Chapter

8

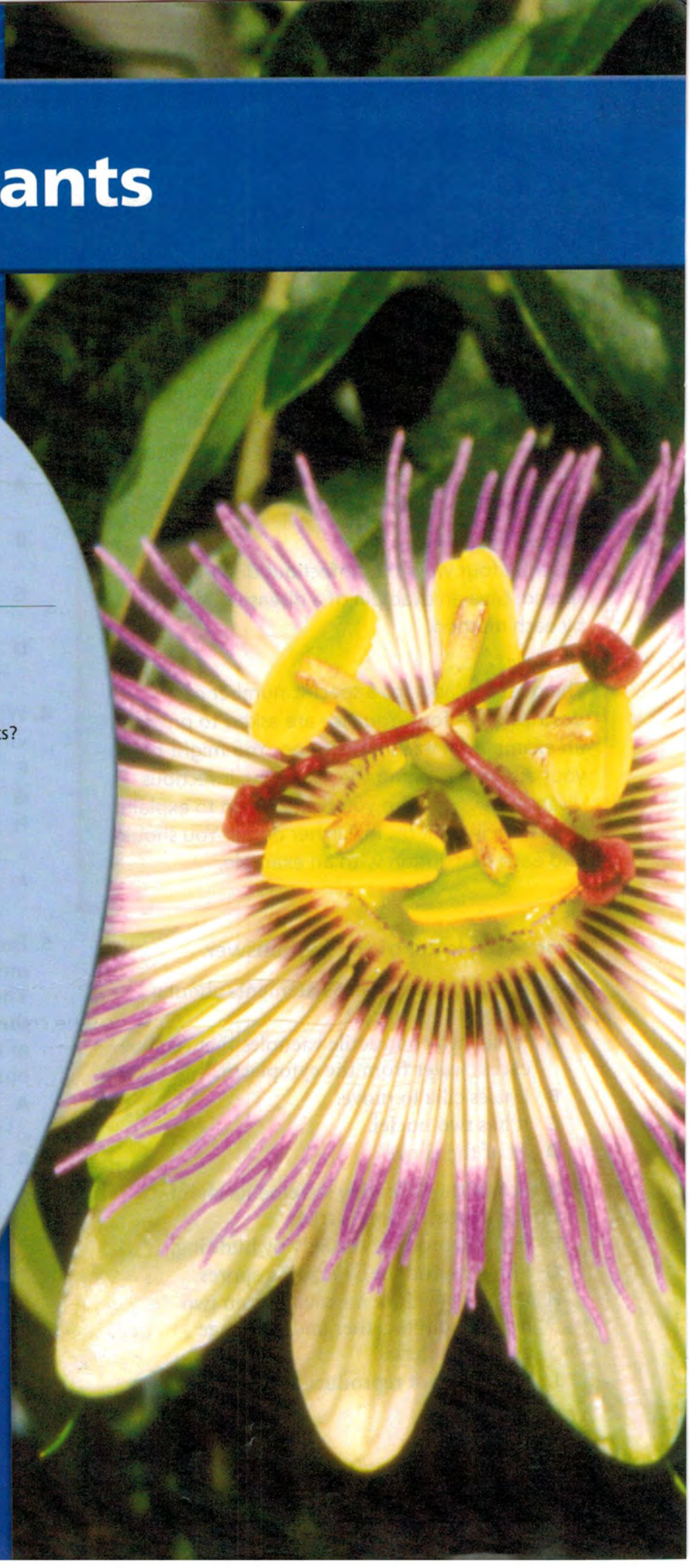
Plants

The BIG Idea

Structure and Function

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

Chapter Preview



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

Discovery CHANNEL SCHOOL

Seed Plants

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

Design and Build an Interactive Exhibit

Cotton, medicines, and paper are just some of the products that come from plants. Which plants are the sources of these products, and how are the products made? In this project, you will build an exhibit to teach young children how a plant becomes a useful product.

Your Goal To build an interactive exhibit showing how a particular plant is transformed into a useful product

To complete this project successfully, you must

- choose one plant product and research where it comes from
- design an interactive exhibit that shows how the product is made
- build your exhibit and ask some children to critique it
- use the children's feedback to redesign your exhibit
- follow the safety guidelines in Appendix A

Plan It! Think of a creative way to teach children about the plant product you chose. Then sketch out your exhibit design and obtain your teacher's approval to build it. Also, identify a few children who can provide you with useful feedback.

Section 1

The Plant Kingdom

Reading Preview

Key Concepts

- 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
- nonvascular plant
- vascular plant
- sporophyte
- gametophyte

Target Reading Skill

Building Vocabulary A definition states the meaning of a word or phrase by telling about its most important feature or function. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

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 to determine which plant lives in the desert and which does not. 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 probably don't see such unusual plants every day. But you probably do see plants every day. You encounter plants whenever you see moss on a tree trunk, run across a lawn, or pick ripe tomatoes from a garden. 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.**

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.

You don't need a microscope to see plants because they are multicellular. Like many other multicellular organisms, plant cells are organized into tissues. Recall that tissues are groups of similar cells that perform a specific function. Plants vary greatly in size. Both the tiniest moss and the tallest redwood tree are plants.

Go Online
active art

For: Plant Cell Structures activity
Visit: PHSchool.com
Web Code: cep-1041

If you were to look at a plant's cells under a microscope, you would see that plants are eukaryotes. But unlike the cells of some other eukaryotes, a plant's cells are enclosed by a cell wall. Within a cell are chloroplasts and a vacuole, which is a large storage sac for water, wastes, food, and other substances.

Adaptations for Living on Land

Most plants live on land. How is living on land different from living in water? Imagine multicellular green algae floating in the ocean. The algae obtain water and other materials directly from the water around them. The water holds their bodies up toward sunlight. When algae reproduce, sperm cells can swim to egg cells.

Now imagine plants living on land. What adaptations must they have to meet their needs without water all around them? **For plants to survive on land, they must have ways 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 other nutrients from the soil.

Reading Checkpoint **Why is obtaining water easy for algae?**

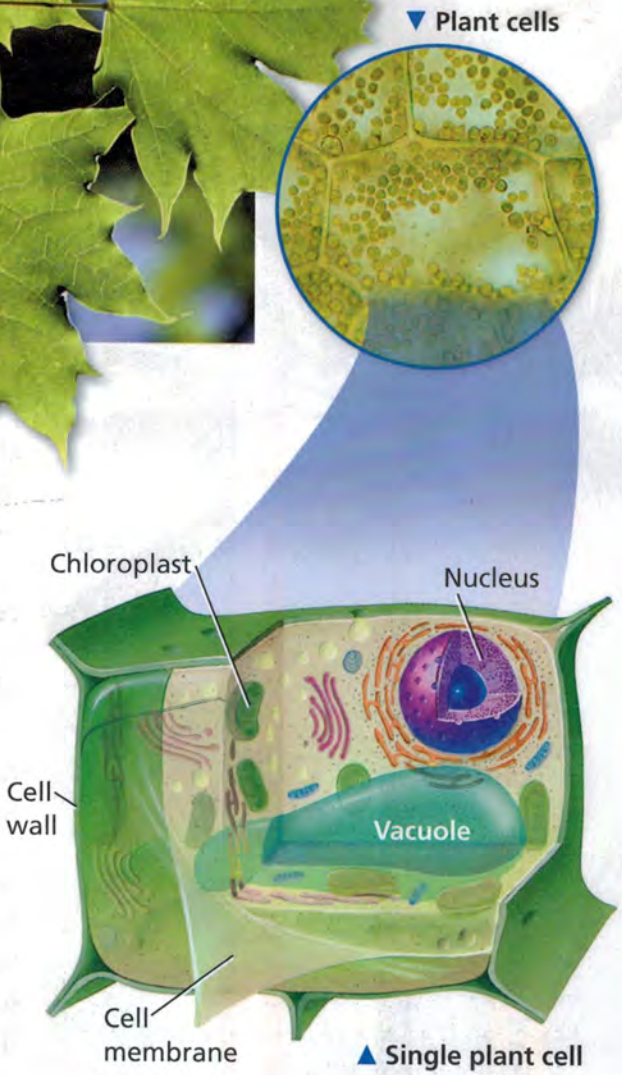
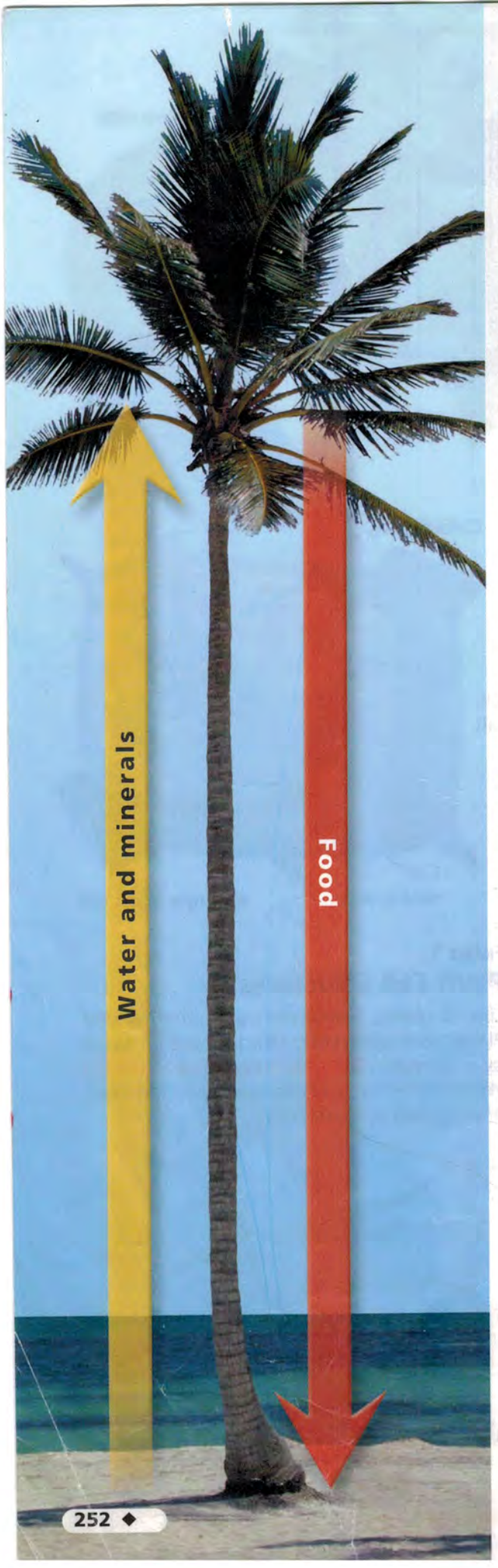


FIGURE 1
Plant Cell Structures
Like all plants, this maple tree is multicellular. Plants have eukaryotic cells that are enclosed by a cell wall. **Relating Diagrams and Photos** *Which cell structures can you see in the inset photograph of plant cells?*



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** that covers the leaves of most plants.

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 transport tissue called vascular tissue. **Vascular tissue** is a system 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 plant's food-making parts 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 an adaptation that makes it possible for fertilization to occur in dry environments.

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

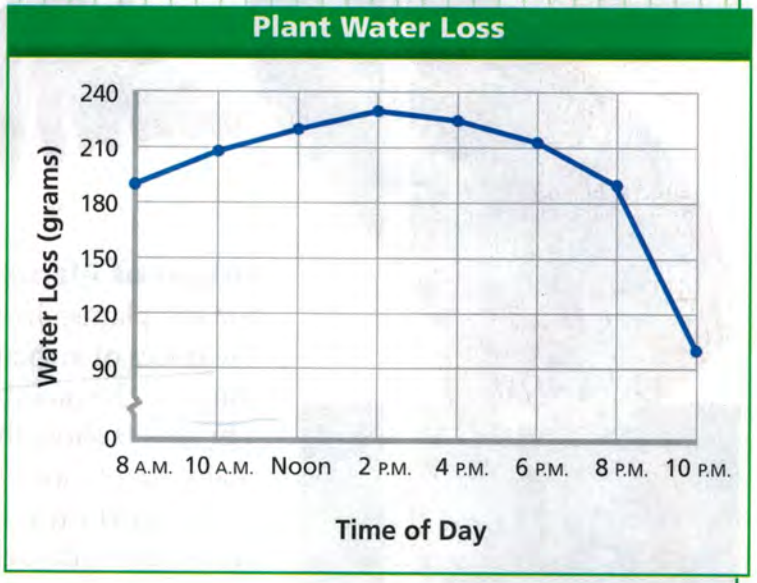
FIGURE 2
Transport and Support
For this tall coconut palm to survive, it must transport water, minerals, and food over long distances. It must also support its body so its leaves are exposed to sunlight.

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** According to the graph, during what part of the day did the plant lose the most water? The least water?
3. **Drawing Conclusions** What could account for the pattern of water loss shown?
4. **Predicting** How would you expect the graph to look from 10 P.M. to 8 A.M.? Explain your reasoning.



Classifying Plants

Hundreds of thousands of plant species exist in the world today. **Scientists informally group plants into two major groups—nonvascular plants and vascular plants.**

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 cell to cell. 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 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.

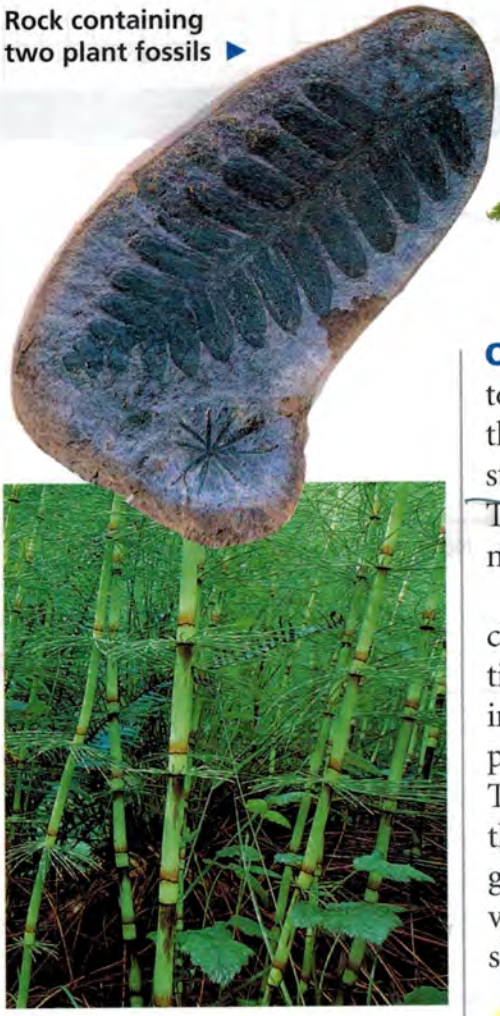


FIGURE 3
Ancient and Modern Plants
Fossils of ancient plants help scientists understand the origin of plants. These fossils are of two plants that lived about 300 million years ago. Notice the similarities between the fossils and modern-day horsetails (above) and ferns (top right).

Origin of Plants Which organisms were the ancestors of today's plants? In search of answers, biologists studied fossils, the traces of ancient life forms preserved in rock and other substances. The oldest plant fossils are about 400 million years old. The fossils show that even at that early date, 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, 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.

Reading Checkpoint **What are the most likely ancestors of today's plants?**

Complex Life Cycles

Plants have complex life cycles that include two different 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 two kinds of sex cells: sperm cells and egg cells.

Figure 4 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?**

Section 2

Plants Without Seeds

Reading Preview

Key Concept

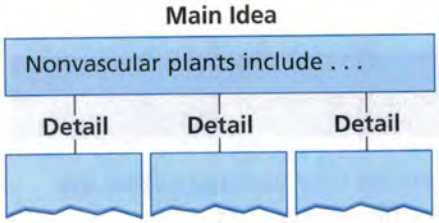
- What characteristics do the three groups of nonvascular plants share?
- What characteristics do the three groups of seedless vascular plants share?

Key Terms

- rhizoid
- frond

Target Reading Skill

Identifying Main Ideas As you read this section, write the main idea—the biggest or most important idea—in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.



Lab zone Discover Activity

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

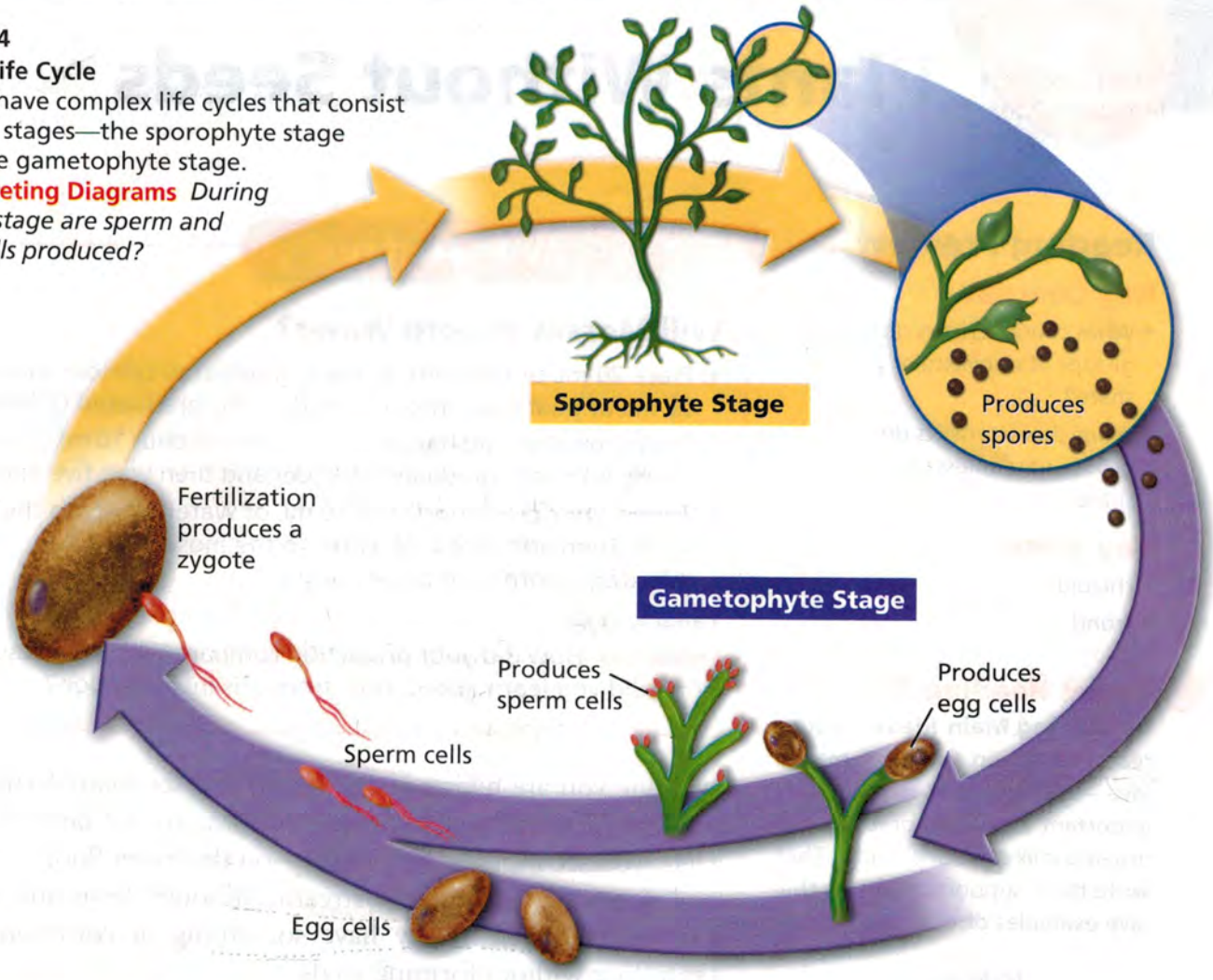
Predicting How did your prediction compare with your results? What did you learn about moss from this investigation?

Imagine you are hiking in the forest. You see many ferns along the trail. You walk a little farther and stop to rest near a stream. Here, 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. They reproduce without forming seeds.

Nonvascular Plants

Mosses are a type of seedless plant that have no 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 surroundings also enable sperm cells to swim to egg cells.

FIGURE 4
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

Target Reading Skill **Building Vocabulary**
Use your sentences to help you answer the questions below.

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.

Writing in Science

Video Script You are narrating a video called *Living on Land*, which is written from the perspective of a plant. Write a one-page script for your narration. Be sure to discuss the challenges that life on land poses for plants and how they meet their needs.

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 5 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.

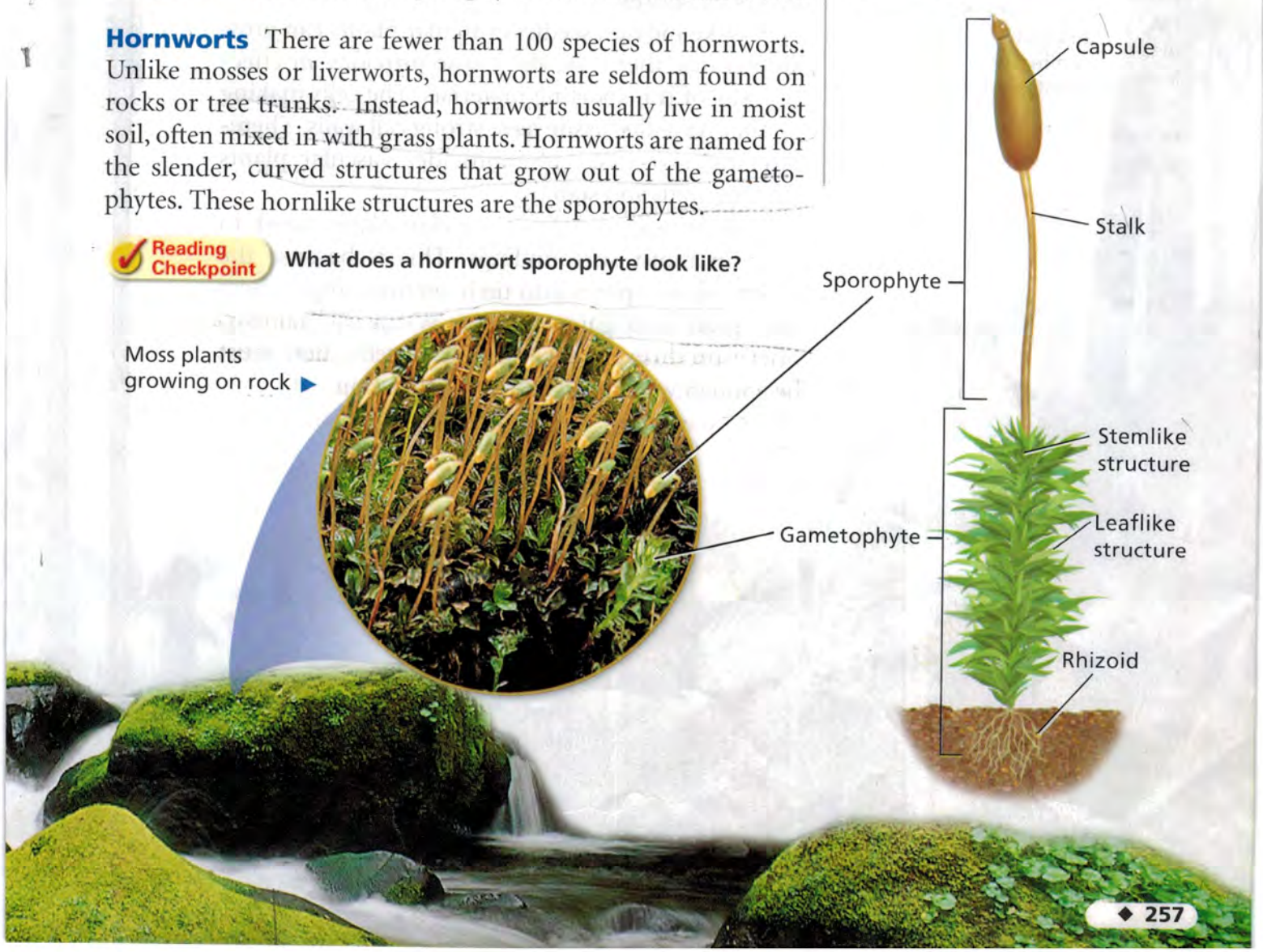
Liverworts There are more than 8,000 species of liverworts. Liverworts are often found growing as a thick crust on moist rocks or soil along the sides of a stream. This group of plants is named for the shape of the plant's leaflike gametophyte, which looks somewhat like a human liver. *Wort* is an old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

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

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

FIGURE 5 A Moss Plant
A moss gametophyte has stemlike, leaflike, and rootlike structures.
Interpreting Diagrams *What structures anchor the gametophyte?*



Seedless Vascular Plants

Figure 6 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, club mosses, and horsetails 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 6
An Ancient Forest
Giant ferns, horsetails, and club mosses dominated ancient forests on Earth.

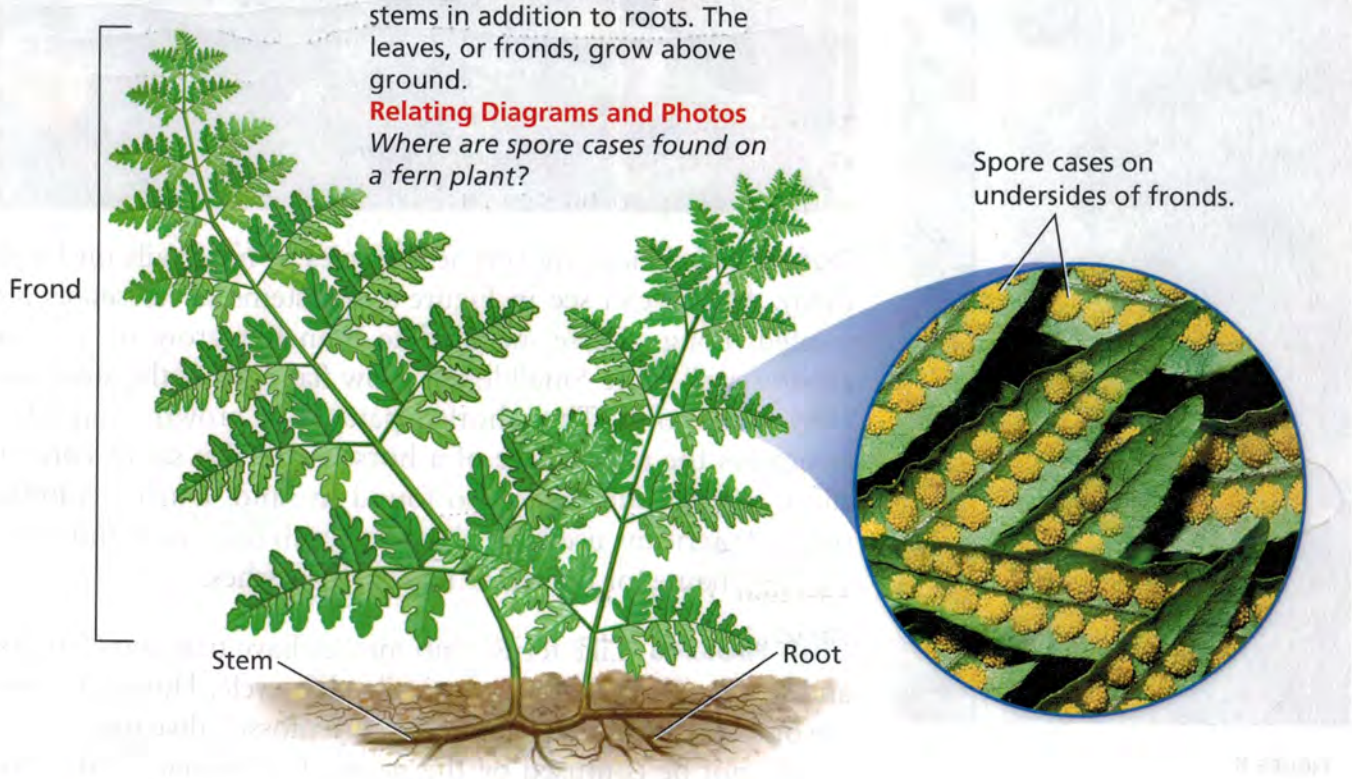


FIGURE 7
A Fern Plant
Most ferns have underground stems in addition to roots. The leaves, or fronds, grow above ground.
Relating Diagrams and Photos *Where are spore cases found on a fern plant?*

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 are 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 7 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 8
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 8, 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

Target Reading Skill **Identifying Main Ideas** Use your graphic organizer to help you answer the questions below.

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, shady 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.

Lab zone **Skills Lab**

Masses of Mosses

Problem

How is a moss plant adapted to carry out its life activities?

Skills Focus

observing, measuring

Materials

- clump of moss
- hand lens
- metric ruler
- toothpicks
- plastic dropper
- water

Procedure

1. Your teacher will give you a clump of moss. Examine the clump from all sides. Draw a diagram of what you see. Measure the size of the overall clump and the main parts of the clump. Record your observations.
2. Using toothpicks, gently separate five individual moss plants from the clump. Be sure to pull them totally apart so that you can observe each plant separately. If the moss plants start to dry out as you are working, moisten them with a few drops of water.
3. Measure the length of the leaflike, stemlike, and rootlike structures on each plant. If brown stalks and capsules are present, measure them. Find the average length of each structure.
4. Make a drawing of a single moss plant. Label the parts, give their sizes, and record the color of each part. When you are finished observing the moss, return it to your teacher. Wash your hands thoroughly.
5. Obtain class averages for the sizes of the structures you measured in Step 3. Also, if the moss that you observed had brown stalks and capsules, share your observations about those structures.

Analyze and Conclude

1. **Observing** Describe the overall appearance of the moss clump, including its color, size, and texture.
2. **Measuring** What was the typical size of the leaflike portion of the moss plants, the typical height of the stemlike portion, and the typical length of the rootlike portion?
3. **Inferring** In which part(s) of the moss does photosynthesis occur? How do you know?
4. **Communicating** Write a paragraph explaining what you learned about mosses from this investigation. Include explanations of why mosses cannot grow tall and why they live in moist environments.

More to Explore

Select a moss plant with stalks and capsules. Use toothpicks to release some of the spores, which can be as small as dust particles. Examine the spores under a microscope. Create a labeled drawing of what you see.

Section 3

The Characteristics of Seed Plants

Reading Preview

Key Concepts

- What characteristics do seed plants share?
- How do seeds become new plants?
- What are the main functions of roots, stems, and leaves?

Key Terms

- phloem • xylem • pollen
- seed • embryo • cotyledon
- germination • root cap
- cambium • transpiration

Target Reading Skill

Outlining As you read, make an outline about seed plants that you can use for review. Use the red headings for the main ideas and the blue headings for the supporting ideas.

The Characteristics of Seed Plants
I. What is a seed plant?
A. Vascular tissue
B.
II. How seeds become new plants
A.
B.

Lab zone Discover Activity

Which Plant Part Is It?

1. With a partner, 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.

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.

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, all seed plants have body plans 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 9
Harvesting Wild Rice
Like all seed plants, wild rice plants have vascular tissue and use seeds to reproduce. The seeds develop in shallow bodies of water, and the plants grow up above the water's surface. These men are harvesting the mature rice grains.

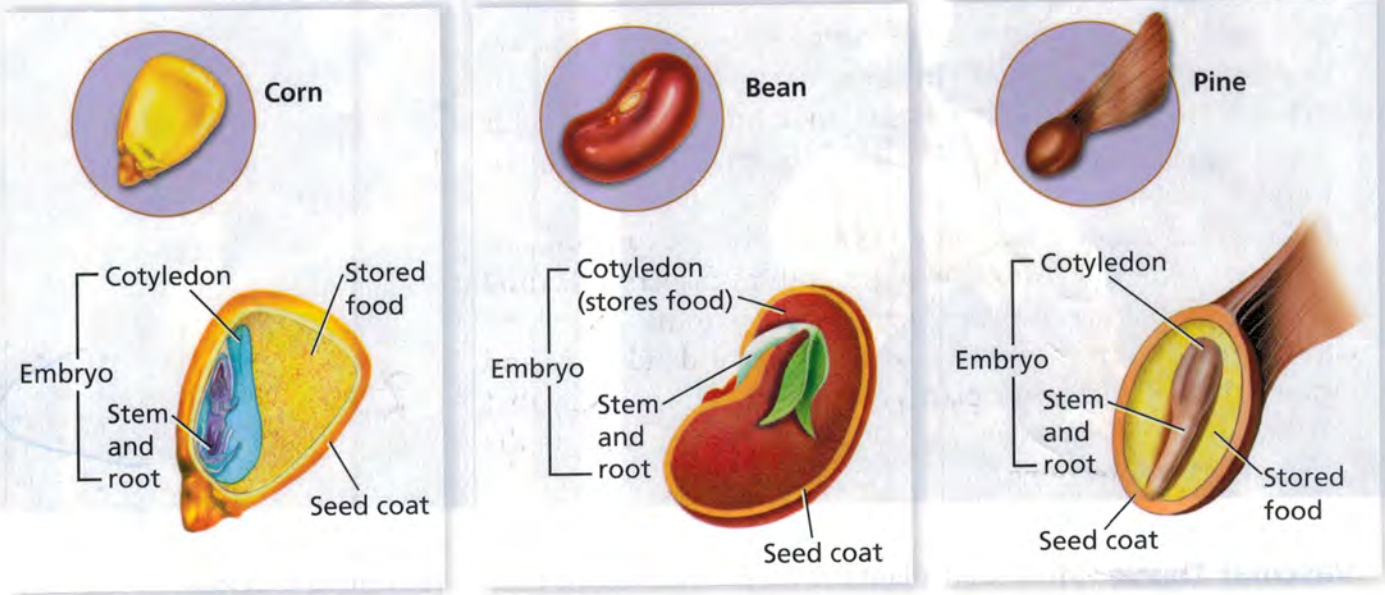
Vascular Tissue Most seed plants live on land. Recall that land plants face many challenges, including standing upright and supplying all their cells with food and water. Like ferns, seed plants meet these two challenges with vascular tissue. The thick walls of the cells in the vascular tissue help support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

There are two types of vascular tissue. **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). The 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 directly near 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.

Reading Checkpoint **What material travels in phloem? What materials travel in xylem?**

FIGURE 10
Seed Structure
The structures of three different seeds are shown here. **Inferring** *How is the stored food used?*



Lab zone Try This Activity

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 coverings of the seeds. Then carefully separate the parts of each seed. Use a hand lens to examine the inside of each seed. Draw what you see.

Observing Based on your observations, label the parts of each seed. Then describe the function of each part next to its label.

How Seeds Become New Plants

All seeds share 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.**

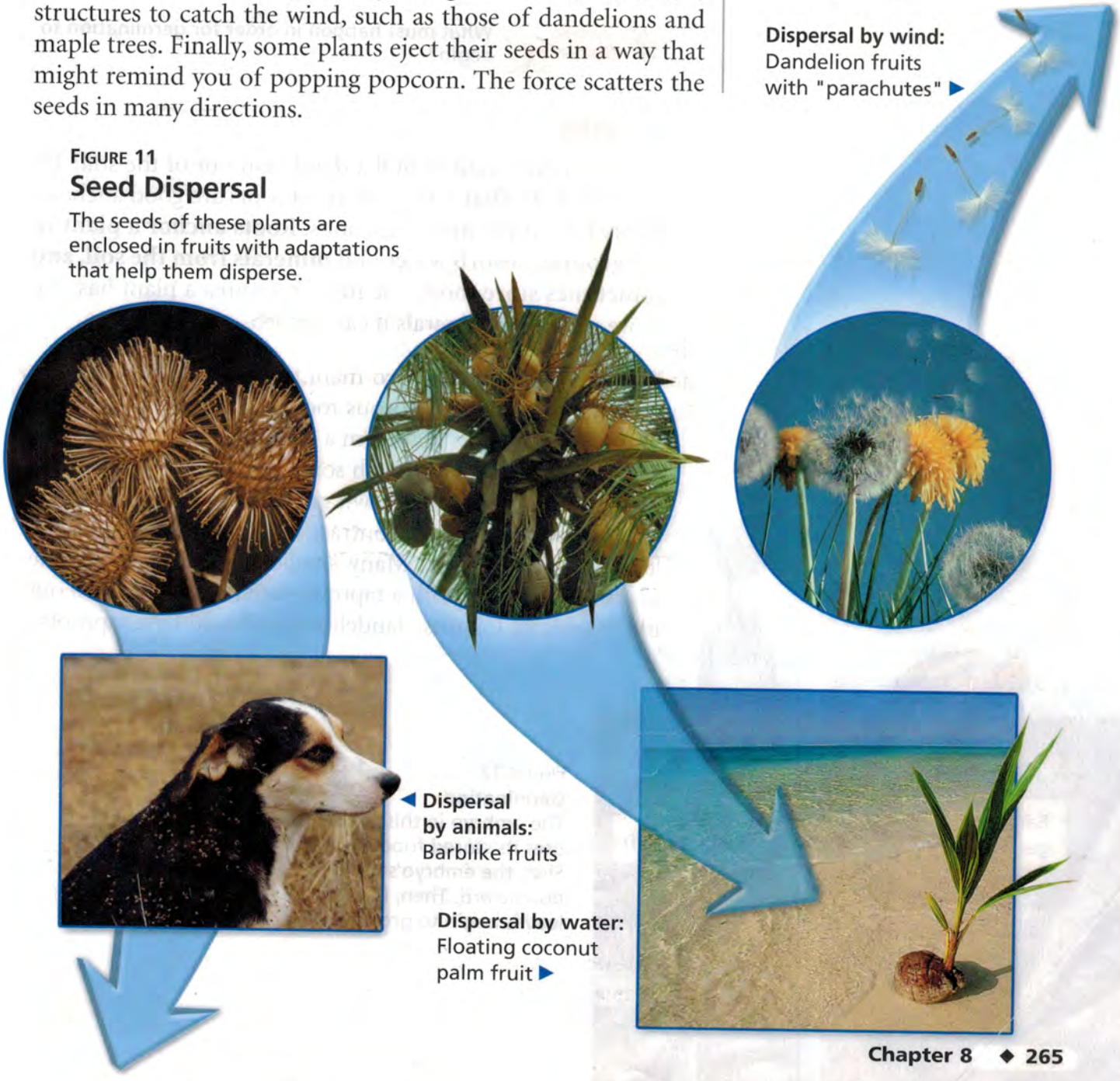
Seed Structure A seed has three main parts—an embryo, stored food, and a seed coat. The young plant that develops from the zygote, or fertilized egg, is called the **embryo.** The embryo already has the beginnings of roots, stems, and leaves. In the seeds of most plants, the embryo stops growing when 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. In all seeds, the embryo has one or more seed leaves, or **cotyledons** (kaht uh LEED unz). In some seeds, food is stored in the cotyledons. In others, food is stored outside the embryo. Figure 10 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.

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.

FIGURE 11
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 begins when the seed absorbs water from the environment. Then the embryo uses its stored food to begin to grow. As shown in Figure 12, the embryo's roots first grow downward; then its stem and leaves grow upward. Once you can see a plant's leaves, the plant is called a seedling.

A seed that is dispersed far from its parent plant 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 must happen in order for germination to begin?**

Roots

Have you ever tried to pull a dandelion 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 shown in Figure 13. 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.

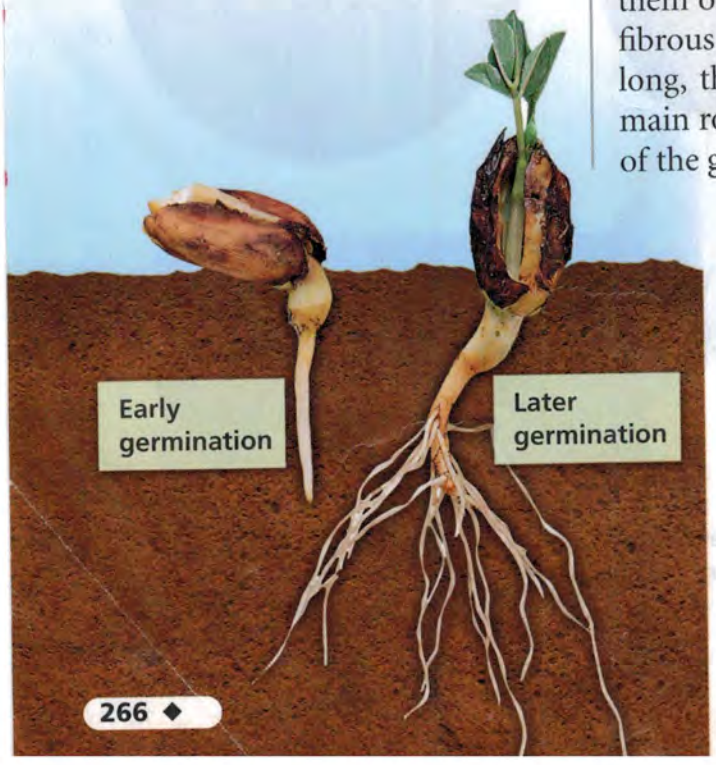


FIGURE 12
Germination
The embryo in this peanut seed uses its stored food to germinate. First, the embryo's roots grow downward. Then, its stem and leaves begin to grow upward.

The Structure of a Root In Figure 13, you can see 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 cells that divide to form 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 substances. The root hairs also help to anchor the plant in the soil.

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.

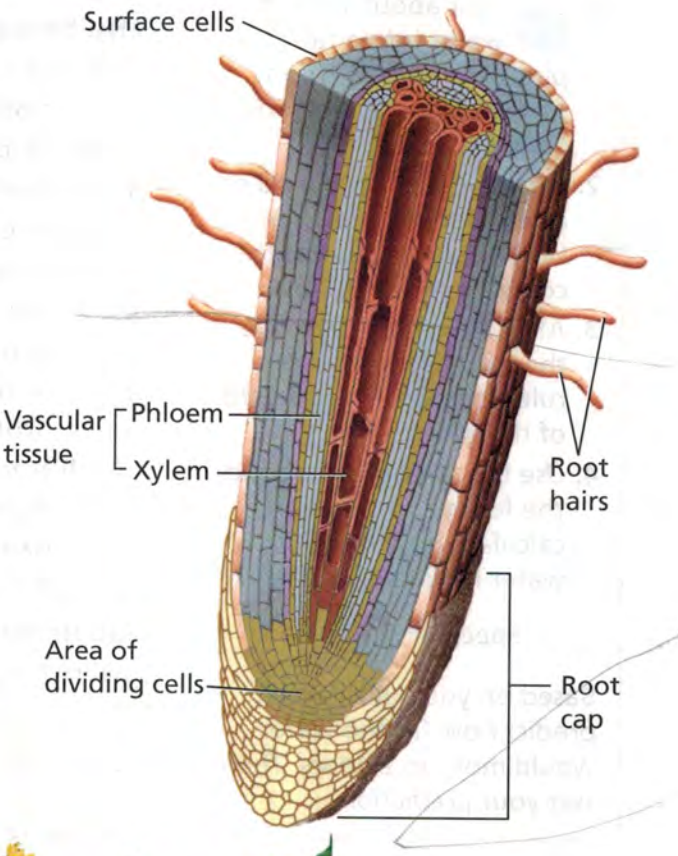
Phloem transports food manufactured in the leaves to the root. The root tissues may then use the food for growth or store it for future use by the plant.

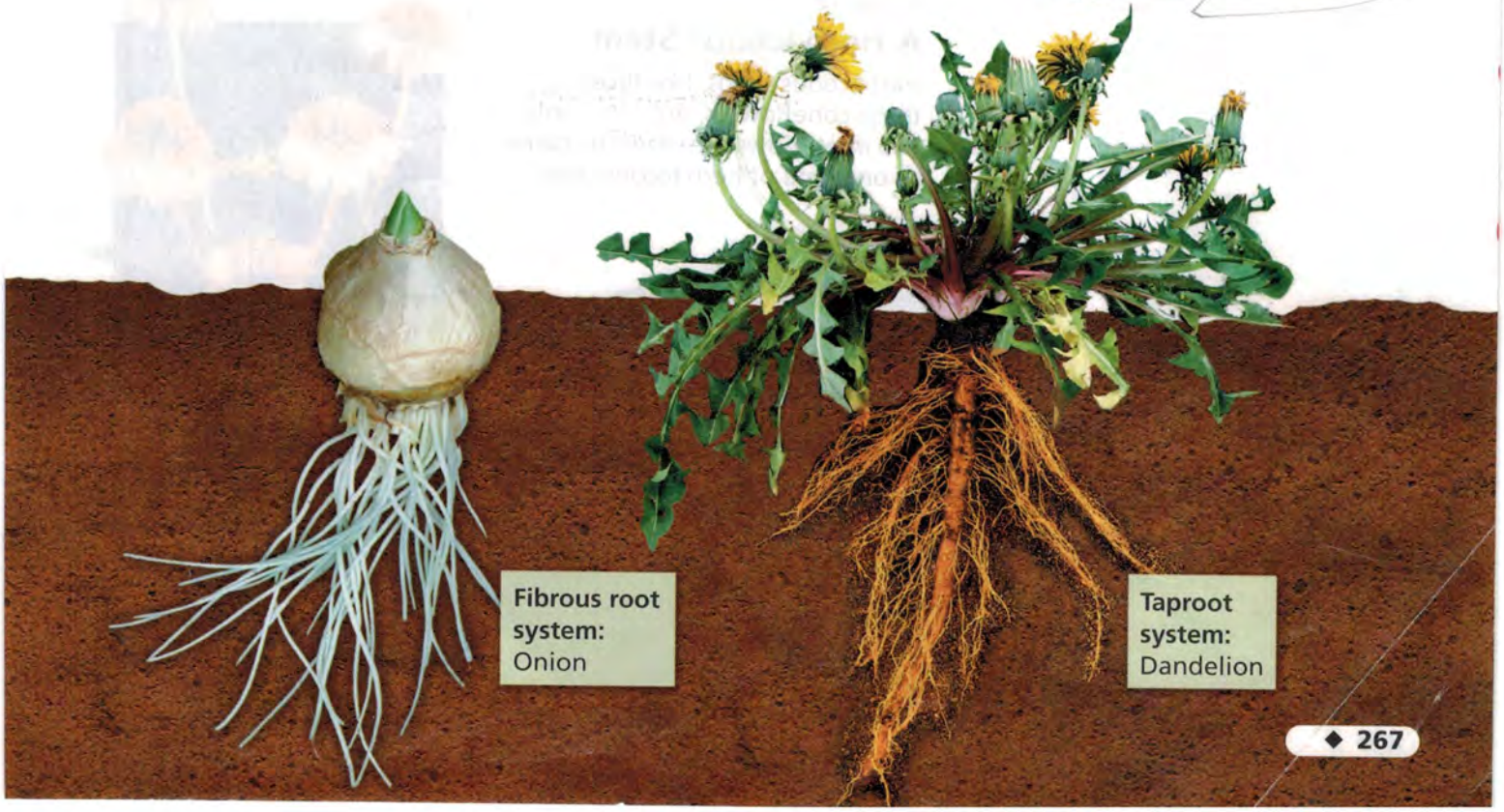
Reading Checkpoint **What is a root cap?**

FIGURE 13

Root Structure

Some plants have fibrous roots while others have taproots. 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?*





Lab zone Skills Activity

Calculating

In this activity, you will calculate the speed at which water moves up a celery stalk.

1. Pour about 1 cm of water into a tall plastic container. Stir in several drops of red food coloring.
2. Place the freshly cut end of a celery stalk in the water. Lean the stalk against the container's side.
3. After 20 minutes, remove the celery. Use a metric ruler to measure the height of the water in the stalk.
4. Use the measurement and the following formula to calculate how fast the water moved up the stalk.

$$\text{Speed} = \frac{\text{Height}}{\text{Time}}$$

Based on your calculation, predict how far the water would move in 2 hours. Then test your prediction.

Stems

The stem of a plant has two main functions. **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.** In addition, some stems, such as those of asparagus, store food.

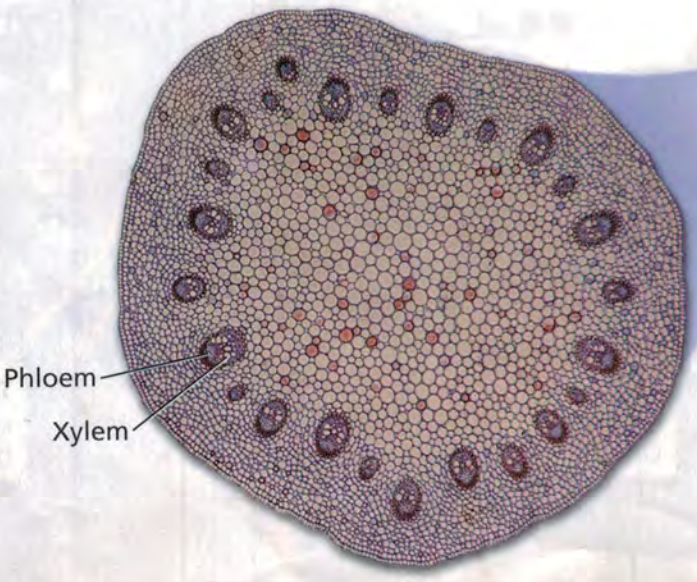
The Structure of a Stem Stems can be either herbaceous (hur BAY shus) or woody. Herbaceous stems contain no wood and are often soft. Coneflowers and pepper plants have herbaceous stems. In contrast, woody stems are hard and rigid. Maple trees and roses have woody stems.

Both herbaceous and woody stems consist of phloem and xylem tissue as well as many other supporting cells. Figure 14 shows the inner structure of one type of herbaceous stem.

As you can see in Figure 15, 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.

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

FIGURE 14
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.



Annual Rings Have you ever looked at a tree stump and seen a pattern of circles that looks something like a target? 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 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. By examining annual rings from some trees in the southwestern United States, scientists were able to infer that severe droughts occurred in the years 840, 1067, 1379, and 1632.

FIGURE 15

A Woody Stem

Trees like these maples have woody stems. 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?*

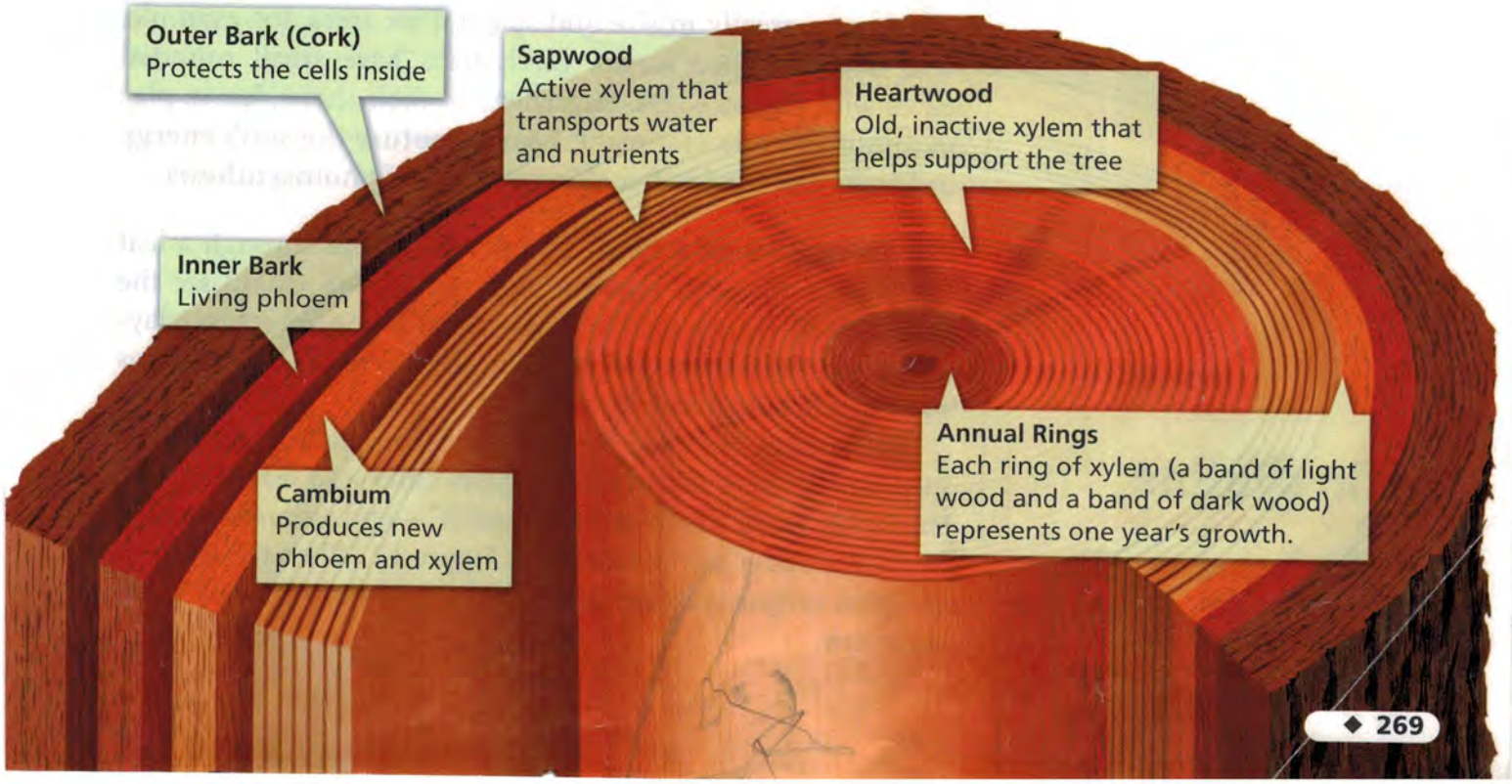
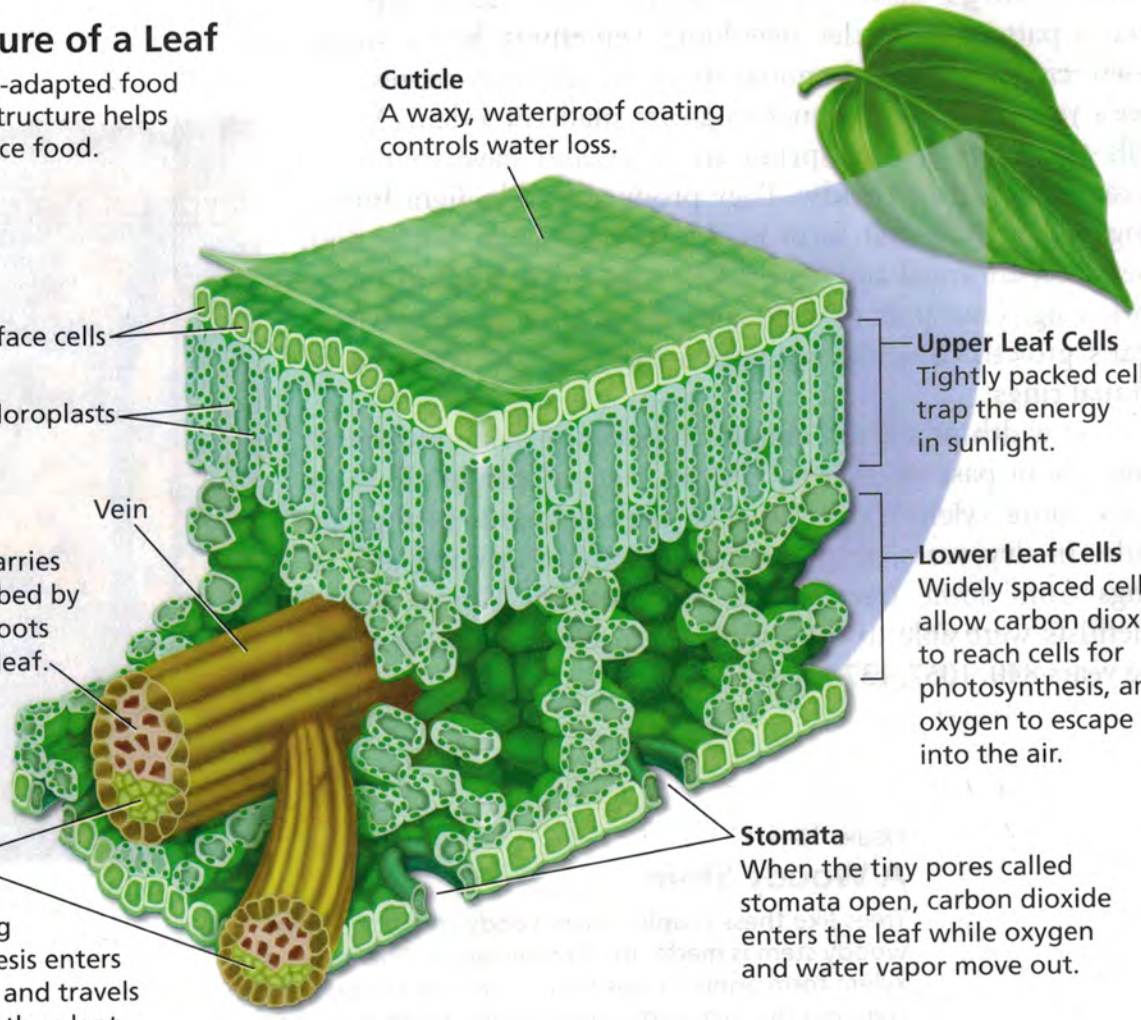


FIGURE 16

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 small rounded leaves with jagged edges. Regardless of their shape, leaves play an important role in a plant. **Leaves capture the sun's energy and carry out the food-making process of 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 16. 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 Greek word *stoma* means "mouth"—and stomata do look like tiny mouths, as you can see in Figure 17. When the stomata are open, carbon dioxide enters the leaf, and oxygen and water vapor exit.

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. Recall that the 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. 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.

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 a plant's leaves is called **transpiration.** 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.

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

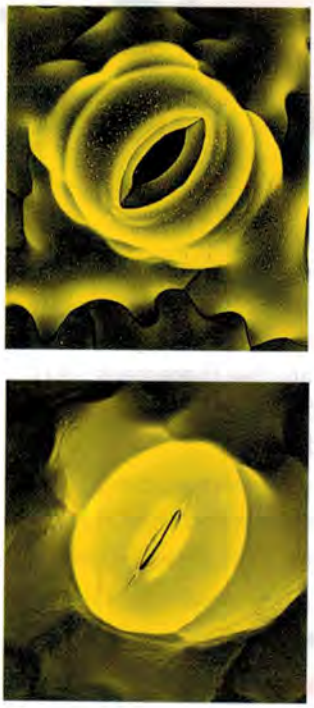


FIGURE 17
Stomata
Stomata open (top) and close (bottom) to control when gases enter and exit the leaf.
Relating Cause and Effect *What gases enter and exit when the stomata open?*

Section 3 Assessment

Target Reading Skill **Outlining** Use the information in your outline about seed plants to help you answer the questions below.

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** List the steps in the sequence in which they must occur for a seed to grow into a new plant.
   c. **Applying Concepts** If a cherry seed were to take root right below its parent tree, what three challenges might the cherry seedling face?
3. a. **Identifying** What are the main functions of a plant's roots, stems, and leaves?
   b. **Comparing and Contrasting** What type of tissue carries water from the roots to the rest of the plant? What type of tissue carries food away from the leaves?
   c. **Applying Concepts** How are the structures of a tree's roots and leaves well-suited for their roles in supplying the tree with water and sugar?

Writing in Science

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

Section 4

Gymnosperms and Angiosperms

Reading Preview

Key Concepts

- What are the characteristics of gymnosperms and how do they reproduce?
- What are the characteristics of angiosperms and their flowers?
- 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

Target Reading Skill

Building Vocabulary Using a word in a sentence helps you think about how best to explain the word. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a meaningful sentence using each Key Term.

Go Online
SCILINKS NSTA

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

Lab zone **Discover Activity**

Are All Leaves Alike?

1. Your teacher will give you a hand lens, a ruler, and the leaves from some seed plants.
2. Using the hand lens, examine each leaf. Sketch each leaf in your notebook.
3. Measure the length and width of each leaf. Record your measurements in your notebook.

Think It Over

Classifying Divide the leaves into two groups on the basis of your observations. Explain why you grouped the leaves as you did.

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 plants that contain seeds. Plants that produce seeds are known as seed plants. Pine trees and apple trees are both seed plants but belong to two different groups—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.

Every gymnosperm produces 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 18

Types of Gymnosperms

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

Ginkgo: ▲
Ginkgo biloba

Gnetophyte: ▲
Welwitschia

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 18 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?**

Reproduction in Gymnosperms

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 19, 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 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 19. **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 is pollen and where is it produced?**

Lab zone **Try This Activity**

The Scoop on Cones

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

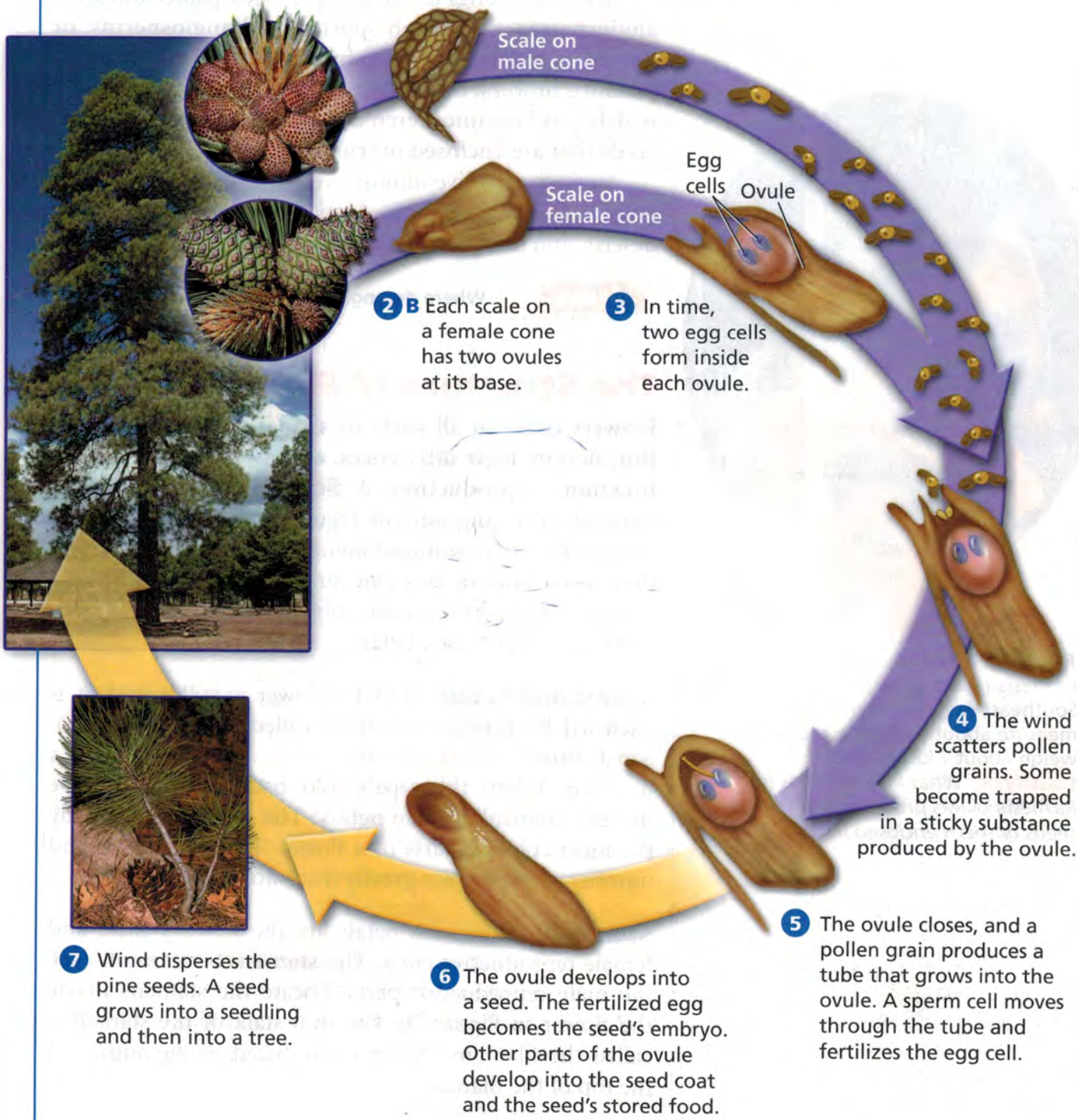
1. Use a hand lens to look closely at the female cone. Gently shake the cone over a piece of white paper. Observe what happens.
2. Break off one scale from the cone. Examine its base. If the scale contains a seed, remove the seed.
3. With a hand lens, examine the seed from Step 2 or examine a seed that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

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

FIGURE 19

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?*



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. You won't be seeing rafflesia in your local florist shop any time soon.

Rafflesia belongs to the group of seed plants known as **angiosperms** (AN jee uh spurmz). **All angiosperms, or flowering plants, 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?**

FIGURE 20 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?*

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 21 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 only male reproductive parts, and some 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 parts. The **stamens** (STAY munz) are the male reproductive parts. Locate the stamens inside the flower in Figure 21. The thin stalk of the stamen is called the filament. Pollen is produced in the anther, at the top of the filament.

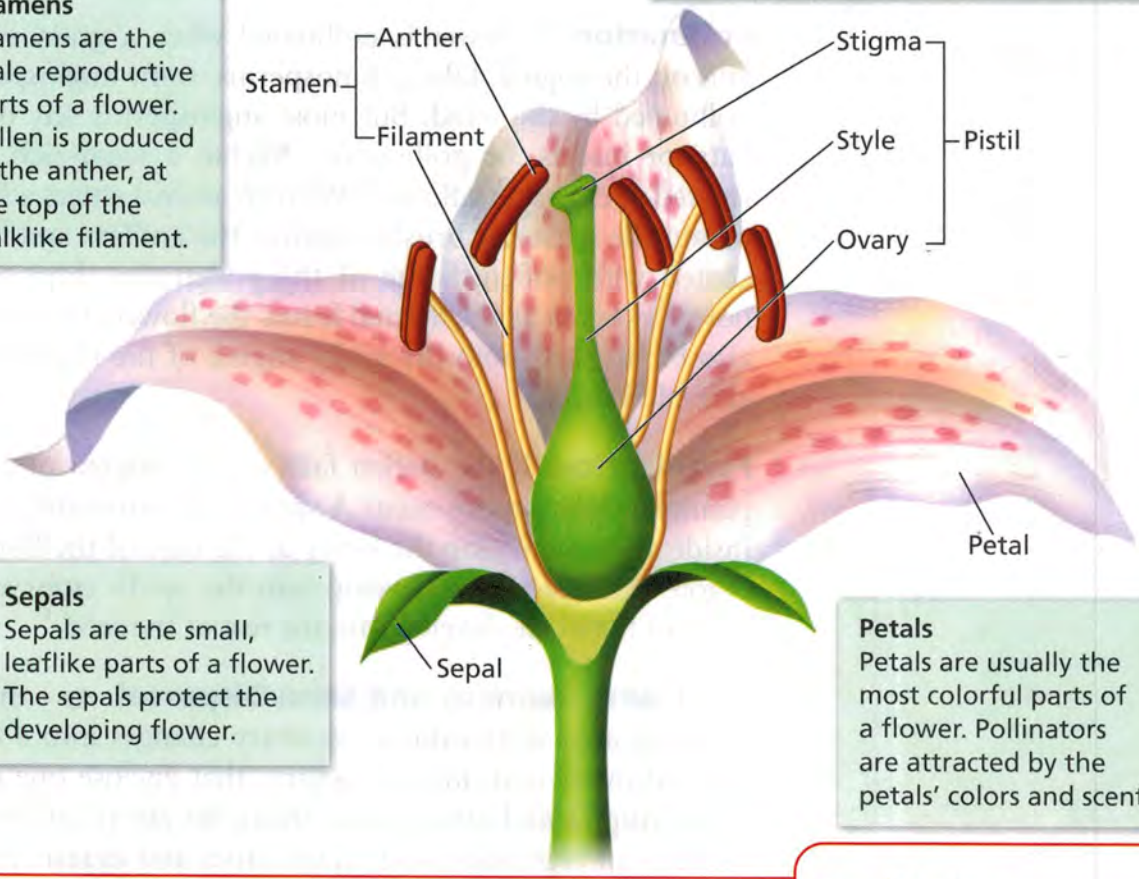
FIGURE 21

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 ensure that pollination occurs. 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 smell of rotting meat.

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

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

Reproduction in Angiosperms

You can follow the process of angiosperm reproduction in Figure 23. **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 pollinated by the wind. 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 sticky stigma of the next flower the animal visits.

Fertilization If the pollen falls on the stigma of a similar plant, fertilization can occur. A sperm cell joins with an egg cell inside an ovule within the ovary at the base of the flower. The zygote then 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 22
Fruits
The seeds of angiosperms are enclosed in fruits, which protect and help disperse the seeds.

▲ Maple ▲ Lemon ▲ Pea ▲ Tomato

FIGURE 23

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 24
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 24, 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, and flowers. People eat vegetables, fruits, and cereals, all of which are angiosperms. People also make clothing and 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 25
Food From Seed Plants
The cucumbers, tomatoes, and spinach in this salad are all angiosperms.

Section 4 Assessment

Target Reading Skill **Building Vocabulary**
Use your sentences to help you answer the questions below.

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

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

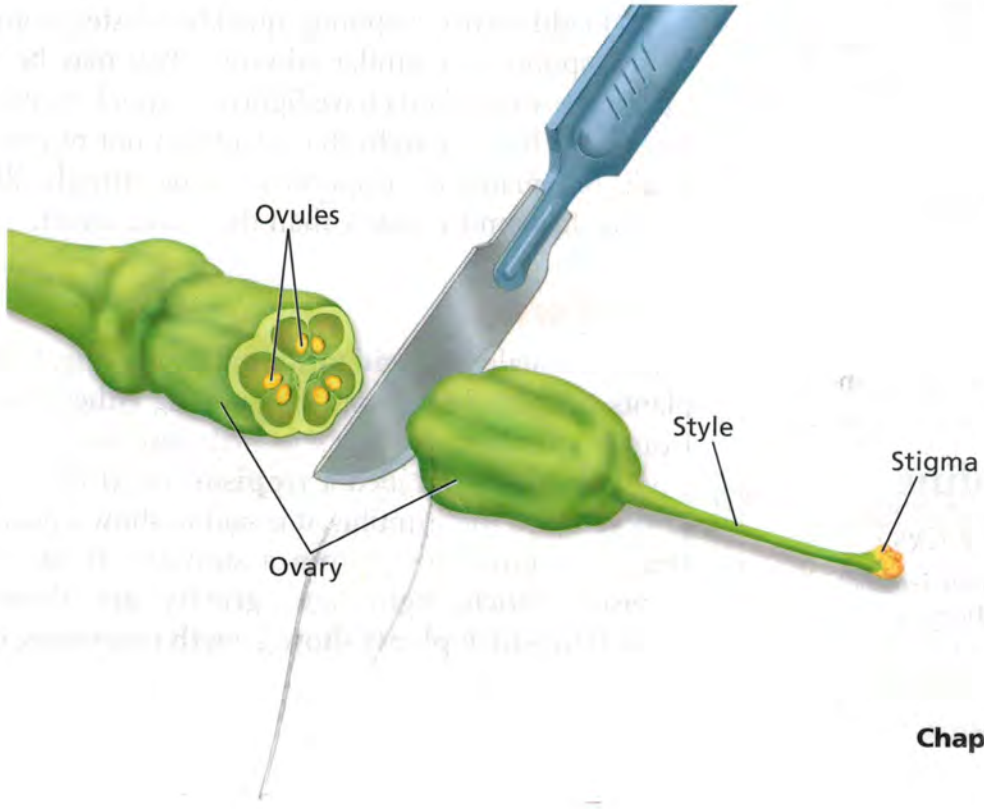
10. Use a scalpel to cut the pistil away from the rest of the flower. Measure the height of the pistil. Examine its shape. Observe the top of the pistil. Determine if that surface will stick to and lift a tiny piece of lens paper. Record your observations.
11. Lay the pistil on the paper towel. Holding 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 are missing. *Obtain your teacher's permission before carrying out your investigation.*



Plant Responses and Growth

Reading Preview

Key Concepts

- What are three stimuli that produce plant responses?
- How do plants respond to seasonal changes?
- How long do different angiosperms live?

Key Terms

- tropism • hormone
- auxin • photoperiodism
- short-day plant
- long-day plant
- critical night length
- day-neutral plant • dormancy
- annual • biennial • perennial

Lab zone **Discover Activity**

Can a Plant Respond to Touch?

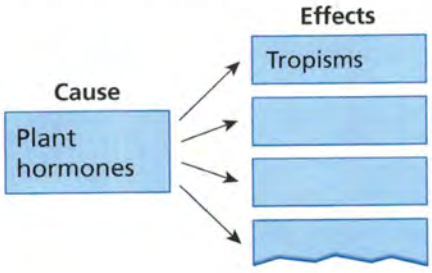
1. Your teacher will give you two plants. Observe the first plant. Gently touch a leaf with the tip of a pencil. Observe what happens over the next three minutes. Record your observations.
2. Repeat Step 1 with the second plant. Record your observations.
3. Wash your hands with soap and water.

Think It Over

Inferring What advantage might a plant have if its leaves responded to touch?

Target Reading Skill

Relating Cause and Effect As you read through the paragraphs under the heading Hormones and Tropisms, identify four effects of plant hormones. Write the information in a graphic organizer like the one below.



Go Online SCILINKS NSTA

For: Links on plant responses
Visit: www.SciLinks.org
Web Code: scn-0154

The bladderwort is a freshwater plant with small yellow flowers. Attached to its floating stems are open structures called bladders. When a water flea touches a sensitive hair on a bladder, the bladder flicks open. Faster than you can blink, the water flea is sucked inside, and the bladder snaps shut. The plant then digests the trapped flea.

A bladderwort responds quickly—faster than many animals respond to a similar stimulus. You may be surprised to learn that some plants have lightning-quick responses. In fact, you might have thought that plants do not respond to stimuli at all. But plants do respond to some stimuli, although they usually do so more slowly than the bladderwort.

Tropisms

Animals usually respond to stimuli by moving. Unlike animals, plants commonly respond by growing either toward or away from a stimulus. A plant's growth response toward or away from a stimulus is called a **tropism** (TROH piz um). If a plant grows toward the stimulus, it is said to show a positive tropism. If a plant grows away from a stimulus, it shows a negative tropism. **Touch, light, and gravity are three important stimuli to which plants show growth responses, or tropisms.**

Touch Some plants, such as bladderworts, show a response to touch called thigmotropism. The prefix *thigmo-* comes from a Greek word that means "touch." The stems of many vines, such as grapes and morning glories, show a positive thigmotropism. As the vines grow, they coil around any object that they touch.

Light Have you ever noticed plants on a windowsill with their leaves and stems facing the sun? All plants exhibit a response to light called phototropism. The leaves, stems, and flowers of plants grow toward light, showing a positive phototropism. By growing towards the light, a plant receives more energy for photosynthesis.

Gravity Plants also respond to gravity. This response is called gravitropism. Roots show positive gravitropism—they grow downward. Stems, on the other hand, show negative gravitropism—they grow upward.

Hormones and Tropisms Plants are able to respond to touch, light, and gravity because they produce hormones. A **hormone** produced by a plant is a chemical that affects how the plant grows and develops.

One important plant hormone is named **auxin** (AWK sin). Auxin speeds up the rate at which a plant's cells grow. Auxin controls a plant's response to light. When light shines on one side of a plant's stem, auxin builds up in the shaded side of the stem. The cells on the shaded side begin to grow faster. Eventually, the cells on the stem's shaded side are longer than those on its sunny side. So the stem bends toward the light.

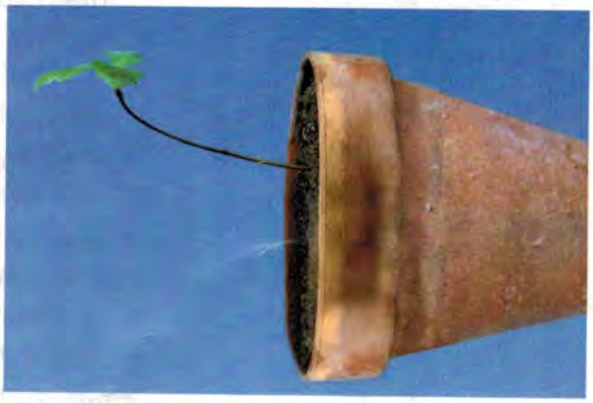
In addition to tropisms, plant hormones also control many other plant activities. Some of these activities are germination, the formation of flowers, stems, and leaves, the shedding of leaves, and the development and ripening of fruit.

Reading Checkpoint **What is one role that the plant hormone auxin plays?**

FIGURE 26
Tropisms
Touch, light, and gravity are three stimuli to which plants show growth responses, or tropisms.

▲ **Touch** A vine coiling around a wire shows positive thigmotropism.

▲ **Light** A plant's stems and flowers growing toward light show positive phototropism.



▲ **Gravity** A plant's stem growing upward, against the pull of gravity, shows negative gravitropism.

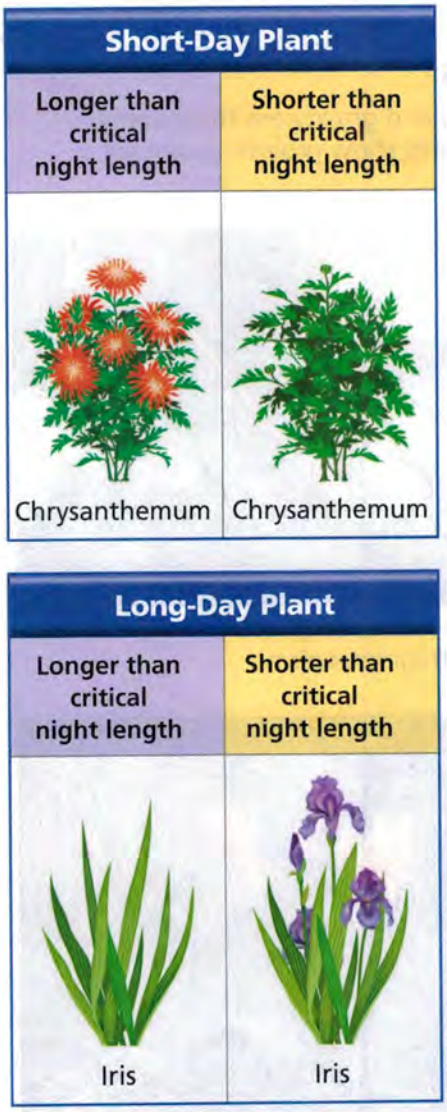


FIGURE 27
Short-Day and Long-Day Plants
A short-day plant flowers when nights are longer than the critical night length. A long-day plant flowers when nights are shorter than the critical night length.
Applying Concepts *Is an iris or chrysanthemum more likely to flower in early summer?*

Seasonal Changes

People have long observed that plants respond to the changing seasons. Some plants bloom in early spring, while others don't bloom until summer. The leaves on some trees change color in autumn and then fall off by winter. **Plant responses to seasonal changes include photoperiodism and dormancy.**

Photoperiodism What environmental factor triggers a plant to flower? The amount of darkness a plant receives determines the time of flowering in many plants. A plant's response to seasonal changes in length of night and day is called **photoperiodism.**

Plants differ in how they respond to the length of nights. **Short-day plants** flower when nights are *longer* than a critical length. **Long-day plants** flower when nights are *shorter* than a critical length. This critical length, called the **critical night length,** is the number of hours of darkness that determines whether or not a plant will flower. For example, if a short-day plant has a critical night length of 11 hours, it will flower only when nights are longer than 11 hours.

Short-day plants bloom in the fall or winter, when nights are growing longer. Chrysanthemums and poinsettias are short-day plants. In contrast, long-day plants flower in the spring or summer, when nights are getting shorter. Long-day plants include irises and lettuce.

Other plants, such as dandelions, rice, and tomatoes, are **day-neutral plants.** Their flowering cycle is not sensitive to periods of light and dark.

Dormancy As winter draws near, many plants prepare to go into a state of dormancy. **Dormancy** is a period when an organism's growth or activity stops. Dormancy helps plants survive freezing temperatures and the lack of liquid water.

With many trees, the first change is that the leaves begin to turn color. Cooler weather and shorter days cause the leaves to stop making chlorophyll. As chlorophyll breaks down, yellow and orange pigments become visible. In addition, the plant begins to produce new red pigments. The brilliant colors of autumn leaves result.

Over the next few weeks, all of the remaining sugar and water are transported out of the tree's leaves. The leaves then fall to the ground, and the tree is ready for winter.

Reading Checkpoint **What is dormancy?**

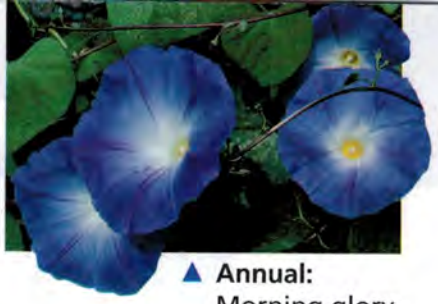
Life Spans of Angiosperms

Angiosperms are classified as annuals, biennials, or perennials based on the length of their life cycles. Flowering plants that complete a life cycle within one growing season are called **annuals.** Most annuals have herbaceous stems. Annuals include marigolds, petunias, wheat, and cucumbers.

Angiosperms that complete their life cycle in two years are called **biennials** (by EN ee ulz). In the first year, biennials germinate and grow roots, very short stems, and leaves. During their second year, biennials lengthen their stems, grow new leaves, and then produce flowers and seeds. Once the flowers produce seeds, the plant dies. Parsley, celery, and foxglove are biennials.

Flowering plants that live for more than two years are called **perennials.** Most perennials flower every year. Some perennials, such as peonies, have herbaceous stems. The leaves and stems of these plants die each winter, and new ones are produced each spring. Most perennials, however, have woody stems that live through the winter. Maple trees are examples of woody perennials.

Reading Checkpoint **How long does a biennial live?**



▲ **Annual:** Morning glory

◀ **Biennial:** Foxglove

Perennial: Peony ▶

FIGURE 28
Life Spans of Angiosperms
Annuals live for one year. Biennials live for two years, and perennials live for many years.

Section 5 Assessment

Target Reading Skill **Relating Cause and Effect** Refer to your graphic organizer about plant hormones to help you answer Question 1.

Reviewing Key Concepts

1. a. **Describing** Describe three tropisms that take place in plants.
   b. **Explaining** How does auxin control a plant's response to light?
   c. **Developing Hypotheses** The stems of your morning glory plants have wrapped around your garden fence. Explain why this has occurred.
2. a. **Defining** What is photoperiodism? What is winter dormancy?
   b. **Comparing and Contrasting** How do short-day plants and long-day plants differ?
   c. **Sequencing** List in order the changes that a tree undergoes as winter approaches.
3. a. **Defining** How do annuals, biennials, and perennials differ?
   b. **Applying Concepts** Is the grass that grows on most lawns an annual, a biennial, or a perennial? Explain.

Lab zone At-Home Activity

Sun Seekers With a family member, soak some corn seeds or lima bean seeds in water overnight. Then push them gently into some soil in a paper cup until they are just covered. Keep the soil moist. When you see the stems break through the soil, place the cup in a sunny window. After a few days, explain to your family member why the plants grew in the direction they did.

Chapter 8 Study Guide

The BIG Idea **Structure and Function** The structure of a plant allows it to obtain water and nutrients and make food, which gives the plant energy to grow, develop, and reproduce.

1 The Plant Kingdom

Key Concepts

- Nearly all plants are autotrophs. All plants are eukaryotes that contain many cells, all of which are surrounded by 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

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

Key Terms

rhizoid frond

3 The Characteristics of Seed Plants

Key Concepts

- Seed plants have vascular tissue and use pollen and seeds to reproduce.
- Roots anchor a plant in the ground and absorb water and minerals. Stems carry substances between roots and leaves, provide support, and hold up the leaves. Leaves capture the sun's energy for photosynthesis.

Key Terms

• phloem • xylem • pollen • seed • embryo
• cotyledon • germination • root cap
• cambium • transpiration

4 Gymnosperms and Angiosperms

Key Concepts

- Every gymnosperm produces naked seeds. In addition, many gymnosperms have needle-like or scalelike leaves, and deep-growing roots.
- In gymnosperm reproduction, pollen falls from a male cone onto a female cone. Sperm and egg cells join in an ovule on the female cone.
- All angiosperms produce flowers and fruits.
- 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

5 Plant Responses and Growth

Key Concepts

- Plant tropisms include responses to touch, light, and gravity.
- Plant responses to seasonal changes include photoperiodism and dormancy.
- Angiosperms are classified as annuals, biennials, or perennials.

Key Terms

tropism
hormone
auxin
photoperiodism
short-day plant
long-day plant
critical night length
day-neutral plant
dormancy
annual
biennial
perennial

Review and Assessment

Go Online PHSchool.com
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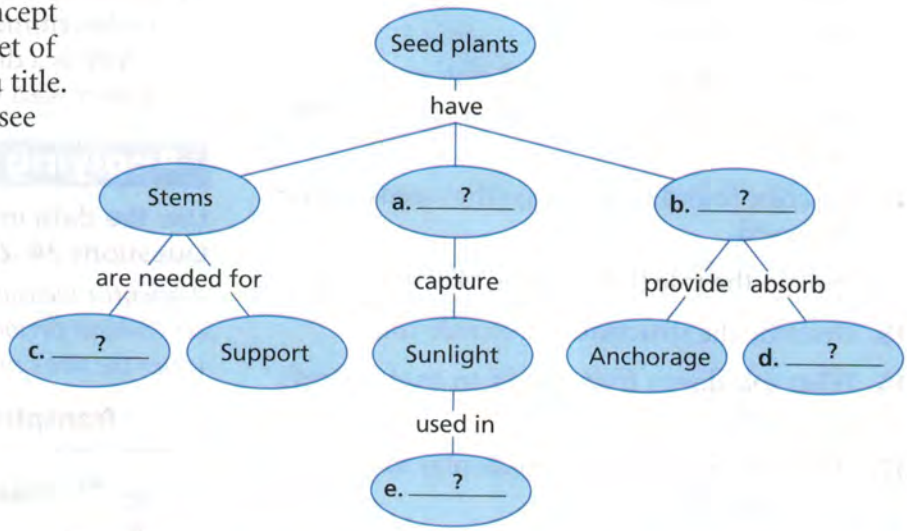
Organizing Information

Concept Mapping Copy the concept map about seed plants onto a sheet of paper. Then complete it and add a title. (For more on Concept Mapping, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. The familiar green, fuzzy moss is the
   a. frond.
   b. rhizoid.
   c. gametophyte.
   d. sporophyte.
2. The leaves of ferns are called
   a. rhizoids.
   b. sporophytes.
   c. fronds.
   d. cuticles.
3. The process by which a seed sprouts is called
   a. pollination. **b.** fertilization.
   c. dispersal. **d.** germination.
4. In woody stems, new xylem cells are produced by the
   a. bark. **b.** cambium.
   c. phloem. **d.** pith.
5. What kind of tropism do roots display when they grow downward into the soil?
   a. positive gravitropism
   b. negative gravitropism
   c. phototropism
   d. thigmotropism

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

6. Vascular tissue is a system of tubelike structures through which water and food move.
7. Stems anchor plants in the soil.
8. The needles of a pine tree are actually its leaves.
9. Gymnosperm seeds are dispersed in fruits.
10. Flowering plants that live for more than two years are called annuals.

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.

Discovery CHANNEL SCHOOL

Seed Plants
Video Preview
Video Field Trip
▶ Video Assessment

Review and Assessment

Checking Concepts

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

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. **Comparing and Contrasting** Which of the plants below is a monocot? Which is a dicot? Explain your conclusions.

Math Practice

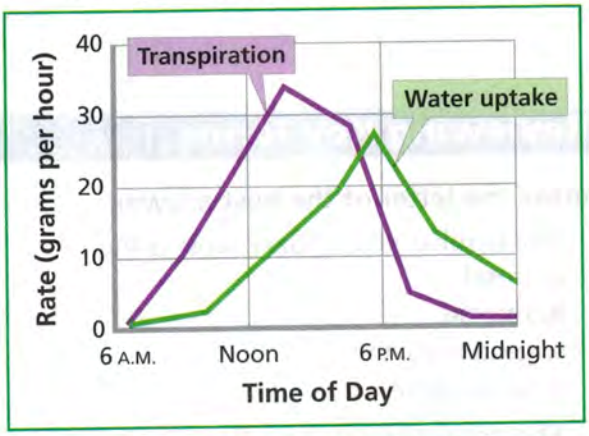
23. **Multiples** Use what you know about multiples to determine which flower is a monocot and which is a dicot: a flower with nine petals; a flower with ten petals. Explain.

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 Chapter Project

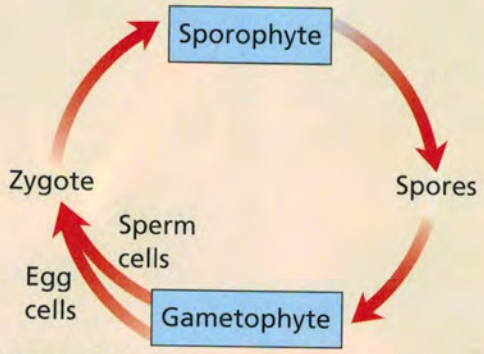
Performance Assessment Present your exhibit to your classmates. Describe your original exhibit and how you changed it based on the feedback you received. Explain what you learned by doing this project. What factors are most important in creating a successful educational exhibit for children?

Standardized Test Prep

Test-Taking Tip

Interpreting a Diagram

On standardized tests, you may be asked to answer questions about a diagram that represents a process. Examine the parts of the diagram. Make sure you understand the meaning of labels and direction of arrows. Think about what happens at each stage of the process. Study the diagram of a plant life cycle below and answer the sample question.



Sample Question

A spore develops into a

A sporophyte. **B** gametophyte.
C sperm cell. **D** egg cell.

Answer

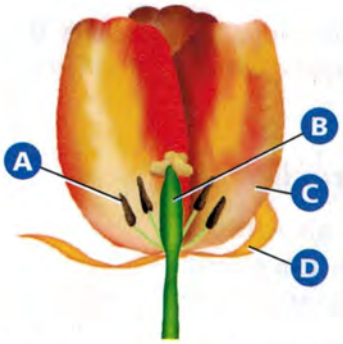
Choice **B** is correct. The arrows in the diagram show that spores develop into gametophytes. Choice **A** is incorrect because it is the sporophyte that produces the spores. Choice **C** and **D** can be eliminated because sperm and egg cells are produced by the gametophyte.

Choose the letter of the best answer.

1. Based on the diagram above, which of these 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

2. Which statement below best explains why mosses and liverworts cannot grow tall?
   - **F** They have no rootlike structures.
   - **G** Taller plants in their surroundings release chemicals that slow down their growth.
   - **H** They cannot take in enough oxygen from their surroundings.
   - **J** They do not have true vascular tissue.

3. 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

4. Which would a student expect to find when examining a dicot?
   - **F** one cotyledon
   - **G** flower parts in multiples of threes
   - **H** stems with bundles of vascular tissue arranged in a ring
   - **J** leaves with parallel veins

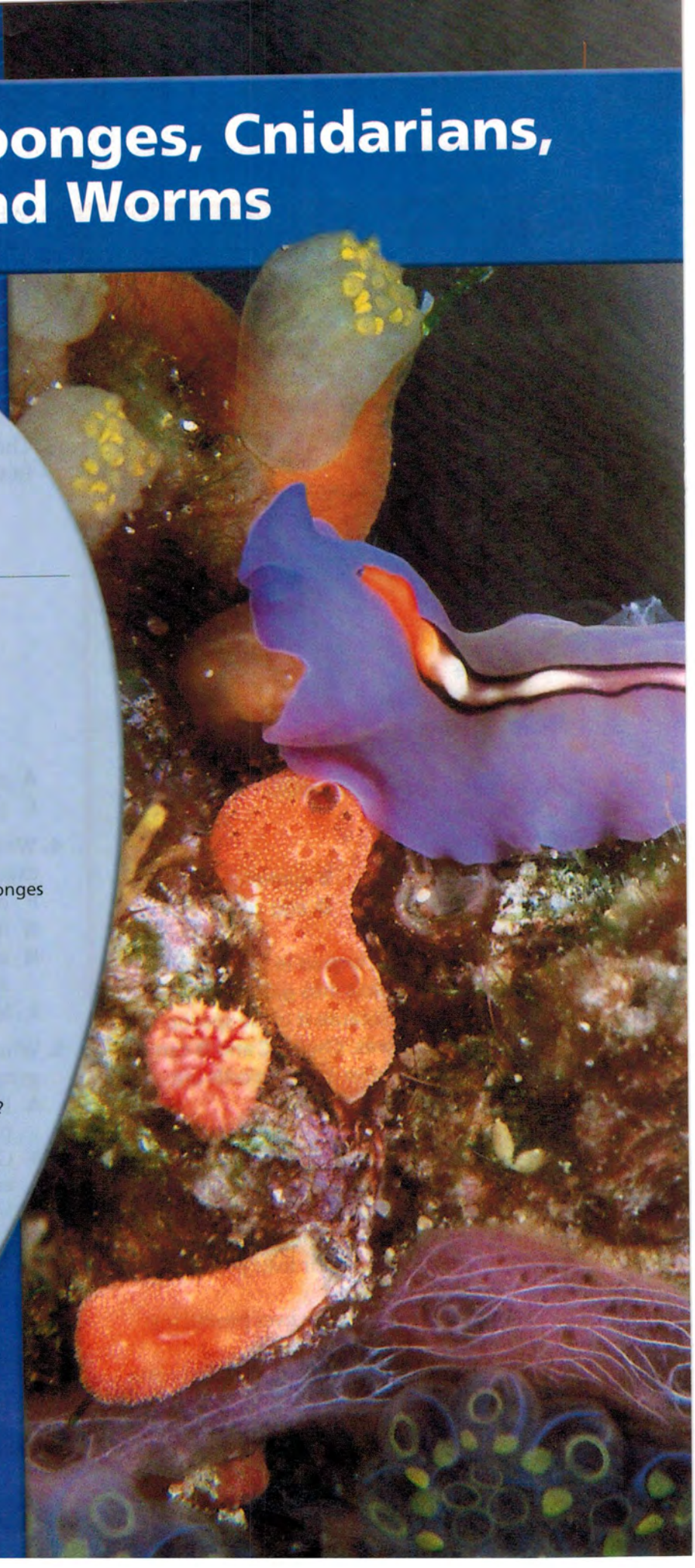
5. Which of the following statements is true about gymnosperms and angiosperms?
   - **A** Both gymnosperms and angiosperms produce flowers.
   - **B** Gymnosperms produce flowers, while angiosperms produce cones.
   - **C** Most gymnosperms have broad leaves, while angiosperms do not.
   - **D** Angiosperm seeds are enclosed within fruits, while gymnosperm seeds are not.

Constructed Response

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

Chapter 9

Sponges, Cnidarians, and Worms



The BIG Idea

Structure and function

What major functions do animals' bodies perform?

Chapter Preview

A purple flatworm glides along the ocean bottom.

Discovery CHANNEL SCHOOL

Sponges, Cnidarians, and Worms

- Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

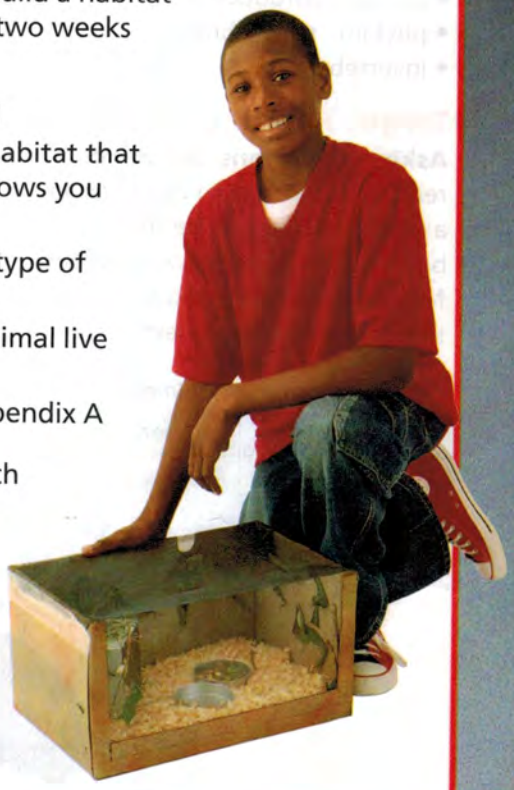
Design and Build an Animal Habitat

Do all animals require the same things to survive? In this project, you will research what it takes to keep a class pet healthy, and then build a habitat to carry out that objective.

Your Goal To research, design, and build a habitat that will keep an animal healthy for two weeks

To complete this project, you must

- research the needs of your animal
- brainstorm various designs for a habitat that meets your animal's needs and allows you to observe its behavior
- select materials and build a prototype of your design
- test your design by having your animal live in the habitat for two weeks
- follow the safety guidelines in Appendix A



Plan It! Choose your animal. Research where it lives, and what types of climate and food it needs. Use this information to design your habitat. Brainstorm some design ideas and make sketches. Select materials to build the habitat. After your teacher approves your design, build and test the habitat.

Section 1

What Is an Animal?

Reading Preview

Key Concepts

- How are animal bodies typically organized?
- What are four major functions of animals?
- How are animals classified?

Key Terms

- cell • tissue • organ
- adaptation
- sexual reproduction
- fertilization
- asexual reproduction
- phylum • vertebrate
- invertebrate

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* or *how* question for each heading. As you read, write the answers to your questions.

Structure of Animals

Question	Answer
What is a cell?	A cell is . . .

Lab zone Discover Activity

Is It an Animal?

1. Carefully examine each of the organisms that your teacher gives you.
2. Decide which ones are animals. For each organism, write down the reasons for your decision. Wash your hands after handling each of the organisms.

Think It Over

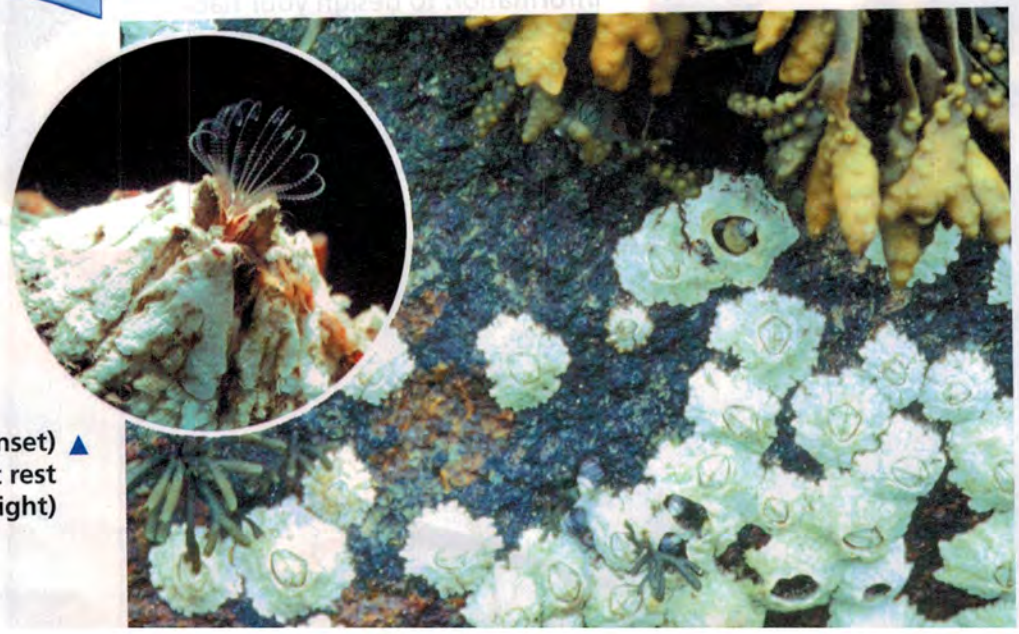
Forming Operational Definitions

Use your notes about each organism to write a definition of "animal."

Your parents may have told you not to eat with your fingers, but they probably never worried that you'd eat with your feet! But animals called barnacles do just that.

A barnacle begins life as a many-legged speck that floats in the ocean. After a while, it settles its head down on a hard surface and fixes itself in place. Then it builds a hard cone around its body. To feed, the barnacle flicks its feathery feet in and out of the cone, as shown below. The feet trap tiny organisms, or living things, that float in the water.

A barnacle may look like a rock, but it is actually an animal. Animals are many-celled organisms that feed on other organisms.



A barnacle feeding (inset) and many barnacles at rest (right) ▲

Structure of Animals

Animals are composed of many cells. A **cell** is the basic unit of structure and function in living things. **The cells of most animals are organized into higher levels of structure, including tissues, organs, and systems.** A group of similar cells that perform a specific function is called a **tissue.** One type of tissue is nerve tissue, which carries messages in the form of electrical signals from one part of the body to another. Another type of tissue is bone tissue, a hard tissue that gives bones strength.

Tissues may combine to form an **organ,** which is a group of several different tissues. For example, a frog's thigh bone is composed of bone tissue, nerve tissue, and blood. An organ performs a more complex function than each tissue could perform alone.

Groups of structures that perform the broadest functions of an animal are called systems. One example of a system is the skeletal system of a frog shown in Figure 1.

Reading Checkpoint **What is an organ?**

FIGURE 1
Levels of Organization
A frog's skeletal system has different levels of organization.
Interpreting Diagrams *List the four levels of organization in order from smallest to largest.*

FIGURE 2
Obtaining Food
This tarantula uses its fangs to kill a grasshopper.

Functions of Animals

From tiny worms to giant whales, animals are diverse. Animals vary not only in size but also in body structure, outward appearance, and the environments in which they live. Despite their diversity, however, all animals carry out the same basic functions. **The major functions of animals are to obtain food and oxygen, keep internal conditions stable, move, and reproduce.** Structures or behaviors that allow animals to perform these basic functions in their environments are called **adaptations.**

Obtaining Food and Oxygen An animal cannot make food for itself—it obtains food by eating other organisms. Animals may feed on plants, other animals, or a combination of plants and animals. They have adaptations that allow them to eat particular kinds of food. For example, the tarantula shown in Figure 2 has an adaptation called fangs—structures it uses to pierce other animals and suck up their juices.

Food provides animals with raw materials for growth and with energy for their bodies' activities, such as breathing and moving. Most animals take food into a cavity inside their bodies. Inside this cavity the food is digested, or broken down into substances that the animal's body can absorb and use. To release energy from food, the body's cells need oxygen. Some animals, like birds, get oxygen from air. Others, like fish, get oxygen from water.

FIGURE 3
Keeping Cool
This dog is keeping cool by getting wet and panting.

Keeping Conditions Stable Animals must maintain a stable environment within their bodies. If this balance is lost, the animal cannot survive for long. For example, cells that get too hot start to die. Therefore, animals in hot environments are adapted, meaning they have adaptations, to keep their bodies cool. Earthworms stay in moist soil during hot days, lizards crawl to shady places, and dogs pant.

Movement All animals move in some way at some point in their lives. Most animals move freely from place to place throughout their lives; for example, by swimming, walking, or hopping. Other animals, such as oysters and barnacles, move from place to place only during the earliest stage of their lives. After they find a good place to attach, these animals stay in one place.

Animal movement is usually related to meeting the basic needs of survival and reproduction. Barnacles wave feathery structures through the water and trap tiny food particles. Some geese fly thousands of miles each spring to the place where they lay eggs. And you've probably seen a cat claw its way up a tree trunk to escape from a barking dog.

Reproduction Because no individual animal lives forever, animals must reproduce. Most animals reproduce sexually. **Sexual reproduction** is the process by which a new organism develops from the joining of two sex cells—a male sperm cell and a female egg cell. The joining of an egg cell and a sperm cell is called **fertilization.** Sperm and egg cells carry information about the characteristics of the parents that produced them, such as size and color. New individuals resulting from sexual reproduction have a combination of characteristics from both parents.

Some animals can reproduce asexually as well as sexually. **Asexual reproduction** is the process by which a single organism produces a new organism identical to itself. For example, animals called sea anemones sometimes split down the middle, producing two identical organisms.

Reading Checkpoint **What is asexual reproduction?**

Lab zone **Try This Activity**

Get Moving

Design an animal with a new and different way of moving. Your design should help your animal obtain food or get out of danger.

1. Make and label a drawing that shows how the animal would move.
2. Using clay, aluminum cans, construction paper, pipe cleaners, and whatever other materials are available, create a three-dimensional model of your animal.
3. Compare your animal to those of other classmates. What are some similarities? What are some differences?

Making Models What features of your design help your animal obtain food or escape danger?

FIGURE 4
Owl Family
Baby owls are produced by sexual reproduction. **Classifying** *Which kind of reproduction involves fertilization?*

Classification of Animals

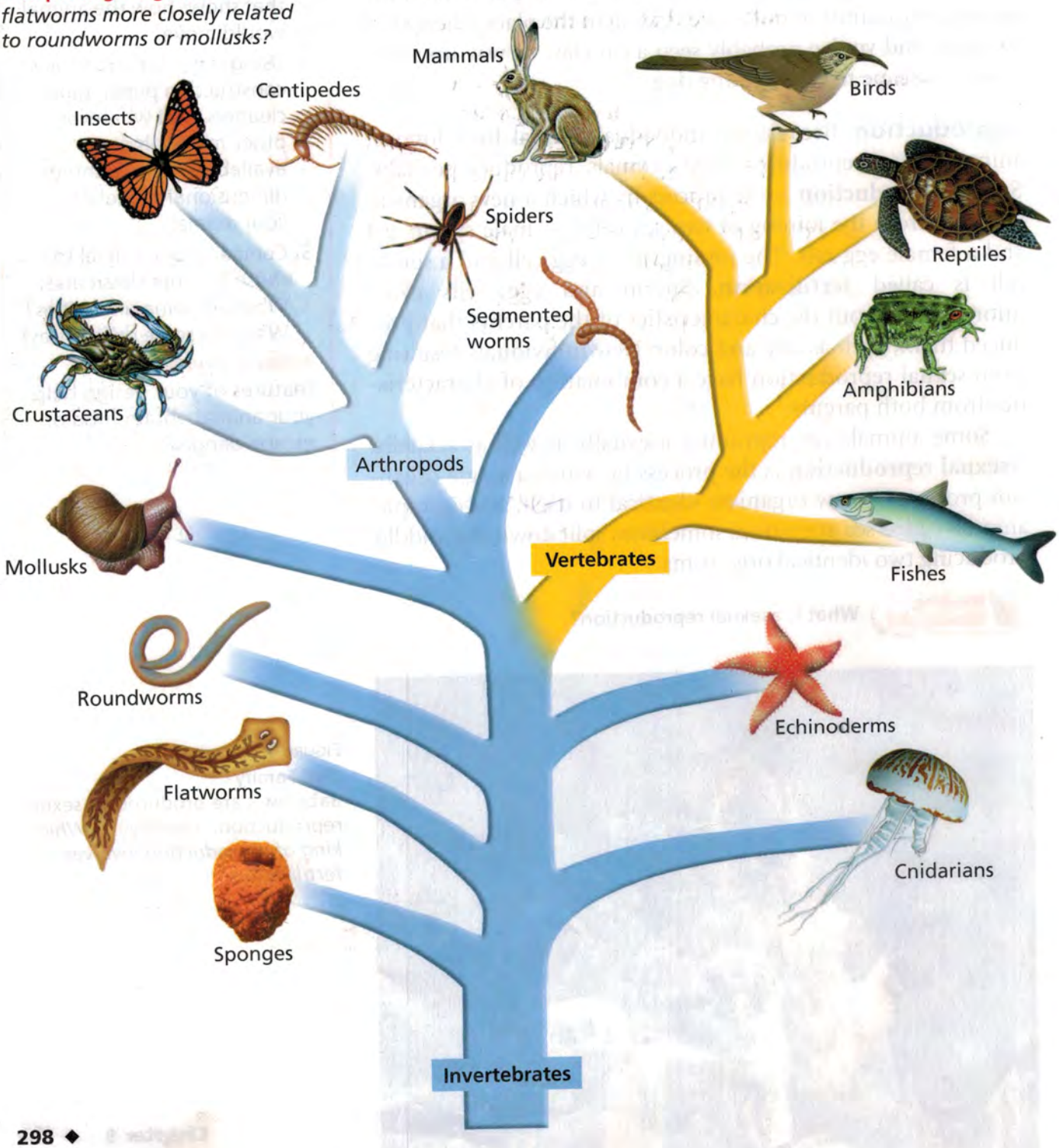
Biologists have already identified more than 1.5 million species, or distinct types, of animals. Each year they discover more. Classifying, or sorting animals into categories, helps biologists make sense of this diversity. Biologists have classified animals into about 35 major groups, each of which is called a **phylum** (FY lum) (plural *phyla*). In Figure 5 you can see some animals from the largest phyla. Notice that the phyla are arranged like branches on a tree.

FIGURE 5

Major Animal Groups

This branching tree shows one hypothesis of how the major animal groups are related.

Interpreting Diagrams *Are flatworms more closely related to roundworms or mollusks?*



The branching pattern of the tree in Figure 5 shows how many biologists think the major groups of animals are related. For example, you can see that segmented worms are more closely related to arthropods than to sponges from their positions on the tree.

A branching tree can also show how biologists think animal life has evolved, or changed over time. This process has resulted in all the different phyla that exist today. Biologists do not know the exact way in which evolution took place. Instead, they can only make inferences on the basis of the best evidence available. Biologists hypothesize that all animals arose from single-celled ancestors.

Animals are classified according to how they are related to other animals. These relationships are determined by an animal's body structure, the way the animal develops, and its DNA. DNA is a chemical in cells that controls an organism's inherited characteristics. All **vertebrates,** or animals with a backbone, are classified in only one phylum. All the other animal phyla contain **invertebrates,** or animals without backbones. Of all the types of animals, about 97 percent are invertebrates!

Reading Checkpoint What is a phylum?

FIGURE 6
Discovering New Species
This biologist is surveying the leaves of rain forest plants, looking for new insect species.

Section 1 Assessment

Target Reading Skill **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. a. **Defining** What is the basic unit of structure and function in an animal?
   b. **Sequencing** Arrange in order from simplest to most complex structure: tissue, system, cell, organ.
2. a. **Reviewing** What are four major functions of animals?
   b. **Summarizing** How do animals obtain food?
   c. **Drawing Conclusions** Why is movement important for animals?
3. a. **Defining** What is a vertebrate?
   b. **Classifying** How do biologists classify animals?
   c. **Interpreting Diagrams** According to the branching tree shown in Figure 5, are reptiles more closely related to mammals or to fishes? Explain your answer.

Writing in Science

Functional Description Write a few paragraphs about how your classroom pet or a pet at home performs the basic functions of an animal.

Section 2

Integrating Mathematics

Animal Symmetry

Reading Preview

Key Concepts

- What is symmetry?
- What can you infer about an animal based on its symmetry?

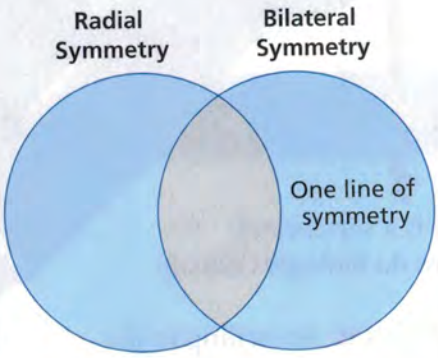
Key Terms

- bilateral symmetry
- radial symmetry

Target Reading Skill

Comparing and Contrasting

As you read, compare and contrast the characteristics of animals with bilateral symmetry and radial symmetry in a Venn diagram like the one below. Write the similarities where the circles overlap, and write the differences on the left and right sides.



Lab zone **Discover Activity**

How Many Ways Can You Fold It?

1. Trace the triangle onto a sheet of paper and cut it out. Then draw a circle by tracing the rim of a glass or other round object. Cut out the circle.
2. Fold the triangle so that one half matches the other. Do the same with the circle.
3. See how many different ways you can fold each figure so that the two halves are identical.

Think It Over

Classifying Name an animal whose body shape can be folded in the same number of ways as the triangle.

Have you ever stopped to look at a butterfly perched on a flower? You probably noticed that bright colors and dark lines criss-cross its wings, making a pretty pattern. Did you also see that the pattern on the left side of the butterfly is a mirror image of the pattern on the right?

The Mathematics of Symmetry

As you can see from the photo of the butterfly in Figure 7, a butterfly's body has two halves. Each half looks like a reflection of the other. **This balanced arrangement of parts, called symmetry, is characteristic of many animals.** A butterfly's symmetry contributes to its pleasing appearance. But, more important, the balanced wings help the butterfly to fly easily.

FIGURE 7
Butterfly Halves
This butterfly's body has two mirror-image halves.
Applying Concepts *What is this balanced arrangement called?*

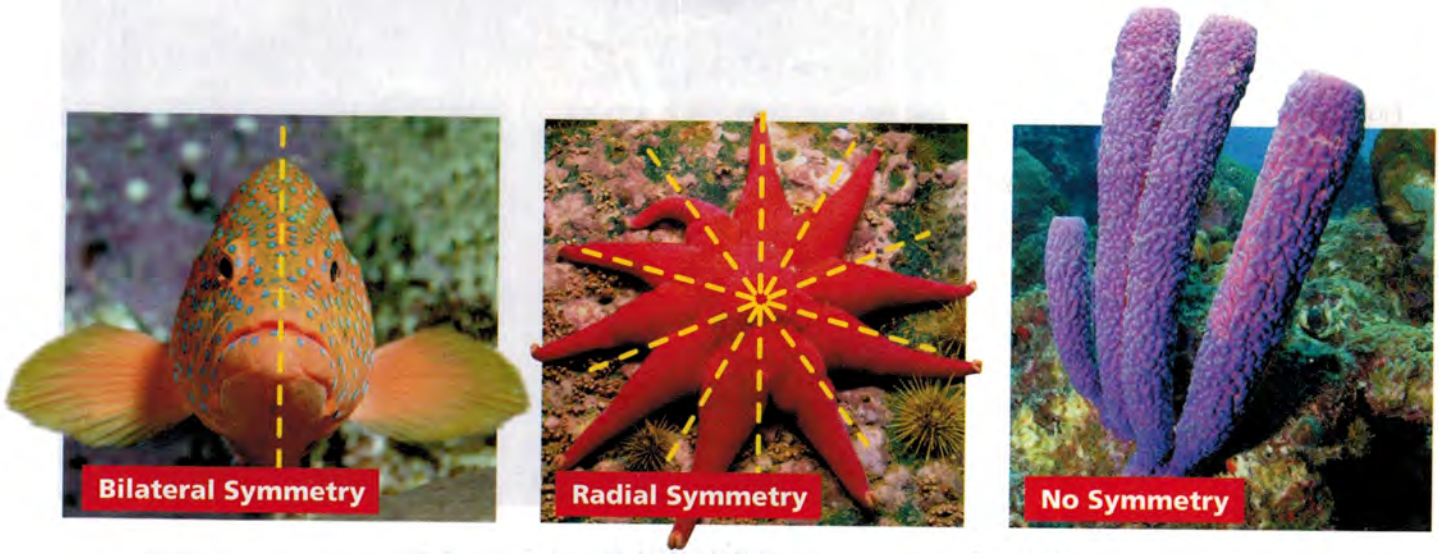


FIGURE 8
Types of Symmetry
Animals have either bilateral or radial symmetry, except for most sponges, which usually have no symmetry.

Animals have different types of symmetry, as shown in Figure 8. In the case of a fish, you can draw a line lengthwise down the middle of its body. This line is called a line of symmetry. An object has **bilateral symmetry** if there is just one line that divides it into halves that are mirror images. In contrast, objects with **radial symmetry** have many lines of symmetry that all go through a central point. For example, the sea star is circular if you look at it from the top. Any line drawn through its center can divide the sea star into two symmetrical halves. A few animals, such as most sponges, have no symmetry.

Reading Checkpoint **How many lines divide an animal with bilateral symmetry into halves?**

Symmetry and Daily Life

Animals without symmetry tend to have simple body plans. In contrast, the bodies of animals with bilateral symmetry or radial symmetry are complex. **Depending on their symmetry, animals share some general characteristics.**

Animals With Radial Symmetry The external body parts of animals with radial symmetry are equally spaced around a central point, like spokes on a bicycle wheel. Because of the circular arrangement of their parts, animals with radial symmetry, such as sea stars, jellyfishes, and sea urchins, do not have distinct front or back ends.

Animals with radial symmetry have several characteristics in common. All of them live in water. Most of them do not move very fast. They stay in one spot, are moved along by water currents, or creep along the bottom.

FIGURE 9
Radial Symmetry
The sea stars in this tide pool have radial symmetry.

FIGURE 10
Bilateral Symmetry
Animals with bilateral symmetry, like this tiger, have a front end with sense organs that pick up information.

Animals With Bilateral Symmetry Most animals you know have bilateral symmetry, including yourself! In general, animals with bilateral symmetry are larger and more complex than those with radial symmetry. They have a front end that typically goes first as the animal moves along. These animals move more quickly and efficiently than most animals with radial symmetry. This is partly because bilateral symmetry allows for a streamlined body. In addition, most animals with bilateral symmetry have sense organs in their front ends that pick up information about what is in front of them. For example, a tiger has eyes, ears, a nose, and whiskers on its head. Swift movement and sense organs help animals with bilateral symmetry obtain food and avoid enemies.

Reading Checkpoint **Where are the sense organs of an animal with bilateral symmetry typically found?**

Go Online
SCILINKS NSTA
For: Links on animal symmetry
Visit: www.SciLinks.org
Web Code: scn-0212

Section 2 Assessment

Target Reading Skill **Comparing and Contrasting**
Use the information in your Venn diagram about symmetry to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Reviewing** What is symmetry?
   b. **Comparing and Contrasting** How are bilateral symmetry and radial symmetry alike? How are they different?
   c. **Applying Concepts** What kind of symmetry does a grasshopper have? Explain.
2. a. **Identifying** What general characteristics do animals with radial symmetry share?
   b. **Summarizing** What four body characteristics do animals with bilateral symmetry usually have?
   c. **Making Generalizations** How would having sense organs in front be helpful to an animal?

Lab zone At-Home Activity

Front-End Advantages With a family member, observe as many different animals as possible in a yard or at a park. Look in lots of different places, such as in the grass, under rocks, and in the air. Explain the advantages an animal with a distinct front end has. Tell the person what this type of body arrangement is called.

Section 3

Sponges and Cnidarians

Reading Preview

Key Concepts

- What are the main characteristics of sponges?
- What are the main characteristics of cnidarians?
- Why are coral reefs important?

Key Terms

- larva
- cnidarian
- polyp
- medusa
- colony
- coral reef

Target Reading Skill

Comparing and Contrasting

As you read, compare and contrast sponges and cnidarians by completing a table like this one.

Sponges and Cnidarians

Feature	Sponge	Cnidarian
Body structure	Hollow bag with pores	
Cell type that traps food		
Method(s) of reproduction		

Lab zone

Discover Activity

How Do Natural and Synthetic Sponges Compare?

1. Examine a natural sponge, and then use a hand lens or a microscope to take a closer look. Look carefully at the holes in the sponge. Draw what you see through the lens.
2. Cut out a small piece of sponge and examine it with a hand lens. Draw what you see.
3. Repeat Steps 1 and 2 with a synthetic kitchen sponge.

Think It Over

Observing What are three ways a natural and a synthetic sponge are similar? What are three ways they are different?

Eagerly but carefully, you and the others in your group put on scuba gear as you prepare to dive into the ocean. Over the side of the boat you go. As you descend through the water, you see many kinds of fishes. When you get to the bottom, you notice other organisms, too. Some are as strange as creatures from a science fiction movie. A few of these unusual organisms may be invertebrate animals called sponges.

Sponges don't look or act like most animals you know. In fact, they are so different that for a long time, people thought that sponges were plants. Like plants, adult sponges stay in one place. But unlike most plants, sponges take food into their bodies.

◀ **Diver investigating a barrel sponge**

Sponges

Sponges live all over the world—mostly in oceans, but also in freshwater rivers and lakes. Adult sponges are attached to hard surfaces underwater. Water currents carry food and oxygen to them and take away their waste products. Water currents also play a role in their reproduction and help transport their young to new places to live.

Body Structure **Sponges are invertebrate animals that usually have no body symmetry and never have tissues or organs.** A sponge looks something like a hollow bag with a large opening at one end and many tiny pores covering its surface. In fact, the name of the phylum to which sponges belong—phylum Porifera—means "having pores."

Look at Figure 11. A sponge's body has different kinds of cells and structures for different functions. For example, most sponges have spikes. The network of spikes throughout the sponge supports its soft body, keeping it upright in the water. The spikes also help a sponge defend itself against an animal that might eat it, which is called a predator. The spikes can be as sharp as needles. Even so, some fish eat sponges.

Go Online
active art

For: Structure of a Sponge activity
Visit: PHSchool.com
Web Code: cep-2013

FIGURE 11
Structure of a Sponge

Structures surrounding the central cavity of a sponge are adapted for different functions.
Interpreting Diagrams *Which kind of cell in the sponge digests and distributes food?*

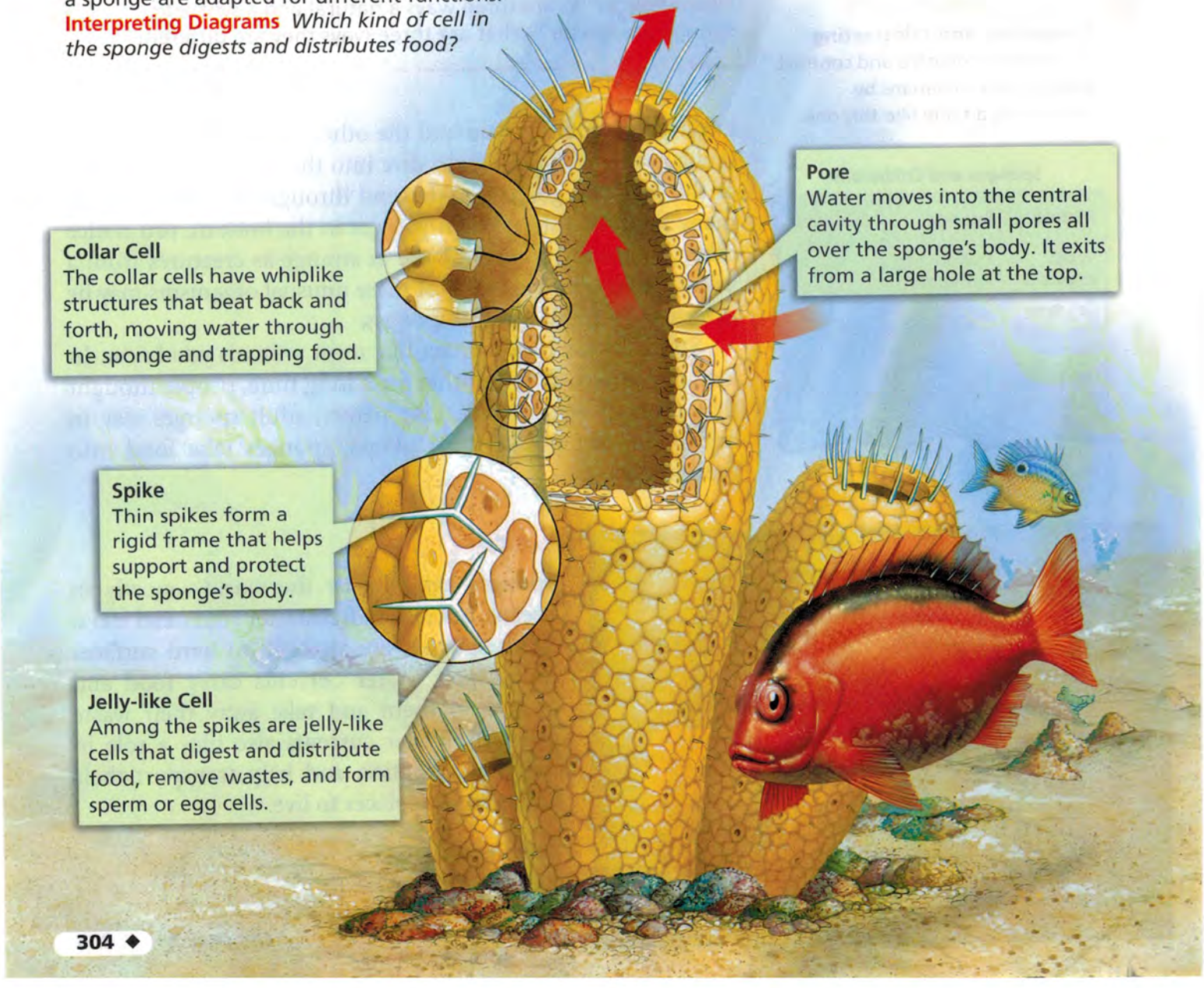
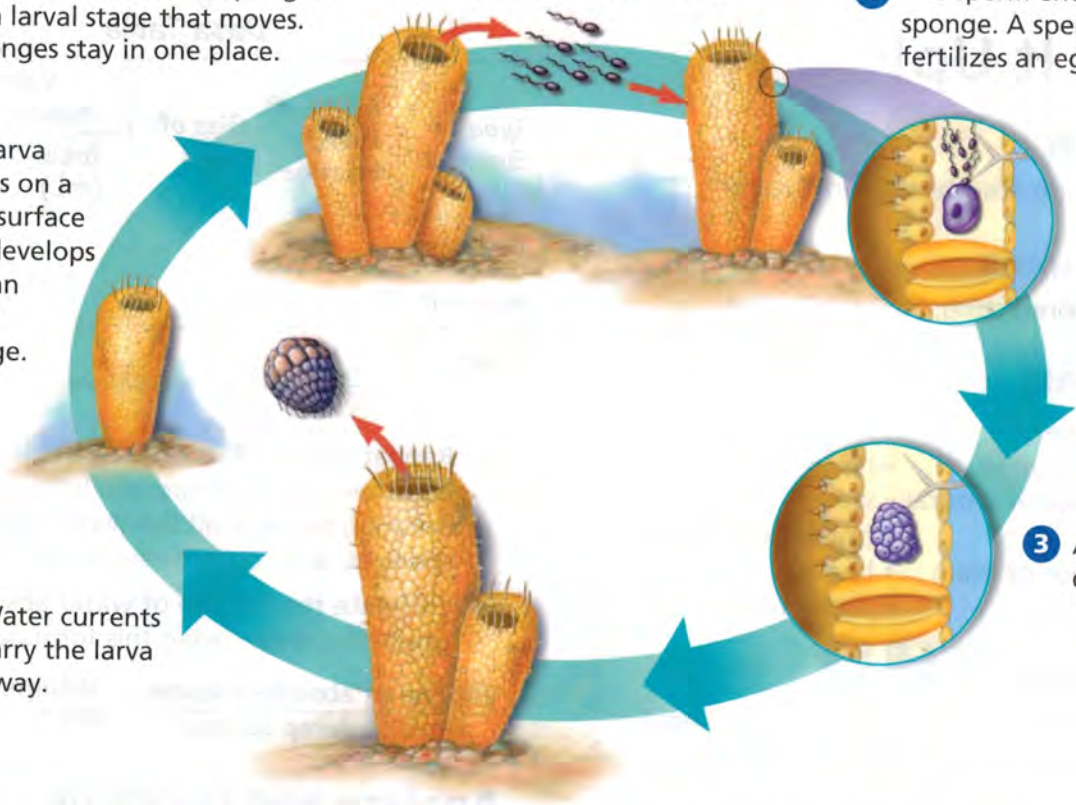


FIGURE 12

Reproduction of a Sponge

The sexual reproduction of sponges involves a larval stage that moves. Adult sponges stay in one place.



Obtaining Food and Oxygen A sponge eats tiny single-celled organisms. The sponge filters these organisms from the water moving through it. The collar cells that line the central cavity trap the tiny organisms. Jelly-like cells inside the sponge then digest, or break down, the food. Larger sponges can filter thousands of liters of water per day!

A sponge gets its oxygen from water, too. After the water moves through a sponge's pores, it passes over cells inside the sponge. Oxygen in the water then moves into the sponge's cells.

Reproduction Sponges reproduce both asexually and sexually. Budding is one form of asexual reproduction in sponges. In budding, small new sponges grow from the sides of an adult sponge. Eventually, the buds break free and begin life on their own.

Sponges reproduce sexually, too, but they do not have separate sexes. A sponge produces both sperm cells and egg cells. The sperm cells are released into the water. They enter another sponge and fertilize its eggs, as shown in Figure 12. After fertilization, a larva develops. A **larva** (plural *larvae*) is an immature form of an animal that looks very different from the adult.

Reading Checkpoint What is a larva?

Math Skills

Calculating a Rate

To calculate the rate of water flow in a sponge, divide the volume of water that the sponge filters by the time it takes the water to pass through the sponge.

$$\text{Flow rate} = \frac{\text{Volume of water}}{\text{Time}}$$

For example, a marble-sized sponge filters 15.6 liters of water in a day. How many liters does it filter per hour?

$$\frac{15.6\ \text{L}}{24\ \text{h}} = 0.65\ \text{L/h}$$

Practice Problem In 4 days, a sponge filters 1,200 L. What is its rate of water flow per day?

Lab zone **Consumer Lab**

Soak It Up!

Problem

Which sponge absorbs the most water?

Skills Focus

observing, predicting, communicating

Materials

- damp piece of cellulose sponge
- damp piece of natural sponge
- damp piece of foam sponge
- balance
- large bowl of tap water
- graduated cylinder
- beaker
- paper towel

Procedure

1. Copy the data table on a separate sheet.
2. Examine the size of the pores in each sponge. Record your observations.
3. Make a prediction about which sponge will absorb the most water. Record your prediction and give a reason.
4. Place a damp piece of cellulose sponge on a balance and measure its mass. Record the mass in the data table. Remove the sponge from the balance.
5. Repeat Step 4 with the natural sponge and then the foam sponge.
6. Submerge the cellulose sponge in a bowl of water. Squeeze it several times to remove all air bubbles. Release the sponge and let it absorb water. Then remove the sponge and place it in the beaker.
7. Squeeze out as much water as possible from the sponge into the beaker. *(Hint:* Squeeze and twist the sponge until no more drops of water come out.)
8. Pour the water from the beaker into the graduated cylinder. Measure the volume of water and record the volume in the data table. Pour the water from the graduated cylinder back into the bowl. Dry the graduated cylinder and beaker with a paper towel.

Data Table

Type of Sponge	Mass of Damp Sponge	Size of Pores	Volume of Absorbed Water	
			Total (mL)	Per Gram (mL/g)
Cellulose				
Natural				
Foam				

9. Repeat Steps 6–8 using the natural sponge and then the foam sponge. When you are finished, squeeze all the water from your sponges, and return them to your teacher.
10. Calculate the volume of water absorbed per gram of sponge, using this formula:

$$\frac{\text{Volume of absorbed water}}{\text{Mass of damp sponge}} = \text{Volume absorbed per gram}$$

Analyze and Conclude

1. **Observing** Which sponge absorbed the most water per gram of sponge? The least? Was your prediction confirmed?
2. **Drawing Conclusions** What can you conclude about the relationship between pore size and the ability of the sponge to absorb water?
3. **Predicting** How would the volume of absorbed water change if each of the sponges had twice the mass of the sponges you studied? Explain.
4. **Communicating** Natural sponges can cost more than cellulose and foam sponges. Consider that information and the results of your investigation. Which sponge would you recommend to consumers for absorbing water spills? Explain your choice.

Design an Experiment

Design an experiment to test the prediction you made in Question 3 above. Write your hypothesis as an "If ... then ..." statement. *Obtain your teacher's permission before carrying out your investigation.*

Cnidarians

Some other animals you might notice on an underwater dive are jellyfishes, corals, and sea anemones. These animals are **cnidarians** (ny DEHR ee unz), invertebrates that have stinging cells and take food into a central body cavity. **Cnidarians use stinging cells to capture food and defend themselves.**

Body Structure Cnidarians have two different body plans, which you can see in Figure 13. Notice that one form looks something like a vase and the other form looks like an upside-down bowl. Both body plans have radial symmetry, a central hollow cavity, and tentacles that contain stinging cells.

The vase-shaped body plan is called a **polyp** (PAHL ip). The sea anemone you see in Figure 13 is a polyp. A polyp's mouth opens at the top and its tentacles spread out from around the mouth. Most polyps are adapted for a life attached to an underwater surface.

The bowl-shaped body plan is called a **medusa** (muh DOO suh). The jellyfish you see in Figure 13 is a medusa. A medusa, unlike a polyp, is adapted for a swimming life. Medusas have mouths that open downward and tentacles that trail down. Some cnidarians go through both a polyp stage and a medusa stage during their lives. Others are either polyps or medusas for their entire lives.

Lab zone Try This Activity

Hydra Doing?

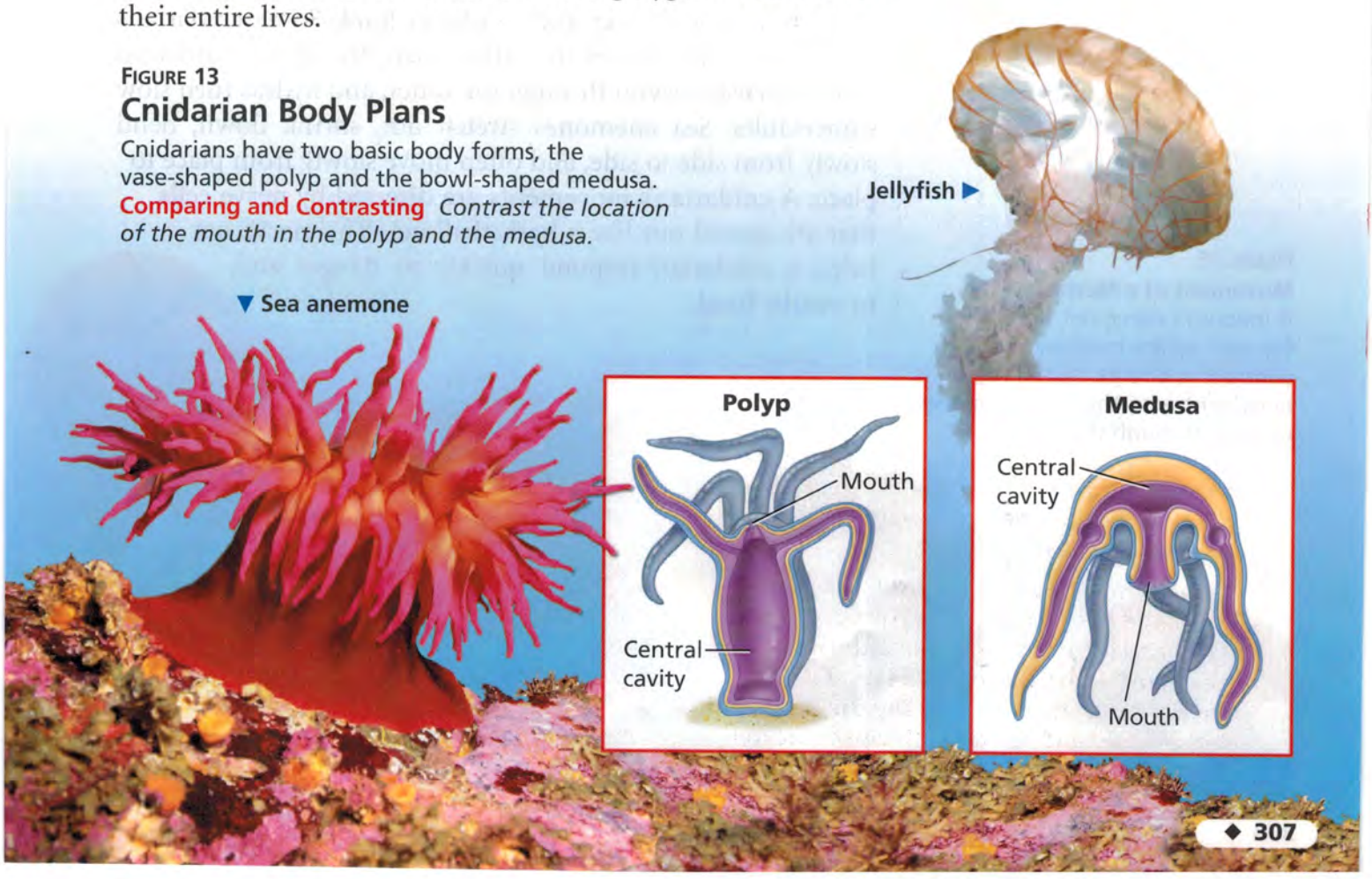
1. Put a drop of water containing hydras in a small unbreakable bowl or petri dish. Allow it to sit for about 15 minutes.
2. Use a hand lens to examine the hydras as they swim. Then gently touch the tentacles of a hydra with the end of a toothpick. Watch what happens.
3. Return the hydras to your teacher. Wash your hands.

Classifying Is a hydra a polyp or a medusa? Describe its method of movement.

FIGURE 13

Cnidarian Body Plans

Cnidarians have two basic body forms, the vase-shaped polyp and the bowl-shaped medusa.
Comparing and Contrasting *Contrast the location of the mouth in the polyp and the medusa.*



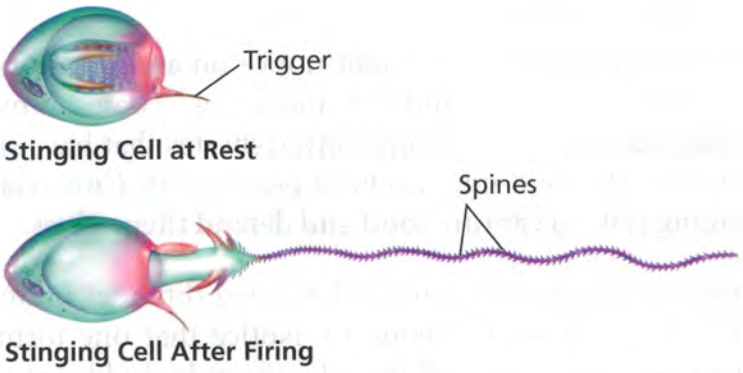


FIGURE 14
Cnidarian Attack!
A stinging cell fires when its trigger brushes against prey, such as a fish.

Obtaining Food Both polyps and medusas obtain food in the same way. Cnidarians use stinging cells to catch the animals they eat, which are called prey. You can see a stinging cell in Figure 14. The cell contains a threadlike structure, which has many sharp spines. When the stinging cell touches prey, this threadlike structure explodes out of the cell and into the prey. Some stinging cells also release venom into the prey. When the prey becomes helpless, the cnidarian uses its tentacles to pull the prey into its mouth. From there, the prey passes into a hollow central body cavity, where it is digested. Undigested food is expelled through the mouth.

Movement Unlike adult sponges, many cnidarians can move to escape danger and to obtain food. Some cnidarians have muscle-like tissues that allow them to move in different ways. Jellyfishes swim through the water, and hydras turn slow somersaults. Sea anemones stretch out, shrink down, bend slowly from side to side, and often move slowly from place to place. A cnidarian's movements are directed by nerve cells that are spread out like a basketball net. This nerve net helps a cnidarian respond quickly to danger and to nearby food.

FIGURE 15
Movement of a Medusa
A medusa's nerve net signals the top part of the medusa's body to contract and relax. As the top of its body contracts, the medusa moves upward through the water.

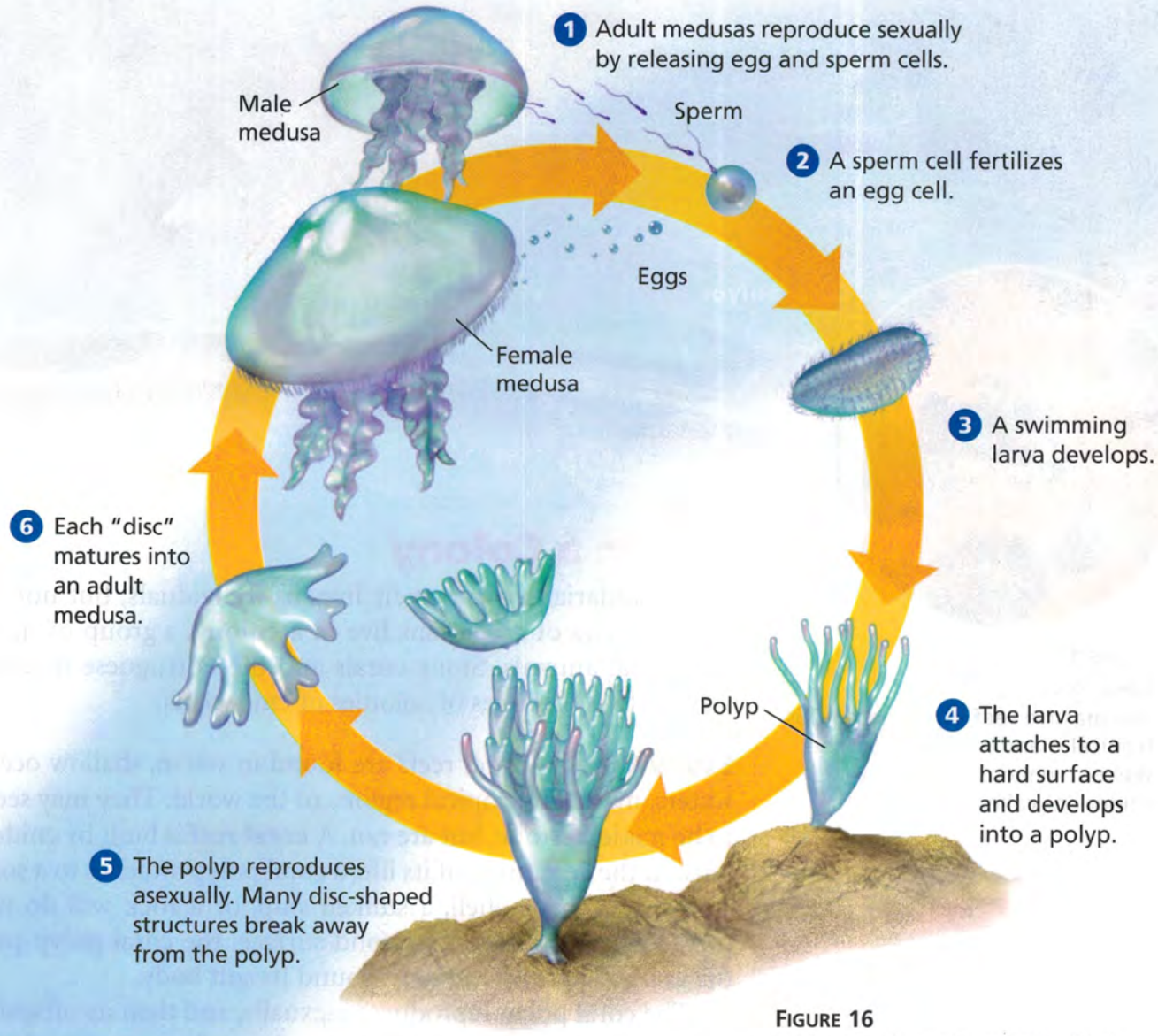


FIGURE 16

Life Cycle of a Jellyfish

The life cycle of a moon jelly has both a polyp and a medusa stage, and both asexual reproduction and sexual reproduction.

Interpreting Diagrams *Which form of the moon jelly (polyp or medusa) shows a form of asexual reproduction? Explain.*

Reproduction Cnidarians reproduce both asexually and sexually. For polyps such as hydras, corals, and sea anemones, budding is the most common form of asexual reproduction. Amazingly, some polyps just pull apart, forming two new polyps. Both kinds of asexual reproduction allow the numbers of polyps to increase rapidly in a short time.

Sexual reproduction in cnidarians occurs in a variety of ways. Some species of cnidarians have both sexes within one individual. In others, the sexes are separate individuals. Many cnidarians have life cycles, or a sequence of different stages of development. In Figure 16, you can see the life cycle of a moon jelly, which involves both asexual and sexual reproduction.

Reading Checkpoint **What are two examples of asexual reproduction seen in polyps?**

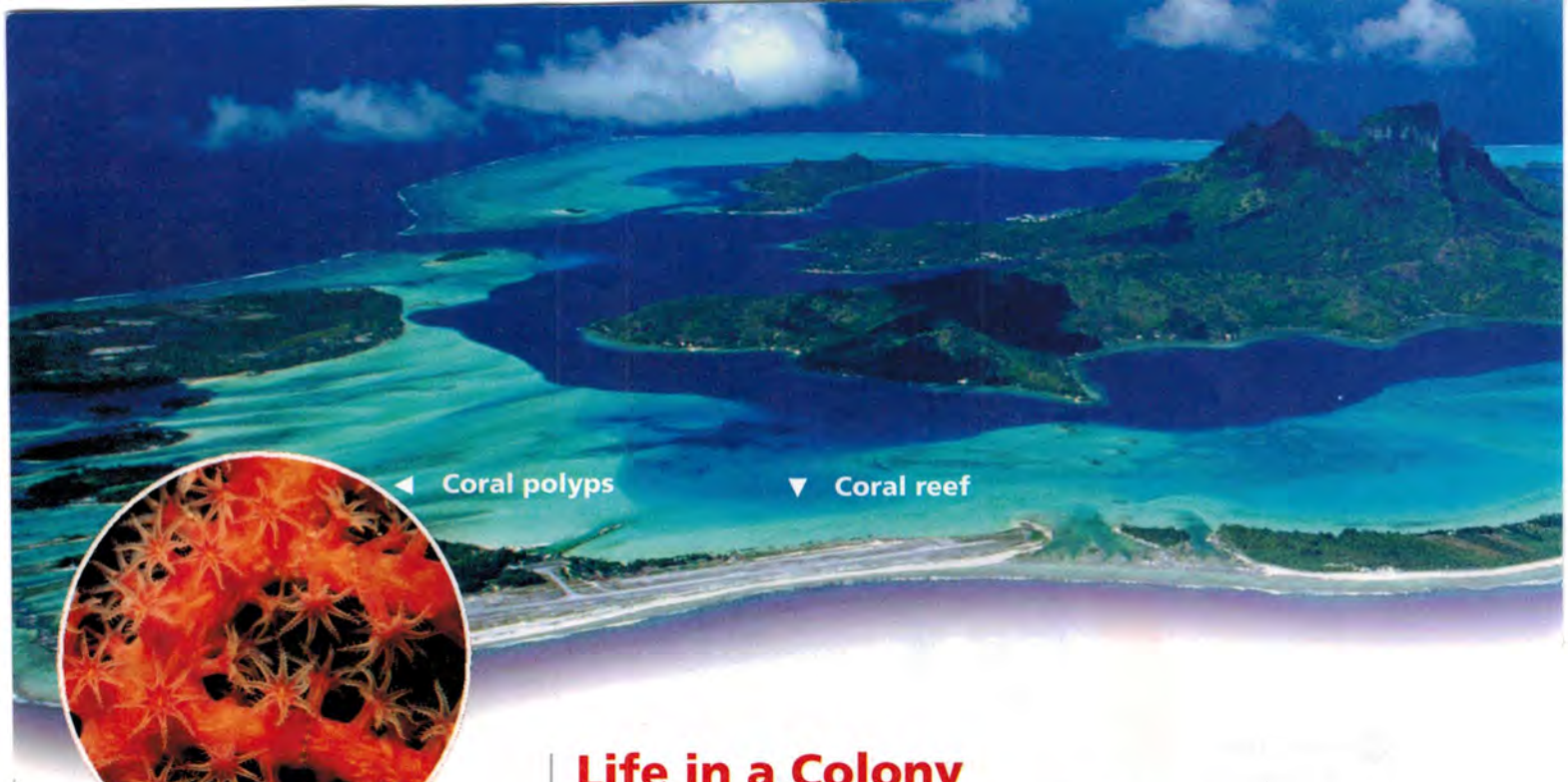


FIGURE 17
Coral Reef
The massive reef surrounding this tropical island is made from the skeletal remains of the tiny cnidarians called coral (inset).

Life in a Colony

Many cnidarians spend their lives as individuals, but not all. Some species of cnidarians live in a **colony,** a group of many individual animals. Stony corals and the Portuguese man-of-war are two examples of colonies of cnidarians.

Stony Corals Coral reefs are found in warm, shallow ocean waters, mainly in tropical regions of the world. They may seem to be made of stone, but are not. A **coral reef** is built by cnidarians. At the beginning of its life, a coral polyp attaches to a solid surface. A broken shell, a sunken ship, or a rock will do just fine. After attaching to the solid surface, the coral polyp produces a hard, stony skeleton around its soft body.

The coral polyp reproduces asexually, and then its offspring reproduce asexually, too. Over time, that polyp may give rise to thousands more, each with a hard skeleton. When the polyps die, their skeletons remain behind. Over thousands of years, as live corals add their skeletons to those that have died, rocklike reefs grow up from the sea floor. The top layer of the reef is covered with hundreds of thousands of still-living coral polyps.

Coral reefs are home to more species of fishes and invertebrates than any other environment on Earth. Hundreds of sponge species live among the corals, constantly filtering water through their bodies. Worms burrow into the coral reef. Giant clams lie with their huge shells slightly open. Shrimp and crabs edge out of hiding places below the corals. At night, bright blue damselfish settle into pockets in the coral. At dawn and dusk, sea turtles, sea snakes, and sharks all visit the reef, hunting for prey. These living things interact in complex ways, creating a rich and beautiful environment.

FIGURE 18
Portuguese Man-of-War
The Portuguese man-of-war is a tightly coordinated colony of polyps and medusas.

Portuguese Man-of-War Sometimes the association of individual animals in a colony is so tight that the colony acts like a single animal. The Portuguese man-of-war contains as many as 1,000 individuals that function together as one unit.

At the top of the Portuguese man-of-war is a gas-filled chamber that allows the colony to float on the surface of the ocean. Various polyps with different functions drift below. Some polyps catch prey for the colony with stinging cells. Others digest the prey. Still other polyps are adapted for reproduction.

Reading Checkpoint **What are two examples of colonies of cnidarians?**

Section 3 Assessment

Target Reading Skill **Comparing and Contrasting** Use your table to quiz a partner about how sponges and cnidarians trap food. How do their methods for trapping food differ?

Reviewing Key Concepts

1. a. **Describing** What are the characteristics of a sponge?
   b. **Comparing and Contrasting** How are the cells of a sponge alike? How are they different?
2. a. **Identifying** What is one type of cell that all cnidarians have?
   b. **Sequencing** What steps are involved in how a cnidarian obtains food?
   c. **Inferring** How might a cnidarian protect itself?
3. a. **Identifying** What is a coral reef?
   b. **Summarizing** How is a coral reef built?
   c. **Making Judgments** Why is it important to protect coral reefs?

Math Practice

4. **Calculating a Rate** A very large sponge can filter 1,500 liters of water in a day. How much water can it filter per hour?

Coral Reefs in Danger

Coral reefs off the coasts of many nations are in danger. Although coral reefs are as hard as rocks, the coral animals themselves are quite delicate. Recreational divers can damage the fragile reefs. Is it possible to protect the reefs while still allowing divers to explore them?

Diving supports local businesses

The Issues

What's the Harm in Diving?

More than 1.5 million recreational divers live in the United States. With so many divers it is hard to guarantee that no harm will occur to coral reefs. Divers can cause significant damage by standing on or even touching these fragile reefs. Harm to the reefs is even more likely to occur when divers collect coral for their own enjoyment or to sell for profit. You can see brightly colored coral from the sea in jewelry and in decorations.

Should Reefs Be Further Protected?

The United States government has passed laws making it illegal, under most circumstances, to remove coral from the sea. Because a few divers break these laws, some people want to ban diving altogether. However, many divers say it's unfair to ban diving just because of a few lawbreakers.

Many divers consider coral reefs the most exciting and beautiful places in the ocean to explore. As divers and other people visit and learn more about these delicate coral reefs, they increase others' awareness of them. Public awareness may be the best way to ensure that these rich environments are protected.

More Than a Diving Issue

Coral reefs are major tourist attractions that bring money and jobs to people in local communities. If diving were banned, local businesses would suffer significantly. Also, although divers can harm coral reefs, other human activities that result in ocean pollution, oil spills, and illegal fishing can also cause harm. In addition, natural events, such as tropical storms, changes in sea level, and changes in sea temperature, can also damage the fragile reefs.

Reefs house and protect many species of sea animals, including sponges, shrimp, sea turtles, and fishes.

What Would You Do?

1. Identify the Problem

In your own words, explain the controversy surrounding diving near coral reefs.

2. Analyze the Options

List the arguments on each side of the issue. Note the pros and cons. How well would each position protect the reefs? Who might be harmed or inconvenienced?

3. Find a Solution

Write a newspaper editorial stating your position on whether diving should be allowed near coral reefs. State your position and reasons clearly.

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Section 4

Worms

Reading Preview

Key Concepts

- What are the three main phyla of worms?
- What are the main characteristics of each phylum of worms?

Key Terms

- parasite • host
- free-living organism
- scavenger • anus
- closed circulatory system

Target Reading Skill

Using Prior Knowledge Before you read, write what you know about worms in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Worms are long and skinny. 2.

What You Learned
1. 2.

Lab zone **Discover Activity**

What Does a Flatworm Look Like?

1. Your teacher will give you a planarian, a kind of flatworm. Pick the worm up with the tip of a small paintbrush. Place it carefully in a container. Use a dropper to cover the planarian with spring water.
2. Observe the planarian with a hand lens for a few minutes. Describe how the planarian moves. Draw a picture of the planarian.
3. Return the planarian to your teacher, and wash your hands.

Think It Over

Observing How does a planarian differ from a sponge?

You might think that all worms are small, slimy, and wriggly. But many worms do not fit that description. Some worms are almost three meters long and are as thick as your arm. Others look like glowing, furry blobs. Worms may glide through water or climb around with paddle-like bristles. Still others are very small and live underwater in tubes cemented to rocks.

Characteristics of Worms

There are many kinds of worms, all with their own characteristics. **Biologists classify worms into three major phyla—flatworms, roundworms, and segmented worms.** Flatworms belong to the phylum Platyhelminthes (plat ee HEL minth eez); roundworms belong to the phylum Nematoda; segmented worms belong to the phylum Annelida.

FIGURE 19
Giant Earthworm
A giant Gippsland earthworm can grow to be more than 1 meter long. It is one of approximately 1,000 earthworm species found in Australia.

FIGURE 20
Three Phyla of Worms
The three major phyla of worms are flatworms, roundworms, and segmented worms.
Observing *How are the body shapes of these three types of worms similar?*

Flatworm ▲
Long, flat body

Roundworm ▲
Long, round body

Segmented Worm ▲
Long, round body made up of linked segments

Body Structure All worms are invertebrates that have long, narrow bodies without legs. In Figure 20, you can compare the body shapes of three types of worms. Unlike sponges or cnidarians, worms have bilateral symmetry. Therefore, they have head and tail ends. In addition, they all have tissues, organs, and body systems.

Nervous System Worms are the simplest organisms with a brain, which is a knot of nerve tissue located in the head end. Because a worm's brain and some of its sense organs are located in its head end, the worm can detect objects, food, mates, and predators quickly. It can respond quickly, too. Sense organs that are sensitive to light, touch, and vibrations pick up information from the environment. The brain interprets that information and directs the animal's response. For example, if an earthworm on the surface of the ground senses the vibrations of a footstep, the worm will quickly return to its underground burrow.

Reproduction Both sexual and asexual reproduction are found in the worm phyla. In many species of worms, there are separate male and female animals, as in humans. In other species of worms, each individual has both male and female sex organs. A worm with both male and female sex organs does not usually fertilize its own eggs. Instead, two individuals mate and exchange sperm. Many worms reproduce asexually by methods such as breaking into pieces. In fact, if you cut some kinds of worms into several pieces, a whole new worm will grow from each piece.

Reading Checkpoint **What type of symmetry do worms have?**

FIGURE 21
Planarian
Planarians are free-living flatworms that live in ponds, streams, and oceans.
Comparing and Contrasting
How does a free-living organism differ from a parasite?

Flatworms

As you'd expect from their name, flatworms are flat. They include such organisms as tapeworms, planarians, and flukes. Although tapeworms can grow to be 10 to 12 meters long, some other flatworms are almost too small to be seen. All flatworms share certain characteristics. **Flatworms are flat and as soft as jelly.**

Many flatworms are parasites. A **parasite** is an organism that lives inside or on another organism. The parasite takes its food from its **host,** the organism in or on which it lives. Parasites may rob their hosts of food and make them weak. They may injure the host's tissues or organs, but they rarely kill their host. All tapeworms and flukes are parasites.

In contrast, some flatworms are free-living. A **free-living organism** does not live in or on other organisms. Free-living flatworms may glide over the rocks in ponds, slide over damp soil, or swim slowly through the ocean like ruffled, brightly patterned leaves.

Planarians Planarians are free-living flatworms. Planarians are **scavengers**—they feed on dead or decaying material. But they are also predators and will attack any animal smaller than they are. A planarian feeds like a vacuum cleaner. The planarian glides onto its food and inserts a feeding tube into it. Digestive juices flow out of the planarian and into the food. These juices begin to break down the food while it is still outside the worm's body. Then the planarian sucks up the partly digested bits. Digestion is completed within a cavity inside the planarian. Undigested food exits through the feeding tube.

If you look at the head of the planarian shown in Figure 21, you can see two dots. These dots are called eyespots. The eyespots can detect light but cannot see a detailed image as human eyes can. A planarian's head also has cells that pick up odors. Planarians rely mainly on smell, not light, to locate food.

Tapeworms Tapeworms are one kind of parasitic flatworm. A tapeworm's body is adapted to absorbing food from the host's digestive system. Some kinds of tapeworms can live in human hosts. Many tapeworms live in more than one host during their lifetime. You can see the life cycle of the dog tapeworm in Figure 22. Notice that this tapeworm has two different hosts—a dog and a rabbit.

Reading Checkpoint **How does a scavenger obtain food?**

FIGURE 22
Life Cycle of a Dog Tapeworm
The tapeworm is a parasite that lives in more than one host during its life cycle.

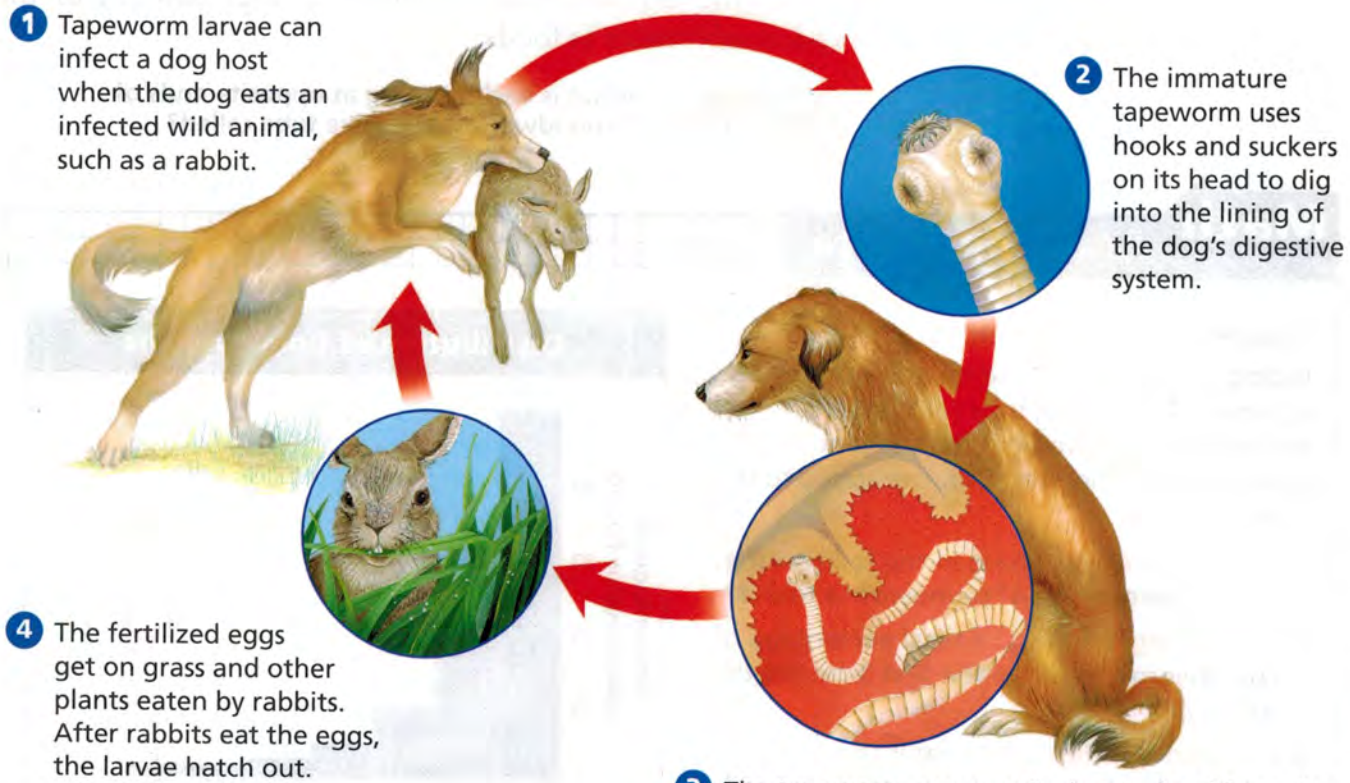


FIGURE 23
A Roundworm
The transparent body of this roundworm has been stained for better viewing under a microscope.

Roundworms

The next time you walk along a beach, consider that about a million roundworms live in each square meter of damp sand. Roundworms can live in nearly any moist environment—including forest soils, Antarctic sands, and pools of super-hot water. Most roundworms are tiny and difficult to see, but they may be the most abundant animals on Earth. Some species are free-living and some are parasites.

Unlike flatworms, roundworms have cylindrical bodies. They look like tiny strands of cooked spaghetti that are pointed at each end. **Unlike cnidarians or flatworms, roundworms have a digestive system that is like a tube, open at both ends.** Food travels in one direction through the roundworm's digestive system. Food enters at the animal's mouth, and wastes exit through an opening, called the **anus,** at the far end of the tube.

A one-way digestive system is efficient. It is something like an assembly line, with a different part of the digestive process happening at each place along the line. Digestion happens in orderly stages. First, food is broken down by digestive juices. Then the digested food is absorbed into the animal's body. Finally, wastes are eliminated. This type of digestive system enables the animal's body to absorb a large amount of the needed substances in foods.

Reading Checkpoint **What is each opening at opposite ends of a roundworm's digestive tube called?**

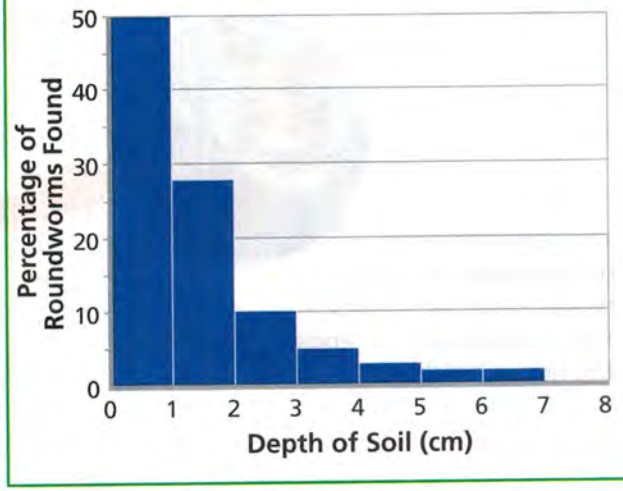
Math Analyzing Data

Roundworm Numbers

Biologists counted all the roundworms living in a plot of soil. Then they calculated the percentage that lives in different centimeter depths of soil. Their results are graphed to the right.

1. **Reading Graphs** Where in the soil was the largest percentage of roundworms found?
2. **Calculating** What is the total percentage of roundworms found in the first 3-cm depth of soil?
3. **Drawing Conclusions** What is the relationship between the depth of the soil and the abundance of roundworms in the soil?

Distribution of Roundworms



Segmented Worms

If you have ever dug in a garden, you have probably seen earthworms wriggling through the moist soil. Earthworms are segmented worms. So are leeches and some sea-floor worms.

Body Structure When you look at an earthworm, you see a body made up of a series of rings separated by grooves, something like a vacuum cleaner hose. **Earthworms and other segmented worms have bodies made up of many linked sections called segments.** On the outside, the segments look nearly identical, as you can see in Figure 24. On the inside, some organs are repeated in most segments. For example, each segment has tubes that remove wastes. Other organs, however, such as the earthworm's reproductive organs, are found only in certain segments.

All segmented worms have a long string of nerve tissue called a nerve cord and a digestive tube that run the length of the worm's body. Like roundworms, segmented worms have a one-way digestive system with two openings.

Circulatory System Segmented worms have a closed circulatory system. In a **closed circulatory system,** blood moves only within a connected network of tubes called blood vessels. In contrast, some animals, such as snails and lobsters, have an open circulatory system in which blood leaves the blood vessels and sloshes around inside the body. In both cases the blood carries oxygen and food to cells. But a closed circulatory system can move blood around an animal's body much more quickly than an open circulatory system can.

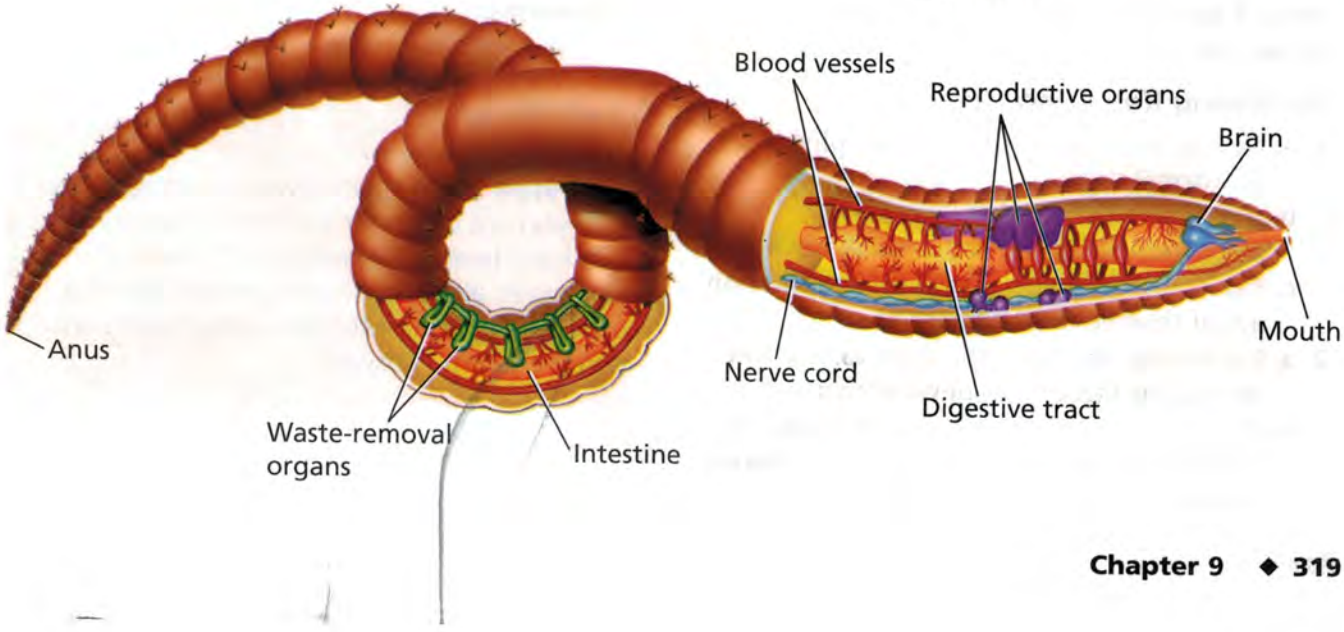


FIGURE 24
Structure of an Earthworm
An earthworm's body is divided into more than 100 segments. Some organs are repeated in most of those segments. Other organs exist in only a few segments.
Interpreting Diagrams *Name an example of a body system that runs through all of the worm's segments.*

FIGURE 25
Earthworms and Garden Health
You are likely to find earthworms when you dig in garden soil.

Earthworms in the Environment Like many segmented worms, earthworms tunnel for a living. On damp nights or rainy days, they come up out of their burrows. They crawl on the surface of the ground, seeking leaves and other decaying matter that they will drag underground and eat. Staying in moist soil or damp air is important because this keeps the worm's skin moist. An earthworm obtains oxygen through moisture on its skin.

Did you know that earthworms are among the most helpful inhabitants of garden and farm soil? They benefit people by improving the soil in which plants grow. Earthworm tunnels loosen the soil, allowing air, water, and plant roots to move through it. Earthworm droppings make the soil more fertile.

Reading Checkpoint **Why must earthworms stay moist?**

Section 4 Assessment

Target Reading Skill **Using Prior Knowledge** Review your graphic organizer about worms and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. a. **Listing** What are the three main phyla of worms?
   b. **Describing** What are the common characteristics of the bodies of all worms?
   c. **Explaining** How do worms get information about their environments?
2. a. **Reviewing** What are the main differences among the three main phyla of worms?
   b. **Classifying** Suppose you use a microscope to look at a tiny worm. What characteristics would you look for to classify it?
   c. **Comparing and Contrasting** Compare and contrast the types of digestive systems found in worms.

Writing in Science

Interview Suppose that worms can talk, and that you are an editor for *Worm* magazine. You have been assigned to interview a tapeworm about its feeding habits. Write a transcript of your interview—your questions and the worm's answers.

Lab zone Skills Lab

Earthworm Responses

Problem

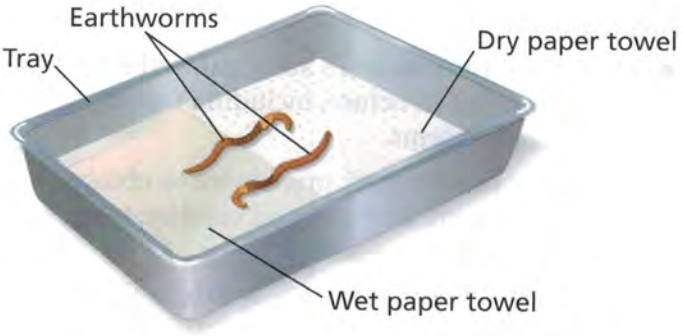
Do earthworms prefer dry or moist conditions? Do they prefer light or dark conditions?

Skills Focus

observing, interpreting data

Materials

- plastic dropper
- water
- cardboard
- clock or watch
- paper towels
- flashlight
- 2 earthworms
- storage container
- tray



Procedure

1. Which environment do you think earthworms prefer—dry or moist? Record your hypothesis in your notebook.
2. Use the dropper to sprinkle water on the worms. Keep the worms moist at all times.
3. Fold a dry paper towel and place it on the bottom of one side of your tray. Fold a moistened paper towel and place it on the other side.
4. Moisten your hands. Then place the earthworms in the center of the tray. Make sure that half of each earthworm's body rests on the moist paper towel and half rests on the dry towel. Handle the worms gently.
5. Cover the tray with the piece of cardboard. After five minutes, remove the cardboard and observe whether the worms are on the moist or dry surface. Record your observations.
6. Repeat Steps 4 and 5.
7. Return the earthworms to their storage container. Moisten the earthworms with water.
8. Which do you think earthworms prefer—strong light or darkness? Record your hypothesis in your notebook.
9. Cover the whole surface of the tray with a moistened paper towel.
10. Place the earthworms in the center of the tray. Cover half of the tray with cardboard. Shine a flashlight onto the other half.
11. After five minutes, note the locations of the worms. Record your observations.
12. Repeat Steps 10 and 11.
13. Moisten the earthworms and put them in the location designated by your teacher. Wash your hands after handling the worms.

Analyze and Conclude

1. **Observing** Which environment did the worms prefer—moist or dry? Bright or dark?
2. **Interpreting Data** Did the worms' behavior support your hypotheses?
3. **Communicating** Explain in a paragraph what knowledge or experiences helped you develop your hypotheses at the beginning of the experiments.

Design an Experiment

Do earthworms prefer a smooth or rough surface? Write your hypothesis. Then design an experiment to answer the question. *Obtain your teacher's permission before carrying out your investigation.*

Chapter 9 Study Guide

The BIG Idea **Structure and Function** The structures of animals' bodies enable them to obtain food and oxygen, keep internal conditions stable, move, and reproduce.

1 What Is an Animal?

Key Concepts

- The cells of most animals are organized into higher levels of structure, including tissues, organs, and systems.
- The major functions of animals are to obtain food and oxygen, keep internal conditions stable, move, and reproduce.
- Animals are classified according to how they are related to other animals. These relationships are determined by an animal's body structure, the way an animal develops, and its DNA.

Key Terms

• cell • tissue • organ • adaptation
• sexual reproduction • fertilization
• asexual reproduction • phylum • vertebrate
• invertebrate

2 Animal Symmetry

Key Concepts

- The balanced arrangement of parts, called symmetry, is characteristic of many animals.
- Depending on their symmetry, animals share some general characteristics.

Key Terms

bilateral symmetry
radial symmetry

3 Sponges and Cnidarians

Key Concepts

- Sponges are invertebrate animals that usually have no body symmetry and never have tissues or organs.
- Cnidarians use stinging cells to capture food and defend themselves.
- Coral reefs are home to more species of fishes and invertebrates than any other environment on Earth.

Key Terms

larva
cnidarian
polyp
medusa
colony
coral reef

4 Worms

Key Concepts

- Biologists classify worms into three major phyla—flatworms, roundworms, and segmented worms.
- Flatworms are flat and soft as jelly.
- Unlike cnidarians or flatworms, roundworms have a digestive system that is like a tube, open at both ends.
- Earthworms and other segmented worms have bodies made up of many linked sections called segments.

Key Terms

• parasite • host • free-living organism
• scavenger • anus • closed circulatory system

Review and Assessment

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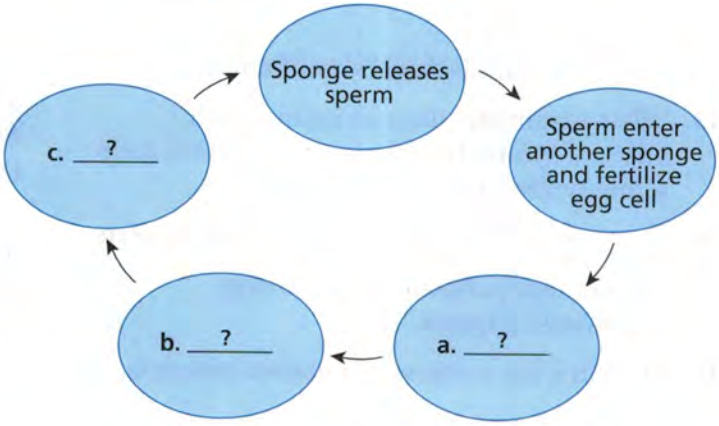
Organizing Information

Sequencing Copy the cycle diagram about the life of a sponge onto a sheet of paper. Then complete it and add a title.



Reviewing Key Terms

Choose the letter of the best answer.

1. The highest level of organization in an animal is a(n)
   a. cell. **b.** tissue.
   c. organ. **d.** system.
2. An animal without a backbone is called a(n)
   a. vertebrate.
   b. invertebrate.
   c. larva.
   d. parasite.
3. An animal with many lines of symmetry
   a. has bilateral symmetry.
   b. has radial symmetry.
   c. has no symmetry.
   d. has a distinct head and tail end.
4. Which animal is a medusa?
   a. coral
   b. moon jelly
   c. planarian
   d. sea anemone
5. An organism that does not live in or on another organism is called a
   a. scavenger.
   b. parasite.
   c. free-living organism.
   d. host.

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

6. A tissue is a group of organs that work together to perform a job.
7. Fishes have bilateral symmetry.
8. Budding is a form of sexual reproduction.
9. A polyp is an immature form of an animal that looks very different from the adult form.
10. Some tapeworms are parasites of dogs.

Writing in Science

Letter Suppose that you have just come back from a trip to a coral reef. Write a letter to a friend that compares corals and jellyfish. Be sure to explain how the two animals are alike and how they are different.

Discovery CHANNEL SCHOOL

Sponges, Cnidarians, and Worms
Video Preview
Video Field Trip
▶ Video Assessment

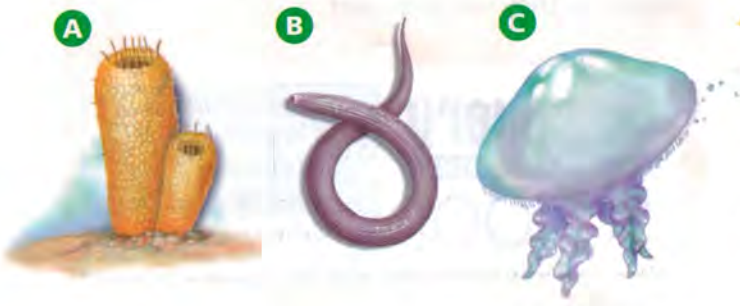
Review and Assessment

Checking Concepts

11. Explain the relationship among cells, tissues, and organs.
12. What are four key functions of animals?
13. What advantages does an animal with bilateral symmetry have over an animal with radial symmetry?
14. Compare and contrast a medusa and a polyp.
15. Are humans parasitic or free-living organisms? Explain.
16. Explain what a one-way digestive system is.

Thinking Critically

17. **Making Judgments** Suppose you check out a book from the library called *Earth's Animals*. You notice that all the animals in the book are vertebrates. Is this title a good one? Explain your reasoning.
18. **Classifying** Classify each of the following animals as having radial symmetry, bilateral symmetry, or no symmetry: sea anemones, sponges, fishes, humans, and butterflies.
19. **Comparing and Contrasting** Compare and contrast the ways in which a sponge, a planarian, and a roundworm digest their food.
20. **Relating Cause and Effect** If a disease killed off many of the earthworms in a garden, how might the plants growing in the soil be affected? Explain.
21. **Classifying** Which of the animals below is a roundworm? A sponge? A cnidarian? Describe the major characteristics of the members of these three phyla.



Math Practice

22. **Calculating a Rate** In 24 hours, 110 L of water pass through a sponge. What is the rate of water flow?

Applying Skills

Use the tables to answer Questions 23–25.

A scientist used a pesticide on one field and left a nearby field untreated. Next, she marked off five plots of equal size in each field. Then she dug up a cubic meter of soil beneath each plot and counted the earthworms in the soil. The tables below show her data.

Field With Pesticide

Plot	Worms per Cubic Meter
A	730
B	254
C	319
D	428
E	451

Untreated Field

Plot	Worms per Cubic Meter
F	901
G	620
H	811
I	576
J	704

23. **Controlling Variables** Identify the manipulated and responding variables in this experiment.
24. **Calculating** Calculate the average number of worms per cubic meter in the field treated with pesticide. Then do the same for the untreated field.
25. **Drawing Conclusions** How did this pesticide affect the number of worms?

Lab zone Chapter Project

Performance Assessment Write a summary explaining what you have learned about your animal. Describe its habitat, the food it eats, its behavior, and any surprising observations that you made. Then introduce your animal to your classmates and share what you have discovered.

Standardized Test Prep

Test-Taking Tip

Sequencing Events

A test question may ask you to order a series of events. For example, you may be given several sequences and asked to determine which is correct, or identify which event comes before another. After you read the question, try to identify the correct sequence of events before you read the answer choices.

Sample Question

Which of the following best describes stages in the sexual life cycle of a sponge in the correct order?

A larva, fertilization, egg, adult
B adult, larva, egg, fertilization
C adult, bud, bud breaks free
D larva, adult, egg, fertilization

Answer

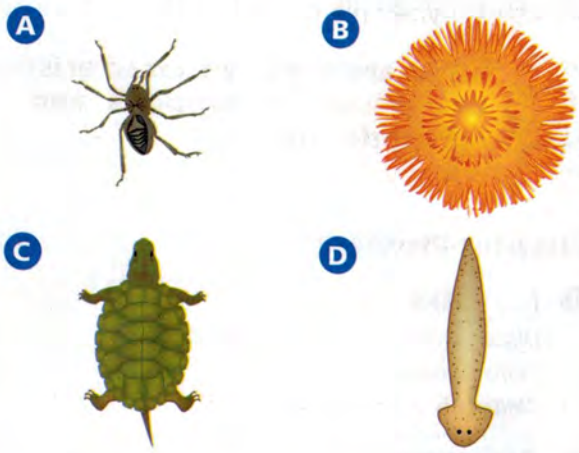
The correct answer is **D**. You can eliminate **C** because it uses terms that describe asexual reproduction. Of the remaining choices, **A** cannot be correct because eggs do not follow fertilization, but must be present before fertilization can occur. **B** cannot be correct because larvae cannot produce eggs.

Choose the letter of the best answer.

1. What is the correct sequence in which a stinging cell reacts to the touch of another organism?
   A trigger brushes against prey, stinging cell fires, barbs snare prey
   B barbs snare prey, stinging cell fires, barbs release prey
   C prey is paralyzed, venom enters prey, stinging cell fires
   D tentacles pull prey to mouth, prey is ingested, stinging cell fires

2. Which of the following is true of a one-way digestive system?
   F It is found in all parasites.
   G It has two openings.
   H It has one opening.
   J It is found in all parasites and has one opening.

3. Of the four animals shown below, which has the same symmetry as a jellyfish?



4. Imagine that the animals illustrated above are real and are resting on this page. Predict which of the animals would travel toward the top of the page if they began moving in a straight line.
   F animals A and D
   G animals A and B
   H animals B and D
   J animals A and C

5. The following terms can all be used to describe a tapeworm *except*
   A parasite
   B invertebrate
   C flatworm
   D medusa

Constructed Response

6. Compare and contrast the feeding process of a sponge with that of an earthworm. How are their feeding processes similar? How are they different?