

# Flowering Plants and Civilization

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## OVERVIEW

This chapter begins with comments on some of the problems involved in distinguishing between fact and fancy in reported past uses of plants. It continues with a brief discussion of Vavilov's centers of origin of cultivated plants and subsequent modifications of Vavilov's theories. A survey of 16 well-known flowering plant families is presented in phylogenetic sequence, and miscellaneous information is given, including brief comments on family characteristics. Some past, present, or possible future uses of family members are explored.

### Some Learning Goals

1. Give reasons for basing scientific evaluation on more than a single sampling.
2. Learn major regions of distribution of cultivated plants and identify several plants from each region.
3. Know characteristics of 10 flowering plant families.
4. Identify which families have flowers with many separate parts and superior ovaries.
5. Know five useful plants in the Laurel, Rose, Legume, and Spurge Families.
6. Identify medicinal plants in the Poppy and Nightshade Families.
7. Construct a simple, original key to five flowering plant families.

*eminder:* In this chapter, there are references to a very large number of plants. As in all chapters throughout the book, a few scientific names are given within the text, but the scientific names of all the plants mentioned are listed in Appendix 1.

Puccoons (*Lithospermum* spp.) are herbaceous plants that grow on dry plains and slopes throughout the western United States and British Columbia. One puccoon with greenish yellow flowers (*L. ruderale*) has seeds that are so hard, it was given the common name of *stoneseed* in Nevada and California.

Native American women of the Shoshoni tribe of Nevada reportedly drank a cold water infusion of the roots of stoneseed every day for 6 months to ensure permanent sterility. Biologist Clellan Ford became curious about these reports and gave extracts of stoneseed plants to mice. He found the extracts effectively eliminated the estrous cycle of the mice and decreased the weights of the ovaries, the thymus, and the pituitary glands.

Although this reported Native American use of a plant was demonstrated experimentally to have a basis in fact, distinguishing between fact and fantasy in recorded past uses of plants is often difficult, particularly if the plants have become rare

or extinct. However, this type of research is essential today if we are going to save potential sources of medicinal drugs and other useful plant products before they are eliminated by clearing of land and other practices in the name of “progress.”

Earlier generations, despite occasional misguided superstition and folklore, did cure some of the diseases they treated with plants, even though they did not know the scientific reasons for the results. As indicated earlier, botanists who have recognized this have teamed with anthropologists, medical doctors, and interpreters to interview tribal and other medical practitioners all over the world. They are gleaning and sifting through as much of this information as possible before it is too late. Their work is already leading to useful new medicinal and other discoveries.

## ORIGIN OF CULTIVATED PLANTS

In the 1880s, Alphonse de Candolle, a Swiss botanist, published a book entitled *Origin of Cultivated Plants*, based on data he had gathered from many sources. He deduced that cultivated plants probably originated in areas where their wild relatives grow.

In 1916, N. I. Vavilov, a Russian botanist and geneticist, began a follow-up of de Candolle’s work. During the next 20 years, he expanded on de Candolle’s work and modified his conclusions. Vavilov became persuaded, as a result of his research, that most cultivated plants differ appreciably from their wild relatives. He also concluded that dispersal centers of cultivated plants are characterized by the presence of dominant genes in plant populations, with recessive genes becoming apparent toward the margins of a plant’s distribution.

Vavilov recognized eight centers of diversity of cultivated plants, with some plants originating in more than one center. The centers, some of which were subdivided, are shown in Figure 24.1.

Since the 1950s, a number of major world crops have been subjected to analysis at the molecular level. These studies have provided evidence that many of the cultivated plants did not originate in Vavilov’s centers. A significant number of such studies were undertaken by agricultural geneticist Jack R. Harlan and his students at the Crop Evolution Laboratory of the University of Illinois. Harlan concluded that some crops do not have centers of origin, and he revised Vavilov’s concept, preferring instead to associate crop origins with regions. These regions are illustrated in Figure 14.2. A sampling of cultivated plants that appear to have originated in six major regions follows.

### Near-Eastern Region

The Near-Eastern region encompasses the Mediterranean area, northern Europe (including the former Soviet Union), Turkey, the Balkans, Pakistan, and Iran. Among the many cultivated plants that appear to have originated in this region are barley, wheat and other cereals, garden pea, lentil, chickpea, lupine, asparagus, beet, carrot, turnip, olive, stone fruits (cherry, plum, apricot), apple, pear, onion, garlic, cabbage, broccoli, lettuce, parsley, flax, clover, pistachio, several range grasses, digitalis, belladonna, opium poppy, and psyllium.

### Chinese Region

Many of the cultivated plants believed to have originated in this region apparently came from the temperate and southern parts of China. Examples of widely known plants from this part of the world include bamboo, peach, litchi, walnut, persimmon, ginger, ginseng, gourds, camphor, tea, tung, soybean, buckwheat, horseradish, Chinese cabbage, and cucumber. While China is known for its centuries-old cultivation and consumption of rice, this cereal probably originated elsewhere in Asia.

### African Continent

Although there is evidence that some cultivated plants originated in South and East Africa, most African plants appear to have come from Ethiopia, Eritrea, West Africa, and other areas between the Sahara and the Congo. Better-known plants include yam, sorghum, okra, oil palm, baobab, the sweet melons, coffee, some cotton, and castor bean.

### South Asia and the Islands of the Pacific

This region encompasses South Asia, Malaysia, Indonesia, Melanesia, the Philippines, and thousands of islands extending across the southern Pacific Ocean. Among the plants from this region are sugar cane, eggplant, mango, banana, citrus fruits, safflower, nutmeg, clove, cardamon, turmeric, black pepper, jute, hemp fiber, coconut, taro, rice, mung bean, sesame, betel nut, onion, and jackfruit.

### North America

Few cultivated plants are believed to have originated in North America and those that did come primarily from tropical and sub-

tropical areas. Such plants include sunflower and tobacco.

## South and Central America

There is no distinct line between South America and areas to the north with respect to some of the cultivated plants originating in the New World. The wild relatives of common garden beans, for example, appear to have been distributed throughout parts of both North and South America. Cultivated plants from the region include corn, peanut, white (Irish) potato, lima bean, common bean, cashew, pineapple, papaya, avocado, red pepper, tomato, cotton, cocaine, amaranth, quinoa, cacao (chocolate), guava, sweet potato, pumpkin, squash, rubber, prickly pear, peyote, chayote, vanilla, sisal, and cassava.

## SELECTED FAMILIES OF FLOWERING PLANTS

The following is a survey of a few of the well-known plant families, indicating not only past uses of some of their members but also possible future uses in a few instances, along with biological notes and miscellaneous observations.

*The reader is cautioned against assuming that past medicinal uses were always effective or without harmful side effects and is urged to refrain from experimenting with such plants.*

More than 300 families of flowering plants have been recognized but are currently undergoing extensive reorganization on the basis of DNA, chemical, and cladistical information. Flowers and fruits are considerably more reliable and stable indicators of heredity than leaves or other vegetative plant parts, so flowering plant families have been distinguished from one another mostly on the basis of flower and fruit parts and structure. Some families include a mere handful of species, while others are very large, their members numbering in the thousands. Space permits only brief discussion of a few of the larger, better-known families here, and the reader is referred to the additional readings at the end of the chapter for other sources of information.

The families are taken up in a more or less phylogenetic (evolutionary) sequence, beginning with those that have more generalized flower structure and progressing to those whose flowers are considered specialized. Generalized flowers tend to have numerous parts that are not fused together, and the ovaries are superior. In specialized flowers, the parts are reduced in number and often fused together; the ovary is inferior. (See Fig. 23.9 and the amplification of this subject on page 436.)

The following is an abbreviated key to the families discussed. (See Chapter 16 for a discussion of keys and their uses.)

1. Flowers with parts in fours or fives or multiples thereof; seeds with two cotyledons (DICOTS)
  2. Petals separate from one another, or lacking
  3. Petals present
    4. Stamens more than twice as many as the petals
      5. Stamens, petals, and sepals attached to the rim of a cup surrounding the one to many pistils  
Rose Family (Rosaceae)
      5. Stamens, petals, and sepals not attached to the rim of a cup
        6. Pistils several to many in each flower Buttercup Family (Ranunculaceae)
        6. Pistil one
          7. Ovary superior Poppy Family (Papaveraceae)
          7. Ovary inferior Cactus Family (Cactaceae)
      4. Stamens not more than twice as many as the petals
        8. Herbaceous vines; fruit a pepo Pumpkin Family (Cucurbitaceae)
        8. Primarily herbs, shrubs, and trees; fruit not a pepo
          9. Fruit a legume Legume Family (Fabaceae)
          9. Fruit not a legume
            10. Fruit a silique or silicle  
Mustard Family (Brassicaceae)
            10. Fruit not a silique or silicle
              11. Ovary superior; stems square in cross section; leaves opposite; fruit of four nutlets Mint Family (Lamiaceae)
              11. Ovary inferior; stems rounded in cross section; leaves alternate;  
fruit a schizocarp Carrot Family (Apiaceae)
        3. Petals lacking; calyx sometimes petal-like
          12. Ovary of three carpels and usually elevated on a gynophore; anthers splitting lengthwise Spurge Family (Euphorbiaceae)
          12. Ovary of one carpel; gynophore lacking; anthers splitting

by raised flaps Laurel Family (Lauraceae)

2. Petals fused together

receptacle; ovary superior 13. Flowers not in a head; each flower with its own  
Nightshade Family (Solanaceae)

13.

Flowers in a head, several to many florets on a common receptacle, comprising a  
"flowerlike" inflorescence; ovary inferior Sunflower Family (Asteraceae)

1. Flowers with parts in threes or multiples thereof; seed with one cotyledon (MONOCOTS)

14. Flowers inconspicuous; without petals or sepals Grass Family

14. Flowers conspicuous; petals and sepals mostly similar

in coloration

15. Ovary superior; petals all alike Lily Family (Liliaceae)

15.

Ovary inferior; one petal different in form

from the other two Orchid Family (Orchidaceae)

## DICOTS (NOW RECOGNIZED IN TWO GROUPS)

### The Buttercup Family (Ranunculaceae)

Nearly all the 1,500 members of the Buttercup Family are herbaceous. The flowers, whose petals often vary in number, have numerous stamens and several to many pistils with superior ovaries (Fig. 24.2). Most have dissected leaves with no stipules and with petioles that are slightly expanded at the base. Well-known representatives include ornamental plants such as buttercup, columbine, larkspur, anemone, monkshood, and *Clematis* (Fig. 24.3). Most members of the Buttercup Family are concentrated in north temperate and arctic regions.

Columbine flowers have five spurred petals that resemble a circle of doves. The name comes from *columba*, the Latin word for dove. A blue and white species of columbine is the state flower of Colorado. Native Americans controlled diarrhea with a tea made from boiled columbine roots, and members of at least two tribes believed columbine seeds to have aphrodisiac properties. A man would pulverize the seeds, and after rubbing them in the palms of his hands, he would try to shake hands with the woman of his choice, believing the woman would then succumb to his advances. Others crushed and moistened the seeds and applied them to the scalp to repel lice.

Most members of the family are at least slightly poisonous, but the cooked leaves of cowslips have been used for food, and the well-cooked roots of the European bulbous buttercup are considered edible. The European buttercup causes blistering on the skin of sensitive individuals. East Indian fakirs are reported to deliberately blister their skin with buttercup juice in order to appear more pitiful when begging. Native Americans of the West gathered buttercup achenes, which they parched and ground into meal for bread. Others made a yellow dye from buttercup flower petals. Karok Indians made a blue stain for the shafts of their arrows from blue larkspurs and Oregon grape berries.

Goldenseal, sold in health-food stores, is a plant that was once abundant in the woods of temperate eastern North America. It has become virtually extinct in the wild because of relentless collecting by herb dealers. They sold the root for various medicinal uses, including remedies for inflamed throats, skin diseases, and sore eyes. At least one Native American tribe mixed the pounded root in animal fat and smeared it on the skin as an insect repellent.

Monkshood yields a drug complex called *aconite* that was once used in the treatment of rheumatism and neuralgia. Although popular as garden flowers, monkshoods are very poisonous. Death may follow within a few hours of ingestion of any part of the plant. Most species have purplish to bluish or greenish flowers, but one Asian monkshood, called *-wolfsbane*, has yellow flowers. Wolf hunters in the past poisoned the animals with a juice obtained from wolfsbane roots.

### The Laurel Family (Lauraceae)

The Laurel Family's primitive flowers have no petals but have six sepals that are sometimes petal-like. The stamens, which occur in three or four whorls of three each, are a curiosity because the anthers open by flaps that lift up. The ovary is superior. Most of the approximately 1,000 species in this family are tropical evergreen shrubs and trees, many with aromatic leaves. The family received its name from the famous laurel cultivated for centuries in Europe. Its foliage was used by the ancient Greeks to crown victors in athletic events and later was used in the conferring of academic -honors.

Several important spices come from members of this family. Powdered cinnamon is the pulverized bark of a small tree native to India and Sri Lanka, although it is also grown commercially elsewhere. Cassia is very similar and is often sold interchangeably with cinnamon. Cinnamon oil is distilled from young leaves of the trees. Use of cinnamon and cassia dates back thousands of years. They were used in perfumes and anointing oils at the time of Moses, and other records reveal their use in Egypt at least 3,500 years ago.

Camphor has been used since ancient times. This evergreen tree, native to China, Japan, and Taiwan, is the main source

of camphor essence still used in cold remedies and inhalants, insecticides, and perfumes. The essence is distilled from wood chips. Camphor trees are smog resistant, and some American cities and towns with milder climates have been using them as street trees.

Sassafras trees, native to the eastern United States and eastern Asia, also have spicy-aromatic wood. A flavoring widely used in toothpaste, chewing gum, mouthwashes, and soft drinks was obtained by distillation of wood chips and bark. Sassafras tea still is considered a refreshing beverage. Sassafras is also an ingredient of some homemade root beers, and in the southern states, an alcoholic beer has been made by adding molasses to boiled sassafras shoots and allowing the mixture to ferment. In Louisiana, powdered sassafras leaves (called *filé*) have been used as a thickening and flavoring agent for gumbo. In the past, it has been used by country physicians for treating hypertension and for inducing a sweat in those with respiratory infections. Reports indicate that in large doses, it has a narcotic-stimulant effect, and it is also reported to be carcinogenic. Most sassafras flavorings now in use are artificial.

The sweet bay, used as a flavoring agent in gravies, sauces, soups, and meat dishes, comes from the leaves of the laurel. Leaves of the related California bay (Fig. 24.4) are sometimes used as a substitute for sweet bay and for making Christmas wreaths. This tree, which is native to California, also occurs in southwestern Oregon, where it is known as myrtle (true myrtles, however, belong to a different family). California bay wood is hard and can be polished to a high luster; it is used for making a variety of bowls, ornaments, and other smaller wooden articles.

Early settlers in the West and Native Americans of the region used California bay for the relief of rheumatism by bathing in hot water to which a quantity of leaves had been added. The nutlike fruits (drupes) were roasted and used for winter food. A leaf was placed under a hat on the head to “cure” a headache (but even a small piece of leaf placed near the nostrils can produce an almost instant headache!). A few leaves placed on top of flour or grains in a canister will keep weevils away, and small branches have been used as chicken roosts to repel bird lice and fleas. A leaf or two rubbed on exposed skin functions as a mosquito repellent.

Avocados are also members of the Laurel Family. The fruits have more energy value by weight than red meats and are rich in vitamins and iron.

## The Poppy Family (Papaveraceae)

Most members of the Poppy Family are herbs distributed throughout temperate and subtropical regions north of the equator, but several poppies occur in the Southern Hemisphere, and a number are widely planted as ornamentals. Poppies, like buttercups, tend to have numerous stamens, but most have a single pistil (Fig. 24.5). Most also have milky or colored sap, and their sepals usually fall off as the flowers open. All members produce alkaloidal drugs.

Bloodroot (*Sanguinaria canadensis*) is a pretty, early-flowering spring plant of eastern North American deciduous forests. A bright reddish sap that is produced in its rhizomes was used by some Native Americans as a facial dye, an insect repellent, and a cure for ringworm; children today paint their nails with it. It has a very bitter taste, except when ingested in minute amounts. The bitterness made it effective in inducing vomiting, but members of one tribe treated sore throats with it after compensating for the bitterness by squeezing a few drops on a lump of maple sugar so that it could be held in the mouth.

Opium poppies have had a significant impact on societies of both the past and the present. Opium itself was described by Dioscorides in the 1st century A.D., and ancient Assyrian medical texts refer to both opium and opium poppies. Opium smoking, which does not extend back nearly as far as the use of the drug in other ways, became a major problem in China in the 1600s. Smoking opium has given way to other forms of use in recent years. The substance is obtained primarily by making small gashes in the green capsules of the poppies (Fig. 24.6). The crude opium appears as a thick, whitish fluid oozing out of the gashes and is scraped off. It contains two groups of drugs. One group contains the narcotic and addicting drugs morphine and codeine, best known for their widespread medicinal use as painkillers and cough suppressants. Members of the other group are neither narcotic nor addictive. They include papaverine, used in the treatment of circulatory diseases, and noscapine, used as a codeine substitute because it functions like codeine in suppressing coughs but does not have its side effects.

Heroin, a scourge of modern societies, is a derivative of morphine. It is from four to eight times more powerful than morphine as a painkiller, and less than 100 years ago, it was advertised and marketed in the United States as a cough suppressant. It is estimated that 75% of American drug addicts used heroin up until the early 1980s, but cocaine has now largely replaced it. The loss to society in terms of its economic, physical, and moral impact is enormous, since addicts frequently commit violent crimes to obtain the funds needed to support their habits, which often cost well over \$200 per day.

The seeds of opium poppies contain virtually no opium and are widely used in the baking industry as a garnish. However, there are reports that even the mere traces of opium in some poppy seeds have produced positive results in urine drug tests. They also contain up to 50% edible oils that are used in the manufacture of margarines and shortenings. Another type of oil obtained from the seeds after the edible oils have been extracted is used in soaps and paints.

## The Mustard Family (Brassicaceae)

The original Latin name for the Mustard Family was *Cruciferae*. The name describes the four petals of the flowers that are arranged in the form of a cross. The flowers also have four sepals, usually four nectar glands, and six stamens, two of which are shorter than the other four. All members produce siliques or silicles that are unique to the family (see Fig. 8.14). All 2,500

species of the family produce a pungent, watery juice, and nearly all are herbs distributed primarily throughout the temperate and cooler regions of the Northern Hemisphere.

Among the widely cultivated edible plants of the Mustard Family are cabbage, Chinese cabbage, cauliflower, brussels sprouts, broccoli, radish, kohlrabi, turnip, horseradish, watercress, and rutabaga. The widely used condiment mustard is a mixture of the ground, dried seeds of two species of *Brassica*. Some edible members are also widespread weeds. The leaves of shepherd's purse (Fig. 24.7), for example, can be cooked and eaten, and the seeds can be used for bread meal. Other wild edible members include several cresses, peppergrass, sea rocket, toothwort, and wild mustard. Wild mustards are often weeds in row crops. Their leaves are sometimes sold as vegetable greens in markets.

The seeds of wild mustard, shepherd's purse, and several other members of this family produce a sticky mucilage when wet. Biologists at the University of California at Riverside discovered a potential new use for these seeds. They fed pelleted alfalfa rabbit food to mosquito larvae in water tanks they were using for experiments on mosquito control. They noticed the larvae, which had to come to the surface at frequent intervals for air, often stuck to the pellets and suffocated. Curious, the workers examined the pellets under a microscope and found that they contained mustard seeds. Evidently, the field where the alfalfa had been harvested had also contained mustard plants. The scientists then tried heating the mustard seeds to kill them and found this did not affect production of mucilage by wet seeds. It was calculated that 0.45 kilogram (1 pound) of such seeds could kill about 25,000 mosquito larvae. A few mosquito abatement districts have used the seeds effectively, but experiments are needed to determine if there is a practical way to harvest many more seeds and control mosquitoes on a much larger scale by such non-polluting means.

Native Americans mixed the tiny seeds of several members of this family with other seeds and grains for bread meal and gruel. To prevent or reduce sunburn, Zuni Indians applied a water mixture of ground western wallflower plants to the skin. Watercress is widely known as a salad plant and has had many medicinal uses ascribed to it. During the 1st century A.D., for example, Pliny listed more than 40 medicinal uses. Native Americans of the west coast of the United States treated liver ailments with a diet consisting exclusively of large quantities of watercress for breakfast, abstinence from any further food until noon, and then resumption of an alcohol-free but otherwise normal diet for the remainder of the day. This was repeated until the disease, if curable, disappeared. Dyer's woad, a European plant that has become naturalized and established in parts of North America, is the source of a blue dye that was used for body markings by the ancient Anglo-Saxons. The seeds of other members of the family produce camelina and canola oils. Camelina oil has been used in soaps and was once used as an illuminant for lamps. Canola oil (obtained from rape seed) is a source of low LDL fats and is widely used in food preparation.

## The Rose Family (Rosaceae)

The Rose Family includes more than 3,000 species of trees, shrubs, and herbs distributed throughout much of the world. The flowers characteristically have the basal parts fused into a cup, with petals, sepals, and numerous stamens attached to the cup's rim (Fig. 24.8). The family is divided into subfamilies on the basis of flower structure and fruits. The flowers of one group have inferior ovaries and produce pomes for fruits. Flowers of other groups have ovaries that are superior or partly inferior and produce follicles, achenes, drupes, or clusters of drupelets.

The economic impact of members of the Rose Family is enormous, with large tonnages of stone fruits (e.g., cherries, apricots, peaches, plums), pome fruits (e.g., apples, pears), and aggregate fruits (e.g., strawberries, blackberries, loganberries, raspberries) being grown annually in temperate regions of the world (Fig. 24.9).

Members of this family have been relevant to humans in many other ways in the past and still continue to be so. Roses themselves, for example, have for centuries been favorite garden ornamentals of countless numbers of gardeners, and the elegant fragrance of some roses delights many. In Bulgaria and neighboring countries, a major perfume industry has grown up around the production from damask roses of a perfume oil known as attar (or otto) of roses. In a valley near Sofia, more than 200,000 persons are involved in the industry, whose product brought more than \$3,000 per kilogram (\$1,360 per pound) during the 1990s. A considerable quantity of the oil is blended with less expensive substances in the perfume industry. Perfume workers are rarely reported to develop respiratory disorders, suggesting that the plant extracts may have medicinal properties.

The fruits of wild roses, called *hips* (Fig. 24.10), are exceptionally rich in vitamin C. In fact, they may contain as much as 60 times the vitamin C of a comparable quantity of citrus fruit. Native Americans from coast to coast included rose hips in their diet (except for members of a British Columbia tribe, who believed they gave one an "itchy seat"), and it is believed that this practice contributed to scurvy being unknown among Native Americans. During World War II when food supplies became scarce in some European countries, children in particular were kept healthy on diets that included wild rose hips. In addition to vitamin C, the hips contain significant amounts of iron, calcium, and phosphorus. Today many Europeans eat *Nyppon Sopa*, a sweet, thick purée of rose hips, whenever they have a cold or influenza.

After giving birth, the women of one western Native American tribe drank western black chokecherry juice to staunch the bleeding. Other tribes frequently made a tea from blackberry roots to control diarrhea. Five hundred Oneida Indians once cured themselves of dysentery with blackberry root tea, while many nearby white settlers, who refused to use "Indian cures," died from the disease. Men of certain tribes used older canes of roses for arrow shafts (presumably after removing the prickles!). Wild blackberries, raspberries, salmonberries, thimbleberries, dewberries, juneberries, and strawberries all provided food for Native Americans and early settlers, and they are still eaten today, either fresh or in pies, jams, and jellies. A spiced

blackberry cordial is still a favorite for “summer complaints” in southern Louisiana. Wild strawberries are considered by many to be distinctly superior in flavor to cultivated varieties.

## The Legume Family (Fabaceae)

The Legume Family, originally referred to as the *Leguminosae*, is the third largest of the approximately 300 families of -flowering plants, with only the Sunflower and Orchid Families having more species. The 13,000 family members of the Fabaceae are cosmopolitan in distribution and include many important plants. The flowers range in symmetry from radial (regular) to bilateral (irregular). The irregular flowers have a boat-shaped *keel* composed of two fused petals that enclose the pistil, two *wing petals*, and a larger *banner* petal (Fig. 24.11). The stamens in such flowers are generally fused in the form of a tube around the ovary. The legume fruit is the common feature shared by all members of the family (see Fig. 8.16).

Important crop plants include peas, many kinds of beans (e.g., kidney, lima, garbanzo, broad, mung, tepary), soybeans, lentils, peanuts, alfalfa, sweet clover, jicama, licorice, and wattle. Wattle is an Australian tree that is grown commercially as a source of tannins for leather tanning. Carob, another member of this family, is widely used as a chocolate substitute. Several copals (hard resins used in varnishes and lacquers) are obtained from certain legume plants, as are gum arabic and gum tragacanth used in mucilages, pastes, paints, and cloth printing. The hard wood of several tropical leguminous trees (e.g., rosewood) is prized for furniture.

Important dyes, such as indigo, logwood (used in staining tissues for microscope slides and now scarce), and woadwaxen (a yellow dye), come from different legume plants. Locoweeds, belonging to *Astragalus*—a genus of about 1,600 species—have killed many horses, cattle, and sheep, particularly in the southwestern United States. The poisonous principle in those species affecting livestock seems to vary in concentration according to the soil type in which the plants are growing. Other poisonous legumes include lupines, jequirity beans, black locusts, and mescal beans.

About 90% of the members of the Legume Family exhibit leaf movements, but few are as rapid as those of the sensitive plant (*Mimosa pudica*), whose leaves fold within seconds in response to a disturbance. Sensitive plants grow as weeds in the tropics and the Deep South of the United States; they are discussed in Chapter 11 and are shown in Figure 11.14. Many of the movements of other legume plant leaves are correlated primarily with day length.

Clovers have been widely used in the past by gatherers of wild food plants. The leaves are difficult to digest in quantity, but the rhizomes were gathered and usually roasted or steamed in salt water, then dipped in grease before being eaten. The seeds of both clovers and vetches also were gathered and either ground for meal or cooked in a little water and eaten as a vegetable. Today, seeds of several legumes, including alfalfa and mung beans, are popular for their sprouts, which are widely used in salads and Oriental dishes. A tropical bean called *winged bean* (Fig. 24.12) has unusually high levels of protein, and all parts of the plant are edible. It is presently being grown in several widely scattered tropical and subtropical regions and also is being marketed on a limited scale in some temperate zones. It is believed to have great potential for improving the diet of undernourished peoples throughout the tropics.

## The Spurge Family (Euphorbiaceae)

Although many of the members of the Spurge Family are tropical, they are widespread in temperate regions both north and south of the equator. The stamens and pistils are produced in separate flowers that often lack a corolla and are inconspicuous. In true spurges (*Euphorbia*), the female flower is elevated on a stalk called a *gynophore* and is surrounded by several male flowers that each consist of little more than an anther. Both the female and male flowers are inserted on a cup composed of fused bracts, the cup usually having distinctive glands on the rim. This type of inflorescence is called a *cyathium* (Fig. 24.13). Sometimes, the inconspicuous flowers are surrounded by brightly colored bracts (e.g., poinsettia, shown in Fig. 7.19) that give the inflorescence the appearance of a single, large flower. Most members of this large family produce a milky latex, and a number of species are poisonous.

Sooner or later, many gardeners experience “urges to purge spurges,” as some members of the family (e.g., spotted spurge) are exceptionally aggressive weeds that reproduce very rapidly. Other large tropical spurges closely resemble columnar cacti.

Several economically important plants are cultivated, particularly in frost-free regions. For example, an estimated 90 million metric tons (100 million tons) of cassava are harvested annually from plants cultivated in South America, Africa, and eastern Asia. The roots develop thickened storage areas that resemble large sweet potatoes (shown in Fig. 5.8) and are a diet staple of the tropics, much as white potatoes and cereals are of temperate areas. Poisonous principles are removed by boiling, fermenting, or squeezing out the juice. In dried and powdered form, the cassava is known as farina. In Western countries, tapioca is prepared by forcing heated cassava pellets through a mesh while it is being agitated. Cassava starch is also used as a base for the production of alcohol, acetone, and other industrial chemicals.

Another cultivated spurge of the tropics is the Pará rubber tree, the source of the crude rubber from which most rubber products are made today. Although wild South American trees were the original commercial source of rubber, rubber trees have been widely planted in Indonesia, Africa, and adjacent areas. The trees vary in height from less than 5 to over 50 meters (16 to 164 feet) and produce most of the latex in the inner bark. The laticifers in which latex is secreted spiral around inside the trunk at an angle of about 30 degrees. Accordingly, cuts are made at the same angle into the inner bark to obtain maxi-

mum yields of latex, which trickles down into collecting cups that are attached to the tree. After collection, the latex is coagulated by chemicals or smoke and then shipped in sheet or crumbled form to processing plants. Sometimes, an anticoagulant is mixed with it, and the liquid is transferred in tankers. Much of the world's rubber goes into the manufacture of automobile and aircraft tires, but other products made from rubber are legion.

The Pará rubber tree should not be confused with a broad-leaved ornamental known as the rubber plant. The rubber plant is popular as a house plant and also produces latex; it is, however, a member of the Fig Family (Moraceae).

The latex of other spurge may hold a key to future sources of fuel and lubricating oils. In 1976, Melvin Calvin, a University of California Nobel Prize winner, proposed the use of latex of gopher plants as a source of materials for oil. He estimated that such plants, which can grow in semidesert areas, would produce 10 to 50 barrels of oil per year on 0.4 hectare (1 acre) of land at a cost of \$3 to \$10 per -barrel.<sup>1</sup>

A spurge called *candelilla* occurs in remote areas of Mexico. It produces a wax on its stems that is used in the making of candles and other wax products. Still another spurge produces seeds with a special oil used in plasticizers, and castor oil (from castor beans) is used in the manufacture of nylon, plastics, and soaps. Castor beans themselves are very poisonous—as few as one to three are sufficient to kill a child. The plants grow very rapidly and are popular as ornamentals despite their being one of the leading natural causes of poisoning among American children.

A Mexican jumping bean is the seed of a certain spurge in which a small moth has laid an egg. When the egg hatches, the grub periodically changes position with a jerk, causing the seed to jump. Crown-of-thorns is an ornamental plant with somewhat flexible twisting stems bearing vicious-looking spines. Some believe it to have been the plant from which the crown of thorns for the head of Christ was made. Poinsettias, or Christmas flowers, are favorite yuletide plants in various parts of the world. Tung oil, used in oil paints and varnishes, and Chinese vegetable tallow, a substance used in the manufacture of soap and candles, are two more commercially important products obtained from the seeds of cultivated members of the Spurge Family.

## The Cactus Family (Cactaceae)

Cacti are native only to the Americas but include many highly regarded ornamentals that have been exported around the world. The flowers are usually showy (Fig. 24.14), with numerous stamens, petals, and sepals. The sepals are often colored like the petals, and the inferior ovary develops into a berry. There are possibly more than 1,500 species, most occurring in drier subtropical regions. The leaves of many are reduced in size or more often in the form of spines, with the fleshy, flattened or cylindrical, often fluted stems carrying on the photosynthesis of the plants (Fig. 24.15). Many cacti can tolerate high temperatures, and some can withstand up to several years without moisture. They vary in size from pinhead-like forms to the giant saguaro (see Fig. 26.7) that can attain heights of 15 meters (50 feet) and weigh more than 4.5 metric tons (5 tons). Cacti are generally -exceptionally slow-growing and, because they need so little care, make good house plants for sunny windows.

In 1944, a marine pilot was forced to bail out of his aircraft over the desert near Yuma, Arizona. Until he was rescued 5 days later, he survived the intense heat and low humidity of the area by chewing the juicy pulp of barrel cacti in the vicinity. Since then, the use of cacti for emergency fluids and food has been recommended in most survival manuals.

Most cacti have edible fruits, and only three cacti (peyote, living rock, and hedgehog cactus) are known to be poisonous. Prickly pear fruits are occasionally sold in American supermarkets and taste a little like pears. Prickly pear fruits also have seeds that Native Americans of the Southwest dried and ground for flour they mixed with water and used as an *atole* (thickened, souplike) staple food. A good syrup is obtained from boiling the fruits of prickly pears and also those of the giant saguaros. In the past, cactus candy was made by partly drying strips of barrel cactus and boiling them in saguaro fruit syrup, but the cactus is now usually boiled in cane sugar syrup.

Native Americans of the Southwest used to scoop out barrel cacti, dry them, and use them for pots. They also mixed the sticky juice of prickly pear cacti in the mortar used in constructing their adobe huts. In Texas, a poultice of prickly pear stem was applied to spider bites. Hopi Indians chewed raw cholla cactus as a treatment for diarrhea, and the skeletons of these cacti were used for flower arrangements.

In the middle of the 19th century, Australians planted a few imported prickly pear cacti in the dry interior. These cacti found no natural enemies in their new environment and multiplied rapidly, infesting more than 24 million hectares (60 million acres) within 75 years. In 1925, in an effort to control them, Australia introduced an Argentine moth among the cacti. The moth's caterpillars feed on prickly pear cacti and gradually brought the plants under control, making the land usable again.

Another cactus parasite, the cochineal insect (related to the mealybug, a common house plant pest), feeds on prickly pear cacti in Mexico. At one time, the insects were collected for a crimson dye they produce; the dye was used in lipstick and rouge before aniline dyes derived from coal tar were introduced in the 1930s.

Peyote cacti are small, button-like plants that have no spines, with roots resembling those of carrots. They contain several drugs, the best known of which is *mescaline*, a powerful hallucinogen. Dried slices of peyote have been used in native religious ceremonies in Mexico for centuries and more recently by at least 30 additional tribes of Native Americans.

## The Mint Family (Lamiaceae)

The 3,000 members of the Mint Family are relatively easy to distinguish since they have a unique combination of angular



stems that are square in cross section, opposite leaves, and bilaterally symmetrical (irregular) flowers (Fig. 24.16). Most also produce aromatic oils in the leaves and stems. The superior ovary is four-parted, with each of the four divisions developing into a nutlet. Included in the family are such well-known plants as rosemary, thyme, sage (not to be confused with sagebrush of the Sunflower Family), oregano, marjoram, basil, lavender, catnip, peppermint, and spearmint.

Mint oils can be distilled at home with ordinary canning equipment. Whole plants (or at least the leaves) are loosely packed to a depth of about 10 centimeters (4 inches) or more in the bottom of a large canning pot. Then a wire rack or other support is also put in the pot, and a bowl is placed in the middle on the rack. Enough water is added to cover the vegetation, the pot is placed on a range, and the lid is inverted over it. The water is brought to a boil, and as it does so, ice is placed on the inverted lid. The oils vaporize and condense when they contact the cold lid, dripping then from the low point into the bowl (Fig. 24.17). Of course, some moisture also condenses, but the oil, being lighter, floats on top. Peppermint oil is easy to collect this way and will keep for a year or two in a refrigerator.

Mint oils have been used medicinally and as an antiseptic in different parts of the world. Mohegan Indians used catnip tea for colds, and dairy farmers in parts of the midwestern United States used local mint oils to wash their milking equipment before antibiotics became popular for this purpose. As a result, mastitis, a common disease of dairy cattle, was seldom encountered in their herds. Horehound, a common mint weed of Europe, has become naturalized on other continents and is cultivated in France. A leaf extract is still used in horehound candy and cough medicines. In England, it is a basic ingredient of horehound beer. Vinegar weed, also known as blue curls, is a common fall-flowering plant of western North America. Native Americans of the area used it in cold remedies, for the relief of toothaches, and in a bath for the treatment of smallpox. It was also used to stupefy fish.

Menthol, the most abundant ingredient of peppermint oil (Fig. 24.18), is widely used today in toothpaste, candies, chewing gum, liqueurs, and cigarettes. Most American mint is grown commercially in the Columbia River basin of Oregon and Washington. Geese are sometimes used in the mint fields to control both insects and weeds, since they do not interfere with the growth of the mint plants themselves.

Ornamental mints include salvias and the popular -variegated-leaf *Coleus* plants, neither of which has typical mint oils in the foliage. *Chia* (Fig. 24.19), another relatively odorless mint, is confined to the drier areas of western North America. Native Americans parched chia seeds and used them in gruel. The seeds, which become mucilaginous when wet, were also ground into a paste that was placed in the eye to aid in the removal of dirt particles. The paste was also used as a poultice for gunshot wounds, and Spanish Californians made a refreshing drink from ground chia seeds, lemon juice, and sugar. Chia seeds reportedly contain an -unidentified -substance that has effects similar to those of caffeine. Before the turn of the century, one physician reported that a tablespoon of chia seeds was sufficient to sustain a man on a 24-hour endurance hike. Since that time, backpackers have experimented with the seeds, and results tend to support the earlier claim. A thorough scientific investigation of the matter is needed. Chia seeds are sold commercially for making into a paste that is spread on clay models and then watered. The seeds sprout and resemble green hair.

## The Nightshade Family (Solanaceae)

The Nightshade Family is concentrated in the tropics of Central and South America. The flowers have fused petals, with the stamen filaments fused to the corolla so that they appear to be arising from it (Fig. 24.20). The superior ovary develops into a berry or a capsule. The more than 3,000 species of the family have alternate leaves and occur as herbs, shrubs, trees, or vines. Well-known representatives include tomato, white potato, eggplant, pepper, tobacco, and petunia.

Many nightshades produce poisonous drugs, some of which have medicinal uses. One of the best-known -medicinal drug producers is the deadly nightshade of Europe. A drug complex called *belladonna* is extracted from its leaves. Belladonna was used in the "magic potions" of the past and also for dilating human pupils for cosmetic purposes. It is now the source of several widely used drugs, including atropine, scopolamine, and hyoscyamine. Atropine is used in shock treatment, for relief of pain, to dilate eyes, and to counteract muscle spasms. Scopolamine is used as a tranquilizer, and hyoscyamine has effects similar to those of atropine. Capsicum, obtained from a pepper, is used as a gastric stimulant and is also a principal ingredient of mace, which is used to repel human or animal assailants. Capsaicin, derived from peppers, is used in ointments for the relief of arthritic and neuropathic pain.

Jimson weed (see Fig. 8.6) is also a source of medicinal drugs that have been used in treatment of asthma and other ailments. The drugs can be fatal if ingested in sufficient quantities but were used in controlled amounts in Native American rituals of the past. Records indicate that users became temporarily insane but had no recollection of their activities when the effects of the drug wore off. The drug solanine is present in most, if not all, members of the family. Many arthritis sufferers apparently are sensitive to solanine, and a number of arthritics have reported partial relief through total abstinence of members of this family (including potatoes, tomatoes, peppers, and eggplant).

Tobacco cultivation occupies more than 800,000 hectares (2 million acres) of American farmland. In its dried form, tobacco contains 1% to 3% of the drug nicotine. Nicotine is used in certain insecticides, and it is used also for killing intestinal worms in farm livestock. It is, however, an addictive drug. The evidence of human tobacco use as a primary cause of heart and respiratory diseases including lung cancer and other cancers such as those of the mouth and throat mounts almost daily. The only "benefit" it may have to humans appears to be as a killer of leeches. It is said that leeches attaching themselves to heavy smokers will drop off dead within 5 minutes from nicotine poisoning—a very dubious justification for continued hu-

man use!

Tomatoes are among the most popular of all “vegetables.” About 18 million metric tons (20 million tons) are grown annually around the world. The plants are day-neutral (day lengths are discussed in Chapter 11), and even though they require warm night temperatures (16°C or 60°F) to set fruit well, they are easily cultivated in greenhouses when natural conditions are unfavorable. Most commercially grown American tomatoes are processed into juice, tomato paste, and catsup. In Italy, a small amount of edible oil is extracted from the seeds after the pulp has been removed. Most American tomatoes are grown in California and Florida, where they are harvested with special machinery developed during the 1960s when inexpensive labor became unavailable (Fig. 24.21).

The white, or Irish, potato is one of the most important foods grown in temperate regions of the world, with annual production estimated at well over 270 million metric tons (300 million tons). The leading producers are China, Poland, the United States, and countries of the former Soviet Union, which account for about 30% of the total. It is believed that white potatoes originated on an island off the coast of Chile and were sent back to Europe by Spanish invaders of South America in the 16th century. In the 1840s, late blight infested and destroyed the potato crop of Ireland, causing severe famine. Irish settlers subsequently emigrated to the United States, Canada, Australia, and other parts of the world.

When potato tubers are exposed to the sun, they turn green at the surface. Poisonous drugs (e.g., solanine) are produced in the green areas. These have proved fatal to both animals and humans and should never be eaten.

## The Carrot Family (Apiaceae)

Members of the Carrot Family are widely distributed in the Northern Hemisphere, and many have savory-aromatic herbage. The flowers tend to be small and numerous and are arranged in umbels. The ovary is inferior, and the stigma is two-lobed. The leaves are generally dissected, and the bases of their petioles usually form sheaths around the stem. Included in the 2,000 members of the family are dill, celery, carrot, parsley, caraway, coriander, fennel, anise, and parsnip. Anise is one of the earliest aromatics mentioned in literature. It is used for flavoring cakes, curries, pastries, and candy. Pocket gophers apparently are attracted by its aroma, and some poison baits are enhanced with anise. A liqueur known as *anisette* is flavored with it.

Caraway seeds are used to flavor a Danish liqueur, called *kümmel*. The seeds are well-known for their use in rye and pumpernickel breads.

Some members of the Carrot Family are poisonous. Water hemlock (Fig. 24.22) and poison hemlock are common weeds in ditches and along streams. All parts of the plants are deadly, often having been fatal to unwary wild-food lovers. Socrates is believed to have died as a result of ingesting poison hemlock, which should not be confused with cone-bearing hemlock trees.

Several members of the Carrot Family, such as cow parsnip, squawroot, and hog fennel, have edible roots and were used for food by Native Americans. The reader is advised, however, to be absolutely certain of the identity of such plants before experimenting with them.

## The Pumpkin Family (Cucurbitaceae)

Although most species in the Pumpkin Family are tropical or subtropical, many occur in temperate areas of both the Northern and Southern Hemispheres. Plants are prostrate or climbing herbaceous vines with tendrils. The flowers have fused petals, and female flowers have an inferior ovary with three carpels. All are unisexual. Some species have both male and female flowers on the same plant, while others have only male or only female flowers on one plant. In male flowers, the stamens cohere to varying degrees, depending on the species. The family has about 700 members, several of which have many horticultural varieties.

This family includes many important edible plants, and some have been cultivated for so long that they are unknown in the wild state. Well-known members of the family include pumpkins, squashes, cucumbers, cantaloupes (Fig. 24.23B), and watermelons.

The vegetable sponge (Fig. 24.23C), when it is growing, resembles a large cucumber and has a highly netted, fibrous skeleton that can serve as a bath sponge after the soft tissues have been removed.

Gourds found in Mexican caves and subjected to radiocarbon dating have proved to be many thousands of years old. Various types of gourds (Fig. 24.23A), serving many purposes, are still grown today. Some are scooped out and used for carrying liquids or for storing food, particularly grains. South Americans drink maté (a tea), from gourds, which are also used for several types of musical instruments. In parts of Africa, gourds are used to catch monkeys. A type of gourd with a narrow neck is scooped out and partly filled with corn or other grains. One end of a rope is then tied to the gourd and the other to a stake driven into the ground. When a monkey tries to grab a fistful of grain, it finds that the neck will not allow its bulging hand to be removed. Most do not realize that letting go of the grain would allow them to escape, and they stubbornly hang on until they are captured.

Melonette, a small cucumber-like vine of the southeastern United States, has seeds that can be *purgative* (drastically laxative). Other cucumber-like plants of the western states, manroots (see Fig. 5.9), produce huge water-storage roots, some weighing as much as 90 kilograms (200 pounds). These roots were crushed by Native Americans and thrown into dammed streams to stupefy fish. An oil from the seeds was applied to the scalp as a remedy for infections that caused hair loss.

## The Sunflower Family (Asteraceae)

The Sunflower Family, with approximately 20,000 species, is the second largest of the flowering plant families in terms of number of species. The individual flowers are called **florets**. They are usually tiny and numerous but are arranged in a compact inflorescence so that they resemble a single flower. A sunflower or daisy, for example, consists of dozens if not hundreds of tiny flowers crowded together, with those around the margin having greatly developed corollas that extend out like straps, forming what appear to be the “petals” of the inflorescence (Fig. 24.24 gives details of a sunflower inflorescence). In dandelions, all the individual florets of the inflorescence have narrow, straplike extensions.

Well-known members of this family include lettuce, endive, chicory, Jerusalem artichoke, globe artichoke, dahlia, chrysanthemum, marigold, sunflower, and thistle.

Santonin, obtained from flower buds of a relative of sagebrush that is native to the Middle East, is used as an intestinal worm remedy. Tarragon, used as a spice in meat dishes and pickles, comes from another relative of sagebrush. Pyrethrum is a natural insecticide obtained from certain chrysanthemum flowers. Fructose, a sugar, is obtained from the tubers of Jerusalem artichokes and dahlias. Dahlias are also renowned for their huge showy flowers, while Jerusalem artichokes are often eaten as a vegetable.

Marigolds are favorite plants of organic gardeners. Their roots are said to release a substance that repels nematodes, and the odor of the leaves repels white flies and other insects. Unfortunately, snails and slugs seem to be immune and voraciously consume the foliage.

Many members of this family were used widely by Native Americans. The dry fruits of balsamroot and mule ears were used for food. Balsamroot plants as a whole were eaten raw or cooked, and in the West, extracts of both mule ears and tarweeds were used to treat poison oak inflammations. Salsify and thistle roots were also used for food.

Young leaves and roots of dandelions have been eaten for centuries, and the flowers have been used to make wine. Roasted dandelion and chicory roots have been used as a coffee substitute. During World War II, chicory was grown as a crop specifically for use as a coffee adulterant.

The dried and boiled leaves of American yarrow are said to make a nourishing broth. European yarrow has become naturalized in North America. Its rhizomes contain an anaesthetic that, when chewed, numbs the tongue and gums, and it has been used to ease the discomfort of teething toddlers; the substance has also been used in suppression of menstruation. This plant is believed to have been used by Achilles in treating the wounds of his soldiers.

Sunflowers themselves were widely used by Native Americans for their dry fruits, which were ground into a meal for bread. They are grown commercially today primarily for the edible oil extracted from the seeds (after removal from the husks), but the seeds are increasingly being eaten by modern Americans.

## MONOCOTS

### The Grass Family (Poaceae)

Individual plants of the the grass family are more numerous and more widely distributed than plants of any other flowering plant family. There are, however, possibly only one-fourth as many species of grasses as there are members of the Sunflower Family. The flowers of grasses are highly specialized in structure and have a terminology all their own (Fig. 24.25). The calyx and corolla are represented by tiny, inconspicuous scales, and the flowers are protected by boat-shaped bracts. The stigmas, when they are exposed, are feathery, and the leaves sheathe the stem at their bases.

Nearly all of the cereals, including wheat, barley, rye, oats, rice, and corn, belong in this family, which includes 9 of the 10 most important crop plants in the world. Indeed, civilization as we know it would be vastly different without them. More than 900 million metric tons (1 billion tons) of cereals, feeding more than half of the world’s population, are harvested each year, primarily in the Orient, North America, and Europe.

Sugar cane (Fig. 24.26), from which about 55 million metric tons (60 million tons) of sugar is extracted annually, is grown at lower elevations throughout humid tropical areas. It is a large grass, often growing to heights of 6 meters (20 feet). After the cane is harvested, raw liquid sugar is squeezed out by a milling process. The juice then is centrifuged, with the solids being crystalized into table sugar. The dark remnant (molasses) may be used to produce rum or alcohol. The solid waste is sometimes made into paper or particle board, and also has been converted to gasoline in South Africa. In Hawaii, the waste is used in the production of electric power.

Grasses have been used widely by primitive peoples for making mats and baskets and for thatching huts. Some varieties of sorghum are grown for their fibers, which are made into brooms, although natural broom fiber now has been replaced to a considerable extent by synthetic materials. Some varieties are grown for the seeds, which are processed into cereal flours. Others are a source of silage and a carnauba-like wax. Citronella oil, once a common ingredient of mosquito repellents, is obtained from a grass grown in Indonesia. It is now used in cheaper soaps, cosmetics, and perfumes. Related grasses are the source of lemon grass oil, used for the same purposes as citronella oil.

Juice squeezed from fresh, young grass mowings has a high protein content and is being investigated as a source of protein for future human consumption.

## The Lily Family (Liliaceae)

In recent classifications, the traditional members of this family have been augmented by members of several other families now included within the Liliaceae. Lily family members are particularly abundant in the tropics and subtropics, but they occur in almost any area that supports vegetation. The flowers are often large, and their parts are all in multiples of three, with the sepals and petals frequently resembling each other in color and form (Fig. 24.27).

In addition to many types of lilies and daffodils used widely as ornamentals, the family includes asparagus, sarsaparilla, squill, meadow saffron, bowstring hemp, and *Aloe*. Sarsaparilla was at one time widely used for flavoring soft drinks and medicines and is obtained from the roots of a genus of woody vines (*Smilax*) whose stems are often covered with prickles. The bulbs of squills are the source of a rodent poison and also of a drug used as a heart stimulant.

Meadow saffron is the source of *colchicine*, a drug once used to treat rheumatism and gout but now much more widely used in experimental agriculture to interfere with spindle formation in cells so that the chromosome number of plants may be artificially increased. This increasing of the chromosome number can result in larger and more vigorous varieties of plants. (Meadow saffron should not be confused with true saffron, a member of the Iris Family and the source of the world's most expensive spice and a powerful yellow dye.)

Bowstring hems are related to the familiar, seemingly indestructible house plants called *sansevierias* (Fig. 24.28), which have long, narrow, stiff, upright leaves. The plants are cultivated in tropical Africa for their long fibers, which are used for string, rope, bowstrings, mats, and cloth. New Zealand flax, a larger plant, is grown in South America and New Zealand for similar purposes but is also widely used in ornamental plantings.

Several *Aloe* species produce juices used in shampoos, cosmetics, sunburn lotions, and in the treatment of burns. African *Aloe* species are prized as ornamentals in areas with milder climates. Their thick, fleshy leaves have short spines along the margins. The spines were once used for phonograph needles.

Many lily bulbs (e.g., onions and garlic) are edible, and wild lily bulbs were used for food extensively by Native Americans. Wild bulbs should no longer be eaten, however, as doing so may endanger the survival of native species. (*Caution: Lily bulbs should not be confused with those of daffodils and their relatives. Daffodil and related bulbs are highly poisonous.*)

The California soaproot (Fig. 24.29) is confined to California and southern Oregon and was important for food to Native Americans of the region. It also had several other uses. The large bulbs are covered with coarse fibers that were removed and tied to sticks to make small brooms. The bulbs themselves produce a lather in water and were used for soap. Sometimes, numbers of bulbs were crushed and thrown in a small stream that had been dammed. Fish would be stupefied and float to the surface. The bulbs were generally eaten after being roasted in a stone-lined pit in which a fire had been made. While they were roasting, a sticky juice would ooze out. This was used for gluing feathers to arrow shafts.

A resin used in stains and varnishes exudes from the stem of dragon's blood plants. Grass trees of Australia yield resins used in sealing waxes and varnishes.

## The Orchid Family (Orchidaceae)

This very large family has, according to some authorities, more than 35,000 species that are widely distributed. Like members of the Lily Family, they are especially abundant in the tropics. In many genera, the number of individual plants at any one location may be quite small—sometimes limited to a single plant.

The flowers are exceptionally varied in size and form, and the habitats of the plants are equally diverse. The flowers of one Venezuelan species have a diameter of less than 1 millimeter (1/25 of an inch), while those of a species native to Madagascar may be more than 45 centimeters (about 18 inches) long. One species of *Dendrobium* orchid from Java has flowers that are so delicate they wither within 5 or 6 minutes after opening. Many orchids are epiphytic on the bark of trees. During its 5-month flowering season, one epiphytic species of Malaysia and the Philippine Islands produces 10,000 flowers on plants that weigh more than 1 metric ton. Others are aquatic or terrestrial, and a saprophytic species (see Fig. 8.1) native to western Australia grows and flowers entirely underground.

Orchids have three sepals and three petals, with one of the petals (the *lip petal*) differing in form from the other two (Fig. 24.30). The stamens and pistil are united in a unique, single structure, the *column* (see Fig. 23.9). The stigma usually consists of a sticky depression on the column. The anthers contain sacs of pollen called *pollinia* and are covered with a cap until they are removed by an insect or other pollinator. The specific adaptations between orchid flowers and their pollinators are extraordinary and sometimes bizarre (as illustrated in Fig. 23.18).

Orchids have minute seeds that are often produced in prodigious numbers (e.g., a single fruit of certain orchid species may contain up to 1 million seeds). Each seed consists of only a few cells, and in order for a seed to germinate, it must become associated with a specific mycorrhizal fungus that produces substances necessary for its development. Once a seed has germinated, it may take from 6 to 12 or more years before the first flower appears.

Contrary to popular belief, some orchids can be grown relatively easily on a windowsill that has bright light, but not direct sunlight (see Appendix 4). Because orchids are among the most beautiful and prized of flowers, a large industry has grown up around their culture and propagation, discussed in the section on mericlone and tissue culture in Chapter 14. One species, the vanilla orchid, is grown commercially in the tropics for its fruits, which are the source of true vanilla flavoring.

## Summary

1. Distinguishing between fact and fantasy in reported past uses of plants is often difficult. Teams of specialists are interviewing tribal medicine men and women of the tropics to try to save potentially useful plants from extinction.
2. N. I. Vavilov proposed eight major centers of distribution of cultivated plants. More recent studies by Harlan and others indicate strict recognition of the centers is without merit.
3. Flowering plant families are surveyed in evolutionary sequence, discussing first those considered primitive.
4. The Buttercup Family (Ranunculaceae) includes buttercup, columbine, larkspur, anemone, monkshood, *Clematis*, goldenseal, and wolfsbane.
5. The Laurel Family (Lauraceae) includes cinnamon, camphor, sassafras, sweet bay, California bay (or myrtle), avocado, and laurel.
6. The Poppy Family (Papaveraceae) includes bloodroot and opium poppy (the source of medicinal drugs and heroin).
7. The Mustard Family (Brassicaceae) includes cabbage, cauliflower, brussels sprouts, broccoli, radish, kohlrabi, turnip, horseradish, watercress, rutabaga, shepherd's purse, western wallflower, dyer's woad, and camelina.
8. The Rose Family (Rosaceae) includes stone fruits (e.g., cherry, apricot, peach, plum), strawberry, raspberry, rose, and related wild species.
9. The Legume Family (Fabaceae) includes pea, bean, lentil, peanut, soybean, alfalfa, clover, licorice, wattle, indigo, logwood, locoweed, jicama, sensitive plant (*Mimosa pudica*), and winged bean.
10. The Spurge Family (Euphorbiaceae) includes poinsettia, spurge, cassava, Pará rubber, gopher plant, candelilla, castor bean, crown-of-thorns, Mexican jumping bean, and tung oil tree.
11. The Cactus Family (Cactaceae) includes all cacti (e.g., prickly pear, cholla, barrel cactus, peyote).
12. The Mint Family (Lamiaceae) includes rosemary, thyme, sage, oregano, marjoram, basil, lavender, catnip, peppermint, spearmint, horehound, salvia, *Coleus*, and chia.
13. The Nightshade Family (Solanaceae) includes tomato, white potato, eggplant, pepper, tobacco, belladonna, petunia, and jimson weed (a source of hallucinogenic drugs).
14. The Carrot Family (Apiaceae) includes dill, caraway, celery, carrot, parsley, coriander, fennel, anise, parsnip, water hemlock, poison hemlock, cow parsnip, squawroot, and hog fennel.
15. The Pumpkin Family (Cucurbitaceae) includes pumpkin, squash, cucumber, cantaloupe, watermelon, vegetable sponge, gourd, melonette, and manroot.
16. The Sunflower Family (Asteraceae) includes sunflower, dandelion, lettuce, endive, chicory, Jerusalem and globe artichokes, dahlia, chrysanthemum, marigold, thistle, sagebrush, pyrethrum, balsamroot, tarweed, and -yarrow.
17. The Grass Family (Poaceae) includes nearly all cereals (e.g., wheat, barley, rye, oats, rice, corn), sugar cane, sorghum, citronella, and lemon grass.
18. The Lily Family (Liliaceae) includes lilies, asparagus, sarsaparilla, squill, meadow saffron, bowstring hemp, *Aloe*, and New Zealand flax.
19. The Orchid Family (Orchidaceae) has highly specialized flowers. It includes a species that is the source of vanilla flavoring.

## Review Questions

1. To which flowering plant family does each of the following belong: poinsettia, lupine, columbine, peach, pear, cinnamon, sarsaparilla, belladonna, peyote, horehound, rubber, gourd, jimson weed, parsley, sorghum, asparagus, broccoli, lettuce, tomato, opium?
2. Make a list of the poisonous plants in the families -discussed.
3. Which plants mentioned are or have been used for -medicines?
4. Which plants mentioned have been used for tools or utensils?
5. Native Americans made extensive use of plants for a wide variety of purposes in the past. List such uses for as many plants as possible.

## Discussion Questions

1. Scientific investigations often take a great deal of time and money. Is it worth the effort to check out scientifically the past uses of plants?
2. A return to exclusively herbal medicines is being advocated in some quarters. Is this a good idea? What are the pros and cons?
3. Would you expect drugs produced naturally by plants to be more effective or better than drugs produced synthetically? Why?
4. If you were asked to single out the three most important families of the 16 discussed, which would you choose? Why?
5. A number of wild edible plants were mentioned in this chapter. What would happen if a large portion of the population were to gather these wild plants as a major source of food?

## Additional Reading

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## Learning Online

Visit our website at <http://www.mhhe.com/stern11e> for additional information and learning tools.

Pods of a tropical cacao tree (*Theobroma cacao*). The seeds are the source of chocolate.

Figure 24.1 Major centers of diversity of cultivated plants according to N. I. Vavilov. Jack Harlan and his associates have abandoned these centers and have associated the plants with regions instead. See text. *After Vavilov, N. I. 1951. The origin, variation, immunity and breeding of cultivated plants. (K. Starr Chester, Trans. New York: The Ronald Press Company, © 1951.)*

Nothing is more important to the relationship of humans to the environment than cultivated plants that provide sources of food, fiber, animal forage, and medicines. Cultivated plants have been developed in nearly all climatic regions of the earth and reflect the wide diversity of environments occupied by humans. Cultivated plants appear to have originated in six major regions: Near Eastern (e.g., wheat, carrot, apple), Chinese (e.g., soybean, cucumber, peach), African (yam, cotton, coffee), South Asian and Pacific (e.g., rice, sugar cane, citrus fruits), North American (e.g., sunflower, tobacco), and South and Central American (e.g., white or Irish potato, squash, pineapple). Plants originating in these regions are now grown throughout the world. Today's most important cultivated plants are a tiny fraction of the thousands of species used by peoples around the world; preserving the knowledge of useful plants held by traditional societies is a major challenge for this generation of botanists.

Figure 24.2 A buttercup flower.

- A.
- B.

C.

D.

Figure 24.3 Representatives of the Buttercup Family. A. Columbine. B. *Hepatica*. C. Monkshood. D. *Isopyrum*. (C. Courtesy Donald E. Brink, Jr.)

Figure 24.4 A fruit and leaves of a California bay tree (also known as Oregon myrtle).

Figure 24.6 Immature opium poppy capsules that were gashed with a razor blade. Note the opium-containing latex oozing from the gashes.

Figure 24.7 Shepherd's purse.

Figure 24.8 A Sitka rose.

Figure 24.9 A raspberry.

Figure 24.10 Mature rose hips.

C.

Figure 24.11 A. Irregular (bilaterally symmetrical) flowers of a coral tree. B. Parts of a sweet pea flower. C. An inflorescence of a powderpuff "flower" consisting of regular radially symmetrical legume flowers.

Figure 24.12 A winged bean. Winged beans are highly nutritious, are easy to grow in the tropics, and hold promise for improving diets in developing countries.

Figure 24.13 A spurge. A. Inflorescence. B. An individual cyathium.

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1. Jojoba, a member of the Box Family (Buxaceae), is a desert shrub with an acorn-sized capsule containing a large oily seed with about 50% liquid wax content. This high-grade wax and another found in the seeds of meadowfoams, which are members of the Meadowfoam Family (Limnanthaceae), are the only known natural substitutes for sperm whale oil, a vital ingredient in engine lubricants. The importing of sperm whale oil into the United States was banned in 1970 to protect the nearly extinct large ocean mammals, and an expensive synthetic substitute is being used. Experiments and research are in progress to find improved strains of jojoba and to test the feasibility of its being grown on a large scale. Two California counties have been using a mixture of petroleum oil and jojoba oil since 1981 in the transmissions of public transportation buses to see if the mixture will keep them from overheating. The results are promising and may reduce the need for transmission oil changes from once every 50,000 miles to once every 100,000 miles.

A.

B.

Figure 24.14 Flowers of two different cacti.

A.

B.

C.

D.

Figure 24.15 Cacti. A. A barrel cactus. B. Prickly pear cacti. C. Peyote. D. An organ-pipe cactus.

Figure 24.16 Flowers of lamb's ear mint.

Figure 24.17 A simple apparatus for distilling mint oil at home. See text.

Figure 24.18 A peppermint plant in flower. Oil from the leaves is a source of menthol.

Figure 24.19 A flowering head of chia.

Figure 24.20 A sectioned petunia flower.

Figure 24.21 Harvesting a field with a mechanical tomato harvester.

Figure 24.22 A water hemlock in flower.

- A.
- B.
- C.

Figure 24.23 Fruits and items associated with members of the Pumpkin Family (Cucurbitaceae). A. A Hawaiian ceremonial gourd with feathers attached and gourds used in South America for drinking maté. A metal straw that strains out the maté leaves is resting in one gourd. B. Cantaloupes. C. A luffa (vegetable sponge).

Figure 24.24 Parts of a sunflower. A. A section through an inflorescence. B. A section through a single floret.

Figure 24.25 Grass flowers. A. An expanded grass spikelet. B. An enlargement of a single flower (floret).

Figure 24.26 Sugar cane plants.

Figure 24.27 A tiger lily flower.

Figure 24.28 *Sansevieria* plants.

Figure 24.29 An uprooted California soaproot plant.

## Coffee and Caffeine

Among all the foods, beverages, and products provided by flowering plants, coffee (*Coffea arabica*) is one that millions of people, particularly Americans, have contact with every day. We take our coffee break seriously. We drink some 350 million cups of coffee daily, which is enough coffee to turn the Metrodome into a deep caffeine pool. Here are some frequently asked questions concerning coffee and caffeine. So grab a cup of coffee, pull up your favorite chair, sit down, and relax while you read about one of the world's favorite beverages.

### Where Does Coffee Grow?

Coffee is a small tree or shrub native to the mountains of Ethiopia but, because of its popularity as a drink, coffee was spread by traders to many tropical regions of the world. Today, Brazil and Colombia are the world's leading coffee producers. Coffee is derived from the seeds (beans) of *Coffea arabica* or *Coffea robusta*, two species of the 70 or more recognized varieties between them. The trees require tropical or subtropical climate and need about 60 to 100 inches of rain per year. They grow best at mountain elevations of 3,000 to 6,000 feet where the temperature is cool and relatively stable (68°F) because they are unable to tolerate frost. Trees start producing fruit around 3 to 5 years of age.

### Botanically Speaking, What Is a Coffee "Bean"?

In Costa Rica, the crop season begins with the first "flowering rains" that come in March or April. Flowering buds that were produced at the end of the dry season are now conditioned to flower by the gentle rains. The white, delicate flowers have little aroma and bloom for 3 days before falling off the trees. Each pollinated flower will produce one fruit, which is called a cherry because of its red color. The coffee cherry contains two seeds that are tightly packed against each other, resulting in each seed having a flat side. The coffee "beans" are actually the two seeds of each fruit. Coffee fruits change color from dark green to deep red and are handpicked when ripe (red color). Each tree is usually harvested three or four times because of the uneven maturation of fruits. A single tree can yield up to 5 to 6 pounds of fruit per year.

### How Much Caffeine Does a Cup of Coffee Have?

A 7-ounce cup of coffee prepared by the drip method contains 115 to 175 milligrams of caffeine, while instant coffee contains 65 to 100 milligrams. Decaffeinated instant coffee contains 2 to 3 milligrams of caffeine.

### How Much Caffeine Is in Soft Drinks?

The following table compares the caffeine content of several brands of soft drinks.

Soft Drink (12-oz can)	Caffeine Content (mg)
------------------------	-----------------------



Jolt	72.0
Mountain Dew	54.0
Coca-Cola	45.6
Dr. Pepper	39.6
Pepsi-Cola	38.4
RC Cola	36.0

## Chemically Speaking, What Is Caffeine?

Caffeine is a plant alkaloid found not only in coffee beans but also in tea leaves, cola nuts, and cacao seeds. It works as a stimulant of the central nervous system and the respiratory system, as well as increasing heart rate and constricting blood vessels. As a stimulant, caffeine makes us more aware and alert and able to work without drowsiness. It is reported that coffee was discovered in the Near East (perhaps in Yemen) by goats, which became frisky and sleepless after eating the wild fruit. A shepherd is said to have located the shrub the goats had chewed and described it as "a shrub with leaves like laurel, flowers like jasmine, and little dark berries the chief object of the animals' nibbling."

## What Are the Effects of Caffeine on the Body?

Caffeine stimulates or increases heartbeat rate, respiration, and basal metabolic rate and increases the production of stomach acid and urine. These effects translate into a stimulating "lift" that a person may feel. Generally, one feels less drowsy, less fatigued, and more alert and focused after consuming caffeine.

## Where Does the Word "Coffee" Come From?

The word "coffee" is probably derived from the Arabic word "kahveh," which means "stimulating," and is thought to have been used to describe the effects of eating coffee seeds (beans).

## What Does Caffeine Taste Like?

Caffeine is very bitter to the taste, as are other plant alkaloids. Caffeine is added as a flavoring agent to beverages such as root beer because it produces the sharp bitterness characteristic of the drink.

## How Is Coffee Decaffeinated?

If green (unroasted) coffee beans are rinsed with hot water above 175°F, caffeine is extracted from the beans. However, in the process of removing caffeine, hot water alone is not used because it strips away too many of the essential flavors and aromatic elements contained in the beans. Along with water, a decaffeinating chemical such as methylene chloride or ethyl acetate is generally used. One common method involves placing the green beans in a rotating drum and softening them with steam for 30 minutes. They are then rinsed for approximately 10 hours with methylene chloride, which removes the caffeine from the beans. Methylene chloride containing the caffeine is drained off, and the beans are steamed a second time for 8 to 12 hours to remove any remaining methylene chloride solvent. Finally, the beans are air- or vacuum-dried to remove excess moisture before the roasting process. Most decaffeinated coffee contains less than 0.1 part per million (ppm) of residual methylene chloride, 100 times less than the maximum level of 10 ppm allowed by the U.S. Food and Drug Administration.

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Figure 24.30 Bamboo orchids growing wild in Hawaii.

Figure 24.5 A prickly poppy flower.