Chapter 23 Organizer

Refer to pages 45-57 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
- Investigative 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 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 23.3 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 slide, coverslip, water, dropper, celery stalk
- p. 640 microscope, microscope slide, coverslip, water, dropper, 5% salt solution, live plant leaf

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.

**LS** These strategies represent student products that can be placed into a best-work portfolio.

**LS** These strategies are useful in a block scheduling format.

**Teacher Classroom Resources**

**Transparencies**

**Section 23.1 Plant Cells and Tissues**
- Reinforcement and Study Guide, p. 101
- Concept Mapping, p. 23
- BioLab and MiniLab Worksheets, p. 105
- Content Mastery, pp. 113-114, 116
- Section Focus Transparency 55

**Section 23.2 Roots, Stems, and Leaves**
- Reinforcement and Study Guide, pp. 102-103
- Critical Thinking/Problem Solving, p. 23
- BioLab and MiniLab Worksheets, p. 106
- Laboratory Manual, pp. 161-170
- Content Mastery, pp. 113-116
- Section Focus Transparency 56

**Section 23.3 Plant Responses**
- Reinforcement and Study Guide, p. 104
- BioLab and MiniLab Worksheets, pp. 107-108
- Content Mastery, p. 113, 115-116
- Section Focus Transparency 57

**Assessment Resources**

- Chapter Assessment, pp. 133-138
- Mindlogger Videodiscs
- Performance Assessment in the Biology Classroom
- Alternate Assessment in the Science Classroom
- Computer Test Bank
- BIO Lab Interactive CD-ROM, Chapter 23 quiz

**Additional Resources**

- Spanish Resources
- English/Spanish Audiocassettes
- MindCanvas
- Cooperative Learning in the Science Classroom
- Lesson Plans/Block Scheduling

**GLENCOE TECHNOLOGY**

**Index to National Geographic Magazine**

The following multimedia resources are available from Glencoe.

**Biology: The Dynamics of Life**
- CD-ROM
- Videodisc Program
- Animation: Water Uptake in Roots

**Products Available From Glencoe**

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

- CD-ROM
- NGSS PictureShow: What It Means to Be Green
- Curriculum Kit
- GeoIt!: Plants
- Transparency Set
- NGSS PicturePack: What It Means to Be Green
- Videodisc
- STV: Plants

**Teacher’s Corner**

The following multimedia resources are available from Glencoe.
interaction is apparent as the Theme Development features is discussed. dependence among these structures is examined and the inter-anatomy of roots, stems, and leaves is stressed through the discussion.

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.

As you look at a potted plant, look at the plant's roots, stems, and leaves. Ask students to suggest possible functions for each. 

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### Chapter 23

### Plant Structure and Function

#### Getting Started

**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?

To find out more about internet sources, visit the Glencoe Science Web Site. www.glencoe.com/sec/science

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### 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 REHN 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

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### 1 Focus

Bellinger

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

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### 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

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### Vocabulary
- parenchyma
- collenchyma
- sclerenchyma
- epidermis
- stomata
- sieve tube member
- tracheid
- vessel element
- phloem
- tube member
- companion cell
- xylem
- phloem
- apical meristem
- vascular cambium
- cork cambium

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### Section Preview

#### Objectives
- Identify the major types of plant cells.
- Distinguish among the functions of the different types of plant tissues.

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### 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.

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### 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.
Parenchyma cells are found throughout the plant. They have thin walls and a large vacuole. These cells are often found in parts of the plant that are no longer growing. Notice the unevenly thickened cell walls.

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

Plant Tissues

Recall that a tissue is a group of cells that function 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 (stomata) are openings in the epidermis of leaves. In many plants, fewer stomata are found on the upper surfaces of leaves than on the lower surface. Stomata are thought to play a role in the exchange of gases. Stomata are found on green stems and leaves. In some cases, trichomes are found on leaves and stems.

Trichomes are hairlike projections from the epidermis. They are often glandular and secrete toxic substances that help protect the plant from predators. Stomata, root hairs, and trichomes are shown in Figure 23.4.

The Biolab at the end of the chapter can be used at this point in the lesson.

Reinvestigate

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 nucleus 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 buds on sieve cells with a companion cell taped next to it.

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. Heads across the top could include: Shape of cells, Nature of cell wall, and Function. Heads down the side of the table should be: Parenchyma, Collenchyma, and Sclerenchyma.

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

Microscope Activity

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

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.

Biotechnology

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.
A Plant

There seems to be an almost endless variety of plants. Regardless of their diversity and numerous modifications, all 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?

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.

Tissues

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

Organs

The organs of a plant are leaves, stems, flowers, 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.

A Plant: Cells, Tissues, and Organs

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 transports water and minerals from the roots to the rest of the plant. In seed plants, xylem is composed of three types of cells: tracheids, vessel elements, and fibers. Parenchyma cells are also present.

Phloem is the tissue that transports food and nutrients. It is composed of two types of cells: sieve tubes and companion cells. Sieve tubes are tubular cells that transport food 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 angiosperms. This difference could be one reason why angiosperms 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 are the other types of tissues are found in vascular plants? To answer this question, look at the Inside Story.

Tissues

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

Organs

The organs of a plant are leaves, stems, flowers, 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.

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.

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.

Have students examine a prepared slide of an onion root tip. Point out that apical meristems produce new cells through the process of mitosis.

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.

Preparation

Locate areas where grass and dandelions are growing. Materials: garden trowel, metric balance

Procedure

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 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.

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 towel 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.

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.

Procedure

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 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.
**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 stems.
2. Transports food downward through stems while sugar moves upward through the plant; flow of sugar and minerals moves upward through the plant.
3. Transport of sugars and other organic compounds is interrupted throughout the plant by the phloem. Phloem is made up of a series of tubular cells that are still living and transport 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 cytoplasms, 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.

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

**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.

**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 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 leaves 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.

### 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. Draw a plant and indicate where on the plant the apical meristems would be located. How do they differ from lateral meristems?

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

**Extension**
Ask students what types of organs or humans are analogous to plant tissues.

**4 Close**

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

**Skill Review**
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.

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**Resource Manager**

- Reinforcement and Study Guide, p. 101
- Content Mastery, p. 114

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**Cultural Diversity**

**Origin and Cultural Significance of Corn**

**Visual-Spatial** Corn was one of the earliest crops to be domesticated, and it 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 occupied 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 present an illustrated essay of its findings.

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**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 concentration of sugar directly below the metal sheet.
- How would the experimental findings have differed if the metal sheet were inserted only into the bark of the tree?

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**Section Assessment**

213. Plant cells and tissues 631
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 Tich 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.

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.

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 all three. There are more than one-quarter million kinds of plants on Earth, and their organs exhibit an amazing variety.

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. 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 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

23.2 Roots, Stems, and Leaves 633

Internet Address Book

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

NATIONAL GEOGRAPHIC

VIDEO DISC

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

632 - PLANT STRUCTURE AND FUNCTION

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

**Water Uptake in Roots**

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.

| 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 in diameter. Each layer of new cells produced by the apical meristem is left farther behind 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 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, herbaeous 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 sclerenchyma 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.

**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.

Kinetestic Use liquid fertilizer to prepare solutions of the following percentages: 100, 80, 60, 40, 20, and 0. For preparation instructions, see page 327 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 make conclusions about the effects of varying concentrations of fertilizer on plant growth.
**Activity**

**Kinesic**

Produce 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.

**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 identify the tissues and their locations. Encourage students to sketch their observations.

**Critical Thinking/Problem Solving**

Use a model leaf to illustrate the importance of the leaf’s shape. Have students research the use of leaves as food for insects. Ask students why insects derived from plants may be more effective than those developed by humans.

**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 antimarial 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, holl wveels, 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.

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**Microscopic Analysis**

**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.

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**Microscopic Analysis**

**Visual-Spatial** Cross sections of leaves. Have students research the use of leaves as food for insects. Ask students why insects derived from plants may be more effective than those developed by humans.

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**Microscopic Analysis**

**Critical Thinking/Problem Solving**

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**Microscopic Analysis**

**Critical Thinking/Problem Solving**

Use a model leaf to illustrate the importance of the leaf’s shape. Have students research the use of leaves as food for insects. Ask students why insects derived from plants may be more effective than those developed by humans.
When water enters the label the external and internal gram of the cross section and pare the slides to the leaf cross sections. Have them come-

Figure 23.18

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

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 a part of the leaf, is called the petiole (pet’ti-0). 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 arrange-

Figure 23.19

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

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 (mes’o-fil) 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-

Figure 23.20

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

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 stems where it is needed for photosynthesis.

Analysis

A student was instructed to observe the effect of temperature on the plant’s surroundings. What might affect its rate of water loss?

1. Which temperature setting might best represent the student’s control data? Explain.
2. What might best represent the student’s experimental data? Explain.
3. Which temperature setting was used to test the hypothesis?
4. What abstraction environmental factor was being tested?
5. Which environmental factor was being tested?

Discussion

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?

Thinking Critically

1. B; water loss from a fan would be highest. Water loss from inside plastic bag would be lowest.
2. c; evaporation is reduced due to high humidity within the bag.
3. a; amount of humidity or moisture in air
4. A; transpiration is accelerated due to decrease of wind.
5. A; plant’s transpiration rate is related to environmental conditions. High humidity reduces the rate of transpiration. windy conditions increase the rate of transpiration.
3 Assess

Check for Understanding

Have students explain the difference between the terms of the following word groups.

1. a. transpiration—evaporation
   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.

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.

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 similarities in the pattern of vascular bundles. Similarities are general anatomy, multicellularity, and the ability to photosynthesize.

4 Close

Discussion

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

Section Assessment

Understanding Main Ideas

1. Compare and contrast the arrangement of xylem and phloem in dicots and stems.
2. 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 structure and function 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.

Table 23.1

<table>
<thead>
<tr>
<th>Monocots</th>
<th>Dicot leaves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomata</td>
<td>Stomata</td>
</tr>
<tr>
<td>Arrangement</td>
<td>Parallel</td>
</tr>
<tr>
<td>Scale</td>
<td>Scattered</td>
</tr>
<tr>
<td>Number</td>
<td>Multiples of three</td>
</tr>
</tbody>
</table>
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 more light, the plant will grow towards the light.

**Gibberellins promote growth**

The group of plant hormones called gibberellins (gib uh leen) 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 in the vascular system, but it usually 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.

Auxins cause stem elongation

The group of plant hormones called auxins (aux in) 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 it usually 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 23.21. 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.

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 cells 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 23.21.

**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.

**Potential Project**

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.

**Field Trip**

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.
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 is missing, there is no phototropic response.
3. Stem tip; when the tip is removed, phototropism does not occur.

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 photographs 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. For example, 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 direct 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 movement response 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 leaves 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 leaflets of the hinged 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.
Determing the Number of Stomata on a Leaf

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
- Ruler
- Glass slide
- Glass cover
- Water and dropper
- Green leaf from an onion plant
- Single-edged razor blade

Safety Precautions
Wear latex gloves when handling an onion.

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

Preparation

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.

Procedure

1. Measure the length and width of your onion leaf in millimeters. Record these values in Data Table 2.
2. Remove a small section of leaf and place it on a glass slide with the dark green side facing DOWN.
3. Add several drops of water and gently scrape away all green leaf tissue using a puck and forth motion with the razor blade. An almost transparent layer of leaf epidermis will be left on the slide.
4. Add water and a cover glass to the epidermis and observe under low-power magnification.

Data Table 1

<table>
<thead>
<tr>
<th>Trial</th>
<th>Number of stomata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td></td>
</tr>
</tbody>
</table>

Data Table 2

<table>
<thead>
<tr>
<th>Length of leaf portion in mm</th>
<th>Width of leaf portion in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Calculate the area of the leaf.
2. Determine the number of stomata per high-power field of view.
3. Calculate the total number of stomata on the entire onion leaf.

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.

- Use a new field in Data Table 1 and 0.07 mm² 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?

Teaching Strategies
- You may find that students will need to use a calculator.
- Review the procedure for determining an average.

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.
- 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.

Resource Manager
- BioLab and MiniLab Workshops, sheets, 107-108

Biology: A Lab Manual, p. 646
- Plant structure and function

www.glencoe.com/sec/science
- Glencoe Science Web Site.
- To find out more about plant anatomy, visit the Science Web Site.
- 23.3 Plant Responses
A new slide: "A new slide is introduced here."

From the text: "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 viewer's eye is drawn 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 sunlight and atmosphere 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 could not say in any other way—things that I had no words for," she said.

In describing her huge paintings of solitary flowers, Georgia O'Keeffe said: "I decided that I could not be spending 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 color, size, point of view, and style—overwhelmed the viewer's senses, just as their colors, size, and detailed interiors of O'Keeffe's flowers naturally attract an insect for reproduction. What makes such flowers so attractive? In Chapter 23, you will learn that nastic movements are caused by changes in cell size and water absorption. The rest of the plant, as well as other water and mineral transport tissues, is also discussed in this chapter.
3. Which of the following plant responses could be demonstrated by placing a pot of cat mint next to a sunny window?
a. phototropism  
b. nastic movement  
c. gravitropism
4. A cross section of a root shows a central star-shaped mass of xylem when the plant is a(n) ______.
   a. dicot
   b. monocot
   c. 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?
8. Water and mineral ions enter the root by absorption into the ______.
   a. phloem
   b. cuticle
   c. root hairs
9. Which of the following cells is a sclerenchyma cell?
   a. meristematic cell
   b. companion cell
   c. guard cell
10. The tissue that contains stomata is ______.
    a. vascular
    b. dermal
    c. meristematic
11. The movement of sugar through phloem is called ______.
    a. dect
    b. Monocot
    c. perennial

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.
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.

**Chapter 23 Assessment**

**Comparing and Contrasting**

- **Comparing and Contrasting**
  - **Phototropism**
  - **Thigmotropism**
  - **Gravitropism**
  - **Nastic movement**

**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?**
  - **Vascular tissue**
  - **Xylem**
  - **Phloem**
  - **Cuticle**

**Concept Mapping**

- **Complete the concept map by using these vocabulary terms: xylem, tracheid, phloem, companion cell, sieve tube member, and vessel element.**

**Thinking Critically**

- **Comparing and Contrasting**
  - **Apical and lateral meristems.**

**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.**

**Assessing Knowledge & Skills**

- **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](http://www.glencoe.com/sec/science)