UNIT 7 Plants

Amazon water lily

Lemon

UNIT 7

Water drops on passion flower tendrils

DISCOVERIES IN SCIENCE

Plants

9400 BCE

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

1325 BCE

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

Golden mask of King Tut

1493 CE

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

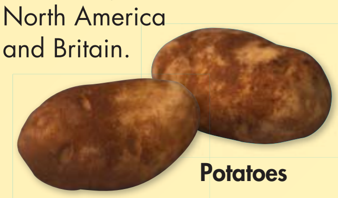
1793

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

Cotton gin

1845

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



Potatoes

1930

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

1944

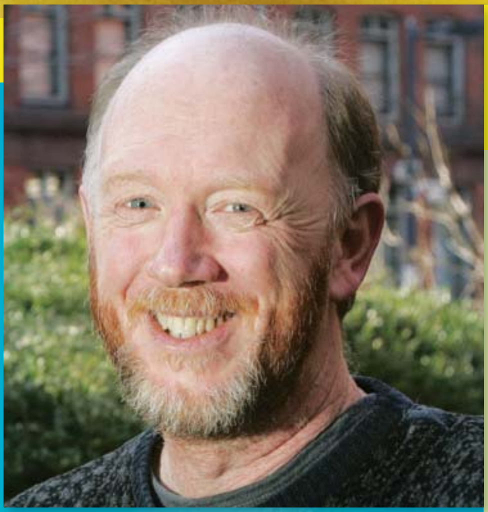
While studying corn genetics, Barbara McClintock discovers that pieces of DNA are mobile and can change position on chromosomes.

Barbara McClintock

1994

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

Sundew with fly



BIOLOGY CAREER

Evolutionary Biologist

David Haig

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

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

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

In addition to science, Haig enjoys studying history.

Pollen grains of ladybell flower

UNIT 7

Chapter Planner 23

Plant Diversity and Life Cycles

	Standards	Teach Key Ideas
CHAPTER OPENER, pp. 540–541 (15 min.)	*National Science Education Standards*	
SECTION 1 Introduction to Plants, pp. 543–546 (30 min.) › What Is a Plant? › Establishment of Plants on Land › Plant Life Cycles	LSCell 5, LSEvol 3, LSEvol 4, LSEvol 5, LSInter 2, LSInter 3, LSMat 2, UCP1, UCP2	**Bellringer Transparency** **Transparencies** G1 Early Cultivated Plants • G3 Medicines Derived from Plants • G4 Relationships Between Plants and Green Algae • G5 Alternation of Generations • G6 Life Cycles of Plants **Visual Concepts** Characteristics of Plants • Requirements for Plants to Survive on Land • Alternation of Generations
SECTION 2 Seedless Plants, pp. 547–552 (45 min.) › Nonvascular Plants › Reproduction in Nonvascular Plants › Seedless Vascular Plants › Reproduction in Seedless Vascular Plants	LSCell 1, LSEvol 5, UCP1	**Bellringer Transparency** **Transparencies** G33 Life Cycle of a Moss • G34 Life Cycle of a Fern **Visual Concepts** Characteristics of Nonvascular Plants • Types of Nonvascular Plants • Parts of Moss • Characteristics of Vascular Plants Without Seeds • Types of Seedless Vascular Plants • Parts of a Fern
SECTION 3 Seed Plants, pp. 553–558 (60 min.) › Kinds of Seed Plants › Reproduction in Seed Plants › Gymnosperms › Life Cycle of a Conifer	LSCell 1, LSEvol 5, UCP1	**Bellringer Transparency** **Transparencies** G42 Seed Structure • G43 Structure and Function of Seeds • G35 Life Cycle of a Conifer **Visual Concepts** Needles and Cones • Characteristics of Vascular Plants with Seeds • Gymnosperms
SECTION 4 Flowering Plants, pp. 559–565 (90 min.) › Kinds of Angiosperms › Reproduction in Angiosperms › Pollination › Fruits › Vegetative Reproduction	LSCell 1, LSEvol 5, UCP1, UCP5	**Bellringer Transparency** **Transparencies** G7 Characteristics of Monocots and Dicots • G8 Familiar Families of Angiosperms • G36 Floral Structure • G39 Life Cycle of an Angiosperm • G45 Stems Modified for Vegetative Reproduction • G48 Methods of Vegetative Plant Propogation **Visual Concepts** Characteristics of Monocots and Dicots • Germination of a Monocot and Dicot • Angiosperms • Parts of a Flower • Ovule Formation • Fertilization of a Flower • Parts of a Pollen Grain • Pollinators • Endosperm • Development of a Fruit

See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 566
- SE Chapter Review, p. 567
- SE Standardized Test Prep, p. 569
- Review Resources
- Chapter Tests A and B
- Holt Online Assessment

CHAPTER Fast Track *To shorten instruction due to time limitations, eliminate activities and cover the four sections in two days.*

Basic Learners

- TE Organizing Concepts, p. 544
- TE Using Concept Maps, p. 547
- TE Fern Ranges, p. 551
- TE What Are Ferns Used For?, p. 551
- TE Seed Germination, p. 555
- TE What's a Ginkgo?, p. 556
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE Unusual Plant Adaptations, p. 545
- TE Imperfect Flowers, p. 561
- TE Research, p. 562
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

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

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

Why It Matters *Build student motivation with resources about high-interest applications.*	Hands-On	Skills Development	Assessment
	SE **Inquiry Lab** Plant Cells, p. 541*■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 540 SE **Reading Toolbox,** p. 542	
	SE **Quick Lab** Cuticle Modeling, p. 545*■		SE **Section Review** TE **Formative Assessment** **Spanish Assessment***■ **Section Quiz**■
TE **Ancient Plants,** p. 550 TE **Demonstration** Variation in Ferns, p. 550 TE **Demonstration** Observing Fern Gametophytes, p. 551	SE **Quick Lab** Fern Gametophytes, p. 552*■	TE **Math Skills** Calculating, p. 548 SE **Reading Toolbox,** Classification, p. 550 TE **Reading Toolbox** Classification, p. 550	SE **Section Review** TE **Formative Assessment** **Spanish Assessment***■ **Section Quiz**■
TE **Demonstration** Observing Seeds, p. 553 TE **Demonstration** Do They Really Jump?, p. 554 TE **Ancient Pines,** p. 556 TE **Biomimetics,** p. 557	SE **Quick Lab** Pine Gametophytes, p. 558*■ **Exploration Lab** Fruits and Seeds*	SE **Reading Toolbox,** Concept Map, p. 554 TE **Reading Toolbox** Concept Map, p. 554	SE **Section Review** TE **Formative Assessment** **Spanish Assessment***■ **Section Quiz**■
TE **Demonstration** Comparing Seeds, p. 559 TE **Demonstration** Flower Dissection, p. 561 TE **Clues from Pollen,** p. 562	SE **Quick Lab** The Arrangement of Parts of a Flower, p. 560*■ SE **Quick Lab** Fruit or Vegetable, p. 563*■ SE **Skills Practice Lab** Plant Diversity, p. 565*■ **Skills Practice Lab** Dissecting Flowers*	SE **Reading Toolbox** Classification, p. 562 TE **Reading Toolbox** Classification, p. 562	SE **Section Review** TE **Formative Assessment** **Spanish Assessment***■ **Section Quiz**■

See also Lab Generator

See also Holt Online Assessment Resources

Resources for Differentiated Instruction

English Learners
- TE Observing Vascular Tissue, p. 550
- TE Diagramming a Process, p. 561
- TE Classifying Ethnic Edibles, p. 563
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide*■
- Note-taking Workbook*
- Multilingual Glossary

Struggling Readers
- TE Deciphering the Key Idea, p. 543
- TE Reproduction in Nonvascular Plants, p. 548
- TE Taking Notes, p. 553
- TE Create Operational Definitions, p. 560
- TE Determining Relative Importance, p. 563
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Note-taking Workbook*

Special Education Students
- TE Seed Germination, p. 555
- TE Variety in Pine Cones, p. 557
- TE Making Models, p. 560
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide*■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Alternative Assessment
- TE Observing Wind Dispersal, p. 555
- Science Skills Worksheets*
- Section Quizzes*■
- Chapter Tests A, B, and C*■

Chapter 23

Overview

The purpose of this chapter is to describe the importance and diversity of plants. The characteristics, reproduction, and life cycles of seedless plants (nonvascular plants and seedless vascular plants) and seed plants (gymnosperms and angiosperms) are discussed.

READING TOOLBOX

Assessing Prior Knowledge Students should understand the following concepts:

- photosynthesis
- basic genetics
- theory of evolution by natural selection
- classification of organisms

Visual Literacy Ask students to describe how the shape of the wasp makes it easy for the wasp to extract nectar from the passionflower. (The wasp is long and slender.) Have students note how the structure of the passionflower is adapted for moving pollen from flower to flower.

Chapter 23 Plant Diversity and Life Cycles

Preview

Why It Matters

Imagine life on Earth without plants. Not only do they supply us with the oxygen we need to breathe, plants also provide us with food, clothing, building materials, and medicines.

A wasp in search of food visits a passion flower. Many flowering plants are pollinated by insects, which are attracted by the smell, color, or shape of the flowers.

Chapter Correlations *National Science Education Standards*

LSCell 1 Cells have particular structures that underlie their functions.

LSCell 5 Plant cells contain chloroplasts, the site of photosynthesis.

LSEvol 3 Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms as well as for the striking molecular similarities observed among the diverse species of living organisms.

LSEvol 4 The millions of difference species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

LSEvol 5 Biological classifications are based on how organisms are related.

LSInter 2 Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

LSInter 3 Organisms both cooperate and compete in ecosystems.

LSMat 2 The energy for life primarily derives from the sun.

UCP1 Systems, order, and organization

UCP2 Evidence, models, and explanation

UCP5 Form and function

InquiryLab

15 min

Plant Cells

Have you ever cut open an onion? If so, you may have observed the tightly wrapped, see-through layers of onion skin. These delicate skin membranes are an ideal tissue in which to observe plant cells.

Procedure

1. Use **tweezers** to peel a thin, moist membrane from a freshly cut **onion slice.**
2. Place this membrane on a **slide.** Add several drops of water. Then, gently position a **coverslip** over the tissue specimen.
3. Examine the tissue by using low-power and medium-power objectives. Describe and draw what you observe.
4. Place a drop of **methylene blue solution** along the edge of the coverslip. Position a piece of **paper towel** at the opposite edge and draw the stain across the specimen.
5. Wait several moments and examine the tissue sample again. Describe and draw what you observe.

Analysis

1. **Identify** which features were easiest to observe in the unstained onion tissue.
2. **Describe** how adding the methylene blue solution affected your observations.

InquiryLab

Teacher's Notes Have students look for evidence of photosynthetic organelles in the cells they observe. Help students understand how an onion grows in the soil and have them suggest why chloroplasts are not found in these onion cells.

Materials

- onion slice
- tweezers
- slide and cover slip
- microscope
- methylene blue solution
- eyedropper
- paper towels

Safety Caution Remind students that if a chemical gets on their skin or clothing or in their eyes, they should rinse it immediately, and alert you.

Answers to Analysis

1. The thin, rectangular cell shapes and the distinct cell walls surrounding the cells were easiest to observe.
2. The stain darkened the nuclei, making these distinct, oval shapes easier to locate. The cell walls also became much darker and easier to see.

READING TOOLBOX

Using Words

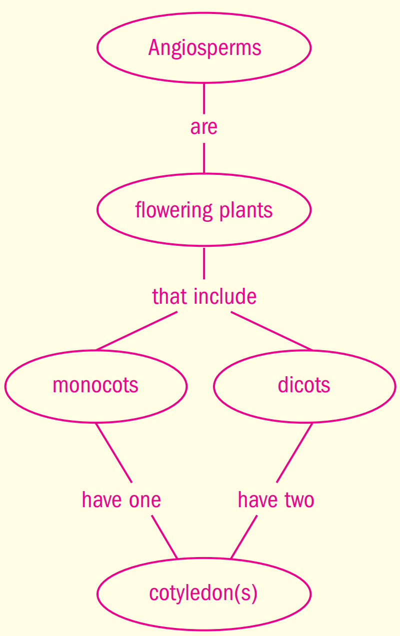
1. An angiosperm contains a box or vessel in which the seeds are formed.
2. A gymnosperm's seeds are bare or naked.

Using Language

1. Club mosses and ferns are two types of seedless vascular plants.
2. Mosses, liverworts, and hornworts are types of nonvascular plants.

Using Science Graphics

You may want to review students' concept maps to see if they have followed the directions accurately. A sample map is shown below.



READING TOOLBOX

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

Using Words

Word Parts You can tell a lot about a word by taking it apart and examining its prefix and suffix.

Your Turn Use the table and information that you read in the chapter to define the following terms in your own words.

1. angiosperm
2. gymnosperm

Word Parts

Word part	Type	Meaning
angio-	prefix	a vessel or box
gymno-	prefix	naked or bare
-sperm	suffix	seed

Using Language

Classification As you read the chapter, make distinctions between general words that describe categories and specific words that describe individuals within a category. Words that name categories are more general than words that describe individuals.

Your Turn Use information that you read in the chapter to answer the following questions.

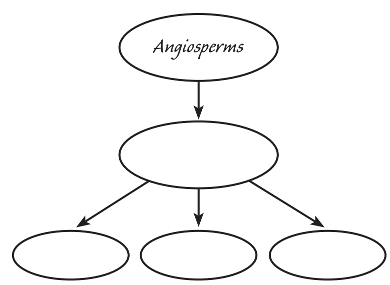
1. What are two types of seedless vascular plants?
2. What is the general term identifying the category that includes mosses, liverworts, and hornworts?

Using Science Graphics

Concept Map Concept maps are useful when you are trying to identify how several ideas are related to a main concept. Concept maps may be based on vocabulary terms or on main topics from the text.

Your Turn As you read about angiosperms, look for terms that can be organized in a concept map.

1. Select a main concept. Place this concept at the top or center of a piece of paper.
2. Place other ideas under or around the main concept based on their relationship to the main concept. Draw a circle around each idea.
3. Draw lines between the concepts, and add linking words to the lines.



Section 1

Introduction to Plants

Key Ideas	Key Terms	Why It Matters
What are the key characteristics of plants? What adaptations helped plants live successfully on land? Why is a plant's life cycle referred to as "alternation of generations?"	cuticle spore sporophyte gametophyte	Most plants live on land, and they've adapted to a variety of habitats, including deserts, tundra, and tropical rainforests.

Humans depend on plants in many ways. All types of plant parts—roots, stems, leaves, flowers, fruits, and seeds—are eaten as food. Plants provide us with the oxygen that makes life possible. They also provide materials for buildings, paper, furniture, clothing, and medicines. Without plants, many other organisms could not exist.

What Is a Plant?

Plants are the dominant group of organisms on land, based on mass. The kingdom Plantae is a very diverse group. Individual plants range from less than 2 mm (0.08 in.) across to more than 100 m (328 ft) tall. But what is a plant and what do plants need? **Plants are multicellular eukaryotes whose cells have cell walls. Most plants are *autotrophs*—they produce their own food through photosynthesis.** Recall that photosynthesis is the process by which plants produce organic materials from inorganic materials by using energy from the sun and carbon dioxide. Photosynthesis occurs in *chloroplasts,* as shown in the plant cell in **Figure 1.** To survive, plants need sunlight, water, air, and minerals.

Reading Check *What do plants need for photosynthesis? (See the Appendix for answers to Reading Checks.)*

Figure 1 Plants make their own food by capturing energy from sunlight. Where in the plant cell does photosynthesis occur?

Section 1

Focus

This section conveys the general characteristics of plants and their adaptations, and describes the basic plant life cycle.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

Gardening and Landscaping Plants Ask students to bring in landscaping books and home magazines to show the types of plants that thrive in your area. Ask students to bring in cuttings of any unusual plants they have in their yards. Have students make comparisons among the pictures and samples. Then, have each student pick a favorite plant to research. By the end of the chapter, each student should create a poster that advertises the plant selected. Encourage them to be creative in developing their poster ads. LS **Visual**

Answers to Caption Questions

Figure 1: chloroplasts

Differentiated Instruction

Struggling Readers

Deciphering the Key Idea Help students break down the meanings of the words in the Key Idea on this page. Review the following terms with them to give meaning to the Key Idea: *multicellular eukaryote, cell walls, autotrophs, photosynthesis.* Ask students to identify which of these terms are things and which is a process. (things: multicellular eukaryote, cell walls, autotrophs; process: photosynthesis) Then, ask students to restate the Key Idea in their own words. LS **Verbal**

Key Resources

Transparencies
- G1 Early Cultivated Plants
- G3 Medicines Originally Derived from Plants
- G4 Evolutionary Relationships Between Plants and Green Algae
- G5 Alternation of Generations
- G6 Life Cycles of Plants

Visual Concepts
- Characteristics of Plants
- Requirements for Plants to Survive on Land
- Alternation of Generations

Teach, continued

Teaching Key Ideas

Tall Tendencies Ask students to suggest characteristics that would enable plants to grow tall. (a vascular system to carry water and nutrients, rigid cell walls to provide support, and thickened stems) Ask students to speculate on the advantages of increased plant height. (Tall plants are able to obtain more sunlight. Tall plants are also able to disperse their pollen, fruit, and seeds over greater distances than shorter plants.) **LS Logical**

Teaching Key Ideas

Survival on Land Ask students to name three factors that are important for the survival of an organism on land. (Most students should recognize the need for obtaining water and nutrients; maintaining homeostasis in a dry, sunny environment; and reproduction out of water.) **LS Verbal**

Teaching Key Ideas

Evolution of Plants Use **Figure 3** to remind students how the cladogram shows the evolutionary relationship of plants. **LS Visual**

Figure 2 Plants of genus *Cooksonia,* the oldest known type of vascular plant, lived about 410 million years ago.

Establishment of Plants on Land

Plants probably evolved from multicellular aquatic green algae. On land, minerals, light, and carbon dioxide are available at the soil surface, but water may be in short supply. *Nonvascular plants* grow close to the soil surface. They photosynthesize when water is available but stop when the surface dries. Many nonvascular plants can survive the loss of most of the water from their bodies and can quickly resume photosynthesis when the surface is wet again.

Other plants can photosynthesize when the soil surface is dry because they have roots that obtain water from soil below the surface. These plants are *vascular plants.* Vascular tissue is a specialized tissue that transports water and mineral nutrients from roots to leaves where photosynthesis occurs. Vascular tissue also transports organic molecules produced by photosynthesis from leaves to roots. **In order to thrive on land, plants had to be able to absorb nutrients from their surroundings, to survive dehydration or avoid drying out, and to have a way of dispersal—or way of scattering—that did not require water.** **Figure 2** shows the earliest known vascular plant, which was of the genus *Cooksonia*. **Figure 3** shows the relationship between plants and algae.

Academic Vocabulary

transport to carry from one place to another

Absorbing Nutrients On land, most vascular plants absorb nutrients from the soil through their roots. Although the first plants lacked roots, fossils show that fungi lived on or within the underground parts of many such early plants. Botanists think that fungi may have helped early land plants get nutrients from Earth's rocky surface. Symbiotic relationships between fungi and plant roots are called *mycorrhizae.*

Preventing Water Loss A watertight covering, which reduces water loss, made it possible for plants to live in dry habitats. This covering, called the **cuticle,** is a waxy layer that covers the nonwoody aboveground parts of most plants. Roots obtain water from the soil and allow vascular plants to replace water lost to the atmosphere.

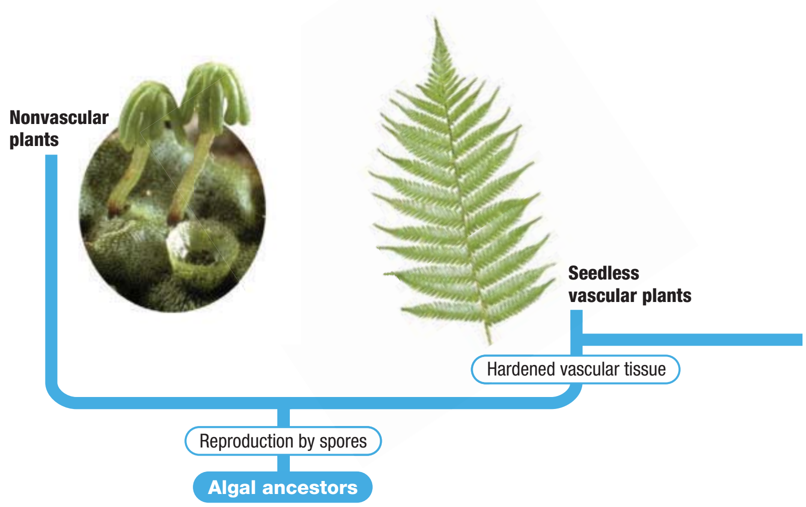
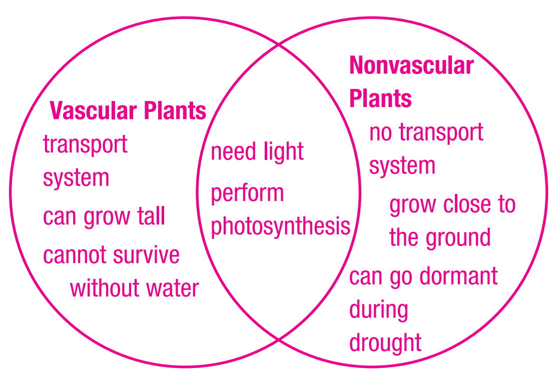


Figure 3 This phylogenetic diagram represents a hypothesis for the evolutionary relationships between plants and green algae. The earliest plants were nonvascular. For updates on phylogenetic information, visit **go.hrw.com.** Enter the keyword **HX8 Phylo.**

Differentiated Instruction

Basic Learners

Organizing Concepts Have students create a Venn diagram comparing vascular and nonvascular plants. Be sure students' diagrams include basic plant characteristics in the overlapping area. **LS Visual**



Hands-On

QuickLab

15 min

Cuticle Modeling

You can use wax paper to model how a plant's cuticle helps to restrict the flow of water out of living tissues.

Procedure

1. Cut out two identical leaf shapes from **construction paper.** Use **tape** and two rectangles of **wax paper** to make a sleeve that is slightly larger than the "leaves."
2. Tape the two leaves side by side to a tabletop so that they extend off the table edge. Place a drop of **alcohol** in the center of each leaf.
3. Quickly, slip the wax paper sleeve over one of the leaves. Use a third sheet of paper to fan both leaves for several minutes. Observe the alcohol spots.

Analysis

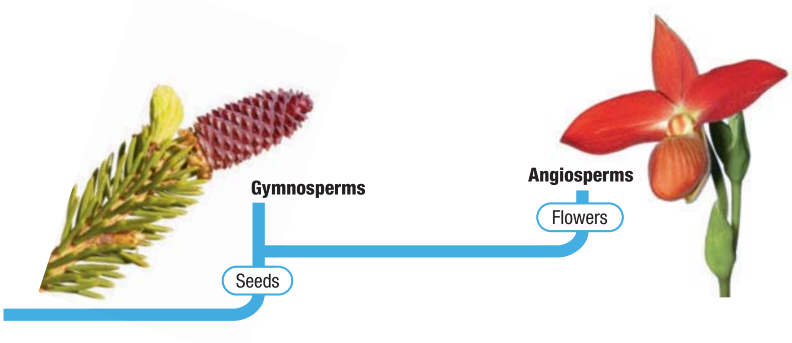
1. **Describe** what happened to the alcohol spot on each of the two leaf models.
2. **Propose** a mechanism for the observed changes.
3. CRITICAL THINKING **Analyzing methods** Why was alcohol used instead of water?

Dispersal on Land Aquatic algae release cells that undergo dispersal by drifting in water currents or by active swimming. The earliest plants produced single cells called **spores** that could dry out and be dispersed to distant locations by wind. Some plants are still dispersed by spores. Seed plants produce a special kind of spore called *pollen* that is scattered across the land by wind or by animals. Pollen transports sperm cells to eggs. After a sperm fertilizes an egg, the zygote becomes an embryo that is dispersed in a seed.

cuticle a waxy or fatty and watertight layer on the external wall of epidermal cells

spore a reproductive cell or multicellular structure that is resistant to environmental conditions

› **Reading Check** *What is the waxy layer on the aboveground parts of most plants that helps prevent water loss called?*



SCILINKS.
www.scilinks.org
Topic: Plant Characteristics
Code: HX81158

QuickLab

Teacher's Notes Students should tape their "leaves" to their tables by the "stem" end so that the alcohol does not damage the table surfaces.

Safety Caution Alcohol is flammable. Students should not use alcohol near a flame. Have students wear chemical safety goggles.

Materials
- safety goggles
- construction paper
- scissors
- tape
- wax paper
- alcohol
- dropper

Safety Caution Remind students of proper procedures for handling chemicals.

Answers to Analysis

1. The spot on the exposed paper surface evaporated. The spot covered by the wax paper envelope did not.
2. Alcohol on the uncovered spot was free to evaporate into the surrounding air, while the alcohol in the spot beneath the wax paper covering could not.
3. Alcohol evaporates more quickly than water, so the results could be observed more quickly.

Differentiated Instruction

Advanced Learners/GATE

Unusual Plant Adaptations Have students research plants that have unusual adaptations for absorbing nutrients, preventing water loss, and dispersing seeds. Students should find photographs, if possible, and share their findings with the class. LS **Verbal**

MISCONCEPTION ALERT

Spores The term *spore* does not have a single, concise definition. However, two things are generally true of spores. First, they are unicellular. Second, they have a protective outer covering. In some bacteria, spores form from regular cells when environmental conditions are harsh. These cells lose most of their water and develop a protective outer covering. The spores of fungi and plants are haploid, resistant to drought, and easily transported by wind or water.

Teach, *continued*

Answers to Caption Questions
Figure 4: spores

Teaching Key Ideas
Visual Literacy Use the following transparencies: B47 Stages of Mitosis, B49 The Stages of Meiosis, F13 The Haploid Life Cycle, and B48 The Diploid Life Cycle to review basic concepts for students so they can understand **Figure 4.** LS **Visual**

Close

Formative Assessment
Alternation of generations describes how _____.

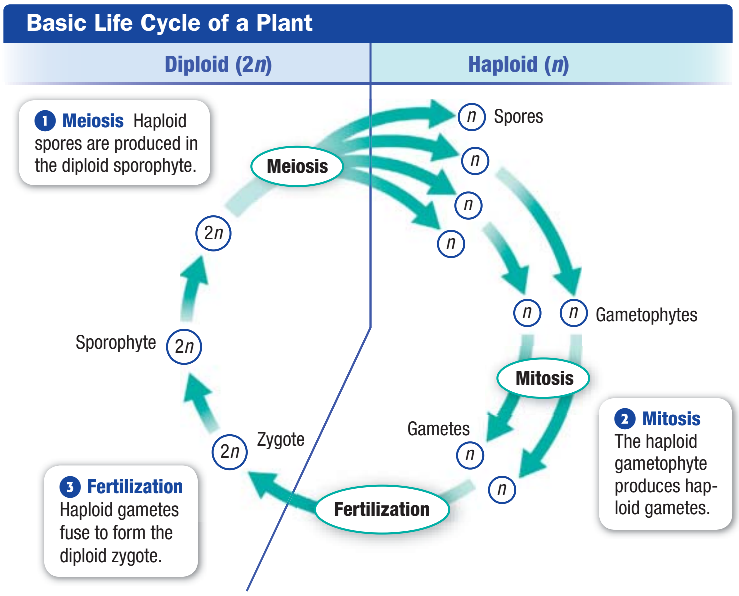
A. haploid gametophytes alternate with diploid sporophytes in plant life cycles (Correct! The gametophyte produces gametes, and the sporophyte produces spores. Each is considered to be a generation.)

B. fertilization occurs in very small plants, such as mosses, and very large plants, such as trees (Incorrect. The size of the plant is irrelevant, and fertilization is a small part of the basic plant life cycle.)

C. meiosis produces gametes and mitosis produces spores (Incorrect. Meiosis produces haploid spores that divide by mitosis to produce haploid gametes.)

D. evolution occurred in plants (Incorrect. The occurance of alternation of generations in green algae is one reason scientists think plants probably evolved from them, but it does not describe how evolution occurred.)

Figure 4 In the life cycle of a plant, a diploid sporophyte generation alternates with a haploid gametophyte generation. **What structure produces gametophytes?**



sporophyte in plants and algae that have alternation of generations, the diploid individual or generation that produces haploid spores

gametophyte in alternation of generations, the phase in which gametes are formed; a haploid individual that produces gametes

Plant Life Cycles
Recall that plants probably evolved from multicellular green algae. In many algae, the zygote is the only diploid cell. It undergoes meiosis following fertilization. As a result of meiosis, the bodies of these algae consist of haploid cells. But in the ancestors of plants, meiosis was delayed. The zygote divided by mitosis and grew into a multicelled **sporophyte** that was diploid. This diploid sporophyte produced haploid spores by meiosis. Spores grew into multicelled **gametophytes** that were haploid and produced gametes by mitosis. **Plants have life cycles in which haploid gametophytes alternate with diploid sporophytes. A life cycle in which a gametophyte alternates with a sporophyte is called *alternation of generations*. Figure 4** shows the basic plant life cycle.

Reading Check ***Is a plant sporophyte diploid or haploid?***

Section 1 Review

KEY IDEAS

1. **Identify** the key characteristics of plants.
2. **Describe** the adaptations that allowed plants to live on land.
3. **Outline** the life cycle of a plant.

CRITICAL THINKING

4. **Applying Information** Is a plant that is thriving in a dark underground cave likely to be an autotroph? Explain your answer.
5. **Applying Logic** Explain why, during fertilization, the diploid zygote cannot be formed from the fusing of two diploid cells.

ALTERNATIVE ASSESSMENT

6. **Creating a Documentary** Make a video showing pollination by insects such as bees, butterflies, and moths. Write a script that narrates the action and documents the process that you are showing.

Answers to Section Review

1. Plants are multicellular eukaryotes whose cells have cell walls. Most plants are autotrophs.
2. the ability to absorb nutrients from their surroundings, the ability to survive dehydration, and the means to disperse that does not require water
3. Haploid gametophytes alternate with diploid sporophytes in alternation of generations.
4. No. Autotrophs produce their own food through photosynthesis, a process that requires sunlight.
5. Diploid cells already have two sets of genetic material ($2n$), whereas haploid cells have only one set, or half, of the required genetic material (n). Therefore, the diploid zygote must come from the fusing of two "halves," or two haploid cells: $n + n = 2n$. When the two haploid cells fuse, the diploid number of chromosomes is restored.
6. Students' videos should include a description of the structure of a flower and the processes involved in pollination and cross-fertilization. If videotaping is not possible, have students narrate a series of photographs.

Section 2

Seedless Plants

Key Ideas	Key Terms	Why It Matters
❯ What are the characteristics of nonvascular plants? ❯ What characterizes reproduction in nonvascular plants? ❯ How do seedless vascular plants differ from nonvascular plants? ❯ How does reproduction in a seedless vascular plant compare to reproduction in a nonvascular plant?	archegonium antheridium sporangium rhizome frond sorus	Peat bogs are composed mainly of decayed sphagnum moss. Well-preserved bodies of humans that lived more than 2,000 years ago have been discovered in peat bogs in Europe.

When you think of a plant, what is the first thing that comes to mind? You may think of grass or a tree. Grasses and trees are examples of seed plants. Some plants do not produce seeds. Mosses and ferns are examples of seedless plants.

Nonvascular Plants

The brilliant green carpet of mosses shown in **Figure 5** is made up of thousands of individual plants. Mosses are most often found near streams, coastlines, and other moist places. Mosses are a type of *nonvascular plant.* ❯ **Nonvascular plants are small plants that reproduce by means of spores. They lack true roots, stems, and leaves, which are complex structures that contain vascular, or conducting, tissues.**

In nonvascular plants, water and nutrients are transported by osmosis and diffusion, which move materials short distances and very slowly. This method of transport greatly limits the size of a nonvascular plant's body. Thus, all nonvascular plants are relatively small.

❯ **Reading Check** *How is water transported in nonvascular plants?*

Figure 5 Mosses grow in tightly packed mats that may contain dozens of plants per square inch. ❯ **Why are nonvascular plants usually small?**

Section 2

❯ Focus

This section describes the characteristics of nonvascular plants and seedless vascular plants and how they reproduce.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Teaching Key Ideas

Observing Habitats Show photographs of several habitats—lush areas by a stream, a desert, a shaded dripping downspout, and so on. Challenge students to point out specific places where they might find nonvascular and vascular plants in each and explain why. (Students should point out that nonvascular plants would most likely be found in shady, moist habitats. Vascular plants can be found in a greater variety of places.) LS **Logical**

Answers to Caption Questions

Figure 5: Nonvascular plants are usually small because water and minerals are transported by osmosis and diffusion, processes that are effective over short distances and very slow.

Differentiated Instruction

Basic Learners

Using Concept Maps Have students begin two concept maps: one for nonvascular plants and the other for seedless vascular plants. Students should add details from each heading and subheading as they move through the section. At the end of the section, challenge students to add concepts that would connect the two maps, making one larger map. LS **Visual**

Key Resources

Transparencies
G33 Life Cycle of a Moss
G34 Life Cycle of a Fern

Visual Concepts
Characteristics of Nonvascular Plants
Types of Nonvascular Plants
Parts of a Moss
Characteristics of Vascular Plants Without Seeds
Types of Seedless Vascular Plants
Parts of a Fern

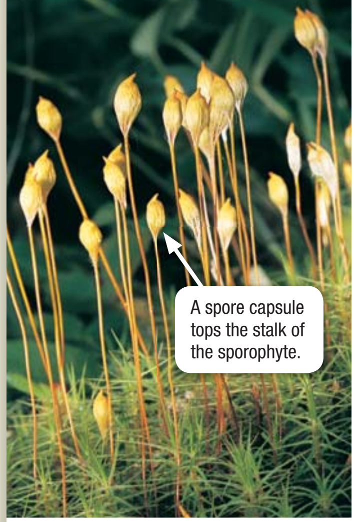
Teach, continued

Teaching Key Ideas

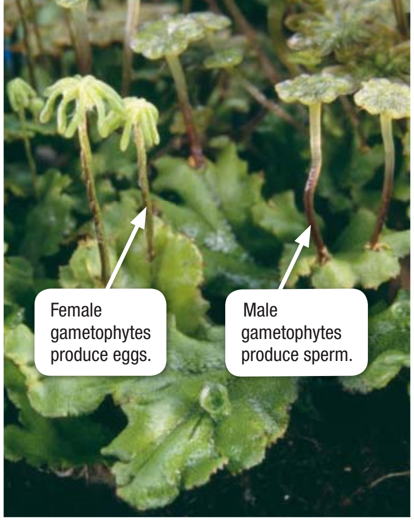
Leaflike Structures Use transparency G30 Structure of a Leaf to review true leaf structure. Then, make comparisons with the leaflike structures of nonvascular plants. Tell students that these structures are "leaf like" because they carry out photosynthesis, but they are composed of only a few types of cells that are specialized for osmosis, gas transport (through the stoma), and water retention (the cuticle). **LS Logical/Visual**

Math Skills

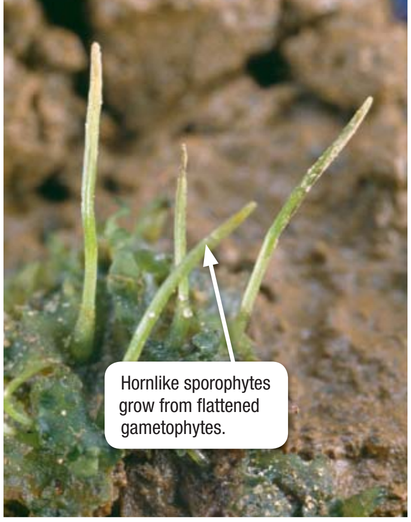
Calculating Have students predict the water holding capacity of *Sphagnum* (peat moss) and then compare the sample's mass before and after having soaked it in water. (The mass of the wet moss should be 20 to 30 times greater than the mass of the dry moss due to its large cell structure.) Ask students to suggest how peat moss might aid gardeners and landscapers. (Its water absorption properties would be useful in dry areas.) **LS Kinesthetic/Logical**



A moss of genus *Polytrichum*
(Phylum Bryophyta)



A liverwort of genus *Marchantia*
(Phylum Hepatophyta)



A hornwort of genus *Anthoceros*
(Phylum Anthocerophyta)

Figure 6 Mosses (left), liverworts (center), and hornworts (right) are all nonvascular plants.

Mosses The mosses are the most familiar nonvascular plants. The seemingly leafy green plants that you recognize as mosses are gametophytes. Moss sporophytes, which are not green, grow from the tip of a gametophyte, as **Figure 6** shows. Each sporophyte consists of a bare stalk topped by a spore capsule. Most mosses have a cuticle, stomata, and simple conducting cells. Because these cells carry water only short distances, mosses never get very large.

Liverworts Like the mosses, liverworts grow in mats of many individual plants. Liverworts have no conducting cells, no cuticle, and no stomata. In some species, such as the common liverwort shown in **Figure 6**, the gametophytes are flattened and have lobes. Structures that resemble stems and leaves make up the gametophytes of most liverworts. The sporophytes of liverworts are very small and consist of a short stalk topped by a spore capsule.

Academic Vocabulary
consist to be made up of

Hornworts The hornworts are a small group of nonvascular plants that, like the liverworts, completely lack conducting cells. The sporophyte of a hornwort has both stomata and a cuticle. The gametophyte of a hornwort is green and flattened. Green hornlike sporophytes grow upward from the gametophytes, as shown in **Figure 6.**

Reproduction in Nonvascular Plants

Like all plants, nonvascular plants have a life cycle characterized by an alternation of generations. **In the life cycle of nonvascular plants, the gametophyte is the dominant generation. Gametophytes must be covered by a film of water in order for fertilization to occur.** Gametophytes produce gametes (eggs and sperm) in two separate structures. The structure that produces eggs is called an **archegonium.** The structure that produces sperm is called an **antheridium.** Sporophytes produce spores in a **sporangium.** The smaller sporophytes grow on the gametophytes and depend on them for nutrients.

archegonium (AHR kuh GOH nee uhm) a female reproductive structure that produces a single egg and in which fertilization and development take place

antheridium (AN thur ID ee uhm) a reproductive structure that produces male sex cells in seedless plants

sporangium (spoh RAN jee uhm) a specialized sac, case, capsule, or other structure that produces spores

MISCONCEPTION ALERT

Mistaken Identity A variety of plants and plantlike organisms are mistakenly called mosses. Examples include Irish moss, Spanish moss, and reindeer moss. Show photos of these examples, and reinforce the concept that common names can be misleading. For example, Irish moss is a red alga, Spanish moss is a flowering vascular plant, and reindeer moss is a lichen.

Differentiated Instruction

Struggling Readers

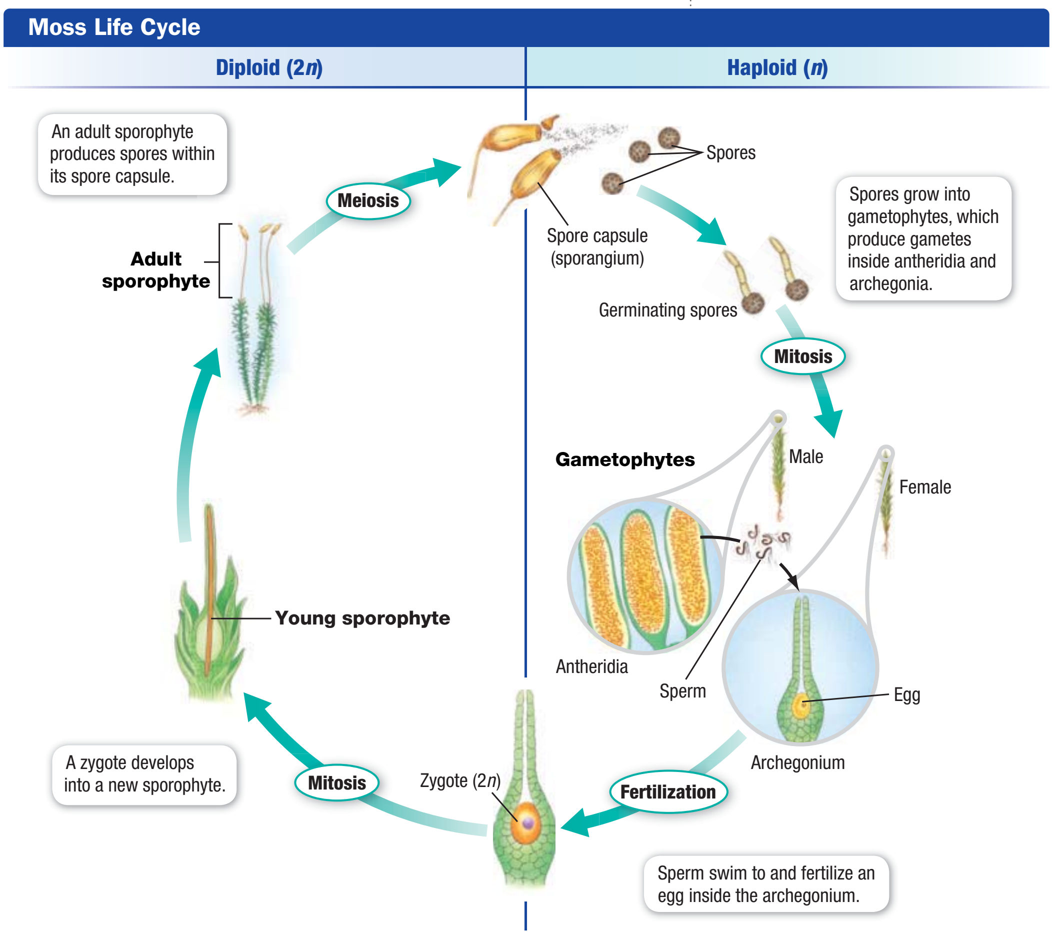
Reproduction in Nonvascular Plants Help students with the last paragraph on this page by reviewing unfamiliar terms before they read, so that they can construct meaning while they read. Review definitions for the following terms: *gametophyte, alternation of generations, nonvascular plant, fertilization, gamete, archegonium, antheridium, sporophyte,* and *sporangium.* **LS Verbal**

Life Cycle of a Moss As you can see in **Figure 7,** a moss sporophyte grows from a gametophyte. The sporophyte consists of a bare stalk with a spore capsule, or sporangium, at its tip. Spores form by meiosis inside the spore capsule. Therefore, the spores are haploid. The spore capsule opens when the spores are mature, and the spores are carried away by wind or water. When a moss spore settles to the ground, it germinates and grows into a leafy-looking green gametophyte. Archegonia and antheridia form at the tips of the haploid gametophytes. Eggs and sperm form by mitosis inside the archegonia and antheridia. Moss gametophytes grow in tightly packed clumps. When water covers a clump of mosses, sperm can swim to nearby archegonia and fertilize the eggs inside them.

Reading Check *Which structure produces male sex cells in nonvascular plants?*

SCILINKS. www.scilinks.org
Topic: Nonvascular Plants
Code: HX81045

Figure 7 In mosses, a sporophyte that consists of a spore capsule on a bare stalk alternates with a leafy-looking green gametophyte. **How are spores dispersed in nonvascular plants?**



Teaching Key Ideas

Moss Life Cycle Have students compare **Figure 7** with **Figure 4.** Ask questions to help students connect the example to the generalized process. "What are the gametes?" (egg and sperm) "Where are the gametes formed?" (in the antheridia and archegonia) "How do antheridia and archegonia relate to the gametophytes?" (structures within the gametophytes) "Which structures are diploid?" (zygote and sporophytes) "Which structures are haploid?" (spores and gametophytes)
LS Visual

Answers to Caption Questions

Figure 7: wind or water

Teach, *continued*

Answers to Caption Questions

Figure 8: Club mosses have roots, stems, and leaves.

Demonstration

Variation in Ferns Bring examples of several kinds of ferns to class, and have students examine them. Also, bring pictures of tree ferns, which are native to many tropical regions. Have students note the shapes of the leaves and any fertile fronds with sori present on the lower surface of the fronds. Point out that there are more than 10,000 species of ferns on Earth today. The species are tremendously diverse in leaf form, ranging from simple, rounded leaves to lacy fronds with hundreds of leaflets. Plant sizes range from 2.0 cm to 24 m tall (about 1 in to 76 ft). **LS Visual**

READING TOOLBOX

Classification club mosses and ferns **LS Verbal**

Figure 8 Club mosses are sometimes known as *ground pines.* The tips of the aerial stems contain conelike structures. **How do club mosses differ from true mosses?**

READING TOOLBOX

Classification What are two types of seedless vascular plants?

Seedless Vascular Plants

Vascular plants that do not produce seeds are called *seedless vascular plants.* **Sporophytes of seedless vascular plants have vascular tissue, but gametophytes lack vascular tissue. Because of their vascular system, vascular plants grow much larger than nonvascular plants and also develop true roots, stems, and leaves.** The much smaller gametophytes of most seedless vascular plants develop on or below the surface of soil. As in nonvascular plants, water is needed for fertilization in seedless vascular plants. When enough water is on or in the soil, the sperm swim to eggs and fertilize them. There are two major groups of seedless vascular plants: club mosses (lycophytes) and ferns and related species (monilophytes).

Club Mosses Unlike true mosses, the club mosses have roots, stems, and leaves. Their leafy green stems branch from an underground **rhizome.** A rhizome is a horizontal, underground stem. Spores develop in sporangia that form on specialized leaves. In some species, such as the one seen in **Figure 8,** clusters of nongreen spore-bearing leaves form a structure called a *cone.*

Ferns and Fern Allies The ferns and fern allies, or relatives, are the most common and familiar seedless vascular plants. Ferns grow throughout the world, but they are most abundant in the tropics. The plants that you recognize as ferns are sporophytes. Most fern sporophytes have a rhizome that is anchored by roots and have leaves called **fronds.** The coiled young leaves of a fern, shown in **Figure 9,** are called *fiddleheads.* Spores are produced in sporangia that grow in clumps on the lower side of fronds. The gametophytes of ferns are flattened, heart-shaped green plants that are usually less than 1 cm (0.5 in.) across. Horsetails are related to ferns. The vertical stems of horsetails, which grow from a rhizome, are hollow and have joints. Whorls of scalelike leaves grow at the joints. Spores form in cones located at the tips of stems.

Reading Check ***Where do sporangia form on ferns?***

Figure 9 The coiled young leaves of a fern (left) are called *fiddleheads.* Horsetails (right) have hollow stems topped by cones.

Why It Matters

Ancient Plants Seedless vascular plants were the most common plants on Earth about 300 million years ago. Many of these were very large trees, including a number of different tree ferns. When these plants died, they became buried and only partly decomposed, forming carbon-rich coal deposits, a very important fossil fuel today. Thus, the period of time in Earth's history when these plants were most abundant is called the Carboniferous period.

Differentiated Instruction

English Learners

Observing Vascular Tissue To help English learners understand the concept of transport through vascular tissue, place a freshly cut stalk of celery in colored water. After the food coloring reaches the leaves, slice the stalk crosswise to observe the colored dots. You might also pull out the fibers from the stalk. Both show how vascular tissue, similar to that in ferns, transports substances and enables these plants to grow taller. **LS Visual**

Reproduction in Seedless Vascular Plants

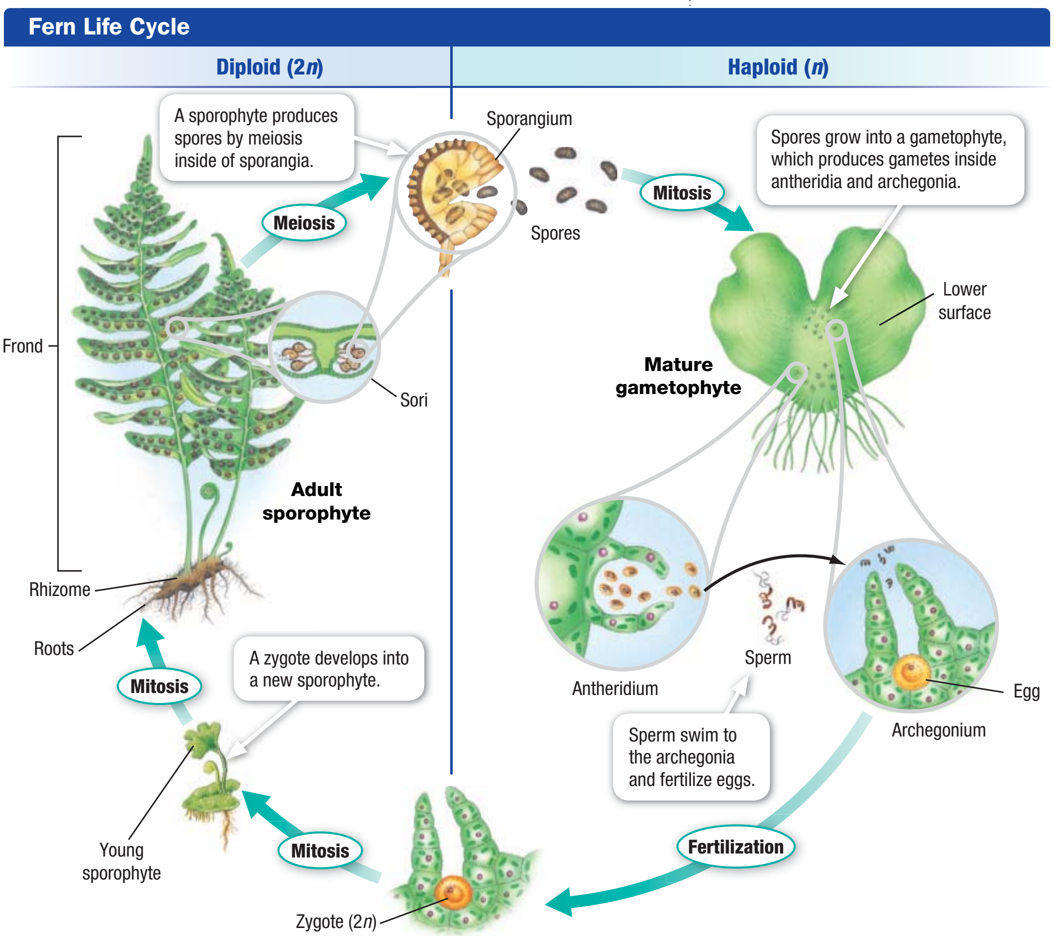
❯ Like nonvascular plants, seedless vascular plants can reproduce sexually only when a film of water covers the gametophyte. Unlike nonvascular plants, seedless vascular plants have sporophytes that are much larger than their gametophytes. Some ferns have sporophytes that are as large as trees. On the other hand, the gametophytes of ferns are less than 1 cm (0.5 in.) across. The archegonia and antheridia develop on the lower surfaces of the gametophytes. In most species of seedless vascular plants, both eggs and sperm are produced by the same individual. In some species, however, eggs and sperm are produced by separate gametophytes. The life cycle of a fern is summarized in **Figure 10.**

❯ Reading Check *How large is a fern gametophyte?*

rhizome a horizontal, underground stem that provides a mechanism for asexual reproduction

frond the leaf of a fern or palm

Figure 10 In ferns, a large sporophyte with leaves called *fronds* alternates with a small, green, heart-shaped gametophyte. **❯ Which generation is dominant in the life cycle of a fern?**



Differentiated Instruction

Basic Learners

Fern Ranges Have students use horticultural catalogs or identification keys to identify the kinds of ferns that live in your area. Have them compare their findings to another area in the country with a very different climate.
LS Verbal/Logical

Basic Learners

What Are Ferns Used For? Have students research the various uses of ferns and share their findings with the class. Ferns are used for medicinal, decorative, and environmental purposes and are eaten as food. **LS Verbal**

Teaching Key Ideas

Fern Life Cycle Have students compare **Figure 10** with **Figure 4.** Ask questions to help students connect the example to the generalized process. **LS Visual**

Demonstration

Observing Fern Gametophytes Show students the clusters of sporangia, called sori, on the lower surface of a fern frond. Instruct them to remove a sorus and crush it on white paper using the eraser end of a pencil. Next, have them sprinkle some spores on a moist peat pellet and place the peat pellet in a sealed plastic bag. The first structures they will observe will be the green, heart-shaped gametophytes.
LS Kinesthetic/Visual

Answers to Caption Questions

Figure 10: sporophyte

Teach, *continued*

QuickLab

Teacher's Notes Tell students that fern gametophytes develop on moist soil and are very small.

Materials
- compound microscope
- prepared slide of fern gametophyte

Answers to Analysis
1. Answers should be consistent with the diagrams in **Figure 10.**
2. It begins in an archegonium. The egg remains in the archegonium while a sperm cell swims there from an antheridium to fertilize the egg.

Close

Formative Assessment
During the life cycles of nonvascular and seedless vascular plants, what special conditions must be present for fertilization to occur?

A. The gametophytes must be below the surface of the soil. (Incorrect. This is not a requirement for fertilization.)

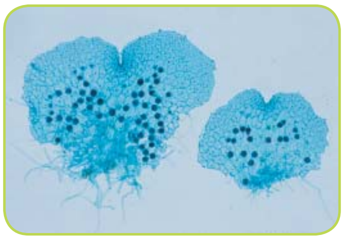
B. Both the sperm and the egg must be located in the same sorus. (Incorrect. A sorus is a cluster of spores on a fern.)

C. The gametophytes must be covered by a film of water. (Correct! The sperm travels to the egg through the water.)

D. The sporophyte must be in a windy area. (Incorrect. While spores are spread by air currents, gametes must remain in water.)

Hands-On **QuickLab** — 15 min

Fern Gametophytes
You can observe the archegonia and antheridia of a fern gametophyte with a microscope.



Procedure

1. Examine a **slide of a fern gametophyte** under low power of a **microscope.** Move the slide until you can see a cluster of archegonia. Now, switch to high power, and focus on one archegonium. Draw and label what you see.
2. Switch back to low power, and move the slide until you can see several egg-shaped structures. These are antheridia. Now, switch to high power, and focus on one antheridium. Draw and label what you see.

Analysis

1. **Describe** the appearance of an archegonium and an antheridium.
2. **Drawing Conclusions** In which structure, an archegonium or antheridium, does the growth of a new sporophyte begin? Explain.

sorus a cluster of sporangia

Spores Recall that a spore is a haploid reproductive cell. A spore is produced by meiosis and is capable of developing into an adult without fusing with another cell. The spores of seedless vascular plants have thickened walls that allow the spores to withstand drying and adverse conditions. The spores are easily dispersed by wind. Sporophytes produce spores in sporangia. In horsetails and club mosses, sporangia develop in conelike structures. In ferns, clusters of sporangia form on the lower surfaces of fronds. A cluster of sporangia on a fern frond is called a **sorus.** The word *sorus* comes from the Greek word *soros,* meaning "a heap." Sori often look like brownish dots on the lower surface of a fern frond, as shown in **Figure 10** on the previous page. Some fern fronds have distinctive patterns of sori. These patterns may be used to help identify the species of the fern.

Reading Check *What is a cluster of sporangia on a fern frond called?*

Section 2 Review

KEY IDEAS
1. **Identify** the characteristics of nonvascular plants.
2. **Describe** reproduction in nonvascular plants.
3. **Describe** how seedless vascular plants differ from nonvascular plants.
4. **Compare** reproduction in seedless vascular plants to reproduction in nonvascular plants.

CRITICAL THINKING
5. **Making Inferences** Ferns grow throughout the world, but they are most abundant in the tropics. Why might a fern have a better chance of reproducing in a tropical environment than in another environment? Explain your answer.

ALTERNATIVE ASSESSMENT
6. **Finding and Communicating Information** Mosses have a variety of commercial uses. Use the Internet or library resources to investigate some of these uses. Create a leaflet about the past and present uses of mosses that you can present to your class or display on a wall in your classroom.

Answers to Section Review
1. They do not have a speciaized system for transporting water and nutrients within their bodies and are generally small because water and nutrients must be transported by osmosis and diffusion.
2. The gametophyte is the dominant generation. Gametophytes must be covered by a film of water for fertilization to occur. They produce gametes in two separate structures. Eggs are produced in the archegonium. Sperm is produced in the antheridium. Sporophytes produce spores in a sporangium. The smaller sporophytes grow on the gametophytes and depend on them for nutrients.
3. Seedless vascular plants have vascular tissue, so they can grow much larger than nonvascular plants and they develop true roots, stems, and leaves.
4. Like nonvascular plants, seedless vascular plants can reproduce sexually only when a film of water covers the gametophyte. Unlike nonvascular plants, seedless vascular plants have sporophytes that are much larger than their gametophytes.
5. Ferns require water for fertilization, and tropical environments have the most rainfall each year.
6. Mosses are used in the florist industry as a soil additive; historically, they aere used as diapers, and as a sort of self-stick bandage on wounds in World War II.

Section 3

Seed Plants

Key Ideas	Key Terms	Why It Matters
❯ What are the two groups into which seed plants are classified? ❯ What characterizes reproduction in seed plants? ❯ What are the four major groups of living gymnosperms? ❯ What characterizes reproduction in a conifer?	gymnosperm angiosperm ovule seed pollen grain pollination	Conifers are extremely important economically. They provide softwood for construction and for the production of paper.

Most plants living today are seed plants—vascular plants that produce seeds. Seeds were an important terrestrial adaptation that enhanced survival and dispersal of offspring.

Kinds of Seed Plants

The first seed plants appeared about 380 million years ago. ❯ **Seed plants are traditionally classified into two groups—gymnosperms and angiosperms.** **Gymnosperms** are seed plants whose seeds do not develop within a fruit. The word *gymnosperm* comes from the Greek words *gymnos*, meaning "naked," and *sperma*, meaning "seed." The seeds of most gymnosperms develop within a cone, as shown in **Figure 11.** **Angiosperms** are seed plants whose seeds develop enclosed within a fruit, a specialized plant structure. The word *angiosperm* comes from the Greek words *angeion*, meaning "case," and *sperma*, meaning "seed." Fruits develop from part of a flower, another specialized plant structure. Therefore, angiosperms are flowering plants. Most species of seed plants are flowering plants.

❯ **Reading Check** ***What is the difference between gymnosperms and angiosperms in terms of seed production?***

gymnosperm (JIM noh spuhrm) a vascular seed plant whose seeds are not enclosed by a fruit

angiosperm (AN jee oh spuhrm) a flowering plant that produces seeds within a fruit

Figure 11 Gymnosperms and angiosperms are both types of seed plants. Unlike the seeds of angiosperms, the seeds of gymnosperms do not develop within a fruit.

Section 3

❯ Focus

This section explains how seed plants differ from other plants and describes the characteristics of living gymnosperms.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Demonstration

Observing Seeds Give each student a variety of seeds (various beans, peas, maple seeds, pine seeds, coconuts, peppercorns, sunflower, and poppy). Have students list the similarities and differences. Ask them to infer whether the seed developed inside of a fruit and to suggest ways in which the seeds might be dispersed. (via wind, water, and so on) **LS Logical/Visual**

Differentiated Instruction

Struggling Readers

Taking Notes Have struggling readers list the headings and subheadings in this section. Then, have them look at the figures on each page and connect what they see in the pictures with the headings and subheadings. **LS Visual/Verbal**

Key Resources

Transparencies
G42 Seed Structure
G43 Structure and Function of Seeds
G35 Life Cycle of a Conifer

Visual Concepts
Needles and Cones
Characteristics of Vascular Plants with Seeds
Characteristics of Gymnosperms
Types of Gymnosperms

Teach, *continued*

Teaching Key Ideas

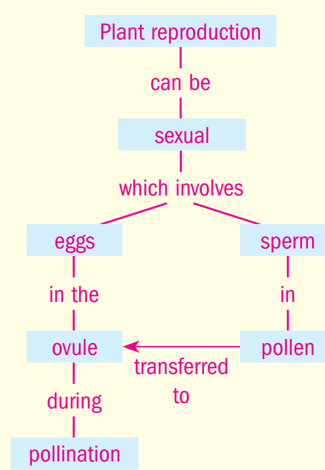
Pollen Grains Provide students with flowers that have pollen, or give them some pollen from a pine tree, for example. For students with pollen allergies, you'll want to make the slides yourself. Have students make wet-mount slides of the pollen to observe the intricately detailed coats of pollen grains and then make drawings. Alternatively, provide them with pictures showing electron micrographs of pollen grains. Ask students to make generalizations about the advantages of the different shapes. **LS Visual**

Why It Matters

Do They Really Jump? Mexican jumping beans are not beans but the seed case of a deciduous shrub in Mexico. The moth *Cydia saltitans* lays eggs in the developing ovary of the shrub's flowers. The larva develops along with the seed and eventually eats it. The jumping movements occur when the moth larva inside changes position with a jerk.

READING TOOLBOX

Concept Map A sample map is shown below. **LS Visual**



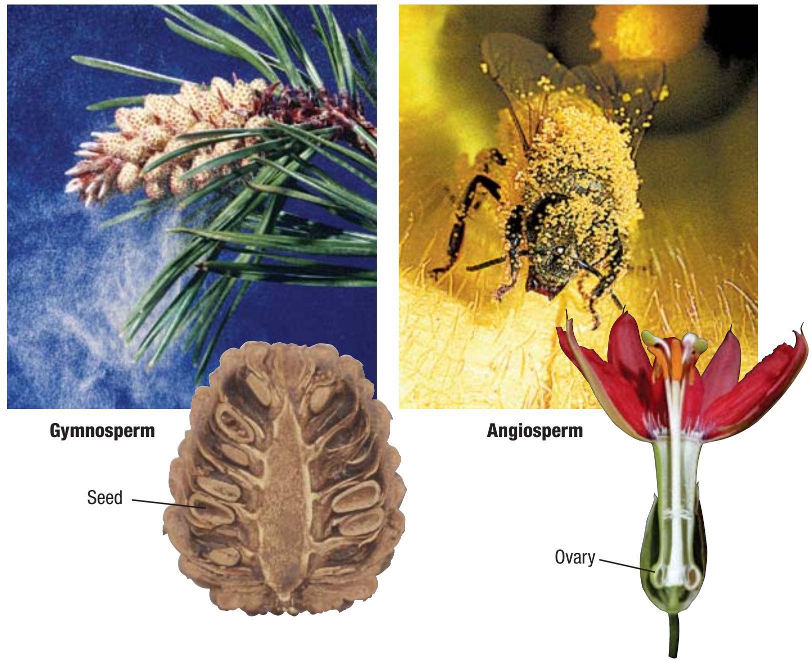


Figure 12 The pollen of gymnosperms is usually dispersed by wind (left). After fertilization, seeds develop inside cones. The pollen of many angiosperms is dispersed by insects (right). Seeds develop from ovules inside the ovary.

SCILINKS. www.scilinks.org
Topic: Seed Plants
Code: HX81367

READING TOOLBOX

Concept Map Create a concept map based on what you learned about reproduction in seed plants.

Reproduction in Seed Plants

Reproduction in seed plants is quite different from reproduction in seedless plants. **Unlike seedless plants, seed plants do not require water to reproduce sexually. Reproduction in seed plants is also characterized by a greatly reduced gametophyte and a dominant sporophyte.** In fact, you often need a microscope to see the gametophytes of seed plants.

Sporophytes produce two kinds of spores that develop into two kinds of gametophytes—female gametophytes, which produce eggs, and male gametophytes, which produce sperm. A female gametophyte of a seed plant develops inside an **ovule,** which is a multicellular structure that is part of the sporophyte. Following fertilization, the ovule and its contents develop into a **seed.** The male gametophyte of seed plants develops inside a **pollen grain.**

Pollination and Fertilization The transfer of pollen grains from the male reproductive structures of a plant to the female reproductive structures of a plant is called **pollination.** Wind or animals transport pollen grains to the structures that contain ovules, as shown in **Figure 12.**

When a pollen grain reaches a compatible female reproductive structure, a tube emerges from the pollen grain. This tube, called a *pollen tube,* grows to the female gametophyte within an ovule and enables a sperm to pass directly to an egg. The fusion of an egg and sperm is called *fertilization.*

Reading Check *Where do gametophytes develop in seed plants?*

Seed Formation After fertilization, the ovule is called a *seed* and contains an *embryo*. A seed is a complex structure. The outer cell layers of an ovule harden to form the seed coat as a seed matures. The tough seed coat protects the embryo in a seed from mechanical injury and from a harsh environment. The seed coat is formed from tissues of the mother sporophyte but contains an embryo which is an offspring sporophyte. Seeds also contain tissue that provides nutrients to plant embryos. In gymnosperms, this nutritious tissue develops from the female gametophyte. The seeds of some angiosperms contain a nutritious tissue called *endosperm*.

Seed Dispersal Seeds are dispersed, or scattered, from the parent plant to locations where the embryos in the seeds develop into new sporophytes. Dispersal may prevent competition for water, nutrients, light, and living space between parents and offspring. Many seeds have structures that help wind, water, or animals carry them away from their parent plant, as shown in **Figure 13.**

Dispersal by Wind Many conifer seeds have winglike structures that act like propellers as seeds fall to the ground. The fruits of maples also have wings. Dandelion and milkweed seeds are dispersed with the help of parachute-like structures that allow the seeds to drift in the wind and travel far from the parent plant.

Dispersal by Animals Fruits are important for seed dispersal by animals. Some fruits have hooks that cling to an animal's fur. Other fruits provide food for animals. Seeds are dispersed when they pass undigested through the animal's body.

ovule (AHV YOOL) a structure of a seed plant that contains a female gametophyte and that develops into a seed after fertilization

seed a plant embryo that is enclosed in a protective coat

pollen grain the structure that contains the male gametophyte of seed plants

pollination the transfer of pollen from the male reproductive structures (anthers) to the tip of a female reproductive structure (pistil) of a flower in angiosperms or to the ovule in gymnosperms

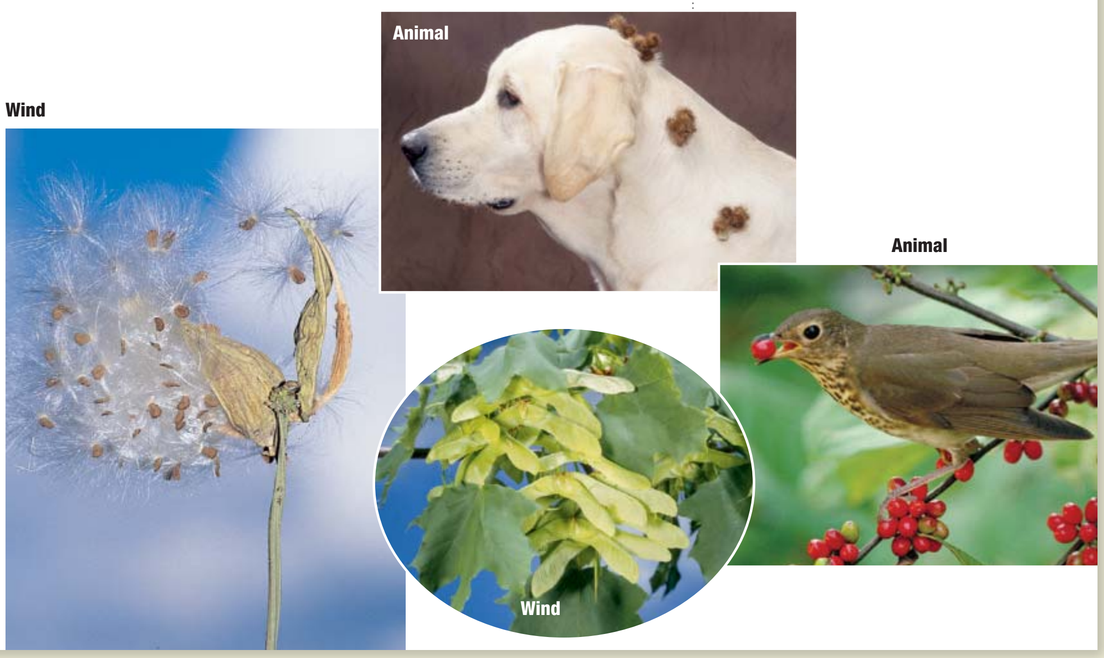


Figure 13 Some seeds, such as milkweed seeds and maple seeds, are dispersed by the wind. Other seeds are dispersed by animals. **❯ How does seed dispersal benefit plants?**

Teaching Key Ideas

Seed Dispersal Bring a variety of fruits and cones containing seeds to class. Include large colorful fruits (apples, oranges, grapes), small fruits with wings (elm, maple) or umbrella-like appendages (dandelion), cones with scales (pine, spruce, fir), and a coconut. Ask students to examine the fruits and cones and to identify which of the fruits are dispersed by the wind. (winged fruits, small fruits with appendages, and conifer seeds) Ask students which seeds are likely to be dispersed by animals. (showy, fleshy fruits) Ask students how the coconut is dispersed. (The coconut can float along coasts and from island to island.) **LS Visual**

Answers to Caption Questions

Figure 13: Dispersal may prevent competition for water, nutrients, light, and living space between parents and offspring.

Differentiated Instruction

Basic Learners/ Special Education Students

Seed Germination Have students collect a variety of seeds and germinate them. The embryos in seeds from pumpkins, avocadoes, tomatoes, and radishes will easily germinate when kept between layers of moist paper towels. Avocado or other pits may take more time and some special handling. Give blind and visually impaired students the opportunity to handle the germinated seeds. Ask them to classify the plants based on feel. **LS Visual, Kinesthetic**

Alternative Assessment

Observing Wind Dispersal To help students understand how seed structures aid dispersal, have them experiment with different structures. Give students a sheet of white paper, tape, scissors, and one dried lima bean. Have them add structures to the seed that will help it move in the wind more easily. Have students test their designs in front of a fan. Students might revise their structures based on their observations and test again. **LS Kinesthetic**

Teach, *continued*

Teaching Key Ideas

Conifer Characteristics Ask students to list the characteristics they may have observed in conifers. (They stay green all year, and have needles and cones.) Have students compare pines and cedars. (Leaves are needle-like for pines and are scale-like for cedars.) **LS Verbal**

Teaching Key Ideas

Conifer Identification Obtain cuttings of several conifers. Allow students to look at the cones and the needle's size, shape, organization, and color. Then, supply students with keys or field guides, and ask them to correctly identify their samples. **LS Kinesthetic/Logical**

Answers to Caption Questions

Figure 14: wind

Gymnosperms

Gymnosperms are among the most successful groups of plants. **There are four major groups of gymnosperms—conifers, cycads, ginkgoes, and gnetophytes.** Examples of each group appear in **Figure 14.**

Conifers The conifers are the most familiar gymnosperms. Conifers have leaves that are needle-like or that are reduced to tiny scales. Some of the tallest living plants, the redwoods of coastal California and Oregon, are conifers. The oldest trees in the world are thought to be bristlecone pines. Some bristlecone pines are about 5,000 years old. Large forests of conifers grow in cool, dry regions of the world. The pollen grains of most conifers are dispersed by wind.

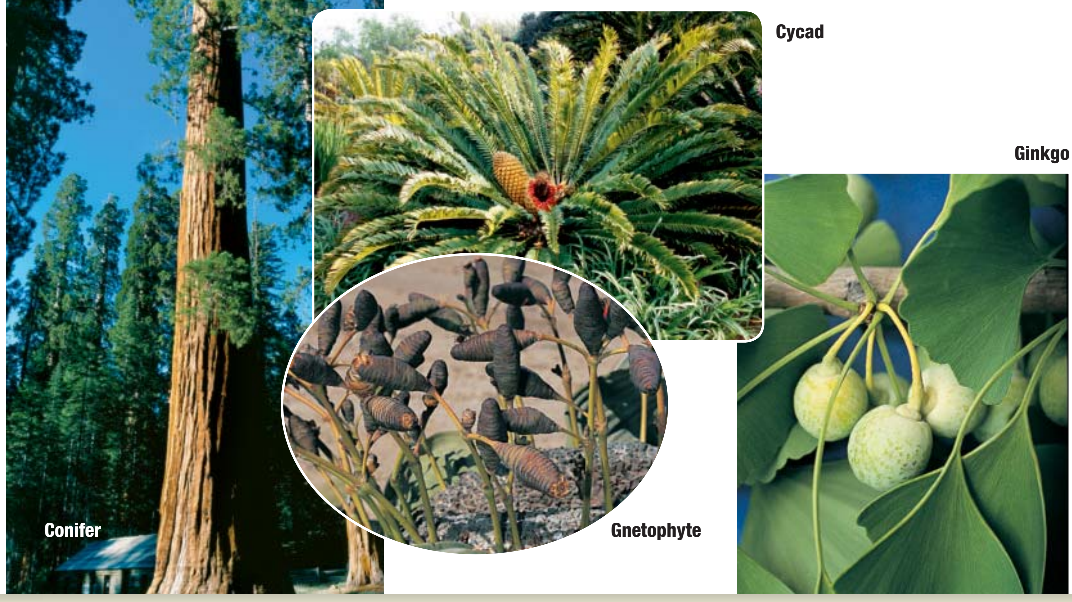
Cycads The cycads have short stems and palmlike leaves. Cones that produce pollen and those that produce seeds develop on different plants. Cycads are widespread throughout the tropics. The pollen grains of most cycads are dispersed by insects.

Ginkgoes The only living species of ginkgo, or maidenhair tree, has fan-shaped leaves. The male and female gametophytes of ginkgoes develop on separate trees. Ginkgo seeds do not develop within a cone. Pollen grains are dispersed by wind.

Gnetophytes The gnetophytes are a diverse group of trees, shrubs, and vines that produce pollen and seeds in cones. One unusual gnetophyte is *Welwitschia,* a desert plant of southwestern Africa. Welwitschia has a short, wide stem and twisting leaves.

Reading Check ***Which gymnosperm has seeds that do not develop within a cone?***

Figure 14 The four living phyla of gymnosperms are made up of conifers, cycads, ginkgoes, and gnetophytes. **How is the pollen of most gymnosperms dispersed?**



Why It Matters

Ancient Pines The Wollemi Pine was known from fossil records and was thought to be extinct for about 2 million years until a small stand was rediscovered by a bushwalker in Australia in 1994. The oldest known Wollemi Pine fossil dates back 90 million years. The Pines may have existed since the Jurassic Period nearly 200 million years ago.

Differentiated Instruction

Basic Learners

What's a Ginkgo? Have students research the unique characteristics of *Ginkgo biloba*—its history, why it is often used in urban landscaping, why the male trees are preferred, and what happens to its leaves in autumn. **LS Verbal**

Life Cycle of a Conifer

Most gymnosperms are conifers, a group that includes pines. **› Reproduction in conifers is characterized by a dominant sporophyte, wind pollination, and the development of seeds in cones.** You can trace the stages in the life cycle of a pine in **Figure 15.**

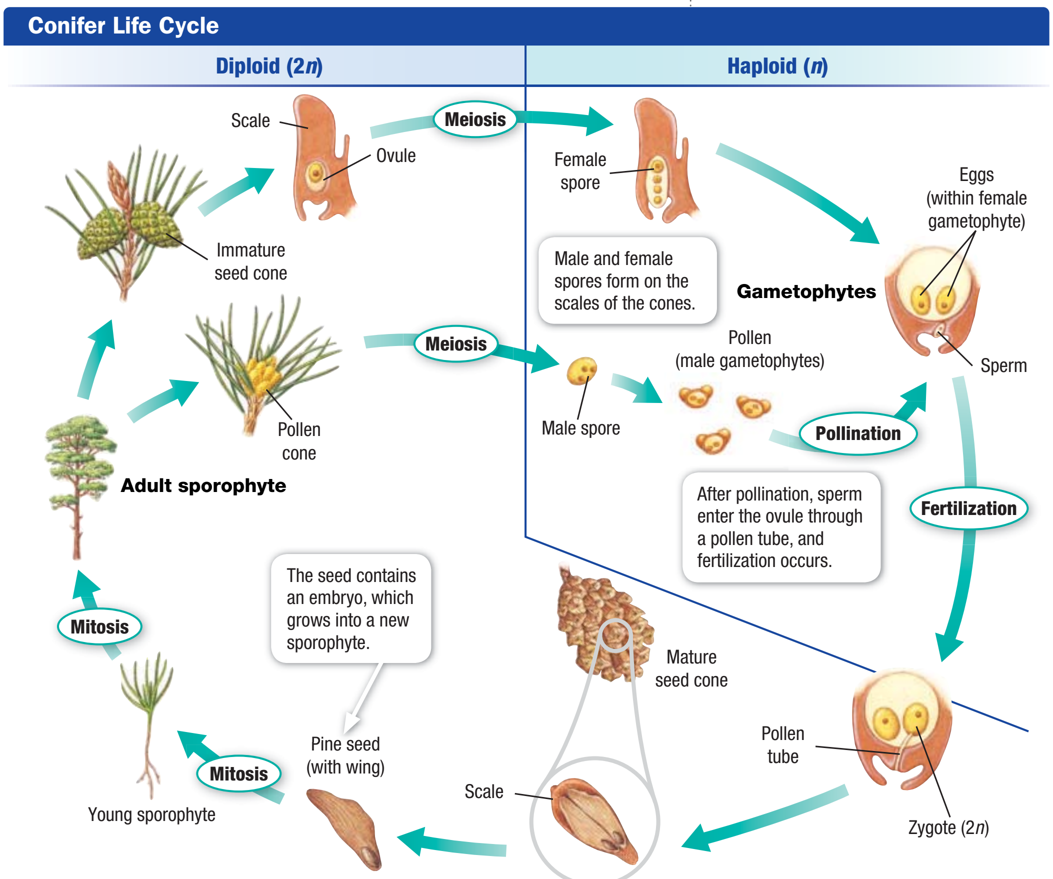
In pines, as in all plants, a diploid zygote results from the fertilization of an egg by a sperm. The zygote develops into an embryo, which then becomes dormant. The embryo and surrounding tissues form a seed. When their seeds are mature, seed cones open, and the seeds fall out. A seed of most pines has a wing that causes it to spin like the blade of a helicopter. Thus, pine seeds often travel some distance from their parent tree. When conditions are favorable, the scattered embryos grow into new sporophytes.

› Reading Check *What characteristic of pine seeds aids in dispersal of the seeds?*

Academic Vocabulary

cycle a repeating series of changes

Figure 15 In conifers, a large sporophyte that produces cones alternates with tiny gametophytes that form on the scales of cones. **› Where is pollen produced in a conifer?**



Differentiated Instruction

Special Education Students

Variety in Pine Cones Give blind and visually impaired students pine cones from various gymnosperms to demonstrate the diversity among species. Pine cones vary from the large western white pine that can be 25 cm (10 in) long to the egg-shaped lodgepole pine that is about 6 cm (2.5 in) long. Ask students to classify the cones based on feel. Discuss how cone shape and size relate to gymnosperm classification. **LS Kinesthetic**

Why It Matters

Biomimetics Two universities in England are developing a "smart" fabric that mimics the actions of pine cones when they release their seeds. Pine cone scales are made up of two stiff fibers running in different directions. As the cone dries out, the inside of the scale expands more than the outside, causing the scale to bend outward and release the seeds. The fabric works similarly with tiny spikes opening up as the wearer gets hot and closing when the wearer cools down.

Teaching Key Ideas

Conifer Life Cycle Have students compare **Figure 15** with **Figure 4.** Ask questions to help students connect the example to the generalized process. **LS Visual**

Teaching Key Ideas

Pine Nuts Tell students that the genus *Pinus* produces meaty seeds that are used as food. The ivory-colored Italian pine nuts and Chinese pine nuts are widely available. The pinon pine in the southwestern United States produces a nut that ranges in size from about 2 cm (0.75 in) to about 4 cm (1.7 in). It was an important food for early Native Americans and is still collected for food and trading.

Answers to Caption Questions

Figure 15: in pollen cones

Teach, *continued*

QuickLab

Teacher's Notes Have students look for similarities between the two types of cones when they are examined under a microscope.

Materials
- compound microscope
- hand lens
- prepared slides, male and female pine cones
- prepared slide, pine ovule

Answers to Analysis
1. Both have whorls of scales. However, male cones are smaller than female cones and contain pollen, while female cones contain eggs and eventually seeds.
2. extremely slow

Close

Formative Assessment
During pollination in seed plants, how does the pollen reach the structures that contain ovules?

A. A film of water must move the pollen to the ovules. (Incorrect. Water is not necessary for pollen transfer.)

B. Wind or animals transport pollen grains to the structures that contain the ovules. (Correct! Pollen is dispersed by wind or animals.)

C. The sporophyte becomes larger so the pollen can reach the ovules. (Incorrect. The sporophyte produces both eggs and sperm.)

D. The pollen tube grows until it reaches the ovules. (Incorrect. The pollen tube does not start growing until after the pollen grain reaches the ovules.)

Hands-On

QuickLab

15 min

Pine Gametophytes

In pines, male gametophytes develop inside male cones, or pollen cones. Female gametophytes develop inside female cones, or seed cones. You can observe the gametophytes of a pine with a microscope.


Immature female pine cone

Procedure
1. Examine **prepared slides of male and female pine cones** first with a **hand lens** and then under the low power of a **microscope.**
2. Make a sketch of each type of pine cone, and label the structures that you recognize.
3. Examine a **prepared slide of a pine ovule** under the low power of a compound microscope. Compare what you see with the photo above.
4. Draw a pine ovule, and label the following structures: scale, ovule, egg, pollen tube (if visible).

Analysis
1. **Compare** the structure and contents of male pine cones to the structure and contents of female cones.
2. CRITICAL THINKING **Applying Information** It takes 15 months for a pine pollen tube to grow through the wall of a pine ovule. How would you describe the rate of pollen-tube growth in pines?

Cones The gametophytes of most gymnosperms develop in cones, which consist of whorls (circles) of modified leaves called *scales*. Gymnosperms produce two types of cones. Male cones, or pollen cones, produce pollen grains within sacs that develop on the surface of their scales. Female cones, or seed cones, produce ovules on the surface of their scales. Many gymnosperms produce both male and female cones on the same plant. In some gymnosperms, male and female cones form on separate plants. At the time of pollination, the scales of a female cone are open, exposing the ovules to pollen grains carried by the wind or by insects. Seed cones close up after pollination and remain closed until the seeds within them are mature.

Reading Check *Are male and female cones always produced on separate plants?*

Section 3 Review

KEY IDEAS
1. **Name** the two groups into which seeds plants are traditionally classified.
2. **Describe** how sexual reproduction in seed plants differs from sexual reproduction in seedless plants.
3. **List** the four major groups of living gymnosperms.
4. **List** three characteristics of a conifer's life cycle.

CRITICAL THINKING
5. **Applying Logic** A classmate states that there is an apple tree in the park that produces apples but never has flowers. Is the classmate's statement logical? Explain your answer.

ALTERNATIVE ASSESSMENT
6. **Mapping Skills** Coniferous forests contain some of the tallest trees on Earth. Use the Internet or library resources to research the location and size of coniferous forests. Make a map of the globe showing where these forests are located.

Answers to Section Review
1. Seed plants are traditionally classified into gymnosperms and angiosperms.
2. Unlike seedless plants, seed plants do not require water to reproduce sexually. Reproduction in seed plants is characterized by a greatly reduced gametophyte stage and dominant sporophyte stage. Seedless plants have sporophytes that are much larger than their gametophytes
3. The four major groups of living gymnosperms are conifers, cycads, ginkgoes, and gnetophytes.
4. Three characteristics of a conifer's life cycle are dominant sporophyte, wind pollination, and development of seeds in cones.
5. No. Fruits develop from flowers. If the apple tree is producing apples, then the tree must have been producing flowers at some time before that. The classmate possibly has not been there at the right time to see the flowers.
6. Students should find that coniferous forests thrive in cool, dry regions. Some species prefer moist habitats. Provide blank outlines of a world map. Accept all well-presented maps.

Section 4

Flowering Plants

Key Ideas	Key Terms	Why It Matters
❯ What are the names of the two subgroups of angiosperms? ❯ What is a flower, and how does it function in reproduction? ❯ How does a flower's structure relate to pollination? ❯ What is the primary function of a fruit? ❯ How do plants reproduce vegetatively?	monocot cotyledon dicot stamen anther pistil fruit	Flowering plants are the most important group of plants in agriculture. Grains such as corn, wheat, and rice are important food sources for humans and livestock.

The angiosperms, or flowering plants, are by far the most successful group of plants, with about a quarter of a million species alive today. In contrast, there are fewer than one thousand known species of gymnosperms.

Kinds of Angiosperms

Angiosperms range in size from tiny herbs to giant trees. ❯ **Botanists traditionally divide the angiosperms into two subgroups—monocots and dicots.** **Monocots** are flowering plants whose seeds have one seed leaf, or **cotyledon.** Most monocots have long, narrow leaves with parallel veins and produce flowers whose parts are in multiples of three. **Dicots** are flowering plants whose seeds have two seed leaves. Most dicots have leaves with branching veins and produce flowers whose parts are in multiples of four or five, as **Figure 16** shows.

❯ **Reading Check** *What are three characteristics of monocots?*

monocot an angiosperm that produces seeds that have only one cotyledon

cotyledon (KAHT uh LEED'n) the embryonic leaf of a seed

dicot an angiosperm that produces seeds that have two cotyledons

Comparing Monocots and Dicots

Plant type	Leaves	Flower parts	Examples
Monocots 	parallel venation 	usually occur in threes 	lilies, irises, palms, orchids, coconut, onions, bananas, pineapples, tulips, bamboo, and grasses (including wheat, corn, rice, and oats)
Dicots 	net venation 	usually occur in fours or fives 	beans, lettuce, oaks, maples, roses, carnations, elms, cactuses, and most broad-leaved forest trees

Figure 16 Angiosperms are divided into two subgroups—monocots and dicots. ❯ **What type of angiosperm has leaves with net venation?**

Section 4

❯ Focus

This section describes how angiosperms are classified and how they reproduce.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Demonstration

Comparing Seeds Give students dry corn and bean seeds to dissect, and a hand lens. Students should observe the number of cotyledons and the embryos. Consider having students use iodine to indicate the food storage areas in each seed. Have students record their observations and make comparisons between the two kinds of seeds.
LS Kinesthetic

Answers to Caption Questions

Figure 16: dicots

Key Resources

Transparencies

G7 Characteristics of Monocots and Dicots
G8 Familiar Families of Angiosperms
G36 Floral Structure
G39 Life Cycle of an Angiosperm
G45 Stems Modified for Vegetative Reproduction
G48 Methods of Vegetative Plant Propogation

Visual Concepts

Comparing Characteristics of Monocots and Dicots
Germination of a Monocot
Germination of a Dicot
Characteristics of Angiosperms
Types of Angiosperms
Parts of a Flower
Ovule Formation in an Angiosperm
Parts of an Angiosperm Ovule
Fertilization of a Flower
Pollen Grain Formation
Parts of a Pollen Grain
Flowers and Animal Pollinators
Endosperm
Development of a Fruit
Parts of Plants Eaten as Food

Teach, continued

QuickLab

Teacher's Notes Provide a variety of monocot and dicot flowers.

Materials
- monocot flower
- dicot flower
- plastic gloves
- tape

Answers to Analysis

1. Students should comment on color, size, and numbers of sepals and petals.
2. Students should suggest that large, brightly colored petals might attract animal pollinators while flowers with small, inconspicuous petals are probably pollinated by wind.
3. Students should note the following: Monocots have flower parts in multiples of three. Dicots have flower parts in multiples of two, four, or five.

Answers to Caption Questions

Figure 17: Sepals protect the flower while it is a bud.

Hands-On

QuickLab

15 min

The Arrangement of Parts of a Flower

By dissecting flowers, you can see how the parts of flowers are arranged.

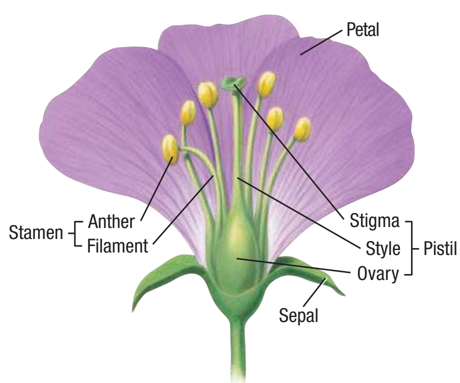
Procedure

1. Put on gloves. Examine a monocot flower and a dicot flower. Locate the sepals, petals, stamens, and pistil of each flower.
2. Separate the parts of each flower, and tape them to a piece of paper. Label each set of parts.
3. Count the number of petals, sepals, and stamens in each flower. Record this information below each flower.

Analysis

1. **Compare** the sepals and petals of the monocot flower to the sepals and petals of the dicot flower.
2. CRITICAL THINKING **Forming a Hypothesis** For each flower, suggest a function for the petals based on their appearance.
3. CRITICAL THINKING **Justifying Conclusions** Explain why each flower is from either a monocot or a dicot.

Figure 17 The four basic parts of a flower—sepals, petals, stamens, and pistils—are arranged in concentric whorls. **What is the function of sepals?**



Reproduction in Angiosperms

A *flower* is a specialized reproductive structure of angiosperms. The male and female gametophytes of angiosperms develop within flowers, which promote pollination and fertilization more efficiently than do cones. The female reproductive part of a flower provides a pathway that enables sperm to reach and fertilize eggs but does not require the sperm to swim through water.

Structure of Flowers The basic structure of a flower is shown in **Figure 17.** Flower parts are arranged in four concentric whorls, or circular swirls. The outermost whorl consists of *sepals,* which protect a flower from damage while it is a bud. The second whorl consists of *petals,* which attract pollinators. The third whorl consists of **stamens,** which produce pollen. Each stamen is made of a thread-like filament that is topped by a pollen-producing sac called an **anther.** The fourth and innermost whorl of a flower consists of one or more **pistils,** which produce ovules. Ovules develop in a pistil's swollen lower portion, which is called the *ovary.* Recall that after fertilization, ovules develop into seeds. Usually, a stalk, called the *style,* rises from the ovary. Pollen lands on and sticks to the stigma—the swollen, sticky tip of the style.

Kinds of Flowers Flowers may or may not have all four of the basic flower parts. A flower that has all four parts is a complete flower. A flower that lacks any one of the four types of parts is an incomplete flower.

Reading Check *What is the function of a stamen?*

Differentiated Instruction

Special Education Students

Making Models Using **Figure 17** as a guide, help learning disabled students to make clay models of the basic flower structure. The parts of the flower can be labeled with strips of paper and straight pins stuck into the model. The model should be made to lie flat on a piece of cardboard for easy display. LS **Kinesthetic**

Struggling Readers

Create Operational Definitions Activate students' prior knowledge regarding this section by listing the italicized and bold-faced terms on the board. Ask volunteers to define each in their own words. Reproduce this list, and have students update and refine it while studying the section. LS **Verbal**

Life Cycle of an Angiosperm You can trace the life cycle of an angiosperm in **Figure 18.** Adult sporophytes produce haploid spores by meiosis. These spores grow into gametophytes. Female gametophytes grow inside ovules, which develop within the ovary of a pistil. Male gametophytes, or pollen grains, are produced in the anther of a stamen. Pollination occurs when a pollen grain is carried from an anther to a stigma. The pollen grain forms a pollen tube that grows down the style to the ovules in the ovary of a flower. The pollen tube releases two sperm cells into the female gametophyte within an ovule. One sperm fuses with the egg, forming the zygote. The zygote develops into an embryo that will grow into a new sporophyte. The other sperm fuses with two other haploid (n) nuclei to form a triploid ($3n$) cell that develops into endosperm. This is a process called *double fertilization.* The endosperm may form a nutrient store for growth of the embryo.

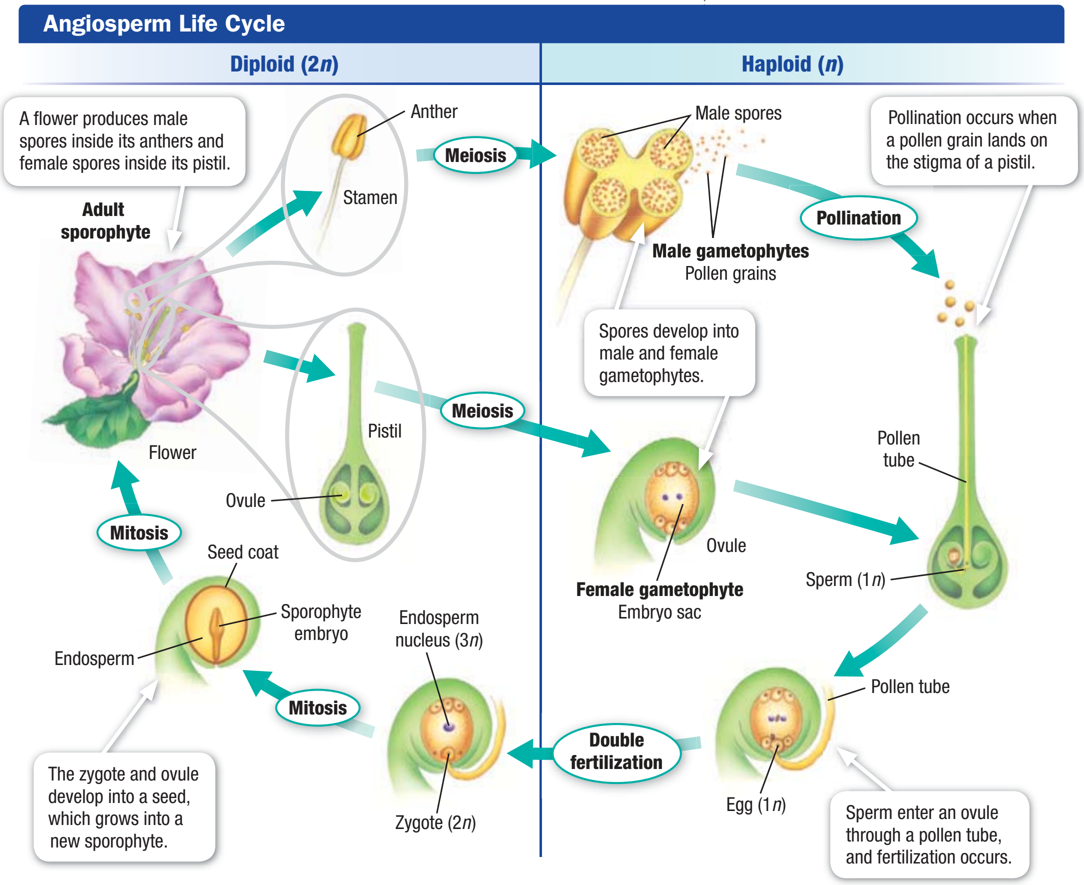
Reading Check *What is the function of a pollen tube?*

stamen (STAY muhn) the male reproductive structure of a flower that produces pollen and consists of an anther at the tip of a filament

anther the tip of a stamen, which contains the pollen sacs where pollen grains form

pistil the female reproductive part of a flower that produces seeds and consists of an ovary, style, and stigma

Figure 18 In angiosperms, a large sporophyte alternates with a tiny gametophyte.



Teaching Key Ideas

Angiosperm Life Cycle Have students compare **Figure 18** with **Figure 4.** Ask questions to help students connect the example to the generalized process. **LS Visual**

Demonstration

Flower Dissection Obtain out-of-date perfect flowers, such as tulips, lilies, or another type with both pistil and stamens, from a local florist. Allow students to dissect the flowers and look for the specific parts described in **Figure 18.** Consider giving students scalpels to cut the pistil open and hand lenses for closer observation. **LS Kinesthetic**

Differentiated Instruction

English Learners

Diagramming a Process Work with students to diagram the steps in double fertilization described in the student text paragraph. Emphasize to students that while they may label the steps 1, 2, 3 and so on in a life cycle, one can position step 1 at any point, and there is no specific last step. Diagrams should include the following: plant growth, flower development, pollination, fertilization, fruit development, seed development, dispersal, dormancy, and germination. **LS Visual**

Advanced Learners/GATE

Imperfect Flowers Have students research imperfect flowers such as willows, poplars, date palms, persimmons, box elders, and corn. Students could then suggest how **Figure 18** might be modified to reflect the life cycle of plants with imperfect flowers. (The process is the same except that the pollen comes from a different plant.) **LS Logical**

Teach, *continued*

Teaching Key Ideas

Animal Pollinators Sketch a spectrum that includes infrared through ultraviolet light with these approximate measurements: infrared, 750 nm or longer; red/orange, 600–750 nm; yellow/green 500–600 nm; blue/violet, 400–500 nm; ultraviolet, 400 or shorter.

Tell students that hummingbirds perceive light in the 300–660 nm range, whereas bees perceive light in the 300–550 nm range. Ask students why they think hummingbirds pollinate red flowers more often than bees do. (Hummingbirds see more of that part of the spectrum.) "Why are bee-pollinated flowers more often yellow or blue?" (Bees see those colors more easily.) "If both hummingbirds and bees can see in the blue to yellow range, why do hummingbirds more often visit red flowers?" (There is not as much competition for food.) **LS Verbal**

READING TOOLBOX

Classification

Insect-pollinated flowers
1. contain structural elements to attract insects (color, odor, food source)
2. are pollinated by insects moving from flower to flower

Wind-pollinated flowers
1. are small
2. lack elements to attract pollinators

LS Verbal/Logical

SCILINKS. www.scilinks.org
Topic: Pollination
Code: HX81177

READING TOOLBOX

Classification List two characteristics of insect-pollinated flowers, then list two characteristics of wind-pollinated flowers.

Pollination

Some plants have pollen that can fertilize the plant's own ovules. These plants can breed by *self-fertilization.* Often, a plant's pollen is unable to fertilize the plant's own ovules. These plants breed by *cross-fertilization.* **The flowers of many angiosperms are adapted for pollination by wind or by animals.**

Flowers may have brightly colored petals, sugary nectar, strong odors, and shapes that attract animal pollinators. Flowers are a source of food for pollinators such as insects, birds, and bats. For example, bees eat nectar and collect pollen, which is a rich source of protein that they feed to their larvae. As a bee visits a flower, picks up pollen, and carries that pollen to other flowers, the bee gets coated with pollen. Bees locate flowers by scent first and then by color and shape. Bee-pollinated flowers are usually blue or yellow and often have markings that show the location of nectar. Moths feed at night and tend to visit heavily scented white flowers, which are easy to find in dim light. Flies may pollinate flowers that smell like rotten meat.

Many flowers are not pollinated primarily by insects. Red flowers, for example, may be pollinated by hummingbirds. Some large white flowers that open at night are pollinated by nighttime visitors, such as bats, as seen in **Figure 19.** Some flowers, such as those of grasses and oaks, are pollinated by wind. Wind-pollinated flowers are usually small and lack bright colors, strong odors, and nectar.

Reading Check ***Name three characteristics of flowers that might attract pollinators.***

Figure 19 Many flowers are adapted for pollination by wind or animals. Some species of orchids, such as the bee orchid shown at left below, have evolved to resemble their pollinators.

Why It Matters

Clues from Pollen Explain to students that scientists use pollen grains to learn about climate change. Pollen trapped in soil sediments can become preserved as microfossils. These pollen grains reveal the past plant life of a geographic area, helping scientists learn how climates have changed throughout the last several thousand years. For example, sediments containing pine pollen suggest that an area might once have been covered with conifer forests during a cold and dry time.

Differentiated Instruction

Advanced Learners/GATE

Research Have students research carrion flowers. Have them prepare short reports that include specific adaptations, physical characteristics, where they usually grow, and what role they occupy in their particular niche. **LS Verbal**

Hands-On

QuickLab

15 min

Fruit or Vegetable?

Some of the foods that we think of as vegetables—parts of plants such as roots, stems, and leaves—are actually fruits. You can find out if a plant product is a fruit—the mature ovary of a flowering plant—by cutting the product open and examining its internal structure.

Procedure

1. Look at several examples of common **fruits** and **vegetables.** Classify each one as either a fruit or a vegetable in the familiar sense.
2. Use a **plastic knife** to cut open each fruit and vegetable.
3. Look at the fruits and vegetables again. Classify each by its botanical function—either as a fruit or as a vegetative part.

Analysis

1. **Compare** the familiar and botanical classifications that you gave each fruit and vegetable.
2. CRITICAL THINKING **Analyzing Data** Which fruits and vegetables did you change the classification of?
3. CRITICAL THINKING **Analyzing Results** Defend the classifications that you made for item 2.
4. CRITICAL THINKING **Drawing Conclusions** Based on your observations, when is a vegetable a fruit?

Fruits

The ovary of a pistil is called a **fruit** after its ovules are fertilized. A fruit is a structure that develops from an ovary of a flower and contains seeds. This botanical meaning of *fruit* is different from the everyday meaning of *fruit*. A tomato is a fruit, a pumpkin is a fruit, a pea pod is a fruit, and a nut is a fruit. The thistledown of a dandelion is a fruit with a seed inside. **Although fruits provide some protection for developing seeds, they primarily function in seed dispersal.**

The angiosperms produce many types of fruits. **Figure 20** shows one example of a fruit. Many fruits are eaten by animals. The fruits' seeds are dispersed as they pass undigested through the animals. For example, the mesquite tree is thought to have been spread throughout the southwestern United States by cattle that ate the tree's sugary seed pods. Other fruits, such as the maple seed, have structures that help them float on wind or water. Some plants, such as the witch-hazel plant, forcefully eject their seeds.

fruit a mature plant ovary; the plant organ in which the seeds are enclosed

Reading Check *From which part of a flower does a fruit develop?*

Figure 20 The seeds of this pomegranate are enclosed inside a fruit. The fruit protects the seeds and aids in their dispersal. **How do you think pomegranate seeds are dispersed?**

Differentiated Instruction

Struggling Readers

Determining Relative Importance Once struggling readers understand the general concept of a fruit, have them focus on the words in the second part of the key concept: *primarily function in seed dispersal.* Have students look up the definition of each word in the phrase and write their own interpretations of the phrase. LS **Verbal**

English Learners

Classifying Ethnic Edibles Ask students whose families regularly shop at an Asian, Hispanic, Indian, or other ethnic market to supply samples of produce. Have students repeat the QuickLab with those items. LS **Verbal**

QuickLab

Teacher's Notes Some true fruits do not have obvious seeds. For example, commercially produced bananas are sterile triploids ($3n$).

Materials

- assorted vegetables and fruits from the grocery
- plastic knife

Answers to Analysis

1. Apples are commonly labeled as fruits. Green beans are true fruits even though most people label them as vegetables. Potatoes are one type of vegetative structure that is commonly labeled as a vegetable.
2. Students will probably need to reclassify plant parts such as tomatoes.
3. True fruits contain seeds. Many of the "vegetables" in this lab contain seeds, which makes them true fruits.
4. A vegetable is a fruit if it is produced from a flower, contains parts of the flower, and contains seeds.

Answers to Caption Questions

Figure 20: Animals that eat the fruit probably disperse pomegranate seeds.

Teach, *continued*

Answers to Caption Questions

Figure 21: In most plants, vegetative reproduction is faster than sexual reproduction, so plants can spread more quickly in a favorable habitat.

Teaching Key Ideas

Asexual Reproduction Give students these facts: asexual reproduction usually requires less energy but produces genetically identical offspring; sexual reproduction usually requires more energy but produces genetically diverse offspring. Have students suggest advantages and disadvantages of each method.
LS Verbal

Close

Formative Assessment

During the angiosperm life cycle, the process of double fertilization results in _____.

A. two genetically identical offspring (Incorrect. Only one potential offspring results, along with a nutrient store.)

B. a 4n zygote that will undergo mitosis (Incorrect. The zygote is 2n and the endosperm is 3n.)

C. male and female gametophytes (Incorrect. The gametophytes produce the pollen grains and embryo sac; this occurs before fertilization.)

D. an embryo and endosperm (Correct! The embryo will then develop into the sporophyte, and the endosperm forms a nutrient store for the embryo's growth.)

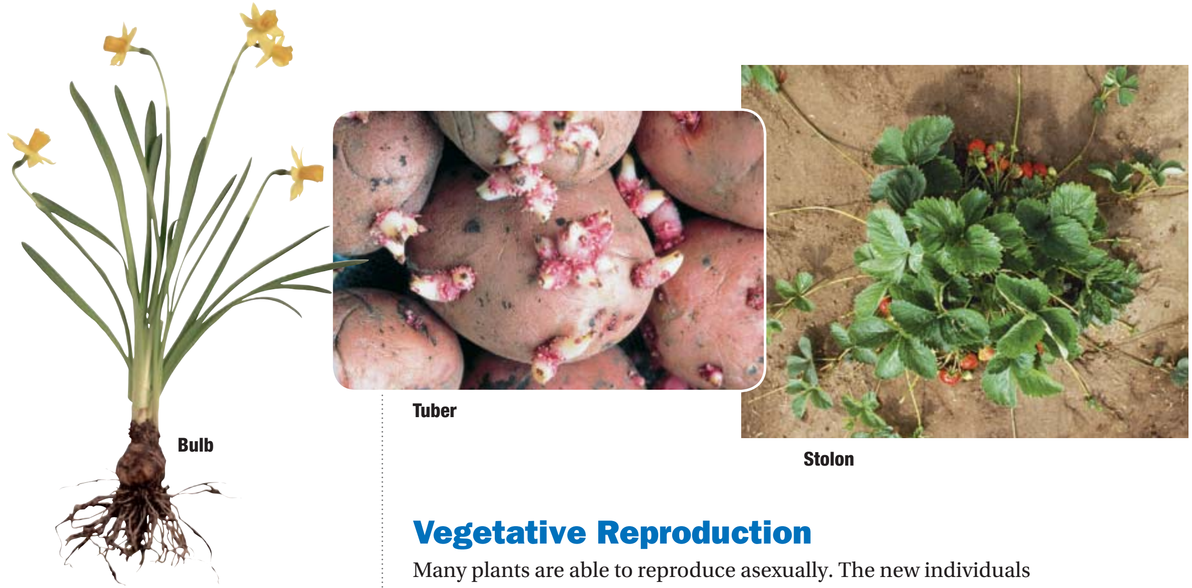


Figure 21 Plants can reproduce vegetatively through modified stems. Examples of modified stems include bulbs (left), tubers (center), and stolons (right). **What is an advantage of vegetative reproduction?**

Vegetative Reproduction

Many plants are able to reproduce asexually. The new individuals that result from asexual reproduction are genetically the same as the parent plant. **Plants reproduce asexually in a variety of ways that involve nonreproductive parts, such as stems, roots, and leaves. The reproduction of plants from these parts is called *vegetative reproduction.*** Many of the structures by which plants reproduce vegetatively are modified stems, such as bulbs, tubers, and stolons, as shown in **Figure 21.**

In most plants, vegetative reproduction is faster than sexual reproduction. By reproducing vegetatively, a single plant can spread rapidly in a habitat that is ideal for its growth. Therefore, a mass of hundreds or even thousands of individuals, such as a stand of grasses or ferns, may have come from one individual.

People often grow plants from vegetative parts that are specialized for vegetative reproduction. For example, in tubers such as potatoes, a single tuber can be cut or broken into pieces such that each piece has at least one bud. Each of these pieces can grow into new shoots.

Reading Check *What are three types of modified stems by which plants can reproduce vegetatively?*

Section 4 Review

KEY IDEAS

1. **Name** the two main subgroups of angiosperms.
2. **Describe** the role of a flower in angiosperm reproduction.
3. **List** three adaptations that flowers have developed to attract pollinators.
4. **Identify** the primary function of a fruit.
5. **List** three nonreproductive parts of a plant that may be involved in vegetative reproduction.

CRITICAL THINKING

6. **Predicting Outcomes** Explain how a significant reduction in the bird population of an area could affect the number of angiosperms growing in that area.

ALTERNATIVE ASSESSMENT

7. **Career Connection** Use the Internet or library resources to find out about the field of plant breeding. Write a report on your findings. Your report should include a job description, the training required, names of employers, growth prospects, and an average starting salary.

Answers to Section Review

1. monocots and dicots
2. The male and female gametophytes of angiosperms develop within flowers, which promote pollination more efficiently than do cones.
3. Three adaptations are brightly colored petals, sugary nectars, and strong odors.
4. seed dispersal
5. Roots, stems, and leaves can be involved in vegetative reproduction.
6. Many angiosperms rely on birds for seed dispersal. Fruits are eaten by birds and are dispersed as they pass undigested from the birds' bodies. If there were significantly fewer birds, the seeds of many angiosperms would not be dispersed. This would result in overcrowding of the existing angiosperms in a certain area, and more competition for water, nutrients, and light. This would lead to fewer angiosperms reproducing and fewer angiosperms growing in that area.
7. Accept all well-written and well-researched reports.

Skills Practice

Chapter 23 Lab

30 min

Objectives

- Identify similarities and differences among four phyla of living plants.
- Relate structural adaptations of plants to plants' success on land.

Materials

- live or preserved specimens of mosses, ferns, conifers, and angiosperms
- stereomicroscope or hand lens
- compound microscope
- prepared slides of fern gametophytes
- prepared slides of pine pollen

Safety

Plant Diversity

Most plants are photosynthetic organisms that live on land. In this lab, you will examine representatives of the four most familiar plant phyla.

Procedure

1. Visit the station for each of the plants listed below, and examine the specimens there. Record your observations.
2. **Mosses** Use a stereomicroscope or hand lens to examine a moss gametophyte that has a sporophyte attached to it. Draw what you see, and label the parts that you recognize.
3. **Ferns** Examine the sporophyte of a fern, and look for evidence of reproductive structures on the underside of the fronds. Use a compound microscope to examine a slide of a fern gametophyte. Draw what you see, and label any structures you recognize.
4. **Conifers** Draw a part of a branch of one of the conifers at this station. Label a leaf, stem, and cone (if present). Examine a prepared slide of pine pollen. Draw a few of the pollen grains.
5. **Angiosperms** Draw one of the representative angiosperms at this station. Label a leaf, stem, root, and flower (if present). Indicate the sporophyte and location of gametophytes.
6. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.


Moss


Fern


Conifer


Angiosperm

Analyze and Conclude

1. **Recognizing Patterns** How do the gametophytes of gymnosperms and angiosperms differ from the gametophytes of mosses and ferns?
2. **Comparing Structures** What structures are present in both gymnosperms and angiosperms but absent in both mosses and ferns?

Answers to Procedure

Drawings will vary depending on the plant species used. Look for relative features and appropriate labeling.

Answers to Analyze and Conclude

1. Gymnosperm and angiosperm gametophytes develop within tissues of the sporophyte; moss and fern gametophytes are distinct plants.
2. pollen and seeds

Lab

Time Required

30 minutes

Ratings

EASY → HARD

Teacher Prep: 1
Student Setup: 1
Concept Level: 2
Cleanup: 1

Safety Cautions

Review all safety symbols and caution statements with students. Remind students to be careful with glass containers and prepared slides. Review the procedure for cleaning and disposing of broken glass.

Tips and Tricks

Review the four major plant groups before conducting the lab. Set up at least two stations for each group of plants. Provide a stereomicroscope or hand lens for stations with mosses and ferns. Provide a compound microscope for stations with prepared slides.

Key Resources

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

Chapter 23

SUPER SUMMARY

Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the keyword **HX8PRPS** to access the Super Summary for this chapter.

Reteaching Key Ideas

Characteristics of Plants Have students imagine they are plants and write two to three paragraphs that describe themselves. **LS Verbal**

Life Cycle Have groups of students write each stage of the moss life cycle and the fern life cycle on index cards, then switch cards with another group. Groups arrange the cards in the proper order. **LS Visual**

Characteristics of Seed Plants Have each student write a question and answer from information in this section. Collect the cards and play "host" to a game show where you provide the answers, and teams of students provide the questions. **LS Interpersonal**

Parts of a Flower Provide students with a picture of a flower similar to that on p. 560 (you might copy the flower and remove the labels). Ask students to label each part and write a brief description of the function of each part. **LS Visual**

Chapter 23 Summary

go.hrw.com
SUPER SUMMARY
Keyword: HX8PRPS

Key Ideas	Key Terms
1 Introduction to Plants	

1 Introduction to Plants

- Plants are multicellular eukaryotes whose cells have cell walls made of cellulose. Most plants produce their own food through photosynthesis.
- In order to thrive on land, plants had to be able to absorb nutrients from their surroundings, to survive dehydration or avoid drying out, and to have a way of dispersal—or way of scattering—that did not require water.
- In plant life cycles, haploid gametophytes alternate with diploid sporophytes.

Key Terms: **cuticle** (544), **spore** (545), **sporophyte** (546), **gametophyte** (546)

2 Seedless Plants

- Nonvascular plants do not have a vascular system for transporting water and nutrients within their bodies.
- In the life cycle of nonvascular plants, the gametophyte is the dominant generation.
- Sporophytes of seedless vascular plants have vascular tissue. Because of their vascular system, vascular plants grow much larger than nonvascular plants and also develop true roots, stems, and leaves.
- In the life cycle of seedless vascular plants, the sporophyte is the dominant generation.

Key Terms: **archegonium** (548), **antheridium** (548), **sporangium** (548), **rhizome** (550), **frond** (550), **sorus** (552)

3 Seed Plants

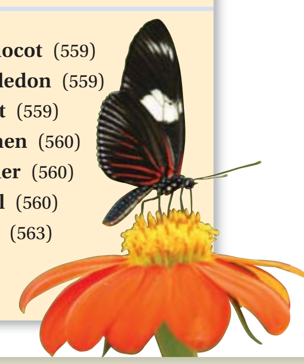
- Seed plants are classified into two groups—gymnosperms and angiosperms.
- Reproduction in seed plants is characterized by a greatly reduced gametophyte and a dominant sporophyte.
- There are four major groups of gymnosperms—conifers, cycads, ginkgoes, and gnetophytes.
- Reproduction in conifers is characterized by a dominant sporophyte, wind pollination, and the development of seeds in cones.

Key Terms: **gymnosperm** (553), **angiosperm** (553), **ovule** (554), **seed** (554), **pollen grain** (554), **pollination** (554)

4 Flowering Plants

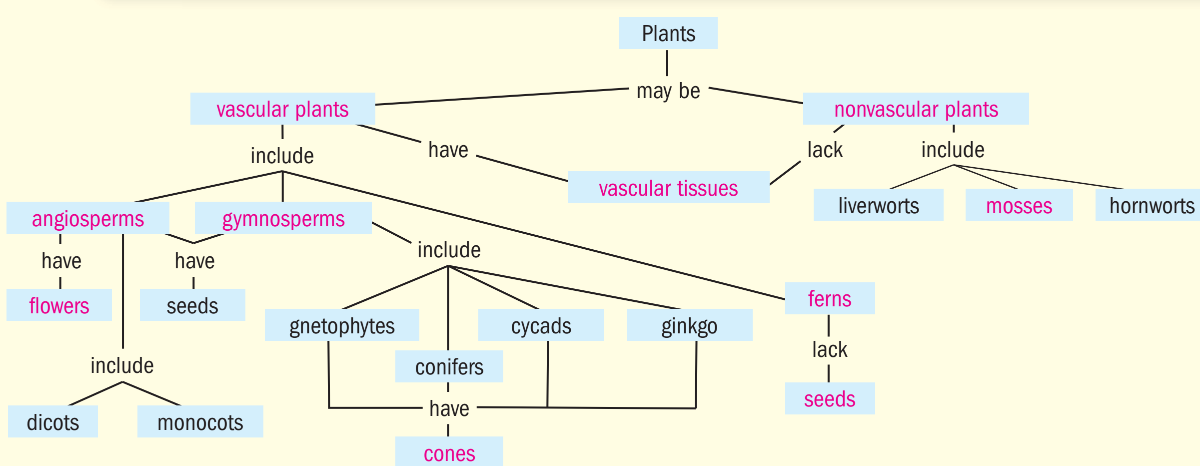
- Angiosperms are divided into two subgroups—monocots and dicots.
- In angiosperms, sexual reproduction takes place within a specialized structure called a *flower.*
- Flowers often have adaptations for pollination by wind or by animals.
- The primary function of fruits is to promote seed dispersal.
- Plants reproduce asexually by vegetative reproduction, which occurs by means of nonreproductive parts, such as stems, roots, and leaves.

Key Terms: **monocot** (559), **cotyledon** (559), **dicot** (559), **stamen** (560), **anther** (560), **pistil** (560), **fruit** (563)



Answer to Concept Map

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



Chapter 23 Review

READING TOOLBOX

1. **Word Parts** Use what you know about word parts to define the words *monocot* and *dicot* in your own words.
2. **Concept Map** Make a concept map that shows how plants are classified. Try to include the following terms in your map: *vascular plants, nonvascular plants, ferns, angiosperms, gymnosperms, mosses, cones, vascular tissue, seeds,* and *flowers.*

Using Key Terms

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

3. *cuticle*
4. *sorus*
5. *pollen*
6. *sepal*
7. *anther*
8. *pistil*

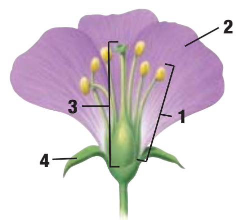
For each pair of terms, explain how the meanings of the terms differ.

9. *sporophyte* and *gametophyte*
10. *archegonium* and *antheridium*
11. *gymnosperm* and *angiosperm*

Understanding Key Ideas

12. Most plants produce their own food through
    a. osmosis.
    b. diffusion.
    c. absorption.
    d. photosynthesis.
13. The cuticle of a plant functions as
    a. a primary location of cellular regeneration.
    b. a barrier around the roots to protect them from rotting.
    c. a special layer of tissue to transport water from roots to leaves.
    d. a watertight covering to reduce moisture loss and drying out.
14. The most familiar nonvascular plants that contain simple conducting cells are
    a. ferns.
    b. mosses.
    c. horsetails.
    d. ground pines.
15. The horizontal, underground stem found on most seedless vascular plants is called a
    a. cone.
    b. frond.
    c. rhizome.
    d. fiddlehead.
16. Seed plants whose seeds do not develop within a fruit are called
    a. monocots.
    b. angiosperms.
    c. gymnosperms.
    d. flowering plants.

Use the diagram of a flower to answer the following questions.



17. Which structure contains the ovules?
    a. Structure 1
    b. Structure 2
    c. Structure 3
    d. Structure 4
18. Which structure is made of an anther and a filament and produces pollen?
    a. Structure 1
    b. Structure 2
    c. Structure 3
    d. Structure 4

Explaining Key Ideas

19. **List** the three structures that club mosses have that true mosses do not.
20. **Identify** which group of gymnosperms includes the redwoods, some of the world's tallest living plants.
21. **Describe** how insects such as bees help with the cross-fertilization of many angiosperms.

Assignment Guide

Section	Questions
1	3, 9, 12, 13
2	2, 4, 10, 14, 15, 19, 26, 27
3	2, 5, 11, 16, 20, 28, 31, 32
4	1, 2, 6, 7, 8, 17, 18, 21, 29, 30

Review

Reading Toolbox

1. *Monocot* means "one cotyledon" because *mono-* means "one" and *cot* refers to cotyledon. *Dicot* means "two cotyledons" because *di-* means "two."
2. See previous page for answer to concept map.

Using Key Terms

3. **cuticle** a waxy or fatty and watertight layer on the external wall of epidermal cells
4. **sorus** a cluster of sporangia
5. **pollen** the tiny granules that contain the male gametophyte of seed plants
6. **sepal** in a flower, one of the outermost rings of modified leaves that protect the flower bud
7. **anther** in flowering plants, the tip of a stamen, which contains the pollen sacs where grains form
8. **pistil** the female reproductive part of a flower that produces seeds and consists of an ovary, style, and stigma
9. A *sporophyte* is the diploid individual or generation that produces haploid spores. A *gametophyte* is a haploid individual that produces gametes.
10. An *archegonium* is a female reproductive structure that produces a single egg. An *antheridium* is a reproductive structure that produces male sex cells.
11. A *gymnosperm* is a woody, vascular seed plant whose seeds are not enclosed by an ovary or fruit. An *angiosperm* is a flowering plant that produces seeds within a fruit.

Understanding Key Ideas

12. d 13. d 14. b 15 c
16. c 17. c 18. a

Explaining Key Ideas

19. Club mosses are seedless vascular plants and have roots, stems, and leaves.
20. Redwoods are in the group of gymnosperms called conifers.
21. When insects land on a flower and are coated with pollen, they carry it to other flowers. The pollen from one plant fertilizes a different plant of the same species, which is cross-fertilization.

Using Science Graphics

22. 1998

23. Years should be on the *x*-axis and the pounds of pesticide should be on the *y*-axis. The line should reflect the values at the top of the bars on the bar graph.

24. $215{,}000{,}000 \times 0.001 = 215{,}000$ pounds remained on their target; $215{,}000{,}000 - 215{,}000 = 214{,}785{,}000$ pounds became environmental contaminants

25. Because many plants rely on insects and birds for pollination, decreasing the insect and bird population by environmental contamination could reduce plant reproduction.

Critical Thinking

26. Without vascular systems, small plants rely on osmosis and diffusion to transport water and nutrients. However, these processes are effective only over short distances, limiting the size of a nonvascular plant's body.

27. As long as there is enough water to cover the moss at some point, the sperm can swim to the eggs and fertilize them.

28. Answers should include details of this sequence: Eggs and sperm form, pollination occurs, fertilization occurs, the ovule and its contents develop into a seed, outer layers of the seed harden, and finally, the seeds are dispersed by wind and by animals.

29. No. Wind-pollinated flowers such as those of grasses and oaks, are usually small and lack bright colors and strong odors.

Alternative Assessment

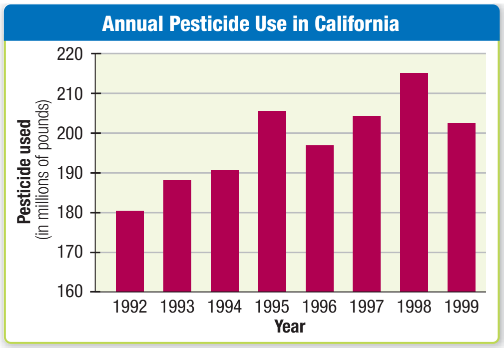
30. Posters should include that monocot plants have flower parts that usually occur in multiples of three, and that dicot plants have flower parts that usually occur in multiples of two, four, or five.

Writing Skills

31. Answers should include information about the role that birds and insects play in the pollination and seed dispersal of many plants.

Using Science Graphics

Use the graph showing annual pesticide use in California to answer the following questions.



Source: State of California Environmental Protection Agency, Department of Pesticide Regulation, February 2000.

22. Identify the year in which the most pesticide was used in California.

23. Graphing Skills Use the data on the graph to make a line graph titled *Amount of Pesticide Used in California.*

24. Math Skills Scientists estimate that less than 0.1% of applied pesticides stay on the intended target, while the remaining amount of pesticide becomes an environmental contaminant. For the year 1998, estimate how many pounds of pesticide stayed on the intended target, and then calculate how many pounds became environmental contaminants.

25. Predicting Results What effect do you think the overall increase in the amount of pesticide use shown in these data and the subsequent environmental contamination might have on the reproduction of many plants? Explain your answer.

Critical Thinking

26. Explaining Relationships Explain the relationship between the small size of most nonvascular plants and the means by which they transport water and nutrients.

27. Applying Information In the life cycle of a moss, a haploid spore may germinate in a location far from its parent plant. Explain how this might happen and why the availability of enough water will determine whether this moss will reproduce.

28. Sequencing Outline the sequence of events that takes place in the reproduction of seed plants from the time eggs and sperm are formed to the time of seed dispersal.

29. Supporting Conclusions A classmate shows you a large orange and yellow flower that has a heavy scent and tells you that the plant is probably pollinated by wind because it was found growing on a tall stem in an open field. Can you support your classmate's conclusion? Explain your answer.

Alternative Assessment

30. Finding and Communicating Information Visit a local garden center or nursery, and see how many plants you can identify as monocots or dicots. Take pictures of the flowers, and use the pictures to create a poster that shows examples of monocots and dicots. Include in your poster an explanation of the difference between each subgroup based on the number of flower parts. Are most of the plants for sale monocots or dicots? Present your poster to your class, and explain your findings.

Writing Skills

31. Speech Writing Imagine that your city council is planning to rezone 20 acres of heavily wooded land for commercial development. The land is located next to a large park and botanical gardens. Write a short speech giving the council your opinion about how destroying the habitat for all of the birds and insects in 20 acres might affect the reproduction and dispersal of the seed plants in the botanical gardens and park.

32. Short Story Paleobotany is a branch of paleontology dealing with the recovery and identification of plant remains from geological fossils. Imagine that you are a paleobotanist searching for evidence of the first trees, which many scientists believe to be the *Archaeopteris.* Write a short story describing how you recover and identify your first *Archaeopteris* specimen. Use the Internet or library resources to research paleobotany and *Archaeopteris* to help gather information for your story.

32. Accept all reasonable answers. The first seed plants are believed to have developed about 380 million years ago. Fossils of *Archaeopteris* are found in Europe, North America, Morocco, and Australia. The *Archaeopteris* had reinforced branch joints, buds, and branched trunks similar to today's trees, combining characteristics of both woody trees and herbaceous ferns.

Chapter 23 Standardized Test Prep

TEST TIP For questions involving life cycles, draw as much of the life cycle as you can remember. Looking at such a model may help you understand the question better and help you determine the correct answer.

Science Concepts

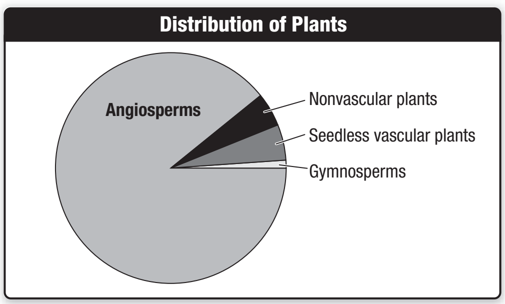
1. Plants are
- **A** multi-celled eukaryotes.
- **B** multi-celled prokaryotes.
- **C** single-celled eukaryotes.
- **D** single-celled prokaryotes.

2. Nonvascular plants transport water and nutrients within their bodies by
- **F** absorption alone.
- **G** osmosis and diffusion.
- **H** specialized vascular tissue.
- **J** absorption and condensation.

3. The seeds of most gymnosperms develop within a
- **A** fruit.
- **B** cone.
- **C** pistil.
- **D** flower.

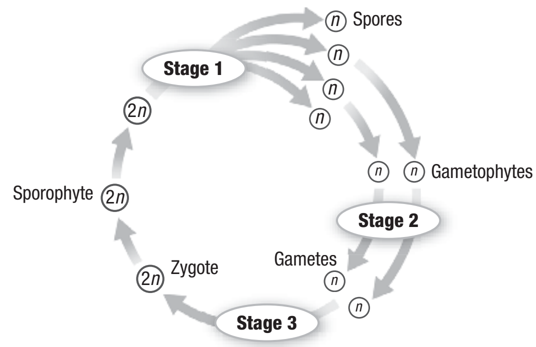
Using Science Graphics

Use the pie chart showing the distribution of plants by group to answer the following question.



4. If the total number of plant species is about 260,000, and gymnosperms make up 0.35% of the total, about how many species of gymnosperms are there?
- **F** 910
- **G** 7429
- **H** 9100
- **J** 91000

Use the diagram showing the basic life cycle of a plant to answer the following questions.



5. In the basic life cycle of a plant, what occurs at Stage 1?
- **A** Diploid zygotes are produced by mitosis.
- **B** Haploid spores are produced by mitosis.
- **C** Haploid spores are produced by meiosis.
- **D** Haploid gametes are produced by meiosis.

6. The correct order of events that take place at Stage 1, Stage 2, and Stage 3 is
- **F** mitosis, meiosis, and fertilization.
- **G** meiosis, fertilization, and mitosis.
- **H** meiosis, mitosis, and fertilization.
- **J** mitosis, fertilization, and meiosis.

Writing Skills

7. Extended Response All plants have a life cycle that alternates between haploid and diploid phases. Name the two phases of a plant life cycle and describe how they differ from each other. Describe the life cycle of one nonvascular plant and one vascular plant, including the relative sizes of the different forms and other characteristics.

Answers

1. A **2.** G **3.** B
4. F **5.** C **6.** H

7. Answers should include the term *alternation of generations*, descriptions of the sporophyte and gametophyte generations, and other characteristics.

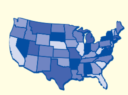
TEST DOCTOR

Question 2 **F** and **J** are incorrect because not all cells are in direct contact with the environment. **G** is correct because water and nutrients can move cell-to-cell by these processes. **H** is incorrect because nonvascular plants have no vascular tissue.

Question 5 **A** is incorrect because zygotes are produced by fertilization at Stage 3. **B** is incorrect because mitosis maintains the chromosome number. **C** is correct because meiosis reduces the diploid number to haploid. **D** is incorrect because haploid gametes are produced at Stage 2.

Question 6 **F** is incorrect because mitosis would maintain $2n$ cells, meiosis would reduce the cells to $1/2n$, while fertilization would create $2n$ cells. **G** is incorrect because meiosis reduces $2n$ cells to $1n$ cells, and fertilization restores the cells to $2n$, but too soon. **H** is correct because meiosis reduces $2n$ cells to $1n$ cells, mitosis maintains the $1n$ state, and fertilization restores cells to $2n$. **J** is incorrect because mitosis maintains the chromosome count while meiosis would halve it.

State Resources



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

Test Practice with Guided Reading Development