Lab zone **Skills Lab**

Invertebrates on Branches

S 7.3.d, 7.7.d

Problem

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

Skills Focus

classifying, interpreting data

Materials

- index cards

Procedure

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

Analyze and Conclude

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

More to Explore

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

Characteristics of Some Invertebrates

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

Section 5

Echinoderms

CALIFORNIA Standards Focus

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

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

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

Key Terms

- echinoderm
- endoskeleton
- water vascular system
- tube feet

Lab zone Standards Warm-Up

How Do Sea Stars Hold On?

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

Think It Over

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

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

Characteristics of Echinoderms

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

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

Go Online
active art

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

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

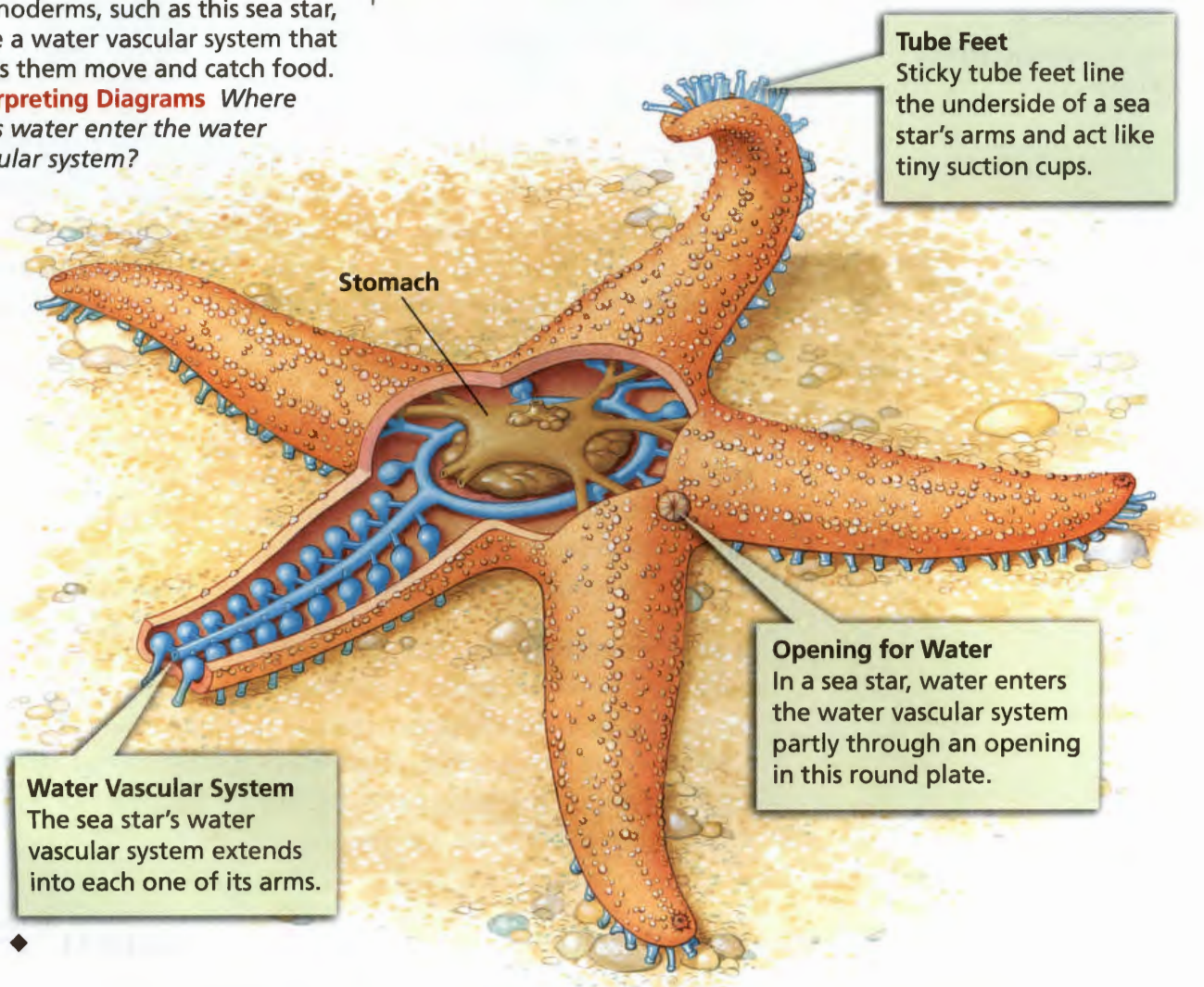
The ends of tube feet are sticky. When filled with water, they act like small, sticky suction cups. The stickiness and suction enable the tube feet to grip the surface beneath the echinoderm. Most echinoderms use their tube feet to move along slowly and to capture food.

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

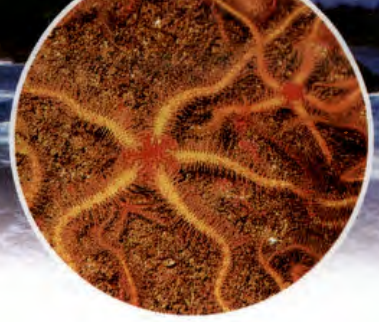
Reading Checkpoint **What are the functions of an echinoderm's tube feet?**

FIGURE 30
A Water Vascular System

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



Sea Star



Brittle Star

Sea Urchin

Diversity of Echinoderms

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

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

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

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

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

Sea Cucumber

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

Section 5 Assessment

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

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

Reviewing Key Concepts

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

Writing in Science

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

Chapter 11 Study Guide

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

1 What Is an Animal?

Key Concepts S 7.5.a

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

Key Terms

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

2 Sponges and Cnidarians

Key Concepts S 7.2.a, 7.5.a

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

Key Terms

• larva • cnidarian • polyp • medusa

3 Worms and Mollusks

Key Concepts S 7.2.a, 7.5.a

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

Key Terms

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

4 Arthropods

Key Concepts S 7.2.a, 7.5.b

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

Key Terms

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

5 Echinoderms

Key Concepts S 7.2.a, 7.5.b

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

Key Terms

• echinoderm • endoskeleton • water vascular system • tube feet

Review and Assessment

Go Online PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cva-3110

Target Reading Skill

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

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

Reviewing Key Terms

Choose the letter of the best answer.

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

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

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

Writing in Science

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

Video Assessment
Discovery Channel School
Mollusks, Arthropods, and Echinoderms

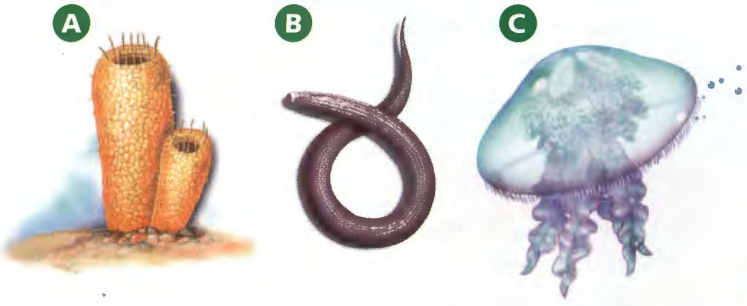
Review and Assessment

Checking Concepts

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

Thinking Critically

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



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

Applying Skills

Use the data table to answer Questions 26–28.

The following data appeared in a book on insects.

Flight Characteristics

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

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

Lab zone Standards Investigation

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

Choose the letter of the best answer.

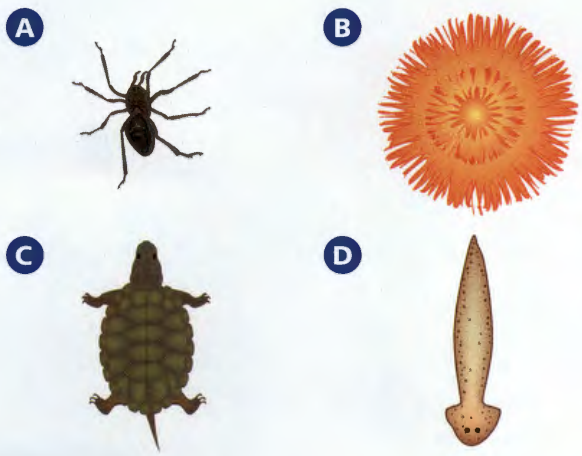
1. What is the correct sequence in which a stinging cell reacts to the touch of another organism?
   - **A** trigger brushes against prey, stinging cell fires, barbs snare prey
   - **B** barbs snare prey, stinging cell fires, barbs release prey
   - **C** prey is paralyzed, venom enters prey, stinging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

   S 7.5.b

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

   S 7.5.a

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



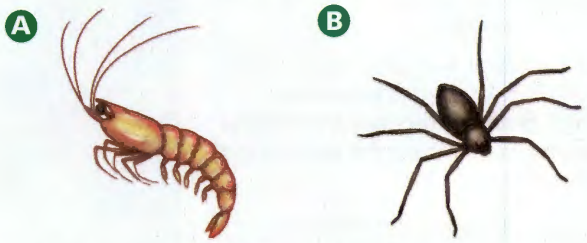
3. Of the four animals above, which have sense organs concentrated at one end of their bodies?
   - **A** animals A and D
   - **B** animals A, B, and D
   - **C** animals B and D
   - **D** animals A, C, and D

   S 7.5.a

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

   S 7.2.a

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



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

   S 7.3.d

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

   S 7.2.a

Apply the BIG Idea

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

   S 7.5.b

Chapter 12

Structure and Function of Vertebrates

CALIFORNIA Standards Preview

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

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

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

e. Students know that extinction of species occurs when the environment changes and the adaptive characteristics of a species are insufficient for survival.

S 7.4 Evidence from rocks allows us to understand the evolution of life on Earth. As a basis for understanding this concept:

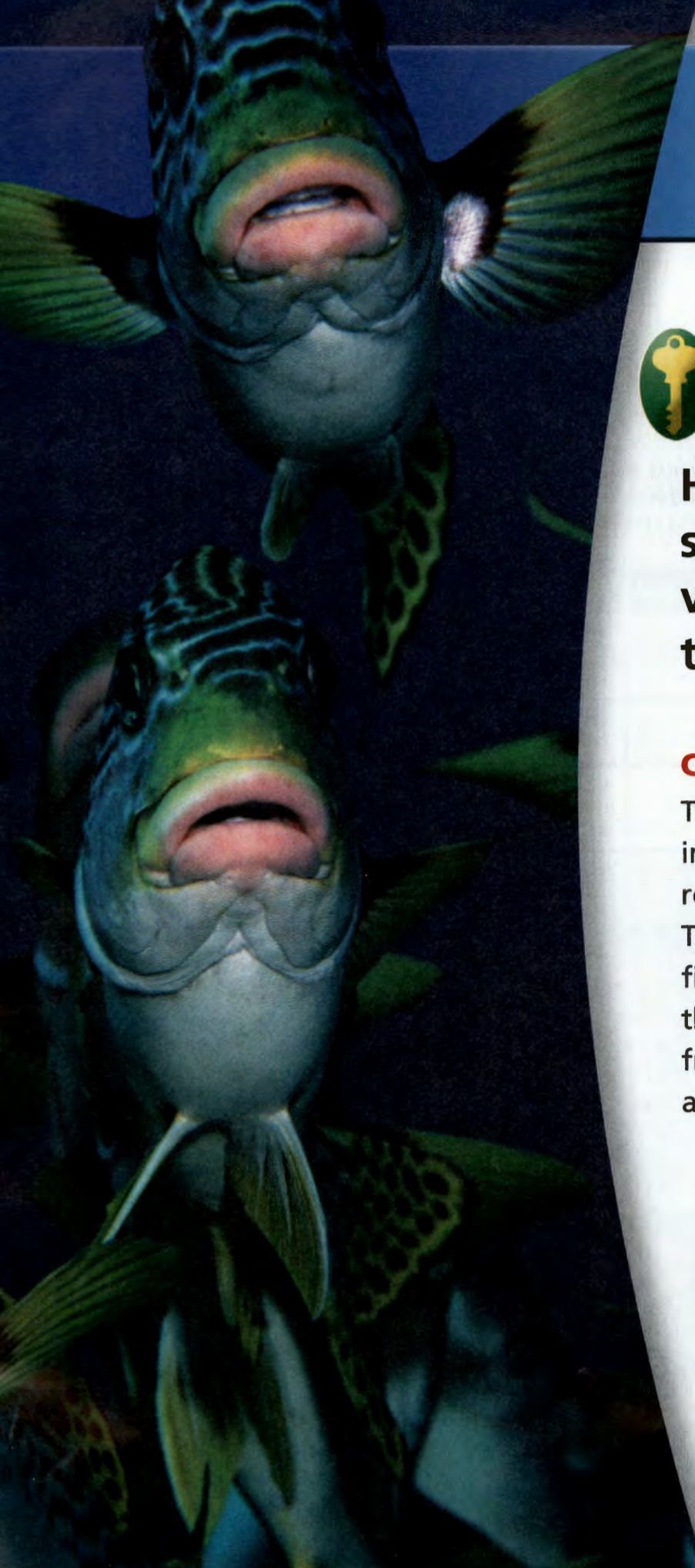
g. Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

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

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

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

Like all fishes, the fish in this school of "sweetlips" are vertebrates. ▶



Video Preview
Discovery Channel School
Birds and Mammals

S 7.5.a

Focus on the
BIG Idea

How does the structure of vertebrates help them to function ?

Check What You Know

Two friends are looking at fishes in an aquarium. One friend refers to the fishes as animals. The other friend argues that fishes aren't animals because they don't have four legs. Which friend is correct? Explain your answer.

Build Science Vocabulary

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

Vocabulary Skill

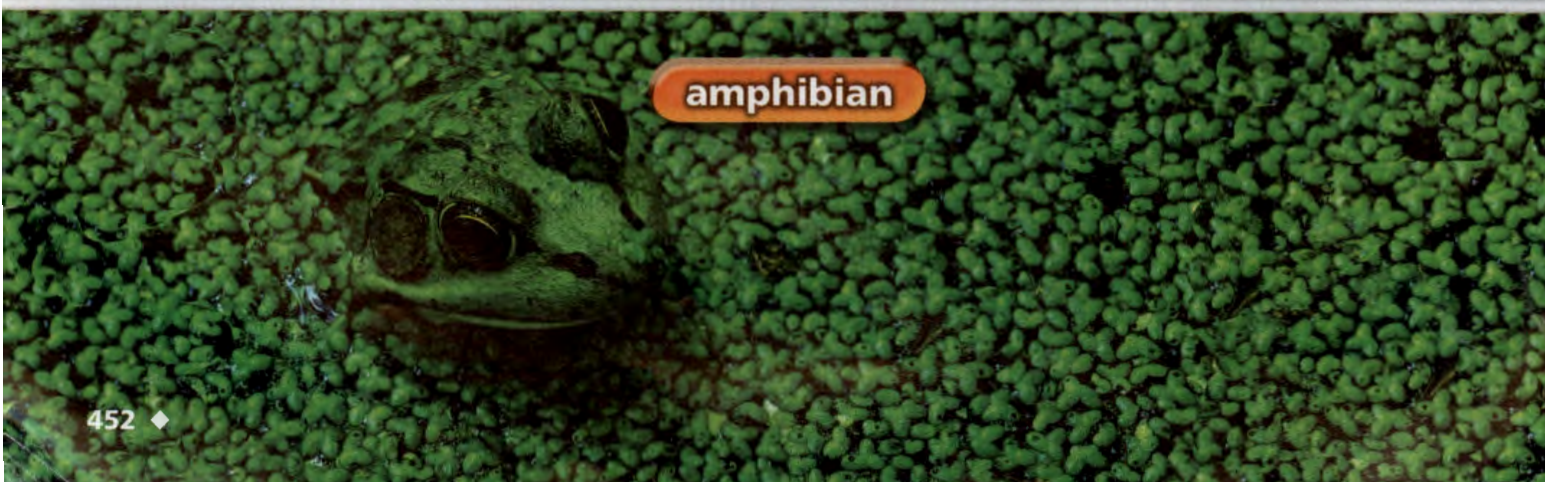
Greek Word Origins

Some key terms in this chapter contain word parts whose origins are Greek. The table below lists some of the Greek words that key terms come from. Learning the meanings of these Greek words will help you understand and remember some key terms.

Greek Word	Meaning of Greek Word	Key Term
amphibios	living a double life	**amphibian** An animal that spends part of its life cycle on land and part in water
chordé	string, cord	**chordate** An animal that has a flexible rod that supports the animal's back
therme	heat	**endotherm** An animal that produces enough heat within its body to control its body temperature

Apply It!

1. How does the meaning of *amphibian* relate to the Greek word from which it comes?
2. Can you think of an English word besides *chordate* that might come from the Greek word *chordé*?
3. In the list of key terms on the next page, find another term besides *endotherm* that might come from the Greek word *therme.* Then look up the meaning of the key term and check how its meaning relates to the meaning of *endotherm.*



Chapter 12 Vocabulary

Section 1 (page 456)
chordate
notochord
vertebra
ectotherm
endotherm

Section 2 (page 462)
fish
cartilage
swim bladder

Section 3 (page 468)
amphibian
tadpole
lung
atrium
ventricle
habitat

Section 4 (page 472)
reptile
kidney
urine
amniotic egg

Section 5 (page 480)
bird
contour feather
down feather
crop
gizzard

Section 6 (page 486)
mammal
mammary gland
diaphragm
monotreme
marsupial
gestation period
placental mammal
placenta

Interactive Textbook

Build Science Vocabulary *Online*
Visit: PHSchool.com
Web Code: cvj-3120

How to Read Science

Reading Skill

Compare and Contrast

When you compare and contrast, you examine similarities and differences between things. You can do this by using a table. Follow these steps to set up a compare/contrast table.

- List the characteristics to be compared across the top.
- List the items to be compared in the left column.
- Complete the table by filling in information about each characteristic.

Vertebrates can be divided into two groups—ectotherms and endotherms—depending on how their body temperatures are controlled. Study the table and then answer the questions.

Type of Body-Temperature Control	Characteristics of Body-Temperature Control	Groups With This Type of Temperature Control
Ectotherm	Body temperature changes, depending on the temperature of the environment.	Fishes, amphibians, reptiles
Endotherm	Body temperature stays about the same, no matter what the temperature of the environment.	Birds, mammals

Apply It!

1. Which vertebrate groups are ectotherms?
2. Which type of animal—ectotherm or endotherm—has a body temperature that is more affected by the temperature of the environment?

As you read, construct compare/contrast tables. For Section 2, compare the characteristics of jawless fishes, cartilaginous fishes, and bony fishes. For Section 6, compare the reproduction of monotremes, marsupials, and placental mammals.

Lab zone

Standards Investigation

S 7.3.a, 7.5.b

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 investigation, 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?

CALIFORNIA Standards Focus

S 7.4.g Students know how to explain significant developments and extinctions of plant and animal life on the geologic time scale.

S 7.5.c Students know how bones and muscles work together to provide a structural framework for movement.

- What are the characteristics of chordates and vertebrates?
- How have scientists been able to infer the relationships of major groups of vertebrates?
- How do vertebrates differ in the way they control body temperature?

Key Terms

- chordate
- notochord
- vertebra
- ectotherm
- endotherm

Lab zone Standards Warm-Up

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.

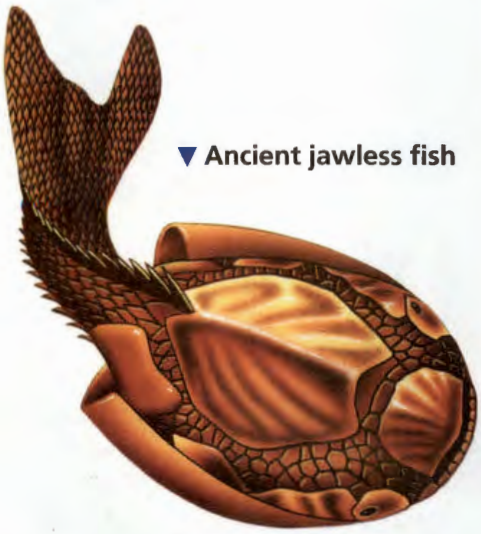
Think It Over

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). **At some point in their lives, all chordates have three characteristics: a notochord, a nerve cord that runs down their back, and slits in their throat area.** Most chordates, including fishes, amphibians, and reptiles, are vertebrates. So are birds and mammals. But a few chordates, such as lancelets, are invertebrates.



▼ 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.

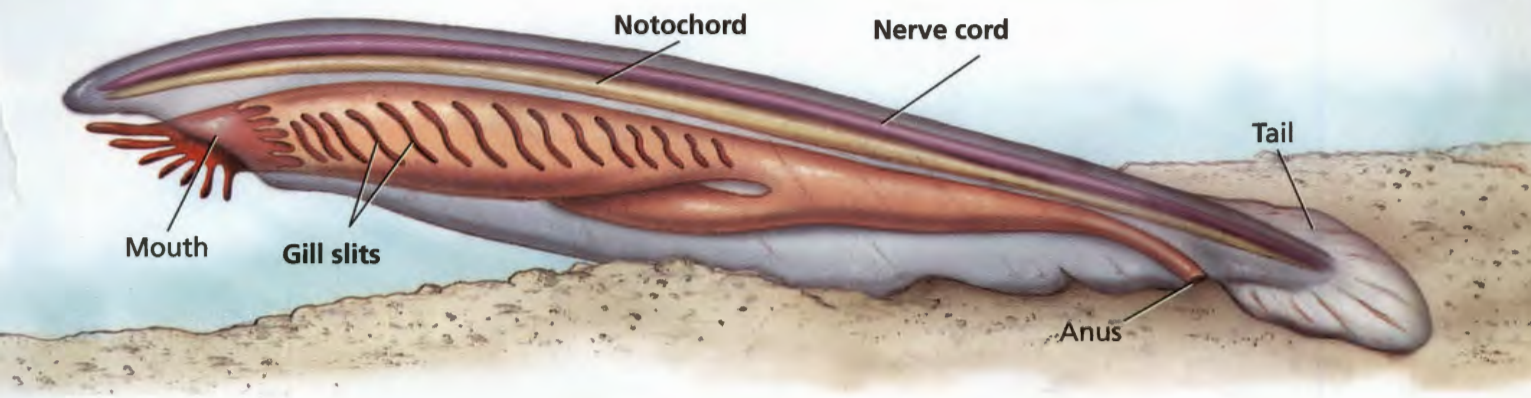


FIGURE 1
Characteristics of a Lancelet
This lancelet shows the characteristics of a chordate: a notochord that helps support its body, a nerve cord down its back, and gill slits.

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.

Slits in Throat Area At some point in their lives, chordates have slits in their throat area called pharyngeal (fuh RIN jee ul) slits, or gill slits. Some chordates, including fishes, keep these slits as part of their gills for their entire lives. But in many vertebrates, including humans, pharyngeal slits disappear before birth.

Reading Checkpoint **What is a notochord?**

Characteristics of Vertebrates

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

Backbone You can see in Figure 2 that a vertebrate's backbone, which is also called a spine, runs down the center of its back. 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 it did not have joints?*

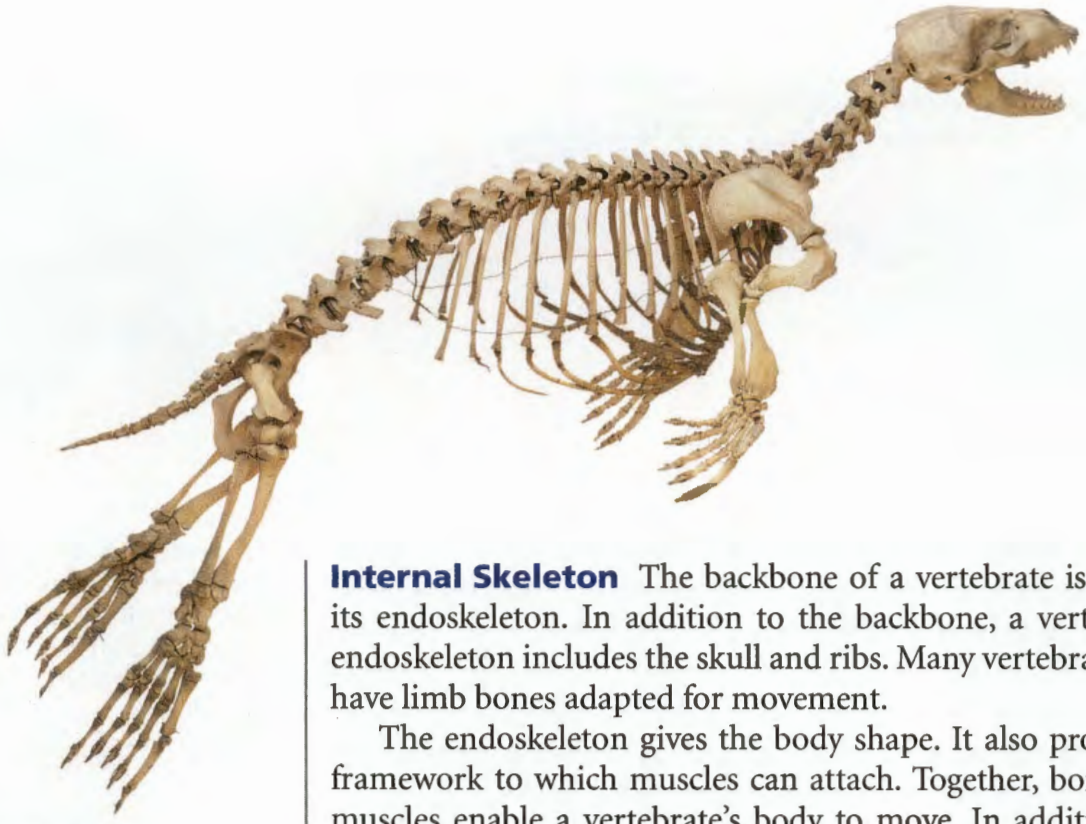


FIGURE 3
The Skeleton of a Seal
This seal's skeleton has adaptations for swimming. Long, flat bones support the flippers. The flat skull helps the seal move smoothly through the water.

Internal Skeleton The backbone of a vertebrate is part of its endoskeleton. In addition to the backbone, a vertebrate's endoskeleton includes the skull and ribs. Many vertebrates also have limb bones adapted for movement.

The endoskeleton gives the body shape. It also provides a framework to which muscles can attach. Together, bones and muscles enable a vertebrate's body to move. In addition, the endoskeleton protects internal organs. The skull protects the brain. The ribs protect the heart, lungs, and other organs.

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

Reading Checkpoint **What are two functions of an endoskeleton?**

Evolution of Vertebrates

The first tiny chordates swam in Earth's waters long before vertebrates appeared. Vertebrates probably evolved from an invertebrate chordate ancestor. **By studying fossils and other evidence, such as DNA, scientists have been able to infer the relationships of the major groups of vertebrates—fishes, amphibians, reptiles, birds, and mammals.** Figure 4 shows the probable order of vertebrate evolution.

Fossils show that the first vertebrates to live on Earth were probably fishes. Fishes appeared on Earth over 500 million years ago. Amphibians are descended from fishes. Then, amphibians gave rise to reptiles. Both mammals and birds are descended from reptiles. Birds were the latest group of vertebrates to arise.

Go Online NSTA SCILINKS
For: Links on vertebrates
Visit: www.SciLinks.org
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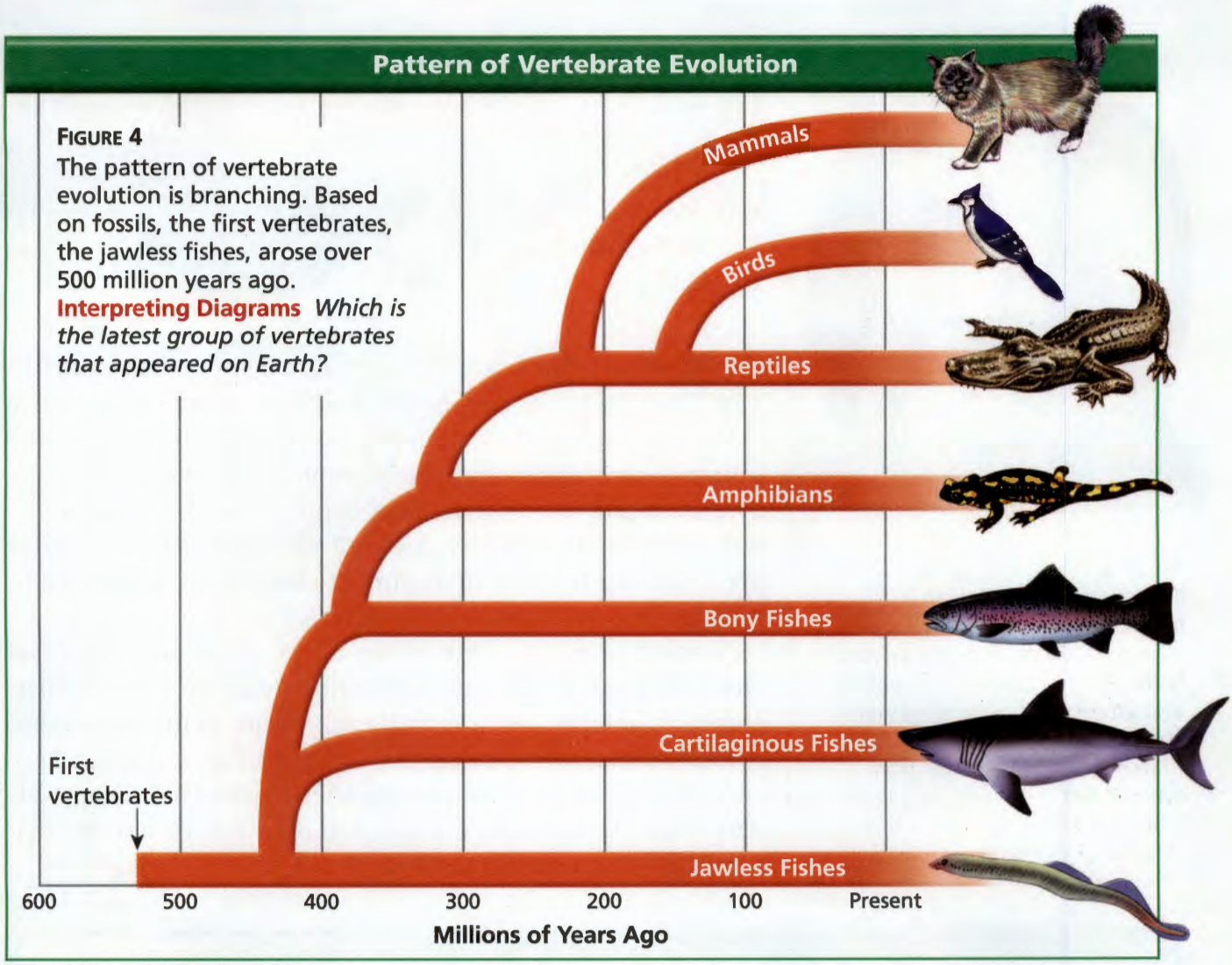


FIGURE 4
The pattern of vertebrate evolution is branching. Based on fossils, the first vertebrates, the jawless fishes, arose over 500 million years ago.
Interpreting Diagrams *Which is the latest group of vertebrates that appeared on Earth?*

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** (EK toh thurm) is an animal whose body does not produce much internal heat. An ectotherm's 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 ectotherms' blood is often quite warm.

▼ Emperor penguins

Woma python ▶

FIGURE 5
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?*

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** (EN doh thurm)—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.

Section 1 Assessment

S 7.4.g, 7.5.c,
E-LA: Reading 7.1.2

Vocabulary Skill **Greek Word Origins** The Greek word *ektos* means "outside." The Greek word *endon* means "within." How do these meanings relate to the meanings of *ectotherm* and *endotherm*?

Reviewing Key Concepts

1. a. **Listing** List three chordate characteristics.
   b. **Identifying** What characteristic do only vertebrates have?
   c. **Relating Cause and Effect** How does this characteristic give a vertebrate's body flexibility?
2. a. **Reviewing** What evidence indicates relationships among vertebrate groups?
   b. **Interpreting Data** Use Figure 4 to determine how many groups of fishes there are.
   c. **Sequencing** Which fish group appeared last?
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.

A Model Backbone

S 7.5.b, 7.7.a, 7.7.c

Problem

Can you build a functional model of a backbone?

Skills Focus

making models, observing

Materials

- 20 pieces each of 3 different types of cylindrical dried pasta
- 120 cm of plastic lanyard or string

Procedure

1. Examine the properties of the materials. Begin by cutting a 1-foot section of string.
2. Choose a shape of pasta that you think would make good vertebrae and thread them onto the string to make a simple model of a backbone. **CAUTION**: *Do not eat any of the pasta or other food substance in this lab.*
3. Bend and twist your backbone model. Can it easily rotate and bend? Try to mimic the motions of several different vertebrates—for example, a snake, a frog, a horse, or a cat.
4. Using what you learned about the spinal column and the model you just constructed, design and build an improved model backbone for an imaginary vertebrate of your choice. Your model should have the following characteristics:
   - The backbone should be made of the materials approved by your teacher.
   - The backbone should be strong enough to protect the spinal cord.
   - The backbone should be highly flexible so that it can easily twist and rotate to match the motions of the vertebrate you chose.
   - As the backbone flexes, the bones should not rub directly together.
   - The backbone should also provide shock absorption for when the vertebrate jumps.

Analyze and Conclude

1. **Making Models** As you designed, built, and tested your model backbone, what problems did you encounter? How did you solve these problems?
2. **Observing** How are the pieces of pasta like vertebrae? How are they different?
3. **Communicating** Write a letter to a friend in which you describe how you designed and built a model backbone. Be sure to explain to your friend what you learned about backbones by doing this activity.

Design an Experiment

Write a procedure for an experiment to test the strength of the model backbone you constructed and to compare the strength to the models built by other students. Select appropriate tools to use. Do not perform the experiment until your teacher has approved your procedure.

Section 2

Fishes

CALIFORNIA Standards Focus

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

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

Key Terms

- fish
- cartilage
- swim bladder

Lab zone Standards Warm-Up

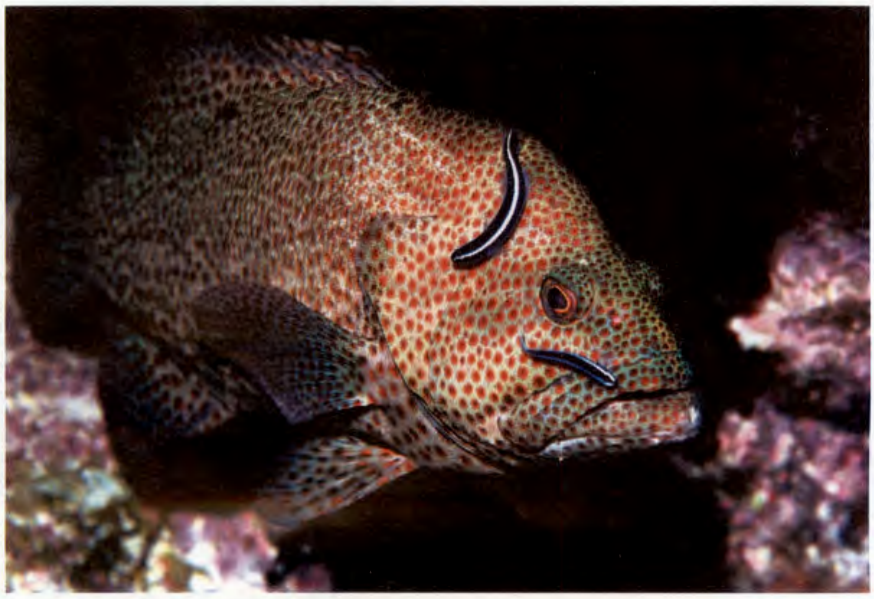
How Does Water Flow Over a Fish's Gills?

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.

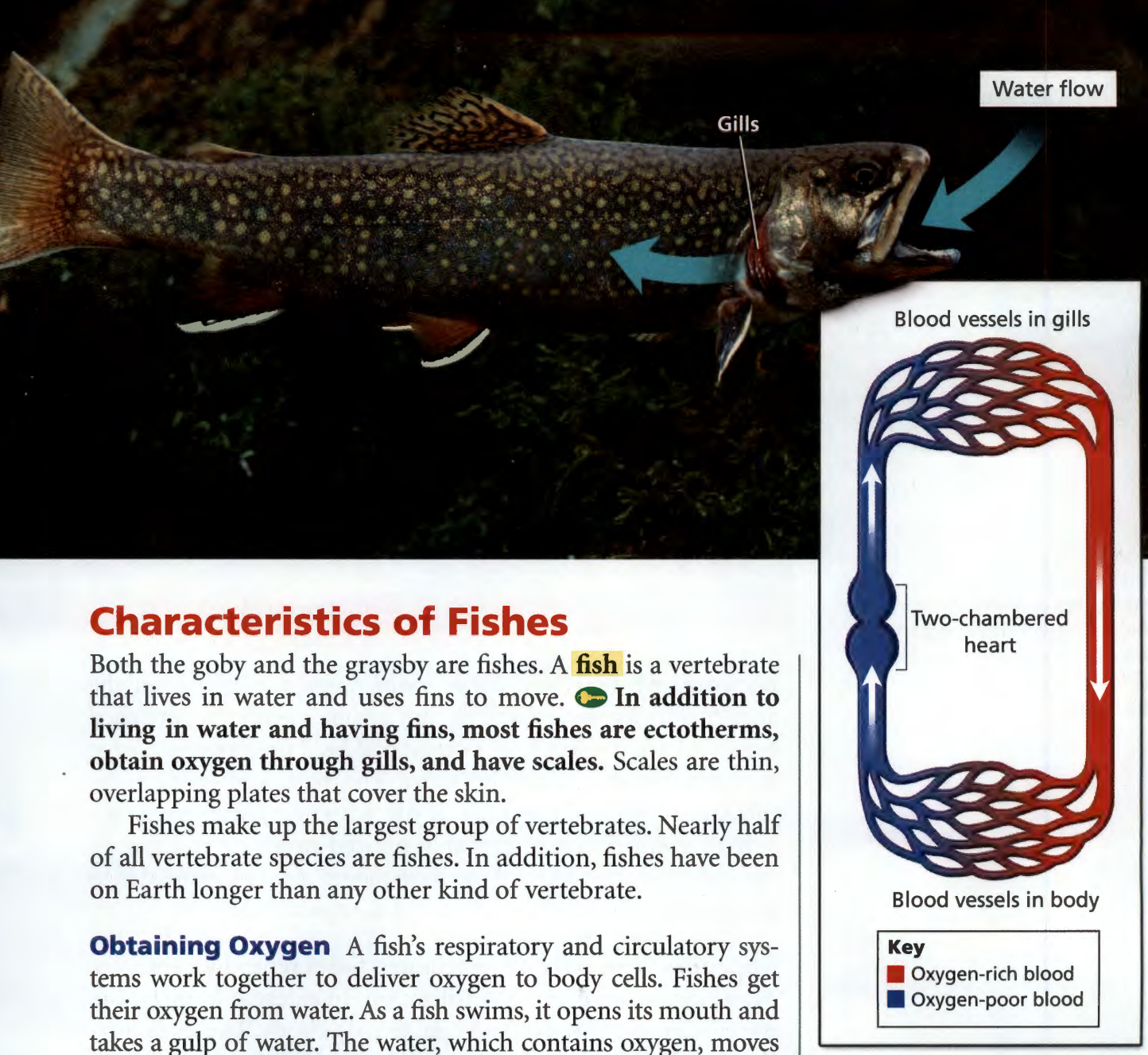
Think It Over

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

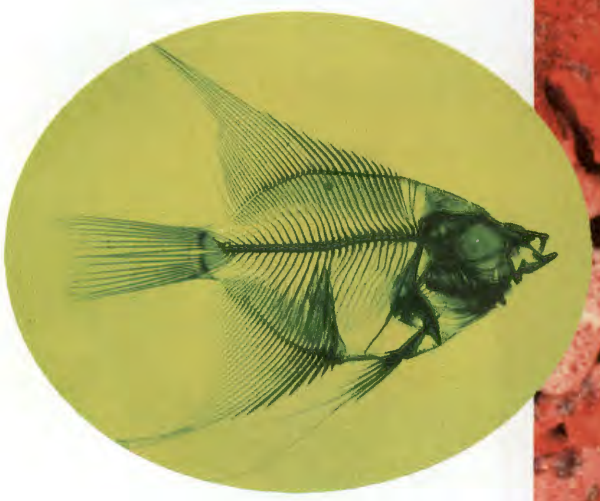
Both the goby and the graysby are fishes. A **fish** is a vertebrate that lives in water and uses fins to move. **In addition to living in water and having fins, most fishes are ectotherms, obtain oxygen through gills, and have scales.** Scales are thin, overlapping plates that cover the skin.

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 A fish's respiratory and circulatory systems work together to deliver oxygen to body cells. Fishes get their oxygen from water. As a fish swims, it opens its mouth and takes a gulp of water. 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, are the main organs in a fish's respiratory system. Gills have many blood vessels. 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 6.

FIGURE 6
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 7
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 7. 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 Like all vertebrates, fishes reproduce sexually. Most fishes have external fertilization. In external fertilization, the eggs are fertilized outside the female's body. The male hovers near the female and spreads a cloud of sperm 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 the young fishes are mature enough to live on their own, she gives birth to them.

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

FIGURE 8
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, such as the catfish in Figure 9, have taste organs in unusual places.

FIGURE 9
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.

Diversity of Fishes

Fishes are classified into three main groups based on the mouth structure and type of skeleton. **The major groups of fishes are jawless fishes, cartilaginous fishes, and bony fishes.**

Jawless Fishes Jawless fishes were the first vertebrates to appear on Earth. **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 alive 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 10, you can probably imagine the damage it can do.

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

FIGURE 10
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

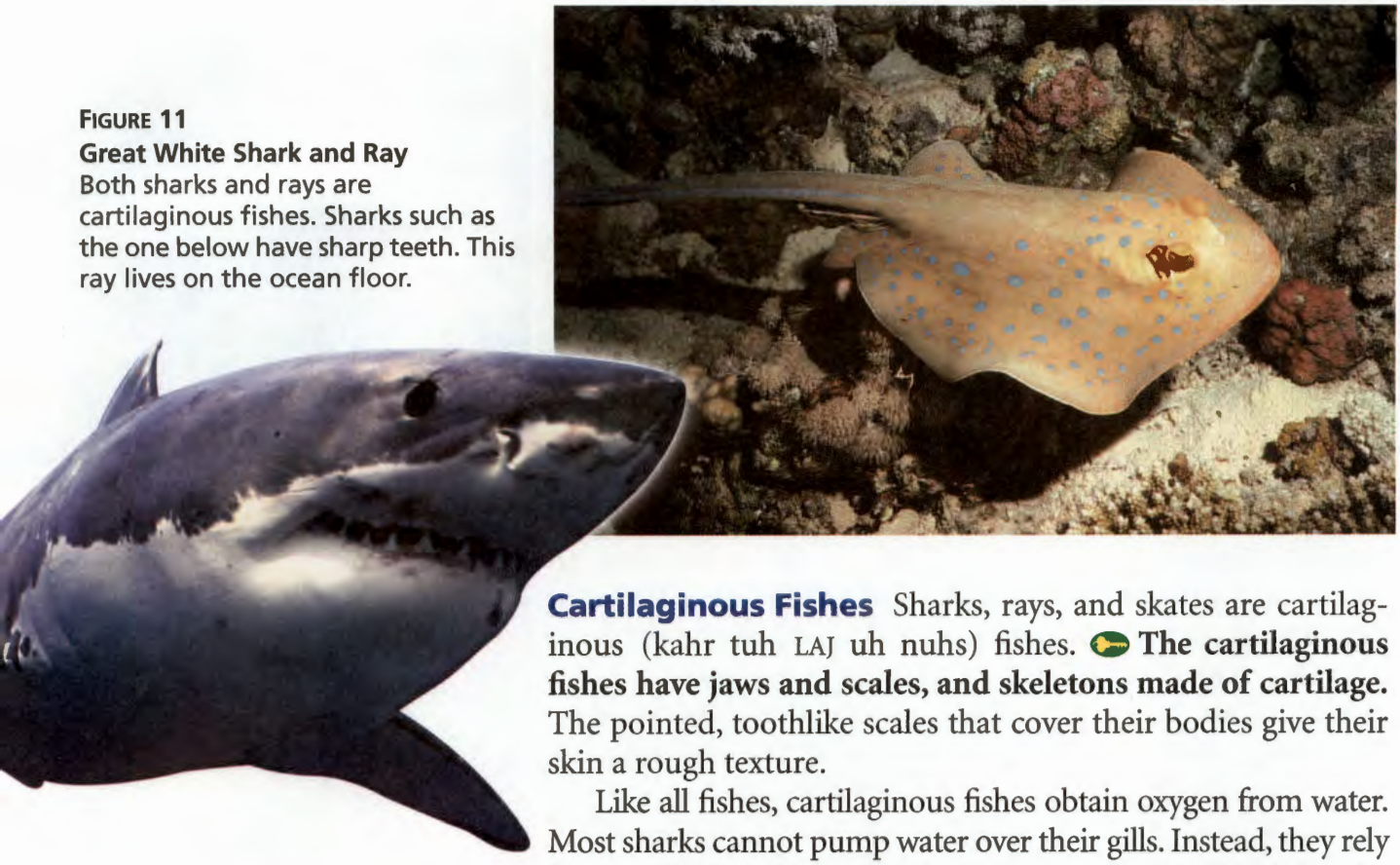


FIGURE 11
Great White Shark and Ray
Both sharks and rays are cartilaginous fishes. Sharks such as the one below have sharp teeth. This ray lives on the ocean floor.

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 rough texture.

Like all fishes, cartilaginous fishes obtain oxygen from water. Most sharks cannot pump water over their gills. Instead, they rely on swimming or currents to keep water moving across their gills. 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 on the ocean floor. During this time, they take in water through small holes behind their eyes. Water leaves through gill openings on the fishes' undersides.

Bony Fishes Most familiar kinds of fish, such as trout, tuna, and goldfish, 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 this 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. Because of this adjustment, 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.

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

Lab zone Skills Activity

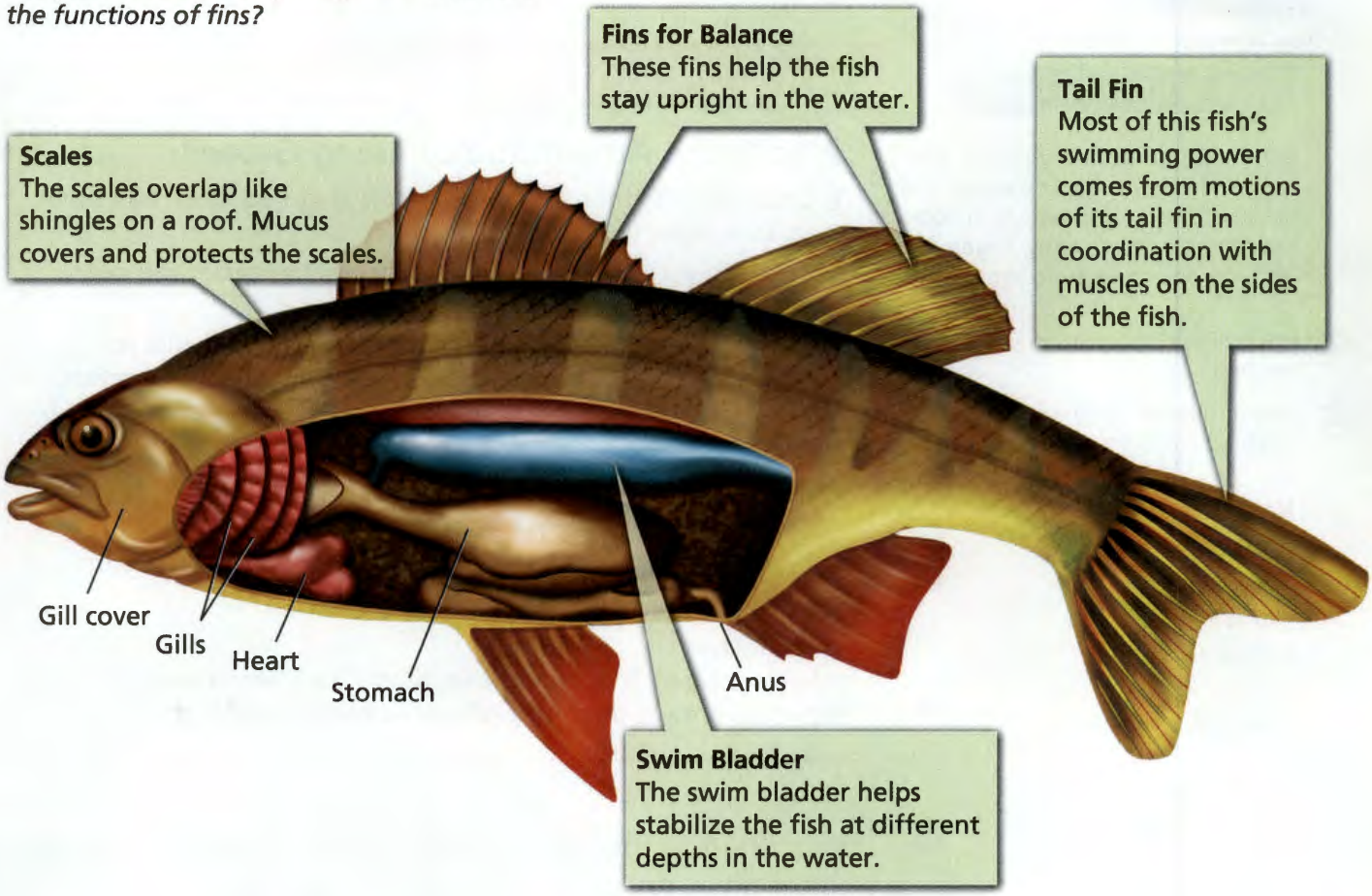
Observing

Put on your goggles and disposable gloves. Place a preserved bony 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 12

Structure of a Bony Fish

The yellow perch has the characteristics of a bony fish. **Interpreting Diagrams** *What are the functions of fins?*



Section 2 Assessment

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

Target Reading Skill **Compare and Contrast** Use your compare/contrast chart about the different groups of fishes to help you answer Question 2.

Reviewing Key Concepts

1. a. **Reviewing** What are the main characteristics of fishes?
   b. **Explaining** What is the function of 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 does shark reproduction differ from the reproduction of most fishes?

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.

Section 3

Amphibians

CALIFORNIA Standards Focus

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

- What is the life cycle of an amphibian?
- How are adult amphibians adapted to living on land?

Key Terms

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

Lab zone Standards Warm-Up

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?

In a pond, a frog lies in wait. In the air above the frog, a dragonfly approaches. Because the frog blends in with its surroundings, the dragonfly doesn't notice the frog. Zip! The frog's tongue shoots out, capturing the dragonfly.

Frogs and toads have camouflage that helps them obtain food and avoid predators. Most frogs and toads are green or brownish-green, making them hard to see in their environment. If you did the Standards Warm-Up, you learned that it is hard to see something green against a green background.

This green frog blends in with green duckweed in a pond. ▼

What Is an Amphibian?

A frog is one kind of amphibian. Toads and salamanders are other kinds. An **amphibian** (am FIB ee un) 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.**

FIGURE 13
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?*

Reproduction and Development 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 13. The larva of a frog or a toad is called a **tadpole**. Like fishes, tadpoles obtain oxygen through gills.

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?**

Diversity of Amphibians There are two major groups of amphibians. Salamanders form one group. Frogs and toads form the other. You can distinguish between the groups by the presence of a tail in the adults. Salamanders keep their tails in adulthood, while most frogs and toads do not.

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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 moving.**

Obtaining Oxygen Amphibian larvae use gills to obtain oxygen from the water. During metamorphosis, most amphibians lose their gills and develop lungs. **Lungs** are organs of air-breathing vertebrates in which oxygen moves from the air into the blood. Carbon dioxide moves from the blood into the air. 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 adult amphibian in Figure 14. 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.

Go Online active art

For: Respiration and Circulation activity
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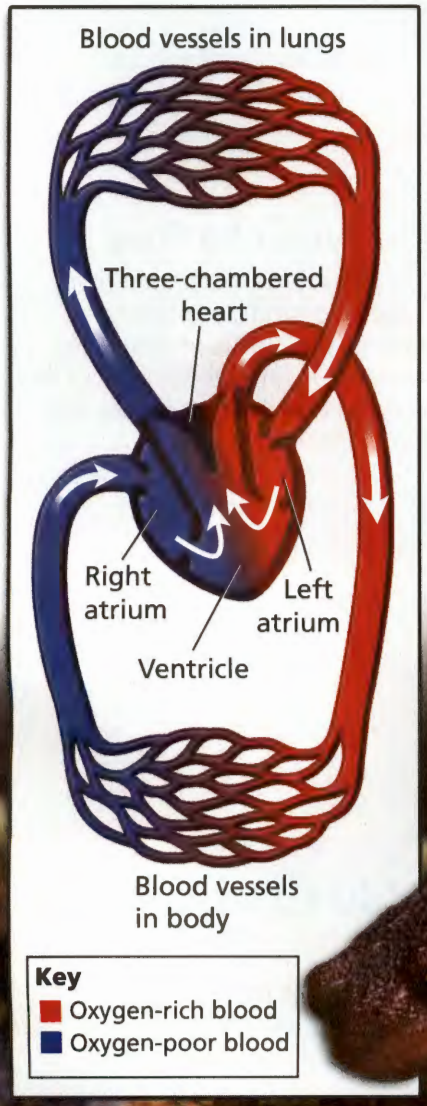


FIGURE 14
Respiration and Circulation
This adult salamander has lungs and a double-loop circulatory system. **Interpreting Diagrams** *Why is the blood in the right atrium colored blue?*

Movement A vertebrate that lives on land needs a strong skeleton to support its body. 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. 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.

Amphibians in Danger Worldwide, amphibian populations are decreasing. One reason is the destruction of amphibian habitats. An animal's **habitat** is the 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 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.

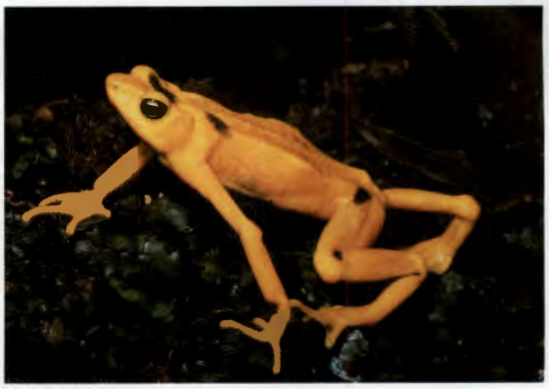


FIGURE 15
Golden Frog
Golden frogs, like the one shown here, are rarely seen anymore in their native habitat—the rain forests of Panama.
Relating Cause and Effect *What are two possible causes for the decrease in the number of golden frogs?*

Reading Checkpoint What is a habitat?

Section 3 Assessment

S 7.5.a, E-LA: Reading 7.1.2, Writing 7.2.0

Vocabulary Skill **Greek Word Origins** In the Greek word *amphibios,* the word part *bios* means "life." What do you think the word part *amphi-* means?

Reviewing Key Concepts

1. a. **Defining** What is an amphibian?
   b. **Sequencing** Describe a frog's life cycle, beginning with the egg.
   c. **Comparing and Contrasting** Contrast the ways in which tadpoles and adult frogs obtain oxygen.
2. a. **Reviewing** What are three adaptations of adult amphibians for living on land?
   b. **Sequencing** How does blood move in the circulatory system of an adult amphibian? (*Hint:* Start with blood leaving the ventricle of the heart and going to the lungs.)
   c. **Interpreting Diagrams** How is an adult amphibian's circulatory system different from that of a fish? Use Figure 6 and Figure 14 to help answer this question.

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

CALIFORNIA Standards Focus

S 7.3.e Students know that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.

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

- What adaptations allow reptiles to live on land?
- What are the characteristics of each of the three main groups of reptiles?
- What environmental change may have caused the extinction of the dinosaurs?

Key Terms

- reptile
- kidney
- urine
- amniotic egg

Lab zone Standards Warm-Up

How Do Snakes Feed?

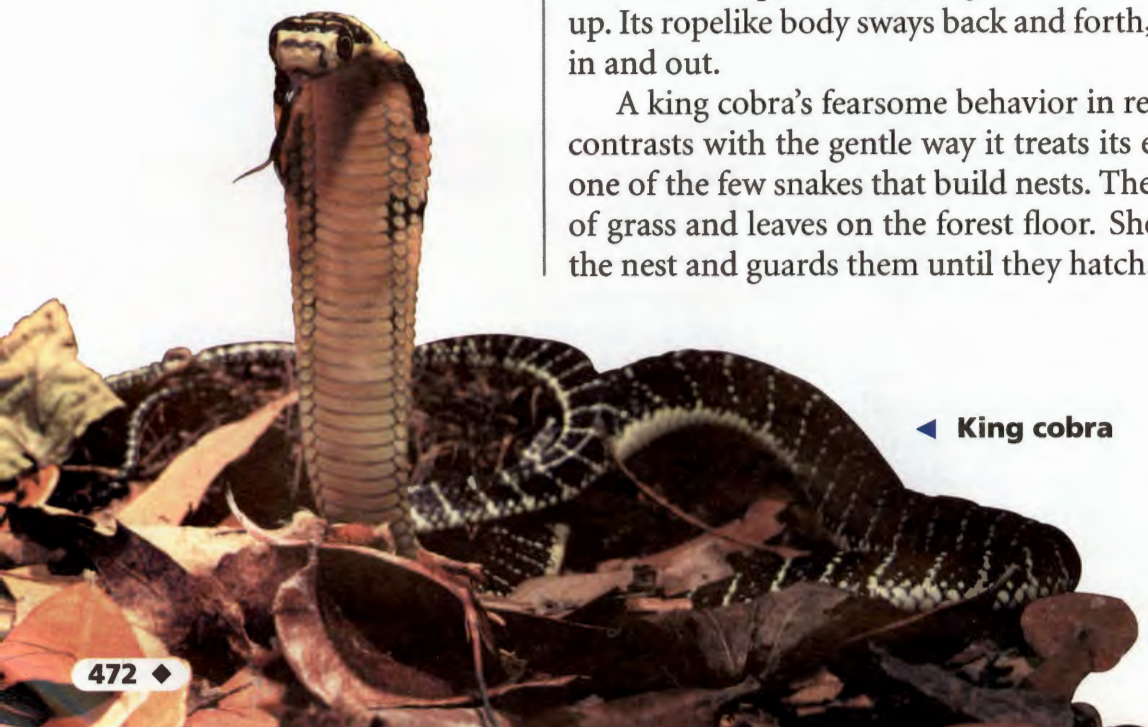
1. To model how a snake feeds, stretch a sock cuff over a grapefruit "prey" by first pulling on one side and then on the other. Work the grapefruit down into the "stomach." A snake's jawbones can spread apart like the sock cuff.
2. Remove the grapefruit and put a rubber band around the sock about 8 centimeters 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?

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 16
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 sea turtles 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?**

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 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** (am nee AHT ik). Pores in the shell let oxygen gas in and carbon dioxide gas out.

Look at Figure 17 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 17

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?*

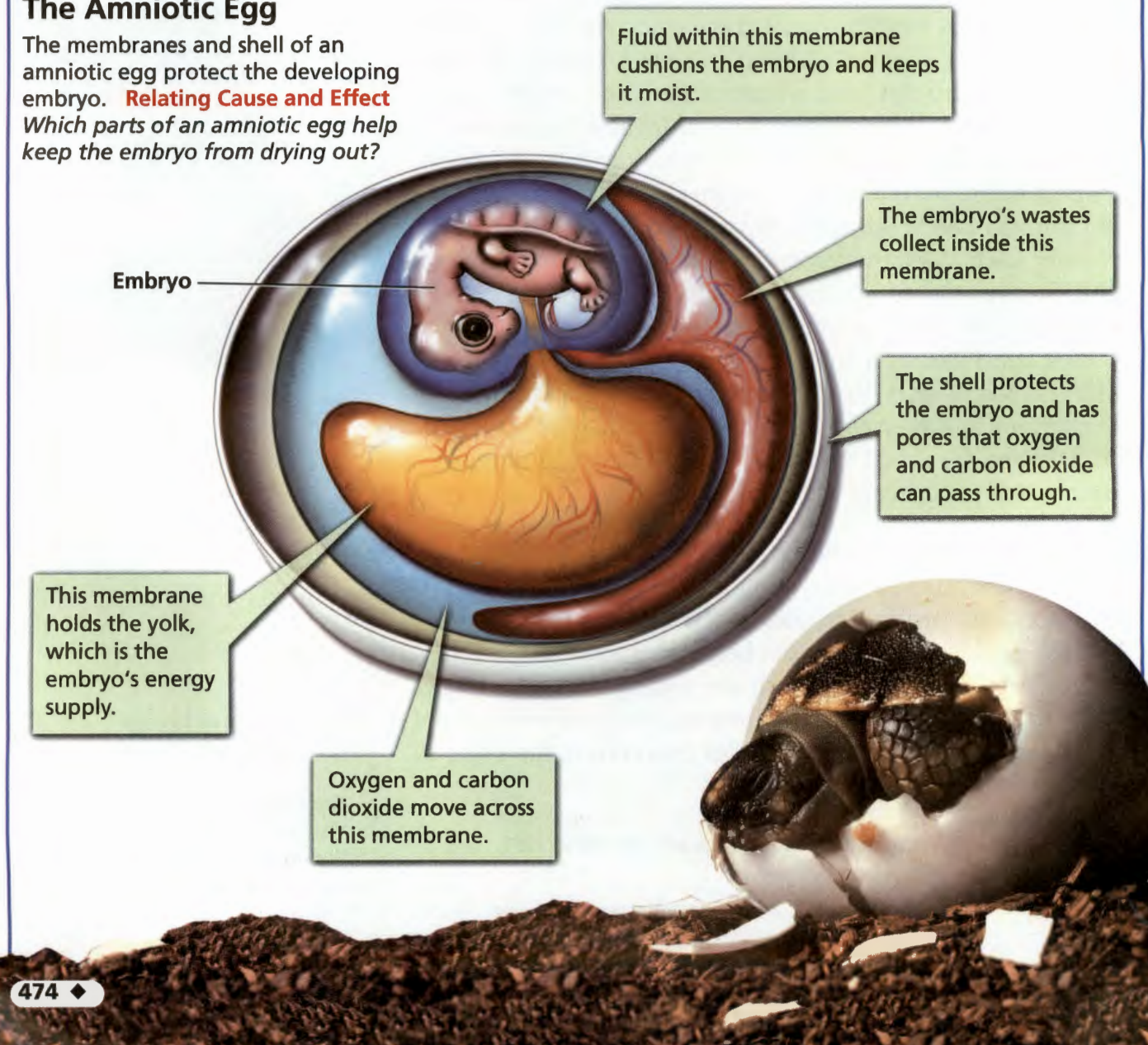


FIGURE 18
An Egg-Eating Snake
The jawbones of this snake's skull have moved to let the snake swallow an egg.
Making Generalizations *How are snakes different from lizards?*

Diversity of Reptiles

Reptiles that are alive today include lizards, snakes, and turtles. The dinosaurs are reptiles that are now extinct.

Lizards and Snakes Most reptiles alive today are either lizards or snakes. **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. Lizards differ from snakes in an obvious way. Lizards have four legs and snakes have streamlined bodies with no legs. Snakes move by contracting bands of muscles that are connected to their ribs and backbones.

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 eat frogs and birds, most smaller lizards hunt insects.

All snakes are carnivores. Most snakes feed on small animals, such as mice, but some eat large prey. If you did the Standards Warm-Up, 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.

Reading Checkpoint **How do rattlesnakes capture prey?**

FIGURE 19
A Sidewinder Snake
The 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.

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. The American alligator can grow to be more than 5 meters long.

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. Alligators and crocodiles are carnivores that often hunt at night.

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*.

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.

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.

1670 — 1760 — 1820

Unlike most reptiles, crocodiles and alligators care for their eggs and newly hatched young. The female lays her eggs in a nest of rotting plants. The female stays near the nest. From time to time, she comes out of the water and crawls over to the nest to keep it moist. After the tiny young hatch, the female scoops them up in her huge mouth. She carries the young from the nest to a nursery area in the water, where they will be safer.

For as long as a year after young alligators have hatched, the female stays near her young. The young alligators make gulping quacks when they are alarmed. When their mother hears her young quack, she rushes toward them. She protects her young until they can feed and protect themselves.

Reading Checkpoint **How can you tell an alligator from a crocodile?**

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

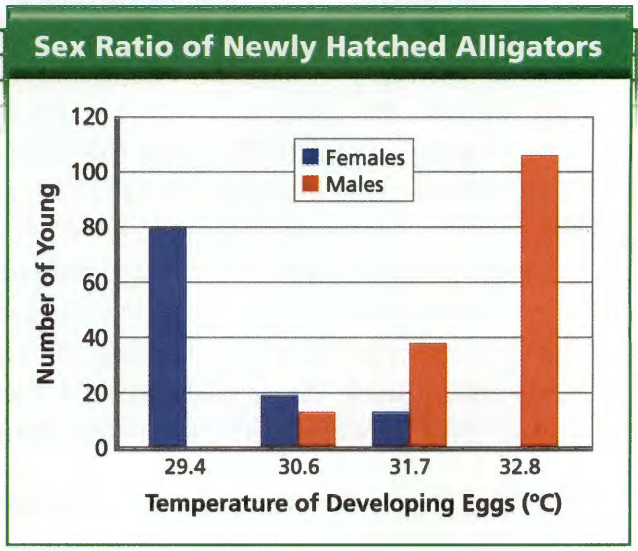
Reviewing Math: Number Sense 6.1.2

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. The leatherbacks' 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?**

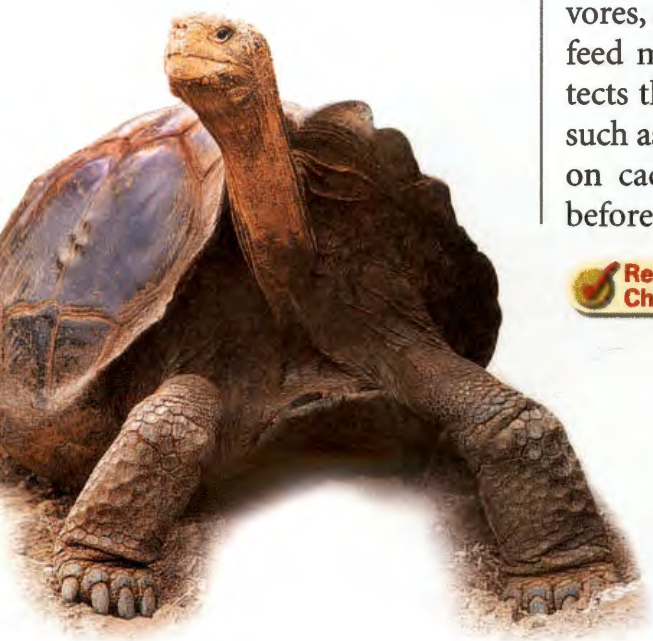


FIGURE 20
A Galápagos Tortoise
The Galápagos tortoise lives on land, where it eats mainly cacti.

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. Some dinosaurs were the largest land animals that ever lived. Unlike today's reptiles, some dinosaurs may have been endothermic.

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. **Climate change may have caused the extinction of dinosaurs and other organisms.** Scientists hypothesize that Earth became much cooler because huge clouds of dust and gases blocked sunlight. As you learned in Chapter 8, volcanoes or the impact of a huge object from space may have caused the clouds. Lack of sunlight would have caused the death of many plants—and the animals that depended on the plants. The dinosaurs did not have adaptations that let them survive.

FIGURE 21
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?*

Section 4 Assessment

S 7.3.e, 7.5.a, E-LA: Writing 7.2.5, Reading 7.1.2

Vocabulary Skill **Greek Word Origins**
Tyrannosaurus comes from the Greek words *tyrannos*, meaning "a cruel ruler," and *sauros*, meaning "lizard." How do these Greek words relate to the characteristics of *Tyrannosaurus rex*?

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. **Inferring** How do you think a gecko captures its prey? Explain your answer.
3. a. **Reviewing** When did the dinosaurs become extinct?
   b. **Relating Cause and Effect** What may have caused the dinosaurs to become extinct?

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.

Section 5

Birds

CALIFORNIA Standards Focus

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

What are the main characteristics of birds?

Key Terms

- bird
- contour feather
- down feather
- crop
- gizzard

Lab zone Standards Warm-Up

What Are Feathers Like?

1. Observe the overall shape and structure of a feather. Then use a hand lens to examine the many hairlike barbs that project out from the feather's central shaft.
2. Gently separate two barbs in the middle of the feather. Rub the separated edges with your fingertip. How do they feel?
3. Use the hand lens to examine the edges of the two separated barbs. Draw a diagram of what you observe.
4. Rejoin the two separated barbs by gently pulling outward from the shaft. Then wash your hands.

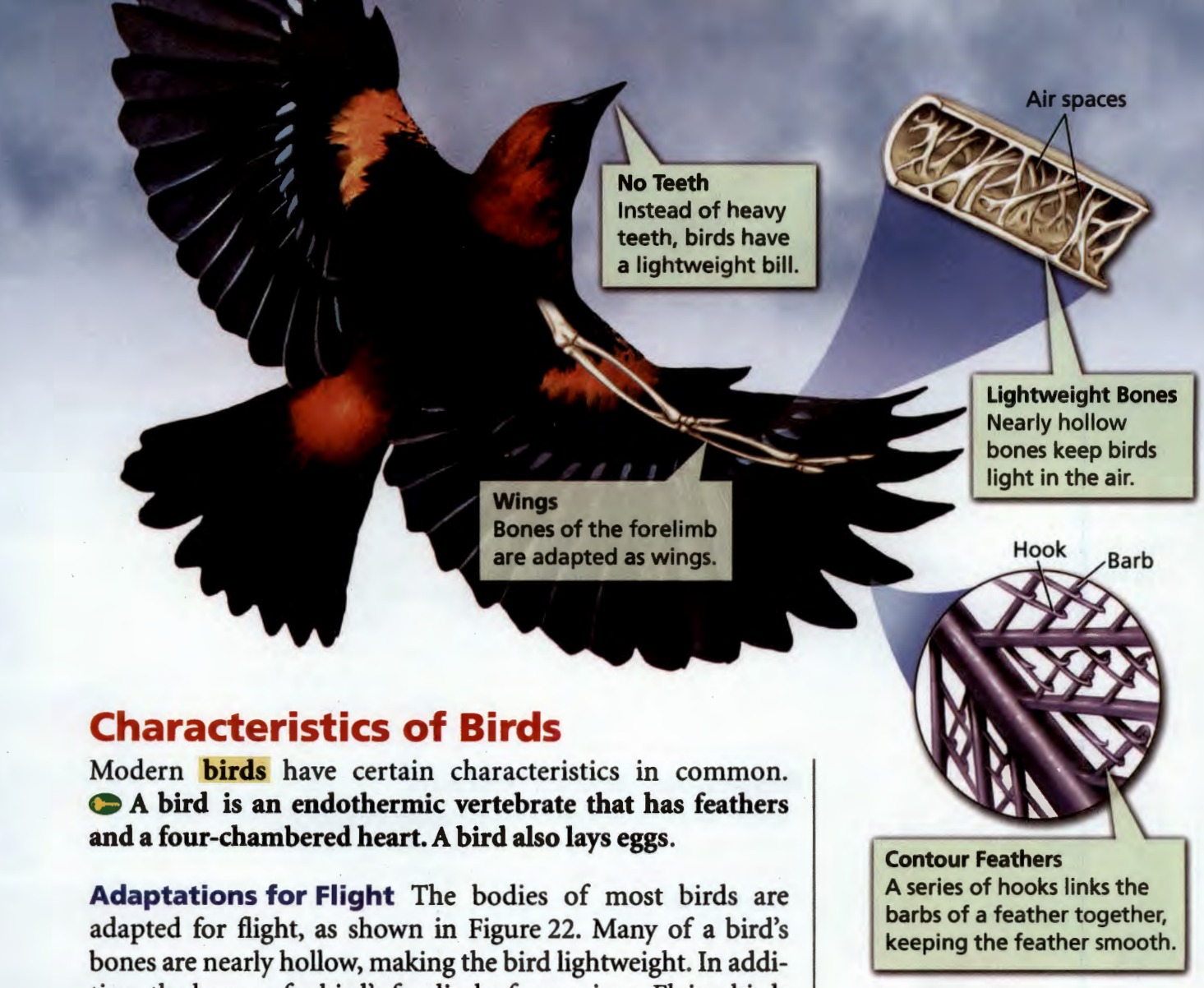
Think It Over

Observing Once the barbs have been separated, is it easy to rejoin them? How might this be an advantage to the bird?

One day in 1861, in a limestone quarry in what is now Germany, Hermann von Meyer was inspecting rocks. Meyer, a fossil hunter, spotted something dark in a rock. It was the blackened imprint of a feather! Excited, he began searching for a fossil of an entire bird. He eventually found it—a skeleton surrounded by the imprint of many feathers. The fossil was given the scientific name *Archaeopteryx* (ahr kee AHP tur iks), meaning "ancient winged thing."

Paleontologists now think that *Archaeopteryx* lived about 145 million years ago. *Archaeopteryx* didn't look much like the birds you know. It looked more like a reptile with wings. Unlike any modern bird, *Archaeopteryx* had a long, bony tail and a mouth full of teeth. But, unlike a reptile, it had feathers and wings. Paleontologists think that *Archaeopteryx* and modern birds descended from some kind of reptile. Many scientists think that birds descended from dinosaurs.

◀ A model of *Archaeopteryx*



Characteristics of Birds

Modern **birds** have certain characteristics in common. **A bird is an endothermic vertebrate that has feathers and a four-chambered heart. A bird also lays eggs.**

Adaptations for Flight The bodies of most birds are adapted for flight, as shown in Figure 22. Many of a bird's bones are nearly hollow, making the bird lightweight. In addition, the bones of a bird's forelimbs form wings. Flying birds have large chest muscles that move the wings. Finally, feathers help birds fly. Birds are the only animals with feathers.

Feathers are not all the same. If you have ever picked up a feather, it was probably a contour feather. A **contour feather** is one of the large feathers that give shape to a bird's body. The long contour feathers that extend beyond the body on the wings and tail are called flight feathers. When a bird flies, these feathers help it balance and steer. You can see in Figure 22 that a contour feather consists of a central shaft and many projections, called barbs. Hooks hold the barbs together.

In addition to contour feathers, birds have short, fluffy **down feathers** that are specialized to trap heat and keep the bird warm. Down feathers are found right next to the bird's skin, at the base of the contour feathers. Down feathers are soft and flexible, unlike contour feathers.

Reading Checkpoint **How are the structures of contour feathers and down feathers different?**

FIGURE 22
Adaptations for Flight
The bodies of most birds have adaptations for flight.
Interpreting Diagrams *What are two adaptations that make birds light?*

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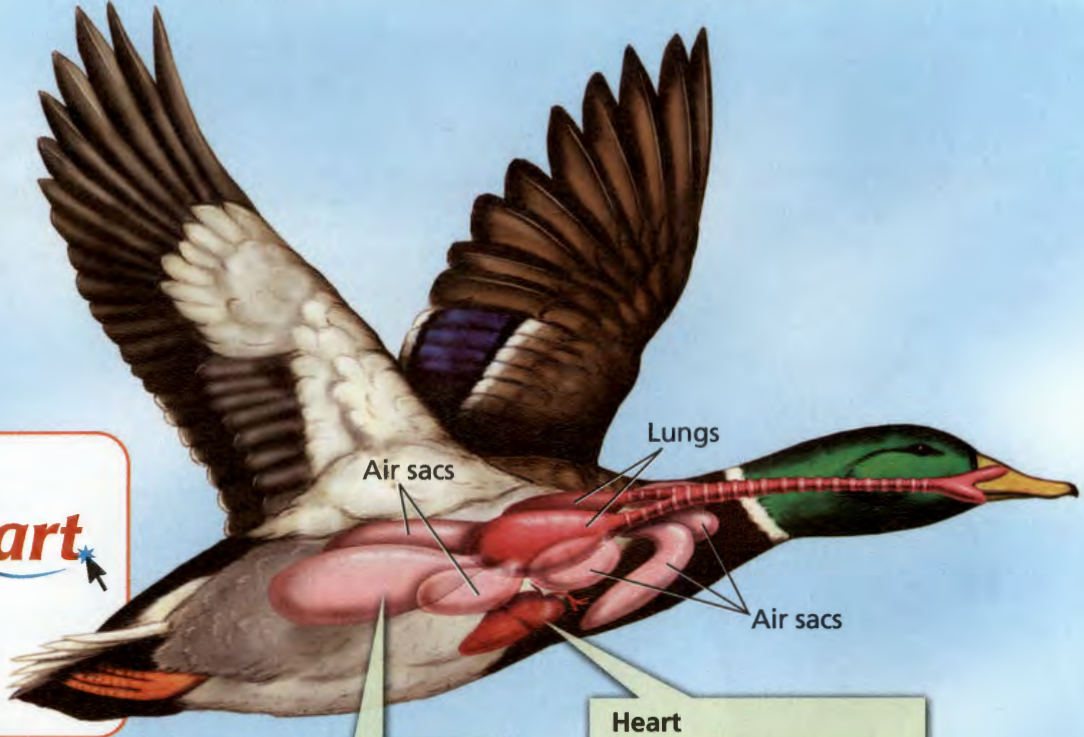

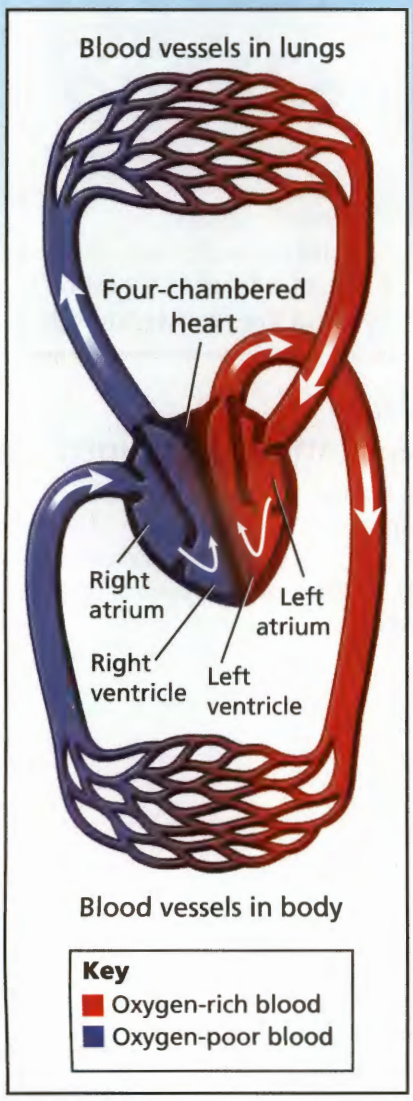

FIGURE 23
Respiration and Circulation

Air sacs and a four-chambered heart help birds obtain oxygen and move it to their cells.
Applying Concepts *Why is a four-chambered heart efficient?*

Obtaining Oxygen Flying uses a lot of energy. Therefore, cells must receive plenty of oxygen to release the energy contained in food. Birds have a highly efficient way to get oxygen into their bodies and to their cells. Birds have a system of air sacs in their bodies that connects to the lungs. The air sacs enable birds to obtain more oxygen from each breath of air than other animals can.

The circulatory systems of birds are also efficient at getting oxygen to the cells. Birds have hearts with four chambers—two atria and two ventricles. Trace the path of blood through a bird's two-loop circulatory system in Figure 23. The right side of a bird's heart pumps oxygen-poor blood to the lungs, where oxygen is picked up. Oxygen-rich blood returns to the left side of the heart, which pumps it to the cells.

The advantage of a four-chambered heart over a three-chambered heart is that oxygen-rich blood does not mix with oxygen-poor blood. Therefore, blood carried to the cells of the body has plenty of oxygen.

Obtaining Food Birds must obtain a lot of food to provide the energy needed for flight. To capture, grip, and handle food, birds mainly use their bills. Bills are shaped to help birds feed quickly and efficiently. For example, the pointy, curved bill of a hawk acts like a meat hook to pull off bits of its prey. In contrast, a duck's bill acts like a kitchen strainer, separating out seeds and tiny animals from muddy pond water.

After a bird eats its food, digestion begins. Each organ in a bird's digestive system is adapted to process food. Many birds have an internal storage tank, or **crop**, for storing food inside the body after swallowing it. Find the crop in Figure 24. The crop is connected to the stomach.

A bird's stomach has two parts. In the first part, food is bathed in chemicals that begin to break it down. Then the food moves to a thick-walled, muscular part of the stomach called the **gizzard**. The gizzard squeezes and grinds the partially digested food. Birds do not have teeth. The gizzard does the same grinding function for birds that your teeth do for you. The gizzard may contain small stones that the bird has swallowed. These stones help grind the food by rubbing against it and crushing it.

Video Field Trip
Discovery Channel School
Birds and Mammals

Reading Checkpoint **What is a gizzard?**

FIGURE 24
Digestive System of a Hawk
Some birds like this hawk have a crop and a gizzard. The crop stores food, and the gizzard crushes food. **Interpreting Diagrams** *Does food reach the crop or the gizzard first?*

Down Feather ▶

FIGURE 25
Keeping Warm
A pine grosbeak puffs out its feathers to trap air in the layer of down feathers next to its skin. Down feathers help keep birds warm.

Lab zone Try This Activity

"Eggs-amination"

1. Observe the surface of a chicken egg with a hand lens. Then gently crack the egg into a bowl. Do not break the yolk.
2. Note the membrane attached to the inside of the shell. Then look at the blunt end of the egg. What do you see?
3. Fill one part of the eggshell with water. What do you observe?
4. Find the egg yolk. What is its function?
5. Look for a small white spot on the yolk. This marks the spot where the embryo would have developed if the egg had been fertilized.
6. Wash your hands with soap.

Observing Draw a labeled diagram of the egg that names each structure and describes its function.

Keeping Conditions Stable Like all animals, birds use their food for energy. You know that birds need energy for flight. Because birds are endotherms, they also need a lot of energy to maintain their body temperature. Each day, an average bird eats food equal to about a quarter of its body weight. When people say, "You're eating like a bird," they usually mean that you're eating very little. But if you were actually eating as much as a bird does, you would be eating huge meals. You might be eating as many as 100 hamburger patties in one day!

To maintain their body temperature, birds use feathers as well as energy from food. As you read earlier, down feathers are specialized to trap heat. They are found right next to a bird's skin. In Figure 25, you can see what a down feather looks like. Unlike contour feathers, down feathers are soft and flexible. So, they mingle and overlap, trapping air. Air is a good insulator—a material that does not conduct heat well and therefore helps prevent heat from escaping. By trapping a blanket of warm air next to the bird's skin, down feathers slow the rate at which the skin loses heat. In effect, down feathers cover a bird in lightweight long underwear.

Reading Checkpoint **Why do birds need a lot of food?**

Reproduction and Caring for Young Like reptiles, birds have internal fertilization and lay eggs. Bird eggs are similar to reptile eggs. However, the shells of bird eggs are harder. In most bird species, the female lays the eggs in a nest that has been prepared by one or both parents.

Bird eggs will only develop at a temperature close to the body temperature of the parent bird. Thus, a parent bird usually incubates the eggs by sitting on them to keep them warm. In some species, incubating the eggs is the job of just one parent. For example, female robins incubate their eggs. In other species, such as pigeons, the parents take turns incubating the eggs. Chicks may take from 12 to 80 days to develop, depending on the species.

When it is ready to hatch, a chick pecks its way out of the eggshell. Some newly hatched chicks, such as ducks, chickens, and partridges, are covered with down and can run about soon after they have hatched. Other chicks, such as baby blue jays and robins, are featherless, blind, and so weak they can barely lift their heads to beg for food. Most parent birds feed and protect their young at least until they are able to fly.

FIGURE 26
Parental Care
The partridge chicks (left) find their own food from the day they hatch. In contrast, the blue jay chicks (above) are featherless, blind, and totally dependent on their parents for food for several weeks.

Section 5 Assessment

S 7.5.a, E-LA: Reading 7.1.2

Vocabulary Skill **Greek Word Origins** *Archaeopteryx* comes from the Greek words *archaios,* meaning "ancient," and *pteron,* meaning "wing." How do these Greek words relate to the characteristics of *Archaeopteryx*?

Reviewing Key Concepts

1. a. **Identifying** What characteristics do birds share?
   b. **Explaining** How is a bird's body adapted for flight?
   c. **Relating Cause and Effect** Why do birds need so much oxygen? What adaptation helps them obtain oxygen?
2. a. **Reviewing** How does a parent bird usually incubate its eggs?
   b. **Explaining** Why is the incubating process necessary for the development of birds?

Lab zone At-Home Activity

Count Down Look for products in your home that contain down feathers. What common purpose do these items have? Explain to a family member how down feathers function on a bird.

Section 6

Mammals

CALIFORNIA Standards Focus

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

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

- What characteristics do all mammals share?
- What are the main groups of mammals and how do they differ in their reproduction?

Key Terms

- mammal
- mammary gland
- diaphragm
- monotreme
- marsupial
- gestation period
- placental mammal
- placenta

Lab zone **Standards Warm-Up**

What Are Mammals' Teeth Like?

1. Wash your hands before you begin. Then, with a small mirror, examine the shapes of your teeth. Observe the incisors (the front teeth); the pointed canine teeth; the premolars behind the canine teeth; and the molars, which are the large teeth in the very back.
2. Compare and contrast the structures of the different kinds of teeth.
3. Use your tongue to feel the cutting surfaces of the different kinds of teeth in your mouth.
4. Bite off a piece of cracker and chew it. Observe the teeth that you use to bite and chew. Wash your hands when you are finished.

Think It Over

Inferring What is the advantage of having teeth with different shapes?

High in the Himalaya Mountains of Tibet, several yaks inch their way, single file, along a narrow cliff path. The cliff plunges thousands of meters to the valley below, so one false step can mean disaster. But the sure-footed yaks, carrying heavy loads of grain, slowly but steadily cross the cliff and make their way through the mountains.

People who live in the mountains of central Asia have depended on yaks for thousands of years. Not only do yaks carry materials for trade, they also pull plows and provide milk. Mountain villagers weave blankets from yak hair and make shoes and ropes from yak hides.

The yak is a member of the group of vertebrates called **mammals.** Today about 4,000 different species of mammals exist. Some, like the yak and wildebeest, you may never have seen. But others, such as dogs, cats, and mice, are very familiar to you. What characteristics do mammals share?

▲ Himalayan yak

Characteristics of Mammals

All mammals are endothermic vertebrates that have a four-chambered heart and skin covered with fur or hair. Most mammals are born alive, and every young mammal is fed with milk produced by organs in its mother's body. These organs are called **mammary glands.** The word *mammal,* in fact, comes from the term *mammary.*

Obtaining Food In addition to their other characteristics, most mammals have teeth. Their teeth are adapted to chew their food, breaking it into small bits that make digestion easier. Most mammals have teeth with four different shapes. If you did the Standards Warm-Up, you observed these shapes. Incisors are flat-edged teeth used to bite off and cut food. Canines are pointed teeth that stab food and tear into it. Premolars and molars have broad, flat upper surfaces for grinding and shredding food.

The size, shape, and hardness of a mammal's teeth reflect its diet. For example, the canines of carnivores are especially large and sharp. Large carnivores, such as the lion in Figure 27, use their canines to hold their prey while they kill it. In contrast, herbivores, such as a springbok, have molars for grinding and mashing plants.

FIGURE 27
Teeth of Different Shapes
Lions have sharp, pointed canines. Springboks have broad molars.
Inferring *What kind of diet does each of these mammals eat?*

Reading Checkpoint **Which teeth stab and tear into food?**

FIGURE 28
Fur and Hair
A hippo has hardly any hair. In contrast, a wolf has a thick coat of fur.
Inferring *What can you infer about the environment each animal lives in?*

Obtaining Oxygen To release energy, food must combine with oxygen inside cells. Therefore, a mammal must have an efficient way to get oxygen into the body and to the cells that need it. Like reptiles and birds, all mammals breathe with lungs. Mammals breathe in and out because of the combined action of rib muscles and a large muscle called the **diaphragm** (DY uh fram). The diaphragm is located at the bottom of the ribs. The lungs have a huge, moist surface area where oxygen can move into the blood.

Like birds, mammals have a four-chambered heart and a two-loop circulatory system. This efficient system takes oxygen to the cells.

Keeping Conditions Stable Like birds, mammals are endotherms. They need the energy in food to keep a steady internal temperature. In addition, all mammals have fur or hair at some point in their lives that helps them keep their internal temperature stable. Each strand of fur or hair is composed of dead cells strengthened with the same tough material that strengthens feathers. The amount of fur or hair that covers a mammal's skin varies greatly. In general, animals that live in cold regions, like the wolf shown in Figure 28, have more fur than animals that live in warmer environments.

Fur is not the only adaptation that allows mammals to live in cold climates. Mammals also have a layer of fat beneath their skin. Like fur and feathers, fat is an insulator.

Lab zone Try This Activity

Insulated Mammals

Discover whether or not fat is an effective insulator.

1. Put on a pair of rubber gloves.
2. Spread a thick coating of solid white shortening on the outside of one of the gloves. Leave the other glove uncoated.
3. Put both hands in a bucket or sink filled with cold water.

Inferring Which hand got cold faster? Explain how this activity relates to mammalian adaptations.

Movement Like all vertebrates, mammals have a musculoskeletal system, which consists of muscles and bones working together. Each muscle consists of a bundle of fibers that are muscle cells. When muscles pull on bones, they make the bones move. Energy for this movement is supplied by the action of mitochondria in muscle cells.

Mammals have adaptations that allow them to move in more ways than members of any other group of vertebrates. Most mammals walk or run on four limbs, but some have specialized ways of moving. For example, kangaroos hop. Bats have wings adapted from their front limbs. The front limbs of whales, dolphins, and other sea mammals are adapted as flippers for swimming. These specialized ways of moving allow mammals to survive in many habitats.

Nervous System A mammal's nervous system coordinates its movements. In addition, the nervous system receives information about the environment. The brains of mammals enable them to learn, remember, and behave in complex ways. For example, in order for squirrels to eat nuts, they must crack the nutshell to get to the meat inside. Squirrels learn to use different methods to crack different kinds of nuts, depending on where the weak point in each kind of shell is located.

The senses of mammals are highly developed and adapted for the ways a species lives. Tarsiers, which are active at night, have huge eyes that let them see in the dark. Bats use keen hearing to navigate and catch prey. Dogs, cats, and bears often use smell to track their prey.

FIGURE 29
A Swinging Orangutan
This young orangutan can grasp branches with its limbs and swing from place to place.

Reading Checkpoint **What are three ways that mammals can move?**

FIGURE 30
The Senses of Seals
Seals can see under water in near darkness. Their long whiskers help them obtain food by detecting the movements of their prey.

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Diversity of Mammals

Mammals are a very diverse group. **The three main groups of mammals are monotremes, marsupials, and placental mammals. The groups differ in how they reproduce and how their young develop.**

Monotremes Egg-laying mammals are called **monotremes** (MAHN oh treemz). There are just three species of monotremes—two species of spiny anteaters and the duck-billed platypus. A female spiny anteater lays one to three leathery-shelled eggs directly into a pouch on her belly. After the young hatch, they stay in the pouch for six to eight weeks. There they drink milk that seeps out of pores on the mother's skin. In contrast, the duck-billed platypus lays her eggs in an underground nest. The tiny young feed by lapping at the milk that oozes from slits onto the fur of their mother's belly.

FIGURE 31
A Spiny Anteater
The young of this spiny anteater, a monotreme, hatch from eggs.

Marsupials Koalas, kangaroos, and opossums are some of the better-known marsupials. **Marsupials** (mahr SOOP ee ulz) are mammals whose young are born at an early stage of development, and they usually continue to develop in a pouch on their mother's body.

Marsupials have a very short **gestation period,** the length of time between fertilization and birth. For example, opossums have a gestation period of about 13 days. Newborn marsupials are tiny—some opossums are less than 1 centimeter long at birth! When they are born, marsupials are blind, hairless, and pink. They crawl along the wet fur of their mother's belly until they reach her pouch. Once inside, they find one of her nipples and attach to it. They remain in the pouch until they have grown enough to peer out of the pouch opening.

Reading Checkpoint **What is a marsupial?**

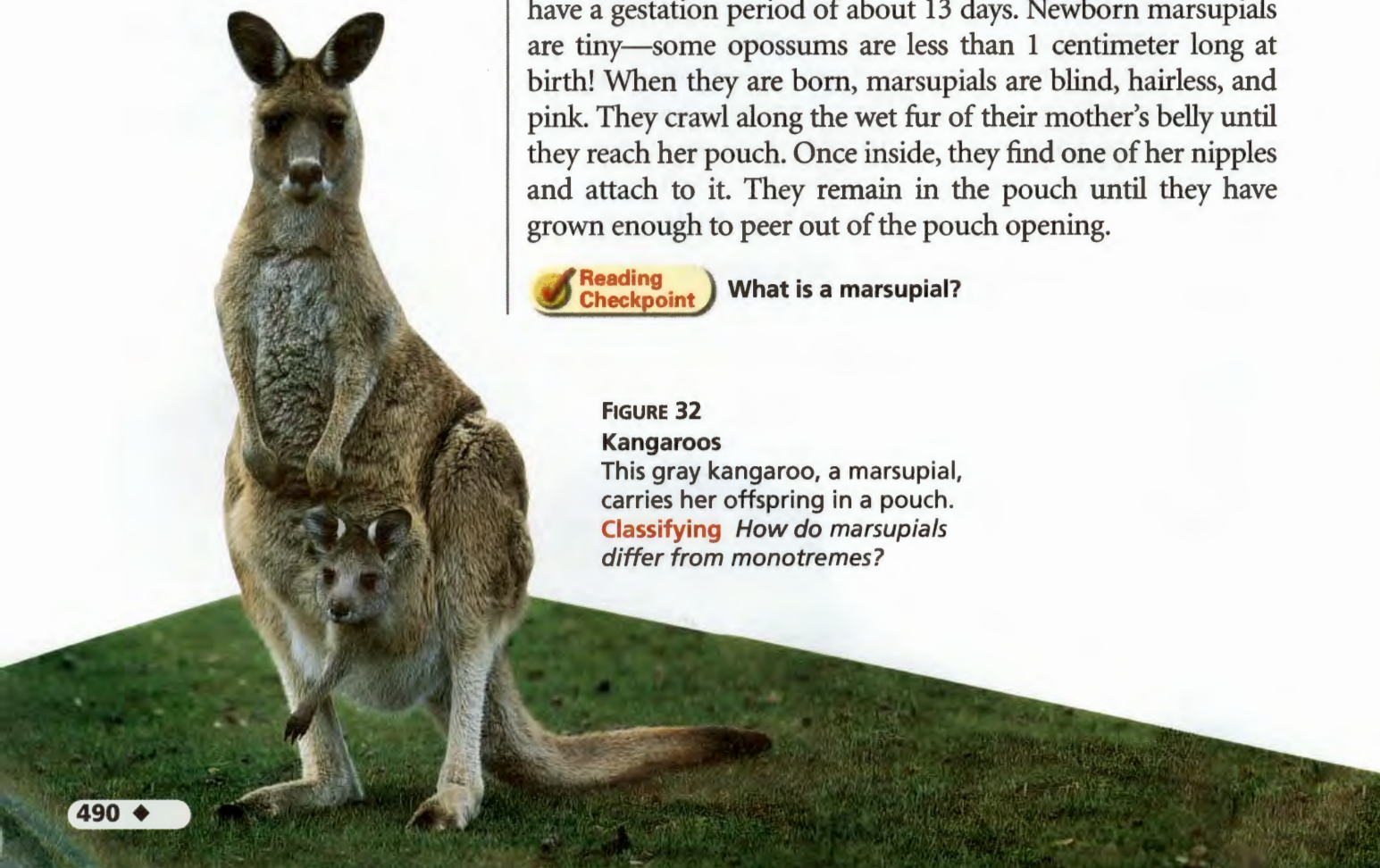

FIGURE 32
Kangaroos
This gray kangaroo, a marsupial, carries her offspring in a pouch.
Classifying *How do marsupials differ from monotremes?*

Placental Mammals Unlike a monotreme or a marsupial, a **placental** (pluh SEN tal) **mammal** develops inside its mother's body until its body systems can function independently. The name of this group comes from the **placenta**, an organ in pregnant female mammals that passes materials between the mother and the developing embryo. Food and oxygen pass from the mother to her young. Wastes pass from the young to the mother, who eliminates them. An umbilical cord connects the young to the mother's placenta. Most mammals, including humans, are placental mammals. Gestation periods of placental mammals are generally longer than those of marsupials. Usually, the larger the placental mammal, the longer the gestation period. The gestation period for an elephant, for example, averages about 21 months, but for a mouse, it's only about 20 days.

Placental mammals are classified into groups on the basis of characteristics such as how they eat and how their bodies move. You can see the diversity of placental mammals in Figure 34 on the next page.

Reading Checkpoint **What is a placenta?**

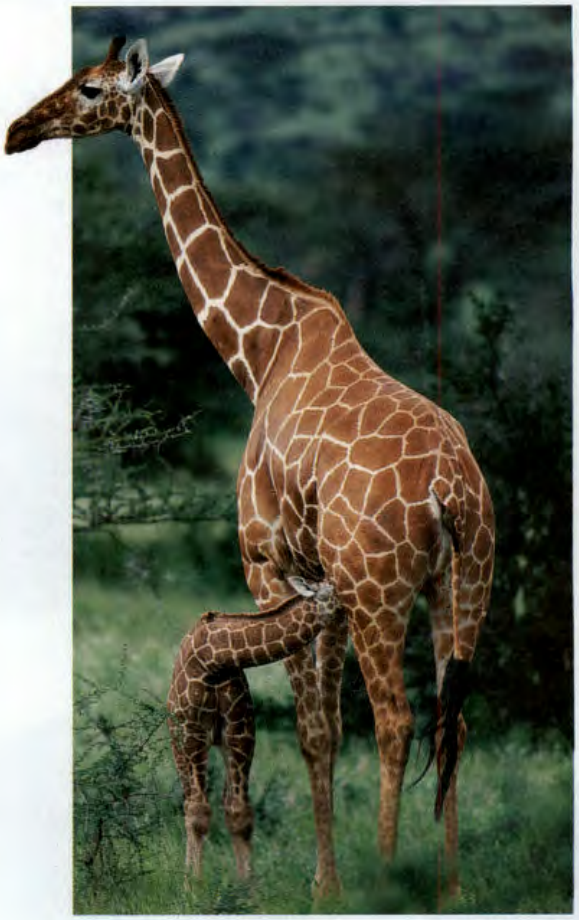

FIGURE 33 Mother and Baby Giraffe This baby giraffe, a placental mammal, feeds on milk produced by its mother.

Reviewing Math: Algebra and Functions 7.1.5

Math Analyzing Data

Mammal Diversity

This circle graph shows the percentage of species of some types of mammals.

1. **Reading Graphs** What percentage of species are bats?
2. **Calculating** What percentage of species are not bats?
3. **Graphing** Suppose you used the data shown in the circle graph to make a bar graph. Which bar would be tallest?
4. **Predicting** What total should all the percentages in the pie chart add up to? Do you have to add the percentages to obtain your answer? Explain.

Percentages of Mammal Species

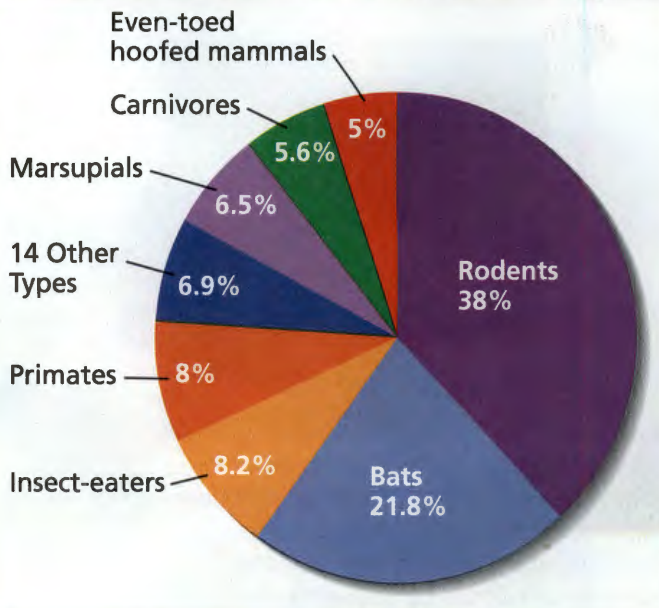

FIGURE 34

Diversity of Placental Mammals

From tiny moles to huge elephants, placental mammals are diverse. They are grouped on the basis of how they eat and move as well as other characteristics.

Rabbits and Hares ▶
Leaping mammals like this black-tailed jack rabbit have long hind legs specialized for spectacular jumps. Rabbits and hares have long, curved incisors for gnawing.

Carnivores ▶
This river otter belongs to the group known as carnivores. Dogs, raccoons, and seals are other members of this group. Most carnivores have large canine teeth and clawed toes that help them catch and eat their prey.

Marine Mammals ▲
Whales, manatees, and these Atlantic spotted dolphins are ocean-dwelling mammals with a body shape adapted for swimming.

Rodents ▶
Rodents are gnawing mammals such as mice, rats, beavers, and the capybaras shown here. The incisor teeth of most rodents keep growing throughout their lives but are constantly worn down by gnawing.

Mammals With Trunks ▲
Elephants' noses are long trunks that they use for collecting food and water.

Insect-Eaters ▲
Moles and their relatives have sharp cutting surfaces on all of their teeth. This star-nosed mole spends much of its time searching for prey with its sensitive, tentacled snout.

◀ Flying Mammals
The wings of bats are made of a thin skin that stretches from their wrists to the tips of their long finger bones.

◀ Toothless Mammals
Armadillos, such as the one shown here, are toothless mammals. So are sloths. Although a few members of this group have small teeth, most have none.

Hoofed Mammals ▲
Some mammals with hooves have an even number of toes and some have an odd number of toes. Cows, deer, and pigs all have an even number of toes. Horses and zebras have an odd number of toes.

Primates ▼
This group of mammals with large brains and eyes that face forward includes humans, monkeys, and apes such as this chimpanzee.

FIGURE 35
Parental Care by Dall's Sheep
Young mammals usually require much parental care. On a rocky slope in Alaska, this Dall's sheep, a placental mammal, keeps a close watch on her lamb.

Caring for Young Whether a monotreme, a marsupial, or a placental mammal, young mammals are usually quite helpless for a long time after being born. Many are born without a coat of insulating fur. Their eyes are often sealed and may not open for weeks. For example, black bear cubs are surprisingly tiny when they are born. The blind, nearly hairless cubs have a mass of only 240 to 330 grams—about the same mass as a grapefruit. The mass of an adult black bear, in contrast, ranges from about 120 to 150 kilograms—about 500 times as much as a newborn cub!

Young mammals usually stay with their mother or both parents for an extended time. After black bear cubs learn to walk, they follow their mother about for the next year, learning how to be a bear. They learn things that are important to their survival, such as which mushrooms and berries are good to eat and how to rip apart a rotten log and find good-tasting grubs within it. During the winter, when black bears go through a period of inactivity, the young bears stay with their mother. The following spring, she will usually force them to live independently.

Reading Checkpoint **Why are most young mammals dependent on one or both parents after they are born?**

Section 6 Assessment

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

Target Reading Skill **Compare and Contrast** Use your compare/contrast table to help you answer Question 2.

Reviewing Key Concepts

1. a. **Defining** What characteristics do mammals share?
   b. **Describing** Describe the adaptation that most mammals have for obtaining food.
   c. **Relating Cause and Effect** What enables mammals to live in colder environments than reptiles? Explain.
2. a. **Reviewing** What are the three main groups of mammals?
   b. **Explaining** How do these groups differ in their manner of reproduction?
   c. **Comparing and Contrasting** Why might scientists consider monotremes to be a link between reptiles and mammals?

Lab zone At-Home Activity

Mammals' Milk With a family member, examine the nutrition label on a container of whole milk. What types of nutrients does whole milk contain? Discuss why milk is an ideal source of food for young, growing mammals.

Keeping Warm

S 7.5.b, 7.7.c

Problem

Wool products are made from the hair of mammals, such as sheep. Do wool products provide insulation from the cold? How well does wool insulate when it is wet?

Skills Focus

graphing, interpreting data

Materials

- tap water, hot
- scissors
- beaker, 1-L
- 3 thermometers
- clock or watch
- graph paper
- a pair of wool socks
- tap water, room temperature
- 3 containers, 250-mL, with lids

Procedure

1. Put one container into a dry woolen sock. Soak a second sock with water at room temperature, wring it out so it's not dripping, and then slide the second container into the wet sock. Both containers should stand upright. Leave the third container uncovered.
2. Create a data table in your notebook, listing the containers in the first column. Provide four more columns in which to record the water temperatures during the experiment.
3. Use scissors to carefully cut a small "X" in the center of each lid. Make the X just large enough for a thermometer to pass through.
4. Fill a beaker with about 800 mL of hot tap water. Then pour hot water nearly to the top of each of the three containers. **CAUTION:** *Avoid spilling hot water on yourself or others.*
5. Place a lid on each of the containers, and insert a thermometer into the water through the hole in each lid. Gather the socks around the thermometers above the first two containers so that the containers are completely covered.

6. Immediately measure the temperature of the water in each container, and record it in your data table. Take temperature readings every 5 minutes for at least 15 minutes.

Analyze and Conclude

1. **Graphing** Graph your results using a different color to represent each container. Graph time in minutes on the horizontal axis and temperature on the vertical axis.
2. **Interpreting Data** Compare the temperature changes in the three containers. Relate your findings to the insulation characteristics of mammal skin coverings.
3. **Communicating** Suppose a company claims that its wool socks keep you warm even if they get wet. Do your findings support this claim? Write a letter to the company explaining why or why not.

Design an Experiment

Design an experiment to compare how wool's insulating properties compare with those of other natural materials (such as cotton) or manufactured materials (such as acrylic). Obtain your teacher's permission before carrying out your investigation.

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Chapter 12 Study Guide

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

1 What Is a Vertebrate?

Key Concepts S 7.4.g, 7.5.c

- Chordates have a notochord, a nerve cord that runs down their back, and slits in their throat area.
- A vertebrate has a backbone that is part of an internal skeleton.
- By studying fossils and other evidence, scientists infer the relationships between vertebrate groups.
- The body temperature of most fishes, amphibians, and reptiles is close to that of their environment. In contrast, birds and mammals have a stable body temperature.

Key Terms

• chordate • notochord • vertebra
• ectotherm • endotherm

2 Fishes

Key Concepts S 7.5.b

- 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 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 S 7.5.a

- 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.

Key Terms

• amphibian • tadpole • lung • atrium
• ventricle • habitat

4 Reptiles

Key Concepts S 7.3.e, 7.5.a

- 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 with a protective shell that includes the ribs and the backbone.
- Climate changes may have caused the extinction of dinosaurs and other organisms.

Key Terms

• reptile • urine • kidney • amniotic egg

5 Birds

Key Concepts S 7.5.a

- A bird is an endothermic vertebrate that has feathers and a four-chambered heart. A bird also lays eggs.

Key Terms

• bird • contour feather • down feather
• crop • gizzard

6 Mammals

Key Concepts S 7.2.a, 7.5.a

- All mammals are endothermic vertebrates that have a four-chambered heart and skin covered with fur or hair. Most mammals are born alive, and every young mammal is fed with milk.
- There are three main groups of mammals—monotremes, marsupials, and placental mammals. The groups differ in how their young develop.

Key Terms

• mammal • mammary gland • diaphragm
• monotreme • marsupial • gestation period
• placental mammal • placenta

Review and Assessment

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Target Reading Skill

Compare and Contrast Complete the compare/contrast table below, which compares the circulatory systems of four vertebrate groups.

Vertebrate Group	Number of Loops in Circulatory System	Number of Chambers in Heart
Fishes	one	a. ?
Adult amphibians	b. ?	c. ?
Birds	d. ?	e. ?
Mammals	f. ?	four

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 reptile
   a. is an endotherm.
   b. lays eggs.
   c. has a swim bladder.
   d. has a thin skin.
4. The gizzard of a bird
   a. stores air.
   b. removes oxygen from air.
   c. helps a bird fly.
   d. grinds food.
5. A monotreme differs from a placental mammal because the monotreme
   a. has fur.
   b. has a placenta.
   c. lays eggs.
   d. feeds its young with milk.

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

6. At some point, all chordates have a **notochord,** which is a(n) _____ .
7. The life cycles of **amphibians** are different from those of most vertebrates because amphibians _____ .
8. Unlike an amphibian's eggs, a reptile's **amniotic eggs** have _____ .
9. A **contour feather** functions to _____ .
10. The **placenta** is an organ whose function is to _____ .

Writing in Science

Cause and Effect Paragraph Which adaptations improve a bird's ability to fly? Write a paragraph in which you describe the adaptations that enable a bird to fly. Be sure to include a topic sentence.

Video Assessment
Discovery Channel School
Birds and Mammals

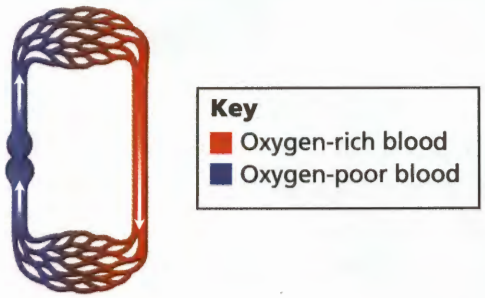
Review and Assessment

Checking Concepts

11. What evidence has enabled scientists to infer the order in which vertebrate groups evolved?
12. How do fishes reproduce?
13. Describe the adaptations of an adult amphibian for obtaining oxygen from the air.
14. Explain how the structure of a reptile's egg protects the embryo inside.
15. Describe the position of dinosaurs' legs on their bodies. How did this give dinosaurs an advantage?
16. What adaptations help a bird obtain enough oxygen for flight?
17. How does the structure of an incisor relate to its function?
18. Describe how mammals breathe in and out.

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?



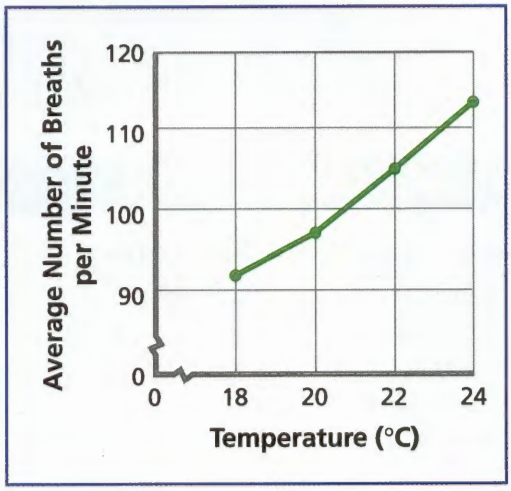
21. **Classifying** A museum has a vertebrate fossil that is over 500 million years old. To which group—fishes, amphibians, reptiles, birds, or mammals—does the fossil most likely belong? Explain your answer.
22. **Comparing and Contrasting** Compare temperature regulation in ectotherms and endotherms.

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 Standards Investigation

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?

CALIFORNIA Standards Practice

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Choose the letter of the best answer.

1. Which of the following is the order in which vertebrate groups appeared on Earth, beginning with the group that appeared earliest?
   - **A** amphibians, fishes, birds, reptiles, mammals
   - **B** fishes, birds, reptiles, amphibians, mammals
   - **C** birds, fishes, mammals, amphibians, reptiles
   - **D** fishes, amphibians, reptiles, mammals, birds

   S 7.4.g

2. The dinosaurs probably became extinct because they lacked adaptations to survive
   - **A** attacks by predators.
   - **B** disease.
   - **C** in a cool climate.
   - **D** in a warm climate.

   S 7.3.e

Use the diagram below to answer Question 3.

3. In the diagram above, the front of the mouth faces left. What is the most likely function of the large teeth in the center of the mouth?
   - **A** grinding food
   - **B** killing prey
   - **C** biting food
   - **D** cutting and tearing food

   S 7.5.a

4. Suppose a bony fish injured its swim bladder. The fish would probably have difficulty
   - **A** digesting food.
   - **B** regulating its body temperature.
   - **C** staying stable at different depths.
   - **D** obtaining oxygen from water.

   S 7.5.b

Use the table below to answer Question 5.

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

5. A scientist observed four different animals and recorded her data in the table shown above. Which of the animals most likely reproduces by means of amniotic eggs?
   - **A** Animal 1
   - **B** Animal 2
   - **C** Animal 3
   - **D** Animal 4

   S 7.2.a

6. Which of the following organs together enable all vertebrates to move from place to place?
   - **A** crop and gizzard
   - **B** lungs and fins
   - **C** bones and muscles
   - **D** air sacs and kidneys

   S 7.5.c

7. All vertebrates reproduce
   - **A** sexually.
   - **B** asexually.
   - **C** by means of internal fertilization.
   - **D** by means of external fertilization.

   S 7.2.a

Apply the BIG Idea

8. Describe the structure of a vertebrate's backbone and explain how this structure gives flexibility to a vertebrate's body.

   S 7.5.a

Unit 3 Review Structure and Function in Living Systems

Chapter 9
Viruses, Bacteria, Protists, and Fungi

The BIG Idea

Organisms in different domains and kingdoms display varying levels of organization, from single cells to more complex structures.

- What is the structure of a virus?
- How do the cells of bacteria differ from those of eukaryotes?
- What are the characteristics of animal-like, plantlike, and funguslike protists?
- What characteristics do fungi share?

Chapter 10
Structure and Function of Plants

The BIG Idea

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

- What do plants need to live successfully on land?
- What characteristics do the three groups of seedless vascular plants share?
- What characteristics do seed plants share?

Chapter 11
Structure and Function of Invertebrates

The BIG Idea

The structures of animal's bodies enable them to obtain food and oxygen, keep internal conditions stable, move, and reproduce.

- What are four major functions of animals?
- What are the main characteristics of cnidarians?
- What are the main characteristics of worms?
- What are the distinguishing structures of insects, crustaceans, arachnids, centipedes, and millipedes?

Chapter 12
Structure and Function of Vertebrates

The BIG Idea

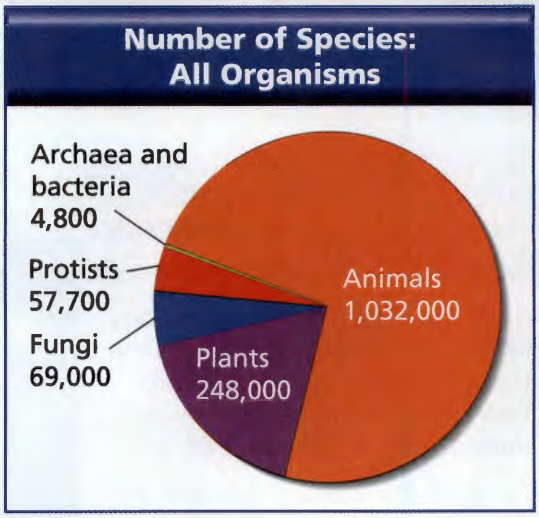
Vertebrates have endoskeletons that include backbones. Backbones provide support and enable movement.

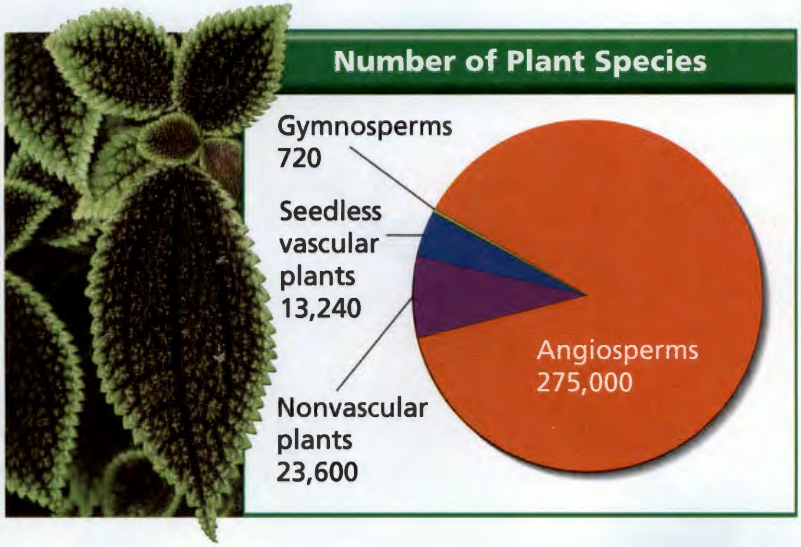
- What are the characteristics of chordates and vertebrates?
- What adaptations allow reptiles to live on land?
- What are the main characteristics of birds?
- What characteristics do all mammals share?

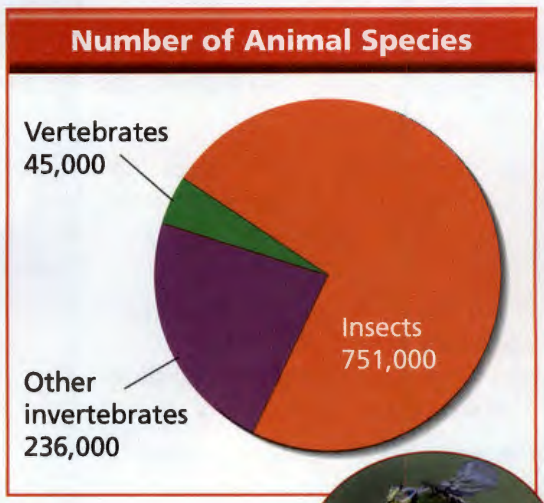
Unit 3 Assessment

Connecting the BIG Ideas

The circle graphs compare the number of species in each group of organisms. These graphs include only the species that scientists have named and described. There may be millions more species that have yet to be discovered or described! Keep in mind that the graphs include only the number of species, not the total number of organisms. For example, there are relatively few named species of bacteria, but there are more bacteria on Earth than any other kind of organism.







1. Look at the graph that compares all organisms. How do the cells of organisms in the smallest group differ from those in other groups? *(Chapter 9)*
   - **a.** They have cell walls.
   - **b.** They are prokaryotic.
   - **c.** They have no genetic material.
   - **d.** They have more than one nucleus.
2. What is the role of vascular tissue in plants? *(Chapter 10)*
   - **a.** performing photosynthesis
   - **b.** preventing water loss
   - **c.** producing sperm and egg cells
   - **d.** transporting water and food
3. Which statement is true of the animals in the largest group? *(Chapter 11)*
   - **a.** They reproduce asexually.
   - **b.** They have internal skeletons.
   - **c.** They have external skeletons.
   - **d.** They have radial symmetry.
4. Which of the following is found only in vertebrates? *(Chapter 12)*
   - **a.** bony endoskeleton
   - **b.** closed circulatory system
   - **c.** brain and nerves
   - **d.** bilateral symmetry
5. **Summary** Choose one plant, one animal, and one protist. Summarize how each organism reproduces.