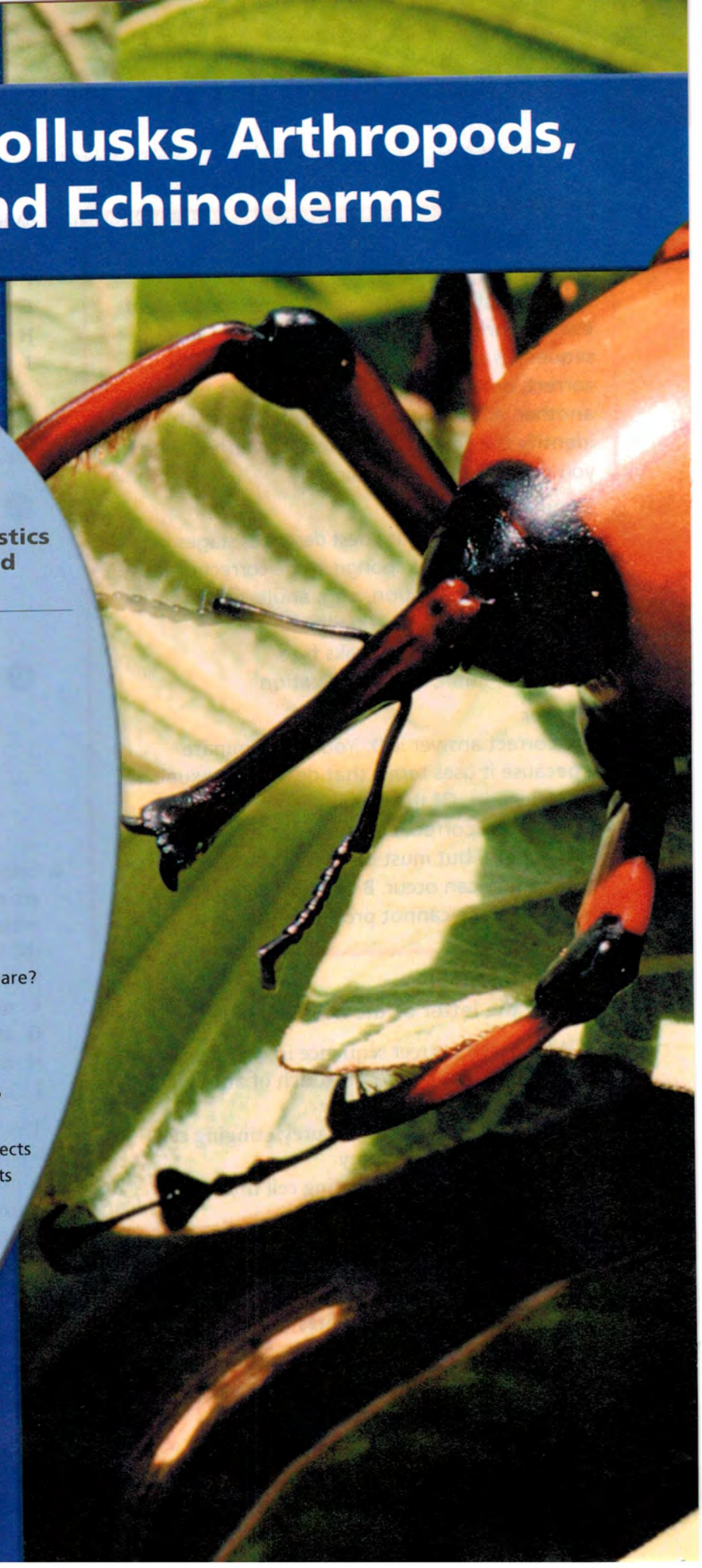
Chapter 10

Mollusks, Arthropods, and Echinoderms

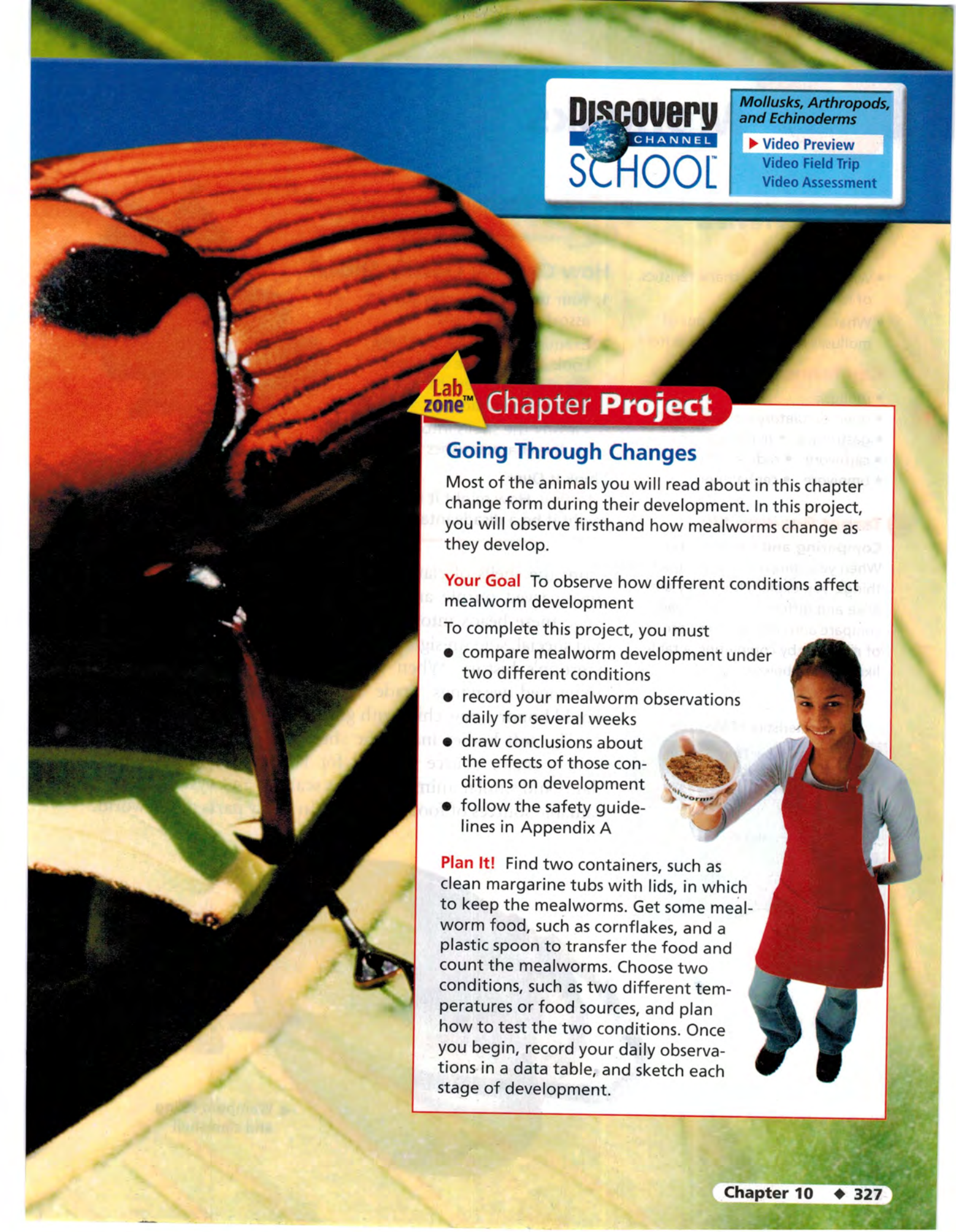
The BIG Idea
Diversity and Adaptations

What are the key characteristics of mollusks, arthropods, and echinoderms?

Chapter Preview



This weevil from Southeast Asia uses its impressive front legs to court females.



Discovery CHANNEL SCHOOL

Mollusks, Arthropods, and Echinoderms

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™

Chapter Project

Going Through Changes

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

Your Goal To observe how different conditions affect mealworm development

To complete this project, you must

- compare mealworm development under two different conditions
- record your mealworm observations daily for several weeks
- 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

Mollusks

Reading Preview

Key Concepts

- What are the main characteristics of mollusks?
- What are the major groups of mollusks and how do they differ?

Key Terms

- mollusk
- open circulatory system • gill
- gastropod • herbivore
- carnivore • radula • bivalve
- omnivore • cephalopod

Target Reading Skill

Comparing and Contrasting

When you compare and contrast things, you explain how they are alike and different. As you read, compare and contrast three groups of mollusks by completing a table like the one below.

Characteristics of Mollusks

Type of Mollusk	How They Obtain Food	How They Move
Gastropod		
Bivalve		
Cephalopod		

Lab zone **Discover Activity**

How Can You Classify Shells?

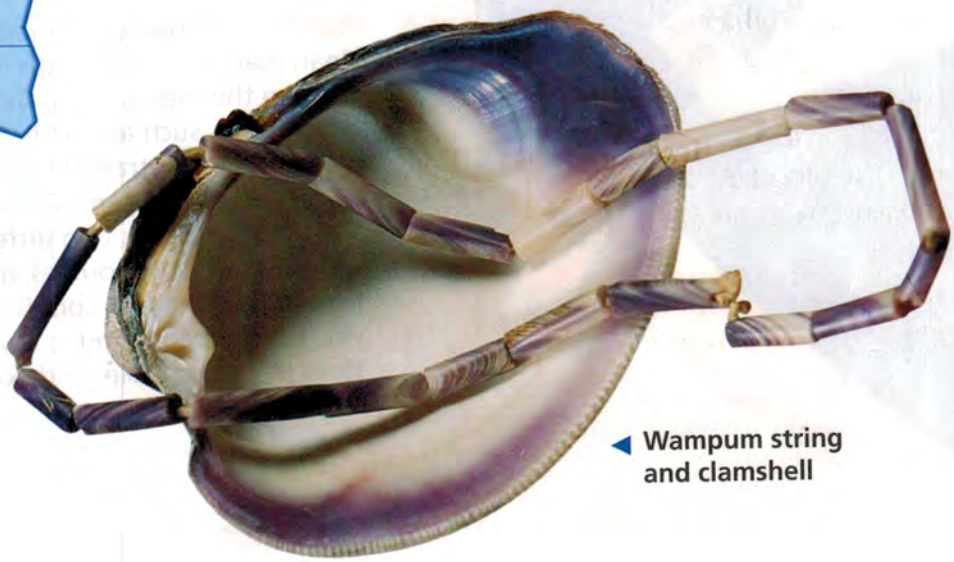
1. Your teacher will give you an assortment of shells.
2. Examine each shell carefully. Look at the shape and color of the shells and feel their inner and outer surfaces.
3. Classify the shells into groups based on the characteristics you observe.

Think It Over

Inferring How might it help an animal to have a shell? How might it be a disadvantage?

From the shells of clams, Native Americans in the Northeast once carved purple and white beads called wampum. They wove these beads into belts with complex designs that often had special, solemn significance. A wampum belt might record a group's history. When warring groups made peace, they exchanged weavings made of wampum. Iroquois women would honor a new chief with gifts of wampum strings.

The soft bodies inside the shells used to make wampum were a major source of food for Native Americans. Today, clams and similar animals, such as scallops and oysters, are still valuable sources of food for people in many parts of the world.



◀ Wampum string and clamshell

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. **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 1.

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?**

FIGURE 1

Comparing Mollusks

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

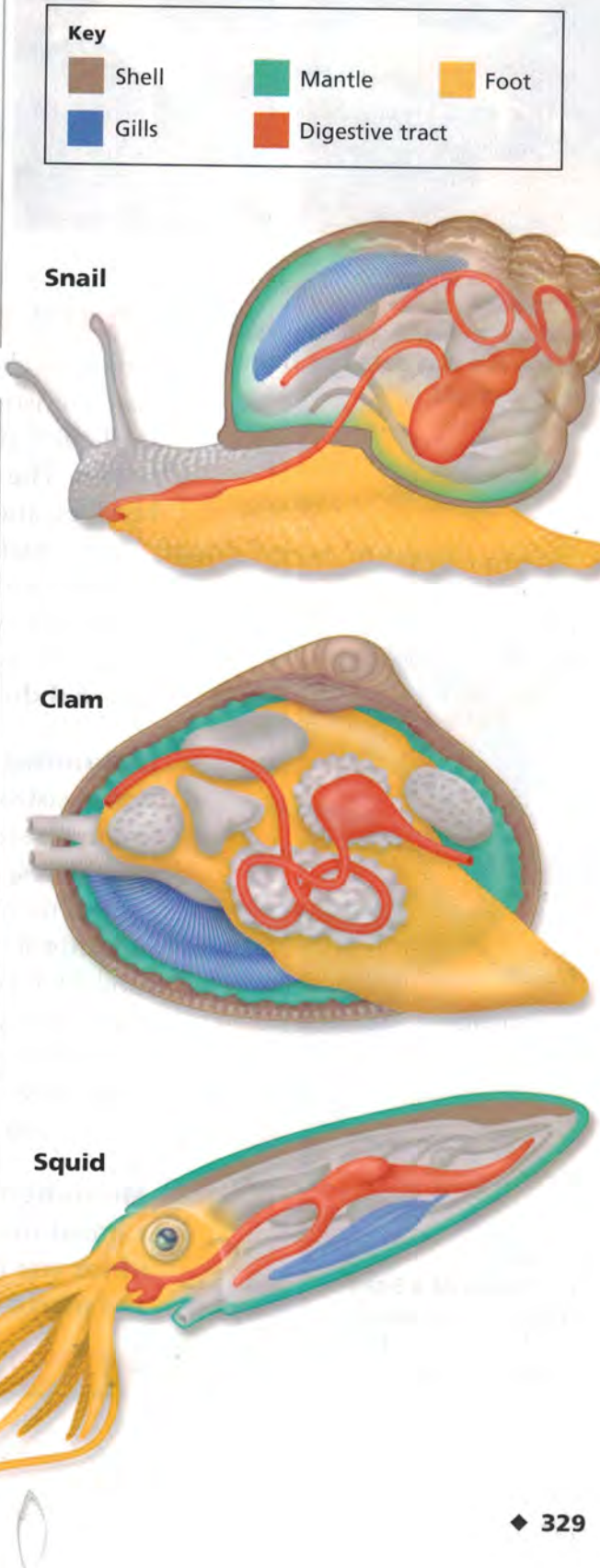


FIGURE 2
Gastropods
Although the land snail has a shell and the sea slug does not, both are gastropods.

Snails and Slugs

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

The **gastropods** are the largest group of mollusks. They include snails and slugs, like the ones shown in Figure 2, and live nearly everywhere on Earth. They live in oceans, on rocky shores, in fresh water, and on land. **Gastropods have a single external shell or no shell at all.**

Obtaining Food Like all organisms, gastropods need food. 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.

But no matter what they eat, gastropods use an organ called a **radula** (RAJ oo luh), a flexible ribbon of tiny teeth, to obtain food. Herbivores use the radula like sandpaper to tear through plant tissues. Carnivores use their radulas in different ways. For example, a gastropod called an oyster drill uses its radula to bore a hole through an oyster's shell. Then it scrapes up the oyster's soft body tissues.

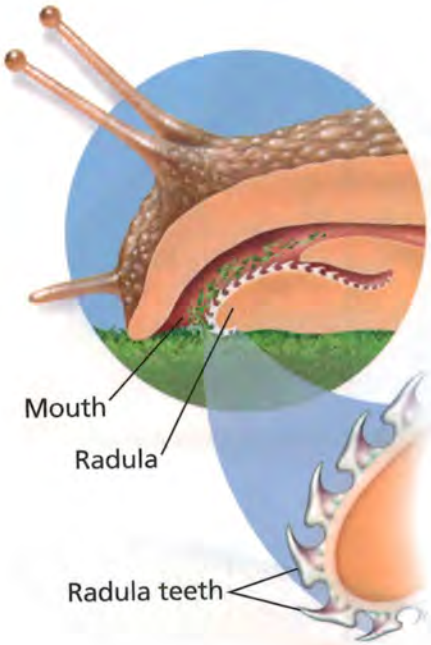


FIGURE 3
The Radula of a Snail
A snail has a food-gathering organ called a radula, which tears and scrapes up food.

Movement A gastropod usually moves by creeping along on a broad foot. The foot may ooze a carpet of slippery mucus, which you may have seen if you've ever watched a snail move. The mucus makes it easier for the gastropod to move.

Reading Checkpoint **What is the function of a radula?**

Two-Shelled Mollusks

A second group of mollusks, **bivalves,** includes oysters, clams, scallops, and mussels. **Bivalves are mollusks that have two shells held together by hinges and strong muscles.** They are found in all kinds of watery environments.

Obtaining Food Like gastropods, bivalves need food. But unlike gastropods, bivalves do not have radulas. Instead, most are filter feeders that strain tiny organisms from water. Bivalves capture food as water flows over their gills. Food particles stick to mucus that covers the gills. The cilia on the gills then move the food particles into the bivalve's mouth. Most bivalves are **omnivores,** animals that eat both plants and animals.

Movement Like gastropods, bivalves don't move quickly. The larvae of most bivalves float or swim through the water. But the adults stay in one place or use their foot to move very slowly. For example, oysters and mussels attach themselves to rocks or other underwater surfaces. Clams, in contrast, move. Look at Figure 4 to see how a clam digs into mud.

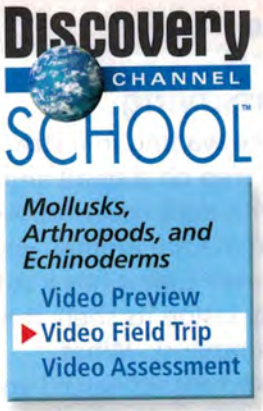
Protection Sometimes an object such as a grain of sand gets stuck between a bivalve's mantle and shell. The object irritates the soft mantle. Just as you might put smooth tape around rough bicycle handlebars to protect your hands, the bivalve's mantle produces a smooth, pearly coat to cover the irritating object. Sometimes a pearl forms eventually around the object. Some oysters make beautiful pearls that are used in jewelry.

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 4
How a Clam Digs
A razor clam digs into the mud by changing the shape of its foot.
Predicting *How might the clam use its foot to move back up?*

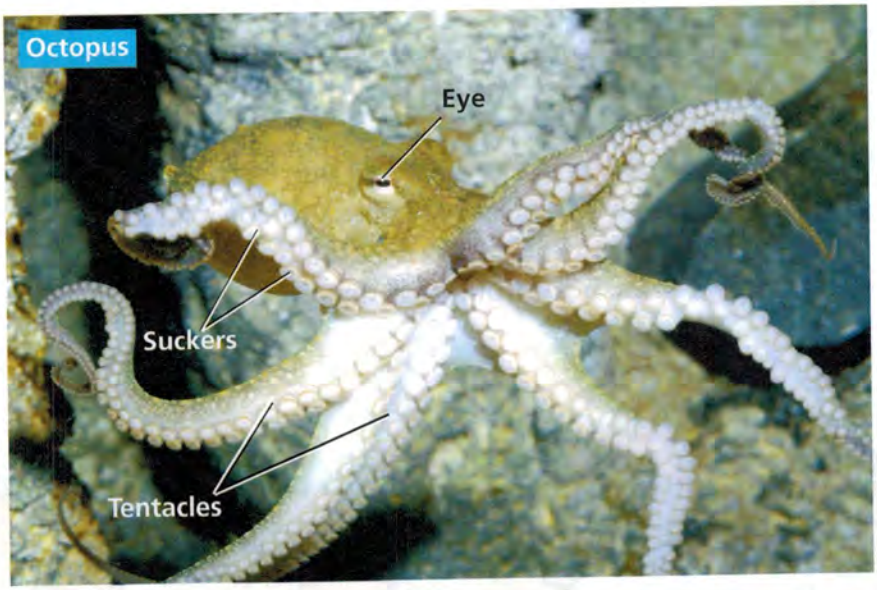


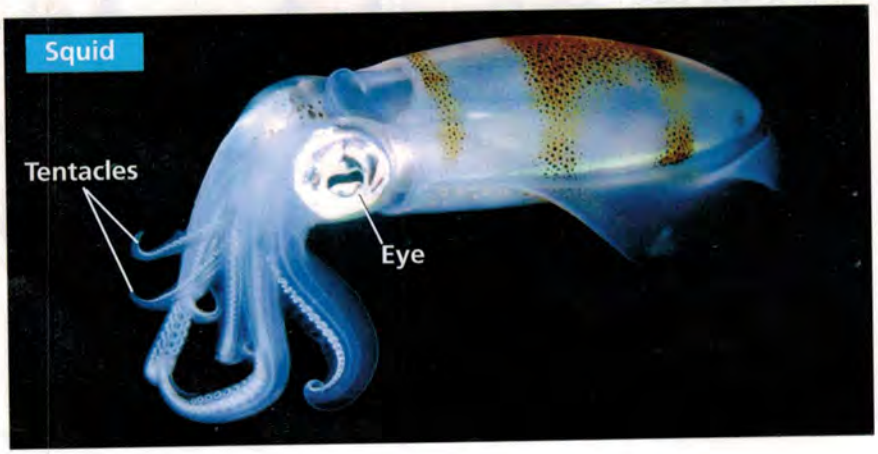
Octopuses and Their Relatives

Octopuses and squids are **cephalopods** (SEF uh luh pahdz). So are nautiluses and cuttlefishes. **A cephalopod is an ocean-dwelling mollusk whose foot is adapted to form tentacles around its mouth.** Unlike bivalves, not all cephalopods have shells. For example, nautiluses have an external shell, squids and cuttlefish have a small shell within the body, and octopuses have no shells. Cephalopods are the only mollusks with a closed circulatory system.

Obtaining Food Cephalopods are carnivores. A cephalopod captures prey using its muscular tentacles. Then it crushes the prey in a beak and scrapes and cuts the flesh with its radula.

A cephalopod's tentacles contain sensitive suckers, which you can see on the octopus in Figure 5. The suckers receive sensations of taste as well as touch. A cephalopod doesn't have to touch something to taste it because the suckers respond to chemicals in the water. For example, when an octopus feels beneath a rock, its tentacles may find a crab by taste before touching it.





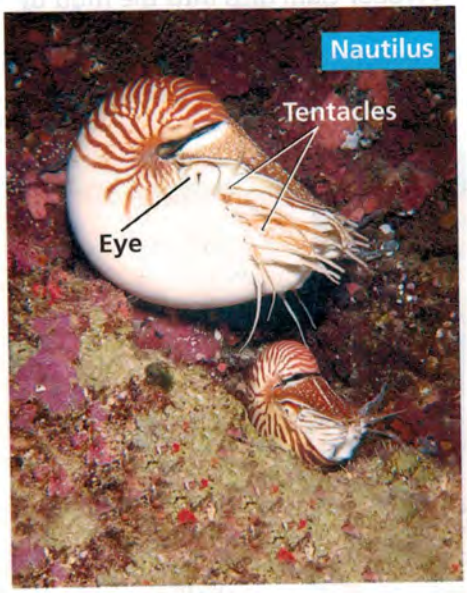


FIGURE 5
Three Cephalopods
A nautilus, an octopus, and a squid are all cephalopods. In cephalopods, the foot is adapted to form tentacles.
Drawing Conclusions *Why is* cephalopod, *which is Greek for "head foot," a good name for members of this group?*

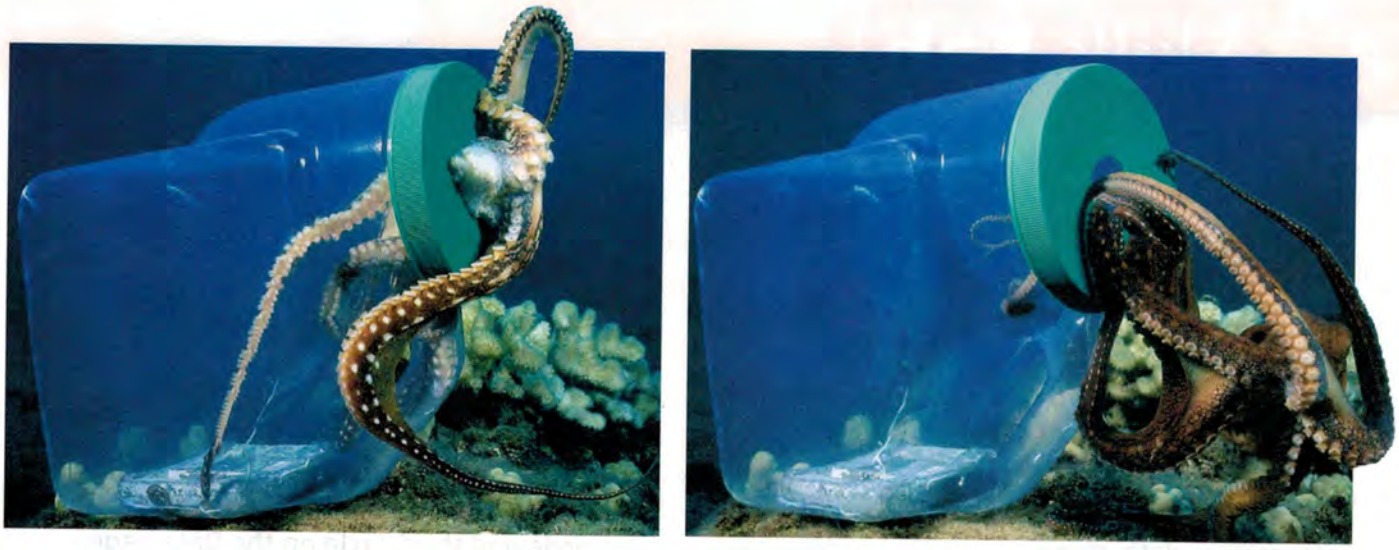


FIGURE 6
An Escaping Octopus
This octopus has figured out how to escape from a jar through a tiny hole in the lid.

Nervous System Cephalopods have large eyes and excellent vision. They also have the most complex nervous system of any invertebrate. Cephalopods have large brains and can remember things they have learned. For example, in captivity, octopuses can learn when to expect deliveries of food. Some even figure out how to escape from their tanks.

Movement Cephalopods swim by jet propulsion. They squeeze a current of water out of the mantle cavity and through a tube. Then, like rockets, they shoot off in the opposite direction. By turning the tube around, they can reverse direction.

Reading Checkpoint **What does the foot of a cephalopod look like?**

Section 1 Assessment

Target Reading Skill **Comparing and Contrasting** Use the information in your table about mollusks to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Listing** List the characteristics of a mollusk.
   b. **Explaining** How is a mollusk's mantle related to its shell?
   c. **Predicting** What would happen to a mollusk if the cilia on its gills did not work? Explain.
2. a. **Identifying** What are three groups of mollusks?
   b. **Classifying** What are the characteristics of the three groups of mollusks?
   c. **Comparing and Contrasting** How are the foot structures of a snail, a clam, and an octopus similar? How are they different?

Lab zone At-Home Activity

Edible Mollusks Visit a local supermarket with a family member and identify any mollusks that are being sold as food. Be sure to look in places other than the fish counter, such as the canned-foods section. Discuss the parts of the mollusks that are used for food and the parts that are not edible.

Lab zone **Skills Lab**

A Snail's Pace

Problem

How do changes in the temperature of the environment affect the activity level of a snail?

Skills Focus

interpreting data, predicting

Materials

- freshwater snail
- thermometer
- ruler
- plastic petri dish
- graph paper, 2 sheets
- timer
- spring water at three temperatures: cool (9–13°C); medium (18–22°C); warm (27–31°C)

Procedure

1. Create a data table for recording the water temperatures and the distance the snail travels at each temperature.
2. On one sheet of graph paper labeled *Snail,* trace a circle using the base of an empty petri dish. Divide and label the circle as shown in the illustration. On a second sheet of graph paper labeled *Data,* draw three more circles like the one in the illustration.
3. Place the petri dish over the circle on the Snail page, fill it with cool water, and record the water temperature. Then place the snail in the water just above the "S" in the circle. Handle the snail gently.
4. For five minutes, observe the snail. Record its movements by drawing a line that shows its path in the first circle on the Data page.
5. Find the distance the snail moved by measuring the line you drew. You may need to measure all the parts of the line and add them together. Record the distance in your data table.
6. Repeat Steps 3 through 5, first with medium-temperature water and then with warm water. Record the snail's paths in the second circle and third circle on the Data page.
7. Return the snail to your teacher when you are done. Wash your hands thoroughly.
8. For each temperature, compute the class average for distance traveled.

Analyze and Conclude

1. **Graphing** Make a bar graph showing the class average for each temperature.
2. **Interpreting Data** How does a snail's activity level change as temperature increases?
3. **Predicting** Do you think the pattern you found would continue at higher temperatures? Explain.
4. **Communicating** Write an e-mail to a friend describing how you conducted your experiment, any problems you ran into, and your results. Did your results help answer the question posed at the beginning of the lab? Explain your results to your friend.

Design an Experiment

Design an experiment to measure how different kinds of natural surfaces beneath the snail affect its rate of movement. Obtain three surface materials, such as fine sand, medium-grain gravel, and coarse gravel. Explain how you would modify the procedure. *Obtain your teacher's permission before carrying out your investigation.*

Section 2

Arthropods

Reading Preview

Key Concepts

- What are the four major groups of arthropods and what are their characteristics?
- How do crustaceans, arachnids, and centipedes and millipedes differ?

Key Terms

- arthropod • exoskeleton
- molting • antenna
- crustacean • metamorphosis
- arachnid • abdomen

Target Reading Skill

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

Characteristics of Arthropods

Question	Answer
What is an arthropod?	

Lab zone **Discover Activity**

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 7
A Spider at Work
This spider wraps its prey, a grasshopper, in silk. Both animals are arthropods.

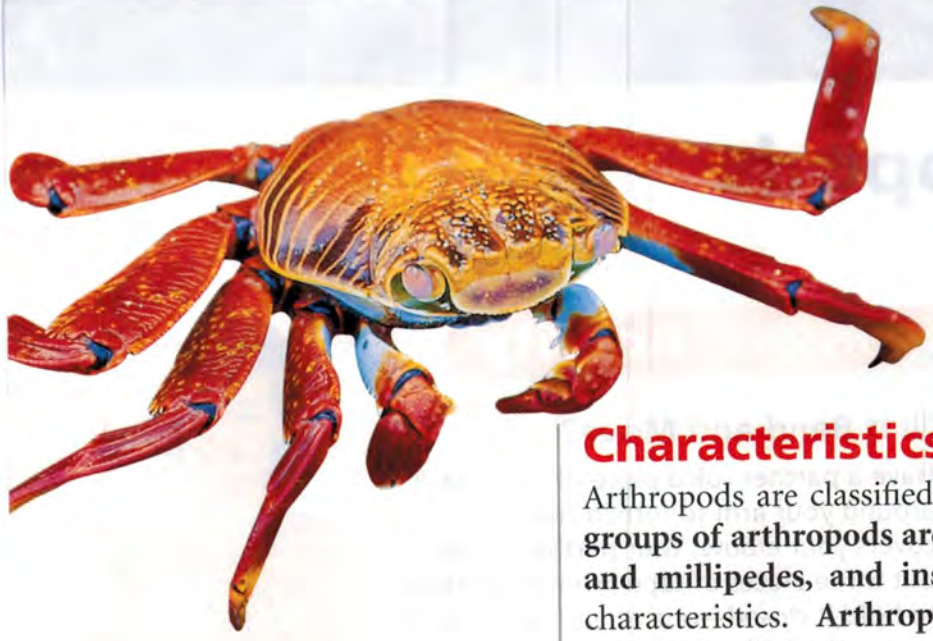


FIGURE 8
Arthropod Characteristics
This Sally light-foot crab shows the tough exoskeleton, the segmented body, and the jointed appendages that are characteristic of arthropods.

Characteristics of Arthropods

Arthropods are classified into four major groups. **The major groups of arthropods are crustaceans, arachnids, centipedes and millipedes, and insects.** All arthropods share certain 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 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 If you were an arthropod, you would have a waterproof covering. This waxy covering is 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.

FIGURE 9
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?*

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

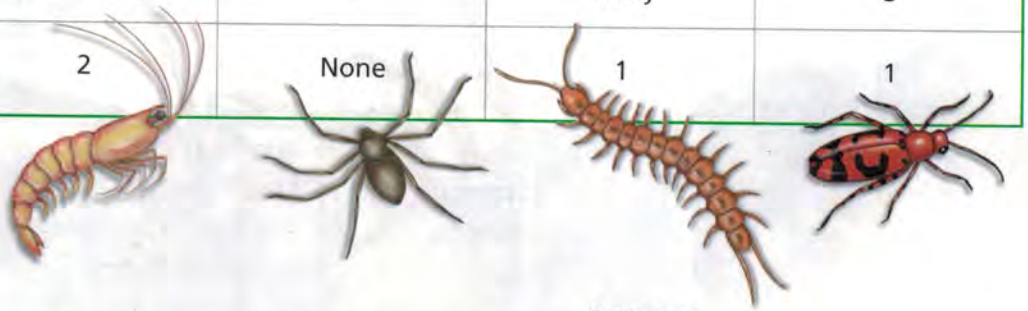


FIGURE 10
Members of the largest arthropod groups differ in several characteristics. **Interpreting Tables** *Which group of arthropods has no antennae?*

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. In fact, their bodies look something like the bodies of earthworms. 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. If you did the Discover activity, you saw how important joints are for allowing movement. 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.

Diversity 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 yet been discovered. Look at Figure 10 to compare some characteristics of the four major groups of arthropods.

Reading Checkpoint **What does an antenna do?**

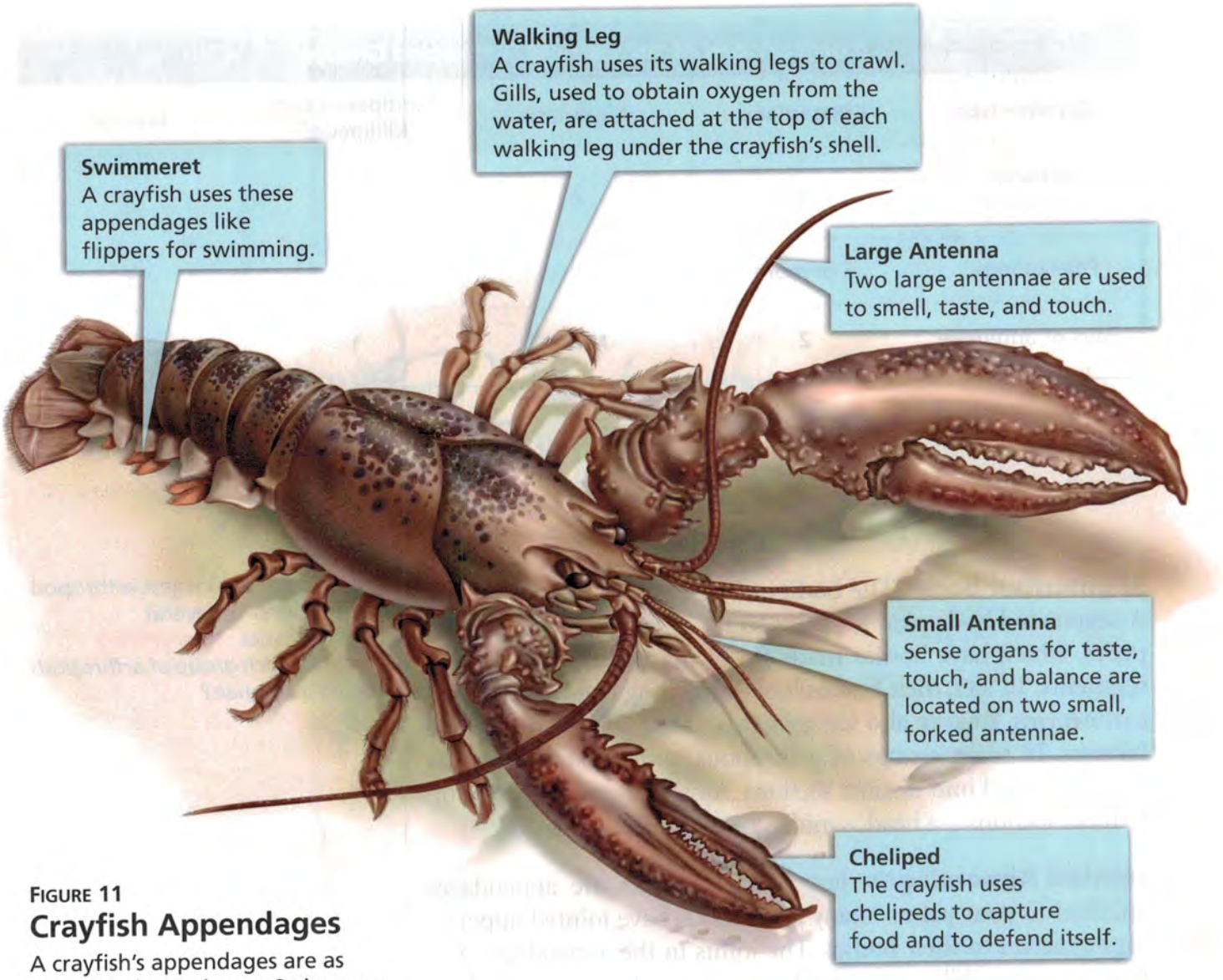


FIGURE 11
Crayfish Appendages
A crayfish's appendages are as varied as the tools on a Swiss army knife. The appendages are adapted for different functions.
Interpreting Diagrams *What functions do the chelipeds serve?*

Crustaceans

If you've ever eaten shrimp cocktail or crab cakes, you've dined on **crustaceans** (krus TAY shunz). Crayfish and lobsters are other familiar crustaceans. Crustaceans thrive in freshwater lakes and rivers, and even in puddles that last a long time. You can find them in the deepest parts of oceans and along coastlines. A few, like the pill bug, live in damp places on land.

Body Structure Crustaceans share certain characteristics. **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 type of appendage attached to it. The various types of appendages function differently, as you can see in Figure 11.

The appendages attached to the head of a crayfish include two pairs of antennae that are used for smelling, tasting, touching, and keeping balance. The crayfish uses most of its leg appendages for walking. However, it uses its first pair of legs, called chelipeds, for obtaining food and defending itself.

Obtaining Oxygen and Food Because crustaceans live in watery environments, most have gills to obtain oxygen. The gills are located beneath the shell of a crustacean. Water containing oxygen reaches the gills as a crustacean moves along in its environment.

Crustaceans obtain food in many ways. Some are scavengers that eat dead plants and animals. Others are predators, eating animals they have killed. The pistol shrimp is a predator with an appendage that moves with such force that it stuns its prey. Krill, which are shrimplike crustaceans that live in cold ocean waters, are herbivores that eat plantlike microorganisms. In turn, krill are eaten by predators such as fishes, penguins, seals, and even great blue whales, the world's largest animals.

Life Cycle Most crustaceans, such as crabs, barnacles, and shrimp, begin their lives as microscopic, swimming larvae. The bodies of these larvae do not resemble those of adults. Crustacean larvae develop into adults by **metamorphosis** (met uh MAWR fuh sis), a process in which an animal's body undergoes dramatic changes in form during its life cycle.

Reading Checkpoint **What organs does a crustacean use to obtain oxygen?**

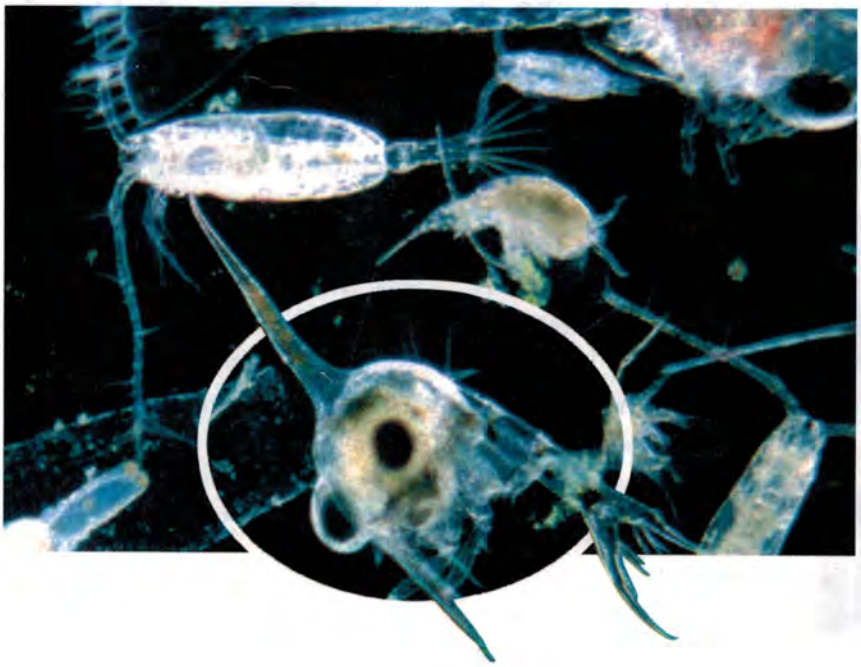


FIGURE 12
Crab Larva
This larva of a crab floats in the ocean with other microscopic animals.

Lab zone Try This Activity

Pill Bugs—Wet or Dry?

1. Line a box with aluminum foil. Tape down two paper towels side by side in the box. Tape a strip of masking tape between the two towels. Moisten one of the paper towels. Keep the other towel dry.

2. Put ten pill bugs on the masking tape. Then put a lid on the box.
3. After 5 minutes, lift the lid and count the pill bugs on the dry towel, the moist towel, and the masking tape. Record your results in a data table.
4. Repeat Steps 2 and 3 two more times. Then average the results of the three trials. Wash your hands after handling the pill bugs.

Interpreting Data Do pill bugs prefer a moist or a dry environment?

FIGURE 13
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 Spiders are probably the most familiar, most feared, and most fascinating kind of arachnid. All spiders are predators, and most of them eat insects. Some, such as tarantulas and wolf spiders, run down their prey. Others, such as golden garden spiders, spin sticky webs to trap their prey.

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 not life-threatening. However, the bite of a brown recluse or a black widow may require hospital care.

FIGURE 14
Dust Mite
This microscopic dust mite feeds on dead skin and hair shed by humans. **Classifying** *Would you describe the mite as a carnivore, scavenger, or filter feeder? Why?*

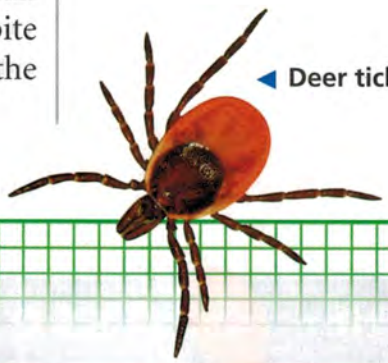
Mites If chiggers have ever given you an itchy rash, you've had an unpleasant encounter with tiny arachnids called mites. Chiggers and many other mites are parasites. Ear mites, for example, give dogs and cats itchy ears. Mites are everywhere. Even the cleanest houses have microscopic dust mites. If you are allergic to dust, you may actually be allergic to the exoskeletons of dust mites. In addition to living in dry areas, mites also live in fresh water and in the ocean.

Reading Checkpoint **What kind of arachnid is a chigger?**

FIGURE 15
Scorpion
A scorpion is a carnivore that injects venom from a stinger at the end of its abdomen.

Scorpions Scorpions live mainly in hot climates, and are usually active at night. During the day, scorpions hide in cool places—under rocks and logs, or in holes in the ground, for example. At the end of its abdomen, a scorpion has a spinelike stinger. The scorpion uses the stinger to inject venom into its prey, which is usually a spider or an insect.

Ticks Ticks are parasites that live on the outside of a host animal's body. Nearly every kind of land animal has a species of tick that sucks its blood. Some ticks that attack humans can carry diseases. Lyme disease, for example, is spread by the bite of an infected deer tick. You can see an enlarged deer tick to the right. In reality, a deer tick is just a few millimeters long.



◀ Deer tick

Math Analyzing Data

Lyme Disease Cases

The graph shows the numbers of cases of Lyme disease by age group reported by Connecticut during one year. Use the graph to answer the questions.

1. **Reading Graphs** What variable is plotted on the *y*-axis? What does the first bar tell you?
2. **Interpreting Data** Which age group is least at risk for Lyme disease? Explain.
3. **Interpreting Data** Which two age groups are most at risk?
4. **Calculating** Suppose a particular school in Connecticut has 1,000 students ranging in age from 10 to 19. About how many of these students would you expect to get Lyme disease per year?

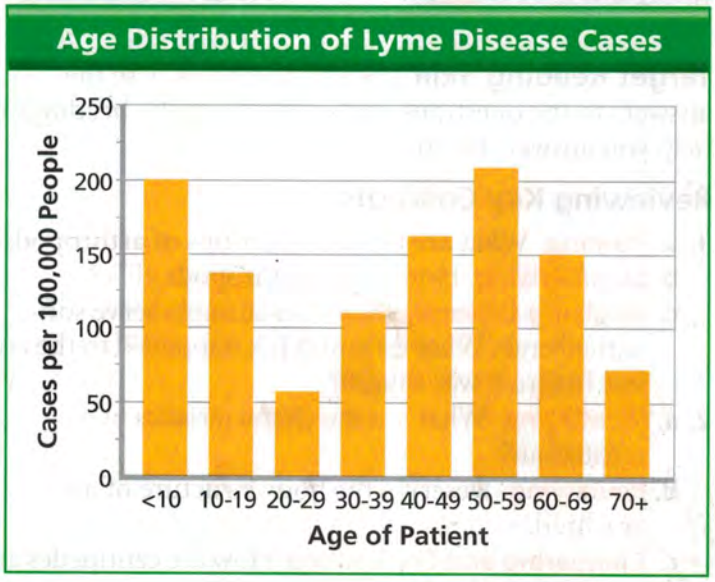


FIGURE 16
Centipede and Millipede
Both centipedes and millipedes have many pairs of legs.
Interpreting Photographs *How many pairs of legs does each segment of the centipede have?*

Centipedes and Millipedes

Centipedes and millipedes are arthropods with two body sections and many pairs of legs. The two body sections are 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." Centipedes are swift predators that inject venom into their prey.

Millipedes, which may have more than 80 segments, have two pairs of legs on each segment—more legs than any other arthropod. Though *millipede* means "thousand feet," they don't have quite that many legs. Most millipedes are scavengers that graze on partly decayed leaves. When they are disturbed, millipedes can curl up into a ball, protected by their tough exoskeleton. Some will also squirt an awful-smelling liquid at a potential predator.

Section 2 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. **Naming** What are the major groups of arthropods?
   b. **Summarizing** How are all arthropods alike?
   c. **Applying Concepts** Some restaurants serve soft-shelled crab. What do you think happened to the crab just before it was caught?
2. a. **Identifying** What are the characteristics of a crustacean?
   b. **Reviewing** Describe the body structure of an arachnid.
   c. **Comparing and Contrasting** How are centipedes and millipedes alike? How are they different?

Writing in Science

Observation Write about an arthropod that you have observed. Describe details about its physical appearance, its movements, and any other behaviors that you observed.

Section 3

Insects

Reading Preview

Key Concepts

- What are the main characteristics of insects?
- What is one way insects are adapted to obtain particular types of food?
- What are two types of metamorphosis that insects undergo?

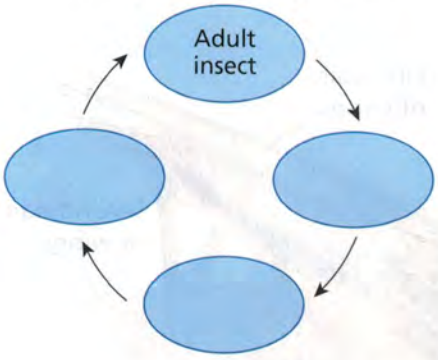
Key Terms

- insect
- thorax
- complete metamorphosis
- pupa
- gradual metamorphosis
- nymph

Target Reading Skill

Sequencing A sequence is the order in which a series of events or steps in a process occurs. As you read, make a cycle diagram that shows the steps in the complete metamorphosis of an insect. Write each step in a separate circle.

Complete Metamorphosis



Lab zone Discover Activity

What Characteristics Do Insects Share?

1. Your teacher will give you a collection of insects. Observe the insects carefully.
2. Note the physical characteristics of each insect's body covering. Count the number of body sections.
3. Count the number of legs, wings, and antennae on each insect. Then return the insects to your teacher and wash your hands.

Think It Over

Inferring Compare the legs and the wings of two different species of insect. How is each insect adapted to move?

What do you do if you want to avoid being noticed? You keep perfectly quiet and you don't do anything that will attract attention. You might even wear clothes that help you to blend into the environment—a tactic called camouflage. The thorn insect is a master of camouflage. Not only does it look like a thorn, but it acts like one, too, staying quite still unless a predator like a bird comes too close. Then it springs away to safety.

Other kinds of insects have different camouflage tactics. For example, some caterpillars look like bird droppings, and others look and act like twigs. Plant hoppers may gather in clusters that look like yellow blossoms. And many kinds of moths resemble dead leaves.

Thorn insect ▶

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

Body Structure

Moths are **insects,** as are caterpillers, plant hoppers, dragonflies, cockroaches, and bees. 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 17.

Head Most of an insect's sense organs, such as the eyes and antennae, are located on the head. Insects usually have two large compound eyes. These eyes contain many lenses, which are structures that focus light to form images. Compound eyes are especially keen at seeing movement. Most insects also have small 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 species of insects can fly once they are adults. Insects are the only invertebrates that can fly. By flying, insects can travel long distances to find mates, food, and new places to live. Being able to fly also enables insects to escape from many predators.

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?**

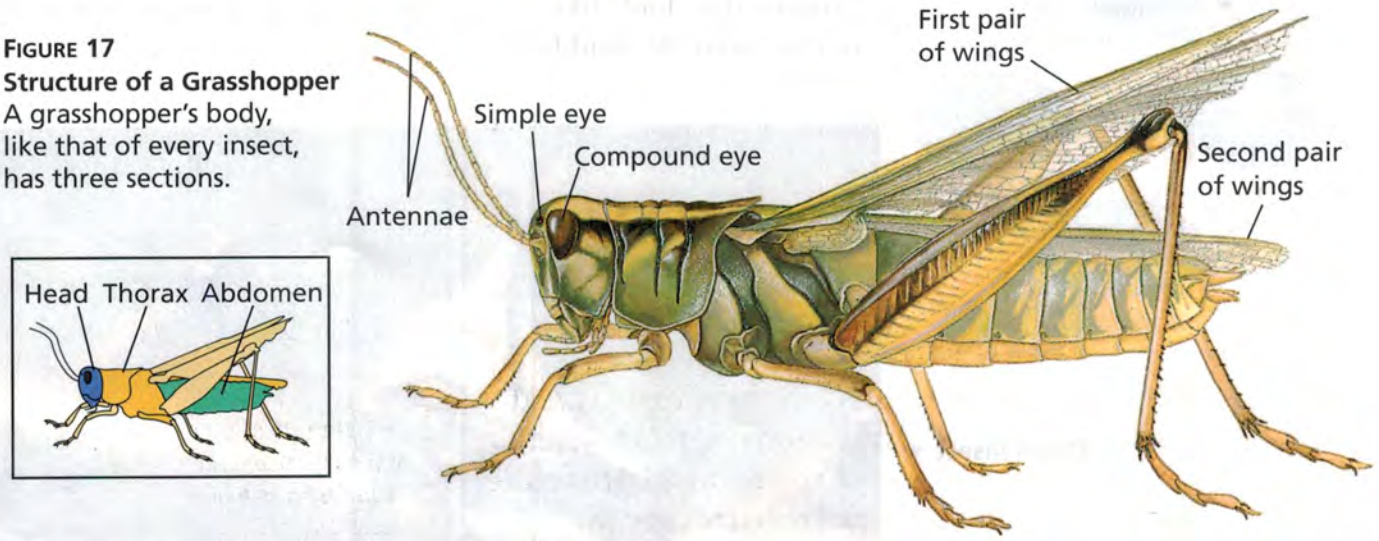


FIGURE 17
Structure of a Grasshopper
A grasshopper's body, like that of every insect, has three sections.

FIGURE 18
Diversity of Mouthparts
The mouthparts of this fly, butterfly, and wood ant are very different in their structure.
Inferring *Could a butterfly eat an ant's food? Explain.*

Obtaining Food

The rule seems to be this: If it is living, or if it once was living, some kind of insect will eat it. You probably know that many insects eat parts of plants, such as leaves or nectar. But insects also eat products that are made from plants, such as paper. If you open a very old book, watch for book lice. These tiny insects live in old books, chewing crooked tunnels through the pages.

Insects may feed on animals, too. Some, like fleas and mosquitoes, feed on the blood of living animals. Others, like dung beetles, feed on animal droppings. Still others, like burying beetles, feed on the decaying bodies of dead animals.

An insect's mouthparts are adapted for a highly specific way of getting food. You can see some of these adaptations in Figure 18. Some flies have a sponge-like mouthpart that they use to lap up decaying flesh. A butterfly's mouthparts are shaped like a coiled tube, which can be uncoiled and used like a drinking straw to suck up nectar from flowers. Most ants have sharp-edged mouthparts that can cut through seeds, wood, and other foods.

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

Life Cycle

Insects begin life as tiny, hard-shelled, fertilized eggs. After they hatch, insects begin a process of metamorphosis that eventually produces an adult insect. **Each insect species undergoes either complete metamorphosis or gradual metamorphosis.**

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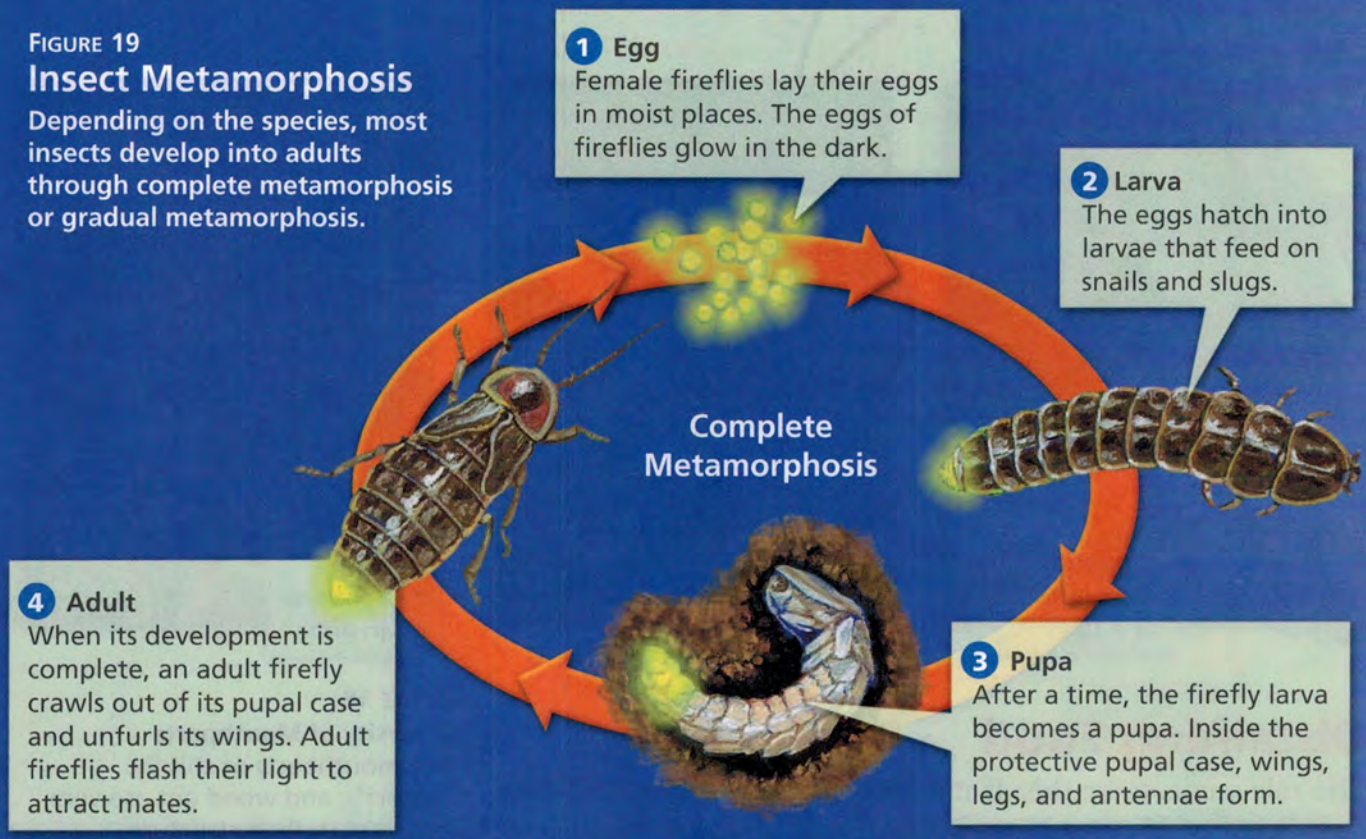
FIGURE 19
Insect Metamorphosis
Depending on the species, most insects develop into adults through complete metamorphosis or gradual metamorphosis.

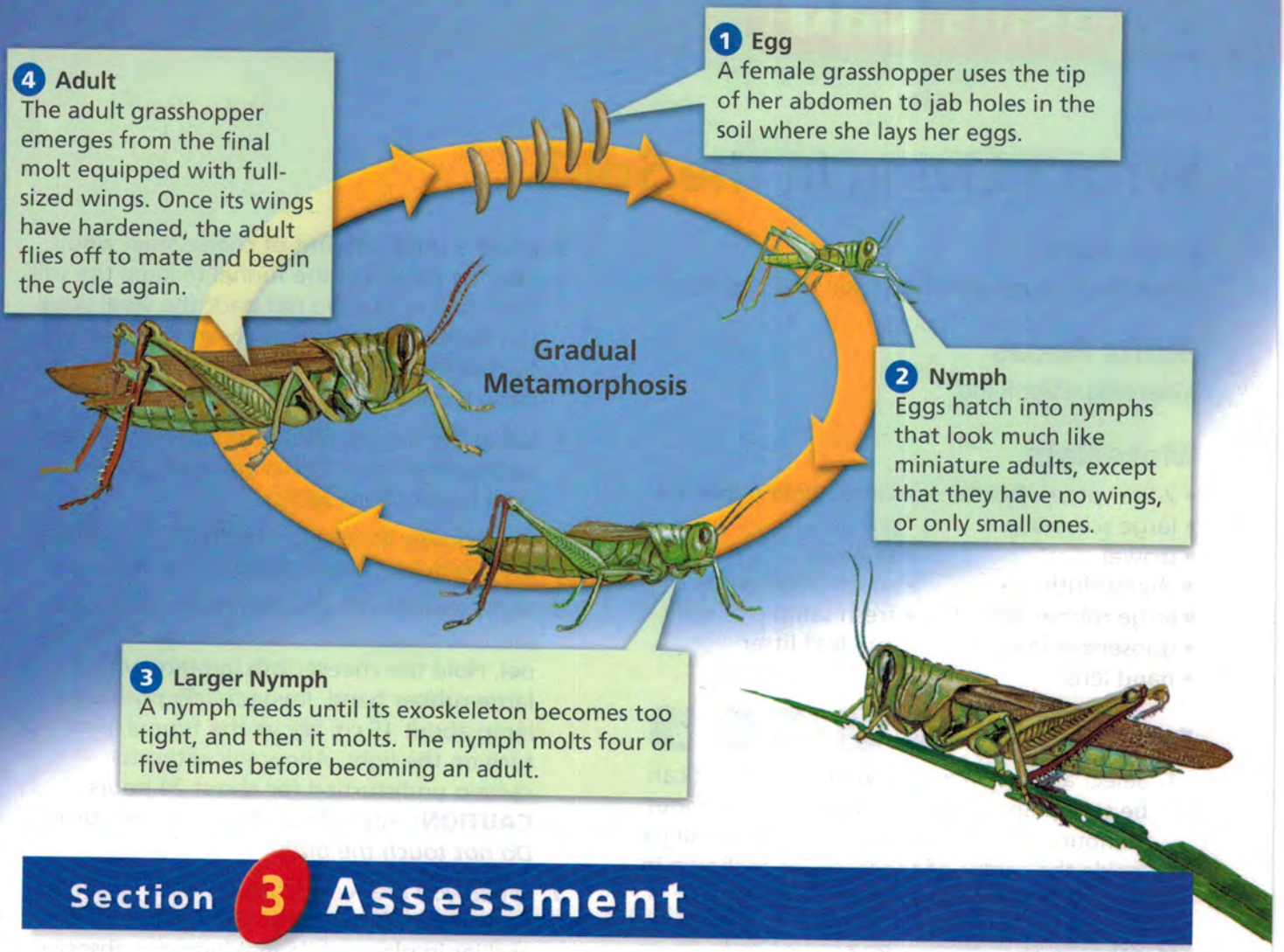


Complete Metamorphosis In Figure 19 you can see that an insect with **complete metamorphosis** has four different stages: egg, larva, pupa, and adult. Eggs hatch into larvae. The larvae, such as the caterpillars of butterflies and the grubs of beetles, usually look something like worms. Larvae are specialized for eating and growing. After a time, a larva enters the next stage of the process and becomes a **pupa** (PYOO puh). As a pupa, the insect is enclosed in a protective covering.

Although the pupa does not eat and moves very little, it is not resting. 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.

Reading Checkpoint **What is gradual metamorphosis?**



Section 3 Assessment

Target Reading Skill **Sequencing** Refer to your cycle diagram about complete metamorphosis as you answer Question 3.

Reviewing Key Concepts

1. a. **Identifying** What characteristics do insects share?
   b. **Interpreting Diagrams** Look at Figure 17. To which body section are a grasshopper's wings attached?
   c. **Making Generalizations** Suppose the adaptation of wings was suddenly lost in all insects. Predict what would happen to the number and diversity of insects.
2. a. **Naming** Name a type of insect that has chewing mouthparts.
   b. **Reviewing** What are three ways that the mouthparts of insects are adapted for obtaining food?
3. a. **Listing** List the stages of gradual metamorphosis and the stages of complete metamorphosis.
   b. **Interpreting Diagrams** Look at Figure 19. How are complete metamorphosis and gradual metamorphosis different?
   c. **Applying Concepts** Why is a nymph more likely than a larva to eat the same food as its parents?

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**

What's Living in the Soil?

Problem

What kinds of animals live in soil and leaf litter?

Skills Focus

observing, classifying

Materials

- 2-liter plastic bottle
- large scissors
- trowel
- cheesecloth
- large rubber band
- gooseneck lamp
- hand lens
- large, wide-mouthed jar
- small jar
- coarse steel wool
- fresh sample of soil and leaf litter

Procedure

1. Select a location where your equipment can be set up and remain undisturbed for about 24 hours. At that location, place the small jar inside the center of the large jar as shown in the photograph on page 61.
2. Use scissors to cut a large plastic bottle in half. **CAUTION:** *Cut in a direction away from yourself and others.* Turn the top half of the bottle upside down to serve as a funnel.

3. Insert a small amount of coarse steel wool into the mouth of the funnel to keep the soil from falling out. Do not pack the steel wool too tightly. Leave spaces for small organisms to crawl through. Place the funnel into the large jar as shown in the photograph.
4. Using the trowel, fill the funnel with soil and surface leaf litter. When you finish, wash your hands thoroughly.
5. Look closely to see whether the soil and litter are dry or wet. Record your observation.
6. Make a cover for your sample by placing a piece of cheesecloth over the top of the funnel. Hold the cheesecloth in place with a large rubber band. Immediately position a lamp about 15 cm above the funnel, and turn on the light. Allow this setup to remain undisturbed for about 24 hours. **CAUTION:** *Hot light bulbs can cause burns. Do not touch the bulb.*
7. When you are ready to make your observations, turn off the lamp. Leave the funnel and jar in place while making your observations. Use a hand lens to examine each organism in the jar. **CAUTION:** *Do not touch any of the organisms.*
8. Use a data table like the one shown to sketch each type of organism and to record other observations. Be sure to include evidence that will help you classify the organisms. (*Hint:* Remember that some animals may be at different stages of metamorphosis.)
9. Examine the soil and leaf litter, and record whether this material is dry or wet.
10. When you are finished, follow your teacher's directions about returning the organisms to the soil. Wash your hands with soap.

Data Table

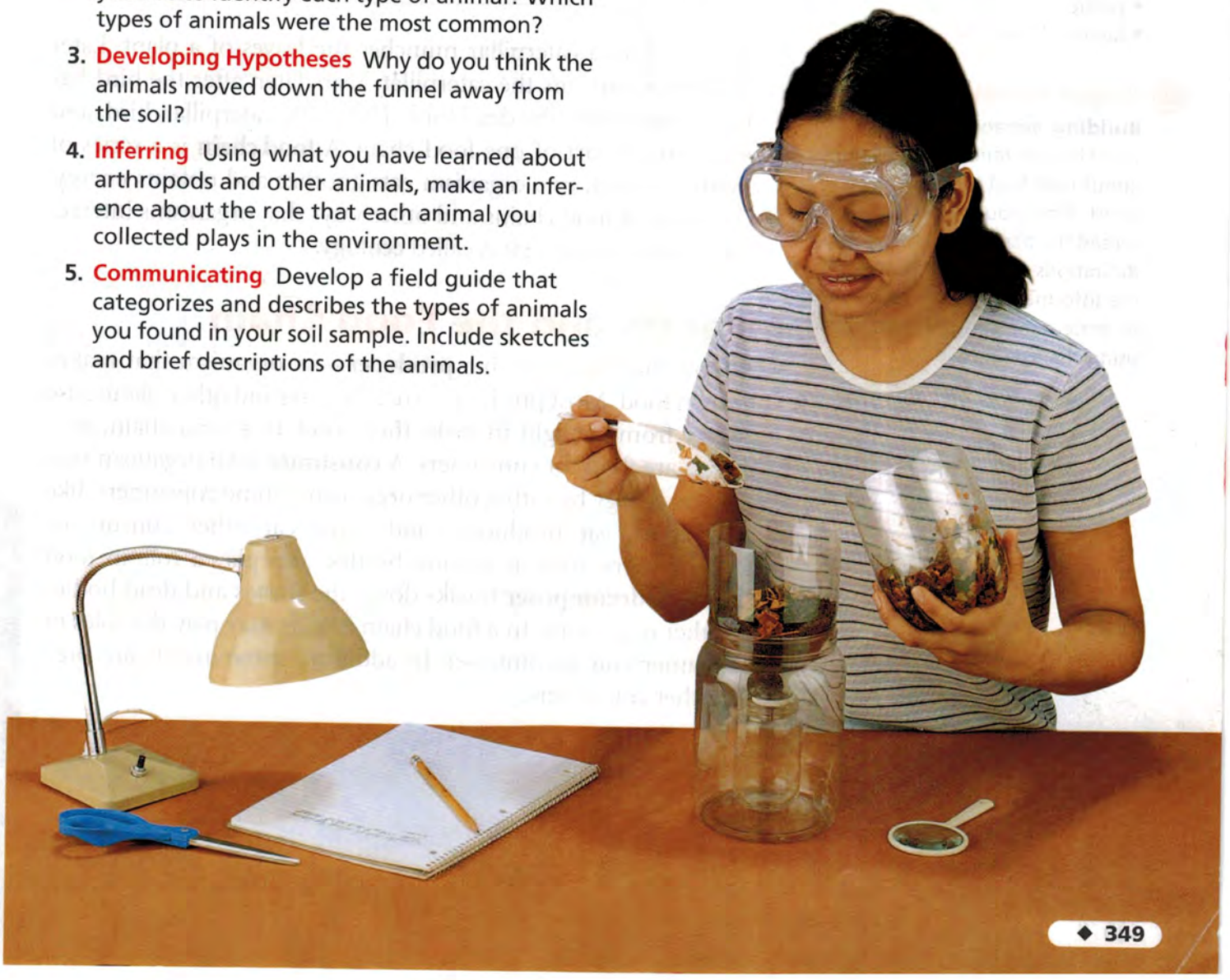
Sketch of Organism	Number Found	Size	Important Characteristics	Probable Phylum

Analyze and Conclude

1. **Observing** Describe the conditions of the soil environment at the beginning and end of the lab. What caused the change?
2. **Classifying** What types of animals did you collect in the small jar? What characteristics did you use to identify each type of animal? Which types of animals were the most common?
3. **Developing Hypotheses** Why do you think the animals moved down the funnel away from the soil?
4. **Inferring** Using what you have learned about arthropods and other animals, make an inference about the role that each animal you collected plays in the environment.
5. **Communicating** Develop a field guide that categorizes and describes the types of animals you found in your soil sample. Include sketches and brief descriptions of the animals.

Design an Experiment

What kinds of organisms might live in other soil types—for example, soil at the edge of a pond, dry sandy soil, or commercially prepared potting soil? Design an experiment to answer this question.



Insect Ecology

Reading Preview

Key Concepts

- Why are insects important in food chains?
- What are two other ways insects interact with their environments?
- What are some ways used to control insect pests?

Key Terms

- food chain
- ecology
- producer
- consumer
- decomposer
- pollinator
- pesticide
- biological control

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 the Key Term.

Lab zone **Discover Activity**

What Materials Carry Pollen Best?

1. Use an eraser to transfer some pollen between two flowers your teacher gives you.
2. Next, use a cotton swab to do the same. Did the eraser or cotton swab transfer pollen better?

Think It Over

Inferring How might its ability to transfer pollen between flowers affect an insect's role in the environment?

In a meadow, a caterpillar munches the leaves of a plant. Later that day, a bird eats the caterpillar. Years later, after the bird has died, a beetle eats the dead bird. The plant, caterpillar, bird, and beetle are all part of one food chain. A **food chain** is a series of events in which one organism eats another and obtains energy. The study of food chains and other ways that organisms interact with their environment is called **ecology.**

Insects and the Food Chain

A food chain starts with a **producer**—an organism that makes its own food. Most producers, such as grass and other plants, use energy from sunlight to make their food. In a food chain, producers are food for consumers. A **consumer** is an organism that obtains energy by eating other organisms. Some consumers, like caterpillars, eat producers, and some eat other consumers. Decomposers, such as carrion beetles, also play a role in food chains. A **decomposer** breaks down the wastes and dead bodies of other organisms. In a food chain insects may play the roles of consumer and decomposer. In addition, some insects are prey for other consumers.

Insects as Consumers of Plants The roles of insects in a food chain are shown in Figure 20. **Insects play key roles in food chains because of the many different ways that they obtain food and then become food for other animals.**

Many insects are consumers of plants. Perhaps you have tried growing tomato plants and seen how fat green caterpillars ate up the leaves. In fact, insects eat about 20 percent of the crops grown for humans. Insects eat most species of wild plants, too. Some insects eat the leaves of plants, while others eat the sap, bark, roots, and other parts of plants.

Insects as Prey Insects play another role in food chains—they are prey for many animals. That is, other consumers eat insects. Many fishes and birds eat insects to survive. For example, the main source of food for trout and bass is insects. Indeed, that's why people use lures called "flies" to catch fishes like these. The lures look like the mayflies and stoneflies these fishes normally eat. Some species of birds feed their young, called chicks, only insects. And the chicks are big eaters! A single swallow chick, for example, may consume about 200,000 insects before it leaves the nest.

Math Skills

Percentage

A percentage is a ratio that compares a number to 100. If 25 percent of 900,000 insect species eat other insects, how many insect-eating species are there? Set up a proportion and solve it.

$$\frac{\text{Insect-eating species}}{\text{900,000 insect species}} = \frac{25\%}{100\%}$$

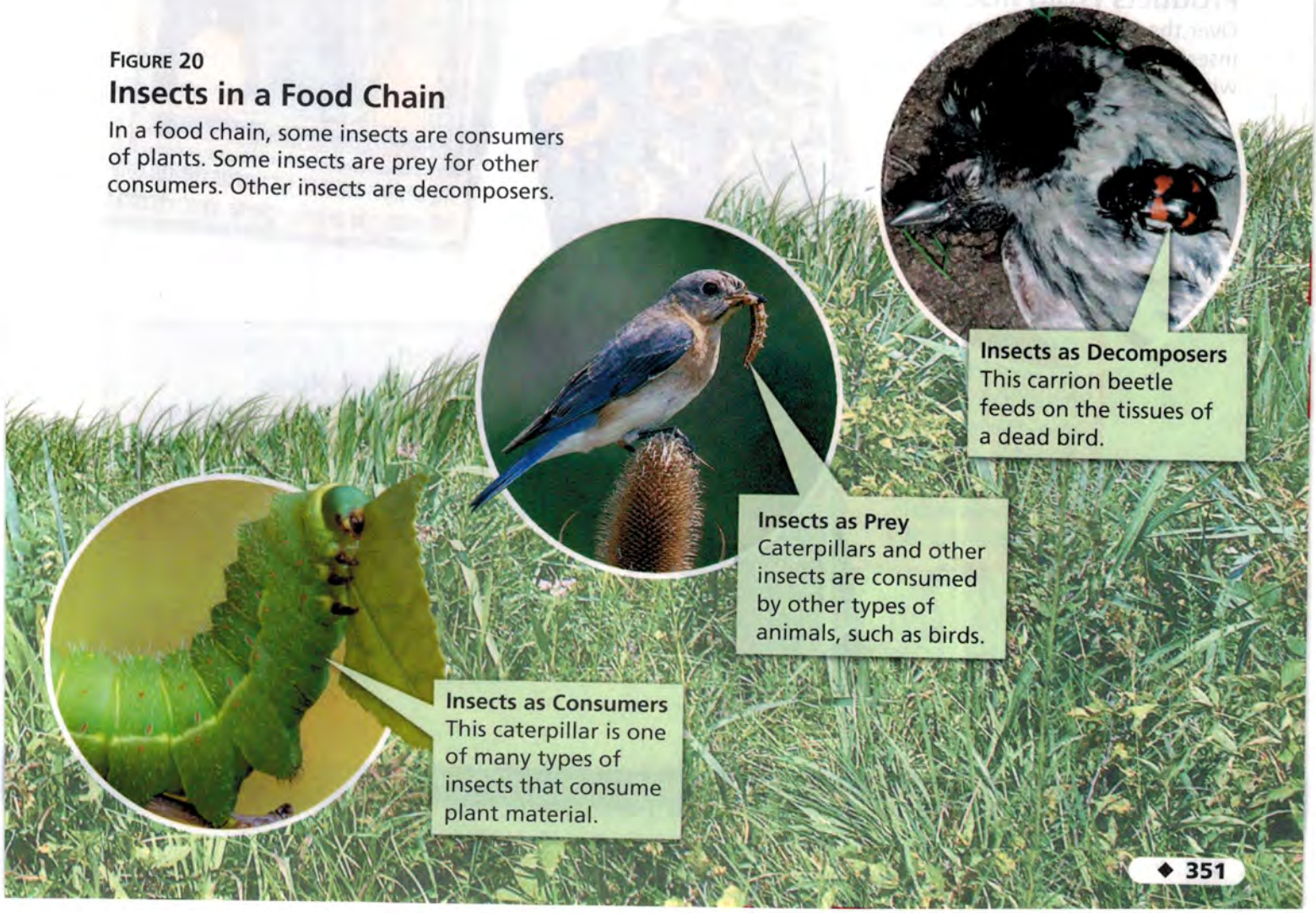
$$\text{Insect-eating species} = 225{,}000$$

Practice Problem A swallow chick eats 200,000 insects. If 12 percent of the insects are beetles, how many beetles does it eat?

FIGURE 20

Insects in a Food Chain

In a food chain, some insects are consumers of plants. Some insects are prey for other consumers. Other insects are decomposers.



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Insects as Decomposers In a food chain some insects play the role of decomposers by breaking down the wastes and bodies of dead organisms. For example, in some tropical food chains, termites may break down up to one third of the dead wood, leaves, and grass produced there every year. In other food chains, flies and dung beetles break down animal droppings, called manure. By doing this, the buildup of manure from large animals is prevented.

The substances that insect decomposers break down enrich the soil. In addition, insect decomposers may burrow and nest in the ground. By doing so, these insects expose soil to oxygen from the air and mix up the nutrients in the soil.

• Tech & Design in History •

Products From Insects

Over the last few thousand years, insects have supplied humans with some important products.

100 B.C.
Silk Draping
Humans first spun silk from silkworm cocoons into fine fabrics more than 4,000 years ago. This silk draping, found in a Chinese tomb from 100 B.C., depicts scenes of the netherworld.

A.D. 1200
Medieval Bee Hives
Collecting honey to eat and wax for candles and other products became much easier when humans began keeping bees. At first, humans made hives from mud or clay. In the middle ages, bees were kept in inverted woven baskets, called skeps, like those shown above. Today, honeybees are kept in wooden boxes.

100 B.C. | A.D. 1000 | 1250

Insects as Food for Humans Did you know that insects were an important source of nutrition for prehistoric humans? Even today, insects are collected and eaten by people in many parts of the world. In some Mexican villages, dried grasshoppers are ground up and mixed with flour to make tortillas. In other parts of the world, the larvae of certain species of beetles are roasted over an open fire. Ants, crickets, and cicadas are just a few of the other types of insects eaten by humans.

Maybe you are thinking, "Yuck! I'd never eat an insect." Even if you'd never allow an insect on your dinner plate, you are likely to have used the products of insects in other aspects of your daily life. You can see some of the major uses of insect products through history in the timeline below.

Reading Checkpoint **What is an animal that breaks down wastes and dead organisms called?**

Writing in Science

Research and Write
Research one of the products described in the timeline below. Then write an advertisement for the product. Include information about the species of insect used to develop the product, and details about how the product is made.

1518
Cochineal Dye
Explorer Hernando Cortez reported the use of the red dye, cochineal, in Mexico. The dye is extracted from a tiny cactus-eating insect called the cochineal scale. Today, humans use the dye to color some textiles, foods, and cosmetics.

1920s
Shellac Records
Humans make shellac from a waxy substance secreted by the lac scale insect. Shellac has been used to seal furniture, polish floors, and coat records. Shellac was especially important to the record industry in the 1920s and 1930s (until synthetic vinyl came along in the 1940s).

1980s
Firefly Light
Since the 1980s, scientists have used the light-producing chemicals from fireflies in many applications, including the study of genes and diseases.

1500 — 1750 — 2000

FIGURE 21
A Bee as a Pollinator
This bee is getting dusted with yellow pollen as it drinks nectar from the flower. **Observing** *On which of the bee's structures can you observe pollen grains?*

Other Interactions

Besides eating and being eaten, insects interact in other ways with the living things in their environments. **Two ways insects interact with other living things are by moving pollen among plants and by spreading disease-causing organisms.**

Pollen Carriers Have you ever seen a bee crawling into a flower on a warm summer day? Have you wondered what it is doing? The bee is helping itself to the plant's nectar and pollen, which are food for bees. But plants also need to share their pollen with other plants. Pollen contains cells that become sperm cells, allowing plants to reproduce. When the bee crawls into a flower to obtain its food, it gets dusted with pollen, as shown in Figure 21. Then, as the bee enters the next flower, some of the pollen on its body is left in the second flower. An animal that carries pollen among plants is called a **pollinator.** Bees are pollinators, and so are many beetles and flies. Without pollinators, some plants cannot reproduce.

Disease Carriers Not all interactions between insects and other living things have happy endings. While some insects transfer pollen, others spread diseases to both plants and animals, including humans. Insects that spread diseases include some mosquitoes and fleas. These insects often have sucking mouthparts that pierce the skin of their prey, providing an opening for the disease-causing organisms to enter. Diseases that are carried by insects include malaria, which is spread by mosquitoes. Malaria causes high fevers and can be treated with medicines today.

Reading Checkpoint **What is a pollinator?**

FIGURE 22
Disease-Causing Mosquito
A mosquito like the one shown here can spread disease-causing organisms such as malaria among humans.

Controlling Pests

Some insects are harmful, even though they don't spread diseases. Harmful insects are called pests. **To try to control pests, people use chemicals, traps, and living things, including other insects.** Chemicals that kill pests are called **pesticides.** However, pesticides also kill pollinators, such as bees, and can harm other animals.

What are the alternatives to pesticides? Biologists are using their knowledge of insect ecology to develop new pest controls. One such control is a trap that attracts mosquitoes in a way similar to how humans attract mosquitoes. Another control is to surround crops with wild plants that are bad-tasting or even poisonous to the harmful insect.

People may prefer to use biological controls. A **biological control** is a natural predator or disease released into an area to fight a harmful insect. For example, ladybugs, which eat other insects, have been introduced to some areas where crops grow to control aphids. Aphids are tiny insects that damage plants by sucking plant sap.

FIGURE 23
Biological Control
Ladybugs are used as biological control agents against aphids. Here, one ladybug consumes its prey.

Reading Checkpoint **What is a chemical intended to kill pest insects called?**

Section 4 Assessment

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

Reviewing Key Concepts

1. a. **Defining** What is a food chain?
   b. **Interpreting Photographs** What three roles do insects play in the food chain shown in Figure 20?
2. a. **Reviewing** Besides their role in food chains, what are two other ways insects interact with their environment?
   b. **Summarizing** What effect do pollinators have on their environment?
   c. **Predicting** What would a world without pollinators be like?
3. a. **Reviewing** How can insect pests be controlled?
   b. **Comparing and Contrasting** How are the effects of using biological controls similar to the effects of using pesticides? How are they different?
   c. **Applying Concepts** Some insect species are harmful only in areas of the world where they do not normally live but have been accidentally released. Why might this be?

Math Practice

4. **Percentage** Suppose 33 percent of the 50 tons of wood produced in one year by a forest is consumed by termites and other insects. How many tons do the insects eat?

Battling Pest Insects

It's hard to believe that insects can cause much harm. But some species, such as the cotton boll weevil, can devastate crops. Boll weevils eat cotton bolls, the part of the plant that produces cotton fibers. Other insects, such as some mosquitoes, spread diseases. To control insect pests, people often use pesticides—chemicals or substances that kill insects or alter their life processes.

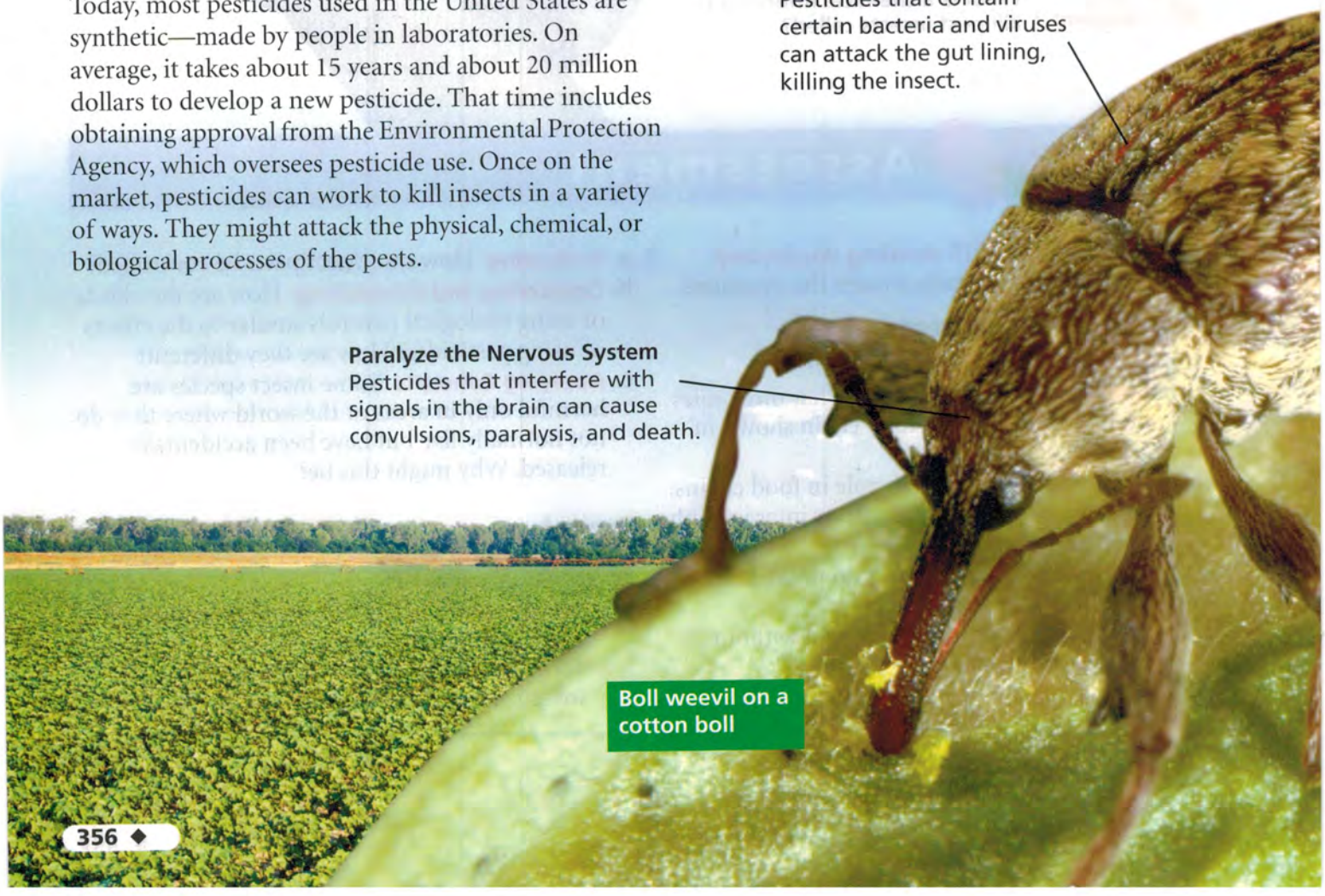
What Are Pesticides?

Since ancient times, people have used substances such as sulfur to kill pests. In the 1900s, people began developing new chemicals to battle harmful insects. Today, most pesticides used in the United States are synthetic—made by people in laboratories. On average, it takes about 15 years and about 20 million dollars to develop a new pesticide. That time includes obtaining approval from the Environmental Protection Agency, which oversees pesticide use. Once on the market, pesticides can work to kill insects in a variety of ways. They might attack the physical, chemical, or biological processes of the pests.

How Pesticides Work
Pesticides kill insects in a variety of ways. People may select one or more pesticides to attack a particular pest.

Attack the Gut
Pesticides that contain certain bacteria and viruses can attack the gut lining, killing the insect.

Paralyze the Nervous System
Pesticides that interfere with signals in the brain can cause convulsions, paralysis, and death.



Boll weevil on a cotton boll

Problems With Pesticides

Using pesticides has increased food production worldwide. However, the technology of pesticides has drawbacks. Pesticides that kill harmful insects can also kill helpful insects, such as bees. In large doses, these chemicals are also toxic to humans and pets. Even low levels of chemicals can build up and affect animals in the food chain. Rain can carry pesticides into rivers and lakes and pollute water supplies. The best pesticides target only pests and do not stay in the environment for a long time.

Applying the Pesticide
One way to apply pesticides is by using an airplane to spray crops.

Destroy the Exoskeleton
Pesticides can cause the exoskeleton to become so thin that the insect dies while molting. Pesticides can also absorb the waxy coating, leading to water loss and death.

Disrupt the Life Cycle
Certain pesticides prevent larvae from maturing into adults.

Interfere With Reproduction
Pesticides that are oils can smother and kill insect eggs. Other pesticides sterilize adult insects.

Weigh the Impact

1. Identify the Need
Why do people use pesticides?

2. Research
Using the Internet, research different insects affecting major crops in your state. Choose one pest insect. Find out the methods used in controlling it. Are there alternatives to pesticides?

3. Write
Write a proposal to your governor for insect control in your state. Use your research and notes to explain how your method works.

Go Online
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For: More on pesticides
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Section 5

Echinoderms

Reading Preview

Key Concepts

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

Key Terms

- echinoderm
- endoskeleton
- water vascular system
- tube feet

Target Reading Skill

Previewing Visuals When you preview, you look ahead at the material to be read. Preview Figure 24. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Water Vascular System

Q. What are tube feet?
A.
Q.

Lab zone Discover Activity

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 give the animal 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.

Movement The internal 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 24. Portions of the tubes in this system can contract, or squeeze together, forcing water into structures called **tube feet.** This process is something like how you move water around in a water balloon by squeezing different parts of the balloon.

The tube feet stick out from the echinoderm's sides or underside. 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?**

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active art

For: Water Vascular System activity
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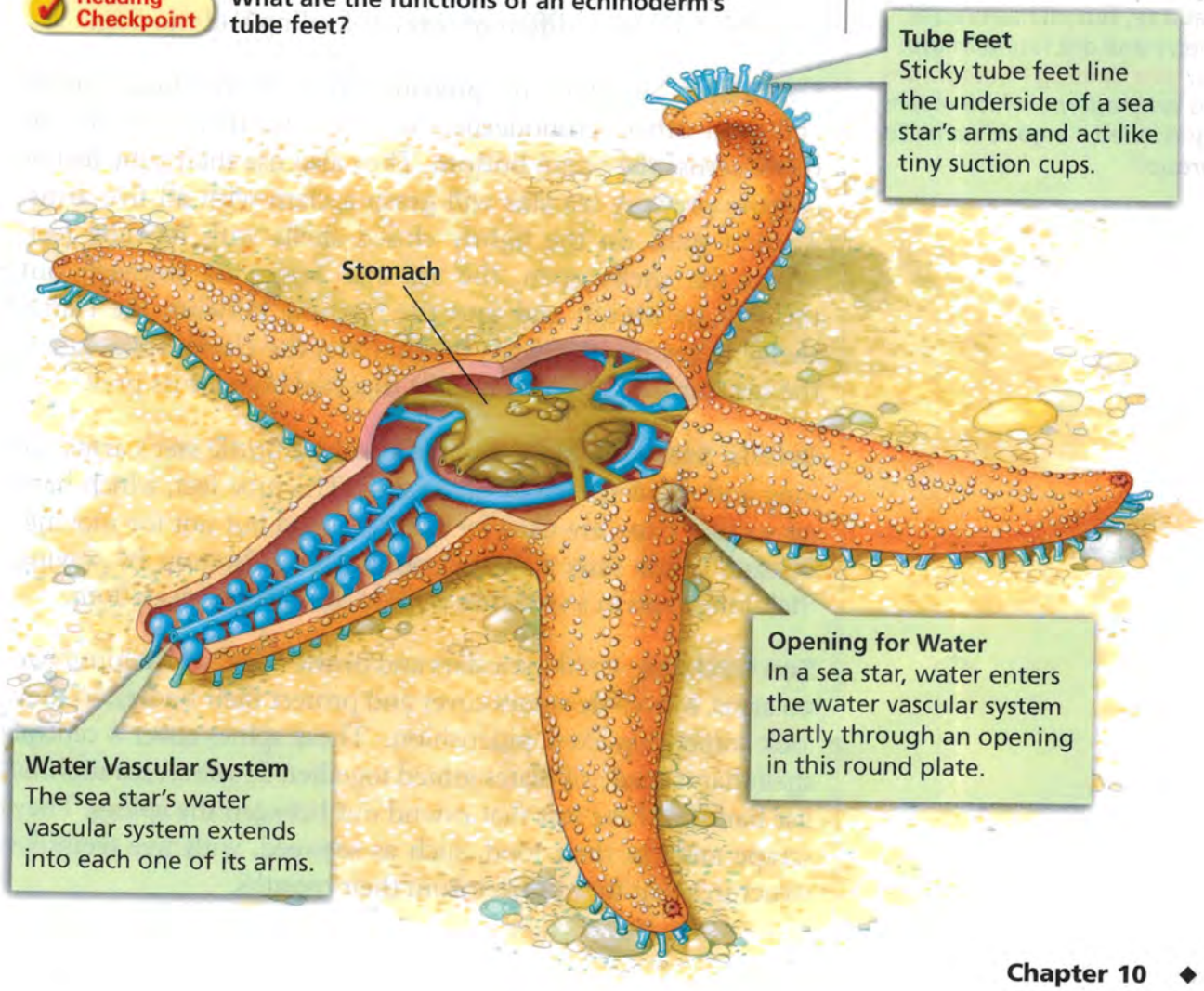
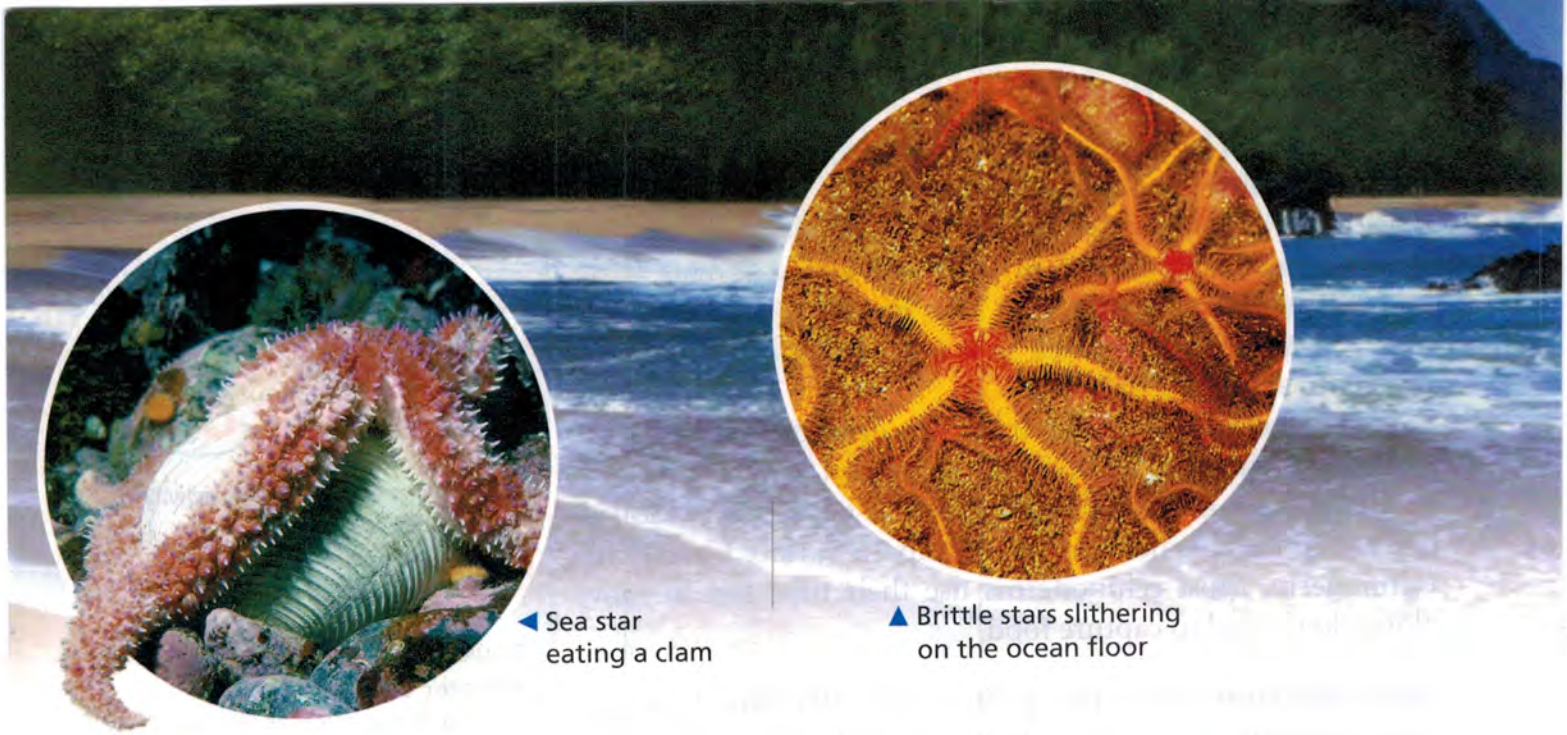
FIGURE 24
A Water Vascular System
Echinoderms, such as this sea star, have a water vascular system that helps them move and catch food.
Interpreting Diagrams *Where does water enter the water vascular system?*





◀ Sea star eating a clam

▲ Brittle stars slithering on the ocean floor

FIGURE 25

Diversity of Echinoderms

Echinoderms are diverse in their appearance, but all have radial symmetry and are found in the ocean. **Interpreting Photographs** *Why is echinoderm, which means "spiny skinned," a good name for this group?*

Diversity of Echinoderms

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

Sea Stars Sea stars are predators that eat mollusks, crabs, and even other echinoderms. Sea stars use their tube feet to move across the ocean bottom. They also use their tube feet to capture prey. A sea star will grasp a clam with all five arms. Then it pulls on the tightly closed shells with its tube feet. When the shells open, the sea star forces its stomach out through its mouth and into the opening between the clam's shells. Digestive chemicals break down the clam's tissues, and the sea star sucks in the partially digested body of its prey.

Brittle Stars Unlike a sea star's arms, a brittle star's arms are long and slender, with flexible joints. The tube feet, which have no suction cups, are used for catching food but not for moving. Instead, brittle stars slither along the ocean bottom by waving their long arms in a snakelike motion against the ocean floor.

Sea Urchins Unlike sea stars and brittle stars, sea urchins have no arms. Moveable spines cover and protect their bodies, so they look something like a pincushion. These spines cover a central shell that is made of plates joined together. To move, sea urchins use bands of tube feet that extend out between the spines. They scrape and cut their food, such as seaweed, with five teethlike structures that they project from their mouths.

▲ Sea urchins eating seaweed

▲ Sea cucumber crawling on the ocean floor

Sea Cucumbers As you might expect from their name, sea cucumbers look a little bit like the cucumbers you eat. These animals can be red, brown, blue, or green. Underneath their leather-like skin, their bodies are soft, flexible, and muscular. Sea cucumbers have rows of tube feet on their underside, enabling them to crawl slowly along the ocean floor where they live. At one end of a sea cucumber is a mouth surrounded by tentacles. The sea cucumber, which is a filter feeder, can lengthen its tentacles to sweep food toward its mouth.

Reading Checkpoint **How does a sea cucumber move?**

Section 5 Assessment

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 24 to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Reviewing** What characteristics do echinoderms have?
   b. **Summarizing** How does an echinoderm use its tube feet to grip a surface?
   c. **Inferring** Why is movement using tube feet slow?
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 10 Study Guide

The BIG Idea **Diversity and Adaptations** Each group of invertebrates has distinctive characteristics, such as a mantle, an exoskeleton, or a water vascular system.

1 Mollusks

Key Concepts

- 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.
- The three major groups of mollusks are gastropods, bivalves, and cephalopods.
- Gastropods are mollusks that have a single external shell or no shell at all.
- Bivalves are mollusks that have two shells held together by hinges and strong muscles.
- A cephalopod is an ocean-dwelling mollusk whose foot is adapted to form tentacles around its mouth.

Key Terms

• mollusk • open circulatory system • gill
• gastropod • herbivore • carnivore • radula
• bivalve • omnivore • cephalopod

2 Arthropods

Key Concepts

- The major groups of arthropods are crustaceans, arachnids, centipedes and millipedes, and insects.
- Arthropods are invertebrates that have an external skeleton, a segmented body, and jointed attachments called appendages.
- 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.
- Centipedes and millipedes are arthropods with two body sections and many pairs of legs.

Key Terms

arthropod
exoskeleton
molting
antenna
crustacean
metamorphosis
arachnid
abdomen

3 Insects

Key Concepts

- Insects are arthropods with three body sections, six legs, one pair of antennae, and usually one or two pairs of wings.
- An insect's mouthparts are adapted for a highly specific way of getting food.
- Each insect species undergoes either complete metamorphosis or gradual metamorphosis.

Key Terms

• insect • thorax • complete metamorphosis
• pupa • gradual metamorphosis • nymph

4 Insect Ecology

Key Concepts

- Insects play key roles in food chains because of the many different ways that they obtain food and then become food for other animals.
- Two ways insects interact with other living things are by moving pollen among plants and by spreading disease-causing organisms.
- To try to control pests, people use chemicals, traps, and living things, including other insects.

Key Terms

• food chain • ecology • producer
• consumer • decomposer • pollinator
• pesticide • biological control

5 Echinoderms

Key Concepts

- Echinoderms are invertebrates with an internal skeleton and a system of fluid-filled tubes called a water vascular system.
- There are four major groups of echinoderms: 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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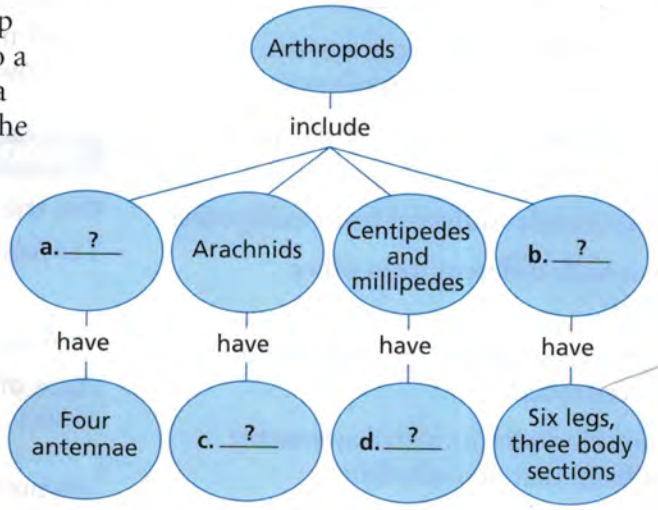
Organizing Information

Concept Mapping Copy the concept map about the classification of arthropods 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. An animal that eats other animals is a(n)
   a. carnivore. **b.** omnivore.
   c. filter feeder. **d.** herbivore.
2. Mollusks with two shells are known as
   a. cephalopods. **b.** gastropods.
   c. bivalves. **d.** sea stars.
3. An arthropod's antennae are located on its
   a. head. **b.** thorax.
   c. abdomen. **d.** mantle.
4. To obtain oxygen from their environments, mollusks and crustaceans use which organ?
   a. radula **b.** lungs
   c. gills **d.** legs
5. The shedding of an outgrown exoskeleton is called
   a. complete metamorphosis.
   b. incomplete metamorphosis.
   c. molting.
   d. reproduction.
6. At which stage of development would an insect be enclosed in a cocoon?
   a. egg **b.** larva
   c. pupa **d.** adult
7. One example of a biological control is
   a. catching pest insects in traps.
   b. making and selling honey by raising bees in hives.
   c. killing pest insects with pesticides.
   d. introducing a pest insect's natural predator.
8. An echinoderm has
   a. a radula.
   b. tube feet.
   c. antennae.
   d. an exoskeleton.

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.

Discovery Channel School
Mollusks, Arthropods, and Echinoderms
Video Preview
Video Field Trip
▶ Video Assessment

Review and Assessment

Checking Concepts

9. Explain how a snail uses its radula.
10. How is a cephalopod's nervous system different from that of other mollusks?
11. Describe four things that a crayfish can do with its appendages.
12. How are centipedes different from millipedes?
13. How are insects different from other arthropods?
14. Identify two reasons why insects sometimes must be controlled.
15. How is an echinoderm's radial symmetry different from that of a jellyfish?

Thinking Critically

16. **Comparing and Contrasting** Compare and contrast bivalves and cephalopods.
17. **Classifying** Which phylum does each of the animals below belong to? Explain your answer.

A

B

18. **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.
19. **Drawing Conclusions** A rancher imports dung beetles from Africa to help control manure build-up from cattle. Later, he observes that the pastures are producing more grass for the cattle to eat. What conclusion could the rancher draw about the dung beetles?
20. **Making Judgments** Do you think pesticides should be used to kill insect pests? Explain.
21. **Comparing and Contrasting** How is a spider's method of obtaining food similar to that of a sea star? How is it different?

Math Practice

22. **Percentage** Of approximately 150,000 species of mollusks, 27 percent are gastropods. About how many species of gastropods are there?

Applying Skills

Use the data table to answer Questions 23–25.

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

23. **Graphing** Use the data to make two bar graphs: one showing the three insect wing-beat rates and another showing the flight speeds.
24. **Interpreting Data** Which of the three insects has the highest wing-beat rate? Which insect flies the fastest?
25. **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 Chapter Project

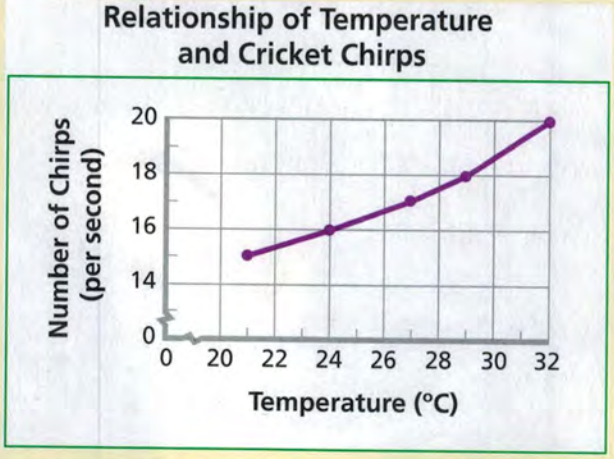
Performance Assessment Prepare a display to show how you set up your experiment and what your results were. Construct and display graphs to show the data you collected. Include pictures of the mealworms in each stage of development. Write your conclusion of how the experimental conditions affected the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

Standardized Test Prep

Test-Taking Tip

Interpreting Graphs

Before you answer a question about a line graph, read all of its labels. The labels on the axes tell you what variables are being compared. On the graph below, the variables are temperature and the number of cricket chirps (sounds).



Sample Question

How is the number of cricket chirps related to temperature?

- **A** The number of chirps increases as the temperature decreases.
- **B** The number of chirps stays the same as the temperature increases.
- **C** The number of chirps increases as the temperature increases.
- **D** The graph does not show a relationship.

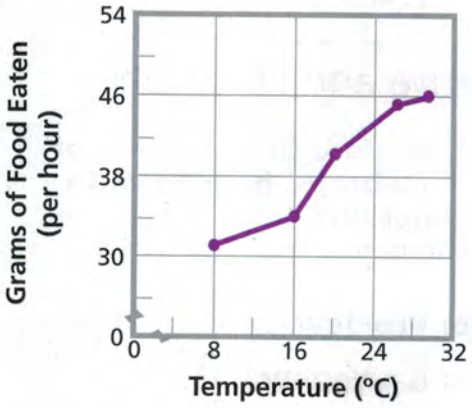
Answer

The correct answer is **C**. The plotted line reveals that as the temperature increases, the number of chirps also increases. Therefore, **A**, **B**, and **D** can not be correct.

Choose the letter of the best answer.

1. An animal that has a soft, unsegmented body surrounded by a hard outer shell is most likely
   - **A** an earthworm.
   - **B** a cnidarian.
   - **C** a mollusk.
   - **D** an arthropod.

2. Which animal feature most likely evolved as an adaptation to provide direct protection from a predator's attack?
   - **F** a snail's radula
   - **G** a sea urchin's spines
   - **H** a crayfish's antennae
   - **J** an insect's thorax



3. Examine the information in the graph above. Which is the best title for the graph?
   - **A** Effect of Caterpillar Feeding Rate on Temperature
   - **B** Caterpillar Behavior and Temperature
   - **C** Respiration Rate and Temperature
   - **D** Relationship of Temperature and Caterpillar Feeding Rate

4. What is the most reasonable prediction for what the feeding rate would be at 32°C?
   - **F** 60 g/hr
   - **G** 46 g/hr
   - **H** 40 g/hr
   - **J** 0 g/hr

Constructed Response

5. In a certain small country, mosquitoes are very common. The mosquitoes spread a disease that is deadly to humans. The government decides to spray the entire country with a pesticide that will kill all mosquitoes and other flying insects as well. How is this action likely to affect the food chain?

Chapter 11

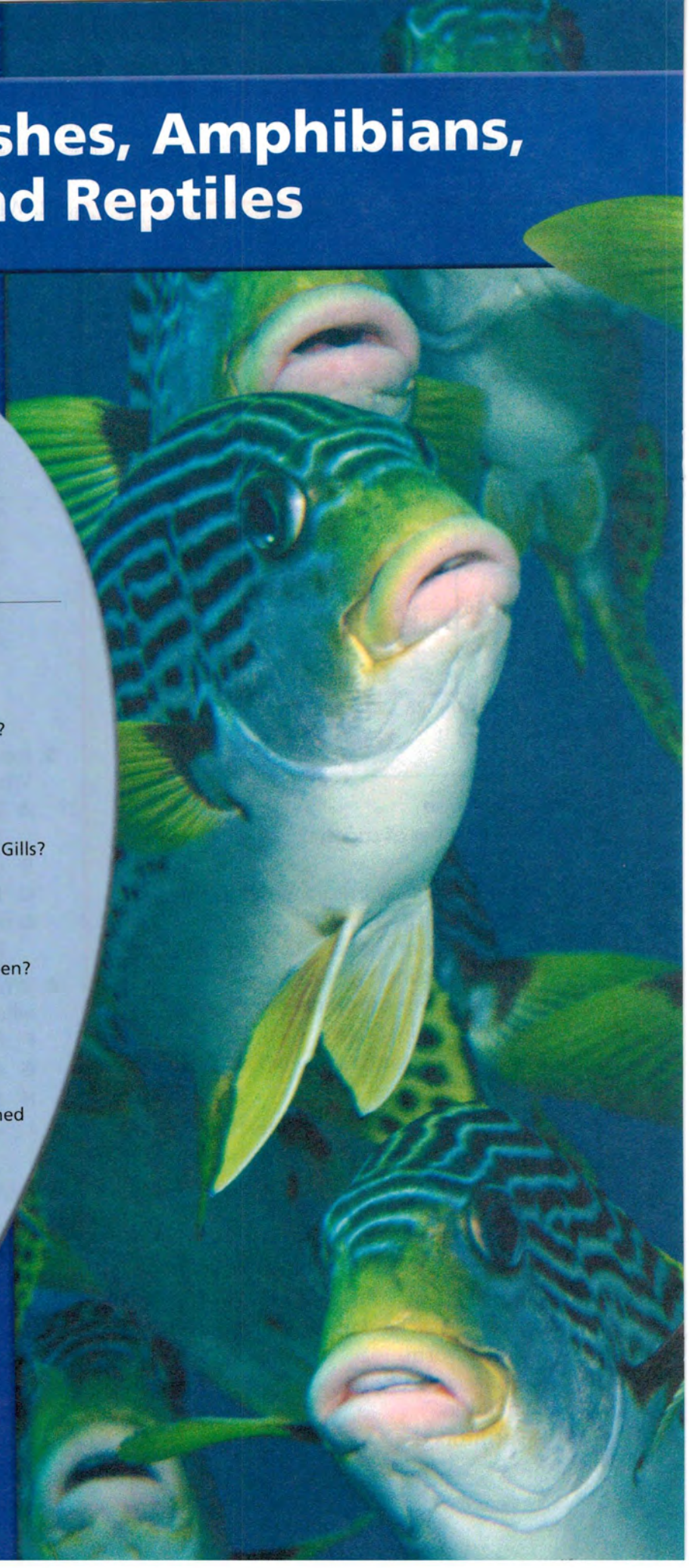
Fishes, Amphibians, and Reptiles

The BIG Idea

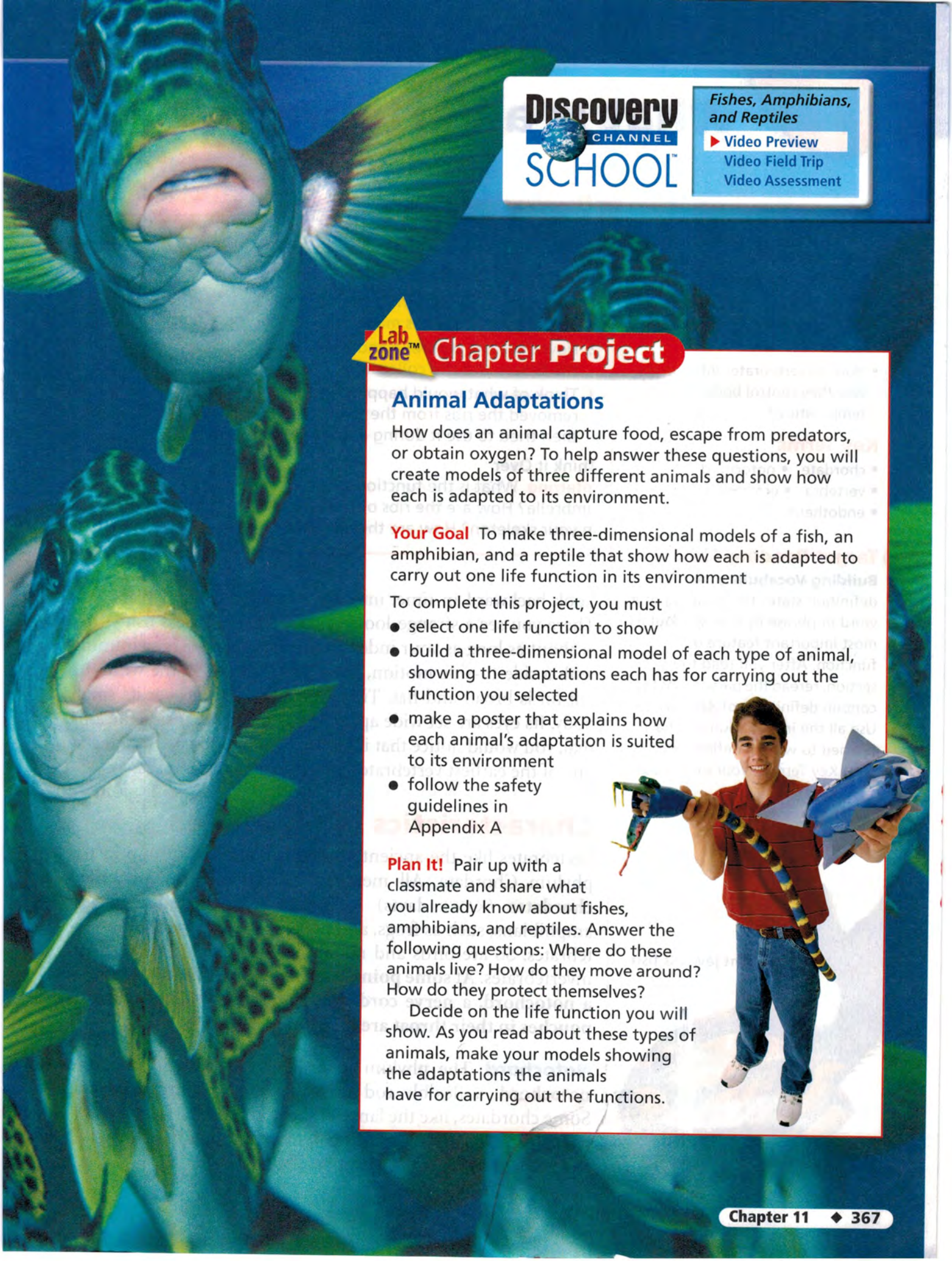
Structure and Function

How does the structure of vertebrates help them to function?

Chapter Preview



The fishes in this school are named "sweetlips."



Discovery CHANNEL SCHOOL

Fishes, Amphibians, and Reptiles

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

Animal Adaptations

How does an animal capture food, escape from predators, or obtain oxygen? To help answer these questions, you will create models of three different animals and show how each is adapted to its environment.

Your Goal To make three-dimensional models of a fish, an amphibian, and a reptile that show how each is adapted to carry out one life function in its environment

To complete this project, you must

- select one life function to show
- build a three-dimensional model of each type of animal, showing the adaptations each has for carrying out the function you selected
- make a poster that explains how each animal's adaptation is suited to its environment
- follow the safety guidelines in Appendix A

Plan It! Pair up with a classmate and share what you already know about fishes, amphibians, and reptiles. Answer the following questions: Where do these animals live? How do they move around? How do they protect themselves?

Decide on the life function you will show. As you read about these types of animals, make your models showing the adaptations the animals have for carrying out the functions.

Section 1

What Is a Vertebrate?

Reading Preview

Key Concepts

- What characterisics do chordates share?
- What characteristic do all vertebrates have?
- How do vertebrates differ in the way they control body temperature?

Key Terms

- chordate • notochord
- vertebra • ectotherm
- endotherm

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

How Is an Umbrella Like a Skeleton?

1. Open an umbrella. Turn it upside down and examine how it is made.
2. Now close the umbrella and watch how the braces and ribs collapse.
3. Think of what would happen if you removed the ribs from the umbrella and then tried to use it during a rainstorm.

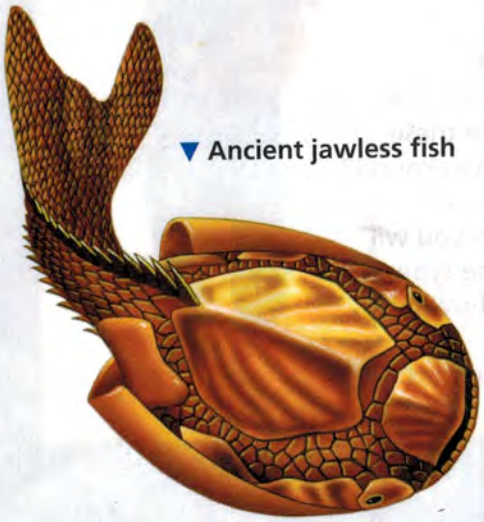
Think It Over

Inferring What is the function of the ribs of an umbrella? How are the ribs of the umbrella similar to the bones in your skeleton? How are they different?

Look backward in time, into an ocean 530 million years ago. There you see a strange-looking creature—a jawless fish—that is about as long as your index finger. The creature is swimming with a side-to-side motion, like a flag flapping in the wind. Its tail fin is broad and flat. Tiny armorlike plates cover its small body. Its eyes are set wide apart. If you could see inside the animal, you would notice that it has a backbone. You are looking at one of the earliest vertebrates at home in an ancient sea.

Characteristics of Chordates

Vertebrates like the ancient jawless fish are a subgroup in the phylum Chordata. All members of this phylum are called **chordates** (KAWR dayts). Most chordates, including fishes, amphibians, such as frogs, and reptiles, such as snakes, are vertebrates. So are birds and mammals. But a few chordates are invertebrates. **At some point in their lives, chordates will have a notochord, a nerve cord that runs down their back, and pouches in their throat area.**



▼ Ancient jawless fish

Notochord The phylum name Chordata comes from the **notochord,** a flexible rod that supports a chordate's back. Some chordates, like the lancelet shown in Figure 1, have notochords all their lives. In contrast, in vertebrates, part or all of the notochord is replaced by a backbone.

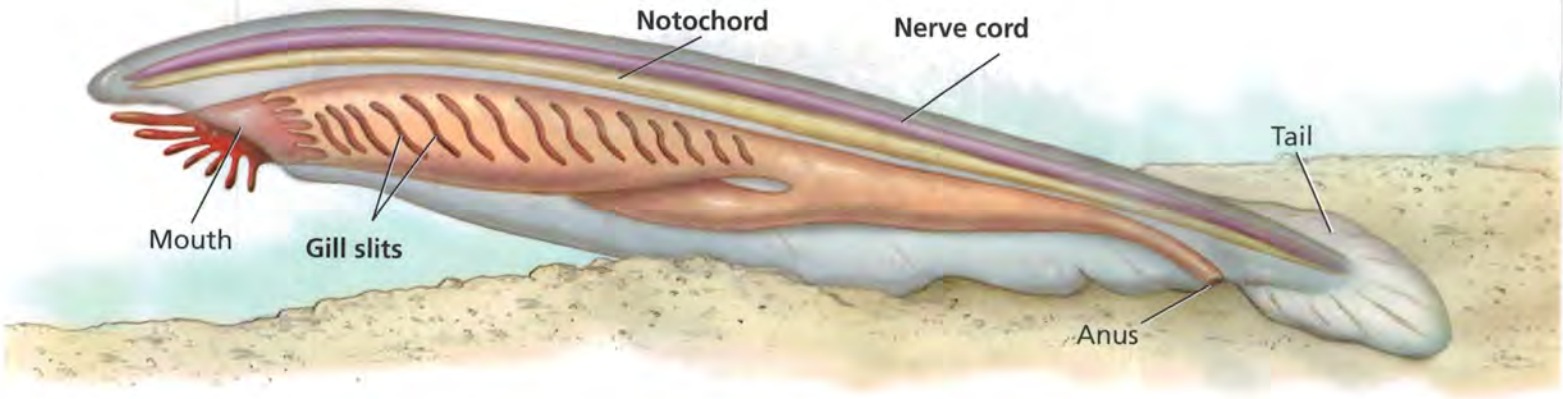


FIGURE 1
Characteristics of a Lancelet
This lancelet shows the characteristics of a chordate: a notochord that helps support its body, a nerve cord down its back, and gill slits that develop from pouches.

Nerve Cord in Back In addition to having a notochord, all chordates have a nerve cord that runs down their back. Your spinal cord is such a nerve cord. The nerve cord is the connection between the brain and the nerves, on which messages travel back and forth. Many other groups of animals—arthropods and segmented worms, for example—have nerve cords, but their nerve cords do not run down their backs.

Pouches in Throat Area At some point in their lives, chordates have pouches in their throat area. In some chordates, such as fishes and the lancelet shown in Figure 1, grooves between these pouches become slits called gill slits. In many vertebrates, including humans, the pouches disappear before birth.

Reading Checkpoint **What is a notochord?**

Characteristics of Vertebrates

Most chordates are vertebrates. In addition to the characteristics shared by all chordates, vertebrates share certain other characteristics. **A vertebrate has a backbone that is part of an internal skeleton.** This endoskeleton supports the body and allows it to move.

Backbone A vertebrate's backbone, which is also called a spine, runs down the center of its back. You can see in Figure 2 that the backbone is formed by many similar bones called **vertebrae** (singular *vertebra*). The vertebrae are lined up in a row like beads on a string. Joints, or movable connections between the vertebrae, give the spine flexibility. You can bend over and tie your shoes because your backbone has flexibility. Each vertebra has a hole in it that allows the spinal cord to pass through it. The spinal cord fits into the vertebrae like fingers fit into rings.

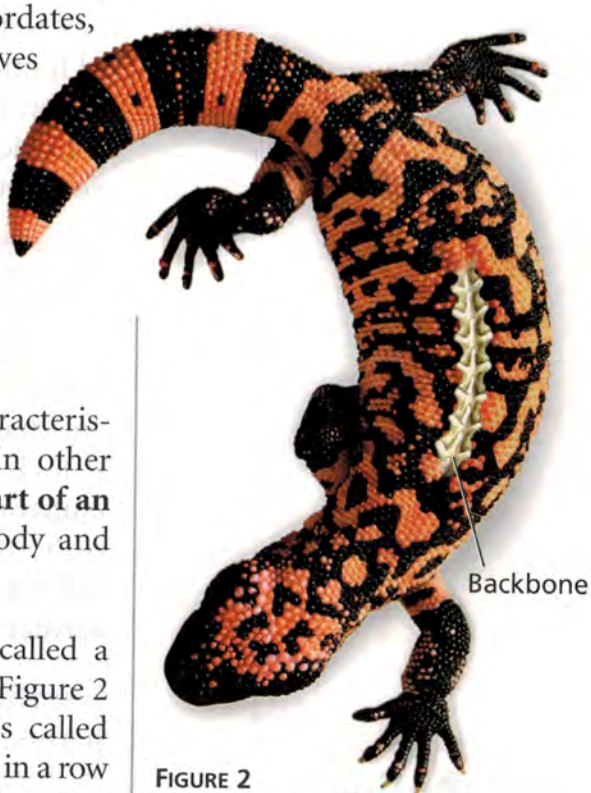


FIGURE 2
The Backbone of a Lizard
The backbone of this gila monster has flexibility. **Predicting** *Could the backbone bend if the vertebrae did not have joints?*

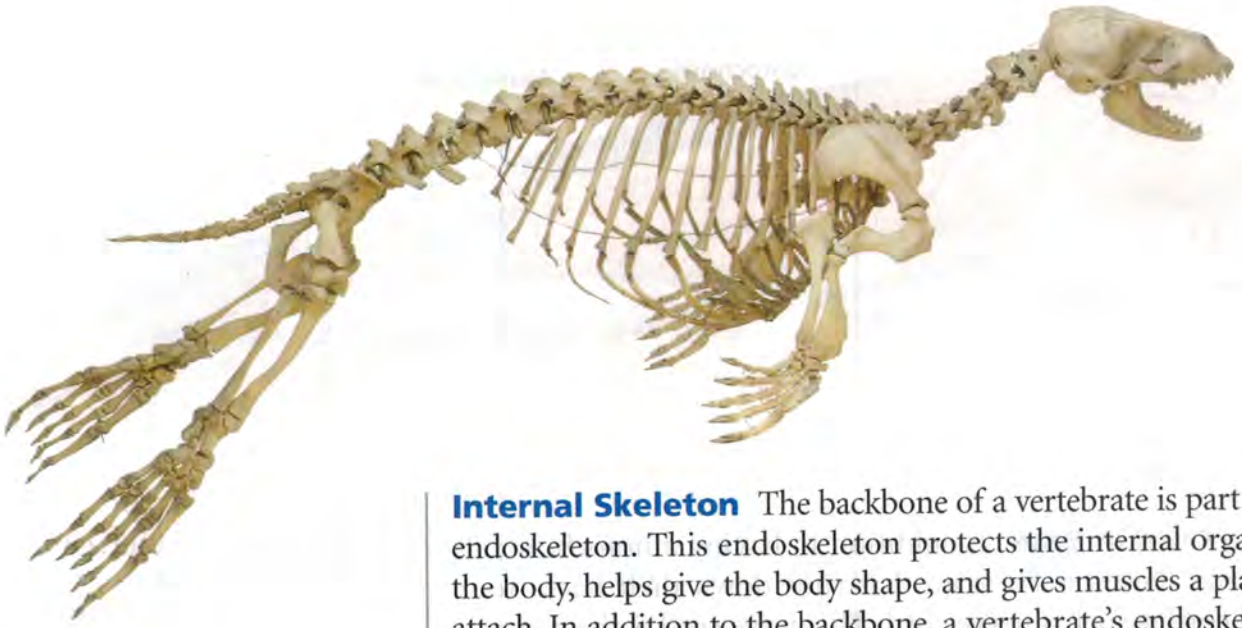


FIGURE 3
The Skeleton of a Seal
This seal's skeleton has adaptations for swimming. Long, flat bones support the flippers. The flat skull helps the seal move smoothly through the water.

Internal Skeleton The backbone of a vertebrate is part of its endoskeleton. This endoskeleton protects the internal organs of the body, helps give the body shape, and gives muscles a place to attach. In addition to the backbone, a vertebrate's endoskeleton includes the skull and ribs. The skull protects the brain. The ribs attach to the vertebrae and protect the heart, lungs, and other internal organs. Many vertebrates, like the seal shown in Figure 3, also have arm and leg bones adapted for movement.

A vertebrate's endoskeleton has several characteristics. Unlike an arthropod's exoskeleton, an endoskeleton doesn't need to be replaced as the animal grows. It also forms an internal frame that supports the body against the downward pull of gravity, while allowing easy movement. Because of these characteristics, vertebrates can grow bigger than animals with exoskeletons or no skeletons at all.

Reading Checkpoint **What does an endoskeleton protect?**

Keeping Conditions Stable

One characteristic that differs among the major groups of vertebrates is the way they control their body temperature. **The body temperature of most fishes, amphibians, and reptiles is close to the temperature of their environment. In contrast, birds and mammals have a stable body temperature that is often warmer than their environment.**

Ectotherms Fishes, amphibians, and reptiles are ectotherms. An **ectotherm** is an animal whose body does not produce much internal heat. Its body temperature changes depending on the temperature of its environment. For example, when a turtle is lying on a sunny riverbank, it has a higher body temperature than when it is swimming in a cool river. Ectotherms are sometimes called "coldblooded." This term is misleading because their blood is often quite warm.

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Visit: www.SciLinks.org
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Woma python ▶

▼ Emperor penguins

Endotherms In contrast to a turtle, a beaver would have the same body temperature whether it is in cool water or on warm land. The beaver is an example of an **endotherm**—an animal whose body regulates its own temperature by controlling the internal heat it produces. An endotherm's body temperature usually does not change much, even when the temperature of its environment changes. Birds and mammals, such as beavers, are endotherms.

Endotherms also have other adaptations, such as sweat glands and fur or feathers, for maintaining their body temperature. On hot days, some endotherms sweat. As the sweat evaporates, the animal is cooled. On cool days, fur or feathers keep endotherms warm. Because endotherms can keep their body temperatures stable, they can live in a greater variety of environments than ectotherms can.

FIGURE 4
Temperature Regulation
On a cool, sunny morning, a woma python raises its body temperature by basking in the sun. In contrast, an emperor penguin stays warm by producing internal heat.
Inferring *Which animal is an endotherm?*

Section 1 Assessment

Target Reading Skill **Building Vocabulary** Use your definitions to help answer the questions.

Reviewing Key Concepts

1. a. **Listing** List three characteristics of chordates.
   b. **Comparing and Contrasting** In chordates, how does the notochord of a vertebrate differ from that of an invertebrate?
   c. **Explaining** An earthworm has a nerve cord that runs along its body. Is an earthworm a chordate? Explain.
2. a. **Identifying** What characteristic do only vertebrates have?
   b. **Describing** Describe a backbone.
   c. **Relating Cause and Effect** What gives a backbone flexibility?
3. a. **Summarizing** What is the difference between an ectotherm and an endotherm?
   b. **Making Generalizations** Would an ectotherm or an endotherm be more active on a cold night? Explain your answer.

Lab zone At-Home Activity

Bumpy Back Rub Have members of your family feel the tops of the vertebrae running down the center of their backs. Then have them feel the hard skull beneath the skin on their foreheads. Tell them about the functions of the backbone and skull.

Lab zone **Skills Lab**

Soaking Up Those Rays

Problem

How do some lizards control their body temperatures in the extreme heat of a desert?

Skills Focus

interpreting data, predicting

Materials

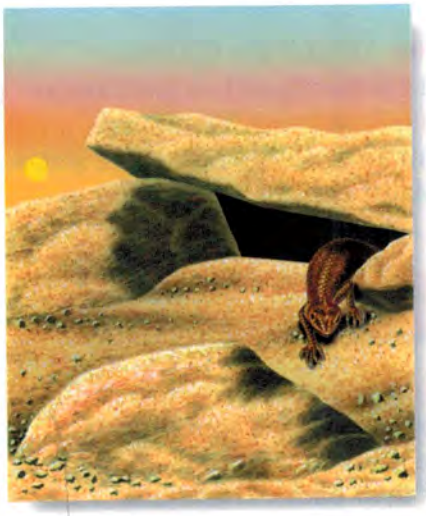
- paper
- pencil

Procedure

1. The data below were collected by scientists studying how lizards control their body temperature. Examine the data.
2. Copy the data table into your notebook.
3. Organize the data in the diagrams by filling in the table, putting the appropriate information in each column. Begin by writing a brief description of each type of lizard behavior.
4. Complete the data table using the information in the diagrams.

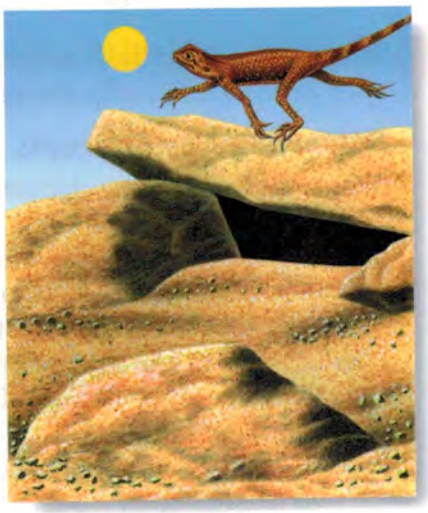
Analyze and Conclude

1. **Interpreting Data** Describe how the lizard's body temperature changed between 6 A.M. and 9 P.M.
2. **Inferring** What are three sources of heat that caused the lizard's body temperature to rise during the day?
3. **Interpreting Data** During the hottest part of the day, what were the air and ground temperatures? Why do you think the lizard's temperature remained below 40°C?
4. **Predicting** Predict what the lizard's body temperature would have been from 9 P.M. to 6 A.M. Explain your prediction.
5. **Predicting** Predict what would happen to your own body temperature if you spent a brief period outdoors in the desert at noon. Predict what your temperature would be if you spent time in a burrow at 7 P.M. Explain your predictions.



6 A.M.–7 A.M.
Emerging from burrow
Air temperature **20°C**
Ground temperature **28°C**
Body temperature **25°C**

7 A.M.–9 A.M.
Basking (lying on ground in sun)
Air temperature **27°C**
Ground temperature **29°C**
Body temperature **32.6°C**



9 A.M.–12 NOON
Active (moving about)
Air temperature **27°C**
Ground temperature **30.8°C**
Body temperature **36.6°C**

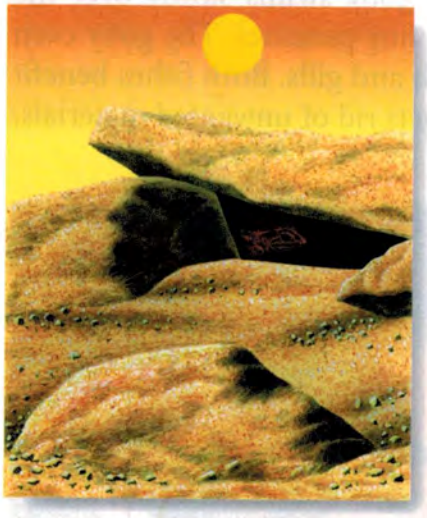
Data Table

Activity	Description of Activity	Time of Day	Air Temperature (°C)	Ground Temperature (°C)	Body Temperature (°C)
1. Emerging					
2. Basking					
3. Active					
4. Retreat					
5. Stilting					
6. Retreat					

6. **Drawing Conclusions** Based on what you learned from the data, explain why it is misleading to say that an ectotherm is a "cold-blooded" animal.
7. **Communicating** Write a paragraph explaining why it is helpful to organize data in a data table before you try to interpret the data.

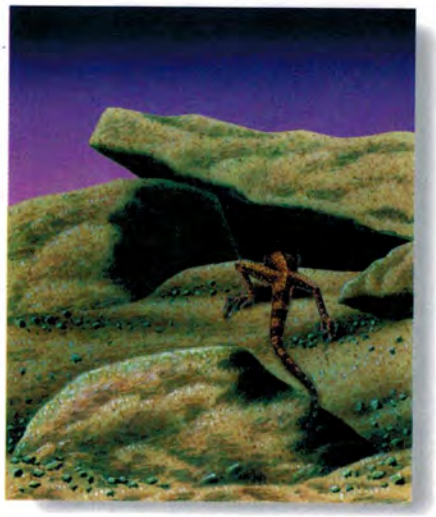
More to Explore

Make a bar graph of the temperature data. Explain what the graph shows you. How does this graph help you interpret the data about how lizards control their body temperature in the extreme heat of a desert?



12 NOON–2:30 P.M.
Retreat to burrow
Air temperature **40.3°C**
Ground temperature **53.8°C**
Body temperature **39.5°C**

2:30 P.M.–6 P.M.
Stilting (belly off ground)
Air temperature **34.2°C**
Ground temperature **47.4°C**
Body temperature **39.5°C**



6 P.M.–9 P.M.
Retreat to burrow
Air temperature **25°C**
Ground temperature **26°C**
Body temperature **25°C**

Section 2

Fishes

Reading Preview

Key Concepts

- What are the characteristics of most fishes?
- What are the major groups of fishes and how do they differ?

Key Terms

- fish
- cartilage
- swim bladder

Target Reading Skill

Previewing Visuals Before you read, preview Figure 12. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Structure of a Fish

Q. What is a swim bladder?
A.
Q.

Lab zone Discover Activity

How Does Water Flow Over a Fish's Gills?

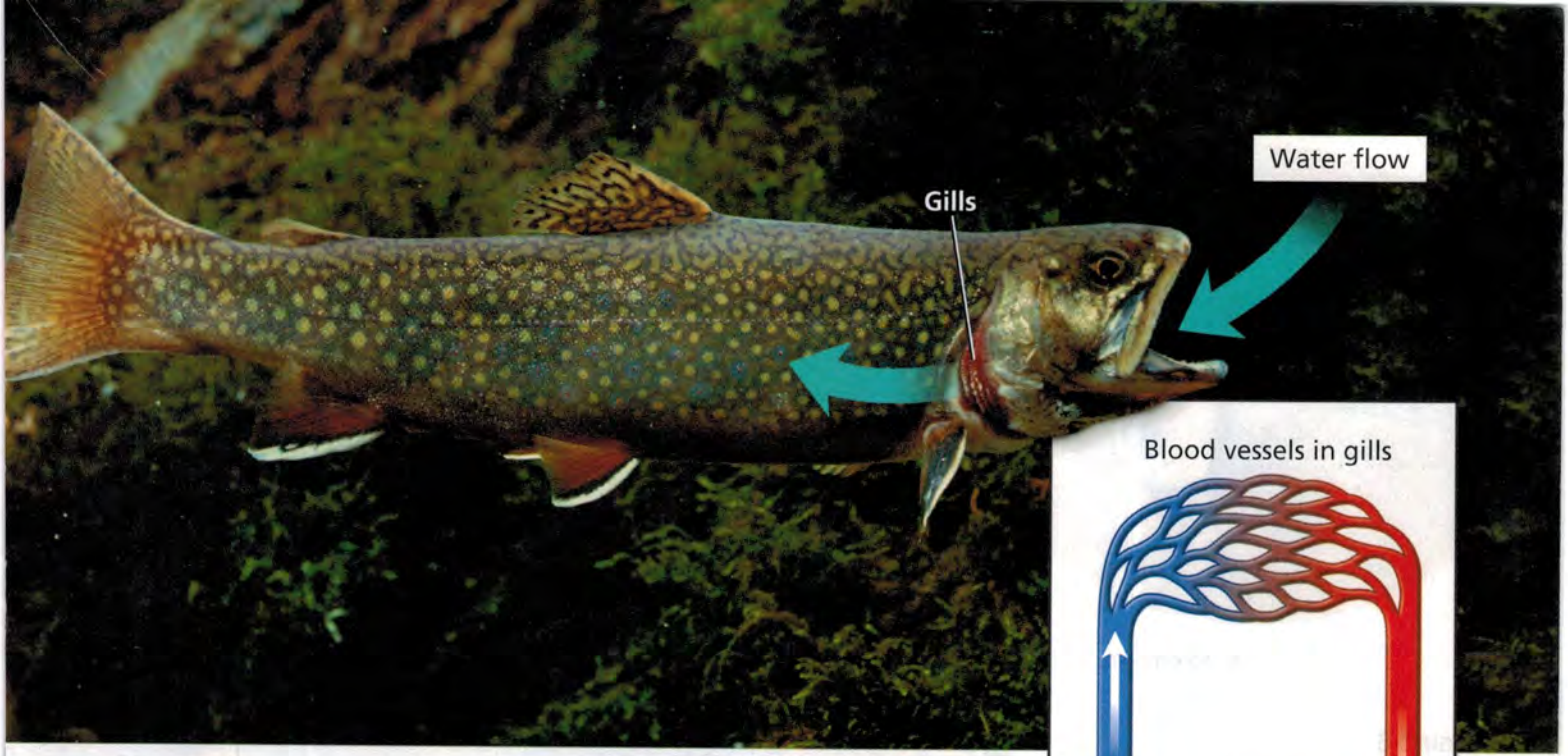
1. Closely observe a fish in an aquarium for a few minutes. Note how frequently the fish opens its mouth.
2. Notice the flaps on each side of the fish's head behind its eyes. Observe how the flaps open and close.
3. Observe the movements of the mouth and the flaps at the same time. Note any relationship between the movements of these two structures.

Think It Over

Observing What do the flaps on the sides of the fish do when the fish opens its mouth? What role do you think these two structures play in a fish's life?

In the warm waters of a coral reef, a large spotted fish called a graysby hovers in the water, barely moving. A smaller striped fish called a goby swims up to the graysby. Then, like a vacuum cleaner moving over a rug, the goby swims slowly over the larger fish, eating dead skin and tiny parasites. The goby even cleans inside the graysby's mouth and gills. Both fishes benefit from this cleaning. The graysby gets rid of unwanted materials, and the goby gets a meal.

Gobies cleaning a graysby ▶



Characteristics of Fishes

Both the goby and the graysby it cleans are fishes. A **fish** is a vertebrate that lives in water and uses fins to move. **In addition to living in water and having fins, most fishes are ectotherms, obtain oxygen through gills, and have scales.** Scales are thin, overlapping plates that cover the skin.

Fishes make up the largest group of vertebrates. Nearly half of all vertebrate species are fishes. In addition, fishes have been on Earth longer than any other kind of vertebrate.

Obtaining Oxygen Fishes get their oxygen from water. As a fish swims, it opens its mouth and takes a gulp of water, as you observed if you did the Discover Activity. The water, which contains oxygen, moves through openings in the fish's throat region that lead to the gills. Gills, which look like tiny feathers, have many blood vessels within them. As water flows over the gills, oxygen moves from the water into the fish's blood. At the same time, carbon dioxide, a waste product, moves out of the blood and into the water. After flowing over the gills, the water flows out of the fish through slits beneath the gills.

Circulatory System From the gills, the blood travels throughout the fish's body, supplying the body cells with oxygen. Like all vertebrates, fishes have a closed circulatory system. The heart of a fish has two chambers, or inner spaces. The heart of a fish pumps blood in one loop—from the heart to the gills, from the gills to the rest of the body, and back to the heart. You can trace this path in Figure 5.

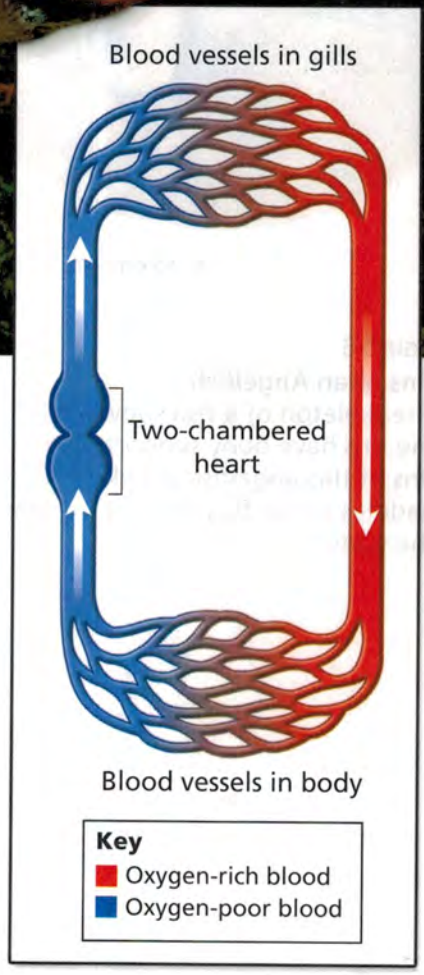


FIGURE 5
Respiration and Circulation
Water flows into the mouth of this fish and then over its gills. Oxygen moves into the blood and is delivered to the cells of the fish.
Interpreting Diagrams *Where does oxygen get into the blood of a fish?*

▲ Skeleton

FIGURE 6
Fins of an Angelfish
The skeleton of a fish shows that the fins have bony support. The fins of this angelfish act like paddles as the fish moves through the water.

Movement Fins help fishes swim. Look at the fins on the angelfish in Figure 6. Each fin has a thin membrane stretched across bony supports. Like a canoe paddle, a fin provides a large surface to push against the water. The push allows for faster movement through the water. If you have ever swum wearing a pair of swim fins, you probably noticed how fast you moved through the water. Most of the movements of fishes are related to obtaining food, but some are related to reproduction.

Reproduction Most fishes have external fertilization. In external fertilization, the eggs are fertilized outside the female's body. The male hovers close to the female and spreads a cloud of sperm cells over the eggs she releases. The young develop outside the female's body.

In contrast, some fishes, such as sharks and guppies, have internal fertilization. In internal fertilization, eggs are fertilized inside the female's body. The young develop inside her body. When they are mature enough to live on their own, she gives birth to them.

Reading Checkpoint **What is the structure of a fin?**

FIGURE 7
Trout Eggs
Young brook trout fish are developing in these eggs on the bottom of a stream.

Nervous System The nervous system and sense organs of fishes help them find food and avoid predators. Most fishes can see much better in water than you can. Keen senses of touch, smell, and taste also help fishes capture food. Some fishes have taste organs in unusual places. For example, the catfish shown in Figure 8 tastes with its whiskers.

FIGURE 8
A Catfish
The whiskers of a catfish have many taste buds. To find food, the catfish drags its whiskers along muddy lake or river bottoms.

Jawless Fishes

Fishes have lived on Earth longer than any other kind of vertebrate. Fishes are organized into three main groups based on the structures of their mouths and the types of skeletons they have. **The major groups of fishes are jawless fishes, cartilaginous fishes, and bony fishes.**

Jawless fishes are unlike other fishes in that they have no jaws and no scales. Jaws are hinged bony structures that allow animals to open and close their mouths. Instead of jaws, jawless fishes have mouths containing structures for scraping, stabbing, and sucking their food. Their skeletons are made of **cartilage,** a tissue that is more flexible than bone.

Hagfishes and lampreys are the only kinds of jawless fishes that exist today. Hagfishes look like large, slimy worms. They crawl into the bodies of dead or dying fishes and use their rough tongues to scrape decaying tissues. Many lampreys are parasites of other fishes. They attach their mouths to healthy fishes and then suck in the tissues and blood of their victims. If you look at the lamprey's mouth in Figure 9, you can probably imagine the damage it can do.

Reading Checkpoint **What material makes up the skeleton of a jawless fish?**

FIGURE 9
A Lamprey
Lampreys have eel-shaped bodies. They use sharp teeth and suction-cup mouths to feed on other fishes. **Classifying** *To which group of fishes do lampreys belong?*

▲ Mouth

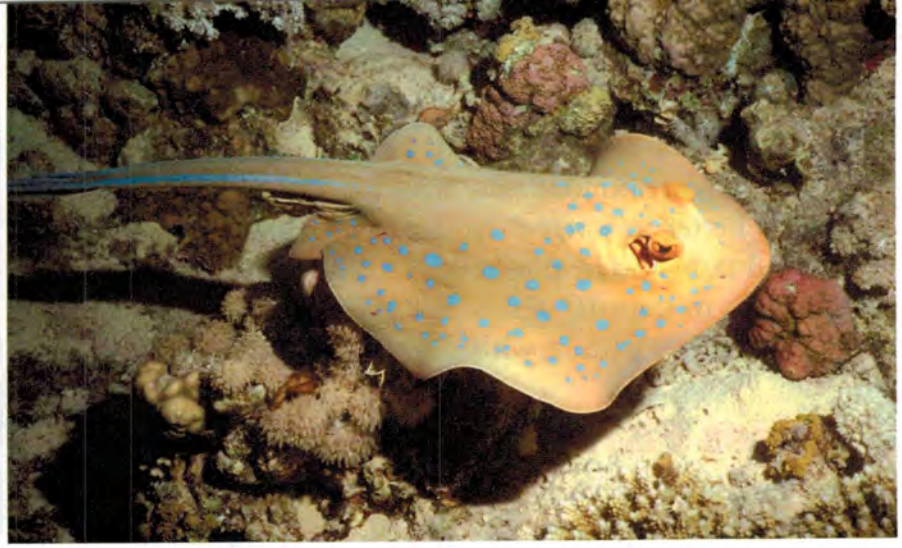


FIGURE 10
Blue-Spotted Ray
This ray is a cartilaginous fish that lives on the ocean floor.

Cartilaginous Fishes

Sharks, rays, and skates are cartilaginous (kahr tuh LAJ uh nuhs) fishes. **The cartilaginous fishes have jaws and scales, and skeletons made of cartilage.** The pointed, toothlike scales that cover their bodies give their skin a texture that is rougher than sandpaper.

Obtaining Oxygen Most sharks cannot pump water over their gills. Instead, they rely on swimming or currents to keep water moving across their gills. For example, when sharks sleep, they position themselves in currents that send water over their gills.

Rays and skates are not as active as sharks. They spend a lot of time partially buried in the sand of the ocean floor. During this time, they take in water through small holes located behind their eyes. Water leaves through gill openings on their undersides.

Obtaining Food Cartilaginous fishes are usually carnivores. Rays and skates hunt on the ocean floor, crushing mollusks, crustaceans, and small fishes with their teeth. Sharks will attack and eat nearly anything that smells like food. They can smell and taste even a tiny amount of blood—as little as one drop in 115 liters of water! Although sharks have a keen sense of smell their eyesight is poor. Because they see poorly, sometimes they swallow strange objects. Indeed, one shark was found to have a raincoat and an automobile license plate in its stomach.

The mouth of a shark contains jagged teeth arranged in rows. Most sharks use only the first couple of rows for feeding. The remaining rows are replacements. If a shark loses a front-row tooth, a tooth behind it moves up to replace it.

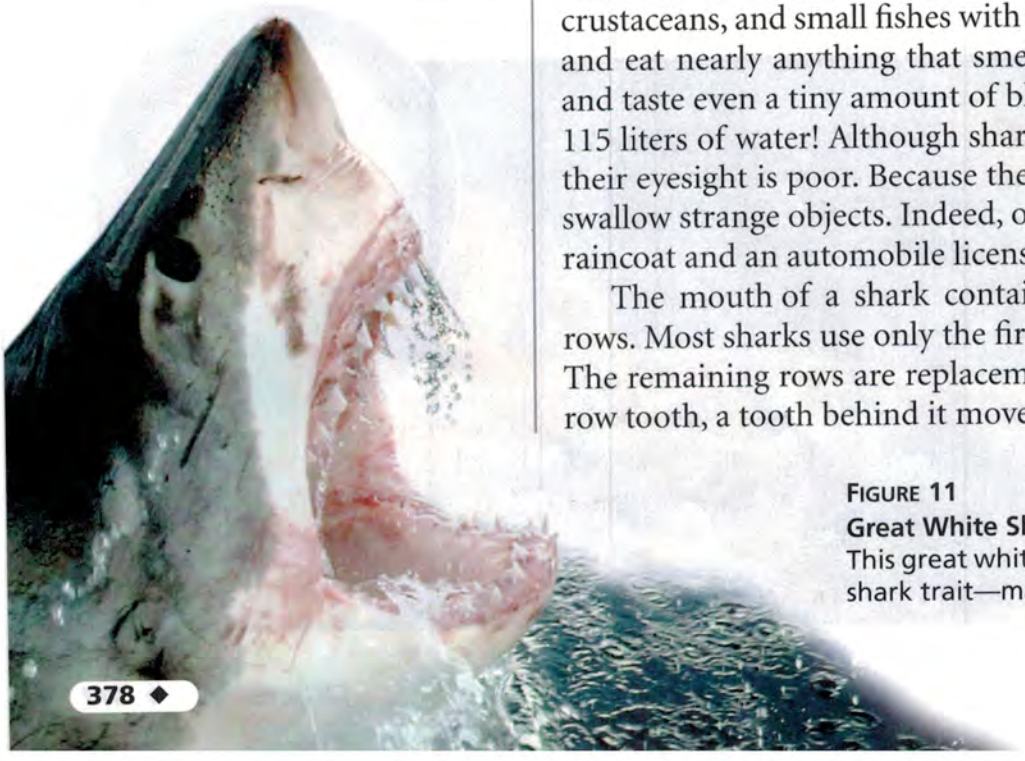
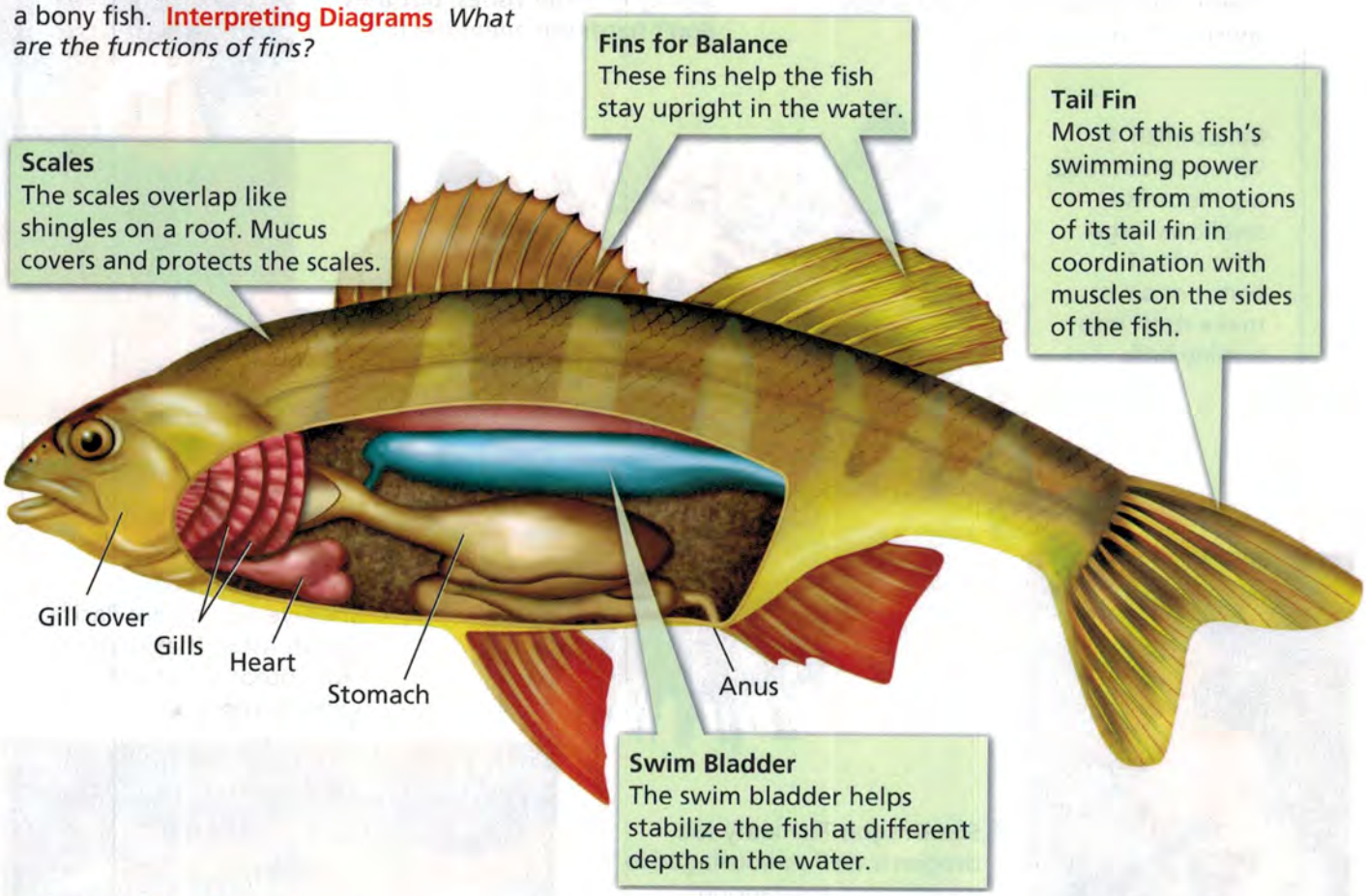


FIGURE 11
Great White Shark
This great white shark has a familiar shark trait—many sharp teeth.

FIGURE 12
Structure of a Bony Fish
This yellow perch has the characteristics of a bony fish. **Interpreting Diagrams** *What are the functions of fins?*



Bony Fishes

Most familiar kinds of fishes, such as trout, tuna, and goldfishes, are bony fishes. **A bony fish has jaws, scales, a pocket on each side of the head that holds the gills, and a skeleton made of hard bones.** Each gill pocket is covered by a flap that opens to release water.

The major structures of a bony fish are shown in Figure 12. Notice that a bony fish has an organ called a **swim bladder,** which is an internal, gas-filled sac that helps the fish stay stable at different depths in the water. Gas levels in the swim bladder are adjusted after the fish reaches its desired depth. By adjusting these levels, the fish can stay at a depth without using a lot of energy.

Bony fishes make up about 95 percent of all fish species. They live in both salt water and fresh water. Some live in the dark depths of the ocean. Others thrive in light-filled waters, such as those around coral reefs. Figure 13 on the next page shows some of the great variety of bony fishes.

Reading Checkpoint **Which organ helps a bony fish maintain its position in the water?**

Lab zone Skills Activity

Observing

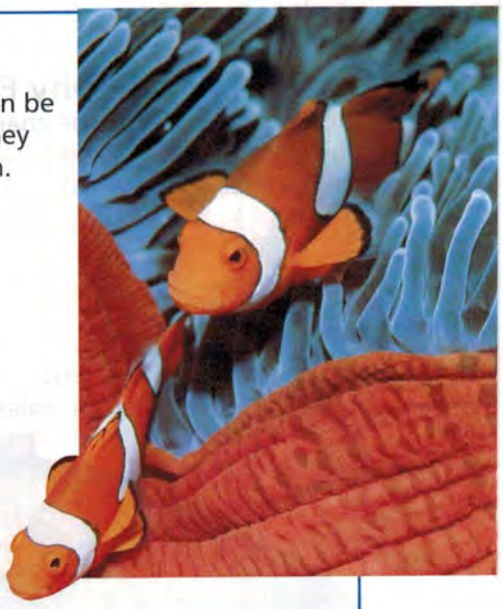
Put on your goggles and disposable gloves. Place a preserved fish on newspaper on your desk and examine it closely. Note its size and shape, and the number and locations of its fins. Lift the gill cover and observe the gills with a hand lens. Use your observations to make a diagram of the fish. Wash your hands when you are finished.

FIGURE 13

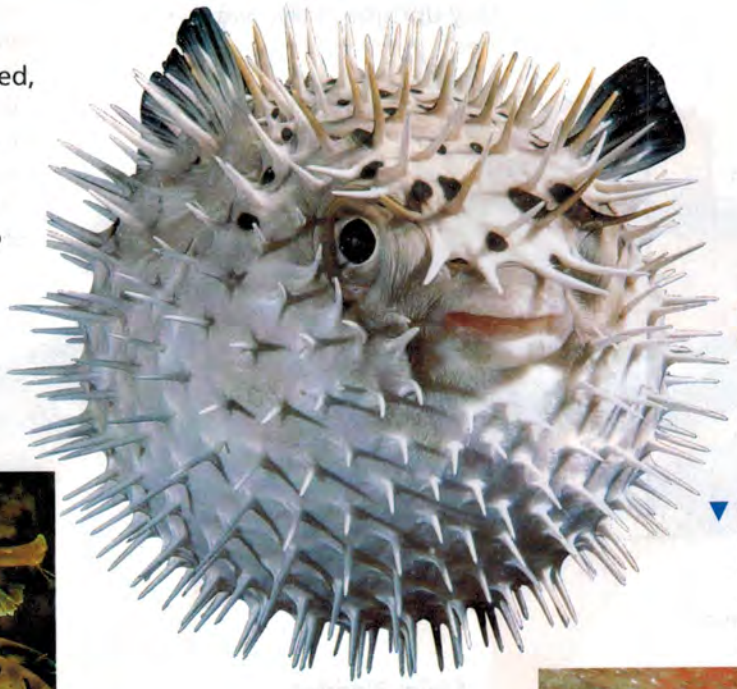
Diversity of Bony Fishes

These photographs show just a few species of bony fishes.

Anemone Fish ▶
A sea anemone's tentacles can be deadly to other fishes, but they don't harm the anemone fish.



Balloonfish ▶
When threatened, a balloonfish swallows large amounts of water or air to make itself into a spiny ball.



◀ **Sea Dragon** The leafy sea dragon is well camouflaged in weedy bays and lagoons.

▼ **Sockeye Salmon**
Sockeye salmon are Pacific Ocean fishes that migrate from ocean to inland lakes to reproduce.

Section 2 Assessment

Target Reading Skill **Previewing Visuals** Use the information in your graphic organizer about the structure of a fish to quiz a partner.

Reviewing Key Concepts

1. a. **Reviewing** What are the main characteristics of fishes?
   b. **Explaining** Why do fishes have gills?
   c. **Applying Concepts** What would happen to a goldfish that could not open its mouth? Explain.
2. a. **Identifying** What are three major groups of fishes?
   b. **Classifying** Into which group of fishes would you classify a fish with jaws and a skeleton made of cartilage?
   c. **Comparing and Contrasting** How do sharks and hagfishes obtain food?

Writing in Science

Wanted Poster Design a "Wanted" poster for a lamprey. Present the lamprey as a "criminal of the ocean." Include the lamprey's physical characteristics, feeding habits, and any other details that will allow people to track down this fish.

Lab zone **Skills Lab**

Home Sweet Home

Problem

What features does an aquarium need for fish to survive in it?

Skills Focus

observing, making models

Materials

- gravel • metric ruler • guppies • snails
- guppy food • dip net
- tap water • thermometer • water plants
- aquarium filter • aquarium heater
- rectangular aquarium tank (15 to 20 liters) with cover

Procedure

1. Wash the aquarium tank with lukewarm water—do not use soap. Then place it on a flat surface in indirect sunlight.
2. Rinse the gravel and spread it over the bottom of the tank to a depth of about 3 cm.
3. Fill the tank about two-thirds full with tap water. Position several water plants in the tank by gently pushing their roots into the gravel. Wash your hands after handling the plants.
4. Add more water until the level is about 5 cm from the top.
5. Place the filter in the water and turn it on. Insert an aquarium heater into the tank and turn it on. Set the temperature to 25°C. **CAUTION:** *Do not touch electrical equipment with wet hands.*
6. Allow the water to "age" by letting it stand for two days. Aging allows the chlorine to evaporate.
7. When the water has aged and is at the proper temperature, add guppies and snails to the tank. Include one guppy and one snail for each 4 liters of water. Cover the aquarium. Wash your hands after handling the animals.
8. Observe the aquarium every day for two weeks. Feed the guppies a small amount of food daily. Look for evidence that the fishes and snails have adapted to their new environment. Also look for the ways they carry out their life activities, such as feeding and respiration. Record your observations.
9. Use a dip net to keep the gravel layer clean and to remove any dead plants or animals.

Analyze and Conclude

1. **Observing** How does the aquarium meet the following needs of the organisms living in it: (a) oxygen supply, (b) proper temperature, and (c) food?
2. **Inferring** What happens to the oxygen that the fishes take in from the water in this aquarium? How is that oxygen replaced?
3. **Making Models** How is an aquarium like a guppy's natural environment? How is it different?
4. **Communicating** Write an e-mail to a friend or relative in which you summarize the record you made during the two weeks you observed the aquarium.

Design an Experiment

Write a one-page procedure for adding a second kind of fish to the aquarium. Include a list of questions that you would need to have answered before you could carry out your plan successfully. (Success would be marked by both types of fishes surviving together in the tank.) *Obtain your teacher's permission before carrying out your investigation.*

Section 3

Amphibians

Reading Preview

Key Concepts

- What are the main characteristics of amphibians?
- What are some adaptations of adult amphibians for living on land?

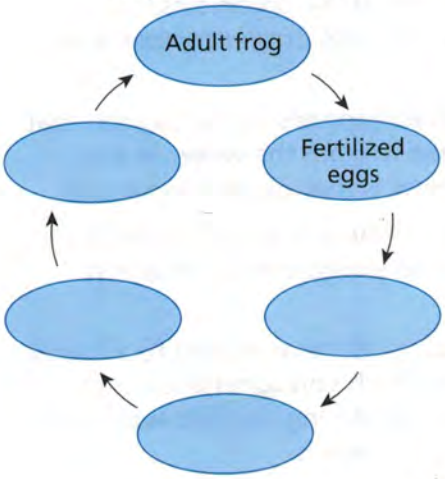
Key Terms

- amphibian
- tadpole
- lung
- atrium
- ventricle
- habitat

Target Reading Skill

Sequencing As you read, make a cycle diagram like the one below that shows the different stages of a frog's metamorphosis during its life cycle. Write each step of the process in a separate circle.

Frog Metamorphosis



Lab zone Discover Activity

What's the Advantage of Being Green?

1. Count out 20 dried yellow peas and 20 green ones. Mix them up in a paper cup.
2. Cover your eyes. Have your partner gently scatter the peas onto a large sheet of green paper.
3. Uncover your eyes. Have your partner keep time while you pick up as many peas, one at a time, as you can find in 15 seconds.
4. When 15 seconds are up, count how many peas of each color you picked up.
5. Repeat Steps 2 through 4, but this time you scatter the peas and keep time while your partner picks up the peas.
6. Compare your results with those of your partner and your classmates.

Think It Over

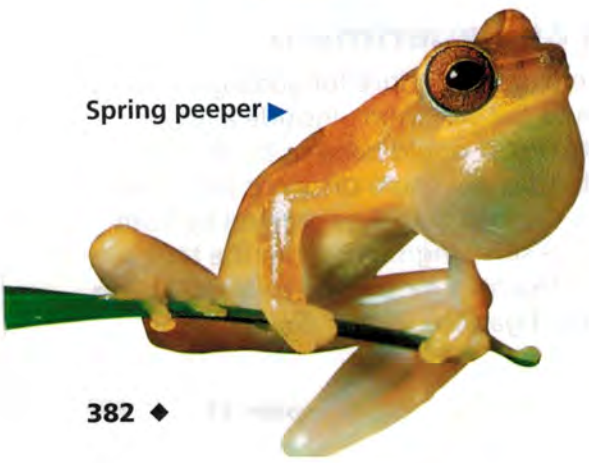
Inferring Many frogs are green, as are their environments. What advantage does a frog have in being green?

What's that sound coming from the pond? Even 1 kilometer away you can hear the shrill calls of frogs called spring peepers on this damp spring night. By the time you reach the pond, the calls are ear-splitting. You might think that the frogs must be huge to make such a loud sound. But each frog is smaller than the first joint of your thumb! In the beam of your flashlight, you see the puffed-up throats of the males, vibrating with each call. Female peepers bound across roads and swim across streams to mate with the noisy males.

What Is an Amphibian?

A frog is one kind of amphibian; toads and salamanders are other kinds. An **amphibian** is a vertebrate that is ectothermic and spends its early life in water. Indeed, the word *amphibian* means "double life," and amphibians have exactly that. **After beginning their lives in water, most amphibians spend their adulthood on land, returning to water to reproduce.**

Spring peeper ▶



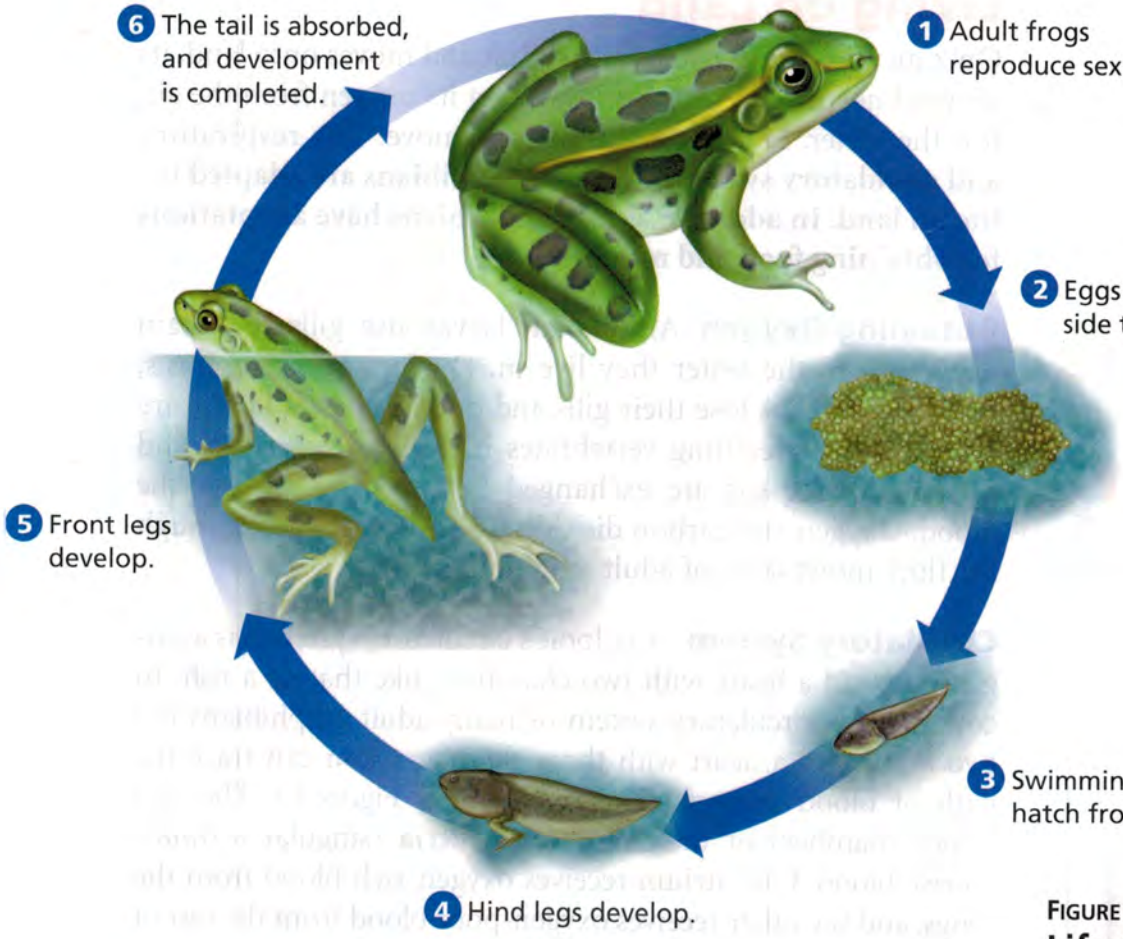


FIGURE 14
Life Cycle of a Frog
During its metamorphosis from tadpole to adult, a frogs body undergoes a series of dramatic changes. **Applying Concepts** *How do these changes prepare a frog for living on land?*

Groups of Amphibians The two major groups of amphibians are salamanders and frogs and toads. You can distinguish between the groups by the presence of a tail in the adults. Salamanders keep their tails in adulthood, while almost all frogs and toads do not.

Reproduction and Development Amphibians have a life cycle that suits the "double lives" they lead. Eggs are fertilized internally in most salamanders and externally in most frogs and toads. Fertilized eggs develop in water. After a few days, larvae wriggle out of a jelly that coats the eggs and begin a free-swimming, fishlike life.

The larvae of most amphibians grow and eventually undergo metamorphosis. You can trace the process of frog metamorphosis in Figure 14. The larva of a frog or a toad is called a **tadpole.**

Unlike tadpoles, the larvae of salamanders look like adults. Most salamander larvae undergo a metamorphosis in which they lose their gills. However, the changes are not as dramatic as those that happen during a frog or toad's metamorphosis.

Reading Checkpoint **What is a frog larva called?**

Living on Land

Once an amphibian becomes an adult and moves onto land, its survival needs change. It must now get its oxygen from the air, not the water. Fins no longer help it move. **The respiratory and circulatory systems of adult amphibians are adapted for life on land. In addition, adult amphibians have adaptations for obtaining food and moving.**

Obtaining Oxygen Amphibian larvae use gills to obtain oxygen from the water they live in. During metamorphosis, most amphibians lose their gills and develop lungs. **Lungs** are organs of air-breathing vertebrates in which oxygen gas and carbon dioxide gas are exchanged between the air and the blood. Oxygen and carbon dioxide are also exchanged through the thin, moist skins of adult amphibians.

Circulatory System A tadpole's circulatory system has a single loop and a heart with two chambers, like that of a fish. In contrast, the circulatory system of many adult amphibians has two loops and a heart with three chambers. You can trace the path of blood through an amphibian in Figure 15. The two upper chambers of the heart, called **atria** (singular *atrium*), receive blood. One atrium receives oxygen-rich blood from the lungs, and the other receives oxygen-poor blood from the rest of the body. From the atria, blood moves into the lower chamber, the **ventricle,** which pumps blood out to the lungs and body. Oxygen-rich and oxygen-poor blood mix in the ventricle.

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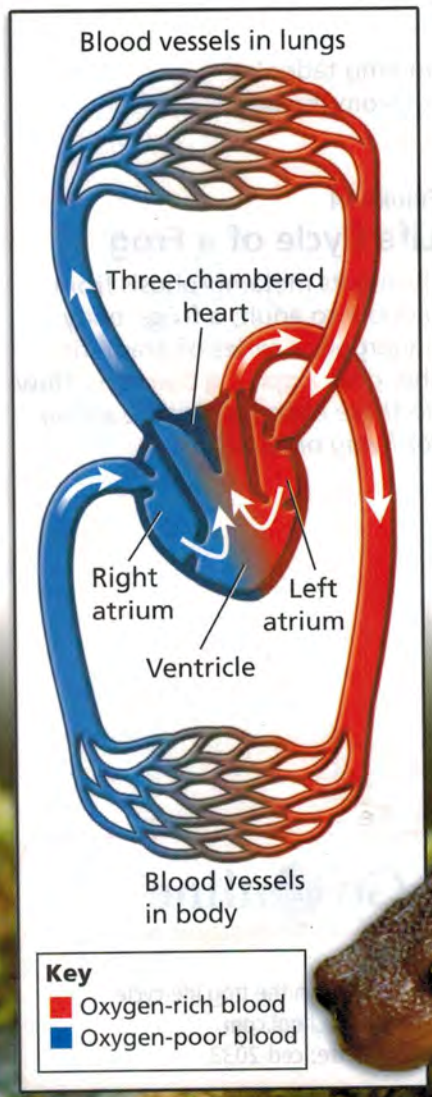


FIGURE 15
Respiration and Circulation
This adult salamander has lungs and a double-loop circulatory system. **Interpreting Diagrams** *What kind of blood is in the ventricle?*

FIGURE 16
Adaptations for Movement
Some frogs have sticky pads on their toes for climbing. Others have webbed feet for swimming.

Obtaining Food Although most tadpoles are herbivores, most adult salamanders, frogs, and toads are carnivores that feed on small animals. Frogs and toads usually wait for their prey to come close. But salamanders, unlike frogs and toads, actively stalk and ambush their prey.

Frogs and toads have camouflage that helps them obtain food. Most frogs and toads are brownish-green, making them hard to see in their environment. In the Discover Activity, you learned that it is hard to see something green against a green background.

Movement A vertebrate that lives on land needs a strong skeleton to support its body against the pull of gravity. In addition, a land animal needs some way of moving. Fins work in water, but they don't work on land. Most adult amphibians have strong skeletons and muscular limbs adapted for moving on land.

Salamanders usually crawl in their environments, but frogs and toads have adaptations for other kinds of movements. Perhaps you've tried to catch a frog or a toad only to have it leap away from you. The legs of frogs and toads have adaptations for leaping. Leaping requires powerful hind-leg muscles and a skeleton that can absorb the shock of landing. The feet of frogs and toads have adaptations, too, as you can see in Figure 16.

Lab zone Try This Activity

Webbing Along

1. Fill a sink or pail with water.
2. Spread your fingers and put your hand into the water just far enough so that only your fingers are under water. Drag your fingers back and forth through the water.
3. Now dry your hand and cover it with a small plastic bag. Secure the bag around your wrist with a rubber band.
4. Repeat Step 2. Note any difference in the way in which your fingers push the water.

Making Models Use your model to explain how a frog's webbed feet help it move through water.

FIGURE 17
Golden Frog
Golden frogs, like the one shown here, are rarely seen anymore in their native habitat—the rain forests of Panama. **Relating Cause and Effect** *What are two possible causes for the decrease in the number of golden frogs?*

Amphibians in Danger Worldwide, amphibian populations are decreasing. One reason for the decrease is the destruction of amphibian habitats. An animal's **habitat** is the specific environment in which it lives. When a swamp is filled in or a forest is cut, an area that was moist becomes drier. Few amphibians can survive for long in dry, sunny areas. But habitat destruction does not account for the whole problem of population decrease. Amphibians are declining even in areas where their habitats have not been damaged. Because their skins are delicate and their eggs lack shells, amphibians are especially sensitive to changes in their environment. Poisons in the environment, such as pesticides and other chemicals, can pollute the waters that amphibians need to live and reproduce. Even small amounts of these chemicals can weaken adult amphibians, kill amphibian eggs, or cause tadpoles to become deformed.

Reading Checkpoint **What is a habitat?**

Section 3 Assessment

Target Reading Skill **Sequencing** Review your cycle diagram about frog metamorphosis with a partner. Add any necessary information.

Reviewing Key Concepts

1. a. **Defining** What is an amphibian?
   b. **Summarizing** What are three main characteristics of amphibians?
   c. **Comparing and Contrasting** How is the metamorphosis of a salamander different from the metamorphosis of a frog?
2. a. **Reviewing** What are four adaptations of adult amphibians for living on land?
   b. **Describing** What are three adaptations frogs and toads have for moving? How does each adaptation help the amphibian survive in its environment?
   c. **Sequencing** How does blood move in the circulatory system of an amphibian? (*Hint:* Start with blood leaving the ventricle of the heart.)

Writing in Science

Web Site Design the home page of a Web site that introduces people to amphibians. First, come up with a catchy title for your Web site. Then, design your home page, the first page people will see. Consider these questions as you come up with your design: What information will you include? What will the illustrations or photos show? What links to specific topics relating to amphibians will you have?

Section 4

Reptiles

Reading Preview

Key Concepts

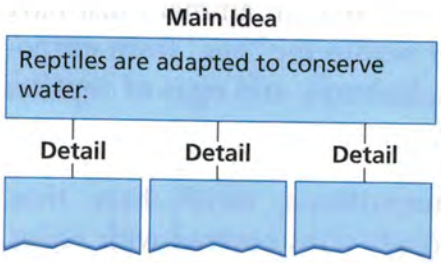
- What are some adaptations that allow reptiles to live on land?
- What are the characteristics of each of the three main groups of reptiles?
- What adaptation helped dinosaurs survive before they became extinct?

Key Terms

- reptile
- kidney
- urine
- amniotic egg

Target Reading Skill

Identifying Main Ideas As you read the information under the heading titled Adaptations for Life on Land, write the main 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

How Do Snakes Feed?

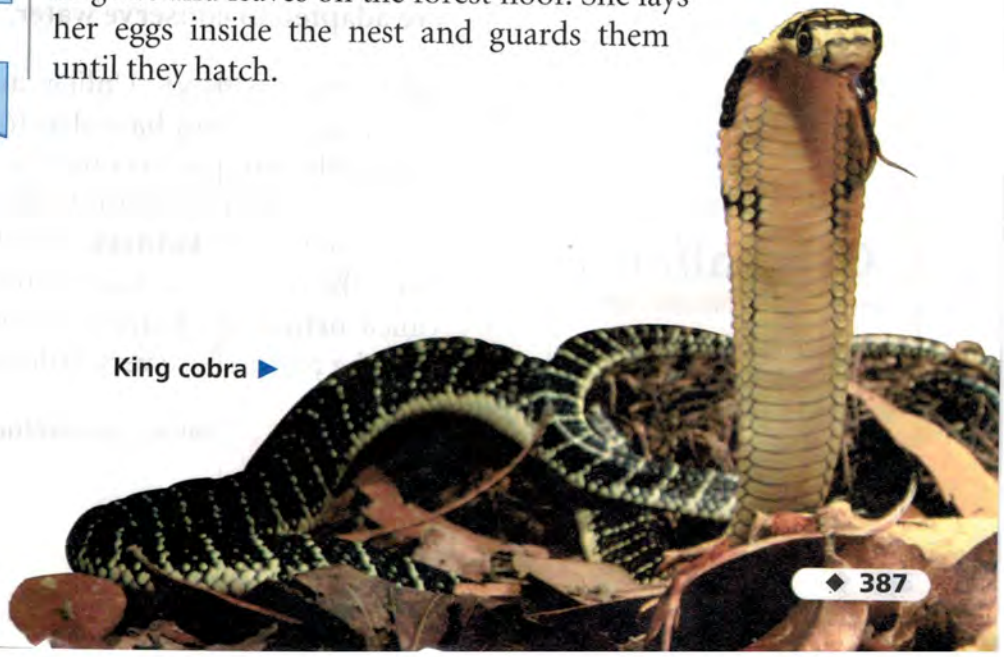
1. To model how a snake feeds, stretch a sock cuff over a grapefruit "prey" by first pulling on one side and then on the other. Work the grapefruit down into the "stomach." A snake's jawbones can spread apart like the sock cuff.
2. Remove the grapefruit and put a rubber band around the sock about 8 centimeters below the opening. The rubber band represents the firmly joined jawbones of a lizard. Now try to repeat Step 1.

Think It Over

Inferring What is the advantage of having jawbones like a snake's?

The king cobra of Southeast Asia is the world's longest venomous snake. It can grow to more than 4 meters long. When it encounters a predator, a king cobra flattens its neck and rears up. Its ropelike body sways back and forth, and its tongue flicks in and out.

A king cobra's fearsome behavior in response to a predator contrasts with the gentle way it treats its eggs. King cobras are one of the few snakes that build nests. The female builds a nest of grass and leaves on the forest floor. She lays her eggs inside the nest and guards them until they hatch.



King cobra ▶

FIGURE 18
A Desert Tortoise
The tough, scaly skin of this desert tortoise helps it survive in a dry environment.

Adaptations for Life on Land

Like other reptiles, king cobras lay their eggs on land rather than in water. A **reptile** is an ectothermic vertebrate that has lungs and scaly skin. In addition to snakes such as the king cobra, lizards, turtles, and alligators are also reptiles. Unlike amphibians, reptiles can spend their entire lives on dry land.

The ancestors of modern reptiles were the first vertebrates adapted to life completely out of water. Reptiles get their oxygen from air and breathe entirely with lungs. Reptiles that live in water, such as sea turtles, evolved from reptiles that lived on land. So, even though they live in water, they still breathe with lungs and come ashore to lay eggs.

You can think of a land animal as a pocket of water held within a bag of skin. To thrive on land, an animal must have adaptations that keep the water within the "bag" from evaporating in the dry air. **The skin, kidneys, and eggs of reptiles are adapted to conserve water.**

Skin and Kidneys Unlike amphibians, which have thin, moist skin, reptiles have dry, tough skins covered with scales. This scaly skin protects reptiles and helps keep water in their bodies. Another adaptation that helps keep water inside a reptile's body is its **kidneys,** which are organs that filter wastes from the blood. The wastes are then excreted in a watery fluid called **urine.** The kidneys of reptiles concentrate the urine so that the reptiles lose very little water.

Reading Checkpoint **What are two functions of a reptile's skin?**

Go Online
PHSchool.com
For: More on reptiles
Visit: PHSchool.com
Web Code: ced-2034

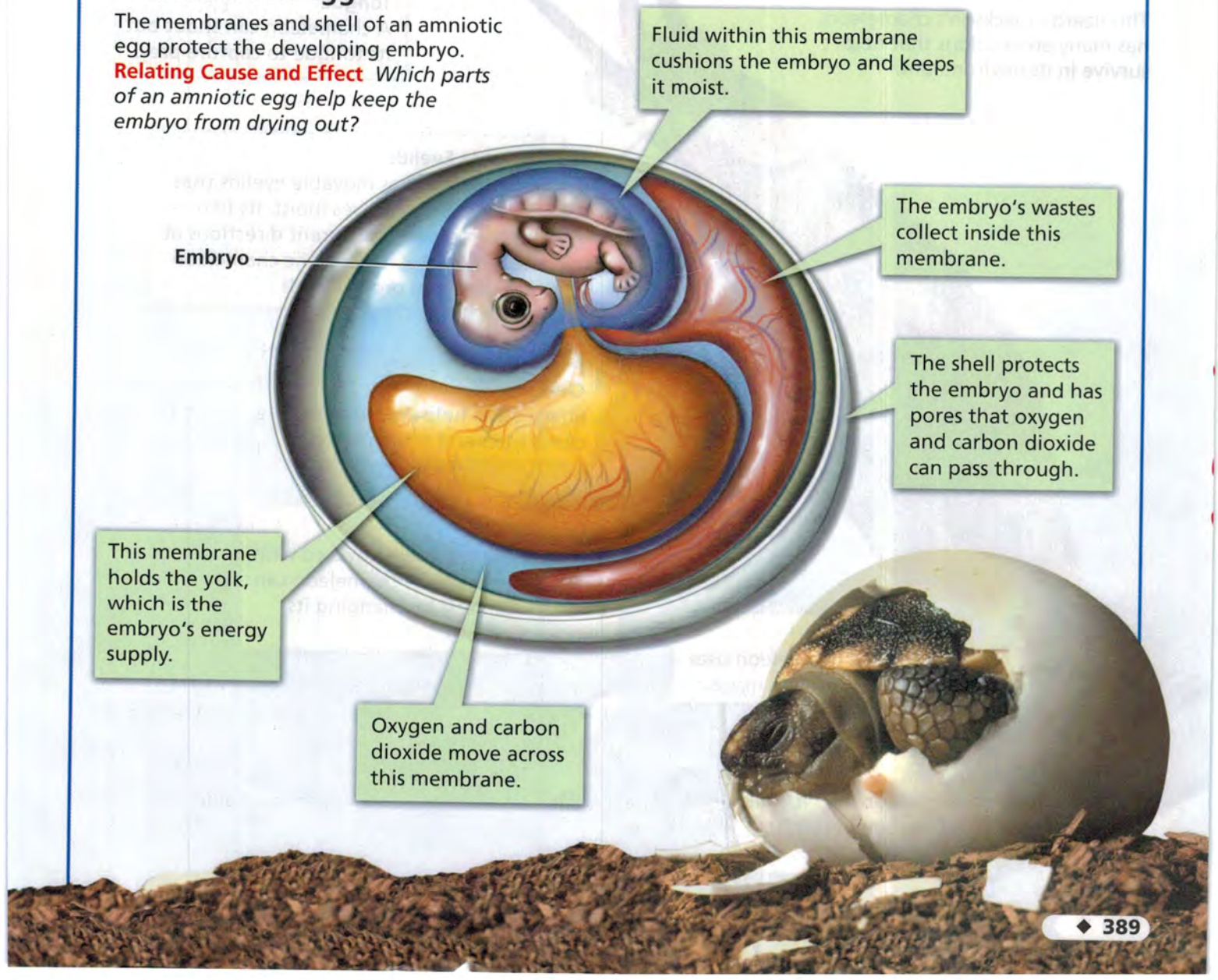
An Egg With a Shell Reptiles have internal fertilization and lay their eggs on land. While still inside a female's body, fertilized eggs are covered with membranes and a leathery shell. Unlike an amphibian's egg, a reptile's egg has a shell and membranes that protect the developing embryo and help keep it from drying out. An egg with a shell and internal membranes that keep the embryo moist is called an **amniotic egg.** Pores in the shell let oxygen gas in and carbon dioxide gas out.

Look at Figure 19 to see the membranes of a reptile's egg. One membrane holds a liquid that surrounds the embryo. The liquid protects the embryo and keeps it moist. A second membrane holds the yolk, or food for the embryo. A third membrane holds the embryo's wastes. Oxygen and carbon dioxide are exchanged across the fourth membrane.

FIGURE 19

The Amniotic Egg

The membranes and shell of an amniotic egg protect the developing embryo.
Relating Cause and Effect *Which parts of an amniotic egg help keep the embryo from drying out?*



Lizards and Snakes

Most reptiles alive today are either lizards or snakes. These two groups of reptiles share some important characteristics. **Both lizards and snakes are reptiles that have skin covered with overlapping scales.** As they grow, they shed their skin and scales, replacing the worn ones with new ones. Most lizards and snakes live in warm areas.

Lizards differ from snakes in an obvious way. Lizards have four legs, usually with claws on the toes, and snakes have no legs. In addition, lizards have long tails, external ears, movable eyelids, and two lungs. In contrast, snakes have streamlined bodies, no external ears, and no eyelids, and most have only one lung. You can see the characteristics of a lizard in Figure 20.

FIGURE 20

Characteristics of a Lizard

This lizard, a Jackson's chameleon, has many adaptations that help it survive in its environment.

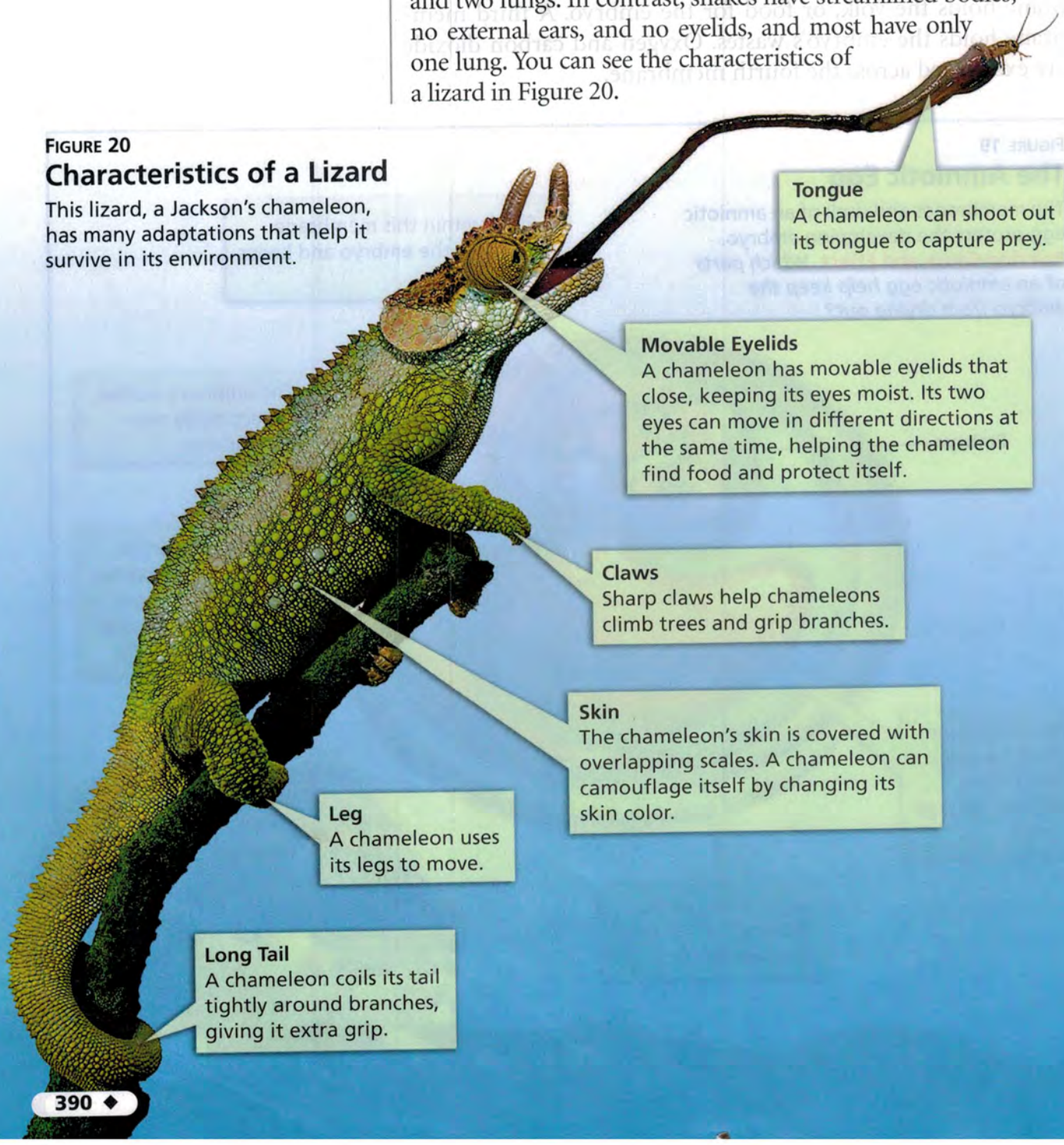


FIGURE 21
An Egg-Eating Snake
The jawbones of this snake's skull have moved to let the snake swallow an egg. **Making Generalizations** *How are snakes different from lizards?*

Obtaining Food A few lizards are herbivores that eat leaves. Most lizards, however, are carnivores that capture their prey by jumping at it. While some large lizards will eat frogs and birds, most smaller lizards are adapted to hunt insects. For example, chameleons have sticky tongues adapted for snaring insects.

All snakes are carnivores. Most snakes feed on small animals, such as mice, but some eat large prey. If you did the Discover Activity, you learned that a snake's jawbones can spread wide apart. In addition, the bones of a snake's skull can move to let the snake swallow an animal larger in diameter than itself. Snakes capture their prey in different ways. For example, some snakes have long, curved front teeth for hooking slippery prey. Other snakes, such as rattlesnakes and copperheads, have venom glands attached to hollow teeth called fangs. When these snakes bite their prey, venom flows down through the fangs and enters the prey.

Movement While lizards walk and run using their legs, snakes cannot move in this way. If you've ever seen a snake slither across the ground, you know that when it moves, its long, thin body bends into curves. Snakes move by contracting, or shortening, bands of muscles that are connected to their ribs and their backbones. Alternate contractions of muscles on the right and left sides produce a slithering side-to-side motion. Instead of slithering, sidewinder snakes, like the one shown in Figure 22, lift up their bodies as they move.

Reading Checkpoint **How do lizards move?**

FIGURE 22
A Sidewinder Snake
This sidewinder snake lifts loops of its body off the desert sand as it moves along. Only a small part of its body touches the sand at one time.

FIGURE 23
Alligator and Crocodile
Alligators and crocodiles are the largest reptiles still living on earth. They are similar in many ways, including appearance.
Comparing and Contrasting *How can you tell the difference between an alligator and a crocodile?*

Alligators and Crocodiles

If you walk along a lake in Florida, you just might see an alligator swimming silently in the water. Most of its body lies beneath the surface, but you can see its large, bulging eyes above the surface. Alligators, crocodiles, and their relatives are the largest living reptiles. **Both alligators and crocodiles are large, carnivorous reptiles that care for their young.** So, how do you tell an alligator from a crocodile? Alligators have broad, rounded snouts, with only a few teeth visible when their mouths are shut. In contrast, crocodiles have pointed snouts, with most of their teeth visible when their mouths are shut.

Obtaining Food Alligators and crocodiles are carnivores that often hunt at night. They have several adaptations for capturing prey. They use their strong, muscular tails to swim rapidly. Their jaws are equipped with many large, sharp, and pointed teeth. Their jaw muscles are extremely strong when biting down. Although alligators will eat dogs, raccoons, and deer, they usually do not attack humans.

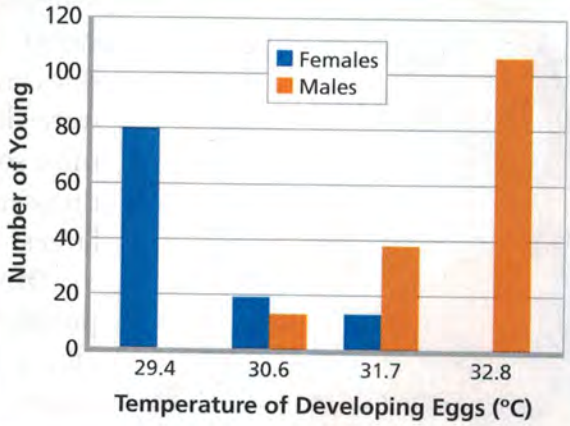
Reproduction Unlike most other reptiles, crocodiles and alligators care for their eggs and newly hatched young. After laying eggs, the female stays near the nest. From time to time, she comes out of the water and crawls over the nest to keep it moist. After the tiny alligators or crocodiles hatch, the female scoops them up in her huge mouth. She carries them from the nest to a nursery area in the water where they will be safer. For as long as a year, she will stay near her young until they can feed and protect themselves.

Reading Checkpoint **When do alligators and crocodiles hunt?**

Math Analyzing Data

The Sex Ratio of Newly Hatched Alligators

The temperature of the developing eggs of the American alligator affects the sex ratio of the young. (Sex ratio is the number of females compared with the number of males.) The graph on the right shows the numbers of young of each sex that hatched from eggs in which the young developed at different temperatures.



1. **Reading Graphs** At which temperature(s) did only females hatch?
2. **Drawing Conclusions** What effect does the temperature of developing eggs have on the sex of the baby alligators?
3. **Calculating** If 100 eggs developed at 31.7°C, about how many of the young would be male?

Turtles

Turtles live in the ocean, in fresh water, and on land. Turtles that live on land are commonly called "tortoises." **A turtle is a reptile whose body is covered by a protective shell that includes the ribs and the backbone.** The bony plates of the shell are covered by large scales made from the same material as the skin's scales. Some turtles have shells that can cover the whole body. Most turtles can draw the head, legs, and tail inside the shell for protection. Turtle shells may be hard or as soft as pancakes.

Turtles feed in a variety of ways, but all have a sharp-edged beak instead of teeth for tearing food. Some turtles are carnivores, such as the largest turtles, the leatherbacks. Leatherbacks feed mainly on jellyfishes. Their tough skin protects them from the effects of the stinging cells. Other turtles, such as the Galápagos tortoise, are herbivores. They feed mainly on cacti, using their beaks to scrape off the prickly spines before swallowing the cactus.

Reading Checkpoint **What are turtles that live on land called?**

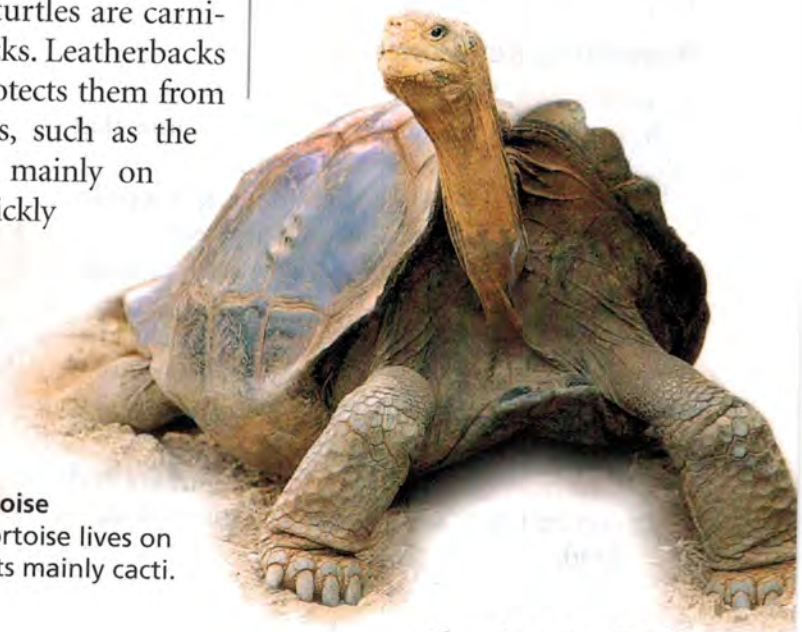


FIGURE 24
A Galápagos Tortoise
The Galápagos tortoise lives on land, where it eats mainly cacti.

FIGURE 25
Brachiosaurus
Brachiosaurus grew to be more than 22.5 meters long—longer than two school buses put together end to end. **Inferring** *What advantage did a long neck give* Brachiosaurus*?*

Extinct Reptiles—The Dinosaurs

Millions of years ago, huge turtles and fish-eating reptiles swam in the oceans. Flying reptiles soared through the skies. Snakes and lizards basked on warm rocks. And there were dinosaurs of every description. Unlike today's reptiles, some dinosaurs may have been endothermic. Some dinosaurs, such as *Brachiosaurus* in Figure 25, were the largest land animals that ever lived.

Dinosaurs were the earliest vertebrates that had legs positioned directly beneath their bodies. This adaptation allowed them to move more easily than animals such as salamanders and lizards, whose legs stick out from the sides of their bodies. Most herbivorous dinosaurs, such as *Brachiosaurus*, walked on four legs. Most carnivores, such as the huge *Tyrannosaurus rex*, ran on two legs.

Dinosaurs became extinct, or disappeared from Earth, about 65 million years ago. No one is certain why. Today, it's only in movies that dinosaurs shake the ground with their footsteps. But the descendants of dinosaurs may still exist. Some biologists think that birds descended from certain small dinosaurs.

Reading Checkpoint **Give an example of a dinosaur that ran on two legs.**

Section 4 Assessment

Target Reading Skill **Identifying Main Ideas** Use the information in your graphic organizer to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Defining** What is a reptile?
   b. **Explaining** What are three adaptations that allow reptiles to survive on land?
   c. **Predicting** What might happen to a reptile egg if part of its shell were removed?
2. a. **Identifying** What are the three main groups of reptiles?
   b. **Classifying** A gecko is a small reptile that has no shell protecting its body. It uses its legs to climb trees. Into which reptile group would you classify the gecko?
   c. **Comparing and Contrasting** Compare and contrast how alligators and turtles obtain food.
3. a. **Reviewing** When did the dinosaurs become extinct?
   b. **Interpreting Diagrams** What adaptation did the dinosaur in Figure 25 have that helped it survive?
   c. **Inferring** What advantage might a dinosaur that was an endotherm have had over other reptiles?

Writing in Science

Product Label Write a "packaging label" that will be pasted onto the eggshell of a reptile. Include on your label a list of the contents of the shell and a one-paragraph description of the egg's ability to survive in a dry environment.

Vertebrate History in Rocks

Reading Preview

Key Concepts

- Where are fossils most frequently found?
- What can scientists learn from studying fossils?

Key Terms

- fossil
- sedimentary rock
- paleontologist

Target Reading Skill

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

Vertebrate History in Rocks

Question	Answer
How do fossils form?	Fossils form by . . .

Lab zone Discover Activity

What Can You Tell From an Imprint?

1. Flatten some modeling clay into a thin sheet on a piece of paper.
2. Firmly press two or three small objects into different areas of the clay. The objects might include such things as a key, a feather, a postage stamp, or a flower. Don't let anyone see the objects you are using.
3. Carefully remove the objects from the clay, leaving only the objects' imprints.
4. Exchange your imprints with a partner. Try to identify the objects that made the imprints.

Think It Over

Observing What types of objects made the clearest imprints? If those imprints were fossils, what could you learn about the objects by looking at their "fossils"? What couldn't you learn?

Millions of years ago, in an ancient pond, some fishes died and their bodies settled into the mud on the bottom. Soon heavy rains fell, and more mud washed into the pond, covering the fishes. The soft tissues of the fishes decayed, but their bones remained. After many thousands of years, the mud hardened into rock, and the bones became the fossils shown here.

Fossilized fishes ▶

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Visit: www.SciLinks.org
Web Code: scn-0235

What Are Fossils?

A **fossil** is the hardened remains or other evidence of a living thing that existed a long time ago. Sometimes a fossil is an imprint in rock, such as an animal's footprint or the outline of a leaf. Other fossils are the remains of bones, shells, skeletons, or other parts of living things. Fossils are made when a chemical process takes place over time, during which an organism's tissues are replaced by hard minerals. Because most living tissues decay rapidly, only a very few organisms are preserved as fossils.

Fossils are found most frequently in sedimentary rock. Hardened layers of sediments make up **sedimentary rock.** Sediments contain particles of clay, sand, mud, or silt.

Science and History

Discovering Vertebrate Fossils

People have been discovering fossils since ancient times. Here are some especially important fossil discoveries.

1822 Dinosaur Tooth
In a quarry near Lewes, England, Mary Ann Mantell discovered a strange-looking tooth embedded in stone. Her husband Gideon drew the picture of the tooth shown here. The tooth belonged to the dinosaur *Iguanodon*.

1677 Dinosaur-Bone Illustration
Robert Plot, the head of a museum in England, published a book that had an illustration of a huge fossilized thighbone. Plot thought that the bone belonged to a giant human, but it probably was the thighbone of a dinosaur.

1811 Sea Reptile
Along the cliffs near Lyme Regis, England, 12-year-old Mary Anning discovered the fossilized remains of the giant sea reptile now called *Ichthyosaurus*. Mary became one of England's first professional fossil collectors.

1670 | 1760 | 1820

How do sediments build up into layers? Have you ever washed a dirty soccer ball and seen sand and mud settle in the sink? If you washed a dozen soccer balls, the sink bottom would be covered with layers of sediments. Sediments build up in many ways. For example, wind can blow a thick layer of sand onto dunes. Sediments can also form when muddy water stands in an area for a long time. Muddy sediment in the water eventually settles to the bottom and builds up.

Over a very long time, layers of sediments can be pressed and cemented together to form rock. As sedimentary rock forms, traces of living things that have been trapped in the sediments are sometimes preserved as fossils.

Reading Checkpoint **How does sedimentary rock form?**

Writing in Science

Research and Write If you could interview the person who discovered one of the fossils, what questions would you ask about the fossil and how it was found? Write a list of those questions. Then use reference materials to try to find the answers to some of them.

1861
Bird Bones
A worker in a stone quarry in Germany found *Archaeopteryx*, a feathered, birdlike animal that also had many reptile characteristics.

1902
Tyrannosaurus
A tip from a local rancher sent Barnum Brown, a fossil hunter, to a barren, rocky area near Jordan, Montana. There Brown found the first relatively complete skeleton of *Tyrannosaurus rex*.

1964 *Deinonychus*
In Montana, paleontologist John Ostrom discovered the remains of a small dinosaur, *Deinonychus*. This dinosaur was probably a predator that could move rapidly. This fossil led scientists to hypothesize that dinosaurs may have been endotherms.

1991
Dinosaur Eggs in China
Digging beneath the ground, a farmer on Green Dragon Mountain in China uncovered what may be the largest nest of fossil dinosaur eggs ever found. A paleontologist chips carefully to remove one of the eggs from the rock.

1880 1940 2000

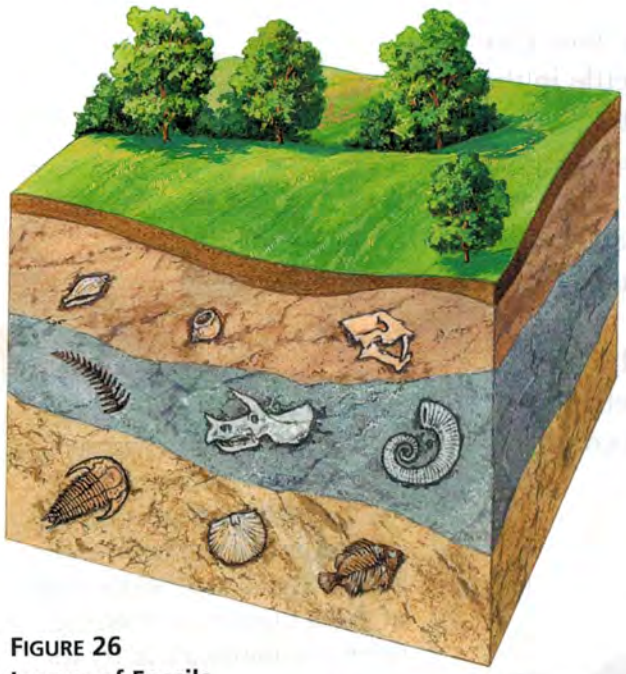

FIGURE 26
Layers of Fossils
Fossils most often form in layers of sedimentary rock.
Interpreting Diagrams *Which rock layer probably contains the oldest fossils?*

Interpretation of Fossils

What information can scientists learn from fossils? **Paleontologists** (pay lee un TAHL uh jists), the scientists who study extinct organisms, examine fossil structure and make comparisons to present-day organisms. **By studying fossils, paleontologists can infer how animals changed over time.** One important piece of information that paleontologists can learn from a fossil is its approximate age.

A Fossil's Age One method for estimating a fossil's age takes advantage of the process in which sediments form. Think about sediments settling out of water—the lowest layers are deposited first, and newer sediments settle on top of the older layers. Therefore, fossils in higher layers of rock are often younger than fossils in lower layers.

However, rock layers can become tilted or even turned upside down by events such as earthquakes. So, a fossil's position in rock is not always a good indication of its age. Scientists usually rely on other methods to help determine a fossil's age. For example, fossils—and the rocks in which they are found—contain some radioactive chemical elements. These radioactive elements decay, or change into other chemical elements, over a known period of time. The more there is of the decayed form of the element, the older the fossil.

Using Fossils Paleontologists have used fossils to determine a likely pattern of how vertebrates changed over time. You can see in Figure 27 that this pattern of vertebrate evolution looks something like a branching tree. Fossils show that the first vertebrates to live on Earth were fishes. Fishes first appeared on Earth about 530 million years ago. Amphibians, which appeared on Earth about 380 million years ago, are descended from fishes. Then, about 320 million years ago, amphibians gave rise to reptiles. Both mammals and birds, which you will learn about in the next chapter, are descended from reptiles. Based on the age of the oldest mammal fossils, mammals first lived on Earth about 220 million years ago. Birds were the latest group of vertebrates to arise. Their oldest fossils show that birds first appeared on Earth 150 million years ago.

Reading Checkpoint **What is a paleontologist?**

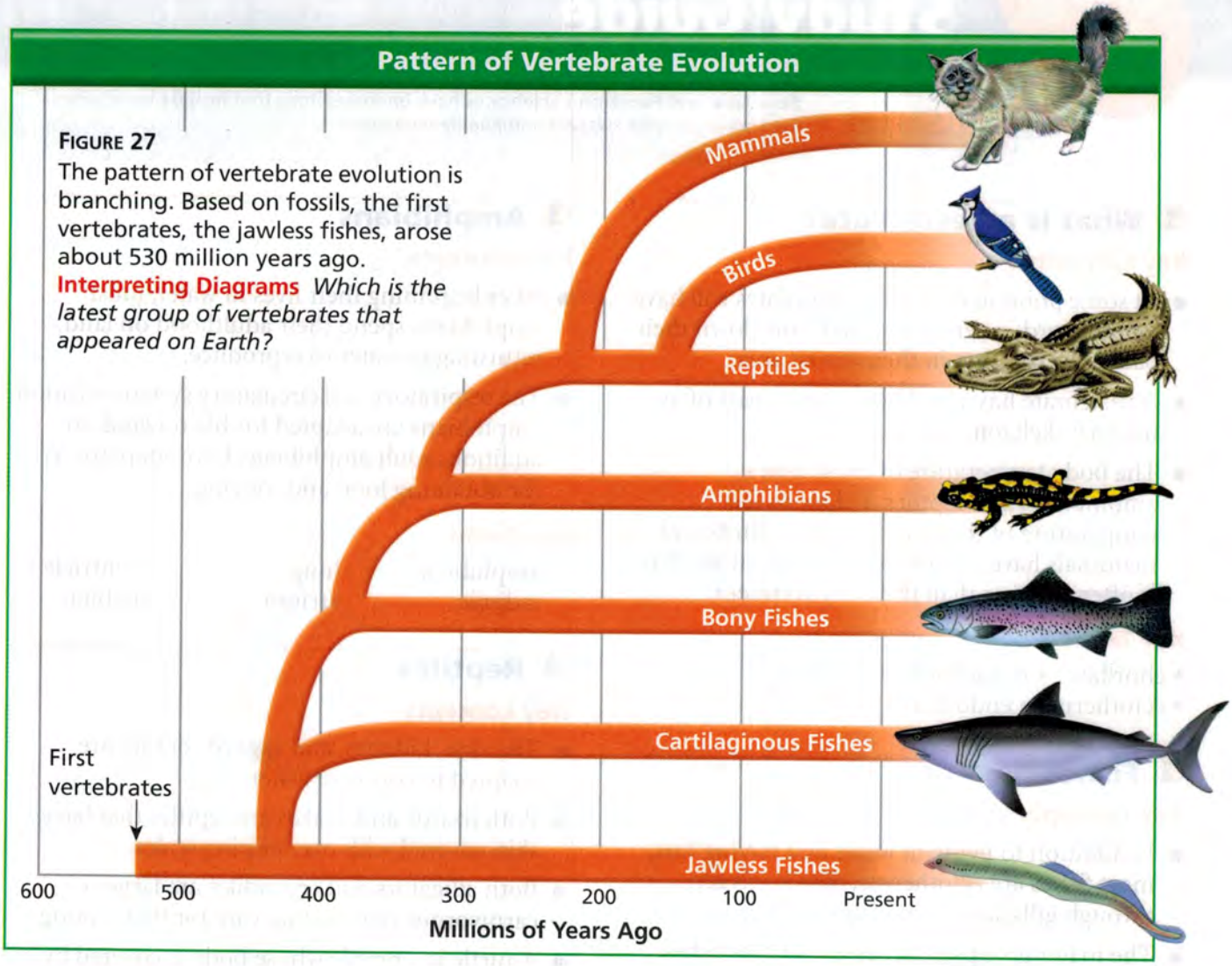

FIGURE 27
The pattern of vertebrate evolution is branching. Based on fossils, the first vertebrates, the jawless fishes, arose about 530 million years ago.
Interpreting Diagrams *Which is the latest group of vertebrates that appeared on Earth?*

Section 5 Assessment

Target Reading Skill **Asking Questions** Use your graphic organizer to answer the questions below.

Reviewing Key Concepts

1. a. **Identifying** Where are fossils most often found?
   b. **Describing** What are some types of fossils?
   c. **Inferring** How might a small fish that dies in a muddy pool become a fossil?
2. a. **Reviewing** What can be learned from studying fossils?
   b. **Summarizing** How does the measurement of radioactive elements help scientists calculate a fossil's age?
   c. **Interpreting Diagrams** Look at Figure 27. About how much time passed between the first appearance of vertebrates and the time birds appeared?

Lab zone At-Home Activity

Sedimentary Newspaper? If your family keeps newspapers in a stack, check the dates of the newspapers in the stack with a family member. Are the newspapers in any kind of order? If the oldest ones are on the bottom and the newest are on the top, you can relate this to the way in which sediments are laid down. Ask family members to imagine that two fossils were trapped in different newspapers. Explain which fossil would probably be older.

Chapter 11 Study Guide

The BIG Idea **Structure and Function** Vertebrates have endoskeletons that include backbones. Backbones provide support and enable movement.

1 What Is a Vertebrate?

Key Concepts

- At some point in their lives, chordates will have a notochord, a nerve cord that runs down their back, and pouches in their throat area.
- A vertebrate has a backbone that is part of an internal skeleton.
- The body temperature of most fishes, amphibians, and reptiles is close to the temperature of their environment. Birds and mammals have a stable body temperature that is often warmer than their environment.

Key Terms

- chordate
- notochord
- vertebra
- ectotherm
- endotherm

2 Fishes

Key Concepts

- In addition to living in water and having fins, most fishes are ectotherms, obtain oxygen through gills, and have scales.
- The major groups of fishes are jawless fishes, cartilaginous fishes, and bony fishes.
- Jawless fishes are unlike other fishes in that they have no jaws and no scales.
- Cartilaginous fishes have jaws and scales, and skeletons made of cartilage.
- A bony fish has jaws, scales, a pocket on each side of the head that holds the gills, and a skeleton made of hard bone.

Key Terms

fish
cartilage
swim bladder

3 Amphibians

Key Concepts

- After beginning their lives in water, most amphibians spend their adulthood on land, returning to water to reproduce.
- The respiratory and circulatory systems of adult amphibians are adapted for life on land. In addition, adult amphibians have adaptations for obtaining food and moving.

Key Terms

amphibian
tadpole
lung
atrium
ventricle
habitat

4 Reptiles

Key Concepts

- The skin, kidneys, and eggs of reptiles are adapted to conserve water.
- Both lizards and snakes are reptiles that have skin covered with overlapping scales.
- Both alligators and crocodiles are large, carnivorous reptiles that care for their young.
- A turtle is a reptile whose body is covered by a protective shell that includes the ribs and the backbone.
- Dinosaurs were the earliest vertebrates that had legs positioned directly beneath their bodies.

Key Terms

- reptile
- urine
- kidney
- amniotic egg

5 Vertebrate History in Rocks

Key Concepts

- Fossils are found most frequently in sedimentary rock.
- By studying fossils, paleontologists can infer how a species changed over time.

Key Terms

fossil
sedimentary rock
paleontologist

Review and Assessment

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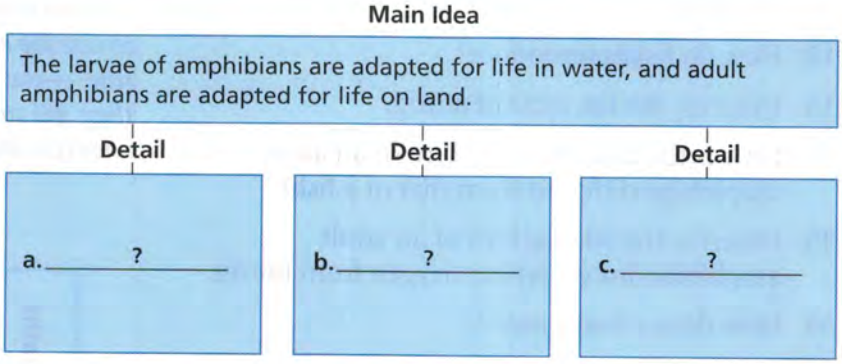
Organizing Information

Identifying Main Ideas Copy the graphic organizer about amphibians onto a sheet of paper. Then complete it.



Reviewing Key Terms

Choose the letter of the best answer.

1. Vertebrates are a subgroup of
   - **a.** chordates.
   - **b.** fishes.
   - **c.** amphibians.
   - **d.** reptiles.
2. A fish
   - **a.** is an endotherm.
   - **b.** has fins.
   - **c.** has lungs.
   - **d.** has a three-chambered heart.
3. A tadpole is the larva of a
   - **a.** fish.
   - **b.** salamander.
   - **c.** frog or toad.
   - **d.** lizard or snake.
4. A reptile
   - **a.** is an endotherm.
   - **b.** lays eggs.
   - **c.** has a swim bladder.
   - **d.** has a thin skin.
5. Layers of clay, sand, mud, or silt harden and become
   - **a.** radioactive chemicals.
   - **b.** sedimentary rock.
   - **c.** fossils.
   - **d.** dinosaur bones.

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

6. A notochord is replaced by a backbone in many vertebrates.
7. A bony fish uses its gills to stabilize its position in the water.
8. Amphibians obtain oxygen through gills and have scales.
9. An amniotic egg is a characteristic of reptiles.
10. Paleontologists are scientists who study fossils.

Writing in Science

Description Suppose you are a journalist for a nature magazine and you have spent a week observing crocodiles. Write a paragraph describing how crocodiles obtain their food.

Discovery Channel School
Fishes, Amphibians, and Reptiles
Video Preview
Video Field Trip
▶ Video Assessment

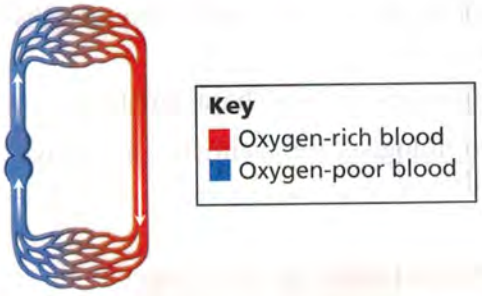
Review and Assessment

Checking Concepts

11. Describe the main characteristics of chordates.
12. How do fishes reproduce?
13. Describe the life cycle of a frog.
14. How is the circulatory system of an adult amphibian different from that of a fish?
15. Describe the adaptations of an adult amphibian for obtaining oxygen from the air.
16. How does a snake move?
17. Explain how the structure of a reptile's egg protects the embryo inside.
18. Describe two methods that scientists use to determine the age of a fossil.

Thinking Critically

19. **Relating Cause and Effect** Explain why an endoskeleton allows vertebrates to grow larger than animals without endoskeletons.
20. **Interpreting Diagrams** How does blood move in the circulatory system shown below?



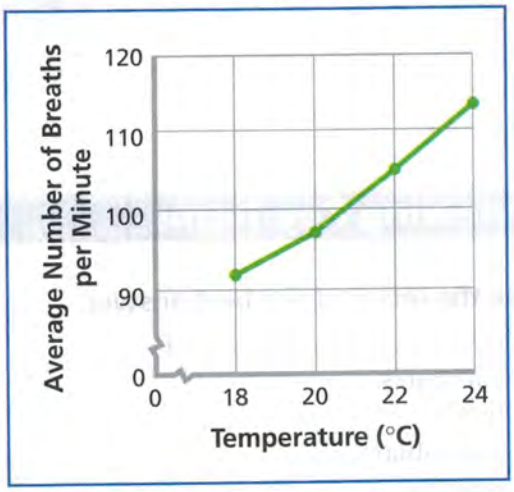
21. **Applying Concepts** Imagine that you are in a hot desert with a wet paper towel. You must keep the towel from drying out. What strategy can you copy from reptiles to keep the towel from drying out?
22. **Inferring** A scientist discovers a fossilized fish with a body streamlined for fast movement, a large tail fin, and sharp, pointed teeth. What could the scientist infer about the type of food that this fish ate and how it obtained its food? On what evidence is the inference based?

Applying Skills

Use the graph to answer Questions 23–25.

A scientist performed an experiment on five goldfishes to test the effect of water temperature on "breathing rate"—the rate at which the fishes open and close their gill covers. The graph shows the data that the scientist obtained at four different temperatures.

Fish Breathing Rate at Different Temperatures



23. **Controlling Variables** Identify the manipulated variable and the responding variable in this experiment.
24. **Interpreting Data** How does the breathing rate at 18°C compare to the breathing rate at 22°C?
25. **Drawing Conclusions** Based on the data shown, what is the relationship between water temperature and fish breathing rate?

Lab zone Chapter Project

Performance Assessment Display your models in a creative and interesting way—for example, show the models in action and show details of the animals' habitats. Also display your poster. List all the adaptations you learned from your classmates' presentations. How did constructing a three-dimensional model help you understand the characteristics of these groups?

Standardized Test Prep

Test-Taking Tip

Interpreting Data Tables

Before you answer a question about a data table, read the title and the headings of the columns and rows. The title identifies the type of data the table contains. The headings reveal how the data are organized. For example, the table below shows that jawless fishes have skeletons made of cartilage. Read the questions about the table before you spend too much time studying the data.

Characteristics of Fishes

Group	Skeleton	Jaws	Scales
Jawless Fishes	Cartilage	None	None
Cartilaginous Fishes	Cartilage	Yes	Yes
Bony Fishes	Bone	Yes	Yes

Sample Question

Axel has found a fish washed up on the beach that has scales and a skeleton made of cartilage. According to the table, what kind of fish is it?

A a jawless fish
B a cartilaginous fish
C a bony fish
D The fish cannot be classified using this table.

Answer

The correct answer is **B**. Choices **A, C,** and **D** cannot be correct because only cartilaginous fishes have a cartilaginous skeleton and scales.

Choose the letter of the best answer.

1. If you monitored the body temperature of a snake in four different air temperatures, what would you notice about its body temperature?
A It rises or falls with the air temperature.
B It always stays at about 37°C .
C It is higher than the air temperature.
D It is lower than the air temperature.

Characteristics of Observed Animals

Animal	Skeleton	Scales	Outer Covering of Egg
1	Bone	None	Clear jelly
2	Bone	Yes	Leathery shell
3	Bone	Yes	Thin, moist membrane
4	Cartilage	Yes	No eggs observed

2. A scientist observed four different animals and recorded her data in the table shown above. Which of the animals is most likely a reptile?
F Animals 1 and 3
G Animal 2
H Animal 3
J Animal 4

3. Based on the data in the table above, what kind of animal can you infer Animal 3 might be?
A amphibian
B bony fish
C cartilaginous fish
D reptile

4. Suppose you are conducting an experiment that requires you to handle live bullfrogs. Which laboratory safety procedure should you carry out at the conclusion of each work session?
F Carefully clean the bullfrog's container.
G Put on gloves.
H Wash your hands thoroughly.
J Turn the heat on.

Constructed Response

5. Explain why amphibians can be said to have a "double life." Be sure to include details describing the two different phases in the life of a typical amphibian.