Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 23.1 **Plant Cells and Tissues** National Science Education Standards UCP.1, UCP.2, UCP.5; A.1, A.2; C.1, C.5 (1 session, $^1/_2$ block)	1. **Identify** the major types of plant cells. 2. **Distinguish** among the functions of the different types of plant tissues.	**Inside Story:** A Plant, p. 628 **MiniLab 23-1:** Examining Plant Tissues, p. 629 **Problem-Solving Lab 23-1,** p. 630 **Investigate BioLab:** Determining the Number of Stomata on a Leaf, p. 646 **Art Connection:** *Red Poppy* by Georgia O'Keeffe, p. 648
Section 23.2 **Roots, Stems, and Leaves** National Science Education Standards UCP.1, UCP.2, UCP.3, UCP.5; A.1, A.2; C.1, C.5 (1 session, 1 block)	3. **Identify** the structures of roots, stems, and leaves. 4. **Describe** the functions of roots, stems, and leaves.	**Problem-Solving Lab 23-2,** p. 639 **MiniLab 23-2:** Looking at Stomata, p. 640
Section 23.2 **Plant Responses** National Science Education Standards UCP.1, UCP.2, UCP.5; A.1, A.2; C.1, C.5, C.6; G.1 (2 sessions, 1 block)	5. **Identify** the major types of plant hormones. 6. **Analyze** the different types of plant responses.	**Problem-Solving Lab 23-3,** p. 644

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab

p. 646 microscope, microscope slide, coverslip, water, dropper, metric ruler, single-edged razor blade, leaf from onion plant

MiniLabs

p. 629 microscope, microscope slides, coverslips, water, dropper, celery stalk

p. 640 microscope, microscope slides, coverslips, water, dropper, 5% salt solution, live plant leaf

Alternative Lab

p. 628 balance, garden trowel, water

Quick Demos

p. 626 slices of apple, celery and pear

p. 633 potato, iodine stain

p. 643 potted houseplants

Key to Teaching Strategies

- **L1** Level 1 activities should be appropriate for students with learning difficulties.
- **L2** Level 2 activities should be within the ability range of all students.
- **L3** Level 3 activities are designed for above-average students.
- **ELL** ELL activities should be within the ability range of English Language Learners.
- **COOP LEARN** Cooperative Learning activities are designed for small group work.
- **P** These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 23.1 **Plant Cells and Tissues**	Reinforcement and Study Guide, p. 101 L2 Concept Mapping, p. 23 L3 ELL BioLab and MiniLab Worksheets, p. 105 L2 Content Mastery, pp. 113-114, 116 L1	Section Focus Transparency 55 L1 ELL Reteaching Skills Transparency 32 L1 ELL
Section 23.2 **Roots, Stems, and Leaves**	Reinforcement and Study Guide, pp. 102-103 L2 Critical Thinking/Problem Solving, p. 23 L3 BioLab and MiniLab Worksheets, p. 106 L2 Laboratory Manual, pp. 161-170 L2 Content Mastery, pp. 113-116 L1	Section Focus Transparency 56 L1 ELL Basic Concepts Transparencies 36, 37 L2 ELL Reteaching Skills Transparencies 33, 34 L1 ELL
Section 23.3 **Plant Responses**	Reinforcement and Study Guide, p. 104 L2 BioLab and MiniLab Worksheets, pp. 107-108 L2 Content Mastery, p. 113, 115-116 L1	Section Focus Transparency 57 L1 ELL

Assessment Resources

Chapter Assessment, pp. 133-138
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 23 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Products Available From Glencoe

To order the following products, call Glencoe at 1-800-334-7344:

CD-ROM
NGS PictureShow: What It Means to Be Green

Curriculum Kit
GeoKit: Plants

Transparency Set
NGS PicturePack: What It Means to Be Green

Videodisc
STV: Plants

Index to National Geographic Magazine

The following articles may be used for research relating to this chapter:

"Beyond Supermouse: Changing Life's Genetic Blueprint," by Robert F. Weaver, December 1984.

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life

CD-ROM ELL
Animation: *Water Uptake in Roots*

Videodisc Program
Water Uptake in Roots

Getting Started Demo

Visual-Spatial Have students examine a potted plant. Look at the plant's roots, stems, and leaves. Ask students to suggest possible functions for each. L1

Theme Development

The theme of **systems and interaction** is apparent as the anatomy of roots, stems, and leaves is examined and the interdependence among these structures is discussed. **Homeostasis** is stressed through the discussion of how plant hormones help maintain balance in plants.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Chapter 23 Plant Structure and Function

What You'll Learn

- You will describe the major types of plant cells and tissues.
- You will analyze the structure and functions of roots, stems, and leaves.
- You will identify plant hormones and determine the nature of plant responses.

Why It's Important

Plants are composed of cells, tissues, and organs. You need to be familiar with the structure of plants so you can understand how they function and how they respond to their environment.

Getting Started

Looking at Plant Organs

Examine a potted plant. *What different plant organs are you able to identify?*

interNET CONNECTION To find out more about plants, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

As you look at this African tulip tree, it is important to remember that plants are composed of individual cells such as the one in the inset photograph.

Section 23.1 Plant Cells and Tissues

The surface of a leaf or flower reveals amazing complexity when viewed under a high-power microscope. When you pick a flower or eat a piece of fruit, you may not give its microscopic structure a minute's thought. The structure of each plant tissue is related to the function it performs. For example, the epidermis of a tomato leaf with its covering of hairs helps protect the delicate tissues of the leaf from possible insect predators.

Tomato plant leaves and fruit (top); glandular hair on leaf (inset)

Section Preview

Objectives

Identify the major types of plant cells.

Distinguish among the functions of the different types of plant tissues.

Vocabulary

parenchyma
collenchyma
sclerenchyma
epidermis
stomata
guard cells
trichome
xylem
tracheid
vessel element
phloem
sieve tube member
companion cell
meristem
apical meristem
vascular cambium
cork cambium

Types of Plant Cells

Like all organisms, plants are composed of cells. Plant cells can be distinguished from animal cells because they have a cell wall, a central vacuole, and can contain chloroplasts. ***Figure 23.1*** shows a typical plant cell. Plants, just like other organisms, are composed of many different types of cells.

Parenchyma

Parenchyma (puh RENG kuh muh) cells are the most abundant kind of plant cell. They are found throughout the tissues of a plant. These spherical cells have thin, flexible cell walls. Most parenchyma cells usually have a large central vacuole, which

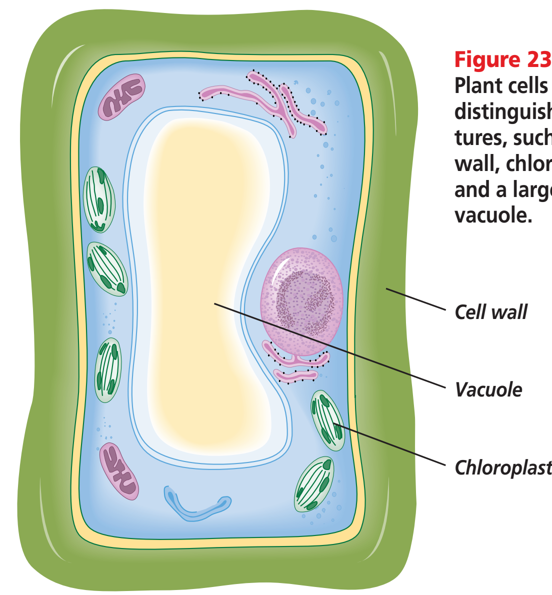


Figure 23.1 Plant cells have many distinguishing features, such as a cell wall, chloroplasts, and a large central vacuole.

Prepare

Key Concepts

This section focuses on the structure and function of plant cells and tissues. The different types of cells and their location in a plant are described. The section concludes with a discussion of plant tissues.

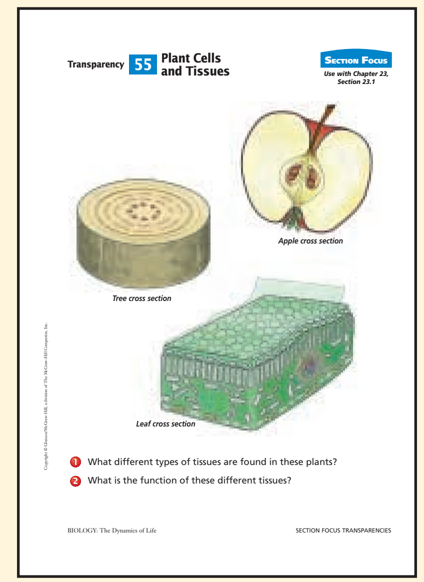
Planning

- Purchase apple, celery, and pear for the Quick Demo.
- Assemble materials for the Reinforcement.
- Purchase celery for MiniLab 23-1.
- Purchase or locate prepared onion root tip slides for the Inside Story.
- Purchase onion leaves for the BioLab.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 55** on the overhead projector and have students answer the accompanying questions. L1 ELL



Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Reinforcement, p. 627; Tech Prep, p. 635; Activity, p. 636; Meeting Individual Needs, pp. 637, 638

Visual-Spatial Getting Started Demo, p. 624; Microscope Activity, pp. 627, 636, 638, 643; Portfolio, pp. 627, 636, 644; Cultural Diversity, p. 630; Meeting Individual Needs, p. 640; Extension, p. 641; Quick Demo, p. 643

Interpersonal Project, p. 634

Linguistic Biology Journal, pp. 627, 639, 642; Reteach, p. 645

Logical-Mathematical Enrichment, p. 635

Assessment Planner

Portfolio Assessment
- Assessment, TWE, pp. 627, 633
- Problem-Solving Lab, TWE, p. 644

Performance Assessment
- Alternative Lab, TWE, p. 628-629
- MiniLab, SE, pp. 629, 640
- MiniLab, TWE, p. 629
- Problem-Solving Lab, TWE, p. 639
- Assessment, TWE, p. 644
- BioLab, SE, p. 646-647

Knowledge Assessment
- Section Assessment, SE, p. 631, 641, 645
- Assessment, TWE, p. 645
- Chapter Assessment, SE, p. 649-651

Skill Assessment
- Problem-Solving Lab, TWE, p. 630
- MiniLab, TWE, p. 640
- Assessment, TWE, pp. 641, 643
- BioLab, TWE, pp. 646-647

2 Teach

Quick Demo

Provide students with slices of apple, celery, and pear. Point out to the students that the soft fleshy tissue of each specimen is composed mostly of parenchyma cells, the stringy fibers in the celery are composed of collenchyma cells, and the gritty particles in the pear are clusters of sclerenchyma cells.

Resource Manager

Section Focus Transparency 55 and Master L1 ELL

Word Origin

par-
From the Greek word *para,* meaning "beside."

coll-
From the Greek word *kolla,* meaning "glue."

scler-
From the Greek words *skleros,* meaning "hard."

With *en* meaning "in," and *chymein* meaning "to pour." Parenchyma, collenchyma, and sclerenchyma are all types of plant tissues.

sometimes contains a fluid called sap, ***Figure 23.2A.***

Parenchyma cells have two main functions: storage and food production. The large vacuole found in these cells can be filled with water, starch grains, or oils. The edible portions of many fruits and vegetables you eat are composed mostly of parenchyma cells. Parenchyma cells are also important in producing food for the plant. These cells contain numerous chloroplasts that produce glucose during photosynthesis.

Collenchyma

Collenchyma (coh LENG kuh muh) cells are long cells with unevenly thickened cell walls, as illustrated in ***Figure 23.2B.*** The structure of the cell wall is important because it allows the cells to grow. The thin portions of the wall can stretch as the cell grows while the thicker parts of the wall provide strength and support. These cells are arranged in tubelike strands or cylinders. The strands of collenchyma provide support for surrounding tissue. The long tough strands you may have noticed in celery are composed of collenchyma.

Sclerenchyma

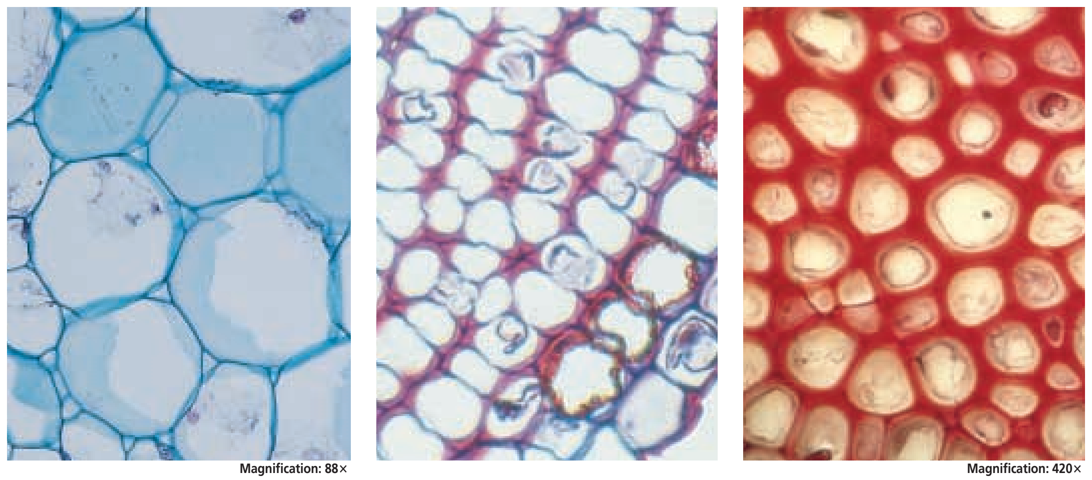
The walls of **sclerenchyma** (skler ENG kuh muh) cells are very thick and rigid. At maturity, these cells often die. Although their cytoplasm disintegrates, their strong, thick cell walls remain and provide support for the plant. Sclerenchyma cells can be seen in ***Figure 23.2C.*** There are two types of sclerenchyma cells commonly found in plants: fibers and stone cells. Fibers are long, thin cells that form strands. These strands provide support and strength for the plant and are the source of fibers used in the manufacture of linen and rope. Stone cells are circular and usually found in clusters. They are responsible for the gritty texture of pears and are a major component of the pits found in peaches and other fruits. Sclerenchyma cells are also a major part of vascular tissue, which you will learn about later in this section.

Figure 23.2
Plants are composed of three basic types of cells, which are shown stained with dyes here.

A Parenchyma cells are found throughout the plant. They have thin walls and a large vacuole.

B Collenchyma cells are often found in parts of the plant that are still growing. Notice the unevenly thickened cell walls.

C The walls of sclerenchyma cells are very thick. These dead cells are able to provide support for the plant.



Meeting Individual Needs

Learning Disabled

Have students prepare a table to summarize the characteristics of plant cells. Organizing these characteristics into a table will help students with learning disabilities to distinguish these cell types. Headings across the top could include: Shape of cells, Nature of cell wall, and Function. Headings down the side of the table should be: Parenchyma, Collenchyma, and Sclerenchyma. L1

Plant Tissues

Recall that a tissue is a group of cells that functions together to perform an activity. There are several different tissue types in plants. Each one is composed of cells working together.

Dermal tissues

The dermal tissue, or **epidermis,** is composed of flattened parenchyma cells that cover all parts of the plant. It functions much like the skin of an animal, covering and protecting the body of a plant. As shown in ***Figure 23.3,*** the cells that make up the epidermis are tightly packed and often fit together like a jigsaw puzzle. The epidermal cells produce the waxy cuticle that helps prevent water loss.

Another structure that helps control water loss from the plant, the stomata, are part of the epidermal layer. The **stomata** (STOH mut uh) are openings in the cuticle of the leaf that control the exchange of gases. Stomata are found on green stems and on the upper and lower surfaces of leaves. In many plants, fewer stomata are located on the upper surface of the leaf as a means of conserving water. Cells called **guard cells** control the opening and closing of the stomata. The opening and closing of the guard cells regulates the flow of water vapor from the leaf tissues. You can learn more about stomata in the *BioLab* at the end of this chapter.

The dermal tissue of roots may have root hairs. Root hairs are extensions of individual cells that help the root absorb water and minerals. On the stems and leaves of some plants, there are structures called trichomes. **Trichomes** are hairlike projections that extend from the epidermis and give the epidermis a "fuzzy" appearance. They help reduce the evaporation of water from the surface of leaves. In some cases, trichomes are glandular and secrete toxic substances that help protect the plant from predators. Stomata, root hairs, and trichomes are shown in ***Figure 23.4.***

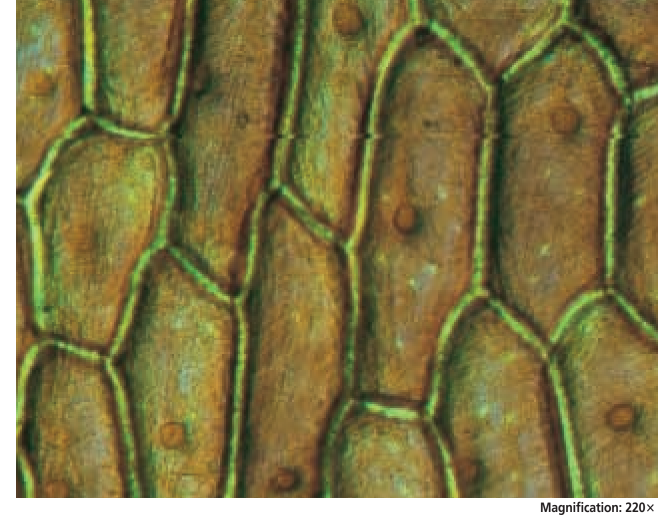
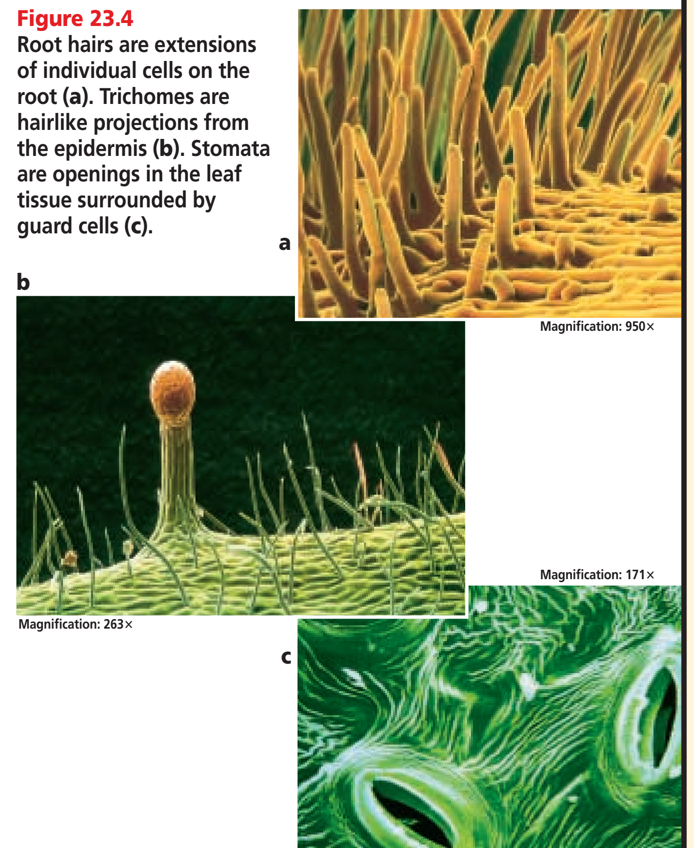


Figure 23.3
The cells of the epidermis fit together tightly to help protect the plant and prevent water loss.

Figure 23.4
Root hairs are extensions of individual cells on the root (a). Trichomes are hairlike projections from the epidermis (b). Stomata are openings in the leaf tissue surrounded by guard cells (c).



Biology Journal

Building a Plant

Linguistic Have students imagine that they are going to build a plant using traditional building materials such as wood, brick, mortar, insulation, etc. Have them describe what materials they would use to build each type of tissue in the plant. L2

Portfolio

Mapping Cells and Tissues

Visual-Spatial Have students construct a concept map showing the relationship between the different types of plant cells and tissues. Have students include their completed concept map in their portfolio. L3 P

Microscope Activity

Visual-Spatial Students can see xylem cells under the microscope if they prepare wet mounts of wood shavings from the pencil sharpener. L1 ELL

Assessment

Portfolio Have students construct a table that includes both the characteristics and functions of plant tissues. Have students place their completed table in their portfolio. L2 P

Reinforcement

Kinesthetic Provide students with scissors, a dissecting needle, tape, and several paper straws. Ask them to use these materials to construct models of vessel cells and sieve cells with their companion cells. Have students draw the nuclei on the straw cells that contain them. Advise students that most xylem cells are dead and, therefore, lack a nucleus. Have students add labels to the straw to identify each type. *Models should have open ends on vessels and closed ends with holes on sieve cells with a companion cell taped next to it.* L2 ELL

The BioLab at the end of the chapter can be used at this point in the lesson. **Investigate BioLab**

Resource Manager

Reteaching Skills Transparency 32 and Master L1 ELL
Concept Mapping, p. 23 L1 ELL
BioLab and MiniLab Worksheets, p. 105 L2

INSIDE STORY

Purpose
Students will study the basic body plan of a plant.

Teaching Strategies
■ Ask students to describe the functions of the four tissue types. L2

Visual Learning
■ Ask students to bring in samples or pictures of leaves, stems, and roots. Have them describe the similarities and differences among the different organs. L2
■ Have students examine a prepared slide of an onion root tip. Point out that apical meristems produce new cells through the process of mitosis. L1

Critical Thinking
Apical meristems are located at the tips of stems and roots. They increase the height of the plant by producing new cells. The vascular cambium produces new phloem and xylem cells. The cork cambium produces the outer layers of bark.

INSIDE STORY

A Plant

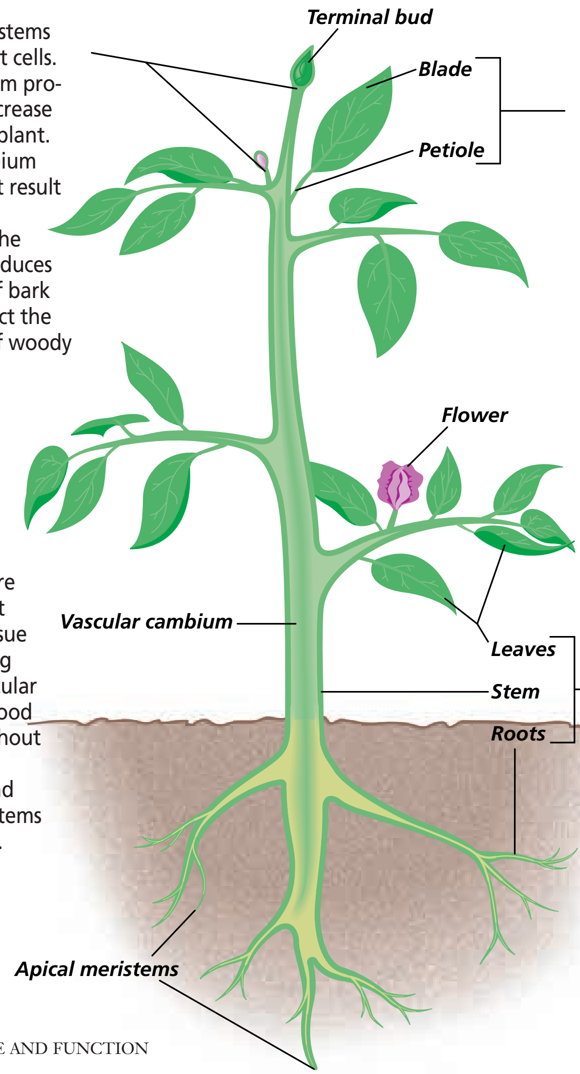
There seems to be an almost endless variety of plants. Regardless of their diversity and numerous modifications, all vascular plants have the same basic body plan. They are composed of cells, tissues, and organs.

Critical Thinking *What are the different types of meristems and how do they help the plant to grow new tissues and organs?*

House plants

1 Meristems Meristems produce new plant cells. The apical meristem produces cells that increase the height of the plant. The vascular cambium produces cells that result in an increase in a stem's diameter. The cork cambium produces the outer layers of bark that help to protect the stems and roots of woody plants.

2 Leaves The leaf of a plant is made up of a blade and petiole. The blade contains cells filled with chloroplasts. The epidermis of a leaf has stomata, which regulate the movement of water and gases between the interior of the leaf and the environment. Sugar that is produced by photosynthesis is transported through the veins of the leaf to other parts of the plant. The petiole connects the leaf to the stem.



3 Organs The organs of a plant are the stem, leaves, and roots. The stem holds the leaves. The leaves are the primary site for photosynthesis. The roots anchor the plant in the soil and absorb water and minerals.

4 Tissues There are four types of plant tissues. Dermal tissue provides a covering for the plant. Vascular tissue transports food and water throughout the plant. Ground tissue produces and stores food. Meristems produce new cells.

Vascular tissues

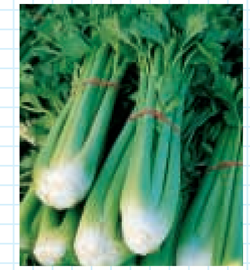
Food, minerals, and water are transported throughout the plant by vascular tissue. Xylem and phloem are the two types of vascular tissues. **Xylem** is plant tissue composed of tubular cells that transport water and minerals from the roots to the rest of the plant. In seed plants, xylem is composed of three types of sclerenchyma cells—tracheids, vessel elements, and fibers. Parenchyma cells are also present.

Tracheids are tubular cells tapered at each end that transport water throughout a plant. As you can see in *Figure 23.5*, both tracheids and vessel elements are cylindrical and dead at maturity. The cell walls between adjoining tracheids have pits through which water and minerals flow. Conifers have tracheids but no vessel elements in their vascular tissues.

Vessel elements are tubular cells that transport water throughout the plant. They are wider and shorter than tracheids. Vessel elements also have openings in their end walls. In some plants, mature vessel elements lose their end walls and water and minerals flow freely from one cell to another. Although almost all vascular plants have tracheids, vessel elements are most commonly found in anthophytes. This difference could be one reason why anthophytes are the most successful plants on Earth. Vessel elements are thought to transport water more efficiently than tracheids because water can flow freely from vessel element to vessel element through the openings in their end walls.

You can learn more about how vascular tissues transport water in the *MiniLab* on this page. What other types of tissues are found in vascular plants? To answer this question, look at the *Inside Story.*

MiniLab 23-1 Observing



Examining Plant Tissues Pipes are hollow. Their shape or structure allows them to be used efficiently in transporting water. Plant vascular tissues have this same efficiency in structure.

Procedure
1. Snap a celery stalk in half and remove a small section of "stringy tissue" from its inside.
2. Place the material on a glass slide. Add several drops of water. Place a second glass slide on top. **CAUTION:** ***Use caution when working with a microscope and slides.***
3. Press down evenly on the top glass slide with your thumb directly over the plant material.
4. Remove the top glass slide. Add more water if needed. Add a cover slip.
5. Examine the celery material under low-and high-power magnification. Diagram what you see.
6. Repeat steps 2-5 using some of the soft tissue inside the celery stalk.

Analysis
1. Describe the appearance of the stringy tissue inside the celery stalk. What may be the function of this tissue?
2. Describe the appearance of the soft tissue inside the celery stalk. What may be the function of this tissue?
3. Does the structure of these tissues suggest their functions?

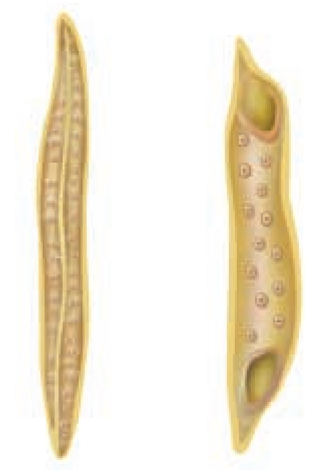


Figure 23.5
Tracheids and vessel elements make up the xylem. The xylem transports water and minerals from the roots, up the stem, and to the leaves.

MiniLab 23-1

Purpose
Students will use a squash technique to prepare, observe, and determine the function of two plant tissue types.

Process Skills
draw a conclusion, interpret data, observe and infer, predict

Safety Precautions
Caution students to be careful while using a razor blade and to cut away from their bodies. To reduce the possibility of injury resulting from glass slide breakage during the squash technique, have students place several layers of paper toweling between their thumb and the top glass slide before pressing down on the slide.

Teaching Strategies
■ One grocery store celery bunch will be sufficient for all classes.
■ Provide students with single-edged razor blades or scalpels for cutting the celery.

Expected Results
The stringy tissue will appear as nongreen tissue that resembles a track, or roadway. The soft tissue will appear green and cubelike in shape.

Analysis
1. tubelike, pipelike, stringlike, nongreen or colorless; transport of materials
2. cubelike, square cells, green in color; storage
3. Yes. Long, narrow cells are ideal for transporting water and nutrients. Cubelike cells would be most suitable for food storage.

Alternative Lab

Differences Between Taproots and Fibrous Roots

Purpose
This lab will allow students to compare taproots and fibrous roots.

Preparation
Locate areas where grass and dandelions are growing.

Materials
garden trowel, metric balance

Procedure
Give students the following directions.
1. Examine pictures of taproots and fibrous roots in your textbook. Which type of root do you think contains more root hairs?
2. Using a trowel, loosen the soil around a dandelion plant. Gently pull the plant out of the soil. Repeat this process with a clump of grass.
3. Record the mass of each plant with its clinging ball of soil. Carefully, rinse away the soil under running water. Weigh and record the mass of the plants again.
4. Determine the ratio between plant mass and plant mass plus soil by dividing the plant mass by the plant mass plus soil.

Expected Results
The fibrous roots should hold more soil in close contact to its roots.

Analysis
1. Based on your ratio, which root type holds more soil in close contact to its roots?
2. Which root type would have a greater surface area for water absorption?

Assessment
Performance Have students write a lab report summarizing this lab. Use the Performance Task Assessment List for Lab Report in **PASC,** p. 47. L3

Assessment
Performance Have students observe other plant tissues. One possible activity is to prepare slide squashes of banana "strings" that remain on the fruit after peeling. Use the Performance Task Assessment List for Making Observations and Inferences in **PASC,** p. 17. L1 ELL

Problem-Solving Lab 23-1

Purpose

Students will determine that water and minerals move upward through stems while sugar moves downward through stems.

Process Skills

analyze information, apply concepts, interpret data, predict, recognize cause and effect

Teaching Strategies

- Review the nature of vascular tissue within the stem of anthophytes but do not specifically mention the role of xylem and phloem.
- Point out to students that many trees are anthophytes.
- Diagrams may be consulted to show that vascular tissue is continuous through a plant's stem.

Thinking Critically

1. Transports food downward through plant; flow of sugar was blocked above metal sheet, causing sugar to accumulate above the metal sheet.
2. Transports water and minerals upward through plant; flow of water and minerals was blocked by metal sheet, causing water to accumulate below the metal sheet.
3. Water and minerals would not be blocked from flowing up the stem, but sugars would be blocked above the metal sheet as phloem is located just inside the bark.

Assessment

Skill Ask students to write a hypothesis describing the experimental concentrations of water, minerals, and sugars 24 hours after inserting a metal sheet all the way through the stem. Have them predict the final outcome if the metal sheet were to remain in place across the tree's stem. Use the Performance Task Assessment List for Formulating a Hypothesis in **PASC**, p. 21. L3

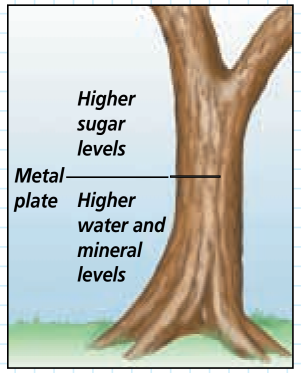
Problem-Solving Lab 23-1 Applying Concepts

What happens if vascular tissue is interrupted? Anthophytes have tissues within their organs that transport materials from roots to leaves and from leaves to roots. What happens if this pathway is experimentally interrupted?

Analysis

A thin sheet of metal was inserted into the stem of a living tree as shown in the diagram. One day later, the following analysis of chemicals was made:

- Concentration of water and minerals directly below the metal sheet was higher than water and minerals directly above the metal sheet.
- Concentration of sugar directly above the metal sheet was higher than sugar concentration directly below the metal sheet.



Thinking Critically

1. What is the function of phloem? Why was the concentration of sugars different on either side of the metal sheet?
2. What is the function of xylem? Why was the concentration of minerals and water different on either side of the metal sheet?
3. How would the experimental findings have differed if the metal sheet were inserted only into the bark of the tree?

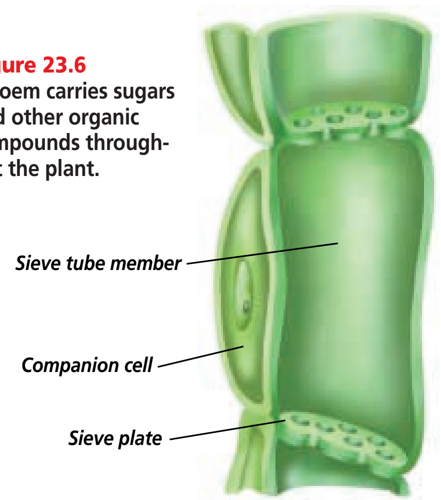


Figure 23.6
Phloem carries sugars and other organic compounds throughout the plant.

Sugars and other organic compounds are transported throughout the plant by the phloem. **Phloem** is made up of a series of tubular cells that are still living and transports sugars from the leaves to all parts of the plant. The structure of phloem, ***Figure 23.6***, is similar to xylem because it is also composed of long cylindrical cells. However the phloem cells, called **sieve tube members,** are alive at maturity. Sieve tube members are unusual because, although they contain cytoplasm, they do not have a nucleus or ribosomes. Next to each sieve tube member is a companion cell. **Companion cells** are nucleated cells that help manage the transport of sugars and other organic compounds through the sieve cells of the phloem. In anthophytes, the end walls between two sieve tube members are called sieve plates. The sieve plates have large pores. The sugar and organic compounds move from cell to cell through these pores. Phloem transports materials from the roots to the leaves as well as from the leaves to the roots.

The vascular tissue of many plants contains fibers. Although the fibers are not used for transporting materials, they are important because they provide support for the plant. You can learn more about vascular tissues in the *Problem-Solving Lab* shown here.

Ground tissue

Ground tissue includes all tissues other than the dermal tissues and vascular tissues. Ground tissue is mostly composed of parenchyma cells but may also include collenchyma and sclerenchyma cells. The functions of ground tissue include photosynthesis, storage, and support. The cells of ground tissue in leaves and green stems contain numerous chloroplasts that carry on photosynthesis. Cells in the stem and root contain large vacuoles that store starch grains and water. Cells, such as those seen in ***Figure 23.7,*** are often seen in ground tissue.

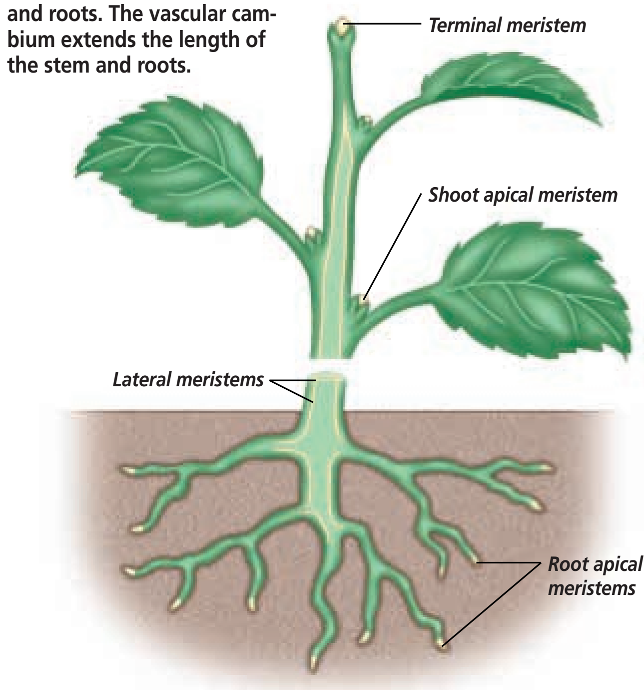
Figure 23.7
The numerous chloroplasts in this ground tissue produce food for the plant.

Meristematic tissues

A growing plant needs to produce new cells. These new cells are produced in areas called meristems. **Meristems** are regions of actively dividing cells. Meristematic cells are small, spherical parenchyma cells with large nuclei. There are several types of meristems.

Apical meristems are found at or near the tips of roots and stems. They produce cells that allow the roots and stems to increase in length. Lateral meristems are cylinders of dividing cells located in roots and stems. ***Figure 23.8*** will help you visualize the location of these meristems. The production of cells by the lateral meristems results in an increase in diameter. Most woody plants have two kinds of lateral meristems: a vascular cambium and cork cambium. The lateral meristem called the **vascular cambium** produces new xylem and phloem cells in the stems and roots. The other lateral meristem, the **cork cambium,** produces a tough covering for the surface of stems and roots. The outer bark of a tree is produced by the cork cambium.

Figure 23.8
The apical meristems are found in the tips of the stem and roots. The vascular cambium extends the length of the stem and roots.



Section Assessment

Understanding Main Ideas

1. What are the distinguishing traits of the three types of plant cells?
2. What is the function of vascular tissue? What are the two different types of vascular tissue?
3. Explain the function of stomata.
4. Draw a plant and indicate where on the plant the apical meristems would be located. How do they differ from lateral meristems?

Thinking Critically

5. What type of plant cell would you expect to find in the photosynthetic tissue of a leaf?

Skill Review

6. **Compare and Contrast** Compare and contrast the cells that make up the xylem and the phloem. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

3 Assess

Check for Understanding

Quiz students orally about the basic characteristics of plant cells and tissues.

Reteach

Write the following terms on the board: storage, food production, support. Ask students to explain what types of cells and tissues would carry out each function. L1

Extension

Ask students what tissues or organs in humans are analogous to plant tissues. L3

Assessment

Skill Have students draw a simple diagram of a plant with roots, stems, and leaves. Have them label the location of the four types of plant tissues. L1 ELL

4 Close

Discussion

Have students explain what types of plant cells they would find in each of the following tissues: dermal, ground, vascular, and meristematic. L2

Resource Manager

Reinforcement and Study Guide, p. 101 L2
Content Mastery, p. 114 L1

Cultural Diversity

Origin and Cultural Significance of Corn

Visual-Spatial Corn was one of the earliest crops to be domesticated, and has been a major food source for Native Americans of both North and South America for about 7000 years. In addition to its importance as a food source, corn also occupies a symbolic place in the culture of many Native American tribes. Ask students working in groups to research uses for corn other than as a food source. Ask each group to prepare an illustrated essay of its findings. L2 COOP LEARN

Section Assessment

1. Parenchyma are spherical, thin-walled cells. Collenchyma are cells with unevenly thickened cell walls. Sclerenchyma cells have very thick cell walls.
2. Vascular tissue transports water, food, and minerals throughout the plant. Xylem and phloem are the two types of vascular tissues.
3. Stomata control the flow of water vapor from the leaf tissue.
4. Apical meristems are found at the tips of stems and roots. Lateral meristems increase stem and root diameter; apical meristems increase root and stem length.
5. parenchyma
6. Xylem and phloem are both composed of cylindrical cells. Xylem cells are dead at maturity, whereas phloem cells are alive.

Prepare

Key Concepts

Roots, stems, and leaves are the focus of this section. The function of roots as water and mineral absorbers is discussed. Next, the function of stems as conduits for water and minerals is presented. Leaf structures are described as they relate to photosynthesis.

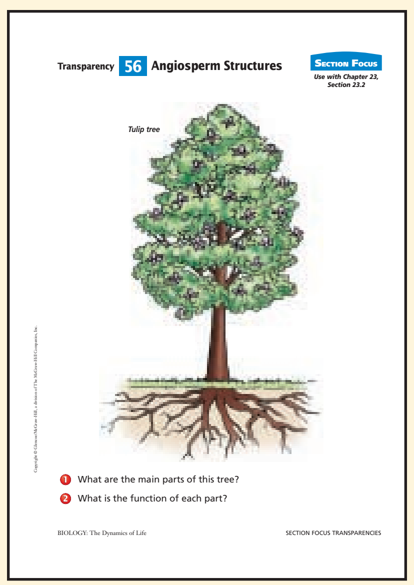
Planning

- Purchase potato and iodine for the Quick Demo.
- Purchase bromothymol blue (BTB) solution and bean seeds for the Project.
- Find leaves for MiniLab 23-2.
- Purchase fertilizer and locate film canisters for Tech Prep.
- Locate thin slices of tree trunk sections for the Activity.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 56** on the overhead projector and have students answer the accompanying questions. L1 ELL


Transparency 56 Angiosperm Structures

SECTION FOCUS
Use with Chapter 23, Section 23.2

Tulip tree

1. What are the main parts of this tree?
2. What is the function of each part?

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BIOLOGY: The Dynamics of Life — SECTION FOCUS TRANSPARENCIES

SECTION PREVIEW

Objectives

Identify the structures of roots, stems, and leaves.

Describe the functions of roots, stems, and leaves.

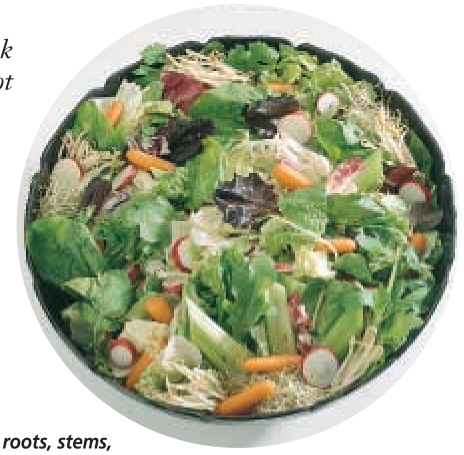
Vocabulary

cortex
endodermis
pericycle
root cap
sink
translocation
petiole
mesophyll
transpiration

Section

23.2 Roots, Stems, and Leaves

The next time you eat salad, look closely at your plate. The carrot is a root, the celery is a leaf stalk, lettuce is a leaf, and a bean sprout includes stems, leaves, and roots. Roots, stems, and leaves are organs of plants and your salad contains several. There are more than one-quarter million kinds of plants on Earth, and their organs exhibit an amazing variety.


Salad of roots, stems, and leaves

Roots

Roots are the underground parts of a plant. They anchor the plant in the ground, absorb water and minerals from the soil, and transport these materials up to the stem. Some plants, such as carrots, also accumulate and store food in their fleshy roots. The total surface area of a plant's roots may be as much as 50 times greater than the surface area of its leaves. As ***Figure 23.9*** illustrates, roots may be short or long, thick or thin, massive or threadlike. Some roots even extend above the ground.

Root systems vary according to the needs of the plant and the texture and moisture content of the soil. The two main types of root systems are taproots and fibrous roots. A taproot is a central fleshy root with smaller branch roots. For example, carrots and beets are taproots. Fibrous root systems have numerous roots branching from a central point. ***Figure 23.9*** shows examples of these root systems. Some plants, such as the corn in ***Figure 23.10***, have adventitious roots called prop roots, which are aboveground roots that help support tall plants. Many climbing plants have aerial roots that cling to objects such as walls and provide support for climbing stems. Bald cypress trees produce modified roots called pneumatophores, which are often referred to as "knees." The knees grow above the water upward from the mud and help supply oxygen to roots in waterlogged areas.

Figure 23.9
The taproot of the carrot can store large quantities of food and water for the plant (a). The fibrous roots of grasses absorb water and anchor the plant (b).

a


b

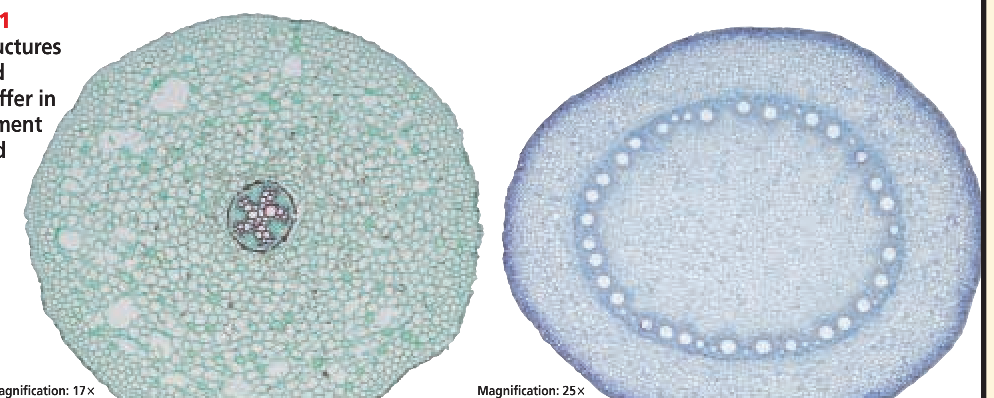

The structure of roots

If you look at the cross section of a typical root in ***Figure 23.11***, you can see that the epidermis forms the outermost cell layer. A root hair is a tiny extension of a single epidermal cell that increases the surface area of the root and its contact with the soil. Root hairs absorb water, oxygen, and dissolved minerals. The next layer is a part of the ground tissue called the **cortex**, which is involved in the transport of water and ions into the vascular core at the center of the root. The cortex is made up of parenchyma cells that sometimes act as a storage area for food and water.

At the inner limit of the cortex lies the **endodermis**, a single layer of cells that forms a waterproof seal that surrounds the root's vascular tissue. The waterproof seal between each cell of the endodermis forces all water and minerals to pass through the cells of the endodermis. Thus, the endodermis controls the flow of water and dissolved ions into the root. Just within the endodermis is the **pericycle.** The pericycle is a tissue that gives rise to lateral roots. Lateral roots are roots that are produced as offshoots of

Figure 23.10
Corn is a monocot with shallow, fibrous roots. As the plants grow to maturity, roots called prop roots grow from the stem to help keep the tall and heavy plants upright.

Figure 23.11
The root structures of dicots and monocots differ in the arrangement of xylem and phloem.



A The xylem in a dicot root is arranged in a central star-shaped fashion. The phloem is found between the points of the star.

B In monocots, there are alternating strands of xylem and phloem that surround a pith of parenchyma cells.

2 Teach

Quick Demo

Demonstrate starch storage in root tubers by adding a few drops of an iodine stain to several slices of potato tuber. Explain that the blue-black color indicates the presence of starch.

Assessment

Portfolio Tell the students to imagine themselves as a drop of water trying to get from the soil to the central vascular tissue of a root. Have them write a paragraph describing their journey. L2 P

Resource Manager

Section Focus Transparency 56 and Master L1 ELL
Laboratory Manual, pp. 161-166 L2

Internet Address Book

interNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants, *What Is a Plant?*
Unit 1, Side 1, 1 min. 40 sec.
Roots and Stems

Tying to Previous Knowledge

Have students recall the differences among facilitated diffusion, active transport, diffusion, and osmosis. If necessary, briefly review these concepts.

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *Water Uptake in Roots*, Disc 3

VIDEODISC
Biology: The Dynamics of Life
Water Uptake in Roots (Ch. 22)
Disc 1, Side 2
40 sec.

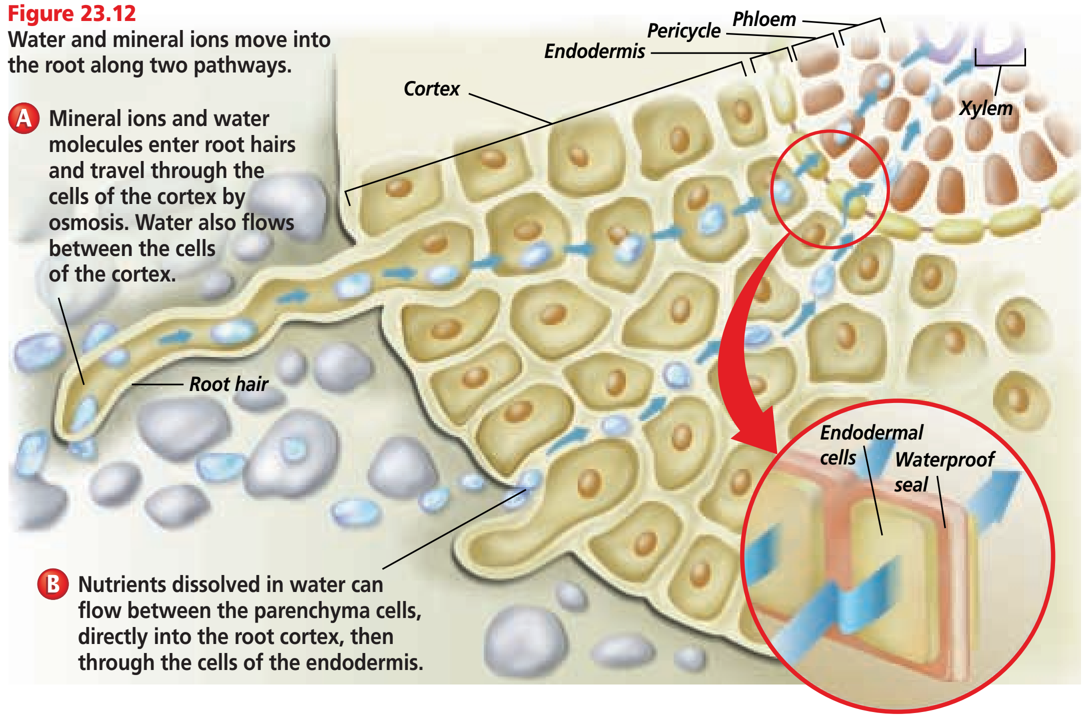


Figure 23.12
Water and mineral ions move into the root along two pathways.

A Mineral ions and water molecules enter root hairs and travel through the cells of the cortex by osmosis. Water also flows between the cells of the cortex.

B Nutrients dissolved in water can flow between the parenchyma cells, directly into the root cortex, then through the cells of the endodermis.

WORD Origin

pericycle
From the Greek words *peri*, meaning "around," and *kykos*, meaning "circle." In vascular plants, the pericycle can produce lateral roots.

endodermis
From the Greek words *endon*, meaning "within," and *dermis*, meaning "skin." In vascular plants, the endodermis is the layer of cells forming the innermost layer of the cortex in roots.

older roots. *Figure 23.12* traces the two pathways by which water and mineral ions move into the root.

Xylem and phloem are located in the center of the root. The arrangement of this xylem and phloem tissue accounts for one of the major differences between monocots and dicots. In dicot roots, the xylem forms a central star-shaped mass with phloem cells between the rays of the star. Monocot roots have strands of xylem that alternate with strands of phloem. There is usually a central core of parenchyma cells in the monocot root that is called a pith. The differences between monocot and dicot roots are illustrated in *Figure 23.11.*

Root growth

There are two meristematic regions in roots where growth is initiated by the production of new cells. Recall that meristems are areas of rapidly dividing cells. The apical meristem produces cells that cause the root to increase in length. As cells produced by the apical meristem begin to mature, they differentiate into different types of cells. The vascular cambium, which is located between the xylem and phloem, soon begins contributing to the root's growth by adding cells that increase its diameter.

Each layer of new cells produced by the apical meristem is left farther and farther behind as more new cells are added and the root pushes forward through the soil. The tip of each root is covered by a tough, protective layer of parenchyma cells called the **root cap.** As the root pushes through the soil, the cells of the root cap wear away. Replacement cells are produced by the apical meristem so the root tip is never without its protective covering. Examine *Figure 23.13* on the following page to see if you can locate all the structures of a root.

Stems

Stems are the aboveground parts of plants that support leaves and flowers. Their form ranges from the thin, herbaceous stems of daisies, which die back every year, to the massive woody trunks of trees that may live for centuries. Green, herbaceous stems are soft and flexible and usually carry out some photosynthesis. Petunias, impatiens, and carnations are examples of plants with herbaceous stems. Trees, shrubs, and some other perennials have woody stems. Woody stems are hard and rigid and contain strands of schlerenchyma fibers and xylem.

Stems have several important functions. They provide support for all the aboveground parts of the plant. The vascular tissues that run the length of the stem transport water, mineral ions, and sugars to and from roots and leaves.

Like roots, stems are adapted to storing food. This enables the plant to survive drought, cold, or seasons with shorter days. Stems that act as food-storage organs include corms, tubers, and rhizomes. A corm is a short, thickened, underground stem surrounded by leaf scales. The term "tuber" may refer to a swollen leaf or stem. When used to refer to a stem, a tuber is a swollen, underground stem that has buds that will sprout new plants. Rhizomes are also underground stems that store food. Some examples of these food-storing stems appear in *Figure 23.14.*

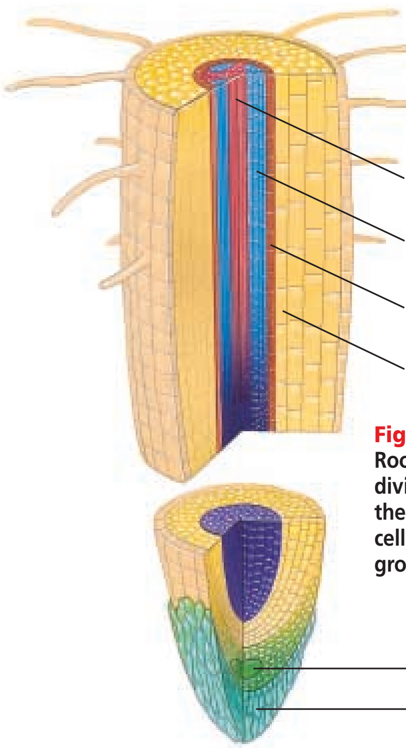
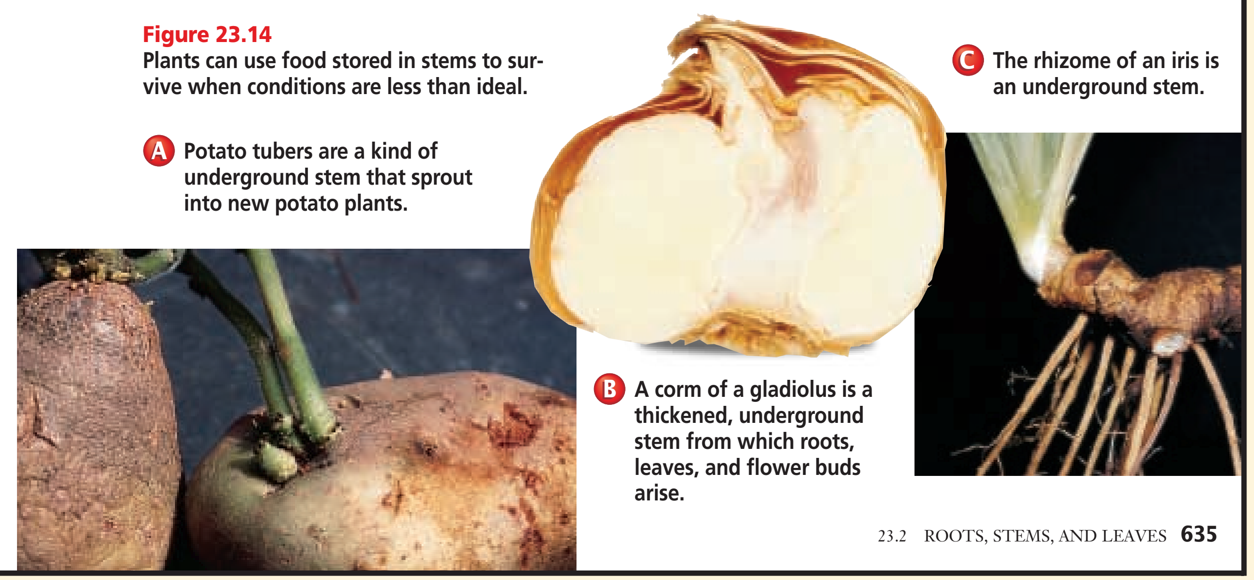


Figure 23.13
Roots develop by both cell division and elongation. As the number and size of cells increases, the root grows in length and width.

Figure 23.14
Plants can use food stored in stems to survive when conditions are less than ideal.



A Potato tubers are a kind of underground stem that sprout into new potato plants.

B A corm of a gladiolus is a thickened, underground stem from which roots, leaves, and flower buds arise.

C The rhizome of an iris is an underground stem.

Enrichment

Logical-Mathematical Hydroponics is an agricultural process in which plants are grown in a nutrient solution rather than soil. Commercial hydroponics was begun in an attempt to reduce famine and eliminate the need for farmers to contend with poor soil conditions and constant weather changes. Unfortunately, hydroponics has not worked well on a large scale.

Ask students to research hydroponics, make a list of all the necessary nutrients and supplies required for a hydroponics garden, and to evaluate the pros and cons of this growth method. L3

PROJECT

Do Roots Respire?

Interpersonal Have student groups carry out the following experiment to answer the question: Do roots carry out respiration and release carbon dioxide? Have students germinate bean seeds and grow young plants (this takes about 10 days). Have students remove plants from soil and place the roots into tubes of bromothymol blue (BTB) solution. Have them seal the roots from the air using a cotton or clay plug. Suggest that they prepare a control tube . Advise students that BTB turns from blue to light blue or green/yellow in the presence of carbon dioxide. Have students observe the liquid 24 hours later. Ask them to write a report summarizing what conclusions can be made regarding root tissue respiration. L2 ELL COOP LEARN

TECHPREP

Which Fertilizers Work Best?

Kinesthetic Use liquid fertilizer to prepare solutions of the following percentages: 100, 80, 60, 40, 20, and 0. For preparation instructions, see page 32T of the Teacher Guide. Assign each student a different concentration. Have students plant seeds (turnip or mustard seeds work well) in film canisters filled with moist potting soil. Place film canisters in a warm sunny location or under fluorescent lights. Once a week, students should add 5 mL of their assigned fertilizer concentration. Students should water their plants as needed, make observations of plant height and appearance, and record observations in individual or class journals. After several weeks, students should compile their observations and draw conclusions about the effects of varying amounts of fertilizer on plant growth. L2 ELL

Activity

Kinesthetic Provide thin slices of tree trunk sections to student groups. Have students count the rings to determine the age of their sample. Ask them to mark with a labeled pin the ring that represents the year when most group members were born, assuming that the tree was cut this year. L2 ELL

Microscope Activity

Visual-Spatial Prepared slides of root cross sections are available from biological supply houses. Allow students to view such slides to help them become familiar with the various tissue names and their locations. Encourage students to sketch their observations. L1 ELL

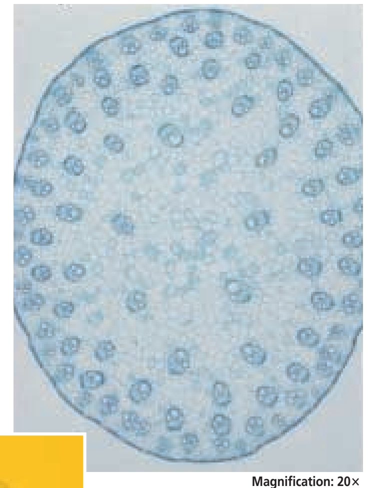
NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants
Woody Stem, Cross Section Showing Rings

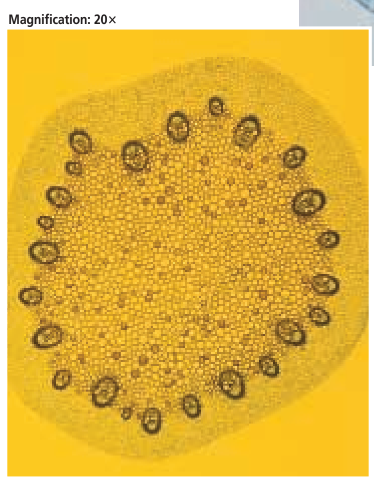
Resource Manager

Critical Thinking/Problem Solving, p. 23 L3

Figure 23.15
One of the primary differences between roots and stems is that stems have the vascular bundles arranged in a circular pattern.

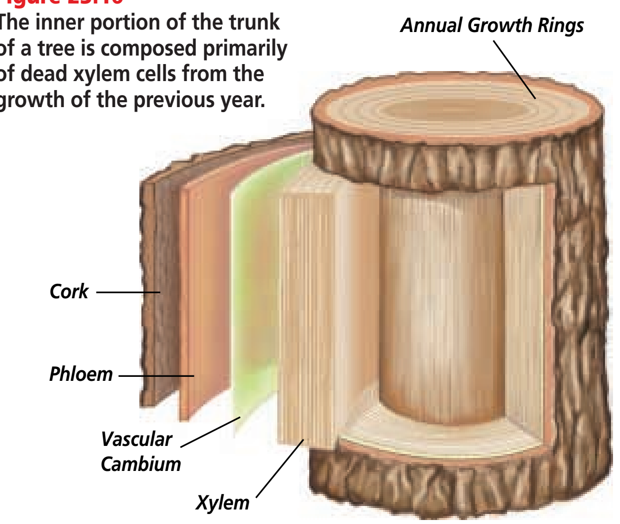


Ⓐ The vascular bundles in a monocot are scattered throughout the stem.



Ⓑ In young herbaceous dicot stems, discrete bundles of xylem and phloem form a ring. In older stems, the vascular tissues form a continuous cylinder.

Figure 23.16
The inner portion of the trunk of a tree is composed primarily of dead xylem cells from the growth of the previous year.



Internal structure

Both stems and roots have vascular tissues. However, the vascular tissues in stems are arranged differently from that of roots. Stems have a bundled arrangement or circular arrangement of vascular tissues within a surrounding mass of parenchyma tissue. As you can see in ***Figure 23.15***, monocots and dicots differ in the arrangement of vascular tissues in their stems. In dicots, xylem and phloem are in a circle of vascular bundles that form a ring in the cortex. The vascular bundles of monocots are scattered throughout the stem.

Woody stems

Many conifers and perennial dicots produce thick, sturdy stems, as shown in ***Figure 23.16***, that may last several years, or even decades. As the stems of these plants grow in height, they also grow in thickness. This added thickness, called secondary growth, results from cell division in the vascular cambium of the stem. The xylem tissue produced by secondary growth is also called wood. In temperate regions, a tree's annual growth rings are the layers of vascular tissue produced each year by secondary growth. These annual growth rings can be used to determine the age of the plant. The vascular tissues often contain sclerenchyma fibers that provide support for the growing plant.

As secondary growth continues, the outer portion of a woody stem develops bark. Bark is composed of phloem cells and the cork cambium. Bark is a tough, corky tissue that protects the stem from damage by burrowing insects and browsing herbivores.

Stems transport materials

Water, sugars, and other organic compounds are transported through the stem. Xylem transports water from the roots to the leaves. The water that is lost through the leaves is continually replaced by water moving up the xylem. The water molecules form an unbroken column within the xylem. As this water moves up through the xylem, it also carries minerals that are needed by all living plant cells.

Phloem transports sugars, minerals, and hormones throughout the plant. The source of these sugars is photosynthetic tissue, which is mostly in the leaves in most kinds of plants. Any portion of the plant that stores these sugars is called a **sink,** such as the parenchyma cells that make up the cortex in the root. The movement of sugars from the leaves through the phloem is called **translocation** (trans loh KAY shun). ***Figure 23.17*** shows the movement of materials through the vascular tissues of a plant.

Growth of the stem

Primary growth in a stem is similar to primary growth in a root. This increase in length is due to the production of cells by the apical meristem, which lies at the top of a stem. As mentioned earlier, secondary growth or an increase in diameter is caused by production of cells by the vascular cambium or lateral meristem. Additional meristems located at intervals along the stem give rise to leaves and branches.

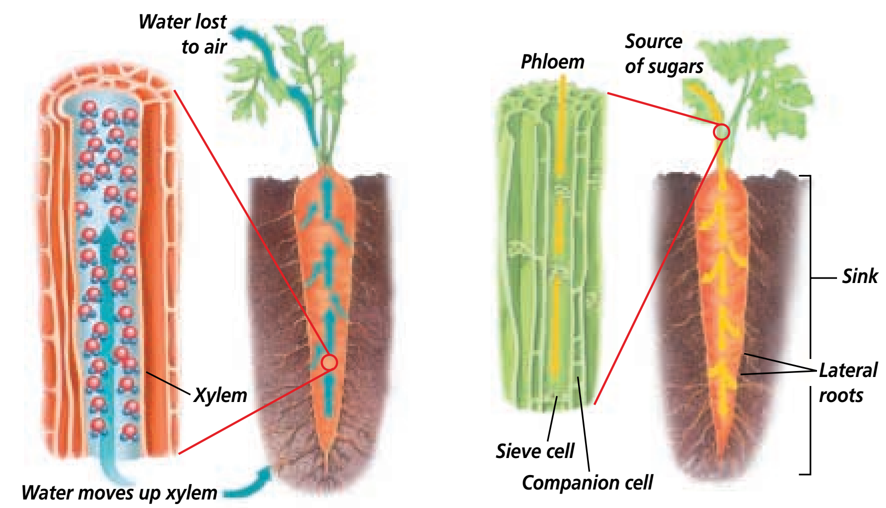
Leaves

The primary function of the leaves is to trap light energy for photosynthesis. Most leaves have a relatively large surface area so they can receive plenty of sunlight. They are also often flattened, so sunlight can penetrate to the photosynthetic tissues just beneath the leaf surface.

Leaf variation

When you think of a leaf, you probably think only of a flat, broad, green structure known as the leaf blade. In fact, sizes, shapes, and types of leaves vary enormously. The giant Victoria water lily that inhabits the rivers of Guyana has leaves that may grow more than two meters in diameter.

Figure 23.17
Xylem carries water up from roots to leaves. Phloem transports sugars from the source in the leaves to sinks located throughout the plant.



Ⓐ The open ends of xylem vessel cells form complete pipeline tubes.

Ⓑ Sugars in the phloem of this carrot plant are moving to sinks.

Enrichment

The neem tree is an anthophyte that grows in India and Thailand. The tree produces a flower with a honey scent and fruit that resembles olives. The neem tree has been called a "cornucopia tree" because of the diverse chemical products made from it. The tree is used to make soap and oils for lubricants and fuel. It has also been used to make an antimalarial agent.

The neem tree is also a powerful insecticide. The tree was found to have a harmful effect on fleas, houseflies, head lice, gypsy moths, boll weevils, and cockroaches. Today, chemicals from the tree are being marketed as a home-and-garden insecticide under the name Bioneem.

Have students research the use of other plants as natural insecticides. Ask students why insecticides derived from plants may be more effective than those developed by humans. L3

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants
What Is a Leaf?
Unit 5, Side 3, 14 min. 15 sec.
What Is a Leaf?
(in its entirety)

Portfolio

A Tree Has Good Years and Bad Years

Visual-Spatial Annual ring thickness is an indication of annual growing conditions. For example, good growing conditions yield a wider ring than years when conditions are poor. Have students use this information to make simple stylized diagrams of a woody stem cross section that illustrates years of both good and poor growth. Have them label their diagrams to show which ring corresponds to which type of growing condition. Encourage students to include additional labels that identify the general location of bark, phloem, cambium, and xylem. L2 P

MEETING INDIVIDUAL NEEDS

Visually Impaired

Kinesthetic Construct a model leaf blade from cardboard. Use straws taped to the cardboard to represent leaf veins and a piece of straw extending beyond the blade to represent the petiole. Allow visually impaired students to compare the model to an actual leaf. L1 ELL

Microscope Activity

Visual-Spatial Students can view prepared slides of leaf cross sections. Have them compare the slides to the leaf cross section in Figure 23.19. Encourage students to draw a diagram of the cross section and label the external and internal structures of the leaf. L2 ELL

NATIONAL GEOGRAPHIC

VIDEODISC
STV: Plants
Cell Layers of a Leaf, Artwork

Transpiration, Artwork

Resource Manager

Reteaching Skills Transparency 33 and Master L1 ELL
Reteaching Skills Transparency 34 and Master L1 ELL
Basic Concepts Transparency 36 and Master L2 ELL
Basic Concepts Transparency 37 and Master L2 ELL

Figure 23.18
Leaf shapes vary, but most are adapted to receive sunlight.

A The leaves of the walnut are compound with many leaflets.

B The arrangement of the needlelike leaves of the evergreen yew allows them to receive the maximum amount of sunlight.

C The tulip poplar is a deciduous tree with broad, distinctive, simple leaves.

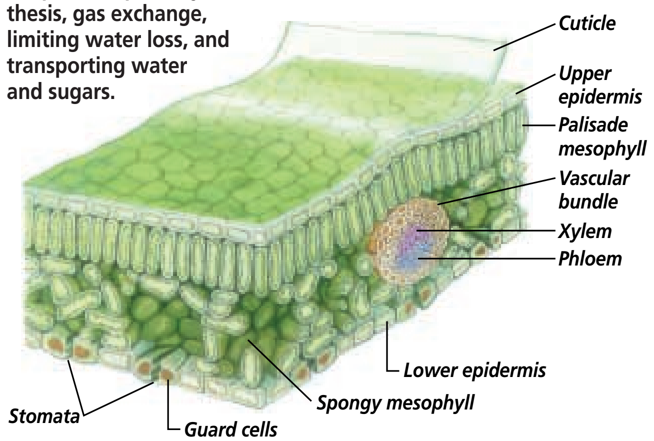


Figure 23.19
The tissues of a leaf are adapted for photosynthesis, gas exchange, limiting water loss, and transporting water and sugars.

The leaves of the tiny duckweed, a common plant of ponds and lakes, are measured in millimeters. Ferns, pines, and flowering plants commonly produce different forms of leaves on the same plant.

Some leaves, such as grass blades, are joined directly to the stem. In other leaves, a stalk joins the leaf blade to the stem. This stalk, which is part of the leaf, is called the **petiole** (PET ee ohl). The petiole contains vascular tissues that extend from the stem into the leaf to form veins. If you look closely, you will notice these veins as lines or ridges running along the leaf blade.

Leaves vary in their shape and arrangement on the stem. A simple leaf is a single leaf with a blade that is not divided. When the blade is divided into leaflets, it is called a compound leaf. Leaves also vary in their arrangement on a stem. When only one leaf is present at each point of the stem, the leaves are arranged in an alternate pattern. When two leaves are arranged in pairs along the length of the stem, the leaves form an opposite pattern. The pairs of leaves may also alternate in position along the stem forming opposite and alternate arrangements. Three or more leaves occurring at the same place on the stem are said to be whorled. ***Figure 23.18*** gives some examples of the variety of leaf shapes and arrangements.

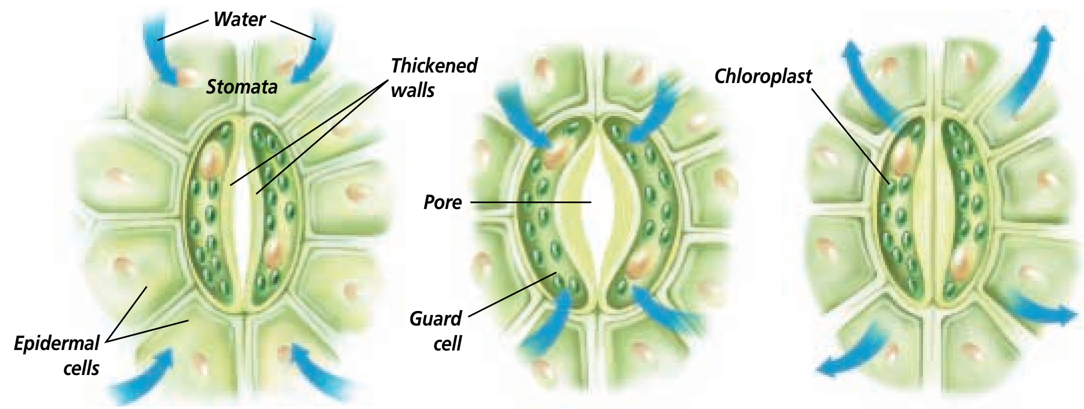
Leaf structure

The internal structure of a typical leaf is shown in ***Figure 23.19.*** The vascular tissue of the leaf is located in the veins that run through the midrib and veins of the leaf. Just beneath the epidermal layer are two layers of mesophyll. **Mesophyll** (MEZ uh fihl) is the photosynthetic tissue of a leaf. It is usually made up of two types of parenchyma cells—palisade mesophyll and spongy mesophyll. The palisade mesophyll is made up of column-shaped cells containing many chloroplasts. These cells are found just under the upper epidermis, allowing for maximum exposure to the sun. Most photosynthesis takes place in the palisade mesophyll. Below the palisade mesophyll is the spongy mesophyll, which is composed of loosely packed, irregularly shaped cells. These cells are surrounded by many air spaces. These air spaces allow carbon dioxide, oxygen, and water vapor to freely flow around the cells. These gases can also move in and out of the stomata, which are located in the dermal layer.

Transpiration

You read previously that leaves have an epidermis with a waxy cuticle and stomata that help prevent water loss. Guard cells are cells that surround and control the size of the opening in stomata, ***Figure 23.20.*** The loss of water through the stomata

Figure 23.20
Guard cells regulate the size of the opening of the stomata according to the amount of water in the plant.



A The guard cells have a thickened inner wall.

B When water enters the guard cells, the pressure causes them to bow out, opening the pore.

C As water leaves the guard cells, the pressure is released and the cells sag together, closing the pore.

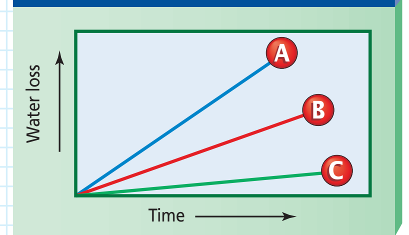
Problem-Solving Lab 23-2 — Drawing Conclusions

What factors influence the rate of transpiration? Plants lose large amounts of water during transpiration. This process aids in pulling water up from roots to stem to leaves where it is needed for photosynthesis.

Analysis

A student was interested in seeing if a plant's surroundings might affect its rate of water loss. A geranium plant was set up as a control. A second geranium was sealed within a plastic bag and a third geranium was placed in front of a fan. All three plants were placed under lights. The student's experimental data are shown in the graph.

Rate of Water Loss



Thinking Critically

1. Which line, A, B, or C, might best represent the student's control data? Explain.
2. a. Which line might best represent the data with the plant sealed within a bag? Explain.
   b. What abiotic environmental factor was being tested?
3. Which line might best represent the data with the plant in front of a fan? Explain.
4. Write a conclusion for the student's experiment.

Meeting Individual Needs

Visually Impaired

Kinesthetic Use two long, inflated balloons as a model of guards cells for visually impaired students. Place the balloons next to each other. Typically, a bow will exist in the center to simulate the stoma opening. Allow students to examine the component parts, guard cells and stoma opening, as you explain what they represent. Push the two balloons together to close the stoma and allow students to reexamine the model. L1 ELL

Biology Journal

A Leaf Analogy

Linguistic Ask students to describe in their journals how a cross-sectional view of a leaf can be represented by a sandwich. Ask students to describe the makeup of a sandwich and relate its component parts to those in the leaf. To get started, tell them to compare the upper epidermis to the top slice of bread. L1

Assessment

Performance Have students perform this experiment. Ask them to prepare an outline of their experimental procedure. Use the Performance Task Assessment List for Carrying Out a Strategy and Collecting Data in **PASC,** p. 25. L2

Problem-Solving Lab 23-2

Purpose

Students will analyze a graph and relate it to factors that influence transpiration rates.

Process Skills

analyze information, compare and contrast, identify and control variables, design an experiment, draw a conclusion, hypothesize, interpret data, make and use graphs, recognize cause and effect, think critically

Teaching Strategies

- Students must be able to correlate sealing of a plant within a plastic bag with a corresponding rise in humidity within the bag. Discuss this idea with students prior to starting this activity. Based on their own experience, does perspiration evaporate from their skin more quickly on a humid day or a less humid day?
- Students must also be able to correlate presence of wind with an increase in water loss through evaporation. Discuss this idea with students prior to starting this activity. Based on their own experience, why is it cooling to sit in front of a fan?

Thinking Critically

1. B; water loss from a fan would be highest, water loss from inside plastic bag would be lowest.
2. a. C; evaporation is reduced due to high humidity within the bag.
   b. amount of humidity or moisture in air
3. A; evaporation is accelerated due to presence of wind.
4. A plant's transpiration rate is related to environmental conditions. High humidity reduces the rate of transpiration. Windy conditions increase the rate of transpiration.

MiniLab 23-2

Purpose
Students will observe stomata and determine how a salt solution affects stomata.

Process Skills
observe and infer, compare and contrast, use the microscope

Safety Precautions
Remind students to be careful when working with microscopes, glass slides, and coverslips.

Teaching Strategies
- Geranium, *Coleus*, or *Tradescantia* leaves work well. If these are unavailable, purchase fresh spinach.
- The epidermis will appear as a clear strip of tissue at the jagged torn edge. Have students use the lower epidermis of the leaf.

Expected Results
Chloroplasts will be seen only in guard cells. The saltwater mount will show closed guard cells. Thus, stomata will appear closed in comparison to the plain water wet mount.

Analysis
1. Cells look like interlocked puzzle pieces. The cells are protective.
2. Guard cells are sausage-shaped and have chloroplasts. Epidermal cells do not have chloroplasts and are irregular in shape.
3. Stomata are closed in the salt solution. The higher water concentration inside the cells compared with that outside of the cells caused water to move out of the guards cells. This causes the guard cells to collapse and close the stomata.

Assessment
Skill Provide students with a diagram of leaf epidermis cells, guard cells, and stomata. Ask them to make a display in which they label each cell type and indicate which cells are capable of carrying out photosynthesis. Use the Performance Task Assessment List for Display in **PASC**, p. 63. L2

MiniLab 23-2 Observing

Looking at Stomata The lens-shaped openings in the epidermis of a leaf allow gas exchange and help control water loss.

Magnification: 3240×

Stomata

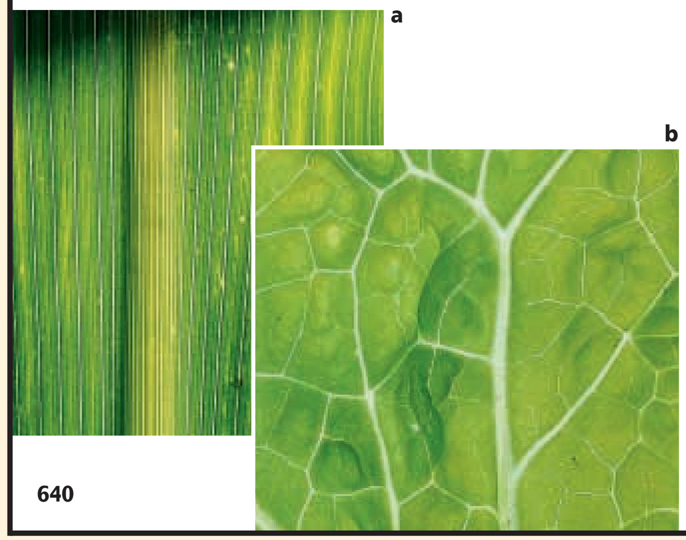
Procedure

1. Make a wet mount by tearing a leaf at an angle to expose a thin section of epidermis. Use tap water to make wet mounts of both the upper and lower epidermis.
2. Examine each of your slide preparations under the microscope. Draw or take down a written description of what you see. **CAUTION:** ***Use caution when working with a microscope, microscope slides, and coverslips.***
3. Make another wet mount using a 5 percent salt solution instead of tap water. Examine the slide under the microscope and record your observations.

Analysis

1. What do the cells of the leaf epidermis look like? What is their function?
2. How do the epidermal cells differ from guard cells? Which cells, if any, contain chloroplasts?
3. What differences in the stomata did you notice when you used a salt solution to prepare your wet mount? Can you explain what happened in terms of osmosis?

Figure 23.21
Leaf venation patterns help distinguish between monocots and dicots. Leaves of corn plants have parallel veins, a characteristic of many monocots (a). Leaves of lettuce plants are net veined, a characteristic of many dicots (b).



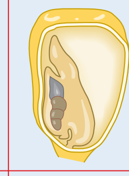
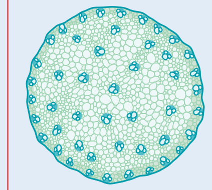
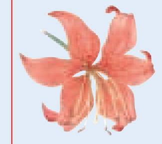
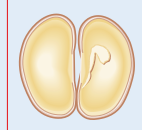
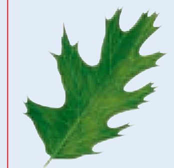
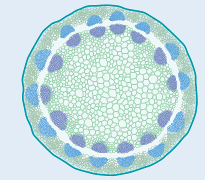
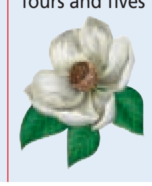
is called **transpiration.** You can learn more about how a plant's surroundings may influence transpiration in the *Problem-Solving Lab* on the previous page.

The opening and closing of guard cells regulate transpiration. As you read about how guard cells work, be sure to look carefully at the diagrams in ***Figure 23.20.*** Guard cells are cells scattered among the cells of the epidermis. The inner walls of these cells are thickened more than the outer walls. When there is plenty of water available in surrounding cells, guard cells take in water by osmosis. When water enters, the thicker inner walls prevent the guard cells from expanding in width, so they expand in length. Because the two guard cells are attached at either end, this expansion in length forces them to bow out and the pore opens. When water is not readily available, there is less water in tissues surrounding the guard cells. Water leaves the guard cells, thus lowering their cell pressure. The cells return to their previous shape, reducing the size of the stomatal pore. The proper functioning of guard cells is important because plants lose up to 90 percent of all the water they transport from the roots through transpiration. You can learn more about the structure and function of stomata in the *MiniLab* shown here.

Venation patterns

One way to distinguish among different groups of plants is to examine the pattern of veins in their leaves. The veins of vascular tissue run through the mesophyll of the leaf. As shown in ***Figure 23.21,*** leaf venation patterns may be parallel, as in many monocots, or netlike, as in most dicots. ***Table 23.1*** summarizes the many differences among the tissues of monocots and dicots.

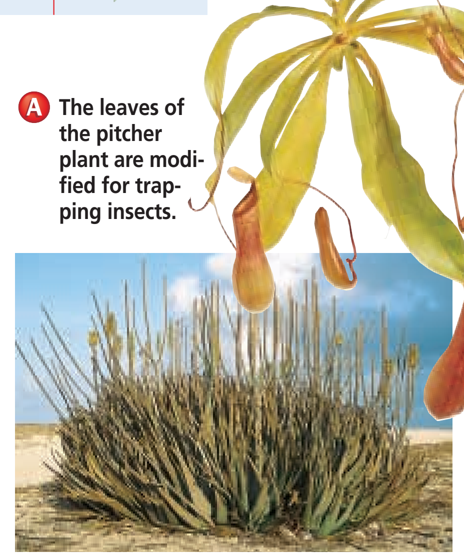
Table 23.1 Distinguishing characteristics of monocots and dicots

	Seed leaves	Veins in leaves	Vascular bundles in stems	Flower parts
Monocots	one cotyledon 	usually parallel 	scattered 	multiples of threes 
Dicots	two cotyledons 	usually netlike 	arranged in ring 	multiples of fours and fives 

Leaf modifications

Many plants have leaves that are modified for functions other than photosynthesis, such as protection and food storage. Cactus spines are modified leaves that reduce water loss and protect the plant from herbivores. A bulb is a short stem covered by enlarged, fleshy leaf bases. The first flowers of spring usually bloom from bulbs. The fleshy leaf bases of onion and daffodil bulbs are modified for food storage. The leaves of some plants are even modified to catch insects. Examples of modified leaves are shown in ***Figure 23.22.***

Figure 23.22
Modified leaves serve many functions in addition to photosynthesis.



A **The leaves of the pitcher plant are modified for trapping insects.**

B **The leaves of this *Aloe vera* plant are adapted to store water in a dry desert environment.**

Section Assessment

Understanding Main Ideas
1. Compare and contrast the arrangement of xylem and phloem in dicot roots and stems.
2. In a plant with leaves that float on water, such as a water lily, where would you expect to find stomata? Explain.
3. What is the primary function of most leaves? What are some other functions of leaves?
4. Explain how guard cells regulate the size of the stomatal pore.

Thinking Critically
5. Compare and contrast the function and structure of the epidermis and the endodermis in a vascular plant.

Skill Review
6. **Making and Using a Table** Construct a table that summarizes the structure and functions of roots, stems, and leaves. For more help, refer to *Organizing Information* in the **Skill Handbook.**

3 Assess

Check for Understanding
Have students explain the difference between the terms of the following word groups. L2
a. transpiration—translocation
b. palisade mesophyll—spongy mesophyll
c. guard cells—stomata
d. epidermis—endodermis

Reteach
Have students explain how the words in each pair listed above are alike or related. L2

Extension
Visual-Spatial Provide students with black line drawings of cross sections of roots, stems, and leaves. Have students label the drawings using terms from the text. L1

Assessment
Skill Have students list in a table as many differences and similarities as possible between monocots and dicots. Differences should center on vein patterns and differences in the pattern of vascular bundles. Similarities are general anatomy, multicellularity, and the ability to photosynthesize. L2

4 Close

Discussion
Have students compare and contrast the functions of roots, stems, and leaves. L1

Meeting Individual Needs

Learning Disabled
Visual-Spatial Have students sequence the steps involved in the opening and closing of stomata. Sequencing each step will help learning disabled students to understand the overall functioning of the stomata. L1

Resource Manager

BioLab and MiniLab Worksheets, p. 106 L2
Reinforcement and Study Guide, pp. 102-103 L2
Content Mastery, pp. 114-115 L1
Laboratory Manual, pp. 167-170 L2

Section Assessment

1. In dicot roots, xylem forms a star-shaped figure in the center with phloem between the star rays. In stems, xylem and phloem are arranged in bundles that form a circle with the phloem outside of the xylem.
2. Stomata would be on the upper surface that is exposed to the air. This will allow for gas exchange with the air.
3. The primary function is to trap light energy for photosynthesis. Some are modified for storage and protection.
4. When there is plenty of water, the guard cells swell and bow out, opening the stomata.
5. The endodermis and epidermis both control the movement of water. The endodermis is located within the root, whereas the epidermis is the external covering of a plant.
6. Roots anchor the plant in the ground, absorb water and minerals and transport material up to the stem. Stems provide support and transport water, mineral ions and sugars to and from roots and leaves. Leaves trap light energy for photosynthesis.

Prepare

Key Concepts

In this section the major types of plant hormones are described and their effects on plant growth are discussed. Tropic and nastic plant responses are explained.

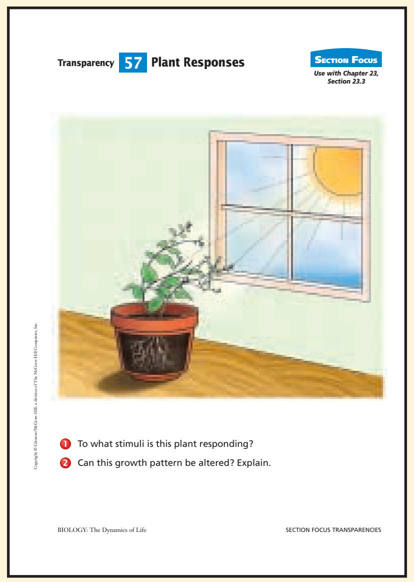
Planning

- Locate onion root tip slides for Microscope Activity.
- Obtain plants and gibberellic acid for the Meeting Individual Needs - Gifted.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 57** on the overhead projector and have students answer the accompanying questions. L1 ELL



SECTION PREVIEW

Objectives

Identify the major types of plant hormones.

Analyze the different types of plant responses.

Vocabulary

hormone
auxin
gibberellin
cytokinin
ethylene
tropism
nastic movement

Section

23.3 Plant Responses

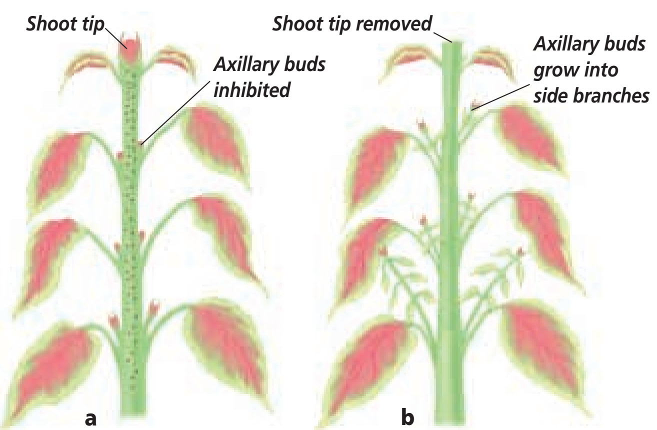
Plants cannot laugh or cry. They do not exhibit behaviors you commonly see in animals, but they do react to their environment. They move in response to light and gravity. The flowering heads of sunflowers can be seen to turn in response to the movement of the sun as it moves across the sky. If a plant is growing in a dark forest and a tree falls allowing in more light, the plant will grow towards the light.

Sunflowers

Plant Hormones

Plants, like animals, have hormones that regulate growth and development. A **hormone** is a chemical that is produced in one part of an organism and transported to another part, where it causes a physiological change. Only a small amount of the hormone is needed to make this change.

Figure 23.23 Auxin from the tip of the main shoot inhibits the growth of side branches (a). Once the main tip is removed, the side branches start to grow (b).



Auxins cause stem elongation

The group of plant hormones called **auxins** (AWK sunz) promote cell elongation. Indoleacetic acid (IAA) is a naturally occurring auxin that is produced in the apical meristems of a growing plant stem. It causes an increase in stem length by increasing the rate of cell division and promoting cell elongation. IAA weakens the connections between the cellulose fibers in the cell wall. This allows the cells to stretch and grow longer. The combination of new cells and increasing cell lengths leads to stem growth. Auxin is not transported in the vascular system, but rather it moves from one parenchyma cell to the next by active transport.

Auxins have a number of other effects on plant growth and development. Auxin produced in the apical meristem inhibits the growth of side branches.

Removing the stem tip reduces the amount of auxin present in the stem and allows the formation of branches as they are no longer inhibited by auxins at the tip of the main stem, *Figure 23.23*. High concentrations of auxin also promote fruit formation and inhibit the dropping of fruit from the plant. When auxin concentrations decrease, the ripened fruits of some trees fall to the ground and deciduous trees begin to shed their leaves.

Gibberellins promote growth

The group of plant hormones called **gibberellins** (jihb uh REL uns) are growth hormones that cause plants to grow taller because, like auxins, they stimulate cell elongation. Many dwarf plants, such as the dwarf bean plants in *Figure 23.24*, are short because the plant either cannot produce gibberellins or its cells are not receptive to the hormone. If gibberellins are applied to the tip of the dwarf plant, it will grow taller. Gibberellins also increase the rate of seed germination and bud development. Farmers have learned to use gibberellins to enhance fruit formation. Florists often use gibberellins to induce flower buds to open.

Cytokinins stimulate cell division

The hormones called **cytokinins** are so named because they stimulate cell division or cytokinesis. Cytokinins increase cell division by stimulating the production of proteins needed for mitosis. Most cytokinins are produced in the meristems in the root. This hormone travels up the xylem to other parts of the plant. The effect of cytokinins is often enhanced by the presence of other hormones.

Ethylene gas promotes ripening

The plant hormone **ethylene** (ETH uh leen) is a simple, gaseous compound composed of carbon and hydrogen that speeds the ripening of fruits. It is produced primarily by fruits, but also by leaves and stems. Ethylene is released during a specific stage of fruit ripening. It causes the cell walls to weaken and become soft. Ethylene also promotes the breakdown of complex carbohydrates to simple sugars. If you have ever enjoyed a ripe red apple you know that it tastes sweeter than an immature fruit.

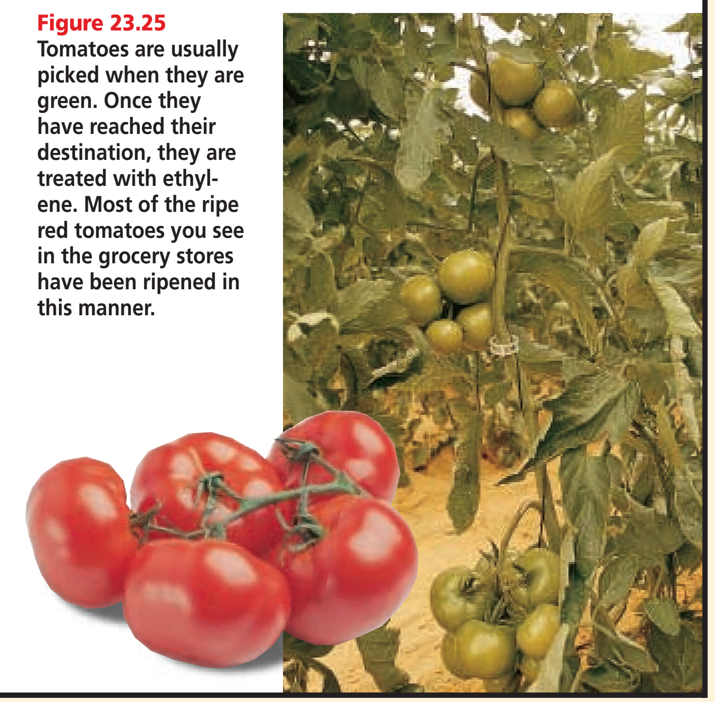
Many farmers use ethylene to ripen fruits or vegetables that have been picked when they are immature as shown in *Figure 23.25*.

Figure 23.24 The bean plants in this picture are genetic dwarfs. However, the two plants on the right were treated with gibberellin and have grown to a normal height.

Word Origin

auxin
From the Greek word *auxein*, meaning "to increase." Auxin causes stem elongation by increasing cell growth

Figure 23.25 Tomatoes are usually picked when they are green. Once they have reached their destination, they are treated with ethylene. Most of the ripe red tomatoes you see in the grocery stores have been ripened in this manner.



2 Teach

Quick Demo

Visual-Spatial Show students broadleaf houseplants that have been on a sunny windowsill. Ask them if they notice anything special about the leaves. Direct their attention to the orientation of the leaves. Ask students to propose ideas as to why the leaves are all facing the same direction. L1

Assessment

Skill Have students construct a table of the different types of plant hormones and their effects on plants. L2

Microscope Activity

Visual-Spatial Students can view the numerous cells in various stages of mitosis in onion root tip slides. Remind students that cytokinins produced in the root tip stimulate this cell division. L1

Assessment

Performance Assessment in the Biology Classroom, p. 47, *Controlling the Rate at Which Fruit Ripens.* Have students carry out this activity to observe plant hormones at work. L2

Biology Journal

Auxins and Stem Elongation

Linguistic Ask students to write a paragraph explaining how auxin causes stem elongation at the cellular level. Encourage students to draw pictures to illustrate their paragraph. L2

Resource Manager

Section Focus Transparency 57 and Master L1 ELL

Meeting Individual Needs

Gifted

Have students research and design an experiment to test the effect of different concentrations of gibberellins on dwarf plants. Dwarf peas and the rosette variety of Wisconsin Fast Plants work well for this type of experiment. L3

Problem-Solving Lab 23-3

Purpose

Students will conclude from experimental evidence that light and the tip end of a young stem are needed for phototropism.

Process Skills

predict, think critically, analyze information, compare and contrast, draw a conclusion, hypothesize, interpret data, recognize cause and effect

Teaching Strategies

- Explain to students that the seed in each diagram is below the soil surface.
- Define the term "opaque" if necessary.
- Use the term "coleoptile" to refer to the young oat stem.

Thinking Critically

1. A and C; if there is no light source or the stem tip is not able to detect light, there is no phototropic response.
2. Student answers may vary. When the tip is intact (as in A), there is a phototropic response as the stem bends towards light. However, when the tip end is missing, there is no phototropic response.
3. Stem tip end; when the tip end is removed, phototropism does not occur.

Assessment

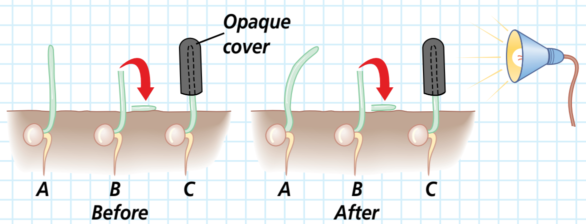
Portfolio Ask students to design an experiment that would show that the tip end of the young stem does indeed contain a chemical that influences the bending of the stem toward light. Students should place their written experiment in their portfolio. Use the Performance Task Assessment List for Assessing a Whole Experiment and Planning the Next Experiment in **PASC**, p. 33. L3

Problem-Solving Lab 23-3 — Drawing a Conclusion

How do plant stems respond to light? While working with young oat plants, Charles Darwin made a number of discoveries about the response of young plant stems to light. His discoveries helped to explain why plants undergo phototropism. Scientists now know that this response is the result of an auxin that causes rapid cell elongation to occur along one side of a young plant stem. However, the discovery of auxins was not yet known during Darwin's time.

Analysis

Study the before and after diagrams marked A-C. The three plants are young oat stems that are already above ground. Note that the light source is directed at the plants from one side.



Thinking Critically

1. Which diagram (or diagrams) supports the conclusion that light is a needed factor for phototropism? Explain.
2. Which diagram (or diagrams) supports the conclusion that the stem tip is a needed factor for phototropism? Explain.
3. Where might the auxin responsible for phototropism be produced? Explain.

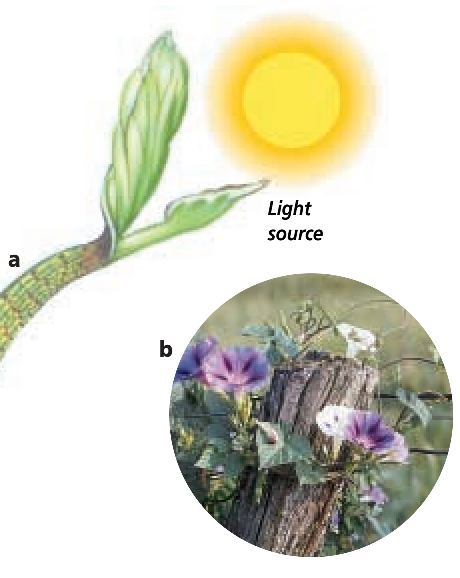


Figure 23.26
Phototropism is the growth of a plant toward light (a). Thigmotropism is a growth response to touch (b).

Plant Responses

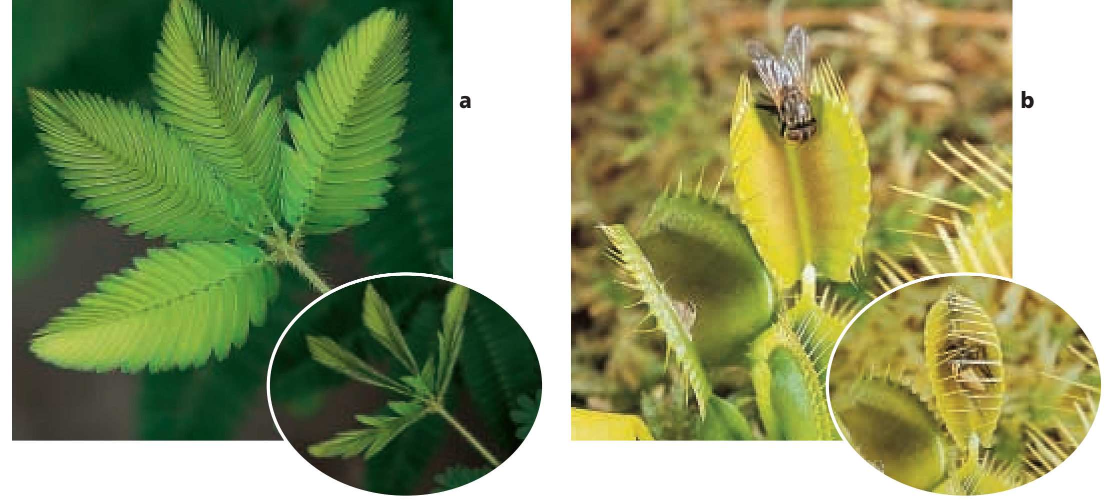
Why do roots grow down into the soil and stems grow up into the air? Although plants lack a nervous system and usually cannot make quick responses to stimuli, they do have mechanisms that enable them to respond to their environment. Plants grow, reproduce, and shift the position of their roots, stems, and leaves in response to environmental conditions such as gravity, sunlight, temperature, and day length.

Tropic responses in plants

If you look at the photograph of sunflowers at the beginning of this section, it is obvious that they are all responding to the same stimulus—the sun. **Tropism** is a plant's response to an external stimulus that comes from a particular direction. If the tropism is positive, the plant grows toward the stimulus. If the tropism is negative, the plant grows away from the stimulus.

The growth of a plant towards light is caused by an unequal distribution of auxin in the plant's stem. There is more auxin on the side of the stem away from the light. This results in cell elongation, but only on that side. As the cells grow, the stem bends toward the light, as shown in ***Figure 23.26a***. The growth of a plant toward light is called phototropism. You can learn more about phototropism in the *Problem-Solving Lab* shown here.

There is another tropism associated with the upward growth of stems and the downward growth of roots. Gravitropism is the direction of plant growth in response to gravity. Gravitropic responses are beneficial to plants because the leaves receive more light if they grow upward. By growing down into the soil, roots are able to anchor the plant and can take in water and minerals.



Some plants exhibit another tropism called thigmotropism, which is a growth response to touch. The tendrils of the vine in ***Figure 23.26b*** have coiled around a trellis after making contact during early growth.

Because tropisms involve growth, they are not reversible. The position of a stem that has grown several inches in a particular direction cannot be changed. But, if the direction of the stimulus is changed, the stem will begin growing in another direction.

Nastic responses in plants

A responsive movement of a plant that is not dependent on the direction of the stimulus is called a **nastic movement.** An example of a nastic movement is the folding up of the leaflets of a *Mimosa* leaf when the plant is touched, as shown in ***Figure 23.27a.*** The folding is caused by a change in turgor pressure in the cells at the base of each leaflet. A dramatic drop in pressure causes the cells to become limp. This causes the leaflets to change orientation.

Another example of a nastic response is the sudden closing of the hinged leaf of a Venus flytrap, ***Figure 23.27b.*** The movement of an insect on the leaf triggers the sensitive hairs on the inside of the leaf, causing the trap to snap shut. Plant responses that are due to changes in cell pressure are reversible because they do not involve growth. The *Mimosa* and Venus flytrap's leaves open once the stimulus ends.

Figure 23.27
Mimosa pudica is also known as the sensitive plant (a). When touched, it folds its leaves in less than one-tenth of a second. The Venus flytrap's hinged leaf snaps shut when triggered by an insect crawling on its leaf (b).

Section Assessment

Understanding Main Ideas

1. What is a hormone?
2. What are two differences between tropic responses and nastic movements?
3. Explain how a plant can bend towards the sun. What term describes this response?
4. Name one hormone and describe how it influences growth and development.

Thinking Critically

5. One technique that has been used for years to ripen fruit has been to put a ripened banana in a paper bag with the unripe fruit. Why does this help the unripe fruit to ripen?

Skill Review

6. **Designing an Experiment** Explain how you would design an experiment to test the effect of different colors of light on phototropism in one plant. For more help, refer to *Practicing Scientific Methods* in the **Skill Handbook.**

3 Assess

Check for Understanding

Have students explain how the words in each of the following pairs are related. L2

a. auxin—hormone
b. cytokinin—cell division
c. ethylene—ripe fruit
d. tropic response—nastic response

Reteach

Linguistic Have students write sentences correctly using each of the groups of words in Check for Understanding. L2

Extension

Have students do research on the use of plant hormones in agriculture. L3

Assessment

Knowledge Show students pictures of different plant responses and ask them to identify the type of response. L1

4 Close

Biology Journal

Ask students to write a paragraph describing the relationship between plant hormones and plant responses. L2

Portfolio

Plant Responses

Visual-Spatial Have students collect pictures or drawings that show different plant responses. Have them glue or tape the pictures onto construction paper and write captions for each one. Students should place their completed pictures or drawings in their portfolios. L1 ELL P

Resource Manager

Reinforcement and Study Guide, p. 104 L2
Content Mastery, pp. 113, 115-116 L1

Section Assessment

1. A hormone is a chemical produced in one part of an organism and transported to another part, where it then causes a physiological change.
2. Nastic movements are reversible, whereas tropic responses are not. Nastic movements are not dependent upon the direction of the stimulus, whereas tropic responses are.
3. A plant can bend towards the light as a result of cell elongation on the side of the stem away from the light. The term phototropism describes this response.
4. Possible answers: auxins cause stem elongation; gibberellins promote growth; cytokinins stimulate cell division; and ethylene gas promotes fruit ripening.
5. Ripe fruits release ethylene gas that stimulates the ripening of other fruits.
6. Expose the plant to red light for 24 hours and measure the response. Next expose the plant to blue light for 24 hours. Continue testing until all available light colors have been tested and compare results.

INVESTIGATE BioLab

Time Allotment
One class period

Process Skills
collect data, communicate, interpret data, recognize cause and effect, draw a conclusion, compare and contrast, measure in SI, observe and infer, use numbers

Safety Precautions
Review the need for care when working with single-edged razor blades. Remind students to cut away from their bodies. Remind students that special care should be taken when viewing slides under high-power so the objective does not break the slide. Have students wash their hands after handling plant materials.

PREPARATION

Alternative Materials

- Any type of leaf may be substituted. Green onion is ideal because it is inexpensive and easily available in supermarkets. It also is easily scraped with the razor blade to yield a clear epidermis.
- Other leaves may be used. Students will have to calculate the area of differently shaped leaves. Step 3 will no longer be valid if other leaves are used. Geranium and Ficus leaves also work well.

INVESTIGATE BioLab

Determining the Number of Stomata on a Leaf

If asked to count the total number of stomata on a single leaf, you might answer by saying "that's an impossible task." It may not be necessary for you to count each and every stomate. Sampling is a technique that is used to arrive at a close answer to the actual number. You will use a sampling technique in this BioLab.

PREPARATION

Problem
How can you count the total number of stomata on a leaf?

Objectives
In this BioLab you will:

- **Measure** the area of a leaf.
- **Observe** the number of stomata seen under a high-power field of view.
- **Calculate** the total number of stomata on a leaf.

Materials
microscope
glass slide
water and dropper
green leaf from an onion plant
single-edged razor blade
ruler
glass cover

Safety Precautions
Wear latex gloves when handling an onion.

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

PROCEDURE

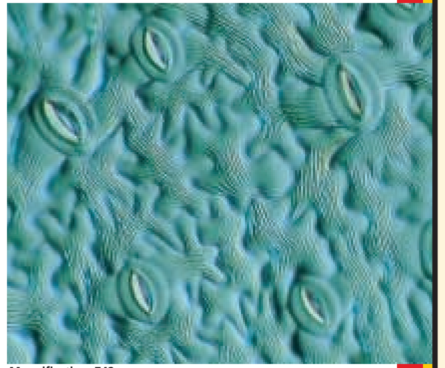
1. Copy Data Tables 1 and 2.
2. Obtain an onion leaf and carefully cut it open lengthwise using a single-edged razor blade. **CAUTION:** ***Be careful when cutting with a razor blade.***
3. Measure the length and width of your onion leaf in millimeters. Record these values in Data Table 2.
4. Remove a small section of leaf and place it on a glass slide with the dark green side facing DOWN.
5. Add several drops of water and gently scrape away all green leaf tissue using a back and forth motion with the razor blade. An almost transparent layer of leaf epidermis will be left on the slide.
6. Add water and a cover glass to the epidermis and observe under low-power magnification. Locate an area where guard cells and stomata can be clearly seen. **CAUTION:** ***Use caution when working with a microscope, microscope slides, and coverslips.***
7. Switch to high-power magnification.
8. Count and record the number of stomata in your field of view. Consider this trial 1. Record your count in Data Table 1.
9. Move the slide to a different area. Count and record the number of stomata in this field of view. Consider this trial 2.
10. Repeat step 9 three more times. Calculate the average number of stomata observed in a high-power field of view.
11. Calculate the total number of stomata on the entire onion leaf by following the directions in Data Table 2.

Data Table 1

Trial	Number of stomata
1	
2	
3	
4	
5	
Total	
Average	

Data Table 2

Length of leaf portion in mm	= ____ mm
Width of leaf portion in mm	= ____ mm
Calculate area of leaf (length × width)	= ____ mm^2
Calculate number of high-power fields of view on leaf (area of leaf ÷ 0.07 mm^2, the area of one high-power field of view)	= ____
Calculate total number of stomata (number of high-power fields of view × average number of stomata per high-power field of view from Data Table 1)	= ____



Magnification: 742×

ANALYZE AND CONCLUDE

1. **Communicating** Compare your data with those of your other classmates. Offer several reasons why your total number of stomata for the leaf may not be identical to your classmates.
2. **Thinking Critically** Analyze the following steps of this experiment and explain how you can change the procedure to improve the accuracy of your data.
   a. five trials in Data Table 1
   b. using 0.07 mm^2 as the area of your high-power field of view
3. **Concluding** Would you expect all plants to have the same number of stomata per high-power field of view? Explain your answer.
4. **Comparing and Contrasting** What are the advantages to using sampling techniques? What are some limitations?

Going Further

Application Carry out the same sampling technique to determine the total number of stomata present on leaves of a variety of different plant species in your neighborhood.

interNET CONNECTION To find out more about plant anatomy, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

INVESTIGATE BioLab

ANALYZE AND CONCLUDE

1. mathematical errors, different average numbers of stomata, different leaf sizes
2. a. increase the number of samples
   b. calculate microscope's high-power area
3. Different plants will have different numbers of stomata per high-power field; stomate numbers are characteristic for specific plant species.
4. Saves time and energy; you do not get an actual or true count, only an approximation.

Assessment

Skill Provide students with sample data for leaf area and number of stomata per high-power field. Ask students to calculate the total number of stomata. Use the Performance Task Assessment List for Using Math in Science in **PASC**, p. 29. L3

Going Further

Determine if there is a difference between the number of stomata on the upper and lower epidermis of selected species of trees or shrubs. L2

Resource Manager

BioLab and MiniLab Worksheets, pp. 107-108 L2

PROCEDURE

Teaching Strategies

- You may find that students will need to use a calculator.
- Review the procedure for determining an average.
- Students may want to know where the value of 0.07 mm^2 came from. This value is close to the area of the circle of light seen through high-power magnification.
- You may wish to go through all of the math steps by using sample data on the overhead projector.

Troubleshooting

- Students may have difficulty observing the stomata. Most problems are the result of not having scraped away enough of the spongy layer of the leaf.
- On occasion, the epidermis will tear when students scrape too vigorously. Have students discard their wet mounts and try a new sample of leaf material.
- Failure to see or find any stomata may be due to the fact that students did not place their leaf sample with the dark side down. Green onions do not have stomata on their inside surface.

Data and Observations
Student answers will vary. The number of stomata will be several thousand.

Art Connection

Purpose
To illustrate the relationship between nature and art.

Teaching Strategies
■ Posters of O'Keeffe's works are available in art shops and museum gift shops. Bring in several examples to illustrate more of her work. Have students visit an art gallery to view paintings by artists who use flowers as their subject matter. As an alternative, have students examine art books to find the names of artists who use flowers. Ask students to present oral reports on their findings. L1

Visual Learning
Ask students what plant hormone may have influenced the flowering of the red poppy.

Connection to Biology
One possible answer is that color attracts pollinators to the flowers.

Art Connection

Red Poppy by Georgia O'Keeffe (1887–1986)

"When you take a flower in your hand and really look at it," she said, cupping her hand and holding it close to her face, "it's your world for the moment. I want to give that world to someone else. Most people in the city rush around so, they have no time to look at a flower. I want them to see it whether they want to or not."

American artist Georgia O'Keeffe attracted much attention when the first of her many floral scenes was exhibited in New York in 1924. Everything about these paintings—their color, size, point of view, and style—overwhelmed the viewer's senses, just as their creator had intended.

In describing her huge paintings of solitary flowers, Georgia O'Keeffe said: "I decided that I wasn't going to spend my life doing what had already been done." Indeed, she did do what had not been done by painting enormous poppies, lilies, and irises on giant canvases. Her use of colors and emphasis on shapes suggests nature rather than copying it with photographic realism. Her work can be described as abstract. "I found that I could say things with color and shapes that I couldn't say in any other way—things that I had no words for," she said.

The viewer's eye is drawn into the flower's heart In this early representation of one of her familiar poppies, O'Keeffe directed the viewer's eye down into the poppy's center, much as the flower naturally attracts an insect for reproduction purposes. By contrasting the light tints of the outer ring of petals with the darkness of the poppy's center, the viewer's eye is pulled, beelike, into the heart of the flower. The overwhelming size and detailed interiors of O'Keeffe's flowers give an effect similar to a photographer's close-up camera angle.

During her long life of 98 years, Georgia O'Keeffe created hundreds of paintings. Her subjects included the flowers for which she is perhaps most famous, as well as other botanical themes. She spent many years in New Mexico. Her paintings of the New Mexico deserts are characterized by sweeping forms, portraying sunsets, rocks, and cliffs.

At the age of 90, she said of her success. "It takes more than talent. It takes a kind of nerve and a lot of hard, hard work." She died in New Mexico in 1986. Georgia O'Keeffe will be remembered for her bold, vivid paintings that are, indeed, larger than life.

CONNECTION TO BIOLOGY

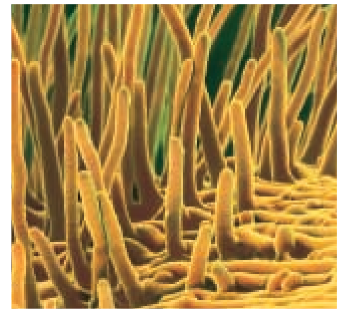
Color plays a prominent role in the artistic effect of O'Keeffe's flowers. What role does color play in the life of a real flower?

interNET CONNECTION To find out more about Georgia O'Keeffe, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Chapter 23 Assessment

SUMMARY

Section 23.1
Plant Cells and Tissues



Main Ideas
- Most plant tissues are composed of parenchyma cells, collenchyma cells, and sclerenchyma cells.
  - Dermal tissue is a plant's protective covering.
  - Xylem moves water and minerals up the stem. Phloem transports sugars and organic compounds throughout the plant.
  - Ground tissue often functions in food production and storage.
  - Meristematic tissues produce new cells.

Vocabulary
apical meristem (p. 631)
collenchyma (p. 626)
companion cell (p. 630)
cork cambium (p. 631)
epidermis (p. 627)
guard cells (p. 627)
meristem (p. 631)
phloem (p. 630)
parenchyma (p. 625)
sclerenchyma (p. 626)
sieve tube member (p. 630)
stomata (p. 627)
tracheid (p. 629)
trichome (p. 627)
vascular cambium (p. 631)
vessel element (p. 629)
xylem (p. 629)

Section 23.2
Roots, Stems, and Leaves

Main Ideas
- Roots grow downward as cells elongate and transport water and minerals from the root to the rest of the plant.
- The stem supports leaves and transports food and water.
- Leaves contain chloroplasts and perform photosynthesis.

Vocabulary
cortex (p. 633)
endodermis (p. 633)
mesophyll (p. 638)
pericycle (p. 633)
petiole (p. 638)
root cap (p. 634)
sink (p. 637)
translocation (p. 637)
transpiration (p. 640)

Section 23.3
Plant Responses

Main Ideas
- Three major plant hormones are auxins, gibberellins, and cytokinins. They promote cell division and cell elongation.
- Phototropism, gravitropism, and thigmotropism are all growth responses to external stimuli.
- Nastic responses are caused by changes in cell pressure.

Vocabulary
auxin (p. 642)
cytokinin (p. 643)
ethylene (p. 643)
gibberellin (p. 643)
hormone (p. 642)
nastic movement (p. 645)
tropism (p. 644)

UNDERSTANDING MAIN IDEAS

1. The tissue that makes up the protective covering of a plant is _______ tissue.
   a. vascular
   b. meristematic
   c. ground
   d. dermal

2. Cambium and apical meristem are examples of _______.
   a. photosynthetic tissues
   b. protective tissues
   c. growth tissues
   d. transport tissues

Main Ideas
Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary
To reinforce chapter vocabulary, use the Content Mastery Booklet and activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.
www.glencoe.com/sec/science

THE PRINCETON REVIEW *All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.*

UNDERSTANDING MAIN IDEAS

1. d
2. c

GLENCOE TECHNOLOGY

VIDEOTAPE
MindJogger Videoquizzes
Chapter 23: *Plant Structure and Function*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager

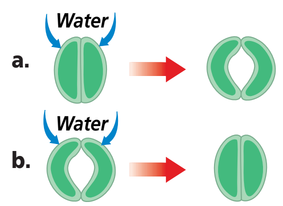
Chapter Assessment, pp. 133-142
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 23 quiz

3. b
4. a
5. a
6. c
7. b
8. d
9. c
10. b
11. translocation
12. dicot
13. ethylene
14. water
15. gibberellin
16. parenchyma
17. auxins
18. sink
19. stem; root
20. stem

Applying Main Ideas

21. Transpiration occurs most rapidly during the day and aids in the movement of water through the xylem. Thus, water movement is greater during the day than at night.
22. Since it is late afternoon, the sun will be in the west; the flowers will be facing west towards the light source.

3. Which of the following plant responses could be demonstrated by placing a potted plant next to a sunny window?
   a. thigmotropism **c.** nastic movement
   b. phototropism **d.** gravitropism
4. A cross section of a root shows a central star-shaped mass of xylem when the plant is a(n) _______.
   a. dicot **c.** annual
   b. monocot **d.** perennial
5. One of the primary structural differences between roots and stems is the _______.
   a. arrangement of vascular tissue within the stem and root
   b. arrangement of pith within the stem and root
   c. differences in xylem and phloem function
   d. differences in the numbers of stomata
6. What is the primary function of leaves?
   a. to provide protection for the plant
   b. to provide water for the plant
   c. to trap light energy for photosynthesis
   d. to enable the plant to grow taller
7. Which diagram correctly shows the functioning of guard cells?



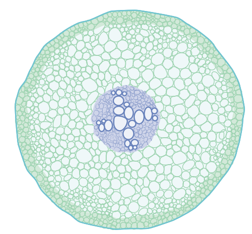
Test-Taking Tip

THE PRINCETON REVIEW

Best Times

If your test is timed, then practice under timed conditions. Try timing yourself on specific sections to see if you can improve your overall speed while maintaining accuracy. Do you notice an improvement in your score if you give yourself a few moments to double-check each answer? Learn from yourself.

8. Water and mineral ions enter the root by absorption into the _______.
   a. phloem **c.** stomata
   b. cuticle **d.** root hairs
9. Which of the following cells is a sclerenchyma cell?
   a. meristematic cell **c.** vessel element
   b. companion cell **d.** guard cell
10. The tissue that contains stomata is _______.
    a. vascular **c.** ground
    b. dermal **d.** meristematic
11. The movement of sugar through phloem is called _______.
12. The picture shown to the right is a _______ root.



13. The plant hormone that speeds up the ripening of fruit is _______.
14. An analysis of the composition of the fluid transported by the xylem tissue would reveal that it is mostly _______.
15. A dwarf plant can be induced to reach normal height by the application of the hormone _______.
16. The thin-walled cells that make up most of the ground tissue are _______.
17. Because the tip of a stem produces _______, removal of the tip stimulates lateral growth.
18. The portion of a plant that uses sugars is referred to as a _______.
19. Apical meristems are found in the _______ and _______.
20. The potato tuber is a type of _______.

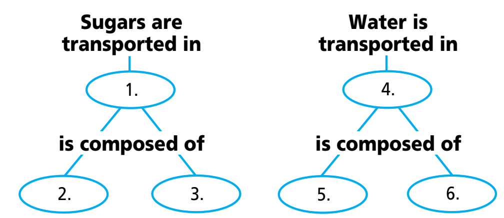
Applying Main Ideas

21. Compare the expected rates of water movement in xylem tissues during the day and at night.

22. In late afternoon you are standing near a field of sunflowers. The flowers are all facing away from you. Explain how you know which direction they are facing.
23. Explain how the endodermis controls the flow of water and ions into the vascular tissue of the root.
24. Every spring, sap, a sugary fluid that travels through phloem, is collected from sugar maple trees to make maple syrup. Which type of vascular tissue do the farmers tap into to remove the sap? Explain.

Thinking Critically

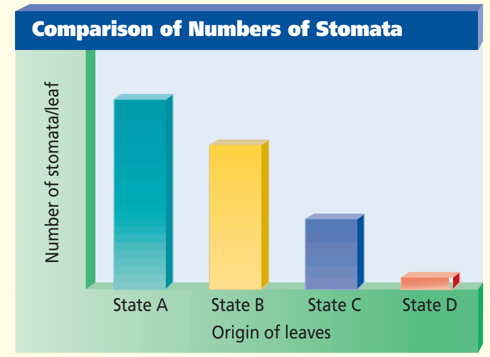
25. **Comparing and Contrasting** Compare and contrast the flow of material through the xylem and phloem.
26. **Recognizing Cause and Effect** To allow some trees to grow straighter, foresters may remove surrounding trees by a process called girdling. To girdle a tree the forester removes a circle of bark from around the trunk of the tree. How does girdling eventually kill a tree?
27. **Comparing and Contrasting** Compare and contrast apical and lateral meristems.
28. **Concept Mapping** Complete the concept map by using these vocabulary terms: xylem, tracheid, phloem, companion cell, sieve tube member, and vessel element.



CD-ROM
For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

The graph below illustrates data on daisies collected by scientists in four different states. Remember that stomata are the openings in the leaves through which water vapor escapes.



Interpreting Data Examine the graph and answer the following questions.

1. In which state might there be the most rainfall?
   a. state A **c.** state C
   b. state B **d.** state D
2. In which state might there be the least rainfall?
   a. state A **c.** state C
   b. state B **d.** state D
3. How is rainfall correlated with numbers of stomata on leaves?
   a. the more stomata, the less rain
   b. the fewer the stomata, the less rain
   c. the more stomata, the more rain
   d. the fewer the stomata, the more rain
4. **Making a Graph** Make a bar graph similar to the one above that shows how the thickness of the leaf cuticle of a particular plant varies from one state to another. In state A, cuticles are thickest; state B, thinner than state A; state C, thicker than state B but not as thick as state A; state D, thinner than state B.

23. The endodermis creates a barrier to the flow of water and ions, forcing them to flow through the endodermal cells. These cells can then regulate the movement of these substances.
24. Phloem; Since sap contains sugar, it is transported by the phloem.

Thinking Critically

25. Xylem and phloem both transport materials throughout the plant. Water and ions are transported up the plant through the xylem. Water, sugars and other nutrients are transported up and down the plant through the phloem.
26. Girdling interrupts the passage of nutrients in phloem cells from leaves to roots. Roots are unable to receive food and eventually will die, resulting in death of the tree.
27. Both types of meristems produce new cells for growth. The apical meristem is responsible for vertical growth. Production of cells by the lateral meristem results in an increase in girth.
28. 1. Phloem; 2. Companion cell; 3. Sieve tube member; 4. Xylem; 5. Vessel element; 6. Tracheid

Assessing Knowledge & Skills

1. a
2. d
3. c
4.