wheat may exceed the consumption of rice in southern Asia. Because of this trend, southern Asia will likely increase its importation of wheat. The appetite for wheat may be insatiable.

Christopher Cumo

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White Bryony

White bryony is usually considered a weed, but it has an old history as a cultivated plant. It is easily grown, and it thrives in all types of soil. Although poisonous (it contains cucurbitacine), it has been widely used as a medicinal herb. About 40 berries make a deadly dose. Its poisonous nature has earned it such names as Devil's Turnip in English and Teufelrübe in German. White bryony has also served as an ornamental plant, since it can be trained to cover porches and fences. In many parts of the world, it has become naturalized. In North America, for instance, it started to spread as an invasive plant during the last quarter century, and it is now classified as a noxious plant (in some U.S. states it is known as kudzu of the Northwest). It is also found in Australia and New Zealand, where it is still used as a garden plant.

An herbaceous perennial vine, white bryony clings to other vegetation with the help of tendrils. It grows extremely quickly, with creepers 10 to 16 feet long. The leaves are triangular or heart shaped, and broadly toothed. The stout root, which resembles a turnip, is yellowish white. The entire plant is succulent. The species is monoecious; that is, both male and female flowers are found on the same plant. The blossoms are greenish white. The plant is unusual in being a diploid apomict with the capacity for sexual reproduction. Its black pea-size berries—each containing three to six large seeds—emit a fetid, unpleasant smell. Under favorable conditions, the plant spreads quickly. Birds help to spread the seeds. Due to its less than pleasant odor, white bryony is known in Swedish as *hundrova*, "dog-turnip," with the first word being understood pejoratively.

History as a Cultivated Plant

Scientists and historians know little about the origin and spread of white bryony, or indeed of most other old cultivated plants from the eastern Mediterranean region. The plant likely originated in southwestern Asia and made its way with the help of cultivation to large parts of Europe, including Russia. The first emperor of Rome, Augustus, is said to have worn a wreath of white bryony during thunderstorms, to protect himself against being struck by lightning. European peasants in the early modern era wore amulets made from it for the same purpose. The 12th-century abbess Saint Hildegard von Bingen averred that the boiled root could be used to treat foot sores and that the smell of the root drives away toads and snakes. In the Middle Ages, it was used against such afflictions as leprosy. A number of late medieval and early modern authors mention its use for medicinal purposes in Northern and Western Europe. But it has been cultivated for other reasons too. In Scandinavia, for example, peasants often grew it close to henhouses, in the belief that it kept away birds of prey. By the early modern era, furthermore, it had become naturalized in Europe and the British Isles. "It is seldom admitted in gardens, though a plant or two for variety merits a place in a large ground as climbers," noted *The Universal Gardener or Botanist* (1778), a Scottish handbook on gardening written by Thomas Mawe and John Abercrombie. The plant has also become naturalized over wide areas, including many parts of Central, Eastern, and Northern Europe. Reports from 1975 tell of its growing wild in the U.S. state of Washington. Since then, it has established itself locally in other parts of the western United States as well.

Uses

It is above all the root that has been useful, in both a fresh and a dried form. The usual practice was to harvest it in the autumn. The ancients used the root against gout, epilepsy, paralysis, vertigo, hysteria, sores, and coughs. Greek physician Hippocrates (460–370 BCE) prescribed it against tetanus. First-century CE Greek physician Dioscorides recommended it for treating burns. In later periods, European medicine commended it. According to the Danish canon Christiern Pedersen, writing in 1533, wearing the root around the neck counteracted epilepsy, while boiling the root in oil yielded a remedy for stitches in the side. German herbalists in the 15th and 16th centuries hence used the name *Stickwurz* for it. Juices from the plant and berry were used to treat edema. The English physician Nicholas Culpeper, writing in 1653, claimed that white bryony was effective against many complaints, including palsies, cramps, convulsions, and stitches in the side. Physicians in the 18th century averred that if slices of the fresh root were placed against aches and sores, the effect was to cure the ailment. The root was deemed effective against parasitic worms, and it was used as a laxative. Indeed, in a medical work from the 17th century, the Swiss botanist Gaspard Bauhin called it *Scheißwurz* ("shit root"), because of its purgative power. It has also, according to information from 19th-century Ukraine, been used as an abortifacient, due to its contractive effect upon the uterus. Due to these many uses, European pharmacies long carried the root of white bryony.

Within traditional medicine, white bryony figured until modern times. Russians used it to treat hemorrhoids. Ukrainians gave it to their children in order to drive out intestinal worms. It was considered especially helpful for the treatment of rheumatism, inspiring such designations as *Gichtrübe* in German and *giktrot* in Swedish. In rural England, it has gone by the name of mandrake, due to the similarity of its appearance with that of a well-known medicinal herb also featuring a large root to which medicinal properties have been ascribed. In Northern Europe, swindlers were known in former times to carve white bryony roots into a certain shape, to bury them in dry sand for some days, and then to sell them as mandrake.

White bryony has also figured in veterinary medicine. English country folk, for example, often used it as a conditioner for horses.

Since the plant is poisonous, its role as a medicinal herb is now considered obsolete. It is mainly within homeopathy that white bryony is still used. It is given in very small doses for the relief of joint and muscle pain. It also serves as a homeopathic veterinary remedy.

Tanners used the flowers for dressing leather, and starch was obtained from the root. Erasmus Darwin, English physician and grandfather of Charles Darwin, wrote in his famous *The Botanic Garden* (1791) that he had eaten the tops of white bryony and found them "nearly as grateful as Asparagus, and [thought] this plant might be profitably cultivated as an early garden-vegetable." It bears stressing, however, that his example should not be followed, for the entire plant is poisonous and can induce vomiting and cramps if ingested.

In Germany, white bryony was once used to make a kind of love potion. When dancing, moreover, young women would keep thin slices of the root in their shoes, in order to attract men.

As a hardy perennial climber, white bryony still has ornamental qualities for some gardens. The species has a fast growth and is easily propagated with seeds. It is available through some specialized nurseries.

Ingvar Svanberg

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White Horehound

A member of the mint family, white horehound is an herbaceous perennial with white-felted erect stems 10 to 24 inches high. Upon these stems grow egg-shaped toothed leaves, green-gray and downy on the top and white and downy underneath. The numerous flowers are white, growing in clusters on the upper part of the main stem. White horehound blooms between July and September. The entire plant is infused with a light fragrance. Its leaves contain 0.3–1 percent bitter principles (chiefly marrubin), diterpene alcohols (peregrionol, vulgarol, marrubiol, and phynol), and up to 7 percent tannins. The plant is rich in essential oils. It is hardy and easily grown and flourishes best in a dry, barren soil. Its seeds are dispersed by animals.

Today, in most parts of Europe, its former use as a medicinal herb is almost forgotten. Yet European peasants grew it widely in former times, as did their countrymen and women who had ventured to other continents. Its onetime popularity as a medicinal herb is evident from its spread not just to Northern and Central Europe but to other parts of the world as well. Emigrants from Europe brought it along with them to their new homes. Where climate has allowed, furthermore, it has taken root among the local flora. In the Western Hemisphere, accordingly, the species is found from Canada in the north to Argentina in the south (although not in the tropical areas in between). It has also made its way with human assistance to Australia, Tasmania, and New Zealand. Sheep breeding has contributed to its spread. The report from Australia, where it was introduced in the 1830s, is that it now grows widely on grazing lands as a weed and that it is difficult to eradicate. Its consumption by the sheep imparts a bad flavor to the meat. It grows thickly over large areas, imposing large costs on sheep farmers.

Origin and Cultivation

White horehound has its origins in inner Asia, southwestern Asia, and the Mediterranean region. Due to its virtues as a medicinal herb, it spread to Europe as a cultivated plant and also became naturalized in many areas. The ancients knew of white horehound under its generic Latin name *marrubium*. The origin of this designation is unknown. Some authors trace it to Hebrew, from a word meaning "bitter." Only fragmentary records tell of the plant's spread into Northern and Central Europe. In the British Isles, however, arcaheological finds from the Iron Age and up to medieval times attest to it. The Anglo-Saxons used it to treat lung trouble. The name for the plant in Old English is *hārhūne* (Middle English *horhoune*). The name horehound has nothing to do with dogs or hounds: *hār* means "hoar" or "grayish-white," while *hūne* is of unknown origin. Archaeobotanical findings from the Czech Republic, Germany, and Switzerland confirm the use of the plant during medieval times. Danish documents point to its presence in that country from the 14th century. It was mainly peasants who cultivated white horehound in Northern Europe. In the British Isles, it was used to make tea and sweetened cough drops until well into the 19th century.

White horehound has largely disappeared from home gardens in Northern Europe today. The same is also true in Central Europe, another region where peasants once grew it. It survives now mostly as a relic of cultivation. It can be found growing along roadsides, as well as in courtyards, cemeteries, garbage dumps, and worn-out old pastures.

While it has disappeared from home gardens in most of Europe, white horehound is grown today for commercial purposes. In Hungary, Italy, Morocco, and southern France, it is used in the making of cough medicine. The leaves are also used for flavoring liqueurs.

Medicinal Plant

Ancient writers, including first-century CE Roman encyclopedist Pliny the Elder and his contemporary the Greek physician Dioscorides, cited its uses as a medicinal herb. Bishop Albert of Cologne, writing in the 13th century, noted its effectiveness against coughs. Herbals from the late medieval period also commend its virtues. Herbalists and physicians of the 16th and 17th centuries knew it well: Leonhart Fuchs, John Gerard, and Nicholas Culpeper called for its use against tuberculosis and other afflictions. Gerard wrote in 1597 that "sirupe made of the greene fresh leaves and sugar, is a most singular remedie against the cough, and wheezing of the lungs." The herb also found its way into official medicine. Indeed, syrup made from it has been offered by European pharmacies up to our own day. A British author, Arnold James Cooley, wrote in 1845 that the herb was a popular remedy for chronic pulmonary complaints (especially catarrh), as well as for uterine and liver maladies. Even today it is used to treat asthma, dry cough, flatulence, and lack of appetite. When taken in large doses, it works as a laxative.

Practitioners of traditional folk medicine have also used it widely. Well into the 19th century, it was used to make tea and sweetened cough drops in the British Isles. On the Danish island of Bornholm, it was known as *moderurt* ("mother herb") and was prescribed for certain women's diseases. German women used it to ease labor pains. The people of northern Sardinia found that it counteracted asthma. The inhabitants of Guernsey, where the plant was known as *orâne*, judged it effective against coughs and colds. The Irish used an infusion of the plant against aches of the ear and head. Romanian peasants used it to stimulate the appetite, and to relieve kidney pain, headache, and cough. Recent ethnobotanical research has recorded 21 different uses of the species in Italy and 18 in Tunisia. These relate to a wide range of maladies (cardiotonic, antimalarial, hypoglycemic, and hypotensive). Reports from Iran tell of its use there for digestive and respiratory problems. In Texas, white horehound was made "into candy or syrups, with sorghum or sugar, for dosing youngsters with throat ailments." In the Rio Grande Valley in New Mexico, the Spanish-speaking population still considers it beneficial to drink tea mixed with extract of the herb. Native Americans also used it for coughs, colds, and sundry respiratory ailments. The Navaho used a decoction of the root to help a woman through childbirth. Farmers in many parts of the world used the herb to treat hog and horse diseases.

Household remedies have also featured white horehound. A work by Arnold James Cooley, *A Cyclopaedia of Practical Receipts* (1845), contains a recipe for candied horehound, a cough suppressant once popular in England and among immigrant communities in the United States. One pint of horehound juice is mixed with 4 pounds of white sugar and 6 pounds of moist sugar (or with 10 pounds of white sugar). This is boiled, then poured into paper cases well dusted with finely powdered lump sugar, and then cut into squares when cooled. White horehound is also in demand within complementary medicine, especially as an herbal tea and a tincture. It is sold in capsule form as well.

Other Uses

The denizens of Norfolk and other rural districts used horehound to brew horehound ale, an appetizing and, according to reports, healthy brew that was very popular. The inhabitants of the Isle of Man, perhaps influenced by the zealous temperance of the Methodists, favored a nonalcoholic drink made from white horehound.

Some have seen white horehound as an antidote to bewitchment and supernatural influence. Americans have considered it "a well-tried" remedy for rattlesnake bites. According to German botanist Johann David Schöpf, writing in 1788, said remedy was "made known not many years ago by Caesar," a black man "who was rewarded by the state of North Carolina with his freedom and a considerable sum of money. Having been many times tried, the especial efficacy of this remedy seemed to be admitted." The remedy consisted of roots of white horehound and leaves of greater plantain, boiled in water.

Italians made brooms from the aromatic branches of this plant and used them to remove the odor of burnt food from their ovens. The herb is also said to repel grasshoppers, and it is sometimes planted as a barrier to these insects. Beekeepers have found it useful because it attracts bees.

Ingvar Svanberg

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Willow

The willow is a tree in the genus *Salix*, as classified by Swedish botanist Carl Linnaeus in the 18th century. *Salix* is a large genus of more than 400 species that includes not only deciduous trees but fast-growing shrubs as well. *Salix* prefers moist soils and its typical habitat is in the cold-to-temperate climates of the Northern Hemisphere.

Description

There is great variety among *Salix*. Most species are considered willows, such as the white willow, or *Salix alba*, which reaches 75 feet in height, but the genus also includes the broader-leafed sallow and the narrow-leafed shrub called "osier." An example of these is the low-lying creeping shrub known as the dwarf willow, or *Salix herbacea*, which averages just two inches in height, although it spreads widely.

Willow branches are slender, fibrous, and tenacious, and the roots are tough and also tenacious, with some roots growing outside the ground. The leaves of the willow tend to be lanceolate, or tapered, although some are rounded; and the species is dioecious, meaning some trees have male and others have female flowers, which aids cross-fertilization and produces many hybrids. The fruits of the willow appear as capsules that contain downy seeds. Probably the best-known willow variety is the weeping willow, or *Salix* × *sepulcralis*.

Uses of the Willow

Willows are easily cultivated. They grow well from cuttings or from broken branches fallen to the ground. They are grown for their appearance and to provide screening and shelter. Because they prefer to grow in damp conditions and have interlacing roots, they are a good tree to plant for stabilizing riverbanks. Willow branches are flexible and therefore are a good wood for making baskets, furniture, and wattle-and-daub walls. The wood has been used to manufacture boxes, brooms, flutes, toys, whistles, wands, fences, and poles. Willow fibers can be made into rope, paper, and tannin.

In its bark the willow produces salicylic acid, which is an anti-inflammatory and pain-relieving ingredient now made into aspirin. In fact, salicylic acid was first discovered in the salicin in the willow bark. Use of the willow goes back centuries to the ancient Sumerians, Egyptians, and Assyrians, who used the leaves and bark as a fever and pain reducer. Greek physician Hippocrates (460–370 BCE) also noted the medicinal value of the willow.

The Native Americans have long used the willow for medicinal and other purposes. They chewed or boiled the leaves and bark into a tea to help relieve the pain of toothaches, headaches, and inflamed joints. In fact, the willow is sometimes referred to as the "toothache tree." In other uses, the Native Americans made the branches of the willow into arrow shafts and the twigs into paint brushes. Willow is a common wood in the Native American tradition of basket weaving, too, and the twigs are made into beds, fish traps, and backrests on chairs. The Arapaho fashioned willow into cradleboards for babies to be carried by their mothers, and the Ojibway made willow into dream catchers and dolls. In the Blackfoot tradition of the Brave Society, a "willow brave" is chosen and he ranks just below the leader of the society. In a ceremonial procession, the willow brave carries a branch of willow that has been fashioned with yellow-painted plumes.

Culture and Myth

The willow has long been a part of myth and has been associated with femininity and the moon. The Sumerian goddess of the moon, Belili, lived in a willow tree and in springs and wells. The ancient Greeks believed that Persephone, the daughter of Zeus and Demeter and who ruled the underworld with Pluto, had a willow grove.

The ancient Celts believed that the wood to be used for harps came only from the willow, and in turn the harp became a sacred instrument. The willow also appears in the Christian Bible. Psalm 137 reads: "By the waters of Babylon, there we sat down and wept, when we remembered Zion. On the willows there we hung our lyres." The weeping willow's scientific name, in fact, is *Salix babylonica*, presumably derived from this biblical reference. Generations of poets and writers to follow interpreted the willow as a symbol of mourning, and it is a tree that is planted in burial grounds in China and Turkey.

Willow is also important in modern religious ceremonies. The Jewish holiday of Sukkot features the willow, along with the citron, the palm, and the myrtle, as one of the "four species" carrying symbolic significance in the ceremony. The willow also plays a prominent role in Buddhism, as it is the item depicted in artwork of the bodhisattva of compassion, Kuan Yin. Kuan Yin is believed to use the willow branch to sprinkle the divine nectar of life on her followers. In Wicca, the willow is believed to guide the dead to the "Summerland," or afterlife. And in some Northern European Catholic churches, the willow branch is used in place of the scarce palm in ceremonies taking place on Passion, or Palm, Sunday. In the past in Poland and parts of England, Palm Sunday was sometimes referred to as Willow Sunday.

The Willow in Literature

The willow is found in many literary references, from English playwright William Shakespeare (1564–1616) to British author J. K. Rowling (1965–). In Shakespeare's *Hamlet*, the willow is the tree Ophelia climbs and falls from before drowning. In Shakespeare's *Othello*, Desdemona expresses her lost love in a song featuring a willow tree, and the willow represents forsaken love in the play *Twelfth Night*. The 19th-century Danish author Hans Christian Andersen featured the willow in his book *Under the Willow Tree*, and it is in the title of the famous 1908 children's animal adventure story *The Wind in the Willows* by Scottish author Kenneth Grahame (1859–1932). It also appears in the title of several other works of literature, including British writer Algernon Blackwood's (1869–1951) *The Willows* (1907); a Native American Osage Nation story called "Wisdom of the Willow Tree," in which a young man approaches the willow he calls Grandfather for answers; and a Japanese ghost story titled "Green Willow." It also is the title of a 1988 fantasy film directed by American actor and director Ron Howard.

Old Man Willow is a willow tree character in *The Fellowship of the Ring*, a book in British writer J. R. R. Tolkien's (1892–1973) Lord of the Rings trilogy; he casts a spell on the hobbits and traps them until they are rescued by Tom Bombadil. Grandmother Willow is the name of the title character's elder relative in the Disney production of *Pocahontas*, and the ancient tree growing on the Hogwarts Academy school grounds is named the "Whomping Willow," in J. K. Rowling's *Harry Potter and the Chamber of Secrets* and *Harry Potter and the Prisoner of Azkaban*.

Rosemarie Boucher Leenerts

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Wintergreen

Wintergreen (*Gaultheria procumbens*) is an evergreen, perennial herb native to North America. Wintergreen is indigenous to the eastern part of North America; it can be found growing wild as far south as Georgia and as far north as Newfoundland, where it prefers the sandy and rocky soil of plains and mountains. Some *Gaultheria* species are indigenous to Asia, though *Gaultheria procumbens* is the species most commonly referred to as wintergreen. It is the source of true oil of wintergreen. The oil of the sweet birch, *Betula lenta*, which is chemically similar, has similar properties, and smells the same as oil of *Gaultheria procumbens*, is also marketed as oil of wintergreen. Wintergreen has analgesic and other medicinal properties. Native Americans used this herb to treat rheumatism, aches, pains, sore throats, and other conditions. They passed on the knowledge of its use to European settlers when they arrived in the New World. Though wintergreen has little commercial value, its cultivation continues on a small scale. Wintergreen's common names include mountain tea, teaberry, Canada tea, spiceberry, and checkerberry. Wintergreen is also sometimes known as deerberry or partridgeberry because these animals feed on the plant's red berries. Native American and European settlers in

North America used wintergreen to treat a range of inflammatory medical conditions. European colonists introduced wintergreen to Europe, and Great Britain in particular, after its effectiveness as a medicinal herb was discovered.

Medicinal Use

Members of the genus *Gaultheria* contain methyl salicylate, a compound with properties similar to those of aspirin. Sweet birch also contains methyl salicylate. The oil of sweet birch can be used for the same purposes as aspirin, and is often marketed as oil of wintergreen. Methyl salicylate is an anti-inflammatory; it works in much the same way as aspirin to relieve pain, fever, and swelling. Methyl salicylate blocks the hormonal processes inside the body that cause inflammation and pain. Wintergreen also contains mucilage, which is known for its softening and soothing properties, and tannins, which are astringent.

Herbalists consider wintergreen to have astringent, carminative, diuretic, emmenagogue, stimulant, tonic, and analgesic properties. Folk tradition names it as a remedy for headaches, sore throat, body, back and joint pain, tooth decay and halitosis, rheumatism, inflammation, skin diseases, colic, chronic mucous discharge, and fever. American farmers once fed wintergreen leaves to sickly cattle and horses as a restorative and anthelmintic (dewormer). During the American Revolution, colonists drank wintergreen tea as a substitute for regular tea, which was scarce in the colonies at the time.

An Asian species of wintergreen, *Gaultheria cumingiana*, is used in traditional Chinese medicine to treat cirrhosis of the liver and ascites, a condition characterized by fluid accumulation in the abdominal cavity. *Gaultheria cumingiana* is also used in Chinese medicine to treat rheumatism, fevers, injuries, and pain, just like its New World counterpart, *Gaultheria procumbens*. Methyl salicylate absorbs through the skin, and is generally applied topically for the treatment of sprains, aches, and bruises. Modern topical pain relievers often contain oil of wintergreen as an active ingredient.

A Cautionary Note

While the methyl salicylate found in wintergreen does have medicinal value, pure oil of wintergreen can be toxic if ingested. Symptoms of methyl salicylate poisoning include vomiting, nausea, acidosis, pulmonary edema, convulsions, pneumonia, and death. Traditional folk medicine and herbal medicine often requires drinking a tea made from the leaves of the wintergreen plant; the leaves contain so little oil that drinking wintergreen tea is not dangerous. There have never been any reported cases of poisoning as a result of drinking wintergreen tea, but ingesting the pure oil can be fatal. Pure oil of wintergreen should never be ingested; even those food products that contain it as a flavoring do so in very small amounts. Topical application of the pure oil should be approached with caution. Because methyl salicylate absorbs through the skin, topical application of the pure oil of wintergreen can lead to toxicity and is dangerous. Pure oil of wintergreen should never be applied to the skin for more than 3 days in any 30-day period. Muscle rubs and other topical pain relievers, which contain lower concentrations of the oil, can be used more frequently, as they contain lower concentrations of the pure oil. Children are especially vulnerable to methyl salicylate toxicity; as little as one teaspoon of oil of wintergreen can be deadly to a child under age 12 if ingested. Most doctors and herbalists advise against children using methyl salicylate products or ingesting foods or candies flavored with oil of wintergreen; the dangers of methyl salicylate for children may include an increased susceptibility to Reye's syndrome.

Competition from Synthetic Sources and Current Status

In the past, oil of wintergreen was considered valuable for its medicinal properties, and the herb was far more widely cultivated than it is now. These days, methyl salicylate can be synthesized from coal tar. Synthetic methyl salicylate is far cheaper to produce than the natural oil. Oil of wintergreen is distilled from the leaves of the plant, which contain on average 0.5–0.8 percent oil. That oil is 96–99 percent methyl salicylate. The oil must be allowed to ferment for 12 to 24 hours before it can be used medicinally. Because there is so little oil to be found in fresh wintergreen leaves, synthesized methyl salicylate has grown in popularity since the process of synthesis was discovered. A German process, involving increased maceration of the fresh wintergreen leaves, has allowed modern herbalists to distill a slightly higher quantity of oil from the fresh leaves.

In addition to its medicinal uses, oil of wintergreen is also used as a fragrance and flavoring. It is still added to toothpastes and mouthwashes, as a breath freshener and antioxidant. It is also used to flavor candies and chewing gums. Most of the wintergreen leaves used today are harvested from wild plants. Leaves can be harvested twice during a single growing season. The process of harvesting wild wintergreen leaves is, however, somewhat tedious. Happily, wintergreen can be easily cultivated from seed. Small-scale cultivation continues in Appalachia and the American Northeast.

Marjorie McAtee

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Wormwood

Wormwood is one of the common names for the herb *Artemisia absinthum*, of the family Compositae. *Artemisia* is comprised of over 180 species of hardy herbaceous plants known for their aromatic oils. Wormwood, native to temperate regions of Europe, Asia, and North Africa, was first introduced to North America as an ornamental. It has subsequently become naturalized in some regions of the country, specifically range and pasturelands, by outcompeting native species.

Identifying the Herb among the Weeds

Two obvious characteristics of wormwood are its silvery-green foliage and the strong aroma of sage. The spirally positioned leaves are covered in tiny hairs, called trichomes, and bear minute oil-producing glands that give the plant its distinctive odor and taste. Wormwood grows about three feet tall, supported by grooved stems and a root rhizome, with two- to five-inch deeply lobed leaves. During the summer, a stalk develops from each upper lobe and produces numerous small heads of tiny, yellow tubular flowers further organized in leafy clusters. Wind and animals, together with gravity, disperse the seeds.

The cultivation of wormwood does not require much effort. The plant is easy to grow, even in soil that lacks nutrients, although it prefers plenty of nitrogen. Its main requirement is well-drained earth, neither particularly moist nor overly dry, in bright light. As an ornamental, it can be successfully grown among rocks and along pathways. Its attractive foliage and bright flowers are a welcome addition to native plant gardens. Wormwood is propagated straightforwardly either by seed or by root cuttings. In optimal conditions, it is rarely affected by pests or diseases and is widely cultivated.

The Name Wormwood Is Associated with a Bitter Taste

Over 3,500 years ago, the Greeks were said to consume wormwood to rid themselves of intestinal worms. Wormwood has been documented as being used by the Romans as an herbal remedy since at least the first century. Roman soldiers made it into a poultice for relieving foot pain after long marches. Physicians prescribed it for relief of menstrual pain, and for anemia, rheumatism, and jaundice. Some believe the name wormwood reflects the use of this treatment. Others say it is from the Anglo-Saxon word *vermode*, which is roughly translated as "mind preserver." This may be due to the dependence upon wormwood as a remedy against many health problems of the day. Wormwood may have been considered a source of comfort and relief. Alternatively, the name may be a reference to its effect on the nervous system as a narcotic when used in increased quantities.

In fact, it is surprising that wormwood is consumed at all, considering how bitter it tastes. Interestingly, the plant was used in large-scale breweries for a short time instead of hops because wormwood is slower to rot. It also most likely added a unique flavor to the beer. The French spirit absinthe, and the German drink vermouth are actually characterized by the unusual flavor. Specifically, the taste is due to an oily compound called absinthol, containing the bitter absinthin and an active ingredient thujone. In large quantities, thujone is a convulsant poison and narcotic. It is similar to THC (tetrahydrocannabinol), the active ingredient in the illegal substance marijuana. It is believed they both react with the same receptor in the brain.

Research and history have shown that the active ingredients in wormwood, consumed in large quantities over an extended period of time, can contribute to nerve depression, can deeply impair mental stability, and may lead to complete loss of reproductive function. These dangers are probably best known in regard to the history of the French liqueur absinthe. Made from the leaves and flowering tops of wormwood, together with other fragrant plants, absinthe is one of the better known and loved "stimulating beverages." Unfortunately, history tells the story of the rise and fall of absinthe as an addictive and deteriorating drink that led to severe mental disturbance, seizures, and often death. It is believed that the impressionist painter Vincent van Gogh was influenced by absinthe when he cut off his ear and sent it to a lady friend. Absinthe was banned in most countries by 1915.

Despite a Difficult History, Wormwood Is Valued among Modern Herbalists and Gardeners

Wormwood continues to be added as flavoring to vermouth and other foods and beverages with caution. Some people may experience side effects including diarrhea and sedation. If taken over a long period of time, people may experience nausea or may find the herb habit forming. Today's holistic doctors prescribe wormwood tea or tincture for many of the same ailments that plagued people of long ago. These recommendations come, however, with strict guidelines on the amount of wormwood used and the length of time it is taken.

It is not surprising that wormwood has been used as insect and weed repellent. Sachets of the herb or prepared tea sprays work well to repel fleas and moths indoors, and aphids, slugs, and other pests outdoors. The bitterness of wormwood is due to large amounts of the compound absinthin. Since it is water-soluble, absinthin will wash off plant leaves and into the soil. It is toxic to other plants, inhibiting their growth. The substance also repels larvae and other grubs that may affect the health of the plant and others in the same bed. As a result, wormwood does not make a good companion plant but is useful in the struggle against weeds.

Although necessary to treat it with caution, wormwood has a fascinating history and is regarded well enough to be cultivated widely. While there are definite negative health effects, there have been as many reasons to utilize the herb in a responsible way. At the very least, wormwood has value as an attractive ornamental, with few requirements or challenges to optimal growth.

Gwendolyn Vesenka

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Y

Yam

A crop primarily of the tropics and subtropics, the yam is a perennial tuber. During the rainy season, a tuber produces a vine, which in turn generates one or more tubers. At the end of the rainy season, the vine dies and the farmer, treating the plant as an annual, harvests the tubers. Left in the ground, however, a tuber will produce a new vine during the next rainy season, displaying its perennial habit. The yam is like the potato in yielding a tuber and unlike the sweet potato and cassava, which do not produce tubers but rather swollen roots. The distinction between the yam and the sweet potato is lost on many Americans who mistakenly call the sweet potato a yam. The Yam Belt of the southern United States is really an area of sweet potato culture. Worldwide, people confuse the yam with the cocoyam (*Xanthosma*), taro, eddoe, and arrowroot. Some people assume erroneously that the cocoyam is a type of yam. The elephant yam of India is not a yam but a relative of the cocoyam. The term "yam bean" refers to a legume, not the yam.

The term "yam" is properly applied only to members of the *Dioscorea* genus, which is in turn part of the Dioscoreaceae family. The English word "yam" derives from the older *jugnamis*, *iniamea*, *yamme*, and *yame*. The French term for yam, *ignome*, derives from the earlier *igniame*. The Spanish *name* derives from *niame* and *nyame*. The Portuguese *inhame* derives from *ynhame*. In Dutch "yam" is *iniame*, in Italian *gname* and *ignamo*, in German *ignamkolle* and *yamswurtzel* and in Arabic *ighnam*. In 1492, Spanish-Italian explorer Christopher Columbus used the term *niam* to refer to the yam, though some speculate that he had observed a sweet potato rather than a yam. The Mande of West Africa used the term *niam* for yam.

The yam, depending on the species, is 63–83 percent water compared to 68–82 percent for the potato and 58–81 percent for the sweet potato. The yam is a rich source of carbohydrates, though they have fallen into disfavor among some nutritionists. The yam is 15–38 percent carbohydrate, whereas the potato is 14–27 percent and the sweet potato 17–43 percent. Ninety-nine percent of the yam's carbohydrates are starch. Low in fat, the yam contains only 0.03–1.1 percent lipids compared to 0.02–0.18 percent for the potato and 0.18–1.66 percent for the sweet potato. The yam is not a rich source of protein, containing 1.02–2.78 percent protein compared to 1.14–2.98 percent for the potato and 0.18–1.66 percent for

Yam (Mrdoomits/Dreamstime.com)

the sweet potato. Although the yam cannot boast an abundance of protein, it has more protein than cassava. The yam contains the minerals calcium, iron, and phosphorus. Some varieties of yam have 6 milligrams of vitamin A per 100 grams of flesh, though other varieties have no vitamin A. Of the B vitamins, the yam has thiamine, riboflavin, and niacin. The yam has 4.5 to 21.5 milligrams of vitamin C per 100 grams of tuber. The species *Dioscorea alata* and *Dioscorea trifida* lose more than half their vitamin C when stored just a few weeks. *Dioscorea rotunda* loses 20 percent of its vitamin C in four months' storage. Little vitamin C is lost during cooking. A little over two pounds of yam supply 33 percent of the recommended daily allowance of calories, 23 percent of protein, 19 percent of calcium, 84 percent of iron, 84 percent of thiamine, 17 percent of riboflavin, 33 percent of niacin, and more than 100 percent of vitamin C. Because people derive an adequate amount of vitamin C from yams, scurvy is rare in yam-producing countries. Although the yam is a staple in the diets of the people of Africa, Asia, South America, and the Caribbean, it is not consumed alone. People eat it with meat, fish, and vegetables.

Origin and History

Dioscorea is an ancient genus. By the end of the Cretaceous Period (65 million years ago), *Dioscorea* was distributed worldwide. By the Miocene Epoch (23 million years ago), the yams of Africa and Asia had split into separate lineages. Although *Dioscorea* contains more than 500 species, only about 60 are edible and of these only 10 are widely cultivated. In 1886, French botanist Alphonse de Candolle supposed that *Dioscorea opposita* and *Dioscorea japonica* originated in China and *Dioscorea alata* in Indonesia. He doubted that the Caribbean had indigenous species of yam but instead adopted the species that Europeans imported. One authority avers that *Dioscorea cayenensis*, *Dioscorea rotundata*, and *Dioscorea dumeturum* originated in West Africa, *Dioscorea alata*, *Dioscorea pentaphylla*, *Dioscorea esculenta*, and *Dioscorea bulbifera* in Southeast Asia, *Dioscorea opposita* and *Dioscorea japonica* in southern China, and *Dioscorea trifida* in the Caribbean.

One school of thought proposes independent domestication of the yam in Southeast Asia, southern China, West Africa, the Caribbean, and South America about 3000 BCE. One hypothesis holds that the yam originated in India and Myanmar and migrated to Southeast Asia, Indonesia, and Thailand by 100 BCE. From Indonesia, the yam spread to New Guinea, the Solomon Islands, Fiji, Samoa, Polynesia, and the rest of the tropical Pacific. The yam did not gain a foothold in New Zealand, which was too far south of the equator. One authority proposes Myanmar and Thailand as the original centers of cultivation. The people of Southeast Asia cultivated the yam at least 2,000 years ago and possibly in prehistory. One hypothesis holds that fishers gathered wild yams to diversify their diet. Those they did not eat sprouted and were planted. Focusing on Asia as the continent of cultivation, Russian agronomist Nikolai Vavilov asserted in the 20th century that the species *Dioscorea alata*, *Dioscorea esculenta*, *Dioscorea hispida*, *Dioscorea pentaphylla*, *Dioscorea bulbifera*, *Dioscorea opposite*, and *Dioscorea japonica* originated in several regions of Asia. Alphonse de Candolle asserted that the Chinese used the yam for medicine before 2000 BCE. In the third century CE, the Chinese cultivated *Dioscorea esculenta*. Around 600 CE, an Indian text noted that farmers grew the yam in the Ganges River Basin. The tuber was then widespread as a food. In Asia, foraging pigs ate the tubers near the surface of the soil. Under this pressure, *Dioscorea alata* evolved the habit of developing its tubers deep in the soil.

Given an Asia-first hypothesis, the yam must have migrated to Africa in prehistory. One hypothesis holds that Malaysians brought the yam from Asia to Africa when they settled Madagascar. Yet Madagascar had indigenous species of yam, which the inhabitants cultivated before the arrival of Malaysians in the first or second century CE. From the island, the yam spread to East Africa and then west through the tropics. Yet the yams grown in East Africa originated in Africa not Asia, weakening this hypothesis. Another hypothesis asserts that a "pre-Negro people" from Southeast Asia brought the yam to Africa, possibly overland through Iran and Arabia, though these areas are bereft of the yam. This hypothesis supposes that people brought *Dioscorea batata*, a Chinese species, to Africa, yet this species is little cultivated in Africa.

In West Africa, people may have harvested the tubers from wild yams. Noting the ability of a plant to generate a new tuber to replace the one taken, people may have visited the plant later for a second harvest. Humans protected these plants from injury and transplanted them in their gardens, marking the beginning of yam cultivation in Africa. Africans cultivate *Dioscorea alata*, an Asian cultigen, but they also grow *Dioscorea cayenensis* and *Dioscorea rotundata*, which appear to be indigenous to Africa. In some areas of Africa, farmers may use only wooden implements to cultivate the yam, suggesting that yam culture predated the Iron Age some 2,000 years ago. Yam cultivation arose independently in Central and South America and the Caribbean. The people of the Caribbean cultivated the yam before the arrival of Columbus. The Amerindians probably began cultivating the yams before the rise of the Maya. The Amerindians cultivated the native *Dioscorea trifida*, which Europeans and Africans adopted when they settled the Caribbean.

Africans may have begun to cultivate the yam around 5000 BCE. Despite the early cultivation of the yam in Africa, the ancient Egyptians appear not to have grown it. The same appears to be true of the people of Mesopotamia (now Iraq) and the Near East. The yam was unknown in the Mediterranean Basin, where winters were too cold. The yam was also unknown in Arabia. In the 16th century, Portuguese explorer Pacheco Pereira observed the cultivation of yams in Guinea, western Ghana, and eastern Nigeria.

The Portuguese learned that Indians and Malaysians provisioned their ships with yams. Adopting this practice, the Portuguese introduced the yam to Elmina, Ghana, and Sao Thome, Brazil. Portuguese ships laden with yams disembarked in Africa, taking on new provisions. Old yams that had been dumped to make room for new provisions may have sprouted and been taken into cultivation. Slavers carried yams as provision because they were a food that Africans would eat. The people of the Caribbean, taking surplus rations of *Dioscorea rotundata* and *Dioscorea cayenensis*, planted them for food. As early as 1522, the Amerindians of the Caribbean may have cultivated African species. By the mid-17th century, the Asian cultigen *Dioscorea alata* was widely grown in the Americas. Europeans must have brought *Dioscorea esculenta* to the Caribbean, though it does not store well and so was unsuitable for ocean crossings. From the Americas, the Portuguese took *Dioscorea trifida* to Sri Lanka, where it was grown in the 16th and 17th centuries. In the 19th century, the Japanese introduced *Dioscorea opposita* and *Dioscorea japonica* to Hawaii, though the yam never emerged as an important crop in the islands. Queensland, Australia, grew *Dioscorea alata*, though it was never widespread.

The Columbian Exchange brought the potato, sweet potato, cassava, and cocoyam, all American indigenes, to the Old World, where they competed with yams. In many parts of Africa and Asia, sweet potato replaced yams. In other areas, cocoa replaced yams. By the end of the 19th century, cassava competed against the yam in Africa and Asia. Cassava was cheaper and easier to prepare than yam.

Species

The world's most widely cultivated species of yam, *Dioscorea alata*, is known as the greater yam, the winged yam, the Ubi yam, and the water yam. The last designation arose from the belief that the Portuguese carried the yam across the Indian Ocean to Africa. Originating in Southeast Asia, the species yields at least one tuber and sometimes as many as several. Having cultivars in both Asia and Africa, *Dioscorea bulbifera* is known as the potato yam and the aerial yam. The later designation derives from the fact that the species produces aerial tubers, known as bulbils, in addition to underground tubers. The bulbils resemble tubers but are produced above ground rather than in the soil. Each tuber weighs 21 to 25 ounces and measures three inches, though it is often hard and bitter. Confusingly, *Dioscorea esculenta* is also known as the potato yam. Its other appellations are the lesser yam, the Asiatic yam, and the Chinese yam. Despite the last designation, the species arose in Southeast Asia rather than China. Now widely cultivated throughout Asia, *Dioscorea esculenta* may yield a single tuber, though more often it produces a large number of small tubers. Because tubers lie close to the surface of the soil, they are easily harvested. A tuber of this species has thin skin and cylindrical shape. Known as the intoxicating yam or starch yam, *Dioscorea hispida* originated in India or Southeast Asia. Like *Dioscorea esculenta*, *Dioscorea hispida* yields its tubers near the surface of the soil. The tubers of some varieties of the species, like cassava, must be detoxified before consumption. Known as the Jinenjo yam, *Dioscorea japonica* still grows wild in the mountains of Japan, though it is a domesticate. Unusual among yams, this species tolerates cold weather and so may be grown in temperate locales. *Dioscorea opposita* is known as the cinnamon yam and the Chinese yam, the latter designation deriving from the fact that it originated in China. It too tolerates cold weather. Japan produces 100,000 tons of *Dioscorea opposita* per year. The Japanese cultivate three types of this species. Nega imo is a temperate cultivar, yielding long, club-shaped tubers. Icho imo yields fan-shaped tubers. Yamato yields spherical tubers. This third type is not as cold tolerant as the other two.

Known as the yellow yam, *Dioscorea cayenensis* originated in West Africa. The archetypal tropical yam, the species needs a long growing season, warm weather, and a long rainy season. Its tubers do not store well. Originating in Africa, *Dioscorea dumetorum* is known as the cluster yam, bitter yam, and trifoliate yam. Tubers are large and have high alkaloid content. After cooking, the tubers of this species harden. Originating in West Africa, *Dioscorea rotunda* is known as the white yam and the Ebore yam. Needing an 8- to 10-month growing season, the species yields a single spherical tuber. Africans use it to make fufu. Probably originating in South America rather than the Caribbean, *Dioscorea trifida* is known as the Cush-Cush yam, Yampi yam, or Aja yam. The species is widely grown in South America and the Caribbean. The tubers, easy to mistake for the sweet potato, are numerous and small.

Attributes and Cultivation

Most species of yam tolerate neither drought nor cold. Adverse conditions kill the vine, though the tuber remains unharmed and generates a new vine in warm, wet weather. The yam produces a large number of shallow roots. Because the yam has been in cultivation so long and because humans have propagated it vegetatively, it seldom flowers. The flowers, when they are produced, are fragrant and attract insects, often thrips, to pollinate them. A fertilized flower yields small, light, winged seeds that the wind disperses. Because the yam issues forth from an underground stem rather than a root, it is, like the potato, a true tuber. Depending on the species, one tuber weighs between 1 and more than 100 grams. Most yams yield tubers between 4.4 and 22 pounds. The flesh of a tuber is white, light yellow, pink, or purple. The tuber is an adaptation to variable rainfall. In dry weather, it is dormant. When the rains return, it uses its store of energy to generate a new vine.

The yam grows best at 86°F. Temperatures below 68°F or above 95°F impede growth. The yam needs 60 inches of rain per year and yields poorly when rainfall dips below 24 inches per year. Although it must have moisture, the yam does not tolerate waterlogged soil. The soil should be loose, deep, and well drained. Where it is in rotation with other crops, the yam often follows a legume to benefit from residual nitrogen in the soil. A heavy feeder of nitrogen and potassium, the yam requires more fertile soil than root crops. Because the yam is a crop of poor farmers, it rarely receives fertilizer. Farmers often interplant yam with corn, whose stalks support the vine. Yet yam yields less when interplanted with another crop than when planted alone and for this reason intercropping has become less popular in recent years. Whether planted with corn or not, yam vines must be supported to maximize exposure to sunlight. In the absence of support, yields decline. Weeds may overwhelm young plants and so must be minimized.

Bulbils may be planted to yield new vines, but the growing season must be long and only small tubers will be produced. Alternatively, small tubers may be planted to produce new vines. The farmer may cut large tubers into sections, with each section generating a new vine. The proximal end of a tuber produces the most vigorous vine, the distal end the least vigorous, and the middle section yields a plant intermediary in vigor. The farmer must have six tons of tubers to plant five acres. As a rule, the farmer sells the best yams, using the leftovers for planting. A tuber needs high humidity to produce rootlets. A new vine germinates between 77°F and

86°F. Farmers do not use yam seeds because the yield is low and the quality of the tubers is poor. The farmer plants sections of tubers four to six inches deep. Twenty thousand sections plant five acres. The denser the planting the smaller is the tuber. Long days favor vine growth whereas short days favor tuber enlargement, though in the tropics day length varies little. The vine grows rapidly when young and slows when the plant puts its energy into tuber enlargement. Tubers may be harvested in as little as 7 months, though the farmers must typically wait 10 or 11 months before the harvest. Some farmers leave tubers in the ground, harvesting only as much as they need for a few days. Worldwide, the yield averages 4.8 tons per acre, though some areas report more than 16 tons per acre. Yams should be stored at 60°F and 70 percent humidity. In storage, yams lose 5 percent of their mass per month because they lose water.

According to one authority, "yams are the potatoes of the tropics" because they are a staple, especially in Africa and the Caribbean. The yam is an important food in Africa, Asia, Oceania, South America, and the Caribbean and fetches a higher price than sweet potato or cassava. Most yams are consumed locally with only a small amount traded over distances. Yet markets for yams are emerging in the United States and Europe. People boil, bake, and fry yams. Yams are also made into flour, flakes, and chips. Yams are too expensive to feed to livestock or convert into biofuel. Africa produces 95 percent of the world's yams. Nigeria alone yields 72 percent. In Africa, the leading producers are Nigeria, Cote d'Ivoire, Benin, Ghana, Togo, Zaire, Ethiopia, Chad, and the Central African Republic. Outside Africa, the leading producers are Papua New Guinea, Brazil, Haiti, Japan, and Jamaica.

The Importance of Yams

West Africans celebrate the planting and harvesting of yams. The New Yam Festival marks the harvest and is the greatest celebration of the year in some villages in West Africa. Priests, officials, or village elders take charge of the festival. On the day of the festival, the people harvest yams from sacred soil and offer them to the gods. After this offering, the people eat these yams. Having fasted before eating the yams, West Africans consider it sinful to eat yams before the first offering has been made to the gods. According to one authority, some people starved rather than consume yams before the festival. The prohibition against eating yams before the festival may have arisen because millennia ago some yams may have been toxic when young and edible when mature. Alternatively, the prohibition may have arisen from the desire to avoid damaging a young plant by harvesting a tuber too soon.

The Ibo of Nigeria worship Ajokuji, the "Great Spirit of the Yam." The priests of Ajokuji determined when to plant and harvest yams. So important is the yam to many Africans that parents give infants it as the first food. The Ibo deem the theft of yams as more serious than the theft of other items. Adultery, if committed in a yam field, is a crime, whereas adultery in other places is merely a civil offense because adultery corrupts the soil, leaving it to yield a poor crop. In this instance Ajokuji may cause misfortune as punishment for the defilement of a yam field. The people of Malaysia and Indonesia believe the species *Dioscorea pentaphylla* to be sacred. Some Malaysians put yam juice in the mouth of an infant at its naming ceremony.

Christopher Cumo

See also Sweet Potato

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Z

Zinnia

Zinnia (*Zinnia elegans*) is one of the favorite garden plants. An ornamental, zinnia symbolizes several traits. An indigene of Mexico, Central America, and the American Southwest, zinnia attracted the attention of the Spanish and Dutch in the early modern era. A tender plant, zinnia will not endure cold.

Classification and Cultivars

Zinnia, with its varied names like common zinnia and garden zinnia, belongs to the Asterales order and Asteraceae family. The genus *Zinnia* has 20 species, among them *Zinnia angustifolia*, *Zinnia bicolor*, *Zinnia elegans*, *Zinnia grandiflora*, *Zinnia haageana*, *Zinnia linearis*, *Zinnia peruviana*, *Zinnia tenuifolia*, *Zinnia violacea*.

Origin and History

The name zinnia derives from the German botanist Johann Gottfried Zinn (1727–1759). The plant originated in Mexico, Central America, and the southwestern United States. The Aztecs living in Mexico City were growing zinnias in their gardens at the time of Spanish occupation. From Mexico have come innumerable varieties and hybrid strains of zinnia. In the United States, the Dutch immigrants tended zinnia plants. The breeding process that began in the 19th century resulted in about 100 cultivars.

Attributes and Cultivation

Zinnia plants grow from 6 to 36 inches tall depending on whether they are dwarf, medium, or tall varieties. Ranging from oval to linear shape and found without a stalk, the leaves are green in hue. Zinnia comes in different sizes and colors. The flowers of garden zinnias have a single row of petals or a dome-shaped flower. The range is from 1 inch in diameter to three feet. The long-stemmed single, semidouble, or double flowers are of different colors including white, maroon, yellow, orange, red, purple, magenta, violet, and scarlet. Zinnia plants may be grown from seeds. They need full sun and fertile as well as well-drained soil with a temperature between 65°F and 70°F. The gardener may add compost to the soil. Each zinnia seed is planted in an area of one square foot. The seed bed is mildly raked as well as watered. Seeds may be planted 0.25 inch deep. The plant needs fertilizer, and watering is necessary at least once in a week. The stems are regularly trimmed and dead flowers removed from the plant. Zinnias are very tender and die with hard frost. They are also very susceptible to diseases including fungi, and to insects. Caterpillars, spider mites, and mealybugs may harm zinnias. Insect repellent and fungicide are used to prevent these problems. Zinnia leaves develop powdery white spores because of mildew, which drains moisture. The gardener may use a few drops of liquid soap and a mixture of baking soda and water to eradicate mildew. In a well-planned garden, the zinnia plants grow very well.

Utility of Zinnia

Zinnias are best suited for ornamenting beds, borders, and pots. The cut flowers look very elegant in any type of flower arrangement. Interior decorators recommend bunches of zinnias to beautify rooms. Even the dried stems of zinnias are used in bouquets. Although culinary use of zinnias is not much in vogue, sometimes they are used in soups, pasta sauces, and tomato dishes because of their aroma. A garden of zinnia plants is very useful to educate children about the basics of tending plants. The zinnia flower symbolizes goodness, constancy, and everlasting love. The varied colors of the flower have different meanings. A scarlet zinnia represents constancy, a white one symbolizes goodness, a yellow-colored flower indicates daily remembrance, and a magenta zinnia denotes everlasting love.

Patit Paban Mishra

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Organizations Providing Information on Cultivated Plants

The following organizations are noted for their regional, national, or international scope. This list has several organizations devoted to crop plants because of their importance to this encyclopedia. Several organizations, the U.S. Department of Agriculture, for example, have a strong scientific component, another core feature of this encyclopedia. This is by no means an exhaustive list. Several entomological societies have connections to plants, particularly crops, but I have omitted them because their primary focus is insects, not plants. This list also does not include organizations whose primary focus is pesticides or herbicides, even though these organizations are linked to plants.

American Society for Horticultural Science
http://www.ashs.org

American Society of Plant Biologists
http://my.aspb.org

American Society of Agronomy
http://www.agronomy.org

Australian Plants Society
http://www.vicnet.net.au/~sgapvic

Botanical Society of America
http://www.botany.org

Brooklyn Botanic Garden
http://www.bbg.org

Canadian Ornamental Plant Foundation
http://www.copf.org

Consultative Group on International Agricultural Research
http://www.cgiar.org

Crop Life America
http://www.croplifeamerica.org

Crop Science Society of America
http://www.crops.org

Desert Botanical Garden
http://www.dbg.org/

Flowers and Plants Association
http://www.flowersand plants.org.uk

Food and Agriculture Organization of the United Nations
http://www.fao.org

International Carnivorous Plant Society
http://www.carnivorousplants.org

Iowa State University Plant Sciences Institute
http://www.plantsciences.iastate.edu/organization

Kew Royal Botanic Gardens
http://www.kew.org
Includes "Plants and Fungi, A–Z" database as well as information on science and conservation, in addition to information about the gardens in London.

The Linnean Society of London
http://www.linnean.org.uk

Missouri Botanical Garden
http://www.missouribotanicalgarden.org
The Missouri Botanical Garden is one of the premier organizations of its kind and was a leader in botanical research and extension, particularly under the directorship of Peter Raven. It is also an important tourist attraction in St. Louis. Its Plant Finder Database, available online, contains more than 5,400 plants, and their collection of databases is found at http://www.mobot.org/mobot/research/alldb.shtml.

National Tropical Botanical Garden
http://www.ntbg.org

New York Botanical Garden
http://www.nybg.org

Society for Economic Botany
http://cms.gogrid.econbot.org

Soil Science Society of America
http://www.soils.org

United States Department of Agriculture
http://www.usda.gov

The Agricultural Research Service of the USDA is among the world's most respected organizations in pursuit of scientific research on crops. The USDA maintains a nutrition database, an Economic Research Service, the Forest Service, the National Agricultural Library, the People's Garden Initiative, and other resources.

The Plants Database from the Natural Resources Conservation Service is located at http://plants.usda.gov/java/. From its website: "The PLANTS Database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories."

United States National Arboretum
http://www.usna.usda.gov

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About the Editor and Contributors

Editor

CHRISTOPHER CUMO is the author of three books and a number of articles, essays, reviews, and short stories. He has written about history, science, agriculture, education, economics, African American studies, leisure and sports, and global warming and climate change. He received a PhD in history from The University of Akron in Akron, Ohio.

Contributors

MATTHEW ALEXANDER is a writer in Denton, Texas.

DEB CARLTON is a retired technical writer and gardening enthusiast. She has gardened in Florida, Arizona, and North Carolina. She has published horticultural works for the Boy Scouts and local newspapers.

CHARALAMPOS DOKOS is a Greek-Cypriot who graduated from the Medical School of Aristotle University of Thessaloniki. He is a clinical fellow of the Department of Pediatric Hematology/Oncology of University Hospital of Muenster, Germany. He has more than 120 publications in international and Greek peer-reviewed journals and is a reviewer for many journals himself. His clinical interests involve bone metabolism, children oncology, ethnopharmacology, marine pharmacology, and medicinal chemistry.

BONNIE ELLMAN is a freelance writer from New York. She holds a graduate degree in literature from Royal Holloway, University of London, and has completed additional postgraduate work in English and comparative literature from Columbia University. Her work has previously been published in *Natural History Magazine*, *The Long Island Press*, *Mr. Beller's Neighborhood*, and OffManhattan.com.

HELGA GEORGE is a plant science researcher and freelance writer who has written a number of online articles about plants. She has a PhD in plant pathology from Cornell University in Ithaca, New York, and a master's degree in the same field from the University of Massachusetts in Amherst.

EMILY GOODMAN is a writer and gardener based in Brooklyn, New York. Her previous publications include the award-winning children's book *Plant Secrets* (2009) and articles in the Chicago Botanic Garden *Encyclopedia of Gardens: History and Design*. She is currently writing about plants and animals in city environments and is interested in plant and garden history.

RICHARD HUNTER is a historical geographer at the State University of New York at Cortland. His research focuses on the mechanisms of landscape change in a region of highland central Mexico known as the Valle del Mezquital. In particular, he is interested in the role of livestock and native depopulation as agents of environmental degradation. His work has appeared in the *Journal of Latin American Geography*, *Journal of Historical Geography*, and *Historical Methods*.

HEIDRUN KORDHOLSTE-NIKANDER is a writer and former English teacher who lives in Finland.

KAWAL DEEP KOUR is a research scholar at the Department of Humanities and Social Sciences, Indian Institute of Technology in Guwahati, India. Her research interests include the history of psychoactive plants and substances. She has presented her work at both national and international forums. She is presently writing her doctoral dissertation on the history of intoxication, a study of the opium poppy, during the British colonial period in Assam, a work aiming to explore the many dimensions of its use and abuse in history to contemporary times.

LYNN C. KRONZEK is a writer, independent scholar, and consulting historian with two books and many articles and projects to her credit. Her primary research interests focus on Southern California, as well as immigrant and ethnic studies. She also helps nonprofit and government agencies develop innovative public programs and obtain the funding necessary for their implementation, sustainability, and growth.

ROSEMARIE BOUCHER LEENERTS has worked in the publishing industry for more than 20 years as a writer, editor, and journalist. She has contributed to a number of publications, including academic titles, encyclopedias, and online and print articles in the fields of science, history, popular culture, and education, among others. She is based in San Diego, California.

RONDA LEE LEVINE is an independent scholar and editorial consultant living in Chico, California. Her work has appeared in *What Philosophy Can Tell You about Your Lover*, *Native America: A State-by-State Historical Encyclopedia*, and *The Early Republic and Antebellum America: An Encyclopedia of Social, Political, Cultural, and Economic History*. She has published more than 1,000 articles on a variety of subjects, including project management, education, and finance.

MARJORIE MCATEE was educated at Hollins University. She provides search engine optimization (SEO) content and advertising copy for a number of websites, and contributes to web magazines including *Listosaur*, *The Circumference*, and *BakPak Traveler's Guide*. Her creative work has appeared in *Amarillo Bay*, *Flashquake*, *The Blotter*, and *Center: A Journal of the Literary Arts*. She writes the award-winning blog *Don't Call Me Marge*.

PATIT PABAN MISHRA obtained his PhD from Jawaharlal Nehru University, New Delhi. In 1998, Professor Mishra was awarded the DLitt degree from Rabindra Bharati University, Kolkata. He began a post as visiting professor at the Northern University of Malaysia (UUM) in September 2011.

AMANDA MITTRA is an author, poet, botanist, entrepreneur, and management professional. Her educational background includes a bachelor's degree in botany, a master's diploma in hospital management, and a postgraduate certificate in project management. She has created a website and publishing company, Mandy's Pages. Her works have been published in *Painted My Way* and *On Awakening*, both poetry anthologies. She also writes under the name Amanda Dcosta.

KERSTIN MÜLLER studied plant physiology and plant ecology in Freiburg, Germany. She has published articles in various international scientific journals and is currently working on a molecular seed physiology project at Simon Fraser University in Vancouver, Canada.

CARYN E. NEUMANN is a lecturer in integrative studies and an affiliate in history at Miami University of Ohio. She earned a doctorate in U.S. history from The Ohio State University. Her teaching focuses on environmental history.

DANA NICHOLS received her PhD in American literature from Georgia State University and has conducted extensive research on food and food cultures throughout her career, developing a class on food films, and publishing articles on everything from the invention of the corkscrew to the history of frozen foods. She has also contributed scholarly articles and entries to the *Dictionary of Literary Biography*, *Companion to the World Novel*, *Student's Companion to American*

Literary Characters, and other works. Currently, she serves as coordinator of evening programs at Lanier Technical College.

TAMARA STROMQUIST'S career as a publications designer, editor, and freelance artist includes work for state and federal governments, universities, and other information sources. Currently, she produces gardening-themed cartoons, calligraphy, haiku, and small illustrations inspired by her overgrown lot in Sherwood, Oregon, known as "the house on the corner with all the plants."

ERIKA STUMP is a former high school English teacher and now an education researcher at the University of Southern Maine. She endures the long Maine winters by using local foods to test new culinary endeavors and works in her family's backyard gardens.

INGVAR SVANBERG is an ethnobiologist and cultural anthropologist at Uppsala Centre for Russian and Eurasian Research, Uppsala University, Uppsala, Sweden. He has written several books and scientific articles within the fields of ethnobotany and ethnobiology and has a special interest in the cultural history of plants, folk biology among ethnic minorities, local plant knowledge among children, old cultivated plants, traditional dye plants (including lichens), and the use of wild plants as food.

GWENDOLYN VESENKA, PhD, is a biologist and freelance writer in Maine with a strong interest in plants and gardening. She balances her time between her family, the lab, and her garden. Previous publications include papers on such diverse topics such as morphogenesis of *Drosophila melanogaster*, the role of alcohol in pancreatitis, and the science of human lactation.

HARRIET WEINSTEIN is a journalist and gardener who writes magazine articles about business and the environment. She is based in Connecticut.

VICTORIA WILLIAMS studied environmental geography as an undergraduate, before going on to write a PhD thesis (King's College, London) on European fairytales in 19th-century British art and literature for which she examined plant folklore and flower symbolism. Her main research areas are folklore, film, and Victorian literature, and she has worked on projects including *Movies in American History: An Encyclopedia* (ABC-CLIO, 2011), the *Nineteenth-Century Serials Edition* database (http://www.ncse.ac.uk), and *Dictionary of Nineteenth-Century Journalism* (2009). At present, she is a contributor to the *Annotated Bibliography of English Studies*.

GERALD ZHANG-SCHMIDT is a human ecologist and cultural anthropologist working as an independent scholar. His interests revolve around the intersection of ecological sustainability with ways of life more conducive to human happiness—one of which lies with the cultivation, cooking, and culture of spicy plants.

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