Chapter

12

Birds and Mammals

The BIG Idea
Structure and Function

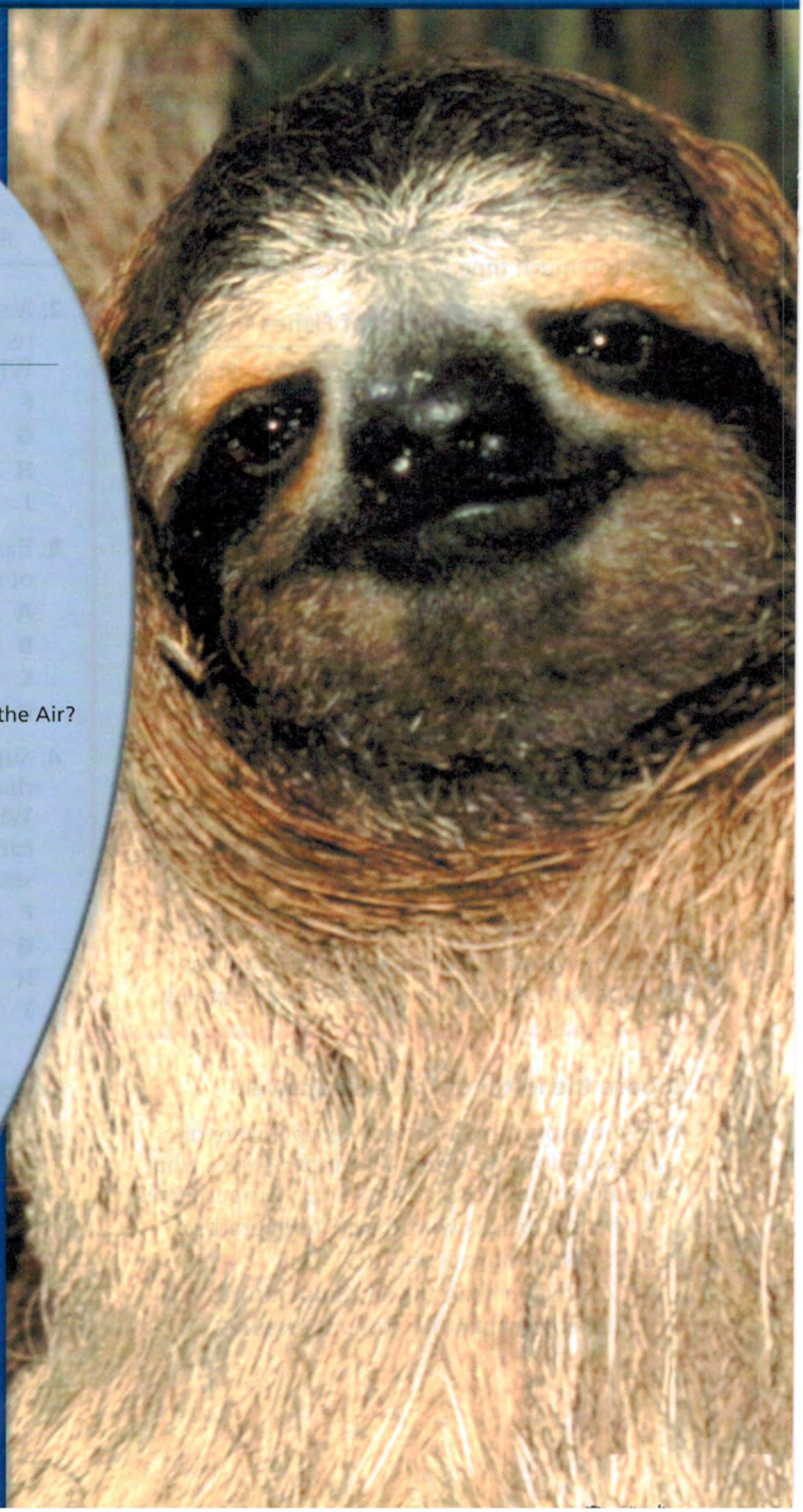
What key characteristics do birds and mammals share?

Chapter Preview

1 Birds
- ***Discover*** What Are Feathers Like?
- ***Active Art*** Respiration and Circulation
- ***Try This*** "Eggs-amination"
- ***At-Home Activity*** Count Down
- ***Skills Lab*** Looking at an Owl's Leftovers

2 The Physics of Bird Flight
- ***Discover*** What Lifts Airplanes and Birds Into the Air?
- ***Try This*** It's Plane to See

3 Mammals
- ***Discover*** What Are Mammals' Teeth Like?
- ***Try This*** Insulated Mammals
- ***Analyzing Data*** Mammal Diversity
- ***At-Home Activity*** Mammals' Milk
- ***Consumer Lab*** Keeping Warm



A three-toed sloth hangs from a tree branch in Costa Rica.

Discovery CHANNEL SCHOOL

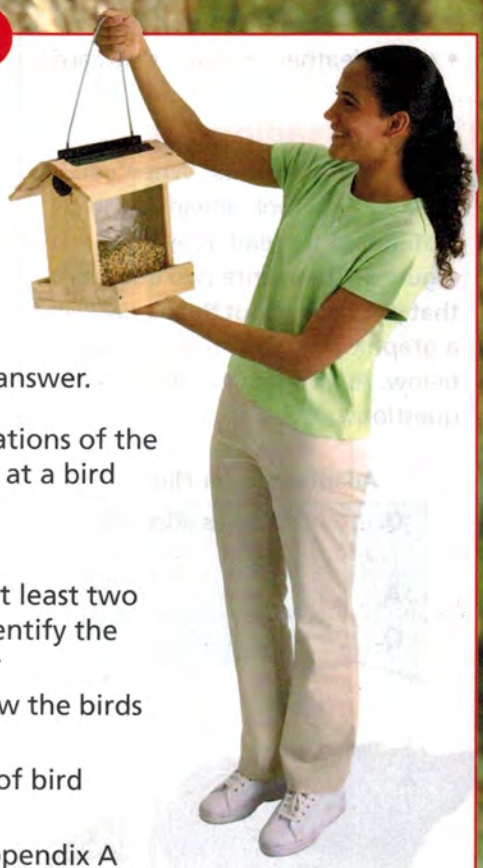
Birds and Mammals

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™

Chapter Project

Bird Watch



One of the best ways to learn about animals is to watch them in action. In this project, you'll watch birds and other animals that visit a bird feeder. You will discover how they eat and interact. What you observe may raise new questions for you to answer.

Your Goal To make detailed observations of the birds and other animals that appear at a bird feeder

To complete this project, you must

- observe the feeder regularly for at least two weeks and use a field guide to identify the kinds of birds that visit the feeder
- make detailed observations of how the birds at your feeder eat
- describe the most common kinds of bird behavior
- follow the safety guidelines in Appendix A

Plan It! Begin by sharing knowledge about the birds in your area with some classmates. What kinds of birds can you expect to see? What types of foods do birds eat? Then, using this knowledge, start observing your feeder. Record all your observations in detail in your notebook. After completing your observations, you will interpret your data and observations and make graphs and charts for your display.

Section 1

Birds

Reading Preview

Key Concepts

- What are the main characteristics of birds?
- How are birds adapted to their environments?

Key Terms

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

Target Reading Skill

Previewing Visuals When you preview, you look ahead at the material to be read. Preview Figure 1. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Adaptations for Flight

Q. How are birds adapted for flight?
A.
Q.

Lab zone Discover Activity

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.

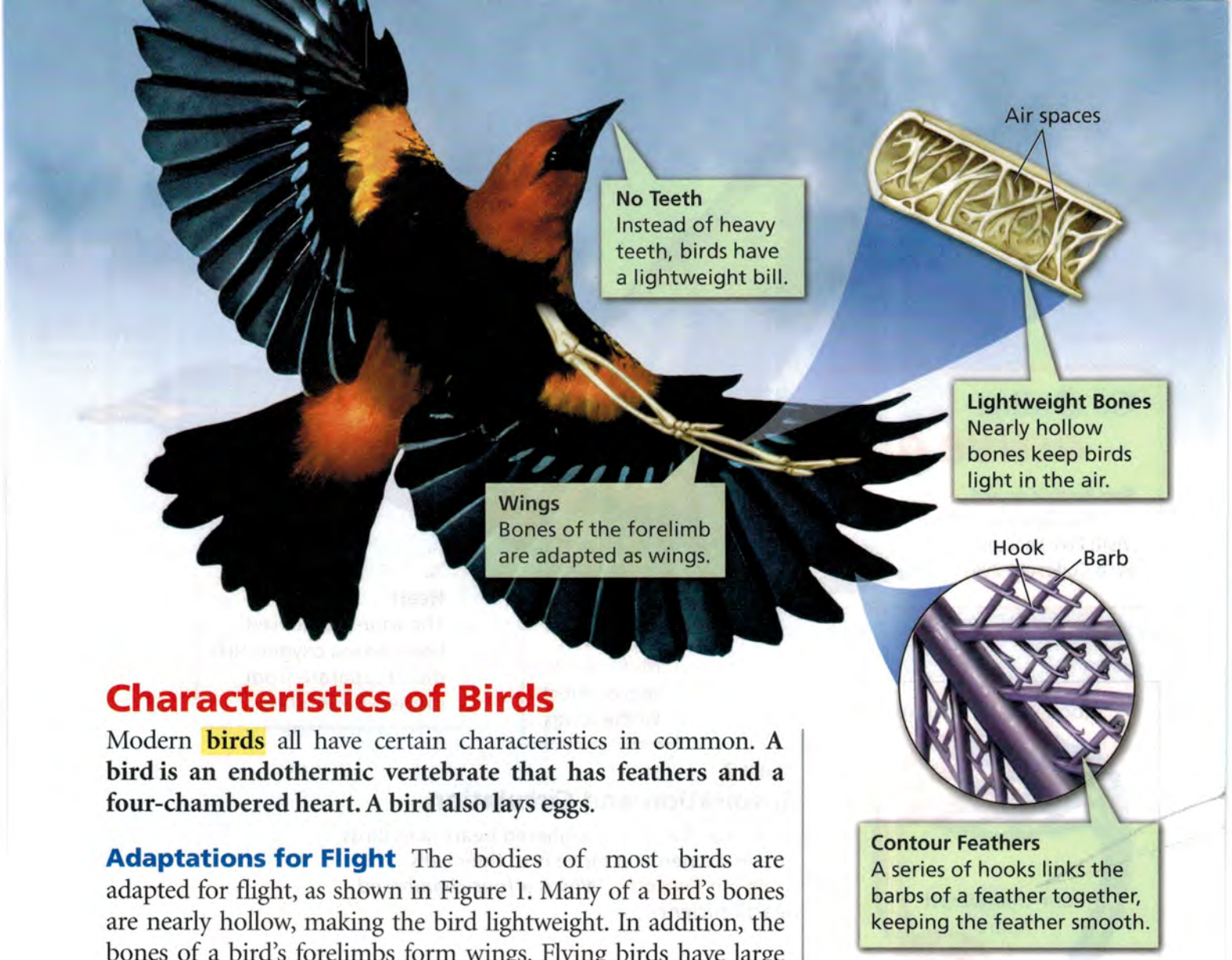
Think It Over

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 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, possibly a dinosaur.

◀ A model of *Archaeopteryx*



Characteristics of Birds

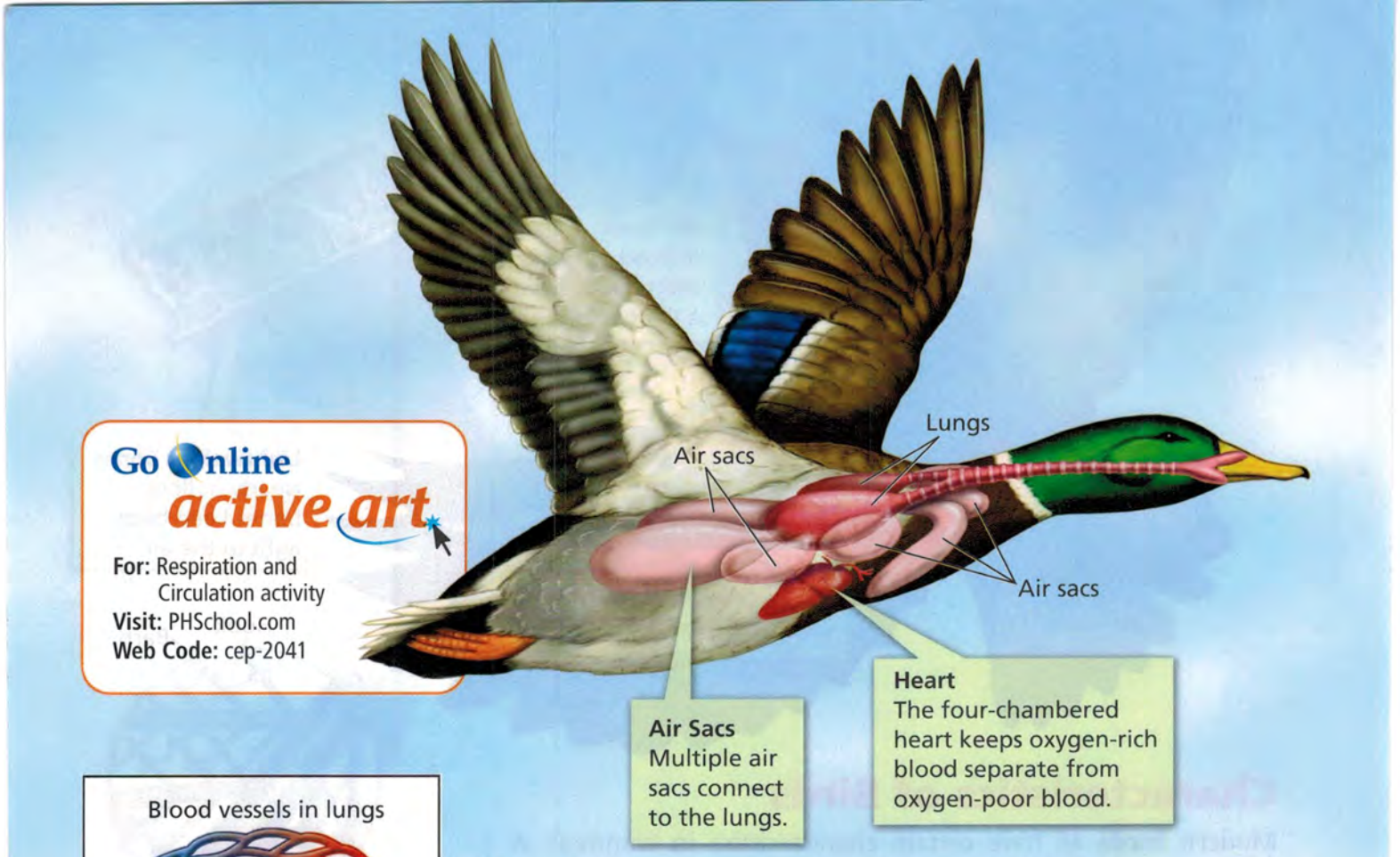
Modern **birds** all have certain characteristics in common. **A bird is an endothermic vertebrate that has feathers and a four-chambered heart. A bird also lays eggs.**

Adaptations for Flight The bodies of most birds are adapted for flight, as shown in Figure 1. 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 1 that a contour feather consists of a central shaft and many projections, called barbs. Hooks hold the barbs together. When birds fly, their barbs may pull apart, "unzipping" their feathers. Birds often pull the feathers through their bills to "zip" the barbs back together again.

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.

FIGURE 1
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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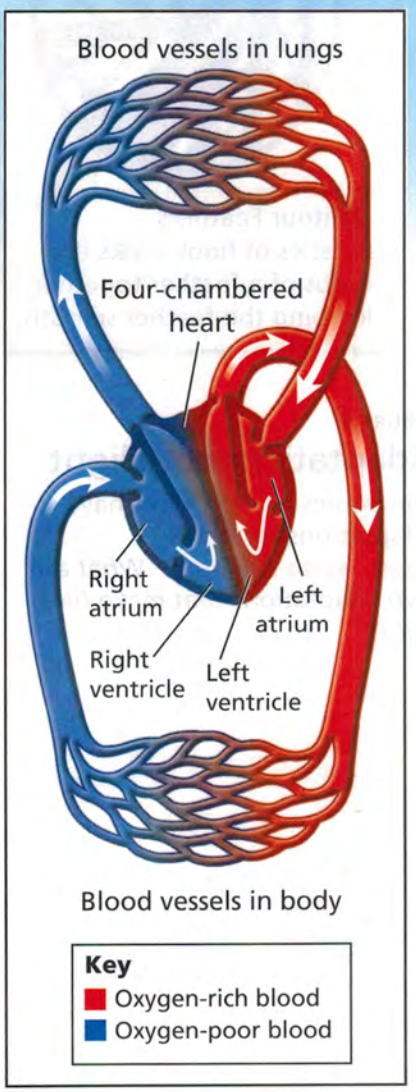


FIGURE 2
Respiration and Circulation
Air sacs and a four-chambered heart help birds obtain oxygen and move it to their cells.
Applying Concepts *Why is a four-chambered heart efficient?*

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. This system 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 2. 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 3. The crop is connected to the stomach.

The 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. Remember that 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.

Reading Checkpoint **What is a gizzard?**

FIGURE 3
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?*

FIGURE 4
Keeping Warm
A pine grosbeak puffs out its feathers to trap air in the layer of down feathers next to its skin.

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 4, 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. Humans use down feathers from the eider duck to insulate jackets, sleeping bags, and bedding.

FIGURE 5
A Down-Filled Jacket
Wearing a jacket stuffed with down feathers helps this boy stay warm.
Applying Concepts *Why is his down jacket so puffy?*

FIGURE 7

Diversity of Birds

Every bird has adaptations that help it live in its natural environment.

Owls ▲
Sharp vision and keen hearing help owls hunt at night. Razor-sharp claws and great strength allow larger owls, like this eagle owl, to prey on animals as large as deer.

Bee-Eaters ▲
This rainbow bee-eater feeds on bees and other insects, which it catches as it flies. Bee-eaters are found in Africa, Europe, Australia, and Asia.

◀ Game Birds
Wild turkeys are found in North America. When courting females, the male fans his tail feathers, holds his head high, and gobbles.

Birds in the Environment

With almost 10,000 species, birds are the most diverse land-dwelling vertebrates. **Birds are adapted for living in diverse environments. You can see some of these adaptations in the shapes of their legs, claws, and bills.** For example, the long legs and toes of wading birds, such as herons, cranes, and spoonbills, make wading easy. The claws of perching birds, such as goldfinches and mockingbirds, can lock onto a branch or other perch. The bills of woodpeckers are tools for chipping into the wood of trees. Birds also have adaptations for finding mates and caring for their young.

Birds play an important role in the environment. Nectar-eating birds, like hummingbirds, are pollinators. Seed-eating birds, like sparrows, carry the seeds of plants to new places. This happens when the birds eat the fruits or seeds of a plant, fly to a new location, and then eliminate some of the seeds in digestive wastes. In addition, birds are some of the chief predators of animals that may be pests. Hawks and owls eat rats and mice, while many perching birds feed on insect pests.

Reproduction and Caring for Young Like reptiles, birds have internal fertilization and lay eggs. Bird eggs are similar to reptile eggs except that their shells 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.

Reading Checkpoint **How is a bird egg different from a reptile egg?**

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 egg-shell 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.

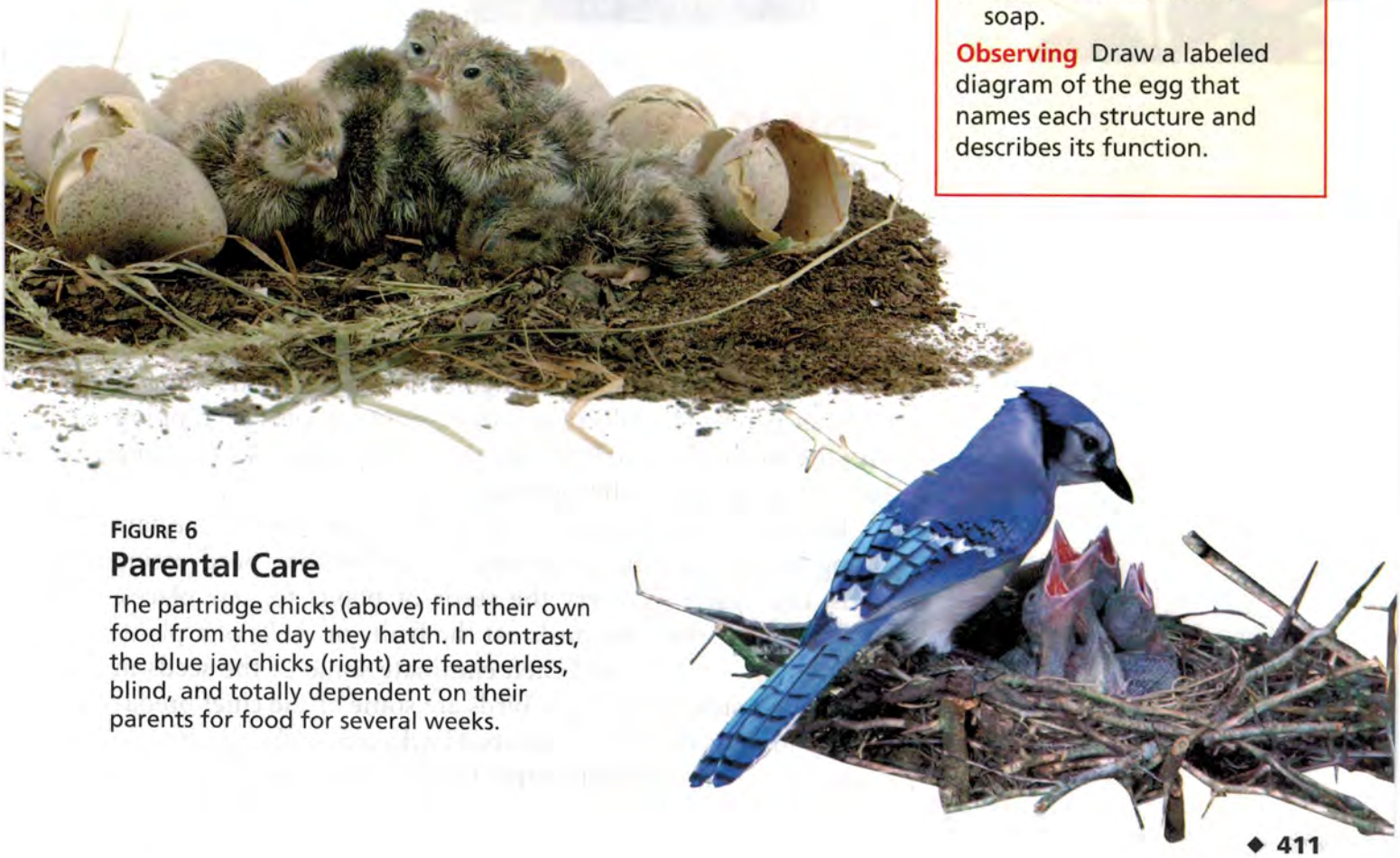


FIGURE 6
Parental Care
The partridge chicks (above) find their own food from the day they hatch. In contrast, the blue jay chicks (right) are featherless, blind, and totally dependent on their parents for food for several weeks.

Ostriches ▼
The ostrich, found in Africa, is the largest living bird. It cannot fly, but it can run at speeds greater than 60 kilometers per hour. Its speed helps it escape from predators.

◀ Long-Legged Waders
The roseate spoonbill is found in the southern United States and throughout much of South America. The spoonbill catches small animals by sweeping its long, flattened bill back and forth under water.

Perching Birds ▶
Perching birds represent more than half of all the bird species in the world. The painted bunting, a seed-eating bird, lives in the southern United States and northern Mexico.

Section 1 Assessment

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

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. **Listing** What are three types of adaptations that allow birds to survive in diverse environments?
   b. **Summarizing** What are three roles birds play in the environment?
   c. **Comparing and Contrasting** Look at Figure 7. Compare and contrast the adaptations of an eagle owl and a roseate spoonbill for obtaining food.

Lab zone At-Home Activity

Count Down With the help of a family member, look for products in your home that contain down feathers. (*Hint:* Don't forget to check closets!) What kinds of items contain down feathers? What common purpose do these items have? Explain to your family member what down feathers look like and where they are found on a bird.

Lab zone **Skills Lab**

Looking at an Owl's Leftovers

Problem

What can you learn about owls' diets from studying the pellets that they cough up?

Skills Focus

observing, drawing conclusions

Materials

- owl pellet
- hand lens
- dissecting needle
- metric ruler
- forceps

Procedure

1. An owl pellet is a collection of undigested materials that an owl coughs up after a meal. Write a hypothesis describing what items you expect an owl pellet to contain. List the reasons for your hypothesis.
2. Use a hand lens to observe the outside of an owl pellet. Record your observations.
3. Use one hand to grasp the owl pellet with forceps. Hold a dissecting needle in your other hand, and use it to gently separate the pellet into pieces. **CAUTION:** *Dissecting needles are sharp. Never cut material toward you; always cut away from your body.*
4. Using the forceps and dissecting needle, carefully separate the bones from the rest of the pellet. Remove any fur that might be attached to bones.
5. Group similar bones together in separate piles. Observe the skulls, and draw them. Record the number of skulls, their length, and the number, shape, and color of the teeth.
6. Use the chart on the right to determine what kinds of skulls you found. If any skulls do not match the chart exactly, record which animal skulls they resemble most.

Skull Identification Key

Shrew		Upper jaw has at least 18 teeth; tips of the teeth are reddish brown. Skull length is 23 mm or less.
House mouse		Upper jaw has two biting teeth and extends past lower jaw. Skull length is 22 mm or less.
Meadow vole		Upper jaw has two biting teeth that are smooth, not grooved. Skull length is 23 mm or more.
Mole		Upper jaw has at least 18 teeth. Skull length is 23 mm or more.
Rat		Upper jaw has two biting teeth. Upper jaw extends past lower jaw. Skull length is 22 mm or more.

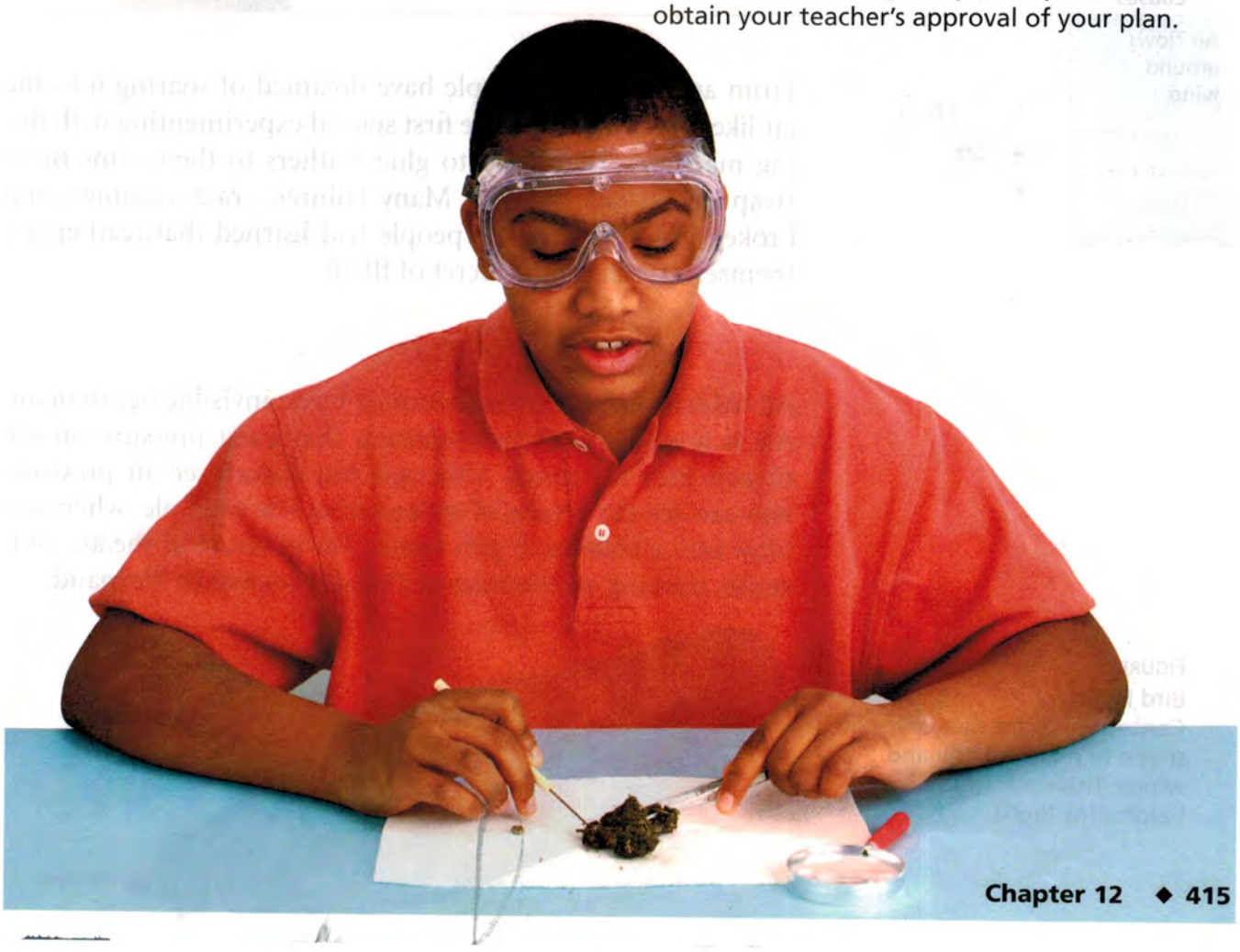
7. Try to fit together any of the remaining bones to form complete or partial skeletons. Sketch your results.
8. Wash your hands thoroughly with soap when you are finished.

Analyze and Conclude

1. **Observing** How many animals' remains were in the pellet? What observations led you to that conclusion?
2. **Drawing Conclusions** Combine your results with the results of your classmates. Based on your class's data, which three animals were eaten most frequently? How do these results compare to your hypothesis?
3. **Calculating** Owls cough up about two pellets a day. Based on your class's data, what can you conclude about the number of animals an owl might eat in one month?
4. **Communicating** In this lab, you were able to examine only the part of the owl's diet that it did not digest. In a paragraph, explain how this fact might affect your confidence in the conclusions you reached.

Design an Experiment

Design an experiment to determine how an owl's diet varies at different times of the year. Give an example of a hypothesis you could test with such an experiment. What variables would you control? Before carrying out your experiment, obtain your teacher's approval of your plan.



The Physics of Bird Flight

Reading Preview

Key Concepts

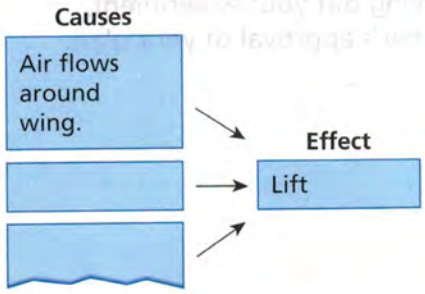
- What causes a bird to rise in the air?
- How may birds fly?

Key Term

- lift

Target Reading Skill

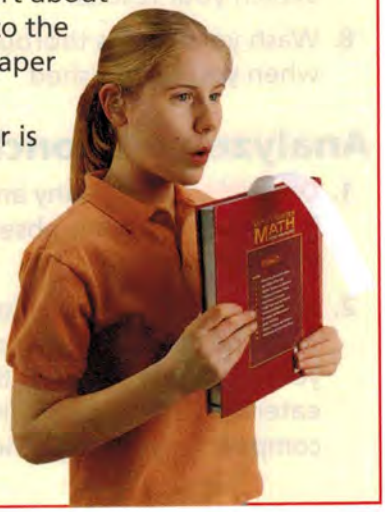
Relating Cause and Effect A cause makes something happen. An effect is what happens. As you read, identify the physical properties of a bird's wing that cause lift. Write them in a graphic organizer like the one below.



Lab zone Discover Activity

What Lifts Airplanes and Birds Into the Air?

1. Cut a strip of notebook paper 5 centimeters wide and 28 centimeters long. Insert about 5 centimeters of the paper strip into the middle of a book. The rest of the paper strip should hang over the edge.
2. Hold the book up so that the paper is below your mouth.
3. Blow gently across the top of the paper and watch what happens to the paper. Then blow harder.



Think It Over

Predicting If a strong current of air flowed across the top of a bird's outstretched wing, what might happen to the bird?

From ancient times, people have dreamed of soaring into the air like birds. When people first started experimenting with flying machines, they tried to glue feathers to their arms or to strap on feathered wings. Many failures, crash-landings, and broken bones later, these people had learned that feathers by themselves weren't the secret of flight.

Staying in the Air

All objects on land are surrounded by an invisible ocean of air. Air is a mixture of gas molecules that exert pressure on the objects they surround. Although you cannot see air pressure, you can see the results of air pressure. For example, when you blow into a balloon, it gets larger. The pressure of the air molecules pushing on the sides of the balloon makes it expand.

FIGURE 8
Bird Feather
Contour feathers give a smooth shape to a bird's body and wings. This smooth shape is helpful for flight.

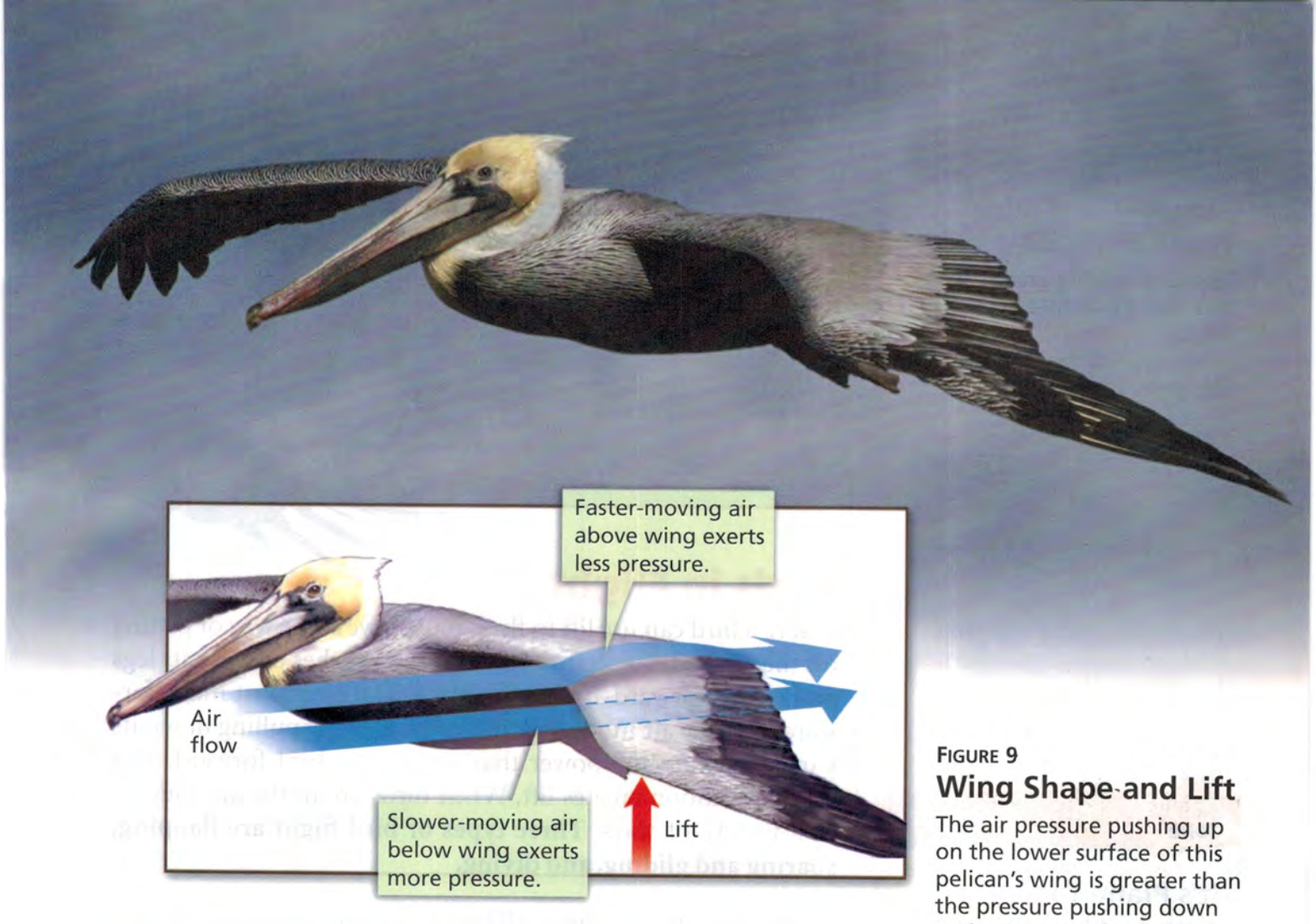


FIGURE 9
Wing Shape and Lift
The air pressure pushing up on the lower surface of this pelican's wing is greater than the pressure pushing down on its upper surface.
Relating Cause and Effect *How does the difference in pressure help a bird fly?*

Movement and Air Pressure Air does not have to be inside a balloon to exert pressure. Moving air exerts pressure, too. The faster air moves, the less pressure it exerts. You saw this in the Discover Activity. The air blowing across the top of the paper was in motion. This moving air exerted less pressure on the paper than the air beneath it, so the paper rose.

Air Movement Around a Wing Like the paper, a flying bird's wing is surrounded by air molecules that exert pressure on the wing's surfaces. The wing allows air to flow smoothly over and under it. When a bird is between wing beats, the angle and shape of the wing cause the air to move faster above the wing than below it, as shown in Figure 9. The faster-moving air above the bird's wing exerts less pressure than the slower-moving air below it. **The difference in pressure above and below the wings as a bird moves through the air produces an upward force that causes the bird to rise.** That upward force is called **lift.**

Reading Checkpoint **As air moves faster, what happens to the pressure it exerts?**

FIGURE 10
Types of Flight
Flapping, soaring and gliding, and diving are three types of flight. **Applying Concepts** *Which type of flight requires the most energy? Explain.*

Birds in Flight

Before a bird can use lift to fly, it must have some way of getting off the ground. To get into the air, a bird pushes off with its legs and moves forward at the same time. The bird must move forward to make air move over its wings. Sharply pulling down its wings provides the power that pushes the bird forward. The forward motion creates lift. When birds are in the air, they fly in a variety of ways. **Three types of bird flight are flapping, soaring and gliding, and diving.**

Flapping Once in flight, all birds continue to flap their wings at least part of the time. To flap, a bird must sharply pull down its wings as it did when it pushed off the ground. Most small birds, such as sparrows, depend heavily on flapping flight. Canada geese and many other birds that travel long distances also use flapping flight. Flapping requires a lot of energy.

Soaring and Gliding Unlike flapping flight, soaring and gliding flight involve little wing movement. Birds soar and glide with their wings extended. When soaring, birds use rising currents of warm air to move upward. In contrast, when gliding, birds use falling currents of cool air to move downward. Soaring and gliding use less energy than flapping because they require less wing movement.

Sometimes birds fly using a combination of soaring and gliding. They "take the elevator up" by flying into a current of warm, rising air. The birds stretch their wings out and circle round and round, moving upward within the current of rising air. As the warm air rises it starts to cool. Finally, the air stops rising. At this point the bird begins gliding downward until it reaches another "up elevator" of rising air.

Lab zone **Try This Activity**

It's Plane to See

1. Work with a partner to design a paper airplane with wings shaped like those of a bird. You can use any of these materials: paper, tape, glue, paper clips, string, rubber bands, and staples. Draw a sketch of your design.
2. Construct your "birdplane" and make one or two trial flights. If necessary, modify your design and try again.
3. Compare your design with those of other groups. Which designs were most successful?

Making Models In what ways was the flight of your airplane like the flight of a bird? In what ways was it different?

By soaring and gliding, this bald eagle moves up, down, and forward using very little energy.

This pelican is beginning its dive toward a meal of fish.

Diving A type of flight that doesn't use lift is diving. Birds that hunt their prey from the sky may use diving flight. For example, a brown pelican flies above the ocean, looking for schools of fish under the water's surface. Once it spots the fish, the pelican dives with great speed. As it dives, the pelican pulls its wings in close to its body. Pulling in the wings changes the pelican's body shape. The new body shape produces no lift at all. Without lift, the pelican falls from the sky headfirst into the ocean and hits the fish with enough force to stun them.

Some hawks and falcons dive from high in the sky towards their prey, too. Peregrine falcons can clock speeds up to 300 kilometers per hour while diving for pigeons or other prey.

Reading Checkpoint **Which type of bird flight is the fastest?**

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Section 2 Assessment

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

Reviewing Key Concepts

1. a. **Defining** What is lift?
   b. **Explaining** What effect does lift have on a flying bird?
   c. **Applying Concepts** What causes lift in an airplane?
2. a. **Identifying** What are three types of bird flight?
   b. **Summarizing** How does a bird take off from the ground to fly?
   c. **Comparing and Contrasting** How are soaring and gliding alike? How are they different?

Writing in Science

Advertisement You have been hired by an outdoor adventure company to write an exciting ad for one of their birdwatching hikes. In the ad, describe several interesting birds and types of bird flight that people will see on the hike.

Section 3

Mammals

Reading Preview

Key Concepts

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

Key Terms

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

Target Reading Skill

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

Lab zone

Discover Activity

What 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

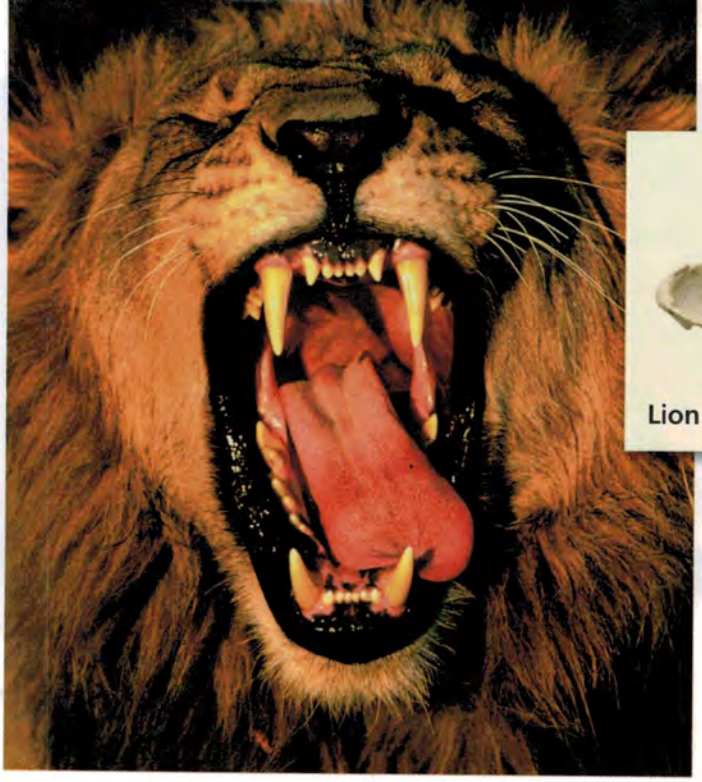
Inferring What is the advantage of having teeth with different shapes?

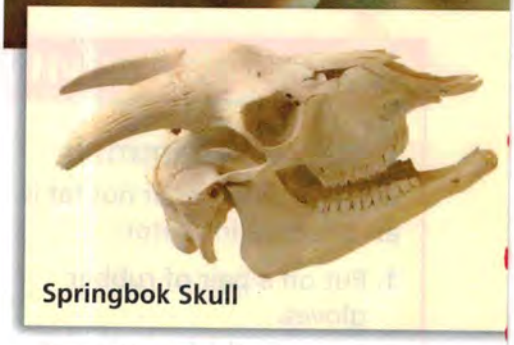
High in the Himalaya Mountains of Tibet, several yaks inch their way, single file, along a narrow cliff path. The cliff plunges thousands of meters to the valley below, so one false step can mean disaster. But the sure-footed yaks, carrying heavy loads of grain, slowly but steadily cross the cliff and 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 Discover Activity, 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 11, 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.

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

FIGURE 11
Teeth of Different Shapes
Lions have sharp, pointed canines. Springboks have broad molars.
Inferring *What kind of diet does each of these mammals eat?*

FIGURE 12
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. The amount of fur or hair that covers a mammal's skin varies greatly. Each strand of fur or hair is composed of dead cells strengthened with the same tough material that strengthens feathers. In general, animals that live in cold regions, like the wolf shown in Figure 12, have more fur than animals from 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 In addition to adaptations for living in cold environments, 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, orangutans swing by their arms from branch to branch, and "flying" squirrels can spread their limbs and glide down from high perches. Bats have wings adapted from their front limbs. Whales, dolphins, and other sea mammals lack hind limbs, but their front limbs are adapted as flippers for swimming in water. 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 enable them to see in the dark. Bats use a keen sense of hearing to navigate in the dark and catch prey. Dogs, cats, and bears often use smell to track their prey. Other mammals, such as antelopes, can smell approaching predators in time to flee.

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

FIGURE 13
A Swinging Orangutan
This young orangutan can grasp branches with its limbs and swing from place to place.

FIGURE 14
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. Look at the spiny anteater and the kangaroo shown on this page. Both are mammals that feed their young milk. But, in other ways, they are different. **There are three main groups of mammals—monotremes, marsupials, and placental mammals. The groups differ in how their young develop.**

FIGURE 15
A Spiny Anteater
The young of this spiny anteater, a monotreme, hatch from eggs.

Monotremes Egg-laying mammals are called **monotremes.** 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.

Marsupials Koalas, kangaroos, and opossums are some of the better-known marsupials. **Marsupials** 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.

FIGURE 16
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 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 18 on the next page.

Reading Checkpoint What is a placenta?

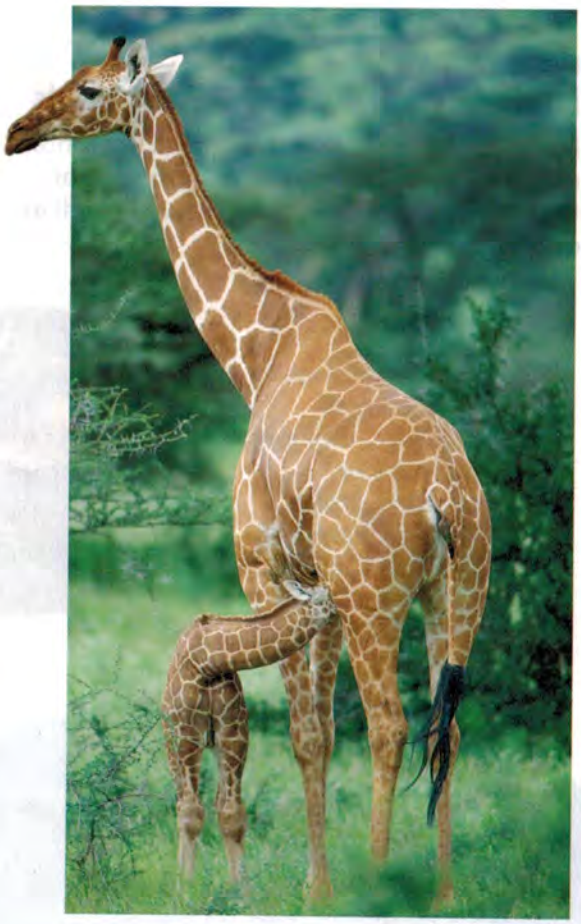


FIGURE 17 Mother and Baby Giraffe This baby giraffe, a placental mammal, feeds on milk produced by its mother.

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

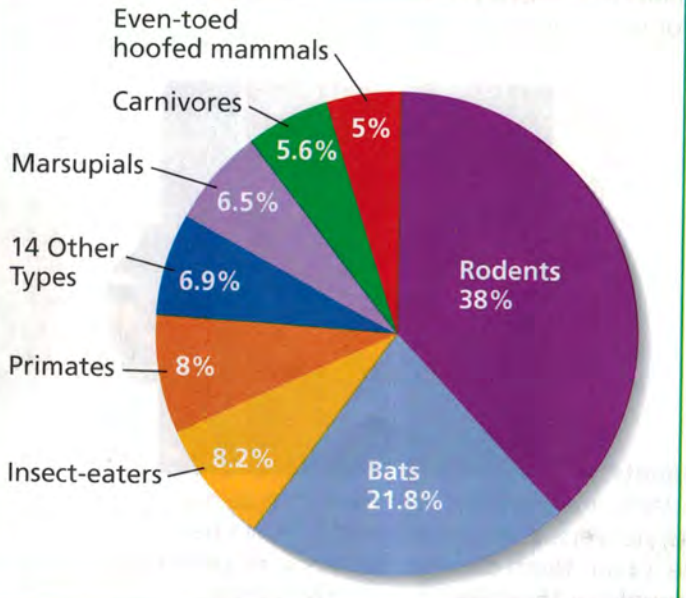


FIGURE 18

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 19
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 3 Assessment

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

Reviewing Key Concepts

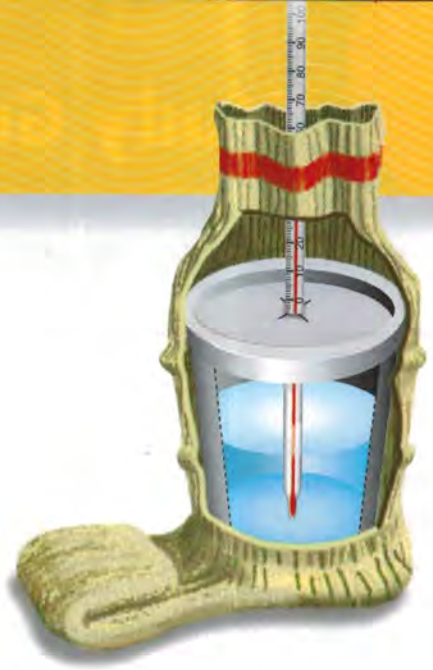
1. a. **Defining** What characteristics do mammals share?
   b. **Describing** Describe the adaptation that most mammals have for obtaining food.
   c. **Relating Cause and Effect** What enables mammals to live in colder environments than reptiles? Explain.
2. a. **Reviewing** What are the three main groups of mammals?
   b. **Explaining** How do monotremes, marsupials, and placental mammals differ?
   c. **Interpreting Photographs** Look at Figure 18. Describe the adaptations for movement of marine mammals and flying 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.

Lab zone **Consumer Lab**

Keeping Warm



Problem

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 **Structure and Function** Both birds and mammals are endothermic vertebrates with four-chambered hearts.

1 Birds

Key Concepts

- A bird is an endothermic vertebrate that has feathers and a four-chambered heart. A bird also lays eggs.
- Birds are adapted for living in diverse environments. You can see some of these adaptations in the shapes of their legs, claws, and bills.

Key Terms

bird
contour feather
down feather
crop
gizzard

2 The Physics of Bird Flight

Key Concepts

- The difference in pressure above and below the wings as the bird moves through the air produces an upward force that causes the bird to rise.
- Three types of bird flight are flapping, soaring and gliding, and diving.

Key Term

lift

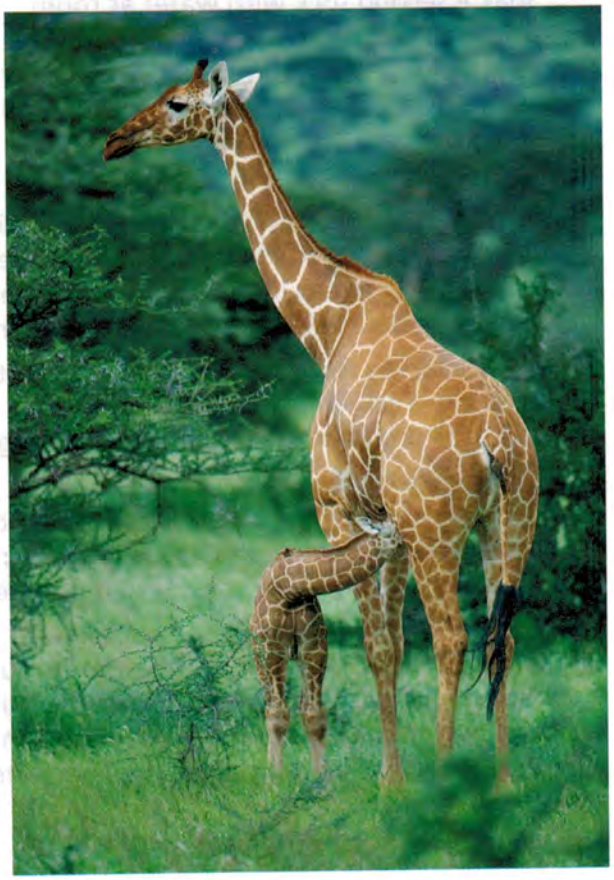
3 Mammals

Key Concepts

- 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.
- 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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Organizing Information

Comparing and Contrasting Copy the table comparing mammal groups onto a sheet of paper. Then fill in the empty spaces and add a title.

Characteristic	Monotremes	Marsupials	Placental Mammals
How Young Begin Life	a. ?	b. ?	c. ?
How Young Are Fed	milk from pores or slits on mother's skin	d. ?	e. ?
Example	f. ?	g. ?	h. ?

Reviewing Key Terms

Choose the letter of the best answer.

1. Birds are the only animals with
   a. scales.
   b. wings.
   c. feathers.
   d. a four-chambered heart.
2. The gizzard of a bird
   a. stores air.
   b. removes oxygen from air.
   c. helps a bird fly.
   d. grinds food.
3. An organ that produces milk to feed the young is called a
   a. mammary gland.
   b. placenta.
   c. pouch.
   d. egg.
4. Which muscle helps mammals move air into and out of their lungs?
   a. air muscle
   b. diaphragm
   c. placenta
   d. gestation
5. A monotreme differs from a placental mammal because it
   a. has fur.
   b. has a placenta.
   c. lays eggs.
   d. feeds its young milk.

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

6. Down feathers give shape to a bird's body.
7. A bird's crop stores food.
8. The upward force on a bird's moving wing is called lift.
9. The function of contour feathers is similar to the function of fur.
10. A diaphragm is the length of time between fertilization and birth.

Writing in Science

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

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Birds and Mammals
Video Preview
Video Field Trip
▶ Video Assessment

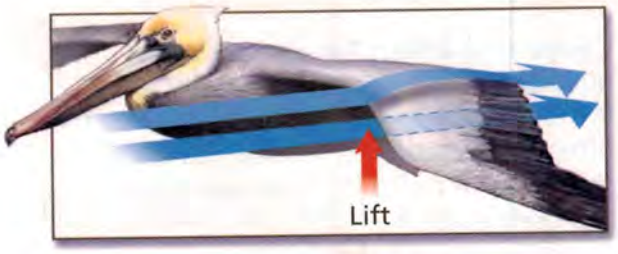
Review and Assessment

Checking Concepts

11. Explain how the skeleton of a bird is adapted for flight.
12. What adaptations help a bird obtain enough oxygen for flight? Explain.
13. Why is a bird's circulatory system efficient? Explain.
14. What causes lift?
15. Explain how soaring and gliding birds such as vultures use air currents in their flight.
16. How does the structure of an incisor relate to its function?
17. Identify and explain two ways in which mammals are adapted to live in climates that are very cold.
18. What is the function of a mammal's nervous system?

Thinking Critically

19. **Making Generalizations** What is the general relationship between whether an animal is an endotherm and whether it has a four-chambered heart? Relate this to the animal's need for energy.
20. **Relating Cause and Effect** Look at the diagram below. Explain how lift occurs and what effect it has on the bird.



21. **Applying Concepts** Why do whales, polar bears, and seals have a thick layer of fat?
22. **Predicting** If a rodent were fed a diet consisting only of soft food that it did not need to gnaw, what might its front teeth look like after several months? Explain.

Applying Skills

Use the information in the table to answer Questions 23–25.

The data table below shows the approximate gestation period of several mammals and the approximate length of time that those mammals care for their young after birth.

Mammal	Gestation Period	Time Spent Caring for Young After Birth
Deer mouse	0.75 month	1 month
Chimpanzee	8 months	24 months
Harp seal	11 months	0.75 month
Elephant	21 months	24 months
Bobcat	2 months	8 months

23. **Graphing** Decide which kind of graph would be best for showing the data in the table. Then construct two graphs—one for gestation period and the other for time spent caring for young.
24. **Interpreting Data** Which mammals listed in the table care for their young for the longest time? The shortest time?
25. **Drawing Conclusions** How are the size of the mammal and the length of time it cares for its young related? Which animal is the exception to this pattern?

Lab zone Chapter Project

Performance Assessment When you present your bird-watch project, display your graphs, charts, and pictures. Describe the ways in which birds eat and the interesting examples of bird behavior you observed. Then, analyze how successful the project was. Was the bird feeder located in a good place for attracting and observing birds? Did many birds come to the feeder? If not, why might this have happened? What are the advantages and limitations of using field guides for identifying birds?

Standardized Test Prep

Test-Taking Tip

Answering a Constructed Response Question

Be sure you understand the question before you begin. For example, are you being asked to write a description or to compare and contrast two items? Consider what information you should include in order to give a complete answer that addresses all the specific points asked for in the question. Your answer should also be organized. Take the time to decide how to best sequence the information in your response.

Sample Question

Both birds and mammals are endotherms. Compare and contrast how the two different groups of animals maintain their body temperatures. Consider the physical characteristics of each group in your response.

Answer

You might begin your answer with a brief review of the word *endotherm* and then continue by stating the similarities and differences in how birds and mammals maintain their body temperatures. Give specific examples that support your answer. For instance, if you state that birds and mammals have different body coverings to help keep them warm, you would state that down feathers help insulate a bird, whereas fur or hair helps insulate a mammal.

Choose the letter of the best answer.

1. Of the following structures found in a bird, which one's main function is to store food?
   - **A** stomach
   - **B** gizzard
   - **C** crop
   - **D** bill

2. Which characteristics do birds and mammals share?
   - **F** Both are endothermic vertebrates.
   - **G** Both have fur or hair.
   - **H** Both have a three-chambered heart.
   - **J** Both are vertebrates that produce milk.

3. The diagram above shows the jawbone and teeth of an animal. The front of the mouth faces left. Which of the following best describes the teeth?
   - **A** many sharp canines
   - **B** broad molars at the back of the mouth
   - **C** molars at the front of the mouth
   - **D** flat incisors at the back of the mouth

4. Based on the kinds of teeth you observe in the diagram above, make your best inference about what this animal might be.
   - **F** bird
   - **G** cow
   - **H** rabbit
   - **J** bear

5. Which of the following best describes the function of the placenta?
   - **A** to deliver oxygen to the body's cells
   - **B** to store food inside the body before swallowing and digesting it
   - **C** to direct and coordinate a mammal's complex movements
   - **D** to pass materials between a mother and her offspring before it is born

Constructed Response

6. Describe how birds care for their eggs and newly hatched young. Your answer should include information about why this care is necessary.

Chapter 13

Animal Behavior

The BIG Idea

Animal Behavior and Communication

How does an animal's behavior contribute to its survival?

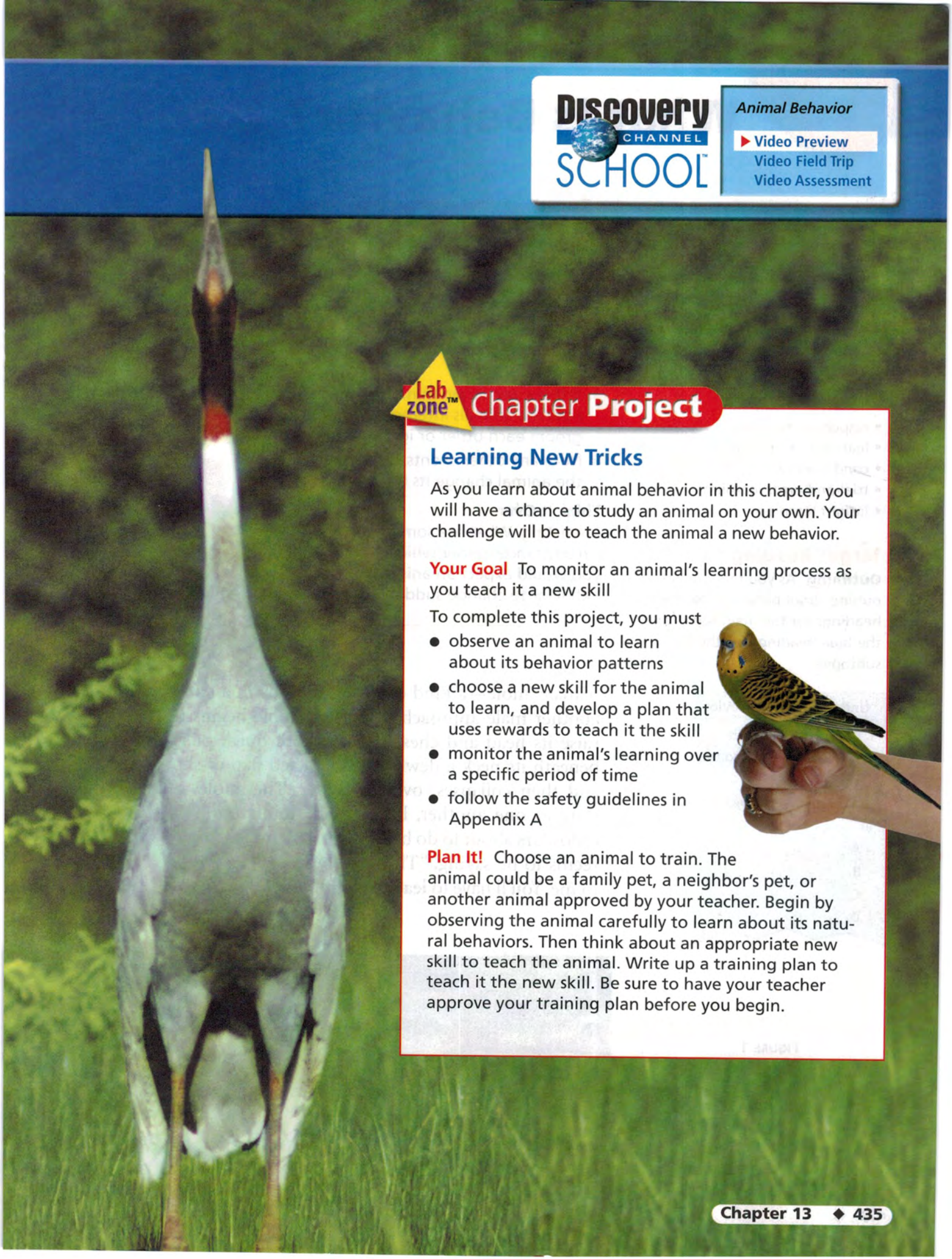
Chapter Preview

1 What Is Behavior?
Discover What Behaviors Can You Observe?
Skills Activity Predicting
Analyzing Data "A-maze-ing" Mice
Design Your Own Lab Become a Learning Detective

2 Patterns of Behavior
Discover What Can You Express Without Words?
Active Art Pheromones
Skills Activity Developing Hypotheses
Try This Worker Bees
At-Home Activity Animal Signs
Skills Lab One for All

3 Tracking Migrations
Discover How Can You Track Animals?

This pair of Sarus cranes is engaged in an elaborate courtship dance.



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Animal Behavior

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

Learning New Tricks

As you learn about animal behavior in this chapter, you will have a chance to study an animal on your own. Your challenge will be to teach the animal a new behavior.

Your Goal To monitor an animal's learning process as you teach it a new skill

To complete this project, you must

- observe an animal to learn about its behavior patterns
- choose a new skill for the animal to learn, and develop a plan that uses rewards to teach it the skill
- monitor the animal's learning over a specific period of time
- follow the safety guidelines in Appendix A

Plan It! Choose an animal to train. The animal could be a family pet, a neighbor's pet, or another animal approved by your teacher. Begin by observing the animal carefully to learn about its natural behaviors. Then think about an appropriate new skill to teach the animal. Write up a training plan to teach it the new skill. Be sure to have your teacher approve your training plan before you begin.

Section 1

What Is Behavior?

Reading Preview

Key Concepts

- What causes animal behavior?
- What are instincts?
- What are four types of learned behaviors?

Key Terms

- behavior
- stimulus
- response
- instinct
- learning
- imprinting
- conditioning
- trial-and-error learning
- insight learning

Target Reading Skill

Outlining As you read, make an outline about behavior. Use the red headings for the main topics and the blue headings for the subtopics.

Understanding Behavior
I. Behavior of animals
A. Behavior as response
B.
II. Behavior by instinct
III.
A.
B.
C.
D.

Lab zone Discover Activity

What Behaviors Can You Observe?

1. Observe the behavior of a small vertebrate, such as a gerbil or a goldfish, for a few minutes. Write down your observations.
2. Place some food near the animal and observe the animal's behavior.
3. If there are other animals in the cage or aquarium, observe how the animals interact—for example, do they groom each other or ignore each other?
4. Note any other events that seem to make the animal change its behavior.

Think It Over

Predicting What are some circumstances under which you would expect an animal's behavior to change suddenly?

A male anole—a kind of lizard—stands in a patch of sun. As another male approaches, the first anole begins to lower and raise its head and chest in a series of quick push-ups. From beneath its neck a dewlap, a bright red flap of skin, flares out and then collapses, over and over. The anoles stare at one another, looking like miniature dinosaurs about to do battle. The first anole seems to be saying, "This area belongs to me. You'll have to leave or fight!"

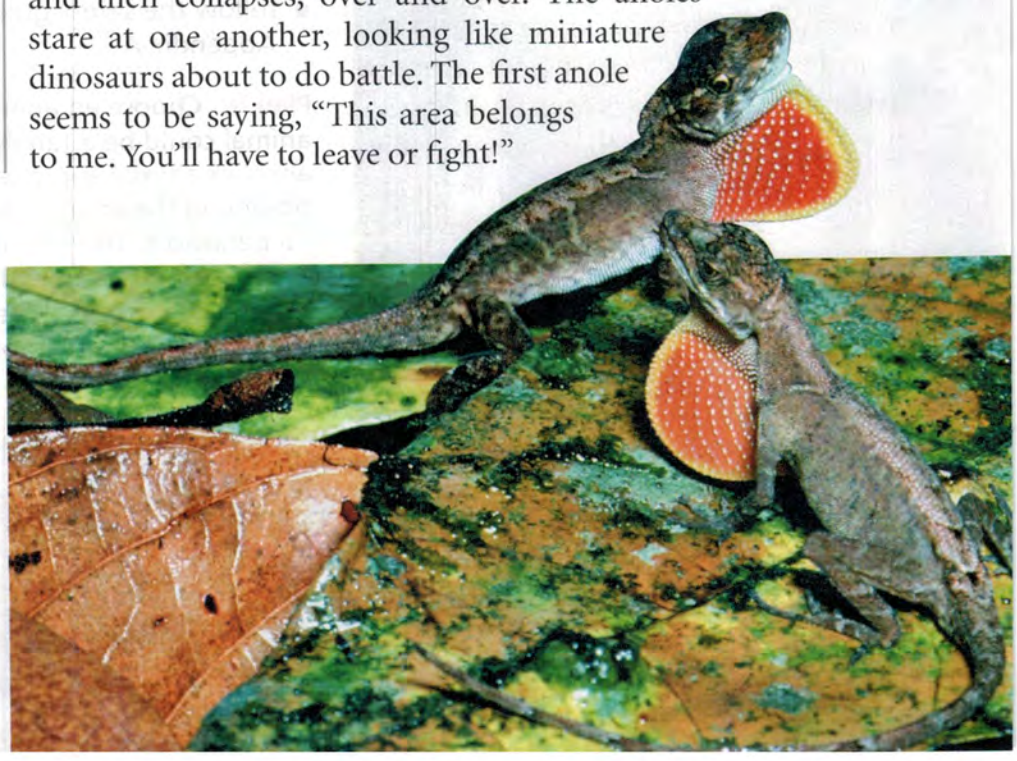


FIGURE 1
Dewlap Display
These two anoles are displaying their dewlaps in a dispute over space.

The Behavior of Animals

The dewlap display by anole lizards is one example of behavior. An animal's **behavior** consists of all the actions it performs. For example, behaviors include actions an animal takes to obtain food, avoid predators, and find a mate. Like body structures, the behaviors of animals are adaptations that have evolved over long periods of time.

Most behavior is a complex process in which different parts of an animal's body work together. Consider what happens when a water current carries a small animal to a hydra's tentacles. After stinging cells on the tentacles catch the prey, the tentacles bend toward the hydra's mouth. At the same time, the hydra's mouth opens to receive the food.

Behavior as Response In the previous situation, the touch of the prey on the tentacles acts as a stimulus to the hydra. A **stimulus** (plural *stimuli*) is a signal that causes an organism to react in some way. The organism's reaction to the stimulus is called a **response.** The hydra's response to the prey is to sting it. **All animal behaviors are caused by stimuli.**

Some stimuli, such as prey brushing a hydra's tentacles, are outside the animal. Other stimuli, such as hunger, come from inside. An animal's response may include external actions or internal changes (such as a faster heartbeat), or both.

The Functions of Behavior Most behaviors help an animal survive or reproduce. When an animal looks for food or hides to avoid a predator, it is doing something that helps it stay alive. When animals search for mates and build nests for their young, they are behaving in ways that help them reproduce.

Reading Checkpoint What is a stimulus?

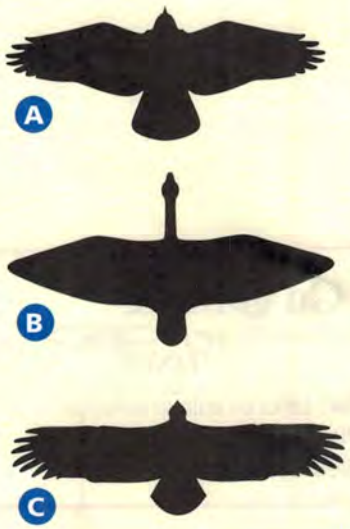
FIGURE 2
A Moth's Startling "Eyes"
Certain moths have markings on their underwings that resemble eyes. When the moth is poked by a predator, it raises its forewings to reveal the "eyes." **Predicting** *How is this behavior important to the moth's survival?*

FIGURE 3
A Web Built by Instinct
Most spiders know by instinct how to build elaborate webs.

Lab zone Skills Activity

Predicting

Hawks, which have short necks, prey on gull chicks. Geese, which have long necks, do not prey on the chicks. When newly hatched gull chicks see any bird's shadow, they instinctively crouch down. As the chicks become older, they continue to crouch when they see the shadow of a hawk, but they learn not to crouch when they see a goose's shadow. Predict how older gull chicks will behave when they see bird shadows shaped like A, B, and C. Explain your prediction.



Behavior by Instinct

Animals perform some behaviors by **instinct,** without being taught. **An instinct is a response to a stimulus that is inborn and that an animal performs correctly the first time.** For example, a newborn kangaroo instinctively crawls into its mother's pouch and attaches itself to a nipple. Without this instinct, baby kangaroos could not obtain the milk they need to survive.

Some instincts are fairly simple. Earthworms, for example, crawl away from bright light. Other instincts are complex. Spiders spin complicated webs on their first try without making mistakes in the pattern. Most birds build their nests without ever being taught how.

Reading Checkpoint **What is an instinct?**

Learned Behavior

Recall the first time you rode a bicycle. It probably took a few tries before you did it well—you had to learn how. **Learning** is the process that leads to changes in behavior based on practice or experience. In general, the larger an animal's brain, the more the animal can learn. **Learned behaviors include imprinting, conditioning, trial-and-error learning, and insight learning.** Because learned behaviors result from an animal's experience, they are not usually done perfectly the first time.

All learned behaviors depend in part on inherited traits that have passed from parents to offspring. For example, lion cubs inherit physical features and instincts that are necessary for hunting. They are born with claws that help them capture prey. They also are born with the instinct to pounce on any object that attracts their attention. However, only through experience can they learn how to master hunting skills.

Imprinting Imprinting is a learned behavior. In **imprinting,** certain newly hatched birds and newborn mammals recognize and follow the first moving object they see. This object is usually the mother of the young animals. Imprinting involves a combination of instinct and learning. The young animal has an instinct to follow a moving object, but is not born knowing what its parent looks like. The young animal learns from experience what object to follow.

Once imprinting takes place, it cannot be changed. That is true even if the young animal has imprinted on something other than its mother. Young animals have imprinted on moving toys and even humans. Konrad Lorenz, an Austrian scientist, conducted experiments in which he, rather than the mother, was the first moving object that newly hatched birds saw. Figure 4 shows the result of one such experiment. Even as adults, the ducks followed Lorenz around.

Imprinting is valuable for two reasons. First, it keeps young animals close to their mothers, who know where to find food and how to avoid predators. Second, imprinting allows young animals to learn what other animals of their own species look like. This ability protects the animals while they are young. In later life, this ability is important when the animals search for mates.

FIGURE 4
Imprinting
Konrad Lorenz got these ducks to imprint on him by making himself the first moving object they ever saw.
Relating Cause and Effect *Why are the ducks following the swimmer?*

FIGURE 5

Conditioning

Pavlov followed specific steps to condition a dog to salivate at the sound of a bell.

Predicting *Predict what the dog would do if it heard a bell ringing in another part of the house.*

1 When a hungry dog sees or smells food, it produces saliva. Dogs do not usually salivate in response to other stimuli, such as the sound of a ringing bell.

2 For many days, Pavlov rang a bell every time that he fed the dog. The dog learned to associate the ringing of the bell with the sight and smell of food.

3 Thus, when Pavlov rang a bell but did not give the dog food, the dog still produced saliva. The new stimulus produced the response that normally only food would produce.

Conditioning When a dog sees its owner approaching with a leash, the dog may jump up, eager to go for a walk. The dog has learned to associate the leash with a pleasant event—a brisk walk. Learning that a particular stimulus or response leads to a good or a bad outcome is called **conditioning.**

Pets are often trained using a form of conditioning. Suppose you want to train a puppy to come when you call it. The desired response is the puppy coming to you when it hears your call. The good outcome you will use is a food reward: a dog biscuit.

Here is how the conditioning works. At first, the puppy rarely comes when you call. But every now and then, the puppy runs to you in response to your call. Each time the puppy comes when you call, you give it a dog biscuit. Your puppy will soon learn to associate the desired response—coming when called—with the good outcome of a food reward. To get the reward, the puppy learns to come every time you call. After a while, the puppy will come to you even if you don't give it a dog biscuit.

During the early 1900s, the Russian scientist Ivan Pavlov performed experiments involving one kind of conditioning. Figure 5 shows the steps that Pavlov followed in his experiments.

FIGURE 7
Insight Learning
Using insight, this raven has figured out how to bring meat hanging from a string close enough to eat.

Insight Learning The first time you try out a new video game, you may not need someone to explain how to play it. Instead, you may use what you already know about other video games to figure out how the new one works. When you solve a problem or learn how to do something new by applying what you already know, without a period of trial-and-error, you are using **insight learning.**

Insight learning is most common in primates, such as gorillas, chimpanzees, and humans. For example, chimpanzees use twigs to probe into the nests of termites and other insects that they eat. The chimps use insight to bend or chew their twig "tools" into a shape that will best fit the holes.

In addition to primates, other kinds of animals have also shown insight learning. For example, you may be surprised to learn that the raven shown in Figure 7 is using insight learning to obtain food. The raven uses its beak to draw up a loop of string. Then, it holds the loop under its foot and draws up a second loop, and so on. Soon the food is within reach.

Reading Checkpoint **Give two examples of animals showing insight learning.**

Section 1 Assessment

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

Reviewing Key Concepts

1. a. **Defining** What are signals that cause behavior called?
   b. **Describing** What is meant by *response?* Describe an example of a response.
   c. **Relating Cause and Effect** What are the functions of behavior? Think about the response you described. What function did that response serve?
2. a. **Listing** What are instincts? List two examples.
   b. **Inferring** Would instincts get better with practice? Explain.
   c. **Developing Hypotheses** Why do you think instincts are particularly important for newborn animals?
3. a. **Identifying** Identify the types of learned behaviors.
   b. **Reviewing** Describe what happens during imprinting.
   c. **Predicting** Right after hatching, before seeing anything else, a duckling sees a child riding a tricycle. What will probably happen the next time the child rides the tricycle in front of the duckling? Explain.

Writing in Science

List of Questions Suppose you could travel back in time and interview Dr. Pavlov and Dr. Lorenz. Formulate a list of five questions you would ask each scientist about his research on animal learning.

Math Analyzing Data

"A-maze-ing" Mice

A scientist conducted an experiment to find out whether mice would learn to run a maze more quickly if they were given rewards. She set up two identical mazes. In one maze, cheese was placed at the end of the correct route through the maze. No cheese was placed in the second maze. Use the graph below to answer the questions.

Maze Completion Times

1. **Reading Graphs** On Day 1, what was the average time it took mice with a cheese reward to complete the maze?
2. **Calculating** On Day 6, how much faster did mice with a reward complete the maze than mice without a reward?
3. **Interpreting Data** What was the manipulated variable in this experiment? Explain.
4. **Drawing Conclusions** Was the rate of learning faster for mice with the cheese reward or without the cheese reward? Explain.

Trial-and-Error Learning One form of conditioning is trial-and-error learning. In **trial-and-error learning,** an animal learns to perform a behavior more and more skillfully. Through repeated practice, an animal learns to repeat behaviors that result in rewards and avoid behaviors that result in punishment. When you learned to ride a bicycle, you did it by trial-and-error. You may have wobbled at first, but eventually you got better. You learned to move in ways that adjusted your balance and kept you from falling over.

Many animals learn by trial-and-error which methods are best for obtaining food. They also learn which methods to avoid. Think of what happens when a predator tries to attack a skunk. The skunk sprays the predator with a substance that stings and smells awful. In the future, the predator is likely to avoid skunks. The predator has learned to associate the sight of a skunk with its terrible spray.

FIGURE 6
Trial-and-Error Learning
After several failed attempts, this squirrel has finally figured out how to jump onto a hummingbird feeder, balance itself, and drink the water.

Lab zone

Design Your Own Lab

Become a Learning Detective

Problem

What are some factors that make it easier for people to learn new things?

Skills Focus

calculating, posing questions, designing experiments

Materials

- paper
- pencil

Design a Plan

1. Look over the two lists of words shown in the diagram on this page. Researchers use groups of words like these to investigate how people learn. Notice the way the two groups differ. The words in List A have no meanings in ordinary English. List B contains familiar but unrelated words.
2. What do you think will happen if people try to learn the words in each list? Write a hypothesis about which list will be easier to learn. How much easier will it be to learn that list?
3. With a partner, design an experiment to test your hypothesis. Brainstorm a list of the variables you will need to control in order to make the results of your experiment reliable. Then write out your plan and present it to your teacher.
4. If necessary, revise your plan according to your teacher's instructions. Then perform your experiment using people your teacher has approved as test subjects. Keep careful records of your results.

List A	List B
zop	bug
rud	rag
tig	den
wab	hot
hev	fur
paf	wax
mel	beg
kib	cut
col	sip
nug	job

Analyze and Conclude

1. **Calculating** Find the average (mean) number of words people learned from each list. How do the results compare with your hypothesis?
2. **Posing Questions** What factors may have made one list easier to learn than the other? What other questions can you ask about your data?
3. **Designing Experiments** Look back at your experimental plan. Think about how well you were able to carry it out in the actual experiment. What difficulties did you encounter? What improvements could you make, either in your plan or in the way you carried it out?
4. **Communicating** Share your results with the rest of the class. How do the results of the different experiments in your class compare? What factors might explain the similarities or differences?

More to Explore

Plan an experiment to investigate how long people remember what they learn. Develop a hypothesis, and design an experiment to test your hypothesis.

Section 2

Patterns of Behavior

Reading Preview

Key Concepts

- What are three main ways animals communicate?
- What are some examples of competitive behaviors and cooperative behaviors?
- What is a cyclic behavior?

Key Terms

- pheromone • aggression
- territory • courtship behavior
- society • circadian rhythm
- hibernation • migration

Target Reading Skill

Using Prior Knowledge Your prior knowledge is what you already know before you read about a topic. Before you read, write what you know about the different ways animals communicate in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Dogs bark at intruders. 2.

What You Learned
1. 2.

Lab zone

Discover Activity

What Can You Express Without Words?

1. Use facial expressions and body movements, but no words, to show surprise or another emotion to your partner.
2. By observing your behavior, your partner should infer what you are communicating. Your partner should also note the behavior clues that led to this inference.
3. Now your partner should try to communicate a feeling or situation to you without words. Infer what your partner is trying to communicate, and note the behavior clues that led to your inference.

Think It Over

Forming Operational Definitions Write your own definition of *communication*. How did this activity change your idea of communication?

Oh no—ants have gotten into the sugar! As you watch in dismay, a stream of ants moves along the kitchen counter. They are heading right for the sugar bowl. Using their sense of smell, the ants follow a chemical trail that was first laid down by the ant that discovered the sugar. Each ant adds to the trail by depositing a tiny droplet of scent onto the counter. The droplet quickly evaporates, making an invisible cloud of scent above the path of the ants. The ants hold their antennae forward and use them to sniff their way to the sugar bowl. Then they turn around and follow the same chemical signal back to their nest.

Communication

You've just read that ants can communicate the location of foods using scent. Animal communication comes in many forms. Perhaps you've seen a cat hissing and arching its back. It is using sound and body posture to communicate a message that seems to say, "Back off!" **Animals use mostly sounds, scents, and body movements to communicate with one another.** An animal's ability to communicate helps it interact with other animals.

Animals communicate many kinds of messages using sound. Some animals use sound to attract mates. Female crickets, for example, are attracted to the sound of a male's chirping. Animals may also communicate warnings with sound. When it sees a coyote or other predator approaching, a prairie dog makes a yipping sound that warns other prairie dogs to take cover in their burrows. The wolf in Figure 8 is warning wolves outside its pack to keep away.

Animals also communicate with chemical scents. A chemical released by one animal that affects the behavior of another animal of the same species is called a **pheromone** (FEHR uh mohn). For example, perhaps you have seen a male house cat spraying a tree. The musky scent he leaves contains pheromones that advertise his presence to other cats in the neighborhood. The scent trail that leads the ants to the sugar bowl in Figure 9 is also made of pheromones.

Reading Checkpoint **What is a pheromone?**

FIGURE 8
Howling Wolf
Wolves in a pack may howl all together to warn other packs to stay away.

Go Online
active art
For: Pheromones activity
Visit: PHSchool.com
Web Code: cep-2052

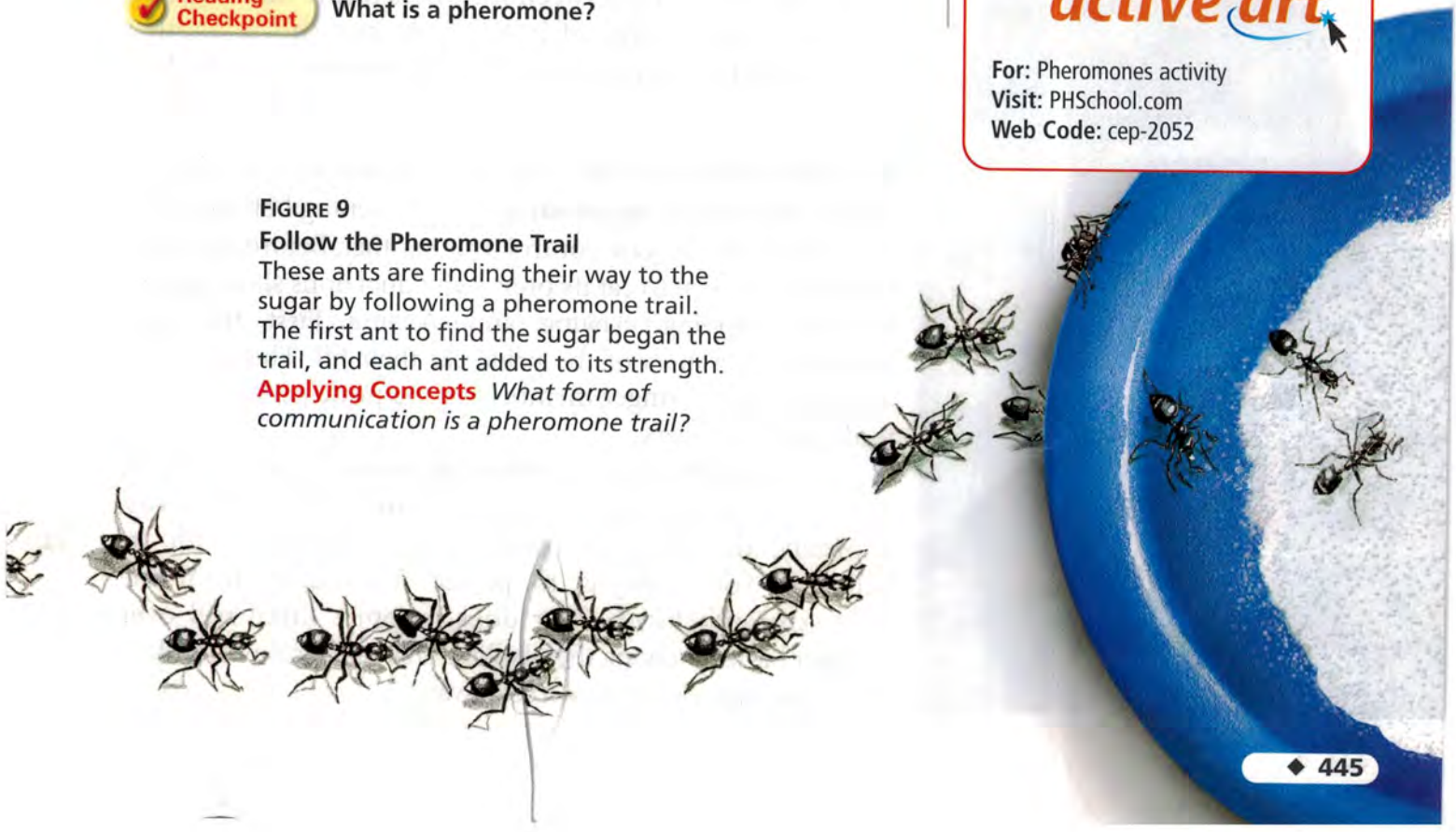


FIGURE 9
Follow the Pheromone Trail
These ants are finding their way to the sugar by following a pheromone trail. The first ant to find the sugar began the trail, and each ant added to its strength.
Applying Concepts *What form of communication is a pheromone trail?*

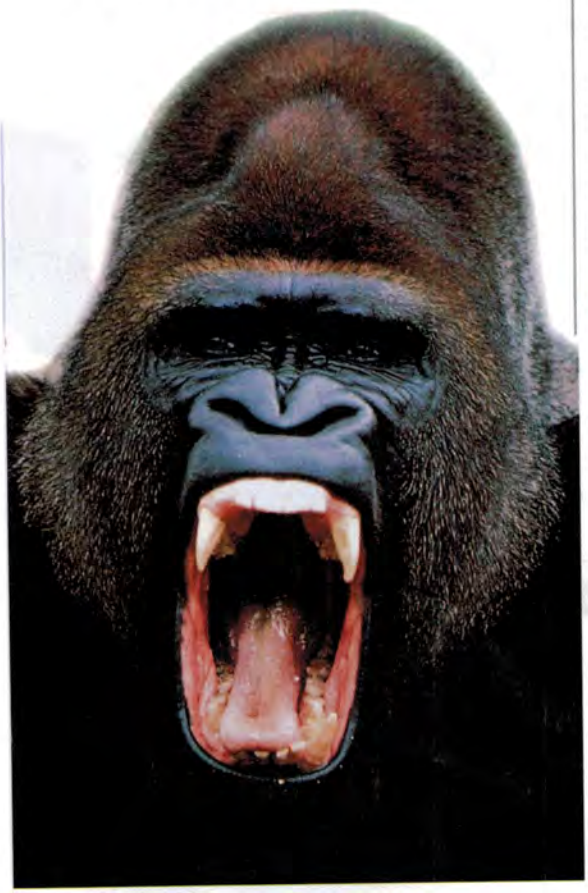
FIGURE 10
Boxing Hares
These Arctic hares are resolving their conflict by boxing. **Inferring** *What event might have led to this behavior?*

Competitive Behavior

Have you ever fed ducks in the park or pigeons on the street? Then you have probably seen how they fight over every crumb. These animals compete because there usually isn't enough food to go around. **Animals compete with one another for limited resources, such as food, water, space, shelter, and mates.**

Competition can occur among different species of animals. For example, a pride of lions may try to steal a prey from a troop of hyenas that has just killed the prey. Competition can also occur between members of the same species. A female aphid, a type of insect, kicks and shoves another female aphid while competing for the best leaf on which to lay eggs.

FIGURE 11
Aggressive Gorilla
This lowland gorilla needs no words to say, "Stay away!"



Showing Aggression When they compete, animals may display aggression. **Aggression** is a threatening behavior that one animal uses to gain control over another. Before a pride of lions settles down to eat its prey, individual lions show aggression by snapping, clawing, and snarling. First, the most aggressive members of the pride eat their fill. Then, the less aggressive and younger members of the pride get a chance to feed on the leftovers.

Aggression between members of the same species hardly ever results in the injury or death of any of the competitors. Typically, the loser communicates, "I give up" with its behavior. For example, to protect themselves from the aggressive attacks of older dogs, puppies often roll over on their backs, showing their bellies. This signal calms the older dog. The puppy can then creep away.

Establishing a Territory On an early spring day, a male oriole fills the warm air with song. You may think the bird is singing just because it is a nice day. But in fact, he is alerting other orioles that he is the "owner" of a particular territory. A **territory** is an area that is occupied and defended by an animal or group of animals. If another animal of the same species enters the territory, the owner will attack the newcomer and try to drive it away. Birds use songs and aggressive behaviors to maintain their territories. Other animals may use calls, scratches, droppings, or pheromones.

By establishing a territory, an animal protects its access to resources such as food and possible mates. A territory also provides a safe area. Within it, animals can raise their young without competition from other members of their species. In most songbird species, and in many other animal species, a male cannot attract a mate unless he has a territory.

Attracting a Mate A male and female salamander swim gracefully in the water, moving around one another. They are engaging in **courtship behavior,** which is behavior in which males and females of the same species prepare for mating. Courtship behavior ensures that the males and females of the same species recognize one another, so that mating and reproduction can take place. Courtship behavior is typically also competitive. For example, in some species, several males may perform courtship behaviors for a single female. She then chooses one of them to mate with.

Reading Checkpoint How does having a territory help an animal survive?

Lab zone Skills Activity

Developing Hypotheses

The three-spined stickleback is a kind of fish in which the males' undersides turn red during the mating season. The males readily attack other male sticklebacks that enter their territory. In the laboratory, a biologist notices that males also show aggressive behavior whenever a red object passes their tank. What do you think is the stimulus for the stickleback's aggressive display in the wild? How could you test your hypothesis? Explain.

FIGURE 12
Kingfisher Courtship
These common kingfishers are engaged in courtship. The male on the left is offering the female a gift of food—a freshly caught fish.

FIGURE 13
Safety in Groups
When a predator threatens, musk oxen form a horn-rimmed circle with their young sheltered in the center. **Predicting** *Would a potential predator be more or less likely to attack a group arranged in this way? Explain.*

Group Behavior

Not all animal behaviors are competitive. **Living in groups enables animals to cooperate.** Although many animals live alone and only rarely meet one of their own kind, other animals live in groups. Some fishes form schools, and some insects live in large groups. Hoofed mammals, such as bison and wild horses, often form herds. Living in a group usually helps animals survive. For example, group members may protect one another or work together to find food.

How can group members help one another? If an elephant gets stuck in a mudhole, for example, other members of its herd will dig it out. When animals such as lions hunt in a group, they usually can kill larger prey than a single hunter can.

Safety in Groups Living in groups often protects animals against predators. Fishes that swim in schools are often safer than fishes that swim alone. It is harder for predators to see and select an individual fish in a group. In a herd, some animals may watch for danger while others feed.

Animals in a group sometimes cooperate in fighting off a predator. For example, the North American musk oxen shown in Figure 13 make a defensive circle against a predator, such as a wolf. Their young calves are sheltered in the middle of the circle. The adult musk oxen stand with their horns lowered, ready to charge. The predator often gives up rather than face a whole herd of angry musk oxen.

Animal Societies Some animals, including ants, termites, honeybees, naked mole rats, and pistol shrimp, live in groups called societies. A **society** is a group of closely related animals of the same species that work together in a highly organized way. In a society, there is a division of labor—different individuals perform different tasks. In a honeybee society, for example, there are thousands of worker bees that take on different tasks in the beehive. Some workers feed larvae. Some bring back nectar and pollen from flowers as food for the hive. Other worker bees guard the entrance to the hive.

Reading Checkpoint **What is a society?**

Lab zone Try This Activity

Worker Bees

1. Make a paper chain by cutting paper strips for loops and gluing or taping the loops together. After 5 minutes, count the loops in the chain.
2. Now work in a small group to make a paper chain. Decide how to divide up the work before beginning. After 5 minutes, count the loops in the chain.

Calculating Find the difference between the number of loops in your individual and group chains. For Step 2, calculate the number of loops made per person by dividing the total number of loops by the number of people in your group. Was it more productive to work individually or as a group?

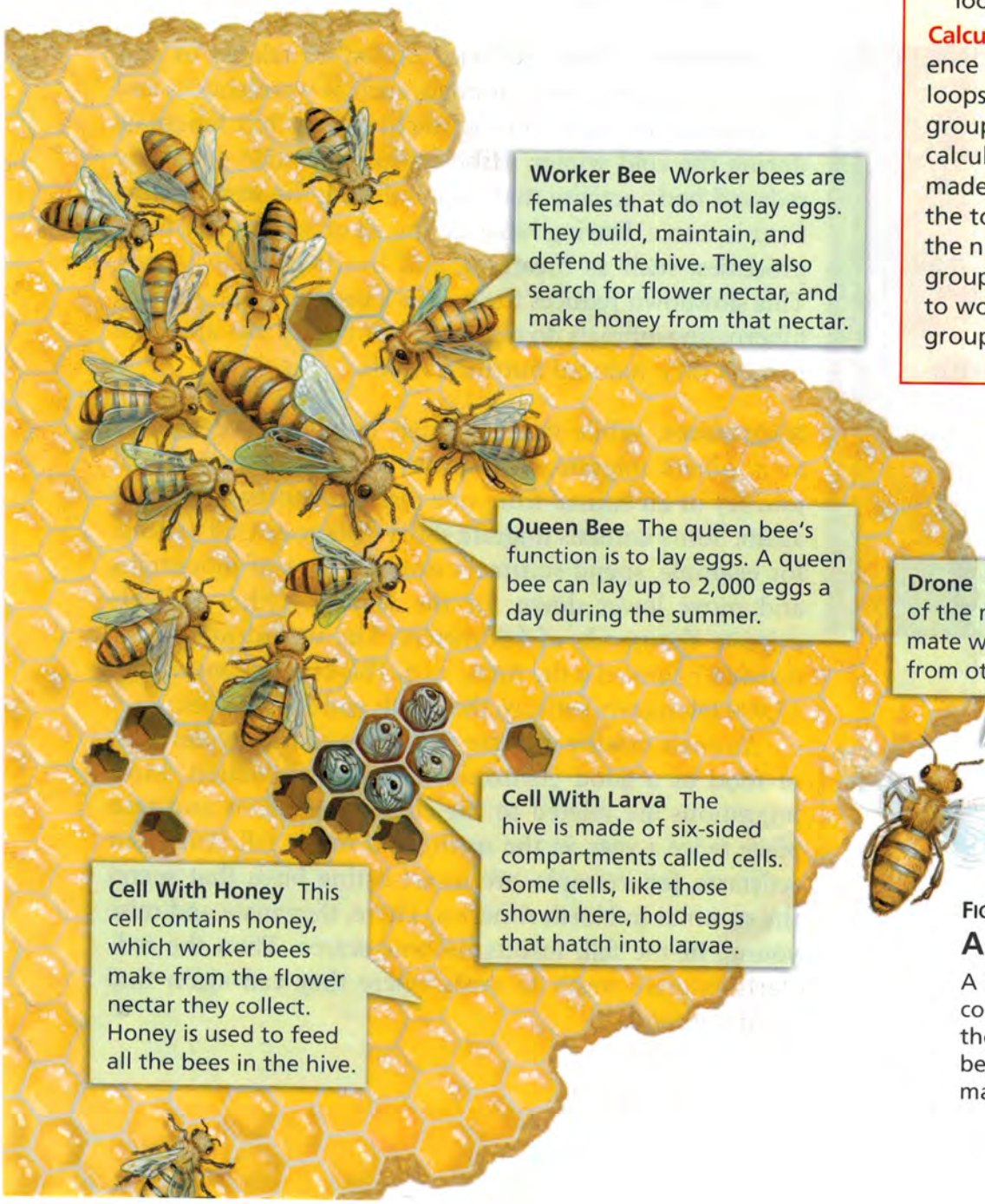


FIGURE 14
A Honeybee Society
A honeybee hive usually consists of one queen bee, thousands of female worker bees, and a few hundred male drones.

Behavior Cycles

Some animal behaviors, called cyclic behaviors, occur in regular, predictable patterns. **Cyclic behaviors usually change over the course of a day or a season.**

Daily Cycles Behavior cycles that occur over a period of approximately one day are called **circadian rhythms** (sur KAY dee un). For example, blowflies search for food during the day and rest at night. In contrast, field mice are active during the night and rest by day. Animals that are active during the day can take advantage of sunlight, which makes food easy to see. On the other hand, animals that are active at night do not encounter predators that are active during the day.

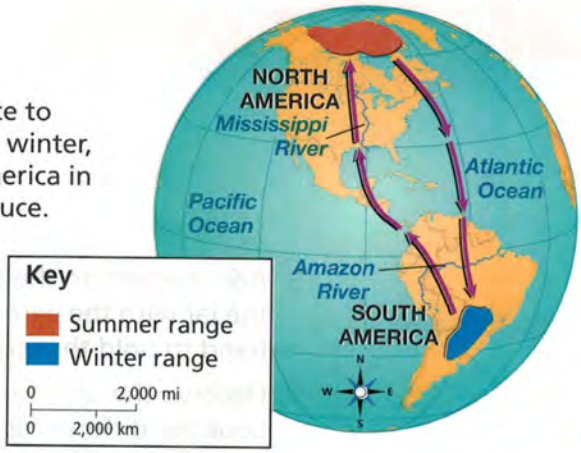
FIGURE 15
Hibernation
This common dormouse is hibernating for the winter.
Inferring *Why is hibernation during the winter a useful adaptation for animals?*

Hibernation Other behavior cycles are related to seasons. For example, some animals, such as woodchucks and chipmunks, are active during warm seasons but hibernate during the cold winter. **Hibernation** is a state of greatly reduced body activity that occurs during the winter when food is scarce. During hibernation, all of an animal's body processes, such as breathing and heartbeat, slow down. This slowdown reduces the animal's need for food. In fact, hibernating animals do not eat. Their bodies use stored fat to meet their reduced nutrition needs.

Migration While many animals live their lives in one area, others migrate. **Migration** is the regular, seasonal journey of an animal from one place to another and back again. Some animals migrate short distances. Dall's sheep, for example, spend summers near the tops of mountains and move lower down for the winters. Other animals migrate thousands of kilometers. The record-holder for distance migrated is the Arctic tern. This bird flies more than 17,000 kilometers between the North and South poles.

Animals usually migrate to an area that provides a lot of food or a good environment for reproduction. Most migrations are related to the changing seasons and take place twice a year, in the spring and in the fall. American redstarts, for example, are insect-eating birds that spend the summer in North America. There, they mate and raise young. In the fall, insects become scarce. Then the redstarts migrate south to areas where they can again find plenty of food.

FIGURE 16
Migration
Golden plovers migrate to South America for the winter, and back to North America in the summer to reproduce.



Scientists are still learning about how migrating animals find their way. But they have discovered that animals use sight, taste, and other senses, including some that humans do not have. Some birds and sea turtles, for example, have a magnetic sense that acts something like a compass needle. Migrating birds also seem to navigate by using the positions of the sun, moon, and stars, as sailors have always done. Salmon use scent and taste to locate the streams where they were born, and return there to mate.

Reading Checkpoint **What happens to an animal during hibernation?**

Section 2 Assessment

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

Reviewing Key Concepts

1. a. **Reviewing** What are three main ways animals communicate?
   b. **Explaining** When house cats spray a tree with their scent, are they communicating? Explain.
   c. **Developing Hypotheses** What are some advantages of using pheromones to communicate instead of using sound?
2. a. **Listing** List examples of competitive behavior and cooperative behavior.
   b. **Explaining** Explain how competition is involved in establishing a territory.
   c. **Predicting** What might happen when a male mockingbird flies into the territory of another male mockingbird?
3. a. **Reviewing** What are behaviors that change over the course of a day or a season called?
   b. **Comparing and Contrasting** How are circadian rhythm and hibernation the same? How are they different?

Lab zone At-Home Activity

Animal Signs With a family member, spend some time making detailed observations of the behavior of an animal—a pet, an insect, a bird, or another animal. Watch the animal for signs of aggressive behavior or other communication. Try to figure out why the animal is behaving aggressively or what it is trying to communicate.

Lab zone Skills Lab

One for All

Problem

How does an ant society show organization and cooperative behavior?

Skills Focus

observing, inferring

Materials

- large glass jar
- sandy soil
- shallow pan
- water
- wire screen
- sponge
- 20–30 ants
- hand lens
- bread crumbs
- sugar
- black paper
- tape
- glass-marking pencil
- forceps
- large, thick rubber band

Procedure

1. Read over the entire lab to preview the kinds of observations you will be making. Copy the data table into your notebook. You may also want to leave space for sketches.
2. Mark the outside of a large jar with four evenly spaced vertical lines, as shown in the photograph on the next page. Label the sections with the letters A, B, C, and D. You can use these labels to identify the sections of soil on and below the surface.
3. Fill the jar about three-fourths full with soil. Place the jar in a shallow pan of water to prevent any ants from escaping. Place a wet sponge on the surface of the soil as a water source for the ants.
4. Observe the condition of the soil, both on the surface and along the sides of the jar. Record your observations.
5. Add the ants to the jar. Immediately cover the jar with the wire screen, using the rubber band to hold the screen firmly in place.
6. Observe the ants for at least 10 minutes. Look for differences in the appearance of adult ants, and look for eggs, larvae, and pupae. Examine both individual behavior and interactions between the ants.
7. Remove the screen cover and add small amounts of bread crumbs and sugar to the soil surface. Close the cover. Observe the ants for at least 10 more minutes.
8. Create dark conditions for the ants by covering the jar with black paper above the water line. Remove the paper only when you are making your observations.
9. Observe the ant colony every day for two weeks. Remove the dark paper, and make and record your observations. Look at the soil as well as the ants, and always examine the food. If any food has started to mold, use forceps to remove it. Place the moldy food in a plastic bag, seal the bag, and throw it away. Add more food as necessary, and keep the sponge moist. When you finish your observations, replace the dark paper.
10. At the end of the lab, follow your teacher's directions for returning the ants.

Data Table				
Date	Section A	Section B	Section C	Section D

Analyze and Conclude

1. **Observing** Describe the various types of ants you observed. What differences, if any, did you observe in their behavior? What evidence did you see of different kinds of ants performing different tasks?
2. **Inferring** How do the different behaviors you observed contribute to the survival of the colony?
3. **Inferring** How did the soil change over the period of your observations? What caused those changes? How do you know?
4. **Communicating** What kinds of environmental conditions do you think ant colonies need to thrive outdoors? Use the evidence you obtained in this lab to write a paragraph that supports your answer.

Design an Experiment

Design an experiment to investigate how an ant colony responds when there is a change in the ants' environment, such as the introduction of a new type of food. *Obtain your teacher's permission before carrying out your investigation.*

Section 3

• Tech & Design •

Tracking Migrations

Reading Preview

Key Concepts

- How do electronic technologies help scientists track animals?
- What are the benefits of tracking animal migrations?

Key Terms

- transmitter
- receiver
- satellite

Target Reading Skill

Comparing and Contrasting As you read, compare and contrast three types of animal tags by completing a table like the one below.

Animal Tags

Feature	Simple Banding	Radio	Satellite
Kind of Signal	None		
Cost			
Weight			

Lab zone **Discover Activity**

How Can You Track Animals?

1. On a sheet of graph paper, sketch a map of your classroom.
2. Your teacher will produce a set of "signals" from a tracking device on an animal. Record the location of each signal on your map. Sketch the path of the animal you just tracked.
3. Your teacher will produce a second set of tracking signals. Record the location of each signal, then draw the animal's path. Compare the two pathways.

Think It Over

Inferring What does this activity show about actual animal tracking?

Have you ever changed your mind because of new information? Scientists who study manatees have done just that. The information came from a signaling device on a manatee.

Florida manatees are marine mammals that spend their winters in Florida and migrate north for the summer. Scientists once thought that the manatees didn't go any farther north than Virginia. Then they attached signaling devices to manatees to track their migration. They were quite surprised when they picked up a signal from a manatee swimming off the coast of Rhode Island, which is far north of Virginia.

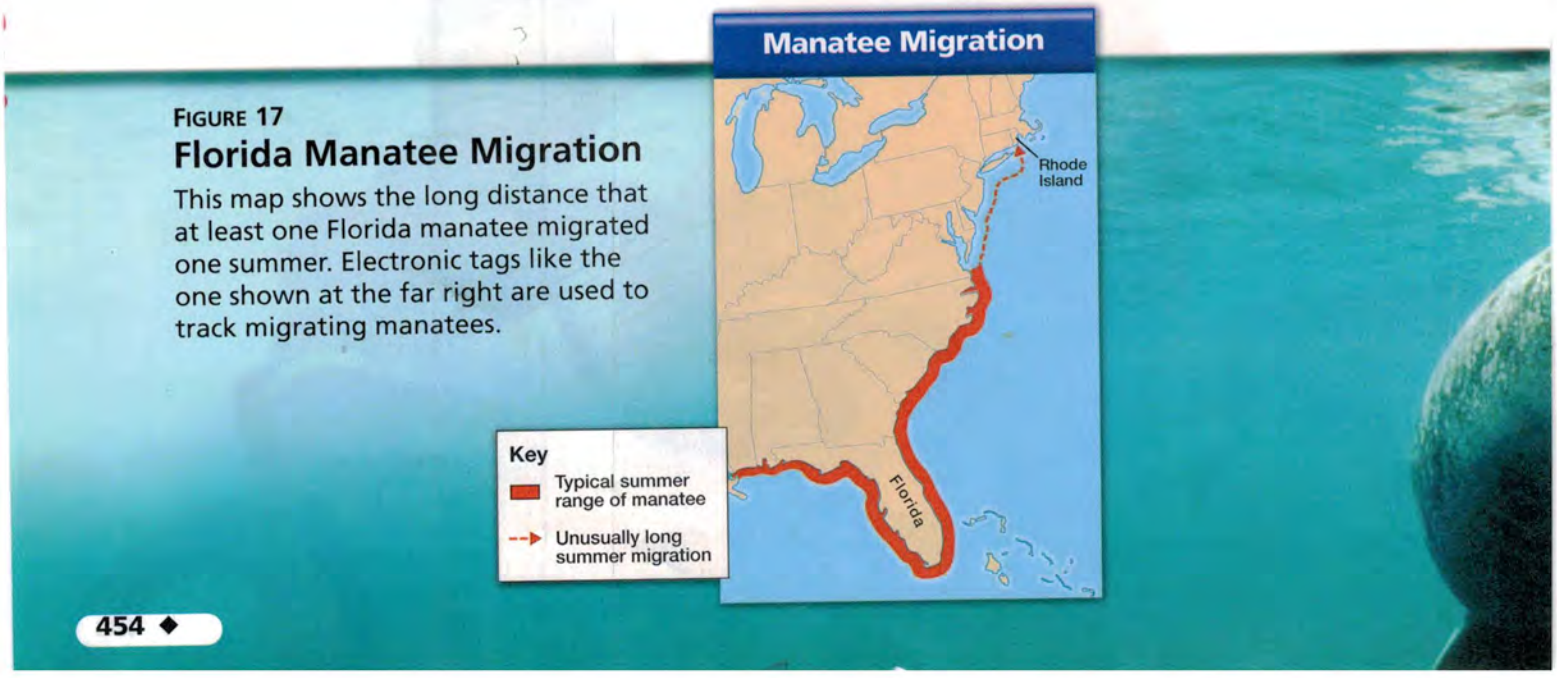


FIGURE 17
Florida Manatee Migration
This map shows the long distance that at least one Florida manatee migrated one summer. Electronic tags like the one shown at the far right are used to track migrating manatees.

Technologies for Tracking

In the fall of 1803, American naturalist John James Audubon wondered whether migrating birds returned to the same place each year. So he tied a string around the leg of a bird before it flew south. The following spring, Audubon saw the bird with the string. He learned that the bird had indeed come back.

Scientists today still attach tags, such as metal bands, to track the movement of animals. But metal bands are not always useful tags. That is because the tagged animals have to be caught again for the scientists to get any data. Unfortunately, most tagged animals are never seen again.

Recent technologies have helped solve this problem. **Electronic tags give off repeating signals that are picked up by radio devices or satellites. Scientists can track the locations and movements of the tagged animals without recapturing them.** These electronic tags can provide a great deal of data. However, they are much more expensive than the "low-tech" tags that aren't electronic. Also, because of their weight, electronic tags may harm some animals by slowing them down.

FIGURE 18
Banded Puffin
Bands like the ones around the ankles of this Atlantic puffin are low-tech tags. **Inferring** *Why is a metal band tag useful?*

Radio Tracking Tracking an animal by radio involves two devices. A **transmitter** attached to the animal sends out a signal in the form of radio waves, just as a radio station does. A scientist might place the transmitter around an animal's ankle, neck, wing, or fin. A **receiver** picks up the signal, just like your radio at home picks up a station's signal. The receiver is usually in a truck or an airplane. To keep track of the signal, the scientist follows the animal in the truck or plane.

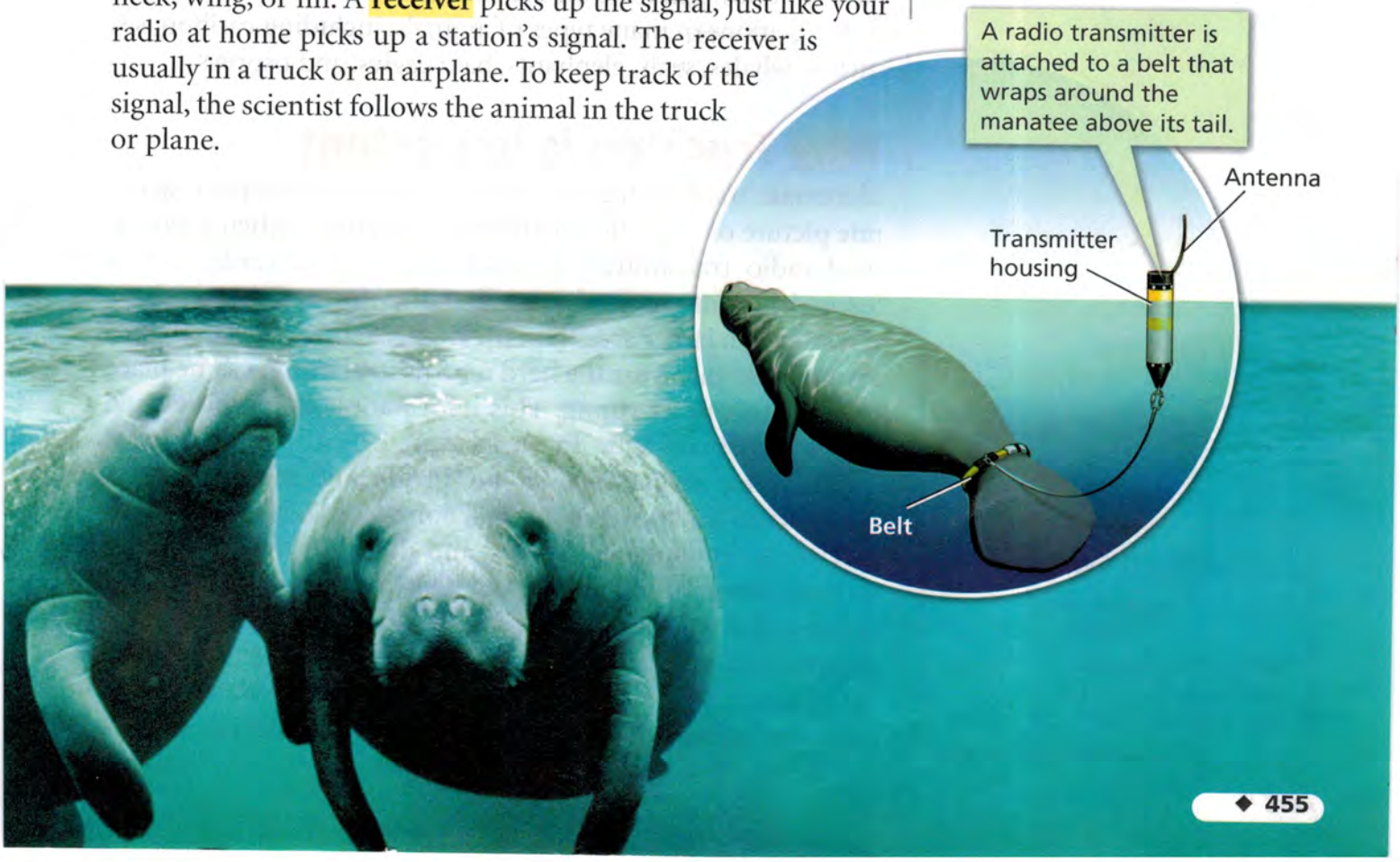


FIGURE 19
Tracking Caribou
Scientists are fitting this caribou with a collar containing a satellite transmitter. **Inferring** *Why would it be difficult to track caribou without a satellite receiver?*

Satellite Tracking Receivers can be placed in satellites as well as in airplanes and trucks. A **satellite** is an instrument in orbit thousands of kilometers above Earth. Networks, or groups, of satellites are used to track animals. Each satellite in a network picks up electronic signals from a transmitter on an animal. Together, the signals from all the satellites determine the precise location of the animal.

Satellites can also track an animal's path as it moves. Satellite tracking is especially useful because the scientists do not have to follow after the animal. Satellite networks have tracked the migrations of many types of animals, including caribou, sea turtles, whales, seals, elephants, bald eagles, and ospreys.

Why Tracking Is Important

Electronic tracking tags are giving scientists a complete, accurate picture of migration patterns. For example, when scientists used radio transmitters to track one herd of caribou, they learned two important things. First, they learned that the herd moves over a larger area than previously thought. Second, they learned that each year the herd returns to about the same place to give birth to its young. This information would have been difficult to obtain with "low tech" tags.

Tracking migrations is an important tool to better understand and protect species. For example, Florida manatees are an endangered species, and therefore they need protection. Radio tracking showed that Florida manatees may travel as far north as Rhode Island when they migrate. This information suggests that the manatees may need protection along much of the Atlantic Coast of the United States. Previously, protection efforts focused mainly in the Florida area.

FIGURE 20
Caribou Migration
These caribou are migrating across Alaska on the same path used by caribou for thousands of years.

Technologies for tracking animals may also help people whose work or recreation affects animals. For example, suppose officials at a state park want to protect a group of migrating animals during the spring. The officials plan to ban fishing or boating for the entire spring season. Detailed migration information, however, might give the officials a better choice. They might be able to decrease the length of time the ban is in effect, or ban fishing and boating only in those few areas visited by the animals.

Reading Checkpoint **What information did tracking provide biologists about a caribou herd?**

Section 3 Assessment

Target Reading Skill

Comparing and Contrasting Use the information in your table about animal tags to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Identifying** What are two methods of electronic animal tracking?
   b. **Comparing and Contrasting** How are electronic tracking methods similar? How are they different?
   c. **Making Judgments** Are electronic tags better than traditional tags?
2. a. **Reviewing** What are the benefits of tracking migrations?
   b. **Applying Concepts** Migrating birds are sometimes killed by crashing into cellular telephone towers. How could tracking bird migrations help people protect the birds?
   c. **Making Judgments** Should governments spend more money tracking migrations? Defend your position.

Writing in Science

Persuasive Letter Suppose you are a scientist who needs money to study the migrations of an endangered sea turtle species. Write a letter justifying why you need money for electronic tags.

Chapter 13

Study Guide

The BIG Idea **Animal Behavior and Communication** Most behaviors help animals to obtain food or mates, protect territory, or avoid predators.

1 What Is Behavior?

Key Concepts

- All animal behaviors are caused by stimuli.
- An instinct is a response to a stimulus that is inborn and that an animal performs correctly the first time.
- Learned behaviors include imprinting, conditioning, trial-and-error learning, and insight learning.

Key Terms

• behavior • stimulus • response • instinct
• learning • imprinting • conditioning
• trial-and-error learning • insight learning

2 Patterns of Behavior

Key Concepts

- Animals use mostly sounds, scents, and body movements to communicate with one another.
- Animals compete with one another for limited resources, such as food, water, space, shelter, and mates.
- Living in groups enables animals to cooperate.
- Cyclic behaviors usually change over the course of a day or a season.

Key Terms

pheromone
aggression
territory
courtship behavior
society
circadian rhythm
hibernation
migration

3 Tracking Migrations

Key Concepts

- Electronic tags give off repeating signals that are picked up by radio devices or satellites. Scientists can track the locations and movements of the tagged animals without recapturing them.
- Tracking migrations is an important tool to better understand and protect species.

Key Terms

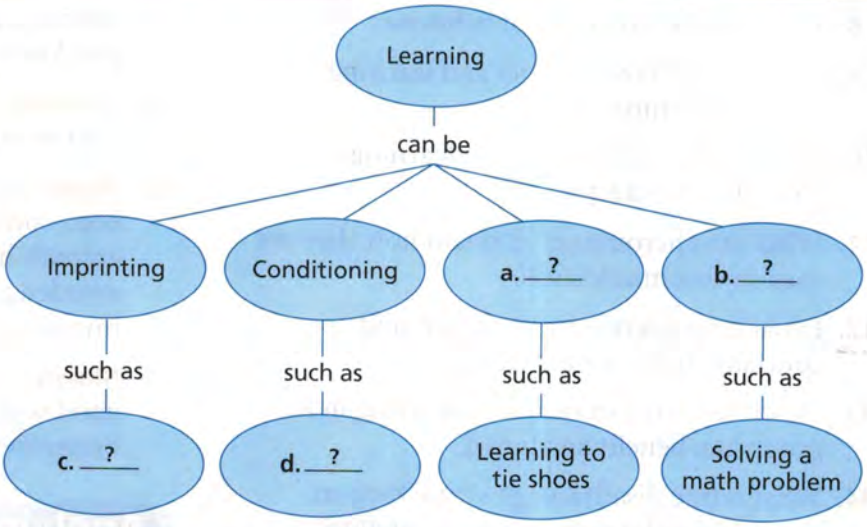
• transmitter • receiver • satellite

Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cea-2050

Organizing Information

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



Reviewing Key Terms

Choose the letter of the best answer.

1. An organism's reaction to a signal is called
   a. a response. **b.** a stimulus.
   c. aggression. **d.** learning.
2. A process that leads to a change in behavior based on practice is called
   a. instinct. **b.** response.
   c. learning. **d.** behavior.
3. Learning that a particular stimulus or response leads to a good or a bad outcome is called
   a. instinct.
   b. imprinting.
   c. conditioning.
   d. insight learning.
4. A chemical released by one animal that affects the behavior of another animal of the same species is called a(n)
   a. stimulus.
   b. instinct.
   c. pheromone.
   d. circadian rhythm.
5. A threatening behavior that one animal uses to gain control over another is called
   a. courtship behavior.
   b. aggression.
   c. conditioning.
   d. cyclic behavior.
6. When a bird travels from its winter home in South America to its nesting area in New York, this is called
   a. learning.
   b. conditioning.
   c. migration.
   d. territorial behavior.
7. An instrument in orbit thousands of kilometers above Earth is called a
   a. pheromone. **b.** transmitter.
   c. receiver. **d.** satellite.

Writing in Science

Health Article Write a magazine article describing how dogs can be trained. Explain how trained dogs might assist people with special needs.

Discovery CHANNEL SCHOOL

Animal Behavior
Video Preview
Video Field Trip
▶ Video Assessment

Review and Assessment

Checking Concepts

8. What are the functions of behavior?
9. Explain how both instinct and learning are involved in imprinting.
10. Explain what trial-and-error learning is. Describe an example.
11. What are pheromones? Explain how they are used in communication.
12. Explain how territorial behavior and courtship behavior are related.
13. Describe two examples of how living in a group can benefit an animal.
14. What is one disadvantage of tracking an animal by radio rather than by satellite?

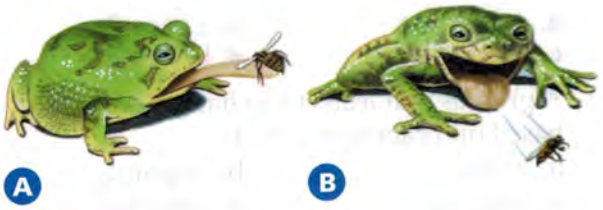
Thinking Critically

15. **Inferring** Look at the photograph below. On its first try, this weaver bird is building a nest of grass with a hole at the bottom just the right size for the bird to enter. What kind of behavior is this? Explain.

16. **Applying Concepts** Explain how a racehorse's ability to win races is a combination of inherited and learned characteristics.
17. **Problem Solving** A dog keeps jumping onto a sofa. Describe how the owner might train the dog not to do this. The procedure must not involve any pain or harm to the dog.
18. **Applying Concepts** Give an example of something that you have learned by insight learning. Explain how you made use of your past knowledge and experience in learning it.
19. **Drawing Conclusions** How can hibernation help an animal survive the winter?
20. **Applying Concepts** Because a highway has been constructed through a forest, many animals have had to move to a different wooded area. Is their move an example of migration? Explain.
21. **Making Judgments** Is satellite tracking a good way to track the migration of monarch butterflies? Explain.

Applying Skills

Use the diagrams below, showing (A) a toad catching a bee and (B) the toad's reaction, to answer Questions 22–24.



22. **Inferring** Explain why the toad probably behaves as it does in diagram B.
23. **Predicting** If another bee flies by, how will the toad probably behave? Explain.
24. **Classifying** What type of learning might result from the toad's experience? Explain.

Lab zone Chapter Project

Performance Assessment Obtain your teacher's permission before bringing an animal to class. You can also show photographs or illustrations of the animal's training. Describe your training plan. What did you discover about the animal's learning process? How could you have improved your plan?

Standardized Test Prep

Test-Taking Tip

Watching for Qualifiers *(Most, Least, Best)*

Multiple-choice questions often use qualifiers, words that change or limit the meaning of a phrase or sentence. Qualifiers include words such as *best*, *least*, and *most*. You need to read and compare all the answer choices carefully. While some of the answers may not be incorrect, another answer may be the best choice. Look for the best and most complete answer.

Sample Question

Which of the following is the best definition of *instinct*?

- **A** all the actions an animal performs
- **B** a behavior pattern that an animal performs
- **C** an inborn behavior pattern that an animal performs correctly the first time
- **D** a behavior pattern that an animal performs after practice and experience

Answer

C is the best answer. **A** is not a valid answer because it defines all behavior, not instinct, which is a specific type of behavior. **D** defines a learned behavior. **B** is not incorrect, but it does not completely describe instinct. As written, **B** could apply to several types of behavior.

Choose the letter of the best answer.

1. An enclosed cage at a university laboratory holds dozens of birds. When a biologist adjusts the light schedule and temperature in the cage to match fall conditions, she observes that the birds spend most of their time at the south end of the cage. What is the most likely explanation for the behavior?
   - **A** The birds are forming a society.
   - **B** There is more food at the south end of the cage.
   - **C** The birds are exhibiting migratory behavior.
   - **D** The scientist has conditioned the birds to prefer the south end of the cage.

2. The chimpanzee in the diagram below has learned a way to reach the bananas. What type of learning most likely applies to this situation?
   - **F** instinct
   - **G** conditioning
   - **H** insight
   - **J** imprinting

3. Ants have laid a pheromone trail to a food source. While the ants are in their nest at night, a researcher pours gasoline over the entire trail. Which of the following will probably happen the next morning?
   - **A** The gasoline will have no effect on the ants.
   - **B** The ants will find the food more rapidly.
   - **C** The ants will eat the gasoline.
   - **D** The ants will be unable to find the food.

4. You are awake during the day and asleep at night. This behavior is an example of
   - **F** circadian rhythm.
   - **G** aggression.
   - **H** trail-and-error learning.
   - **J** hibernation.

Constructed Response

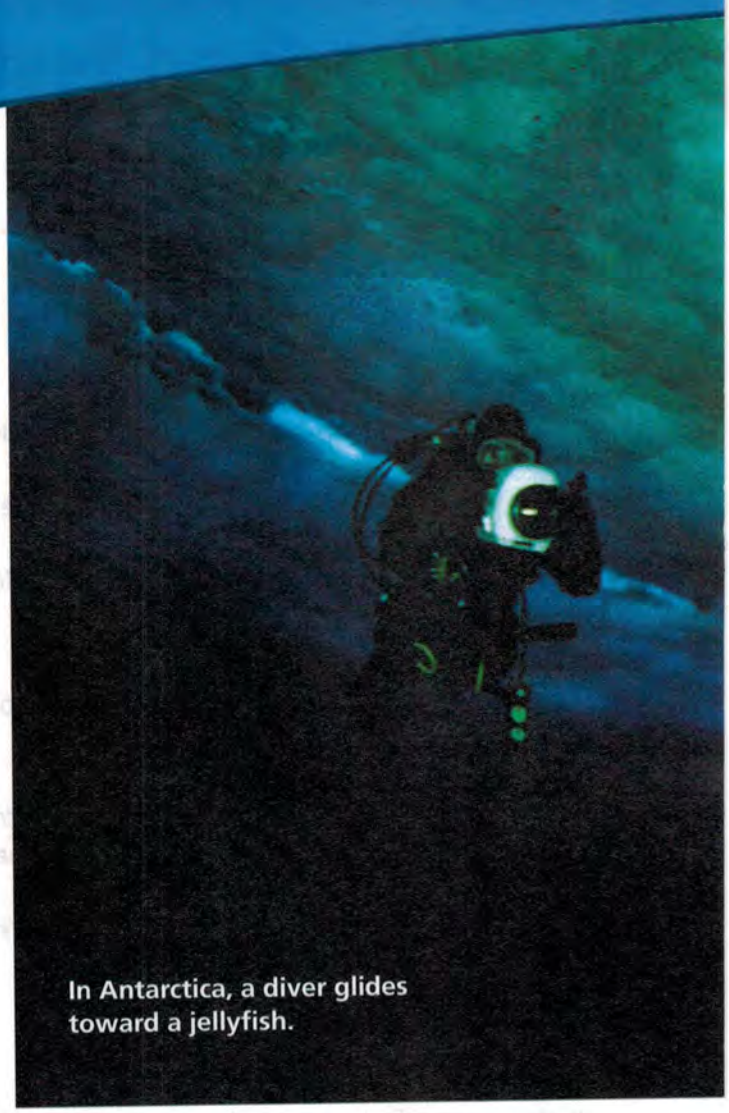
5. Describe the organization of a honeybee society, including daily tasks.

Through the Lens of an Ocean Scientist

Norbert Wu dives for his photographs. (He took all the photographs in this feature.) A trained marine biologist, he roams the underwater world looking for the perfect shot. "Photography has become a way of life for me," Norbert says. "At my best, I am both a scientist and an artist. Photographing new life forms and learning about the connections between different species makes my work a blend of science and art. Taking an in-depth look at the habits and behavior of marine life has become my specialty."

Norbert has followed the trail of manta rays slowly circling the top of an undersea mountain off the Mexican coast. He's photographed octopuses and snails on coral reefs. He's swum with jellyfish in the Antarctic Ocean.

"I went as far south as you can go and still have ocean," Norbert says. "And I fell in love with Antarctica. When you first get there at the beginning of the Antarctic spring, the water is clearer than anywhere in the world. It's really the last untouched place on Earth. That's what draws me back.

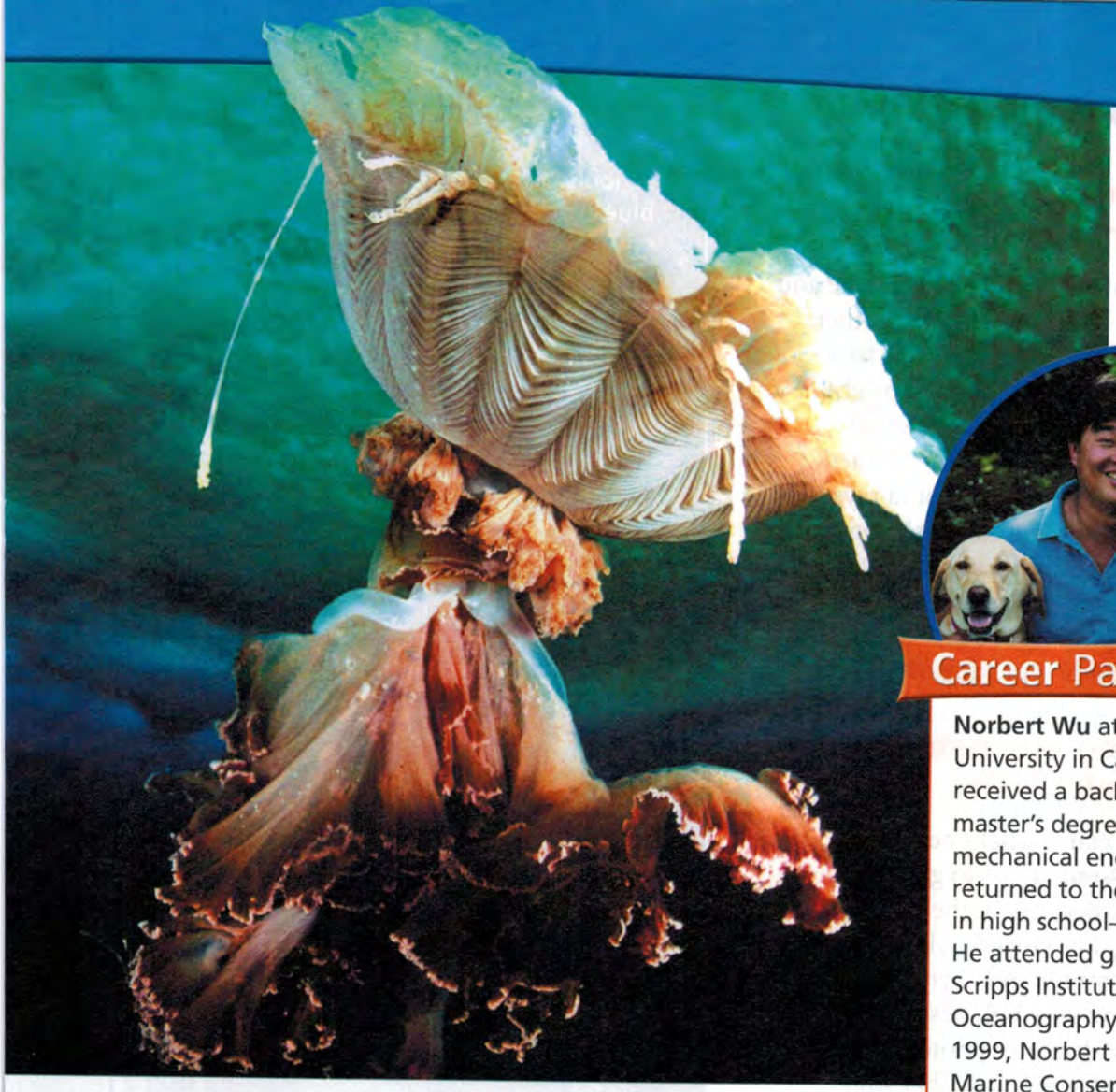


In Antarctica, a diver glides toward a jellyfish.

Talking With Norbert Wu

What protects divers from the cold?

Underwater photography in polar seas is a challenge. For one thing, it's very cold. In Antarctica, scientists used to wear wet suits—suits that allow a thin layer of water to touch the skin. Now divers use dry suits, which are waterproof and sealed at the neck and wrists. You can wear long underwear or polyester fleece underneath. Dry suits make polar diving bearable, but it's never very pleasant.



Norbert is shown below with his dogs Ange, a labrador, and Sam, a golden retriever.

Career Path

Norbert Wu attended Stanford University in California, where he received a bachelor's degree and master's degree in electrical and mechanical engineering. He then returned to the subject he loved in high school—marine biology. He attended graduate school at Scripps Institution of Oceanography in San Diego. In 1999, Norbert received a Pew Marine Conservation Fellowship to photograph threatened underwater habitats.

How did you become an underwater photographer?

After college, I decided to pursue a career in marine biology. I got a job with a scientist working off the San Blas Islands near Panama. I counted sea urchins and measured coral growth. Before the trip, I'd never had any interest in photography. But I brought along books on photography, as well as an underwater flash and camera system.

My career didn't happen overnight. I returned to California to continue graduate school in marine biology. I sold some photographs taken at San Blas and gradually my career in photography just took over.

How do you locate ocean organisms?

You learn the places in the world where particular ocean organisms are found. In the waters of Antarctica, you find seals, penguins, and jellyfish. Squid come up in the waters off California at certain times of the year. Local guides can also put you exactly on the right site to locate ocean organisms.

If you dive a reef every day, you get to know the organisms that live there. During the months I spent on the San Blas Islands, I was able to return again and again to photograph an octopus or a flamingo tongue snail. Being able to spend weeks, rather than a few weekends, makes a big difference in the photographs.

How is your science background useful?

You need to know how ocean animals behave and how different animals interact with each other. I've taken pictures of manta rays coming to a seamount to be cleaned of parasites by bright orange clarion angelfish. Parasites are small organisms that live on and can harm another organism like a manta ray. As the manta rays swoop past the seamount, the angelfish come out from their shelter, dance about, and flash their bright orange bodies as if signaling their arrival. The manta rays may pause and allow the angelfish to go all about their bodies, picking off parasites.

Why are you interested in an animal's behavior?

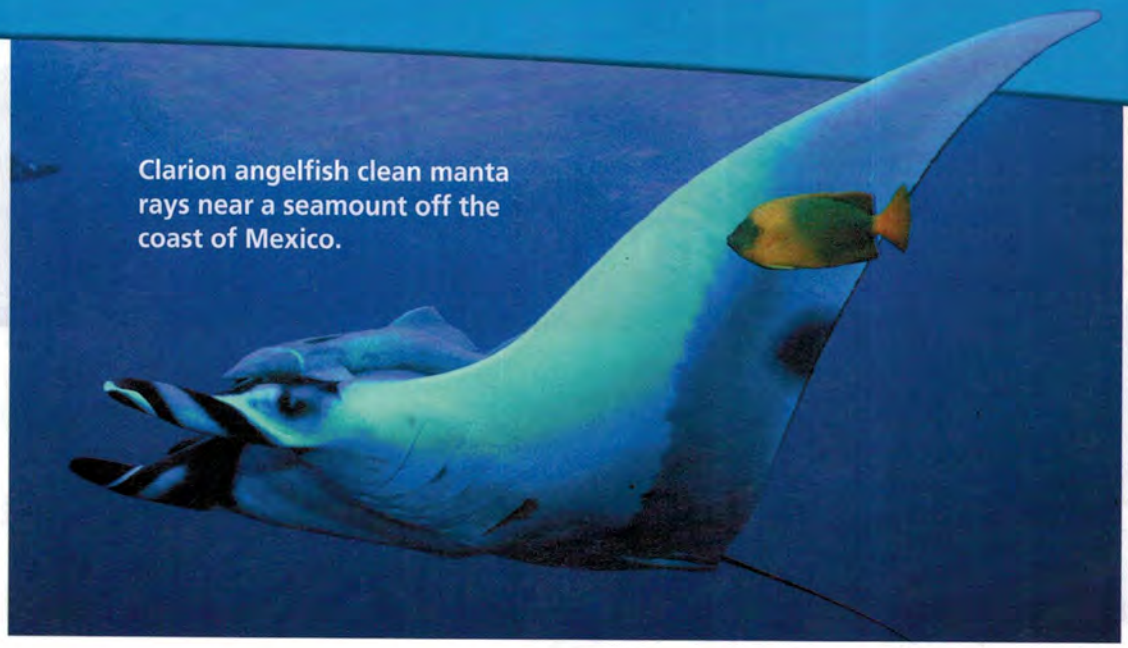
Understanding an ocean animal's behavior and its reactions is essential just to get near enough for a picture. Because of the limited visibility underwater, I am usually close to my subjects—often no more than a meter away. As a diver, the noise of your bubbles tells animals you're there. So an underwater photographer must move slowly and act in ways that won't threaten or frighten animals.

What do you do on a typical diving trip?

Most of my diving trips last two to three weeks. Once I'm there, almost all my time is on a boat or getting ready to go underwater. My next trip is to Cocos Island, in Costa Rica, where I will photograph seamounts. Seamounts are undersea mountain tops that serve as gathering places for marine life. They attract some of the ocean's largest and most exciting animals.

Seamounts form in areas of volcanic action, where the ocean floor abruptly rises to the surface. These volcanic hot spots can be close to the coast or hundreds of miles offshore. In the Cocos, there are a lot of sharks to photograph—hammerheads and white-tipped reef sharks as well as manta rays and snappers.

Schooling snappers and blue-striped snappers swim around a seamount off the Cocos Island in the Pacific Ocean.



Clarion angelfish clean manta rays near a seamount off the coast of Mexico.

What new technology do you use in your work?

Two new technologies have made a big difference—closed-circuit rebreathers and digital cameras. A rebreather recycles your exhaled breath in a closed loop, so you can breathe the unused oxygen you took in during earlier breaths. You can get up to twelve hours on one tank of oxygen. If you can breathe an oxygen-rich mixture in the ocean, you can stay deeper, longer.

With digital cameras, I can also stay down a long time without running out of film. I can put a memory card in the camera and take 300 or 500 exposures. (A large roll of film takes just 36 exposures.)

What would you tell students?

I've talked to young people a good deal. I'm amazed at how much they know about the world and the environment. I'd tell students that any subject you're passionate about is going to lead to good things. I'm very lucky. I've been able to combine a lot of things I love into my career—biology and diving and photography.

◀ Norbert on Antarctic ice

Writing in Science

Career Link For Norbert, one key to taking great scientific photographs is being at the right place at the right time. To do that, he says you need "an understanding of your subject's behavior." Choose an animal you know. In a paragraph, describe the right time and place to take a good photograph of that animal. Explain your choice.

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