Chapter 10

Structure and Function of Plants

CALIFORNIA Standards Preview

S 7.1 All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:

d. Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

S 7.2 A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences. As a basis for understanding this concept:

a. Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.

S 7.5 The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. As a basis for understanding this concept:

a. Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

f. Students know the structures and processes by which flowering plants generate pollen, ovules, seeds, and fruit.

The *Passiflora* plant produces delicate, highly scented flowers. ▶

Video Preview

Discovery Channel School

Seed Plants

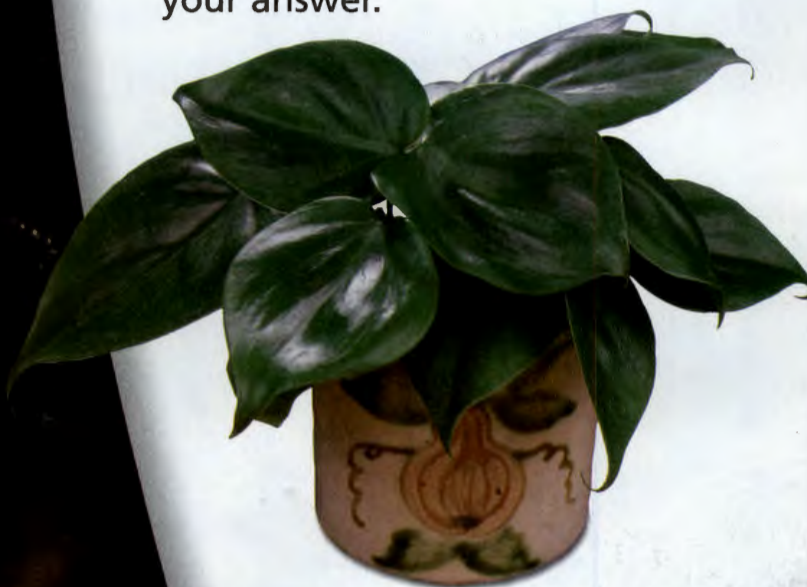
Focus on the BIG Idea

S 7.5.a

How does the structure of a plant allow it to grow and reproduce?

Check What You Know

Suppose you were to put a healthy, growing plant into a completely dark room for two weeks. How would this affect the growth of the plant? Explain your answer.



Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

High-Use Academic Words

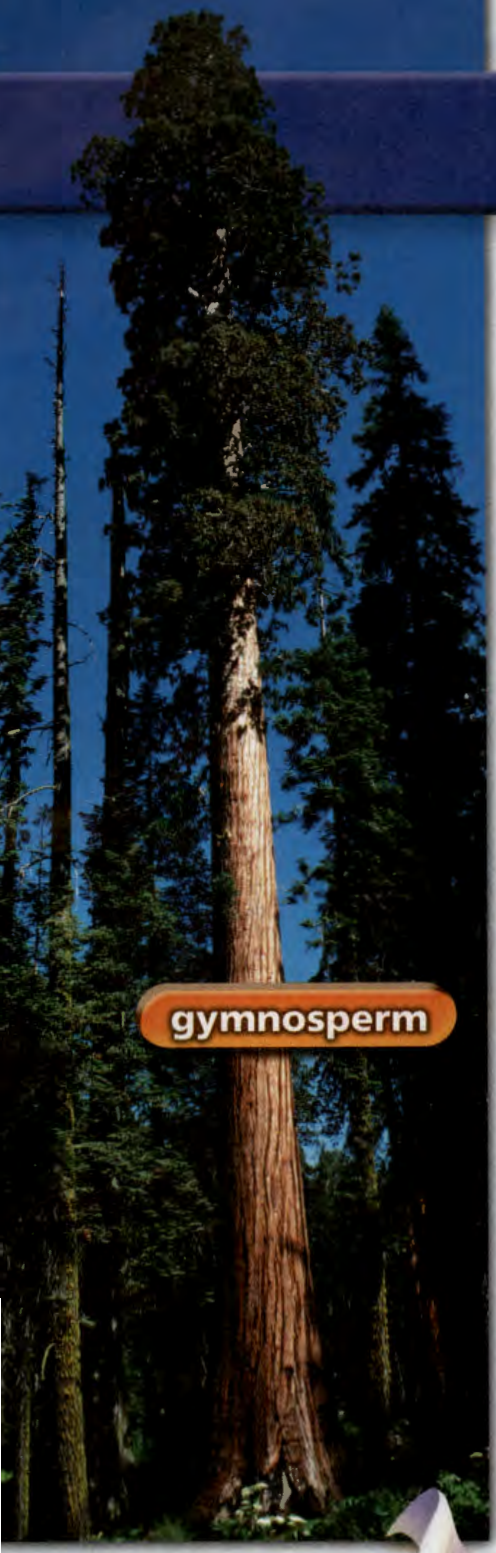
High-use academic words are words that are used frequently in classrooms. High-use academic words appear frequently in textbooks. Look for the words in the table as you read this chapter.

Word	Definition	Example Sentence
consist (kun SIST) pp. 363, 382	*v.* To be formed or made of	Plant stems consist of several kinds of cells.
diverse (duh VURS) p. 371	*adj.* Different, varied	California has a diverse population, including people from many different countries.
survival (sur VY vul) p. 379	*n.* The act of staying alive or existing	The survival of the accident victim depends on quick medical attention.
transport (trans PAWRT) pp. 365, 381	*v.* To carry from one place to another	Trucks transport products from factories to stores.

Apply It!

Choose the word that best completes the sentence.

1. For their _____, plants need water and sunlight.
2. A plant needs to _____ materials from one part of its body to another.
3. The structure of many plants _____ of leaves, stems, and roots.



Chapter 10 Vocabulary

Section 1 (page 362)

cuticle
vascular tissue
zygote
nonvascular plant
vascular plant
sporophyte
gametophyte

Section 2 (page 370)

rhizoid
frond

Section 3 (page 375)

phloem
xylem
pollen
seed
embryo
cotyledon
germination

Section 4 (page 380)

root cap
cambium
transpiration

Section 5 (page 388)

gymnosperm
cone
ovule
pollination
angiosperm
flower
sepal
petal
stamen
pistil
ovary
fruit
monocot
dicot

Interactive Textbook

Build Science Vocabulary *Online*

Visit: PHSchool.com
Web Code: cvj-3100

How to Read Science

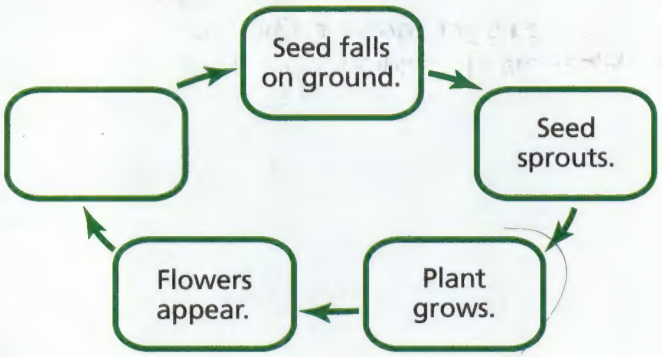
Reading Skill

Sequence

Science textbooks often describe sequences—that is, the order in which events happen. A cycle is a sequence that does not have a beginning or end. When the final event is over, the first event begins again. You will learn about complex life cycles of plants in this chapter. Here is a simplified description of one life cycle.

> Many plants reproduce by means of seeds. At some point after a seed falls on the ground, the seed sprouts. Slowly, the new plant grows. After a time, flowers appear. Seeds form in flowers. When the seeds are fully developed, they fall onto the ground. Sooner or later, some of these new seeds will sprout.

The partially completed cycle diagram below shows the sequence of events described in the paragraph.



Apply It!

1. In your notebook, complete the diagram shown above.
2. After you read Section 1, draw a cycle diagram of a plant life cycle, including the sporophyte and the gametophyte stages. After reading Section 5, prepare two cycle diagrams—one for gymnosperms and one for angiosperms.

Lab zone

Standards Investigation

S 7.2.a

Cycle of a Lifetime

How long is a seed plant's life? Redwood trees can live for thousands of years. Tomato plants die after only one season. Can organisms that seem so different have anything in common? In this chapter, you'll find out. Some answers will come from this chapter's investigation. In this project, you'll grow plants from seeds and then care for the plants until they produce seeds.

Your Goal

To care for and observe a plant throughout its life cycle

To complete this investigation, you must

- grow a plant from a seed
- observe and describe key parts of your plant's life cycle, such as seed germination and pollination
- harvest and plant the seeds that your growing plant produces
- follow the safety guidelines in Appendix A

Plan It!

Observe the seeds that your teacher gives you. In a small group, discuss what conditions the seeds might need to grow. What should you look for after you plant the seeds? What changes do you expect your plant to undergo during its life cycle? When you are ready, plant your seeds.

Section 1

The Plant Kingdom

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

- What characteristics do all plants share?
- What do plants need to live successfully on land?
- How do nonvascular plants and vascular plants differ?
- What are the different stages of a plant's life cycle?

Key Terms

- cuticle
- vascular tissue
- zygote
- vegetative reproduction
- nonvascular plant
- vascular plant
- sporophyte
- gametophyte

Lab zone Warm-Up

What Do Leaves Reveal About Plants?

1. Your teacher will give you two leaves from plants that grow in two very different environments: a desert and an area with average rainfall.
2. Carefully observe the color, size, shape, and texture of the leaves. Touch the surfaces of each leaf. Examine each leaf with a hand lens. Record your observations in your notebook.
3. When you have finished, wash your hands thoroughly with soap and water.

Think It Over

Inferring Use your observations of the structure of the leaves to determine which plant lives in the desert. Explain.

There are some very strange plants in the world. There are plants that trap animals, plants that bloom only once every thirty years, and plants with flowers that smell like rotting meat. You don't see these plants every day. But whenever you see moss on a tree trunk, a grassy lawn, or ripe tomatoes in a garden, you see plants. And all plants, both the unfamiliar and the familiar, have a lot in common.

What Is a Plant?

Members of the plant kingdom share several characteristics. **Nearly all plants are autotrophs, organisms that produce their own food. All plants are eukaryotes that contain many cells. In addition, all plant cells are surrounded by cell walls.**

Autotrophs Plants are autotrophs. You can think of a plant as a sun-powered, food-making factory. Sunlight provides the energy for this food-making process, photosynthesis.

Plant Cells Plants are multicellular eukaryotes. Recall that plant cells are enclosed by a cell wall. Many plant cells also contain chloroplasts and a large vacuole for storing water, wastes, food, and other substances.

Plant Body Organization Like many other multicellular organisms, plants have levels of organization for structure and function. Figure 1 shows some of the cells, tissues, organs, and organ systems that make up a typical plant.

Take a look at the leaf. Notice that it is made of layers of similar cells. Recall that tissues are groups of similar cells that perform a specific function. The flat layer of cells that cover the outer surfaces of the leaf is one type of tissue. The layers of tightly packed cells with chloroplasts make up another type of tissue. Tissues work together to form organs. Leaves, stems, and roots are organs.

Organs that work together to perform a major function comprise organ systems. A plant has two organ systems—one above ground and one below ground. Above ground is the shoot system, which consists of stems, leaves, and buds. The shoot system produces food for the plant. Below ground is the root system. As you can probably guess, the root system consists of roots, which absorb water and nutrients and anchor the plant in the soil.

FIGURE 1
Plant Body Structure
The body of a plant is organized into organ systems, organs, tissues, and cells.
Interpreting Diagrams *What functions are the cells of the leaf specialized to do?*

FIGURE 2
Retaining Water
Plants have adaptations that help them retain water. The shiny, waterproof cuticle on this leaf slows down evaporation.

Adaptations for Living on Land

Most plants live on land. How is living on land different from living in water? Imagine multicellular algae floating in the ocean. The algae obtain water and other materials directly from the water around them. Their bodies are held up toward the sunlight by the water. The water also aids in reproduction, allowing sperm cells to swim to egg cells.

Now imagine plants living on land. What adaptations would help them meet their needs without water all around them? **To survive on land, plants must have structures that allow them to obtain water and other nutrients from their surroundings, retain water, transport materials in their bodies, support their bodies, and reproduce.**

Obtaining Water and Other Nutrients Recall that all organisms need water to survive. Obtaining water is easy for algae because water surrounds them. To live on land, though, plants need adaptations for obtaining water from the soil. Plants must also have ways of obtaining nutrients from the soil.

Retaining Water Plants must have ways of holding onto the water they obtain. Otherwise, they could easily dry out due to evaporation. When there is more water in plant cells than in the air, the water leaves the plant and enters the air. One adaptation that helps a plant reduce water loss is a waxy, waterproof layer called the **cuticle.** A cuticle covers the leaves of most plants.

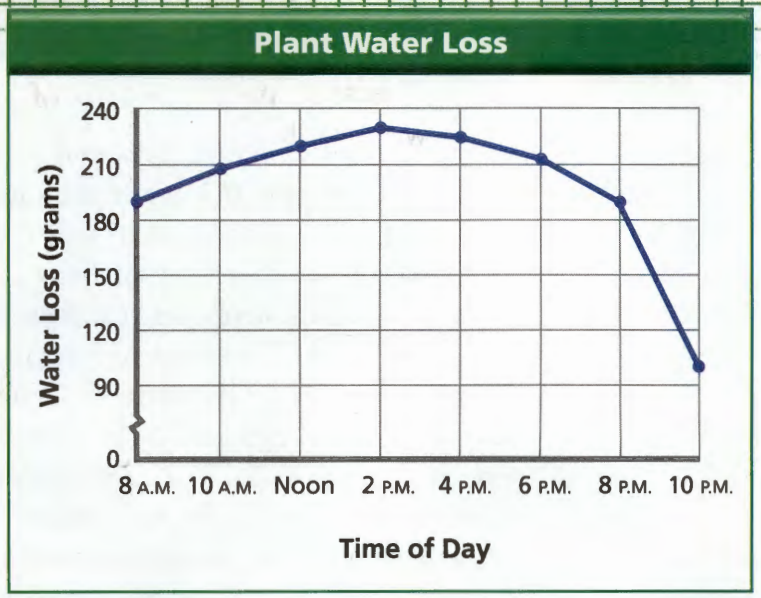
Reviewing Math: Statistics, Data Analysis, and Probability 7.1.2

Math Analyzing Data

Water Loss in Plants

The graph shows how much water a certain plant loses during the hours shown.

1. **Reading Graphs** What variable is plotted along each axis?
2. **Interpreting Data** During what part of the day did the plant lose the most water? The least water?
3. **Drawing Conclusions** What could cause this pattern of water loss?
4. **Predicting** How would you expect the graph to look from 10 P.M. to 8 A.M.? Explain your reasoning.



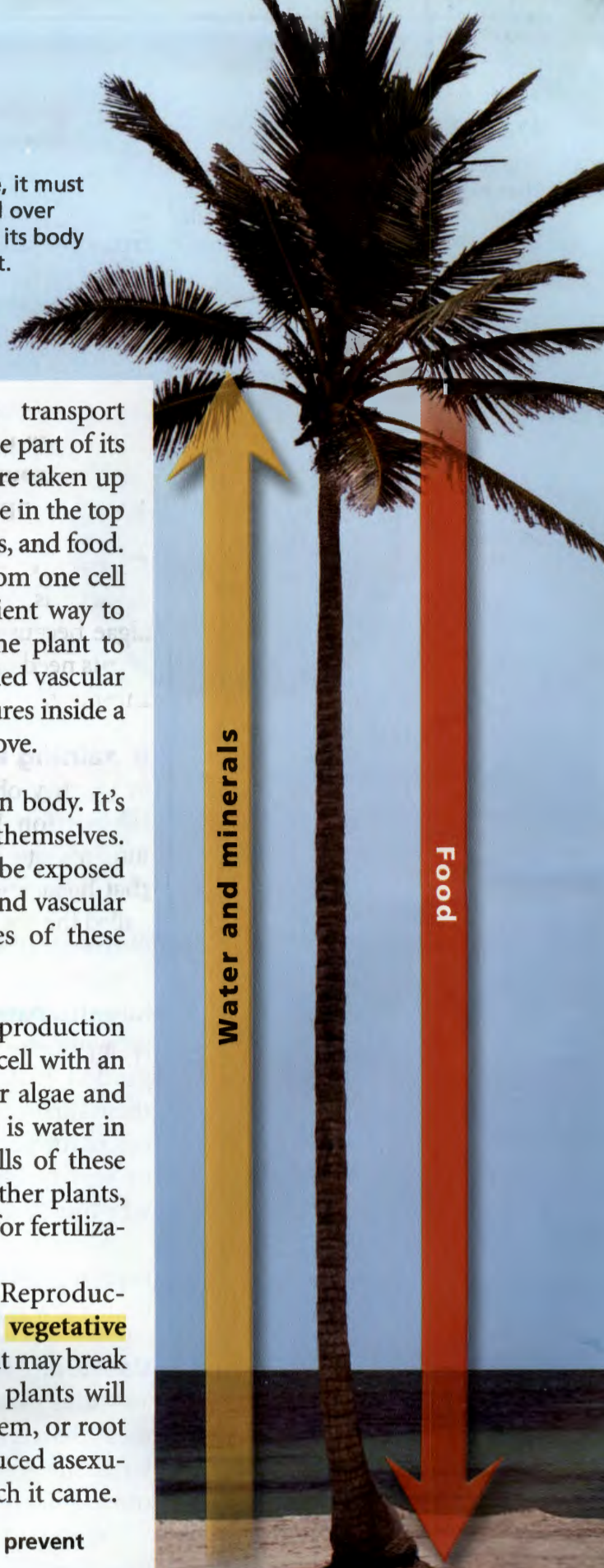


FIGURE 3
Transport and Support
For this tall coconut palm to survive, it must transport water, minerals, and food over long distances. It must also support its body so its leaves are exposed to sunlight.

Transporting Materials A plant needs to transport water, minerals, food, and other materials from one part of its body to another. In general, water and minerals are taken up by the bottom part of the plant, while food is made in the top part. But all of the plant's cells need water, minerals, and food.

In small plants, materials can simply move from one cell to the next. But larger plants need a more efficient way to transport materials farther, from one part of the plant to another. These plants have transporting tissue called vascular tissue. **Vascular tissue** consists of tubelike structures inside a plant through which water, minerals, and food move.

Support A plant on land must support its own body. It's easier for small, low-growing plants to support themselves. But for larger plants to survive, the leaves must be exposed to as much sunlight as possible. Rigid cell walls and vascular tissue strengthen and support the large bodies of these plants.

Reproduction All plants undergo sexual reproduction that involves fertilization, the joining of a sperm cell with an egg cell. The fertilized egg is called a **zygote.** For algae and some plants, fertilization can only occur if there is water in the environment. This is because the sperm cells of these plants swim through the water to the egg cells. Other plants, however, have adaptations that makes it possible for fertilization to occur in dry environments.

Many plants can also reproduce asexually. Reproduction in plants by asexual methods is called **vegetative reproduction.** For example, pieces of a parent plant may break off and develop into a whole new plant. Many plants will also grow from a cutting, which may be a leaf, stem, or root cut from a plant. Of course, a plant that is produced asexually is genetically identical to the plant from which it came.

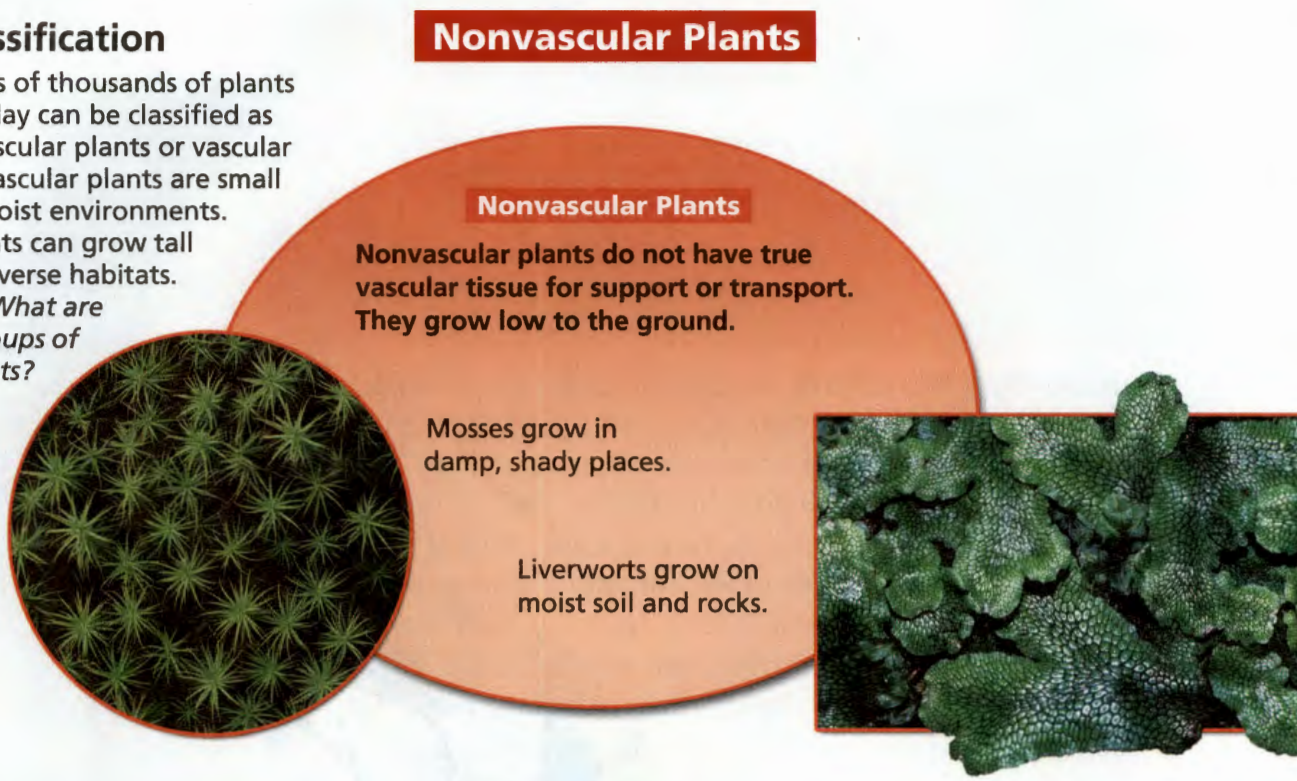
Reading Checkpoint **Why do plants need adaptations to prevent water loss?**

FIGURE 4

Plant Classification

The hundreds of thousands of plants that exist today can be classified as either nonvascular plants or vascular plants. Nonvascular plants are small and live in moist environments. Vascular plants can grow tall and live in diverse habitats.

Classifying *What are the three groups of vascular plants?*



Classification of Plants

Scientists informally group plants into two major groups—nonvascular plants and vascular plants. Figure 4 shows examples of the major groups of plants living today.

Nonvascular Plants Plants that lack a well-developed system of tubes for transporting water and other materials are known as **nonvascular plants.** Nonvascular plants are low-growing and do not have roots for absorbing water from the ground. Instead, they obtain water and materials directly from their surroundings. The materials then simply pass from one cell to the next. This means that materials do not travel very far or very quickly. This slow method of transport helps explain why most nonvascular plants live in damp, shady places.

Most nonvascular plants have only thin cell walls to provide support. This is one reason why these plants cannot grow more than a few centimeters tall.

Vascular Plants Plants with true vascular tissue are called **vascular plants.** Vascular plants are better suited to life in dry areas than are nonvascular plants. Their well-developed vascular tissue solves the problem of transport, moving materials more quickly and efficiently throughout the plant's body.

Vascular tissue also provides strength, stability, and support to a plant. Thus, vascular plants are able to grow quite tall.

Vascular Plants

Seedless Vascular Plants

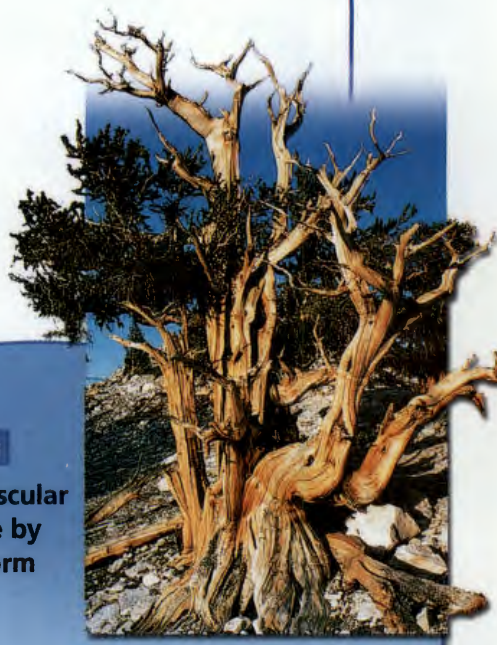
Seedless vascular plants reproduce by making spores.

◀ The staghorn fern produces spores at the tips of its antler-shaped leaves. This fern clings to the bark of trees in tropical areas.

Gymnosperms

Gymnosperms are vascular plants that reproduce by seeds. They do not form flowers or fruits.

◀ Ginkgo trees produce fleshy seeds that resemble fruits but are not. The seeds smell like vomit!

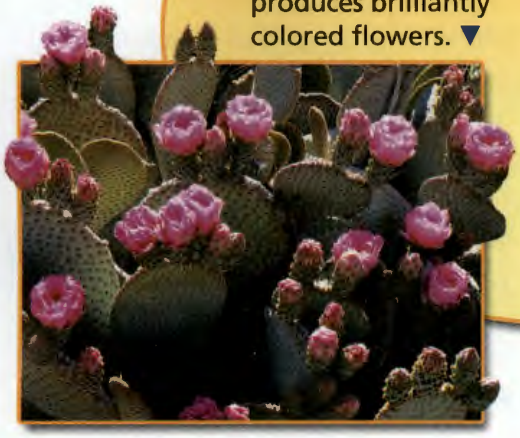


▲ The bristlecone pine can live for more than 4,000 years.

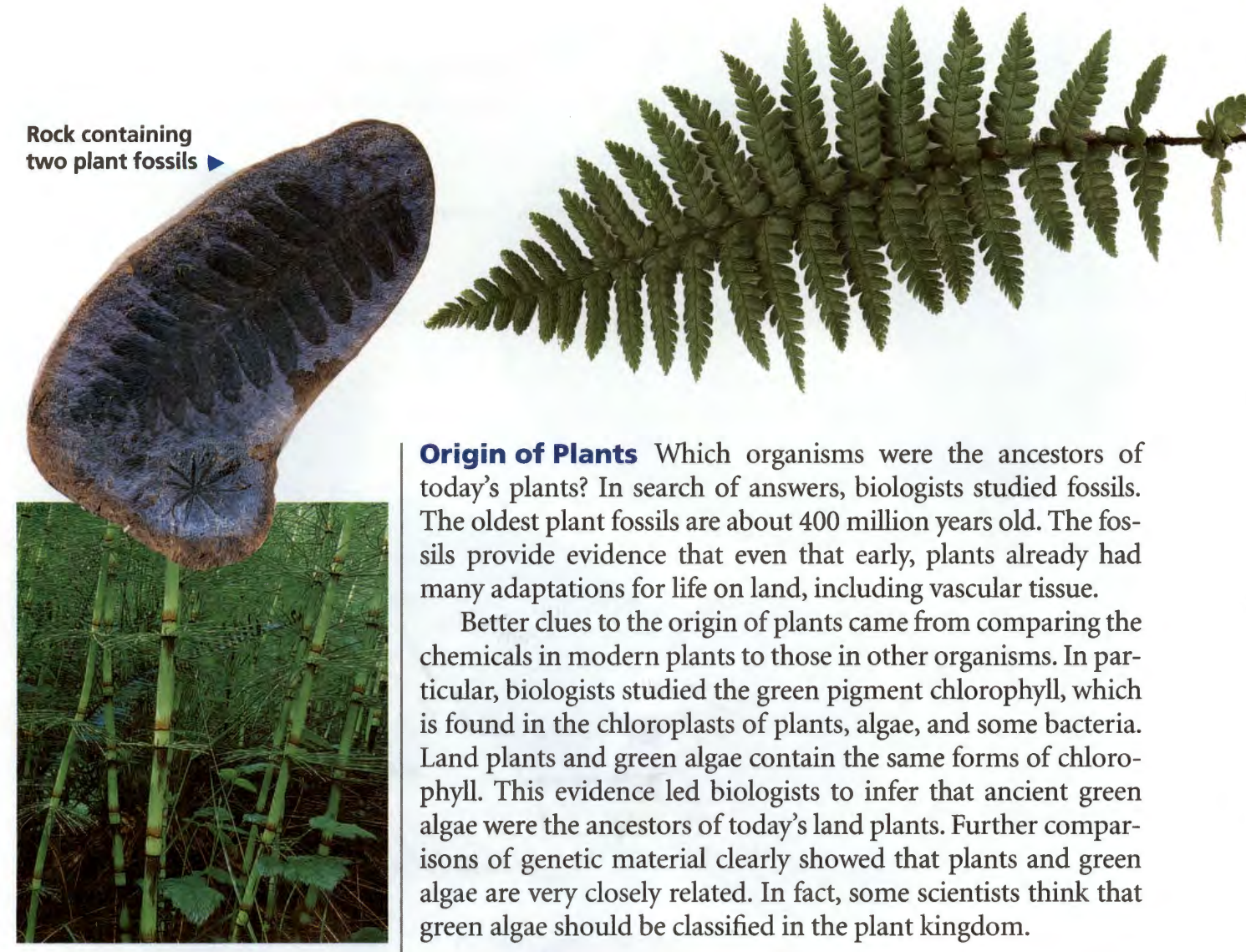
Angiosperms

Angiosperms are vascular plants that flower, and produce seeds that are surrounded by fruit.

The beavertail cactus produces brilliantly colored flowers. ▼



Wheat has been an important food crop for thousands of years. The grains, or fruits, are ground to make flour. ▶



Origin of Plants Which organisms were the ancestors of today's plants? In search of answers, biologists studied fossils. The oldest plant fossils are about 400 million years old. The fossils provide evidence that even that early, plants already had many adaptations for life on land, including vascular tissue.

Better clues to the origin of plants came from comparing the chemicals in modern plants to those in other organisms. In particular, biologists studied the green pigment chlorophyll, which is found in the chloroplasts of plants, algae, and some bacteria. Land plants and green algae contain the same forms of chlorophyll. This evidence led biologists to infer that ancient green algae were the ancestors of today's land plants. Further comparisons of genetic material clearly showed that plants and green algae are very closely related. In fact, some scientists think that green algae should be classified in the plant kingdom.

FIGURE 5
Ancient and Modern Plants
Fossils of ancient plants help scientists understand the origin of plants. These fossils are of two plants that lived about 300 million years ago. Notice the similarities between the fossils and modern-day ferns (top right) and horsetails (above).

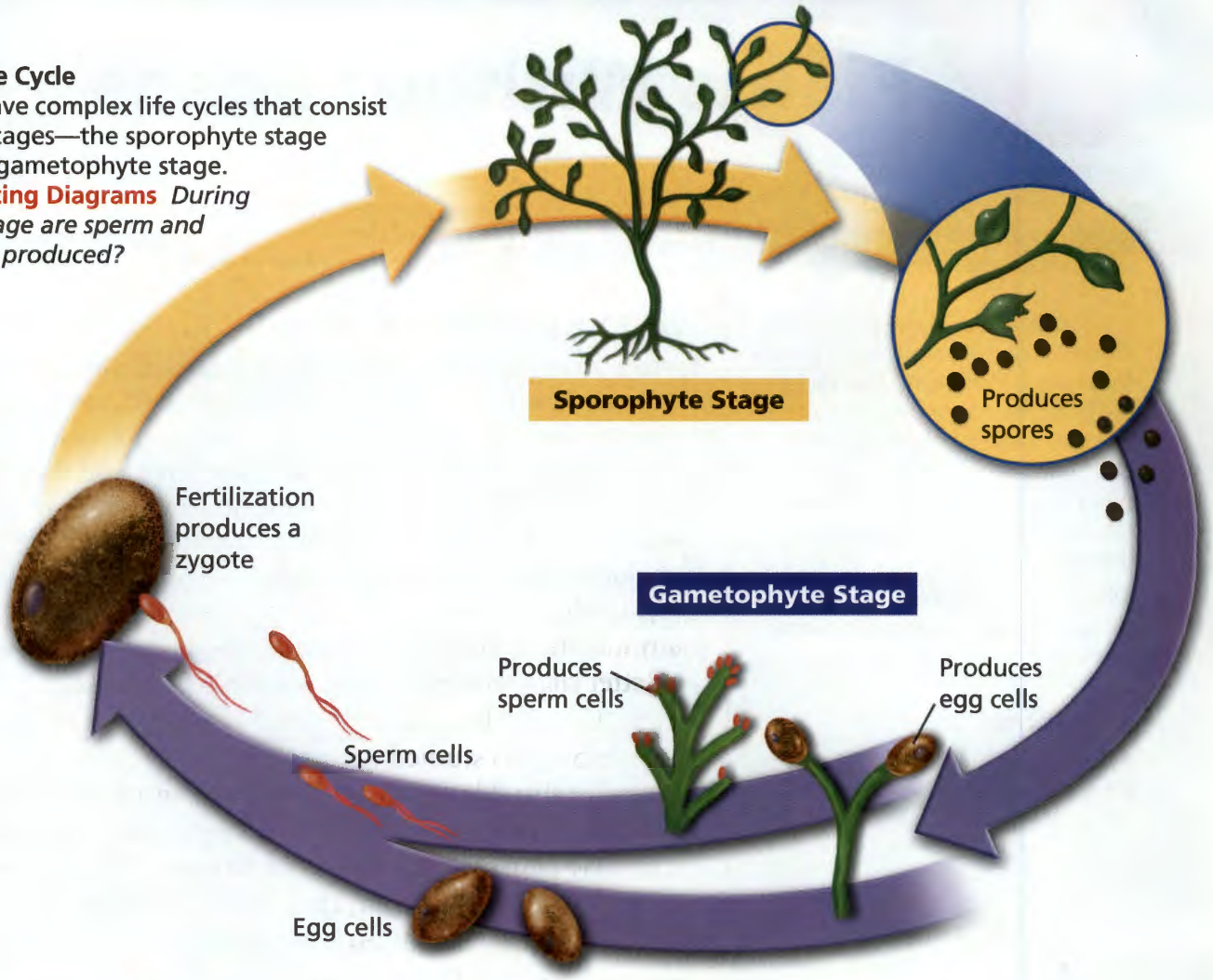
Complex Life Cycles

Plants have complex life cycles that include two stages, the sporophyte stage and the gametophyte stage. In the **sporophyte** (SPOH ruh fyt) stage, the plant produces spores, tiny cells that can grow into new organisms. A spore develops into the plant's other stage, called the gametophyte. In the **gametophyte** (guh MEE tuh fyt) stage, the plant produces sex cells, or gametes. The gametophyte stage produces two kinds of sex cells: sperm cells and egg cells.

Figure 6 shows a typical plant life cycle. A sperm cell and egg cell join to form a zygote. The zygote then develops into a sporophyte. The sporophyte produces spores, which develop into the gametophyte. Then the gametophyte produces sperm cells and egg cells, and the cycle starts again. The sporophyte of a plant usually looks quite different from the gametophyte.

Reading Checkpoint **During which stage does a plant produce spores?**

FIGURE 6
Plant Life Cycle
Plants have complex life cycles that consist of two stages—the sporophyte stage and the gametophyte stage.
Interpreting Diagrams *During which stage are sperm and egg cells produced?*



Section 1 Assessment

S 7.5.a, E-LA: Reading 7.2.0

Target Reading Skill Sequencing Events

Use your cycle diagram to help answer Question 4.

Reviewing Key Concepts

1. a. **Listing** List three characteristics of plants.
   b. **Comparing and Contrasting** Describe three ways that plant cells differ from the cells of some other eukaryotes.
   c. **Predicting** How might a plant cell be affected if it lacked chloroplasts?
2. a. **Identifying** What are five adaptations that plants need to survive on land?
   b. **Inferring** Why is a cuticle a useful adaptation in plants but not in algae?
3. a. **Reviewing** How do vascular plants differ from nonvascular plants?
   b. **Explaining** Explain why vascular plants are better suited to life in dry areas.
   c. **Classifying** Would you expect a tall desert plant to be a vascular plant? Explain.
4. a. **Describing** What are the two major stages of a plant's life cycle?
   b. **Sequencing** Describe in order the major events in the life cycle of a plant, starting with a zygote.

Lab zone At-Home Activity

Classifying Plants Look through old magazines and cut out pictures of plants. Classify each plant as vascular or nonvascular. Create a poster of your classification. Present your poster to your family and explain the differences between nonvascular and vascular plants.

Section 2

Plants Without Seeds

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

- What characteristics do the three groups of nonvascular plants share?
- What characteristics do the three groups of seedless vascular plants share?

Key Terms

- rhizoid
- frond

Lab zone Standards Warm-Up

Will Mosses Absorb Water?

1. Place 20 mL of sand into a plastic graduated cylinder. Place 20 mL of peat moss into a second plastic graduated cylinder.
2. Predict what would happen if you were to pour 10 mL of water slowly into each graduated cylinder and then wait five minutes.
3. To test your prediction, add 10 mL of water slowly to the sand. Then add 10 mL of water to the moss. After five minutes, record your observations.

Think It Over

Predicting How did your prediction compare with your results? What did you learn about moss from this investigation?

As you hike in the forest, you see ferns along the trail. Near a stream, you see mosses everywhere—on the forest floor, on rocks, and along the banks of the stream. Although ferns and mosses look very different, they have something in common. Both reproduce without forming seeds.

Nonvascular Plants

Mosses are a type of seedless plant with no true vascular tissue. **There are three major groups of nonvascular plants: mosses, liverworts, and hornworts. These low-growing plants live in moist areas where they can absorb water and other nutrients directly from their environment.** The watery environment enables sperm cells to swim to egg cells during sexual reproduction.

Go Online NSTA SCILINKS

For: Links on nonvascular plants
Visit: www.SciLinks.org
Web Code: scn-0143

Mosses With more than 10,000 species, mosses are the most diverse group of nonvascular plants. You have probably seen mosses growing in sidewalk cracks, on tree trunks, and in other damp, shady spots.

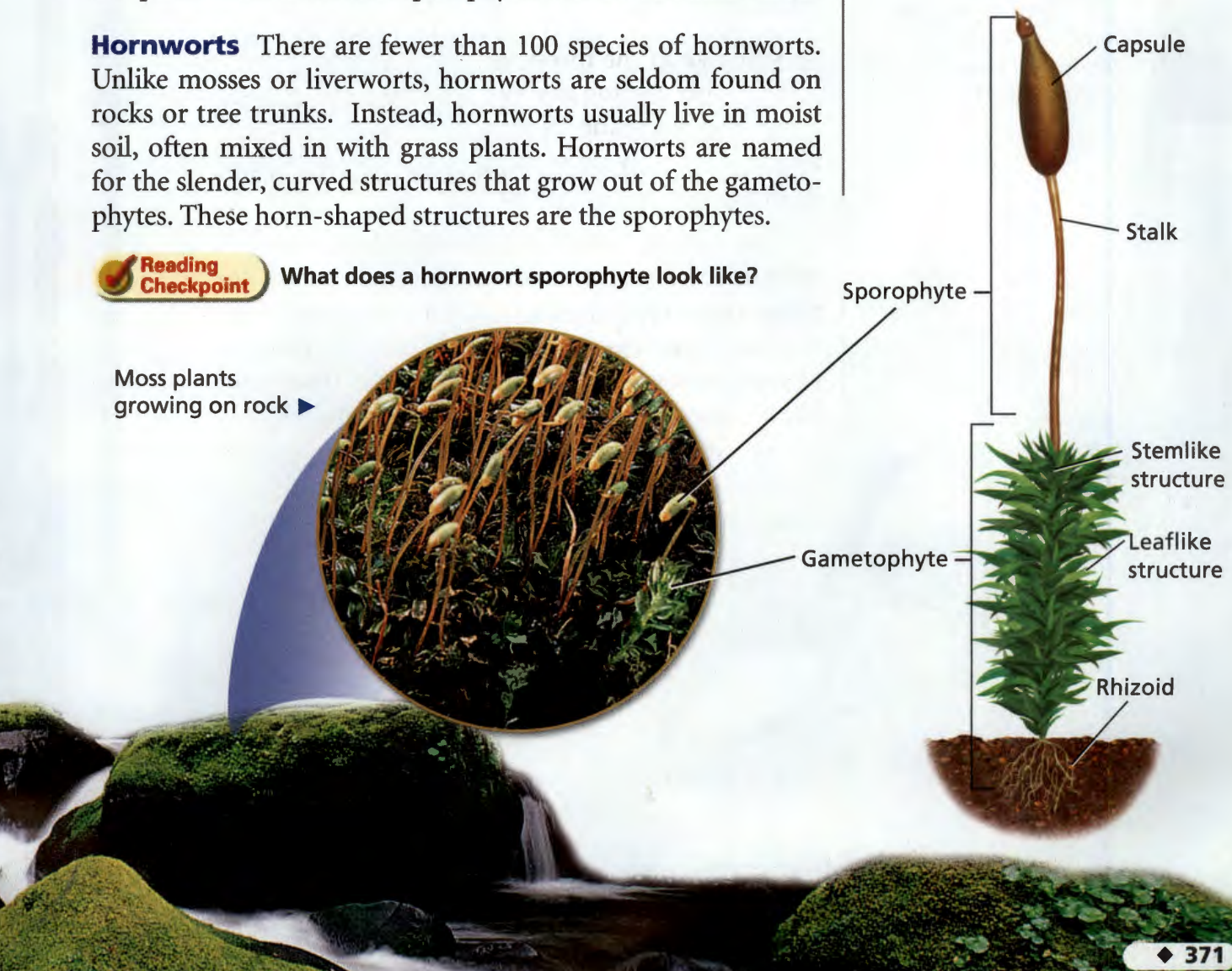
Figure 7 shows the structure of a moss plant. The familiar green, fuzzy moss is the gametophyte generation of the plant. Structures that look like tiny leaves grow off a small, stemlike structure. Thin, rootlike structures called **rhizoids** anchor the moss and absorb water and nutrients from the soil. The sporophyte generation grows out of the gametophyte. It consists of a slender stalk with a capsule at the end. The capsule contains spores.

Liverworts There are more than 8,000 species of liverworts. Liverworts are often found growing as a thick crust on moist rocks or soil along the sides of a stream. This group of plants is named for the shape of the plant's leaflike gametophyte, which looks somewhat like a human liver. *Wort* is an old English word for "plant." Liverworts have sporophytes that are too small to see.

Hornworts There are fewer than 100 species of hornworts. Unlike mosses or liverworts, hornworts are seldom found on rocks or tree trunks. Instead, hornworts usually live in moist soil, often mixed in with grass plants. Hornworts are named for the slender, curved structures that grow out of the gametophytes. These horn-shaped structures are the sporophytes.

Reading Checkpoint **What does a hornwort sporophyte look like?**

FIGURE 7
A Moss Plant
A moss gametophyte has stemlike, leaflike, and rootlike structures.
Interpreting Diagrams *What structures anchor the moss plant?*



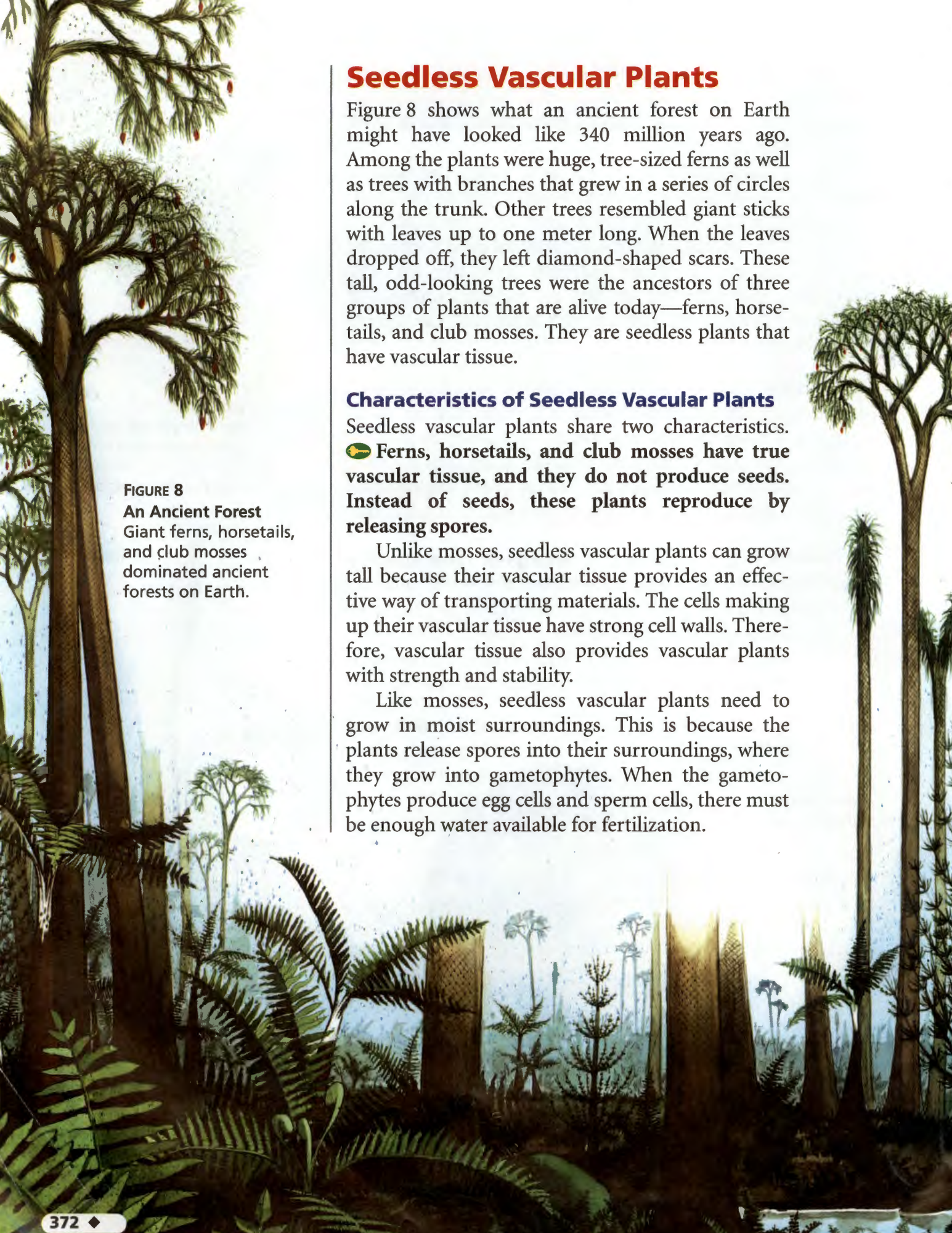


FIGURE 8
An Ancient Forest
Giant ferns, horsetails, and club mosses dominated ancient forests on Earth.

Seedless Vascular Plants

Figure 8 shows what an ancient forest on Earth might have looked like 340 million years ago. Among the plants were huge, tree-sized ferns as well as trees with branches that grew in a series of circles along the trunk. Other trees resembled giant sticks with leaves up to one meter long. When the leaves dropped off, they left diamond-shaped scars. These tall, odd-looking trees were the ancestors of three groups of plants that are alive today—ferns, horsetails, and club mosses. They are seedless plants that have vascular tissue.

Characteristics of Seedless Vascular Plants

Seedless vascular plants share two characteristics. **Ferns, horsetails, and club mosses have true vascular tissue, and they do not produce seeds. Instead of seeds, these plants reproduce by releasing spores.**

Unlike mosses, seedless vascular plants can grow tall because their vascular tissue provides an effective way of transporting materials. The cells making up their vascular tissue have strong cell walls. Therefore, vascular tissue also provides vascular plants with strength and stability.

Like mosses, seedless vascular plants need to grow in moist surroundings. This is because the plants release spores into their surroundings, where they grow into gametophytes. When the gametophytes produce egg cells and sperm cells, there must be enough water available for fertilization.

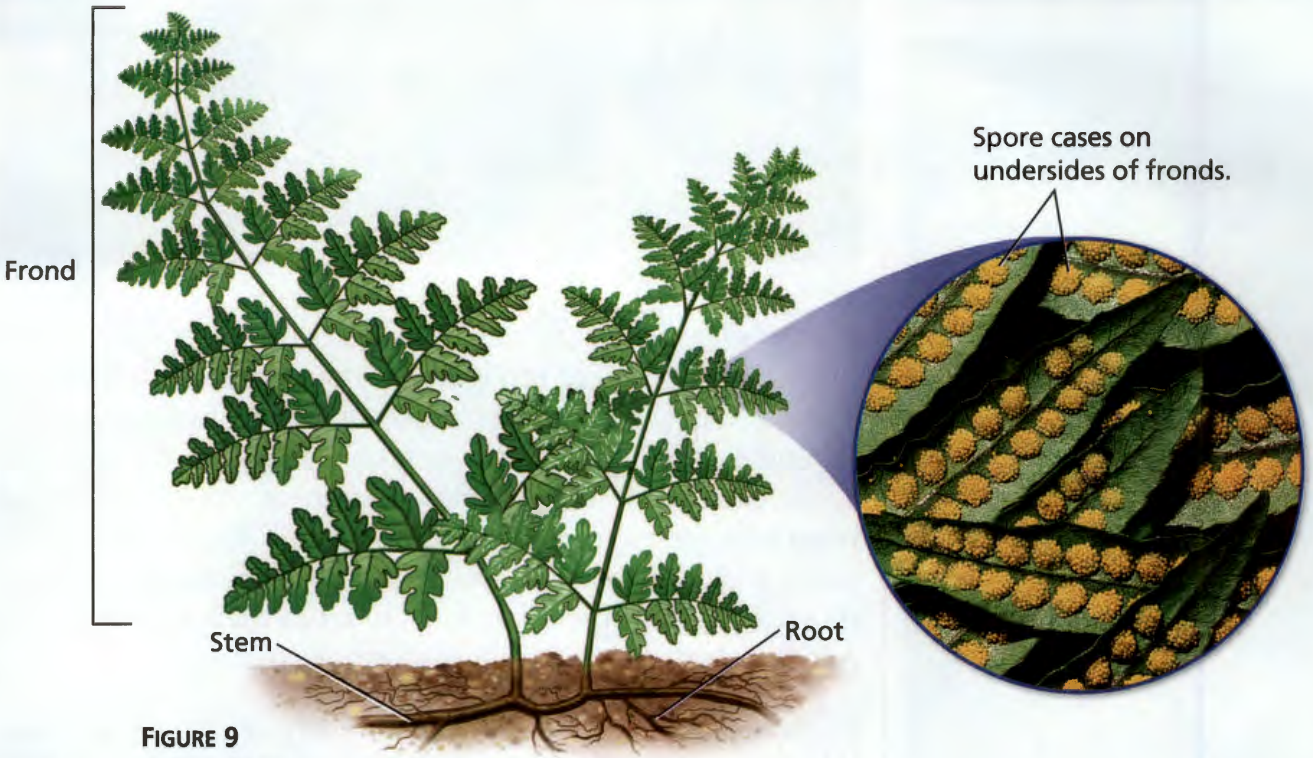


FIGURE 9
A Fern Plant
Fern leaves, or fronds, grow above ground. Most ferns have underground stems in addition to roots. Ferns can reproduce asexually by sending up fronds from the stems.
Relating Diagrams and Photos *Where are spore cases found on a fern plant?*

Ferns There are more than 12,000 species of ferns alive today. Like other vascular plants, ferns have true stems, roots, and leaves. The stems of most ferns run horizontally underground. Leaves grow upward from the top side of the stems, while roots grow downward from the bottom of the stems. The roots anchor the fern to the ground and absorb water and nutrients from the soil. These substances enter the root's vascular tissue and travel through the tissue into the stems and leaves.

Figure 9 shows a fern's structure. Notice that the fern's leaves, or **fronds**, are divided into many smaller parts that look like small leaves. The upper surface of each frond is coated with a cuticle that helps the plant retain water.

The familiar fern, with its visible fronds, is the sporophyte stage of the plant. On the underside of mature fronds, spores develop in tiny spore cases. Wind and water can carry the spores great distances. If a spore lands in moist, shaded soil, it develops into a gametophyte. Fern gametophytes are tiny plants that grow low to the ground.

Reading Checkpoint **How are seedless vascular plants like mosses?**

Lab zone Try This Activity

Examining a Fern

1. Your teacher will give you a fern plant to observe.
2. Draw a diagram of the plant and label the structures that you see.
3. Use a hand lens to observe the top and lower surfaces of the leaf. Run a finger over both surfaces.
4. With a plastic dropper, add a few drops of water to the top surface of the leaf. Note what happens.

Inferring Use your observations to explain how ferns are adapted to life on land.

FIGURE 10
Horsetails and Club Mosses
Horsetails (left) have branches and leaves that grow in a circle around each joint. Club mosses (right) look like tiny pine trees.
Inferring *Which grow taller—true mosses or club mosses?*

Horsetails There are very few species of horsetails on Earth today. As you can see in Figure 10, the stems of horsetails are jointed. Long, coarse, needle-like branches grow in a circle around each joint. Small leaves grow flat against the stem just above each joint. The whorled pattern of growth somewhat resembles the appearance of a horse's tail. The stems contain silica, a gritty substance also found in sand. During colonial times, Americans used the plants to scrub their pots and pans. Another name for horsetails is scouring rushes.

Club Mosses Like ferns, club mosses have true stems, roots, and leaves. They also have a similar life cycle. However, there are only a few hundred species of club mosses alive today.

Do not be confused by the name *club mosses*. Unlike true mosses, club mosses have vascular tissue. The plant, which looks a little like the small branch of a pine tree, is sometimes called ground pine or princess pine. Club mosses usually grow in moist woodlands and near streams.

Reading Checkpoint **Where do club mosses usually grow?**

Section 2 Assessment

S 7.5.a, E-LA: Reading 7.1.0, Writing 7.2.0

Vocabulary Skill **High-Use Academic Words** Which are more *diverse*—liverworts or hornworts? Explain your answer.

Reviewing Key Concepts

1. a. **Describing** What two characteristics do mosses, liverworts, and hornworts share?
   b. **Relating Cause and Effect** How are these two characteristics related?
   c. **Comparing and Contrasting** In what ways are mosses, liverworts, and hornworts similar? In what ways do they differ?
2. a. **Listing** What two characteristics do ferns, horsetails, and club mosses share?
   b. **Comparing and Contrasting** In what ways do ferns, horsetails, and club mosses differ from true mosses? In what way are they similar to mosses?
   c. **Inferring** Although ferns have vascular tissue, they still must live in moist environments. Explain why.

Writing in Science

Product Label Create a product label to be attached to pots of fern plants for sale at a garden shop. Describe the structure of ferns and growing instructions. Include other helpful information or diagrams.

Section 3

The Characteristics of Seed Plants

CALIFORNIA Standards Focus

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

- What characteristics do seed plants share?
- How do seeds become new plants?

Key Terms

- phloem
- xylem
- pollen
- seed
- embryo
- cotyledon
- germination

Lab zone Standards Warm-Up

What's the "In-Seed" Story?

1. Your teacher will give you a hand lens and two different seeds that have been soaked in water.
2. Carefully observe the outside of each seed. Draw what you see.
3. Gently remove the covering of each seed. Then carefully separate the structures. Use a hand lens to examine them. Draw what you see.

Think It Over

Posing Questions Write two questions about the structures in each seed. How could you find out the answers?

Have you ever planted seeds in a garden? If so, then you may remember how it seemed to take forever before those first green shoots emerged. Shortly afterwards, you saw one set of leaves, and then others. Then a flower may have appeared. Did you wonder where all those plant parts came from? How did they develop from one small seed? Read on to find out.

▲ A salad of seed plants

What Is a Seed Plant?

The plant growing in your garden was a seed plant. So are most of the other plants around you. In fact, seed plants outnumber seedless plants by more than ten to one. You eat many seed plants—rice, peas, and squash, for example. You wear clothes made from seed plants, such as cotton and flax. You may live in a home built from seed plants—oak, pine, or maple trees. In addition, seed plants produce much of the oxygen you breathe.

Seed plants share two important characteristics. They have vascular tissue, and they use pollen and seeds to reproduce. In addition, most seed plants have organs that include roots, stems, and leaves. Like seedless plants, seed plants have complex life cycles that include the sporophyte and the gametophyte stages. In seed plants, the plants that you see are the sporophytes. The gametophytes are microscopic.

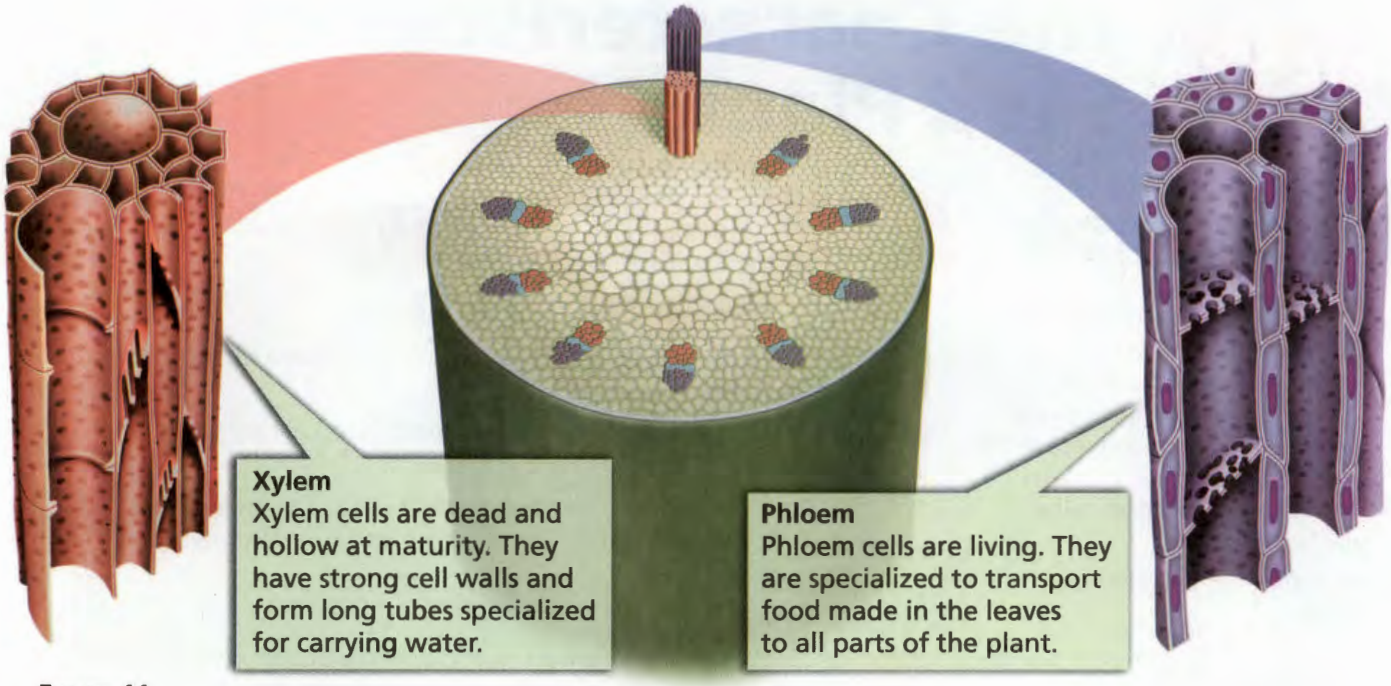


FIGURE 11
Phloem and Xylem
The stems of vascular plants contain bundles of phloem and xylem. **Observing** *How is the structure of vascular tissue adapted for transporting materials?*

Vascular Tissue Most seed plants live on land. Recall that land plants face many challenges, including standing upright and supplying all their cells with food and water. Like ferns, seed plants meet these two challenges with vascular tissue. The thick walls of the cells in the vascular tissue help support the plant body. In addition, vascular tissue transports food, water, and nutrients throughout the plant.

There are two types of vascular tissue. Figure 11 shows these two tissues. **Phloem** (FLOH um) is the vascular tissue through which food moves. When food is made in the leaves, it enters the phloem and travels to other parts of the plant. Water and minerals, on the other hand, travel in the vascular tissue called **xylem** (ZY lum). Roots absorb water and minerals from the soil. These materials enter the root's xylem and move upward into the stems and leaves.

Pollen and Seeds Unlike seedless plants, seed plants can live in a wide variety of environments. Recall that seedless plants need water in their surroundings for fertilization to occur. Seed plants do not need water for sperm to swim to the eggs. Instead, seed plants produce **pollen,** tiny structures that contain the cells that will later become sperm cells. Pollen delivers sperm cells near to the eggs.

After sperm cells fertilize the eggs, seeds develop. A **seed** is a structure that contains a young plant inside a protective covering. Seeds protect the young plant from drying out.

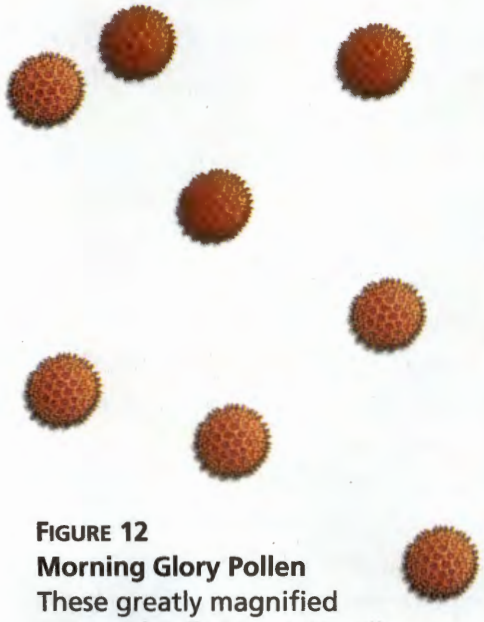


FIGURE 12
Morning Glory Pollen
These greatly magnified grains of pollen contain cells that will develop into sperm.

How Seeds Become New Plants

All seeds share several important similarities. **Inside a seed is a partially developed plant. If a seed lands in an area where conditions are favorable, the plant sprouts out of the seed and begins to grow.**

Seed Structure A seed has three main parts—an embryo, stored food, and a seed coat. The young plant that develops from the zygote, or fertilized egg, is the **embryo** (em BREE oh). The embryo already has the beginnings of roots, stems, and leaves. In the seeds of most plants, the embryo stops growing when it is quite small. When the embryo begins to grow again, it uses the food stored in the seed until it can make its own food by photosynthesis.

The embryo has one or more seed leaves, or **cotyledons** (kaht uh LEED unz). In some seeds, food is stored in the cotyledons. In other seeds, food is stored outside the embryo, in tissue called endosperm. Figure 13 compares the structure of corn, bean, and pine seeds.

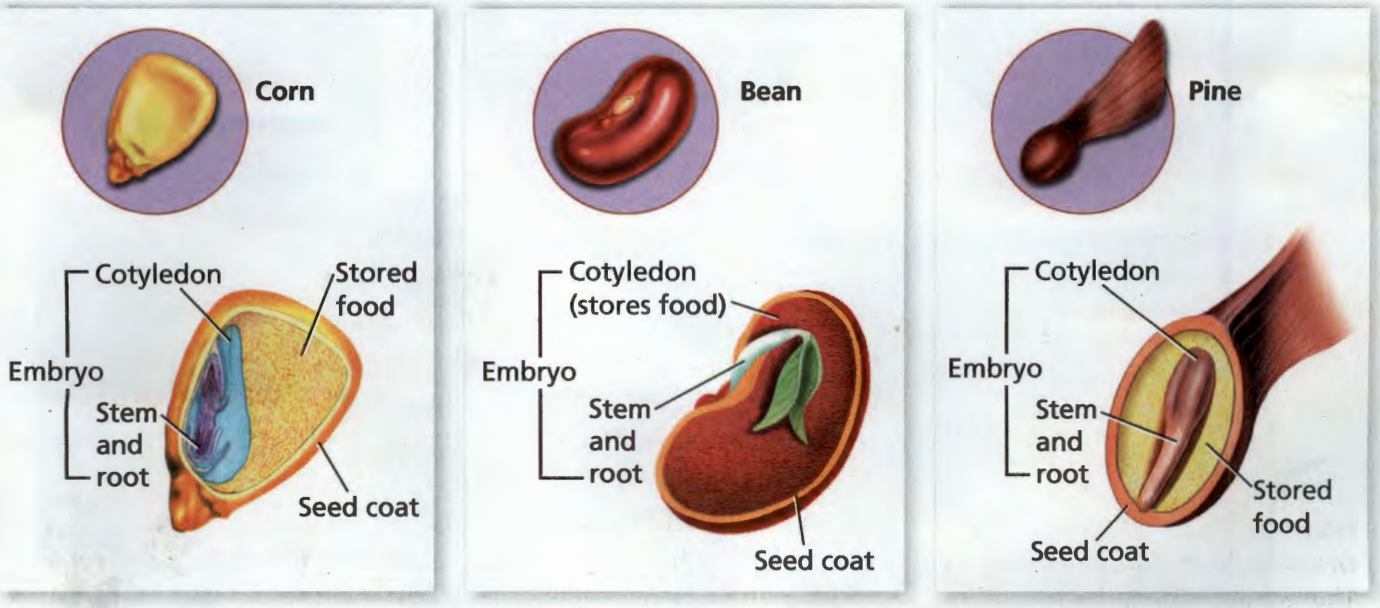
The outer covering of a seed is called the seed coat. Some familiar seed coats are the "skins" on lima beans and peanuts. The seed coat acts like plastic wrap, protecting the embryo and its food from drying out. This allows a seed to remain inactive for a long time. In many plants, the seeds are surrounded by a structure called a fruit.

Reading Checkpoint **What is a cotyledon?**

Go Online
NSTA SCILINKS

For: Links on seed plants
Visit: www.SciLinks.org
Web Code: cvn-3103

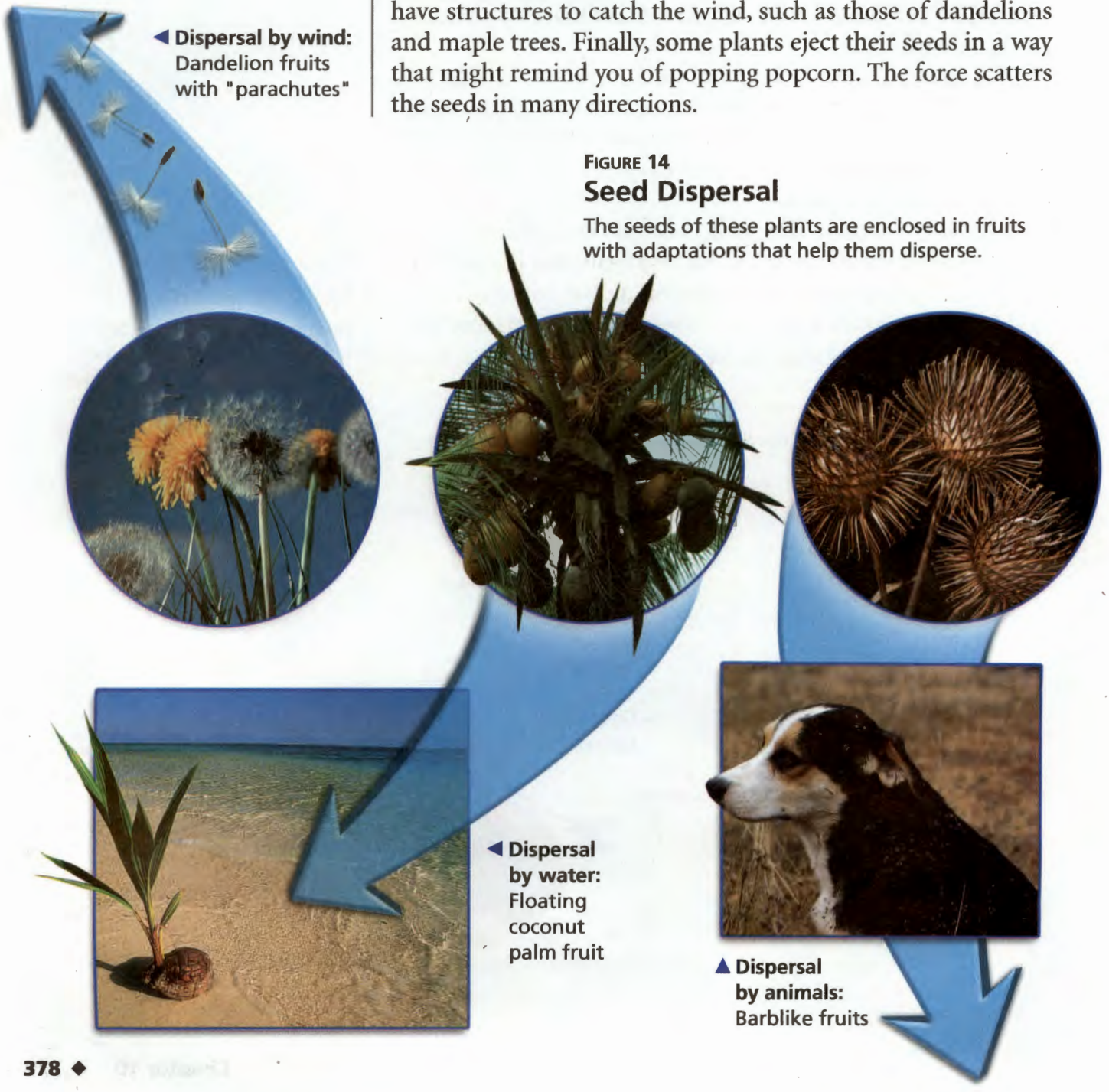
FIGURE 13
Seed Structure
The structures of three different seeds are shown here. In bean seeds, the cotyledon stores food. In corn and pine seeds, food is stored in endosperm. **Inferring** *How is the stored food used?*



Video Field Trip
Discovery Channel School
Seed Plants

Seed Dispersal After seeds have formed, they are usually scattered, sometimes far from where they were produced. The scattering of seeds is called seed dispersal. Seeds are dispersed in many ways. One method involves other organisms. For example, some animals eat fruits, such as cherries or grapes. The seeds inside the fruits pass through the animal's digestive system and are deposited in new areas. Other seeds are enclosed in barblike structures that hook onto an animal's fur or a person's clothes. The structures then fall off the fur or clothes in a new area.

A second means of dispersal is water. Water can disperse seeds that fall into oceans and rivers. A third dispersal method involves wind. Wind disperses lightweight seeds that often have structures to catch the wind, such as those of dandelions and maple trees. Finally, some plants eject their seeds in a way that might remind you of popping popcorn. The force scatters the seeds in many directions.



◀ **Dispersal by wind:** Dandelion fruits with "parachutes"

◀ **Dispersal by water:** Floating coconut palm fruit

▲ **Dispersal by animals:** Barblike fruits

FIGURE 14
Seed Dispersal
The seeds of these plants are enclosed in fruits with adaptations that help them disperse.

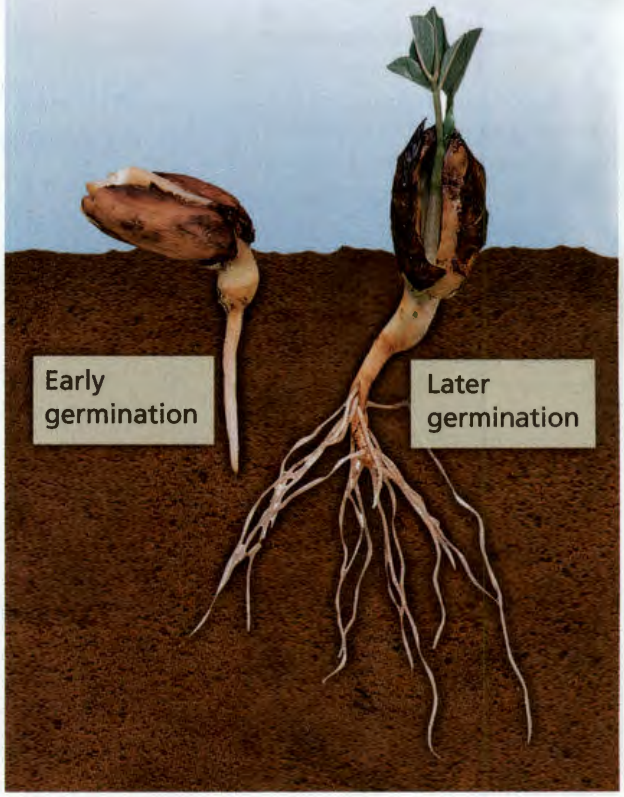
Germination After a seed is dispersed, it may remain inactive for a while before it germinates. **Germination** (jur muh NAY shun) occurs when the embryo begins to grow again and pushes out of the seed. Germination starts when the seed absorbs water from the environment. Then the embryo uses its stored food to grow. As shown in Figure 15, first the embryo's roots grow downward. Then its stem and leaves grow upward. Once you can see a plant's leaves, the plant is called a seedling.

Environmental conditions, such as temperature and moisture, must be just right in order for a seed to germinate. For example, some seeds will germinate only after a cold winter or after being exposed to a fire. If environmental conditions are not suitable for germination, some seeds may remain inactive for years.

A seed that is dispersed far from its parent plant usually has a better chance of survival. When a seed does not have to compete with its parent for light, water, and nutrients, it has a better chance of becoming a seedling.

Reading Checkpoint **What conditions are needed in order for germination to begin?**

FIGURE 15
Germination
The embryo in this peanut seed uses its stored food to germinate. First, the embryo's roots grow downward. Then, its stem and leaves begin to grow upward.



Section 3 Assessment

S 7.5.a, E-LA: Reading 7.1.0, Writing 7.2.0

Vocabulary Skill **High-Use Academic Words**
Why is the way in which a seed is dispersed important? Use the word *survival* in your answer.

Reviewing Key Concepts

1. a. **Reviewing** What two characteristics do all seed plants share?
   b. **Relating Cause and Effect** What characteristics enable seed plants to live in a wide variety of environments? Explain.
2. a. **Listing** Name the three main parts of a seed.
   b. **Sequencing** What steps must occur for a seed to grow into a new plant? List the steps in sequence.
   c. **Applying Concepts** If a cherry seed were to take root right below its parent tree, what three challenges might the cherry seedling face?

Writing in Science

Product Label Write a "packaging label" for a seed. Include a name and description for each structure of the seed. Be sure to describe the function of each structure in producing a new plant.

Section 4

Roots, Stems, and Leaves

CALIFORNIA Standards Focus

S 7.1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

S 7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

What are the main functions of roots, stems, and leaves?

Key Terms

- root cap
- cambium
- transpiration

Lab zone Standards Warm-Up

Which Plant Part Is It?

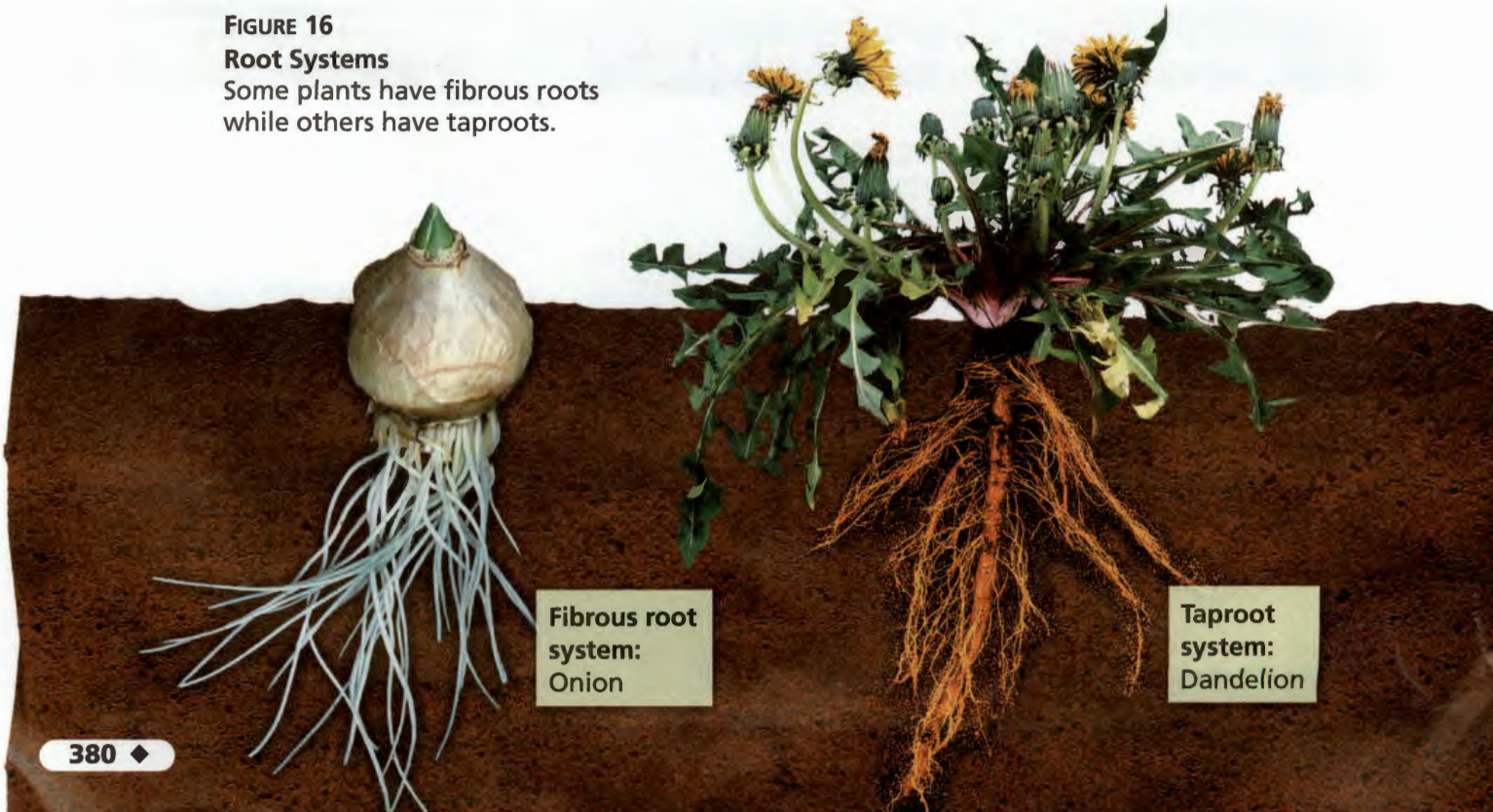
1. Carefully observe the items of food your teacher gives you.
2. Make a list of the food items.
3. For each food item, write the name of the plant part—root, stem, or leaf—from which you think it is obtained.

Think It Over

Classifying Classify the items into groups depending on the plant part from which the food is obtained. Compare your groupings with those of your classmates.

Chances are you've eaten carrots, potatoes, and lettuce. But how much do you know about these common seed plants? For example, did you know that when you eat a carrot, you are eating a root? A potato is actually a stem. And lettuce leaves have many adaptations for photosynthesis. The structure of roots, stems, and leaves varies greatly among seed plants. However, they perform similar functions critical to the plants' survival.

FIGURE 16
Root Systems
Some plants have fibrous roots while others have taproots.



Roots

Have you ever tried to pull a dandelion plant out of the soil? It's not easy, is it? That is because most roots are good anchors. Roots have three main functions. **Roots anchor a plant in the ground, absorb water and minerals from the soil, and sometimes store food.** The more root area a plant has, the more water and minerals it can absorb.

Types of Roots The two main types of root systems are fibrous root systems and taproot systems. A fibrous root system consists of many similarly sized roots that form a dense, tangled mass. Plants with fibrous roots take much soil with them when you pull them out of the ground. Lawn grass, corn, and onions have fibrous root systems. In contrast, a taproot system has one long, thick main root. Many smaller roots branch off the main root. A plant with a taproot system is hard to pull out of the ground. Carrots, dandelions, and cacti have taproots.

The Structure of a Root Figure 17 shows the structure of a typical root. Notice that the tip of the root is rounded and is covered by a structure called the root cap. The **root cap** protects the root from injury from rocks as the root grows through the soil. Behind the root cap are the unspecialized cells that differentiate into new root cells.

Root hairs grow out of the root's surface. These tiny hairs can enter the spaces between soil particles, where they absorb water and minerals. By increasing the surface area of the root that touches the soil, root hairs help the plant absorb large amounts of water and other substances.

Locate the vascular tissue in the center of the root. The water and nutrients that are absorbed from the soil quickly move into the xylem. From there, these substances are transported upward to the plant's stems and leaves.

Phloem transports food manufactured in the leaves to the root. The root tissues may then use the food for growth or store it for future use by the plant.

Reading Checkpoint **What is the function of a root cap?**

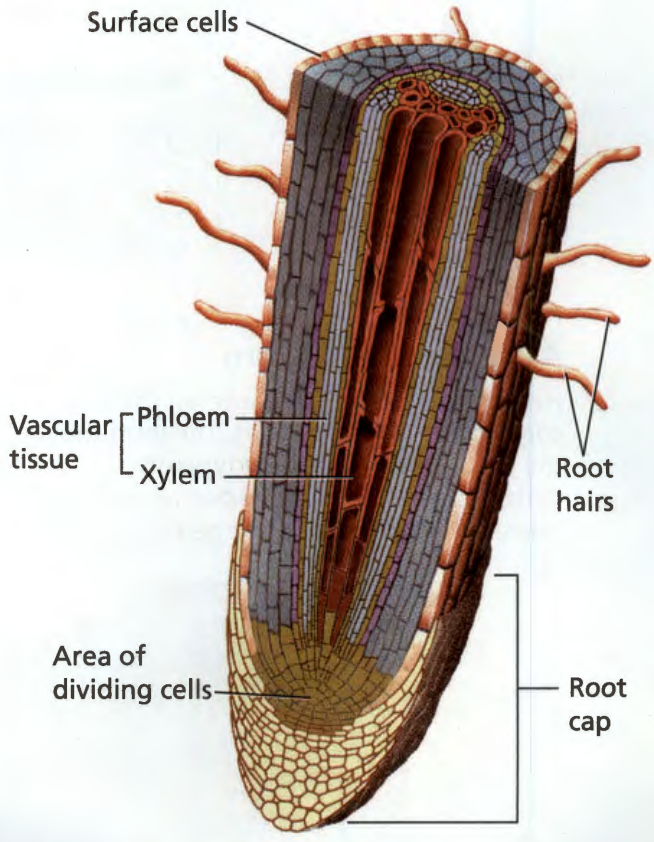
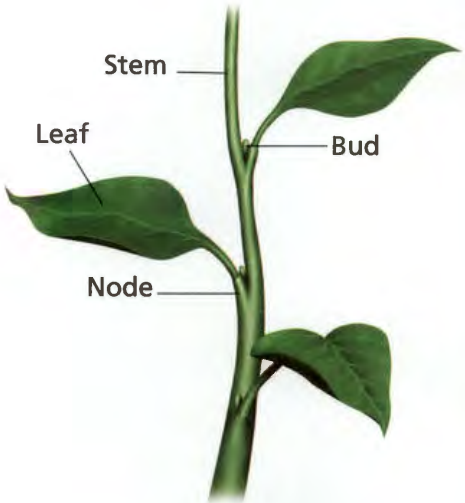


FIGURE 17
Root Structure
A root's structure is adapted for absorbing water and minerals from the soil.
Relating Cause and Effect *How do root hairs help absorb water and minerals?*

FIGURE 18
Structure of a Stem
Leafs are attached at nodes along the stem. Buds are also at the nodes. Buds can develop into new branches, leaves, or flowers.



Stems

A plant stem has several main functions. **The stem produces branches, leaves, and flowers. It carries substances between the plant's roots and leaves. The stem also provides support for the plant and holds up the leaves so they are exposed to the sun.** In addition, some stems store food. For example, a potato is a stem that is adapted to store food.

The Structure of a Stem Stems consist of vascular tissue as well as many other supporting cells. Bundles of xylem and phloem run all the way up from the roots to the leaves. Depending on the type of plant, the bundles of vascular tissue can be scattered randomly throughout the stem, or arranged in rings within the stem.

In most plants, a stem has regions called nodes where leaves are attached. Buds are found at the nodes. Buds contain tissue that can differentiate into new branches, leaves, or flowers. Figure 19 shows the structure of a typical stem. Stems can either be herbaceous (hur BAY shus) or woody.

Herbaceous Stems You are probably familiar with many plants that have herbaceous stems. Daisies, geraniums, and parsley have herbaceous stems. Herbaceous stems contain no wood and are often soft. Figure 19 shows the inner structure of a herbaceous stem with one type of vascular tissue arrangement.

FIGURE 19
A Herbaceous Stem
Herbaceous stems, like those on these coneflowers, are often soft. The inset shows the inner structure of one type of herbaceous stem. The bundles of vascular tissue in this stem are arranged in a ring.

Woody Stems As you can see in Figure 20, a woody stem contains several layers of tissue. The outermost layer is bark. Bark includes an outer protective layer and an inner layer of living phloem, which transports food through the stem. Next is a layer of cells called the **cambium** (KAM bee um), which divide to produce new phloem and xylem. It is xylem that makes up most of what you call "wood." Sapwood is active xylem that transports water and minerals through the stem. The older, darker, heartwood is inactive but provides support.

Notice the pattern of circles that looks something like a target in woody stems. These circles are called annual rings because they represent a tree's yearly growth. Annual rings are made of xylem. Xylem cells that form in the spring are large and have thin walls because they grow rapidly. They produce a wide, light brown ring. Xylem cells that form in the summer grow slowly and, therefore, are small and have thick walls. They produce a thin, dark ring. One pair of light and dark rings represents one year's growth. You can estimate a tree's age by counting its annual rings.

The width of a tree's annual rings can also provide important clues about past weather conditions, such as rainfall. In rainy years, more xylem is produced, so the tree's annual rings are wide. In dry years, rings are narrow.

Reading Checkpoint **What function does the bark of a woody stem perform?**

FIGURE 20
A Woody Stem
A typical woody stem is made up of many layers. The layers of xylem form annual rings that can reveal the age of the tree and the growing conditions it has experienced.
Interpreting Diagrams *Where is the cambium located?*

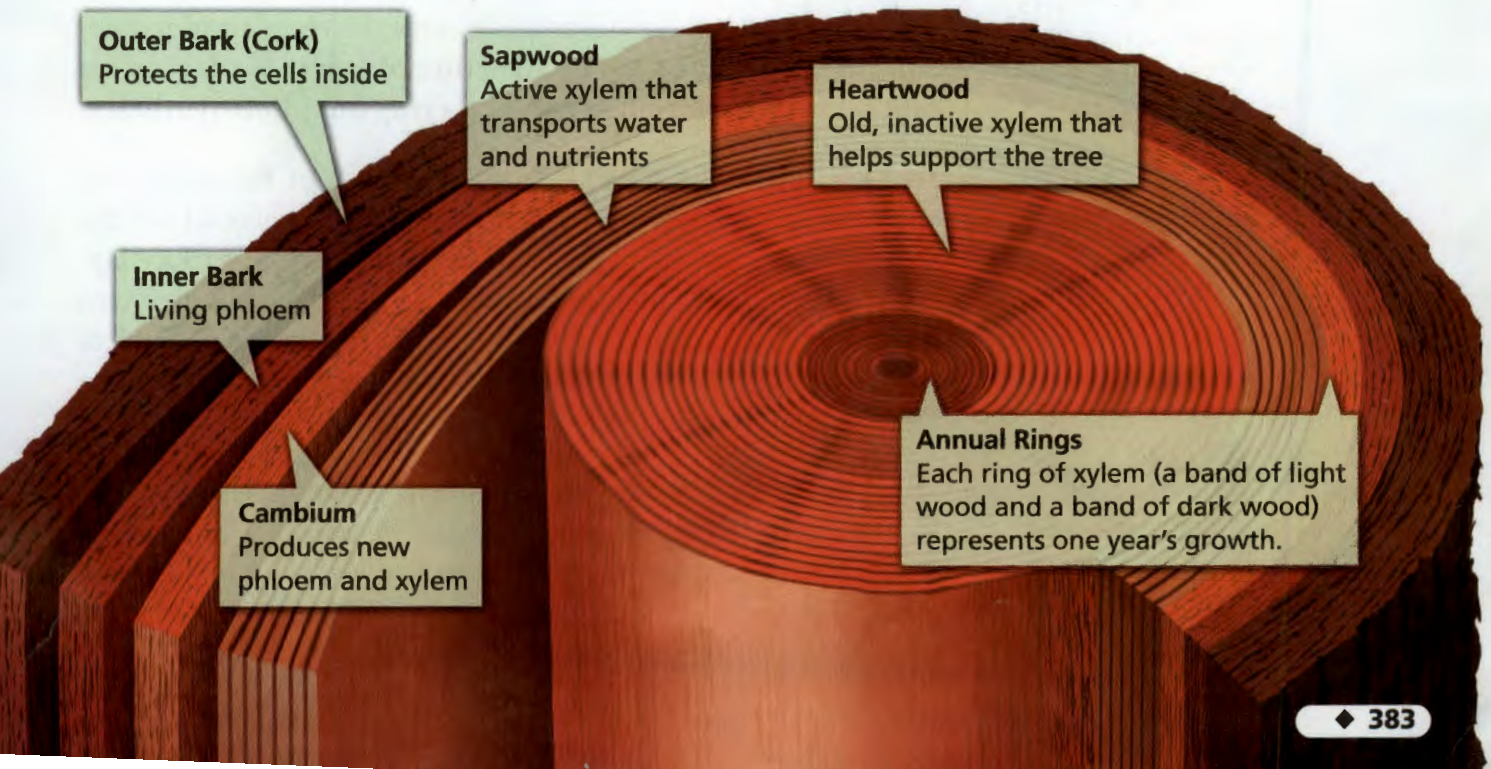
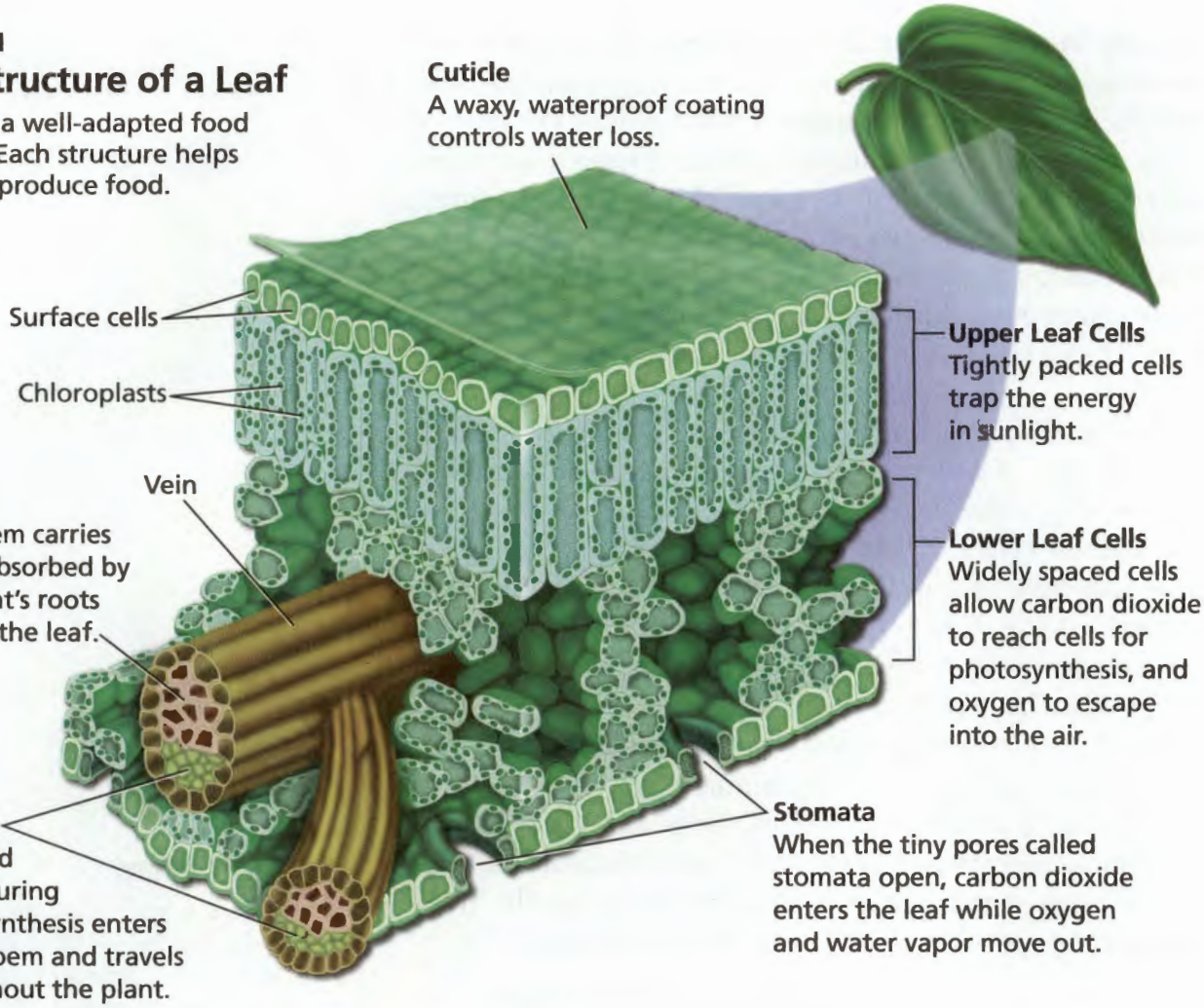


FIGURE 21

The Structure of a Leaf

A leaf is a well-adapted food factory. Each structure helps the leaf produce food.



Leaves

Leaves vary greatly in size and shape. Pine trees, for example, have needle-shaped leaves. Birch trees have flat rounded leaves with jagged edges. Whatever their shape, leaves play an important role in a plant. **The structure of leaves is adapted for capturing the sun's energy and carrying out photosynthesis.**

The Structure of a Leaf If you were to cut through a leaf and look at the edge under a microscope, you would see the structures in Figure 21. The leaf's top and bottom surface layers protect the cells inside. Between the layers of cells are veins that contain xylem and phloem. The surface layers of the leaf have stomata, the pores that open and close to control when gases enter and leave the leaf.

The Leaf and Photosynthesis The structure of a leaf is ideal for carrying out photosynthesis. The cells that contain the most chloroplasts are located near the leaf's upper surface, where they get the most light. Chlorophyll in the chloroplasts traps the sun's energy.

Carbon dioxide enters the leaf through open stomata. Water, which is absorbed by the plant's roots, travels up the stem to the leaf through the xylem. Recall that during photosynthesis, sugar and oxygen are produced from the carbon dioxide and water. Oxygen passes out of the leaf through the open stomata. The sugar enters the phloem and then travels throughout the plant. The many chemical reactions of photosynthesis can be summarized by this equation:

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{light energy}} \text{sugar} + \text{oxygen}$$

Controlling Water Loss Because such a large area of a leaf is exposed to the air, water can quickly evaporate, or be lost, from a leaf into the air. The process by which water evaporates from leaves is called **transpiration** (tran spuh RAY shun).

A plant can lose a lot of water through transpiration. A corn plant, for example, can lose almost 4 liters of water on a hot summer day. Without a way to slow down the process of transpiration, a plant would shrivel up and die.

Fortunately, plants have ways to slow down transpiration. One way that plants retain water is by closing the stomata. The stomata often close when leaves start to dry out. Figure 22 shows open and closed stomata.

Reading Checkpoint **How does water get into a leaf?**

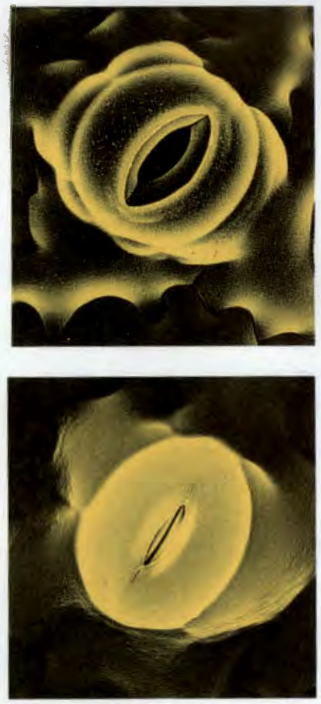


FIGURE 22
Stomata
Stomata open (top) and close (bottom) to control when gases enter and exit the leaf.
Relating Cause and Effect *What gases enter and exit when the stomata open?*

Section 4 Assessment

S 7.1.d, 7.5.a E-LA: Reading 7.1.0

Vocabulary Skill **High-Use Academic Words**
How does food get from a plant's leaves to its roots? Use the word *transport* in your answer.

Reviewing Key Concepts

1. a. **Listing** Name three main functions of roots.
   b. **Explaining** How do root hairs aid in the function of roots?
   c. **Inferring** Weeds have taken over your garden. While removing the weeds, you notice that the roots grow very deep. How do you think the weeds' roots contribute to their success in your garden?
2. a. **Identifying** What roles do stems play?
   b. **Sequencing** List in order the layers of tissue within a woody stem, moving from the center of the stem to the outermost layer.
3. a. **Reviewing** What food-making process are leaves adapted to carry out?
   b. **Relating Cause and Effect** How are stomata adapted to carry out this process?
   c. **Predicting** Water lilies live in fresh water, with leaves that float on the water's surface. Where would you expect to find the stomata on the leaves of water lilies?

Lab zone At-Home Activity

Plant Walk With a family member, go on a plant walk in your neighborhood. Look for different kinds of seed plants. Describe the adaptations in their roots, stems, and leaves that enable the plants to survive.

Eye on Photosynthesis

S 7.1.d, 7.7.c

Problem

What raw materials and conditions are involved in photosynthesis?

Skills Focus

observing, controlling variables, designing experiments

Materials

- *Elodea* plants
- water (boiled, then cooled)
- wide-mouthed container
- sodium bicarbonate solution
- 2 test tubes
- wax pencil
- lamp (optional)

Procedure

PART 1 Observing Photosynthesis

1. Use a wax pencil to label two test tubes *1* and *2*. Fill test tube 1 with sodium bicarbonate solution. Sodium bicarbonate provides a source of carbon dioxide for photosynthesis.
2. Fill the wide-mouthed container about three-fourths full of sodium bicarbonate solution.
3. Hold your thumb over the mouth of test tube 1. Turn the test tube over, and lower it to the bottom of the container. Do not let in any air. If necessary, repeat this step so that test tube 1 contains no air pockets. **CAUTION:** *Glass test tubes are fragile. Handle the test tubes carefully. Do not touch broken glass.*
4. Fill test tube 2 with sodium bicarbonate solution. Place an *Elodea* plant in the tube with the cut stem at the bottom. Put your thumb over the mouth of the test tube, and lower it into the container without letting in any air. Wash your hands.
5. Place the container with the two test tubes in bright light. After a few minutes, examine both test tubes for bubbles.
6. If bubbles form in test tube 2, observe the *Elodea* stem to see if it is producing the bubbles. The bubbles are oxygen bubbles. The production of oxygen signals that photosynthesis is taking place.
7. Leave the setup in bright light for 30 minutes. Observe what happens to any bubbles that form. Record your observations.

PART 2 Is Carbon Dioxide Needed for Photosynthesis?

8. Your teacher will provide a supply of water that has been boiled and then cooled. Boiling removes gases that are dissolved in the water, including carbon dioxide.
9. Based on what you learned in Part 1, design an experiment to show whether or not carbon dioxide is needed for photosynthesis. Obtain your teacher's approval before carrying out your experiment. Record all your observations.

PART 3 What Other Conditions Are Needed for Photosynthesis?

10. Make a list of other conditions that may affect photosynthesis. For example, think about factors such as light, the size of the plant, and the number of leaves.
11. Choose one factor from your list. Then design an experiment to show how the factor affects photosynthesis. Obtain your teacher's approval before carrying out your experiment. Record all your observations.

Analyze and Conclude

1. **Observing** What process produced the bubbles you observed in Part 1? In what cell organelle did this process occur?
2. **Controlling Variables** In Part 1, what was the purpose of test tube 1?
3. **Designing Experiments** For the experiments you carried out in Parts 2 and 3, identify the manipulated variable and the responding variable. Explain whether or not your experiments were controlled experiments.
4. **Drawing Conclusions** Based on your results in Part 2, is carbon dioxide necessary for photosynthesis?
5. **Posing Questions** What question about photosynthesis did you explore in Part 3? What did you learn?
6. **Communicating** In a paragraph, summarize what you learned about photosynthesis from this investigation. Support your conclusions with data you collected during your experiments.

More to Explore

A small animal in a closed container will die, even if it has enough water and food. A small animal in a closed container with a plant, water, and food might live. Use what you have learned from this experiment to explain these facts.

Section 5

Reproduction in Seed Plants

CALIFORNIA Standards Focus

S 7.2.a Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.

S 7.5.f Students know the structures and processes by which flowering plants generate pollen, ovules, seeds, and fruit.

- What are the characteristics of gymnosperms and how do they reproduce?
- What are the characteristics of angiosperms?
- How do angiosperms reproduce?
- What are the two types of angiosperms?

Key Terms

- gymnosperm
- cone
- ovule
- pollination
- angiosperm
- flower
- sepal
- petal
- stamen
- pistil
- ovary
- fruit
- monocot
- dicot

Go Online NSTA SciLINKS

For: Links on gymnosperms
Visit: www.SciLinks.org
Web Code: scn-0152

Lab zone Standards Warm-Up

What Is a Fruit?

1. Your teacher will give you three different fruits that have been cut in half.
2. Use a hand lens to carefully observe the outside of each fruit. For each fruit, record its color, shape, size, and other external features. Record your observations in your notebook.
3. Carefully observe the structures inside the fruit. Record your observations.

Think It Over

Forming Operational Definitions Based on your observations, how would you define the term *fruit?*

Here's a question for you: What do pine cones and apples have in common? The answer is that they are both the parts of seed plants. Pine trees and apple trees are both seed plants. However, they belong to two different groups of seed plants—gymnosperms and angiosperms.

Gymnosperms

Pine trees belong to the group of seed plants known as gymnosperms. A **gymnosperm** (JIM nuh spurm) is a seed plant that produces naked seeds. The seeds of gymnosperms are referred to as "naked" because they are not enclosed by a protective fruit.

All gymnosperms produce naked seeds. In addition, many gymnosperms have needle-like or scalelike leaves, and deep-growing root systems. Gymnosperms are the oldest type of seed plant. According to fossil evidence, gymnosperms first appeared on Earth about 360 million years ago. Fossils also indicate that there were many more species of gymnosperms on Earth in the past than there are today. Four groups of gymnosperms exist today.

FIGURE 23

Types of Gymnosperms

Gymnosperms are the oldest seed plants. Cycads, conifers, ginkgoes, and gnetophytes are the only groups that exist today.

Gnetophyte: ▲
Welwitschia

Ginkgo: ▲
Ginkgo biloba

Cycad: ▲
Sago palm

Conifer: ▶
Giant sequoia

Cycads About 175 million years ago, the majority of plants were cycads. Today, cycads (SY kadz) grow mainly in tropical and subtropical areas. Cycads look like palm trees with cones. A cycad cone can grow as large as a football.

Conifers Conifers (KAHN uh furz), or cone-bearing plants, are the largest and most diverse group of gymnosperms today. Most conifers, such as pines, sequoias, and junipers, are evergreens—plants that keep their leaves, or needles, year-round. When needles drop off, they are replaced by new ones.

Ginkgoes Ginkgoes (GING kohz) also grew hundreds of millions of years ago. But today, only one species of ginkgo, *Ginkgo biloba*, exists. It probably survived only because the Chinese and Japanese cared for it in their gardens. Today, ginkgo trees are planted along city streets because they can tolerate air pollution.

Gnetophytes Gnetophytes (NEE tuh fyts) live in hot deserts and in tropical rain forests. Some gnetophytes are trees, some are shrubs, and others are vines. The *Welwitschia* shown in Figure 23 grows in the deserts of West Africa and can live for more than 1,000 years.

Reading Checkpoint **What are the four types of gymnosperms?**

Lab zone Try This Activity

The Scoop on Cones

In this activity, you will observe the structure of a female cone.

1. Use a hand lens to look closely at the female cone. Gently shake the cone over a piece of white paper. Observe what happens.
2. Break off one scale from the cone. Examine its base. If the scale contains a seed, remove the seed.
3. With a hand lens, examine the seed from Step 2 or examine a seed that fell on the paper in Step 1.
4. Wash your hands.

Inferring How does the structure of the cone protect the seeds?

Gymnosperm Life Cycle

Most gymnosperms have reproductive structures called **cones.** Cones are covered with scales. Most gymnosperms produce two types of cones: male cones and female cones. Usually, a single plant produces both male and female cones. In some types of gymnosperms, however, individual trees produce either male cones or female cones. A few types of gymnosperms produce no cones at all.

In Figure 24, you can see the male and female cones of a Ponderosa pine. Male cones produce tiny grains of pollen—the male gametophyte. Pollen contains the cells that will later become sperm cells. Each scale on a male cone produces thousands of pollen grains.

The female gametophyte develops in structures called ovules. An **ovule** (OH vyool) is a structure that contains an ovum, or egg cell. Female cones contain at least one ovule at the base of each scale. After fertilization occurs, the ovule develops into a seed.

You can follow the process of gymnosperm reproduction in Figure 24. **First, pollen falls from a male cone onto a female cone. In time, a sperm cell and an egg cell join together in an ovule on the female cone.** After fertilization occurs, the seed develops on the scale of the female cone.

Pollination The transfer of pollen from a male reproductive structure to a female reproductive structure is called **pollination.** In gymnosperms, wind often carries the pollen from the male cones to the female cones. The pollen collects in a sticky substance produced by each ovule.

Fertilization Once pollination has occurred, the ovule closes and seals in the pollen. The scales also close, and a sperm cell fertilizes an egg cell inside each ovule. The fertilized egg then develops into the embryo part of the seed.

Seed Development Female cones remain on the tree while the seeds mature. As the seeds develop, the female cone increases in size. It can take up to two years for the seeds of some gymnosperms to mature. Male cones, however, usually fall off the tree after they have shed their pollen.

Seed Dispersal When the seeds are mature, the scales open. The wind shakes the seeds out of the cone and carries them away. Only a few seeds will land in suitable places and grow into new plants.

Reading Checkpoint **What structure produces pollen?**

FIGURE 24

The Life Cycle of a Gymnosperm

Ponderosa pines have a typical life cycle for a gymnosperm. Follow the steps of pollination, fertilization, seed development, and dispersal in the pine tree.

Interpreting Diagrams *Where do the pine seeds develop?*

FIGURE 25 Rafflesia
Rafflesia plants grow in the jungles of Southeast Asia. The giant flowers measure about 1 meter across and weigh about 7 kilograms!
Classifying *What kind of seeds do Rafflesia plants produce—uncovered seeds or seeds enclosed in fruits?*

Angiosperms

You probably associate the word *flower* with a sweet-smelling plant growing in a garden. You certainly wouldn't think of something that smells like rotting meat. But that's exactly what the corpse flower, or rafflesia, smells like.

Rafflesia belongs to the group of seed plants known as angiosperms. An **angiosperm** (AN jee uh spurm) is a flowering plant. **All angiosperms share two important traits. First, they produce flowers. Second, in contrast to gymnosperms, which produce uncovered seeds, angiosperms produce seeds that are enclosed in fruits.**

Angiosperms live almost everywhere on Earth. They grow in frozen areas in the Arctic, tropical jungles, barren deserts, and at the ocean's edge.

Reading Checkpoint **Where do angiosperms live?**

The Structure of Flowers

Flowers come in all sorts of shapes, sizes, and colors. But, despite their differences, all flowers have the same function—reproduction. A **flower** is the reproductive structure of an angiosperm. Figure 26 shows the parts of a typical flower. As you read about the parts, keep in mind that some flowers lack one or more of the parts. For example, some flowers have male structures, but no female reproductive structures. Other flowers lack petals.

Sepals and Petals When a flower is still a bud, it is enclosed by leaflike structures called **sepals** (SEE pulz). Sepals protect the developing flower and are often green in color. When the sepals fold back, they reveal the flower's colorful, leaflike **petals.** The petals are generally the most colorful parts of a flower. The shape, size, and number of petals vary greatly from flower to flower.

Stamens Within the petals are the flower's male and female reproductive structures. The **stamens** (STAY munz) are the male reproductive structures. Locate the stamens inside the flower in Figure 26. The thin stalk of the stamen is called the filament. Pollen is produced in the anther, at the top of the filament. The filament connects the anther to the base of the flower, which is called the receptacle.

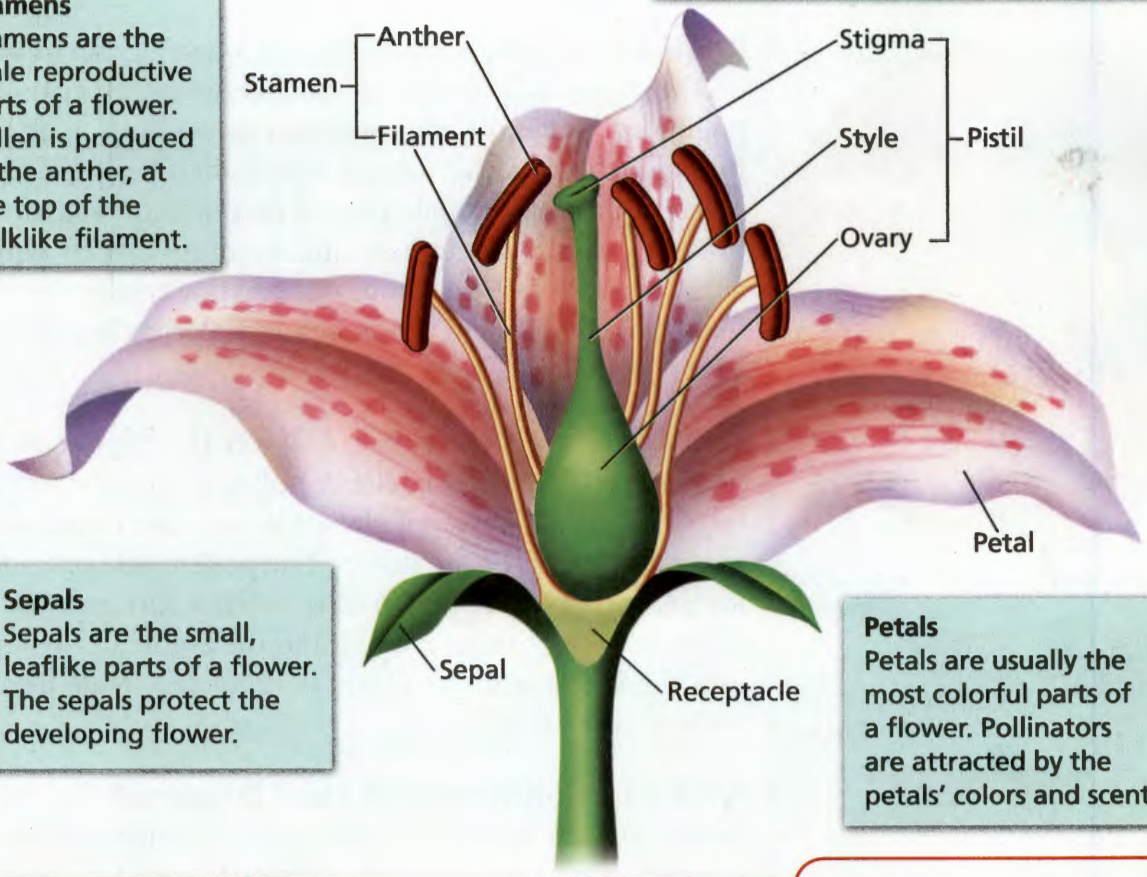
FIGURE 26

The Structure of a Flower

Like most flowers, this lily contains both male and female reproductive structures.

Pistils
Pistils are the female reproductive parts of a flower. A pistil consists of a sticky stigma, a slender tube called the style, and a hollow structure, called the ovary, at the base.

Stamens
Stamens are the male reproductive parts of a flower. Pollen is produced in the anther, at the top of the stalklike filament.



Sepals
Sepals are the small, leaflike parts of a flower. The sepals protect the developing flower.

Petals
Petals are usually the most colorful parts of a flower. Pollinators are attracted by the petals' colors and scent.

Pistils The female parts, or **pistils** (PIS tulz), are found in the center of most flowers. Some flowers have two or more pistils; others have only one. The sticky tip of the pistil is called the stigma. A slender tube, called a style, connects the stigma to a hollow structure at the base of the flower. This hollow structure is the **ovary**, which protects the seeds as they develop. An ovary contains one or more ovules.

Pollinators The colors and shapes of most petals and the scents produced by most flowers attract insects and other animals. These organisms carry pollen from one flower to another. Pollinators include birds, bats, and insects such as bees and flies. The rafflesia flower you read about at the beginning of the section is pollinated by flies. The flies are attracted by the strong, rotting-meat smell.

Go Online
active art
For: The Structure of a Flower activity
Visit: PHSchool.com
Web Code: cep-1053

Reading Checkpoint **What are the male and female parts of a flower?**

FIGURE 27
A Bee as a Pollinator
This bee is getting dusted with yellow pollen as it drinks nectar from the flower. **Observing** *On which of the bee's structures can you observe pollen grains?*

Angiosperm Life Cycle

You can follow the life cycle of an angiosperm in Figure 29. **First, pollen falls on a flower's stigma. In time, the sperm cell and egg cell join together in the flower's ovule. The zygote develops into the embryo part of the seed.**

Pollination A flower is pollinated when a grain of pollen falls on the stigma. Like gymnosperms, some angiosperms are wind-pollinated. But most angiosperms rely on birds, bats, or insects for pollination. Nectar, a sugar-rich food, is located deep inside a flower. When an animal enters a flower to obtain the nectar, it brushes against the anthers and becomes coated with pollen. Some of the pollen can drop onto the flower's stigma as the animal leaves the flower. The pollen can also be brushed onto the stigma of the next flower the animal visits.

Fertilization If the pollen falls on the stigma of a similar plant, fertilization can occur. A pollen grain produces a pollen tube that grows through the style into the ovule, within the ovary at the base of the flower. The pollen tube provides a path for the sperm of the pollen tube down to the egg cell. A sperm cell then joins with an egg cell, and the zygote begins to develop into the seed's embryo. Other parts of the ovule develop into the rest of the seed.

Fruit Development and Seed Dispersal As the seed develops after fertilization, the ovary changes into a **fruit**—a ripened ovary and other structures that enclose one or more seeds. Apples and cherries are fruits. So are many foods you usually call vegetables, such as tomatoes and squash. Fruits are the means by which angiosperm seeds are dispersed. Animals that eat fruits help to disperse their seeds.

Reading Checkpoint **What flower part develops into a fruit?**

FIGURE 28
Fruits
The seeds of angiosperms are enclosed in fruits, which protect and help disperse the seeds.

FIGURE 29

The Life Cycle of an Angiosperm

All angiosperms have a similar life cycle. Follow the steps of pollination, fertilization, seed development, and dispersal in this apple tree.

Interpreting Diagrams *What plant part does the ovule develop into?*

1 An apple tree produces flowers.

2 A The cells in the anther produce pollen grains.

Anther

Ovary

Ovule

2 B Inside the ovary, an egg cell is produced in each ovule.

3 Pollen grains are trapped on the stigma.

Pollen tube

Sperm cells

4 The pollen grain produces a pollen tube that grows into the ovule. A sperm cell moves through the pollen tube and fertilizes the egg cell.

Embryo

5 The ovule develops into a seed. The fertilized egg becomes the seed's embryo. Other parts of the ovule develop into the seed coat and the seed's stored food.

6 The ovary and other structures develop into a fruit that encloses the seeds. The fruit helps in seed dispersal.

7 A seed grows into a new plant.

FIGURE 30
Monocots and Dicots Monocots and dicots differ in the number of cotyledons, the pattern of veins and vascular tissue, and the number of petals.
Interpreting Tables *How do monocot and dicot leaves differ?*

Comparing Monocots and Dicots

Plant Part	Monocots	Dicots
Seed	 One cotyledon	 Two cotyledons
Leaf	 Parallel veins	 Branching veins
Stem	 Bundles of vascular tissue scattered throughout stem	 Bundles of vascular tissue arranged in a ring
Flower	 Flower parts in threes	 Flower parts in fours or fives

Math Skills

Multiples

Is a flower with 6 petals a monocot? To answer this question, you need to determine if 6 is a multiple of 3. A number is a multiple of 3 if there is a nonzero whole number that, when multiplied by 3, gives you that number.

In this case, 6 is a multiple of 3 because you can multiply 2 (a nonzero whole number) by 3 to get 6.

$$2 \times 3 = 6$$

Therefore, a flower with 6 petals is a monocot. Other multiples of 3 include 9 and 12.

Practice Problem Which of these numbers are multiples of 4?

6, 10, 12, 16

Types of Angiosperms

Angiosperms are divided into two major groups: monocots and dicots. "Cot" is short for *cotyledon*. Recall that in some seeds, the cotyledon, or seed leaf, provides food for the embryo. *Mono* means "one" and *di* means "two." **Monocots** are angiosperms that have only one seed leaf. **Dicots,** on the other hand, produce seeds with two seed leaves. In Figure 30, you can compare the characteristics of monocots and dicots.

Monocots Grasses, including corn, wheat, and rice, and plants such as lilies and tulips are monocots. The flowers of a monocot usually have either three petals or a multiple of three petals. Monocots usually have long, slender leaves with veins that run parallel to one another like train rails. The bundles of vascular tissue in monocot stems are usually scattered randomly throughout the stem.

Dicots Dicots include plants such as roses and violets, as well as dandelions. Both oak and maple trees are dicots, as are food plants such as beans and apples. The flowers of dicots often have either four or five petals or multiples of these numbers. The leaves are usually wide, with veins that branch many times. Dicot stems usually have bundles of vascular tissue arranged in a ring.

Reading Checkpoint **How do the petals of monocots and dicots differ in number?**

Seed Plants in Everyday Life

Products from seed plants are all around you. Gymnosperms, especially conifers, provide useful products such as paper and the lumber used to build homes. Conifers are also used to produce turpentine, the rayon fibers in clothes, and the rosin used by baseball pitchers, gymnasts, and musicians.

Angiosperms are an important source of food, clothing, and medicine for other organisms. Plant-eating animals eat various parts of flowering plants, including stems, leaves, buds, and flowers. People eat vegetables, fruits, and cereals, all of which are angiosperms. People also make clothing and many other products from angiosperms. For example, cotton fibers come from cotton plants. The sap of rubber trees is used to make rubber for tires and other products. The wood of maple, cherry, and oak trees is often used to make furniture.

Reading Checkpoint **What are two products made from gymnosperms?**

FIGURE 31
Cotton Bolls
Angiosperms, such as cotton plants, provide many important products. Cotton seeds, which develop in fruits called bolls, are covered with fibers that are manufactured into cotton fabric.

Section 5 Assessment

S 7.2.a, 7.5.f
E-LA: Reading 7.2.0

Target Reading Skill **Sequencing Events** Use your sequence diagram to help answer Question 1.

Reviewing Key Concepts

1. a. **Listing** What characteristics do all gymnosperms share? What other characteristics do many gymnosperms have?
   b. **Describing** What is a cone? What role do cones play in gymnosperm reproduction?
   c. **Sequencing** Briefly describe the steps in the reproduction of a gymnosperm.
2. a. **Reviewing** What two characteristics do all angiosperms share?
   b. **Identifying** What is the function of an angiosperm's flowers?
3. a. **Reviewing** On what part of a flower must pollen land for pollination to occur?
   b. **Sequencing** Briefly describe the steps in the reproduction of an angiosperm, from pollination to seed dispersal.
4. a. **Listing** Name the two major groups of angiosperms.
   b. **Comparing and Contrasting** How do the seeds, leaves, stems, and flowers of these two groups differ?
   c. **Classifying** A plant's leaves have parallel veins, and each of its flowers has six petals. To which group does it belong? Explain.

Math Practice

5. **Multiples** Which of the following numbers are multiples of 3? Which of the numbers are multiples of 4?

   5, 6, 8, 10, 12, 15

6. **Multiples** Suppose you found a flower with 12 petals. Would you know from the number of petals whether the flower is a monocot or a dicot? Explain.

Lab zone **Skills Lab**

A Close Look at Flowers

S 7.5.f, 7.7.a

Problem

What is the function of a flower, and what roles do its different parts play?

Skills Focus

observing, inferring, measuring

Materials

- paper towels
- plastic dropper
- hand lens
- microscope
- slide
- large flower
- coverslip
- scalpel
- tape
- water
- metric ruler
- lens paper

Procedure

PART 1 The Outer Parts of the Flower

1. Tape four paper towel sheets on your work area. Obtain a flower from your teacher. While handling the flower gently, observe its shape and color. Use the ruler to measure it. Notice whether the petals have any spots or other markings. Does the flower have a scent? Record your observations with sketches and descriptions.
2. Observe the sepals. How many are there? How do they relate to the rest of the flower? (*Hint:* The sepals are often green, but not always.) Record your observations.
3. Use a scalpel to carefully cut off the sepals without damaging the structures beneath them. **CAUTION:** *Scalpels are sharp. Cut in a direction away from yourself and others.*
4. Observe the petals. How many are there? Are all the petals the same, or are they different? Record your observations.

PART 2 The Male Part of the Flower

5. Carefully pull off the petals to examine the male part of the flower. Try not to damage the structures beneath the petals.
6. Observe the stamens. How many are there? How are they shaped? How tall are they? Record your observations.
7. Use a scalpel to carefully cut the stamens away from the rest of the flower without damaging the structures beneath them. Lay the stamens on the paper towel.
8. Obtain a clean slide and coverslip. Hold a stamen over the slide, and gently tap some pollen grains from the anther onto the slide. Add a drop of water to the pollen. Then place the coverslip over the water and pollen.
9. Observe the pollen under both the low-power objective and the high-power objective of a microscope. Draw and label a pollen grain.

PART 3 The Female Part of the Flower

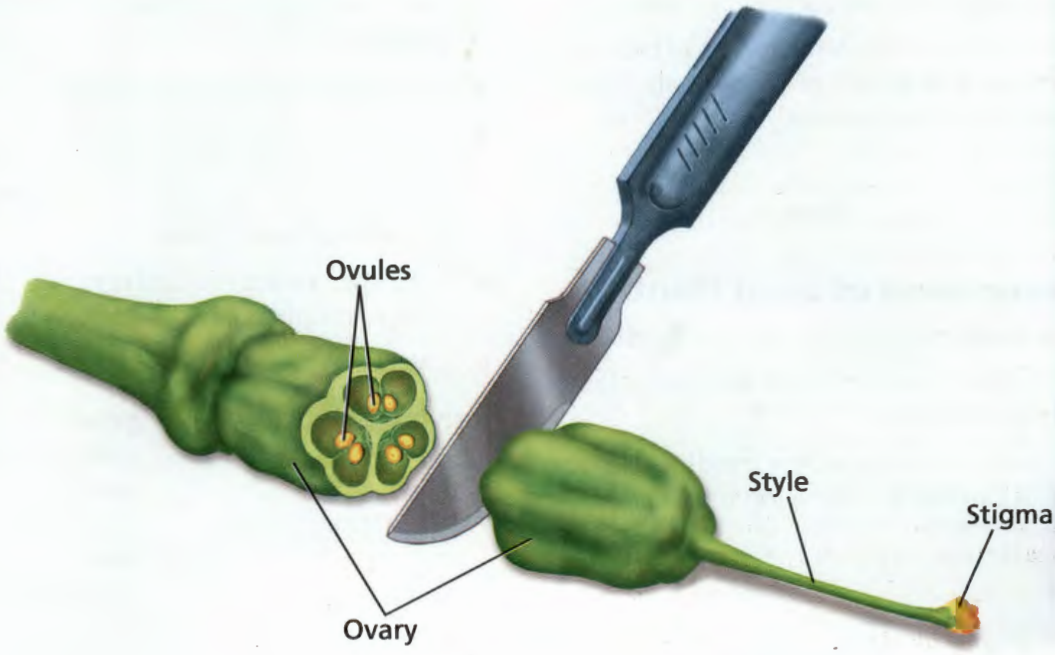
10. Use a scalpel to cut the pistil away from the rest of the flower. Measure the height of the pistil. Examine its shape. Observe the top of the pistil. Determine if that surface will stick to and lift a tiny piece of lens paper. Record your observations.
11. Lay the pistil on the paper towel. Holding it firmly at its base, use a scalpel to cut the pistil in half at its widest point, as shown in the diagram below. **CAUTION:** *Cut away from your fingers.* How many compartments do you see? How many ovules do you see? Record your observations.

Analyze and Conclude

1. **Observing** Based on your observations, describe how the sepals, petals, stamens, and pistils of a flower are arranged.
2. **Inferring** How are the sepals, petals, stamens, and pistil involved in the function of this flower?
3. **Measuring** Based on your measurements of the heights of the pistil and stamens, how do you think the flower you examined is pollinated? Use additional observations to support your answer.
4. **Classifying** Did you find any patterns in the number of sepals, petals, stamens, or other structures in your flower? If so, describe that pattern. Is your flower a monocot or a dicot?
5. **Communicating** Write a paragraph explaining all you can learn about a plant by examining one of its flowers. Use your observations in this lab to support your conclusions.

More to Explore

Some kinds of flowers do not have all the parts found in the flower in this lab. Obtain a different flower. Find out which parts that flower has, and which parts, if any, are missing. *Obtain your teacher's permission before carrying out your investigation.*



Chapter 10 Study Guide

The BIG Idea The structure of plants enables them to obtain water and nutrients, make food, grow, develop, and reproduce.

1 The Plant Kingdom

Key Concepts S 7.5.a

- Nearly all plants are autotrophs. All plants are multicellular eukaryotes with cell walls.
- Land plants must have ways to obtain water and other nutrients from their surroundings, retain water, transport materials in their bodies, support their bodies, and reproduce.
- Scientists informally group plants as nonvascular plants and vascular plants.
- Plants have complex life cycles that include the sporophyte stage and the gametophyte stage.

Key Terms

cuticle
vascular tissue
zygote
nonvascular plant
vascular plant
sporophyte
gametophyte

2 Plants Without Seeds

Key Concepts S 7.5.a

- Mosses, liverworts, and hornworts are low-growing plants that live in moist areas where they can absorb water and other nutrients.
- Ferns, horsetails, and club mosses have true vascular tissue and do not produce seeds. They reproduce by releasing spores.

Key Terms

rhizoid
frond

3 Characteristics of Seed Plants

Key Concepts S 7.5.a

- Seed plants have vascular tissue and use pollen and seeds to reproduce.
- If a seed lands in an area where conditions are favorable, it can begin to develop into a plant.

Key Terms

phloem
xylem
pollen
seed
embryo
cotyledon
germination

4 Roots, Stems, and Leaves

Key Concepts S 7.1.d, 7.5.a

- Roots anchor a plant, absorb water and minerals, and sometimes store food.
- The stem carries substances between the plant's roots and leaves. The stem also provides support for the plant and holds up the leaves so they are exposed to the sun.
- A leaf's structure is adapted for capturing the sun's energy and carrying out photosynthesis.

Key Terms

root cap
cambium
transpiration

5 Reproduction in Seed Plants

Key Concepts S 7.2.a, 7.5.f

- All gymnosperms produce naked seeds. In addition, many gymnosperms have needle-like or scalelike leaves, and deep-growing roots.
- During gymnosperm reproduction, pollen falls from a male cone onto a female cone. In time, sperm and egg cells join in an ovule on the female cone.
- All angiosperms produce flowers and fruits.
- All flowers function in reproduction. During angiosperm reproduction, pollen falls on a flower's stigma. In time, sperm and egg cells join in the flower's ovule.
- Angiosperms are divided into two major groups: monocots and dicots.

Key Terms

gymnosperm
cone
ovule
pollination
angiosperm
flower
sepal
petal
stamen
pistil
ovary
fruit
monocot
dicot

Review and Assessment

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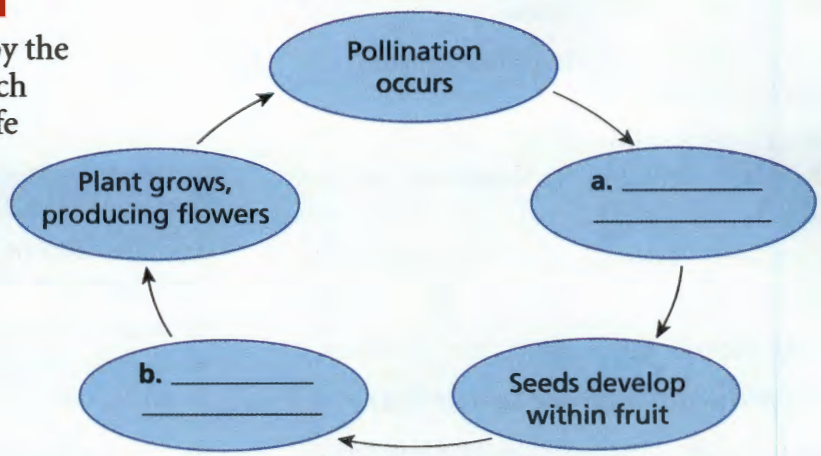
Target Reading Skill

To review part of Section 5, copy the sequence diagram at right, which shows the main events in the life cycle of angiosperms.

Angiosperm Life Cycle



Reviewing Key Terms

Choose the letter of the best answer.

1. The waxy, waterproof layer that covers leaves is called the
   a. zygote.
   b. cuticle.
   c. frond.
   d. cambium.
2. You see a fuzzy, green moss growing at the base of a tree. To which generation does this familiar leaf-like structure belong?
   a. frond
   b. rhizoid
   c. gametophyte
   d. sporophyte
3. The leaves of ferns are called
   a. rhizoids.
   b. sporophytes.
   c. fronds.
   d. cuticles.
4. The process by which a seed sprouts is called
   a. pollination.
   b. fertilization.
   c. dispersal.
   d. germination.
5. Which of the following is the male part of a flower?
   a. pistil **b.** ovule
   c. stamen **d.** petal

Complete the following sentences so that your answers clearly explain the key terms.

6. Water from the soil can reach the highest branches of a tall tree because the tree has **vascular tissue,** which is _____ .
7. The rootlike **rhizoids** of a moss plant are structures that serve to _____ .
8. On a hot day, a plant can dry out due to **transpiration,** the process by which _____ .
9. After fertilization, an ovule develops into a **seed,** which is _____ .
10. For fertilization to occur, pollen must reach the **pistil,** which is _____ .

Writing in Science

Firsthand Account Write a story from the viewpoint of a seedling. Describe how you were dispersed as a seed and how you grew into a seedling.

Video Assessment
Discovery Channel School
Seed Plants

Review and Assessment

Checking Concepts

11. What are three plant organs?
12. Name one adaptation that distinguishes plants from algae.
13. In what ways do mosses and club mosses differ from each other? In what ways are they similar?
14. Describe four different ways that seeds can be dispersed.
15. Explain the role that stomata play in leaves.
16. Describe the structure of a female cone.
17. What role does a fruit play in an angiosperm's life cycle?

Thinking Critically

18. **Comparing and Contrasting** How does the sporophyte generation of a plant differ from the gametophyte generation?
19. **Applying Concepts** A friend tells you that he has seen moss plants that are about 2 meters tall. Is your friend correct? Explain.
20. **Relating Cause and Effect** When a strip of bark is removed all the way around the trunk of a tree, the tree dies. Explain why.
21. **Predicting** Pesticides are designed to kill harmful insects. Sometimes, however, pesticides kill helpful insects as well. What effect could this have on angiosperms?
22. **Classifying** Which of the plants below is a monocot? Which is a dicot? Explain your conclusions.

Math Practice

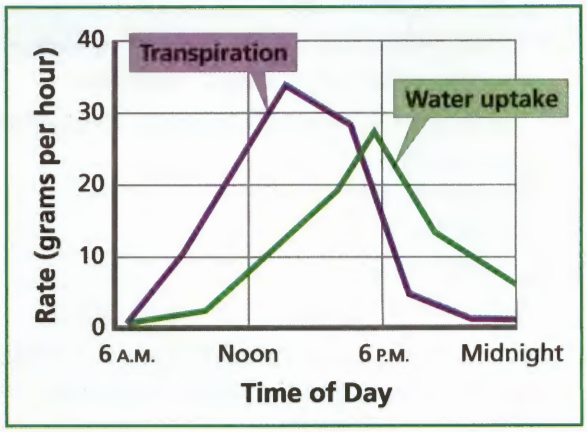
23. **Multiples** Use what you know about multiples to determine which flower is a monocot and which is a dicot: a flower with nine petals; a flower with eight petals. Explain.

Applying Skills

Use the data in the graph below to answer Questions 24–26.

A scientist measured transpiration in an ash tree over an 18-hour period. She also measured how much water the tree's roots took up in the same period.

Transpiration and Water Uptake



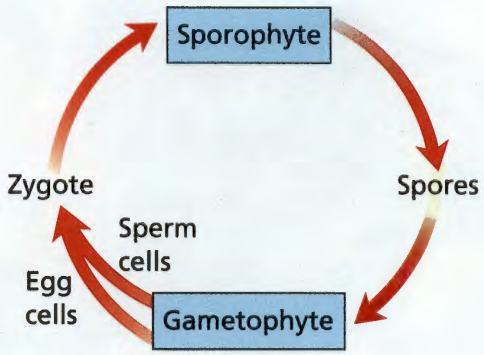
24. **Interpreting Data** At what time is the rate of transpiration highest? At what time is the rate of water uptake highest?
25. **Inferring** Why do you think the transpiration rate increases and decreases as it does during the 18-hour period?
26. **Drawing Conclusions** Based on the graph, what is one conclusion you can reach about the pattern of water loss and gain in the ash tree?

Lab zone Standards Investigation

Performance Assessment Design a poster that shows the results of your investigation. You may wish to use a cycle diagram to show the main events in the plant's life. What new information did you learn about seed plants by doing this investigation?

Choose the letter of the best answer.

1. Based on the diagram below, which of the following statements about a plant's life cycle is true?



- **A** Plants spend part of their lives producing spores.
- **B** Plants spend part of their lives producing sperm and egg cells.
- **C** A zygote develops into the spore-producing stage of the plant.
- **D** all of the above

S 7.2.a

2. You examine plant cells under a microscope and notice many green round bodies within the cells. The green structures are most likely involved in

- **A** directing the cell's functions.
- **B** photosynthesis.
- **C** storing food and water.
- **D** making proteins.

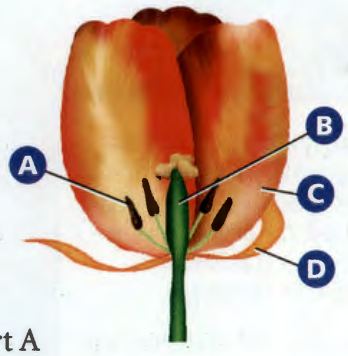
S 7.1.d

3. Which statement below best explains why mosses and liverworts cannot grow tall?

- **A** They have no rootlike structures.
- **B** Taller plants in their surroundings release chemicals that slow down their growth.
- **C** They cannot take in enough oxygen from their surroundings.
- **D** They do not have true vascular tissue.

S 7.5.a

4. The diagram below shows the parts of a flower. In which flower part is pollen produced?



- **A** part A
- **B** part B
- **C** part C
- **D** part D

S 7.5.f

5. Which would a student expect to find when examining a dicot?

- **A** one cotyledon
- **B** flower parts in multiples of threes
- **C** stems with bundles of vascular tissue arranged in a ring
- **D** leaves with parallel veins

S 7.5.a

6. Which of the following statements is true about gymnosperms and angiosperms?

- **A** Both gymnosperms and angiosperms produce flowers.
- **B** Gymnosperms produce flowers, while angiosperms produce cones.
- **C** Most gymnosperms have broad leaves, while angiosperms do not.
- **D** Angiosperm seeds are enclosed within fruits, while gymnosperm seeds are not.

S 7.2.a

Apply the BIG Idea

7. Describe three adaptations that plants have for living on land. Explain why each adaptation is important for a plant to survive on land.

S 7.5.a