



Section 1

Plant Cells and Tissues

MAIN <Idea> Different types of plant cells make up plant tissues.

Section 2

Roots, Stems, and Leaves

MAIN <Idea> The structures of plants are related to their functions.

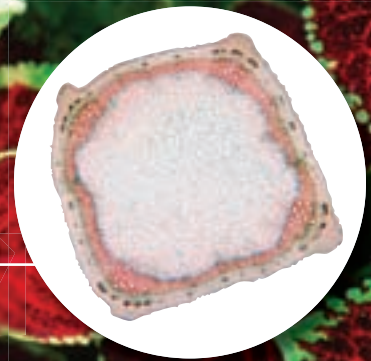
Section 3

Plant Hormones and Responses

MAIN <Idea> Hormones can affect a plant's responses to its environment.

BioFacts

- The pigment in coleus leaves that give them their reddish color serves as a Sun block—it protects the plant from harmful UV rays from the Sun.
- For over 2000 years, humans have grown plants for their stem fibers that are woven to make linen fabrics.
- With a few exceptions, 80–90 percent of a plant's roots grow in the top 30 cm of the soil.



Cross section of coleus stem
Stained LM Magnification: 47×



Cross section of coleus leaf
Stained LM Magnification: 75×

LAUNCH Lab

What structures do plants have?

Most plants have structures that absorb light and others that take in water and nutrients. In this lab, you will examine a plant and observe and describe structures that help the plant survive.

Procedure

1. Read and complete the lab safety form.
2. Carefully examine a **potted plant** provided by your teacher. Use a **hand lens** to get a closer look. Make a list of each type of structure you observe.
3. Gently remove the plant from the pot and observe the plant structures in the soil. Do not break up the soil. Record your observations and place the plant back into the pot.
4. Sketch your plant and label each part.

Analysis

1. **Compare** your list with those of other students. What structures were common to all plants?
2. **Infer** how each structure might be related to a function of the plant.
3. **Predict** the type of structural adaptations of plants living in dry environments.



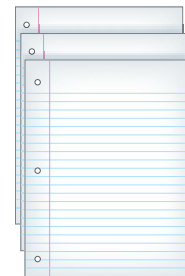
Visit biologygmh.com to:

- ▶ study the entire chapter online
- ▶ explore the Concepts in Motion, Interactive Tables, Virtual Labs, Microscopy Links, and links to virtual dissections
- ▶ access Web links for more information, projects, and activities
- ▶ review content online with the Interactive Tutor, and take Self-Check Quizzes

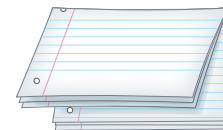
FOLDABLES™ Study Organizer

Leaf Structure and Function Make this Foldable to help you investigate the structure and function of a typical leaf.

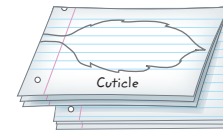
- ▶ **STEP 1** Stack three sheets of paper, keeping all edges aligned.



- ▶ **STEP 2** Fold the stack in half. Crease and staple the fold to make a six-page booklet.



- ▶ **STEP 3** Draw the outline of a large leaf on the front page and label the page *Cuticle*.



- ▶ **STEP 4** Label the remaining five pages in the following order: *Epidermis*, *Palisade mesophyll*, *Spongy mesophyll*, *Epidermis*, and *Cuticle*.

FOLDABLES Use this Foldable with Section 22.2. As you read the section, write a description of each layer's structure and function on its page.

Section 22.1

Objectives

- Describe the major types of plant cells.
- Identify the major types of plant tissues.
- Distinguish among the functions of plant cells and tissues.

Review Vocabulary

adaptation: inherited characteristic that results from response to an environmental factor

New Vocabulary

parenchyma cell
collenchyma cell
sclerenchyma cell
meristem
vascular cambium
cork cambium
epidermis
guard cell
xylem
vessel element
tracheid
phloem
sieve tube member
companion cell
ground tissue

Plant Cells and Tissues

MAIN Idea Different types of plant cells make up plant tissues.

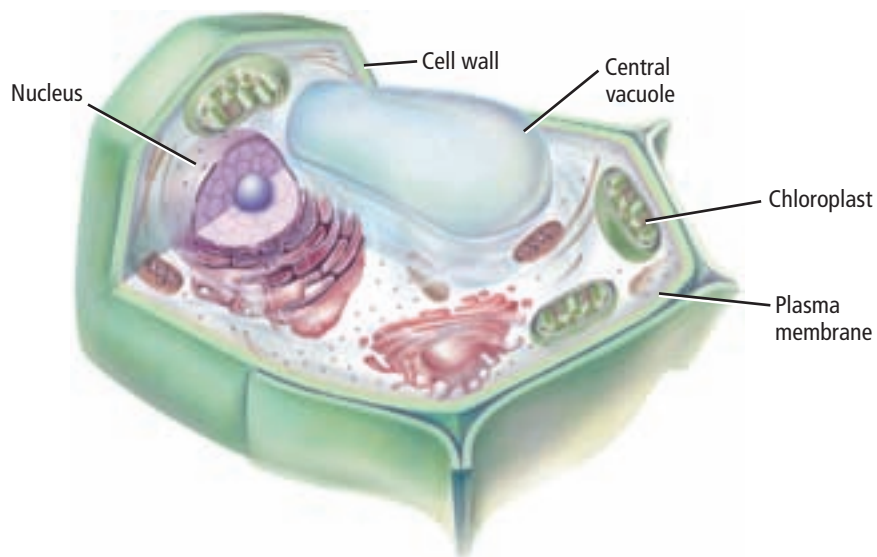
Real-World Reading Link Buildings are made of a variety of materials. Different materials are used for stairways, plumbing, doors, and the electrical system, because each of these has a different function. Similarly, different plant structures have cells and tissues that function efficiently for specific tasks.

Plant Cells

Recall from Chapters 7 and 21 that you can identify a typical plant cell, like the one in **Figure 22.1**, by the presence of a cell wall and large central vacuole. Also, plant cells can have chloroplasts. However, there are many different types of plant cells—each with one or more adaptations that enable it to carry out a specific function. Three types of plant cells form most plant tissues. Together they provide storage and food production, strength, flexibility, and support.

Parenchyma cells Most flexible, thin-walled cells found throughout a plant are **parenchyma** (puh RENG kuh muh) **cells**. They are the basis for many plant structures and are capable of a wide range of functions, including storage, photosynthesis, gas exchange, and protection. These cells are spherical in shape and their cell walls flatten when they are packed tightly together, as shown in **Table 22.1**. An important trait of parenchyma cells is that they can undergo cell division when mature. When a plant is damaged, parenchyma cells divide to help repair it.

Depending on their function, parenchyma cells can have special features. Some parenchyma cells have many chloroplasts, also shown in **Table 22.1**. These cells often are found in leaves and green stems, and can carry on photosynthesis, producing glucose. Some parenchyma cells, such as those found in roots and fruits, have large central vacuoles that can store substances, such as starch, water, or oils.



■ **Figure 22.1** Features unique to a plant cell include a cell wall and a large central vacuole. Plant cells also can contain chloroplasts where photosynthesis occurs.

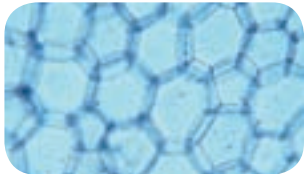

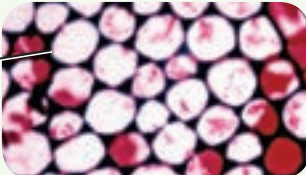
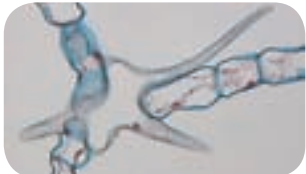
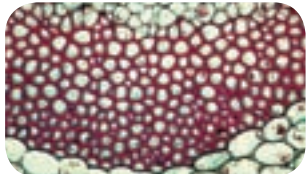
Infer why chloroplasts are not part of all plant cells.



Interactive Table To explore more about plant cells and their functions, visit biologygmh.com.

Table 22.1

Plant Cells and Functions

Cell Type	Example	Functions
Parenchyma	 Without chloroplasts	<ul style="list-style-type: none"> • Storage • Photosynthesis • Gas exchange • Protection • Tissue repair and replacement
	 With chloroplasts	
Collenchyma	 Collenchyma	<ul style="list-style-type: none"> • Support for surrounding tissues • Provides flexibility for plant • Tissue repair and replacement
Sclerenchyma	 Sclereid	<ul style="list-style-type: none"> • Support • Transport of materials
	 Fibers	

(2)Dr. Arnold Karpoff/Visuals Unlimited, (3)Ed Reschke/Peter Arnold, (4)Dr. Kent Simmons, (5)Jack Bostrack/Visuals Unlimited

(ow from top)Brad Mogen/Visuals Unlimited,

Collenchyma cells If you have eaten celery, you might be familiar with collenchyma (coh LENG kuh muh) cells. These cells make up those long strings that you can pull from a celery stalk. **Collenchyma cells** are plant cells that often are elongated and occur in long strands or cylinders that provide support for the surrounding cells. As shown in **Table 22.1**, collenchyma cells can have unevenly thickened cell walls. As a collenchyma cell grows, the thinner portions of its cell wall can expand. Because of this growth pattern, collenchyma cells are flexible and can stretch, which enables plants to bend without breaking. Like parenchyma cells, collenchyma cells retain the ability to undergo cell division when mature.

Sclerenchyma cells Unlike parenchyma and collenchyma cells, **sclerenchyma** (skle RENG kuh muh) **cells** are plant cells that lack cytoplasm and other living components when they mature, but their thick, rigid cell walls remain. These cells provide support for a plant, and some are used for transporting materials within the plant. Sclerenchyma cells make up most of the wood we use for shelter, fuel, and paper products.

There are two types of sclerenchyma cells—sclereids and fibers—also shown in **Table 22.1**. You might have eaten sclereids—they create the gritty texture of pears. Sclereids, also called stone cells, can be distributed randomly throughout a plant, are shorter than fibers, and are somewhat irregularly shaped. The toughness of seed coats and nut shells results from the presence of sclereids. Sclereids also function in transport, which you will learn more about later in this section. A fiber cell is needle-shaped, has a thick cell wall, and has a small interior space. When stacked end-to-end, fibers form a tough, elastic tissue. Humans have used these fibers for making ropes and linen, canvas, and other textiles for centuries, as shown in **Figure 22.2**.

■ **Figure 22.2** Fiber cells in plants have been used to make textiles such as these ancient Egyptian sandals.





Mini Lab 22.1

Observe Plant Cells

How can a microscope be used to distinguish plant cell types? Investigate the three different types of plant cells by making and observing slides of some common plant parts.

Procedure 

WARNING: *Iodine is poisonous if swallowed and can stain skin and clothes.*

1. Read and complete the lab safety form.
2. Obtain a small, thin slice of potato and a thin cross section of a celery stalk from your teacher.
3. Place the potato slice on a slide, add a drop of iodine, and cover with a coverslip. Use a microscope to observe the potato slice. Record your observations.
4. Place the celery slice on a slide, add a drop of water, and cover with a coverslip.
5. Put a drop of dye at one end of the coverslip, and then touch a paper towel to the other end to draw the dye under the coverslip. Use a microscope to observe the celery slice. Record your observations.
6. Obtain a small amount of pear tissue, place it on a slide, and add a coverslip.
7. Using a pencil eraser, press gently but firmly on the coverslip until the pear tissue is a thin even layer. Use a microscope to observe the pear tissue. Record your observations.

Analysis

1. **Identify** the type of specialized plant cell observed on each slide.
2. **Infer** why there are different cell types in a potato, a celery stalk, and pear tissue.

Plant Tissues

You learned in Chapter 9 that a tissue is a group of cells that work together to perform a function. Depending on its function, a plant tissue can be composed of one or many types of cells. There are four different tissue types found in plants—meristematic (mer uh stem AH tihk), dermal, vascular, and ground. These are illustrated in **Figure 22.3**.

Meristematic tissue Throughout their lives, plants can continue to produce new cells in their meristematic tissues. Meristematic tissues make up **meristems**—regions of rapidly dividing cells. Cells in meristems have large nuclei and small vacuoles or, in some cases, no vacuoles at all. As these cells mature, they can develop into many different kinds of plant cells. Meristematic tissues are located in different regions of a plant.

Apical meristems Meristematic tissues at the tips of roots and stems, which produce cells that result in an increase in length, are apical (AY pih kul) meristems, as shown in **Figure 22.3**. This growth is called primary growth. Since plants usually are stationary, it enables stems and roots to enter different environments or different areas of the same environments.

Intercalary meristems Another type of meristem, called intercalary (in TUR kuh LAYR ee) meristem, is related to a summer job you might have had—mowing grass. This meristem is found in one or more locations along the stems of many monocots. Intercalary meristem produces new cells that result in an increase in stem or leaf length. If grasses only had apical meristems, they would stop growing after the first mowing. They continue to grow because they have more than one type of meristematic tissue.

Lateral meristems Increases in root and stem diameters result from secondary growth produced by two types of lateral meristems. Only nonflowering seed plants, eudicots or dicots, and a few monocots have secondary growth.

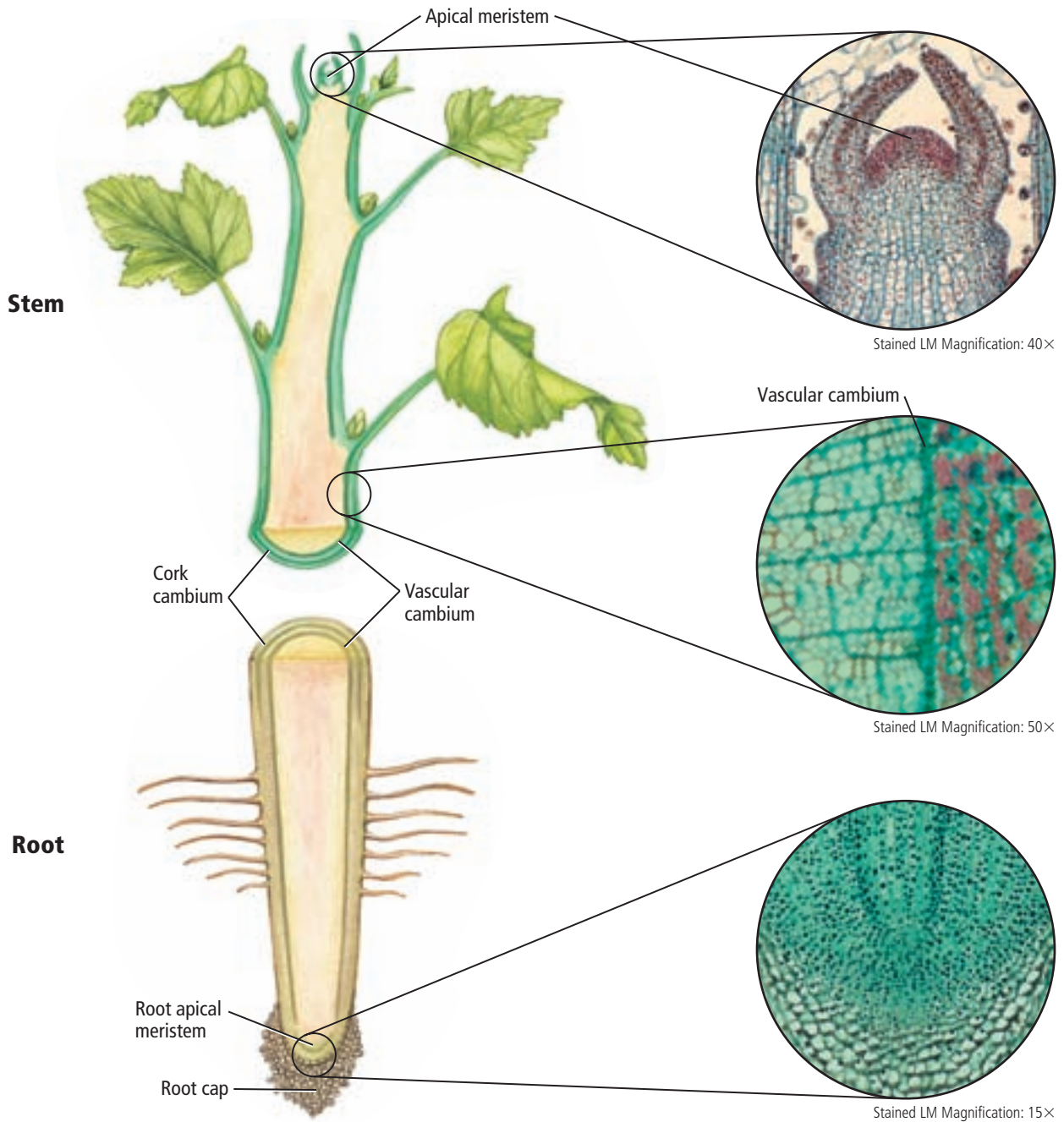
The **vascular cambium**, also shown in **Figure 22.3**, is a thin cylinder of meristematic tissue that can run the entire length of roots and stems. It produces new transport cells in some roots and stems.

In some plants, another lateral meristem, the **cork cambium**, produces cells that develop tough cell walls. These cells form a protective outside layer on stems and roots. Cork tissues make up the outer bark on a woody plant like an oak tree. Recall that cells of cork tissue are what Robert Hooke observed when he looked through his microscope.

Visualizing Meristematic Tissues

Figure 22.3

Most plant growth results from the production of cells by meristematic tissues. Stems and roots increase in length mostly due to the production of cells by apical meristems. A plant's vascular cambium produces cells that increase root and stem diameters.



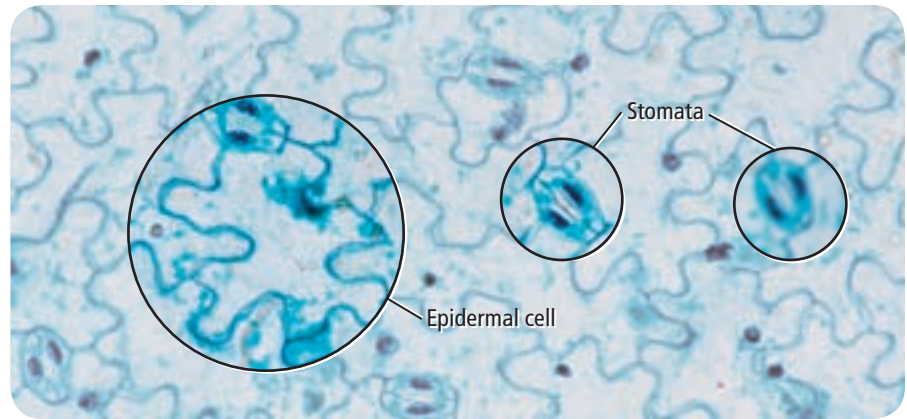
Concepts in Motion Interactive Figure To see an animation of plant tissues, visit biologygmh.com.





Stained LM Magnification: 200×

■ **Figure 22.4** The surface of a leaf is composed of tightly-packed epidermal cells that help protect the plant and prevent water loss. Stomata open and close to allow gases in and out.



(l)Barry Funk/Stan Schoenberger/Grant Heilman Photography

Dermal tissue—the epidermis The layer of cells that makes up the outer covering on a plant is dermal tissue, also called the **epidermis**. Cells of the epidermis resemble pieces of a jigsaw puzzle with interlocking ridges and dips, as shown in **Figure 22.4**. Most epidermal cells can secrete a fatty substance that forms the cuticle. You might recall from Chapter 21 that the cuticle helps reduce water loss from plants by slowing evaporation. The cuticle also can help prevent bacteria and other disease-causing organisms from entering a plant.

Stomata Plants can have several adaptations of their epidermis. Recall from Chapter 21 that the epidermis of most leaves and some green stems have stomata—small openings through which carbon dioxide, water, oxygen, and other gases pass. The two cells that form a stoma are **guard cells**. Changes in the shapes of guard cells result in the opening and closing of stomata, as shown in **Figure 22.4**.

Trichomes Some epidermal cells on leaves and stems produce hairlike projections called trichomes (TRI kohmz), shown in **Figure 22.5**. Trichomes can give leaves a fuzzy appearance and can help protect the plant from insect and animal predators. Some trichomes even release toxic substances when touched. Trichomes help keep some plants cool by reflecting light.

VOCABULARY

WORD ORIGIN

Trichome

from the Greek word *trichma*, meaning *growth of hair*.

Color-Enhanced SEM Magnification: 240×



Trichomes on a leaf

Magnification: unavailable



Root hairs

■ **Figure 22.5** Epidermal adaptations help plants survive. The tiny glands at the tip of a trichome can contain toxic substances. Root hairs increase the root's surface area.

Infer why it is important to water recently replanted plants.





Root hairs Some roots have root hairs—fragile extensions of root epidermal cells. Root hairs, as shown in **Figure 22.5**, increase a root’s surface area and enable the root to take in a greater volume of materials than it can without root hairs.

Vascular tissues Food, water, and other substances are carried throughout your body in your blood vessels. In a plant, the transportation of water, food, and dissolved substances is the main function of two types of vascular tissue—xylem and phloem.

Xylem Water that contains dissolved minerals enters a plant through its roots. Some of the water is used in photosynthesis. The dissolved minerals have many functions in cells. This water with dissolved minerals is transported throughout a plant within a system of xylem that flows continuously from the roots to the leaves. **Xylem** (ZI lum) is the water-carrying vascular tissue composed of specialized cells—vessel elements and tracheids (tray KEY ihdz). When mature, each vessel element and tracheid consists of just its cell wall. This lack of cytoplasm at maturity allows water to flow freely through these cells.

Vessel elements are tubular cells that are stacked end-to-end, forming strands of xylem called vessels. Vessel elements are open at each end with barlike strips across the openings. In some plants, mature vessel elements lose their end walls. This enables the free movement of water and dissolved substances from one vessel element to another.

Tracheids (tray KEY ihdz) are long, cylindrical cells with pitted ends. The cells are found end-to-end and form a tubelike strand. Unlike some mature vessel elements, mature tracheids have end walls. For this reason, tracheids are less efficient than vessel elements at transporting materials. Compare the structure of tracheids to vessel elements in **Figure 22.6**.

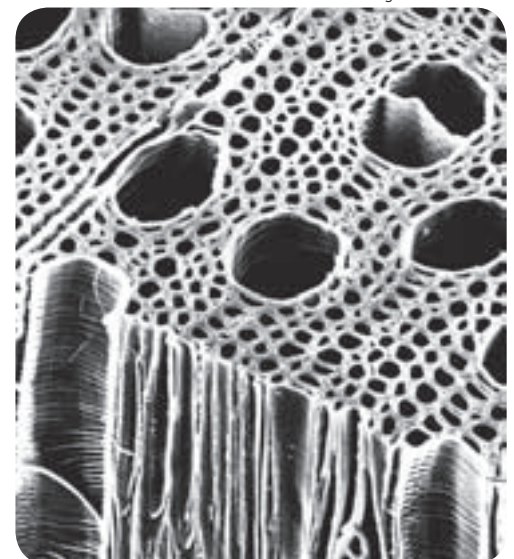
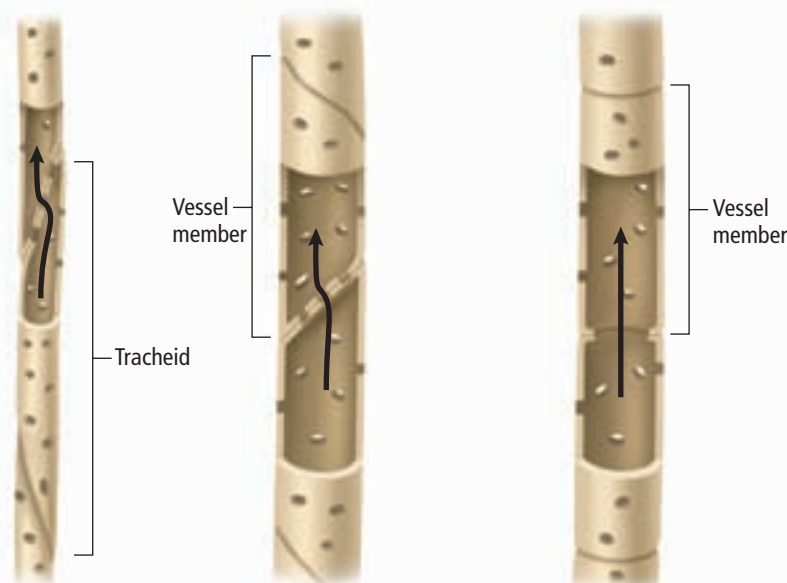
In gymnosperms or nonflowering seed plants, xylem is composed almost entirely of tracheids. However, in flowering seed plants, xylem consists of tracheids and vessels. Because vessels are more efficient at transporting water and materials, scientists propose that this might explain why flowering plants inhabit many different environments.

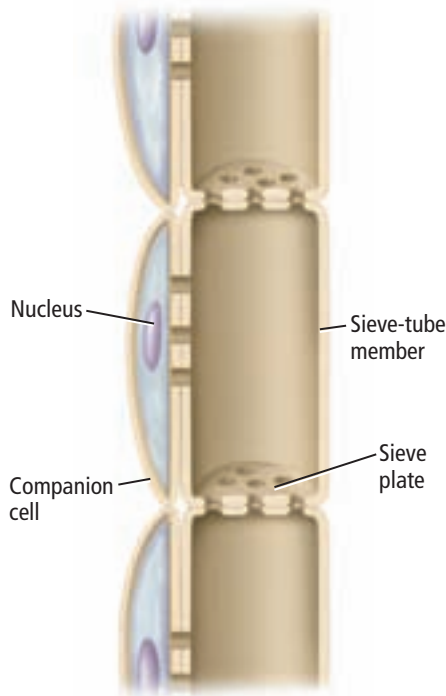
CAREERS IN BIOLOGY

Turf Scientist Parks, golf courses, and sports stadiums require the skills of a turf scientist to help maintain the grasses that grow there. He or she has an educational background that includes science, managerial, and business courses. For more information on biology careers, visit biologygmh.com.

■ **Figure 22.6** Tracheids and vessel elements are the conducting cells of the xylem.

Color-Enhanced SEM Magnification: 350×





■ **Figure 22.7** Notice the openings in the sieve plates between the sieve-tube members.

Phloem The main food-carrying tissue is **phloem** (FLOH em). It transports dissolved sugars and other organic compounds throughout a plant. Recall that xylem only transports materials away from the roots. Phloem, however, transports substances from the leaves and stems to the roots and from the roots to the leaves and stems. Although not used for transport, there are sclereids and fibers associated with the phloem. These sturdy sclerenchyma cells provide support for the plant.

Phloem consists of two types of cells—sieve tube members and companion cells, shown in **Figure 22.7**. Each **sieve tube member** contains cytoplasm but lacks a nucleus and ribosomes when it is mature. Next to sieve tube members are **companion cells**, each with a nucleus. Scientists hypothesize that this nucleus functions for both the companion cell and the mature sieve tube member. In flowering plants, structures called cell plates are at the end of the sieve tube members. The cell plates have large pores through which dissolved substances can flow.

Some of the glucose produced in leaves and other photosynthetic tissue is metabolized by the plant. However, some is converted to other carbohydrates and transported and stored in regions of the plant called sinks. Examples of sinks are the parenchyma storage cells in the root cortex, which are described in the next section of this chapter. The transport in phloem of dissolved carbohydrates from sources to sinks and other dissolved substances is translocation.

Ground tissue The category for plant tissues that are not meristematic tissues, dermal tissues, or vascular tissues is ground tissue.

Ground tissues consist of parenchyma, collenchyma, and sclerenchyma cells and have diverse functions, including photosynthesis, storage, and support. Most of a plant consists of ground tissue. The ground tissue of leaves and green stems contains cells with numerous chloroplasts that produce glucose for the plant. In some stems, roots, and seeds, cells of ground tissue have large vacuoles that store sugars, starch, oils, or other substances. Ground tissues also provide support when they grow between other types of tissue.

VOCABULARY

WORD ORIGIN

Phloem

from the Greek word *phloios*, meaning *bark*.

Section 22.1 Assessment

Section Summary

- ▶ There are three types of plant cells—parenchyma, collenchyma, and sclerenchyma cells.
- ▶ The structure of a plant cell is related to its function.
- ▶ There are several different types of plant tissues—meristematic, dermal, vascular, and ground tissues.
- ▶ Xylem and phloem are vascular tissues.

Understand Main Ideas

1. **MAIN Idea** Describe the different types of plant cells in plant tissues.
2. **Compare and contrast** the types of plant cells.
3. **Describe** a root hair and explain its function.
4. **Identify** the location and function of vascular cambium.
5. **Compare** the two types of specialized xylem cells.

Think Scientifically

6. **Make a table**, using information in this section, that summarizes the structures and functions of the different plant tissues.
7. **Evaluate** the advantage of vessel elements without end walls.
8. **WRITING in Biology** Compose a limerick about a type of plant tissue.

Section 22.2

Objectives

- **Relate** the structures of roots, stems, and leaves to their functions.
- **Compare and contrast** the structure and function of roots, stems, and leaves.

Review Vocabulary

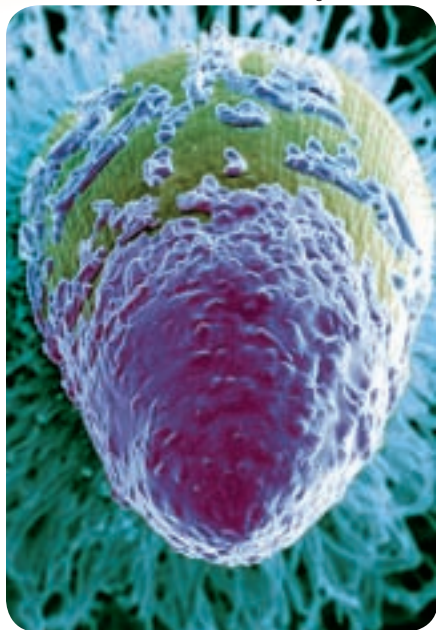
apical meristem: tissue at the tips of roots and stems that produces cells, which results in an increase in length

New Vocabulary

root cap
cortex
endodermis
pericycle
petiole
palisade mesophyll
spongy mesophyll
transpiration

- **Figure 22.8** The root cap covers the root tip and loses cells as the root grows through soil.

Color-Enhanced SEM Magnification: 220×



Dr. Jeremy Burgess/Photo Researchers

Roots, Stems, and Leaves

MAIN Idea The structures of plants are related to their functions.

Real-World Reading Link Using a fork to eat a lettuce salad usually is more effective than using a spoon. However, if you were eating tomato soup, a spoon would be more useful than a fork. These are examples of the common expression “the right tool for the right job.” The same applies in nature. The variety of plant structures relates to the diversity of plant functions.

Roots

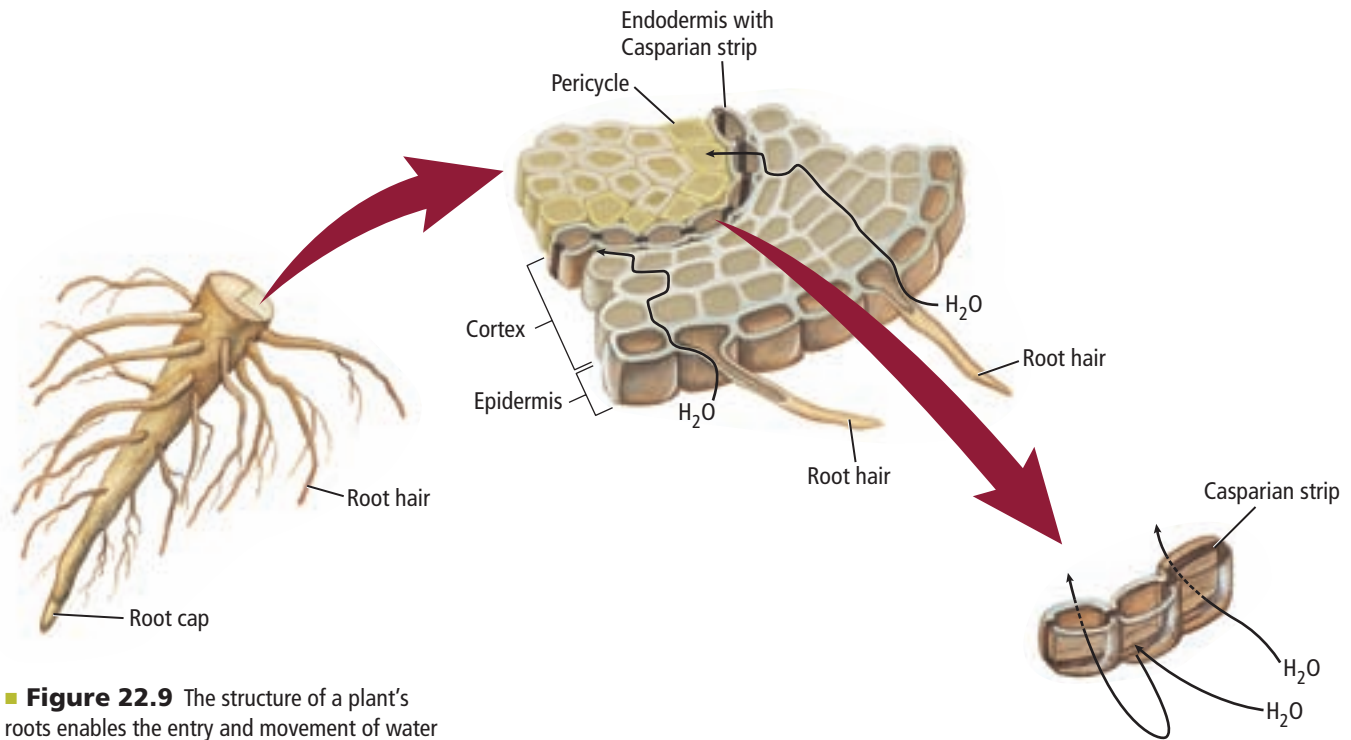
If you ever have eaten a carrot, a radish, or a sweet potato, then you have eaten part of a plant root. The root usually is the first structure to grow out of the seed when it sprouts. For most plants, roots take in water and dissolved minerals that are transported to the rest of the plant. If you have tried to pull a weed, you experienced another function of roots—they anchor a plant in soil or to some other plant or object. Roots also support a plant against the effects of gravity, extreme wind, and moving water.

In some plants, the root system is so vast that it makes up more than half of the plant’s mass. The roots of most plants grow 0.5 to 5 m down into the soil. However, some plants, such as the mesquite (mes KEET) that grows in the dry southwestern part of the United States, have roots that grow downward as deep as 50 m toward available water. Other plants, such as some cacti, have many, relatively shallow branching roots that grow out from the stem in all directions as far as 15 m. Both root types are adaptations to limited water resources.

Root structure and growth The tip of a root is covered by the **root cap**, as shown in **Figure 22.8**. It consists of parenchyma cells that help protect root tissues as the root grows. The cells of the root cap produce a slimy substance that, together with the outside layer of cells, form a lubricant that reduces friction as the root grows through the soil, a crack in a sidewalk, or some other material. Cells of the root cap that are rubbed off as the root grows are replaced by new cells produced in the root’s apical meristem. Recall from Section 22.1 that the root’s apical meristem also produces cells that increase the root’s length. These cells develop into the numerous types of root tissues that perform different functions.

You also learned in Section 22.1 that an epidermal layer covers the root. Some root epidermal cells produce root hairs that absorb water and dissolved minerals. The layer below this epidermal layer is the **cortex**. It is composed of ground tissues made of parenchyma cells that are involved in transport and storage of plant substances. The cortex is between the epidermis and the vascular tissues of the root. To reach vascular tissues, all water and nutrients that are taken in by the epidermal cells must move through the cortex.

Reading Check List three functions of roots.



■ **Figure 22.9** The structure of a plant's roots enables the entry and movement of water and dissolved minerals into the plant.

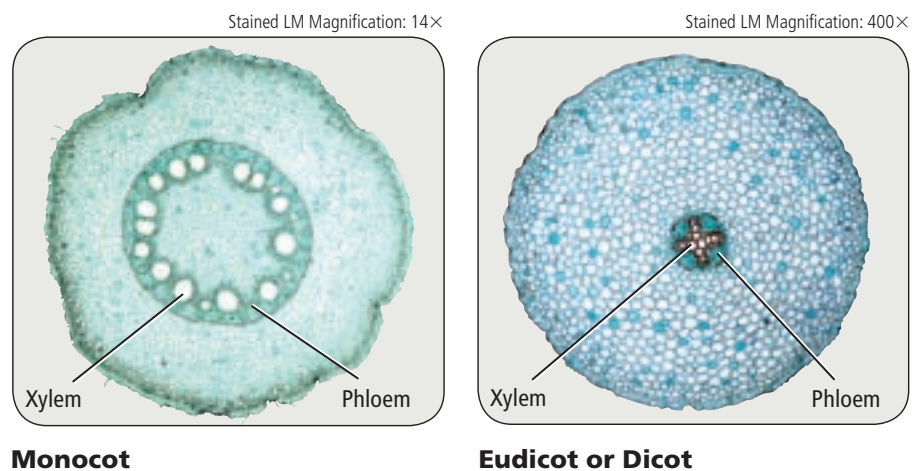
Sequence *the tissues through which water passes as it moves from a root hair to xylem tissue of a root.*



Interactive Figure To see an animation showing ways that nutrients can enter the cells of roots, visit biologygmh.com.

At the inner boundary of the cortex is a layer of cells called the **endodermis**, as illustrated in **Figure 22.9**. Encircling each cell of the endodermis as part of the cell wall is a waterproof strip called a Casparian strip. Its location is similar to that of mortar that surrounds bricks in a wall. The Casparian strip creates a barrier that forces water and dissolved minerals to pass through endodermal cells rather than around them. Therefore, the plasma membranes of endodermal cells regulate the material that enters the vascular tissues.

The layer of cells directly next to the endodermis toward the center of the root is called the **pericycle**. It is the tissue that produces lateral roots. In dicots, most eudicots, and some monocots, a vascular cambium develops from part of the pericycle. Recall that the vascular cambium produces vascular tissues that contribute to an increase in the root's diameter. The vascular tissues—xylem and phloem—are in the center of a root. Monocots and eudicots or dicots can be distinguished by the pattern of the xylem and phloem in their roots, as shown in **Figure 22.10**.



■ **Figure 22.10** In monocots, strands of xylem and phloem cells alternate, usually surrounding a central core of cells called pith. The xylem in eudicot and dicot roots is in the center and forms an X shape. Phloem cells are between the arms of the X.



Types of roots The two major types of root systems are taproots and fibrous roots. A taproot system consists of a thick root with few smaller, lateral-branching roots. Some plants, such as radishes, beets, and carrots, as shown in **Table 22.2**, store food in the parenchyma cells of a taproot. Other taproots, like those of poison ivy plants, grow deep into the soil toward available water.

Fibrous root systems, also shown in **Table 22.2**, have numerous branching roots that are about the same size and grow from a central point, similar to the way that the spokes of a bicycle wheel are arranged. Plants also can store food in fibrous roots systems. For example, sweet potatoes develop on fibrous roots.

Other root types, also shown in **Table 22.2**, are adapted to diverse environments. In arid regions, some plants produce huge water-storage roots. Cypress, mangrove, and some other trees that live in water develop modified roots that help supply oxygen to the roots called pneumatophores (new MA toh forz). Adventitious (ad vehn TIH shus) roots form where roots normally do not grow and can have different functions. For example, some tropical trees have adventitious roots that help support their branches. As these roots develop, they resemble trunks.

LAUNCH Lab

Review Based on what you've read about plant structures, how would you now answer the analysis questions?








Interactive Table To explore more about root systems and adaptations, visit biologygmh.com.



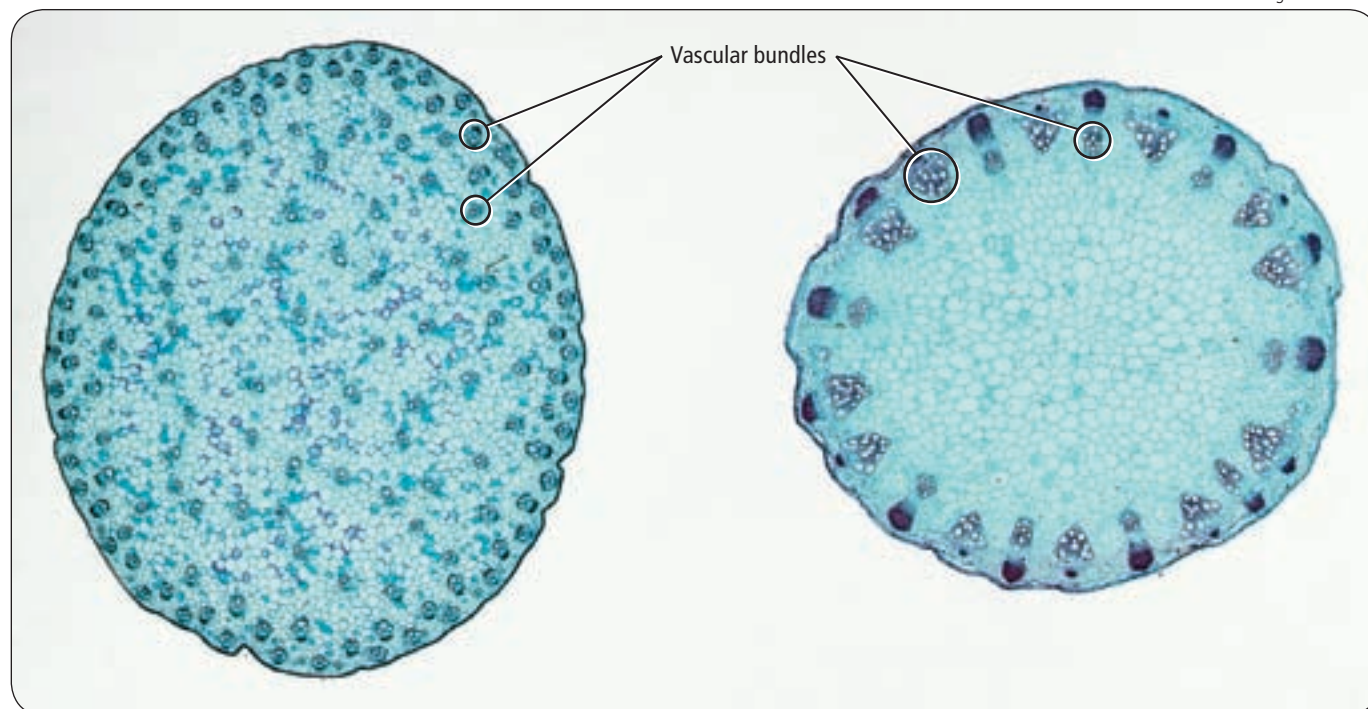
Table 22.2

Root Systems and Adaptations

Type	Taproot system	Fibrous root system	Modified root
Example			
Function	<ul style="list-style-type: none"> • Anchors plant • Food and water storage 	<ul style="list-style-type: none"> • Anchors plant • Rapid water storage 	Water storage

Type	Modified roots—pneumatophores	Adventitious roots—prop roots
Example		
Function	Supplied oxygen to submerged roots	Support plant stems



**Monocot****Eudicot and Dicot**

■ **Figure 22.11** The xylem and phloem of stems are grouped together in vascular bundles. The vascular bundles in a monocot stem are scattered. Eudicot and dicot stems have one ring or concentric rings of vascular bundles.

■ **Figure 22.12** An annual growth ring forms in the stem of a woody plant when growth resumes after a period of little or no growth.

Infer how the amount of available moisture might affect the width of an annual growth ring.



Stems

While you might know that asparagus spears are stems, you might be surprised to learn that there are many types of plant stems. Some stems, like asparagus, are soft, flexible, and green due to the presence of chloroplasts, and therefore can perform photosynthesis. These stems are called herbaceous (hur BAY shus) and most annual plants have this type of stem. Palms and bamboos have rigid, fibrous stems. Trees, shrubs, and many perennials have sturdy, woody stems that do not carry on photosynthesis. Some older plants have stems that are covered with bark. This tough, corky tissue can protect the stem from physical damage and insect invasion. Some trees even have survived a forest fire with minimal damage because of the bark that covers their trunks.

Stem structure and function The main function of a plant's stem is support of a plant's leaves and reproductive structures. Vascular tissues in stems transport water and dissolved substances throughout the plant and provide support. These tissues are arranged in bundles, or groups, that are surrounded by parenchyma cells. As is true for roots, the pattern of these tissues can be used to distinguish between monocots and eudicots and dicots, as shown in **Figure 22.11**.

Growth of a stem Cells produced by the apical meristem result in an increase in the length of the stem. As the plant grows taller, an increase in stem diameter provides additional support. In annual plants, an increase in stem diameter mostly is due to an increase in cell size. The increase in stem diameter in plants, such as perennial eudicots and conifers, is due to the production of cells by the vascular cambium. The production of xylem and phloem throughout the year can produce annual growth rings. The age of a tree can be estimated by counting the annual growth rings at the base of its trunk, like those of the white oak shown in **Figure 22.12**.



Types of stems All stems have adaptations that help plants survive. In some plants, these adaptations enable stems to store excess food, and in other plants, they help withstand drought, cold, or heat. While you easily might identify stems of tomatoes and oaks, other plants have stems that do not resemble typical stems.

For example, a white potato is a type of stem called a tuber—a swollen, underground stem with buds from which new potato plants can grow. The stem of an onion, a tulip, or a tiger lily is part of a bulb. A bulb is a shortened, compressed stem surrounded by fleshy leaves. Irises and some ferns have rhizomes—underground horizontal stems. Some rhizomes store food. Runners, or stolons, are horizontal stems that grow along the soil’s surface in nature, like those of strawberry plants and some grasses. Crocuses and gladiolas are examples of plants that form corms. A corm is composed almost entirely of stem tissue with some scaly leaves at its top. Examples of some of these stem types are shown in **Table 22.3**.







Interactive Table To explore more about types of stems, visit biologygmh.com.



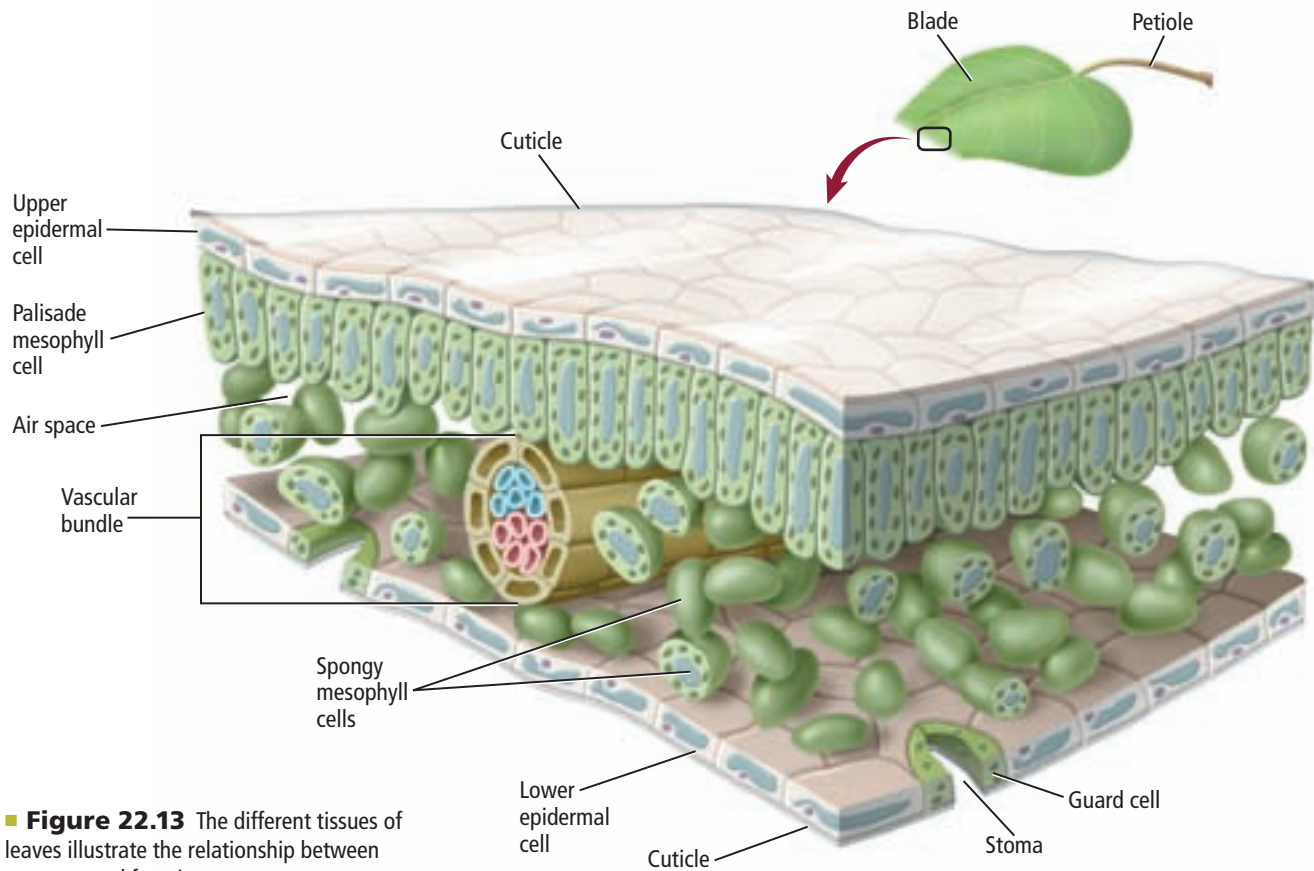
Table 22.3

Types of Stems

Type	Tuber	Rhizome	Runner
Example	 White potato	 Iris	 Spider plant
Function	Food storage	<ul style="list-style-type: none"> • Food storage • Asexual reproduction 	Asexual reproduction

Type	Bulb	Corm
Example	 Narcissus	 Crocus
Function	Food storage	Food storage





■ **Figure 22.13** The different tissues of leaves illustrate the relationship between structure and function.

Infer why having a transparent cuticle is important to a plant.

Leaves

There are many shapes and colors of leaves, and their arrangements on plants are different for different species. Also, the sizes of leaves can range from as large as 2 m in diameter to less than 1 mm in length. In a growing season, the number of leaves that a plant can produce varies from a few, such as for a daffodil, to over five million produced by a mature American elm tree.

Leaf structure The main function of leaves is photosynthesis, and their structure is well-adapted for this function. Most leaves have a flattened portion called the blade that has a relatively large surface area. Depending on the plant species, the blade might be attached to the stem by a stalk called a **petiole** (PET ee ohl). The petiole's vascular tissue connects the stem's vascular tissues to the leaf's vascular tissue or veins. Plants such as grasses lack petioles, and their leaf blades are attached directly to the stem.

The internal structure of most leaves is well-adapted for photosynthesis. **Figure 22.13** shows tightly packed cells directly below a leaf's upper epidermis. This location has the maximum exposure to light, and therefore, most photosynthesis takes place in these column-shaped cells. They contain many chloroplasts and make up the tissue called the **palisade mesophyll** (mehz uh fihl), or palisade layer. Below the palisade mesophyll is the **spongy mesophyll**, consisting of irregularly-shaped, loosely packed cells with spaces surrounding them. Oxygen, carbon dioxide, and water vapor move through the spaces in the spongy mesophyll. Cells of the spongy mesophyll also contain chloroplasts, but have fewer per cell than in the palisade mesophyll.

VOCABULARY

WORD ORIGIN

Mesophyll

meso—comes from the Greek word *mesos*, meaning *middle*

-phyll comes from the Greek word *phyllon*, meaning *leaf*.



Gas exchange and transpiration The epidermis covers a leaf. Except for submerged leaves of aquatic plants, the epidermis contains stomata. There usually are more stomata on the underside of leaves than on the upper side. Recall that two guard cells border a stoma. When more water diffuses into the guard cells than out of them, their shapes change in such a way that the stoma opens. Conversely, when more water diffuses out of the guard cells than into them, their shapes change in such a way that the stoma closes. In Chapter 8, you learned that carbon dioxide is used in photosynthesis, and that oxygen gas is a by-product of photosynthesis. The diffusion of these and other gases into and out of a plant also occurs through stomata.

In most plants, water travels from the roots up through the stems and into the leaves, replacing the water used in photosynthesis and lost from the plant by evaporation. Water evaporates from the inside of a leaf to the outside through stomata in a process called **transpiration** that helps pull the water column upward.

Characteristics of leaves Can you identify a maple tree by looking at its leaves? Some people can use differences in the size, shape, color, and texture of leaves to help them identify types of plants. Some leaves are simple, which means the leaf blade is not divided into smaller parts. Compound leaves have leaf blades that are divided into two or more smaller parts called leaflets, as shown in **Figure 22.14**.

The arrangement of leaves on the stem, also shown in **Figure 22.14**, also can be used to distinguish between types of plants. If two leaves are directly opposite of each other on a stem, the growth arrangement is called opposite. An alternate growth arrangement is when the positions of leaves alternate on opposite sides of the stem. A third arrangement, called whorled, is when three or more leaves are evenly spaced around a stem at the same position.

The arrangement of veins in a leaf, or the venation pattern, also can be used to identify leaves. Monocots usually have parallel venation and eudicots and dicots usually have branched or netlike venation.

VOCABULARY

ACADEMIC VOCABULARY

Conversely:

with the conditions of a relation reversed.









All anthophytes are seed plants.

Conversely, not all seed plants are anthophytes.

FOLDABLES

Incorporate information from this section into your Foldable.

■ **Figure 22.14** Each species of seed plants has leaves with a unique set of characteristics, some of which are shown here.

Leaf type	Leaf venation	Leaf arrangement
Simple 	Palmate 	Opposite 
Compound 	Pinnate 	Alternate 
	Parallel 	Whorled 



■ **Figure 22.15** Cactus spines grow in clusters from small, raised areas on the stem called areoles. The leaves of a jade plant are water-storage organs.



Cactus



Jade plant

(l) Peter Marbach/Grant Heilman Photography, (r) The Picture Store/SPL/Photo Researchers

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Spine

Science usage: thin, pointed modified leaf of a cactus or other succulent.

The cactus's spines pierced the animal's flesh.

Common usage: the backbone of an animal.

The motorcyclist's spine was injured as a result of the accident.

Leaf modifications Although the primary function of leaves is photosynthesis, there are many chemical and structural leaf modifications related to other functions. Many succulents, like the cacti in **Figure 22.15**, have modified leaves called spines. In addition to reducing water loss, the spines help protect cacti from being eaten by animals. Other succulents have leaves used as water storage sites. The leaves swell with water when water is available, and when water is scarce, these reserves can help ensure the long-term survival of plants.

DATA ANALYSIS LAB 22.1

Based on Real Data*

Form a Hypothesis

Do *Pieris* caterpillars prefer certain plants?

A scientist wanted to learn what type of input—smell, taste, or touch—helps *Pieris* caterpillars choose food. She used four Petri dishes each of intact leaves and cut leaves. Each set of leaves consisted of a nonmustard family plant (the control) and three different mustard family plants. A caterpillar was added to each dish and its behavior was observed and recorded.

Data and Observations

The table shows the results of the experiment. *T* represents the caterpillar touched the plant but did not bite it. *A* represents the caterpillar took a bite but then abandoned the leaf. *C* represents that the caterpillar chose the leaf and ate it for a time.

*Data obtained from: Chew, F. S. 1980. Foodplant preferences of *Pieris* caterpillars. *Oecologia* 46: 347–353.

Plants offered	Intact leaves			Cut leaves		
	T	A	C	T	A	C
Control	8	0	0	8	0	0
Mustard 1	14	16	14	17	18	13
Mustard 2	16	18	19	22	24	25
Mustard 3	8	10	9	15	19	23

Think Critically

- Examine** the data. What trend do you observe about caterpillars choosing mustard-family plants and control plants?
- Compare** the data from intact and cut leaves.
- Form a hypothesis** to explain the caterpillars' choice of leaves.



(l)Darrell Gulin/CORBIS, (r)David Sieren/Visuals Unlimited, (b)Anelei Sourakov and Consuelo De Moraes



Poinsettias

In plants like poinsettias, leaves called bracts at the tips of stems change from green to another color in response to the number of hours of darkness in their environments. These plants usually have tiny flowers at the center of the colored leaves, shown in **Figure 22.16**. The leaves look like flower petals and attract pollinators.

The leaves of the sundew plant produce a sticky substance that traps insects. The pitcher plant, also shown in **Figure 22.16**, has cylinderlike modified leaves that fill with water and can trap and drown insects and small animals. Both of these adaptations enable the plants to get nutrients, especially nitrogen, from the insects they capture.

You might be familiar with poison ivy or poison oak that can cause severe skin irritation for some people. These are examples of leaves that contain toxic chemicals that deter organisms from touching them. Some leaves have modifications that deter herbivores from eating them. For example, the epidermis of tomato and squash leaves and stems have tiny hairs with glands at their tips. The glands contain substances that repel insects and other herbivores.

When you read about stems, you learned that bulbs were shortened stems with leaves. A bulb's leaves are modified food storage structures. They provide the dormant bulb with necessary energy resources when favorable growth conditions exist.



Pitcher plant

■ **Figure 22.16** Leaf modifications relate to different functions. Bracts grow below flowers and attract pollinators. The inside of the pitcher plant's modified leaf has hairs that grow downward. This prevents a trapped animal from crawling out.

Section 22.2 Assessment

Section Summary

- Roots anchor plants and absorb water and nutrients.
- Stems support the plant and hold the leaves.
- Leaves are the sites of photosynthesis and transpiration.
- There are many different modifications of roots, stems, and leaves.
- Modifications help plants survive in different environments.

Understand Main Ideas

1. **MAIN Idea** Summarize the functions of the root cap, cortex, and endodermis.
2. **Compare** a leaf's palisade mesophyll to its spongy mesophyll.
3. **Describe** two leaf modifications and their functions.
4. **Draw and label** the arrangement of vascular tissue in a monocot stem and root and in a eudicot stem and root.

Think Scientifically

5. **Evaluate** why the role of stomata in a plant is important.
6. **MATH in Biology** A forest produces approximately 970 kg of oxygen for every metric ton of wood produced. If the average person breathes about 165 kg of oxygen per year, how many people does this forest support?

Section 22.3

Objectives

- ▶ **Identify** the major types of plant hormones.
- ▶ **Explain** how hormones affect the growth of plants.
- ▶ **Describe and analyze** the different types of plant responses.

Review Vocabulary

active transport: the movement of materials across the plasma membrane against a concentration gradient; requires energy

New Vocabulary

auxin
gibberellins
ethylene
cytokinin
nastic response
tropism

Plant Hormones and Responses

MAIN Idea Hormones can affect a plant's responses to its environment.

Real-World Reading Link As you might have learned in health class or another science course, various responses of your body are controlled by hormones. When you eat, hormones signal cells of your digestive system to release digestive enzymes. Although plants don't have digestive systems with enzymes, hormones do control many aspects of their growth and development.

Plant Hormones

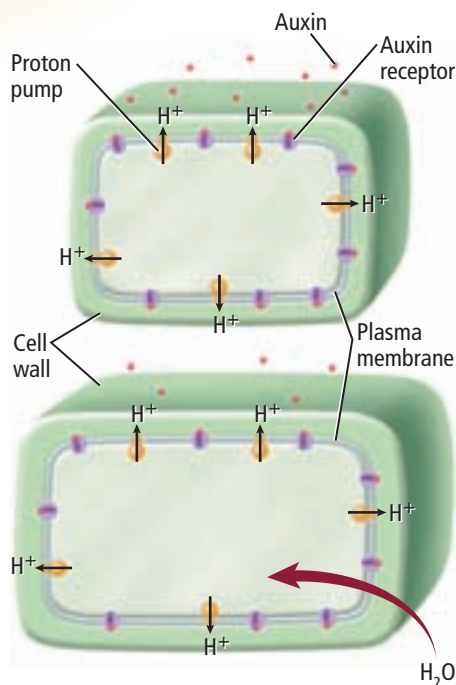
You read in Chapter 6 that hormones are organic compounds that are made in one part of an organism, and then are transported to another part where they have an effect. It takes only a tiny amount of a hormone to cause a change in an organism. Were you surprised to read that plants produce hormones? Plant hormones can affect cell division, growth, or differentiation. Research results indicate that plant hormones work by chemically binding to the plasma membrane at specific sites called receptor proteins. These receptors can affect the expression of a gene, the activity of enzymes, or the permeability of the plasma membrane. You will learn more about human hormones in Chapter 35.

Auxin One of the first plant hormones to be identified was **auxin**. There are different kinds of auxins, but indoleacetic (IHN doh luh see tihk) acid (IAA) is the most widely studied. IAA is produced in apical meristems, buds, young leaves, and other rapidly growing tissues. It moves throughout a plant from one parenchyma cell to the next by a type of active transport. The rate of this movement has been measured at 1 cm per hour. Some auxins also move in the phloem. Also, an auxin moves in only one direction—away from where it was produced.

Connection to Chemistry Auxin usually stimulates the lengthening, or elongation, of cells. Research indicates that in young cells this is an indirect process. Auxin promotes a flow of hydrogen ions through proton pumps from the cytoplasm into the cell wall. This creates a more acidic environment, which weakens the connections between the cellulose fibers in the cell wall. It also activates certain enzymes that help to break down the cell wall. Due to the loss of hydrogen ions in the cytoplasm, water enters the cell, as shown in **Figure 22.17**. The combination of weakened cell walls and increased internal pressure results in cell elongation.

The effect of auxin in a plant varies greatly depending on its concentration and location. For example, in some plants the concentration of auxin that promotes stem growth can inhibit root growth. Low concentrations of auxin usually stimulate cell elongation. However, at higher concentrations, auxin can have the reverse effect. The presence of other hormones can modify the effects of an auxin.

■ **Figure 22.17** Auxin promotes the flow of hydrogen ions into the cell wall, which weakens the cell wall. Water enters the cell and the cell lengthens.





The presence of auxin also creates a phenomenon called apical dominance, which is when plant growth is mostly upward with few or no side branches. The auxin produced by an apical meristem inhibits the growth of side or lateral branches. Removing a plant's apical meristem, however, decreases the amount of auxin present. This promotes the growth of side branches. **Figure 22.18** shows the difference this makes.

Auxins affect fruit formation and inhibit the dropping of fruit. Research results show that the production of auxin slows as cells mature. At the end of the growing season, the decreased amount of auxin in some trees and shrubs causes ripened fruits to fall to the ground and leaves to fall before winter.

 **Reading Check** Compare and contrast how different concentrations of auxin can affect a plant.

Gibberellins The group of plant hormones called **gibberellins** causes cell elongation, stimulates cell division, and affects seed growth. Gibberellins are transported in vascular tissue. Dwarf plants often lack either the genes for gibberellins production or the genes for gibberellins protein receptors. When treated with gibberellins, plants that lack the genes for gibberellins but have gibberellins receptors grow taller. Applying gibberellins to a plant can cause an increase in height, as shown in **Figure 22.19**.

Ethylene The only known gaseous hormone is **ethylene**. It is a simple compound composed of two carbon and four hydrogen atoms. Ethylene is found in plant tissues such as ripening fruits, dying leaves, and flowers. Since ethylene is a gas, it can diffuse through the spaces between cells. It also is transported within the phloem.

Although ethylene can affect other parts of plants, it primarily affects the ripening of fruits. Ethylene causes cell walls of unripe fruit to weaken and complex carbohydrates to break down into simple sugars. The results of ethylene exposure are fruits that are softer and sweeter than unripe fruits.

Because ripe fruits and vegetables are bruised easily during shipping, growers often pick and ship unripe fruits and vegetables. Once they reach their destinations, a treatment with ethylene speeds up the ripening process.



■ **Figure 22.18**
Top: Auxin inhibits the growth of side or lateral branches.
Bottom: Removing the apical meristem decreases the amount of auxin and the side branches grow.



■ **Figure 22.19** These plants do not have genes for gibberellins production. However, the plant on the right grew when treated with gibberellins.


CAREERS IN BIOLOGY

Plant Physiologist The chemistry of plants, including how plant hormones work, is one of many topics studied by plant physiologists. Many plant physiologists teach and conduct research at universities. For more information on biology careers, visit biologygmh.com.

Study Tip

Clarification Ask another student to discuss vocabulary and difficult concepts of this chapter with you. As a team, write a statement about the most important idea concerning plant structure and function.

Cytokinins Growth-inducing **cytokinins** (si tuh KI nihnz) are produced in rapidly dividing cells. They travel to other parts of the plant within xylem. Cytokinins promote cell division by stimulating the production of the proteins needed for mitosis and cytokinesis. Because cytokinins increase the rate of growth, they often are added to the growth media used for plant tissue culture—a laboratory technique for growing plants from pieces of plant tissues. The presence of other hormones, especially auxins, influences the effects of cytokinins. For example, IAA alone stimulates cell elongation, but combined with a cytokinin, it promotes rapid cell division and results in rapid growth.

 **Reading Check** Describe two ways hormones can affect plants.

Plant Responses

Have you ever wondered why the leaves of a houseplant grow toward a window, or how a vine can climb a pole? These and other events—roots growing down, stems growing upward, trees dropping their leaves, and leaves of some plants trapping an insect—are due to responses of plants to their environment.

Nastic responses A response of a plant that causes movement independent of the direction of the stimulus is a **nastic response**. It is not a growth response, is reversible, and can be repeated many times.

Connection to Earth Science Solar tracking that is exhibited by some plants, such as a sunflower, is a nastic response. As Earth rotates, the flower of a sunflower plant moves in relation to the apparent changing position of the Sun. It can be inferred that this response provides maximum light exposure.

Mini Lab 22.2

Investigate a Plant Response

What stimulus causes a Venus flytrap to shut its leaves? A Venus flytrap has specialized leaves that trap and digest insects. In this lab, you will learn what type of stimulus is necessary to trigger the trapping response.

Procedure   

1. Read and complete the lab safety form.
2. Examine a **Venus flytrap plant** with open leaves.
3. Using a **small paintbrush**, carefully touch one of the trigger hairs on the inner surface of a leaf.
4. Wait 60 seconds. Now use your paintbrush and touch two different trigger hairs. Alternatively, touch one trigger hair and then touch it again in about ten seconds.
5. After you have stimulated the leaves to snap shut, whenever possible, observe your plant to determine how long it takes the trap to open again.

Analysis

1. **Identify** the type of stimulus necessary to trigger the plant leaf to shut. How long did it take the leaf to reopen?
2. **Think Critically** If you drop a dead insect onto a leaf, the leaf might close. However, it will not close tightly and will reopen later without digesting the insect. Based on this lab, hypothesize how the plant might distinguish between a living insect and a dead one.



(c) Maryann Frazier/Photo Researchers, (c) David M. Dennis, (c) Adam Jones/Visuals Unlimited

Another example of a nastic response is the closing of a Venus flytrap's leaves. Recent research shows that this results from a movement of water within each half of the leaf trap. The movement results in uneven expansion until the leaf's curved shape suddenly changes and snaps the trap shut.

Tropic responses What do you notice about the plants in **Table 22.4**? These are examples of tropic responses, or tropisms. A **tropism** (TROH pih zum) is a plant's growth response to an external stimulus. If resulting plant growth is toward the stimulus, it is called a positive tropism. If the resulting plant growth is away from the stimulus, it is called a negative tropism. There are several different types of tropisms, including phototropism, gravitropism, and thigmotropism.

Phototropism is a plant growth response to light caused by an unequal distribution of auxin. There is less auxin on the side of the plant toward the light source and more auxin on the side away from the light source. Because auxin can cause cell elongation, the cells on the side away from the light elongate, making that side of the stem longer. This results in the stem curving toward the direction of the light.




Gravitropism is a plant growth response to gravity. Roots generally show a positive gravitropism. The downward growth of roots into soil helps to anchor the plant and brings roots in contact with water and minerals. However, a stem exhibits a negative gravitropism when it grows upward, away from gravity. This growth positions leaves for maximum exposure to light.

Another tropism found in some plants is thigmotropism. This is a growth response to mechanical stimuli, such as contact with an object, another organism, or even wind. Thigmotropism is evident in vining plants that twist around a nearby structure such as a fence or tree.

Table 22.4

Plant Tropisms

Interactive Table To explore more about phototropism, visit biologygmh.com.

Tropism	Stimulus/Response	Example
Phototropism	Light • Growth toward light source	
Gravitropism	Gravity • Positive: downward growth • Negative: upward growth	
Thigmotropism	Mechanical • Growth toward point of contact	



Section 22.3 Assessment

Section Summary

- Plant hormones are produced in very small amounts.
- Hormones can affect cell division, growth, and differentiation.
- Nastic responses are not dependent on the direction of the stimulus.
- Tropisms are responses to stimuli from a specific direction.

Understand Main Ideas

- MAIN Idea** Identify plant hormones and classify them according to the effects that they have on a plant.
- Name and describe** three tropisms.
- Compare and contrast** tropisms and nastic responses.

Think Scientifically

- Construct** a model to show how auxin can move from one cell to another.
- Judge** the scientific basis of the saying, "One rotten apple spoils the whole barrel."



BioDiscoveries

©Andrei Sourakov and Consuelo De Moraes

Plants and Their Defenses

When you think of a food chain, you might picture a predator stalking and capturing prey. However, plants are sessile—they cannot move away from herbivores. How do plants defend themselves against predators? Understanding plant chemical defenses helps humans devise strategies to protect crops and other vegetation.

Defend or die Some plants evolved adaptations, such as hairs, spines, prickles, or thorns on the epidermis, to repel predators. Others have silica inside their leaves, which makes them tough to eat and wears down the predator's teeth.

Many plants produce secondary plant compounds not needed for plant metabolism. These substances might be bitter to taste or toxic to the predator. Some interfere with the predator's digestion, growth, or reproduction. In 2005, researchers discovered that the roots of a type of cabbage produce substances that protect the plant by killing a wide variety of bacteria in the soil.

Insect or not It is known that plants can distinguish between an insect attack and other types of damage, such as pruning. Scientists have learned that some plants respond to certain chemicals in insect saliva. For example, a team of biochemists determined that when an insect nibbles on the plant's leaves, a chemical signal spreads throughout the plant. This signal stimulates increased toxin production by all the leaves—not just the attacked leaves.

Calling for help When some plants are damaged by herbivores, the plants release chemical signals that attract natural enemies of the herbivores. For example, the tobacco plant in the photos guides the parasitic wasp to the caterpillar eating the tobacco leaves.



As a caterpillar feeds on a tobacco plant, the caterpillar's saliva causes the plant to release chemicals into the air, which attract a parasitic wasp—a predator of the caterpillar.

Chemical labeling studies confirmed that the signaling chemicals are not stored in the undamaged plant. Plants develop and release the signals soon after damage begins, and release them most strongly during the time when the natural enemies are most active. Also, different herbivores elicit different signals. Although advances in chemical technology and biotechnology speed the discovery of natural plant signals that might aid in protecting crops, evidence shows that the signals might also help herbivores locate food.

WRITING in Biology

Advertisement Imagine that you developed a remarkable new pesticide using natural plant defenses. For more information about natural plant pesticides, visit biologygmh.com. Write an advertisement describing your product, why it is different from other available products, and how it can prevent pest resistance.

BIOLAB

Design Your Own

INTERNET: HOW DO DWARF PLANTS RESPOND TO GIBBERELLINS?

Background: Some dwarf plants lack a gene for gibberellin production and some lack gibberellin receptors. In this lab, you will design an experiment to determine if you can change the growth pattern of dwarf pea-plant seedlings by applying gibberellic acid (a form of gibberellins) to them.

Question: *Can you use gibberellins to change the growth of dwarf pea plants?*

Materials

gibberellic acid in varying concentrations
sheets of poster board or cardboard
dishwashing liquid (wetting agent)
potted dwarf pea-plant seedlings
spray bottles
cotton swabs
light source
large plastic bags
plant fertilizer
distilled water
metric rulers
graph paper
Choose materials that would be appropriate for this lab.

Safety Precautions

Plan and Perform the Experiment

1. Read and complete the lab safety form.
2. Form a hypothesis that explains how gibberellins will affect the growth of dwarf pea plants.
3. Design an experiment to test your hypothesis. Be sure that your experiment has a control group.
4. Make a list of factors that must be constant for your experimental and control groups. Be sure to test only one variable.
5. Determine a way to apply gibberellins to the plants and decide how often you will apply it.

6. Design and construct a data table to record data from your experiment.
7. Make sure your teacher approves your plan before you proceed.
8. Collect the supplies you need and set up your experimental and control plants.
9. Complete the approved experiment.
10. Record measurements and observations of the plants in your data table.
11. Graph the data from your experimental and control groups.
12. **Cleanup and Disposal** Return unused gibberellic acid to your teacher for disposal. Empty spray bottles and thoroughly rinse. Dispose of used cotton swabs in the trash. Dispose of plants as directed by your teacher.

Analyze and Conclude

1. **Analyze** your graph and determine the effect of gibberellic acid on the dwarf pea plants.
2. **Hypothesize** Based on your results, explain why the pea plants are dwarfs.
3. **Think Critically** Why might a genetic change, such as one that causes a plant not to produce gibberellins, be a problem for plants in a natural environment?
4. **Error Analysis** What might have occurred in your experimental setup that could have caused your data to be inaccurate? How would you change your procedure?

SHARE YOUR DATA

Peer Review Visit BioLabs at biologygmmh.com and post a summary of your procedures and your data. Compare and contrast your graph to those of other students who completed this lab.



FOLDABLES **Justify** On the back of your Foldable, rank the leaf layers in order of importance to a plant. Justify your ranking.

Vocabulary

Key Concepts

Section 22.1 Plant Cells and Tissues

- collenchyma cell (p. 633)
- companion cell (p. 638)
- cork cambium (p. 634)
- epidermis (p. 636)
- ground tissue (p. 638)
- guard cell (p. 636)
- meristem (p. 634)
- parenchyma cell (p. 632)
- phloem (p. 638)
- sclerenchyma cell (p. 633)
- sieve tube member (p. 638)
- tracheid (p. 637)
- vascular cambium (p. 634)
- vessel element (p. 637)
- xylem (p. 637)

- MAIN** **Idea** Different types of plant cells make up plant tissues.
- There are three types of plant cells—parenchyma, collenchyma, and sclerenchyma cells.
 - The structure of a plant cell is related to its function.
 - There are several different types of plant tissues—meristematic, dermal, vascular, and ground tissues.
 - Xylem and phloem are vascular tissues.

Section 22.2 Roots, Stems, and Leaves

- cortex (p. 639)
- endodermis (p. 640)
- palisade mesophyll (p. 644)
- pericycle (p. 640)
- petiole (p. 644)
- root cap (p. 639)
- spongy mesophyll (p. 644)
- transpiration (p. 645)

- MAIN** **Idea** The structures of plants are related to their functions.
- Roots anchor plants and absorb water and nutrients.
 - Stems support the plant and hold the leaves.
 - Leaves are the sites of photosynthesis and transpiration.
 - There are many different modifications of roots, stems, and leaves.
 - Modifications help plants survive in different environments.

Section 22.3 Plant Hormones and Responses

- auxin (p. 648)
- cytokinin (p. 650)
- ethylene (p. 649)
- gibberellins (p. 649)
- nastic response (p. 650)
- tropism (p. 651)

- MAIN** **Idea** Hormones can affect a plant's responses to its environment.
- Plant hormones are produced in very small amounts.
 - Hormones can affect cell division, growth, and differentiation.
 - Nastic responses are not dependent on the direction of the stimulus.
 - Tropisms are responses to stimuli from a specific direction.

Section 22.1

Vocabulary Review

Distinguish between the words in each pair.

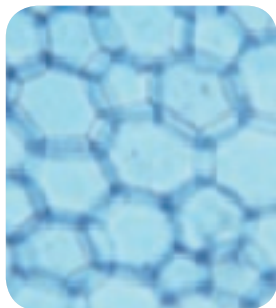
- sclerenchyma, collenchyma
- xylem, phloem
- epidermis, guard cell

Understand Key Concepts

- Which is the vascular tissue that transports water and dissolved minerals from roots to leaves?
 - epidermis
 - parenchyma
 - xylem
 - phloem
- Which is the region of actively dividing cells at the tip of the stem?
 - apical meristem
 - vascular tissue
 - dermal tissue
 - lateral meristem

Use the photos below to answer questions 6 and 7.

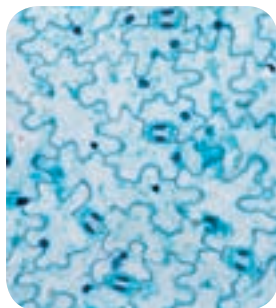
- Which image shows a trichome?



A.



B.



C.



D.

- Which image shows parenchyma cells?
 - A
 - B
 - C
 - D

- Which is one of the differences between nonflowering seed plants and flowering seed plants?
 - presence of stomata in the roots
 - amount of sugar stored in the roots
 - presence of tracheids and vessels
 - structure of parenchyma cells

Constructed Response

Use the image below to answer question 9.



- Short Answer** Explain one advantage of these vessels.
- Short Answer** Compare and contrast root hairs and trichomes.
- Open Ended** Do you think plants could survive without ground tissue? Defend your answer.

Think Critically

- Construct** a graphic organizer that lists each of the four different types of tissue, the function of each, and the types of cells it contains.
- Compare** the dermal tissue of plants to your skin. What are some characteristics that make it more efficient than your skin? What are some characteristics that make your skin more efficient than the plant's epidermis?

Section 22.2

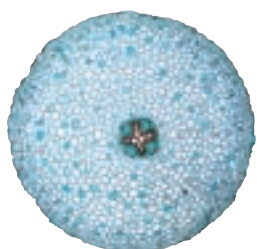
Vocabulary Review

Correctly use each set of words in a sentence.

- endodermis, pericycle
- petiole, transpiration
- spongy mesophyll, palisade mesophyll

Understand Key Concepts

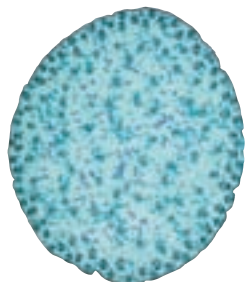
17. Which fill(s) the space between spongy mesophyll cells?
A. chlorophyll **C.** cells
B. gases **D.** vascular tissue
18. Which image shows a eudicot stem?



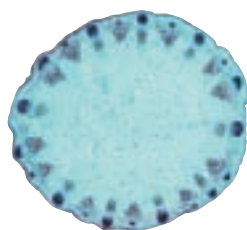
A.



B.



C.



D.

19. Which image above shows one ring of vascular bundles?
A. A **C.** C
B. B **D.** D
20. Which plant structure is not part of a root?
A. endodermis **C.** pericycle
B. root cap **D.** stomata
21. Which control(s) the movement of water vapor through the stomata?
A. bark
B. pericycle
C. guard cells
D. vascular tissues

Constructed Response

22. **Open Ended** List some environmental factors that might affect transpiration.
23. **Short Answer** Describe the control of materials as they are transported from soil to a root's vascular tissue.

Think Critically

24. **Evaluate** some leaf modifications in terms of their functions.
25. **Summarize** the reasons why eudicot stems can have a greater increase in diameter than most monocot stems.

Section 22.3

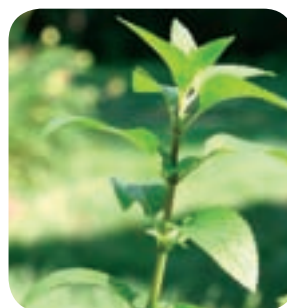
Vocabulary Review

Explain the difference between the terms in each pair below. Then explain how they are related.

26. hormone, auxin
 27. ethylene, gibberellins
 28. tropic response, nastic response

Understand Key Concepts

Use these photos to answer questions 29 and 30.



29. What plant condition do these photos show?
A. apical dominance **C.** leaf drop
B. dwarfism **D.** nastic movements
30. Which hormone controls this plant condition?
A. auxin **C.** ethylene
B. gibberellin **D.** cytokinin
31. Which describes a positive phototropism?
A. The plant grows away from the light.
B. The plant grows toward the light.
C. The plant grows toward gravity.
D. The plant grows away from gravity.
32. Which is involved in the transport of gibberellins throughout the plant?
A. cork cambium **C.** vascular tissue
B. guard cells **D.** apical meristem

(t)Brad Mogen/Visuals Unlimited, (tr) Science VU/Visuals Unlimited, (b)Chris Althof, (br)Chris Althof

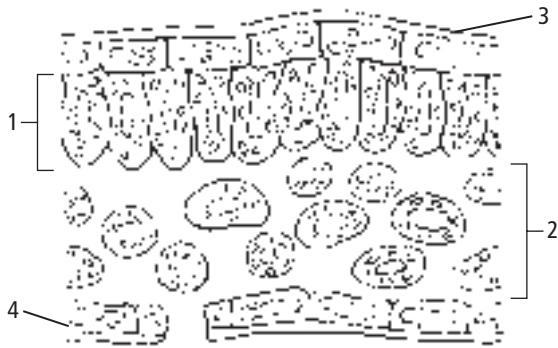
Standardized Test Practice

Cumulative

Multiple Choice

- The Miller-Urey experiment tested which hypothesis?
 - Margulis's endosymbiont theory
 - Miller's amino acid origin
 - Oparin's primordial soup idea
 - Pasteur's biogenesis theory

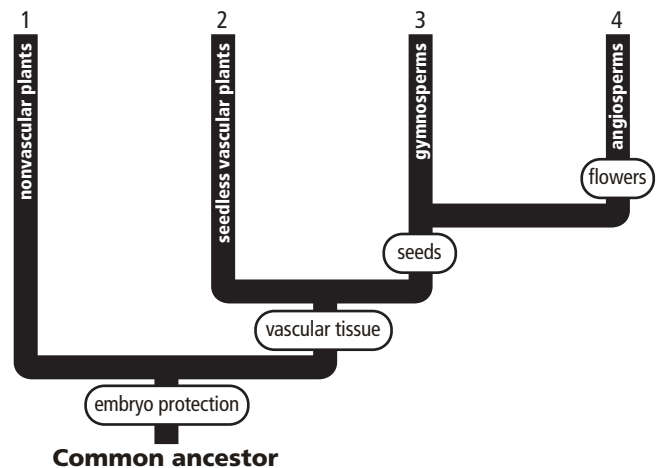
Use the diagram below to answer question 2.



- Which leaf structure is the site where the most photosynthesis takes place?
 - 1
 - 2
 - 3
 - 4
- Lichens can be an indicator of environmental quality. If a coal-fired electric plant was built and then the lichens in the area decreased, which would be the most likely cause?
 - air quality decreased
 - annual temperatures decreased
 - humidity patterns changed
 - rainfall patterns changed
- Which is one method of asexual reproduction that can occur in fungi?
 - conjugation
 - fragmentation
 - segmentation
 - transformation

- Which development in plants contributed most to the evolution of large trees?
 - alternation of generations
 - flowers
 - seeds
 - vascular tissue
- Which describes how funguslike protists obtain food?
 - They absorb nutrients from decaying organisms.
 - They obtain nutrients by feeding on unicellular organisms.
 - They have a symbiotic relationship with an animal host, obtaining nutrients from it.
 - They produce sugars as a nutrient source by using energy from sunlight.
- Which is the function of a plant's root cap?
 - generate new cells for root growth
 - help the root tissues absorb water
 - protect root tissue as the root grows
 - provide support for the root tissues

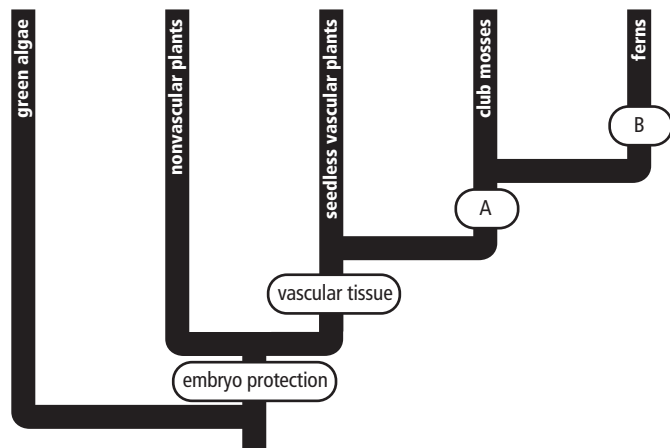
Use the diagram below to answer question 8.



- Which number represents where you would expect to find cycadophytes on this evolutionary tree?
 - 1
 - 2
 - 3
 - 4

Short Answer

Use the illustration below to answer question 9.



Common ancestor

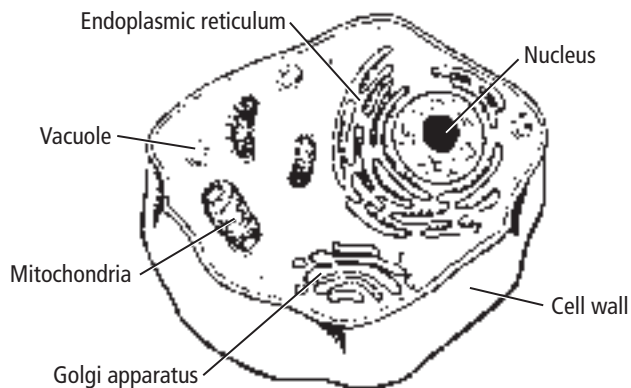
- Look at the evolutionary tree in the diagram above. What word or phrase would best describe branching points A and B in the diagram?
- Compare and contrast septate and aseptate hyphae.
- Write a hypothesis about the benefit of the stem adaptations that allow some plants to store excess food.
- Use a chart to organize information about how annuals, biennials, and perennials are similar and different.
- Name and describe the function of the two types of vascular tissue found in plants.
- What are three characteristics of ancient algae that enabled them to survive and can be found in all plants today?
- Describe the function of the vascular tissue in a leaf.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Review Section . . .	14.2	22.2	20.3	20.1	21.1, 21.3	19.4	22.2	21.1	21.2	20.1	22.2	21.4	22.1	21.1	22.2	17.3	8.2	21.2, 21.4

Extended Response

Use the illustration below to answer question 16.



- Based on the characteristics of the cell above, how would you classify the organism from which it was taken? Justify your method for classifying the organism.
- Evaluate why the structure of the thylakoid in a chloroplast is well suited for its function.

Essay Question

Imagine that you are planning to turn an area of land near your school into a small garden. You can order seeds to plant, or you can transplant small plants to the site. Your main goal is to have some plants growing in your garden every season of the year.

Using the information in the paragraph above, answer the following question in essay format.

- Based on what you know about plants and the climate where your school is located, what type of plants would be best to grow? Describe your plan in a well-organized essay, and be sure to explain how the different types of plants you plan to use will meet the criteria for the garden.