CHAPTER 27

The Importance of Plants

Rice fields, often called paddies, thrive in regions with abundant rainfall. Rice is a prime food source for more than 60 percent of the world's population. About 90 percent of the world's rice is grown in Asia, primarily in China and India.

SECTION 1 ***Plants and People***

SECTION 2 ***Plants and the Environment***

PLANTS AND PEOPLE

Plants are essential to our survival because they produce virtually all our food. We eat plants either directly, in the form of fruits, vegetables, and grains, or indirectly, by eating animals that consume plants. Plants also provide medicines, clothing, paper, cosmetics, and many other products. Plants play a major role in the continuous cycling of the Earth's water, oxygen, carbon dioxide, and mineral nutrients. The study of plants is called ***botany*** *(BAHT-nee).*

SECTION 1

OBJECTIVES

- **Summarize** the history of plant cultivation.
- **Identify** the categories of food crops.
- **Explain** how humans have increased food production in the world.
- **Describe** non-food uses of plants.

VOCABULARY

botany
agriculture
cultivar
cereal
root crop
legume
fruit
vegetable
nut
spice
herb
quinine
fertilizer
pesticide
aspirin
gasohol

PLANT CULTIVATION

Of the more than 350,000 plant species, people use at least 10,000 species for food. Incredibly, fewer than 20 plant species provide more than 90 percent of our food supply. The cultivation of plants for food probably began about 11,000 years ago in the Middle East. Wheat, barley, lentils, and peas were the first domesticated food crops. Growing plants and raising animals for human use is called **agriculture** (AG-ri-KUHL-chuhr). People propagated, or reproduced, individual plants that had valuable characteristics, such as plants that produced the largest or tastiest fruits.

In the 11,000 years that humans have been cultivating plants, we have changed many of the plants so much that they could not grow and survive without us. For example, the wild wheat stalk, as shown in Figure 27-1, breaks easily in the wind, an adaptation that increases the dispersal of its seeds. But early farmers used seeds from plants with stalks that did not break easily for replanting. When these plants were grown, the seeds could be harvested before they fell from the plant. This form of selection—with people acting as selecting agents—has resulted in high-quality food plants.

You have probably eaten Thompson Seedless grapes, McIntosh apples, or Valencia oranges. They are just three examples of several hundred thousand different cultivars. The word *cultivar* is a contraction of the two terms *cultivated* and *variety*. **Cultivars** (KUHL-ti-VAHRZ) are selected by people, and they have at least one distinguishing characteristic that sets them apart from other members of their species. The famous Japanese flowering cherry trees in Washington, D.C., Yoshino cherries, are another example of a cultivar.

FIGURE 27-1
Wheat is one of the world's most important food crops. It is used to make breads, crackers, macaroni, and spaghetti.

Quick Lab

Making a Plant-Based Menu

Materials paper, pencil

Procedures

1. Prepare a written lunch menu that consists only of plant-derived foods. Be careful to design a fully nutritional meal. Then, write a description of a lunch setting that is also completely derived from plants, including utensils and furniture.
2. Share your menu and lunch-setting description with your classmates.

Analysis Was it difficult or easy to devise a lunch that includes only plant-based items? Write down any interesting or unusual plant choices or purposes for them that you and your classmates included.

FOOD CROPS

Food crops are usually classified partly by use and partly by family. The classification system in Table 27-1 is not like the taxonomic classification used by scientists because most categories contain species that are not closely related. Also, many crops fit into more than one category. For example, corn is a cereal, but it can also be classified as an oil crop, a sweetener, a vegetable, and a beverage.

Cereals

Cereals are grasses that contain grains. Grains are the edible, dry fruits of a cereal. Over half of the world's cultivated land is devoted to cereal crops, such as rice, wheat, corn, oats, sorghum, rye, and millet. Worldwide, cereals provide about 50 percent of the calories in the average human diet. In addition, much of the harvested grain is used for animal feed, so it is indirectly consumed by people as meat, poultry, eggs, and dairy products.

Wheat and corn are produced in the largest amounts. Wheat grows well in moderate to cold climates, including parts of the United States, Russia, and Canada. The United States is the leading producer of corn, also called maize. Rice is different from other cereals because it grows best in shallow water. Rice thrives in areas with warm temperatures.

TABLE 27-1 ***Food Crops***

Category	Example plants
Cereals	rice, wheat, corn, oats, sorghum, rye, barley, millet
Root crops	potato, cassava, sweet potato, yam, taro
Legumes	soybean, peanut, bean, pea, alfalfa, lentils
Fruits	apple, peach, banana, grape, orange, blueberry, pineapple, cherry, mango, pear
Nuts	walnut, cashew, pecan, coconut, almond, macadamia, filbert, pistachio
Vegetables	spinach, cabbage, sweet corn, pea, turnip, asparagus, tomato, artichoke, zucchini
Forages	cereals, legumes, grasses
Oils	cottonseed, rapeseed, palm, sesame, soybean, corn, safflower, sunflower
Beverages	coffee, tea, cola, cacao, fruit juice, grape (wine), corn (whiskey), barley and hops (beer)
Sweeteners	sugar cane, sugar beet, sugar maple, corn
Spices	pepper, cinnamon, vanilla, paprika, cloves, saffron, nutmeg, ginger, allspice
Herbs	rosemary, thyme, sage, dill, basil, oregano, mint
Flavorings	cacao (chocolate), coconut, carob, licorice, quinine
Colorings	red beet, anatto, turmeric, saffron, carrot
Additives	guar, locust bean, citrus (pectin), gum arabic, chicle tree
Garnishes	sesame, caraway, and poppy seeds; parsley; pimento
Snacks	popcorn, sunflower seeds, pumpkin seeds

Root Crops

Root crops are roots or underground stems that are rich in carbohydrates. In many parts of the world, root crops substitute for cereals in providing the major part of the diet. However, diets of root crops or cereals alone are usually low in some important amino acids. To correct this deficiency, people must eat other foods, such as legumes or animal protein.

Root crops include beets, carrots, radishes, rutabagas, turnips, and sweet potatoes. Other kinds of potatoes and yams are actually *tubers* (modified underground stems) but are considered root crops because they grow underground. You may have eaten tapioca pudding, which comes from cassava, a root crop grown in the Tropics and shown in Figure 27-2.

FIGURE 27-2

An important root crop in the Tropics is cassava, which has thick roots that are eaten like potatoes. The starch-filled roots of cassava can be 30–120 cm (1–4 ft) long.

Legumes

Legumes are members of the pea family and bear seeds in pods. Soybean, shown in Figure 27-3, is the most important legume crop because it is produced in the largest amount and has many important uses. Soybean is used to make vegetable oil, soy milk, soy sauce, tofu, and margarine. Alfalfa and clover are legumes used mainly as feed for livestock. Legumes are important in agriculture because they improve the nitrogen content of soil. Recall that some bacteria form a symbiotic relationship with many legumes and convert atmospheric nitrogen into a form that plants can use.

Fruits, Vegetables, and Nuts

Many "vegetables" we know, such as tomatoes, green beans, and squash, are actually botanically classified as fruits. A **fruit** is the part of a flowering plant that usually contains seeds. Foods derived from the leaves, stems, seeds, and roots of nonwoody plants are often called **vegetables.** Fruits and vegetables are excellent sources of many important vitamins and minerals, making them essential parts of a healthy diet. A **nut** is a dry, hard fruit that does not split open to release its seed. Nuts include almonds, walnuts, pecans, and hazelnuts. Peanuts are commonly considered to be nuts but are actually classified as legumes. Nuts and legumes are higher in protein than other plant foods.

FIGURE 27-3

Soybean is an important legume crop grown in the midwestern and southern parts of the United States. The soybean plant is covered with short, fine fibers and is usually 60–120 cm (2–4 ft) tall. It is an inexpensive and useful source of protein.

Spices, Herbs, and Flavorings

Other food crops add variety and pleasure to our diet by flavoring our water, beverages, and food. More than half the population ingests caffeine through drinking coffee, tea, and cola drinks. Both **spices** and **herbs** are used to add taste to food. In general, spices come from plant parts other than the leaf and are tropical. Herbs usually come from leaves and usually can be grown in a home garden. Flavorings, such as chocolate and coconut, are not usually considered spices or herbs and are therefore placed in a separate category. Another flavor, quinine, is used to make tonic water. **Quinine** comes from the bark of the cinchona tree and is used to treat malaria.

Eco Connection

Making Your Own Fertilizer—Composting

Many people are making their own fertilizer through a technique called *composting.* Compost is a type of organic fertilizer that is made from decayed plant matter. Compost improves the texture of soil and provides inorganic nutrients that plants need.

It's easy to start your own compost pile. Collect dead plant matter, such as grass clippings, leaves, coffee grounds, or sawdust. Make a pile by alternating layers of plant matter with a thin layer of soil or manure. Sprinkle water on the pile to speed the process of decay. After the compost has been allowed to decay for about six months, it should be ready for use in your garden.

Food Production

For decades, experts have been predicting widespread food shortages due to the continuing increase in the world population. However, massive food shortages have not occurred mainly because of increased use of irrigation, fertilizers, and pesticides. Improvements in cultivars; farm machinery; food preservation techniques; and methods of controlling diseases, weeds, and pests have also helped improve food production. **Fertilizers** supply plants with essential mineral nutrients like nitrogen and phosphorus. **Pesticides** are chemicals that kill undesirable organisms that harm crops, such as some insects.

People have made many trade-offs to support an adequate food supply. The negative consequences include massive soil erosion, depletion of fossil fuel and water supplies, pollution, and destruction of wild populations of plants and animals as more land is cultivated.

NONFOOD USES OF PLANTS

In addition to providing us with food, plants provide us with thousands of other essential products. It is hard to imagine how we could live without plants, given the variety of products that contain substances from plants.

Medicines

The ancient Greeks treated headaches with the bark of the white willow tree, which contains the chemical salicin. This use gave scientists the idea to test the chemical acetylsalicylic (uh-SEET-uhl-SAL-uh-SIL-ik) acid. The willow is in the genus *Salix,* hence the names *salicin* and *salicylic.* Acetylsalicylic acid is **aspirin,** the world's most widely used medicine. Besides pain relief, aspirin is used to thin blood and thereby prevent heart attacks and strokes. Plants were our first medicines, and early plant biologists, like Linnaeus, were often doctors.

Word Roots and Origins

pesticide

contains the suffix *-cide,* from the Latin *cida,* meaning "cut down" or "kill"

TABLE 27-2 *Plants in Medicine*

Plant	Genus name	Drug	Use
Cinchona	*Cinchona*	quinine	treat malaria and certain disorders of heart rhythm
Foxglove	*Digitalis*	digitalis	treat heart disease, help regulate heart rate
Yam	*Dioscorea*	cortisone	treat inflammation and allergies
White willow	*Salix*	acetylsalicylic acid (aspirin)	relieve pain, prevent heart attacks and strokes
Yew	*Taxus*	taxol	treat ovarian cancer, breast cancer, and some types of lung cancer

(a)

(b)

FIGURE 27-4

(a) Taxol, originally derived from the bark of the Pacific yew, is a recently discovered cancer drug. This evergreen tree or shrub produces seeds that look like berries. (b) Foxglove is the source of digitalis, which is used in the treatment of heart disease. The beautiful flowers grow in a cluster.

Many modern medicines either still come from plants or were originally obtained from plants and are now synthesized in the laboratory. Table 27-2 lists examples of plants that are used in medicine. Two of these plants, yew and foxglove, are shown in Figure 27-4. Scientists are currently evaluating thousands of plant species that may have medicinal properties. One of the reasons scientists are very concerned about the destruction of rain forests is because many rain-forest plant species have yet to be researched. In addition to medicines, plants provide many other products, which are summarized on the next page in Table 27-3.

Your local health-food store carries a wide range of plant products that claim to prevent disease or improve health. These substances are not regulated by the Food and Drug Administration (FDA). Consumers should remember that the effectiveness and safety of herbal remedies have not been confirmed by the rigorous scientific testing that new medicines must undergo before receiving FDA approval. The FDA, pharmaceutical companies, and health-care providers are working together to investigate the claims of those who market these remedies.

Clothing and Fabric Dyes

Figure 27-5 shows cotton, which is used to make most of our clothing. Some clothing is woven with linen, which is made from the flax plant. Artificial fabrics, like rayon, arnel, and cellulose acetate, are made from processed wood fibers. Leather is made from animal hides, but it is usually treated with tannin, a chemical obtained from many tree species. Tannin makes leather stronger and prevents it from rotting.

Prior to the mid-1800s, fabrics were dyed with natural plant dyes. Today most clothing is colored with dyes manufactured from coal, which is formed from the remains of ancient plants.

FIGURE 27-5

Cotton, the world's most widely used source of clothing, consists of fibers attached to the seed.

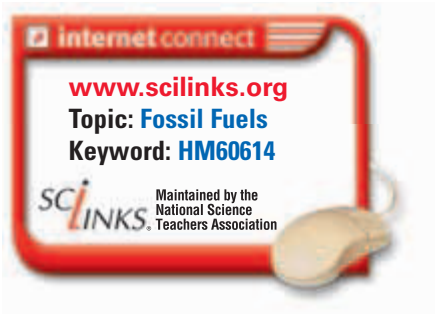
TABLE 27-3 *Nonfood Uses of Plants*

Use	Example plants
Brooms/brushes	broomcorn, palms, coconut
Building materials	trees, bamboo, reeds, palms, grasses
Carpets/mats	jute, coconut (coir), cotton, trees
Clothing	cotton, flax (linen), ramie, pineapple, trees (rayon and arnel)
Cosmetics	corn, avocado, carrot, almond, cacao, soybean, macadamia, aloe
Fabric dyes	indigo (blue), madder (red), onion (yellow), black walnut (brown), peach (green), maple (pink)
Fuels	trees, bamboo, water hyacinth, grain alcohol, vegetable oils, gopher plant
Furniture	redwood, oak, rattan, teak, willow (wicker), rushes
Hair dyes	henna, rhubarb, chamomile, black walnut
Incense	frankincense, myrrh, cinnamon
Inks	soybean, flax (linseed oil), tung-oil tree
Leather	black wattle, quebracho, Spanish chestnut (tannin)
Lipstick	jojoba, castor bean, carnauba palm, soybean, coconut
Medicines and remedies	foxglove (digitalis), cinchona (quinine), yew (taxol), opium poppy (morphine and codeine), yam (cortisone), aloe, ipecac, ginseng, ginkgo, guarana, purple coneflower, kudzu, saw palmetto
Miscellaneous	cork oak (cork), incense cedar (pencil shafts), trees (disposable baby diapers and cellulose acetate plastic), kapok (life preserver stuffing), rosary pea (bead necklaces), water hyacinth (water purification), lignum vitae (submarine engine bearings)
Musical instruments	ebony (black piano keys), maple (violins), reed (woodwind reeds), African blackwood (woodwinds)
Ornamentals	shade trees, shrubs, lawns, cut flowers, Christmas trees, houseplants
Paints	flax (linseed oil), tung-oil tree, soybean, pine (turpentine)
Paper/cardboard	trees, cotton, flax, hemp, bamboo, papyrus
Perfumes	rose, orange, lavender, orchids, sandalwood, lilac, jasmine, lily of the valley, pine
Pesticides/repellents	tobacco (nicotine sulfate), derris (rotenone), chrysanthemum (pyrethrum), citronella, garlic, citrus
Rope	hemp, agave (sisal)
Rubber	rubber tree, guayule
Shampoo	palm oil, coconut, jojoba, aloe, trees, herbs, fruits
Soaps	coconut, palm oil, cacao, lavender, herbs, fruits
Sports equipment	balata (golf balls), persimmon (golf club heads), ash (baseball bats), ebony and ash (pool cues)
Toothpaste	mint, wheat, palm oil, coconut
Tourist attractions	redwoods, giant sequoias, saguaro cactuses, fall foliage, Holland tulips
Waxes	carnauba palm, cauassu, candelilla, bayberry

FIGURE 27-6
Coal is a dark-colored, organic rock. Complex chemical and physical changes produced coal from the remains of plants that grew in prehistoric swamps millions of years ago.

Fuels

Most of the energy we use for heat, electricity, and machine fuel comes from fossil fuels—coal, oil, and natural gas. Figure 27-6 shows a coal deposit being uncovered by an earth-moving machine. Fossil fuels are composed of stored photosynthetic energy from millions of years ago. In developing nations, much of the fuel comes from wood or other plant materials. For example, grains can be fermented into alcohol and mixed with gasoline to make gasohol. **Gasohol,** which is made of about 10 percent alcohol, is an alternative fuel for automobiles.



Careers in BIOLOGY

Ethnobotanist

Job Description Ethnobotanists are scientists who study the ways in which people make use of plants, whether for food, medicine, or other purposes. Ethnobotanists are often involved in the collection of plants, the conservation of endangered species, and the research of traditional plant medicines.

Focus On an Ethnobotanist Ethnobotanist Paul Cox travels to remote places to look for plants that can help cure diseases. He seeks the advice of native healers in his search. For example, Cox traveled to the Pacific island of Samoa in 1984 to meet a 78-year-old healer named Epenesa. She was able to identify more than 200 medicinal plants, and she had an accurate understanding of human anatomy. Epenesa gave Cox samples of her medicines, which he brought back to the United States for study. American researchers studying her remedies discovered antiviral and anti-inflammatory compounds. Many other plant substances, obtained by ethnobotanists with the assistance of native healers, are being studied in laboratories for their healing properties. Many of the practitioners of traditional medicine are elderly. When they die, generations of medical knowledge often die with them. The need for Cox and other ethnobotanists to record the ancient wisdom of native healers is urgent.

Education and Skills

- **High school**—three years of science courses and four years of math courses.
- **College**—bachelor of science (B.S.) in biology, including course work in botany, chemistry, and anthropology, followed by a doctoral degree (Ph.D.) in botony, chemistry, anthropology, or linguistics, plus field and lab experience.
- **Skills**—patience, ability to learn new languages, self-motivation, respect for other cultures, and field survivial skills.

For more about careers, visit go.hrw.com and type in the keyword HM6 Careers.

FIGURE 27-7

The California redwood trees are a majestic sight. Redwoods usually grow 60–84 m (200–275 ft) high. The bark is very thick, making the trees resistant to fires.

Other Uses of Plants

Ornamental trees, shrubs, and other plants outside our homes do much more than provide beauty. Besides their decorative function, they improve the environment by preventing soil erosion, reducing noise, providing habitats for wild animals, acting as windbreaks, providing shade, and moderating temperatures, which, in turn, reduces home heating and cooling costs. Scientists have also found that ornamental plants improve our mental well-being. Gardening has long been a popular hobby in the United States, and it is an important form of exercise for millions of people.

Many plants have become major tourist attractions, such as the California redwoods shown in Figure 27-7. Another popular American tourist attraction is the Petrified Forest National Park in Arizona. The park features large areas of fossilized trees. And many yearly festivals, including the Tournament of Roses in California every New Year's Day and the Cherry Festival in Michigan each May, are held around the United States to celebrate plants. In addition, many people visit the forests of the northeastern United States every fall to view the spectacular changing leaf colors.

Plants are essential to our survival because they produce virtually all of our food, and they enhance our lives in many ways. Growing cut flowers is now a multibillion-dollar-a-year industry, and it is only a small part of the huge business of growing and using plants. Plants can also provide the inspiration to develop innovative products. The cocklebur plant provided the idea for hook and loop fasteners when the hooked fruit was caught in the inventor's clothing. Plants have made our lives better in numerous ways, and they undoubtedly will continue to do so in the future.

SECTION 1 REVIEW

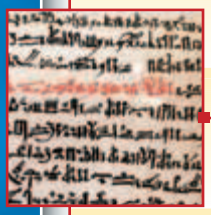
1. Define the term *agriculture*.
2. Distinguish between the food crops known as *cereals, root crops, legumes, fruits,* and *vegetables.*
3. List three activities that humans have conducted to increase production of food crops, thus avoiding predicted food shortages.
4. List four personal grooming products that are manufactured using ingredients from plants.

CRITICAL THINKING

5. **Applying Information** How might transferring specific genes from legumes into rice plants help reduce malnutrition?
6. **Analyzing Information** How might farmers use legumes to reduce their use of fertilizers?
7. **Relating Concepts** Swiss physician Paracelsus (1493–1541) stated that the difference between a poison and a remedy is the dose. Explain how this statement might apply to the investigation of herbal remedies.

MILESTONES IN Using Plants for Medicine

Timeline

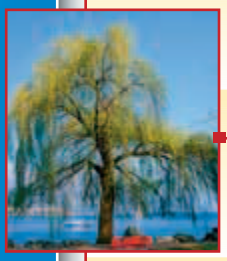


4000 BC Sumerian clay tablets list plant remedies.

1500 BC Egyptian scroll lists 850 plant remedies.

1000 BC The *Pen Tsao* lists 375 botanicals, including opium and ephedra.

300 BC Theophrastus writes *Historia Plantarum.*



100 AD Dioscorides mentions white willow tree in *de Materia Medica.*

1658 Cinchona bark is advertised for sale in England.

1899 Aspirin, a buffered form of salicin, is introduced.

1957 Extracts from the rosy periwinkle are found to cure childhood leukemia.

1993 Taxol, derived from the Pacific yew, is approved by the FDA as an anticancer drug.

Today, one-quarter of all prescription drugs contain a useful plant ingredient. More than 100 prescription drugs are made from plants. When did the relationship between plants, people, and medicine begin?

Throughout human history, people have used and passed down information about plants that can ease pain, infections, and physical maladies. About 4000 BC, Sumerian healers engraved cuneiform characters for various medicinal plants onto clay tablets. These may have been the first *herbals,* or lists of healing plants. A 70-foot-long Egyptian scroll dated to 1500 BC recorded 850 plant remedies, including garlic, for preventing illness.

An Indian poem from this same era, called the *Rig Veda,* describes many plant remedies, including snakeroot (*Rauvolfia serpentina*) for snakebite. Modern researchers discovered that snakeroot contains the compound reserpine, which lowers blood pressure. A Chinese herbal from 1000 BC, the *Pen Tsao,* lists 375 botanicals, including opium and ephedra, that are still used as painkillers and stimulants.

Around 300 BC, Aristotle described various herbal remedies, and his student Theophrastus wrote the text *Historia Plantarum.* In 100 AD, the Roman scholar Dioscorides wrote *de Materia Medica,* in which he mentions white willow, later found to be a source of aspirin. Both books were still in use in the Middle Ages. At least one herbal written in 1250 AD includes foxglove (*Digitalis purpurea*), the source of a heart stimulant.

The modern era of medicinal plants began with the use of quinine for treating malaria. Peruvian Indians had long recognized the value of the cinchona tree for treating feverish patients. Bark from this tree was first advertised for sale in England in 1658. However, it wasn't until 1820 that quinine was isolated from the bark of the cinchona tree by French chemists.

The development of aspirin presents a similar story. Extracts from the white willow tree had been known from the time of the ancient Greeks to ease pain. However, the pain-relieving substance, salicin, wasn't isolated until 1829. Because salicin causes stomach problems, more research was required for the development of a buffered derivative, aspirin, which was offered to the public in 1899.

During the 1950s, drug companies began to seek medicinal plants all over the world. In 1957, scientists discovered that extracts from the Madagascar rosy periwinkle are effective against childhood leukemia. Deaths from childhood leukemia have since dropped by 80 percent. Taxol, derived from the Pacific yew and approved for medical use in 1993, is an effective treatment against ovarian cancer. So far, however, only a small percentage of the world's plants have been tested for useful medicines such as these.

Review

1. Name two medicinal plants used in ancient times and today.
2. **Critical Thinking** Why is it important to preserve the medicinal knowledge of indigenous cultures?
3. **Critical Thinking** How might the destruction of rain forests impact the future of medicine?

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SECTION 2

OBJECTIVES

- **Summarize** the contributions of plants to the environment.
- **Describe** the ways that plants interact with other organisms.
- **Explain** how some plants can cause harm.

VOCABULARY

plant ecology
weed
hay fever

PLANTS AND THE ENVIRONMENT

Based solely on weight, algae and photosynthetic bacteria are dominant organisms in the oceans, and plants are dominant on land. Photosynthetic plants are called producers because they make food for other living things. Organisms that eat other organisms, like animals, are called consumers and depend on plants for a source of organic compounds.

PLANT ECOLOGY

The study of the interactions between plants and the environment is called **plant ecology.** The most important interaction involves the ability of plants to capture solar energy through photosynthesis. In photosynthesis, plants absorb carbon dioxide from the air, produce sugar and starch, and break apart water, releasing oxygen into the air. Consumers, like the one shown in Figure 27-8, use sugar and oxygen in cellular respiration and produce carbon dioxide and water. Organic compounds from plants provide consumers with energy, cellular "building blocks," and essential compounds such as vitamins and fiber.

Plants also provide organisms with inorganic nutrients. Plant roots are very efficient at mining the soil for inorganic nutrients, such as nitrogen, phosphorus, potassium, iron, and magnesium. Plants use these inorganic nutrients for metabolism and to make organic compounds. Consumers ingest these organic compounds and incorporate the inorganic nutrients into their own bodies.

FIGURE 27-8
About half of the world's species of plants and animals live in tropical rain forests. One of the reasons scientists are very concerned about the destruction of rain forests is because many plant species have yet to be researched.

Eventually, these same inorganic nutrients are returned to the soil when the consumer's waste material or dead body is decomposed by bacteria and fungi. Plants thus play a major role in the continuous cycling of the Earth's water, oxygen, carbon dioxide, and inorganic nutrients.

Plants are also responsible for the formation and maintenance of soil. Roots bind soil particles together, leaves reduce the soil-eroding impact of wind and rain, and dead plant parts add organic matter to the soil.

Plant-Animal Interactions

Plants interact with animals in many fascinating ways. Many flowering plants attract pollinators, animals that carry pollen from one plant to another. Usually the pollinator gets a reward for its efforts in the form of food from nectar. The size, shape, color, and odor of many flowers make them attractive to their pollinators. For example, Figure 27-9 shows that in some orchid species, the flowers have evolved to look and smell like the female of their wasp or bee pollinators. A male wasp or bee lands on a flower believing he has located a mate. The pollen he touches sticks to his body and is transferred to the next orchid he visits. In this case, the flower lures the pollinator with the promise of a mate, but fools the insect into picking up pollen without receiving a reward.

FIGURE 27-9
Some orchid species have evolved to resemble their wasp or bee pollinators.

Plant-Microbe Interactions

Two important aspects of plant ecology are plant interactions with fungi and with bacteria. Plant-microbe interactions may be harmful to plants, as in the case of fungal and bacterial diseases. Diseases often cause major crop losses. However, bacteria and fungi also form important beneficial relationships with plants.

The majority of plant species form *mycorrhizae,* which are symbiotic relationships between fungi and the roots of a plant. A mycorrhizal fungus penetrates a root, often changing the root structure. However, the fungus does not harm the root. Instead, it greatly increases the root's ability to absorb water and other inorganic nutrients, such as phosphorus and potassium. In return, the root supplies the fungus with energy.

The roots of many plant species also form beneficial associations with bacteria. Some bacteria can take nitrogen gas from the air and "fix" it, or convert it to a form that plants can use. Plants of the legume family, such as peas, beans, and peanuts, commonly host bacteria that fix nitrogen.

Plant-Human Interactions

We protect and care for many plants that provide us with food, clothing, shelter, medicine, and many other products. However, humans have drastically changed natural plant populations by introducing foreign plant species, diseases, and animals. Introduced plants, such as the water hyacinth shown in Figure 27-10, kudzu, crabgrass, and dandelion have become widespread weeds.

FIGURE 27-10
The water hyacinth has become a weed that clogs waterways in the southeastern United States.

Word Roots and Origins

pollen

Latin word meaning "fine flour"

Weeds are undesirable plants that often crowd out crop plants or native plant species. For example, water hyacinths float on lakes and rivers, growing so fast and dense that they impede boats and shade underwater plants. The introduction of a fungal disease, chestnut blight, in 1904 virtually wiped out the American chestnut as a dominant forest tree in the eastern United States. Government inspectors now carefully screen plant materials entering the country to prevent the introduction of plant pests and diseases that native plants have no resistance against.

HARMFUL PLANTS

Despite the many benefits plants provide, some plants can also cause harm. Many deaths are caused by addictive plant products, such as tobacco, cocaine, opium, and alcohol. Some plant species are harmful when eaten or touched. Poison ivy and poison oak give an itchy rash to millions of Americans each year. Children are often poisoned, though usually not fatally, when they eat the leaves or colorful berries of house or garden plants. Despite widespread reports to the contrary, the popular Christmas plant poinsettia is not deadly, but its sap may cause skin irritation. However, holly berries and parts of mistletoe are poisonous.

Tens of millions of people suffer from pollen allergies, one cause of hay fever. **Hay fever** is an allergic reaction that results in sneezing, a runny nose, and watering eyes. Pollen allergies occur at three seasons. In early spring, deciduous trees, such as oak, ash, birch, and sycamore release pollen. In late spring or early summer, it is mainly wild and pasture grasses that cause allergy problems. Of the cereal crops, only rye pollen seems to be an important cause of allergies. In late summer and fall, the highly allergenic pollen of ragweeds, shown in Figure 27-11, affects many people. Contrary to popular belief, large, colorful flowers do not cause hay fever. Pollen that causes allergies comes from small, drab flowers that are wind-pollinated.

FIGURE 27-11

Giant ragweed, which can grow to more than 4 m (13 ft.) tall, produces massive amounts of pollen that is a major cause of hay fever. The small, dull flowers indicate that it is wind-pollinated.

SECTION 2 REVIEW

1. What is the name for the study of the interactions that occur between plants and the environment?
2. How do plants play a role in the continuous recycling of many of the Earth's inorganic nutrients?
3. How do plants benefit from their interactions with animals?
4. List three ways that some plants can cause harm to people.

CRITICAL THINKING

5. **Recognizing Differences** Purple loosestrife, a weed that can dominate American wetlands, does not cause problems in its native Europe and Asia. Explain a possible reason for this.
6. **Relating Concepts** Explain the adaptive benefits for plants that have evolved to look like insects.
7. **Recognizing Relationships** Considering how pollination occurs, why do you think hay fever is caused by pollen from grasses and trees?

CHAPTER HIGHLIGHTS

SECTION 1 Plants and People

- The study of plants is called botany. The practical applications of botany are evident in agriculture, which is the raising of crops and livestock for food or other uses.
- Humans have cultivated plants for approximately 11,000 years and have changed, by selection, many plant species so much that these plants can no longer survive in the wild.
- Food crops can be classified in many ways, including by their use and by their taxonomic classification.
- The major part of the human diet is provided by a few cereal crops in the grass family, especially corn, wheat, and rice.
- Everyday definitions of fruits and vegetables are different from botanical definitions. Many common vegetables, such as green beans, tomatoes, squash, and pumpkins, are actually fruits. Botanically speaking, a fruit is the part of a flowering plant that usually contains seeds.
- Plants provide many important medicines, such as digitalis, quinine, morphine, and anti-cancer drugs.
- Several factors have increased food production, including the use of fertilizers and pesticides. As land is cultivated to produce an adequate food supply, the health of the environment is compromised by soil erosion, depleted water supplies, and pollution.
- Plants provide thousands of nonfood products, including clothing, fabric dye, lumber, paper, cosmetics, fuel, cork, rubber, turpentine, and pesticides.
- Ornamental plants improve the human environment in many important ways: they provide shade, minimize soil erosion, reduce noise, and lower home energy costs.

Vocabulary

botany (p. 545)
agriculture (p. 545)
cultivar (p. 545)
cereal (p. 546)
root crop (p. 547)
legume (p. 547)
fruit (p. 547)
vegetable (p. 547)
nut (p. 547)
spice (p. 547)
herb (p. 547)
quinine (p. 547)
fertilizer (p. 548)
pesticide (p. 548)
aspirin (p. 548)
gasohol (p. 551)

SECTION 2 Plants and the Environment

- Plant ecology is the study of the interactions between plants and the environment.
- Plants play a major role in recycling the Earth's water, oxygen, carbon dioxide, and inorganic nutrients.
- Plants provide animals with inorganic nutrients as well as organic nutrients.
- Most plant roots are penetrated by beneficial mycorrhizal fungi, which greatly increase the roots' ability to absorb inorganic nutrients.
- Most nitrogen in living organisms must first be fixed by bacteria, which may live in association with plant roots, especially the roots of legumes.
- Plants associate with animals in many mutually beneficial ways. For example, plants provide food to animals that protect them or carry their pollen.
- People have affected wild plant populations negatively by introducing foreign species of plants, animals, and disease organisms.
- Plants can cause harm in several ways. Many deaths are caused by addictive plant products. Some plant species are poisonous when eaten or touched. And millions of people suffer from allergies to pollen.

Vocabulary

plant ecology (p. 554)
weed (p. 556)
hay fever (p. 556)

CHAPTER REVIEW

USING VOCABULARY

1. For each pair of terms, explain the relationship between the terms.
   a. *botany* and *agriculture*
   b. *fertilizer* and *pesticide*
   c. *fruit* and *vegetable*
   d. *aspirin* and *quinine*
2. Choose the term that does not belong in the following group, and explain why it does not belong: *legume, nut,* and *root crop*.
3. Use the following terms in the same sentence: *gasohol, plant ecology,* and *cereal.*
4. **Word Roots and Origins** The word *herb* is derived from the Latin *herba,* which means "grass." Using this information, explain why the term *herb* is a good name for the plants that the term describes.

UNDERSTANDING KEY CONCEPTS

5. **Describe** how people have acted as selecting agents in the evolution of food plants.
6. **Distinguish** between a fruit and a vegetable.
7. **State** two negative impacts of modern agricultural methods.
8. **List** three nonfood, nonmedicinal uses of plants.
9. **Name** three types of plants that provide fiber used in clothing.
10. **List** five medicines that are derived from plants.
11. **Describe** how ornamental trees improve the environment.
12. **Identify** one inorganic plant nutrient, and describe the role of plants in recycling this nutrient.
13. **Explain** how plants and microbes interact in mutually beneficial ways.
14. **Explain** why plant materials entering the country are screened by government inspectors.
15. **Name** three addictive plant products.
16. **CONCEPT MAPPING** Use the following terms to create a concept map that illustrates plant ecology: *humans, pollination, plants, animals, hay fever, mycorrhizae, bees* and *microbes.*

CRITICAL THINKING

17. **Predicting Results** If all animals disappeared from the Earth, what would the positive and negative effects be on plants?
18. **Analyzing Information** During the rainy season in the Brazilian rain forest, the rivers flood the land. Many fish from these rivers then swim among the land plants and eat their fruit. How might this intermingling of fish and plants help the plants?
19. **Analyzing Concepts** Suppose a friend asks you why corn, which he or she considers to be a vegetable, is listed as a cereal crop in the encyclopedia. To answer this question, write a paragraph that explains why corn is a cereal crop, agriculturally, and why corn is a fruit, botanically. Identify other examples of foods that are classified as vegetables or grains but also are fruits.
20. **Relating Concepts** How did artificial selection by humans play a role in the origin of agricultural crops? How is artificial selection similar to natural selection?
21. **Interpreting Graphics** Many athletes consume carbohydrates before a competition to increase their endurance. The table below shows a variety of legumes and grains that can be purchased at a grocery store. Compare their prices and nutritional composition. Determine which food is the least expensive source of carbohydrates.

Common Legumes and Grains

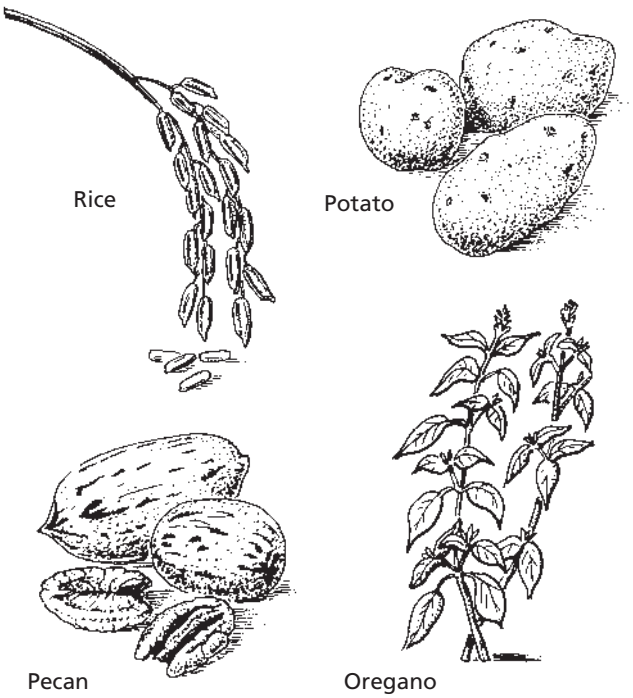
Food	Package size	Price	Serving (g)	Per serving			
				Calories	Total fat (g)	Total carbohydrate (g)	Total protein (g)
Navy beans	454 g	.69	45	80	0	23	8
Rice	907 g	.79	45	150	0	35	3
Barley	454 g	.49	45	100	0	24	3
Soybeans	454 g	.89	45	170	8	14	15
Spaghetti	907 g	.79	45	200	1	34	6

Standardized Test Preparation

DIRECTIONS: Choose the letter of the answer choice that best answers the question.

1. Early farmers selected wheat plants that had which of the following characteristics?
   A. fewest grains
   B. largest seed pods
   C. easily dispersed seeds
   D. stalks not easily broken in the wind
2. Which plants are the major source of food for the world today?
   F. spices
   G. cereals
   H. legumes
   J. root crops
3. Which of the following is an inorganic nutrient recycled by plants?
   A. sugar
   B. starch
   C. cellulose
   D. phosphorus

INTERPRETING GRAPHICS: The illustration below shows four types of food plants. Use the illustration to answer the question that follows.

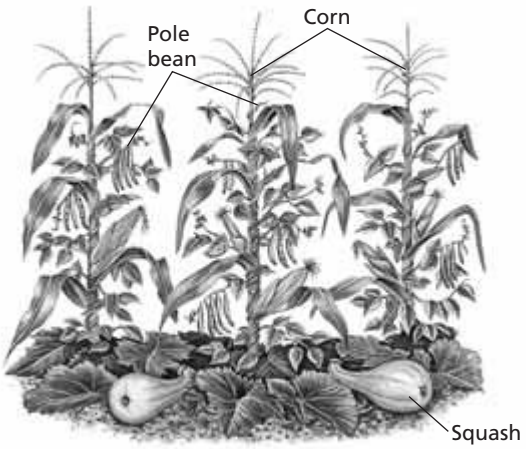


4. Plants classified as root crops have edible underground structures. Which of the food plants shown above is a root crop?
   F. rice
   G. pecan
   H. potato
   J. oregano

DIRECTIONS: Complete the following analogy.

5. vegetable : root crop :: grain :
   A. herb
   B. spice
   C. cereal
   D. quinine

INTERPRETING GRAPHICS: The illustration below shows how plants might be grown together. Use the illustration to answer the question that follows.



6. How does this arrangement help these plants?
   F. The squash can use the corn as a support.
   G. The beans grow apart from the squash and corn.
   H. The corn covers the ground and reduces erosion.
   J. Beans, which are legumes, will provide nitrogen fertilizer for the corn and squash.

SHORT RESPONSE

Look again at the illustration above.

Explain the advantage to the human diet of growing and eating these food crops together.

EXTENDED RESPONSE

Plants have been cultivated for at least 11,000 years.

Part A Identify 5 plants people use for food and 5 plants people use for other purposes.

Part B How has human cultivation changed some plants?

Test TIP For a question that uses a word you don't know, try to determine the meaning of the word by breaking it down into smaller parts and inferring the meaning of these parts.

Comparing Soil-Grown Plants with Hydroponic Plants

OBJECTIVES

- Compare hydroponic plant-cultivation techniques with conventional plant-cultivation techniques.
- Observe the germination of wheat seeds over a two-week period.

PROCESS SKILLS

- analyzing data
- measuring
- comparing and contrasting

MATERIALS

- 2 clear plastic cups
- plastic-foam floater with 6 holes in it
- 50 mL of potting soil
- cheesecloth (must be large enough to cover the plastic-foam floater)
- 12 wheat seeds
- 50 mL of complete nutrient solution
- plastic dropper
- labeling tape
- marking pen
- 50 mL graduated cylinder
- metric ruler

Background

1. Hydroponic cultivation is a technique for growing plants in a solution that contains all of the inorganic nutrients the plant needs. Plants that are grown hydroponically do not require soil.
2. The beginning of growth in a seed is called *germination.*

PART A Day 1

1. Using the marking pen and the labeling tape, label one clear plastic cup "Soil Cultivated," and label the other plastic cup "Hydroponically Cultivated."
2. Fill the cup labeled "Soil Cultivated" halfway with moist potting soil. Place six wheat seeds on the surface of the soil; use the distance between the holes in the foam floater as a guide to determine the spacing of the wheat seeds. (Do not place the floater on the soil.)
3. Press the seeds into the soil until they are approximately 0.5 cm below the surface. Cover the seeds with soil, and press down firmly.
4. Water the seeds with 10 mL of distilled water.
5. Add 50 mL of complete nutrient solution to the cup labeled "Hydroponically Cultivated," and place the plastic-foam floater on the surface of the solution, as shown in the figure below.

6. Place the cheesecloth on top of the floater, as illustrated in the figure. Press lightly at the location of the holes in the floater to moisten the cheesecloth.

7. Place the remaining six wheat seeds on top of the cheesecloth in the cup labeled "Hydroponically Cultivated." Position the seeds so that each one lies in an indentation formed by the cheesecloth in a hole in the floater. Press each seed lightly into the hole until the seed coat is moistened.
8. Place both cups in a warm, dry location. Water the soil-cultivated seeds as needed, monitoring the amount of water added. Aerate the roots of the hydroponic plants every day by using a clean plastic dropper to blow air into the nutrient solution.
9. In your lab report, prepare data tables similar to Table A and Table B. Write your observations of the seeds in your data tables.
10. Clean up your lab materials and wash your hands before leaving the lab.

TABLE A *OBSERVATIONS OF SOIL-GROWN PLANTS*

Day	Appearance of seedlings	Average height (mm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

TABLE B *OBSERVATIONS OF HYDROPONICALLY GROWN SEEDS*

Day	Appearance of seedlings	Average height (mm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

PART B Days 2–14

11. Compare the contents of each cup every day for two weeks, and record the appearance of the wheat seedlings in your data tables. If you are unable to observe your seedlings over the weekend, be sure to note in your data table that no observations were made on those days.

12. Each time that you observe the seedlings after they have begun to grow, measure their height and record the average height of the seedlings in each cup in your data tables. To find the average height for one cup, add the heights of each seedling in the cup together and divide by the number of seedlings (6).

13. After the seeds in the cup containing nutrient solution have germinated and formed roots, allow an air pocket to form between the floater and the surface of the nutrient solution. A portion of the roots should still be submerged in the nutrient solution. The air pocket allows the roots of the seeds to absorb the oxygen necessary for metabolic processes while continuing to absorb nutrients from the nutrient solution. Continue to observe and record the progress of the seedlings in each cup on a daily basis.

14.  Clean up your lab materials and wash your hands before leaving the lab.

Analysis and Conclusions

1. Based on the data you recorded, which seeds germinated more quickly? Which seeds attained the greatest height?
2. Compare your results with those of your classmates. Were the results the same for each group of students?
3. You planted six seeds in each cup. Why do you think the lab had you do this instead of having you plant a single seed in each cup? Why is the use of more than one sample important?
4. How could hydroponic growing techniques be useful to countries that have either a growing season that is too short to grow a variety of crops or soil that does not support most agricultural crops?

Further Inquiry

The nutrient solution you used in this investigation should have provided all of the inorganic nutrients that the wheat seeds needed for proper growth. How could you determine exactly which inorganic nutrients a plant requires by using hydroponic cultivation?