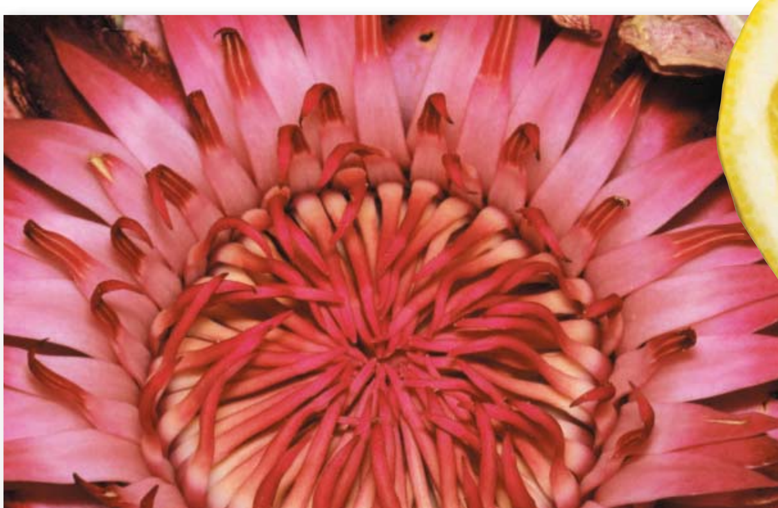
UNIT 7

# Plants





Lemon

Amazon water lily

UNIT 7

Water drops on passion flower tendrils

DISCOVERIES IN SCIENCE

# Plants

## 9400 BCE

Neolithic people in the Middle East grow figs by cultivating shoots from infertile fig trees. This may be the first food crop intentionally grown in human history. The fig trees grew about 1,000 years before the domestication of cereal crops such as wheat and barley in the Middle East.

## 1325 BCE

Plant products, including seeds, spices, olive oil, and barley are entombed with King Tutankhamen in Egypt.

**Golden mask of King Tut**

## 1493 CE

Christopher Columbus makes his second voyage across the Atlantic. This time, he brings sugar cane to plant in Santo Domingo. He also brings lemon, lime, and orange seeds to plant in Hispaniola.

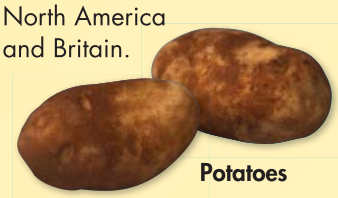
## 1793

Eli Whitney invents the cotton gin, a machine that removes the seeds from cotton. Cotton production in the American South soars, along with the demand for slave labor.

**Cotton gin**

## 1845

An outbreak of potato blight, a fungal disease, destroys the potato crop in Ireland. About 1,000,000 people die of starvation, and about 1,500,000 more emigrate to North America and Britain.



**Potatoes**

## 1930

Dutch elm disease is introduced to the United States from Europe. Over time, the disease devastates American elms throughout the country, killing an estimated 77 million trees by 1970. Many urban areas, once lush with elms, are treeless.

## 1944

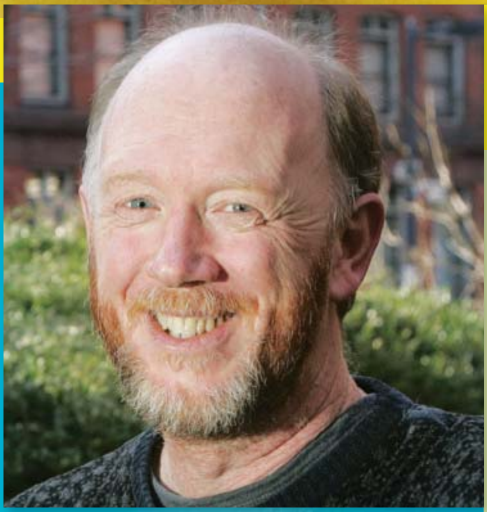
While studying corn genetics, Barbara McClintock discovers that pieces of DNA are mobile and can change position on chromosomes.

**Barbara McClintock**

## 1994

While hiking in a canyon in Australia, David Noble discovers a grove of pine trees, *Wollemia nobilis,* thought to have been extinct for 65 million years. The trees were discovered growing just 150 km from Sydney.

Sundew with fly



# BIOLOGY CAREER

UNIT 7

## Evolutionary Biologist

**David Haig**

David Haig is a professor of organismic and evolutionary biology at Harvard University. His academic and postgraduate training was in the evolution of plant reproduction.

Haig enjoys being a scientist, especially learning about the natural world and solving puzzles. Watching birds in his native Australia as a child inspired Haig to become a scientist.

Haig's current research focuses on the evolution of conflicts within the genome and in parent-offspring relations. Haig's particular interest is in genes in which parental origin matters—genes inherited from the egg behave differently than genes inherited from the sperm.

In addition to science, Haig enjoys studying history.

Pollen grains of ladybell flower

Chapter Planner 24

# Seed Plant Structure and Growth

| | Standards | Teach Key Ideas |
|---|---|---|
| **CHAPTER OPENER,** pp. 570–571 (15 min.) | *National Science Education Standards* | |
| **SECTION 1 Plant Tissue Systems,** pp. 573–578 (45 min.)<br>› Plant Tissues<br>› Dermal Tissue System<br>› Vascular Tissue System<br>› Ground Tissue System | LSCell 1, UCP1, UCP5 | **Bellringer Transparency**<br>**Transparencies** G11 Structure of a Vascular Plant • G13 Vascular Tissue • G14 Structure of Xylem • G15 Structure of Phloem • G31 Stomata and Guard Cells<br>**Visual Concepts** Dermal Tissue Systems in Plants • Ground Tissue System in Plants • Vascular Tissue System in Plants • Xylem • Phloem • Stomata |
| **SECTION 2 Roots, Stems, and Leaves,** pp. 579–584 (45 min.)<br>› Roots<br>› Stems<br>› Leaves | LSCell 1, LSCell 5, UCP5 | **Bellringer Transparency**<br>**Transparencies** G17 Radish Root Structure • G23 Dicot and Monocot Stem Structure • G22 Structure of Stems • G28 Simple and Compound Leaves • G30 Structure of a Leaf<br>**Visual Concepts** Types of Roots • Root Structure • Stem • Parts of a Stem • Leaf • Types of Leaves • Leaf Adaptations • Parts of a Leaf • Cross Section of a Leaf |
| **SECTION 3 Plant Growth and Development,** pp. 585–589 (60 min.)<br>› The Plant Embryo<br>› Meristems<br>› Primary Growth<br>› Secondary Growth | LSCell 1, LSCell 6 | **Bellringer Transparency**<br>**Transparencies** G64 Seed Germination • G18 Apical Meristems • G24 Development of a Woody Stem • G40 Bread Wheat<br>**Visual Concepts** Germination of a Monocot • Germination of a Dicot • Primary Growth in Plants • Meristem • Secondary Growth in Plants |

See also PowerPoint® Resources

## Chapter Review and Assessment Resources

- SE Super Summary, p. 592
- SE Chapter Review, p. 593
- SE Standardized Test Prep, p. 595
- Review Resources
- Chapter Tests A and B
- Holt Online Assessment

CHAPTER Fast Track

*Through instruction will require the times shown.*

## Basic Learners

- TE Plant Similarities and Differences, p. 574
- TE Graphic Organizer, p. 587
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

## Advanced Learners

- TE Plant Cells and Tissues, p. 575
- TE Design a Flower Bed, p. 586
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

**Key**
SE Student Edition
TE Teacher's Edition
[Chapter Resource File icon] Chapter Resource File
[Workbook icon] Workbook
[Transparency icon] Transparency
[CD icon] CD or CD-ROM
* Datasheet or blackline master available
■ Also available in Spanish

**All resources listed below are also available on the Teacher's One-Stop Planner.**

| Why It Matters | Hands-On | Skills Development | Assessment |
|---|---|---|---|
| *Build student motivation with resources about high-interest applications.* | SE **Inquiry Lab** Function of Plant Parts, p. 571* ■ | TE **Reading Toolbox** Assessing Prior Knowledge, p. 570<br>SE **Reading Toolbox,** p. 572 | |
| TE **Demonstration** Wetting Agents, p. 573<br>TE **Girdling,** p. 576 | SE **Quick Lab** Behavior of Stomata, p. 575* ■ | TE **Reading Toolbox** Vocabulary Development, p. 575<br>TE **Reading Toolbox** Visual Literacy, p. 576<br>SE **Reading Toolbox** Word Origins, p. 578<br>TE **Reading Toolbox** Word Origins, p. 578 | SE **Section Review**<br>TE **Formative Assessment**<br>**Spanish Assessment*** ■<br>**Section Quiz** ■ |
| TE **Demonstration** Vascular Bundles, p. 580<br>TE **Demonstration** Annual Rings in Woody Plants, p. 581<br>SE **Extreme Plants** p. 584 | SE **Quick Lab** Internal Structures of Roots and Stems, p. 581* ■<br>**Quick Lab** Observing Stems*<br>**Quick Lab** Inferring Leaf Function from Structure* | TE **Reading Toolbox** Visual Literacy, p. 579<br>SE **Reading Toolbox** Booklet, p. 582<br>TE **Reading Toolbox** Visual Literacy, p. 582<br>TE **Reading Toolbox** Booklet, p. 582<br>TE **Reading Toolbox** Visual Literacy, p. 584 | SE **Section Review**<br>TE **Formative Assessment**<br>**Spanish Assessment*** ■<br>**Section Quiz** ■ |
| TE **The Asian Art of Bonsai** p. 588<br>TE **Demonstration** Seed Germination, p. 586 | SE **Quick Lab** The Effect of Cold on Seed Germination, p. 587* ■<br>SE **Skills Practice Lab** Monocot and Dicot Seeds, p. 590* ■ | TE **Reading Toolbox** Cause and Effect, p.586<br>SE **Reading Toolbox** Cause and Effect, p.586<br>TE **Reading Toolbox** Visual Literacy, p. 586<br>TE **Reading Toolbox** Visual Literacy, p. 588<br>TE **Reading Toolbox** Visual Literacy, p. 589 | SE **Section Review**<br>TE **Formative Assessment**<br>**Spanish Assessment*** ■<br>**Section Quiz** ■ |

**See also Lab Generator**

**See also Holt Online Assessment Resources**

## Resources for Differentiated Instruction

### English Learners
- TE Vocabulary Aids, p. 580
- TE Vocabulary Aids, p. 582
- TE Seed Structure, p. 585
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Multilingual Glossary

### Struggling Readers
- TE Vocabulary Aids, p. 580
- TE Vocabulary Aids, p. 582
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide*
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

### Special Education Students
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

### Alternative Assessment
- TE Summarizing Plant Structures and Functions, p. 584
- Science Skills Worksheets*
- Section Quizzes* ■
- Chapter Tests A, B, and C* ■

Chapter 24

## Overview

The purpose of this chapter is to help students understand that plants are composed of structures that adapt to help them survive in their environments. As plants grow, they develop specialized cells, tissues, and structures in a coordinated manner.

READING TOOLBOX

**Assessing Prior Knowledge** Students should understand the following concepts:

- the relationships between cells, tissues, and organs
- the importance of plants adapting to the environment for survival

**Visual Literacy** Ask students what adaptations the tescalama tree would need to survive the punishing environment of the Sonoran Desert. (Answers may include the fact that its roots are able to grow around hard surfaces such as rock to hold the tree securely in place.)

Chapter 24

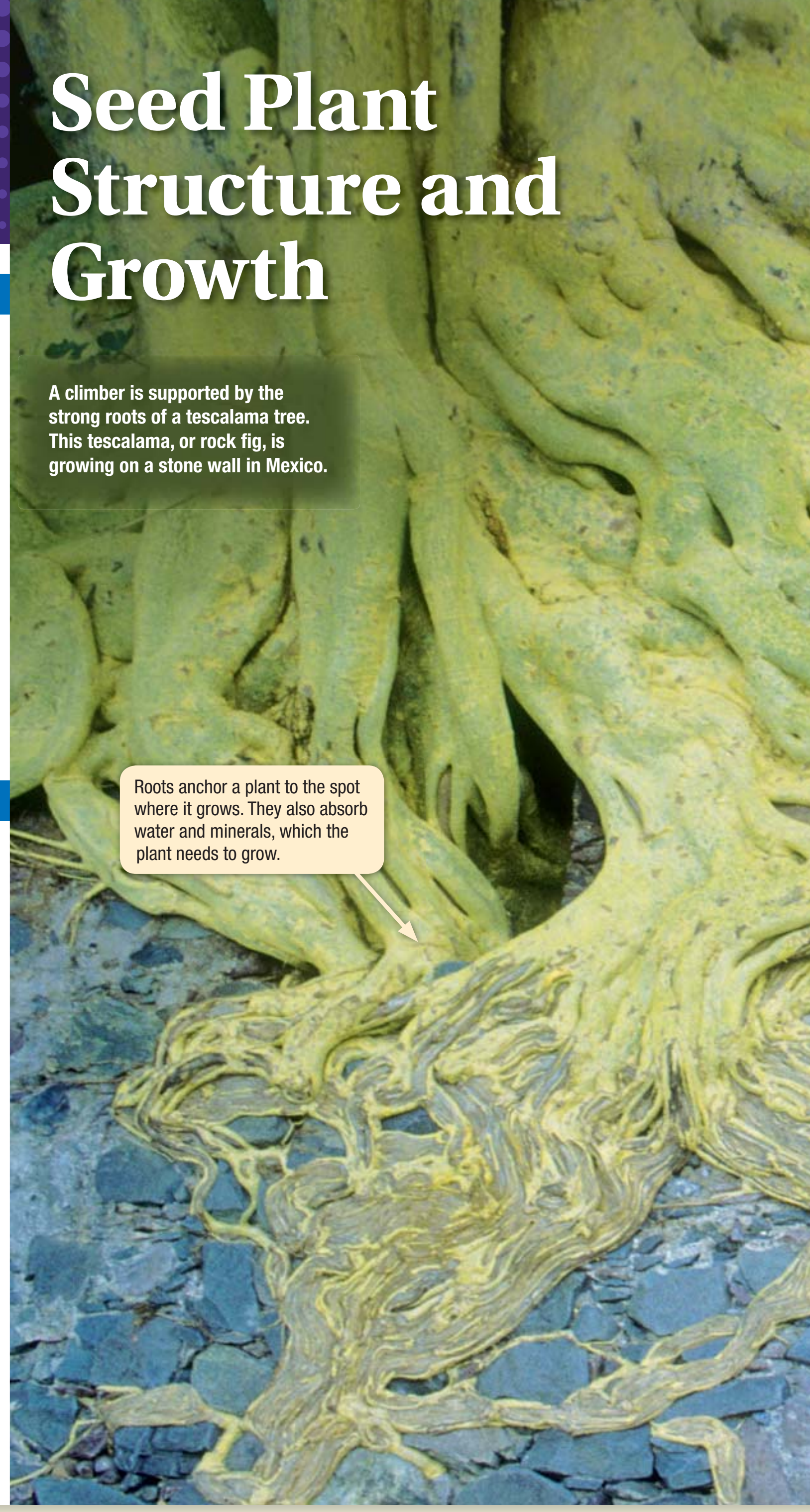
# Seed Plant Structure and Growth

## Preview



## Why It Matters

Like your body, a plant's body is made up of tissues, which make up organs. Seeds were an important terrestrial adaptation that enhanced survival and dispersal of plants.



A climber is supported by the strong roots of a tescalama tree. This tescalama, or rock fig, is growing on a stone wall in Mexico.

Roots anchor a plant to the spot where it grows. They also absorb water and minerals, which the plant needs to grow.

| Chapter Correlations | National Science Education Standards |
|---|---|
| **LSCell 1** Cells have particular structures that underlie their functions. | |
| **LSCell 5** Plant cells contain chloroplasts, the site of photosynthesis. | |
| **LSCell 6** Cells can differentiate and form complete multicellular organisms. | |
| **UCP1** Systems, order, and organization | |
| **UCP5** Form and function | |

## InquiryLab

15 min

### Function of Plant Parts

How closely related are structure and function in a plant? Can you infer the function of a plant part by analyzing its structure?

#### Procedure

1. Without removing a **potted plant** from its container, examine the plant's outer appearance.
2. Carefully remove the plant from its container. Use a **cotton swab** to gently brush soil from the roots.
3. Locate the plant's leaves. Use a **hand lens** to closely examine these plant parts. Can you see small, veinlike vessels in the leaf?
4. Locate the main stem and the smaller stalks that connect the leaves to the stems.
5. Locate the roots. Use a hand lens to closely examine these plant parts. Can you see any small hairs that emerge from the main root parts?
6. Record your observations. Then, try to infer the function of each plant part based on its structure.

#### Analysis

1. **Explain** how the hand lens improved your observational skills.
2. **Describe** how the stem section that was below the soil differs from the stem section above the soil.
3. **Explain** how the root system is adapted to anchor the plant in soil.

The roots of this rock fig grow down the rock wall and eventually fuse, forming what looks like a wooden waterfall or lava flow. Rock figs are sometimes called *lava figs.*

## InquiryLab

**Teacher's Notes** Provide examples of monocots and dicots, and ask students to note the differences between the two types of angiosperms.

**Materials**

- cotton swab
- hand lens
- plant sample (root, stem, and leaves intact)
- paper
- scrap paper

**Safety Cautions** Remind students to not eat any part of a plant or plant seed used in the lab. Students should avoid touching their faces when working with plants and should wash their hands thoroughly after handling any part of a plant.

### *Answers to Analysis*

1. The hand lens magnified the plant part to provide a more detailed observation.
2. The stem section below the soil was white, but the stem section that rose above the soil was green.
3. The root system is composed of a weblike network of fibers that "hold" onto the surrounding soil.

READING TOOLBOX

## Using Words

1. *Derm* meaning "skin" would suggest the outside of the plant.
2. *Meso* meaning "middle" and *phyll* meaning "leaf" would suggest the interior of the leaf.

## Using Language

1. cause: seeds float in the wind
**effect: seeds are carried over large distances**
2. cause: plants have strong cell walls
**effect: trees can grow tall without breaking**

## Using FoldNotes

Check to see that students have followed the directions accurately.

# READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

## Using Words

**Word Origins** Many of the words we use today come from Greek or Latin words. Knowing the meanings of Greek and Latin roots can help you figure out and remember the meanings of modern English words.

**Word Origins**

| Word part | Origin | Meaning |
|---|---|---|
| *derm* | Greek | skin |
| *vas* | Latin | vessel |
| *meso* | Greek | middle |
| *phyll* | Greek | leaf |

**Your Turn** Use the table to answer the following questions.

1. Where on a plant would you find dermal tissue?
2. Where on a plant would you find mesophyll?

## Using Language

**Cause and Effect** In biological processes, one step leads to another step. When reading, you can recognize cause-and-effect relationships by words that indicate a result, such as *so, consequently, next, then,* and *as a result.*

**Your Turn** Identify the cause and the effect in the following sentences.

1. Some seeds float on the wind, so they are often found far from the parent plant.
2. The substance that makes up plant cell walls is very strong. As a result, trees are able to grow very tall without breaking.

## Using FoldNotes

**Booklet** A booklet is a useful tool for taking notes as you read a chapter. Each page of the booklet can contain a main topic from the chapter and the details that describe the main topic.

**Your Turn** Make a booklet to help you organize your notes for this chapter.

1. Fold a sheet of paper in half from top to bottom.
2. Fold the sheet of paper in half again, from left to right.
3. Fold the sheet of paper one more time, from top to bottom.
4. Completely unfold the paper.
5. Using scissors, cut a slit along the center crease of the sheet from the T made by the top fold to the T made by the bottom fold. Do not cut the entire sheet in half.
6. Fold the sheet of paper in half from top to bottom. While holding the bottom and top edges of the paper, push the bottom and top edges together so that the center collapses at the center slit. Fold the four flaps to form a four-page book.

# Section 1 Plant Tissue Systems

| Key Ideas | Key Terms | Why It Matters |
|---|---|---|
| What three types of tissue are found in vascular plants? <br> What is the dermal tissue system? <br> What are two types of vascular tissue? <br> What is ground tissue? | dermal tissue, vascular tissue, ground tissue, stoma, guard cell, xylem, phloem | Did you know that plants, like animals, have tissues? Plant tissues perform functions such as protection, support, and transport. |

Like your body, a plant's body is made of tissues. Plant tissues are arranged into systems, which are further organized into organs.

## Plant Tissues

**Vascular plants have three tissue systems—the dermal tissue system, vascular tissue system, and ground tissue system.** **Dermal tissue** forms the protective outer layer of a plant. **Vascular tissue** forms strands that conduct water, minerals, and organic compounds throughout a vascular plant. **Ground tissue** makes up much of the inside of the nonwoody parts of a plant, including roots, stems, and leaves. **Figure 1** shows how these three tissues are arranged in a nonwoody dicot. Each type of tissue contains one or more kinds of cells that are specialized to perform particular functions.

**Reading Check** *Where on a plant is dermal tissue found? (See the Appendix for answers to Reading Checks.)*

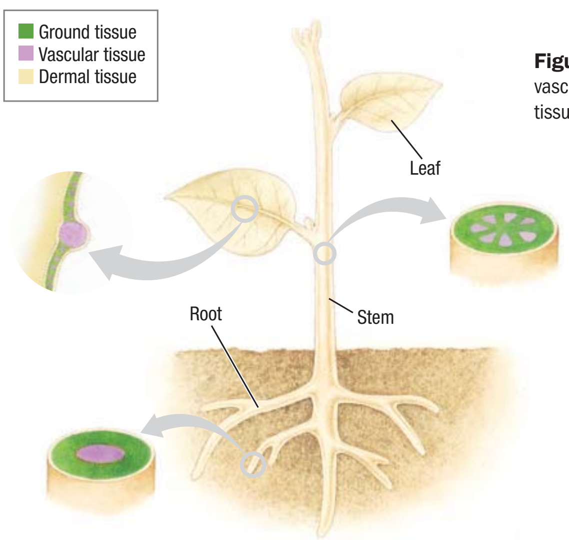



**Figure 1** The leaves, stems, and roots of a vascular plant contain all three kinds of plant tissues. **What is the function of vascular tissue?**

**dermal tissue** the outer covering of a plant

**vascular** (VAS kyuh luhr) **tissue** the specialized conducting tissue that is found in higher plants and that is made up mostly of xylem and phloem

**ground tissue** a type of plant tissue other than vascular tissue that makes up much of the inside of a plant

## Section 1

### Focus

This section explains how plant tissues are adapted to meet the plant's needs. Plant tissues are made up of cells that perform particular functions that allow the plant to survive in its environment.

### Bellringer

Use the Bellringer transparency to prepare students for this section.

### Teach

**Demonstration**

**Wetting Agents** Provide students with wax paper, water, liquid detergent, and two beakers. Place two drops of water on wax paper and ask students what happens when the paper is tilted. (The drops of water roll off the paper.) Then, place two drops of soapy water on the wax paper and have students describe what they see. (The soapy water spreads out over the wax paper.) Tell students that the detergent acts as a "wetting agent" by disrupting the attraction that water molecules have for one another. Wetting agents are often mixed with insecticides so that the drops will spread to better cover the leaves. **LS Kinesthetic**

### Answers to Caption Questions

**Figure 1:** conducts water, minerals, and organic compounds throughout a vascular plant

### Key Resources

**Transparencies**
- G11 Structure of a Vascular Plant
- G13 Vascular Tissue
- G14 Structure of Xylem
- G15 Structure of Phloem
- G31 Stomata and Guard Cells

**Visual Concepts**
- Dermal Tissue Systems in Plants
- Ground Tissue System in Plants
- Vascular Tissue System in Plants
- Xylem
- Phloem
- Stomata

## ❯ Teach, *continued*

### Teaching Key Ideas

**Tissue Types** Separate the class into groups. Provide each group of students with a microscope, three microscope slides, three coverslips, and samples of a red onion, a potato, and a stalk of celery. Have students prepare wet-mount slides of the following: red-onion skin (dermal tissue), potato (ground tissue), and celery (dermal, ground, and vascular tissue). Have students draw what they observe in the field of view under the microscope and label the types of tissues they find in each example. Remind students that they should draw the field of view as a circle. **LS Visual, Kinesthetic**

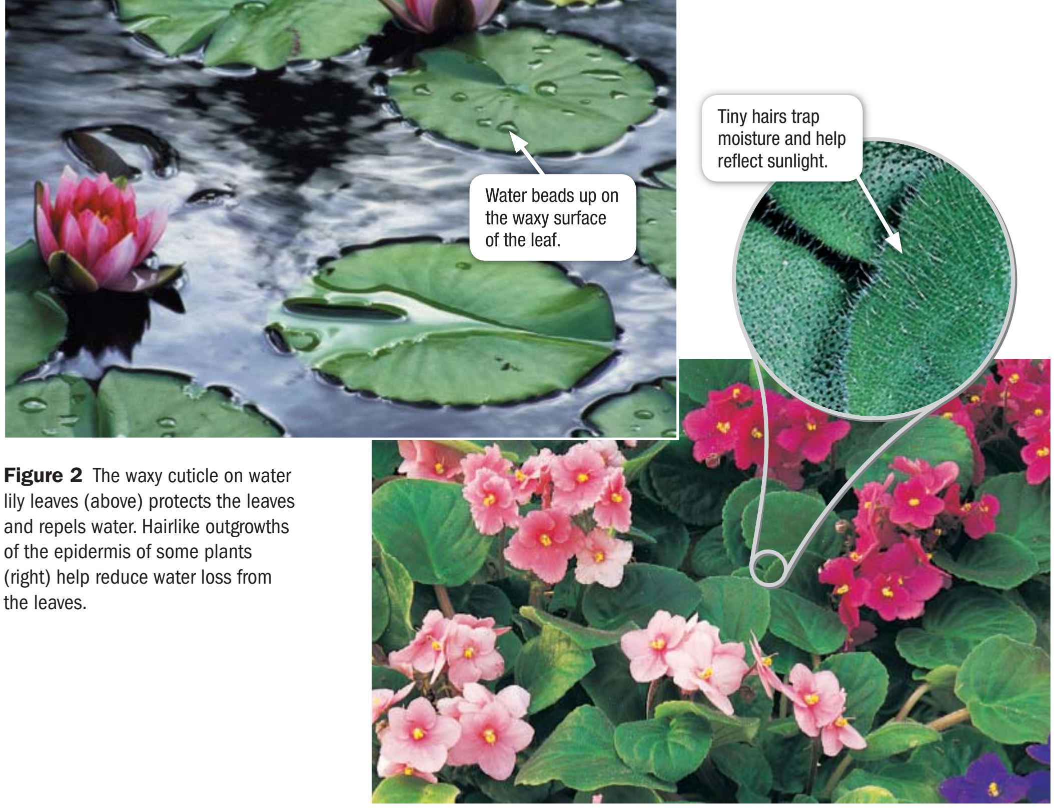



**Figure 2** The waxy cuticle on water lily leaves (above) protects the leaves and repels water. Hairlike outgrowths of the epidermis of some plants (right) help reduce water loss from the leaves.

**stoma** (STOH muh) opening in a leaf or a stem of a plant that enables gas exchange to occur

**guard cell** one of a pair of specialized cells that border a stoma and regulate gas exchange

## Dermal Tissue System

**❯ Dermal tissue covers the outside of a plant's body. In the nonwoody parts of a plant, dermal tissue forms a "skin" called the *epidermis.*** The epidermis of most plants is made up of a single layer of flat cells. Often, the cells of the epidermis have hairlike extensions or other structures, as shown in **Figure 2.** Extensions of the epidermal cells on leaves and stems often help slow water loss by trapping moisture close to the surface of the leaf. Extensions of the epidermal cells on root tips, called *root hairs,* help increase water absorption.

The waxy cuticle coats the epidermis of stems and leaves. The cuticle protects the plant and prevents water loss. Recall that the development of a cuticle made it possible for plants to live in drier habitats. Some aquatic plants, such as the water lilies shown in **Figure 2,** also have a cuticle. The function of the cuticle in these plants is to protect the leaves and repel water.

**Academic Vocabulary**

**function** use or purpose

The dermal tissue on woody stems and roots consists of several layers of dead cells that are referred to as *cork*. Cork cells contain a waterproof chemical and are not covered by a waxy cuticle. In addition to its role in protection, dermal tissue functions in gas exchange and in the absorption of mineral nutrients.

**❯ Reading Check** *What is the function of root hairs?*

### Differentiated Instruction

#### Basic Learners

**Plant Similarities and Differences** Show students three very different plants, such as a cactus, a tomato, and a Venus' flytrap. Have the class compose a list of things that all three plants need to survive. (All the plants need water, carbon dioxide, light energy, and minerals for making organic molecules.) Ask students why these three plants look so different. (They have specialized tissues to accommodate their needs.) **LS Visual**

Hands-On

# QuickLab

15 min

## Behavior of Stomata

You can use nail polish to see that a leaf has many stomata.

### Procedure

1. Paint a thin layer of **clear nail polish** on a 1 × 1 cm area of a leaf on a **plant kept in light** and on a **plant kept in darkness.** Let the nail polish dry for 5 min.
2. Place a **4 to 5 cm strip of clear tape** over the nail polish on each leaf. Press the tape firmly to the nail polish.
3. Carefully pull the tape off each leaf. Stick each piece of tape to a **microscope slide.** Label the slides appropriately.
4. View each slide with a **microscope,** first under low power and then under high power.
5. Draw and label what you see on each slide.

### Analysis

1. **Describe** any differences in the stomata of the two plants.
2. CRITICAL THINKING **Drawing Conclusions** Which plant will lose water more quickly? Explain.

**Stomata** Like the wax on a shiny car, the cuticle does not let gases pass through it. So, how does a plant obtain the carbon dioxide it needs for photosynthesis? Pores called **stomata** (singular, *stoma*) permit plants to exchange oxygen and carbon dioxide. Stomata, which extend through the cuticle and the outer layer of cells, are found on at least some parts of most plants. A pair of specialized cells called **guard cells** border each stoma, as seen in **Figure 3.** Stomata open and close as the guard cells change shape. When the stomata are open, a plant is able to gain carbon dioxide from the air, but the plant loses water vapor through the open stomata. When the stomata are closed, the plant conserves water, but photosynthesis slows down or stops because of a shortage of carbon dioxide.

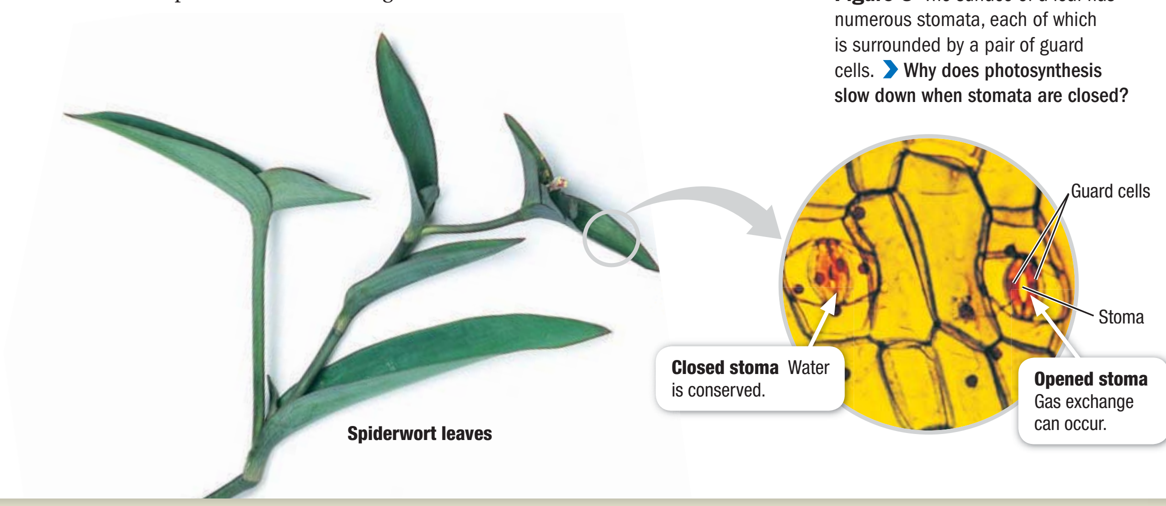



**Figure 3** The surface of a leaf has numerous stomata, each of which is surrounded by a pair of guard cells. **Why does photosynthesis slow down when stomata are closed?**

## Differentiated Instruction

### Advanced Learners

**Plant Cells and Tissues** Have students construct and illustrate a table summarizing the types of plant tissues and the cells they contain. In the table, students should classify each type of cell encountered as part of the dermal tissue, ground tissue, or vascular tissue. LS **Logical**

### Answers to Caption Questions

**Figure 3:** Carbon dioxide, which is needed for photosynthesis, cannot enter the plant when stomata are closed.

## QuickLab

**Teacher's Notes** Tell students to put the nail polish on the lower leaf surface where there are likely to be more stomata. The nail polish makes an impression of the leaf surface and may also remove some of the surface cells.

**Materials**
- goggles
- plant sample (2)
- clear nail polish
- transparent tape
- compound microscope
- microscope slides

**Safety Cautions** Have students wear goggles when handeling glass. Remind students to not eat any part of a plant or plant seed used in the lab. Students should avoid touching their faces when working with plants and should wash their hands thoroughly after handling any part of a plant.

### Answers to Analysis

1. Students should note that the plant kept in the light has more open stomata.
2. The plant exposed to light will lose water more quickly because it has more open stomata. While this seems inefficient for preventing water loss, the stomata must be open during the day to allow photosynthesis to occur.

READING TOOLBOX

**Vocabulary Development** Have students write down each of the key terms for this section on separate note cards. As the students read through the section, have them write a brief definition of each term on the back of the card. Have students use their cards in the Reteaching Key Ideas exercise at the end of the chapter. LS **Verbal**

## ❯ Teach, *continued*

**READING TOOLBOX**

**Visual Literacy** Have students examine **Figure 4.** Ask what similarities they notice between the conducting cells of the xylem and the phloem. (The cells are elongated and connected end to end; they have openings in their cell walls at the ends of the cells and also some in the sides.) Help students relate the 3-D characteristics of the drawings to the flat plane of the root cross-section. Remind them the xylem helps move materials from roots to leaves.
**LS Visual**

### Teaching Key Ideas

**Interconnected Vascular Tissues**
Point out to students that the conducting cells of the xylem in a plant are all interconnected. The strands of vascular tissue in the leaves connect to the vascular tissues in the stem, which, in turn, connect to the vascular tissue in the roots. Water moves from the roots to the stem and from the stem to the leaves through this vascular tissue. The same is true for phloem. To survive underground root cells need a sugar supply from photosynthetic leaves, and the phloem cells can transport this sugar a great distance.
**LS Logical**

**xylem** (ZIE luhm) the type of tissue in vascular plants that provides support and conducts water and nutrients from the roots

**phloem** (FLOH uhm) the tissue that carries organic and inorganic nutrients in any direction, depending on the plant's needs

SCILINKS. www.scilinks.org
Topic: Vascular Plants
Code: HX81595

## Vascular Tissue System

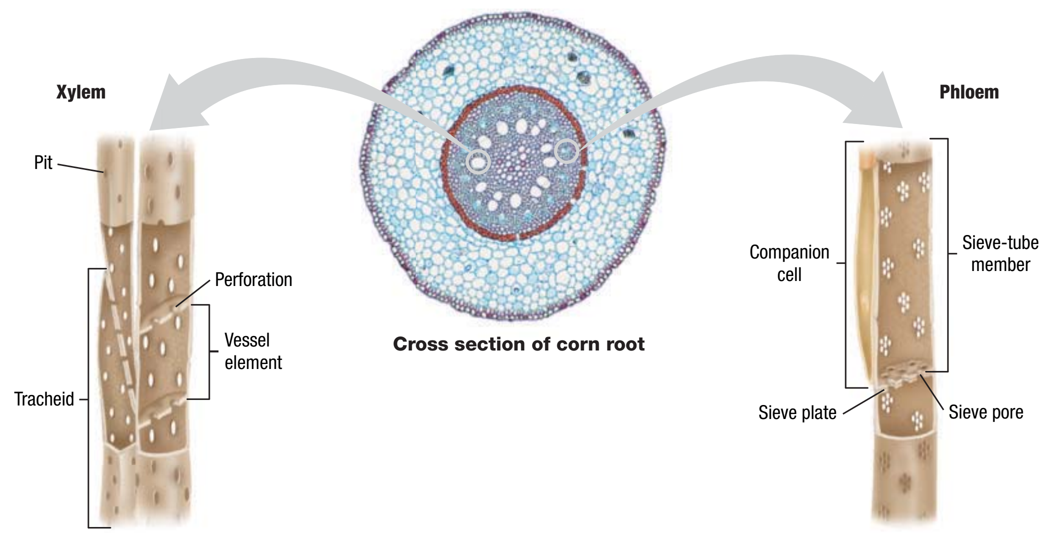
One of the most important changes as plants evolved was the development of vascular tissues. **❯ Vascular plants have two kinds of vascular tissue, called *xylem* and *phloem*, that transport water, minerals, and nutrients throughout the plant.** These tissues are composed of cells that are stacked end to end like sections of pipe, as shown in **Figure 4.** Xylem and phloem allow most vascular plants to grow to much larger sizes than nonvascular plants, which do not have xylem and phloem.

**Xylem** **Xylem** is composed of thick-walled cells that conduct water and mineral nutrients from a plant's roots through its stems to its leaves. At maturity, xylem cells are dead, and all that is left of the cells is their strong cell walls. The two types of conducting cells in xylem are called *tracheids* and *vessel elements.* Water flows from one tracheid to the next through pits, or thin areas in the cell walls. Vessel elements link to form vessels. The vessel elements have large perforations in their ends that allow water to flow more quickly between vessel elements.

**Phloem** **Phloem** is made up of cells that conduct sugars and nutrients throughout a plant's body. The conducting cells of phloem have a cell wall, a cell membrane, and cytoplasm. These cells either lack organelles or have modified organelles. The conducting cells in phloem are called *sieve-tube members.* Sieve-tube members link to form sieve tubes. Pores in the walls between neighboring sieve-tube members connect the cytoplasms and allow substances to pass from cell to cell. Beside the sieve tubes are rows of companion cells, which contain organelles. Companion cells carry out cellular respiration, protein synthesis, and other metabolic functions for the sieve tubes.

**❯ Reading Check** ***What are the conducting cells in phloem called?***

**Figure 4** Both xylem and phloem contain strands of tubular conducting cells that are stacked end to end like sections of pipe. **❯ Which kind of vascular tissue transports water and minerals?**




### Why It Matters

**Girdling** A porcupine can eat a complete ring of bark around a tree. This action severs the phloem cells and prevents sugar from reaching the roots, which causes the tree to die. This process is called *girdling* and can be a problem for orchard growers.

### *Answers to Caption Questions*

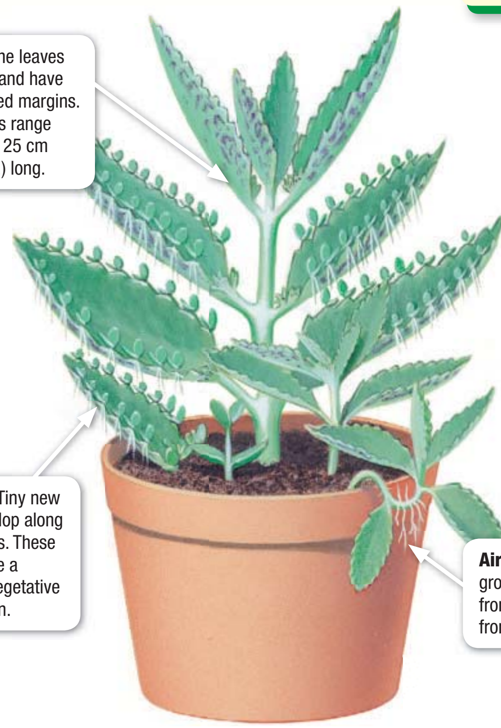
**Figure 4:** xylem

# Up Close Vascular Plant

Kalanchoes belong to the Crassulaceae family, a group of succulent plants that are adapted to hot climates. Kalanchoes can reproduce vegetatively by means of plantlets that develop on leaf margins. A plantlet that falls to the ground grows into a new plant.

**Kalanchoe**

**Scientific name:** *Kalanchoe daigremontiana*
**Size:** grows from 30 cm to 1 m (1 to 3 ft) tall
**Range:** native to southwestern Madagascar; cultivated worldwide
**Habitat:** semiarid tropical grassland with moist summers and well-drained, fertile soil
**Importance:** grown as indoor potted plants and as outdoor perennials in warm climates



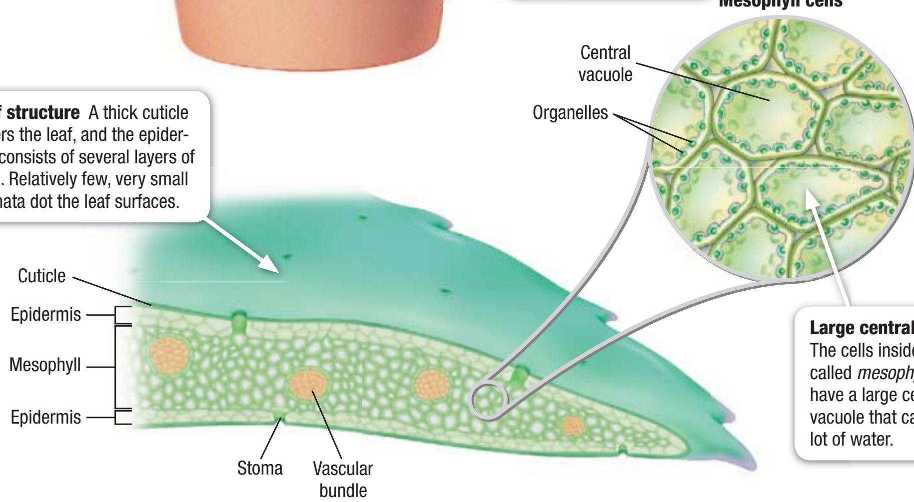
**Leaves** The leaves are fleshy and have saw-toothed margins. Leaf blades range from 12 to 25 cm (4 to 10 in.) long.

**Plantlets** Tiny new plants develop along leaf margins. These plantlets are a means of vegetative reproduction.

**Air roots** The roots that grow from the stems and from plantlets originate from the stem tissue.

**Flowers** A cluster of flowers forms on a flowering stalk that grows from the end of a stem. Flower parts occur in fours. Each flower produces many tiny seeds.

**Leaf structure** A thick cuticle covers the leaf, and the epidermis consists of several layers of cells. Relatively few, very small stomata dot the leaf surfaces.




**Large central vacuole** The cells inside a leaf, called *mesophyll cells,* have a large central vacuole that can hold a lot of water.

## MISCONCEPTION ALERT

**Plants Need Oxygen** A common misconception is that plants do not need oxygen because they produce it in photosynthesis. Oxygen is produced in leaves and green stems during photosynthesis. However, no oxygen is produced in roots because there are no photosynthetic cells. Therefore, roots must obtain oxygen from the soil. Houseplants that are overwatered and crops that are flooded for extended periods will die from a lack of oxygen. This is why gardeners try to keep soil aerated, using organic matter such as mulch and compost, so water will drain.

## Up Close

**Teacher's Notes** Bring specimens of the kalanchoe plant to class. Let students propagate the plant by planting stem cuttings, leaf cuttings, or plantlets. Point out that the formation of plantlets along the leaf margin that occurs in kalanchoes is a very unusual form of asexual reproduction. Tell students that kalanchoes are easy to grow.

## Discussion

1. Ask students to describe sexual and asexual reproduction in kalanchoes. (Kalanchoes are flowering plants that reproduce sexually by forming seeds following pollination and fertilization. They reproduce asexually by forming plantlets containing roots, stems, and leaves on the margins of the mother plant's leaves. They can also produce new plants from pieces of stems and leaves.)
2. Ask students how the genetic composition of a plantlet compares with that of the mother plant. (The two are identical because the plantlets are clones of the mother plant.)
3. Ask students to name some adaptations found in kalanchoes that enable them to survive in dry environments. (Kalanchoes have thick, fleshy leaves and stems that store water. The leaves have a thick cuticle, several layers of epidermal cells, and few stomata. The mesophyll cells have a large central vacuole for water storage.) LS **Verbal**

## Teach, *continued*

READING TOOLBOX

**Word Origins** Vascular tissue transports water, minerals, and nutrients throughout a plant.

## Close

### Formative Assessment

1. If the ground tissue in leaves is damaged, the plant cannot ____.

**A.** obtain water from roots (Incorrect. Ground tissue damage in leaves does not affect the flow of water from roots.)

**B.** stand up straight (Incorrect. Plant support is a function of the structure of the stem, not the leaves.)

**C.** perform photosynthesis (Correct. Leaf ground tissue contains chloroplasts, which absorb light for photosynthesis.)

**D.** absorb carbon dioxide (Incorrect. Carbon dioxide absorption takes place at stomates, not the ground tissue.)

### Answers to Caption Questions

**Figure 5:** photosynthesis

**Figure 6:** taproot

**Characteristics of Plant Tissue Systems**

| Tissue system | Location | Function in roots | Function in stems | Function in leaves |
|---|---|---|---|---|
| Dermal tissue system | outermost layer(s) of cells | absorption, protection | gas exchange, protection | gas exchange, protection |
| Vascular tissue system | tubes throughout plant | transport, support | transport, support | transport, support |
| Ground tissue system | between dermal and vascular tissues in nonwoody plant parts | support, storage | support, storage | photosynthesis |

**Figure 5** All three plant tissue systems are found in the roots, stems, and leaves of vascular plants. **› What is the primary function of ground tissue in leaves?**

READING TOOLBOX

**Word Origins** The root *vas* means vessel. Use this information and the table above to describe the function of vascular tissue.

## Ground Tissue System

The third type of tissue in vascular plants is ground tissue. **› Ground tissue makes up much of the inside of most nonwoody plants, where it surrounds and supports vascular tissue.** Most ground tissue consists of thin-walled cells that remain alive and keep their nucleus after they mature. But ground tissue also contains some thick-walled cells that lose their nucleus and cell contents when they mature.

Ground tissue contains many cell types, each with specific functions based on where the cells are located in a plant. In leaves, the ground tissue is composed of cells that are packed with chloroplasts. These cells are specialized for photosynthesis.

The ground tissue in stems and roots functions mainly in support and in the storage of water, sugar, and starch. Cells in these locations often contain large vacuoles for storage. In angiosperms, ground tissue makes up the flesh of fruits. Ground tissue is largely absent in the woody parts of plants. The characteristics of ground tissue, as well as the other types of plant tissue, are summarized in **Figure 5.**

**› Reading Check** *What is the primary function of ground tissue in roots and stems?*

## Section 1 Review

### › KEY IDEAS

1. **Name** three types of tissue that make up vascular plants.
2. **Describe** the dermal tissue system and its functions.
3. **Name** two types of vascular tissue, and identify their functions.
4. **List** three functions of ground tissue.

### CRITICAL THINKING

5. **Forming Reasoned Opinions** Guard cells are the only cells of the upper epidermis that have chloroplasts. Based on what you know about the function of guard cells, why do you think guard cells contain chloroplasts?
6. **Evaluating Results** Some herbicides (weed killers) contain a chemical that breaks down waxy substances. Explain why such a chemical may be useful in a herbicide.

### WRITING FOR SCIENCE

7. **Comparing Structures** Write a paragraph comparing and contrasting the dermal tissue system of plants with the human integumentary system. In particular, compare and contrast the epidermis.

### Answers to Section Review

1. dermal tissue, vascular tissue, and ground tissue
2. It forms the protective outer covering of a plant and functions in protection, gas exchange, and the absorption of mineral nutrients.
3. Xylem provides support and conducts water from a plant's roots through its stem to its leaves. Phloem conducts organic compounds and some mineral nutrients throughout a plant's body.
4. Ground tissue in leaves contains many chloroplasts, which are important in photosynthesis. Ground tissue in stems and roots functions mainly in the storage of water, sugar, and starch. In nonwoody parts of plants, ground tissue surrounds and supports vascular tissue.
5. Guard cells use energy obtained through photosynthesis, which takes place in the chloroplasts, to open and close the stomata.
6. Dissolving waxy cuticle allows the herbicide to enter epidermal cells, and hence the leaf, increasing its efficiency in killing the plant.
7. Plant epidermis: known as *skin*; single layer of cells; adapted to increase gas exchange and reduce water loss
   Human epidermis: also called *skin;* forms a waterproof barrier on the body
   Both form a protective layer against disease.

Section 2

# Roots, Stems, and Leaves

| Key Ideas | Key Terms | Why It Matters |
|---|---|---|
| What are roots, and what is their function?<br>What are stems, and what is their function?<br>What are leaves, and what is their function? | vascular bundle, pith, heartwood, sapwood, blade, petiole, mesophyll | What is in your salad? Likely, it is plant organs—roots, stems, and leaves of different plants. |

The tissue systems of a plant make up the plant's organs. Plants have three basic kinds of organs—roots, stems, and leaves—and each organ contains all three tissue types.

## Roots

**Most plants are anchored to the spot where they grow by roots, which absorb water and mineral nutrients. In many plants, roots also function in the storage of organic nutrients, such as sugar and starch.** Most monocots, such as grasses, have a highly branched, *fibrous root* system, as shown in **Figure 6.** Many dicots, such as dandelions and radishes, have a large central root from which much smaller roots branch. This type of root system is called a *taproot* system.

A root has a central core of vascular tissue that is surrounded by ground tissue. The ground tissue surrounding the vascular tissue is called the *cortex*. Roots are covered by dermal tissue. An epidermis covers all of a root except the root tip. The epidermal cells just behind a root tip often produce root hairs, which increase the surface area of a root and its ability to absorb water. Recall that root hairs are actually extensions of the epidermal cells. A mass of cells called the *root cap* covers and protects the actively growing root tip.

**Reading Check** *What are three functions of roots?*

SCILINKS.
www.scilinks.org
Topic: Root Structures
Code: HX81330

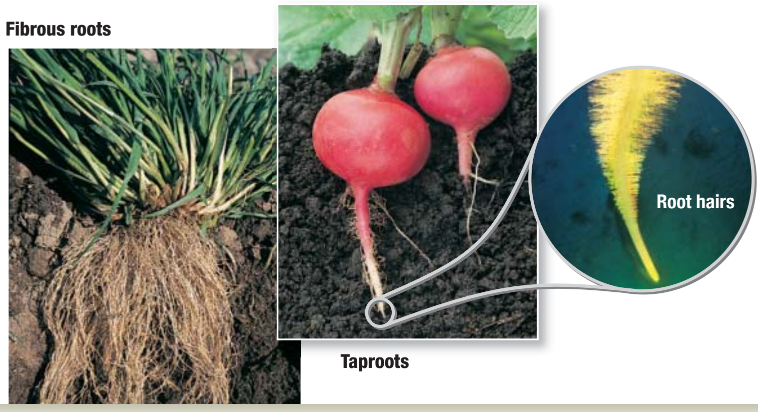



**Figure 6** Grasses (left) have highly branched fibrous roots. Radishes (right) have a large, central root called a *taproot*. Root hairs increase the surface area of a root and help it absorb water. **What type of root system do carrots have?**

Section 2

## Focus

This section explains the structures of roots, stems, and leaves.

**Bellringer**

Use the Bellringer transparency to prepare students for this section.

## Teach

### Teaching Key Ideas

**Guttation** Tell students that sometimes in the early morning, droplets of water appear on the edges of the leaves of some plants. Show photos of leaves with these droplets, which look somewhat like dew except that they form at the tips of the veins. These droplets of water are forced out of the plant by root pressure through specialized pores at the end of tracheids. This pressure develops as water moves into roots by osmosis. This phenomenon, called guttation, occurs only when the air is very moist and the stomata are closed.

READING TOOLBOX

**Visual Literacy** Have students look at **Figure 6.** Ask them what the small and large circles in the figure represent. (The small circle shows a section of the taproot to be magnified. The large circle is the enlarged view of that area.) LS **Visual**

## Key Resources

**Transparencies**
- G17 Radish Root Structure
- G23 Dicot and Monocot Stem Structures
- G22 Structure of Stems
- G28 Simple and Compound Leaves
- G30 Structure of a Leaf

**Visual Concepts**
- Types of Roots
- Root Structure
- Stem
- Parts of a Stem
- Leaf
- Types of Leaves
- Leaf Adaptations
- Parts of a Leaf
- Cross Section of a Leaf

## Teach, *continued*

**Demonstration**

**Vascular Bundles** Show slides of cross sections of various monocot stems, such as corn, iris, tulip, etc. and dicot stems, such as buttercup or geranium. Have students write the name of each plant cross sectional on a piece of paper and determine whether it is a monocot or dicot. They should refer to **Figure 7** for help. Ask students to predict which type of plant stem, monocot or dicot, would have the capability to grow larger in diameter and why. Discuss each answer given. (Dicot stems often grow larger in diameter because their circular arrangement of vascular bundles, and accompanying vascular cambium, allows for organized, outward growth. Monocots typically do not grow as large as some dicots, such as an apple tree or lilac tree, because monocots have scattered vascular bundles.) **LS Visual**

### *Answers to Caption Questions*

**Figure 7:** They are arranged in a ring, with the pith to the inside and the cortex to the outside.

**vascular bundle** a strand of conducting tissue that contains both xylem and phloem

**pith** the tissue that is located in the center of the stem of most vascular plants and that is used for storage

**heartwood** the nonconducting older wood in the center of a tree trunk

**sapwood** the tissue of the secondary xylem that is distributed around the outside of a tree trunk and is active in transporting sap

## Stems

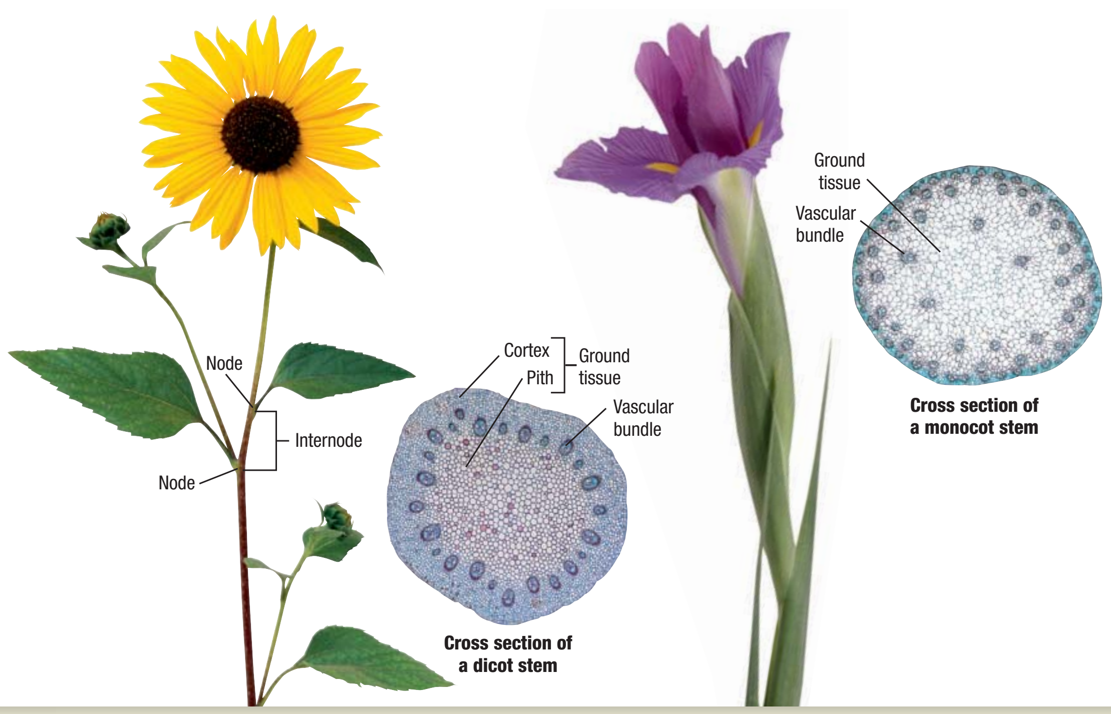
The shoots of most plants consist of stems and leaves. **Stems support the leaves and house the vascular tissue, which transports substances between the roots and the leaves.** Many plants have stems that are specialized for other functions. For example, the stems of cactuses store water. Potatoes are stems that are specialized for nutrient storage and for asexual reproduction.

Leaves attach to a stem at points called *nodes*. The space between two nodes is called an *internode*. Buds that can grow into new branches are also located at the nodes on a stem. Look for these structures in **Figure 7.** Other features of a stem depend on whether the stem is woody or nonwoody.

**Nonwoody Stems** A plant with stems that are flexible and usually green is called a *herbaceous plant*. As **Figure 7** shows, the stems of herbaceous plants contain bundles of xylem and phloem called **vascular bundles.** The vascular bundles are surrounded by ground tissue. In monocot stems, such as those of irises, the vascular bundles are scattered in the ground tissue. In dicot stems, such as those of sunflowers, the vascular bundles are arranged in a ring. The ground tissue outside the ring of vascular bundles is called the *cortex*. The ground tissue inside the ring is called the **pith.** Herbaceous stems are covered by an epidermis.

**Reading Check** ***What is the name of the point where a leaf attaches to a stem?***

**Figure 7** The vascular bundles are arranged differently in dicots (left) and monocots (right). **How are the vascular bundles arranged in a dicot stem?**




### Differentiated Instruction

#### Struggling Readers/English Learners

**Vocabulary Aids** Have several plants on display at the front of the room. Use the plants along with **Figures 7** and **8** to introduce the new vocabulary *before* students read the material on stems. Because most of the vocabulary will be unfamiliar, have students create flash card with the term on one side and a definition on the other. Encourage students to add diagrams, phonetic respellings, and any other memory aids that will help them to their sets of cards. When they encounter a terms in the reading that seem unfamiliar, have them use the cards to find the meaning of the unknown term before they continue reading. **LS Verbal**

Hands-On

## QuickLab

15 min

### Internal Structures of Roots and Stems

You can use a microscope to see differences in the internal structure of roots and stems.

#### Procedure

1. View **cross sections of dicot and monocot roots** with a **compound microscope.** Draw and label what you see under low power. Then, look at the vascular tissue in each root under high power. Draw what you see in each root, and label the xylem and phloem.
2. View **cross sections of dicot and monocot stems** with a compound microscope. Draw and label what you see under low power. Then, look at a vascular bundle in each stem under high power. Draw each vascular bundle, and label the xylem and phloem.

#### Analysis

1. **Compare and contrast** the location of xylem and phloem in roots and stems.
2. **Compare and contrast** the arrangement and structure of the vascular bundles in monocot and dicot stems.
3. CRITICAL THINKING **Describe** the relationship between the structure and function of vascular tissue.

**Woody Stems** Trees, such as oaks, and shrubs, such as hollies, have woody stems. Woody stems are stiff and nongreen. Buds, which produce new growth, are found at the tips and at the nodes of woody stems. A young woody stem has a central core of pith and a ring of vascular bundles, which fuse into solid cylinders as the stem matures. Layers of xylem form the innermost cylinder and are the major component of wood. The cylinder of phloem lies outside the cylinder of xylem. Woody stems are covered by cork, which protects them from physical damage and helps prevent water loss. Together, the layers of cork and phloem make up the bark of a woody stem.

A mature woody stem, such as the one shown in **Figure 8,** contains many layers of wood and is covered by a thick layer of bark. The wood in the center of a mature stem or tree trunk is called **heartwood.** The xylem in heartwood can no longer conduct water. **Sapwood,** which lies outside the heartwood, contains vessel elements that can conduct water.

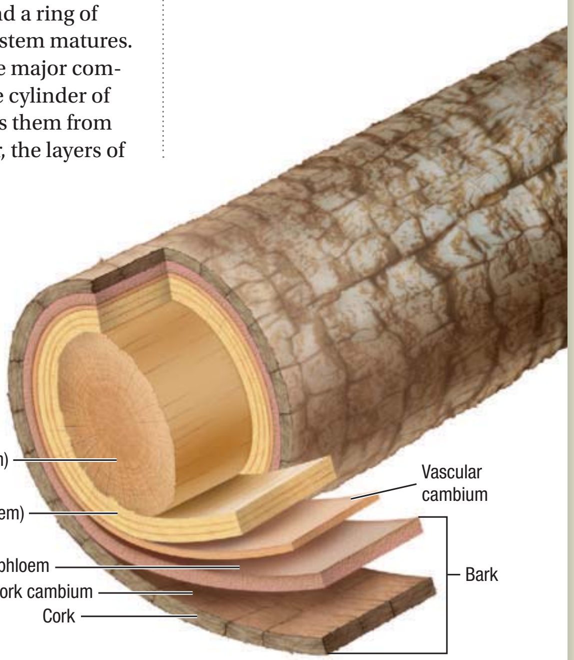



**Figure 8** In a mature woody stem, the xylem that makes up heartwood provides support but no longer conducts water. The xylem of sapwood functions in the transport of water and minerals.

## QuickLab

**Teacher's Notes** Tell students that xylem is located on the inside and phloem is on the outside of each vascular bundle.

**Materials**

- prepared slides of monocot and dicot roots and stems
- compound microscope

### Answers to Analysis

1. Xylem and phloem in the roots are located in the center of the root. Xylem and phloem in the stem are located in discrete, vascular bundles in the cortex.
2. The vascular bundles in monocot stems are scattered in the ground tissue. The vascular bundles of dicot stems are arranged in a ring.
3. The structure of vascular tissue is specialized to conduct water and nutrients. For example, to conduct water, mature xylem cells lack cytoplasm and a nucleus.

## Demonstration

**Annual Rings in Woody Plants** Show a cross section of a tree trunk with irregular growth rings. Ask students to relate the rings to the tree's history. (Close rings usually indicate slow growth; rings that are closer together on one side indicate growth against an obstacle.) Ask a volunteer to count the rings to estimate the age of the tree. If the cross section is from a recently cut tree, have students identify the ring and year that represents the most rapid growth. LS Logical

## MISCONCEPTION ALERT

**Roses Do Not Have Thorns** The structures that protect the stems of many members of the rose family are not really thorns. Botanically, thorns are modified stems that contain xylem. The "thorns" found on a rose are actually called *prickles*, which are derived from dermal tissue. How can you tell thorns from prickles without using a microscope? (Prickles are easily removed; thorns are not.)

## Teach, continued

**READING TOOLBOX**

**Booklet** Answers may vary but should include information about the structure and function of roots, stems, and leaves.

**READING TOOLBOX**

**Visual Literacy** Have students examine the leaves in **Figure 9** and note the differences. Show students examples of simple and compound leaves. Ask students if there are buds in the axils of simple leaves. (yes) Ask students if there are buds in the axils of leaflets. (no) LS **Visual**

### Teaching Key Ideas

**Leaf Structures** Obtain a photo of the cross section of a leaf from a corn plant and have students compare its structure with the structure of the leaf shown in **Figure 10.** How does the structure of the corn leaf shown differ from the structure of the plant leaf in **Figure 10?** (The corn leaf has a ring of cells surrounding the veins, and it does not have palisade and spongy layers in the mesophyll.) LS **Logical**

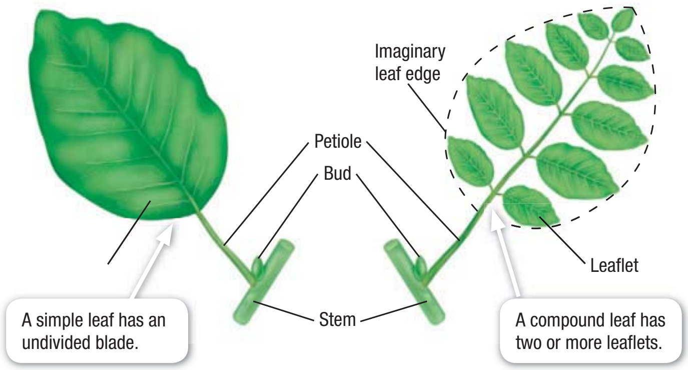



**Figure 9** Most leaves consist of a flattened blade and a petiole that attaches to a stem. **What type of leaf has an undivided blade?**

**READING TOOLBOX**

**Booklet** Make a booklet to help you organize your notes on roots, stems, and leaves.

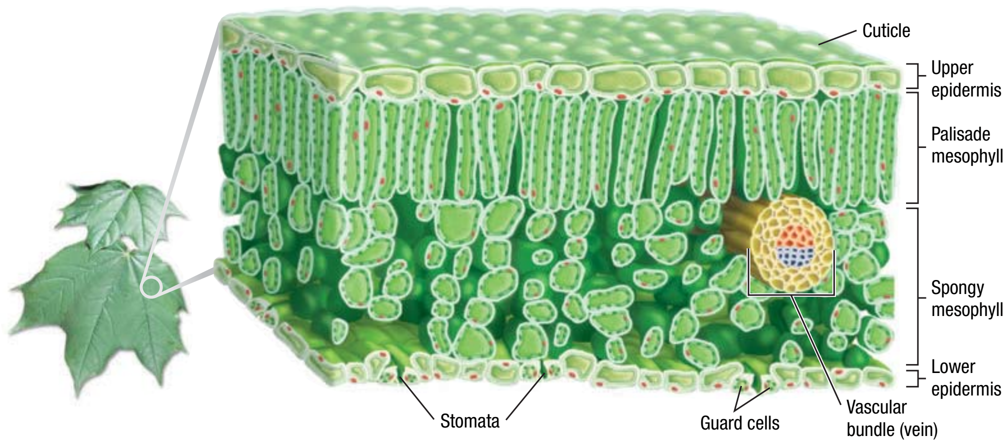
## Leaves

**Leaves are the primary photosynthetic organs of plants.** Most leaves have a flattened portion, the **blade,** which is usually attached to a stem by a stalk, called the **petiole.** A leaf blade may be divided into two or more sections, called *leaflets,* as shown in **Figure 9.** Leaves with an undivided blade are simple leaves. Leaves with two or more leaflets are compound leaves.

A leaf is a mass of ground tissue and vascular tissue covered by epidermis, as shown in **Figure 10.** A cuticle coats the upper and lower epidermis. Both xylem and phloem are found in the veins of a leaf. Veins are extensions of vascular bundles that run from the tips of roots to the edges of leaves.

In leaves, the ground tissue is called **mesophyll.** Mesophyll cells are packed with chloroplasts, where photosynthesis occurs. Most plants have leaves with two layers of mesophyll. One or more rows of closely packed, columnar cells make up the *palisade layer,* which lies just beneath the upper epidermis.

**Figure 10** Cells from all three tissue systems are represented in a leaf. The epidermis is part of the dermal system, and the vascular bundle (vein) is part of the vascular system. The mesophyll is ground tissue, and it generally contains chloroplasts.




### Differentiated Instruction

#### Struggling Readers/English Learners

**Vocabulary Aids** Use the plants from the section on stems along with **Figure 10** to introduce leaf anatomy *before* students read the text. Have them add the terms in **Figure 10** to their flashcard set. They should use the flashcards again, while reading, as an aid to comprehension.

**Figure 11** The spines on a cactus (left) and the tendrils found on many vines (right) are specialized leaves. **› What is one function of cactus spines?**

A layer of loosely packed cells, called the *spongy layer,* lies between the palisade layer and the lower epidermis. The spongy layer has many air spaces through which gases can travel. Stomata, the tiny holes in the epidermis, connect the air spaces to the outside air. Stomata are usually located in the lower epidermis of a leaf.

**Specialized Leaves** Many plants have modified leaves that are specialized for particular functions. For example, the leaves of a water lily are specialized for floating on the surface of ponds. Water lily leaves have stomata on their upper epidermis rather than on their lower epidermis. The leaves of a cactus, such as the one shown in **Figure 11,** have been modified as spines. Spines may help protect the plant from herbivores. Photosynthesis in a cactus takes place in the succulent stem rather than in leaves.

Some of the leaves of the garden pea have been modified to form tendrils that are specialized for climbing, as shown in **Figure 11.** The leaves of the Venus' flytrap have been modified to catch insects that are used by the plant as a source of nitrogen. These plants often grow in areas that are poor in mineral nutrients.

**› Reading Check** ***What are two types of specialized leaves, and what are their functions?***

**blade** the broad, flat portion of a typical leaf

**petiole** (PEHT ee OHL) the stalk that attaches a leaf to the stem of a plant

**mesophyll** (MES oh FIL) in leaves, the tissue between epidermal layers, where photosynthesis occurs

**ACADEMIC VOCABULARY**

**source** the thing from which something else comes

## Section 2 Review

### › KEY IDEAS

1. **Describe** the function of roots, and name two types of root systems.
2. **Describe** the primary functions of stems in a vascular plant.
3. **Name** the primary function of leaves, and describe how leaf structure relates to this function.

### CRITICAL THINKING

4. **Applying Logic** A general recommendation is that you should not remove a lot of the soil from the roots when transplanting plants. Why do you think that this recommendation is made?
5. **Applying Logic** A nail driven into the side of a tree will remain at exactly the same distance from the ground for the life of the tree. Explain.

### ALTERNATIVE ASSESSMENT

6. **Organizing Information** Use library or Internet resources to learn about the many uses of wood. Prepare a poster that includes the types of trees that are common sources of lumber for items such as flooring, furniture, and paper.

## Teaching Key Ideas

**Sugar Maple** Have students do library research on the sugar maple. Then, have each student write an interesting fact about sugar maples on a piece of paper cut in the shape of a maple leaf. Draw the outline of a maple tree on a large sheet of butcher paper, and have students attach their leaves to the branches of the tree. **LS Kinesthetic**

## › Close

### Formative Assessment

The transport channel in the leaf is the ____.

**A.** node (Incorrect. The node is the site where new branch growth occurs.)
**B.** petiole (Incorrect. The petiole anchors the leaf to the stem.)
**C.** vascular bundle (Incorrect. The vascular bundle is the transport channel in the stem and root.)
**D.** vein (Correct. The vein is an extension of the vascular bundles in the stem.)

### *Answers to Caption Questions*

**Figure 9:** simple
**Figure 11:** protection against herbivores

### *Answers to Section Review*

1. Roots function in the uptake of water and nutrients. They also anchor plants in the ground. The roots of some plants store organic nutrients. Two types of root systems are fibrous roots and taproots.
2. Stems provide support and house the vascular tissue, which transports substances between roots and leaves.
3. The primary function is photosynthesis. Leaves are often thin and flat, with a large surface area for gathering light for photosynthesis. Most leaves have stomata, which enable gas exchange to occur.
4. The delicate root hairs could be removed with the soil, which would greatly reduce the surface area of the plant's root system and affect the plant's ability to obtain water and mineral nutrients from the soil.
5. The stem (trunk) of the tree grows in length only at its tips.
6. Reports may vary. White pine is softwood used in many things, from matchsticks to house framing. Hard maple and white oak are hardwoods that are often used for flooring and furniture.

## Why It Matters

**Teacher's Notes** Plants that have adapted successfully to living in extreme environmental conditions have long fascinated scientists. Scientists are conducting research at North Carolina State University in Raleigh to study how plants can be altered to live in extreme conditions in space. Specifically, scientists are looking at the single-celled *Pyrococus furiosus,* which possesses a gene that codes for an excellent antioxidant. This research is a significant step in designing plants that can survive in extreme conditions.

## READING TOOLBOX

**Visual Literacy** Have students identify the adaptations that allow each extreme plant shown to survive and thrive in its environment. Ask students to describe the physical formations that make the plant unusual.

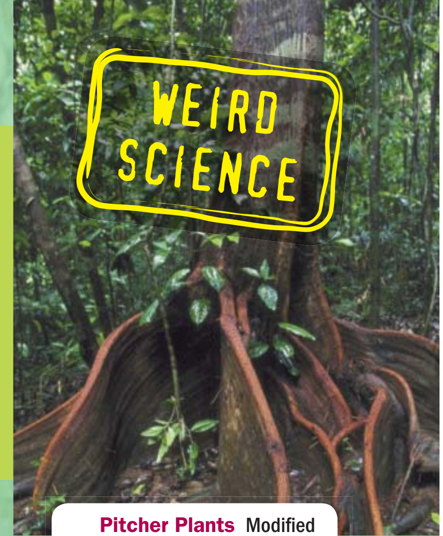
### *Answer to Research*

*Lithops* is derived from the combination of two Greek words: *lithos,* meaning "stone"; and *opsis,* meaning "face or appearance."

## Why It Matters

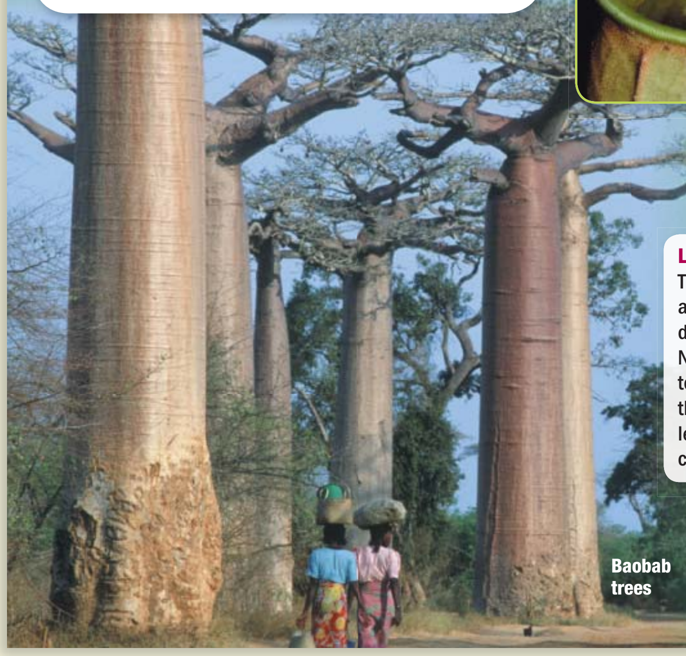
# Extreme Plants

Many plants have developed a variety of strategies to adapt to the unusual and sometimes extreme environments found on Earth. In tropical rainforests, for example, few tree roots penetrate the soil very deeply. This shallow rooting pattern increases the likelihood of trees toppling over, especially during heavy rainfall. Some trees, like the one at right, have special roots called *buttress roots* that grow radially outward from the lower part of the trunk. Buttress roots help stabilize the tree and keep it from toppling over.




### Upside-Down Trees

Baobab trees are among the world's oldest and hardiest trees. They thrive in the harsh, arid environments of Africa. Their unusual barrel-like trunks can reach 9 m (30 ft) in diameter and act as a water tank that can store thousands of gallons of water. Their soft bark is spongy and has adapted to swell with absorbed water in the rainy season. Baobabs have thick, gnarly branches that look like old roots sticking up in the air. For this reason, the baobab has been called the upside-down tree. On the Kalahari Desert, human life would be almost impossible without the baobab. These hollow trees with moisture-rich wood provide sources of water where none otherwise exists. Baobabs are frequently referred to as *Africa's tree of life.*


Baobab trees

**Pitcher Plants** Modified leaves form a "trap" for insects. Insects fall into a pool of liquid at the bottom of the pitcher and are digested by plant enzymes. The proteins from the digested insect supply nitrogen, which otherwise may be unavailable to these plants in the nutrient-poor soil where they grow.

**Living Stones** The "pebbles" shown above are actually highly developed succulent plants called *living stones.* Native to South Africa, living stones are adapted to extreme heat and drought and can survive more than a year without water. Their pebble-shaped leaves minimize evaporation, and their spots and coloring serve as camouflage against herbivores.

**Research** Find the scientific name for living stones, and explain its derivation.

## Differentiated Instruction

### Alternative Assessment

**Summarizing Plant Structures and Functions** Have students take the role of a water molecule in the soil. Ask them to describe their journey from the time they enter a root hair, until they are transpired from a leaf. They should accurately list the structures they pass through as the make their way through the plant.

Section 3

# Plant Growth and Development

| Key Ideas | Key Terms | Why It Matters |
|---|---|---|
| What are the characteristics of a seed plant embryo?<br>How do meristems relate to plant growth?<br>What is the result of primary growth on a plant?<br>What is secondary growth, and what type of meristem is involved? | germination<br>meristem<br>primary growth<br>secondary growth<br>apical meristem<br>lateral meristem | While animals stop growing when they reach maturity, plants continue to grow and develop throughout their lives. |

As in animals, genes guide the development of plants, but the patterns of development in each are very different. Plants continuously make new cells, which differentiate and replace or add to existing tissues.

## The Plant Embryo

Recall that a seed develops from an ovule and contains a plant embryo. **The plant embryo possesses an embryonic root and an embryonic shoot. Leaflike structures called *cotyledons,* or seed leaves, are attached to the embryonic shoot.** The embryos of gymnosperms have two or more cotyledons. For example, pine embryos have eight cotyledons. In the flowering plants, or angiosperms, embryos have one or two cotyledons. Recall that flowering plants with a single cotyledon are called *monocots*. Corn and irises are examples of monocots. Flowering plants with two cotyledons are called *dicots*. Bean plants and sunflowers are examples of dicots. The structure of three types of seeds is shown in **Figure 12.**

**Reading Check** *How many cotyledons does a bean seed have?*

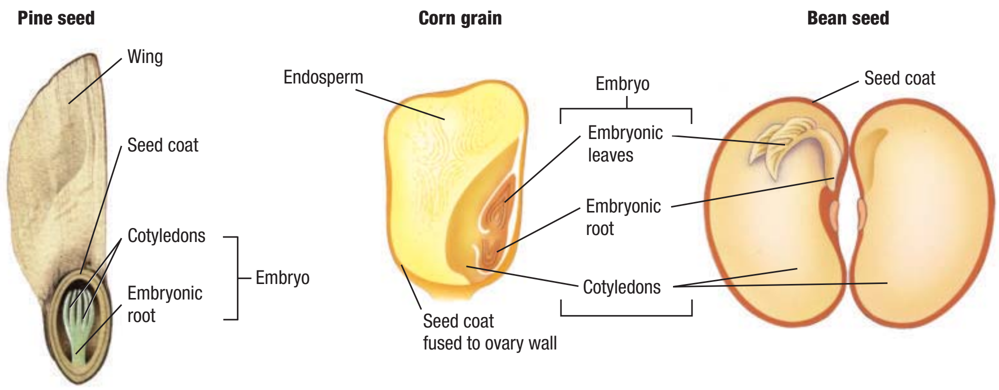



**Figure 12** Seeds contain the embryos of plants. **To which structure are cotyledons attached on the plant embryo?**

Section 3

## Focus

This section explains primary and secondary growth in plants.

**Bellringer**

Use the Bellringer transparency to prepare students for this section.

## Teach

**Demonstration**

**Germination** Show students that plant germination exerts a force that can push the caps off bottles. This demonstration will take a few days. Fill a plastic bottle with beans. Fill another plastic bottle with beans and water. Snap the caps onto the bottles. (Don't use childproof bottles.) In a few days, the germinating beans will knock the caps off or even split the bottle apart. Ask students why the beans with water exert a larger force than the beans without water. (The beans with water are expanding as they germinate.) **LS Logical**

***Answers to Caption Questions***

**Figure 12:** embryonic shoot

## Key Resources

**Transparencies**

G44 Seed Germination
G18 Apical Meristems
G24 Development of a Woody Stem

**Visual Concepts**

Germination of a Monocot
Germination of a Dicot
Primary Growth in Plants
Meristem
Secondary Growth in Plants

## Differentiated Instruction

### English Learners

**Seed Structure** Ask students to draw a cross section showing the structure of a seed. (The drawings should show an embryo, a stored food supply, and a protective outer covering.) Ask students to share their drawings so that you can determine their prior knowledge before beginning this section. Allow ELL students to label their drawings in both their native language and in English. **LS Visual**

## Teach, continued

**Demonstration**

**Seed Germination** Place bean or corn seeds between sheets of wet paper towels, and put the wet towels with seeds in a closed black garbage bag. Place the bag in a warm spot for 3–4 days. Check seeds on days 2 and 3. Cut the germinating seeds for students to view the seeds under a stereomicroscope. Ask students to identify the structures shown in **Figure 13.** LS Visual

**READING TOOLBOX**

**Cause and Effect** Sample answer: When water enters a seed, tissue in the seed swells and the seed coat breaks.

**READING TOOLBOX**

**Visual Literacy** Have students compare the structures of the germinating corn seed and bean seed in **Figure 13.** Ask students how monocot and dicot seedlings differ in the way that they emerge from the soil. (Dicot seedlings have a stem that hooks as it emerges to protect the delicate tip, whereas monocots grow straight out of the soil. Monocot seedlings have a protective sheath that guards the tip.) Ask students what other differences they notice. (The cotyledon and seed coat of the corn seed remain underground, but the cotyledons of the bean emerge from the soil. This difference applies to corn and beans, but not to all monocots and dicots.)

**germination** the beginning of growth or development in a seed, spore, or zygote, especially after a period of inactivity

**meristem** (MER uh STEM) a region of undifferentiated plant cells that are capable of dividing and developing into specialized plant tissues

**primary growth** the growth that occurs as a result of cell division at the tips of stems and roots and that gives rise to primary tissue

**secondary growth** growth that results from cell division in the cambia, or lateral meristems, and that causes the stems and roots to thicken

**Germination** The embryo within a seed is in a state of suspended animation, or *dormancy*. Some embryos can remain in suspended animation for thousands of years. The process by which a plant embryo resumes its growth is called **germination.** The first sign of germination is the emergence of the embryo's root. What happens next varies somewhat from one type of plant to another, as you can see in **Figure 13.** The young shoots of some plants, such as beans, form a hook. The hook protects the tip of the shoot from injury as it grows through the soil. The shoot straightens after the cotyledons emerge from the soil. The young shoots of other plants, such as corn, have a protective sheath around their shoots. The shoot grows straight up, but the cotyledon stays underground. After the shoot of a seedling emerges, its roots and shoots continue to grow throughout its life.

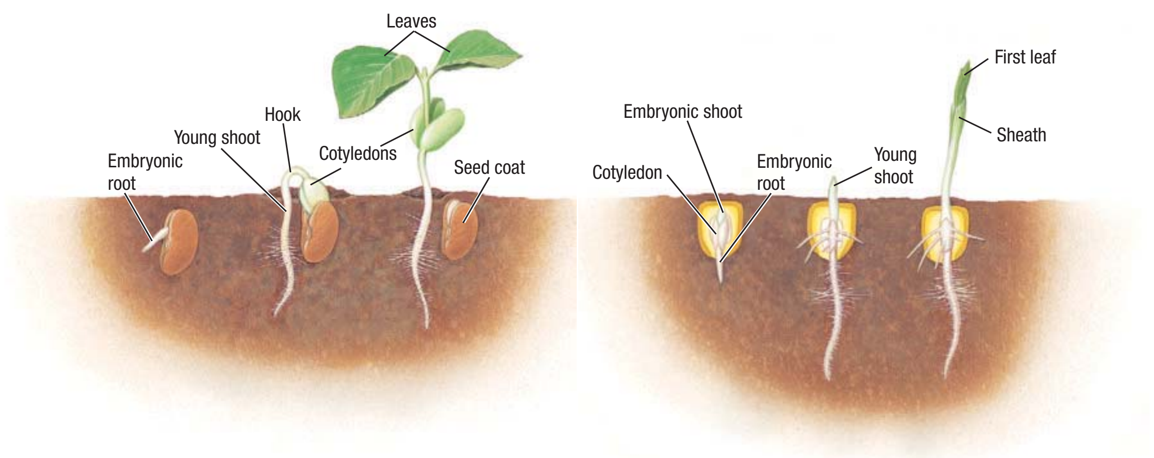
**Breaking Dormancy** Seeds sprout in response to certain changes in the environment. These changes, such as rising temperature and increasing soil moisture, usually signal the start of favorable growing conditions. Many seeds must be exposed to cold before they can sprout. Otherwise, the seeds may sprout too early, such as during warm fall weather. The seed coats of other seeds must be damaged before they can sprout. Being exposed to fire, passing through the digestive system of an animal, and falling onto rocks are several natural ways that seed coats are damaged. A seed cannot sprout until water and oxygen penetrate the seed coat. When water enters a seed, the tissues in the seed swell and the seed coat breaks. If enough water and oxygen are available after the seed coat breaks, the young plant, or seedling, begins to grow.

**READING TOOLBOX**

**Cause and Effect** Use cause and effect language to describe what happens when water penetrates a seed coat.

**Reading Check** ***What are two ways in which the seed coat can be damaged so that the seed will be able to sprout?***

**Figure 13** Beans and corn show two characteristic patterns of seed germination. **How are young shoots protected in dicots and monocots?**




### Answers to Caption Questions

**Figure 13:** In dicots, the shoot forms a hook, which protects the tip of the shoot as it grows through the soil. Monocots have a protective sheath around their shoots.

**Differentiated Instruction**

### Advanced Learners/GATE

**Design a Flower Bed** Have students work in groups of four to design a flower garden that will provide color in every season (or in three seasons, if you live in an area with a harsh winter climate). Provide the students with nursery catalogs to find examples of annuals, biennials, and perennials as well as to determine where each plant will grow and when it will bloom. LS Visual

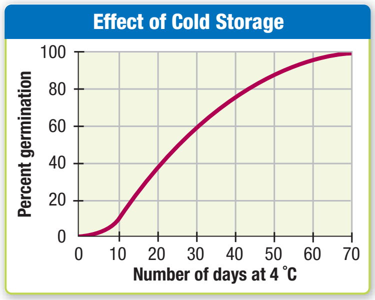
Data

# QuickLab

15 min

## The Effect of Cold on Seed Germination

In some plants, a period of low temperatures is needed to break seed dormancy. Dormancy helps plants to survive by keeping seeds from germinating too early. The graph at right shows how storage at a low temperature (4 °C) affected the ability of apple seeds to germinate. Use the graph to answer the following questions.




### Analysis

1. **Summarize** the overall effect of cold temperatures on the germination of apple seeds.
2. **Calculate** the number of weeks that apple seeds must be stored at 4 °C for at least 80% of the seeds to germinate.
3. CRITICAL THINKING **Interpreting Graphs** What percentage of seeds germinate after storage at 4 °C for 20 days?
4. CRITICAL THINKING **Predicting Patterns** What percentage of apple seeds will germinate after being stored at 4 °C for 80 days?

## Meristems

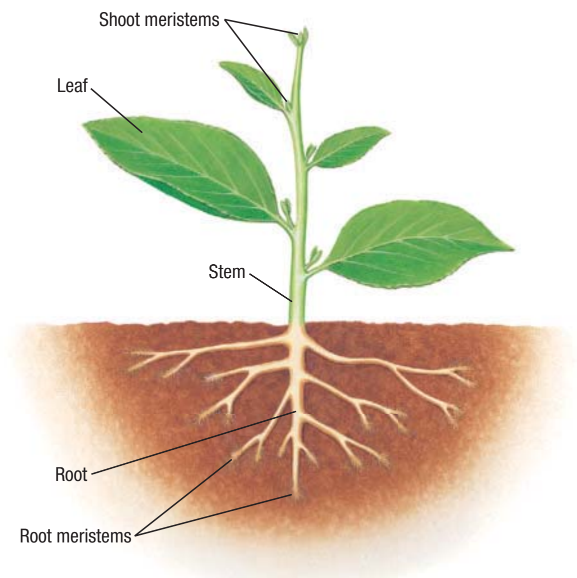
Most seed plants have a body that consists of a vertical shaft from which specialized structures branch, as shown in **Figure 14.** The part of a plant's body that grows mostly upward is called the *shoot,* which consists of stems and leaves. The part of the body that grows downward is called the *root.* The vertical body form results as new cells are made at the tips of the plant body.

**Plants grow by producing new cells in regions of active cell division called meristems.** **Meristems** are made up of undifferentiated cells that divide and can develop into specialized tissues.

Growth that increases the length or height of a plant is called **primary growth.** The tissues that result from primary growth are *primary tissues.* Many plants also become wider as they grow taller. Growth that increases the width of stems and roots is called **secondary growth.** The tissues that result from secondary growth are *secondary tissues.* After new cells are formed by cell division in meristems, the cells grow and undergo differentiation. Recall from your reading that differentiation is the process by which cells become specialized in form and function.

**Reading Check** ***How does primary growth differ from secondary growth?***

**Figure 14** Most vascular plants have an above-ground shoot with stems and leaves and an underground root. Growth occurs in regions called *meristems.*




QuickLab

**Teacher's Notes** Seeds with true dormancy cannot germinate until the plant hormone abscisic acid is either washed away or broken down.

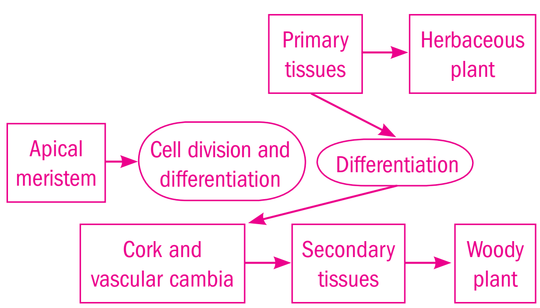
### Answers to Analysis

1. Cold temperatures promote the germination of apple seeds.
2. 45 days ÷ 7 days/week = 6.43 weeks
3. approximately 40 percent
4. 100 percent

## Differentiated Instruction

### Basic Learners

**Graphic Organizer** The diagram shown summarizes the growth patterns for herbaceous and woody plants. Write the terms and phrases, shown in the diagram, as a list on the board. After reading this section, students should use the list to create a graphic organizer for meristems. The diagram shown is one possible answer.



## Teach, *continued*

READING TOOLBOX

**Visual Literacy** Let students observe prepared slides of the apical meristems of the shoots and roots of several plants. Have them draw what they see and label the parts by comparing their drawings to **Figure 14.** Have students write a brief paragraph describing how the cells in the apical meristems differ from those in the surrounding tissues. (The cells of the apical meristems are small and unspecialized. The surrounding cells tend to be larger and longer, and they have thicker walls. Some cells have specialized structures such as chloroplasts or root hairs.) **LS Visual**

### Teaching Key Ideas

**Removal of the Apical Meristem** Ask students what they think would happen if the apical meristem of a stem or root were removed. (Removing or damaging the apical meristems of a plant would stop or limit the vertical growth of the stem or root.) This damage frequently occurs in nature, as tips of stems are broken off by the wind or animals, killed by disease, or eaten by insects or other animals. Lateral buds often begin to grow after the apical meristem is removed. **LS Logical**

**apical** (AP i kuhl) **meristem** the growing region at the tips of stems and roots in plants

**lateral meristem** dividing tissue that runs parallel to the long axis of a stem or a root

SCILINKS
www.scilinks.org
Topic: Primary Growth in Plants
Code: HX81215

## Primary Growth

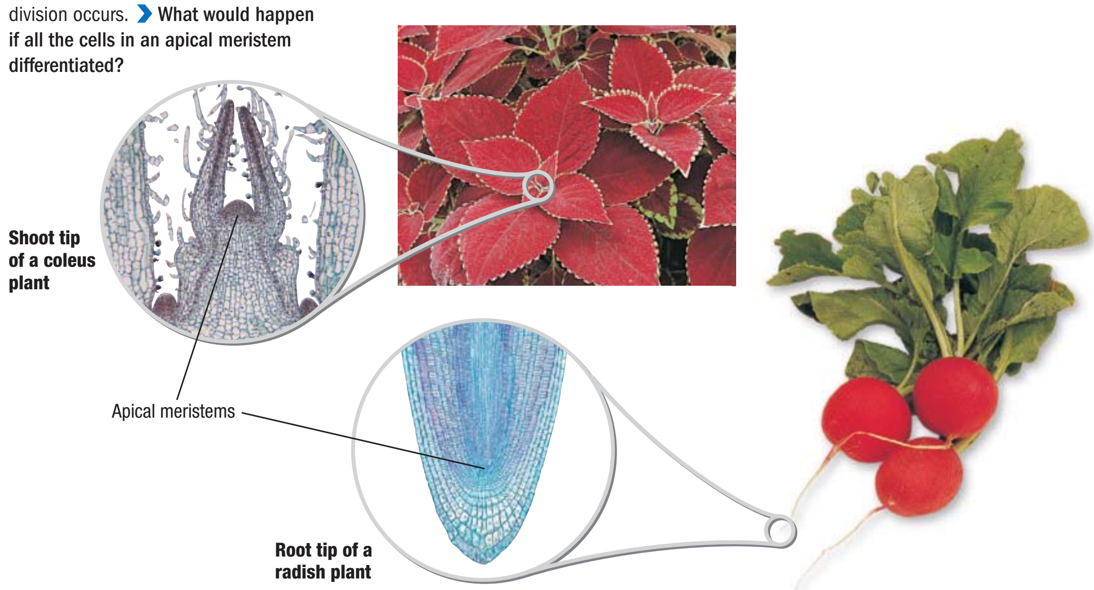
**Apical meristems,** which are located at the tips of stems and roots, produce primary growth through cell division. The new cells produced by apical meristems differentiate into the primary tissues of roots, stems, and leaves. As shown in **Figure 15,** apical meristems are regions of small, undifferentiated cells. The plant embryo within a seed contains two apical meristems, one at the tip of the embryonic root and the other at the tip of the embryonic shoot.

To better understand how primary growth occurs in most plants, imagine a stack of dishes. As you add more dishes to the top, the stack grows taller but not wider. Similarly, the cells in the apical meristems of most plants add more cells to the tips of a plant's body. New cells are added through cell division. The cells then lengthen. **Thus, primary growth makes a plant's stems and roots get longer without becoming wider.**

Primary growth would end if all of the cells produced by an apical meristem differentiated. Some of the new cells produced in an apical meristem are used to replenish the meristem so that primary growth can continue. Other undifferentiated cells are left behind as stems and roots lengthen. These cells can produce new meristems. New apical meristems are found in *buds* at the base of leaves and within roots. When these apical meristems start dividing, the stem or root branches. Each branch of a stem and each branch of a root has its own apical meristem that produces new primary tissues as the branch grows.

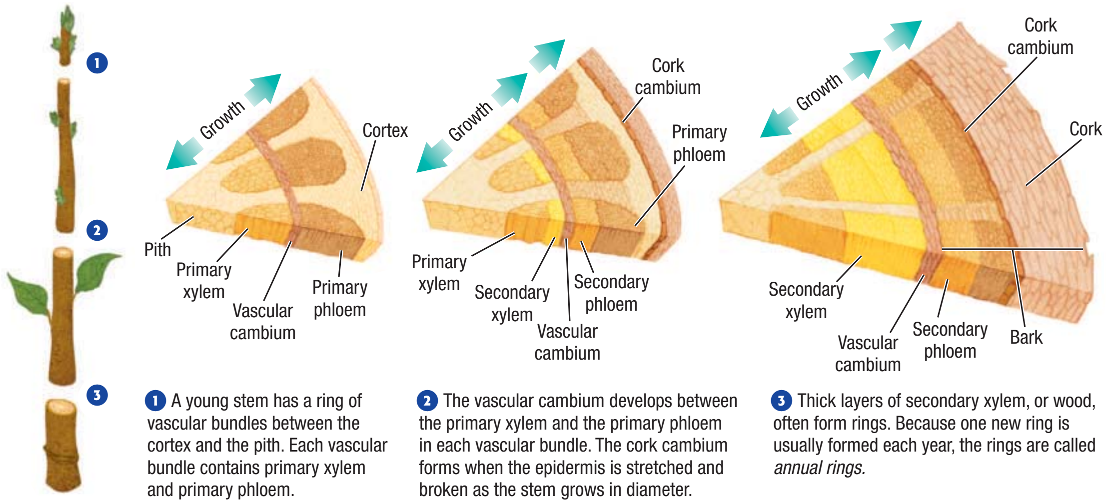
**Reading Check** *How many apical meristems does a plant embryo have?*

**Figure 15** Both shoot tips and root tips contain apical meristems, where cell division occurs. **What would happen if all the cells in an apical meristem differentiated?**




### Why It Matters

**The Asian Art of Bonsai** Bonsai is the cultivation of miniature plant specimens. The effect is obtained by frequent, selective pruning of both the shoots and the roots. Bonsai plants are typically grown in small containers. The word *bonsai* comes from the Japanese characters *bon,* meaning "tray," and *sai*, meaning "plant." The Chinese practiced bonsai in approximately the third century BCE, but the Japanese Buddhist monks perfected the art.




1 A young stem has a ring of vascular bundles between the cortex and the pith. Each vascular bundle contains primary xylem and primary phloem.

2 The vascular cambium develops between the primary xylem and the primary phloem in each vascular bundle. The cork cambium forms when the epidermis is stretched and broken as the stem grows in diameter.

3 Thick layers of secondary xylem, or wood, often form rings. Because one new ring is usually formed each year, the rings are called *annual rings.*

**Figure 16** You can track the development of a woody stem by looking at sequentially older sections of the stem. **› Where in a woody stem does the vascular cambium develop?**

## Secondary Growth

Some of the undifferentiated cells that are left behind as stems and roots lengthen produce **lateral meristems.** **› Lateral meristems are responsible for increases in the width of stems and roots. This increase is called *secondary growth.*** Secondary growth occurs in parts of many herbaceous plants, such as in carrot roots. However, it is most dramatic in woody plants. Secondary growth is produced by cell division in two lateral meristems, which form thin cylinders near the outside of woody stems and roots. One meristem, called the *cork cambium,* lies within the bark and produces cork cells. The other meristem, called the *vascular cambium,* lies just under the bark and produces secondary xylem and secondary phloem. **Figure 16** summarizes secondary growth in woody stems.

**› Reading Check** *What are the names of the two lateral meristems that are responsible for secondary growth?*

## Section 3 Review

### › KEY IDEAS

1. **Identify** the characteristics of a seed plant embryo.
2. **Summarize** the relationship between meristems and plant growth.
3. **Describe** the process of primary growth, and identify the type of meristem involved.
4. **Explain** how secondary growth increases the width of woody stems.

### CRITICAL THINKING

5. **Forming Reasoned Opinions** How might seed dormancy be an evolutionary advantage?
6. **Inferring Conclusions** What would happen to a plant if apical meristems occurred on only one stem and one root of the plant?

### ALTERNATIVE ASSESSMENT

7. **Organizing Information** Use library or Internet resources to research bonsai—the Asian art of growing miniature plants. Relate your findings in an illustrated report that explains plant growth and development in bonsai. Present your report to the class.

## READING TOOLBOX

**Visual Literacy** Review **Figure 16** with students. Many are unlikely to realize that the woody stem shown on the left is related to the cross-section on the right. Ask students why the stem is cut in three places. (to show variation in stem's structure based on its age) If the stem could continue to grow, ask how the drawing might change. (The cross-sections at points 1 and 2 would probably look more like that at point 3 after several years.) What structures appear in the older part of the stem (point 3), that do not appear in the newer stem (points 1 and 2)? (cork and bark)

## › Close

### Formative Assessment

Pruning the apical meristem at the tip of the stem will cause the plant to___.

**A.** wilt (Incorrect. The plant can stil take in water and produce food.)
**B.** die (Incorrect. The plant can still take in water and produce food.)
**C.** develop new apical meristems from buds (Correct. Pruning stimulates the growth of new apical meristems.)
**D.** produce seeds (Incorrect. Removing the apical meristem would not cause seed production.)

### *Answers to Caption Questions*

**Figure 15:** Primary growth would end.
**Figure 16:** between the primary xylem and the primary phloem

### *Answers to Section Review*

1. A seed plant embryo has an embryonic root and embryonic shoot. Seed leaves, or cotyledons, are attached to the embryonic shoot.
2. Cell division that increases the length or height of a plant occurs at the apical meristem. Cell division that increases the width of stems and roots occurs at lateral meristems.
3. Primary growth occurs in the tips of stems, roots, and at buds. The new cells produced by apical meristems differentiate into primary tissues of roots, stems, and leaves.
4. The vascular cambium and the cork cambium add layers of cells to a stem. The vascular cambium produces secondary xylem and phloem. Layers of secondary xylem form wood, and secondary phloem forms the inner layer of the bark. The cork cambium produces cork, which is the outer layer of the bark.
5. Seed dormancy prevents seeds from germinating before conditions are optimal for survival.
6. Sample answer: Only one stem and root would grow in length.
7. Reports may vary. Bonsai plants are shaped by selective pruning, training the roots and shoots, potting in small containers, and limiting water and fertilizer.

# Lab

### Time Required

Three 30-minute lab periods

### Ratings

EASY → HARD

Teacher Prep ⚗⚗
Student Setup ⚗⚗
Concept Level ⚗⚗
Cleanup ⚗

### Safety Cautions

Be sure that students have read and understand all of the safety rules for working in the lab. Caution students to be careful when using the scalpels to avoid injury. Students must wash their hands before leaving the lab.

### Tips and Tricks

Bean seeds and corn kernels may be purchased at a nursery, hardware store, or feed store, or they may be ordered from a biological supply company. **Soak bean seeds and corn kernels prior to this investigation.** Set up labeled containers for the disposal of solutions, broken glass, and seedlings. This investigation must be done in three 30-minute periods over five days. The seed coat of the bean should be easy to remove if the seeds have soaked long enough.

Skills Practice

# Chapter 24 Lab

## Objectives

- Observe the structures of bean seeds and corn kernels.
- Compare and contrast the development of bean embryos as they grow into seedlings.

## Materials

- bean seeds, soaked overnight (6)
- stereomicroscope
- corn kernels, soaked overnight (6)
- scalpel
- paper towels
- rubber bands (2)
- beakers, 150 mL (2)
- pen, glass-marking
- ruler, metric

## Safety

# Monocot and Dicot Seeds

A seed contains an inactive plant embryo. A plant embryo consists of one or more cotyledons, an embryonic shoot, and an embryonic root. Seeds also contain a supply of nutrients. In monocots, the nutrients are contained in the endosperm. In dicots, the nutrients are transferred to the cotyledons as seeds mature. A seed germinates when the embryo begins to grow and breaks through the protective seed coat. The embryo then develops into a young plant, or seedling. In this lab, you will examine bean seeds and corn kernels and then germinate them to observe the development of their seedlings.

## Procedure

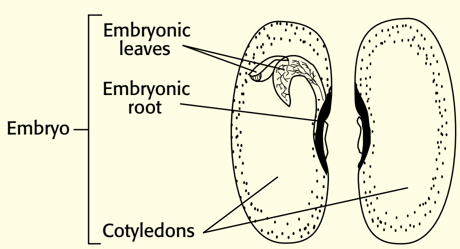
### Observe Seed Structure

1. Remove the seed coat of a bean seed, and separate the two fleshy halves of the seed.
2. Locate the embryo on one of the halves of the seed. Examine the bean embryo with a stereomicroscope. Draw the embryo, and label the parts that you can identify.
3. **CAUTION: Put on goggles before you handle scalpels or glassware. Sharp or pointed objects may cause injury.** Handle scalpels carefully. Examine a corn kernel, and locate a small light-colored oval area. Use a scalpel to cut the kernel in half along the length of this area.
4. Locate the corn embryo, and examine it with a stereomicroscope. Draw the embryo, and label the parts that you can identify.

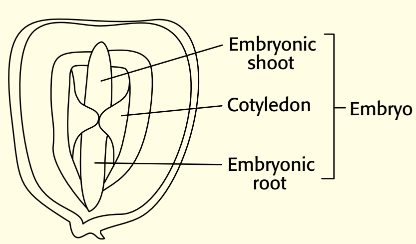
### Observe Seedling Development

5. Fold a paper towel in half. Set five corn kernels on the paper towel.
6. Roll up the paper towel, and put a rubber band around the roll.
7. **CAUTION: Use glass beakers carefully.** Stand the roll in a beaker with 1 cm of water in the bottom.

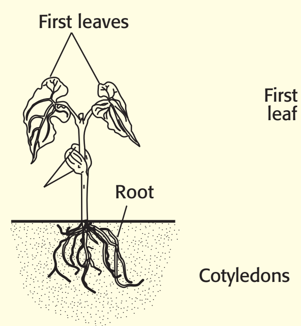
### *Answer to Procedure*



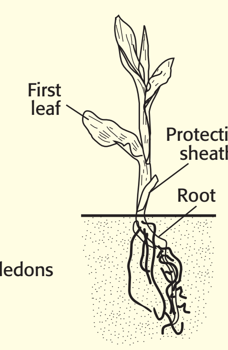

**Bean seed**




**Corn grain**




**Bean seedling**




**Corn seedling**

8 Add water to the beaker as needed to keep the paper towels wet, but do not allow the corn kernels to be covered by water.

9 Repeat step 5 with five bean seeds.

10 After three days, unroll the paper towels, and examine the corn and bean seedlings.

11 Use a glass-marking pen to mark the roots and shoots of the developing seedlings. Starting at the seed, make a mark every 0.5 cm along the root of each seedling. Again, starting at the seed, make a mark every 0.5 cm along the stem of each seedling.

12 Draw a corn seedling and a bean seedling in your lab report. Label the parts of each seedling. Also, show the marks you made on each seedling, and indicate the distance between the marks.

13 Roll up the seeds in a fresh paper towel, place the rolls in the beakers, and add fresh water to the beakers.

14 After two more days, reexamine the seedlings. Measure the distance between the marks. Repeat step 8.

15 Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

Bean seedlings

Corn seedlings

SCILINKS.
www.scilinks.org
Topic: Seed Germination
Code: HX81366

## Analyze and Conclude

1. **Relating Concepts** Corn and beans are often cited as representative examples of monocots and dicots, respectively. Relate the seed structure of each to the terms *monocotyledon* and *dicotyledon.*
2. SCIENTIFIC METHODS **Summarizing Results** What parts of a plant embryo were observed in all seedlings on the third day?
3. **Drawing Conclusions** In which part or parts of bean seedlings and corn seedlings do the seedlings grow in length? Explain.
4. SCIENTIFIC METHODS **Forming Hypotheses** How are the tender young shoots of bean seedlings and corn seedlings protected as the seedlings grow through the soil?
5. **Evaluating Viewpoints** Defend the following statement: There are both similarities and differences in seed structure and seedling development in beans and corn.

## Extensions

6. **Further Inquiry** Write a new question about seedling development that could be explored with another investigation.
7. **Career Connection** Plant physiology is the study of the processes that occur in plants. Do research to discover where plant physiologists work and what types of research are currently being conducted in the field of plant physiology.

### Answers to Analyze and Conclude

1. Corn seeds have only one cotyledon and thus are monocotyledons; bean seeds have two cotyledons and thus are dicotyledons.
2. Embryonic leaves and roots are observed.
3. Bean seedlings grow at the tips of their roots and stems. The distance between the marks has changed at the tips of the stems and the tips of the roots. Corn seedlings grow in length at the tips of their roots. They do not have a visible stem. The distance between the marks changed only on the roots.
4. Bean shoots have a hook in their embryonic stems. The hook pushes through the soil before the cotyledons, which enclose the embryonic shoot. A sheath surrounds and protects corn shoots as they push through the soil.
5. In both beans and corn, the embryo consists of an embryonic shoot, an embryonic root, and cotyledons. As bean embryos and corn embryos develop, their shoots grow up, become green, and form leaves, while their roots grow down and do not become green. Bean seeds have two cotyledons; corn kernels have only one. Corn seeds have endosperm; mature bean seeds do not. The shoots of beans hook as they germinate; a corn shoot grows straight up.
6. Answers will vary. Sample answer: What part of a seedling emerges first?
7. Student reports will vary.

### Key Resources

- Holt Lab Generator
- Lab Datasheet (Levels A, B, C)
- Holt Science Biology Video Labs
- Virtual Investigations

# Chapter 24

## SUPER SUMMARY

Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the keyword **HX8PSFS** to access the Super Summary for this chapter.

### Reteaching Key Ideas

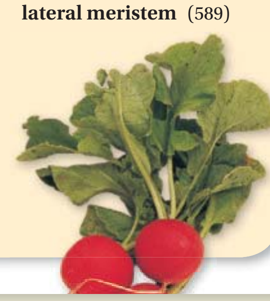
**Vocabulary Development** Have students take out the note cards they prepared in the Reading Toolbox for Section 1. Ask them to arrange the cards in five sets: terms relating to roots; terms relating to stems; terms relating to leaves; terms relating to roots and stems; and terms relating to roots, stems, and leaves. Have students review Section 1 to check the arrangement of their cards. **LS Verbal**

**Media Presentation** Organize students into groups. Have each group use the information in Chapter 24 to prepare a multimedia presentation on plant growth and development that they could give to a middle school science class or to the general public. **LS Visual**

# Chapter 24 Summary

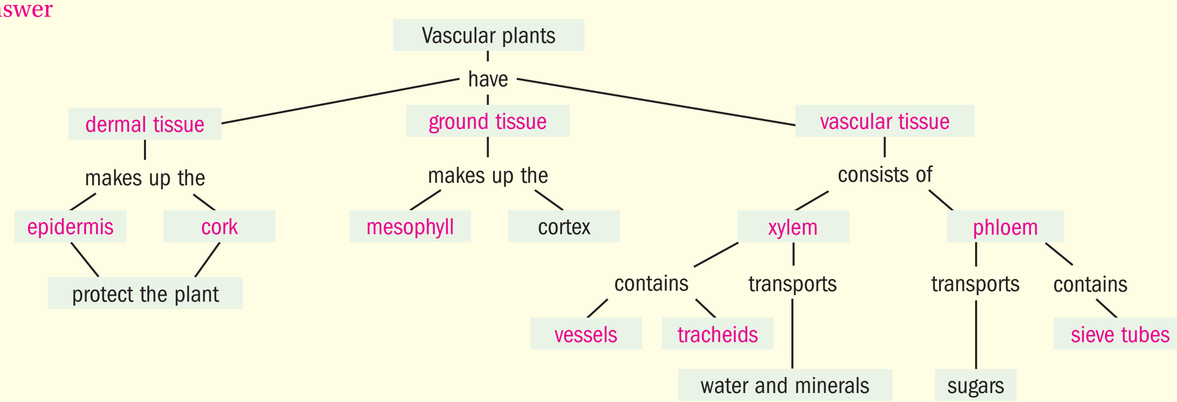
go.hrw.com
SUPER SUMMARY
Keyword: HX8PSFS

| Key Ideas | Key Terms |
|---|---|
| **1 Plant Tissue Systems** | |
| ❯ Vascular plants have three tissue systems—the dermal tissue system, vascular tissue system, and ground tissue system. | dermal tissue (573) |
| ❯ Dermal tissue covers the outside of a plant's body. In the nonwoody parts of a plant, dermal tissue forms a "skin" called the *epidermis.* | vascular tissue (573) |
| ❯ Vascular plants have two kinds of vascular tissue, called *xylem* and *phloem,* that transport water, minerals, and nutrients throughout the plant body. | ground tissue (573) |
| ❯ Ground tissue makes up much of the inside of most nonwoody plants, where it surrounds and supports vascular tissue. | stoma (575) |
| | guard cell (575) |
| | xylem (576) |
| | phloem (576) |
| **2 Roots, Stems, and Leaves** | |
| ❯ Most plants are anchored to the spot where they grow by roots, which absorb water and mineral nutrients. | vascular bundle (580) |
| ❯ Stems support the leaves and house the vascular tissue, which transports substances between the roots and the leaves. | pith (580) |
| ❯ Leaves are the primary photosynthetic organs of plants. | heartwood (581) |
| | sapwood (581) |
| | blade (582) |
| | petiole (582) |
| | mesophyll (582) |
| **3 Plant Growth and Development** | |
| ❯ The plant embryo possesses an embryonic root and an embryonic shoot. Leaflike structures called *cotyledons,* or seed leaves, are attached to the embryonic shoot. | germination (586) |
| ❯ Plants grow by producing new cells in regions of active cell division called *meristems.* | meristem (587) |
| ❯ Apical meristems are reponsible for primary growth, which makes a plant's stems and roots get longer without becoming wider. | primary growth (587) |
| ❯ Lateral meristems are responsible for increases in the width of stems and roots. This increase is called *secondary growth.* | secondary growth (587) |
| | apical meristem (588) |
| | lateral meristem (589) |



### Answer to Concept Map

The following is one possible answer to Chapter Review question 2.



# Chapter 24 Review

## Reading Toolbox

1. **Cause and Effect** Make a list of changes that may occur that cause seeds to break dormancy and germinate.
2. **Concept Map** Make a concept map that describes the organization of the vascular plant body. Try to include the following terms in your map: *cork, dermal tissue, epidermis, ground tissue, mesophyll, phloem, sieve tubes, tracheids, vascular tissue, vessels,* and *xylem.*

## Using Key Terms

**In your own words, write a definition for each of the following terms.**

3. *vascular tissue*
4. *stomata*
5. *petiole*
6. *meristem*

**For each pair of terms, explain how the meanings of the terms differ.**

7. *heartwood* and *sapwood*
8. *primary growth* and *secondary growth*
9. *apical meristem* and *lateral meristem*

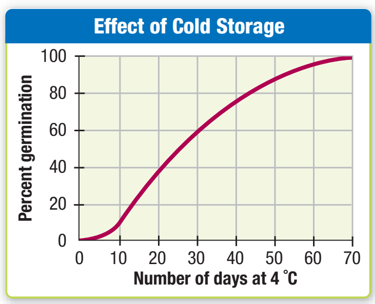
## Understanding Key Ideas

10. Where is dermal tissue normally found in a plant?
    a. within the stem
    b. in the leaves only
    c. covering the outside
    d. in nonwoody plants only
11. Which of the following is *not* a part of the vascular system?
    a. xylem
    b. phloem
    c. tracheid
    d. stomata
12. Which of the following is the main function of ground tissue in stems and roots?
    a. storing nutrients
    b. moving water up the stem
    c. carrying out photosynthesis
    d. helping stomata open and close
13. Which of the following is a characteristic of herbaceous stems?
    a. They are stiff and woody.
    b. They contain heartwood.
    c. They are covered by cork.
    d. They are flexible and green.
14. What are cotyledons?
    a. embryonic leaves of seeds
    b. stalks that attach leaves to stems
    c. regions of undifferentiated plant cells
    d. protective layers of cells that cover root tips
15. Apical meristems located at the tips of stems and roots produce
    a. no growth.
    b. tertiary growth.
    c. primary growth.
    d. secondary growth.

## Explaining Key Ideas

16. **Describe** the function of the cuticle.
17. **Compare** the internal structure of the monocot and dicot nonwoody stem.
18. **Identify** environmental changes that enable seeds to germinate.

**The graph shows how storage at low temperatures affected the ability of apple seeds to germinate. Use the graph to answer the following question.**




19. **Calculate** the number of weeks that apple seeds must be stored at 4 °C for at least 60 percent of the seeds to germinate.

| *Assignment Guide* | |
|---|---|
| **Section** | **Questions** |
| 1 | 2, 3, 4, 10, 11, 12, 16, 24, 25, 26 |
| 2 | 5, 7, 13, 17, 20, 21, 22, 23, 28, 29, 30, 31 |
| 3 | 1, 6, 8, 9, 14, 15, 18, 19, 27 |

# Review

### Reading Toolbox

1. rising temperature, increasing soil moisture, exposure to cold (for some seeds), breaking or damaging the seed coat (for some seeds)
2. See the previous page for answer to concept map.

### Using Key Terms

3. *Vascular tissue* transports material in the plant.
4. *Stomata* open and close to permit the exchange of gases.
5. The *petiole* anchors the leaf to the stem.
6. Cell division at the *meristem* of stems and roots adds to the length or width of the plant.
7. *Heartwood* is in the center or "heart" of the tree. *Sapwood* surrounds the heartwood and contains the vessels for moving water in the woody stem.
8. *Primary growth* adds to the length of the plant; *secondary growth* adds to its girth.
9. The *apical meristem* is a site of primary growth. The *lateral meristem* is the site of secondary growth.

### Understanding Key Ideas

**10.** c **11.** d **12.** a **13.** d
**14.** a **15.** c

### Explaining Key Ideas

16. It prevents water loss.
17. Vascular bundles of the dicot stem are arranged in a ring. Vascular bundles of the monocot stem are scattered throughout the ground tissue.
18. increasing temperature, increasing soil moisture, and exposure to cold or light
19. 4.3 weeks

### Using Science Graphics

**20.** b **21.** d **22.** b **23.** d

### Critical Thinking

24. The vascular tissue system conducts water and nutrients throughout the plant, a function that is similar to the circulatory system of animals.

25. The thin, flexible cell walls of these cells enable expansion to store large amounts of water and nutrients and add support to the plant.

26. *If* the transport of water and nutrients throughout a plant by diffusion limits plant size, *then* plants with vascular systems should be larger than those without vascular systems.

27. The meristems that have not been mowed or eaten will continue to produce primary growth, which keeps the grass growing continuously.

### *Why It Matters*

28. Pitcher plants most likely live in nutrient-deficient soil. They obtain their mineral nutrients from other sources.

29. Students should find that the digestion of insects provides a source of nitrogen for plants adapted to living in nitrogen-deficient habitats, such as peat bogs. Visuals should show the trapping process of each type of plant.

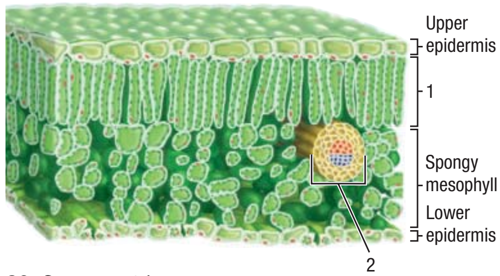
### *Alternative Assessment*

30. Answers may vary, but posters should illustrate or mention the following features: Nonwoody stems are flexible and usually green. They are covered by epidermis and have vascular bundles that contain xylem and phloem. Vascular tissue is surrounded by ground tissue. Woody stems are stiff, nongreen, and contain layers of wood. The vascular tissue is arranged in solid cylinders. The center of a mature stem contains heartwood, which consists of xylem that does not conduct water. Heartwood is surrounded by sapwood, which consists of xylem that does conduct water. Phloem surrounds the cylinder of xylem. Woody stems are covered by cork. Together, the phloem and the cork make up the bark of a woody stem.

31. Reports may vary. Mycorrhizae are mutualistic associations between plants and the fungi associated with their roots. The fungus is able to absorb certain nutrients better than the roots. Mycorrhizae are essential to the normal growth and development of forest trees and many herbaceous plants. They are found extensively throughout forests.

## Using Science Graphics

**Use the diagram of a leaf cross section to answer the following questions.**




**20.** Structure 2 is
- **a.** epidermal tissue.
- **b.** vascular tissue.
- **c.** ground tissue.
- **d.** a strand of heartwood.

**21.** Which of the following events is likely to occur in structure 2?
- **a.** gas exchange
- **b.** manufacture of starch
- **c.** absorption of sunlight
- **d.** transport of water, minerals, and sugars

**22.** Most of the photosynthesis in a leaf occurs in
- **a.** the upper epidermis.
- **b.** structure 1.
- **c.** structure 2.
- **d.** the spongy mesophyll.

**23.** Stomata are found in
- **a.** structure 1.
- **b.** structure 2.
- **c.** the spongy mesophyll.
- **d.** the lower epidermis.

## Critical Thinking

**24. Making Connections** Which plant tissue system functions similarly to the animal circulatory system? Explain your answer.

**25. Applying Logic** Ground tissue functions in nutrient storage and the support of plants. Ground tissue is made mostly of loosely packed, cube-shaped or elongated cells with a large central vacuole and thin, flexible cell walls. Outline how such a cell shape can aid these functions.

**26. Developing Hypotheses** The development of a vascular system has allowed vascular plants to grow much larger than nonvascular plants, such as mosses. Develop this hypothesis.

**27. Applying Logical Thinking** How would the meristems of grasses help them recover from being mowed by people or being grazed by animals?

## Why It Matters

**28. Making Inferences** An unusual leaf modification occurs in carnivorous plants such as the pitcher plant. Pitcher plant leaves function as food traps. The plant receives its mineral nutrients by trapping and digesting insects and small animals. From this information, what can you tell about the type of soil environment in which pitcher plants live? Explain your answer.

**29. Researching and Communicating Information** Use library or Internet resources to learn about carnivorous plants, such as the Venus' flytrap, the sundew, and the pitcher plant. Prepare an illustrated oral presentation in which you describe the trapping process of each type of plant and the importance of insects to the plants.

## Alternative Assessment

**30. Using Graphics Skills** Create a poster that illustrates the differences between and similarities of nonwoody stems and woody stems. Draw, create images on a computer, or use photos from magazine or online resources to illustrate your poster. Display your poster in the classroom.

**31. Evolution in Action** Use library or Internet resources to learn about mycorrhizae, the symbiotic relationship between plants and fungi. Prepare a report, poster, or slide presentation in which you explain the nature of the symbiosis and the frequency of this symbiotic relationship in nature. Present your findings to your class.

# Chapter 24 Standardized Test Prep

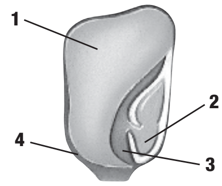
**TEST TIP** When faced with similar answer choices, define the answer choices and then use those definitions to narrow down the choices in a multiple-choice question.

## Science Concepts

1. Which of the following tissues conducts water, minerals, and organic compounds within plants?
   - **A** ground tissue
   - **B** dermal tissue
   - **C** vascular tissue
   - **D** secretory tissue
2. The dermal tissue on woody stems and roots is called
   - **F** sap.
   - **G** skin.
   - **H** cork.
   - **J** cuticle.
3. Grasses have which type of root system?
   - **A** aerial
   - **B** fibrous
   - **C** taproot
   - **D** underground
4. The primary photosynthetic organs of plants are the
   - **F** roots.
   - **G** stems.
   - **H** leaves.
   - **J** flowers.
5. Which of the following phrases describes the structure of a monocot stem?
   - **A** contains vascular bundles that are scattered throughout the ground tissue
   - **B** contains several layers of xylem that are surrounded by a ring of phloem
   - **C** contains a ring of vascular bundles that surrounds a core of ground tissue
   - **D** contains a core of vascular tissue that is surrounded by a ring of ground tissue
6. Primary growth causes
   - **F** seeds to germinate.
   - **G** an increase in the rate of photosynthesis.
   - **H** an increase in the plant's length or height.
   - **J** an increase in the width of stems and roots.

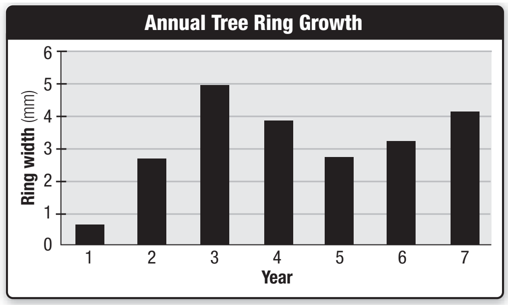
## Using Science Graphics

Use the diagram of a seed to answer the following question.




7. Which structure is the embryonic root?
   - **A** 1
   - **B** 2
   - **C** 3
   - **D** 4

Use the graph showing annual tree ring growth to answer the following questions.




8. Which year showed the greatest growth?
   - **F** 1
   - **G** 3
   - **H** 5
   - **J** 7
9. Which 2 years showed nearly identical growth?
   - **A** 2 and 3
   - **B** 3 and 4
   - **C** 2 and 5
   - **D** 5 and 6

## Writing Skills

10. **Short Response** The primary function of leaves is to carry out photosynthesis. Explain how a leaf's structure is an adaptation that allows intake of carbon dioxide with minimal water loss.

### *Answers*

**1.** C **2.** H **3.** B
**4.** H **5.** A **6.** H
**7.** B **8.** G **9.** C

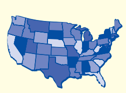
**10.** Leaves have modified epidermal cells (guard cells) that border pores (stomata), which are openings in the leaf surface. Opening of stomata is regulated by guard cells that close the stomata at night and during times of water stress. Other epidermal cells on leaves are covered with a waxy layer (cuticle) that blocks water loss.

### TEST DOCTOR

**Question 2** The term *dermal* should signal that **F** is incorrect. Sap is found within the woody stem. Choice **G** is incorrect because the outer covering of a woody stem is not called skin. Choice **H** is correct. Choice **J** is incorrect because the cuticle is found on a leaf.

**Question 5** Choices **B, C,** and **D** are incorrect because they refer to structures arranged in a ring. This arrangement is characteristic of dicot stems. Choice **A** is correct because the vascular bundles are scattered.

### State Resources



For specific resources for your state, visit go.hrw.com and type in the keyword **HSHSTR**.

**Test Practice with Guided Reading Development**