Chapter 11

Structure and Function of Invertebrates

CALIFORNIA Standards Preview

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

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

S 7.3 Biological evolution accounts for the diversity of species developed through gradual processes over many generations. As a basis for understanding this concept:

d. Students know how to construct a simple branching diagram to classify living groups of organisms by shared derived characteristics and how to expand the diagram to include fossil organisms.

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

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

b. Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

This Asian weevil uses its front legs to court females.

Video Preview

Discovery Channel School

Mollusks, Arthropods, and Echinoderms

S 7.5.a

Focus on the
BIG Idea

What major functions do animals' bodies perform?

Check What You Know

On a walk through the park, you stop to look closely at the leaves of a plant. You see an insect laying eggs. The eggs are the result of sexual reproduction. The cells in each insect egg contain many genes. Where do these genes come from? Explain your answer.

Build Science Vocabulary

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

Vocabulary Skill

Use Clues to Determine Meaning

In this textbook, important new words, or key terms, first appear in dark type with a yellow highlight. The dark type and yellow highlight are clues that the meanings, or definitions, of these words are given in the text. Sometimes the meaning is in the same sentence as the key term. Other times, you need to look at several sentences to understand the key term's meaning completely. Look at the example below.

The animals called cnidarians have two different body plans. One form looks something like a vase. The vase-shaped body plan is called a **polyp.** A polyp's mouth opens at the top and its tentacles spread out from around the mouth.

What a polyp is

Additional information about a polyp

Apply It!

1. In your own words, what is the meaning of *polyp*?
2. What sentence contains the definition of *polyp*?
3. What other clues help you understand the meaning of *polyp*?

Chapter 11 Vocabulary

Section 1 (page 410)

anatomy
physiology
bilateral symmetry
radial symmetry
vertebrate
invertebrate
phylum

Section 2 (page 417)

larva
cnidarian
polyp
medusa

Section 3 (page 424)

brain
parasite
host
anus
mollusk
gill
gastropod
radula
bivalve
cephalopod
open circulatory system
closed circulatory system

Section 4 (page 434)

arthropod
exoskeleton
molting
antenna
crustacean
arachnid
abdomen
metamorphosis
insect
thorax
pupa
nymph

Section 5 (page 443)

echinoderm
endoskeleton
water vascular system
tube feet

Interactive Textbook

Build Science Vocabulary *Online*

Visit: PHSchool.com
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How to Read Science

Reading Skill

Take Notes

When you take notes, you write the important ideas from the textbook in shortened form. See the sample notes below, which are notes on the beginning of Section 1 in this chapter.

- Use a red or blue heading as the title of your notes.
- In the left column, write questions about the text that follows the heading. The questions should ask for important information.
- Write the answers in the right column.
- Write a summary statement that expresses the main idea of the information under the heading.

Questions	Notes: Structure of Animals
What do anatomy and physiology mean?	Anatomy—organism's structure Physiology—function in organisms
How are animal cells organized?	Into tissues, organs, organ systems
What are tissues, organs, and organ systems?	Tissues—similar cells doing similar functions Organ—group of tissues doing complex function Organ system—group of structures that perform broadest function
	Summary Statement: In most animals, cells are organized into tissues, organs, and organ systems.

Apply It!

In your notebook, complete the notes for Section 1. Then take notes on Section 2.

Lab zone

Standards Investigation

S 7.2.a

Going Through Changes

Most of the animals you will read about in this chapter change form during their development. In this investigation, you will observe firsthand how mealworms change as they develop.

Your Goal

To observe mealworm development and how different conditions affect that development

To complete this investigation, you must

- compare mealworm development under two different conditions
- record your mealworm observations daily for several weeks
- describe the process of development that you observe
- draw conclusions about the effects of those conditions on development
- follow the safety guidelines in Appendix A

Plan It!

Find two containers, such as clean margarine tubs with lids, in which to keep the mealworms. Get some mealworm food, such as cornflakes, and a plastic spoon to transfer the food and count the mealworms. Choose two conditions, such as two different temperatures or food sources, and plan how to test the two conditions. Once you begin, record your daily observations in a data table, and sketch each stage of development.

Section 1

What Is an Animal?

CALIFORNIA Standards Focus

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

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

Key Terms

- anatomy
- physiology
- bilateral symmetry
- radial symmetry
- vertebrate
- invertebrate
- phylum

Lab zone Standards Warm-Up

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 swims in the ocean. After a while, it settles its head down on a hard surface. 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 that float in the water.

A barnacle may look like a rock, but it is actually an animal. Animals are many-celled organisms that typically obtain food by eating other organisms.

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

Structure of Animals

An organism's structure is called its **anatomy.** In animals, as in all living things, the basic unit of anatomy is the cell. The cell is also the basic unit that carries out life processes, or functions. **Physiology** is the study of functions in organisms. **The cells of most animals are organized into higher levels of structure, including tissues, organs, and organ systems.** A group of similar cells that perform a specific function is called a tissue. One type of tissue is bone tissue, a hard tissue that gives bones their 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 organ systems. One example is the skeletal system of a frog shown in Figure 1. The skeletal system and the body's other organ systems together make up a whole organism. In this case, the organism is a frog.

Reading Checkpoint **What is an organ?**

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

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

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Functions of Animals

All animals carry out the same basic physiological processes. **Some major functions of animals are obtaining food and oxygen, keeping internal conditions stable, moving, and reproducing.** Adaptations are structures or behaviors that allow animals to perform these functions.

In animals, anatomy is closely related to physiology. In other words, the structures of cells, tissues, organs, and organ systems are closely related to their functions. Think of the frog's skeletal system. Bones have a strong, tough structure. This structure functions to support the frog's body.

Obtaining Food and Oxygen An animal 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 foods. For example, the tarantula in Figure 2 has fangs. Fangs are 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 have adaptations to keep their bodies cool. During hot days, earthworms stay in moist soil, 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.

Many animals have muscles and bones, which are structures that enable them to move. When muscles contract, or shorten, an animal's body moves. Many animals have internal skeletons. In these animals, muscles are attached to bones by structures called tendons. When the muscles contract, they pull on the bones. This pulling makes the bones move.

Reproduction Like all organisms, 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?*

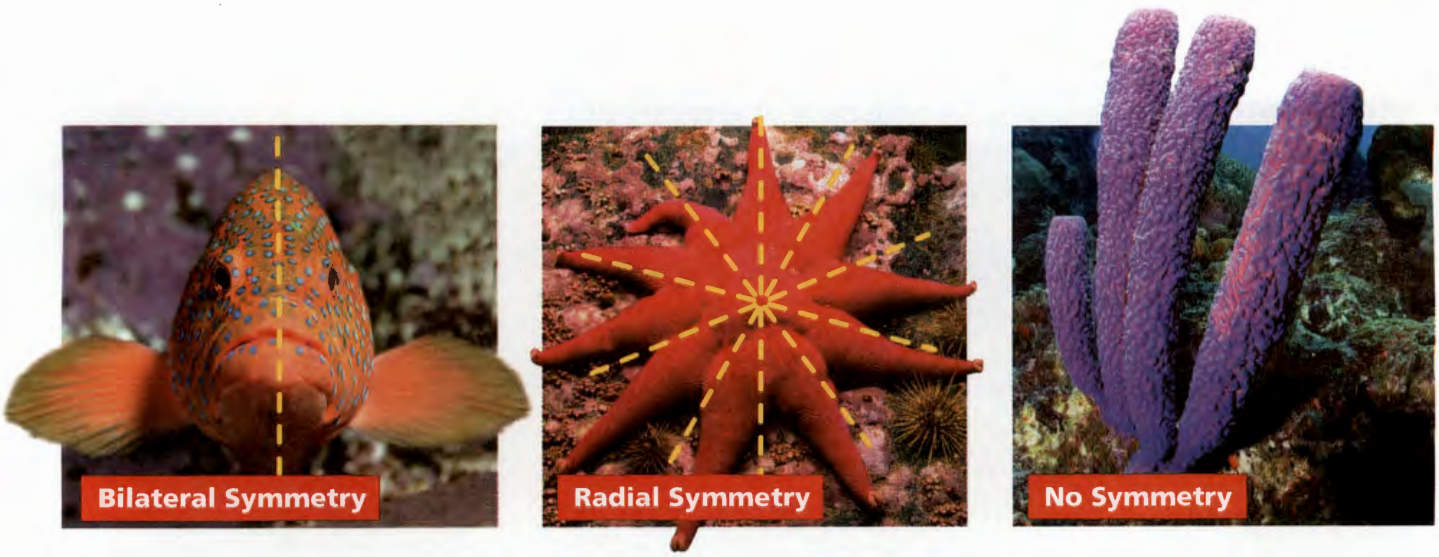

FIGURE 5
Types of Symmetry
Most animals have either bilateral or radial symmetry. Most sponges, however, have no symmetry.

Symmetry

The functions an animal carries out are closely related to its body structure. One part of body structure is the presence or absence of symmetry. **Symmetry is a balanced arrangement of body parts that is characteristic of many animals.**

Animals have different types of symmetry. An animal has **bilateral symmetry** if there is just one line that divides it into halves that are mirror images. Fishes, such as the one in Figure 5, have bilateral symmetry. In contrast, an animal with **radial symmetry,** such as a sea star, has many lines of symmetry that divide it into two identical halves. A few animals, such as sponges, have no symmetry.

Animals With Radial Symmetry The external body parts of animals with radial symmetry are equally spaced around a central point, like spokes on a wheel. Animals with radial symmetry, such as sea urchins and jellyfishes, do not have distinct front or back ends. All animals with radial symmetry live in the water. Most of them do not move very fast.

Animals With Bilateral Symmetry In general, animals with bilateral symmetry, such as insects and frogs, 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. 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. A fish, for example, has eyes on its head.

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

Classification of Animals

Biologists have identified more than 1.5 million species, or distinct types, of animals. Classifying animals helps biologists make sense of this diversity. In Figure 6, you can see some of the largest groups of animals. The pattern of the diagram in Figure 6 shows how some of the major groups of animals may be related. For example, by looking at their positions on the tree, you can see that segmented worms are probably more closely related to arthropods than to sponges.

FIGURE 6

Major Animal Groups

This diagram shows the major animal groups.

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

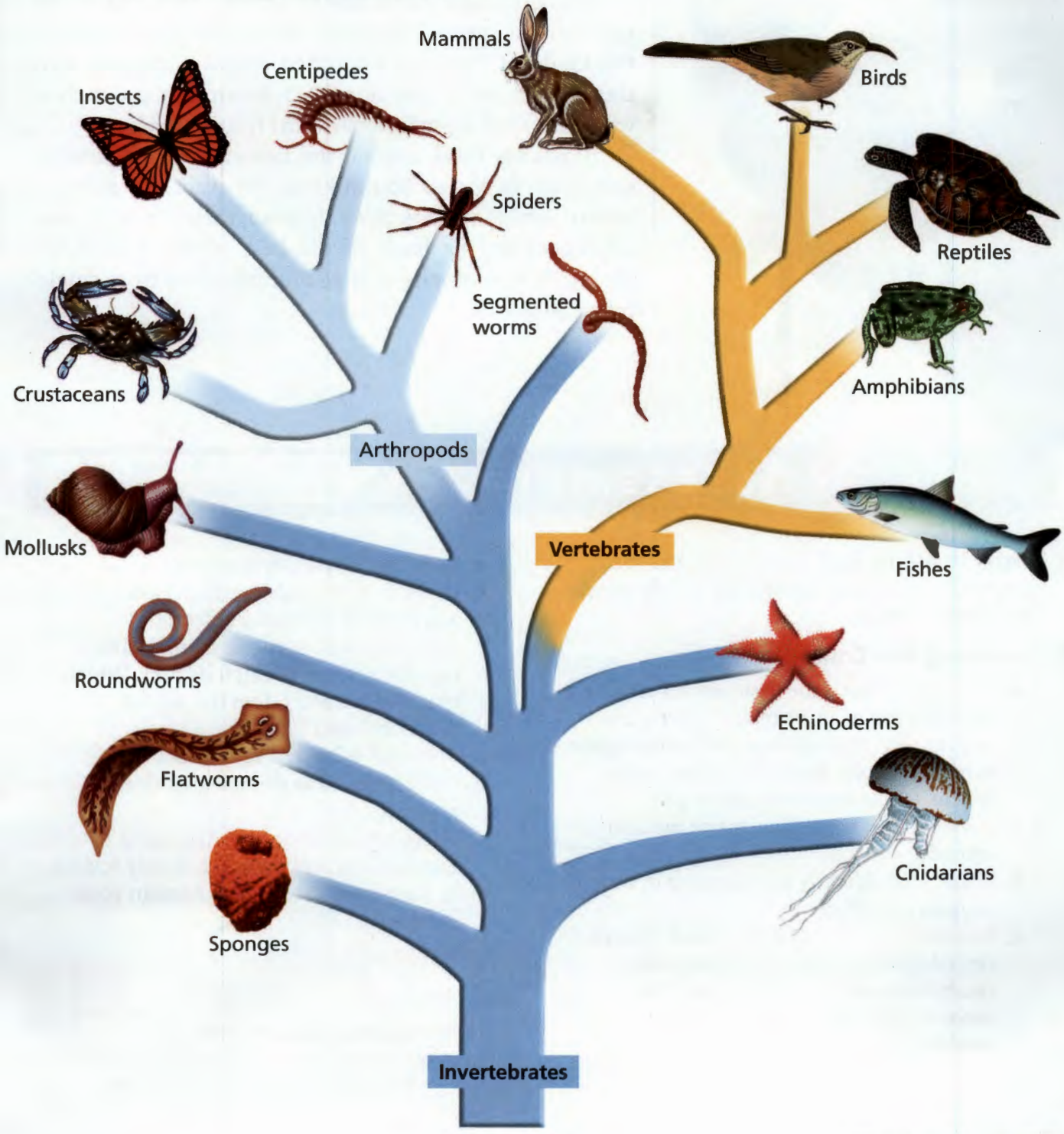

FIGURE 7
Discovering New Species This biologist is surveying the leaves of rain forest plants, looking for new insect species.

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!

Biologists such as the one in Figure 7 continue to find new animal species. New species are classified based on the kinds of evidence identified above. Biologists have classified animals into about 35 major groups, each of which is called a **phylum** (FY lum) (plural *phyla*).

Biologists think animal life has evolved, or changed over time. Biologists do not know the exact way in which animal 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.

Section 1 Assessment

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

Target Reading Skill Take Notes Use the notes you wrote about this section to help 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, organ system, whole organism, cell, organ.
2. a. Reviewing What are five major functions of animals?
   b. Identifying Identify the two ways in which animals reproduce.
   c. Relating Cause and Effect Which type of reproduction produces offspring with a combination of characteristics of two parents? How does it produce the combination?
3. a. Defining What is symmetry?
   b. Comparing and Contrasting How are radial and bilateral symmetry different?
   c. Applying Concepts An animal runs rapidly forward to catch its prey. Which type of symmetry does the animal probably have? Explain.
4. a. Defining What is a vertebrate?
   b. Classifying How do biologists classify animals?
   c. Interpreting Diagrams According to Figure 6, are reptiles more closely related to mammals or to fishes? Explain your answer.

Writing in Science

Functional Description Write a few paragraphs about how a pet you have observed performs the basic functions of an animal.

Section 2

Sponges and Cnidarians

CALIFORNIA Standards Focus

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

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

- What are the main characteristics of sponges?
- What are the main characteristics of cnidarians?

Key Terms

- larva
- cnidarian
- polyp
- medusa

Lab zone Standards Warm-Up

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 invertebrates that usually have no body symmetry and never have tissues or organs.** Although sponges do not have tissues, they have cells that are specialized for different functions. For example, collar cells move water through a sponge and trap food.

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

Reading Checkpoint **What is the function of collar cells?**

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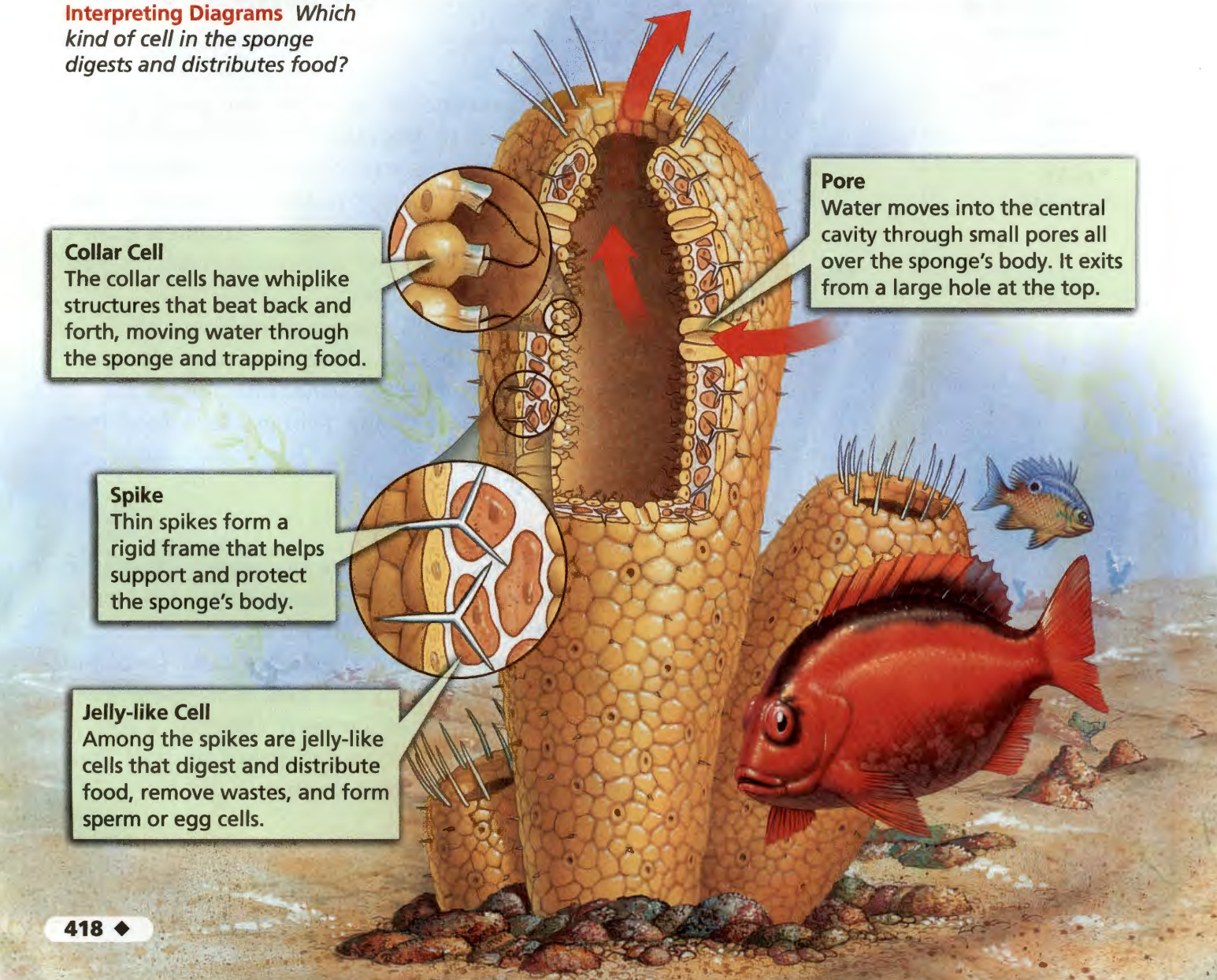
FIGURE 8
Structure of a Sponge

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?*



Cnidarians

Some other animals you might notice on an underwater dive are jellyfishes, sea anemones, and the tiny corals that build coral reefs. 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. 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 with stinging cells.

The vase-shaped body plan is called a **polyp** (PAHL ip). The sea anemone you see in Figure 9 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 9 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?

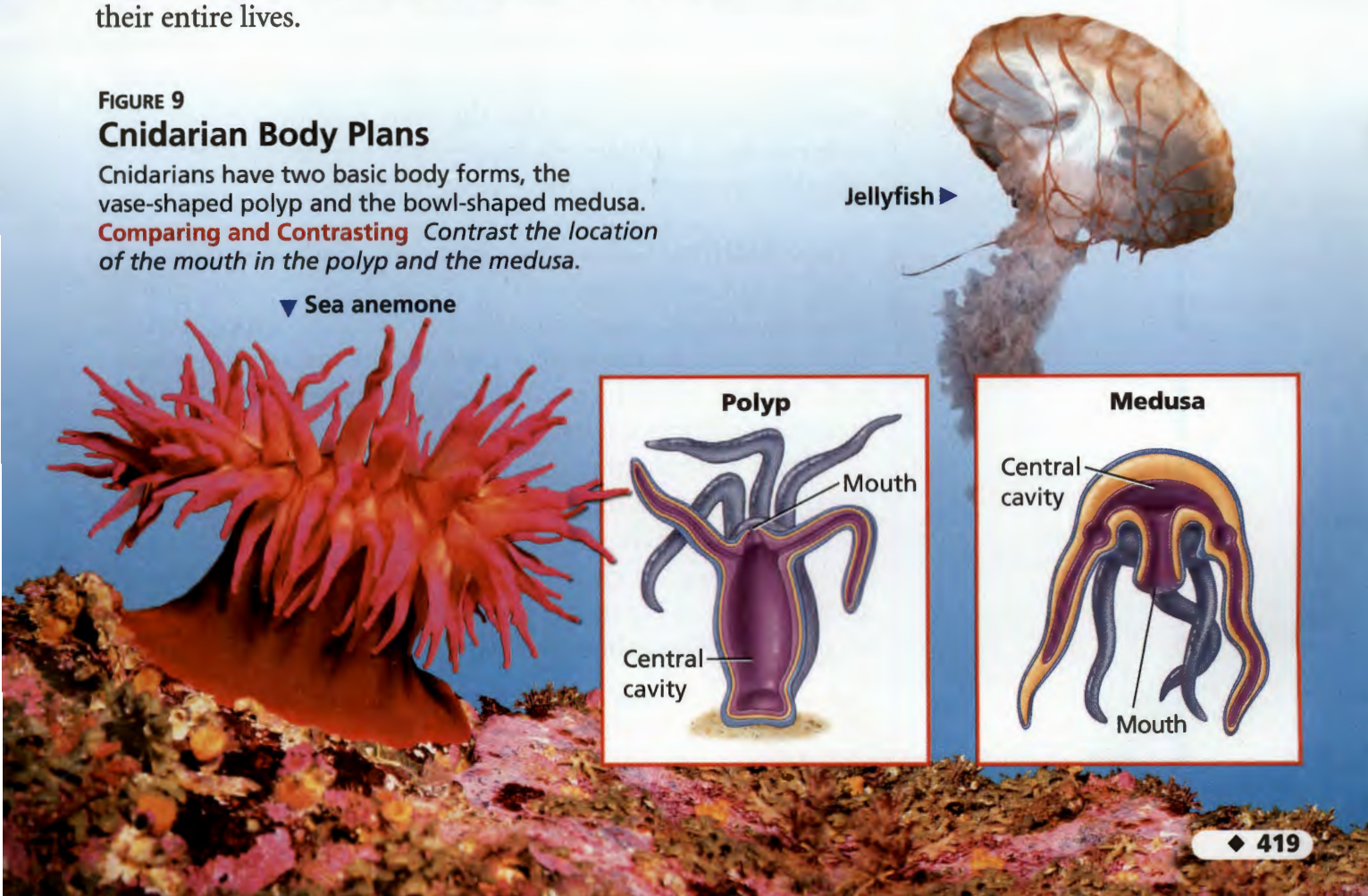
1. Put a drop of water containing hydras in a small unbreakable bowl or petri dish. Allow it to sit for about 15 minutes.
2. Use a hand lens to examine the hydras as they swim. Then gently touch the tentacles of a hydra with the end of a toothpick. Watch what happens.
3. Return the hydras to your teacher.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

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

FIGURE 9

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.*



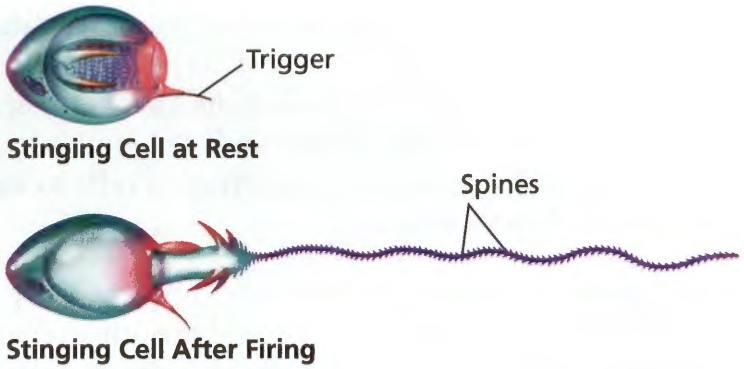


FIGURE 10
Cnidarian Attack!
A stinging cell fires when its trigger brushes against prey, such as a fish. **Applying Concepts** *What is the function of stinging cells?*

Obtaining Food Cnidarians use stinging cells to catch the animals they eat, which are called prey. You can see a stinging cell in Figure 10. 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.

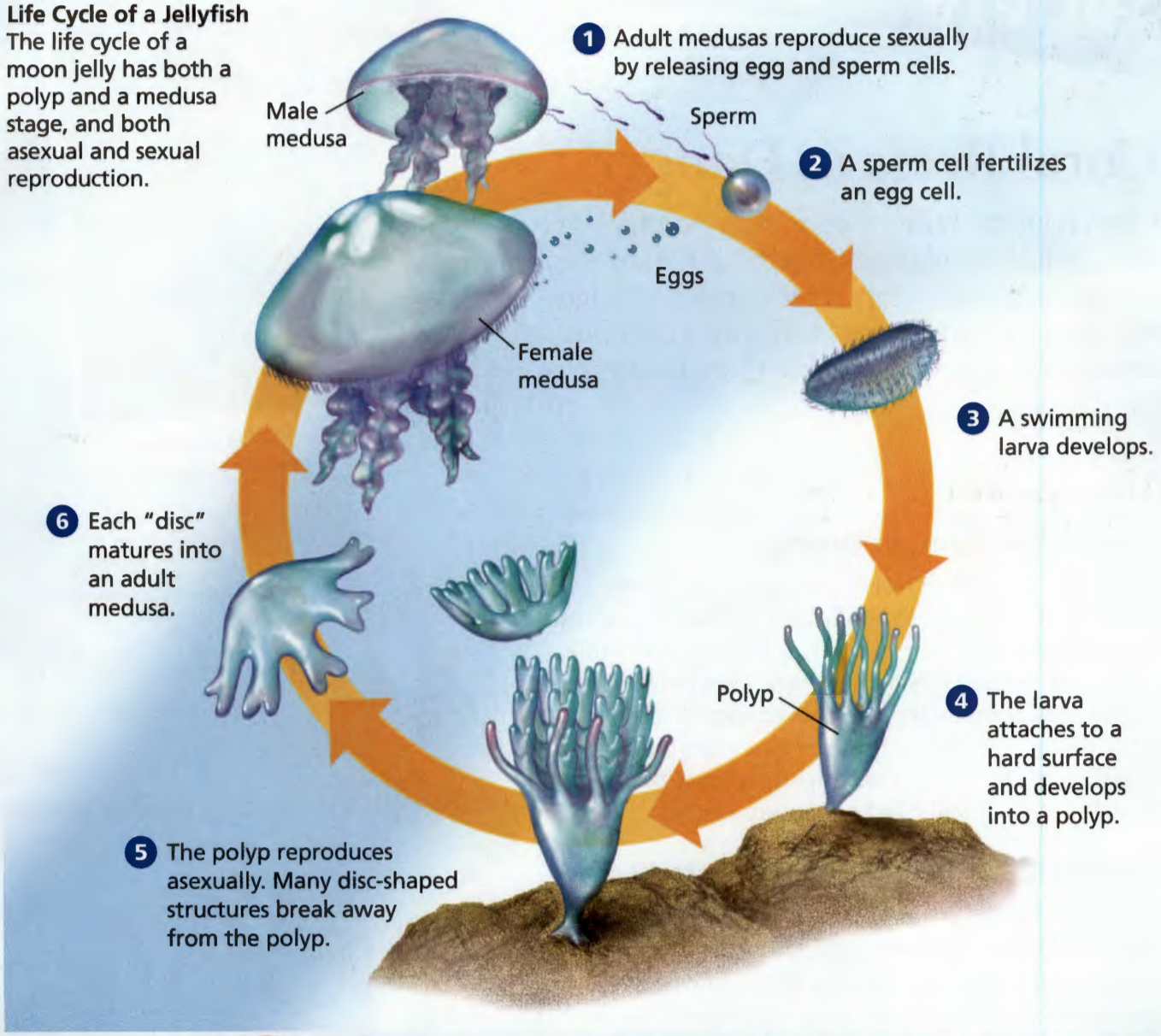
Movement Unlike adult sponges, many cnidarians can move to escape danger and to obtain food. Some cnidarians have muscle-like tissues that allow them to move in different ways. Jellyfishes swim through the water, and hydras turn slow somersaults. A cnidarian's movements are directed by nerve cells that are spread out like a basketball net.

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. In budding, small new animals grow from the side of an adult animal. Asexual reproduction allows 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 11, you can see the life cycle of a moon jelly, which involves both asexual and sexual reproduction.

Reading Checkpoint **What is an example of asexual reproduction seen in polyps?**

FIGURE 11
Life Cycle of a Jellyfish
The life cycle of a moon jelly has both a polyp and a medusa stage, and both asexual and sexual reproduction.



Section 2 Assessment

S 7.2.a, 7.5.a, E-LA: Writing 7.2.5, Reading 7.2.0

Target Reading Skill **Take Notes** Use the notes you wrote about this section to help answer the questions below.

Reviewing Key Concepts

1. a. **Describing** What are the characteristics of a sponge?
   b. **Explaining** How does a sponge reproduce sexually?
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?

Writing in Science

Summary Write a summary, in your own words, of the life cycle of a moon jelly. Include brief descriptions of the polyp and medusa body plans.

S 7.3.e

Coral Reefs in Danger

Coral reefs are built by coral polyps, which are tiny, delicate cnidarians. Recreational divers can damage coral reefs. This damage changes the corals' environment, and corals may not have adaptations that enable them to survive the damage.

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.

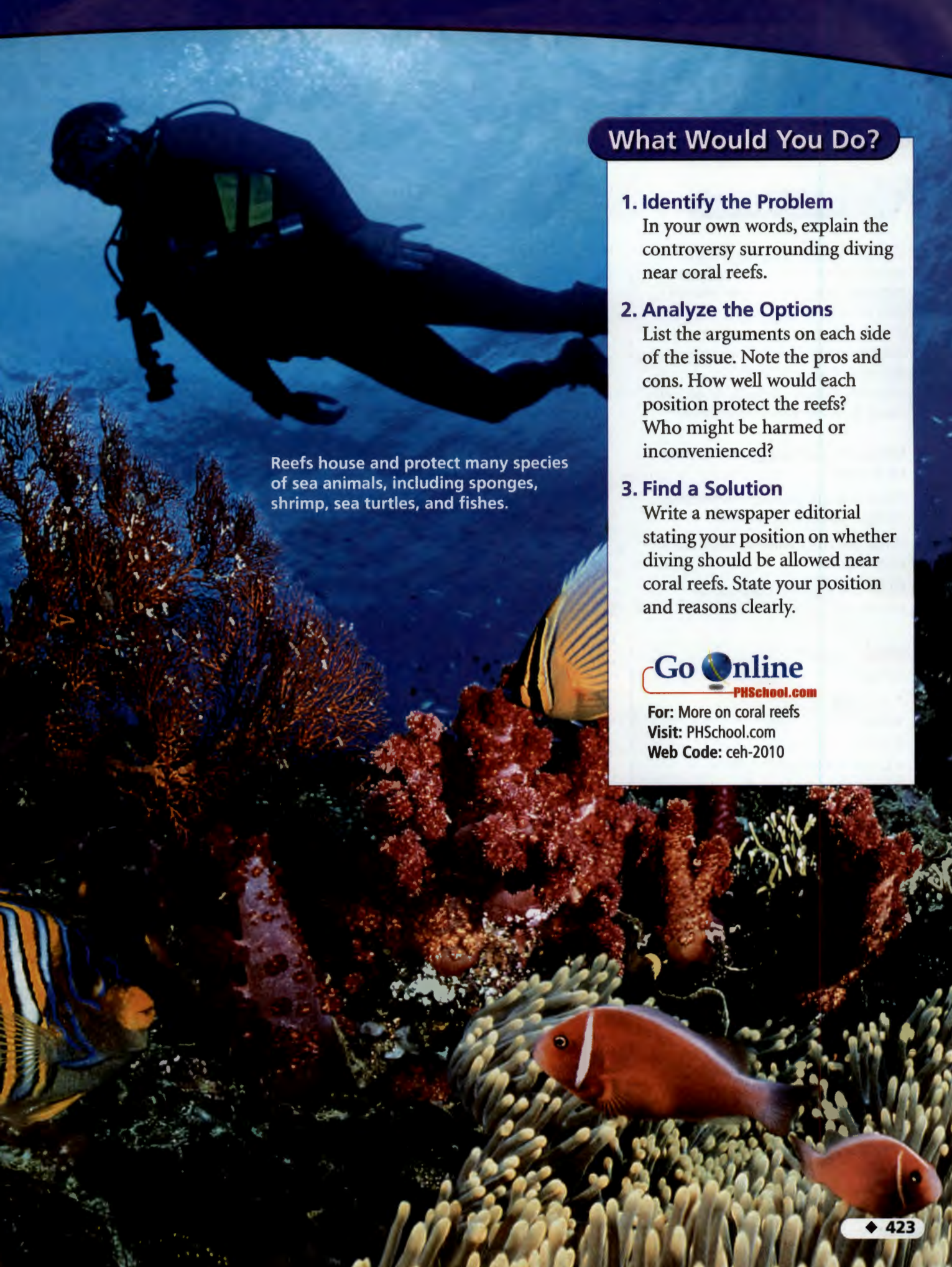
Should Reefs Be Further Protected?

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 3

Worms and Mollusks

CALIFORNIA Standards Focus

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

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

- What are the main characteristics of worms?
- What are the main characteristics of each phylum of worms?
- What are the main characteristics of mollusks?
- What are the main groups of mollusks?

Key Terms

- brain
- parasite
- host
- anus
- closed circulatory system
- mollusk
- open circulatory system
- gill
- gastropod
- radula
- bivalve
- cephalopod

Lab zone Standards Warm-Up

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?

Worms in the soil and snails in an aquarium don't seem to have much in common. But worms and snails are both invertebrates with soft bodies. In fact, some mollusks even look like worms.

Characteristics of Worms

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. **All worms are invertebrates that have long, narrow bodies without legs.** 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 12
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 13
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 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. The brain controls most of the animal's body functions. Sense organs pick up information from the environment. The brain interprets that information and directs the animal's response. For example, suppose an earthworm on the surface of the ground senses the vibrations of a footstep. The worm will respond by returning to its underground burrow. A worm can detect objects, food, mates, and predators quickly. It can respond quickly, too.

Reproduction Both sexual and asexual reproduction are found in the worm phyla. Some worms, such as the flatworm *Planaria*, reproduce asexually by dividing into two separate organisms. The two new organisms are genetically identical.

Most worm species can reproduce sexually. In many species, there are separate males and females, as in humans. In other species, each animal has both male and female sex organs. An animal with both male and female sex organs is called a hermaphrodite (hur MAF ruh dyt). Usually, two individual hermaphrodites mate and exchange sperm. It is rare for a hermaphrodite to fertilize its own eggs. When self-fertilization happens, it is still a form of sexual reproduction, even though there is only one parent.

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

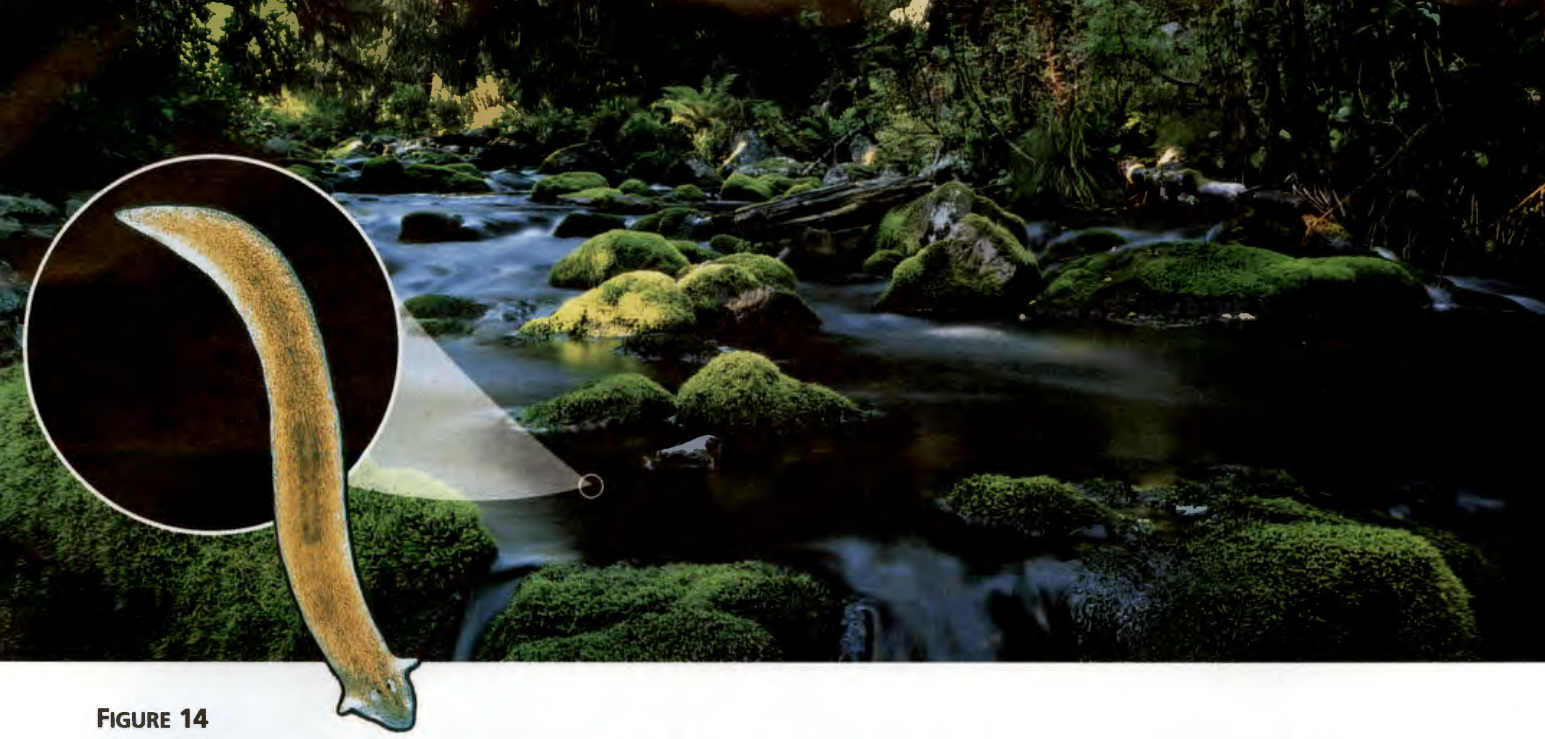


FIGURE 14
Planarian
Planarians are free-living flatworms that live in ponds, streams, and oceans.
Comparing and Contrasting
How does a free-living organism differ from a parasite?

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. **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. A predator is an animal that captures another animal for food. Planarians 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 14, 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. The structure of a tapeworm's body is adapted to the function of 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. Figure 15 shows the life cycle of the dog tapeworm. This tapeworm has two different hosts—a dog and a rabbit.

How does a scavenger obtain food?

FIGURE 15

Life Cycle of a Dog Tapeworm

The tapeworm is a parasite that lives in more than one host during its life cycle.

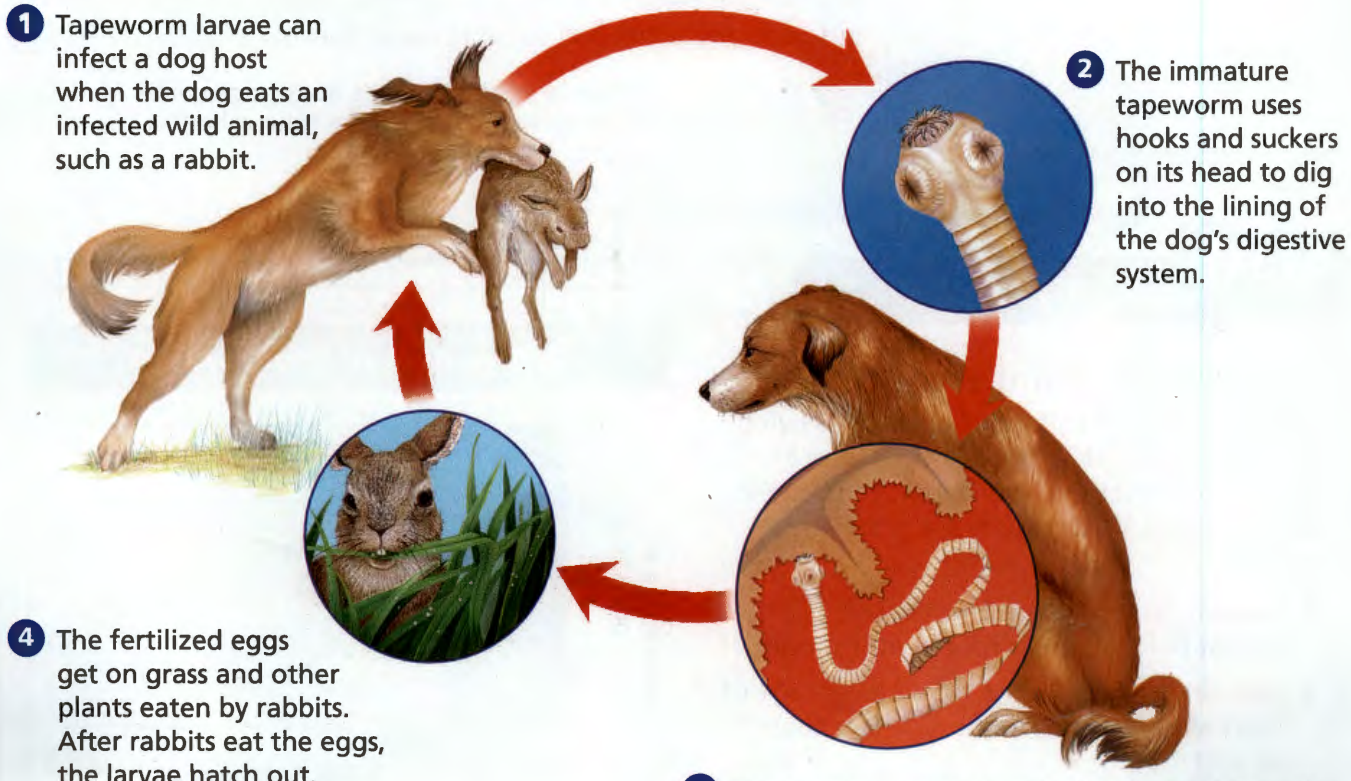


FIGURE 16
A Roundworm
The transparent body of this roundworm has been stained for better viewing under a microscope.

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.

The structure of a one-way digestive system is efficient. It is something like an assembly line, with a different part of the digestive function 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 are the openings at opposite ends of a roundworm's digestive tube called?**

Math: Algebra and Functions 7.1.5

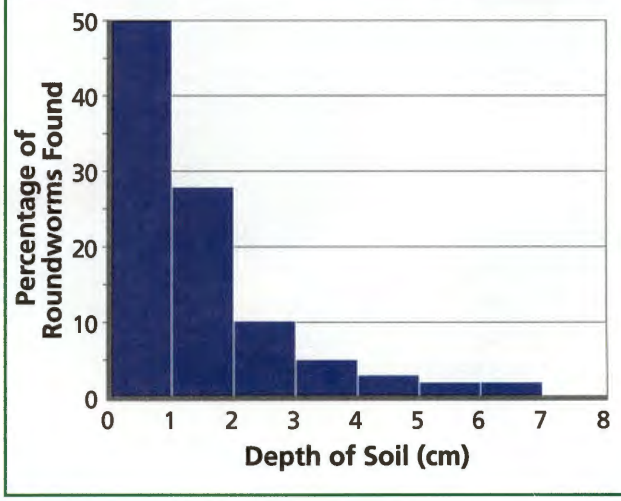
Math Analyzing Data

Roundworm Numbers

Biologists counted all the roundworms living in a plot of soil. Then they calculated the percentages that live 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 17. 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.

Segmented worms have well-developed organ systems. For example, segmented worms have a nervous system that includes a brain and a nerve cord that runs 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 open and closed circulatory systems, blood carries out the physiological process of bringing 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.

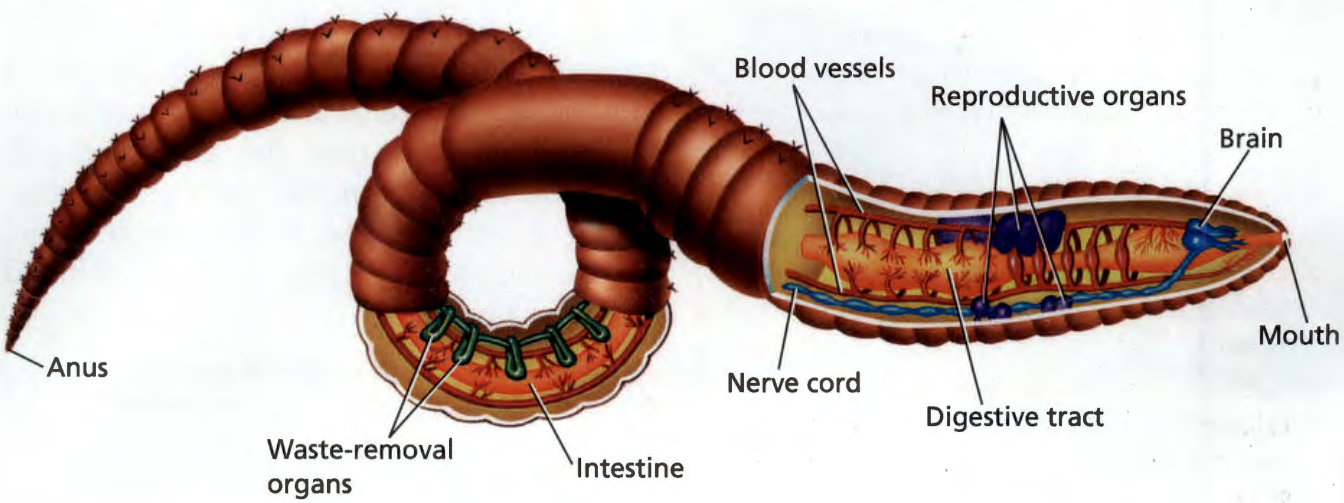
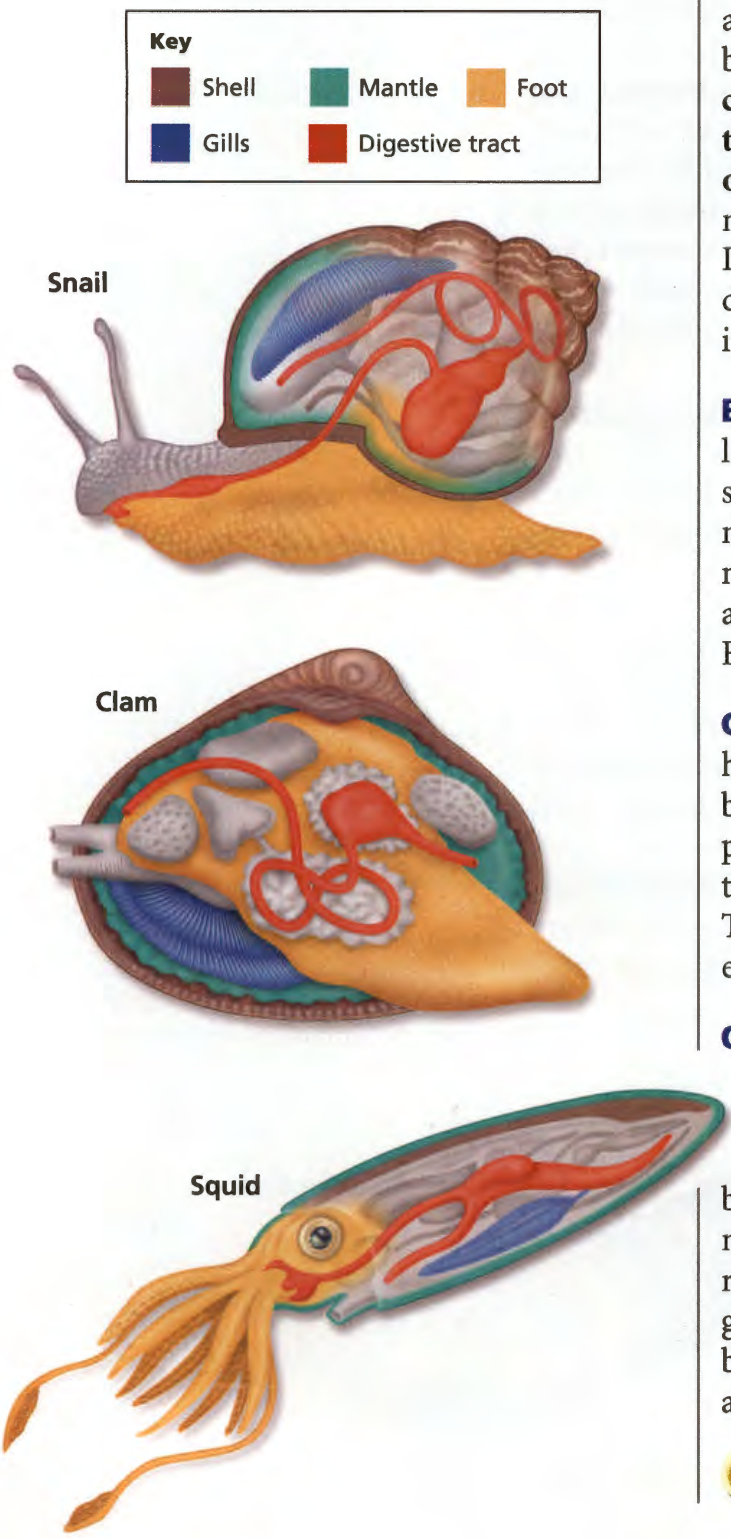


FIGURE 17
Structure of an Earthworm
An earthworm's body is divided into more than 100 segments. Some organs are repeated in most of those segments. Other organs exist in only a few segments.
Interpreting Diagrams *Name an example of a body system that runs through all of the worm's segments.*

FIGURE 18

Comparing Mollusks

Although they don't look much alike at first, a snail, a clam, and a squid have the same basic body structures.



Characteristics of Mollusks

Clams, oysters, and scallops are all mollusks (phylum Mollusca). Snails and squids are mollusks, too. **Mollusks** are invertebrates with soft, unsegmented bodies that are often protected by a hard outer shell. All mollusks have the same basic structure. **In addition to a soft body often covered by a shell, a mollusk has a thin layer of tissue called a mantle that covers its internal organs, and an organ called a foot.** In many mollusks, the mantle produces the hard shell. Depending on the type of mollusk, the foot has different functions—crawling, digging, or catching prey.

Body Structure Like segmented worms, mollusks have bilateral symmetry and a digestive system with two openings. However, unlike segmented worms, the body parts of mollusks are not usually repeated. Instead, the internal organs are located together in one area, as shown in Figure 18.

Circulatory System Most groups of mollusks have an **open circulatory system**, in which the blood is not always inside blood vessels. The heart pumps blood into a short vessel that opens into the body spaces containing the internal organs. The blood sloshes over the organs and returns eventually to the heart.

Obtaining Oxygen Most mollusks that live in water have **gills**, organs that remove oxygen from the water. The gills have tiny, hairlike structures called cilia and a rich supply of blood vessels. The cilia move back and forth, making water flow over the gills. The gills remove the oxygen from the water and the oxygen moves into the blood. At the same time, carbon dioxide, a waste gas, moves out of the blood and into the water.

Reading Checkpoint **Which organs of a mollusk obtain oxygen from water?**

Diversity of Mollusks

Biologists classify mollusks into groups based on their physical characteristics. These characteristics include the presence of a shell, the type of foot, and the type of nervous system. **The three major groups of mollusks are gastropods, bivalves, and cephalopods.**

Gastropods The **gastropods** include snails and slugs. Gastropods have a single shell or no shell at all. Some gastropods are herbivores, animals that eat only plants. Some are scavengers that eat decaying material. Still others are carnivores, animals that eat only other animals. No matter what food they eat, gastropods use an organ called a radula to obtain food. A **radula** (RAJ oo luh) is a flexible organ with tiny teeth.

A gastropod usually moves by creeping along on a broad foot. The foot may ooze a carpet of slippery mucus. The mucus makes it easier for a gastropod to move.

Bivalves Bivalves include oysters, clams, scallops, and mussels. **Bivalves** are mollusks that have two shells held together by hinges and strong muscles. Unlike gastropods, bivalves do not have radulas. Instead, most bivalves are filter feeders that strain tiny organisms from water. Most bivalves are herbivores, animals that eat plants.

Most adult bivalves don't move quickly. They stay in one place or use their foot to move very slowly.

Reading Checkpoint **How do bivalves obtain food?**

Lab zone Skills Activity

Classifying

While wading in a stream, you step on a small animal with a hard covering. As you examine the animal, you discover that it has a soft body inside its shell. It may be a mollusk. What characteristics would you look for to classify the animal into a group of mollusks?

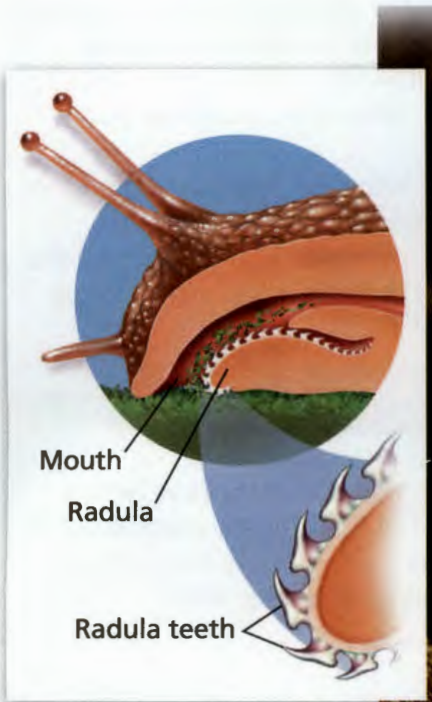


FIGURE 19
The Radula of a Snail
Gastropods such as this land snail have an organ called a radula, which tears and scrapes up food.
Applying Concepts *How is the structure of a radula related to its function?*

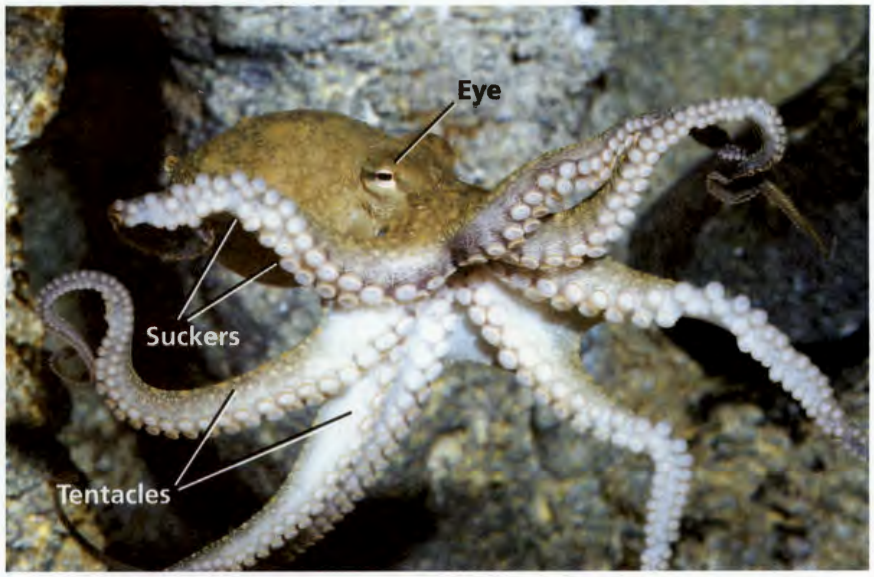


FIGURE 20
A Cephalopod
An octopus is a cephalopod. In cephalopods, the foot forms tentacles.

Video Field Trip
Discovery Channel School
Mollusks, Arthropods, and Echinoderms

Cephalopods Octopuses, squids, nautiluses, and cuttlefishes are cephalopods. A **cephalopod** (SEF uh luh pahd) is an ocean-dwelling mollusk whose foot forms tentacles around its mouth. Some cephalopods lack shells. Cephalopods are the only mollusks with a closed circulatory system.

Cephalopods are carnivores. They use their muscular tentacles to capture prey. Large eyes and a complex nervous system also help them capture prey. Cephalopods have large brains and can remember things they have learned.

Section 3 Assessment

S 7.2.a, 7.5.a, E-LA: Reading 7.1.4

Vocabulary Skill **Use Clues to Determine Meaning** Reread the paragraph on parasites, under Flatworms. What does *parasite* mean? What clues help you understand the meaning?

Reviewing Key Concepts

1. a. **Reviewing** What are the general characteristics of worms?
   b. **Identifying** In what two ways do worms reproduce?
   c. **Explaining** In hermaphrodite worms, how does fertilization usually take place?
2. a. **Listing** List the main phyla of worms.
   b. **Comparing and Contrasting** Contrast the ways the major worm phyla digest food.
   c. **Applying Concepts** A worm takes in food at its front end and expels undigested wastes from the other end. Can the worm be a flatworm? Explain.
3. a. **Listing** List the characteristics of a mollusk.
   b. **Explaining** How is a mollusk's mantle related to its shell?
4. a. **Identifying** What are three groups of mollusks?
   b. **Classifying** What are the characteristics of the three groups of mollusks?
   c. **Comparing and Contrasting** Contrast the functions of the foot in the three groups.

Lab zone At-Home Activity

Edible Mollusks Visit a supermarket with a family member and identify any mollusks that are being sold as food. Identify the parts of the mollusks that are used for food.

Lab zone Skills Lab

Earthworm Responses

S 7.5.b, 7.7.e

Problem

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

Skills Focus

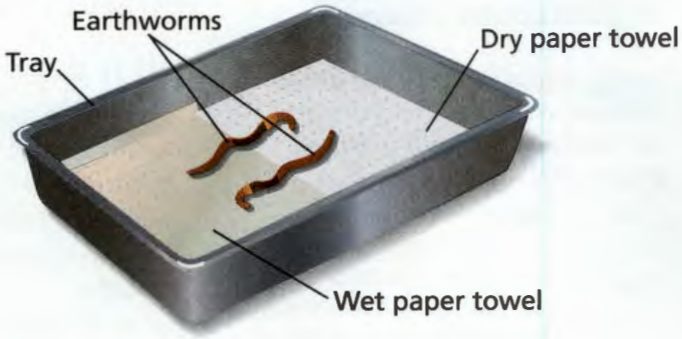
observing, interpreting data

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** How did the earthworms respond to moisture? How did they respond to darkness?
2. **Interpreting Data** What organ in the earthworms' bodies directed their responses? If that organ were damaged, how might the earthworm's response have been different?
3. **Communicating** Write a description of how an earthworm moves. In your description, identify the type of tissue that enables an animal to move.

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.*

Section 4

Arthropods

CALIFORNIA Standards Focus

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

S 7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

- What are the general characteristics of arthropods?
- What are the distinguishing structures of crustaceans, arachnids, centipedes and millipedes, and insects?

Key Terms

- arthropod
- exoskeleton
- molting
- antenna
- crustacean
- metamorphosis
- arachnid
- abdomen
- insect
- thorax
- complete metamorphosis
- pupa
- gradual metamorphosis
- nymph

Lab zone Standards Warm-Up

Will It Bend and Move?

1. Have a partner roll a piece of cardboard around your arm to form a tube that covers your elbow. Your partner should put three pieces of tape around the tube to hold it closed—one at each end and one in the middle.
2. With the tube in place, try to write your name on a piece of paper. Then try to scratch your head.
3. Keep the tube on your arm for 10 minutes. Observe how the tube affects your ability to do things.

Think It Over

Inferring Insects and many other animals have rigid skeletons on the outside of their bodies. Why do their skeletons need joints?

At dusk near the edge of a meadow, a grasshopper leaps through the grass. Nearby, a hungry spider waits in its web. The grasshopper leaps into the web. It's caught! As the grasshopper struggles to free itself, the spider rushes toward it. Quickly, the spider wraps the grasshopper in silk. The grasshopper cannot escape. Soon it will become a tasty meal for the spider.

The spider and grasshopper are both **arthropods**, or members of the arthropod phylum (phylum Arthropoda). Animals such as crabs, lobsters, centipedes, and scorpions are also arthropods.

FIGURE 21
A Spider at Work
This spider wraps its prey, a grasshopper, in silk. Both animals are arthropods.

FIGURE 22
Arthropod Characteristics
This Sally lightfoot crab shows the tough exoskeleton and the jointed appendages that are characteristic of arthropods.

Characteristics of Arthropods

All arthropods share specific characteristics. **Arthropods are invertebrates that have an external skeleton, a segmented body, and jointed attachments called appendages.** Wings, mouthparts, and legs are all appendages. Jointed appendages are such a distinctive characteristic that arthropods are named for it. *Arthros* means "joint" in Greek, and *podos* means "foot" or "leg." Arthropods are classified into four major groups. **The major groups of arthropods include crustaceans, arachnids, centipedes and millipedes, and insects.**

Arthropods share some characteristics with many other animals, too. They have bilateral symmetry, an open circulatory system, and a digestive system with two openings. In addition, most arthropods reproduce sexually.

Outer Skeleton Arthropods have a waxy, waterproof covering called an **exoskeleton,** or outer skeleton. It protects the animal and helps prevent evaporation of water. Water animals are surrounded by water, but land animals need a way to keep from drying out. Arthropods may have been the first animals to live on land. Their exoskeletons probably enabled them to do this because they keep the arthropods from drying out.

As an arthropod grows larger, its exoskeleton cannot expand. The growing arthropod is trapped within its exoskeleton, like a knight in armor that is too small. Arthropods solve this problem by occasionally shedding their exoskeletons and growing new ones that are larger. The process of shedding an outgrown exoskeleton is called **molting.** After an arthropod has molted, its new skeleton is soft for a time. During that time, the arthropod has less protection from danger than it does after its new skeleton has hardened.

Reading Checkpoint **What is an exoskeleton?**

FIGURE 23
A Molting Cicada
This cicada has just molted. You can see its old exoskeleton hanging on the leaf just below it.
Applying Concepts *Why must arthropods molt?*

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For: Links on arthropods
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Segmented Body The bodies of arthropods are segmented. A segmented body plan is easiest to see in centipedes and millipedes, which have bodies made up of many identical-looking segments. You can also see segments on the tails of shrimp and lobsters. In some groups of arthropods, several body segments become joined into distinct sections. An arthropod may have up to three sections—a head, a midsection, and a hind section.

Jointed Appendages Just as your fingers are appendages attached to your palms, many arthropods have jointed appendages attached to their bodies. The joints in the appendages give the animal flexibility and enable it to move. Arthropod appendages tend to be highly specialized tools used for moving, obtaining food, reproducing, and sensing the environment. For example, arthropods use legs to walk and wings to fly. In addition, most arthropods have appendages called antennae (singular *antenna*). An **antenna** is an appendage attached to the head that contains sense organs.

Reading Checkpoint **What is the function of an antenna?**

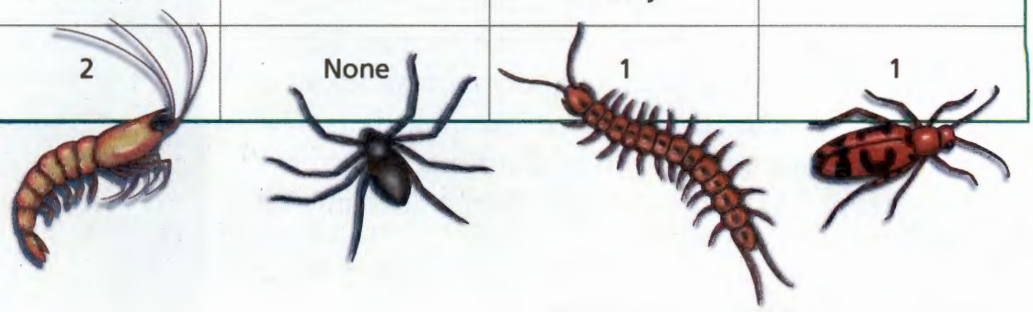
Diversity of Arthropods

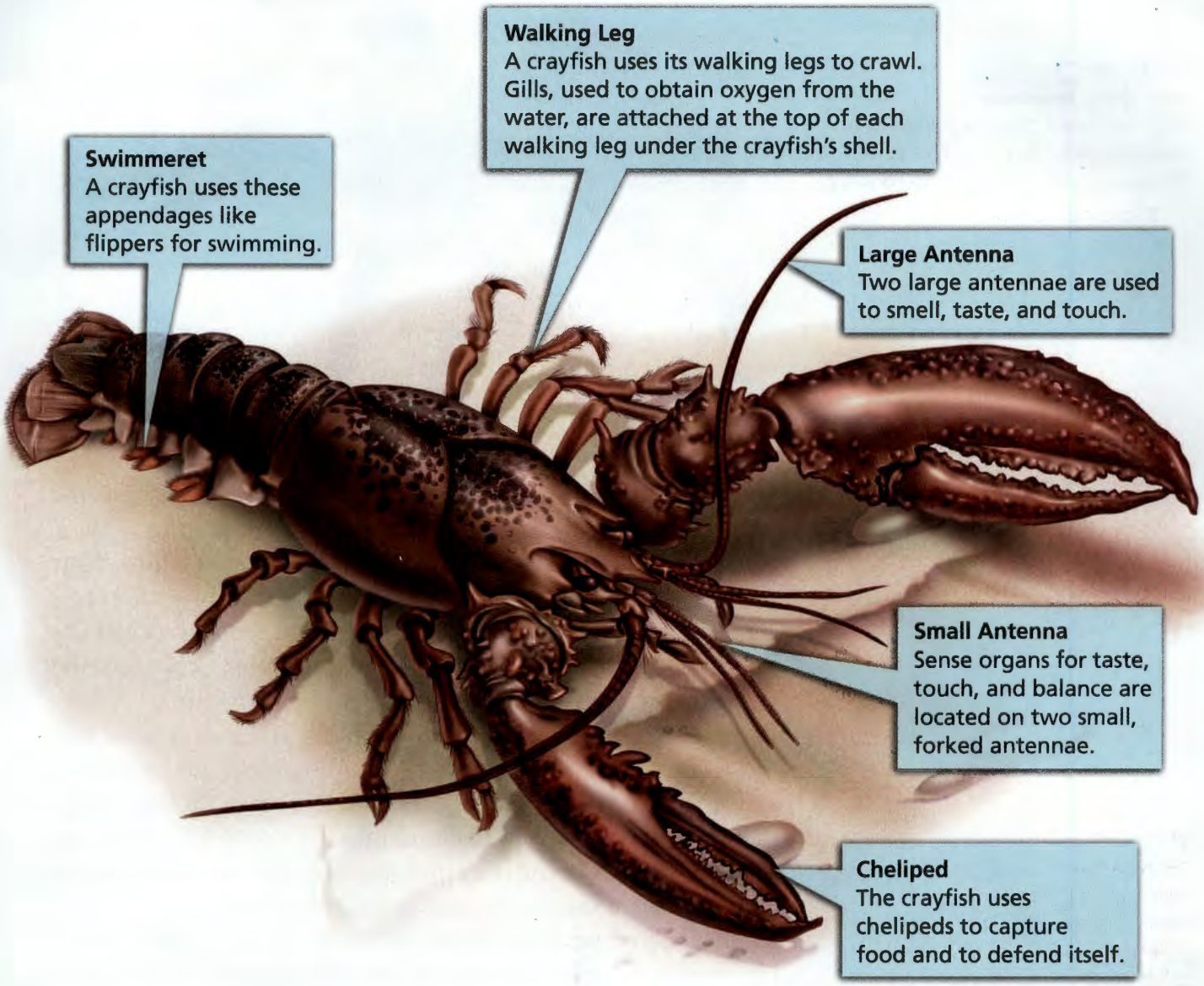
Scientists have identified more species of arthropods—over one million—than all other species of animals combined! There are probably many others that have not been discovered. Look at Figure 24 to compare some characteristics of the four major groups of arthropods.

FIGURE 24
Members of the largest arthropod groups differ in several characteristics.
Interpreting Tables *Which group of arthropods has no antennae?*

Comparisons of the Largest Arthropod Groups

Characteristic	Crustaceans	Arachnids	Centipedes and Millipedes	Insects
Number of body sections	2 or 3	2	2	3
Pairs of legs	5 or more	4	Many	3
Pairs of antennae	2	None	1	1





Crustaceans Crayfish, lobsters, shrimp, and crabs are all examples of **crustaceans** (krus TAY shunz). **A crustacean is an arthropod that has two or three body sections, five or more pairs of legs, and two pairs of antennae.** Each crustacean body segment has a pair of legs or another appendage attached to it. The various types of appendages function differently, as you can see in Figure 25.

Crustaceans live in watery environments. Therefore, most use gills to obtain oxygen. The gills are protected by the crustacean's exoskeleton. Water containing oxygen reaches the gills as the crustacean moves along.

Most crustaceans, such as crabs and shrimp, begin their lives as tiny swimming larvae. Crustacean larvae develop into adults by metamorphosis. **Metamorphosis** (met uh MAWR fuh sis) is a process in which an animal's body undergoes dramatic changes in form during its lifetime.

FIGURE 25
Crayfish Appendages
A crayfish's appendages are as varied as the tools on a Swiss army knife. The appendages are adapted for different functions.
Interpreting Diagrams *What functions do the chelipeds serve?*

FIGURE 26
Red Knee Tarantula
This red knee tarantula lives in an underground burrow. The spider uses fangs to inject venom into its prey.

Arachnids Spiders, mites, ticks, and scorpions are the **arachnids** (uh RAK nidz) that people most often meet. **Arachnids are arthropods with two body sections, four pairs of legs, and no antennae.** Their first body section is a combined head and midsection. The hind section, called the **abdomen**, is the other section. The abdomen contains the reproductive organs and part of the digestive system.

Spiders are probably the most familiar, most feared, and most fascinating kind of arachnid. All spiders are predators, and most of them eat insects. Spiders have hollow fangs through which they inject venom into their prey. Spider venom turns the tissues of the prey into mush. Later the spider uses its fangs like drinking straws, and sucks in the food.

In spite of what some people might think, spiders rarely bite people. When spiders do bite, their bites are often painful but rarely life-threatening. However, the bite of a brown recluse or a black widow may require hospital care.

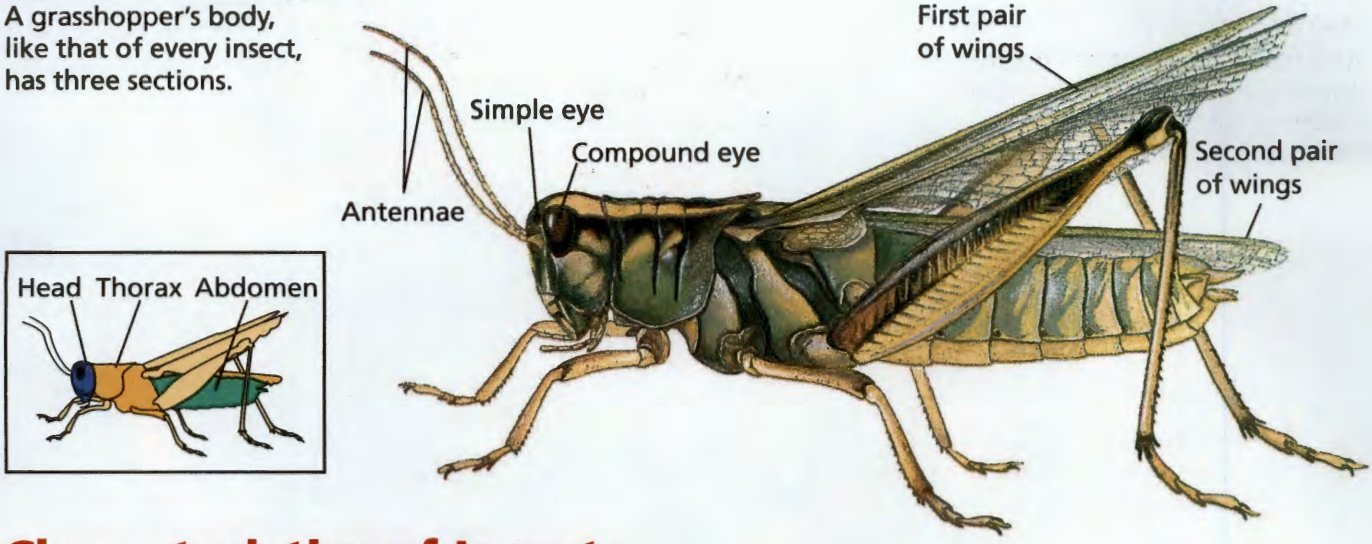
FIGURE 27
Centipede
Centipedes have many pairs of legs. **Interpreting Photographs** *How many pairs of legs does each segment of the centipede have?*

Centipedes and Millipedes Centipedes and millipedes look something like earthworms. However, they are arthropods, not worms. **Centipedes and millipedes are arthropods with two body sections and many pairs of legs.** The two body sections consist of a head with one pair of antennae, and a long abdomen with many segments.

Centipedes have one pair of legs attached to each segment. Some centipedes have more than 100 segments. In fact, the word *centipede* means "hundred feet." Millipedes, which may have more than 80 segments, have two pairs of legs on each segment. Though *millipede* means "thousand feet," millipedes don't have that many legs.

Reading Checkpoint **How many sections does an arachnid's body have?**

FIGURE 28
Structure of a Grasshopper
A grasshopper's body, like that of every insect, has three sections.



Characteristics of Insects

By far the most common of all the arthropods are the **insects.** You can identify insects, like other arthropods, by counting their body sections and legs. **Insects are arthropods with three body sections, six legs, one pair of antennae, and usually one or two pairs of wings.** The three body sections are the head, thorax, and abdomen, as you can see in Figure 28.

Head An insect's brain and most of its sense organs, such as the eyes and antennae, are in its head. The brain, antennae, and eyes are organs that are part of a well-developed nervous system. Each organ, tissue, and cell in this system contributes to the function of sensing the environment and directing body activities.

For example, insects usually have two large compound eyes, which enable them to see their surroundings. These eyes contain many lenses. Each lens is a structure that focuses light and forms images. Compound eyes are especially keen at seeing movement. Most insects also have simple eyes that can distinguish between light and darkness.

Thorax An insect's midsection, or **thorax,** is the section to which wings and legs are attached. Most insects can fly once they are adults. Insects are the only invertebrates that can fly.

Abdomen Inside the abdomen are many of the insect's internal organs. Small holes on the outside of the abdomen lead to a system of tubes inside the insect. These tubes allow air, which contains oxygen, to enter the body. The oxygen in the air travels directly to the insect's cells.

Reading Checkpoint **What are the three sections of an insect's body?**

Lab zone Skills Activity

Graphing

Use the data to make a circle graph that shows the percentage of total insect species in each group. (See the Skills Handbook.)

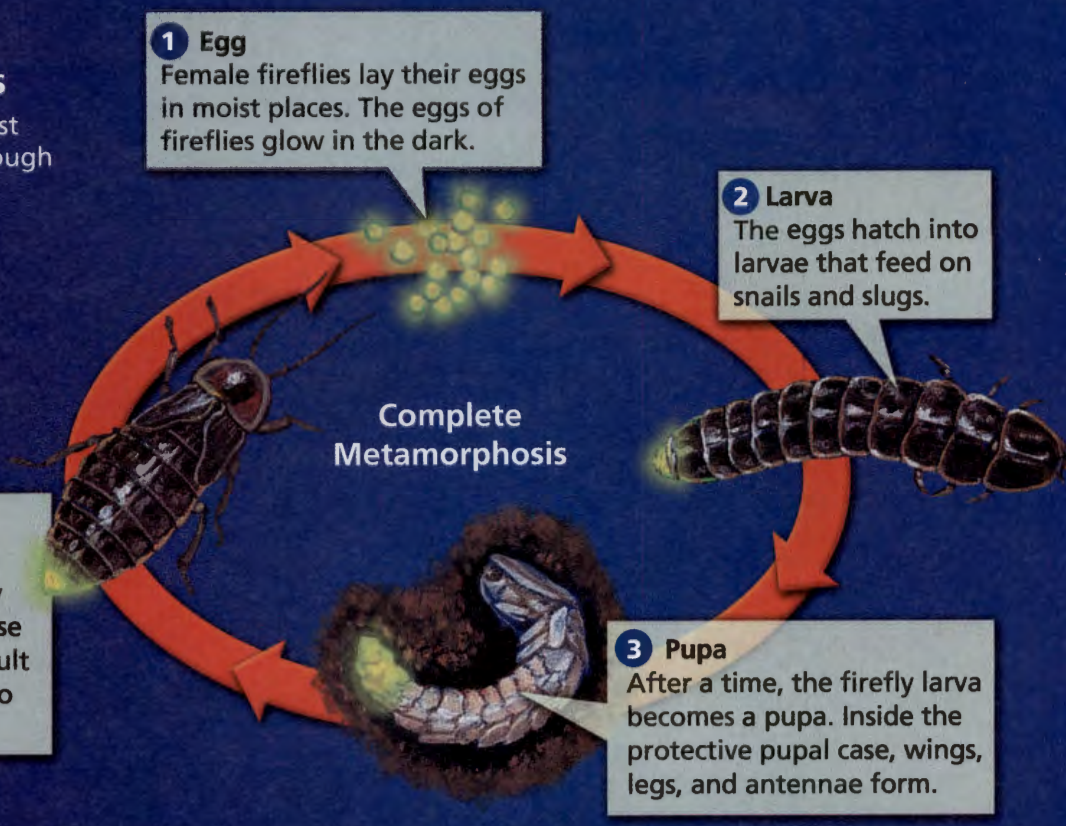
Insect Groups

Group	Number of Species
Ants, bees, and wasps	115,000
Beetles and weevils	350,000
Butterflies and moths	178,000
Flies and mosquitoes	110,000
Other insect groups	147,000

FIGURE 29

Insect Metamorphosis

Depending on the species, most insects develop into adults through complete metamorphosis or gradual metamorphosis.

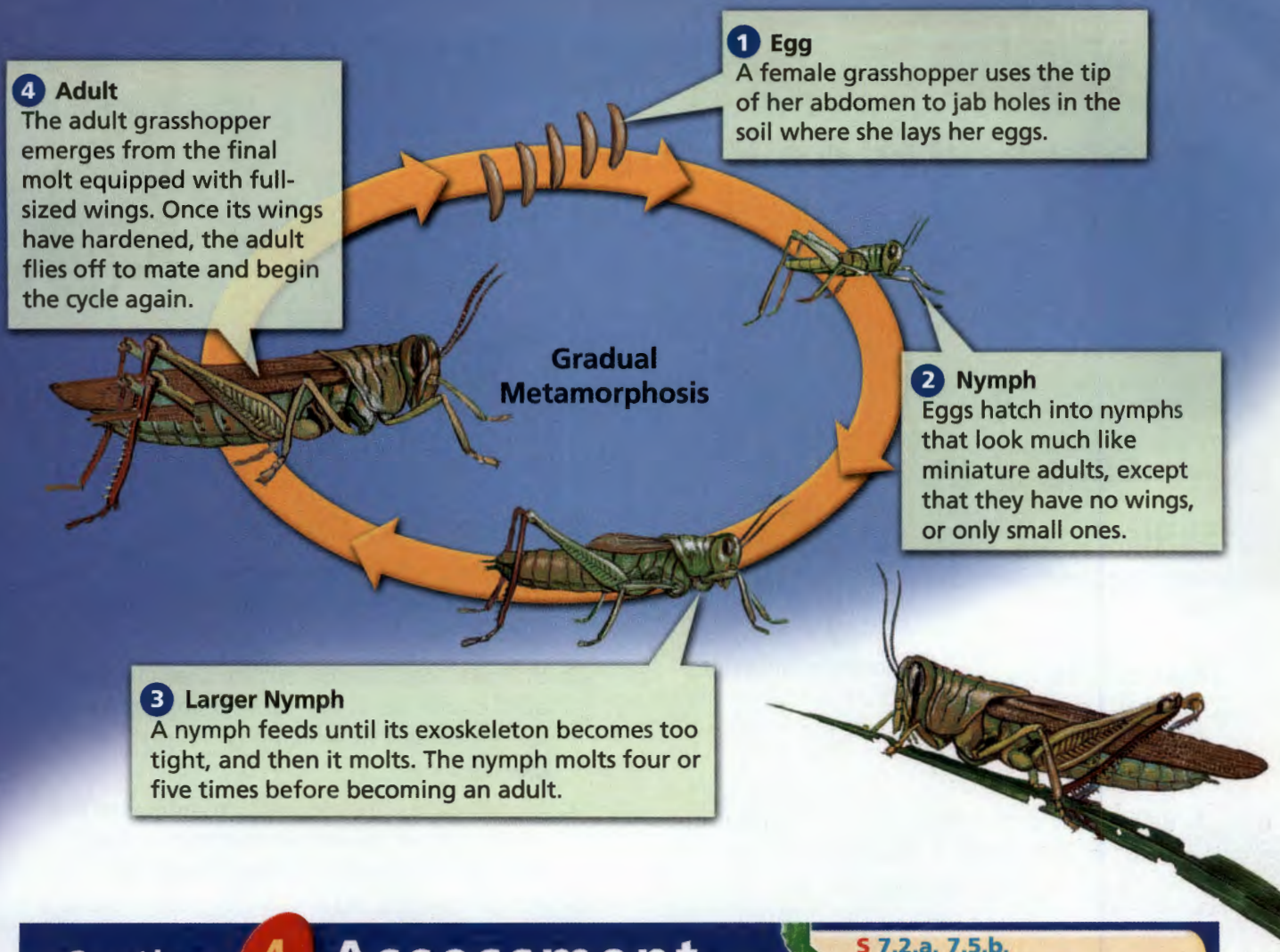


Insect Life Cycles

Insects hatch from eggs. They then develop through metamorphosis. **Each insect species undergoes either complete metamorphosis or gradual metamorphosis.**

Complete Metamorphosis In Figure 29 you can see that an insect with **complete metamorphosis** has four different stages: egg, larva, pupa, and adult. Eggs hatch into larvae. The larvae, such as the caterpillars of butterflies, usually look something like worms. Larvae are specialized for eating and growing. After a time, a larva becomes a **pupa** (PYOO puh). Major changes in body structure are taking place in this stage, as the pupa becomes an adult insect. Beetles, butterflies, flies, and ants all undergo complete metamorphosis.

Gradual Metamorphosis In contrast, the second type of metamorphosis, called **gradual metamorphosis,** has no distinct larval stage. An egg hatches into a stage called a **nymph** (nimf), which usually looks like the adult insect without wings. A nymph may molt several times before becoming an adult. Grasshoppers, termites, cockroaches, and dragonflies go through gradual metamorphosis.



Section 4 Assessment

S 7.2.a, 7.5.b, E-LA: Reading 7.1.4

Vocabulary Skill **Use Clues to Determine Meaning** Find the Key Term *thorax* on page 439. What does *thorax* mean? What clues help you understand its meaning?

Reviewing Key Concepts

1. a. **Identifying** What are the characteristics of arthropods?
   b. **Explaining** What structure protects an arthropod's body from loss of water?
   c. **Relating Cause and Effect** Why does an insect's body need this protection?
2. a. **Listing** List the main groups of arthropods.
   b. **Interpreting Tables** Use Figure 24 to contrast the number of body sections in the major groups of arthropods.
   c. **Applying Concepts** In which section are most of an insect's sense organs located? What organ system are the sense organs a part of?
3. a. **Listing** List the stages of gradual metamorphosis and the stages of complete metamorphosis.
   b. **Interpreting Diagrams** Look at Figure 29. How are complete metamorphosis and gradual metamorphosis different?

Lab zone At-Home Activity

Bug Hunt Walk with a family member in your backyard or neighborhood. Search the undersides of leaves, under woodchips or rocks, and other likely places for insects. Show your family member what distinguishes an insect from other kinds of arthropods.

Lab zone **Skills Lab**

Invertebrates on Branches

S 7.3.d, 7.7.d

Problem

How can you construct a branching tree diagram to classify some invertebrates?

Skills Focus

classifying, interpreting data

Materials

- index cards

Procedure

1. Review the explanation of a branching tree diagram in Chapter 7. Recall that in a branching tree diagram, the organism with none of the characteristics goes at the bottom of the tree. The organism with the greatest number of derived characteristics goes at the top.
2. Examine the incomplete branching tree diagram. Copy it in your notebook.
3. The table below lists characteristics of five invertebrates. Make a card for each animal that lists the characteristics of that animal. Then arrange the cards in order, beginning with the animal that has none of the characteristics and ending with the animal that has all the characteristics.
4. Use the data in the table and your cards to complete the branching tree diagram. Put the missing animals on their correct branches. Identify the missing characteristics.
5. You discover a fossil scorpion similar to the one in the photograph. The fossil animal has an exoskeleton but does not have three body sections. Mark on your copy of the branching tree diagram where the scorpion should go.

Analyze and Conclude

1. **Classifying** Which animal goes at the top of the diagram? How many of the listed characteristics does the animal have?
2. **Interpreting Data** Except for the earthworm, all the animals in the table belong to the same phylum. To which phylum do these animals belong?
3. **Drawing Conclusions** Which animal in the table is most closely related to the fossil scorpion? Explain how you know this.
4. **Communicating** Which two animals on the diagram are most distantly related? Write a paragraph in which you identify the data on which you base your conclusion.

More to Explore

Do research to learn some of the characteristics that are used to classify insects into groups. Write a report about what you have learned.

Characteristics of Some Invertebrates

Invertebrate	Three Body Sections	Wings Present	Tiny Scales on Wings	Exoskeleton
Bristletail	Yes	No	No	Yes
Earthworm	No	No	No	No
Butterfly	Yes	Yes	Yes	Yes
Mosquito	Yes	Yes	No	Yes
Tarantula	No	No	No	Yes

Section 5

Echinoderms

CALIFORNIA Standards Focus

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

S 7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.

- What are the main characteristics of echinoderms?
- What are the major groups of echinoderms?

Key Terms

- echinoderm
- endoskeleton
- water vascular system
- tube feet

Lab zone Standards Warm-Up

How Do Sea Stars Hold On?

1. Use a plastic dropper and water to model how a sea star moves and clings to surfaces. Fill the dropper with water, and then squeeze out most of the water.
2. Squeeze the last drop of water onto the inside of your arm. Then, while squeezing the bulb, touch the tip of the dropper into the water drop. With the dropper tip against your skin, release the bulb.
3. Hold the dropper by the tube and lift it slowly, paying attention to what happens to your skin.

Think It Over

Predicting Besides moving and clinging to surfaces, what might sea stars use their suction structures for?

While exploring a rocky beach one day, you see what looks like a dill pickle at the bottom of a tide pool. You think it might be a plant or a rock covered with green slime. But as you look more closely, the pickle begins to crawl very slowly. This amazing creature is a sea cucumber, a relative of sea stars.

Characteristics of Echinoderms

Sea cucumbers, sea stars, sea urchins, and sand dollars are all **echinoderms** (ee KY noh durmz), members of the phylum Echinodermata. **Echinoderms are invertebrates with an internal skeleton and a system of fluid-filled tubes called a water vascular system.** All echinoderms live in salt water.

Body Structure The skin of most echinoderms is stretched over an internal skeleton, or **endoskeleton**, made of hardened plates. These plates support the animal and give it a bumpy texture. Adult echinoderms have a unique kind of radial symmetry in which the body parts, usually in multiples of five, are arranged like spokes on a wheel.

Go Online
active art

For: Water Vascular System activity
Visit: PHSchool.com
Web Code: cep-2025

Movement The internal organ system of fluid-filled tubes in echinoderms is called the **water vascular system.** You can see a sea star's water vascular system in Figure 30. Portions of the tubes in this system can contract, or squeeze together, forcing water into structures called **tube feet.** This process is something like moving water around in a water balloon by squeezing different parts of the balloon.

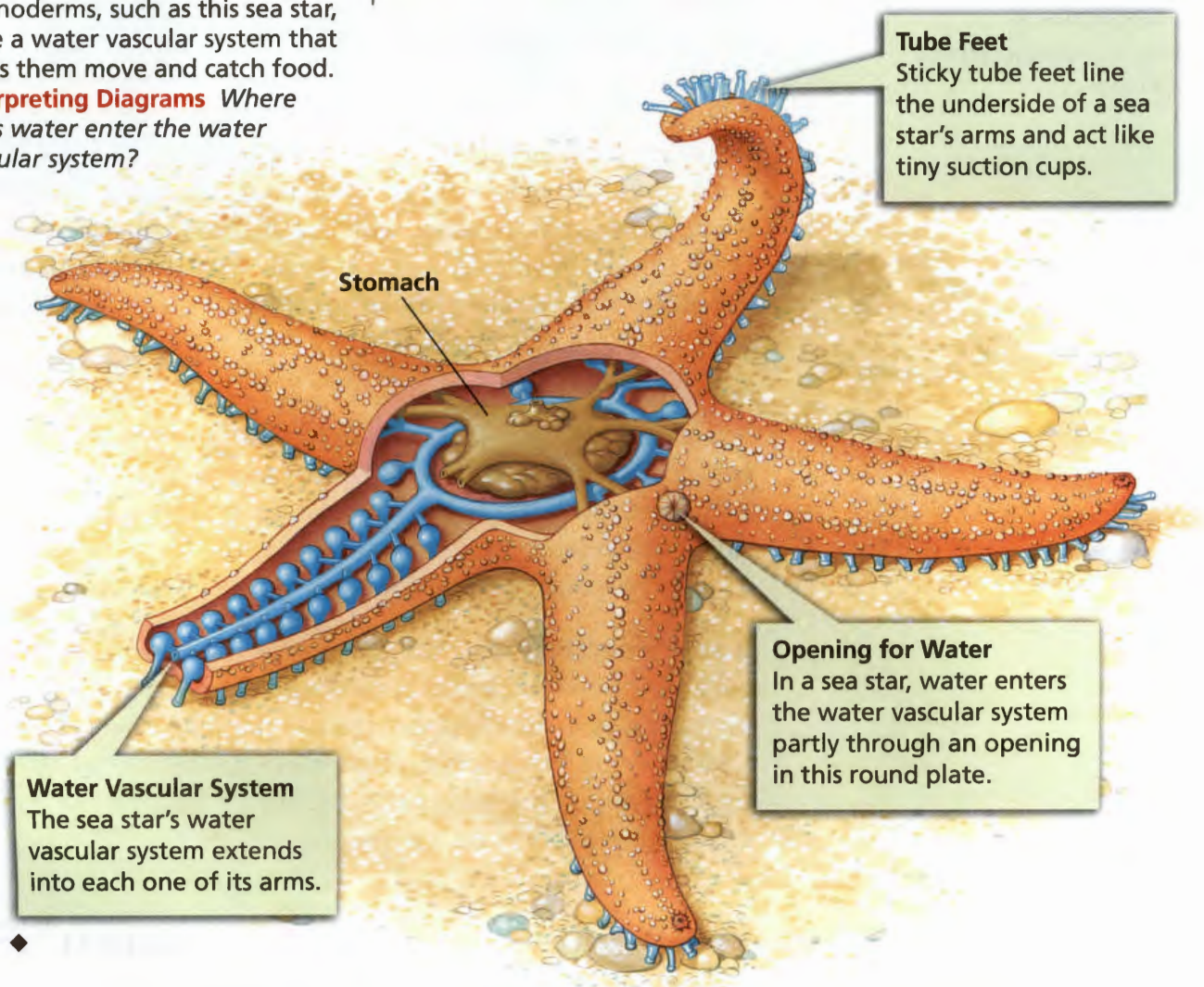
The ends of tube feet are sticky. When filled with water, they act like small, sticky suction cups. The stickiness and suction enable the tube feet to grip the surface beneath the echinoderm. Most echinoderms use their tube feet to move along slowly and to capture food.

Reproduction and Life Cycle Almost all echinoderms are either male or female. Eggs are usually fertilized in the water, after a female releases her eggs and a male releases his sperm. The fertilized eggs develop into tiny, swimming larvae that look very different from the adults. The larvae eventually undergo metamorphosis and become adult echinoderms.

Reading Checkpoint **What are the functions of an echinoderm's tube feet?**

FIGURE 30
A Water Vascular System

Echinoderms, such as this sea star, have a water vascular system that helps them move and catch food.
Interpreting Diagrams *Where does water enter the water vascular system?*



Sea Star

Brittle Star

Sea Urchin

Diversity of Echinoderms

There are four major groups of echinoderms: sea stars, brittle stars, sea urchins, and sea cucumbers. The members of these groups look quite different. They also have different ways of feeding and moving.

Sea stars are predators that eat mollusks, crabs, and even other echinoderms. Sea stars use their tube feet to move across the ocean floor. They also use their tube feet to capture prey. A sea star will grasp a clam with all five arms, and then pull the shells open. Then the sea star feeds on the clam's tissues.

A brittle star's arms are long and slender. To move, a brittle star waves its arms in a snakelike motion against the ocean floor. A brittle star uses its tube feet to catch food.

Sea urchins have no arms. Spines cover and protect their bodies, so they look something like a pincushion. To move, sea urchins use tube feet that extend out between the spines. They scrape and cut food with five toothlike structures.

Sea cucumbers look a little bit like the cucumbers you eat. With tube feet on their underside, sea cucumbers crawl along the ocean floor. They feed with a mouth surrounded by tentacles.

Sea Cucumber

FIGURE 31
Diversity of Echinoderms
Echinoderms are diverse in their appearance, but all have radial symmetry and are found in the ocean.

Section 5 Assessment

S 7.2.a, 7.5.b, E-LA: Writing 7.2.0, Reading 7.1.4

Vocabulary Skill **Use Clues to Determine Meaning**
Look at the definition of *endoskeleton* on page 443. What phrase in the sentence gives the meaning of *endoskeleton*?

Reviewing Key Concepts

1. a. **Reviewing** What characteristics do echinoderms have?
   b. **Summarizing** Explain how echinoderms reproduce.
   c. **Inferring** In echinoderms, could fertilization take place without water? Why or why not?
2. a. **Identifying** Identify the four major groups of echinoderms.
   b. **Comparing and Contrasting** Compare and contrast how sea stars and sea urchins feed.
   c. **Predicting** Would a sea star be able to eat clams without using its tube feet? Explain.

Writing in Science

Comparison Paragraph In a paragraph, compare and contrast how sea stars, brittle stars, and sea urchins move.

Chapter 11 Study Guide

The BIG Idea 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 S 7.5.a

- The cells of most animals are organized into tissues, organs, and organ systems.
- Some major functions of animals are obtaining food and oxygen, keeping internal conditions stable, moving, and reproducing.
- Symmetry is a balanced arrangement of body parts that is characteristic of many animals.
- Animals are classified according to how they are related to other animals.

Key Terms

• anatomy • physiology • bilateral symmetry • radial symmetry • vertebrate • invertebrate • phylum

2 Sponges and Cnidarians

Key Concepts S 7.2.a, 7.5.a

- Sponges are invertebrates that usually lack symmetry and never have tissues or organs.
- Cnidarians use stinging cells to capture food and defend themselves.

Key Terms

• larva • cnidarian • polyp • medusa

3 Worms and Mollusks

Key Concepts S 7.2.a, 7.5.a

- All worms are invertebrates that have long, narrow bodies without legs.
- Unlike cnidarians or flatworms, roundworms have a digestive system that is like a tube, open at both ends.
- Segmented worms have bodies made up of many linked sections called segments.
- In addition to a soft body often covered by a shell, a mollusk has a mantle and a foot.
- The three major groups of mollusks are gastropods, bivalves, and cephalopods.

Key Terms

• brain • parasite • host • anus • closed circulatory system • mollusk • open circulatory system • gill • gastropod • radula • bivalve • cephalopod

4 Arthropods

Key Concepts S 7.2.a, 7.5.b

- Arthropods are invertebrates that have an external skeleton, a segmented body, and jointed attachments called appendages.
- The major groups of arthropods are crustaceans, arachnids, centipedes and millipedes, and insects.
- A crustacean is an arthropod that has two or three body sections, five or more pairs of legs, and two pairs of antennae.
- Arachnids are arthropods with two body sections, four pairs of legs, and no antennae.
- Insects have three body sections, six legs, one pair of antennae, and usually one or two pairs of wings.
- Each insect species undergoes either complete metamorphosis or gradual metamorphosis.

Key Terms

• arthropod • exoskeleton • molting • antenna • crustacean • metamorphosis • arachnid • abdomen • insect • thorax • complete metamorphosis • pupa • gradual metamorphosis • nymph

5 Echinoderms

Key Concepts S 7.2.a, 7.5.b

- Echinoderms are invertebrates with an internal skeleton and a system of fluid-filled tubes called a water vascular system.
- Groups of echinoderms include sea stars, brittle stars, sea urchins, and sea cucumbers.

Key Terms

• echinoderm • endoskeleton • water vascular system • tube feet

Review and Assessment

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Target Reading Skill

Take Notes To review part of Section 5, take notes on the text following the heading Movement. Copy the incomplete graphic organizer shown on the right. Complete it by answering the questions.

Questions	Notes: Movement
What is a water vascular system? What are tube feet?	

Reviewing Key Terms

Choose the letter of the best answer.

1. An animal without a backbone is called a(n)
   a. vertebrate.
   b. invertebrate.
   c. larva.
   d. parasite.
2. Which group of animals uses stinging cells to capture prey?
   a. vertebrates
   b. cnidarians
   c. sponges
   d. echinoderms
3. Which organ do most mollusks and crustaceans use to obtain oxygen?
   a. radula
   b. lungs
   c. gills
   d. legs
4. An arthropod's antennae are located on its
   a. head.
   b. thorax.
   c. abdomen.
   d. mantle.
5. At which stage of insect development do major changes in body structure occur?
   a. egg **b.** larva
   c. pupa **d.** adult
6. Echinoderms move by using structures called
   a. wings. **b.** appendages.
   c. tube feet. **d.** abdomens.

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

7. A sea anemone is a described as a **polyp** because its body is _____ .
8. Unlike the blood in an open circulatory system, the blood in a **closed circulatory system** _____ .
9. A gastropod has a **radula,** which is a(n) _____ .
10. An insect's body is protected by its **exoskeleton,** which is a(n) _____ .
11. Unlike **gradual metamorphosis,** complete metamorphosis has _____ .

Writing in Science

News Report As a television reporter, you are covering a story about a giant squid that has washed up on the local beach. Write a short news story describing the discovery. Be sure to describe how scientists classified the animal as a squid.

Video Assessment
Discovery Channel School
Mollusks, Arthropods, and Echinoderms

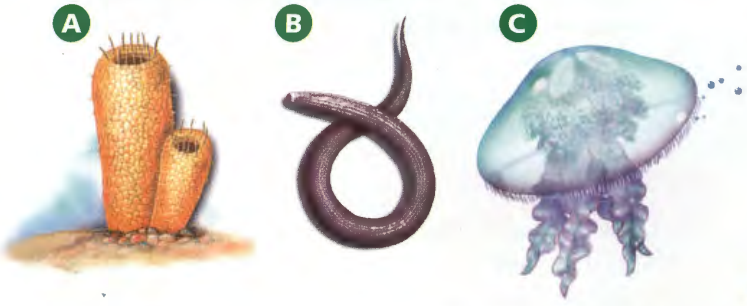
Review and Assessment

Checking Concepts

12. Explain the relationship among cells, tissues, and organs.
13. What are five key functions of animals?
14. Explain what a one-way digestive system is.
15. Describe the structure of a mollusk's gills.
16. Contrast the functions of an insect's compound eyes and simple eyes.
17. What is an endoskeleton? What is its function?

Thinking Critically

18. **Making Judgments** Suppose a book is called *Earth's Animals*. All the animals in the book are vertebrates. Is this title a good one? Explain your reasoning.
19. **Classifying** Classify each of the following animals as having radial symmetry, bilateral symmetry, or no symmetry: sea anemones, sponges, fishes, humans, and butterflies.
20. **Classifying** Which of the animals below is a roundworm? A sponge? A cnidarian? Describe the major characteristics shared by members of each phylum.



21. **Comparing and Contrasting** Compare and contrast bivalves and cephalopods.
22. **Applying Concepts** Explain why the development of a lion, which grows larger as it changes from a tiny cub to a 90-kg adult, is not metamorphosis.
23. **Applying Concepts** Some seafood restaurants serve a dish called soft-shelled crab. What do you think happened to the crab just before it was caught? Why is this process important?
24. **Classifying** Your friend said he found a dead insect that had two pairs of antennae and eight legs. Is this possible? Why or why not?
25. **Comparing and Contrasting** Compare and contrast centipedes and millipedes.

Applying Skills

Use the data table to answer Questions 26–28.

The following data appeared in a book on insects.

Flight Characteristics

Type of Insect	Wing Beats (per second)	Flight Speed (kilometers per hour)
Hummingbird moth	85	17.8
Bumblebee	250	10.3
Housefly	190	7.1

26. **Graphing** Use the data to make two bar graphs: one showing the three insect wing-beat rates and another showing the flight speeds.
27. **Interpreting Data** Which of the three insects has the highest wing-beat rate? Which insect flies the fastest?
28. **Drawing Conclusions** Based on the data, is there a relationship between the rate at which an insect beats its wings and the speed at which it flies? Explain. What factors besides wing-beat rate might affect flight speed?

Lab zone Standards Investigation

Performance Assessment Prepare a display to show how you set up your experiment and what your results were. Construct and display graphs to show the data you collected. Include pictures of the mealworms in each stage of development. Write your conclusion of how the experimental conditions affected the growth and development of the mealworms. Also suggest some possible explanations for your results.

Choose the letter of the best answer.

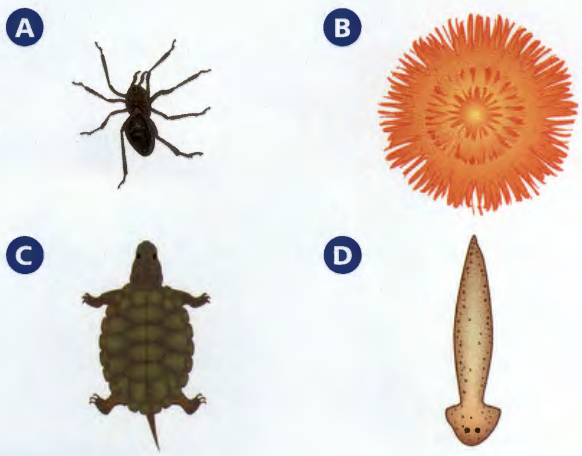
1. What is the correct sequence in which a stinging cell reacts to the touch of another organism?
   - **A** trigger brushes against prey, stinging cell fires, barbs snare prey
   - **B** barbs snare prey, stinging cell fires, barbs release prey
   - **C** prey is paralyzed, venom enters prey, stinging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

   S 7.5.b

2. Which of the following is true of a one-way digestive system?
   - **A** It is found in all parasites.
   - **B** It has two openings.
   - **C** It has one opening.
   - **D** It is found in all parasites and has one opening.

   S 7.5.a

Use the diagram below and your knowledge of science to answer Question 3.



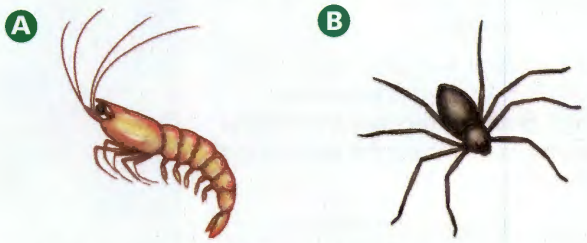
3. Of the four animals above, which have sense organs concentrated at one end of their bodies?
   - **A** animals A and D
   - **B** animals A, B, and D
   - **C** animals B and D
   - **D** animals A, C, and D

   S 7.5.a

4. Which of the following statements is true about gradual metamorphosis?
   - **A** Gradual metamorphosis is a life cycle that involves asexual reproduction.
   - **B** In gradual metamorphosis, a larva develops into a pupa.
   - **C** In gradual metamorphosis, an egg hatches into a nymph.
   - **D** Gradual metamorphosis has four distinct stages.

   S 7.2.a

Use the diagram below and your knowledge of science to answer Question 5.



5. You are constructing a branching tree diagram that shows the relationship between animals A and B above. Which of the following characteristics could you use to place the two animals on different branches?
   - **A** type of circulatory system
   - **B** presence or absence of jointed appendages
   - **C** type of digestive system
   - **D** presence or absence of antennae

   S 7.3.d

6. Which of the following best describes the stages in the sexual life cycle of a sponge in the correct order?
   - **A** larva, fertilization, egg and sperm, adult
   - **B** adult, larva, egg and sperm, fertilization
   - **C** adult, bud, bud breaks free
   - **D** egg and sperm, fertilization, larva, adult

   S 7.2.a

Apply the BIG Idea

7. Explain how a sea star's water vascular system enables the sea star to move.

   S 7.5.b