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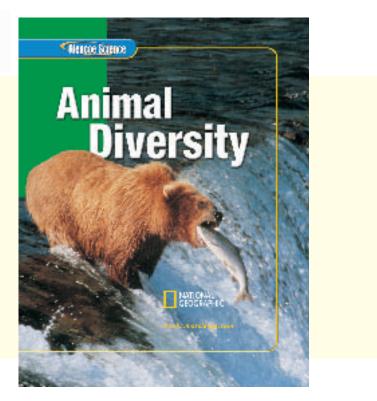
Chicago, Illinois Peoria, Illinois Woodland Hills, California



Clencoe Science

Animal Diversity

This Alaskan brown bear is catching a migrating salmon. This species of bear is the largest carnivore in Alaska, growing up to nine feet tall and weighing up to 1,700 pounds. All Alaskan salmon hatch in freshwater, migrate to the sea, and then eventually return to where they hatched to reproduce.





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Authors

NATIONAL GEOGRAPHIC Education Division

Washington, D.C.

CONTENT

Jerome A. Jackson, PhD

Whitaker Eminent Scholar in

Science

Program Director

Center for Science, Mathematics,

and Technology Education

Florida Gulf Coast University

Fort Meyers, FL

Lucy Daniel, PhD

Teacher/Consultant Rutherford County Schools Rutherfordton, NC

Dinah Zike

Educational Consultant Dinah-Might Activities, Inc. San Antonio, TX

Series Consultants

MATH

Teri Willard, EdD Mathematics Curriculum Writer Belgrade, MT

READING

Carol A. Senf, PhD

School of Literature, Communication, and Culture Georgia Institute of Technology Atlanta, GA

SAFETY

Sandra West, PhD

Department of Biology Texas State University-San Marcos San Marcos, TX

ACTIVITY TESTERS

Nerma Coats Henderson

Pickerington Lakeview Jr. High School Pickerington, OH

Mary Helen Mariscal-Cholka

William D. Slider Middle School El Paso, TX

Science Kit and Boreal Laboratories

Tonawanda, NY

Dominic Salinas, PhD

Middle School Science Supervisor Caddo Parish Schools Shreveport, LA

Maureen Barrett

Thomas E. Harrington Middle

School

Mt. Laurel, NJ

Cory Fish

Burkholder Middle School

Henderson, NV

Series Reviewers

Amy Morgan Berry Middle School Hoover, AL

> Dee Stout Penn State University University Park, PA

Darcy Vetro-Ravndal Hillsborough High School Tampa, FL



HOW-FO...

Use Your Science Book

Why do I need my science book?

Have you ever been in class and not understood all of what was presented? Or, you understood everything in class, but at home, got stuck on how to answer a question? Maybe you just wondered when you were ever going to use this stuff?

These next few pages are designed to help you understand everything your science book can be used for . . . besides a paperweight!

(Landse)

Animal Diversity

Before You Read

- Chapter Opener Science is occurring all around you, and the opening photo of each chapter will preview the science you will be learning about. The Chapter Preview will give you an idea of what you will be learning about, and you can try the Launch Lab to help get your brain headed in the right direction. The Foldables exercise is a fun way to keep you organized.
- Section Opener Chapters are divided into two to four sections. The As You Read in the margin of the first page of each section will let you know what is most important in the section. It is divided into four parts. What You'll Learn will tell you the major topics you will be covering. Why It's Important will remind you why you are studying this in the first place! The Review Vocabulary word is a word you already know, either from your science studies or your prior knowledge. The New Vocabulary words are words that you need to learn to understand this section. These words

will be in **boldfaced** print and highlighted in the section. Make a note to yourself to recognize these words as you are reading the section.

FOLDABLES[™] Study Organizer

Science Vocabulary Make the following Foldable to help you understand the vocabulary terms in this chapter.

As you Read

Headings Each section has a title in large red letters, and is further divided into blue titles and small red titles at the beginnings of some paragraphs. To help you study, make an outline of the headings and subheadings.

• Margins In the margins of your text, you will find many helpful resources. The Science Online exercises and Integrate activities help you explore the topics you are studying. MiniLabs reinforce the science concepts you have learned.

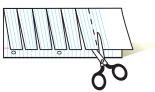
- **Building Skills** You also will find an **Applying Math** or **Applying Science** activity in each chapter. This gives you extra practice using your new knowledge, and helps prepare you for standardized tests.
- Student Resources At the end of the book you will find Student Resources to help you throughout your studies. These include Science, Technology, and Math Skill Handbooks, an English/Spanish Glossary, and an Index. Also, use your Foldables as a resource. It will help you organize information, and review before a test.
- In Class Remember, you can always ask your teacher to explain anything you don't understand.

STEP 1 Fold a vertical sheet of notebook paper from side to side.

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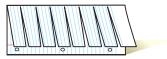


Cut along every third line of only the top layer to form tabs.



ST	E	P	3

Label each tab with a vocabulary word from the chapter.



Build Vocabulary As you read the chapter, list the vocabulary words on the tabs. As you learn the definitions, write them under the tab for each vocabulary word.

Look For...

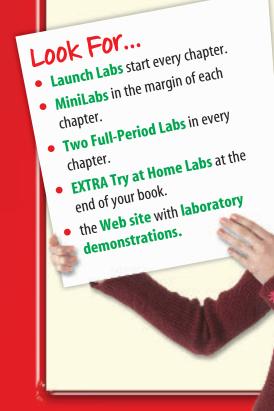
At the beginning of every section.



In Lab

Working in the laboratory is one of the best ways to understand the concepts you are studying. Your book will be your guide through your laboratory experiences, and help you begin to think like a scientist. In it, you not only will find the steps necessary to follow the investigations, but you also will find helpful tips to make the most of your time.

- Each lab provides you with a **Real-World Question** to remind you that science is something you use every day, not just in class. This may lead to many more questions about how things happen in your world.
- Remember, experiments do not always produce the result you expect. Scientists have made many discoveries based on investigations with unexpected results. You can try the experiment again to make sure your results were accurate, or perhaps form a new hypothesis to test.
- Keeping a **Science Journal** is how scientists keep accurate records of observations and data. In your journal, you also can write any questions that may arise during your investigation. This is a great method of reminding yourself to find the answers later.



Before a Test

Admit it! You don't like to take tests! However, there *are* ways to review that make them less painful. Your book will help you be more successful taking tests if you use the resources provided to you.

aor

- Review all of the **New Vocabulary** words and be sure you understand their definitions.
- Review the notes you've taken on your Foldables, in class, and in lab. Write down any question that you still need answered.
- Review the **Summaries** and **Self Check questions** at the end of each section.
- Study the concepts presented in the chapter by reading the **Study Guide** and answering the questions in the **Chapter Review.**

Look For...

- Reading Checks and caption questions throughout the text.
- the Summaries and Self Check questions at the end of each section.
- the Study Guide and Review at the end of each chapter.
- the **Standardized Test Practice** after each chapter.





Let's Get Started

To help you find the information you need quickly, use the Scavenger Hunt below to learn where things are located in Chapter 1.

- 1 What is the title of this chapter?
- 2 What will you learn in Section 1?
- 3 Sometimes you may ask, "Why am I learning this?" State a reason why the concepts from Section 2 are important.
- 4 What is the main topic presented in Section 2?
- 5 How many reading checks are in Section 1?
- 6 What is the Web address where you can find extra information?
- What is the main heading above the sixth paragraph in Section 2?
- B There is an integration with another subject mentioned in one of the margins of the chapter. What subject is it?
- List the new vocabulary words presented in Section 2.
- 10 List the safety symbols presented in the first Lab.
- 10 Where would you find a Self Check to be sure you understand the section?
- 2 Suppose you're doing the Self Check and you have a question about concept mapping. Where could you find help?

101 M

- 13 On what pages are the Chapter Study Guide and Chapter Review?
- Look in the Table of Contents to find out on which page Section 2 of the chapter begins.

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You complete the Chapter Review to study for your chapter test. Where could you find another quiz for more practice?

Teacher Advisory Board

The Teacher Advisory Board gave the editorial staff and design team feedback on the content and design of the Student Edition. They provided valuable input in the development of the 2005 edition of *Glencoe Science*.

John Gonzales Challenger Middle School Tucson, AZ

Rachel Shively Aptakisic Jr. High School Buffalo Grove, IL

Roger Pratt Manistique High School Manistique, MI

Kirtina Hile Northmor Jr. High/High School Galion, OH Marie Renner Diley Middle School Pickerington, OH

Nelson Farrier Hamlin Middle School Springfield, OR

Jeff Remington Palmyra Middle School Palmyra, PA

Erin Peters Williamsburg Middle School Arlington, VA **Rubidel Peoples** Meacham Middle School Fort Worth, TX

Kristi Ramsey Navasota Jr. High School Navasota, TX

Student Advisory Board

The Student Advisory Board gave the editorial staff and design team feedback on the design of the Student Edition. We thank these students for their hard work and creative suggestions in making the 2005 edition of *Glencoe Science* student friendly.

Jack Andrews Reynoldsburg Jr. High School Reynoldsburg, OH

Peter Arnold Hastings Middle School Upper Arlington, OH

Emily Barbe Perry Middle School Worthington, OH

Kirsty Bateman Hilliard Heritage Middle School Hilliard, OH

Andre Brown Spanish Emersion Academy Columbus, OH

Chris Dundon Heritage Middle School Westerville, OH

Ryan Manafee Monroe Middle School Columbus, OH Addison Owen Davis Middle School Dublin, OH

Teriana Patrick Eastmoor Middle School Columbus, OH

Ashley Ruz Karrer Middle School Dublin, OH



The Glencoe middle school science Student Advisory Board taking a timeout at COSI, a science museum in Columbus, Ohio.



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- Reading Checks
- Caption Questions
- Section Review
- Chapter Study Guide
- Chapter Review
- Standardized Test
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- Online practice at bookc.msscience.com

chapter

chapter

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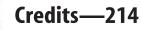
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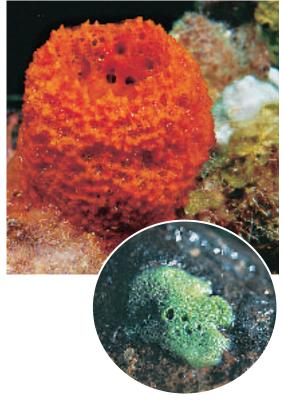
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Scientific Methods



Figure 1 Eastern monarch butterflies lay their eggs on milkweed plants.

Monarch Migration

Ithough the beautiful black and orange wings of the monarch butterfly are a common sight during summer in the United States, as fall and colder temperatures arrive, the butterflies disappear. Each fall they begin a seasonal migration. Scientists have had some success in unlocking the mystery of monarch migration through the use of scientific methods. Through this example, you can see how each step of this scientific method contributes to reliable results that can lead to better-informed conclusions.

The monarch population that lives west of the Rocky Mountains flies to the coast of California. The eastern population of monarchs flies to the mountains of central Mexico. Sometimes they travel up to 145 km per day. Some eastern monarchs, such as those living in southern Canada, fly more than 3,200 km to reach their winter home.



Navigation

Just as astonishing as the distance traveled by these insect voyagers is their ability to find their way. Since no butterfly completes the entire round-trip, the butterflies cannot learn the route from others. So, how do butterflies that have never made the trip before find their way from Canada and the eastern United States to Mexico? This is the question that some entomologists—scientists who study insects—set out to answer.

Figure 2 When they reach Mexico, eastern monarch butterflies gather in large groups.





Figure 3 Magnetite is a mineral with natural magnetic properties.

One of the first hypotheses about how eastern monarchs navigate was that they use the Sun as a guide. Researchers based this hypothesis on other research, which showed that some migrating birds rely on the Sun to guide them. However, this failed to explain how the butterflies find their way on cloudy days.

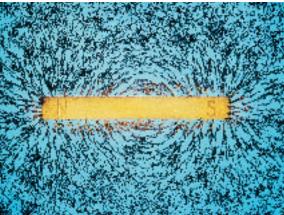
Magnetism

Scientists later discovered that the bodies of eastern monarchs contain tiny grains of a naturally occurring, magnetic substance called magnetite. Magnetite was used to make the first directional compasses. From this discovery, scientists developed a hypothesis that butterflies use an internal magnetic compass to help them plot their route.

University scientists tested this hypothesis by performing an experiment. They caught some eastern monarchs during the fall migration. They divided the monarchs into three groups and exposed each group to different magnetic fields. The group exposed to Earth's normal magnetic field flew to the southwest, which is the correct direction for eastern monarchs to migrate. Those exposed to the opposite of Earth's normal magnetic field flew to the northeast. Finally, those exposed to no magnetic field fluttered about randomly.

Final Conclusions

After analyzing the results, the researchers concluded that eastern monarchs use an internal magnetic compass to navigate from Canada and the eastern United States to Mexico. However, most researchers also believe the butterflies also use the Sun and landmarks, such as mountains and rivers, to make their incredible journey. **Figure 4** A magnet has oppositely charged poles.







Science

Scientists learned about the migration of eastern monarch butterflies by starting with questions such as "Where do monarchs go each fall? How do they find their way there?" Scientists use experiments and careful observations to answer questions about how the world works. When you test an idea, you are doing science.

Life science is the study of living things. In this book, you will learn about the diversity of animals and their adaptations and behaviors, such as migration, that enable them to survive.

Scientific Methods

Researchers used scientific methods to learn about how eastern monarchs navigate. Scientific methods are a series of procedures used to investigate a question scientifically.

Identifying a Question

Figure 5 Sometimes, a scientist must collect data outside of the laboratory. Sometimes, scientific methods begin with identifying a question, such as "Where do eastern monarch butterflies go every autumn?" After one question has been answered, others



often arise. When researchers discovered eastern monarchs migrate to Mexico, the next question was "How do the butterflies find their way?"

Forming a Hypothesis

Once a question is identified, scientists collect information and develop a hypothesis or possible explanation.

They might read the information available on how birds migrate and use it as a basis for the hypothesis that eastern monarchs use the Sun to navigate. This idea, however, failed to explain how the butterflies find their way on cloudy days. As a result, scientists developed another hypothesis—eastern monarchs use an internal magnetic compass that enables them to maintain a course in a specific direction.



Testing the Hypothesis

Scientists test hypotheses to determine if they are true or false. Such tests often involve experiments, such as one where eastern monarchs were exposed to different kinds of magnetic fields.

Analyzing Results

During experiments, scientists gather information, or data. Data about the butterfly experiment included the direction that the butterflies were flying when captured, what type of magnetic field they were exposed to in the experiment, and how they reacted to that magnetic field.

Drawing a Conclusion

After data have been collected and carefully analyzed, scientists draw conclusions. Sometimes the original hypothesis is not supported by the data and scientists must start the entire process over. In the case of the eastern monarchs, researchers observed how the butterflies reacted to the magnetic fields and concluded they use an internal magnetic compass to navigate. Just how the butterflies use Earth's magnetic field to find their way is another question for scientists to answer using scientific methods.



Figure 6 Data from observations are important in science investigations.



Figure 7 Scientists hypothesize that monarchs also navigate by landmarks.

You Do It

When eastern monarch butterflies reach Mexico's mountains, the insects abruptly change direction. Scientists hypothesize that the butterflies then switch to steering by landmarks, such as mountains. Describe one way scientists could test this hypothesis.



Introduction to Animals

chapter preview

sections

- **1** Is it an animal?
- 2 Sponges and Cnidarians Lab Observing a Cnidarian
- **3** Flatworms and Roundworms Lab Comparing Free-living and Parasitic Flatworms
 - Virtual Lab How do sponges, cnidarians, flatworms, and roundworms obtain food?

Plant or Animal?

There are many animals on Earth, and not all look like a cat or a dog. A coral is an animal, and a coral reef is made of millions of these animals. By studying how animals are classified today, scientists can identify the relationships that exist among different animal groups.

Science Journal List all of the animals that you can identify in this picture.

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Start-Up Activities

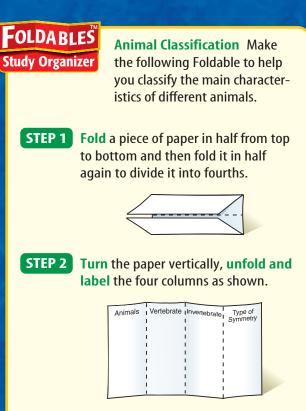


Animal Symmetry

The words *left* and *right* have meaning to you because your body has a left and a right side. But what is left or right to a jellyfish or sea star? How an animal's body parts are arranged is called symmetry. In the following lab, you will compare three types of symmetry found in animals.

- On a piece of paper, draw three shapes—a circle, a triangle with two equal sides, and a free-form shape—then cut them out.
- See how many different ways you can fold each shape through the center to make similar halves with each fold.
- 3. Think Critically Record which shapes can be folded into equal halves and which shapes cannot. Can any of the shapes be folded into equal halves more than one way? Which shape would be similar to a human? A sea star? A sponge?





Read for Main Ideas As you read this chapter, list the characteristics of different animals in the appropriate column.



Preview this chapter's content and activities at bookc.msscience.com

CONTENTS

section

Is it an animal?

as you read

What You'll Learn

- Identify the characteristics common to most animals.
- Determine how animals meet their needs.
- Distinguish between invertebrates and vertebrates.

Why It's Important

Animals provide food, medicines, and companionship in your daily life.

Q Review Vocabulary

adapation: any variation that makes an organism better suited to its environment

New Vocabulary

- herbivore invertebrate
- carnivore radial symmetry
- omnivore bilateral
- vertebrate symmetry

Animal Characteristics

From microscopic worms to giant whales, the animal kingdom includes an amazing variety of living things, but all of them have certain characteristics in common. What makes the animals in **Figure 1** different from plants? Is it because animals eat other living things? Is this enough information to identify them as animals? What characteristics do animals have?

- 1. Animals are made of many cells. Different kinds of cells carry out different functions such as sensing the environment, getting rid of wastes, and reproducing.
- 2. Animal cells have a nucleus and specialized structures inside the cells called organelles.
- 3. Animals depend on other living things in the environment for food. Some eat plants, some eat other animals, and some eat plants and animals.
- 4. Animals digest their food. The proteins, carbohydrates, and fats in foods are broken down into simpler molecules that can move into the animal's cells.
- 5. Many animals move from place to place. They can escape from their enemies and find food, mates, and places to live. Animals that move slowly or not at all have adaptations that make it possible for them to take care of these needs in other ways.
- 6. All animals are capable of reproducing sexually. Some animals also can reproduce asexually.



Figure 1 These organisms look like plants, but they're one of the many plantlike animals that can be found growing on shipwrecks and other underwater surfaces. **Infer** how these animals obtain food. Figure 2 Animals eat a variety of foods.



Chitons eat algae from rocks.

A red-tailed hawk uses its sharp beak to tear the flesh.

How Animals Meet Their Needs

Any structure, process, or behavior that helps an organism survive in its environment is an adaptation. Adaptations are inherited from previous generations. In a changing environment, adaptations determine which individuals are more likely to survive and reproduce.

Adaptations for Obtaining Energy One of the most basic needs of animals is the need for food. All animals have adaptations that allow them to obtain, eat, and digest different foods. The chiton, shown in **Figure 2**, deer, some fish, and many insects are examples of herbivores. **Herbivores** eat only plants or parts of plants. In general, herbivores eat more often and in greater amounts than other animals because plants don't supply as much energy as other types of food.

Reading Check Why are butterflies considered to be herbivores?

Animals that eat only other animals, like the red-tailed hawk in **Figure 2**, are **carnivores**. Most carnivores capture and kill other animals for food. But some carnivores, called scavengers, eat only the remains of other animals. Animal flesh supplies more energy than plants do, so carnivores don't need to eat as much or as often as herbivores.

Animals that eat plants and animals or animal flesh are called **omnivores**. Bears, raccoons, robins, humans, and the cardinal fish in **Figure 2** are examples of omnivores.

Many beetles and other animals such as millipedes feed on tiny bits of decaying matter called detritus (dih TRI tus). They are called detritivores (dih TRI tih vorz).



Cardinal fish eat small invertebrates and some plant material.



Carnivore Lore

Carnivores have always been written about as having great power and strength. Find a poem or short story about a carnivore and interpret what the author is trying to convey about the animal. Figure 3 The pill bug's outer covering protects it and reduces moisture loss from its body.





Modeling Animal Camouflage

Procedure

- Pretend that a room in your home is the world of some fictitious animal. From materials you can find around your home, build a fictitious animal that would be camouflaged in this world.
- Put your animal into its world and ask someone to find it.

Analysis

- 1. In how many places was your animal camouflaged?
- 2. What changes would increase its chances of surviving in its world?

Figure 4 Mimicry helps some animals survive. **Describe** the difference between the two snakes.

Physical Adaptations Some prey species have physical features that enable them to avoid predators. Outer coverings protect some animals. Pill bugs, as seen in **Figure 3**, have protective plates. Porcupines have sharp quills that prevent most predators from eating them. Turtles and many animals that live in water have hard shells that protect them from predators.

Size is also a type of defense. Large animals are usually safer than small animals. Few predators will attack animals such as moose or bison simply because they are so large.

Mimicry is an adaptation in which one animal closely resembles another animal in appearance or behavior. If predators cannot distinguish between the two, they usually will not eat either animal. The venomous coral snake and the nonvenomous scarlet king snake, shown in **Figure 4**, look alike. In some cases, this is a disadvantage for scarlet king snakes because people mistake them for coral snakes and kill them.

Reading Check *How might mimicry be an advantage and a disadvantage for an animal?*

Many animals, like the flounder in **Figure 5**, blend into their surrounding environment, enabling them to hide from their predators. English peppered moths are brown and speckled like the lichens (LI kunz) on trees, making it difficult for their predators to see them. Many freshwater fish, like the trout also in **Figure 5**, have light bellies and dark, speckled backs that blend in with the gravelly bottoms of their habitats when they are viewed from above. Any marking or coloring that helps an animal hide from other animals is called camouflage. Some animals, like the cuttlefish in **Figure 5**, have the ability to change their color depending on their surroundings.



Coral snake



Scarlet king snake



Figure 5 Many types of animals blend with their surroundings.

Bottom fish like this flounder, blend with the ocean floor.

A trout blends with the bottom of a stream.

Predator Adaptations Camouflage is an adaptation for many predators so they can sneak up on their prey. Tigers have stripes that hide them in tall grasses. Killer whales are black on their upper surface and white underneath. When seen from above, the whale blends into the darkness of the deep ocean. The killer whale's white underside appears to be nearly the same color as the bright sky overhead when viewed from below. Adaptations such as these enable predators to hunt prey more successfully.

Behavioral Adaptations In addition to physical adaptations, animals have behavioral adaptations that enable them to capture prey or to avoid predators. Chemicals are used by some animals to escape predators. Skunks spray attacking animals with a bad-smelling liquid. Some ants and beetles also use this method of defense. When squid and octopuses are threatened,

they release a cloud of ink so they can escape, as shown in **Figure 6**.

Some animals are able to run faster than most of their predators. The Thomson's gazelle can run at speeds up to 80 km/h. A lion can run only about 36 km/h, so speed is a factor in the Thomson's gazelle's survival.

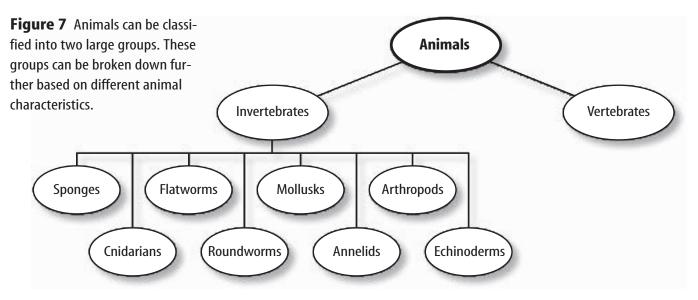
Traveling in groups is a behavior that is demonstrated by predators and prey. Herring swim in groups called schools that resemble an organism too large for a predator fish to attack. On the other hand, when wolves travel in packs, they can successfully hunt large prey that one predator alone could not capture. rream.

Cuttlefish can be especially difficult to find because they can change color to blend with their surroundings.

Figure 6 An octopus's cloud of ink confuses a predator long enough for the octopus to escape.







Animal Classification

Scientists have identified and named more than 1.8 million species of animals. It is estimated that there are another 3 million to 30 million more to identify and name. Animals can be classified into two major groups, as shown in **Figure 7.** All animals have common characteristics, but those in one group have more, similar characteristics because all the members of a group probably descended from a common ancestor. When a scientist finds a new animal, how does he or she begin to classify it?

Check for a Backbone To classify an animal, a scientist first looks to see whether or not the animal has a backbone. Animals with backbones are called **vertebrates**. Their backbones are made up of a stack of structures called vertebrae that support the animal. The backbone also protects and covers the spinal cord—a bundle of nerves that is connected to the brain. The spinal cord carries messages to all other parts of the body. It also carries messages from other parts of the body to the brain. Examples of vertebrates include fish, frogs, snakes, birds, and humans.

An animal without a backbone is classified as an **invertebrate**. About 97 percent of all animal species are invertebrates. Sponges, jellyfish, worms, insects, and clams are examples of invertebrates. Many invertebrates are well protected by their outer coverings. Some have shells, some have a skeleton on the outside of their body, and others have a spiny outer covering.

Symmetry After determining whether or not a backbone is present, a scientist might look at an animal's symmetry (SIH muh tree). Symmetry is how the body parts of an animal are arranged. Organisms that have no definite shape are called asymmetrical. Most sponges are asymmetrical animals.

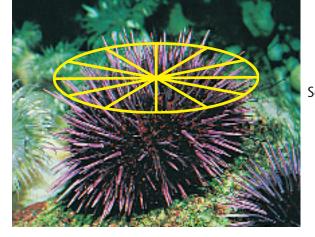


Topic: Animal Classification

Visit bookc.msscience.com for Web links to information about how the classification of an animal can change as new information is learned.

Activity Name a recent reclassification of an animal and one reason it was reclassified.





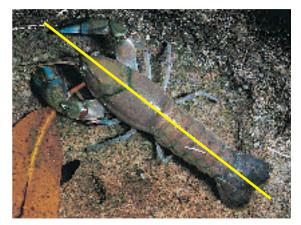
Animals that have body parts arranged in a circle around a center point, the way spokes of a bicycle wheel are arranged, have **radial symmetry**. Hydras, jellyfish, sea urchins, like the one in **Figure 8**, and some sponges have radial symmetry.

Most animals have bilateral symmetry. In Latin, the word *bilateral* means "two sides." An animal with **bilateral symmetry**, like the crayfish shown in **Figure 8**, can be divided into right and left halves that are nearly mirror images of each other.

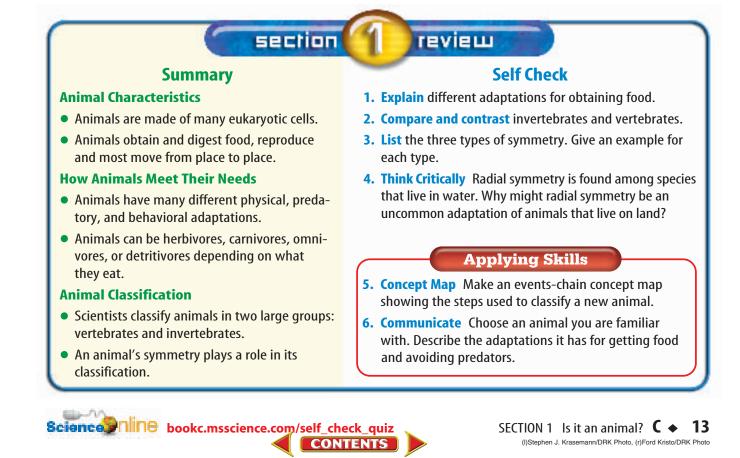
After an animal is classified as an invertebrate or a vertebrate and its symmetry is determined, other characteristics are identified that place it in one of the groups of animals with which it has the most characteristics in common. Sometimes a newly discovered animal is different from any existing group, and a new classification group is formed for that animal.

Figure 8 Symmetry is a characteristic of all animals.

Sea urchins can sense things from all directions.



Most animals have bilateral symmetry like this crayfish. **Name** the type of symmetry you have.



section

Sponges and Cnidarians

as you read

What You'll Learn

- Describe the characteristics of sponges and cnidarians.
- Explain how sponges and cnidarians obtain food and oxygen.
- Determine the importance of living coral reefs.

Why It's Important

Sponges and cnidarians are important to medical research because they are sources of chemicals that fight disease.

Q Review Vocabulary

flagella: long, thin whiplike structures that grow from a cell

New Vocabulary

- sessile medusa
- hermaphrodite tentacle
- polyp stinging cell

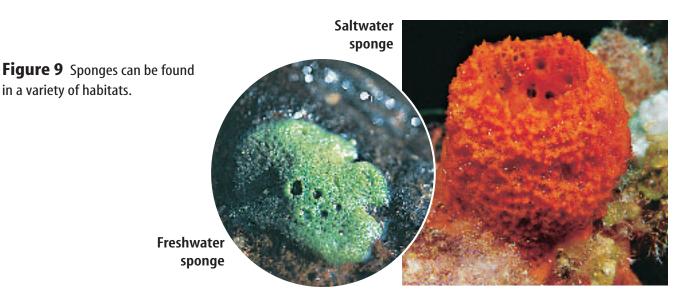
Sponges

In their watery environments, sponges play many roles. They interact with many other animals such as worms, shrimp, snails, and sea stars. These animals live on, in, and under sponges. Sponges also are important as a food source for some snails, sea stars, and fish. Certain sponges contain photosynthetic bacteria and protists that provide oxygen and remove wastes for the sponge.

Only about 17 species of sponges are commercially important. Humans have long used the dried and cleaned bodies of some sponges for bathing and cleaning. Most sponges you see today are synthetic sponges or vegetable loofah sponges, but natural sea sponges like those in **Figure 9** still are available.

Today scientists are finding other uses for sponges. Chemicals made by sponges are being tested and used to make drugs that fight disease-causing bacteria, fungi, and viruses. These chemicals also might be used to treat certain forms of arthritis.

Origin of Sponges Fossil evidence shows that sponges appeared on Earth about 600 million years ago. Because sponges have little in common with other animals, many scientists have concluded that sponges probably evolved separately from all other animals. Sponges living today have many of the same characteristics as their fossilized ancestors.





Characteristics of Sponges

Most of the 5,000 species of sponges are found in warm, shallow salt water near coastlines, although some are found at ocean depths of 8,500 m or more. A few species, like the one in **Figure 9**, live in freshwater rivers, lakes, and streams. The colors, shapes, and sizes of sponges vary. Saltwater sponges are brilliant red, orange, yellow, or blue, while freshwater sponges are usually a dull brown or green. Some sponges have radial symmetry, but most are asymmetrical. Sponges can be smaller than a marble or larger than a compact car.

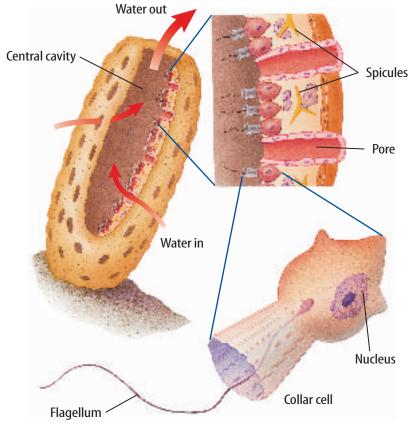
Adult sponges live attached to one place unless they are washed away by strong waves or currents. Organisms that remain attached to one place during their lifetimes are called **sessile** (SE sile). They often are found with other sponges in permanent groups called colonies. Early scientists classified sponges as plants because they didn't move. As microscopes were improved, scientists observed that sponges couldn't make their own food, so sponges were reclassified as animals.

Body Structure A sponge's body, like the one in **Figure 10**, is a hollow tube that is closed at the bottom and open at the top. The sponge has many small openings in its body. These openings are called pores.

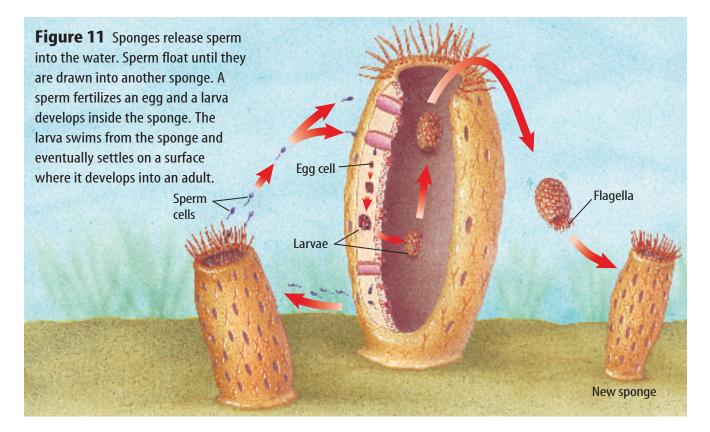
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Sponges have less complex body organization than other groups of animals. They have no tissues, organs, or organ systems. The body wall has two cell layers made up of several different types of cells. Those that line the inside of the sponge are called collar cells. The beating motion of the collar cells' flagella moves water through the sponge.

Many sponge bodies contain sharp, pointed structures called spicules (SPIH kyewlz). The softbodied, natural sponges that some people use for bathing or washing their cars have skeletons of a fibrous material called spongin. Other sponges contain spicules and spongin. Spicules and spongin provide support for a sponge and protection from predators. **Figure 10** Specialized cells, called collar cells, have flagella that move water through the pores in a sponge. Other cells filter microscopic food from the water as it passes through.



SECTION 2 Sponges and Cnidarians C + 15



Obtaining Food and Oxygen Sponges filter microscopic food particles such as bacteria, algae, protists, and other materials from the water as it is pulled in through their pores. Oxygen also is removed from the water. The filtered water carries away wastes through an opening in the top of the sponge.

Reading Check How do sponges get oxygen?

Reproduction Sponges can reproduce sexually, as shown in **Figure 11.** Some species of sponges have separate sexes, but most sponge species are **hermaphrodites** (hur MA fruh dites)— animals that produce sperm and eggs in the same body. However, a sponge's sperm cannot fertilize its own eggs. After an egg is released, it might be fertilized and then develop into a larva (plural, *larvae*). The larva usually looks different from the adult form. Sponge larvae have cilia that allow them to swim. After a short time, the larvae settle down on objects where they will remain and grow into adult sponges.

Asexual reproduction occurs by budding or regeneration. A bud forms on a sponge, then drops from the parent sponge to grow on its own. New sponges also can grow by regeneration from small pieces of a sponge. Regeneration occurs when an organism grows new body parts to replace lost or damaged ones. Sponge growers cut sponges into pieces, attach weights to them, and put them back into the ocean to regenerate.



Spicule Composition

Spicules of glass sponges are composed of silica. Other sponges have spicules of calcium carbonate. Relate the composition of spicules to the composition of the water in which the sponge lives. Write your answer in your Science Journal.



Cnidarians

Another group of invertebrates includes colorful corals, flowerlike sea anemones, tiny hydras, delicate jellyfish, and the iridescent Portuguese man-of-war, shown in **Figure 12.** These animals are classified as cnidarians (ni DAR ee uhnz).

Cnidarian Environments Most cnidarians live in salt water, although many types of hydras live in freshwater. Sea anemones and most jellyfish, also called jellies, live as individual organisms. Hydras and corals tend to form colonies.

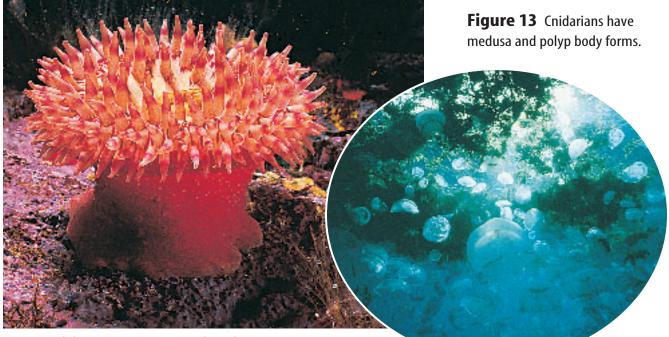
Two Body Forms Cnidarians have two different body forms. The **polyp** (PAH lup) form, shown in **Figure 13** on the left, is shaped like a vase and usually is sessile. Sea anemones, corals, and hydras are cnidarians that live most of their lives as polyps. The **medusa** (mih DEW suh) form, shown in **Figure 13** on the right, is bell-shaped and free-swimming. A jelly spends most of its life as a medusa floating on ocean currents. Some species of jellies have tentacles that grow to 30 m and trail behind the animal.

Figure 12 The Portuguese manof-war also is called the bluebottle. This animal is not one organism. It is four kinds of cnidarians that depend on one another for survival.



🖌 Reading Check

What are some possible benefits of having a medusa and a polyp form?



Adult sea anemones are polyps that grow attached to the ocean bottom, a rock, coral, or any surface. They depend on the movement of water to bring them food.

Jellies can perform upward movements but must float to move downward.



Topic: Cnidarian Ecology

Visit bookc.msscience.com for Web links to information about cnidarian ecology.

Activity Describe a cnidarian that is endangered, and the reasons why it is endangered.

Figure 14 Tentacles surround the mouth of a sea anemone.

A Clown fish are protected from the sea anemone's sting by a special mucous covering. The anemone eats scraps that the fish drop, and the fish are protected from predators by the anemone's sting.

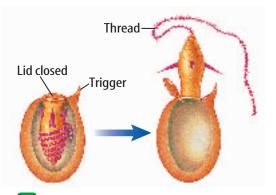
Body Structure All cnidarians have one body opening and radial symmetry. They have more complex bodies than sponges do. They have two cell layers that are arranged into tissues and a digestive cavity where food is broken down. In the two-cell-layer body plan of cnidarians, no cell is ever far from the water. In each cell, oxygen from the water is exchanged for carbon dioxide and other cell wastes.

Cnidarians have a system of nerve cells called a nerve net. The nerve net carries impulses and connects all parts of the organism. This makes cnidarians capable of some simple responses and movements. Hydras can somersault away from a threatening situation.

Armlike structures called **tentacles** (TEN tih kulz) surround the mouths of most cnidarians. Certain fish, shrimp, and other small animals live unharmed among the tentacles of large sea anemones, as shown in Figure 14A. The tentacles have stinging cells. A stinging cell, as shown in Figure 14B, has a capsule with a coiled, threadlike structure that helps the cnidarian capture food. Animals that live among an anemone's tentacles are not affected by the stinging cells. The animals are thought to help clean the sea anemone and protect it from certain predators.

Obtaining Food Cnidarians are predators. Some can stun their prey with nerve toxins produced by stinging cells. The threadlike structure in the stinging cell is sticky or barbed. When a cnidarian is touched or senses certain chemicals in its environment, the threadlike structures discharge and capture the prey. The tentacles bring the prey to the mouth, and the cnidarian ingests the food. Because cnidarians have only one body opening, undigested food goes back out through the mouth.





B A sea anemone's stinging cells have triggerlike structures. When prey brushes against the trigger, the thread is released into the prey. A toxin in the stinging cell stuns the prey.

Identify the type of adaptation this is: physical, behavior, or predatory. Explain your answer.

Figure 15 Cnidarians that spend most of their life as medusae reproduce in two stages. One stage involves sexual reproduction and the other stage involves asexual reproduction.

Medusae _

Female

Sperm

Egg

Asexual reproduction



A medusa buds off the polyp, and the cycle begins again.

> In the asexual stage, the resulting polyp grows and begins to form buds that become tiny medusae.

Male

In the sexual stage, the free-swimming female medusa releases eggs and the male medusa releases sperm into the water.

Sexual reproduction

A fertilized egg can develop into a larva, which can attach to a rock or another surface.

Larva

– Polyp

Reproduction Cnidarians reproduce asexually and sexually, as shown in **Figure 15.** Polyp forms reproduce asexually by producing buds that eventually fall off the cnidarian and develop into new polyps. Polyps also reproduce sexually by producing eggs or sperm. Sperm are released into the water and fertilize the eggs, which also are released into the water.

Medusa (plural, *medusae*) forms of cnidarians have two stages of reproduction—a sexual stage and an asexual stage. Free-swimming medusae produce eggs or sperm and release them into the water. The eggs are fertilized by sperm from another medusa of the same species and develop into larvae. The larvae eventually settle down and grow into polyps. When young medusae bud off the polyp, the cycle begins again.

Origin of Cnidarians

The first cnidarians might have been on Earth more than 600 million years ago. Scientists hypothesize that the medusa body was the first form of cnidarian. Polyps could have formed from larvae of medusae that became permanently attached to a surface. Most of the cnidarian fossils are corals.





Figure 16 Coral reefs are colonies made up of many individual corals. **Infer** the benefit of living in a colony for the corals.



The large coral reef formations found in shallow tropical seas are built as one gen-

eration of corals secretes their hard external skeletons on those of earlier generations. It takes millions of years for large reefs, such as those found in the waters of the Indian Ocean, the south Pacific Ocean, and the Caribbean Sea, to form.

Importance of Corals Coral reefs, shown in **Figure 16**, are productive ecosystems and extremely important in the ecology of tropical waters. They have a diversity of life comparable to tropical rain forests. Some of the most beautiful and fascinating animals of the world live in the formations of coral reefs.

Beaches and shorelines are protected from much of the action of waves by coral reefs. When coral reefs are destroyed or severely damaged, large amounts of shoreline can be washed away.

If you go scuba diving or snorkeling, you might explore a coral reef. Coral reefs are home for organisms that provide valuable shells and pearls. Fossil reefs can give geologists clues about the location of oil deposits.

Like sponges, corals produce chemicals to protect themselves from diseases or to prevent other organisms from settling on them. Medical researchers are learning that some of these chemicals might provide humans with drugs to fight cancer. Some coral is even used as a permanent replacement for missing sections of bone in humans.



Summary

Sponges

- Most sponges live in salt water, are sessile, and vary in size, color, and shape.
- A sponge has no tissues, organs, or organ systems.
- Sponges filter food from the water, and reproduce sexually and asexually.

Cnidarians

- Cnidarians live mostly in salt water and have two body forms: polyp and medusa.
- Cnidarians have nerve cells, tissues, and a digestive cavity.
- Corals are cnidarians that make up a diverse ecosystem called a coral reef.

Self Check

- **1. Compare and contrast** how sponges and cnidarians get their food.
- 2. **Describe** the two body forms of cnidarians and tell how each reproduces.
- 3. Infer why most fossils of cnidarians are coral fossils. Would you expect to find a fossil sponge? Explain.
- **4. Think Critically** What effect might the destruction of a large coral reef have on other ocean life?

Applying Math

5. Solve One-Step Equations A sponge 1 cm in diameter and 10 cm tall can move 22.5 L of water through its body each day. What volume of water will it pump through its body in 1 h? In 1 min?

bookc.msscience.com/self_check_quiz

Observing a Cnidarian

The hydra has a body cavity that is a simple, hollow sac. It is one of the few freshwater cnidarians.

🧔 Real-World Question —

How does a hydra react to food and other stimuli?

Goals

- Predict how a hydra will respond to various stimuli.
- **Observe** how a hydra responds to stimuli.

Materials

dropper hydra culture small dish toothpick *Daphnia* or brine shrimp stereomicroscope

Safety Precautions

🔊 ¥ 🕼 🛣 🜆

Procedure

1. Copy the data table and use it to record your observations.

Hydra Observations							
Features	Observations						
Color	Do not write						
Number of tentacles	in this book.						
Reaction to touch							
Reaction to food							

- 2. Use a dropper to place a hydra and some of the water in which it is living into a dish.
- **3.** Place the dish on the stage of a stereomicroscope. Bring the hydra into focus. Record the hydra's color.
- **4. Identify** and count the number of tentacles. Locate the mouth.



- 5. Study the basal disk by which the hydra attaches itself to a surface.
- 6. Predict what will happen if the hydra is touched with a toothpick. Carefully touch the tentacles with a toothpick. Describe the reaction in the data table.
- **7.** Drop a *Daphnia* or a small amount of brine shrimp into the dish. Observe how the hydra takes in food. Record your observations.
- 8. Return the hydra to the culture.

Conclude and Apply –

- 1. Analyze what happened when the hydra was touched. What happened to other areas of the animal?
- 2. **Describe** the advantages tentacles provide for hydra.



Compare your results with those of other students. Discuss whether all of the hydras studied had the same responses, and how the responses aid hydras in survival.



Flatworms and Roundworms

as you read

What You'll Learn

- List the characteristics of flatworms and roundworms.
- Distinguish between free-living and parasitic organisms.
- Identify disease-causing flatworms and roundworms.

Why It's Important

Many species of flatworms and roundworms cause disease in plants and animals.

P Review Vocabulary

cilia: short, threadlike structures that aid in locomotion

New Vocabulary

- free-living organism
- anus

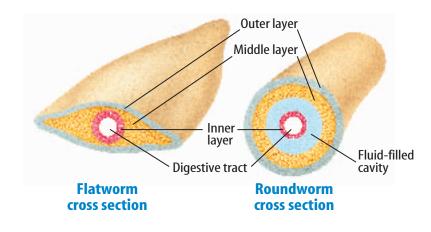
What is a worm?

Worms are invertebrates with soft bodies and bilateral symmetry. They have three tissue layers, as shown in **Figure 17**, which are organized into organs and organ systems.

Flatworms

As their name implies, flatworms have flattened bodies. Members of this group include planarians, flukes, and tapeworms. Some flatworms are free-living, but most are parasites, which means that they depend on another organism for food and a place to live. Unlike a parasite, a **free-living organism** doesn't depend on another organism for food or a place to live.

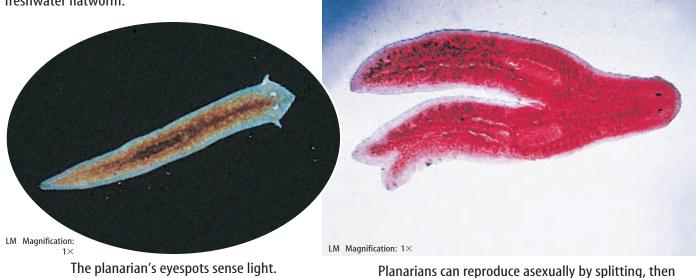
Planarians An example of a free-living flatworm is the planarian, as shown in **Figure 18.** It has a triangle-shaped head with two eyespots. Its one body opening—a mouth—is on the underside of the body. A muscular tube called the pharynx connects the mouth and the digestive tract. A planarian feeds on small organisms and dead bodies of larger organisms. Most planarians live under rocks, on plant material, or in freshwater. They vary in length from 3 mm to 30 cm. Their bodies are covered with fine, hairlike structures called cilia. As the cilia move, the worm is moved along in a slimy mucous track that is secreted from the underside of the planarian.



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Figure 17 Worms have cells that are arranged into three specialized tissue layers and organs.

Figure 18 The planarian is a common freshwater flatworm.



Planarians reproduce asexually by dividing in two, as shown in **Figure 18.** A planarian can be cut in two, and each piece will grow into a new worm. They also have the ability to regenerate. Planarians reproduce sexually by producing eggs and sperm. Most are hermaphrodites and exchange sperm with one another. They lay fertilized eggs that hatch in a few weeks.

Flukes All flukes are parasites with complex life cycles that require more than one host. Most flukes reproduce sexually. The male worm deposits sperm in the female worm. She lays the fertilized eggs inside the host. The eggs leave the host in its urine or feces. If the eggs end up in water, they usually infect snails. After they leave the snail, the young worms can burrow into the skin of a new host, such as a human, while he or she is

standing or swimming in the water.

Of the many diseases caused by flukes, the most widespread one affecting humans is schistosomiasis (shis tuh soh MI uh sus). It is caused by blood flukes—flatworms that live in the blood, as shown in **Figure 19.** More than 200 million people, mostly in developing countries, are infected with blood flukes. It is estimated that 1 million people die each year because of them. Other types of flukes can infect the lungs, liver, eyes, and other organs of their host.

Keading Check

What is the most common disease that is caused by flukes?

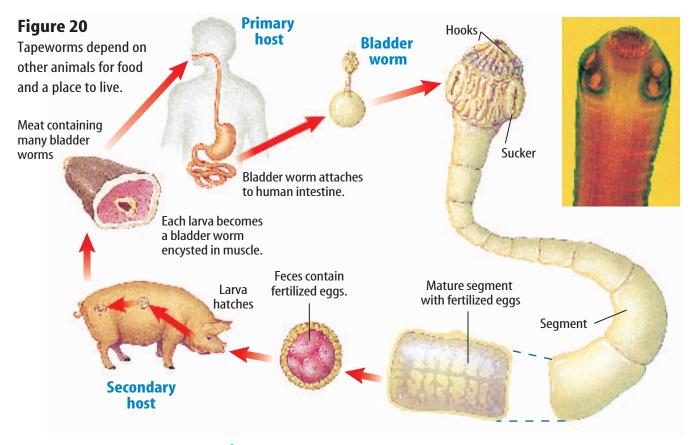
regenerating the other half.

Figure 19 Female blood flukes deposit their eggs in the blood of their host. The eggs travel through the host and eventually end up in the host's digestive system.



Stained LM Magnification: 20imes

CONTENTS





Observing Planarian Movement

Procedure 🐼 🐨

- 1. Use a dropper to transfer a planarian to a watch glass.
- 2. Add enough water so the planarian can move freely.
- 3. Place the glass under a stereomicroscope and observe the planarian.

Analysis

- 1. Describe how a planarian moves in the water.
- 2. What body parts appear to be used in movement?
- **3.** Explain why a planarian is a free-living flatworm.

Tapeworms Another type of flatworm is the tapeworm. These worms are parasites. The adult form uses hooks and suckers to attach itself to the intestine of a host organism, as illustrated in **Figure 20.** Dogs, cats, humans, and other animals are hosts for tapeworms. A tapeworm doesn't have a mouth or a digestive system. Instead, the tapeworm absorbs food that is digested by the host from its host's intestine.

A tapeworm grows by producing new body segments immediately behind its head. Its ribbonlike body can grow to be 12 m long. Each body segment has both male and female reproductive organs. The eggs are fertilized by sperm in the same segment. After a segment is filled with fertilized eggs, it breaks off and passes out of the host's body with the host's wastes. If another host eats a fertilized egg, the egg hatches and develops into an immature tapeworm called a bladder worm.

Origin of Flatworms

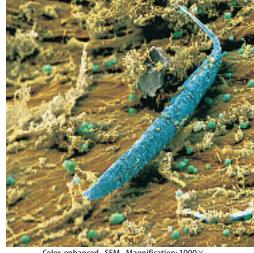
Because of the limited fossil evidence, the evolution of flatworms is uncertain. Evidence suggests that they were the first group of animals to evolve bilateral symmetry with senses and nerves in the head region. They also were probably the first group of animals to have a third tissue layer that develops into organs and systems. Some scientists hypothesize that flatworms and cnidarians might have had a common ancestor.



Roundworms

If you own a dog, you've probably had to get medicine from your veterinarian to protect it from heartworms—a type of roundworm. Roundworms also are called nematodes and more nematodes live on Earth than any other type of many-celled organism. It is estimated that more than a half million species of roundworms exist. They are found in soil, animals, plants, freshwater, and salt water. Some are parasitic, but most are free-living.

Roundworms are slender and tapered at both ends like the one in **Figure 21.** The body is a tube within a tube, with fluid in between. Most nematode species have male and female worms and reproduce sexually. Nematodes have two body openings, a mouth, and an anus. The **anus** is an opening at the end of the digestive tract through which wastes leave the body.



Color-enhanced SEM Magnification: 1000×

Figure 21 Some roundworms infect humans and other animals. Others infect plants, and some are free-living in the soil.

Reading Check

What characteristics of roundworms might contribute to the success of the group?

Applying Math Use Percentages SPECIES COUNTS In a forest ecosystem, about four percent of the 400 different animal species are roundworm species. How many roundworm species are in this ecosystem? Solution **1** This is what you know: • total animal species = 400 • roundworms species = 4% of total animal species **2** This is what you must How many roundworm species are in the ecosystem? find out: • Change 4% to a decimal. $\frac{4}{100} = 0.04$ **3** This is the procedure you need to use: • Use following equation: (roundworm-species percent as a decimal) \times (total animal species) = number of roundworm species • Substitute in known values: $0.04 \times 400 = 16$ roundworm species **4** *Check your answer:* Divide 16 by 0.04 and you should get 400. **Practice Problems 1.** Flatworms make up 1.5 percent of all animal species in the forest ecosystem. How many flatworms species probably are present? 2. If there are 16 bird species present, what percent of the animal species are the bird species? For more practice, visit bookc.msscience.com/ Science math_practice

CONTENTS

NATIONAL GEOGRAPHIC VISUALIZING PARASITIC WORMS

Figure 22

any diseases are caused by parasitic roundworms and flatworms that take up residence in the human body. Some of these diseases result in diarrhea, weight loss, and fatigue; others, if left untreated, can be fatal. Micrographs of several species of roundworms and flatworms and their magnifications are shown here.



6× LIVER FLUKE Humans and other mammals ingest the larvae of these parasites by eating contaminated plant material. Immature flukes penetrate the intestinal wall and pass via the liver into the bile ducts. There they mature into adults that feed on blood and tissue.

78× BLOOD FLUKE These

(br)Cabi

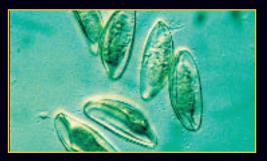
Researchers. (bcl)Andrew Svred/Science Photo Librarv/Photo

chers, (cr)Arthur M. Sieg

ence Photo Library/Photo Researchers. (cl)Sinclair St

parasites live as larvae in lakes and rivers and penetrate the skin of people wading in the water. After maturing in the liver, the flukes settle in veins in the intestine and bladder, causing schistosomiasis (shis tuh soh MI uh sus), which damages the liver and spleen.

▼ 125× PINWORMS Typically inhabiting the large intestine, the female pinworm lays her eggs near the host's anus, causing discomfort. The micrograph below shows pinworm eggs on a piece of clear tape.





◆ 170× ROUNDWORMS The roundworms that cause the disease trichinosis (trih kuh NOH sus) are eaten as larvae in undercooked infected meat. They mature in the intestine, then migrate to muscle tissue, where they form painful cysts.



• 4× HOOKWORM These parasites enter their

human hosts as larvae by penetrating the skin of bare feet. From there, they migrate to the lungs and eventually to the intestine, where they mature.

larvae in muscle tissue



Origin of Roundworms More than 550 million years ago, roundworms appeared early in animal evolution. They were the first group of animals to have a digestive system with a mouth and an anus. Scientists hypothesize that roundworms are more closely related to arthropods than to vertebrates. However, it is still unclear how roundworms fit into the evolution of animals.

Importance of Roundworms Some roundworms, shown in **Figure 22**, cause diseases in humans. Others are parasites of plants or of other animals, such as the fish shown in **Figure 23**. Some nematodes cause damage to fiber, agricultural products, and food. It is estimated that the worldwide annual amount of nematode damage is in the millions of dollars.

Not all roundworms are a problem for humans, however. In fact, many species are beneficial. Some species of roundworms feed on termites, fleas, ants, beetles, and many other types of

insects that cause damage to crops and human property. Some species of beneficial nematodes kill other pests. Research is being done with nematodes that kill deer ticks that cause Lyme disease.

Roundworms also are important because they are essential to the health of soil. They provide nutrients to the soil as they break down organic material. They also help in cycling nutrients such as nitrogen. **Figure 23** This fish's fin is infected with parasitic roundworms. These roundworms damage the fin, which makes it difficult for the fish to swim and escape from predators.



section

Summary

Common Characteristics

 Both flatworms and roundworms are invertebrates with soft bodies, bilateral symmetry, and three tissue layers that are organized into organs and organ systems.

Flatworms

 Flatworms have flattened bodies, and can be free-living or parasitic. They generally have one body opening.

Roundworms

 Also called nematodes, roundworms have a tube within a tube body plan. They have two openings: a mouth and an anus.

Self Check

- 1. Compare and contrast the body plan of a flatworm to the body plan of a roundworm.
- Distinguish between a free-living flatworm and a parasitic flatworm.
- 3. Explain how tapeworms get energy.

review

- 4. Identify three roundworms that cause diseases in humans. How can humans prevent infection from each?
- **5. Think Critically** Why is a flatworm considered to be more complex than a hydra?

Applying Skills

 Concept Map Make an events-chain concept map for tapeworm reproduction.

Science IIII bookc.msscience.com/self_check_quiz

SECTION 3 Flatworms and Roundworms C

R. Calentine/Visuals Unlimited

Design Your Own

Comparing Free-Living and Parasitic Flatworms

Real-World Question —

How are the body parts of flatworms adapted to the environment in which they live? Are the adaptations of free-living flatworms and parasitic flatworms the same?

🧔 Form a Hypothesis

CONTENTS

Form a hypothesis about what adaptations you think free-living and parasitic worms might have. What would be the benefits of these adaptations?

Goals

- Compare and contrast the body parts and functions of freeliving and parasitic flatworms.
- Observe how flatworms are adapted to their environments.

Possible Materials

petri dish with a planarian compound microscope prepared slide of a tapeworm stereomicroscope light source, such as a lamp small paintbrush small piece of liver dropper water

Safety Precautions

🧔 Test Your Hypothesis

Make a Plan

 As a group, make a list of possible ways you might design a procedure to compare and contrast types of flatworms. Your teacher will provide you with information on handling live flatworms.

Using Scientific Methods

- 2. Choose one of the methods you described in step 1. List the steps you will need to take to follow the procedure. Be sure to describe exactly what you will do at each step of the activity.
- 3. List the materials that you will need to complete your experiment.
- **4.** If you need a data table, design one in your Science Journal so it is ready to use when your group begins to collect data.

Follow Your Plan

- **1.** Make sure your teacher approves your plan before you start.
- **2.** Carry out the experiment according to the approved plan.
- **3.** While the experiment is going on, record any observations that you make and complete the data table in your Science Journal.

🧔 Analyze Your Data

- **1. Explain** how parasitic and free-living flatworms are similar.
- 2. Describe the differences between parasitic and free-living worms.

🧔 Conclude and Apply

- 1. **Identify** which body systems are more developed in free-living flatworms.
- **2. Identify** which body system is more complex in parasitic flatworms.
- **3. Infer** which adaptations allow some flatworms to live as free-living organisms.

Communicating Your Data

Compare and discuss your experiment design and conclusions with other students. For more help, refer to the Science Skill Handbook.

SCIENCE SCIENCE AND HISTORY

A natural sponge

A common household item contains a lot of history

ponges and baths. They go together like a hammer and nails. But sponges weren't always used just to scrub people and countertops. Some Greek artists dipped sponges into paint to dab on their artwork and crafts. Greek and Roman soldiers padded their



helmets with soft sponges similar to modern padded bicycle helmets to soften enemies' blows. The Roman soldiers also used sponges like a canteen to soak up water from a nearby stream and squeeze it into their mouths. Sponges have appeared in artwork from prehistoric times and the Middle Ages, and are mentioned in Shakespeare's play Hamlet.

Natural sponges have been gathered over time from the Mediterranean, Caribbean Sea, and off the coast of Florida. Divers used to carry up the sponges from deep water, but today sponges are harvested in shallower water. Synthetic sponges, made of rubber or cellulose, are used more today than natural ones. Natural sponges absorb more water and last longer, but synthetic sponges are less expensive. Natural sponges may also cure diseases. Medical researchers hypothesize that an enzyme produced by sponges might help cure cancer. Who says natural sponges are washed up?

Brainstorm Work with your classmates to come up with as many sayings and phrases as you can using the word *sponge*. Use some of them in a story about sponges. Share your stories with the class.



For more information, visit bookc.msscience.com/time



Reviewing Main Ideas

chapter

Section 1 Is it an animal?

- **1.** Animals are many-celled organisms that must find and digest their food.
- 2. Herbivores eat plants, carnivores eat animals or animal flesh, omnivores eat plants and animals, and detritivores feed on decaying plants and animals.
- **3.** Animals have many ways to escape from predators such as speed, mimicry, protective outer coverings, and camouflage.
- **4.** Invertebrates are animals without backbones. Animals that have backbones are called vertebrates.
- **5.** When body parts are arranged the same way on both sides of the body, it is called bilateral symmetry. If body parts are arranged in a circle around a central point, it is known as radial symmetry. Animals without a specific central point are asymmetrical.

Section 2 Sponges and Cnidarians

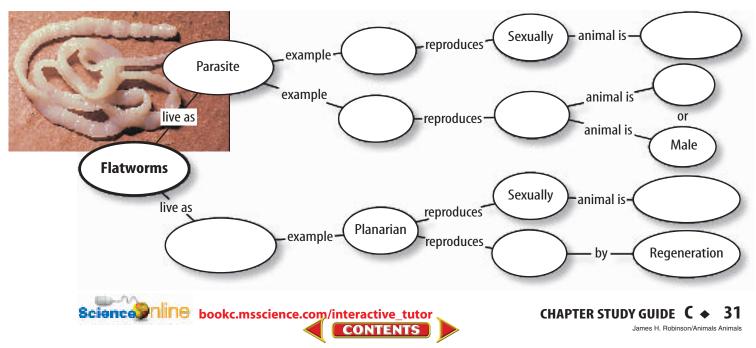
Study Guide

- 1. Adult sponges are sessile and obtain food by filtering water through their pores. Sponges can reproduce sexually and asexually.
- **2.** Cnidarians are hollow-bodied animals with radial symmetry. Most have tentacles with stinging cells to obtain food.
- **3.** Coral reefs have been deposited by reefbuilding corals over millions of years.

Section 3 Flatworms and Roundworms

- **1.** Flatworms have bilateral symmetry. Freeliving and parasitic forms exist.
- **2.** Roundworms have a tube-within-a-tube body plan and bilateral symmetry.
- **3.** Flatworm and roundworm species can cause disease in humans.

Visualizing Main Ideas



Copy and complete the following concept map.

Using Vocabulary

anus p. 25 bilateral symmetry p. 13 carnivore p. 9 free-living organism p. 22 herbivore p. 9 hermaphrodite p. 16 invertebrate p. 12 medusa p. 17

chapter

omnivore p.9 polyp p.17 radial symmetry p.13 sessile p.15 stinging cell p.18 tentacle p.18 vertebrate p.12

Review

Find the correct vocabulary word(s).

- **1.** animal without backbones
- 2. body parts arranged around a central point
- 3. animal that eat only other animals
- 4. animal that eat just plants
- **5.** animal that produce sperm and eggs in one body
- 6. animal with backbones
- **7.** body parts arranged similarly on both sides of the body
- 8. cnidarian body that is vase shaped
- 9. attached to one place
- **10.** cnidarian body that is bell shaped

Checking Concepts

Choose the word or phrase that best answers the question.

- **11.** Which of the following animals is sessile?
 - A) jellyfish C) planarian
 - **B)** roundworm **D)** sponge
- 12. What characteristic do all animals have?
 - A) digest their food
 - **B)** radial symmetry
 - **C)** free-living
 - **D)** polyp and medusa forms
- 32
 C CHAPTER REVIEW

- **13.** Which term best describes a hydra?
 - A) carnivore C) herbivore
 - **B)** filter feeder **D)** parasite
- **14.** Which animal has a mouth and an anus?
 - A) roundworm C) planarian
 - **B)** jellyfish **D)** tapeworm
- **15.** What characteristic do scientists use to classify sponges?
 - A) material that makes up their skeletons
 - **B)** method of obtaining food
 - **C)** reproduction
 - **D)** symmetry
- **16.** Which animal is a cnidarian?
 - A) fluke C) jellyfish
 - **B)** heartworm **D)** sponge

Use the photo below to answer question 17.



- **17.** The photo above shows which hermaphroditic invertebrate organism?
 - A) flukeC) tapeworm
 - **B)** coral **D)** roundworm
- **18.** How do sponges reproduce asexually?
 - A) budding C) medusae
 - **B**) polyps **D**) eggs and sperm
- **19.** What is the young organism that the fertilized egg of a sponge develops into?
 - A) bud C) medusa
 - **B**) larva **D**) polyp
- **20.** Which group do roundworms belong to?
 - A) cnidarians C) planarians
 - **B)** nematodes **D)** sponges



- **21.** Compare and contrast the body organization of a sponge to that of a flatworm.
- **22. Infer** the advantages of being able to reproduce sexually and asexually for animals like sponges, cnidarians, and flatworms.
- **23.** List the types of food that sponges, hydras, and planarians eat. Explain why each organism eats a different size of particle.
- **24. Compare and contrast** the medusa and polyp body forms of cnidarians.
- **25. Infer** why scientists think the medusa stage was the first stage of the cnidarians.
- **26.** Form a hypothesis about why cooking pork at high temperatures prevents harmful roundworms from developing, if they are present in the uncooked meat.
- **27. Predict** what you can about the life of an organism that has no mouth or digestive system but has suckers and hooks on its head.
- **28.** Interpret Scientific Illustrations Look at the photograph below. This animal escapes

from predators by mimicry. Where in nature might you find the animal in this photo?



CONTENTS

Performance Activities

29. Report Research tapeworms and other parasitic worms that live in humans. Find out how they are able to live in the intestines without being digested by the human host. Report your findings to the class. **30. Video Presentation** Create a video presentation using computer software or slides to illustrate the variety of sponges and cnidarians found on a coral reef.

Review

Applying Math

31. Reef Ecology Coral reefs are considered the "rain forests of the ocean" due to the number of different species that depend on them. If scientists estimate that out of 4,000 species, 1,000 are from the coral reef ecosystem, what percentage of life is dependent on the reef?

Use the table below to answer questions 32 and 33.

Reef Area Data		
Country/Geographical Location	Reef Area [km ²]	
Indonesia	51,000	
Australia	49,000	
Philippines	25,100	
France	14,300	
Papua, New Guinea	13,800	
Fiji	10,000	
Maledives	8,900	
Saudi Arabia	6,700	
Marshall Islands	6,100	
India	5,800	
United States	3,800	
Other	89,800	
Uther	89,800	

- **32. Reef Disappearance** Coral reefs are disappearing for many reasons, such as increased temperatures, physical damage, and pollution. In 2003, scientists predict that at the current rate of disappearance, in 2100 coral reefs will be gone. Use the table above to calculate the current rate of coral reef disappearance.
- **33.** Reef Locations What percentage of coral reefs are off of the Australian coast?

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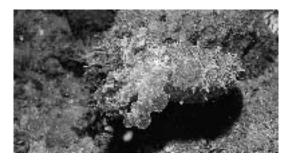
chapter

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- **1.** An animal that kills and then only eats other animals is an
 - A) omnivore. C) carnivore.
 - **B)** herbivore. **D)** scavenger.
- **2.** An animal that does not have a backbone is called
 - A) a vertebrate. C) a hermaphrodite.
 - **B)** an invertebrate. **D)** a medusa.

Use the illustration below to answer questions 3 and 4.



- **3.** This animal escapes from predators by using
 - A) behavioral adaptation.
 - **B**) predator adaptation.
 - **c)** mimicry.
 - **D)** physical adaptation.
- **4.** Markings that help an animal hide from its predators are called
 - A) camouflage. **C)** behaviour.
 - **B)** sessile. **D)** mimicry.
- 5. Which of the following is not a cnidarian?
 - A) coral
- **C)** sea anemone

D) sponge

B) hydra

Test-Taking Tip

Study Advice Do not "cram" the night before a test. It can hamper your memory and make you tired.

- **6.** Animals that have body parts arranged around a center point
 - A) exhibit radial symmetry.
 - B) exhibit bilateral symmetry.
 - **C)** exhibit asymmetry.
 - **D)** exhibit no symmetry.

Use the photo below to answer questions 7 and 8.



- **7.** This organism would typically be found in which environment?
 - A) lakeC) oceanB) riverD) pond
- 8. It would likely spend most of its life
 A) floating on water currents.
 - **B)** attached to rock or coral.
 - **C)** grouped in a colony.
 - **D**) dependent on three other cnidarians.
- 9. Worms have which type of symmetry?
 - A) asymmetry
 - **B)** bilateral symmetry
 - **C)** radial symmetry
 - **D)** no symmetry
- **10.** Which animal's body has the least complex body organization?
 - A) cnidarians C) worms
 - **B**) nematodes **D**) sponges





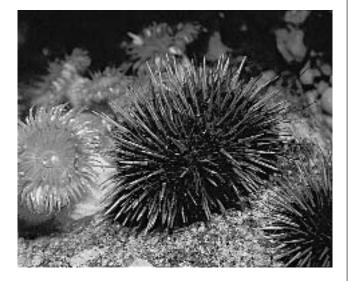
Standardized Test Practice

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

11. Name three adaptations, and give an example for each.

Use the photo below to answer questions 12 and 13.



- **12.** What types of classification and symmetry does this animal have and why?
- **13.** Compare and contrast this with the type of classification and symmetry you have as a human.
- 14. How do sponges get food and oxygen?
- **15.** Explain how sponges reproduce. Do they have more than one method of reproduction?
- **16.** Explain the two forms of cnidarians.
- **17.** Describe structure of the stinging cells unique to cnidarians. What are the purposes of these cells?
- **18.** Explain the primary difference between a roundworm and a flatworm.
- **19.** Roundworms and flatworms are the simplest organism to have what feature?

CONTENTS

Part 3 Open Ended

Record your answers on a sheet of paper.

- **20.** What are the characteristics that animals have in common and causes them to be included in their own kingdom?
- **21.** Animals need energy. They get this from food. Explain the differences between herbivores, carnivores, omnivores and detritivores. Be sure to include examples of all categories.
- **22.** Compare and contrast mimicry and camouflage. Give an example of both mimicry and camouflage.

Use the photo below to answer question 23.



- 23. How is this animal useful to humans?
- 24. Why is coral so important to us?
- **25.** Explain how two types of animals may interact in a host and parasitic relationship. Include humans in this discussion.
- **26.** Compare and contrast flatworms and roundworms. In your opinion, which are more developed? Defend your answer by providing examples.

Science hookc.msscience.com/standardized_test

Mollusks, Worms, Arthropods, Echinoderms

chapter preview

sections

- 1 Mollusks
- 2 Segmented Worms
- **3** Arthropods Lab Observing a Crayfish
- 4 Echinoderms Lab What do worms eat?
- Virtual Lab How are mollusks, worms, arthropods, and echinoderms classified?

An Army of Ants!

CONTENTS

These green weaver worker ants are working together to defend their nest. These ants, and more than a million other species, are members of the largest and most diverse group of animals, the arthropods. In this chapter, you will be studying these animals, as well as mollusks, worms, and echinoderms.

Science Journal Write three animals from each animal group that you will be studying: mollusks, worms, arthropods, and echinoderms.

6 + C

Start-Up Activities



Mollusk Protection

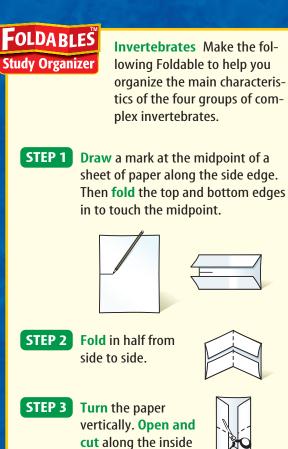
If you've ever walked along a beach, especially after a storm, you've probably seen many seashells. They come in different colors, shapes, and sizes. If you look closely, you will see that some shells have many rings or bands. In the following lab, find out what the bands tell you about the shell and the organism that made it. 🧒 🏰 🐚

- **1.** Use a magnifying lens to examine a clam's shell.
- 2. Count the number of rings or bands on the shell. Count as number one the large, top point called the crown.
- 3. Compare the distances between the bands of the shell.
- 4. Think Critically Do other students' shells have the same number of bands? Are all of the bands on your shell the same width? What do you think the bands represent, and why are some wider than others? Record your answers in your Science Journal.

Science

Preview this chapter's content and activities at bookc.msscience.com

CONTENTS



fold lines to form four tabs.



STEP 4

Label the tabs Mollusks, Worms, Arthropods, and Echinoderms.



Classify As you read the chapter, list the characteristics of the four groups of invertebrates under the appropriate tab.

Mollusks

as you read

What You'll Learn

- Identify the characteristics of mollusks.
- Describe gastropods, bivalves, and cephalopods.
- Explain the environmental importance of mollusks.

Why It's Important

Mollusks are a food source for many animals. They also filter impurities from the water.

Q Review Vocabulary

visceral mass: contains the stomach and other organs

New Vocabulary

- mantle
- gill
- open circulatory system
- radula
- closed circulatory system

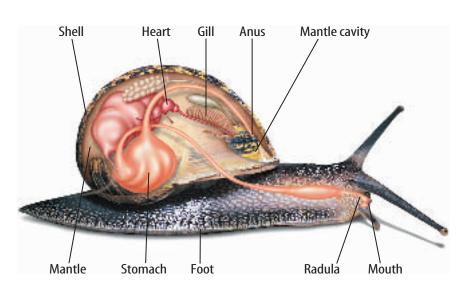
Characteristics of Mollusks

Mollusks (MAH lusks) are soft-bodied invertebrates with bilateral symmetry and usually one or two shells. Their organs are in a fluid-filled cavity. The word *mollusk* comes from the Latin word meaning "soft." Most mollusks live in water, but some live on land. Snails, clams, and squid are examples of mollusks. More than 110,000 species of mollusks have been identified.

Body Plan All mollusks, like the one in **Figure 1**, have a thin layer of tissue called a mantle. The **mantle** covers the body organs, which are located in the visceral (VIH suh rul) mass. Between the soft body and the mantle is a space called the mantle cavity. It contains **gills**—the organs in which carbon dioxide from the mollusk is exchanged for oxygen in the water.

The mantle also secretes the shell or protects the body if the mollusk does not have a shell. The shell is made up of several layers. The inside layer is the smoothest. It is usually the thickest layer because it's added to throughout the life of the mollusk. The inside layer also protects the soft body.

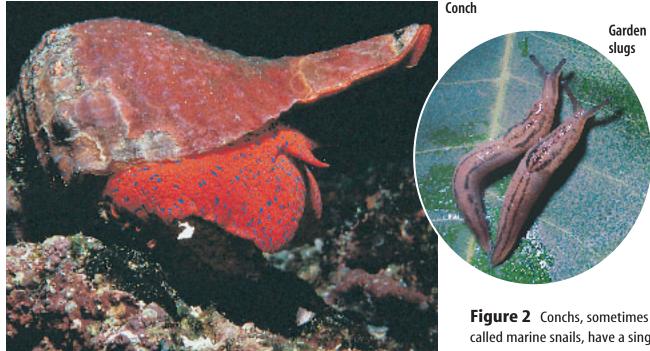
The circulatory system of most mollusks is an open system. In an **open circulatory system**, the heart moves blood out into the open spaces around the body organs. The blood, which contains nutrients and oxygen, completely surrounds and nourishes the body organs.



Most mollusks have a welldeveloped head with a mouth and some sensory organs. Some mollusks, such as squid, have tentacles. On the underside of a mollusk is the muscular foot, which is used for movement.

Figure 1 The general mollusk body plan is shown by this snail. Most mollusks have a head, foot, and visceral mass.

38 C CHAPTER 2 Mollusks, Worms, Arthropods, Echinoderms Wayne Lynch/DBK Photo



Classification of Mollusks

The first thing scientists look at when they classify mollusks is whether or not the animal has a shell. Mollusks that have shells are then classified by the kind of shell and kind of foot that they have. The three most common groups of mollusks are gastropods, bivalves, and cephalopods.

Gastropods The largest group of mollusks, the gastropods, includes snails, conchs like the one in **Figure 2**, abalones, whelks, sea slugs, and garden slugs, also shown in **Figure 2**. Conchs are sometimes called univalves. Except for slugs, which have no shell, gastropods have a single shell. Many have a pair of tentacles with eyes at the tips. Gastropods use a **radula** (RA juh luh)— a tonguelike organ with rows of teeth—to obtain food. The radula works like a file to scrape and tear food materials. That's why snails are helpful to have in an aquarium—they scrape the algae off the walls and keep the tank clean.

Reading Check How do gastropods get food?

Slugs and many snails are adapted to life on land. They move by rhythmic contractions of the muscular foot. Glands in the foot secrete a layer of mucus on which they slide. Slugs and snails are most active at night or on cloudy days when they can avoid the hot Sun. Slugs do not have shells but are protected by a layer of mucus instead, so they must live in moist places. Slugs and land snails damage plants as they eat leaves and stems.

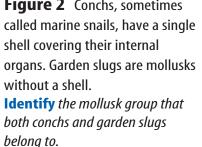






Figure 3 Scallops force water between their valves to move away from sea stars and other predators. They can move up to 1 m with each muscular contraction.

Bivalves Mollusks that have a hinged, two-part shell joined by strong muscles are called bivalves. Clams, oysters, and scallops are bivalve mollusks and are a familiar source of seafood. These animals pull their shells closed by contracting powerful muscles near the hinge. To open their shells, they relax these muscles.

Bivalves are well adapted for living in water. For protection, clams burrow deep into the sand by contracting and relaxing their muscular foot. Mussels and oysters attach themselves with a strong thread or

cement to a solid surface. This keeps waves and currents from washing them away. Scallops, shown in **Figure 3**, escape predators by rapidly opening and closing their shells. As water is forced out, the scallop moves rapidly in the opposite direction.

Cephalopods The most specialized and complex mollusks are the cephalopods (SE fuh luh pawdz). Squid, octopuses, cuttlefish, and chambered nautiluses belong to this group. The word *cephalopod* means "head-footed" and describes the body structure of these invertebrates. Cephalopods, like the cuttlefish in **Figure 4**, have a large, well-developed head. Their foot is divided into many tentacles with strong suction cups or hooks for capturing prey. All cephalopods are predators. They feed on fish, crustaceans, worms, and other mollusks.

Squid and octopuses have a well-developed nervous system and large eyes similar to human eyes. Unlike other mollusks, cephalopods have closed circulatory systems. In a **closed circulatory system**, blood containing food and oxygen moves through the body in a series of closed vessels, just as your blood moves through your blood vessels.

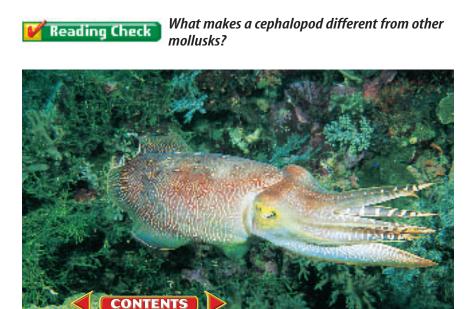


Figure 4 Most cephalopods, like this cuttlefish, have an internal shell. **Infer** why an internal shell would

be a helpful adaptation.

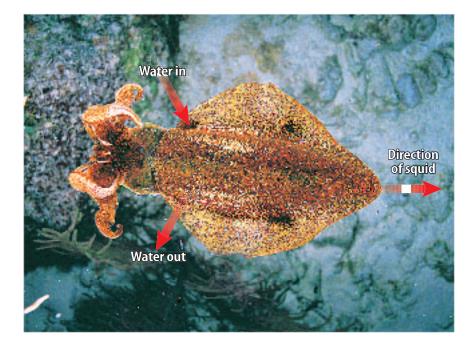


Figure 5 Squid and other cephalopods use jet propulsion to move quickly away from predators.

Cephalopod Propulsion All cephalopods live in oceans and are adapted for swimming. Squid and other cephalopods have a water-filled cavity between an outer muscular covering and its internal organs. When the cephalopod tightens its muscular covering, water is forced out through an opening near the head, as shown in **Figure 5.** The jet of water propels the cephalopod backwards, and it moves away quickly. According to Newton's third law of motion, when one object exerts a force on a second object, the second object exerts a force on the first that is equal and opposite in direction. The movement of cephalopods is an example of this law. Muscles exert force on water under the mantle. Water being forced out exerts a force that results in movement backwards.

NTEGRATE

A squid can propel itself at speeds of more than 6 m/s using this jet propulsion and can briefly outdistance all but whales, dolphins, and the fastest fish. A squid even can jump out of the water and reach heights of almost 5 m above the ocean's surface. It then can travel through the air as far as 15 m. However, squid can maintain their top speed for just a few pulses. Octopuses also can swim by jet propulsion, but they usually use their tentacles to creep more slowly over the ocean floor.

Origin of Mollusks Some species of mollusks, such as the chambered nautilus, have changed little from their ancestors. Mollusk fossils date back more than 500 million years. Many species of mollusks became extinct about 65 million years ago. Today's mollusks are descendants of ancient mollusks.



Mollusk Extinction By about 65 million years ago, many mollusks had become extinct. What were the major physical events of the time that could have contributed to changing the environment? Write your answers in your Science Journal.





Figure 6 A pearl starts as an irritant—a grain of sand or a parasite—to an oyster. The oyster coats the irritant with a material that forms smooth, hard layers. It can take years for a pearl to form. Culturing pearls is a commercial industry in some countries.

Value of Mollusks

Mollusks have many uses. They are food for fish, sea stars, birds, and humans. Many people make their living raising or collecting mollusks to sell for food. Other invertebrates, such as hermit crabs, use empty mollusk shells as shelter. Many mollusk shells are used for jewelry and decoration. Pearls are produced by several species of mollusks, but most are made by mollusks called pearl oysters, shown in **Figure 6.** Mollusk shells also provide information about the conditions in an ecosystem, including the source and distribution of water pollutants. The internal shell of a cuttlefish

is the cuttlebone, which is used in birdcages to provide birds with calcium. Squid and octopuses are able to learn tasks, so scientists are studying their nervous systems to understand how learning takes place and how memory works.

Even though mollusks are beneficial in many ways, they also can cause problems for humans. Land slugs and snails damage plants. Certain species of snails are hosts of parasites that infect humans. Shipworms, a type of bivalve, make holes in submerged wood of docks and boats, causing millions of dollars in damage each year. Because clams, oysters, and other mollusks are filter feeders, bacteria, viruses, and toxic protists from the water can become trapped in the animals. Eating these infected mollusks can result in sickness or even death.

section

Summary

Mollusks

• The body plans of mollusks include a mantle, visceral mass, head, and foot.

Classification of Mollusks

- Gastropods typically have one shell, a foot, and eat using a radula.
- Bivalves have a hinged two-part shell, a muscular foot, and eat by filtering their food from the water.
- Cephalopods have a head, a foot which has been modified into tentacles, and a welldeveloped nervous system.

Value of Mollusks

Mollusks are food for many animals, have commercial uses, and are used for research.

Self Check

review

- **1. Explain** how a squid and other cephalopods can move so rapidly.
- **2. Identify** some positive and negative ways that mollusks affect humans.
- **3. Think Critically** Why is it unlikely that you would find garden slugs or land snails in a desert?

Applying Skills

- 4. Interpret Scientific Illustrations Observe the images of gastropods and bivalves in this section, and infer how bivalves are not adapted to life on land, but gastropods are.
- **5. Use a Computer** Make a data table that compares and contrasts the following for gastropods, bivalves, and cephalopods: *methods for obtaining food, movement, circulation,* and *habitat*.

IDE bookc.msscience.com/self_check_quiz

Segmented Worms

Segmented Worm Characteristics

section

The worms you see crawling across sidewalks after a rain and those used for fishing are called annelids (A nuh ludz). The word *annelid* means "little rings" and describes the bodies of these worms. They have tube-shaped bodies that are divided into many segments.

Have you ever watched a robin try to pull an earthworm out of the ground or tried it yourself? Why don't they slip out of the soil easily? On the outside of each body segment are bristlelike structures called **setae** (SEE tee). Segmented worms use their setae to hold on to the soil and to move. Segmented worms also have bilateral symmetry, a body cavity that holds the organs, and two body openings—a mouth and an anus. Annelids can be found in freshwater, salt water, and moist soil. Earthworms, like the one in **Figure 7,** marine worms, and leeches are examples of annelids.

Reading Check What is the function of setae?

Earthworm Body Systems

The most well-known annelids are earthworms. They have a definite anterior, or front end, and a posterior, or back end. Earthworms have more than 100 body segments. The segments

can be seen on the outside and the inside of the body cavity. Each body segment, except for the first and last segments, has four pairs of setae. Earthworms move by using their setae and two sets of muscles in the body wall. One set of muscles runs the length of the body, and the other set circles the body. When an earthworm contracts its long muscles, it causes some of the segments to bunch up and the setae to stick out. This anchors the worm to the soil. When the circular muscles contract, the setae are pulled in and the worm can move forward.

Figure 7 One species of earthworm that lives in Australia can grow to be 3.3 m long.

as you read

What You'll Learn

- Identify the characteristics of segmented worms.
- Describe the structures of an earthworm and how it takes in and digests food.
- Explain the importance of segmented worms.

Why It's Important

Earthworms condition and aerate the soil, which helps increase crop yields.

Review Vocabulary aerate: to supply with air

New Vocabulary

- setae
- crop
- gizzard







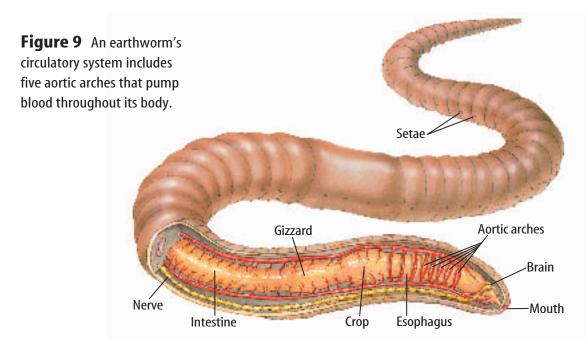
Figure 8 Earthworm castings also called vermicompost—are used as an organic fertilizer in gardens.

Infer why earthworms are healthy to have in a garden or compost pile.

Digestion and Excretion As an earthworm burrows through the soil, it takes soil into its mouth. Earthworms get energy from the bits of leaves and other organic matter found in the soil. The soil ingested by an earthworm moves to the **crop**, which is a sac used for storage. Behind the crop is a muscular structure called the **gizzard**, which grinds the soil and the bits of organic matter. This ground material passes to the intestine, where the organic matter is broken down and the nutrients are absorbed by the blood. Wastes leave the worm through the anus. When earthworms take in soil, they provide spaces for air and water to flow through it and mix the soil. Their wastes pile up at the openings to their burrows. These piles are called castings. Castings, like those in **Figure 8**, help fertilize the soil.

Circulation and Respiration Earthworms have a closed circulatory system, as shown in **Figure 9.** Two blood vessels along the top of the body and one along the bottom of the body meet in the front end of the earthworm. There, they connect to heartlike structures called aortic arches, which pump blood through the body. Smaller vessels go into each body segment.

Earthworms don't have gills or lungs. Oxygen and carbon dioxide are exchanged through their skin, which is covered with a thin film of watery mucus. It's important never to touch earthworms with dry hands or remove their thin mucous layer, because they could suffocate. But as you can tell after a rainstorm, earthworms don't survive in puddles of water either.



Nerve Response and Reproduction Earthworms have a small brain in their front segment. Nerves in each segment join to form a main nerve cord that connects to the brain. Earthworms respond to light, temperature, and moisture.

Earthworms are hermaphrodites (hur MA fruh dites) meaning they produce sperm and eggs in the same body. Even though each worm has male and female reproductive structures, an individual worm can't fertilize its own eggs. Instead, it has to receive sperm from another earthworm in order to reproduce.

Marine Worms

More than 8,000 species of marine worms, or polychaetes, (PAH lee keets) exist, which is more than any other kind of annelid. Marine worms float, burrow, build structures, or walk along the ocean floor. Some polychaetes even produce their own light. Others, like the ice worms in **Figure 10**, are able to live 540 m deep. Polychaetes, like earthworms, have segments with setae. However, the setae occur in bundles on these worms. The word polychaete means "many bristles."

Sessile, bottom-dwelling polychaetes, such as the Christmas tree worms shown in **Figure 11**, have specialized tentacles that are used for exchanging oxygen and carbon dioxide and gathering food. Some marine worms build tubes around their bodies. When these worms are startled, they retreat into their tubes. Free-swimming polychaetes, such as the bristleworm shown in **Figure 11**, have a head with eyes; a tail; and parapodia (per uh POH dee uh). Parapodia are paired, fleshy outgrowths on each segment, which aid in feeding and locomotion.



Figure 10 Ice worms, a type of marine polychaete, were discovered first in 1997 living 540 m deep in the Gulf of Mexico.

Figure 11 These Christmas tree worms filter microorganisms from the water to eat. This bristleworm swims backwards and forwards, so it has eyes at both ends of its body.

Christmas tree worms



CONTENTS



Topic: Beneficial Leeches

Visit bookc.msscience.com for Web links to information about the uses of chemicals from leech saliva.

Activity Describe a possible use for leech saliva, and design a 30-second commercial on how you might sell it.

Figure 12 Medical leeches are used sometimes to prevent blood from clotting or accumulating in damaged skin. **Explain** how a leech can prevent blood clots.

Leeches

A favorite topic for scary movies is leeches. If you've ever had to remove a leech from your body after swimming in a freshwater pond, lake, or river, you know it isn't fun. Leeches are segmented worms, but their bodies are not as round or as long as earthworms are, and they don't have setae. They feed on the blood of other animals. A sucker at each end of a leech's body is used to attach itself to an animal. If a leech attaches to you, you probably won't feel it. Leeches produce many chemicals, including an anesthetic (a nus THEH tihk) that numbs the wound so you don't feel its bite. After the leech has attached itself, it cuts into the animal and sucks out two to ten times its own weight in blood. Even though leeches prefer to eat blood, they can survive by eating aquatic insects and other organisms instead.

Why is producing an anesthetic an advantage to *a leech?*

Leeches and Medicine

Sometimes, leeches are used after surgery to keep blood flowing to the repaired area, as shown in **Figure 12.** For example, the tiny blood vessels in the ear quickly can become blocked with blood clots after surgery. To keep blood flowing in such places, physicians might attach leeches to the surgical site. As the leeches feed on the blood, chemicals in their saliva prevent the blood from coagulating. Besides the anti-clotting chemical, leech saliva also contains a chemical that dilates blood vessels, which improves the blood flow and allows the wound to heal more quickly. These chemicals are being studied to treat patients with heart or circulatory diseases, strokes, arthritis, or glaucoma.



Value of Segmented Worms

Different kinds of segmented worms are helpful to other animals in a variety of ways. Earthworms help aerate the soil by constantly burrowing through it. By grinding and partially digesting the large amount of plant material in soil, earthworms speed up the return of nitrogen and other nutrients to the soil for use by plants.

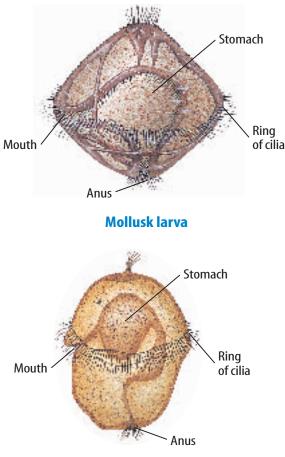
Researchers are developing drugs based on the chemicals that come from leeches because leech saliva prevents blood clots. Marine worms and their larvae are food for many fish, invertebrates, and mammals.

Origin of Segmented Worms

Some scientists hypothesize that segmented worms evolved in the sea. The fossil record for segmented worms is limited because of their soft bodies. The tubes of marine worms are the most common fossils of the segmented worms. Some of these fossils date back about 620 million years.

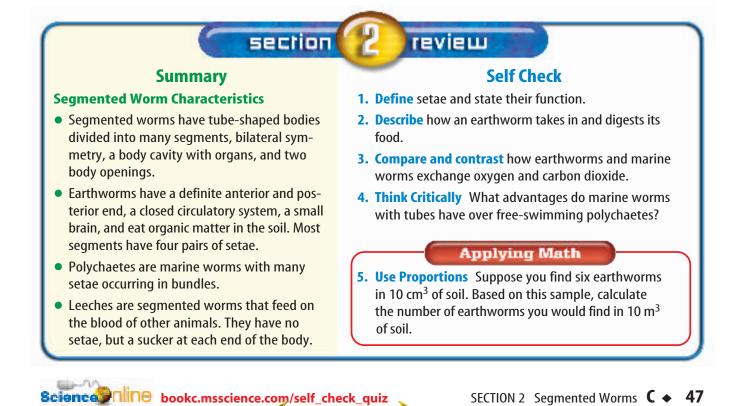
Similarities between mollusks and segmented worms suggest that they could have a common ancestor.

These groups were the first animals to have a body cavity with space for body organs to develop and function. Mollusks and segmented worms have a one-way digestive system with a separate mouth and anus. Their larvae, shown in **Figure 13**, are similar and are the best evidence that they have a common ancestor.



Annelid larva

Figure 13 Some mollusk larvae have many structures that are similar to those of some annelid larvae.



CONTENTS

section

Arthropods

om McHugh/Photo Research

as you read

What You'll Learn

- Determine the characteristics that are used to classify arthropods.
- Explain how the structure of the exoskeleton relates to its function.
- Distinguish between complete and incomplete metamorphosis.

Why It's Important

Arthropods, such as those that carry diseases and eat crops, affect your life every day.

Q Review Vocabulary

venom: toxic fluid injected by an animal

New Vocabulary

- appendage
- exoskeleton
- molting
- spiracle
- metamorphosis

Characteristics of Arthropods

There are more than a million different species of arthropods, (AR thruh pahdz) making them the largest group of animals. The word *arthropoda* means "jointed foot." The jointed **appendages** of arthropods can include legs, antennae, claws, and pincers. Arthropod appendages are adapted for moving about, capturing prey, feeding, mating, and sensing their environment. Arthropods also have bilateral symmetry, segmented bodies, an exoskeleton, a body cavity, a digestive system with two openings, and a nervous system. Most arthropods are adapted to living in almost every environment. They vary in size from microscopic dust mites to the large, Japanese spider crab, shown in **Figure 14**.

Segmented Bodies The bodies of arthropods are divided into segments similar to those of segmented worms. Some arthropods have many segments, but others have segments that are fused together to form body regions, such as those of insects, spiders, and crabs.

Exoskeletons All arthropods have a hard, outer covering called an **exoskeleton**. It covers, supports, and protects the internal body and provides places for muscles to attach. In many land-dwelling arthropods, such as insects, the exoskeleton has a waxy layer that reduces water loss from the animal.

An exoskeleton cannot grow as the animal grows. From time to time, the exoskeleton is shed and replaced by a new one in a process called **molting**. While the animals are molting, they are not well protected from predators because the new exoskeleton is soft. Before the new exoskeleton hardens, the animal swallows air or water to increase its exoskeleton's size. This way the new exoskeleton allows room for growth.

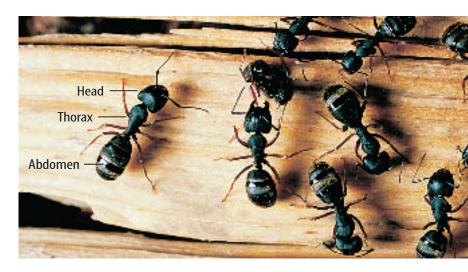
Figure 14 The Japanese spider crab has legs that can span more than 3 m.





Insects

More species of insects exist than all other animal groups combined. More than 700,000 species of insects have been classified, and scientists identify more each year. Insects have three body regions—a head, a thorax, and an abdomen, as shown in **Figure 15.** However, it is almost impossible on some insects to see where one region stops and the next one begins.



Head An insect's head has a pair of antennae, eyes, and a mouth. The antennae are used for touch and smell. The eyes are simple or compound. Simple eyes detect light and darkness. Compound eyes, like those in **Figure 16**, contain many lenses and can detect colors and movement. The mouthparts of insects vary, depending on what the insect eats.

Thorax Three pairs of legs and one or two pairs of wings, if present, are attached to the thorax. Some insects, such as silver-fish and fleas, don't have wings, and other insects have wings only for part of their lives. Insects are the only invertebrate animals that can fly. Flying allows insects to find places to live, food sources, and mates. Flight also helps them escape from their predators.

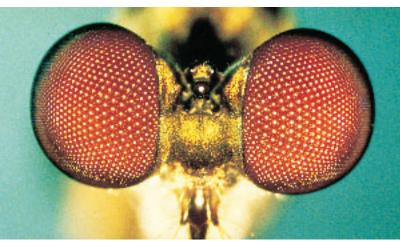
Keading Check How does flight benefit insects?

Abdomen The abdomen has neither wings nor legs but it is where the reproductive structures are found. Females lay thou-

sands of eggs, but only a fraction of the eggs develop into adults. Think about how overproduction of eggs might ensure that each insect species will continue.

Insects have an open circulatory system that carries digested food to cells and removes wastes. However, insect blood does not carry oxygen because it does not have hemoglobin. Instead, insects have openings called **spiracles** (SPIHR ih kulz) on the abdomen and thorax through which air enters and waste gases leave the insect's body. **Figure 15** One of the largest types of ants is the carpenter ant. Like all insects, it has a head, thorax, and abdomen.

Figure 16 Each compound eye is made up of small lenses that fit together. Each lens sees a part of the picture to make up the whole scene. Insects can't focus their eyes. Their eyes are always open and can detect movements.



Stained LM Magnification: 400 \times





Observing **Metamorphosis**

Procedure 🚷 🧼

- 1. Place a 2-cm piece of ripe banana in a jar and leave it open.
- 2. Check the jar every day for two weeks. When you see fruit flies, cover the mouth of the jar with cheesecloth.
- 3. Identify, describe, and draw all the stages of metamorphosis that you observe.

Analysis

- 1. What type of metamorphosis do fruit flies undergo?
- 2. In which stages are the flies the most active?

From Egg to Adult Many insects go through changes in body form as they grow. This series of changes is called metamorphosis (me tuh MOR fuh sihs). Grasshoppers, silverfish, lice, and crickets undergo incomplete metamorphosis, shown in Figure 17. The stages of incomplete metamorphosis are egg, nymph, and adult. The nymph form molts several times before becoming an adult. Many insects-butterflies, beetles, ants, bees, moths, and flies-undergo complete metamorphosis, also shown in Figure 17. The stages of complete metamorphosis are egg, larva, pupa, and adult. Caterpillar is the common name for the larva of a moth or butterfly. Other insect larvae are called grubs, maggots, or mealworms. Only larval forms molt.

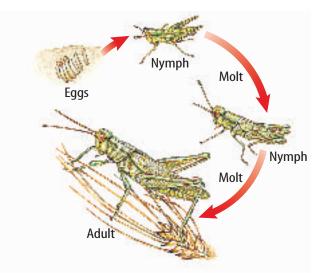
Reading Check When do grasshoppers molt?

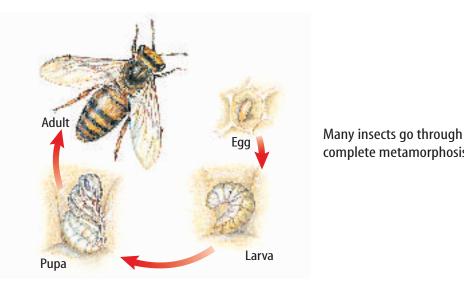
Figure 17 The two types of

metamorphosis are shown here.

In incomplete metamorphosis, nymphs are smaller versions

of their parents.



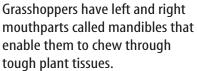


complete metamorphosis.

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Figure 18 Feeding adaptations of insects include different mouthparts.







Butterflies and other nectar eaters have a long siphon that enables them to drink nectar from flowers.



Mosquitoes have mouths that are adapted for piercing skin and suck-ing blood.

Obtaining Food Insects feed on plants, the blood of animals, nectar, decaying materials, wood in houses, and clothes. Mouthparts of insects, such as those in **Figure 18**, are as diverse as the insects themselves. Grasshoppers and ants have large mandibles (MAN duh bulz) for chewing plant tissue. Butterflies and honeybees are equipped with siphons for lapping up nectar in flowers. Aphids and cicadas pierce plant tissues and suck out plant fluids. Praying mantises eat other animals. External parasites, such as mosquitoes, fleas, and lice, drink the blood and body fluids of other animals. Silverfish eat things that contain starch and some moth larvae eat wool clothing.

Insect Success Because of their tough, flexible, waterproof exoskeletons; their ability to fly; rapid reproductive cycles; and small sizes, insects are extremely successful. Most insects have short life spans, so genetic traits can change more quickly in insect populations than in organisms that take longer to reproduce. Because insects generally are small, they can live in a wide range of environments and avoid their enemies. Many species of insects can live in the same area and not compete with one another for food, because many are so specialized in what they eat.

Protective coloration, or camouflage, allows insects to blend in with their surroundings. Many moths resting on trees look like tree bark or bird droppings. Walking sticks and some caterpillars resemble twigs. When a leaf butterfly folds its wings it looks like a dead leaf.



Disease Carriers Some insects may carry certain diseases to humans. Some species of mosquitoes can carry malaria or yellow fever, and can cause problems around the world. Research to learn about one disease that is carried by an insect, where it is a problem, and the steps that are being taken for prevention and treatment. Make a bulletin board of all the information that you and your classmates gather.



Arachnids

Spiders, scorpions, mites, and ticks are examples of arachnids (uh RAK nudz). They have two body regions—a head-chest region called the cephalothorax (se fuh luh THOR aks) and an abdomen. Arachnids have four pairs of legs but no antennae. Many arachnids are adapted to kill prey with venom glands, stingers, or fangs. Others are parasites.

Scorpions Arachnids that have a sharp, venom-filled stinger at the end of their abdomen are called scorpions. The venom from the stinger paralyzes the prey. Unlike other arachnids, scorpions have a pair of well-developed appendages—pincers—with which they grab their prey. The sting of a scorpion is painful and can be fatal to humans.

Applying Math Use Percentages

SILK ELASTICITY A strand of spider's silk can be stretched from 65 cm to 85 cm before it loses its elasticity—the ability to snap back to its original length. Calculate the percent of elasticity of spider's silk.



Solution

- **1** *This is what you know:*
- original length of silk strand = 65 cm
- stretched length of silk strand = 85 cm
- 2 This is what you need to find out:
- 3 This is the procedure you need to use:
- percent of elasticity
- Find the difference between the stretched and original length. 85 cm 65 cm = 20 cm
- $\frac{\text{difference in length}}{\text{original length}} \times 100 = \% \text{ of elasticity}$
- $\frac{20}{65} \frac{\text{cm}}{\text{cm}} \times 100 = 30.7$ % of elasticity

4 *Check your answer:*

Multiply 30.7% by 65 cm and you should get 20 cm.

Practice Problems

- **1.** A 40-cm strand of nylon can be stretched to a length of 46.5 cm before losing its elasticity. Calculate the percent of elasticity for nylon and compare it to that of spider's silk.
- 2. Knowing the elasticity of spider's silk, what was the original length of a silk strand when the difference between the two strands is 44 cm?



Spiders Because spiders can't chew their food, they release enzymes into their prey that help digest it. The spider then sucks the predigested liquid into its mouth.

Oxygen and carbon dioxide are exchanged in book lungs, illustrated in **Figure 19.** Openings on the abdomen allow these gases to move into and out of the book lungs.

Mites and Ticks Most mites are animal or plant parasites. However, some are not parasites, like the mites that live in the follicles of human eyelashes. Most mites are so small that they look like tiny specs to the unaided eye. All ticks are animal parasites. Ticks attach to their host's skin and remove blood from their hosts through specialized mouthparts. Ticks often carry bacteria and viruses that cause disease in humans and other animals. Diseases carried by ticks include Lyme disease and Rocky Mountain spotted fever.

Centipedes and Millipedes

Two groups of arthropods—centipedes and millipedes have long bodies with many segments and many legs, antennae, and simple eyes. They can be found in damp environments, including in woodpiles, under vegetation, and in basements. Centipedes and millipedes reproduce sexually. They make nests for their eggs and stay with them until the eggs hatch.

Compare the centipede and millipede in **Figure 20.** How many pairs of legs does the centipede have per segment? How many pairs of legs does the millipede have per segment? Centipedes hunt for their prey, which includes snails, slugs, and worms. They have a pair of venomous claws that they use to inject venom into their prey. Their pinches are painful to humans but usually aren't fatal. Millipedes feed on plants and decaying material and often are found under the damp plant material.

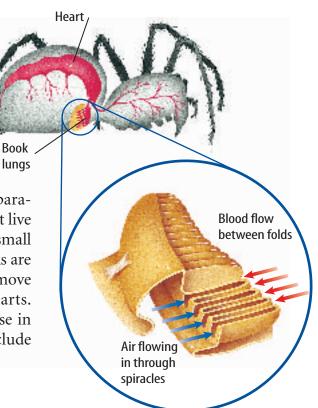


Figure 19 Air circulates between the moist folds of the book lungs bringing oxygen to the blood.

Figure 20 Centipedes are predators—they capture and eat other animals. Millipedes eat plants or decaying plant material.

Centipede



NATIONAL GEOGRAPHIC VISUALIZING ARTHROPOD DIVERSITY

Figure 21

ome 600 million years ago, the first arthropods lived in Earth's ancient seas. Today, they inhabit nearly every environment on Earth. Arthropods are the most abundant and diverse group of animals on Earth. They range in size from nearly microscopic mites to spindly, giant Japanese spider crabs with legs spanning more than 3 m.



GRASS SPIDER Grass spiders spin fine, nearly invisible webs just above the ground.

MONARCH BUTTERFLY

Monarchs are a common sight in much of the United States during the summer. In fall, they migrate south to warmer climates.





LOBSTER Like crabs, lobsters are crustaceans that belong to the group called Decapoda, which means "ten legs." It's the lobster's tail, however, that interests most seafood lovers.

GOOSENECK BARNACLE Gooseneck barnacles typically live attached to objects that float in the ocean. They use their long, feathery setae to strain tiny bits of food from the water.



HISSING COCKROACH Most cockroaches are considered to be pests by humans, but hissing cockroaches, such as this one, are sometimes kept as pets.

HORSESHOE CRAB Contrary to their name, horseshoe crabs are not crustaceans. They are more closely related to spiders than to crabs.

CENTIPEDE One pair of legs per segment distinguishes a centipede from a millipede, which has two pairs of legs per body segment.





Crustaceans

Crabs, crayfish, shrimp, barnacles, pill bugs, and water fleas are crustaceans. Crustaceans and other arthropods are shown in **Figure 21**. Crustaceans have one or two pairs of antennae and mandibles, which are used for crushing food. Most crustaceans live in water, but some, like the pill bugs shown in **Figure 22**, live in moist environments on land. Pill bugs are common in gardens and around house foundations. They are harmless to humans.

Crustaceans, like the blue crab shown in **Figure 22**, have five pairs of legs. The first pair of legs are claws that catch and hold food. The other four pairs are walking legs. They also have five pairs of appendages on the abdomen called swimmerets. They help the crustacean move and are used in reproduction. In addition, the swimmerets force water over the feathery gills where the oxygen and carbon dioxide are exchanged. If a crustacean loses an appendage, it will grow back, or regenerate.

Value of Arthropods

Arthropods play several roles in the environment. They are a source of food for many animals, including humans. Some humans consider shrimp, crab, crayfish, and lobster as food delicacies. In Africa and Asia, many people eat insect larvae and insects such as grasshoppers, termites, and ants, which are excellent sources of protein.

Agriculture would be impossible without bees, butterflies, moths, and flies that pollinate crops. Bees manufacture honey, and silkworms produce silk. Many insects and spiders are predators of harmful animal species, such as stableflies. Useful chemicals are obtained from some arthropods. For example, bee venom is used to treat rheumatic arthritis.

Not all arthropods are useful to humans. Almost every cultivated crop has some insect pest that feeds on it. Many arthropods—mosquitoes, tsetse flies, fleas, and ticks—carry human and other animal diseases. In addition, weevils, cockroaches, carpenter ants, clothes moths, termites, and carpet beetles destroy food, clothing, and property.

Insects are an important part of the ecological communities in which humans live. Removing all of the insects would cause more harm than good.



Figure 22 The segments in some crustaceans, such as this crab, aren't obvious because they are covered by a shieldlike structure. Pill bugs—also called roly polys—are crustaceans that live on land.

Compare and contrast *pill bugs to centipedes and millipedes.*





Figure 23 More than 15,000 species of trilobites have been classified. They are one of the most recognized types of fossils.

Controlling Insects One common way to control problem insects is by insecticides. However, many insecticides also kill helpful insects. Another problem is that many toxic substances that kill insects remain in the environment and accumulate in the bodies of animals that eat them. As other animals eat the contaminated animals, the insecticides can find their way into human food. Humans also are harmed by these toxins.

Different types of bacteria, fungi, and viruses are being used to control some insect pests. Natural predators and parasites of insect pests have been somewhat successful in controlling them. Other biological controls include using sterile males or naturally occurring chemicals that interfere with the reproduction or behavior of insect pests.

Origin of Arthropods Because of their hard body parts, arthropod fossils, like the one in **Figure 23**, are among the oldest and best-preserved fossils of many-celled animals. Some are more than 500 million years old. Because earthworms and leeches have individual body segments, scientists hypothesize that arthropods probably evolved from an ancestor of segmented worms. Over time, groups of body segments fused and became adapted for locomotion, feeding, and sensing the environment. The hard exoskeleton and walking legs allowed arthropods to be among the first successful land animals.

Summary

section

Characteristics of Arthropods

 All arthropods have jointed appendages, bilateral symmetry, a body cavity, a digestive system, a nervous system, segmented bodies, and an exoskeleton.

Arthropod Types

- Insects have three body segments—head, thorax, and abdomen—a pair of antennae, and three pairs of legs. They go through complete or incomplete metamorphosis.
- Arachnids have two body segments—a cephalothorax and an abdomen—four pairs of legs, and no antennae.
- Centipedes and millipedes have long bodies with many segments and legs.
- Crustaceans have five pairs of legs and five pairs of appendages called swimmerets.

review

Self Check

- 1. Infer the advantages and disadvantages of an exoskeleton.
- 2. Compare and contrast the stages of complete and incomplete metamorphosis.
- 3. List four ways arthropods obtain food.
- 4. Evaluate the impact of arthropods.
- **5. Concept Map** Make an events-chain concept map of complete metamorphosis and one of incomplete metamorphosis.
- **6.** Think Critically Choose an insect you are familiar with and explain how it is adapted to its environment.

Applying Math

7. Make a Graph Of the major arthropod groups, 88% are insects, 7% are arachnids, 3% are crustaceans, 1% are centipedes and millipedes, and all others make up 1%. Show this data in a circle graph.

le bookc.msscience.com/self_check_quiz

A crayfish has a segmented body and a fused head and thorax. It has a snout and eyes on movable eyestalks. Most crayfish have pincers.

Real-World Question –

How does a crayfish use its appendages?

Goals

Observe a crayfish.Determine the function of pincers.

Materials

crayfish in a small aquarium uncooked ground beef stirrer

Safety Precautions 🐼 🐨 🐼 🖙

Procedure

1. Copy the data table and use it to record all of your observations during this lab.

Crayfish Observations		
Body Region	Number of Appendages	Function
Head		
Thorax	Do not write in this book.	
Abdomen		

2. Your teacher will provide you with a crayfish in an aquarium. Leave the crayfish in the aquarium while you do the lab. Draw your crayfish.



- **3.** Gently touch the crayfish with the stirrer. How does the body feel?
- 4. **Observe** how the crayfish moves in the water.
- **5. Observe** the compound eyes. On which body region are they located?
- Drop a small piece of ground beef into the aquarium. Observe the crayfish's reaction. Wash your hands.
- **7.** Return the aquarium to its proper place.

Conclude and Apply

- **1. Infer** how the location of the eyes is an advantage for the crayfish.
- **2. Explain** how the structure of the pincers aids in getting food.
- **3. Infer** how the exoskeleton provides protection.



Compare your observations with those of other students in your class. For more help, refer to the Science Skill Handbook.



section

Echinoderms

as you read

What You'll Learn

- List the characteristics of echinoderms.
- Explain how sea stars obtain and digest food.
- Discuss the importance of echinoderms.

Why It's Important

Echinoderms are a group of animals that affect oceans and coastal areas.

Q Review Vocabulary

epidermis: outer, thinnest layer of skin

New Vocabulary

- water-vascular system
- tube feet

Echinoderm Characteristics

Echinoderms (ih KI nuh durm) are found in oceans all over the world. The term *echinoderm* is from the Greek words *echinos* meaning "spiny" and *derma* meaning "skin." Echinoderms have a hard endoskeleton covered by a thin, bumpy, or spiny epidermis. They are radially symmetrical, which allows them to sense food, predators, and other things in their environment from all directions.

All echinoderms have a mouth, stomach, and intestines. They feed on a variety of plants and animals. For example, sea stars feed on worms and mollusks, and sea urchins feed on algae. Others feed on dead and decaying matter called detritus (de TRI tus) found on the ocean floor.

Echinoderms have no head or brain, but they do have a nerve ring that surrounds the mouth. They also have cells that respond to light and touch.

Water-Vascular System A characteristic unique to echinoderms is their water-vascular system. It allows them to move, exchange carbon dioxide and oxygen, capture food, and release wastes. The **water-vascular system**, as shown in **Figure 24**, is a network of water-filled canals with thousands of tube feet connected to it. **Tube feet** are hollow, thin-walled tubes that each end in a suction cup. As the pressure in the tube feet changes, the

> animal is able to move along by pushing out and pulling in its tube feet.

Figure 24 Sea stars alternately extend and withdraw their tube feet, enabling them to move.

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Tube feet

Sieve plate

Ring canal

Types of Echinoderms

Approximately 6,000 species of echinoderms are living today. Of those, more than one-third are sea stars. The other groups include brittle stars, sea urchins, sand dollars, and sea cucumbers.

Sea Stars Echinoderms with at least five arms arranged around a central point are called sea stars. The arms are lined with thousands of tube feet. Sea stars use their tube feet to open the shells of their prey. When the shell is open slightly, the sea star pushes its stomach through its mouth and into its prey. The sea star's stomach surrounds the soft body of its prey and secretes enzymes that help digest it. When the meal is over, the sea star pulls its stomach back into its own body.

Reading Check What is unusual about the way that sea stars eat their prey?

Sea stars reproduce sexually when females release eggs and males release sperm into the water. Females can produce millions of eggs in one season.

Sea stars also can repair themselves by regeneration. If a sea star loses an arm, it can grow a new one. If enough of the center disk is left attached to a severed arm, a whole new sea star can grow from that arm.



Modeling the Strength of Tube Feet

Procedure

- 1. Hold your arm straight out, palm up.
- 2. Place a heavy book on your hand.
- Have your partner time how long you can hold your arm up with the book on it.

Analysis

- 1. Describe how your arm feels after a few minutes.
- If the book models the sea star and your arm models the clam, infer how a sea star successfully overcomes a clam to

obtain food.



Brittle Stars Like the one in Figure 25, brittle stars have fragile, slender, branched arms that break off easily. This adaptation helps a brittle star survive attacks by predators. While the predator is eating a broken arm, the brittle star escapes. Brittle stars quickly regenerate lost parts. They live hidden under rocks or in litter on the ocean floor. Brittle stars use their flexible arms for movement instead of their tube feet. Their tube feet are used to move particles of food into their mouth.



Figure 25 A brittle star's arms are so flexible that they wave back and forth in the ocean currents. They are called brittle stars because their arms break off easily if they are grabbed by a predator.



Figure 26 Like all echinoderms, sand dollars and sea urchins are radially symmetrical.

Science

Topic: Humans and Echinoderms

Visit bookc.msscience.com for Web

Activity Choose one or two uses

and write an essay on why echino-

derms are important to you.

links to information about how echinoderms are used by humans.

Sand dollars live on ocean floors where they can burrow into the sand.



Sea urchins use tube feet and their spines to move around on the bottom of the ocean.

Sea Urchins and Sand Dollars Another group of echinoderms includes sea urchins, sea biscuits, and sand dollars. They are disk- or globe-shaped animals covered with spines. They do not have arms, but sand dollars have a five-pointed pattern on their surface. Figure 26 shows living sand dollars, covered with stiff, hairlike spines, and sea urchins with long, pointed spines that protect them from predators. Some sea urchins have sacs near the end of the spines that contain toxic fluid that is injected into predators. The spines also help in movement and burrowing. Sea urchins have five toothlike structures around their mouth.

Sea Cucumbers The animal shown in **Figure 27** is a sea cucumber. Sea cucumbers are soft-bodied echinoderms that have a leathery covering. They have tentacles around their mouth and rows of tube feet on their upper and lower surfaces. When threatened, sea cucumbers may expel their internal organs. These organs regenerate in a few weeks. Some sea cucumbers eat detritus, and others eat plankton.

What makes sea cucumbers different from other **Reading Check** echinoderms?



Figure 27 Sea cucumbers have short tube feet, which they use to move around. **Describe** the characteristics of sea cucumbers.

Value of Echinoderms

Echinoderms are important to the marine environment because they feed on dead organisms and help recycle materials. Sea urchins control the growth of algae in coastal areas. Sea urchin eggs and sea cucumbers are used for food in some places. Many echinoderms are used in research and some might be possible sources of medicines. Sea stars are important predators that control populations of other animals. However, because sea stars feed on oysters and clams, they also destroy

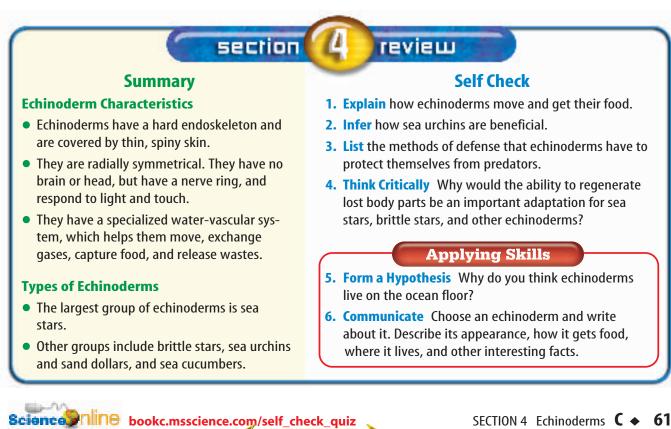


millions of dollars' worth of mollusks each year.

Origin of Echinoderms Like the example in **Figure 28**, a good fossil record exists for echinoderms. Echinoderms date back more than 400 million years. The earliest echinoderms might have had bilateral symmetry as adults and may have been attached to the ocean floor by stalks. Many larval forms of modern echinoderms are bilaterally symmetrical.

Scientists hypothesize that echinoderms more closely resemble animals with backbones than any other group of invertebrates. This is because echinoderms have complex body systems and an embryo that develops the same way that the embryos of animals with backbones develop. Figure 28 Ophiopinna elegans was a brittle star that lived about 165 million years ago. Explain the origins of echinoderms.

Ken Lucas/Visuals Unlimited



CONTENTS



What do w@rms eat?

Goals

- Construct five earthworm habitats.
- Test different foods to determine which ones earthworms eat.

Materials

orange peels apple peels banana skin kiwi fruit skin watermelon rind *skins of five different fruits widemouthed jars (5) potting soil water humus *peat moss earthworms black construction paper (5 sheets) masking tape marker rubber bands (5) *Alternate materials

Safety Precautions



WARNING: Do not handle earthworms with dry hands. Do not eat any materials used in the lab.

Real-World Question —

Earthworms are valuable because they improve the soil in which they live. There can be 50,000 earthworms living in one acre. Their tunnels increase air movement through the soil and improve water drainage. As they eat the decaying material in soil, their wastes can enrich the soil. Other than decaying material, what else do earthworms eat? Do they have favorite foods?



Procedure

- 1. Pour equal amounts of soil into each of the jars. Do not pack the soil. Leave several centimeters of space at the top of each jar.
- **2.** Sprinkle equal amounts of water into each jar to moisten the soil. Avoid pouring too much water into the jars.
- **3.** Pour humus into each of your jars to a depth of 2 cm. The humus should be loose.
- **4.** Add watermelon rinds to the first jar, orange peels to the second, apple peels to the third, kiwi fruit skins to the fourth, and a banana peel to the fifth jar. Each jar should have 2 cm of fruit skins on top of the layer of humus.





Using Scientific Methods

- 5. Add five earthworms to each jar.
- 6. Wrap a sheet of black construction paper around each jar and secure it with a rubber band.
- **7.** Using the masking tape and marker, label each jar with the type of fruit it contains.
- **8.** Copy the data table below in your Science Journal.
- **9.** Place all of your jars in the same cool, dark place. Observe your jars every other day for a week and record your observations in your data table.

Fruit Wastes						
Date	Watermelon rind	Orange peels	Apple peels	Kiwi skins	Banana peels	
Do not write in this book.						



🧔 Analyze Your Data

- 1. Record the changes in your data table.
- 2. Compare the amount of skins left in each jar.
- 3. Record which fruit skin had the greatest change. The least?

🧔 Conclude and Apply

- **1. Infer** the type of food favored by earthworms.
- 2. Infer why some of the fruit skins were not eaten by the earthworms.
- **3. Identify** a food source in each jar other than the fruit skins.
- Predict what would happen in the jars over the next month if you continued the experiment.

Communicating

Use the results of your experiment and information from your reading to help you write a recipe for an appetizing dinner that worms would enjoy. Based on the results of your experiment, add other fruit skins or foods to your menu you think worms might like.



Science Language Fiss

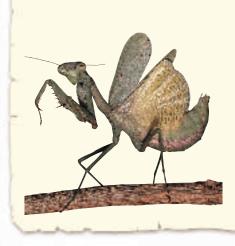
from "The Creatures on My Mind"

by Ursula K. Le Guin

When I stayed for a week in New Orleans... I had an apartment with a balcony... But when I first stepped out on it, the first thing I saw was a



huge beetle. It lay on its back directly under the light fixture. I thought it was dead, then saw its legs twitch and twitch again. Big insects horrify me. As a child I feared moths and spiders, but adolescence cured me, as if those fears evaporated in the stew of hormones. But I never got enough hormones to make me easy with the large, hard-shelled insects: wood roaches, June bugs, mantises, cicadas. This beetle was a couple of inches long; its abdomen was ribbed, its legs long and jointed; it was dull reddish brown; it was dying. I felt a little sick seeing it lie there twitching, enough to keep me from sitting out on the balcony that first day... And if I



had any courage or common sense, I kept telling myself, I'd... put it out of its misery. We don't know what a beetle may or may not suffer...

Understanding Literature

Personal Experience Narrative In this passage, the author uses her personal experience to consider her connection to other living things. In this piece, the author recounts a minor event in her life when she happens upon a dying beetle. The experience allows the author to pose some important questions about another species and to think about how beetles might feel when they die. How do you think the beetle is feeling?

Respond to the Reading

- 1. How do you suppose the beetle injured itself?
- 2. From the author's description, in what stage of development is the beetle?
- 3. Linking Science and Writing Write about a personal experience that caused you to think about an important question or topic in your life.

The author names several arthropod

species in the passage, including insects and an arachnid. Beetles, June bugs, mantises, cicadas, and moths are all insects. The spider is an arachnid. Of the arthropods the author names, can you tell which ones go through a complete metamorphosis?

Reviewing Main Ideas

chapter

Section 1 Mollusks

- Mollusks are soft-bodied invertebrates that usually are covered by a hard shell. They move using a muscular foot.
- 2. Mollusks with one shell are gastropods. Bivalves have two shells. Cephalopods have an internal shell and a foot that is divided into tentacles.

Section 2 Segmented Worms

- Segmented worms have tube-shaped bodies divided into sections, a body cavity that holds the internal organs, and bristlelike structures called setae to help them move.
- 2. An earthworm's digestive system has a mouth, crop, gizzard, intestine, and anus. Polychaetes are marine worms. Leeches are parasites that attach to animals and feed on their blood.

Section 3 Arthropods

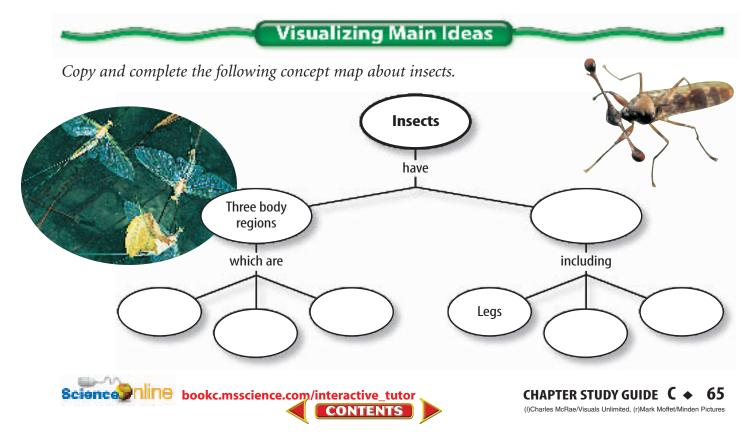
 More than a million species of arthropods exist, which is more than any other group of animals. Most arthropods are insects.

Study Guide

- 2. Arthropods are grouped by number of body segments and appendages. Exoskeletons cover, protect, and support arthropod bodies.
- **3.** Young arthropods develop either by complete metamorphosis or incomplete metamorphosis.

Section 4 Echinoderms

- **1.** Echinoderms have a hard, spiny exoskeleton covered by a thin epidermis.
- 2. Most echinoderms have a water-vascular system that enables them to move, exchange carbon dioxide and oxygen, capture food, and give off wastes.



Using Vocabulary

appendage p.48	I	
closed circulatory		
system p. 40		
crop p.44	1	
exoskeleton p.48	9	
gill p. 38	9	
gizzard p. 44	1	
mantle p. 38	١	
metamorphosis p. 50		

chapter

molting p. 48 open circulatory system p. 38 radula p. 39 setae p. 43 spiracle p. 49 tube feet p. 58 water-vascular system p. 58

Review

Fill in the blanks with the correct vocabulary word or words.

- 1. Mollusk shells are secreted by the
- 2. As earthworms move through soil using their _____, they take in soil, which is stored in the _____.
- **3.** The _____ covers and protects arthropod bodies.
- **4.** Insects exchange oxygen and carbon dioxide through ______.
- **5.** _____ act like suction cups and help sea stars move and feed.
- **6.** Snails use a(n) _____ to get food.
- **7.** The blood of mollusks moves in a(n)

Checking Concepts

Choose the word or phrase that best answers the question.

- 8. What structure covers organs of mollusks?
 - A) gills C) mantle
 - **B)** food **D)** visceral mass
- **9.** What structures do echinoderms use to move and to open shells of mollusks?
 - A) mantle C) spines
 - **B)** calcium plates **D)** tube feet

10. Which organism has a closed circulatory system?

A) earthworm C) slug

B) octopus

- D) snail
- **11.** What evidence suggests that arthropods might have evolved from annelids?
 - A) Arthropods and annelids have gills.
 - **B)** Both groups have species that live in salt water.
 - **C)** Segmentation is present in both groups.
 - **D)** All segmented worms have setae.

Use the photo below to answer questions 12 and 13.



- **12.** Which of the following correctly describes the arthropod pictured above?
 - A) three body regions, six legs
 - B) two body regions, eight legs
 - **C)** many body segments, ten legs
 - **D)** many body segments, one pair of legs per segment
- **13.** What type of arthropod is this animal?
 - A) annelid C) insect
 - **B)** arachnid **D)** mollusk
- 14. Which is an example of an annelid?
 - A) earthworm C) slug
 - **B**) octopus **D**) snail
- **15.** Which sequence shows incomplete metamorphosis?
 - A) egg—larvae—adult
 - B) egg—nymph—adult
 - **C)** larva—pupa—adult
 - **D)** nymph—pupa—adult

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C CHAPTER REVIEW

Science IIII bookc.msscience.com/vocabulary_puzzlemaker

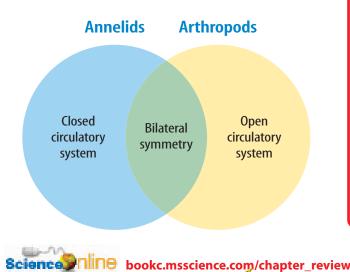
chapter

Thinking Critically

Use the photo below to answer question 16.



- **16. Describe** how this animal obtains food.
- **17. Compare** the ability of clams, oysters, scallops, and squid to protect themselves.
- **18. Compare and contrast** an earthworm gizzard to teeth in other animals.
- **19. Explain** the evidence that mollusks and annelids may share a common ancestor.
- **20. Infer** how taking in extra water or air after molting, but before the new exoskeleton hardens, helps an arthropod.
- **21. Classify** the following animals into arthropod groups: *spider*, *pill bug*, *crayfish*, *grasshopper*, *crab*, *silverfish*, *cricket*, *wasp*, *scorpion*, *shrimp*, *barnacle*, *tick*, and *butterfly*.
- **22.** Compare and Contrast Copy and complete this Venn diagram to compare and contrast arthropods to annelids.



CONTENTS

- **23.** Recognize Cause and Effect If all the earthworms were removed from a hectare of soil, what would happen to the soil? Why?
- **24. Research Information** The suffix *-ptera* means "wings." Research the meaning of the prefix listed below and give an example of a member of each insect group.

U
He
He

Homoptera Hemiptera

Review

Performance Activities

25. Construct Choose an arthropod that develops through complete metamorphosis and construct a three-dimensional model for each of the four stages.

Applying Math

Use the table below to answer questions 26 and 27.

Type of OrganismNumber of Described SpeciesAnthropods1,065,000Land plants270,000
Land plants 270,000
Fungi 72,000
Mollusks 70,000
Nematodes 25,000
Birds 10,000
Mammals 5,000
Bacteria 4,000
0ther 145,000

- 26. Arthropods Using the table above, what percentage of organisms are arthropods? Mollusks?
- **27.** Species Distribution Make a bar graph that shows the number of described species listed in the table above.

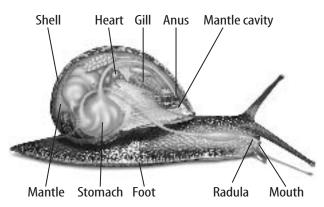
chapter

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- 1. Which of the following is not a mollusk?
 - A. clam C. crab
 - **B.** snail **D.** squid

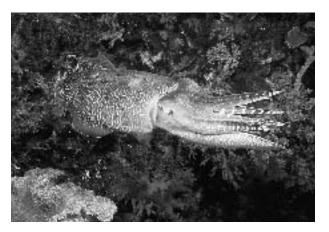
Use the illustration below to answer questions 2 and 3.



- **2.** This mollusk uses which of the following to exchange carbon dioxide with oxygen from the water?
 - A. radula
 - **B.** gill
 - **C.** mantle
 - **D.** shell
- **3.** Which structure covers the body organs of this mollusk?
 - A. radula
 - **B.** gill
 - **C.** mantle
 - **D.** shell
- 4. Which is the largest group of mollusks?
 - A. cephalopods C. monovalves
 - **B.** bivalves **D.** gastropods
- 5. Which openings allow air to enter an insect's body?
 - **A.** spiracles **C.** thorax
 - **B.** gills **D.** setae



Use the photo below to answer questions 6 and 7.



- **6.** This organism is an example of what type of mollusk?
 - A. gastropod

B. bivalve

- **C.** cephalopod **D.** monovalve
- 7. How do these animals move?
 - **A.** a muscular foot
 - **B.** tentacles
 - **c.** contraction and relaxation
 - **D.** jet propulsion
- 8. What does the word annelid mean?
 - **A.** segmented **C.** little rings
 - **B.** bristled **D.** worms
- **9.** What are bristlelike structures on the outside of each body segment of annelids called?
 - A. cropsC. radulaB. gizzardsD. setae
- **10.** What is the largest group of animals?
 - **A.** arthropods **C.** gastropods
 - **B.** cephalopods **D.** annelids
- **11.** What is it called when an arthropod loses its exoskeleton and replaces it with a new one?
 - **A.** shedding**B.** molting**C.** manging**D.** exfoliating



Standardized Test Practice

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- **12.** Describe how a sea star captures and consumes its prey.
- **13.** Explain how sea stars repair or replace lost or damaged body parts.
- **14.** Describe how gastropods, such as snails and garden slugs, eat.



Use the photo below to answer questions 15 and 16.

- **15.** Describe this animal's vascular system. How is it used?
- **16.** This animal has a unique method of movement. What is it and how does it work?
- **17.** Describe the type of reproductive system found in earthworms.
- **18.** What is an open circulatory system? Give three examples of animals that have an open circulatory system.
- **19.** How are pearls formed in clams, oysters, and some other gastropods?

Part 3 Open Ended

Record your answers on a sheet of paper. **Use the photo below to answer questions 20 and 21.**



- **20.** Name and describe the phylum that this sea star belongs to.
- **21.** This animal has a vascular system that is unique. Describe it.
- **22.** What structures allow an earthworm to move? Describe its locomotion.
- **23.** There are more species of insects than all other animal groups combined. In all environments, they have to compete with one another for survival. How do so many insects survive?
- 24. Insect bodies are divided into three segments. What are these three segments and what appendages and organs are in/on each part?

Test-Taking Tip

CONTENTS

Show Your Work For constructed-response questions, show all of your work and any calculations on your answer sheet.

Question 22 Write out all of the adaptations that insects have for survival and determine which are the most beneficial to the success of the group.

Science nine bookc.msscience.com/standardized_test



Fish, Amphibians, and Reptiles

chapter preview

sections

- 1 Chordates and Vertebrates Lab Endotherms and Exotherms
- 2 Fish
- **3** Amphibians
- 4 Reptiles Lab Water Temperature and the Respiration Rate of Fish
- Virtual Lab How are fish adapted to their environment?

Can I find one?

If you want to find a frog or salamander two types of amphibians—visit a nearby pond or stream. By studying fish, amphibians, and reptiles, scientists can learn about a variety of vertebrate characteristics, including how these animals reproduce, develop, and are classified.

Science Journal List two unique characteristics for each animal group you will be studying.

CONTENTS

Start-Up Activities



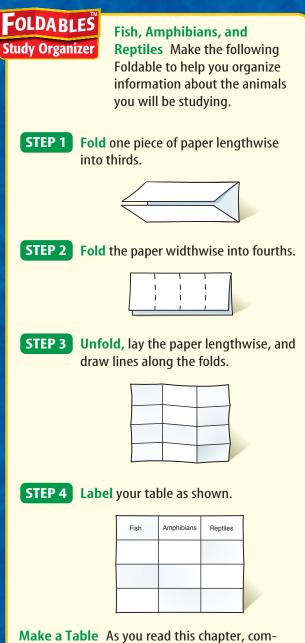
Snake Hearing

How much do you know about reptiles? For example, do snakes have eyelids? Why do snakes flick their tongues in and out? How can some snakes swallow animals that are larger than their own heads? Snakes don't have ears, so how do they hear? In this lab, you will discover the answer to one of these questions.

- Hold a tuning fork by the stem and tap it on a hard piece of rubber, such as the sole of a shoe.
- 2. Hold it next to your ear. What, if anything, do you hear?
- 3. Tap the tuning fork again. Press the base of the stem firmly against your chin. In your Science Journal, describe what happens.
- 4. Think Critically Using the results from step 3, infer how a snake detects vibrations. In your Science Journal, predict how different animals can use vibrations to hear.

sciencenline

Preview this chapter's content and activities at bookc.msscience.com



Make a Table As you read this chapter, complete the table describing characteristics of each type of animal.



Chordates and Vertebrates

as you read

What You'll Learn

- List the characteristics of all chordates.
- Identify characteristics shared by vertebrates.
- Differentiate between ectotherms and endotherms.

Why It's Important

Humans are vertebrates. Other vertebrates play important roles in your life because they provide food, companionship, and labor.

Partiew Vocabulary

motor responses: responses that involve muscular movement

New Vocabulary

- chordate
- notochord
- cartilage
 vertebrae
- postanal tail
 nerve cord
- pharyngeal pouch
- ectotherm

endoskeleton

ngeal • endotherm



Figure 1 Sea squirts get their name because when they're taken out of the ocean, they squirt water out of their body.

Determine what you have in common with a sea squirt.

72 C CHAPTER 3 Fred Bavendam/Minden Pictures

Chordate Characteristics

During a walk along the seashore at low tide, you often can see jellylike masses of animals clinging to rocks. Some of these animals may be sea squirts, as shown in **Figure 1**, which is one of the many types of animals known as chordates (KOR dayts). **Chordates** are animals that have four characteristics present at some stage of their development—a notochord, postanal tail, nerve cord, and pharyngeal pouches.

Notochord All chordates have an internal **notochord** that supports the animal and extends along the upper part of its body, as shown in **Figure 2.** The notochord is flexible but firm because it is made up of fluid-filled cells that are enclosed in a stiff covering. The notochord also extends into the **postanal tail**—a muscular structure at the end of the developing chordate. Some chordates, such as fish, amphibians, reptiles, birds, and mammals, develop backbones that partly or entirely replace the notochord. They are called vertebrates. In some chordates, such as the sea squirt, other tunicates, and the lancelets, the notochord is kept into adulthood.

💅 Reading Check

What happens to the notochord as a bat develops?



Nerve Cord Above the notochord and along the length of a developing chordate's body is a tubelike structure called the **nerve cord**, also shown in **Figure 2**. As most chordates develop, the front end of the nerve cord enlarges to form the brain and the remainder becomes the spinal cord. These two structures become the central nervous system that develops into complex systems for sensory and motor responses.

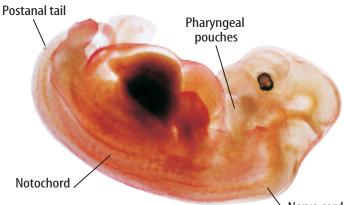
Pharyngeal Pouches All developing chordates have **pharyngeal pouches.** They are found in the region between the mouth and the digestive tube as pairs of openings to the outside. Many chordates have several pairs of pharyngeal pouches. Ancient invertebrate chordates used them for filter feeding. This is still their purpose in some living chordates such as lancelets. In fish, they have developed into internal gills where oxygen and carbon dioxide are exchanged. In humans, pharyngeal pouches are present only during embryonic development. However, one pair becomes the tubes that go from the ears to the throat.

Vertebrate Characteristics

Besides the characteristics common to all chordates, vertebrates have distinct characteristics. These traits set vertebrates apart from other chordates.

Structure All vertebrates have an internal framework called an **endoskeleton**. It is made up of bone and/or flexible tissue called **cartilage**. Your ears and the tip of your nose are made of cartilage. The endoskeleton provides a place for muscle attachment and supports and protects the organs. Part of the endoskeleton is a flexible, supportive column called the backbone, as shown in **Figure 3**. It is a stack of **vertebrae** alternating with cartilage. The backbone surrounds and protects the spinal nerve cord. Vertebrates also have a head with a skull that encloses and protects the brain.

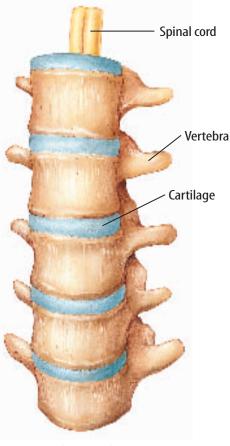
Most of a vertebrate's internal organs are found in a central body cavity. A protective skin covers a vertebrate. Hair, feathers, scales, or horns sometimes grow from the skin.



Nerve cord

Figure 2 At some time during its development, a chordate has a notochord, postanal tail, nerve cord, and pharyngeal pouches.

Figure 3 Vertebrae are separated by soft disks of cartilage.



Vertebrae column

CONTENTS

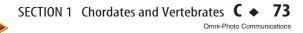


Table 1 Types of Vertebrates				
Group	Estimated Number of Species		Examples	
Jawless fish	60	lamprey, hagfish		
Jawed cartilaginous fish	500 to 900	shark, ray, skate		
Bony fish	20,000	salmon, bass, guppy, sea horse, lungfish		
Amphibians	4,000	frog, toad, salamander		
Reptiles	7,970	turtle, lizard, snake, crocodile, alligator		
Birds	8,700	stork, eagle, sparrow, turkey, duck, ostrich		
Mammals	4,600	human, whale, bat, mouse, lion, cow, otter		

CONTENTS

Vertebrate Groups Seven main groups of vertebrates are found on Earth today, as shown in **Table 1.** Vertebrates are either ectotherms or endotherms. Fish, amphibians, and reptiles are ectotherms, also known as cold-blooded animals. An **ectotherm** has an internal body temperature that changes with the temperature of its surroundings. Birds and mammals are endotherms, which some-



times are called warm-blooded animals. An **endotherm** has a nearly constant internal body temperature.

Vertebrate Origins Some vertebrate fossils, like the one in **Figure 4**, are of water-dwelling, armored animals that lived about 420 million years ago (mya). Lobe-finned fish appeared in the fossil record about 395 mya. The oldest known amphibian fossils date from about 370 mya. Reptile fossils have been found in deposits about 350 million years old. One well-known group of reptiles—the dinosaurs—first appeared about 230 mya.

In 1861, a fossil imprint of an animal with scales, jaws with teeth, claws on its front limbs, and feathers was found. The 150-million-year-old fossil was an ancestor of birds, and was named *Archaeopteryx* (ar kee AHP tuh rihks).

Mammal-like reptiles appeared about 235 mya. However, true mammals appeared about 190 mya, and modern mammals originated about 38 million years ago.

Figure 4 Placoderms were the first fish with jaws. These predatory fish were covered with heavy armor.

section review **Summary** Self Check **Chordate Characteristics 1. Explain** the difference between a vertebra and a notochord. Chordates have four common characteristics at some point in their development: a noto-2. Compare and contrast some of the physical differences chord, postanal tail, nerve cord, and pharynbetween ectotherms and endotherms. geal pouches. 3. Think Critically If the outside temperature decreases by Vertebrate Characteristics 20°C, what will happen to a reptile's body temperature? All vertebrates have an endoskeleton, a backbone, a head with a skull to protect the brain, **Applying Skills** internal organs in a central body cavity, and a 4. Concept Map Construct a concept map using these protective skin. terms: chordates, bony fish, amphibians, cartilaginous Vertebrates can be ectothermic or fish, reptiles, birds, mammals, lancelets, tunicates, endothermic. invertebrate chordates, jawless fish, and vertebrates. There are seven main groups of vertebrates. Science IIII bookc.msscience.com/self_check_quiz SECTION 1 Chordates and Vertebrates C - 75 T. A. Wiewandt/DRK Photo CONTENTS

Endotherms and Ectothearms

Birds and mammals are endotherms. Fish, amphibians and reptiles are ectotherms.

Real-World Question-

How can you determine whether an animal you have never seen before is an endotherm or an ectotherm? What tests might you conduct to find the answer?

Goals

- **Construct** an imaginary animal.
- Determine whether your animal is an endotherm or an ectotherm.

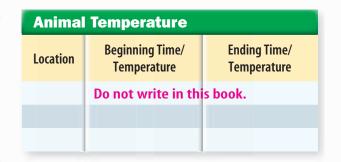
Materials

fiberfill *cotton balls *old socks *tissue cloth thermometer *Alternate materials

Safety Precautions 🛛 🔊 🐨 🛐 🛃

Procedure

- Design an animal that has a thermometer inside. Construct the animal using cloth and some kind of stuffing material. Make sure that you will be able to remove and reinsert the thermometer.
- **2.** Draw a picture of your animal and record data about its size and shape.



- 3. Copy the data table in your Science Journal.
- **4.** Place your animal in three locations that have different



temperatures. Record the locations in the data table.

 In each location, record the time and the temperature of your animal at the beginning and after 10 min.

🧔 Conclude and Apply –

- 1. **Describe** your results. Did the animal's temperature vary depending upon the location?
- **2.** Based on your results, is your animal an endotherm or an ectotherm? Explain.
- **3. Compare** your results to those of others in your class. Were the results the same for animals of different sizes? Did the shape of the animal, such as one being flatter and another more cylindrical, matter?
- Based on your results and information in the chapter, do you think your animal is most likely a bird, a mammal, a reptile, an amphibian, or a fish? Explain.

Communicating Your Data

Compare your conclusions with those of other students in your class. For more help, refer to the Science Skill Handbook.



Fish Characteristics

Did you know that more differences appear among fish than among any other vertebrate group? In fact, there are more species of fish than species of other vertebrate groups. All fish are ectotherms. They are adapted for living in nearly every type of water environment on Earth—freshwater and salt water. Some fish, such as salmon, spend part of their life in freshwater and part of it in salt water. Fish are found at varying depths, from shallow pools to deep oceans.

A streamlined shape, a muscular tail, and fins allow most fish to move rapidly through the water. **Fins** are fanlike structures attached to the endoskeleton. They are used for steering, balancing, and moving. Paired fins on the sides allow fish to move right, left, backward, and forward. Fins on the top and bottom of the body give the fish stability. Most fish secrete a slimy mucus that also helps them move through the water.

Most fish have scales. **Scales** are hard, thin plates that cover the skin and protect the body, similar to shingles on the roof of a house. Most fish scales are made of bone. **Figure 5** illustrates how they can be tooth shaped, diamond shaped, cone shaped, or round. The shape of the scales can be used to help classify fish. The age of some species can be estimated by counting the annual growth rings of the scales.

as you read

What You'll Learn

- List the characteristics of the three classes of fish.
- **Explain** how fish obtain food and oxygen and reproduce.
- Describe the importance and origin of fish.

Why It's Important

Fish are an important food source for humans as well as many other animals.

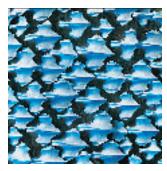
Review Vocabulary

streamline: formed to reduce resistance to motion through a fluid or air

New Vocabulary

- fin
- scale

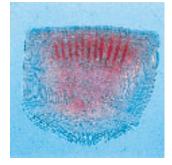
Figure 5 Four types of fish scales are shown here.



Sharks are covered with placoid scales such as these. Shark teeth are modified forms of these scales.



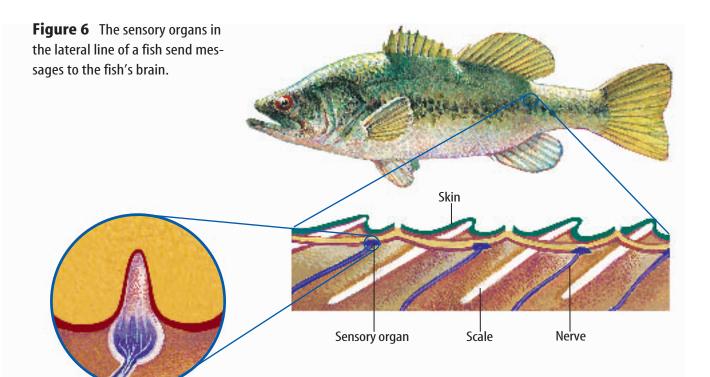
Lobe-finned fish and gars are covered by ganoid scales. These scales don't overlap like other fish scales.



Ctenoid (TEN oyd) scales have a rough edge, which is thought to reduce drag as the fish swims through the water.



Cycloid scales are thin and overlap, giving the fish flexibility. These scales grow as the fish grows.



Body Systems All fish have highly developed sensory systems. Most fish have a lateral line system, as shown in **Figure 6**. A lateral line system is made up of a shallow, canal-like structure that extends along the length of the fish's body and is filled with sensory organs. The lateral line enables a fish to sense its environment and to detect movement. Some fish, such as sharks, also have a strong sense of smell. Sharks can detect blood in the water from several kilometers away.

Fish have a two-chambered heart in which oxygen-filled blood mixes with carbon dioxide-filled blood. A fish's blood isn't carrying as much oxygen as blood that is pumped through a three- or four-chambered heart.

Gas Exchange Most fish have organs called gills for the exchange of carbon dioxide and oxygen. Gills are located on

both sides of the fish's head and are made up of feathery gill filaments that contain many tiny blood vessels. When a fish takes water into its mouth, the water passes over the gills, where oxygen from the water is exchanged with carbon dioxide in the blood. The water then passes out through slits on each side of the fish. Many fish, such as the halibut in **Figure 7**, are able to take in water while lying on the ocean floor.

Figure 7 Even though a halibut's eyes are on one side of the fish, gills are on both sides. **Describe** how a fish breathes.

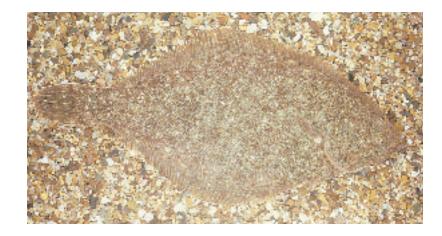




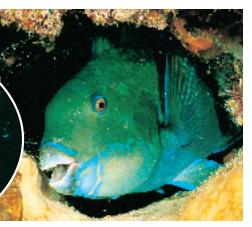


Figure 8 Fish obtain food in different ways.

A whale shark's mouth can open to 1.4 m wide.



Sawfish are rare. They use their toothed snouts to root out bottom fish to eat.



Parrot fish use their hard beaks to bite off pieces of coral.

Feeding Adaptations Some of the adaptations that fish have for obtaining food are shown in **Figure 8**. Some of the largest sharks are filter feeders that take in small animals as they swim. The archerfish shoots down insects by spitting drops of water at them. Even though some fish have strong teeth, most do not chew their food. They use their teeth to capture their prey or to tear off chunks of food.

Reproduction Fish reproduce sexually. Reproduction is controlled by sex hormones. The production of sex hormones is dependent upon certain environmental factors such as temperature, length of daylight, and availability of food.

Female fish release large numbers of eggs into the water. Males then swim over the eggs and release sperm. This behavior is called spawning. The joining of the egg and sperm cells outside the female's body is called external fertilization. Certain species of sharks and rays have internal fertilization and lay fertilized eggs. Some fish, such as guppies and other sharks, have internal fertilization but the eggs develop and hatch inside the female's body. After they hatch, they leave her body.

Some species do not take care of their young. They release hundreds or even millions of eggs, which increases the chances that a few offspring will survive to become adults. Fish that care for their young lay fewer eggs. Some fish, including some catfish, hold their eggs and young in their mouths. Male sea horses keep the fertilized eggs in a pouch until they hatch.

CONTENTS D



Electric eels produce a powerful electric shock that stuns their prey.



Fish Fats Many fish contain oil with omega-3 fatty acids, which seems to reverse the effects of too much cholesterol. A diet rich in fish that contain this oil might prevent the formation of fatty deposits in the arteries of humans. In your Science Journal, develop a menu for a meal that includes fish.

Figure 9 Hagfish have cartilaginous skeletons. They feed on marine worms, mollusks, and crustaceans, in addition to dead and dying fish. Infer how hagfish eat.

Types of Fish

Fish vary in size, shape, color, living environments, and other factors. Despite their diversity, fish are grouped into only three categories—jawless fish, jawed cartilaginous (kar tuh LA juh nuss) fish, and bony fish.

Jawless Fish

Lampreys, along with the hagfish in **Figure 9**, are jawless fish. Jawless fish have round, toothed mouths and long, tubelike bodies covered with scaleless, slimy skin. Most lampreys are parasites. They attach to other fish with their suckerlike mouth. They then feed by removing blood and other body fluids from the host fish. Hagfish feed on dead or dying fish and other aquatic animals.

Jawless fish have flexible endoskeletons made of cartilage. Hagfish live only in salt water, but some species of lamprey live in salt water and other species live in freshwater.

Jawed Cartilaginous Fish

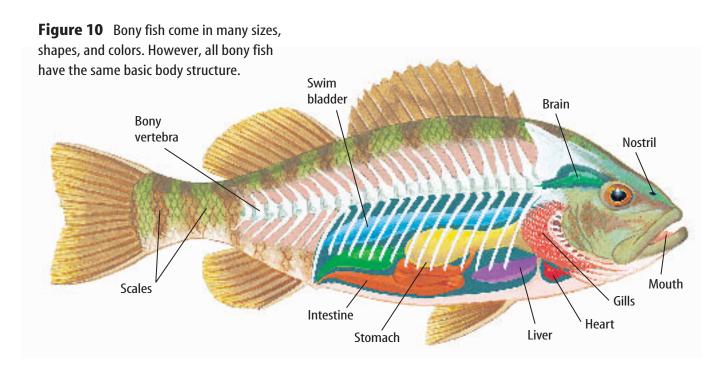
Sharks, skates, and rays are jawed cartilaginous fish. These fish have endoskeletons made of cartilage like jawless fish. Unlike jawless fish, these fish have movable jaws that usually have well-developed teeth. Their bodies are covered with tiny scales that make their skins feel like fine sandpaper.

Sharks are top predators in many ocean food chains. They are efficient at finding and killing their food, which includes other fish, mammals, and some reptiles. Because of overfishing and the fact that shark reproduction is slow, shark populations are decreasing at an alarming rate.

Reading Check Why are shark populations decreasing?







Bony Fish

About 95 percent of all species of fish are bony fish. They have skeletons made of bone. The body structure of a typical bony fish is shown in **Figure 10.** A bony flap covers and protects the gills. It closes as water moves into the mouth and over the gills. When it opens, water exits from the gills.

Swim Bladder An important adaptation in most bony fish is the swim bladder. It is an air sac that allows the fish to adjust its density in response to the density of the surrounding water. The density of matter is found by dividing its mass by its volume. If the density of the object is greater than that of the liquid it is in, the object will sink. If the density of the object is equal to the density of the liquid, the object will neither sink nor float to the surface. If the density of the object is less than the density of the liquid, the object will float on the liquid's surface.

The transfer of gases—mostly oxygen in deepwater fish and nitrogen in shallow-water fish—between the swim bladder and the blood causes the swim bladder to inflate and deflate. As the swim bladder fills with gases, the fish's density decreases and it rises in the water. When the swim bladder deflates, the fish's density increases and it sinks. Glands regulate the gas content in the swim bladder, enabling the fish to remain at a specific depth with little effort. Deepwater fish often have oil in their swim bladders rather than gases. Some bottom-dwelling fish and active fish that frequently change depth have no swim bladders.



Modeling How Fish Adjust to Different Depths

Procedure

- **1.** Fill a **balloon** with air.
- 2. Place it in a bowl of water.
- 3. Fill another balloon partially with water, then blow air into it until it is the same size as the airfilled balloon.
- **4.** Place the second balloon in the bowl of water.

Analysis

- 1. Infer what structure these balloons model.
- 2. Compare where in the water (on the surface, or below the surface) two fish would be if they had swim bladders similar to the two

balloons.





Lobe-Finned Fish One of the three types of bony fish is the lobe-finned fish, as shown in **Figure 11**. Lobe-finned fish have fins that are lobelike and fleshy. These organisms were thought to have been extinct for more than 70 million years. But in 1938, some South African fishers caught a lobe-finned

Figure 11 Coelacanths (SEE luh kanthz) have been found living in the Indian Ocean north of Madagascar.

fish in a net. Several living lobe-finned fish have been studied since. Lobe-finned fish are important because scientists hypothesize that fish similar to these were the ancestors of the first land vertebrates—the amphibians.

Applying Math Solve a One-Step Equation

DENSITY OF A FISH A freshwater fish has a mass of 645 g and a volume of 700 cm³. What is the fish's density, and will it sink or float in freshwater?

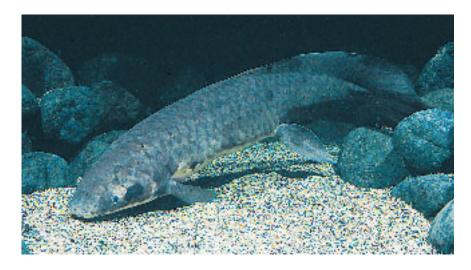
Solution

1	This is what you know:	 density of freshwater = 1g/cm³ mass of fish = 645 g volume of fish = 700 cm³
2	This is the equation you need to use:	$\frac{\text{mass of object (g)}}{\text{mass of object (g/cm^3)}} = \text{density of object (g/cm^3)}$
3	Substitute the known values:	$\frac{645 \text{ g}}{700 \text{ cm}^3} = 0.921 \text{ g/cm}^3$
4	Check your answer:	Multiply 0.921 g/cm ³ by 700 cm ³ . You should get 645 g. The fish will float in freshwater. Its density is less than that of freshwater.
	Practice Problems	
	• Calculate the density of a salt	water fish that has a mass of 215 g and a volume of 180 cm ³ . salt water? The density of ocean salt water is about 1.025 g/cm ³ .

2. A fish with a mass of 440 g and a volume of 430 cm³ floats in its water. Is it a freshwater fish or a saltwater fish?

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Lungfish A lungfish, as shown in **Figure 12**, has one lung and gills. This adaptation enables them to live in shallow waters that have little oxygen. The lung enables the lungfish to breathe air when the water evaporates. Drought conditions stimulate lungfish to burrow into the mud and cover themselves with mucus until water returns. Lungfish have been found along the coasts of South America and Australia.

Ray-Finned Fish Most bony fish have fins made of long, thin bones covered with skin. Ray-finned fish, like those in **Figure 13**, have a lot of variation in their body plans. Most predatory fish have long, flexible bodies, which enable them to pursue prey quickly. Many bottom fish have flattened bodies and mouths adapted for eating off the bottom. Fish with unusual shapes, like the sea horse and anglerfish, also can be found. Yellow perch, tuna, salmon, swordfish, and eels are ray-finned fish.

> Sea horses use their tails to anchor themselves to sea grass. This prevents the ocean currents from washing them away.

Figure 12 Australian lungfish are one of the six species of lungfish. Identify the unique adaptation of a lungfish.

Figure 13 Bony fish have a diversity of body plans.

Most bony fish are ray-finned fish, like this rainbow trout.



Anglerfish have a structure that looks like a lure to attract prey fish. When the prey comes close, the anglerfish quickly opens its mouth and captures the prey.







Figure 14 Lancelets are small, eel-like animals. They spend most of their time buried in the sand and mud at the bottom of the ocean.

Importance and Origin of Fish

Fish play a part in your life in many ways. They provide food for many animals, including humans. Fish farming and commercial fishing also are important to the U.S. economy. Fishing is a method of obtaining food as well as a form of recreation enjoyed by many people. Many fish eat large amounts of insect larvae, such as mosquitoes, which keeps insect populations in check. Some, such as grass carp, are used to keep the plant growth from clogging waterways. Captive fish are kept in aquariums for humans to admire their bright colors and exotic forms.

Reading Check How are fish helpful to humans?

Most scientists agree that fish evolved from small, softbodied, filter-feeding organisms similar to present-day lancelets, shown in Figure 14. The earliest fossils of fish are those of jawless fish that lived about 450 million years ago. Fossils of these early fish usually are found where ancient streams emptied into the sea. This makes it difficult to tell whether these fish ancestors evolved in freshwater or in salt water.

Today's bony fish are probably descended from the first jawed fish called the acanthodians (a kan THOH dee unz). They appeared in the fossil record about 410 mya. Another group of ancient fish-the placoderms-appeared about 400 mya. For about 50 million years, placoderms dominated most water ecosystems then disappeared. Modern sharks and rays probably descended from the placoderms.

section

review

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Summary

Fish Characteristics

- All fish have a streamlined shape, a muscular tail, fins, scales, well-developed sensory systems, and gills.
- All fish reproduce sexually and feed in many different ways.

Types of Fish

- There are three categories of fish: jawless fish, jawed cartilaginous fish, and bony fish.
- There are three types of bony fish: lobe-finned fish, lungfish, and ray-finned fish.

Self Check

- 1. List examples for each of the three classes of fish.
- 2. Explain how jawless fish and cartilaginous jawed fish take in food.
- 3. Describe the many ways that fish are important to humans.
- 4. Think Critically Female fish lay thousands of eggs. Why aren't lakes and oceans overcrowded with fish?

Applying Skills

5. Concept Map Make an events-chain concept map to show what must take place for the fish to rise from the bottom to the surface of the lake.

C CHAPTER 3 Fish, Amphibians, and Reptiles Science Multiple bookc.msscience.com/self check quiz Runk/Schoenberger from Grant Heilman

section

Amphibians

Amphibian Characteristics

The word *amphibian* comes from the Greek word *amphibios*, which means "double life." They are well named, because amphibians spend part of their lives in water and part on land. Frogs, toads, and the salamander shown in **Figure 15** are examples of amphibians. What characteristics do these animals have that allow them to live on land and in water?

Amphibians are ectotherms. Their body temperature changes when the temperature of their surroundings changes. In cold weather, amphibians become inactive and bury themselves in mud or leaves until the temperature warms. This period of inactivity during cold weather is called **hibernation**. Amphibians that live in hot, dry environments become inactive and hide in the ground when temperatures become too hot. Inactivity during the hot, dry months is called **estivation**.

Reading Check How are hibernation and estivation similar?

Respiration Amphibians have moist skin that is smooth, thin, and without scales. They have many capillaries directly beneath the skin and in the lining of the mouth. This makes it possible for oxygen and carbon dioxide to be exchanged through the skin and the mouth lining. Amphibians also have small, simple, saclike lungs in the chest cavity for the exchange of oxygen and carbon dioxide. Some salamanders have no lungs and breathe only through their skin.

as you read

What You'll Learn

- Describe the adaptations amphibians have for living in water and living on land.
- List the kinds of amphibians and the characteristics of each.
- Explain how amphibians reproduce and develop.

Why It's Important

Because amphibians are sensitive to changes in the environment, they can be used as biological indicators.

Review Vocabulary

habitat: place where an organism lives and that provides the types of food, shelter, moisture, and temperature needed for survival

New Vocabulary

- hibernation
- estivation



Figure 15 Salamanders often are mistaken for lizards because of their shape. However, like all amphibians, they have a moist, scaleless skin that requires them to live in a damp habitat.





Figure 16 Red-eyed tree frogs are found in forests of Central and South America. They eat a variety of foods, including insects and even other frogs.

Figure 17 Amphibians go through metamorphosis as they develop.

Circulation The three-chambered heart in amphibians is an important change from the circulatory system of fish. In the threechambered heart, one chamber receives oxygen-filled blood from the lungs and skin, and another chamber receives carbon dioxide-filled blood from the body tissues. Blood moves from both of these chambers to the third chamber, which pumps oxygenfilled blood to body tissues and carbon dioxide-filled blood back to the lungs. Limited mixing of these two bloods occurs.

Reproduction Even though amphibians are adapted for life on land, they depend on

water for reproduction. Because their eggs do not have a protective, waterproof shell, they can dry out easily, so amphibians must have water to reproduce.

Amphibian eggs are fertilized externally by the male. As the eggs come out of the female's body, the male releases sperm over them. In most species the female lays eggs in a pond or other body of water. However, many species have developed special reproductive adaptations, enabling them to reproduce away from bodies of water. Red-eyed tree frogs, like the ones in **Figure 16**, lay eggs in a thick gelatin on the underside of leaves that hang over water. After the tadpoles hatch, they fall into the water below, where they continue developing. The Sonoran Desert toad waits for small puddles to form in the desert during the rainy season. It takes tadpoles only two to 12 days to hatch in these temporary puddles.

After hatching, most young amphibians, like these tadpoles, do not look like adult forms.

Amphibian eggs are laid in a jellylike material to keep them moist.

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Development Most amphibians go through a developmental process called metamorphosis (me tuh MOR fuh sus). Fertilized eggs hatch into tadpoles, the stage that lives in water. Tadpoles have fins, gills, and a two-chambered heart similar to fish. As tadpoles grow into adults, they develop legs, lungs, and a three-chambered heart. **Figure 17** shows this life cycle.

The tadpole of some amphibian species, such as salamanders, are not much different from the adult stage. Young salamanders look like adult salamanders, but they have external gills and usually a tail fin.

Frogs and Toads

Adult frogs and toads have short, broad bodies with four legs but no neck or tail. The strong hind legs are used for swimming and jumping. Bulging eyes and nostrils on top of the head let frogs and toads see and breathe while the rest of their body is submerged in water. On spring nights, males make their presence known with loud, distinctive croaking sounds. On each side of the head, just behind the eyes, are round tympanic membranes. These membranes vibrate somewhat like an eardrum in response to sounds and are used by frogs and toads to hear.

Most frog and toad tongues are attached at the front of their mouths. When they see prey, their tongue flips out and contacts the prey. The prey gets stuck in the sticky saliva on the tongue and the tongue flips back into the mouth. Toads and frogs eat a variety of insects, worms, and spiders, and one tropical species eats berries. sciencenline

Topic: Biological Indicators Visit bookc.msscience.com for Web links to information about amphibians as biological indicators.

Activity What factors make amphibians good biological indicators?



Most adult amphibians are able to move about and live on land.





Describing Frog Adaptations

Procedure 🐼 🦋 🛃 🚁

- Carefully observe a frog in a jar. Notice the position of its legs as it sits. Record all of your observations in your Science Journal.
- 2. Observe its mouth, eyes, nostrils and ears.
- 3. Observe the color of its back and belly.
- **4.** Return the frog to your teacher.

Analysis

- 1. Describe the adaptations the frog has for living in water.
- 2. What adaptations does it have for living on land?

Figure 18 Poison frogs are brightly colored to show potential predators that they are poisonous. Toxins from poison frogs have been used in hunting for centuries.

Salamanders

Most species of salamanders and newts live in North America. These amphibians often are mistaken for lizards because of their long, slender bodies. The short legs of salamanders and newts appear to stick straight out from the sides of their bodies.

Land-living species of salamanders and newts usually are found near water. These amphibians hide under leaf litter and rocks during the day to avoid the drying heat of the Sun. At night, they use their well-developed senses of smell and vision to find and feed on worms, crustaceans, and insects.

Many species of salamanders breed on land, where fertilization is internal. Aquatic species of salamanders and newts release and fertilize their eggs in the water.

Importance of Amphibians

Most adult amphibians are insect predators and are helpful in keeping some insect populations in check. They also are a source of food for other animals, including other amphibians. Some people consider frog legs a delicacy.

Poison frogs, like the one in **Figure 18**, produce a poison that can kill large animals. They also are known as poison dart frogs or poison arrow frogs. The toxin is secreted through their skin and can affect muscles and nerves of animals that come in contact with it. Native people of the Emberá Chocó in Colombia, South America, cover blowgun darts that they use for hunting with the poison of one species of these frogs. Researchers are studying the action of these toxins to learn more about how the nervous system works. Researchers also are using amphibians in regeneration studies in hopes of developing new ways of treating humans who have lost limbs or were born without limbs.





Biological Indicators Because they live on land and reproduce in water, amphibians are affected directly by changes in the environment, including pesticides and other pollution. Amphibians also absorb gases through their skin, making them susceptible to air pollutants. Amphibians, like the one in **Figure 19**, are considered to be biological indicators. Biological indicators are species whose overall health reflects the health of a particular ecosystem.

What is a biological indicator?

Origin of Amphibians The fossil record shows that ancestors of modern fish were the first vertebrates on Earth. For about 150 million years, they were the only vertebrates. Then as the climate changed and competition for food and space increased, some lobe-finned fish might have traveled across land searching for water as their ponds dried up. Fossil evidence shows that from these lobe-finned fish evolved aquatic animals with four limbs. Amphibians probably evolved from these aquatic animals about 350 mya.

Because competition on land from other animals was minimal, evolution favored the development of amphibians. Insects, spiders, and other invertebrates were an abundant source of food on land. Land was almost free of predators, so amphibians were able to reproduce in large numbers, and many new species evolved. For 100 million years or more, amphibians were the dominant land animals.



Figure 19 Beginning in 1995, deformed frogs such as this were found. Concerned scientists hypothesize that an increase in the number of deformed frogs could be a warning of environmental problems for other organisms.

section

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Summary

Amphibian Characteristics

- Amphibians have two phases of life—one in water and one on land.
- All amphibians have a three-chambered heart, reproduce in the water by laying eggs, and go through metamorphosis.

Types and Importance of Amphibians

- Frogs and toads have short, broad bodies, while salamanders have long, slender bodies.
- Amphibians are used for food, research, and are important as biological indicators.

review

Self Check

- **1. List** the adaptations amphibians have for living in water and for living on land.
- 2. Explain how tadpole and frog hearts differ.
- Describe two different environments where amphibians lay eggs.
- 4. Think Critically Why do you suppose frogs and toads seem to appear suddenly after a rain?

Applying Skills

 Concept Map Make an events-chain concept map of frog metamorphosis. Describe each stage in your Science Journal.

Reptiles

as you read

What You'll Learn

- List the characteristics of reptiles.
- Determine how reptile adaptations enable them to live on land.
- Explain the importance of the amniotic egg.

Why It's Important

Reptiles provide information about how body systems work during extreme weather conditions

Review Vocabulary bask: to warm by continued

exposure to heat

New Vocabulary

• amniotic egg

Figure 20 Skinks, like this northern blue-tongue skink, are one of the largest lizard families with around 800 species.

Reptile Characteristics

Reptiles are ectotherms with a thick, dry, waterproof skin. Their skin is covered with scales that help reduce water loss and protect them from injury. Even though reptiles are ectotherms, they are able to modify their internal body temperatures by their behavior. When the weather is cold, they bask in the Sun, which warms them. When the weather is warm and the Sun gets too hot, they move into the shade to cool down.

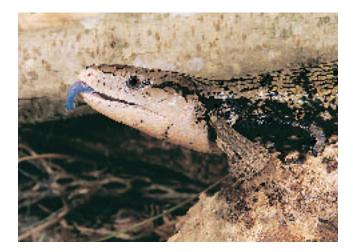
💕 Reading Check

How are reptiles able to modify their body temperature?

Some reptiles, such as turtles, crocodiles, and lizards, like the skink in **Figure 20**, move on four legs. Claws are used to dig, climb, and run. Reptiles, such as snakes and some lizards, move without legs.

Body Systems Scales on reptiles prevent the exchange of oxygen and carbon dioxide through the skin. Reptiles breathe with lungs. Even turtles and sea snakes that live in water must come to the surface to breathe.

The circulatory system of reptiles is more highly developed than that of amphibians. Most reptiles have a three-chambered heart with a partial wall inside the main chamber. This means that less mixing of oxygen-filled blood and carbon dioxide-filled blood occurs than in amphibians. This type of circulatory



system provides more oxygen to all parts of the body. Crocodilians have a four-chambered heart that completely separates the oxygen-filled blood and the carbon dioxidefilled blood and keeps them from mixing.



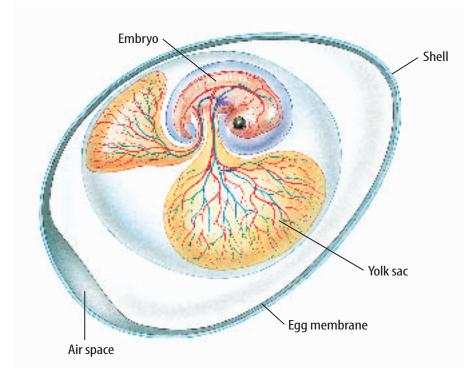


Figure 21 The development of amniotic eggs enabled reptiles to reproduce on land. Infer how an amniotic egg helps reptiles be a more successful group.

Amniotic Egg One of the most important adaptations of reptiles for living on land is the way they reproduce. Unlike the eggs of most fish and amphibians, eggs of reptiles are fertilized internally—inside the body of the female. After fertilization, the females of many reptiles lay eggs that are covered by tough, leathery shells. The shell prevents the eggs from drying out. This adaptation enables reptiles to lay their eggs on land.

The **amniotic egg** provides a complete environment for the embryo's development. **Figure 21** shows the structures in a reptilian egg. This type of egg contains membranes that protect and cushion the embryo and help it get rid of wastes. It also contains a large food supply—the yolk—for the embryo. Minute holes in the shell, called pores, allow oxygen and carbon dioxide to be exchanged. By the time it hatches, a young reptile looks like a small adult.

W Reading Check What is the importance of an amniotic egg?

Types of Modern Reptiles

Reptiles live on every continent except Antarctica and in all the oceans except those in the polar regions. They vary greatly in size, shape, and color. Reticulated pythons, 10 m in length, can swallow small deer whole. Some sea turtles weigh more than 350 kg and can swim faster than humans can run. Three-horned lizards have movable eye sockets and tongues as long as their bodies. The three living groups of reptiles are lizards and snakes, turtles, and crocodilians.



Visit bookc.msscience.com for Web links to recent news about the nesting sites of turtles.

Activity Name two conservation organizations that are giving the turtles a helping hand, and how they are doing it.



Lizards and Snakes Some animals in the largest group of reptiles—the lizards and snakes like those shown in **Figure 22**—have a type of jaw not found in other reptiles, like the turtle also shown in **Figure 22**. The jaw has a special joint that unhinges and increases the size of their mouths. This enables them to swallow their prey whole. Lizards have movable eyelids, external ears, and legs with clawed toes on each foot. They feed on plants, other reptiles, insects, spiders, worms, and mammals.

Snakes have developed ways of moving without legs. They have poor hearing and most have poor eyesight. Recall how you could feel the vibrations of the tuning fork in the Launch Lab. Snakes do not hear sound waves in the air. They "hear" vibrations in the ground that are picked up by the lower jawbone and conducted to the bones of the snake's inner ear. From there, the vibrations are transferred to the snake's brain, where the sounds are interpreted.

Snakes are meat eaters. Some snakes wrap around and constrict their prey. Others inject their prey with venom. Many snakes feed on small mammals, and as a result, help control those populations.

Most snakes lay eggs after they are fertilized internally. In some species, eggs develop and hatch inside the female's body then leave her body shortly thereafter.



Rosy boas are one of only two species of boas found in the United States.

Figure 22 Examples of reptiles

are shown below.

Turtles The only reptiles that have a two-part shell made of hard, bony plates are turtles. The vertebrae and ribs are fused to the inside of the top part of the shell. The muscles are attached to the lower and upper part of the inside of the shell. Most turtles can withdraw their heads and legs into the shell for protection against predators.

What is the purpose of a turtle's shell?

Turtles have no teeth but they do have powerful jaws with a beaklike structure used to crush food. They feed on insects, worms, fish, and plants. Turtles live in water and on land. Those that live on land are called tortoises.

Like most reptiles, turtles provide little or no care for their young. Turtles dig out a nest,

deposit their eggs, cover the nest, and leave. Turtles never see their own hatchlings. Young turtles, like those in **Figure 23**, emerge from the eggs fully formed and live on their own.

Crocodilians Found in or near water in warm climates, crocodilians, such as crocodiles, gavials, and alligators, are similar in appearance. They are lizardlike in shape, and their backs have large, deep scales. Crocodilians can be distinguished from each other by the shape of their heads. Crocodiles have a narrow head with a triangular-shaped snout. Alligators have a broad head with a rounded snout. Gavials, as shown in **Figure 24**, have a very slender snout with a bulbous growth on the end. Crocodiles are aggressive and can attack animals as large as cattle. Alligators are less aggressive than crocodiles, and feed on fish, turtles, and waterbirds. Gavials primarily feed on fish. Crocodilians are among the world's largest living reptiles.

Crocodilians are some of the few reptiles that care for their young. The female guards the nest of eggs and when the eggs

Figure 23 Most turtles are eaten shortly after they hatch. Only a few sea turtles actually make it into the ocean.

Figure 24 Indian gavials are one of the rarest crocodilian species on Earth. Adults are well adapted for capturing fish.

hatch, the male and female protect the young. A few crocodilian females have been photographed opening their nests in response to noises made by hatchlings. After the young hatch, a female carries them in her huge mouth to the safety of the water. She continues to keep watch over the young until they can protect themselves.





NATIONAL GEOGRAPHIC VISUALIZING EXTINCT REPTILES

Figure 25

f you're like most people, the phrase "prehistoric reptiles" probably brings dinosaurs to mind. But not all ancient reptiles were dinosaurs. The first dinosaurs didn't appear until about 115 million years after the first reptiles. Paleontologists have unearthed the fossils of a variety of reptilian creatures that swam through the seas and waterways of ancient Earth. Several examples of these extinct aquatic reptiles are shown here.



▲ ICHTHYOSAUR (IHK thee uh sawr) Ichthyosaurs resembled a cross between a dolphin and a shark, with large eyes, four paddlelike limbs, and a fishlike tail that moved from side to side. These extinct reptiles were fearsome predators with long jaws armed with numerous sharp teeth.



▲ MOSASAUR (MOH zuh sawr) Marinedwelling mosasaurs had snakelike bodies, large skulls, and long snouts. They also had jointed jawbones, an adaptation for grasping and swallowing large prey.

ELASMOSAURUS

(uh laz muh SAWR us) Predatory *Elasmosaurus* had a long neck with as many as 76 vertebrae—topped by a small head.



▲ CHAMPOSAUR (CHAM puh sawr) This ancient reptile looked something like a modern crocodile, with a long snout studded with razor-sharp teeth. Champosaurs lived in freshwater lakes and streams and preyed on fish and turtles.



▲ PLESIOSAUR (PLEE zee uh sawr) These marine reptiles had stout bodies, paddlelike limbs, and long necks. Plesiousaurs might have fed by swinging their heads from side to side through schools of fish.

(tl)John Sibbick, (tr)Karen Carr, (c)Chris Butler/Science Photo Library/Photo Researchers, (bl)J

The Importance of Reptiles

Reptiles are important predators in many environments. In farming areas, snakes eat rats and mice that destroy grains. Small lizards eat insects, and large lizards eat small animals that are considered pests.

Humans in many parts of the world eat reptiles and their eggs or foods that include reptiles, such as turtle soup. The number of reptile species is declining in areas where swamps and other lands are being developed for homes and recreation areas. Coastal nesting sites of sea turtles are being destroyed by development or are becoming unusable because of pollution. For years, many small turtles were collected in the wild and then sold as pets. People now understand that such practices disturb turtle populations. Today most species of turtles and their habitats are protected by law.

Origin of Reptiles Reptiles first appeared in the fossil record about 345 mya. The earliest reptiles did not depend upon water for reproduction. As a result, they began to dominate the land about 200 mya. Some reptiles even returned to the water to live, although they continued to lay their eggs on land. Dinosaurs—descendants of the early reptiles—ruled Earth during this era, then died out about 65 mya. Some of today's reptiles, such as the crocodilians, have changed little from their ancestors, some of which are illustrated in **Figure 25**.



A Changing Environment Dinosaurs, reptiles that ruled Earth for 160 million years, died out about 65 million years ago. In your Science Journal, describe what changes in the environment could have caused the extinction of the dinosaurs.



CONTENTS

Summary

Reptile Characteristics

- Reptiles are ectotherms with a thick, dry, waterproof skin that is covered with scales.
- Most have a three-chambered heart with a partial wall in the main chamber.
- Reptile young develop in an amniotic egg.

Types and Importance of Reptiles

- Lizards and snakes are the largest group of reptiles. Most lizards have legs, while snakes do not.
- Turtles have a two-part bony shell.
- Crocodilians are large reptiles and one of the few reptiles that care for their young.
- Reptiles are important predators. Some reptiles are food sources.

Science Dine bookc.msscience.com/self_check_quiz

Self Check

- 1. **Describe** reptilian adaptations for living on land.
- 2. Explain how turtles differ from other reptiles.
- 3. Infer why early reptiles, including dinosaurs, were so successful as a group.
- 4. Draw the structure of an amniotic egg.

review

5. Think Critically Venomous coral snakes and some nonvenomous snakes have bright red, yellow, and black colors. How is this an advantage and a disadvantage to the nonvenomous snake?

Applying Math

6. Solve One-Step Equations Brachiosaurus, a dinosaur, was about 12 m tall and 22 m long. The average elephant is 3 m tall and 6 m long. How much taller and longer is the Brachiosaurus compared to an elephant?

Design Your Own

Wager Temperature and the Respiration Rate of Fish

🧔 Real-World Question

Imagine that last summer was hot with few storms. One day after many sunny, windless days, you noticed that a lot of dead fish were floating on the surface of your neighbor's pond. What might have caused these fish to die? How does water temperature affect the respiration rate of fish?

🧔 Form a Hypothesis

Fish obtain oxygen from the water. State a hypothesis about how water temperature affects the respiration rate of fish.

O Test Your Hypothesis

Make a Plan

1. As a group, agree upon and write out a plan. You might make a plan that relates the amount of oxygen dissolved in water at different water temperatures and how this affects fish.



Goals

- Design and carry out an experiment to measure the effect of water temperature on the rate of respiration of fish.
- **Observe** the breathing rate of fish.

Possible Materials

goldfish aquarium water small fishnet 600-mL beakers container of ice water stirring rod thermometer aquarium

Safety Precautions

Protect your clothing. Use the fishnet to transfer fish into beakers.

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Using Scientific Methods

- 2. As a group, list the steps that you need to take to follow your plan. Be specific and describe exactly what you will do at each step. List your materials.
- 3. How will you measure the breathing rate of fish?
- **4. Explain** how you will change the water temperature in the beakers. Fish respond better to a gradual change in temperature than an abrupt change. How will you measure the response of fish to changes in water temperature?
- 5. What data will your group collect? Prepare a data table in your Science Journal to record the data you collect. How many times will you run your experiment?
- **6.** Read over your entire experiment to make sure the steps are in logical order. Identify any constants, variables, and controls.



Follow Your Plan

- 1. Make sure your teacher approves your setup and your plan before you start.
- 2. Carry out the experiment according to the approved plan.
- **3.** While the experiment is going on, write down any observations that you make and complete the data table in your Science Journal.

Analyze Your Data

- 1. **Compare** your results with the results of other groups in your class. Were the results similar?
- 2. Infer what you were measuring when you counted mouth or gill cover openings.
- **3. Describe** how a decrease in water temperature affects respiration rate and behavior of the fish.
- **4. Explain** how your results could be used to determine the kind of environment in which a fish can live.

Conclude and Apply –

- **1. Explain** how fish can live in water that is totally covered by ice.
- 2. Predict what would happen to a fish if the water were to become very warm.



Construct a graph of your data on poster board and share your results with your classmates.



TIME SCIENCE AND SCIENCE ISSUES SOCIETY HAT AFFECT YOU!



Venom as Medicine

iss, rattle... Run! Just the sound of a snake sends most people on a sprint to escape what could be a painful bite. Why? The bites could contain venom, a toxic substance injected into prey or an enemy. Venom can harm—or even kill—the victim. Some venomous creatures use it to stun, kill, and digest their prey, while others use it as a means of protection.

Venom is produced by a gland in the body. Some fish use their sharp, bony spines to inject venom. Venomous snakes, such as pit vipers, have fangs. Venom passes through these hollow teeth into a victim's body. The Gila monster, the largest lizard in the United States, has enlarged, grooved teeth in its lower jaw through which its venom travels. It is one of only two species of venomous lizards.

Doctors and scientists have discovered a shocking surprise within this sometimes deadly liquid. Oddly enough, the very same toxin that harms and weakens people can heal, too. In fact, doctors use the deadliest venom—that of some pit viper species—to treat certain types of heart attacks. Cobra venom has been used to soothe the effects of cancer, and other snake venoms reduce the spasms of epilepsy and asthma.



Some venoms also contain substances that help clot blood. Hemophiliacs people whose blood will not clot naturally—rely on the medical benefits that venom-based medicines supply. Venoms also are used in biological research. For instance, venoms that affect the nervous system help doctors and researchers learn more about how nerves function.

It's still smart to steer clear of the rattle or the stinger—but it's good to know that the venom in them might someday help as many as it can hurt.

Research Besides venom, what other defenses do animals use to protect themselves or to subdue their prey? Explore how some animals that are native to your region use their built-in defenses.

Science nline

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Reviewing Main Ideas

chapter

Section 1 Chordates and Vertebrates

- **1.** Chordates include lancelets, tunicates, and vertebrates. Chordates have a notochord, a nerve cord, pharyngeal pouches, and a postanal tail.
- 2. All vertebrates have an endoskeleton that includes a backbone and a skull that protects the brain.
- 3. An endotherm is an animal that has a nearly constant internal body temperature. An ectotherm has a body temperature that changes with the temperature of its environment.

Section 2 Fish

- **1.** Fish are vertebrates that have a streamlined body, fins, gills for gas exchange, and a highly developed sensory system.
- 2. Fish are divided into three groups—jawless fish, jawed cartilaginous fish, and bony fish.
- 3. Bony fish, with scales and a swim bladder, have the greatest number of known fish species.

Section 3 Amphibians

1. The first vertebrates to live on land were the amphibians.

Study Guide

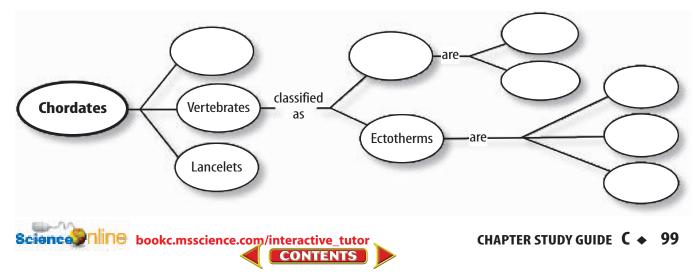
- 2. Amphibians have adaptations that allow them to live on land and in the water. The adaptations include moist skin, mucous glands, and lungs. Most amphibians are dependent on water to reproduce.
- 3. Most amphibians go through a metamorphosis from egg, to larva, to adult. During metamorphosis, legs develop, lungs replace gills, and the tail is lost.

Section 4 Reptiles

- **1.** Reptiles are land animals with thick, dry, scaly skin. They lay amniotic eggs with leathery shells.
- 2. Turtles with tough shells, meat-eating crocodilians, and snakes and lizards make up the reptile groups.
- **3.** Early reptiles were successful because of their adaptations to living on land.

Visualizing Main Ideas

Copy and complete the concept map below that describes chordates.



chapter (

Review

Using Vocabulary

amniotic egg p.91 cartilage p.73 chordate p.72 ectotherm p.75 endoskeleton p.73 endotherm p.75 estivation p.85 fin p.77 hibernation p. 85 nerve cord p. 73 notochord p. 72 pharyngeal pouch p. 73 postanal tail p. 72 scale p. 77 vertebrae p. 73

Fill in the blanks with the correct vocabulary word or words.

- 1. All chordates have a notochord, pharyngeal pouches, postanal tail, and a(n) ______.
- **2.** The inactivity of amphibians during hot, dry weather is ______.
- **3.** All animals with a constant internal temperature are _____.
- **4.** Reptiles are _____ with scaly skin.
- **5.** Jawless fish have skeletons made of a tough, flexible tissue called ______.
- **6.** Reptiles lay _____.
- **7.** The structure that becomes the backbone in vertebrates is the _____.

Checking Concepts

Choose the word or phrase that best answers the question.

- 8. Which animals have fins, scales, and gills?
 - A) amphibians C) reptiles
 - **B)** crocodiles **D)** fish
- 9. Which is an example of a cartilaginous fish?
 - A) hagfish C) perch
 - **B**) tuna **D**) goldfish

- **10.** What fish group has the greatest number of species?
 - A) bony

B) jawless

- **C)** jawed cartilaginous
- **D)** amphibians
- **11.** Which of these fish have gills and lungs?
 - A) shark C) lungfish
 - **B)** ray **D)** perch
- **12.** Biological indicators include which group of ectothermic vertebrates?
 - A) amphibians
 - B) cartilaginous fish
 - **C)** bony fish
 - **D)** reptiles

Use the photo below to answer question 13.



- **13.** Which kinds of reptiles are included with the animal above?
 - A) snakes C) turtles
 - **B)** crocodiles **D)** alligators
- 14. What term best describes eggs of reptiles?
 - A) amniotic C) jellylike
 - **B)** brown **D)** hard-shelled
- **15.** Vertebrates that have lungs and moist skin belong to which group?
 - A) amphibians C) reptiles
 - **B)** fish **D)** lizards
- **16.** How can crocodiles be distinguished from alligators?
 - A) care of the young
 - **B)** scales on the back
 - **C)** shape of the head
 - **D)** habitats in which they live

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 C CHAPTER REVIEW

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CONTENTS

Thinking Critically

- **17. Infer** Populations of frogs and toads are decreasing in some areas. What effects could this decrease have on other animal populations?
- **18. Explain** why some amphibians are considered to be biological indicators.
- **19. Compare and contrast** the ways tunicates and lancelets are similar to humans.
- **20. Describe** the physical features common to all vertebrates.
- **21. Compare and contrast** endotherms and ectotherms.
- **22. Explain** how the development of the amniotic egg led to the success of early reptiles.
- **23. Communicate** In your Science Journal, sequence the order in which these structures appeared in evolutionary history, then explain what type of organism had this adaptation and the advantage it provided: skin has mucous glands; skin has scales; dry, scaly skin.
- **24. Compare and Contrast** Copy and complete this chart that compares the features of some vertebrate groups.

Vertebrate Groups			
Feature	Fish	Amphibians	Reptiles
Heart			
Respiratory organ(s)	Do no	t write in thi	s book.
Reproduction requires water			

25. Explain how a fish uses its swim bladder.

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CONTENTS

26. Identify and Manipulate Variables and Controls Design an experiment to find out the effect of water temperature on frog egg development.

Review

- **27. Classify** To what animal group does an animal with a two-chambered heart belong?
- **28. Identify** why it is necessary for a frog to live in a moist environment.

Performance Activities

- **29. Conduct a Survey** Many people are wary of reptiles. Write questions about reptiles to find out how people feel about these animals. Give the survey to your classmates, then graph the results and share them with your class.
- **30.** Display Cut out pictures of fish from magazines and mount them on poster board. Letter the names of each fish on $3 in \times 5 in$ cards. Have your classmates try to match the names of the fish with their pictures. To make this activity more challenging, use only the scientific names of each fish.

Applying Math

Use the table below to answer questions 31 and 32.

Fish Species		
Kinds of Fish	Number of Species	
Jawless	45	
Jawed cartilaginous	500	
Bony	20,000	

- **31. Fish Species** Make a circle graph of the species of fish in the table above.
- **32. Fish Percentages** What percent of fish species is bony fish? Jawed cartilaginous? Jawless?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- 1. What are fins attached to?
 - A. ectoskeleton C. endoskeleton
 - **B.** notochord **D.** spine
- 2. How many chambers does a fish heart contain, and does it carry more or less oxygen than other types of hearts?
 - **A.** two, less **C.** three, less
 - **B.** four, less **D.** four, more

Use the photo below to answer question 3.



- What type of fish is shown in this picture?
 A. bony
 - **B.** jawed cartilaginous
 - **c.** large-mouth bass
 - **D.** jawless
- **4.** How do amphibians exchange carbon dioxide and oxygen?
 - **A.** lungs only **C.** gills only
 - **B.** lungs and skin **D.** lungs and gills
- 5. How do frogs and toads hear?
 - A. eardrum
 - **B.** tympanic membrane
 - **C.** skin
 - **D.** tongue
- **6.** Fish and amphibians do not have this type of egg so they must reproduce near water.
 - **A.** external **C.** porous
 - **B.** membranous **D.** amniotic

Use the photos below to answer questions 7 and 8.



- **7.** What is the developmental process shown in this diagram?
 - A. metamorphosis
 - **B.** respiration
 - **C.** ectotherm
 - **D.** asexual reproduction
- 8. Where does this transition take place?
 - **A.** land to air **C.** water to land
 - **B.** air to land **D.** land to water
- **9.** What is one way to distinguish a crocodile from an alligator?
 - **A.** the shape of the snout
 - B. number of eggs in nest
 - **c.** size of teeth
 - **D.** placement of nostrils
- **10.** What are turtles missing that all other reptiles have?
 - A. hair
 - **B.** three-chambered heart
 - **C.** teeth
 - **D.** shelled eggs

Test-Taking Tip

Marking on Tests Be sure to ask if it is okay to mark in the test booklet when taking the test, but make sure you mark all of the answers on your answer sheet.

Question 6 Cross out answers you know are wrong or circle answers you know are correct. This will help you narrow your choices.

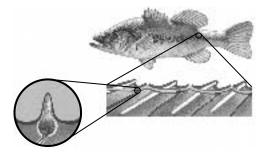


Standardized Test Practice

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer question 11.



- **11.** Describe the body system of the fish shown in this diagram. Why is it important to the fish?
- **12.** What organs do fish have for the exchange of carbon dioxide and oxygen? How does the exchange take place?
- **13.** How does a fish's swim bladder regulate its depth in water?
- **14.** What is the difference between hibernation and estivation?
- **15.** As an amphibian goes through metamorphosis, how do their heart and lungs change?
- **16.** What is one possible reason for the decline in the number of reptiles in swamps and coastal areas?
- **17.** What is the relationship between the number of young produced and the amount of care given by the parents in fish, amphibians, and reptiles?
- 18. How do snakes hear?
- **19.** Are reptiles endothermic or ectothermic? Can reptiles modify their body temperature?
- **20.** During chordate development, what structures originate from the nerve chord?

CONTENTS

Part 3 Open Ended

Record your answers on a sheet of paper.

- **21.** Describe the composition and function of fish scales.
- **22.** How did amphibians evolve and why were they the dominant land animals for a period of time?
- 23. Compare and contrast the circulatory systems of fish, amphibians, and reptiles.Which system provides the most oxygenated blood to the organs?

Use the illustration below to answer question 24.



- **24.** Explain the composition and significance of the structure in this diagram.
- **25.** Discuss the structure of a turtle's shell and what other body parts are attached to it.
- **26.** What are two classifications of how organisms regulate body temperature? How does regulation of body temperature help to determine the climate in which an organism is found?
- **27.** What are pharyngeal pouches and what animal group has them at some point during development? How has their function changed over time?

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STANDARDIZED TEST PRACTICE C

103



Birds and Mammals

chapter preview

sections

1 Birds

2 Mammals

Lab Mammal Footprints Lab Bird Counts

Virtual Lab How are birds adapted to their habitat?

More Alike than Not!

Birds and mammals have adaptations that allow them to live on every continent and in every ocean. Some of these animals have adapted to withstand the coldest or hottest conditions. These adaptations help to make these animal groups successful.

Science Journal List similar characteristics of a mammal and a bird. What characteristics are different?

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Start-Up Activities



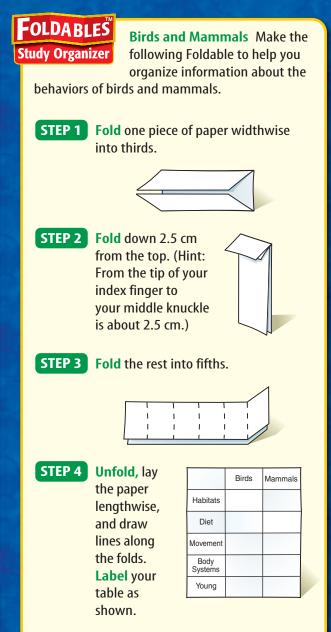
Bird Gizzards

You may have observed a variety of animals in your neighborhood. Maybe you have watched birds at a bird feeder. Birds don't chew their food because they don't have teeth. Instead, many birds swallow small pebbles, bits of eggshells, and other hard materials that go into the gizzard—a muscular digestive organ. Inside the gizzard, they help grind up the seeds. The lab below models the action of a gizzard. ()

- Place some cracked corn, sunflower seeds, nuts or other seeds, and some gravel in an old sock.
- 2. Roll the sock on a hard surface and tightly squeeze it.
- 3. Describe the appearance of the seeds after rolling.
- 4. Think Critically Describe in your Science Journal how a bird's gizzard helps digest the bird's food.

Science

Preview this chapter's content and activities at bookc.msscience.com



Make a Table As you read the chapter, complete the table describing the behaviors of birds and mammals.

Birds

as you read

What You'll Learn

- Identify the characteristics of birds.
- Identify the adaptations birds have for flight.
- Explain how birds reproduce and develop.

Why It's Important

Most birds demonstrate structural and behavioral adaptations for flight.

Q Review Vocabulary

thrust: for an object moving through air, the horizontal force that pushes or pulls the object forward

New Vocabulary

- contour feather
- endothermpreening
- down feather

Figure 1 This robin's round nest is built of grasses and mud in a tree.

Amniotic fluid Yolk sac Shell Embryo

Bird Characteristics

Birds are versatile animals. Geese have been observed flying at an altitude of 9,000 m, and penguins have been seen underwater at a depth of 543 m. An ostrich might weigh 155,000 g, while a hummingbird might weigh only 2 g. Some birds can live in the tropics and others can live in polar regions. Their diets vary and include meat, fish, insects, fruit, seeds, and nectar. Birds have feathers and scales and they lay eggs. Which of these characteristics is unique to birds?

Bird Eggs Birds lay amniotic (am nee AH tihk) eggs with hard shells, as shown in **Figure 1.** This type of egg provides a moist, protective environment for the developing embryo. The hard shell is made of calcium carbonate, the same chemical that makes up seashells, limestone, and marble. The egg is fertilized internally before the shell forms around it. The female bird lays one or more eggs usually in some type of nest, also shown in **Figure 1.** A group of eggs is called a clutch. One or both parents may keep the eggs warm, or incubate them, until they hatch. The length of time for incubation varies from species to species. The young are cared for by one or both parents.





Flight Adaptations People have always been fascinated by the ability of birds to fly. Flight in birds is made possible by their almost hollow but strong skeleton, wings, feathers, strong flight muscles, and an efficient respiratory system. Well-developed senses, especially eyesight, and tremendous amounts of energy also are needed for flight.

Hollow Bones One adaptation that birds have for flight is a unique internal skeleton, as shown in **Figure 2.** Many bones of some birds are joined together. This provides more strength and more stability for flight. Most bones of birds that fly are almost hollow. These bones have thin cross braces inside that also strengthen the bones. The hollow spaces inside of the bones are filled with air.

Reading Check What features strengthen a bird's bones?

A large sternum, or breastbone, supports the powerful chest muscles needed for flight. The last bones of the spine support the tail feathers, which play an important part in steering and balancing during flight and landing.



Star Navigation Many theories have been proposed about how birds navigate at night. Some scientists hypothesize that star positions help night-flying birds find their way. Research the location of the North Star. In your Science Journal, infer how the North Star might help birds fly at night.





Modeling Feather Function

Procedure 🔊 🌱

- Wrap polyester fiber or cotton around the bulb of an alcohol thermometer. Place it into a plastic bag. Record its temperature in your Science Journal.
- Place a second alcohol thermometer into a plastic bag and record its temperature.
- Simultaneously submerge the thermometers into a container of cold water, keeping the top of each bag above the water's surface.
- **4.** After 2 min, record the temperature of each thermometer.

Analysis

- 1. Which thermometer had the greater change in temperature?
- 2. Infer the type of feather that the fiber or cotton models.

Feathers Birds are the only animals that have feathers. Their bodies are covered with two main types of feathers—contour feathers and down feathers. Strong, lightweight **contour feathers** give a bird its coloring and smooth shape. These are also the feathers that a bird uses when flying. The contour feathers on the wings and tail help the bird steer and keep it from spinning out of control.

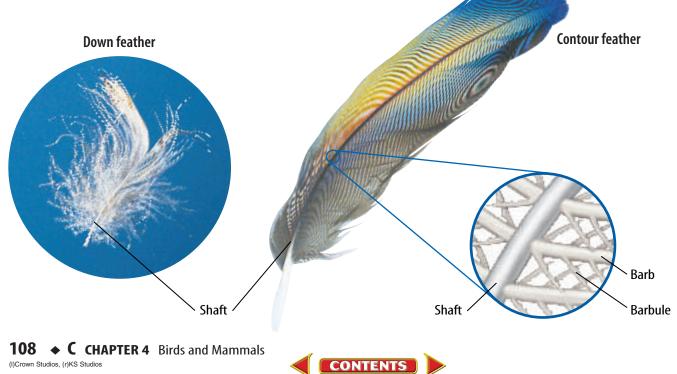
Have you ever wondered how ducks can swim in a pond on a freezing cold day and keep warm? Soft, fluffy **down feathers** provide an insulating layer next to the skin of adult birds and cover the bodies of young birds. Birds are **endotherms**, meaning they maintain a constant body temperature. Feathers help birds maintain their body temperature, and grow in much the same way as your hair grows. Each feather grows from a microscopic pit in the skin called a follicle (FAH lih kul). When a feather falls out, a new one grows in its place. As shown in **Figure 3**, the shaft of a feather has many branches called barbs. Each barb has many branches called barbules that give the feather strength.

Reading Check Why are some young birds covered with down feathers?

A bird has an oil gland located just above the base of its tail. Using its bill or beak, a bird rubs oil from the gland over its feathers in a process called **preening**. The oil conditions the feathers and helps them last longer.

Figure 3 Down feathers help

keep birds warm. Contour feathers are the feathers used for flight, and the feathers that cover the body.









Bald eagles are able to soar for long periods of time because their wings have a large surface area to provide lift.

This glider gets lift from its wings the same way a bald eagle gets lift.

Wings Although not all birds fly, most wings are adapted for flight. Wings are attached to powerful chest muscles. By flapping its wings, a bird attains thrust to go forward and lift to stay in the air. Its wings move up and down, as well as back and forth.

The shape of a bird's wings helps it fly. The wings are curved on top and flat or slightly curved on the bottom. Humans copied this shape to make airplane wings, as shown in **Figure 4**. When a bird flies, air moves more slowly across the bottom than across the top of its wings. Slow-moving air has greater pressure than fast-moving air, resulting in an upward push called lift. The amount of lift depends on the total surface area of the wing, the speed at which air moves over the wing, and the angle of the wing to the moving air. Once birds with large wings, such as vultures, reach high altitudes, they can soar and glide for a long time without having to beat their wings.

Wings also serve important functions for birds that don't fly. Penguins are birds that use their wings to swim underwater. Ostriches use their wings in courtship and to maintain their balance while running or walking.



Bird Pests Some birds have become pests in urban areas. Research to learn what birds are considered pests in urban areas, what effect they have on the urban environment, and what measures are taken to reduce the problems they create. Build a bulletin board showing your results.

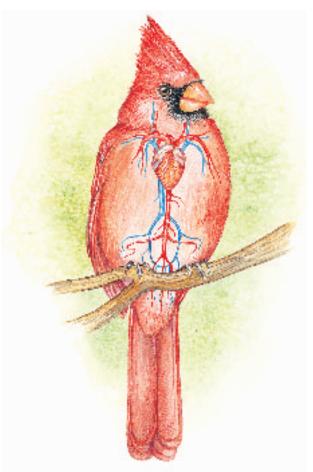




Topic: Homing Pigeons Visit bookc.msscience.com for Web links to information about homing pigeons.

Activity Name two past uses for homing pigeons, and write an advertisement for a new use in the future.

Figure 5 A bird's blood is circulated quickly so enough oxygen-filled blood is carried to the bird's muscles.



Body Systems

Whether they fly, swim, or run, most birds are extremely active. Their body systems are adapted for these activities.

Digestive System Because flying uses large amounts of energy, birds need large amounts of high energy foods, such as nuts, seeds, nectar, insects, and meat. Food is broken down quickly in the digestive system to supply this energy. In some birds, digestion can take less than an hour—for humans digestion can take more than a day.

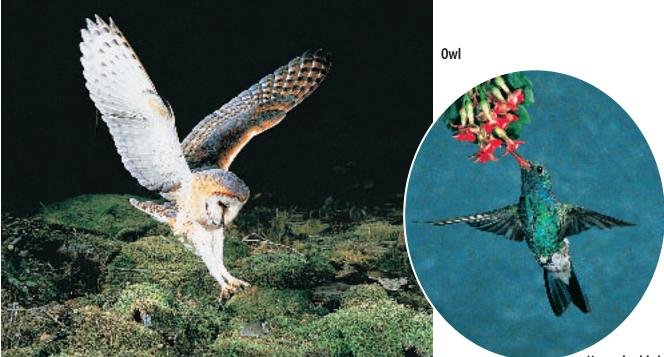
From a bird's mouth, unchewed food passes into a digestive organ called the crop. The crop stores the food until it absorbs enough moisture to move on. The food enters the stomach where it is partially digested before it moves into the muscular gizzard. In the gizzard, food is ground and crushed by small stones and grit that the bird has swallowed. Digestion is completed in the intestine, and then the food's nutrients move into the bloodstream.

Respiratory System Body heat is generated when energy in food is combined with oxygen. A bird's respiratory system efficiently obtains oxygen, which is needed to power flight muscles

and to convert food into energy. Birds have two lungs. Each lung is connected to balloonlike air sacs that reach into different parts of the body, including some of the bones. Most of the air inhaled by a bird passes into the air sacs behind the lungs. When a bird exhales, air with oxygen passes from these air sacs into the lungs. Air flows in only one direction through a bird's lungs. Unlike other vertebrates, birds receive air with oxygen when they inhale and when they exhale. This provides a constant supply of oxygen for the flight muscles.

Circulatory System A bird's circulatory system consists of a heart, arteries, capillaries, and veins, as shown in **Figure 5.** Their four-chambered heart is large compared to their body. On average, a sparrow's heart is 1.68 percent of its body weight. The average human heart is only 0.42 percent of the human's body weight. Oxygen-filled blood is kept separate from carbon dioxide-filled blood as both move through a bird's heart and blood vessels. A bird's heart beats rapidly—an active hummingbird's heart can beat more than 1,000 times per minute.





Hummingbird

The Importance of Birds

Birds play important roles in nature. Some are sources of food and raw materials, and others are kept as pets. Some birds, like the owl in **Figure 6**, help control pests, such as destructive rodents. Barn swallows and other birds help keep insect populations in check by eating them. Some birds, like the hummingbird in **Figure 6**, are pollinators for many flowers. As they feed on the flower's nectar, pollen collects on their feathers and is deposited on the next flower they visit. Other birds eat fruits, then their seeds are dispersed in the birds' droppings. Seed-eating birds help control weeds. Birds can be considered pests when their populations grow too large. In cities where large numbers of birds roost, their droppings can damage buildings. Some droppings also can contain microorganisms that can cause diseases in humans.

Uses of Birds Humans have hunted birds for food and fancy feathers for centuries. Eventually, wild birds such as chickens and turkeys were domesticated and their meat and eggs became a valuable part of human diets. Feathers are used in mattresses and pillows because of their softness and ability to be fluffed over and over. Down feathers are good insulators. Even bird droppings, called guano (GWAH noh), are collected from seabird colonies and used as fertilizer.

Parakeets, parrots, and canaries often are kept as pets because many sing or can be taught to imitate sounds and human voices. Most birds sold as pets are bred in captivity, but some wild birds still are collected illegally, which threatens many species.

CONTENTS

Figure 6 In nature, some birds, like the owl on the left, help control pests. Others, like the hummingbird above, pollinate flowers. **Identify** other important uses of birds.

NATIONAL GEOGRAPHIC VISUALIZING BIRDS

Figure 7

here are almost 9,000 living species of birds. Birds are subdivided into smaller groups based on characteristics such as beak size and shape, foot structure, and diet. Birds belonging to several groups are shown here.



BIRDS OF PREY This osprey has large claws that grasp and a sharp beak that tears flesh.

INSECT EATERS

This nuthatch has a pointed beak that can pry up bark or bore into wood to find insects.

WATERBIRDS Wood ducks have webbed feet that propel them through the water.

FLIGHTLESS BIRDS

The ostrich evolved in places where there were once few mammal predators. Though they cannot fly, some flightless birds are fast runners.

> WADING BIRDS The great blue heron's long legs allow it to

walk in shallow

water.









SEED EATERS This cardinal's thick, strong beak can crack seeds.

112 • C CHAPTER 4 Birds and Mammals

Origin of Birds Birds, like those in **Figure 7**, have some characteristics of reptiles, including scales on their feet and legs. Scientists learn about the origins of most living things by studying their fossils; however, few fossils of birds have been found. Some scientists hypothesize that birds developed from reptiles millions of years ago.



Figure 8 The first

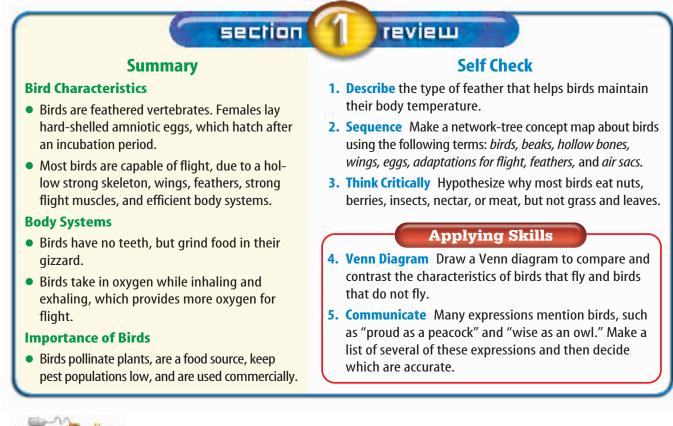
Archaeopteryx fossil was found more than 100 years ago. Archaeopteryx, to the left, is considered a link between reptiles and birds. Protoavis, below, may be an ancestor of birds.



Archaeopteryx (ar kee AHP tuh rihks)—a birdlike fossil—is about 150 million years old. Although it is not known that *Archaeopteryx* was a direct ancestor of modern birds, evidence shows that it had feathers and wings similar to modern birds. However, it had solid bones, teeth, a long bony tail, and clawed front toes, like some reptiles.

In 1991 in Texas, scientists discovered a fossil that had hollow bones and a well-developed sternum with a keel. *Protoavis* (proh toh AY vihs) lived about 225 million years ago. No fossil feathers were found with *Protoavis*. Scientists do not know if it was an ancestor of modern birds or a type of ground-living dinosaur. **Figure 8** shows an artist's idea of what *Archaeopteryx* and *Protoavis* may have looked like.

DIDE bookc.msscience.com/self_check_quiz



CONTENTS

section

Mammals

as you read

What You'll Learn

- Identify the characteristics of mammals and explain how they have enabled mammals to adapt to different environments.
- Distinguish among monotremes, marsupials, and placentals.
- Explain why many species of mammals are becoming threatened or endangered.

Why It's Important

Mammals, including humans, have many characteristics in common.

Q Review Vocabulary

gland: a cell or group of cells that releases fluid

New Vocabulary

- mammalmammary
- gland
- omnivore
- carnivore
- herbivore
- monotreme
- periodplacentaumbilical

marsupial

placental

gestation

cord

Figure 9 Mammals, such as this moose, care for their young after they are born. **Explain** how mammals feed their young.

Characteristics of Mammals

You probably can name dozens of mammals, but can you list a few of their common characteristics? **Mammals** are endothermic vertebrates that have hair and produce milk to feed their young, as shown in **Figure 9.** Like birds, mammals care for their young. Mammals can be found almost everywhere on Earth. Each mammal species is adapted to its unique way of life.

Skin and Glands Skin covers and protects the bodies of all mammals. A mammal's skin is an organ that produces hair and in some species, horns, claws, nails, or hooves. The skin also contains different kinds of glands. One type of gland found in all mammals is the mammary gland. Female mammals have **mammary glands** that produce milk for feeding their young. Oil glands produce oil that lubricates and conditions the hair and skin. Sweat glands in some species remove wastes and help keep them cool. Many mammals have scent glands that secrete substances that can mark their territory, attract a mate, or be a form of defense.



CONTENTS

Figure 10 Mammals have teeth that are shaped specifically for the food they eat. Bears have incisors to cut vegetation, canines to tear meat, and large, flat molars to crush and chew food.



A tiger easily can tear away the flesh of an animal because of large, sharp canine teeth and strong jaw muscles.



A horse's back teeth, called molars, are large. **Infer** how a horse chews.



Teeth Notice that each mammal in **Figure 10** has different kinds of teeth. Almost all mammals have specialized teeth. Scientists can determine a mammal's diet by examining its teeth. Front teeth, called incisors, bite and cut. Sometimes the teeth next to the incisors, called canine teeth, are well developed to grip and tear. Premolars and molars at the back of the mouth shred, grind, and crush. Animals, like the bear in **Figure 10**, and humans, have all four kinds of teeth. They eat plants and other animals, so they are called **omnivores**. A **carnivore**, like the tiger in **Figure 10**, has large canine teeth and eats only the flesh of other animals. **Herbivores**, such as the horse in **Figure 10**, eat only plants. Their large premolars and molars grind the tough fibers in plants.



Inferring How Blubber Insulates Procedure

- 1. Fill a self-sealing plastic bag about one-third full with vegetable shortening.
- 2. Turn another self-sealing plastic bag inside out. Carefully place it inside the bag with the shortening so that you are able to seal one bag to the other. This is a blubber mitten.
- 3. Put your hand in the blubber mitten and place it in ice water for 5 s. Remove the blubber mitten when finished.
- Put your bare hand in the same bowl of ice water for 5 s.

Analysis

- Which hand seemed colder?
- 2. Infer how a layer of blubber provides protection against cold water.

Figure 11 Herbivores, like this elk, have four-chambered stomachs and long intestinal tracts that contain microorganisms, which help break down the plant material.

Explain why herbivores need a longer digestive system than carnivores.

Hair All adult mammals have hair on their bodies. It may be thick fur that covers all or part of the animal's body, or just a few hairs around the mouth. Fur traps air and helps keep the animal warm. Whiskers located near the mouth help many mammals sense their environments. Whales have almost no hair. They rely on a thick layer of fat under their skin, called blubber, to keep them warm. Porcupine quills and hedgehog spines are modified hairs that offer protection from predators.

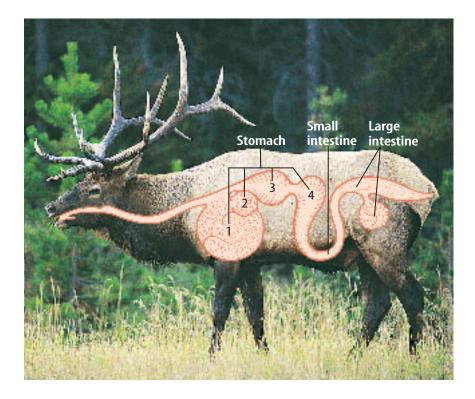
Body Systems

The body systems of mammals are adapted to their activities and enable them to survive in many environments.

Mammals have four-chambered hearts that pump oxygenfilled blood directly throughout the body in blood vessels. Mammals have lungs made of millions of microscopic sacs. These sacs increase the lungs' surface area, allowing a greater exchange of carbon dioxide and oxygen.

A mammal's nervous system consists of a brain, spinal cord, and nerves. In mammals, the part of the brain involved in learning, problem solving, and remembering is larger than in other animals. Another large part of the mammal brain controls its muscle coordination.

The digestive systems of mammals vary according to the kinds of food they eat. Herbivores, like the one shown in **Figure 11**, have long digestive tracts compared to carnivores because plants take longer to digest than meat.





Reproduction and Caring for Young All mammals reproduce sexually. Most mammals give birth to live young after a period of development inside the female reproductive organ called the uterus. Many mammals are nearly helpless, and sometimes even blind, when they are born. They can't care for themselves for the first several days or even years. If you've seen newborn kittens or human babies, you know they just eat, sleep, grow, and develop. However, the young of some mammals, such as antelope, deer, and elephants, are well developed at birth and are able to travel with their constantly moving parents. These young mammals usually can stand by the time they are a few minutes old. Marine mammals, such as the whales, shown in **Figure 12,** can swim as soon as they are born.

Reading Check *Is a house cat or a deer more developed at birth?*

During the time that young mammals are dependent on their female parent's milk, they learn many of the skills needed for their survival. Defensive skills are learned while playing with other young of their own kind. Other skills are learned by imitating adults. In many mammal species only females raise the young. Males of some species, such as wolves and humans, help provide shelter, food, and protection for their young.



Figure 12 When a whale is born, the female whale must quickly push the newborn whale to the water's surface to breathe. Otherwise, the newborn whale will drown.

Applying Science

Does a mammal's heart rate determine how long it will live?

Some mammals live long lives, but other mammals live for only a few years. Do you think that a mammal's life span might be related to how fast its heart beats? Use your ability to interpret a data table to answer this question.

Identifying the Problem

The table on the right lists the average heart rates and life spans of several different mammals. Heart rate is recorded as the number of heartbeats per minute, and life span is recorded as the average maximum years. When you examine the data, look for a relationship between the two variables.

Mammal Heart Rates and Life Spans		
Mammal	Heart Rate (beats/min)	Life Span (years)
Mouse	400	2
Large dog	80	15
Bear	40	15–20
Elephant	25	75

Solving the Problem

- **1.** Infer how heart rate and life span are related in mammals.
- 2. Humans have heart rates of about 70 beats per minute. Some humans may live for more than 100 years. Is this consistent with the data in the table? Explain.





Figure 13 A duck-billed platypus is a mammal, yet it lays eggs. **Explain** why the duck-billed platypus is classified as a mammal.

Figure 14 Opossums are the only marsupials found in North

Types of Mammals

Mammals are classified into three groups based on how their young develop. The three mammal groups are monotremes (MAH nuh treemz), marsupials (mar SEW pee ulz), and placentals (pluh SEN tulz).

Monotremes The duck-billed platypus, shown in Figure 13, is a monotreme. Monotremes are mammals that lay eggs with leathery shells. The female incubates the eggs for about ten days. After the young hatch, they nurse by licking the female's skin and hair where milk oozes from the mammary glands. Monotreme mammary glands do not have nipples.

Marsupials Many of the mammals that are classified as marsupials live in Australia, New Guinea, or South America. Only one type of marsupial, the opossum, lives in North America. Marsupials give birth to immature young that usually crawl into an external pouch on the female's abdomen. However, not all marsupials have pouches. Whether an immature marsupial is in a pouch or not, it instinctively crawls to a nipple. It stays attached to the nipple and feeds until it is developed. In pouched marsupials, the developed young return to the pouch for feeding and protection. Examples of marsupials are kangaroos and opossums, as shown in Figure 14, wallabies, koalas, bandicoots, and Tasmanian devils.



Placentals In **placentals**, embryos completely develop inside the female's uterus. The time during which the embryo develops in the uterus is called the **gestation period**. Gestation periods range from 16 days in hamsters to 650 days in elephants. Placentals are named for the **placenta**, an organ that develops from tissues of the embryo and tissues that line the inside of the uterus. The placenta absorbs oxygen and food from the mother's blood. An umbilical cord connects the embryo to the placenta, as shown in

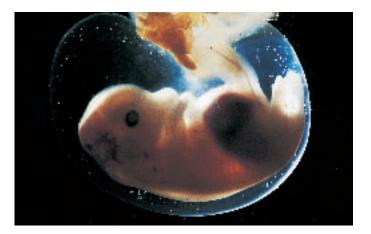
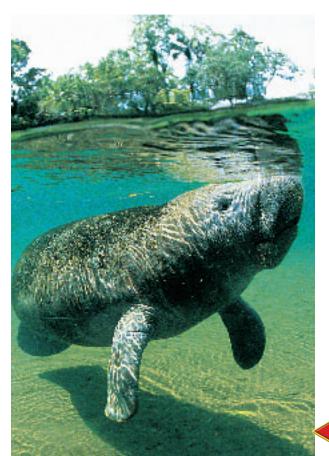


Figure 15. Several blood vessels make up the umbilical cord. Blood in the **umbilical cord** transports food and oxygen from the placenta to the embryo and removes waste products from the embryo. The female parent's blood doesn't mix with the embryo's blood. Examples of placentals are shown in **Table 1** on the following two pages.

W Reading Check How does an embryo receive the things it needs to grow?

Some placental groups include unusual animals such as the manatee shown in **Figure 16.** Dugongs and manatees are aquatic mammals. They have no back legs, and their front legs are modified into flippers. Another group includes small, rabbit-like animals called hyraxes that have hooves and molars for



grinding vegetation. The aardvark is the only member of its group. Aardvarks have tubelike teeth and dig termites for food. Many Southeast Asian islands are home to members of a group that includes gliding lemurs. Pangolins, another group of placentals, look like anteaters covered with scales. **Figure 15** An unborn mammal receives nutrients and oxygen through the umbilical cord. **Compare and contrast** *placen-tal, marsupial, and monotreme development.*



Visit bookc.msscience.com for Web links to recent news or magazine articles about manatees and their habitats.

Activity Create a pamphlet about the manatees' habitat, their threats, and what people can do to help them.

Figure 16 A manatee swims slowly below the surface of the water.

Table 1 Placental	S	
Order	Examples	Major Characteristics
Rodentia (roh DEN chuh)	beavers, mice, rats, squirrels	one pair of chisel-like front teeth adapted for gnawing; incisors grow throughout life; herbivores
Chiroptera (ki RAHP tuh ruh)	bats	front limbs adapted for flying; active at night; different species feed on fruit, insects, fish, or other bats
Insectivora (ihn sek TIH vuh ruh)	moles, shrews, hedgehogs	small; feed on insects, earthworms, and other small animals; most have long skulls and narrow snouts; high metabolic rate
Carnivora (kar NIH vuh ruh)	cats, dogs, bears, foxes, raccoons	long, sharp canine teeth for tearing flesh; most are predators, some are omnivores
Primates (PRI maytz)	apes, monkeys, humans	arms with grasping hands and opposable thumbs; eyes are forward facing; large brains; omnivores
Artiodactyla (ar tee oh DAHK tih luh)	deer, moose, pigs, camels, giraffes, cows	hooves with an even number of toes; most are herbivores with large, flat molars; complex stomachs and intestines

Order	Examples		Major Characteristics
Cetacea (sih TAY shuh)	whales, dolphins, porpoises		one or two blowholes on top of the head for breathing; forelimbs are modified into flippers; teeth or baleen
Lagomorpha (la guh MOR fuh)	rabbits, hares, pikas		some with long hind legs adapted for jumping and runr one pair of large, upper inciso one pair of small, peglike inci
Pinnipedia (pih nih PEE dee uh)	sea lions, seals, walruses		marine carnivores; limbs modified for swimming
Edentata (ee dehn TAH tuh)	anteaters, sloths, armadillos		eat insects and other small animals; most are toothless o have tiny, peglike teeth
Perissodactyla (puh ris oh DAHK tih luh)	horses, zebras, tapirs, rhinoceroses		hooves with an odd number of toes; skeletons adapted for running; herbivores with larg grinding molars
Proboscidea (proh boh SIH dee uh)	elephants	AN	a long nose called a trunk; herbivores; upper incisor teet grow to form tusks; thick, leathery skin

Figure 17 The *Dvinia* was an ancestor of ancient mammals.



Importance of Mammals

Mammals, like other organisms, are important in maintaining a balance in the environment. Carnivores, such as lions, help control populations of other animals. Bats help pollinate flowers and control insects. Other mammals pick up plant seeds in their fur and distribute them. However, mammals and other animals are in trouble today. As millions of wildlife habitats are destroyed for shopping centers, recreational areas, housing, and roads, many mammals are left without food, shelter, and space to survive. Because humans have the ability to reason, they have a responsibility to learn that their survival is related closely to the survival of all mammals. What can you do to protect the mammals in your community?

Origin of Mammals About 65 million years ago, dinosaurs and many other organisms became extinct. This opened up new

habitats for mammals, and they began to branch out into many different species. Some of these species gave rise to modern mammals. Today, more than 4,000 species of mammals have evolved from animals similar to the one in **Figure 17**, which lived about 200 million years ago.

review

Summary

section

Characteristics of Mammals

- Mammals have mammary glands, hair covering all or part of the body, and teeth specialized to the foods they eat.
- A mammal's body systems are well-adapted to the environment it lives in.

Types of Mammals

 There are three types of mammals: monotremes, which lay eggs; marsupials, which give birth to immature young that are nursed until developed, usually in a pouch; and placentals, which completely develop inside the female.

Importance of Mammals

 Mammals help maintain a balance in the environment. They are a food source, pollinators, and used commercially.

Self Check

- Describe five characteristics of mammals and explain how they allow mammals to survive in different environments.
- 2. Compare and contrast birds and mammals.
- **3. Describe** the differences between herbivores, carnivores, and omnivores.
- Classify the following animals into the three mammal groups: whales, koalas, horses, elephants, opossums, kangaroos, rabbits, bats, bears, platypuses, and monkeys.
- **5. Think Critically** How have humans contributed to the decrease in many wildlife populations?

Applying Math

6. Solve One-Step Equations The tallest land mammal is the giraffe at 5.6 m. Calculate your height in meters, and determine how many of you it would take to be as tall as the giraffe.

Intelligence bookc.msscience.com/self_check_quiz

Mammal F^{*}tprints

Have you ever seen an animal footprint in the snow or soft soil? In this lab, you will observe pictures of mammal footprints and identify the mammal that made the footprint.

Real-World Question

How do mammal footprints differ?

Goals

- **Identify** mammal footprints.
- Predict where mammals live based on their footprints.

Materials

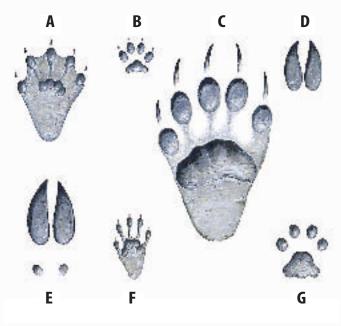
diagram of footprints

Procedure

1. Copy the following data table in your Science Journal.

Identifying Mammal Footprints		
Animal	Letter of Footprint	Traits of Footprint
Bear		
Beaver		
Cougar	Do not write	in this book.
Coyote		
Deer		
Moose		
Raccoon		

- **2.** Compare and contrast the different mammal footprints in the above diagram.
- **3.** Based on your observations, match each footprint to an animal listed in the first column of the data table.



4. Write your answers in the column labeled *Letter of Footprint.* Complete the data table.

Conclude and Apply

- 1. Which mammals have hoofed feet?
- 2. Which mammals have clawed toes?
- 3. Which mammals have webbed feet?
- **4. Explain** how the different feet are adapted to the areas in which these different mammals live.
- 5. What are the differences between track B and track E? How does that help you identify the track?



Compare your conclusions with those of other students in your class. For more help, refer to the Science Skill Handbook.



Use the Internet

Bidd Counts

Goals

- Research how to build a bird feeder and attract birds to it.
- Observe the types of birds that visit your feeder.
- Identify the types of birds that you observe at your bird feeder.
- Graph your results and then communicate them to other students.

Data Source



Visit bookc.msscience.com/ internet_lab for Web links to more information about how to build a bird feeder, hints on bird-watching, and data from other students who do this lab.

Safety Precautions

Real-World Question

What is the most common bird in your neighborhood? Think about the types of birds that you observe around your neighborhood. What types of food do they eat? Do all birds come to a bird feeder? Form a hypothesis about the type of bird that you think you will see most often at your bird feeder.

🧔 Make a Plan —

- **1. Research** general information about how to attract and identify birds. Determine where you will make your observations.
- 2. Search reference sources to find out how to build a bird feeder. Do all birds eat the same types of seeds?
- **3. Select** the type of feeder you will build and the seed you will use based on your research.
- 4. What variables can you control in this lab? Do seasonal changes, length of time, or weather conditions affect your observations?
- 5. What will you do to identify the birds that you do not know?

🧔 Follow Your Plan -

1. Make sure your teacher approves your plan before you start.

Cardinal

2. Record your data in your Science Journal each time you make an observation of the birds at your bird feeder.

American Goldfinch

Using Scientific Methods

Black-capped Chickadee

🧔 Analyze Your Data

- **1. Write** a description of where you placed your feeder and when you made your bird observations.
- 2. **Record** the total number of birds you observed each day.
- **3. Record** the total number of each type of bird species you observed each day.
- **4. Graph** your data using a line graph, a circle graph, or a bar graph.

Conclude and Apply

- 1. Interpret Data What type of bird was most common to your feeder?
- 2. Explain if all of your classmates' data agree with yours. Why or why not?
- **3. Review** your classmates' data and determine if the location of bird observations affected the number of birds observed.
- **4. Infer** if the time of day affected the number of birds observed. Explain.
- **5. Infer** Many birds eat great numbers of insects. What might humans do to maintain a healthy environment for birds?



Birds at a feeder



Find this lab using the link below. Post your data in the table provided. **Compare** your data to those of other students. Combine your data with those of other students and plot the combined data on a map to recognize patterns in bird populations.

Science IIINO bookc.msscience.com/internet_lab



SCIENCE Stats

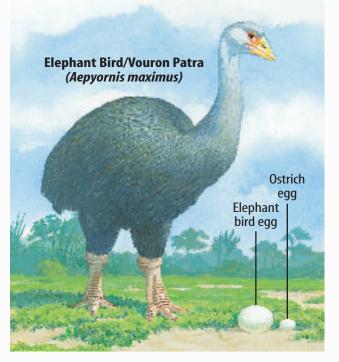
Eggciting Facts

Did you know...

...The ostrich lays the biggest egg of all birds now living. Its egg is 15 cm to 20 cm long and 10 cm to 15 cm wide. The volume of the ostrich egg is about equal to 24 chicken eggs. It can have a mass from approximately 1 kg to a little more than 2 kg. The shell of an ostrich egg is 1.5 mm thick and can support the weight of an adult human.

...The bird that lays the

smallest egg is the hummingbird. Hummingbird eggs are typically 1.3 cm long and 0.8 cm wide. The smallest hummingbird egg on record was less than 1 cm long and weighed 0.36 g.







Ostrich egg

...The elephant bird, extinct within the last 1,000 years, laid an egg that was seven times larger than an ostrich egg. These eggs weighed about 12 kg. They were 30 cm long and could hold up to 8.5 L of liquid. It could hold the equivalent of 12,000 hummingbird eggs.

Applying Math How many elephant bird eggs would it take to equal a dog weighing 48 kg?

Graph It

Go to bookc.msscience.com/science_stats and research the egg length of an American robin, a house sparrow, a bald eagle, and a Canada goose. Make a bar graph of this information.

CONTENTS

Reviewing Main Ideas

chapter

Section 1 Birds

- **1.** Birds are endothermic animals that are covered with feathers and lay eggs.
- 2. Adaptations that enable most birds to fly include wings; feathers; a strong, light-weight skeleton; and efficient body systems.
- **3.** Birds lay eggs enclosed in hard shells. All birds' eggs are incubated until they hatch.

Section 2

📕 Mammals

1. Mammals are endothermic animals with fur or hair.

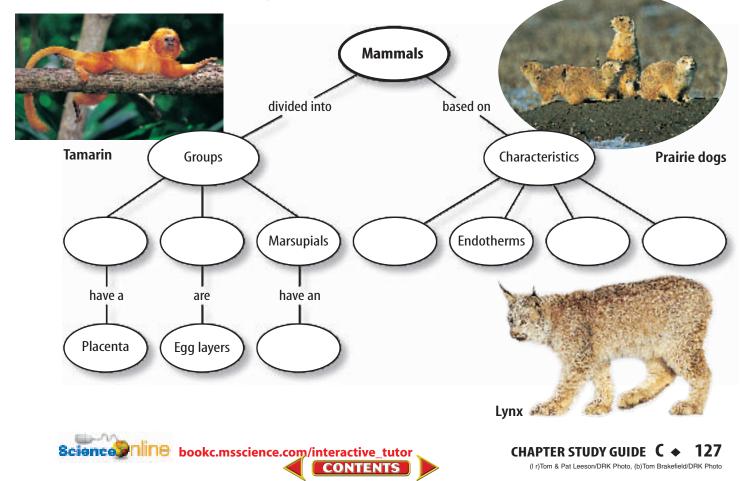
2. Mammary glands of female mammals can produce milk.

Study Guide

- **3.** Mammals have teeth that are specialized for eating certain foods. Herbivores eat plants, carnivores eat meat, and omnivores eat plants and meat.
- 4. There are three groups of mammals. Monotremes lay eggs. Most marsupials have pouches for the development of their young. Placental offspring develop within a uterus and are nourished through a placenta.
- **5.** Mammals are important in maintaining balance in the environment.

Visualizing Main Ideas

Copy and complete the following concept map on mammals.



Review

Using Vocabulary

carnivore p. 115 contour feather p. 108 down feather p. 108 endotherm p. 108 gestation period p. 119 herbivore p. 115 mammal p.114 mammary gland p. 114 marsupial p. 118 monotreme p. 118 omnivore p. 115 placenta p. 119 placental p. 119 preening p. 108 umbilical cord p. 119

Explain the difference between the vocabulary words in each of the following sets.

- 1. omnivore—carnivore—herbivore
- **2.** contour feather—down feather
- 3. monotreme—marsupial
- 4. placenta—umbilical cord
- 5. endotherm—mammal
- 6. placental—monotreme
- 7. mammary gland—mammal
- 8. mammal—omnivore
- 9. endotherm—down feather
- **10.** preening—down feather

Checking Concepts

Choose the word or phrase that best answers the question.

- **11.** Which of the following birds has feet adapted for moving on water?
 - A) duck **C)** owl
 - **B)** oriole **D)** rhea
- **12.** Birds do NOT use their wings for which of the following activities?
 - **A)** flying **C)** balancing
 - **B)** swimming **D**) eating
- **13.** Which of these mammals lay eggs?
 - A) carnivores **C)** monotremes
 - **B)** marsupials **D)** placentals

- **14.** Birds use which of the following organs to crush and grind their food?
 - A) crop **C)** gizzard
 - **D)** small intestine **B)** stomach
- **15.** Which of the following mammals is classified as a marsupial?
 - A) cat **C)** kangaroo **B)** human
 - **D)** camel

Use the photo below to answer question 16.



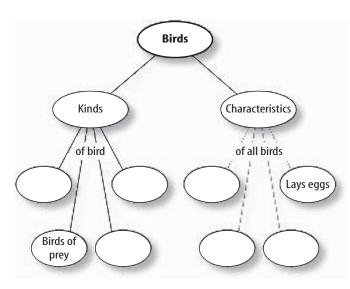
- **16.** What are mammals with pouches, like the koala pictured above, called?
 - A) marsupials **C)** placentals
 - **D)** chiropterans **B)** monotremes
- **17.** Which of the following have mammary glands without nipples?
 - A) marsupials **C)** monotremes
 - **B)** placentals **D)** omnivores
- **18.** Teeth that are used for tearing food are called what?
 - A) canines **C)** molars
 - **B)** incisors **D**) premolars
- 19. Bird eggs do NOT have which of the following structures?
 - A) hard shells **C)** placentas
 - **D)** membranes **B)** yolks
- **20.** Which of the following animals eat only plant materials?
 - A) carnivores **C)** omnivores
 - **B)** herbivores **D)** endotherms

Hans & Judy Beste/Animals Animals

bookc.msscience.com/vocabulary_puzzlemaker CONTENTS

Thinking Critically

- **21.** Compare and contrast bird and mammal reproduction.
- **22.** Classify You are a paleontologist studying fossils. One fossil appears to have hollow bones, a keeled breastbone, and a short, bony tail. How would you classify it?
- **23.** Explain which type of bird, a duck or an ostrich, would have lighter bones.
- **24.** List the features of birds that allow them to be fully adapted to life on land.
- **25.** Concept Map Copy and complete this concept map about birds.



- **26.** Describe A mammal's teeth are similar in size and include all four types of teeth. What kind of mammal has teeth like this?
- **27.** Classify You discover three new species of placentals, with the following traits. Using **Table 1** in this chapter, place each placental into the correct order.

Placental 1 swims and eats meat.

Placental 2 flies and eats fruit.

Placental 3 runs on four legs and hunts.

Science IIINE bookc.msscience.com/chapter_review

CONTENTS

28. Classify Group the following mammals as herbivore, carnivore, or omnivore: bear, tiger, opossum, raccoon, mouse, rabbit, seal, and ape.

Review

29. Compare and contrast the teeth of herbivores, carnivores, and omnivores. How are their types of teeth adapted to their diets?

Performance Activities

30. Song with Lyrics Create a song about bird adaptations for flight by changing the words to a song that you know. Include in your song as many adaptations as possible.

Applying Math

Use the graph below to answer questions 31 and 32.

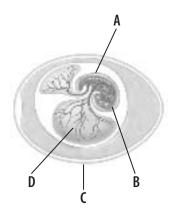
Record of Canada Geese		
Year	Number of Geese	
1996	550	
1997	600	
1998	575	
1999	750	
2000	825	

- **31.** Number of Geese This table is a record of the approximate number of Canada geese that wintered at a midwestern wetland area over a fiveyear time period. Construct a line graph from these data.
- **32.** Population Increase What percent increase occurred in the Canada goose population between 1996 and 2000? What percent increase occurred each year?

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer questions 1–2.



- Which letter represents amniotic fluid?
 A. A
 C. C
 B. B
 D. D
- 2. Which letter represents a developing embryo?

A. A	C. C
B. B	D. D

- **3.** Which of the following features is an adaptation that allows birds to fly?
 - **A.** a gizzard
 - **B.** bones that are almost hollow
 - **C.** a crop
 - **D.** a four-chambered heart
- 4. Which of the following is a monotreme?
 - A. a penguin C. a kangaroo
 - **B.** an eagle **D.** a platypus
- **5.** What is a characteristic that sets mammals apart from birds?
 - **A.** They help pollinate flowers.
 - **B.** They have a four-chambered heart.
 - **c.** They have special glands that produce milk for feeding their young.
 - **D.** They have a special skeleton that is light-weight but strong.

Use the illustration below to answer questions 6–7.



- 6. What part of the mammal's body is indicated by 1–4 in the diagram?
 - A. small intestine C. stomach
 - **B.** large intestine **D.** gizzard
- **7.** Which animals have this type of digestive system?
 - A. carnivorous birds
 - **B.** carnivorous mammals
 - **c.** herbivorous mammals
 - **D.** birds that eat only nuts and seeds
- 8. What is the significance of Archaeopteryx?
 - **A.** It was the first birdlike fossil found.
 - **B.** It represents the direct ancestor of birds.
 - **c.** It was probably a ground-living dinosaur with wings.
 - **D.** It is the oldest birdlike fossil.
- **9.** What is the unique characteristic of a marsupial?
 - **A.** They all live in Australia.
 - **B.** Their young develop in a pouch.
 - **c.** They lay eggs.
 - **D.** They provide milk for their young.



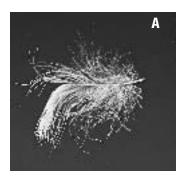
Standardized Test Practice

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- **10.** What are two examples of body features that enable birds to fly?
- **11.** What does it mean if an animal is an endotherm?

Use the photos below to answer questions 12 and 13.





- **12.** What is the purpose of feather B?
- **13.** What is the purpose of feather A?
- 14. In a bird's digestive system, what purpose do the crop and gizzard serve?
- **15.** What adaptation in birds provides a constant supply of oxygen for the flight muscles?
- **16.** Give two examples of special structures produced by the skin of mammals.
- **17.** Give the names of the three groups of mammals based on how their young develop. Give an example of each one.

Test-Taking Tip

Essay Organization For essay questions, spend a few minutes listing and organizing the main points that you plan to discuss. Make sure to do all of this work on your scratch paper, not on the answer sheet.

Question 18 List the characteristics that you want to discuss in one column, and the advantage in flight in another column.

line bookc.msscience.com/standardized_test

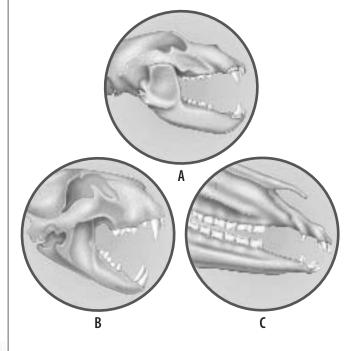
CONTENTS

Part 3 Open Ended

Record your answers on a sheet of paper.

- **18.** Describe the physical characteristics of birds' bones that make flight possible.
- **19.** Compare the barbs of a contour feather with those of a down feather.
- **20.** Describe the function of wings in flightless birds such as penguins and ostriches.
- **21.** Explain how feathers help a bird fly.

Use the illustration below to answer questions 22 and 23.



- **22.** How can you tell that diagram C does NOT represent a carnivore? What can you tell about the diet of the animal that would have the type of teeth shown in diagram C?
- **23.** What can you say about the diets of the animals represented by the teeth shown in diagrams A and B?

STANDARDIZED TEST PRACTICE **C** ◆ (I)Crown Studios, (r)KS Studios

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Animal Behavior

chapter preview

sections

- 1 Types of Behavior
- 2 Behavioral Interactions Lab Observing Earthworm Behavior Lab Animal Habitats
 - Virtual Lab How do mealworms behave in response to various stimuli?

Why do animals fight?

Animals often defend territories from other members of the same species. Fighting is usually a last resort to protect a territory that contains food, shelter, and potential mates.

Science Journal What other behaviors might an animal use to signal that a territory is occupied?

CONTENTS

Start-Up Activities



How do animals communicate?

One way humans communicate is by speaking. Other animals communicate without the use of sound. For example, a gull chick pecks at its parent's beak to get food. Try the lab below to see if you can communicate without speaking.

- **1.** Form groups of students. One at a time, have each student choose an object and describe that object using gestures.
- 2. The other students observe and try to identify the object that is being described.
- **3. Think Critically** In your Science Journal, describe how you and the other students were able to communicate without speaking to one another.



Preview this chapter's content and activities at bookc.msscience.com

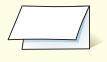
FOLDABLES

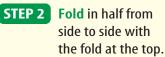
Study Organizer

Behavior As you study behaviors, make the following Foldable to help you find the

similarities and differences between the behaviors of two animals.

- **STEP 1** Fold a vertical sheet of paper in half from top to bottom.







STEP 3 **Unfold** the paper once. Cut only the fold of the top flap to make two tabs.

STEP 4

Turn the paper vertically and label the front tabs as shown.



Read and Write Before you read the chapter, choose two animals to compare. As you read the chapter, list the behaviors you learn about Animal 1 and Animal 2 under the appropriate tab.



Types of Behavior

as you read

What You'll Learn

- Identify the differences between innate and learned behavior.
- Explain how reflexes and instincts help organisms survive.
- Identify examples of imprinting and conditioning.

Why It's Important

Innate behavior helps you survive on your own.

Review Vocabulary salivate: to secrete saliva in

anticipation of food

New Vocabulary

- behavior
- innate behavior

reflex

- instinctimprinting
- conditioning
- insight

Behavior

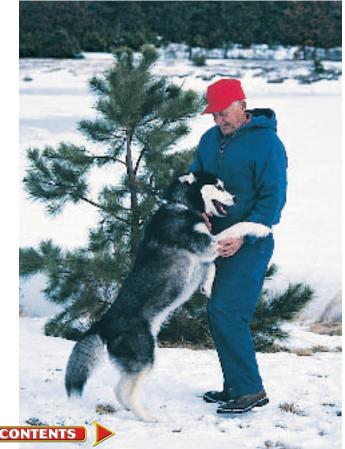
When you come home from school, does your dog run to meet you? Your dog barks and wags its tail as you scratch behind its ears. Sitting at your feet, it watches every move you make. Why do dogs do these things? In nature, dogs are pack animals that generally follow a leader. They have been living with people for about 12,000 years. Domesticated dogs treat people as part of their own pack, as shown in **Figure 1**.

Animals are different from one another in their behavior. They are born with certain behaviors, and they learn others. **Behavior** is the way an organism interacts with other organisms and its environment. Anything in the environment that causes a reaction is called a stimulus. A stimulus can be external, such as a rival male entering another male's territory; or internal, such as hunger or thirst. You are the stimulus that causes your dog to bark and wag its tail. Your dog's reaction to you is a response.

Figure 1 Dogs are pack animals by nature. A pack of wild dogs must work together to survive. This domesticated dog (right) has accepted a human as its leader.



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Hummingbirds build delicate cup-shaped nests on branches of trees.

Innate Behavior

A behavior that an organism is born with is called an **innate behavior**. These types of behaviors are inherited. They don't have to be learned.

Innate behavior patterns occur the first time an animal responds to a particular internal or external stimulus. For birds like the swallows and the hummingbird in **Figure 2** building a nest is innate behavior. When it's time for the female weaverbird to lay eggs, the male weaverbird builds an elaborate nest, also shown in **Figure 2**. Although a young male's first attempt may be messy, the nest is constructed correctly.

The behavior of animals that have short life spans is mostly innate behavior. Most insects do not learn from their parents. In many cases, the parents have died or moved on by the time the young hatch. Yet every insect reacts innately to its environment. A moth will fly toward a light, and a cockroach will run away from it. They don't learn this behavior. Innate behavior allows animals to respond instantly. This quick response often means the difference between life and death.

Reflexes The simplest innate behaviors are reflex actions. A **reflex** is an automatic response that does not involve a message from the brain. Sneezing, shivering, yawning, jerking your hand away from a hot surface, and blinking your eyes when something is thrown toward you are all reflex actions.

In humans a reflex message passes almost instantly from a sense organ along the nerve to the spinal cord and back to the muscles. The message does not go to the brain. You are aware of the reaction only after it has happened. Your body reacts on its own. A reflex is not the result of conscious thinking.

CONTENTS **



Figure 2 Bird nests come in different sizes and shapes. This male weaverbird is knotting the ends of leaves together to secure the nest.



Reflex A tap on a tendon in your knee causes your leg to straighten. This is known as the knee-jerk reflex. Abnormalities in this reflex tell doctors of a possible problem in the central nervous system. Research other types of reflexes and write a report about them in your Science Journal.



Figure 3 Spiders, like this orb weaver spider, know how to spin webs as soon as they hatch.

Figure 4 As they grow older, these quail chicks will learn which organisms to avoid. **Describe** why it is important for young quail to react the same toward all organisms. **Instincts** An **instinct** is a complex pattern of innate behavior. Spinning a web like the one in **Figure 3** is complicated, yet spiders spin webs correctly on the first try. Unlike reflexes, instinctive behaviors can take weeks to complete. Instinctive behavior begins when the animal recognizes a stimulus and continues until all parts of the behavior have been performed.

Reading Check What is the difference between a reflex and an instinct?

Learned Behavior

All animals have innate and learned behaviors. Learned behavior develops during an animal's lifetime. Animals with more complex brains exhibit more behaviors that are the result of learning. However, the

behavior of insects, spiders, and other arthropods is mostly instinctive behavior. Fish, reptiles, amphibians, birds, and mammals all learn. Learning is the result of experience or practice.

Learning is important for animals because it allows them to respond to changing situations. In changing environments, animals that have the ability to learn a new behavior are more likely to survive. This is especially important for animals with long life spans. The longer an animal lives, the more likely it is that the environment in which it lives will change.

Learning also can modify instincts. For example, grouse and quail chicks, shown in **Figure 4**, leave their nests the day they hatch. They can run and find food, but they can't fly. When something moves above them, they instantly crouch and keep perfectly still until the danger has passed. They will crouch without moving even if the falling object is only a leaf. Older birds have learned that leaves will not harm them, but they freeze when a hawk moves overhead.





Imprinting Learned behavior includes imprinting, trial and error, conditioning, and insight. Have you ever seen young ducks following their mother? This is an important behavior because the adult bird has had more experience in finding food, escaping predators, and getting along in the world. **Imprinting** occurs when an animal forms a social attachment, like the condor in **Figure 5**, to another organism within a specific time period after birth or hatching.

Konrad Lorenz, an Austrian naturalist, developed the concept of imprinting. Working with geese, he discovered that a gosling follows the first moving object it sees after hatching. The moving object, whatever it is, is imprinted as its parent. This behavior works well when the first moving object a gosling sees is an adult female goose. But goslings hatched in an incubator might see a human first and become imprinted on that human. Animals that become imprinted toward animals of another species have difficulty recognizing members of their own species.

Trial and Error Can you remember when you learned to ride a bicycle? You probably fell many times before you learned how to balance on the bicycle. After a while you could ride without having to think about it. You have many skills that you learned through trial and error, such as feeding yourself and tying your shoes, as shown in **Figure 6.**

Behavior that is modified by experience is called trial-and-error learning. Many animals learn by trial and error. When baby chicks first try to feed themselves, they peck at many stones before they get any food. As a result of trial and error, they learn to peck only at food particles. **Figure 5** When feeding chicks in captivity, puppets of adult condors are used so the chicks don't learn to associate humans with food.



Topic: Captive Breeding Visit bookc.msscience.com for Web links to information about captive breeding.

Activity Identify and describe techniques used to raise captive species and introduce them into the wild.

Figure 6 Were you able to tie your shoes on the first attempt? **List** other things you do every day that require learning.







Observing Conditioning

Procedure

- Obtain several photos of different foods and landscapes from your teacher.
- 2. Show each picture to a classmate for 20 s.
- 3. Record how each photo made your partner feel.

Analysis

- 1. How did your partner feel after looking at the photos of food?
- 2. What effect did the landscape pictures have on your partner?
- 3. Infer how advertising might condition consumers to buy specific food products.

Figure 7 In Pavlov's experiment, a dog was conditioned to salivate when a bell was rung. It associated the bell with food. **Conditioning** Do you have an aquarium in your school or home? If you put your hand above the tank, the fish probably will swim to the top of the tank, expecting to be fed. They have learned that a hand shape above them means food. What would happen if you tapped on the glass right before you fed them? Soon the fish probably will swim to the top of the tank if you just tap on the glass. Because they are used to being fed after you tap on the glass, they associate the tap with food.

Animals often learn new behaviors by conditioning. In **conditioning**, behavior is modified so that a response to one stimulus becomes associated with a different stimulus. There are two types of conditioning. One type introduces a new stimulus before the usual stimulus. Russian scientist Ivan P. Pavlov performed experiments using this type of conditioning. He knew that the sight and smell of food made hungry dogs secrete saliva. Pavlov added another stimulus. He rang a bell before he fed the dogs. The dogs began to connect the sound of the bell with food. Then Pavlov rang the bell without giving the dogs food. They salivated when the bell was rung even though he did not give them food. The dogs, like the one in **Figure 7**, were conditioned to respond to the bell.

In the second type of conditioning, the new stimulus is given after the affected behavior. Getting an allowance for doing chores is an example of this type of conditioning. You do your chores because you want to receive your allowance. You have been conditioned to perform an activity that you may not have done if you had not been offered a reward.

Reading Check How does conditioning modify behavior?







Insight How does learned behavior help an animal deal with a new situation? Suppose you have a new math problem to solve. Do you begin by acting as though you've never seen it before, or do you use what you have learned previously in math to solve the problem? If you use what you have learned, then you have used a kind of learned behavior called insight. Insight is a form of reasoning that allows animals to use past experiences to solve new problems. In experiments with chimpanzees, as shown in Figure 8, bananas were placed out of the chimpanzees' reach. Instead of giving up, they piled up boxes found in the room, climbed them, and reached the bananas. At some time in their lives, the chimpanzees must have solved a similar problem. The chimpanzees demonstrated insight during the experiment. Much of adult human learning is based on insight. When you were a baby, you learned by trial and error. As you grow older, you will rely more on insight.

Figure 8 This illustration shows how chimpanzees may use insight to solve problems.

section

CONTENTS

Summary

Behavior

- Animals are born with certain behaviors, while other behaviors are learned.
- A stimulus is anything in the environment that causes a reaction.

Innate and Learned Behaviors

- Innate behaviors are those behaviors an organism inherits, such as reflexes and instincts.
- Learned behavior allows animals to respond to changing situations.
- Imprinting, trial and error, conditioning, and insight are examples of learned behavior.

review

Self Check

- 1. Compare and contrast a reflex and an instinct.
- 2. Compare and contrast imprinting and conditioning.
- **3. Think Critically** Use what you know about conditioning to explain how the term *mouthwatering food* might have come about.

Applying Skills

4. Use a Spreadsheet Make a spreadsheet of the behaviors in this section. Sort the behaviors according to whether they are innate or learned behaviors. Then identify the type of innate or learned behavior.

section

Behavioral Interactions

as you read

What You'll Learn

- **Explain** why behavioral adaptations are important.
- Describe how courtship behavior increases reproductive success.
- **Explain** the importance of social behavior and cyclic behavior.

Why It's Important

Organisms must be able to communicate with each other to survive.

Q Review Vocabulary

nectar: a sweet liquid produced in a plant's flower that is the main raw material of honey

New Vocabulary

- social behavior
- society
- aggression
- courtship behavior
- pheromone
- cyclic behavior
- hibernation
- migration

Figure 9 When several zebras are close together, their stripes make it difficult for predators to

140 C Michael Fairchild/Peter Arnold, Inc.

pick out one individual.

Instinctive Behavior Patterns

Complex interactions of innate behaviors between organisms result in many types of animal behavior. For example, courtship and mating within most animal groups are instinctive ritual behaviors that help animals recognize possible mates. Animals also protect themselves and their food sources by defending their territories. Instinctive behavior, just like natural hair color, is inherited.

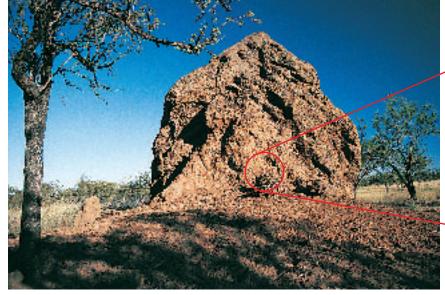
Social Behavior

Animals often live in groups. One reason, shown in **Figure 9**, is that large numbers provide safety. A lion is less likely to attack a herd of zebras than a lone zebra. Sometimes animals in large groups help keep each other warm. Also, migrating animal groups are less likely to get lost than animals that travel alone.

Interactions among organisms of the same species are examples of **social behavior**. Social behaviors include courtship and mating, caring for the young, claiming territories, protecting each other, and getting food. These inherited behaviors provide advantages that promote survival of the species.

Reading Check Why is social behavior important?





Societies Insects such as ants, bees, and the termites shown in **Figure 10**, live together in societies. A **society** is a group of animals of the same species living and working together in an organized way. Each member has a certain role. Usually a specific female lays eggs, and a male fertilizes them. Workers do all the other jobs in the society.

Some societies are organized by dominance. Wolves usually live together in packs. A wolf pack has a dominant female. The top female controls the mating of the other females. If plenty of food is available, she mates and then allows the others to do so. If food is scarce, she allows less mating. During such times, she is usually the only one to mate.

Territorial Behavior

Many animals set up territories for feeding, mating, and raising young. A territory is an area that an animal defends from

other members of the same species. Ownership of a territory occurs in different ways. Songbirds sing, sea lions bellow, and squirrels chatter to claim territories. Other animals leave scent marks. Some animals, like the tiger in Figure 11, patrol an area and attack other animals of the same species who enter their territory. Why do animals defend their territories? Territories contain food, shelter, and potential mates. If an animal has a territory, it will be able to mate and produce offspring. Defending territories is an instinctive behavior. It improves the survival rate of an animal's offspring.



Figure 10 Termites built this large mound in Australia. The mound has a network of tunnels and chambers for the queen termite to deposit eggs into.

Figure 11 A tiger's territory may cover several miles. It will confront any other tiger who enters it. **Explain** what may be happening in this photo.







Figure 12 Young wolves roll over and make themselves as small as possible to show their submission to adult wolves.

Figure 13 During the waggle dance, if the food source is far from the hive, the dance takes the form of a figure eight. The angle of the waggle is equal to the angle from the hive between the Sun and nectar source.

Aggression Have you ever watched as one dog approached another dog that was eating a bone? What happened to the appearance of the dog with the bone? Did its hair on its back stick up? Did it curl its lips and make growling noises? This behavior is called aggression. **Aggression** is a forceful behavior used to dominate or control another animal. Fighting and threatening are aggressive behaviors animals use to defend their territories, protect their young, or to get food.

Many animals demonstrate aggression. Some birds let their wings droop

below their tail feathers. It may take another bird's perch and thrust its head forward in a pecking motion as a sign of aggression. Cats lay their ears flat, arch their backs, and hiss.

Submission Animals of the same species seldom fight to the death. Teeth, beaks, claws, and horns are used for killing prey or for defending against members of a different species.

To avoid being attacked and injured by an individual of its own species, an animal shows submission. Postures that make an animal appear smaller often are used to communicate surrender. In some animal groups, one individual is usually dominant. Members of the group show submissive behavior toward the dominant individual. This stops further aggressive behavior by the dominant animal. Young animals also display submissive behaviors toward parents or dominant animals, as shown in **Figure 12.**



Communication

In all social behavior, communication is important. Communication is an action by a sender that influences the behavior of a receiver. How do you communicate with the people around you? You may talk, make noises, or gesture like you did in this chapter's Launch Lab. Honeybees perform a dance, as shown in **Figure 13**, to communicate to other bees in the hive the location of a food source. Animals in a group communicate with sounds, scents, and actions. Alarm calls, chemicals, speech, courtship behavior, and aggression are forms of communication.

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Figure 14 This male Emperor of Germany bird of paradise attracts mates by posturing and fanning its tail. List other behaviors animals use to attract mates.

Courtship Behavior A male bird of paradise, shown in **Figure 14**, spreads its tail feathers and struts. A male sage grouse fans its tail, fluffs its feathers, and blows up its two red air sacs. These are examples of behavior that animals perform before mating. This type of behavior is called **courtship behavior**. Courtship behaviors allow male and female members of a species to recognize each other. These behaviors also stimulate males and females so they are ready to mate at the same time. This helps ensure reproductive success.

In most species the males are more colorful and perform courtship displays to attract a mate. Some courtship behaviors allow males and females to find each other across distances.



Chemical Communication Ants are

CONTENTS

sometimes seen moving single file toward a piece of food. Male dogs frequently urinate on objects and plants. Both behaviors are based on chemical communication. The ants have laid down chemical trails that others of their species can follow. The dog is letting other dogs know he has been there. In these behaviors, the animals are using chemicals called pheromones (FER uh mohnz) to communicate. A chemical that is produced by one animal to influence the behavior of another animal of the same species is called a **pheromone**. They are powerful chemicals needed only in small amounts. They remain in the environment so that the sender and the receiver can communicate without being in the same place at the same time. They can advertise the presence of an animal to predators, as well as to the intended receiver of the message.

Males and females use pheromones to establish territories, warn of danger, and attract mates. Certain ants, mice, and snails release alarm pheromones when injured or threatened.



Demonstrating Chemical Communication

Procedure 🐼 🛤

- 1. Obtain a sample of perfume or air freshener.
- 2. Spray it into the air to leave a scent trail as you move around the house or apartment to a hiding place.
- **3.** Have someone try to discover where you are by following the scent of the substance.

Analysis

- 1. What was the difference between the first and last room you were in?
- 2. Would this be an efficient way for humans to communicate?

Try at Home

Explain.

Figure 15 Many animals use sound to communicate.



Frogs often croak loud enough to be heard far away.



Morse Code Samuel B. Morse created a code in 1838 using numbers to represent letters. His early work led to Morse code. Naval ships today still use Morse code to communicate with each other using huge flashlights mounted on the ships' decks. In your Science Journal, write what reasons you believe that Morse code is still used by the Navy.



Pileated woodpecker calls often can be heard above everything else in the forest.



Howler monkeys got their name because of the sounds they make.

Sound Communication Male crickets rub one forewing against the other forewing. This produces chirping sounds that attract females. Each cricket species produces several calls that are different from other cricket species. These calls are used by researchers to identify different species. Male mosquitoes have hairs on their antennae that sense buzzing sounds produced by females of their same species. The tiny hairs vibrate only to the frequency emitted by a female of the same species.

Vertebrates use a number of different forms of sound communication. Rabbits thump the ground, gorillas pound their chests, beavers slap the water with their flat tails, and frogs, like the one in **Figure 15**, croak. Do you think that sound communication in noisy environments is useful? Seabirds that live where waves pound the shore rather than in some quieter place must rely on visual signals, not sound, for communication.

Light Communication Certain kinds of flies, marine organisms, and beetles have a special form of communication called bioluminescence. Bioluminescence, shown in **Figure 16**, is the ability of certain living things to give off light. This light is produced through a series of chemical reactions in the organism's body. Probably the most familiar bioluminescent organisms in North America are fireflies. These insects are not flies, but beetles. The flash of light that is produced on the underside of the last abdominal segments is used to locate a prospective mate. Each species has its own characteristic flashing. Males fly close to the ground and emit flashes of light. Females must flash an answer at exactly the correct time to attract males.



NATIONAL GEOGRAPHIC VISUALIZING BIOLUMINESCENCE

Figure 16

any marine organisms use bioluminescence as a form of communication. This visible light is produced by a chemical reaction and often confuses predators or attracts mates. Each organism on this page is shown in its normal and bioluminescent state.

KRILL The blue dots shown below this krill are all that are visible when krill bioluminesce. The krill may use bioluminescence to confuse predators.

JELLYFISH This jellyfish lights up like a neon sign when it is threatened.

> BLACK DRAGONFISH The black dragonfish lives in the deep ocean where light doesn't penetrate. It has light organs under its eyes that it uses like a flashlight to search for prey.







Topic: Owl Behavior

Visit bookc.msscience.com for Web links to information about owl behavior.

Activity List five different types of owl behavior and describe how each behavior helps the owl survive.

Figure 17 Barn owls usually sleep during the day and hunt at night.

Identify the type of behavior the owl is exhibiting.

Uses of Bioluminescence Many bioluminescent animals are found deep in oceans where sunlight does not reach. The ability to produce light may serve several functions. One species of fish dangles a special luminescent organ in front of its mouth. This lures prey close enough to be caught and eaten. Deep-sea shrimp secrete clouds of a luminescent substance when disturbed. This helps them escape their predators. Patterns of luminescence on an animal's body may serve as marks of recognition similar to the color patterns of animals that live in sunlit areas.

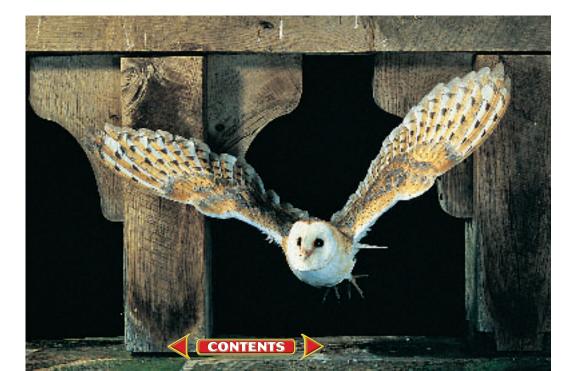
Cyclic Behavior

Why do most songbirds rest at night while some species of owls rest during the day? Some animals like the owl in **Figure 17** show regularly repeated behaviors such as sleeping in the day and feeding at night.

A **cyclic behavior** is innate behavior that occurs in a repeating pattern. It often is repeated in response to changes in the environment. Behavior that is based on a 24-hour cycle is called a circadian rhythm. Most animals come close to this 24-hour cycle of sleeping and wakefulness. Experiments show that even if animals can't tell whether it is night or day, they continue to behave in a 24-hour cycle.

Animals that are active during the day are diurnal (dy UR nul). Animals that are active at night are nocturnal. Owls are nocturnal. They have round heads, big eyes, and flat faces. Their flat faces reflect sound and help them navigate at night. Owls also have soft feathers that make them almost silent while flying.

Reading Check What is a diurnal behavior?





Hibernation Some cyclic behaviors also occur over long periods of time. **Hibernation** is a cyclic response to cold temperatures and limited food supplies. During hibernation, an animal's body temperature drops to near that of its surroundings, and its breathing rate is greatly reduced. Animals in hibernation, such as the bats in **Figure 18**, survive on stored body fat. The animal remains inactive until the



weather becomes warm in the spring. Some mammals and many amphibians and reptiles hibernate.

Animals that live in desertlike environments also go into a state of reduced activity. This period of inactivity is called estivation. Desert animals sometimes estivate due to extreme heat, lack of food, or periods of drought. **Figure 18** Many bats find a frost-free place like this abandoned coal mine to hibernate for the winter when food supplies are low.

Applying Science

How can you determine which animals hibernate?

any animals hibernate in the winter. During this period of inactivity, they survive on stored body fat. While they are hibernating, they undergo several physical changes. Heart rate slows down and body temperature decreases. The degree to which the body temperature decreases varies among animals. Scientists disagree about whether some animals truly hibernate or if they just reduce their activity and go into a light sleep. Usually, a true hibernator's body temperature will decrease significantly while it is hibernating.

Identifying the Problem

The table on the right shows the difference between the normal body temperature and the hibernating body temperature of several animals. What similarities do you notice?

Average Body Temperatures of Hibernating Animals

Animal	Normal Body Temperature (°C)	Hibernating Body Temperature (°C)	
Woodchuck	37	3	
Squirrel	32	4	
Grizzly bear	32–37	27–32	
Whippoorwill	40	18	
Hoary marmot	37	10	

Solving the Problem

- 1. Which animals would you classify as true hibernators and which would you classify as light sleepers? Explain.
- **2.** Some animals such as snakes and frogs also hibernate. Why would it be difficult to record their normal body temperature?



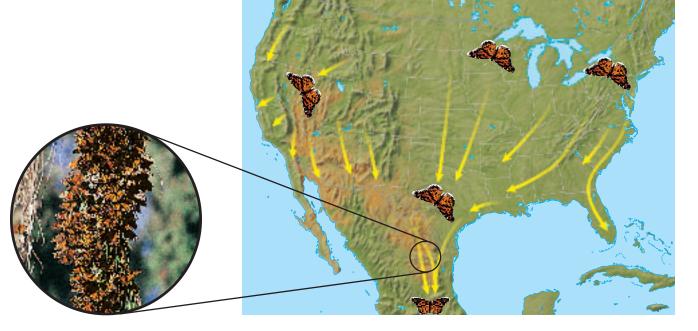


Figure 19 Many monarch butterflies travel from the United States to Mexico for the winter.

Migration Instead of hibernating, many animals move to new locations when the seasons change. This instinctive seasonal movement of animals is called **migration**. Most animals migrate to find food or to reproduce in environments that are more favorable for the survival of offspring. Many bird species fly for hours or days without stopping. The blackpoll warbler flies more than 4,000 km, nearly 90 hours nonstop from North America to its winter home in South America. Monarch butterflies, shown in **Figure 19**, can migrate as far as 2,900 km. Gray whales swim from arctic waters to the waters off the coast of northern Mexico. After the young are born, they make the return trip.

Summary

section

Instinctive Behavior Patterns

- Instinctive behavior patterns are inherited.
- Courtship and mating are instinctive for most animal groups.

Social and Territorial Behaviors

- Interactions among organisms of a group are examples of social behavior.
- Many animals protect a territory for feeding, mating, and raising young.

Communication and Cyclic Behavior

- Species can communicate with each other using behavior, chemicals, sound, or bioluminescence.
- Cyclic behaviors occur in response to environmental changes.

Self Check

review

- **1. Describe** some examples of courtship behavior and how this behavior helps organisms survive.
- 2. Identify and explain two reasons that animals migrate.
- 3. Compare and contrast hibernation and migration.
- 4. Think Critically Suppose a species of frog lives close to a loud waterfall. It often waves a bright blue foot in the air. What might the frog be doing?

Applying Math

5. Solve One-Step Equations Some cicadas emerge from the ground every 17 years. The population of one type of caterpillar peaks every five years. If the peak cycle of the caterpillars and the emergence of cicadas coincided in 1990, in what year will they coincide again?

bookc.msscience.com/self_check_quiz



Earthworms can be seen at night wriggling across wet sidewalks and driveways. Why don't you see many earthworms during the day?

Real-World Question —

How do earthworms respond to light?

Goals

Predict how earthworms will behave in the presence of light.

Materials

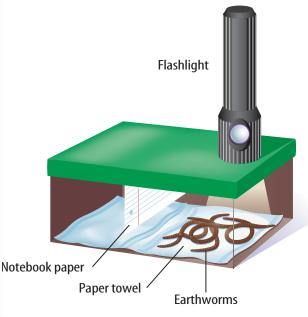
scissors shoe box with lid flashlight tape paper moist paper towels earthworms timer

Safety Precautions



Procedure

- **1.** Cut a round hole, smaller than the end of the flashlight, near one end of the lid.
- Tape a sheet of paper to the lid so it hangs just above the bottom of the box and about 10 cm away from the end with the hole in it.
- **3.** Place the moist paper towels in the bottom of the box.
- **4.** Place the earthworms in the end of the box that has the hole in it.
- **5.** Hold the flashlight over the hole and turn it on.
- **6.** Leave the box undisturbed for 30 minutes, then open the lid and observe the worms.
- **7. Record** the results of your experiment in your Science Journal.



Sonclude and Apply-

- **1. Identify** which direction the earthworms moved when the light was turned on.
- **2. Infer** Based on your observations, what can you infer about earthworms?
- **3. Explain** what type of behavior the earth-worms exhibited.
- **4. Predict** where you would need to go to find earthworms during the day.

Communicating Your Data

Write a story that describes a day in the life of an earthworm. List activities, dangers, and problems an earthworm might face. Include a description of its habitat. For more help, refer to the Science Skill Handbook.



Model and Invent

Amimal Habitats

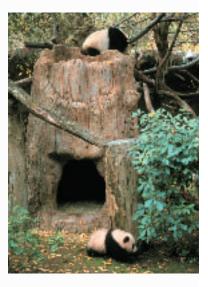
Goals

- Research the natural habitat and basic needs of one animal.
- Design and model an appropriate zoo, animal park, or aquarium environment for this animal. Working cooperatively with your classmates, design an entire zoo or animal park.

Possible Materials poster board markers or colored pencils materials that can be used to make a scale model

Real-World Question

Zoos, animal parks, and aquariums are safe places for wild animals. Years ago, captive animals were kept in small cages or behind glass windows. Almost no attempt was made to provide natural habitats for the animals. People who came to see the animals could not observe the animal's normal behavior. Now, most captive animals are kept in exhibit areas that closely resemble their natural habitats. These areas provide suitable environments for the animals so that they can interact with members of their same species and have healthier, longer lives. What types of environments are best suited for raising animals in captivity? How can the habitats provided at an animal park affect the behavior of animals?



🧔 Make a Model-

 Choose an animal to research. Find out where this animal is found in nature. What does it eat? What are its natural predators? Does it exhibit unique territorial, courtship, or other types of behavior? How is this animal adapted to its natural environment?



2. Design a model of a proposed habitat in which this animal can live successfully. Don't forget to include all of the things, such as shelter, food, and water, that your animal will need to survive. Will there be any other organisms in the habitat?

Using Scientific Methods

- **3. Research** how zoos, animal parks, or aquariums provide habitats for animals. Information may be obtained by contacting scientists who work at zoos, animal parks, and aquariums.
- **4. Present** your design to your class in the form of a poster, slide show, or video. Compare your proposed habitat with that of the animal's natural environment. Make sure you include a picture of your animal in its natural environment.

Test Your Model

- 1. Using all of the information you have gathered, create a model exhibit area for your animal.
- 2. Indicate what other plants and animals may be present in the exhibit area.

🧔 Analyze Your Data

- **1. Decide** whether all of the animals studied in this lab can coexist in the same zoo or wildlife preserve.
- **2. Analyze** problems that might exist in your design. Suggest some ways you might want to improve your design.

CONTENTS

Conclude and Apply

- **1. Interpret Data** Using the information provided by the rest of your classmates, design an entire zoo or aquarium that could include the majority of animals studied.
- 2. Predict which animals could be grouped together in exhibit areas.
- **3. Determine** how large your zoo or wildlife preserve needs to be. Which animals require a large habitat?

Communicating Your Data

Give an oral presentation to another class on the importance of providing natural habitats for captive animals. For more help, refer to the Science Skill Handbook.





Accidents in SCIENCE

SOMETIMES GREAT DISCOVERIES HAPPEN BY ACCIDENT!

D Going to the O U U S

A simple and surprising stroll showed that dogs really are humans' best friends

ou've probably seen visually impaired people walking with their trusted "seeing-eye" dogs. Over 85 years ago, a doctor and his patient discovered this canine ability entirely by accident!

Near the end of World War I in Germany, Dr. Gerhard Stalling and his dog strolled with a patient—a German soldier who had been blinded—around hospital grounds.



A dog safely guides its owner across a street.

While they were walking, the doctor was called away. A few moments later. the doctor returned but the dog and the soldier were gone! Searching the paths frantically, Dr. Stalling made an astonishing discovery. His pet had led the soldier safely around the hospital grounds. Inspired by what his dog could do,



German shepherds make excellent guide dogs.

Dr. Stalling set up the first school in the world dedicated to training dogs as guides.

German shepherds, golden retrievers, and Labrador retrievers seem to make the best guide dogs. They learn hand gestures and simple commands to lead visually impaired people safely across streets and around obstacles. This is what scientists call "learned behavior." Animals gain learned behavior through experience. But, a guide dog doesn't just learn to respond to special commands; it also must learn when not to obey. If its human owner urges the dog to cross the street and the dog sees that a car is approaching, the dog refuses because it has learned to disobey the command. This trait, called "intelligent disobedience," ensures the safety of the owner and the dog-a sure sign that dogs are still humans' best friends.

Write Lead a blindfolded partner around the classroom. Help your partner avoid obstacles. Then trade places. Write in your Science Journal about your experience leading and being led.



For more information, visit bookc.msscience.com/oops



Reviewing Main Ideas

chapter

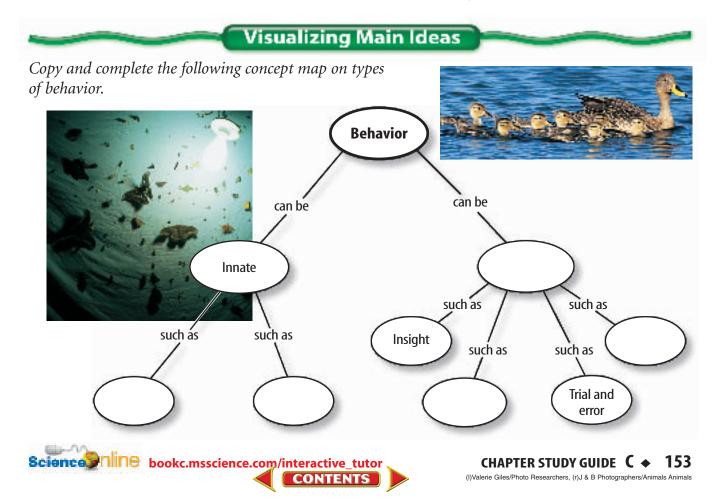
Section 1 Types of Behavior

- Behavior that an animal has when it's born is innate behavior. Other animal behaviors are learned through experience.
- 2. Reflexes are simple innate behaviors. An instinct is a complex pattern of innate behavior.
- **3.** Learned behavior includes imprinting, in which an animal forms a social attachment immediately after birth.
- **4.** Behavior modified by experience is learning by trial and error.
- Conditioning occurs when the response to one stimulus becomes associated with another. Insight is the ability to use past experiences to solve new problems.

Section 2 Behavioral Interactions

Study Guide

- Behavioral adaptations such as defense of territory, courtship behavior, and social behavior help species of animals survive and reproduce.
- **2.** Courtship behaviors allow males and females to recognize each other and prepare to mate.
- **3.** Interactions among members of the same species are social behaviors.
- 4. Communication among organisms occurs in several forms, including chemical, sound, and light.
- **5.** Cyclic behaviors are behaviors that occur in repeating patterns. Animals that are active during the day are diurnal. Animals that are active at night are nocturnal.



chapter

Review

Using Vocabulary

aggression p. 142 behavior p. 134 conditioning p. 138 courtship behavior p. 143 cyclic behavior p. 146 hibernation p. 147 imprinting p. 137 innate behavior p. 135 insight p. 139 instinct p. 136 migration p. 148 pheromone p. 143 reflex p. 135 social behavior p. 140 society p. 141

Explain the differences between the pairs of vocabulary words given below. Then explain how the words are related.

- 1. conditioning—imprinting
- 2. innate behavior—social behavior
- 3. insight—instinct
- 4. social behavior—society
- 5. instinct—reflex
- 6. hibernation—migration
- 7. courtship behavior—pheromone
- 8. cyclic behavior—migration
- 9. aggression—social behavior
- 10. behavior—reflex

Checking Concepts

Choose the word or phrase that best answers the question.

- **11.** What is an instinct an example of?
 - A) innate behavior
 - **B)** learned behavior
 - **C)** imprinting
 - **D)** conditioning
- What is an area that an animal defends from other members of the same species called?
 - A) society C) migration
 - **B)** territory **D)** aggression

- **13.** Which animals depend least on instinct and most on learning?
 - A) birds C) mammals
 - **B)** fish **D)** amphibians
- **14.** What is a spider spinning a web an example of?
 - A) conditioning **C)** learned behavior
 - **B)** imprinting **D)** an instinct
- **15.** What is a forceful act used to dominate or control another called?
 - A) courtship C) aggression
 - **B)** reflex **D)** hibernation
- **16.** What is an organized group of animals doing specific jobs called?
 - A) community C) society
 - **B)** territory **D)** circadian rhythm
- **17.** What is the response of inactivity and slowed metabolism that occurs during cold conditions?
 - A) hibernation C) migration
 - **B)** imprinting **D)** circadian rhythm
- **18.** Which of the following is a reflex?
 - A) writing C) sneezing

B) talking

D) riding a bicycle

Use the photo below to answer question 19.



- **19.** The photo above is an example of what type of communication?
 - A) light communication
 - **B)** sound communication
 - **C)** chemical communication
 - **D)** cyclic behavior

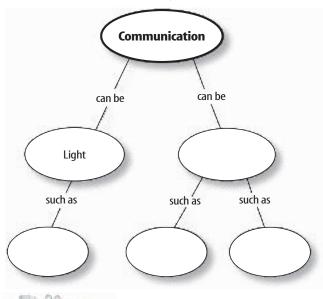
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ence line bookc.msscience.com/vocabulary_puzzlemaker

chapter

Thinking Critically

- **20. Explain** the type of behavior involved when the bell rings at the end of class.
- **21. Describe** the advantages and disadvantages of migration as a means of survival.
- **22. Explain** how a habit, such as tying your shoes, is different from a reflex.
- **23.** Explain how behavior increases an animal's chance for survival using one example.
- 24. Infer Hens lay more eggs in the spring when the number of daylight hours increases. How can farmers use this knowledge of behavior to their advantage?
- **25. Record Observations** Make observations of a dog, cat, or bird for a week. Record what you see. How did the animal communicate with other animals and with you?
- **26. Classify** Make a list of 25 things that you do regularly. Classify each as an innate or learned behavior. Which behaviors do you have more of?
- **27. Concept Map** Copy and complete the following concept map about communication. Use these words: *sound, chirping, bioluminescence,* and *buzzing.*



Science DINE bookc.msscience.com/chapter_review

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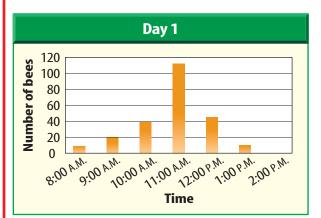
Performance Activities

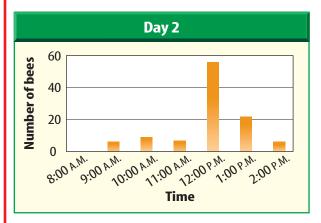
Review

28. Poster Draw a map showing the migration route of monarch butterflies, gray whales, or blackpoll warblers.

Applying Math

Use the graphs below to answer question 29.





- **29. Bee Foraging** Bees were trained to forage from 1:00 P.M. to 2:30 P.M. in New York and then were flown to California. The graphs above show the number of bees looking for food during the first two days in California. What was the difference in peak activity from day 1 to day 2? Was there a difference in the proportion of bees active during peak hours ?
- **30. Bird Flight** A blackpoll warbler flies 4,000 km nonstop from North America to South America in about 90 hours. What is its rate of speed?

chapter

Standardized Test Practice

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- **1.** Which of the following is true about innate behaviors?
 - **A.** They are learned behaviors.
 - **B.** They are observed in only some animals.
 - **c.** They are the result of conscious thought.
 - **D.** They include reflexes.
- 2. A spider spinning its web is an example of a(n)
 - **A.** reflex. **C.** imprinting.
 - **B.** instinct. **D.** conditioning.

Use the illustration below to answer questions 3 and 4.



- **3.** The illustration above describes what kind of learned behavior?
 - A. conditioning
 - **B.** trial and error
 - **c.** imprinting
 - **D.** insight
- **4.** Which of the following best describes this learned behavior?
 - **A.** The dog learns to salivate when presented with food.
 - **B.** The dog learns to eat only if the bell is rung.
 - **c.** The dog is conditioned to stop salivating when a bell is rung.
 - **D.** The dog is conditioned to salivate when a bell is rung.

- **5.** Which of the following is an example of territorial behavior?
 - **A.** A honeybee performs a waggle dance when it returns to the hive.
 - **B.** A peacock fans his tail while approaching a peahen.
 - **c.** A mountain goat charges and attacks an unfamiliar mountain goat.
 - **D.** A group of bats remain in hibernation for the winter.

Use the photo below to answer questions 6 and 7.



- **6.** The male wolf lying on its back is displaying what kind of behavior to the other male wolf?
 - **A.** aggressive behavior
 - **B.** submissive behavior
 - **C.** cyclic behavior
 - **D.** courtship behavior
- **7.** Which of the following statements best describes the behavior of the wolf that is standing?
 - **A.** The wolf is displaying its dominance over the wolf on the ground.
 - **B.** The wolf is displaying courtship behavior to the other wolf.
 - **c.** The wolf is using bioluminescence to communicate with the other wolf.
 - **D.** The wolf is watching the other wolf perform the waggle dance.



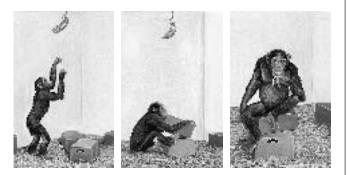
Standardized Test Practice

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

- **8.** Give an example of an innate behavior in a hummingbird.
- **9.** Which is simpler and more automatic, instincts or reflexes?

Use the illustration below to answer questions 10 and 11.



- **10.** What type of learning is shown above?
- **11.** What is required in order for an animal to use this type of learning to solve a problem?
- **12.** Could a young child solve a problem using insight? Why or why not?
- **13.** Give three examples of social behaviors.
- **14.** Why might an animal be submissive to another animal?

Test-Taking Tip

Compare and Contrast Make sure each part of the question is answered when listing discussion points. For example, if the question asks you to compare and contrast, make sure you list both similarities and differences.

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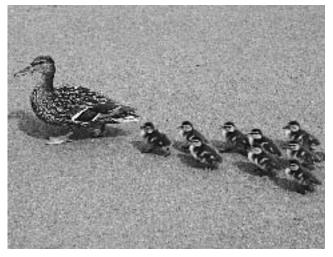
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Part 3 Open Ended

Record your answers on a sheet of paper.

- **15.** Compare and contrast the innate behaviors of animals with short life spans and animals with long life spans.
- **16.** Give three examples of ways bioluminescence is used for communication.
- **17.** Explain the difference between a diurnal animal and a nocturnal animal. Give an example of each.
- **18.** Compare and contrast hibernation and estivation.

Use the photo below to answer questions 19 and 20.



- **19.** Explain the type of behavior that is shown above.
- **20.** How is this behavior related to why zoos feed newborn condors with hand puppets that look like adult condors?
- **21.** A male antelope approaches a female antelope during the breeding season. Is the male antelope responding to an external stimulus, an internal stimulus, or both? Explain.

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Student Resources



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Credits



Scientific Methods

Scientists use an orderly approach called the scientific method to solve problems. This includes organizing and recording data so others can understand them. Scientists use many variations in this method when they solve problems.

Identify a Question

The first step in a scientific investigation or experiment is to identify a question to be answered or a problem to be solved. For example, you might ask which gasoline is the most efficient.

Gather and Organize Information

After you have identified your question, begin gathering and organizing information. There are many ways to gather information, such as researching in a library, interviewing those knowledgeable about the subject, testing and working in the laboratory and field. Fieldwork is investigations and observations done outside of a laboratory.

Researching Information Before moving in a new direction, it is important to gather the information that already is known about the subject. Start by asking yourself questions to determine exactly what you need to know. Then you will look for the information in various reference sources, like the student is doing in **Figure 1.** Some sources may include textbooks, encyclopedias, government documents, professional journals, science magazines, and the Internet. Always list the sources of your information.



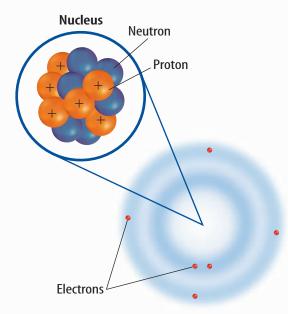
Figure 1 The Internet can be a valuable research tool.

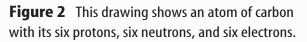
Evaluate Sources of Information Not all sources of information are reliable. You should evaluate all of your sources of information, and use only those you know to be dependable. For example, if you are researching ways to make homes more energy efficient, a site written by the U.S. Department of Energy would be more reliable than a site written by a company that is trying to sell a new type of weatherproofing material. Also, remember that research always is changing. Consult the most current resources available to you. For example, a 1985 resource about saving energy would not reflect the most recent findings.

Sometimes scientists use data that they did not collect themselves, or conclusions drawn by other researchers. This data must be evaluated carefully. Ask questions about how the data were obtained, if the investigation was carried out properly, and if it has been duplicated exactly with the same results. Would you reach the same conclusion from the data? Only when you have confidence in the data can you believe it is true and feel comfortable using it.



Interpret Scientific Illustrations As you research a topic in science, you will see drawings, diagrams, and photographs to help you understand what you read. Some illustrations are included to help you understand an idea that you can't see easily by yourself, like the tiny particles in an atom in **Figure 2.** A drawing helps many people to remember details more easily and provides examples that clarify difficult concepts or give additional information about the topic you are studying. Most illustrations have labels or a caption to identify or to provide more information.





Concept Maps One way to organize data is to draw a diagram that shows relationships among ideas (or concepts). A concept map can help make the meanings of ideas and terms more clear, and help you understand and remember what you are studying. Concept maps are useful for breaking large concepts down into smaller parts, making learning easier. **Network Tree** A type of concept map that not only shows a relationship, but how the concepts are related is a network tree, shown in **Figure 3.** In a network tree, the words are written in the ovals, while the description of the type of relationship is written across the connecting lines.

When constructing a network tree, write down the topic and all major topics on separate pieces of paper or notecards. Then arrange them in order from general to specific. Branch the related concepts from the major concept and describe the relationship on the connecting line. Continue to more specific concepts until finished.

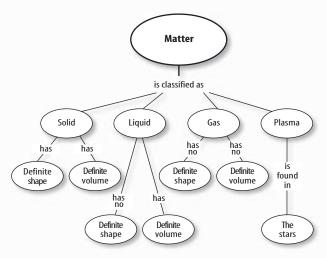


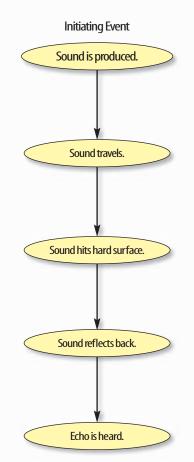
Figure 3 A network tree shows how concepts or objects are related.

Events Chain Another type of concept map is an events chain. Sometimes called a flow chart, it models the order or sequence of items. An events chain can be used to describe a sequence of events, the steps in a procedure, or the stages of a process.

When making an events chain, first find the one event that starts the chain. This event is called the initiating event. Then, find the next event and continue until the outcome is reached, as shown in **Figure 4.**

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Science Skill Handbook

Figure 4 Events-chain concept maps show the order of steps in a process or event. This concept map shows how a sound makes an echo.

Cycle Map A specific type of events chain is a cycle map. It is used when the series of events do not produce a final outcome, but instead relate back to the beginning event, such as in **Figure 5.** Therefore, the cycle repeats itself.

To make a cycle map, first decide what event is the beginning event. This is also called the initiating event. Then list the next events in the order that they occur, with the last event relating back to the initiating event. Words can be written between the events that describe what happens from one event to the next. The number of events in a cycle map can vary, but usually contain three or more events.

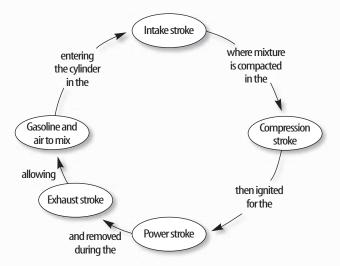
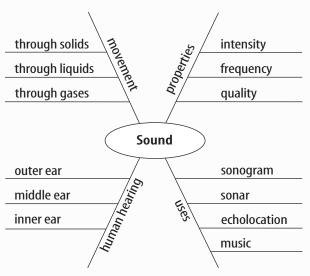
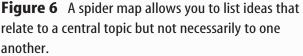


Figure 5 A cycle map shows events that occur in a cycle.

Spider Map A type of concept map that you can use for brainstorming is the spider map. When you have a central idea, you might find that you have a jumble of ideas that relate to it but are not necessarily clearly related to each other. The spider map on sound in **Figure 6** shows that if you write these ideas outside the main concept, then you can begin to separate and group unrelated terms so they become more useful.





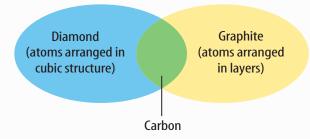


Figure 7 This Venn diagram compares and contrasts two substances made from carbon.

Venn Diagram To illustrate how two subjects compare and contrast you can use a Venn diagram. You can see the characteristics that the subjects have in common and those that they do not, shown in **Figure 7.**

To create a Venn diagram, draw two overlapping ovals that that are big enough to write in. List the characteristics unique to one subject in one oval, and the characteristics of the other subject in the other oval. The characteristics in common are listed in the overlapping section.

Make and Use Tables One way to organize information so it is easier to understand is to use a table. Tables can contain numbers, words, or both.

To make a table, list the items to be compared in the first column and the characteristics to be compared in the first row. The title should clearly indicate the content of the table, and the column or row heads should be clear. Notice that in **Table 1** the units are included.

Table 1 Recyclables Collected During Week				
Day of Week	Paper (kg)	Aluminum (kg)	Glass (kg)	
Monday	5.0	4.0	12.0	
Wednesday	4.0	1.0	10.0	
Friday	2.5	2.0	10.0	

Make a Model One way to help you better understand the parts of a structure, the way a process works, or to show things too large or small for viewing is to make a model. For example, an atomic model made of a plasticball nucleus and pipe-cleaner electron shells can help you visualize how the parts of an atom relate to each other. Other types of models can by devised on a computer or represented by equations.

Form a Hypothesis

A possible explanation based on previous knowledge and observations is called a hypothesis. After researching gasoline types and recalling previous experiences in your family's car you form a hypothesis—our car runs more efficiently because we use premium gasoline. To be valid, a hypothesis has to be something you can test by using an investigation.

Predict When you apply a hypothesis to a specific situation, you predict something about that situation. A prediction makes a statement in advance, based on prior observation, experience, or scientific reasoning. People use predictions to make everyday decisions. Scientists test predictions by performing investigations. Based on previous observations and experiences, you might form a prediction that cars are more efficient with premium gasoline. The prediction can be tested in an investigation.

Design an Experiment A scientist needs to make many decisions before beginning an investigation. Some of these include: how to carry out the investigation, what steps to follow, how to record the data, and how the investigation will answer the question. It also is important to address any safety concerns.



Test the Hypothesis

Now that you have formed your hypothesis, you need to test it. Using an investigation, you will make observations and collect data, or information. This data might either support or not support your hypothesis. Scientists collect and organize data as numbers and descriptions.

Follow a Procedure In order to know what materials to use, as well as how and in what order to use them, you must follow a procedure. **Figure 8** shows a procedure you might follow to test your hypothesis.

Procedure

- 1. Use regular gasoline for two weeks.
- Record the number of kilometers between fill-ups and the amount of gasoline used.
- **3.** Switch to premium gasoline for two weeks.
- **4.** Record the number of kilometers between fill-ups and the amount of gasoline used.

Figure 8 A procedure tells you what to do step by step.

Identify and Manipulate Variables and

Controls In any experiment, it is important to keep everything the same except for the item you are testing. The one factor you change is called the independent variable. The change that results is the dependent variable. Make sure you have only one independent variable, to assure yourself of the cause of the changes you observe in the dependent variable. For example, in your gasoline experiment the type of fuel is the independent variable. The dependent variable. The dependent variable is the efficiency.

Many experiments also have a control an individual instance or experimental subject for which the independent variable is not changed. You can then compare the test results to the control results. To design a control you can have two cars of the same type. The control car uses regular gasoline for four weeks. After you are done with the test, you can compare the experimental results to the control results.

Collect Data

Whether you are carrying out an investigation or a short observational experiment, you will collect data, as shown in **Figure 9**. Scientists collect data as numbers and descriptions and organize it in specific ways.

Observe Scientists observe items and events, then record what they see. When they use only words to describe an observation, it is called qualitative data. Scientists' observations also can describe how much there is of something. These observations use numbers, as well as words, in the description and are called quantitative data. For example, if a sample of the element gold is described as being "shiny and very dense" the data are qualitative. Quantitative data on this sample of gold might include "a mass of 30 g and a density of 19.3 g/cm³."



Figure 9 Collecting data is one way to gather information directly.





Figure 10 Record data neatly and clearly so it is easy to understand.

When you make observations you should examine the entire object or situation first, and then look carefully for details. It is important to record observations accurately and completely. Always record your notes immediately as you make them, so you do not miss details or make a mistake when recording results from memory. Never put unidentified observations on scraps of paper. Instead they should be recorded in a notebook, like the one in **Figure 10.** Write your data neatly so you can easily read it later. At each point in the experiment, record your observations and label them. That way, you will not have to determine what the figures mean when you look at your notes later. Set up any tables that you will need to use ahead of time, so you can record any observations right away. Remember to avoid bias when collecting data by not including personal thoughts when you record observations. Record only what you observe.

Estimate Scientific work also involves estimating. To estimate is to make a judgment about the size or the number of something without measuring or counting. This is important when the number or size of an object or population is too large or too difficult to accurately count or measure.

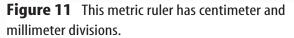
Sample Scientists may use a sample or a portion of the total number as a type of estimation. To sample is to take a small, representative portion of the objects or organisms of a population for research. By making careful observations or manipulating variables within that portion of the group, information is discovered and conclusions are drawn that might apply to the whole population. A poorly chosen sample can be unrepresentative of the whole. If you were trying to determine the rainfall in an area, it would not be best to take a rainfall sample from under a tree.

Measure You use measurements everyday. Scientists also take measurements when collecting data. When taking measurements, it is important to know how to use measuring tools properly. Accuracy also is important.

Length To measure length, the distance between two points, scientists use meters. Smaller measurements might be measured in centimeters or millimeters.

Length is measured using a metric ruler or meter stick. When using a metric ruler, line up the 0-cm mark with the end of the object being measured and read the number of the unit where the object ends. Look at the metric ruler shown in **Figure 11.** The centimeter lines are the long, numbered lines, and the shorter lines are millimeter lines. In this instance, the length would be 4.50 cm.





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Mass The SI unit for mass is the kilogram (kg). Scientists can measure mass using units formed by adding metric prefixes to the unit gram (g), such as milligram (mg). To measure mass, you might use a triple-beam balance similar to the one shown in **Figure 12.** The balance has a pan on one side and a set of beams on the other side. Each beam has a rider that slides on the beam.

When using a triple-beam balance, place an object on the pan. Slide the largest rider along its beam until the pointer drops below zero. Then move it back one notch. Repeat the process for each rider proceeding from the larger to smaller until the pointer swings an equal distance above and below the zero point. Sum the masses on each beam to find the mass of the object. Move all riders back to zero when finished.

Instead of putting materials directly on the balance, scientists often take a tare of a container. A tare is the mass of a container into which objects or substances are placed for measuring their masses. To mass objects or substances, find the mass of a clean container. Remove the container from the pan, and place the object or substances in the container. Find the mass of the container with the materials in it. Subtract the mass of the empty container from the mass of the filled container to find the mass of the materials you are using.



Figure 12 A triple-beam balance is used to determine the mass of an object.

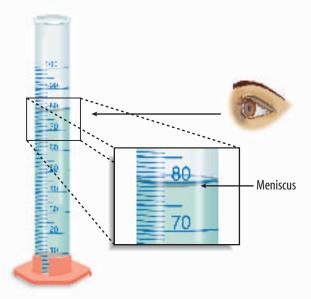


Figure 13 Graduated cylinders measure liquid volume.

Liquid Volume To measure liquids, the unit used is the liter. When a smaller unit is needed, scientists might use a milliliter. Because a milliliter takes up the volume of a cube measuring 1 cm on each side it also can be called a cubic centimeter ($cm^3 = cm \times cm \times cm$).

You can use beakers and graduated cylinders to measure liquid volume. A graduated cylinder, shown in **Figure 13**, is marked from bottom to top in milliliters. In lab, you might use a 10-mL graduated cylinder or a 100-mL graduated cylinder. When measuring liquids, notice that the liquid has a curved surface. Look at the surface at eye level, and measure the bottom of the curve. This is called the meniscus. The graduated cylinder in **Figure 13** contains 79.0 mL, or 79.0 cm³, of a liquid.

Temperature Scientists often measure temperature using the Celsius scale. Pure water has a freezing point of 0°C and boiling point of 100°C. The unit of measurement is degrees Celsius. Two other scales often used are the Fahrenheit and Kelvin scales.





Figure 14 A thermometer measures the temperature of an object.

Scientists use a thermometer to measure temperature. Most thermometers in a laboratory are glass tubes with a bulb at the bottom end containing a liquid such as colored alcohol. The liquid rises or falls with a change in temperature. To read a glass thermometer like the thermometer in **Figure 14,** rotate it slowly until a red line appears. Read the temperature where the red line ends.

Form Operational Definitions An operational definition defines an object by how it functions, works, or behaves. For example, when you are playing hide and seek and a tree is home base, you have created an operational definition for a tree.

Objects can have more than one operational definition. For example, a ruler can be defined as a tool that measures the length of an object (how it is used). It can also be a tool with a series of marks used as a standard when measuring (how it works).

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Analyze the Data

To determine the meaning of your observations and investigation results, you will need to look for patterns in the data. Then you must think critically to determine what the data mean. Scientists use several approaches when they analyze the data they have collected and recorded. Each approach is useful for identifying specific patterns.

Interpret Data The word *interpret* means "to explain the meaning of something." When analyzing data from an experiement, try to find out what the data show. Identify the control group and the test group to see whether or not changes in the independent variable have had an effect. Look for differences in the dependent variable between the control and test groups.

Classify Sorting objects or events into groups based on common features is called classifying. When classifying, first observe the objects or events to be classified. Then select one feature that is shared by some members in the group, but not by all. Place those members that share that feature in a subgroup. You can classify members into smaller and smaller subgroups based on characteristics. Remember that when you classify, you are grouping objects or events for a purpose. Keep your purpose in mind as you select the features to form groups and subgroups.

Compare and Contrast Observations can be analyzed by noting the similarities and differences between two more objects or events that you observe. When you look at objects or events to see how they are similar, you are comparing them. Contrasting is looking for differences in objects or events. **Recognize Cause and Effect** A cause is a reason for an action or condition. The effect is that action or condition. When two events happen together, it is not necessarily true that one event caused the other. Scientists must design a controlled investigation to recognize the exact cause and effect.

Draw Conclusions

When scientists have analyzed the data they collected, they proceed to draw conclusions about the data. These conclusions are sometimes stated in words similar to the hypothesis that you formed earlier. They may confirm a hypothesis, or lead you to a new hypothesis.

Infer Scientists often make inferences based on their observations. An inference is an attempt to explain observations or to indicate a cause. An inference is not a fact, but a logical conclusion that needs further investigation. For example, you may infer that a fire has caused smoke. Until you investigate, however, you do not know for sure.

Apply When you draw a conclusion, you must apply those conclusions to determine whether the data supports the hypothesis. If your data do not support your hypothesis, it does not mean that the hypothesis is wrong. It means only that the result of the investigation did not support the hypothesis. Maybe the experiment needs to be redesigned, or some of the initial observations on which the hypothesis was based were incomplete or biased. Perhaps more observation or research is needed to refine your hypothesis. A successful investigation does not always come out the way you originally predicted.

Avoid Bias Sometimes a scientific investigation involves making judgments. When you make a judgment, you form an opinion. It is important to be honest and not to allow any expectations of results to bias your judgments. This is important throughout the entire investigation, from researching to collecting data to drawing conclusions.

Communicate

The communication of ideas is an important part of the work of scientists. A discovery that is not reported will not advance the scientific community's understanding or knowledge. Communication among scientists also is important as a way of improving their investigations.

Scientists communicate in many ways, from writing articles in journals and magazines that explain their investigations and experiments, to announcing important discoveries on television and radio. Scientists also share ideas with colleagues on the Internet or present them as lectures, like the student is doing in **Figure 15**.



Figure 15 A student communicates to his peers about his investigation.



Science Skill Handbook

SAFETY SYMBOLS	HAZARD	EXAMPLES	PRECAUTION	REMEDY
DISPOSAL	Special disposal proce- dures need to be fol- lowed.	certain chemicals, living organisms	Do not dispose of these materials in the sink or trash can.	Dispose of wastes as directed by your teacher.
	Organisms or other biological materials that might be harmful to humans	bacteria, fungi, blood, unpreserved tissues, plant materials	Avoid skin contact with these materials. Wear mask or gloves.	Notify your teacher if you suspect contact with material. Wash hands thoroughly.
	Objects that can burn skin by being too cold or too hot	boiling liquids, hot plates, dry ice, liquid nitrogen	Use proper protection when handling.	Go to your teacher for first aid.
SHARP OBJECT	Use of tools or glass- ware that can easily puncture or slice skin	razor blades, pins, scalpels, pointed tools, dissecting probes, bro- ken glass	Practice common- sense behavior and follow guidelines for use of the tool.	Go to your teacher for first aid.
FUME	Possible danger to res- piratory tract from fumes	ammonia, acetone, nail polish remover, heated sulfur, moth balls	Make sure there is good ventilation. Never smell fumes directly. Wear a mask.	Leave foul area and notify your teacher immediately.
	Possible danger from electrical shock or burn	improper grounding, liquid spills, short circuits, exposed wires	Double-check setup with teacher. Check condition of wires and apparatus.	Do not attempt to fix electrical problems. Notify your teacher immediately.
	Substances that can irritate the skin or mucous membranes of the respiratory tract	pollen, moth balls, steel wool, fiberglass, potassium perman- ganate	Wear dust mask and gloves. Practice extra care when handling these materials.	Go to your teacher for first aid.
	Chemicals can react with and destroy tissue and other materials	bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammo- nia, sodium hydroxide	Wear goggles, gloves, and an apron.	Immediately flush the affected area with water and notify your teacher.
тохіс 📌	Substance may be poi- sonous if touched, inhaled, or swallowed.	mercury, many metal compounds, iodine, poinsettia plant parts	Follow your teacher's instructions.	Always wash hands thoroughly after use. Go to your teacher for first aid.
FLAMMABLE	Flammable chemicals may be ignited by open flame, spark, or exposed heat.	alcohol, kerosene, potassium perman- ganate	Avoid open flames and heat when using flammable chemicals.	Notify your teacher immediately. Use fire safety equipment if applicable.
OPEN FLAME	Open flame in use, may cause fire.	hair, clothing, paper, synthetic materials	Tie back hair and loose clothing. Follow teacher's instruction on lighting and extinguish- ing flames.	Notify your teacher immediately. Use fire safety equipment if applicable.

Eye Safety Proper eye protection should be worn at all times by anyone performing or observing science activities.



Clothing Protection This symbol appears when substances could stain or burn clothing.



Animal Safety This symbol appears when safety of animals and students must be ensured.

Handwashing After the lab, wash hands with soap and water before removing goggles.

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Science Skill Handbook

Safety in the Science Laboratory

The science laboratory is a safe place to work if you follow standard safety procedures. Being responsible for your own safety helps to make the entire laboratory a safer place for everyone. When performing any lab, read and apply the caution statements and safety symbol listed at the beginning of the lab.

General Safety Rules

- 1. Obtain your teacher's permission to begin all investigations and use laboratory equipment.
- **2.** Study the procedure. Ask your teacher any questions. Be sure you understand safety symbols shown on the page.
- Notify your teacher about allergies or other health conditions which can affect your participation in a lab.
- **4.** Learn and follow use and safety procedures for your equipment. If unsure, ask your teacher.



- Never eat, drink, chew gum, apply cosmetics, or do any personal grooming in the lab. Never use lab glassware as food or drink containers. Keep your hands away from your face and mouth.
- **6.** Know the location and proper use of the safety shower, eye wash, fire blanket, and fire alarm.

Prevent Accidents

- **1.** Use the safety equipment provided to you. Goggles and a safety apron should be worn during investigations.
- 2. Do NOT use hair spray, mousse, or other flammable hair products. Tie back long hair and tie down loose clothing.
- **3.** Do NOT wear sandals or other opentoed shoes in the lab.
- **4.** Remove jewelry on hands and wrists. Loose jewelry, such as chains and long necklaces, should be removed to prevent them from getting caught in equipment.
- **5.** Do not taste any substances or draw any material into a tube with your mouth.
- 6. Proper behavior is expected in the lab. Practical jokes and fooling around can lead to accidents and injury.
- 7. Keep your work area uncluttered.

Laboratory Work

- Collect and carry all equipment and materials to your work area before beginning a lab.
- 2. Remain in your own work area unless given permission by your teacher to leave it.

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Science Skill Handbook



- **3.** Always slant test tubes away from yourself and others when heating them, adding substances to them, or rinsing them.
- **4.** If instructed to smell a substance in a container, hold the container a short distance away and fan vapors towards your nose.
- **5.** Do NOT substitute other chemicals/substances for those in the materials list unless instructed to do so by your teacher.
- **6.** Do NOT take any materials or chemicals outside of the laboratory.
- **7.** Stay out of storage areas unless instructed to be there and supervised by your teacher.

Laboratory Cleanup

- **1.** Turn off all burners, water, and gas, and disconnect all electrical devices.
- **2.** Clean all pieces of equipment and return all materials to their proper places.

- 3. Dispose of chemicals and other materials as directed by your teacher. Place broken glass and solid substances in the proper containers. Never discard materials in the sink.
- **4.** Clean your work area.
- **5.** Wash your hands with soap and water thoroughly BEFORE removing your goggles.

Emergencies

- Report any fire, electrical shock, glassware breakage, spill, or injury, no matter how small, to your teacher immediately. Follow his or her instructions.
- **2.** If your clothing should catch fire, STOP, DROP, and ROLL. If possible, smother it with the fire blanket or get under a safety shower. NEVER RUN.
- **3.** If a fire should occur, turn off all gas and leave the room according to established procedures.
- **4.** In most instances, your teacher will clean up spills. Do NOT attempt to clean up spills unless you are given permission and instructions to do so.
- **5.** If chemicals come into contact with your eyes or skin, notify your teacher immediately. Use the eyewash or flush your skin or eyes with large quantities of water.
- **6.** The fire extinguisher and first-aid kit should only be used by your teacher unless it is an extreme emergency and you have been given permission.
- 7. If someone is injured or becomes ill, only a professional medical provider or someone certified in first aid should perform first-aid procedures.

Extra Try at Home Labs

EXTRA Labs

From Your Kitchen, Junk Drawer, or Yard

A Sponge of Water

Real-World Question

How much water does a sponge hold?

Possible Materials 🛭 🔯

- large natural sponge
- large artificial sponge (without soap)
- bucket
- shallow basin or pan
- water
- measuring cups (2)
- towel

🧔 Procedure

- 1. Submerge a large, natural sponge in a bucket of water for about 2 min so that it fills with water. Wait until bubbles stop rising up from the sponge.
- 2. Place the two measuring cups next to the bucket.

- 3. Carefully remove the sponge from the water and hold it over a measuring cup. Squeeze all the water out of the sponge into the measuring cup. If you reach the top mark on the measuring cup, use the second measuring cup.
- 4. Repeat steps 1–3 using the artificial sponge. Compare your results.

Conclude and Apply

- 1. How much water did each sponge hold?
- 2. Infer how Roman soldiers used sponges as canteens.



2 Invertebrate Groceries

Real-World Question

What types of invertebrates can you find in your local grocery store?

Possible Materials 🛛 🛃

- access to local grocery store
- guidebook to ocean invertebrates

procedure

- **1.** Go with an adult to the largest grocery store in your area.
- 2. Search the seafood section in the store for invertebrates sold as food.
- 3. Search the grocery aisles for invertebrate meat products.

- 4. Record all the invertebrate food you find in the store and identify each invertebrate as a mollusk, worm, arthropod, or echinoderm.
- 5. If you find more than one type of an organism such as crabs, ask a grocery store employee to identify the different types of animals for you.

Conclude and Apply

CONTENTS

- **1.** Identify the types of invertebrates you found.
- 2. What types of invertebrates were not in your grocery store?
- 3. Infer why we should be concerned about ocean pollution.

Adult supervision required for all labs.

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Extra Try at Home Labs

3 Frog Lives

Real-World Question

What do the stages of frog metamorphosis look like?

Possible Materials 🛞 🔯 📨 🖙

- gravel
- small aquarium or bucket
- water
- clean plastic milk jug
- Anacharis plants
- tadpole



🯮 Procedure

- **1.** Pour a 2-cm layer of aquarium gravel or small pebbles into a small aquarium.
- 2. Fill the aquarium with water and allow the water to sit for seven days.
- 3. Fill a clean, plastic milk jug with tap water and allow it to sit for seven days.
- 4. Plant several stalks of *Anacharis* plants in the gravel.
- 5. Purchase or catch a tadpole and place it in the aquarium along with some of the water from the place where you collected it.
- 6. Replace ten percent of the aquarium's water every other day with water from the milk jug.
- Observe your tadpole each day for 2–3 weeks as it completes its metamorphosis into a frog.

Conclude and Apply

- 1. Describe the metamorphosis of your frog.
- 2. Infer why you added the plant *Anacharis* to the aquarium.

4 Fly Like a Bird

Real-World Question

How does a bird's wings keep it in the air?

Possible Materials

- tennis ball, racquetball, or softball
- plastic, throwable disc
- stopwatch or watch with second hand

🟮 Procedure

- 1. Throw a ball in a straight line and parallel to the ground as hard as you can.
- 2. Have a partner use a stopwatch to time how long the ball stays in the air.
- 3. Throw the disc in a straight line and parallel to the ground so that it hovers.
- 4. Have a partner use a stopwatch to time how long the flying disc stays in the air.
- 5. Repeat steps 1–4 several times and record your times in your Science Journal.

🯮 Conclude and Apply

- 1. Compare the maximum time the tennis ball stayed in the air to the longest time the flying disc stayed up.
- Compare the shape of the flying disc when you hold it flat in front of you to the shape of a bird wing. How are they similar?
- 3. Infer how a bird's wings allow it to fly.

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Adult supervision required for all labs.

Extra Try at Home Labs

5 Fighting Fish

Real-World Question

How will a Siamese fighting fish react to a mirror?

Possible Materials 🛛 🐼 🐼

- small fish bowls, glass bowls, or small jars (2)
- water (aquarium, purified)
- male Siamese fighting fish (Betta splendens) (1)
- female Siamese fighting fish (Betta splendens) (1)
- mirror

Procedure

1. Place a male Siamese fighting fish in a small fish bowl with water and a female Siamese fighting fish into a second bowl with water.

- 2. Hold the mirror up to the bowl with the male fish so that he sees his reflection and observe his reaction.
- 3. Hold the mirror up to the bowl with the female fish so that she sees her reflection and observe her reaction.

Conclude and Apply

- **1.** Describe how the male and the female reacted to their reflections.
- 2. What type of behavior did the male Siamese fighting fish display?
- 3. Infer why the male fish displays this type of behavior.

Adult supervision required for all labs.

CONTENTS

Computer Skills

People who study science rely on computers, like the one in **Figure 16**, to record and store data and to analyze results from investigations. Whether you work in a laboratory or just need to write a lab report with tables, good computer skills are a necessity.

Using the computer comes with responsibility. Issues of ownership, security, and privacy can arise. Remember, if you did not author the information you are using, you must provide a source for your information. Also, anything on a computer can be accessed by others. Do not put anything on the computer that you would not want everyone to know. To add more security to your work, use a password.

Use a Word Processing Program

A computer program that allows you to type your information, change it as many times as you need to, and then print it out is called a word processing program. Word processing programs also can be used to make tables.



Figure 16 A computer will make reports neater and more professional looking.

CONTENTS

Learn the Skill To start your word processing program, a blank document, sometimes called "Document 1," appears on the screen. To begin, start typing. To create a new document, click the *New* button on the standard tool bar. These tips will help you format the document.

- The program will automatically move to the next line; press *Enter* if you wish to start a new paragraph.
- Symbols, called non-printing characters, can be hidden by clicking the *Show/Hide* button on your toolbar.
- To insert text, move the cursor to the point where you want the insertion to go, click on the mouse once, and type the text.
- To move several lines of text, select the text and click the *Cut* button on your toolbar. Then position your cursor in the location that you want to move the cut text and click *Paste*. If you move to the wrong place, click *Undo*.
- The spell check feature does not catch words that are misspelled to look like other words, like "cold" instead of "gold." Always reread your document to catch all spelling mistakes.
- To learn about other word processing methods, read the user's manual or click on the *Help* button.
- You can integrate databases, graphics, and spreadsheets into documents by copying from another program and pasting it into your document, or by using desktop publishing (DTP). DTP software allows you to put text and graphics together to finish your document with a professional look. This software varies in how it is used and its capabilities.

Technology Skill Handbook

Use a Database

A collection of facts stored in a computer and sorted into different fields is called a database. A database can be reorganized in any way that suits your needs.

Learn the Skill A computer program that allows you to create your own database is a database management system (DBMS). It allows you to add, delete, or change information. Take time to get to know the features of your database software.

- Determine what facts you would like to include and research to collect your information.
- Determine how you want to organize the information.
- Follow the instructions for your particular DBMS to set up fields. Then enter each item of data in the appropriate field.
- Follow the instructions to sort the information in order of importance.
- Evaluate the information in your database, and add, delete, or change as necessary.

Use the Internet

Technology Skill Handbook

The Internet is a global network of computers where information is stored and shared. To use the Internet, like the students in **Figure 17**, you need a modem to connect your computer to a phone line and an Internet Service Provider account.

Learn the Skill To access internet sites and information, use a "Web browser," which lets you view and explore pages on the World Wide Web. Each page is its own site, and each site has its own address, called a URL. Once you have found a Web browser, follow these steps for a search (this also is how you search a database).



Figure 17 The Internet allows you to search a global network for a variety of information.

- Be as specific as possible. If you know you want to research "gold," don't type in "elements." Keep narrowing your search until you find what you want.
- Web sites that end in .com are commercial Web sites; .org, .edu, and .gov are nonprofit, educational, or government Web sites.
- Electronic encyclopedias, almanacs, indexes, and catalogs will help locate and select relevant information.
- Develop a "home page" with relative ease. When developing a Web site, NEVER post pictures or disclose personal information such as location, names, or phone numbers. Your school or community usually can host your Web site. A basic understanding of HTML (hypertext mark-up language), the language of Web sites, is necessary. Software that creates HTML code is called authoring software, and can be downloaded free from many Web sites. This software allows text and pictures to be arranged as the software is writing the HTML code.



Use a Spreadsheet

A spreadsheet, shown in **Figure 18**, can perform mathematical functions with any data arranged in columns and rows. By entering a simple equation into a cell, the program can perform operations in specific cells, rows, or columns.

Learn the Skill Each column (vertical) is assigned a letter, and each row (horizontal) is assigned a number. Each point where a row and column intersect is called a cell, and is labeled according to where it is located— Column A, Row 1 (A1).

- Decide how to organize the data, and enter it in the correct row or column.
- Spreadsheets can use standard formulas or formulas can be customized to calculate cells.
- To make a change, click on a cell to make it activate, and enter the edited data or formula.
- Spreadsheets also can display your results in graphs. Choose the style of graph that best represents the data.

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Figure 18 A spreadsheet allows you to perform mathematical operations on your data.

Use Graphics Software

Adding pictures, called graphics, to your documents is one way to make your documents more meaningful and exciting. This software adds, edits, and even constructs graphics. There is a variety of graphics software programs. The tools used for drawing can be a mouse, keyboard, or other specialized devices. Some graphics programs are simple. Others are complicated, called computer-aided design (CAD) software.

Learn the Skill It is important to have an understanding of the graphics software being used before starting. The better the software is understood, the better the results. The graphics can be placed in a word-processing document.

- Clip art can be found on a variety of internet sites, and on CDs. These images can be copied and pasted into your document.
- When beginning, try editing existing drawings, then work up to creating drawings.
- The images are made of tiny rectangles of color called pixels. Each pixel can be altered.
- Digital photography is another way to add images. The photographs in the memory of a digital camera can be downloaded into a computer, then edited and added to the document.
- Graphics software also can allow animation. The software allows drawings to have the appearance of movement by connecting basic drawings automatically. This is called in-betweening, or tweening. Remember to save often.

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Technology Skill Handbook

Presentation Skills

Develop Multimedia Presentations

Most presentations are more dynamic if they include diagrams, photographs, videos, or sound recordings, like the one shown in **Figure 19.** A multimedia presentation involves using stereos, overhead projectors, televisions, computers, and more.

Learn the Skill Decide the main points of your presentation, and what types of media would best illustrate those points.

- Make sure you know how to use the equipment you are working with.
- Practice the presentation using the equipment several times.
- Enlist the help of a classmate to push play or turn lights out for you. Be sure to practice your presentation with him or her.
- If possible, set up all of the equipment ahead of time, and make sure everything is working properly.



Figure 19 These students are engaging the audience using a variety of tools.

Computer Presentations

There are many different interactive computer programs that you can use to enhance your presentation. Most computers have a compact disc (CD) drive that can play both CDs and digital video discs (DVDs). Also, there is hardware to connect a regular CD, DVD, or VCR. These tools will enhance your presentation.

Another method of using the computer to aid in your presentation is to develop a slide show using a computer program. This can allow movement of visuals at the presenter's pace, and can allow for visuals to build on one another.

Learn the Skill In order to create multimedia presentations on a computer, you need to have certain tools. These may include traditional graphic tools and drawing programs, animation programs, and authoring systems that tie everything together. Your computer will tell you which tools it supports. The most important step is to learn about the tools that you will be using.

- Often, color and strong images will convey a point better than words alone. Use the best methods available to convey your point.
- As with other presentations, practice many times.
- Practice your presentation with the tools you and any assistants will be using.
- Maintain eye contact with the audience. The purpose of using the computer is not to prompt the presenter, but to help the audience understand the points of the presentation.





Math Review

Use Fractions

A fraction compares a part to a whole. In the fraction $\frac{2}{3}$, the 2 represents the part and is the numerator. The 3 represents the whole and is the denominator.

Reduce Fractions To reduce a fraction, you must find the largest factor that is common to both the numerator and the denominator, the greatest common factor (GCF). Divide both numbers by the GCF. The fraction has then been reduced, or it is in its simplest form.

Example Twelve of the 20 chemicals in the science lab are in powder form. What fraction of the chemicals used in the lab are in powder form?

Step 1 Write the fraction.

- $\frac{\text{part}}{\text{whole}} = \frac{12}{20}$
- Step 2 To find the GCF of the numerator and denominator, list all of the factors of each number. Factors of 12: 1, 2, 3, 4, 6, 12 (the numbers that divide evenly into 12) Factors of 20: 1, 2, 4, 5, 10, 20 (the numbers that divide evenly into 20)
- Step 3 List the common factors. 1, 2, 4.
- **Step 4** Choose the greatest factor in the list. The GCF of 12 and 20 is 4.
- **Step 5** Divide the numerator and denominator by the GCF. $\frac{12 \div 4}{20 \div 4} = \frac{3}{5}$

In the lab, $\frac{3}{5}$ of the chemicals are in powder form.

Practice Problem At an amusement park, 66 of 90 rides have a height restriction. What fraction of the rides, in its simplest form, has a height restriction?

Add and Subtract Fractions To add or subtract fractions with the same denominator, add or subtract the numerators and write the sum or difference over the denominator. After finding the sum or difference, find the simplest form for your fraction.

Example 1 In the forest outside your house, $\frac{1}{8}$ of the animals are rabbits, $\frac{3}{8}$ are squirrels, and the remainder are birds and insects. How many are mammals?

Step 1 Add the numerators.

$$\frac{1}{8} + \frac{3}{8} = \frac{(1+3)}{8} = \frac{4}{8}$$

Step 2 Find the GCF.

$$\frac{4}{8}$$
 (GCF, 4)

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{4}{4} = 1, \ \frac{8}{4} = 2$$

 $\frac{1}{2}$ of the animals are mammals.

Example 2 If $\frac{7}{16}$ of the Earth is covered by freshwater, and $\frac{1}{16}$ of that is in glaciers, how much freshwater is not frozen?

Step 1 Subtract the numerators.

 $\frac{7}{16} - \frac{1}{16} = \frac{(7-1)}{16} = \frac{6}{16}$

Step 2 Find the GCF.

CONTENTS

$$\frac{6}{16}$$
 (GCF, 2)

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{6}{2} = 3, \ \frac{16}{2} = 8$$

 $\frac{3}{8}$ of the freshwater is not frozen.

Practice Problem A bicycle rider is going 15 km/h for $\frac{4}{9}$ of his ride, 10 km/h for $\frac{2}{9}$ of his ride, and 8 km/h for the remainder of the ride. How much of his ride is he going over 8 km/h?

Math Skill Handbook

Unlike Denominators To add or subtract fractions with unlike denominators, first find the least common denominator (LCD). This is the smallest number that is a common multiple of both denominators. Rename each fraction with the LCD, and then add or subtract. Find the simplest form if necessary.

Example 1 A chemist makes a paste that is $\frac{1}{2}$ table salt (NaCl), $\frac{1}{3}$ sugar (C₆H₁₂O₆), and the rest water (H₂O). How much of the paste is a solid?

Step 1 Find the LCD of the fractions.

 $\frac{1}{2} + \frac{1}{3}$ (LCD, 6)

Step 2 Rename each numerator and each denominator with the LCD.

 $1 \times 3 = 3$, $2 \times 3 = 6$ $1 \times 2 = 2, 3 \times 2 = 6$

Step 3 Add the numerators.

 $\frac{3}{6} + \frac{2}{6} = \frac{(3+2)}{6} = \frac{5}{6}$

 $\frac{5}{6}$ of the paste is a solid.

Example 2 The average precipitation in Grand Junction, CO, is $\frac{7}{10}$ inch in November, and $\frac{3}{5}$ inch in December. What is the total average precipitation?

Step 1 Find the LCD of the fractions.

 $\frac{7}{10} + \frac{3}{5}$ (LCD, 10)

Step 2 Rename each numerator and each denominator with the LCD.

$7 \times 1 = 7$,	$10 \times 1 = 10$
$3 \times 2 = 6$,	$5 \times 2 = 10$

Step 3 Add the numerators.

$$\frac{7}{10} + \frac{6}{10} = \frac{(7+6)}{10} = \frac{13}{10}$$

$$\frac{13}{10}$$
 inches total precipitation, or $1\frac{3}{10}$ inches.

Practice Problem On an electric bill, about $\frac{1}{8}$ of the energy is from solar energy and about $\frac{1}{10}$ is from wind power. How much of the total bill is from solar energy and wind power combined?

Example 3 In your body, $\frac{7}{10}$ of your muscle contractions are involuntary (cardiac and smooth muscle tissue). Smooth muscle makes $\frac{3}{15}$ of your muscle contractions. How many of your muscle contractions are made by cardiac muscle?

Step 1 Find the LCD of the fractions. 7 3 (160.20)

$$\frac{10}{10} = \frac{1}{15}$$
 (LCD, 30)

Step 2 Rename each numerator and each denominator with the LCD.

> $7 \times 3 = 21, 10 \times 3 = 30$ $3 \times 2 = 6$, $15 \times 2 = 30$

- **Step 3** Subtract the numerators. $\frac{21}{30} \frac{6}{30} = \frac{(21 6)}{30} = \frac{15}{30}$
- Step 4 Find the GCF.

$$\frac{15}{30}$$
 (GCF, 15)
 $\frac{1}{2}$

 $\frac{1}{2}$ of all muscle contractions are cardiac muscle.

Example 4 Tony wants to make cookies that call for $\frac{3}{4}$ of a cup of flour, but he only has $\frac{1}{3}$ of a cup. How much more flour does he need?

Step 1 Find the LCD of the fractions.

$$\frac{3}{4} - \frac{1}{3}$$
 (LCD, 12)

Step 2 Rename each numerator and each denominator with the LCD.

$$3 \times 3 = 9, 4 \times 3 = 12$$

 $1 \times 4 = 4, 3 \times 4 = 12$

Step 3 Subtract the numerators.

$$\frac{9}{12} - \frac{4}{12} = \frac{(9-4)}{12} = \frac{5}{12}$$

 $\frac{5}{12}$ of a cup of flour.

Practice Problem Using the information provided to you in Example 3 above, determine how many muscle contractions are voluntary (skeletal muscle).



Multiply Fractions To multiply with fractions, multiply the numerators and multiply the denominators. Find the simplest form if necessary.

Example Multiply $\frac{3}{5}$ by $\frac{1}{3}$. **Step 1** Multiply the numerators and denominators. $\frac{3}{5} \times \frac{1}{3} = \frac{(3 \times 1)}{(5 \times 3)} = \frac{3}{15}$

 $\frac{3}{15}$ (GCF, 3)

Step 3 Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \frac{15}{3} = 5$$

 $\frac{1}{5}$
 $\frac{3}{5}$ multiplied by $\frac{1}{3}$ is $\frac{1}{5}$.

Practice Problem Multiply $\frac{3}{14}$ by $\frac{5}{16}$.

Find a Reciprocal Two numbers whose product is 1 are called multiplicative inverses, or reciprocals.

Example Find the reciprocal of $\frac{3}{8}$.

Step 1 Inverse the fraction by putting the denominator on top and the numerator on the bottom. $\frac{8}{3}$

The reciprocal of $\frac{3}{8}$ is $\frac{8}{3}$.

Practice Problem Find the reciprocal of $\frac{4}{9}$.

Divide Fractions To divide one fraction by another fraction, multiply the dividend by the reciprocal of the divisor. Find the simplest form if necessary.

Example 1 Divide $\frac{1}{9}$ by $\frac{1}{3}$.

Step 1 Find the reciprocal of the divisor. The reciprocal of $\frac{1}{3}$ is $\frac{3}{1}$.

Step 2 Multiply the dividend by the reciprocal of the divisor.

$$\frac{1}{9}{\frac{1}{9}}{\frac{1}{9}}{\frac{1}{9}}{\frac{1}{9}}{\frac{3}{1}}{\frac{1}{9}}{\frac{1}{9}}{\frac{1}{1}}{\frac{1}{9}}{\frac{$$

Step 3 Find the GCF.

Step 4 Divide the numerator and denominator by the GCF.

$$\frac{3}{3} = 1, \frac{9}{3} = 3$$

 $\frac{1}{3}$
divided by $\frac{1}{3}$ is $\frac{1}{3}$.

1

9

Example 2 Divide $\frac{3}{5}$ by $\frac{1}{4}$.

Step 1 Find the reciprocal of the divisor.

The reciprocal of $\frac{1}{4}$ is $\frac{4}{1}$.

Step 2 Multiply the dividend by the reciprocal of the divisor.

$$\frac{\frac{3}{5}}{\frac{1}{4}} = \frac{3}{5} \times \frac{4}{1} = \frac{(3 \times 4)}{(5 \times 1)} = \frac{12}{5}$$

 $\frac{3}{5}$ divided by $\frac{1}{4}$ is $\frac{12}{5}$ or $2\frac{2}{5}$.

Practice Problem Divide $\frac{3}{11}$ by $\frac{7}{10}$.



Use Ratios

When you compare two numbers by division, you are using a ratio. Ratios can be written 3 to 5, 3:5, or $\frac{3}{5}$. Ratios, like fractions, also can be written in simplest form.

Ratios can represent probabilities, also called odds. This is a ratio that compares the number of ways a certain outcome occurs to the number of outcomes. For example, if you flip a coin 100 times, what are the odds that it will come up heads? There are two possible outcomes, heads or tails, so the odds of coming up heads are 50:100. Another way to say this is that 50 out of 100 times the coin will come up heads. In its simplest form, the ratio is 1:2.

Example 1 A chemical solution contains 40 g of salt and 64 g of baking soda. What is the ratio of salt to baking soda as a fraction in simplest form?

- **Step 1** Write the ratio as a fraction. $\frac{\text{salt}}{\text{baking soda}} = \frac{40}{64}$
- **Step 2** Express the fraction in simplest form. The GCF of 40 and 64 is 8. $40 \quad 40 \div 8 \quad 5$

 $\frac{40}{64} = \frac{40 \div 8}{64 \div 8} = \frac{5}{8}$

The ratio of salt to baking soda in the sample is 5:8.

Example 2 Sean rolls a 6-sided die 6 times. What are the odds that the side with a 3 will show?

Step 1 Write the ratio as a fraction.

 $\frac{\text{number of sides with a 3}}{\text{number of sides}} = \frac{1}{6}$

Step 2 Multiply by the number of attempts.

 $\frac{1}{6} \times 6$ attempts $= \frac{6}{6}$ attempts = 1 attempt

1 attempt out of 6 will show a 3.

Practice Problem Two metal rods measure 100 cm and 144 cm in length. What is the ratio of their lengths in simplest form?

Use Decimals

A fraction with a denominator that is a power of ten can be written as a decimal. For example, 0.27 means $\frac{27}{100}$. The decimal point separates the ones place from the tenths place.

Any fraction can be written as a decimal using division. For example, the fraction $\frac{5}{8}$ can be written as a decimal by dividing 5 by 8. Written as a decimal, it is 0.625.

Add or Subtract Decimals When adding and subtracting decimals, line up the decimal points before carrying out the operation.

Example 1 Find the sum of 47.68 and 7.80.

- Step 1 Line up the decimal places when you write the numbers.
 47.68
 47.80
 Step 2 Add the decimals.
 - 47.68 + 7.80 55.48

The sum of 47.68 and 7.80 is 55.48.

Example 2 Find the difference of 42.17 and 15.85.

Step 2 Subtract the decimals.

The difference of 42.17 and 15.85 is 26.32.

Practice Problem Find the sum of 1.245 and 3.842.



Multiply Decimals To multiply decimals, multiply the numbers like any other number, ignoring the decimal point. Count the decimal places in each factor. The product will have the same number of decimal places as the sum of the decimal places in the factors.

Example Multiply 2.4 by 5.9.

- **Step 1** Multiply the factors like two whole numbers. $24 \times 59 = 1416$
- **Step 2** Find the sum of the number of decimal places in the factors. Each factor has one decimal place, for a sum of two decimal places.
- **Step 3** The product will have two decimal places. 14.16

The product of 2.4 and 5.9 is 14.16.

Practice Problem Multiply 4.6 by 2.2.

Divide Decimals When dividing decimals, change the divisor to a whole number. To do this, multiply both the divisor and the dividend by the same power of ten. Then place the decimal point in the quotient directly above the decimal point in the dividend. Then divide as you do with whole numbers.

Example Divide 8.84 by 3.4.

Step 1 Multiply both factors by 10. $3.4 \times 10 = 34, 8.84 \times 10 = 88.4$

Step 2 Divide 88.4 by 34.

 $\begin{array}{r}
 2.6 \\
 34)88.4 \\
 -\underline{68} \\
 204 \\
 -\underline{204} \\
 0
 \end{array}$

8.84 divided by 3.4 is 2.6.

Practice Problem Divide 75.6 by 3.6.

Use Proportions

An equation that shows that two ratios are equivalent is a proportion. The ratios $\frac{2}{4}$ and $\frac{5}{10}$ are equivalent, so they can be written as $\frac{2}{4} = \frac{5}{10}$. This equation is a proportion.

When two ratios form a proportion, the cross products are equal. To find the cross products in the proportion $\frac{2}{4} = \frac{5}{10}$, multiply the 2 and the 10, and the 4 and the 5. Therefore $2 \times 10 = 4 \times 5$, or 20 = 20.

Because you know that both proportions are equal, you can use cross products to find a missing term in a proportion. This is known as solving the proportion.

Example The heights of a tree and a pole are proportional to the lengths of their shadows. The tree casts a shadow of 24 m when a 6-m pole casts a shadow of 4 m. What is the height of the tree?

- Step 1Write a proportion. $height of tree \\ height of pole = length of tree's shadow$
- **Step 2** Substitute the known values into the proportion. Let *h* represent the unknown value, the height of the tree.

$$\frac{h}{6} = \frac{2}{4}$$

- **Step 3** Find the cross products. $h \times 4 = 6 \times 24$
- **Step 4** Simplify the equation. 4h = 144

Step 5 Divide each side by 4.

$$\frac{4h}{4} = \frac{144}{4}$$
$$h = 36$$

The height of the tree is 36 m.

Practice Problem The ratios of the weights of two objects on the Moon and on Earth are in proportion. A rock weighing 3 N on the Moon weighs 18 N on Earth. How much would a rock that weighs 5 N on the Moon weigh on Earth?



Use Percentages

The word *percent* means "out of one hundred." It is a ratio that compares a number to 100. Suppose you read that 77 percent of the Earth's surface is covered by water. That is the same as reading that the fraction of the Earth's surface covered by water is $\frac{77}{100}$. To express a fraction as a percent, first find the equivalent decimal for the fraction. Then, multiply the decimal by 100 and add the percent symbol.

Example Express $\frac{13}{20}$ as a percent.

Step 1 Find the equivalent decimal for the fraction.

		.65
20)1	3	.00
1	2	0
	1	00
	1	00
		0

Step 2 Rewrite the fraction
$$\frac{13}{20}$$
 as 0.65.

Step 3 Multiply 0.65 by 100 and add the % sign. $0.65 \times 100 = 65 = 65\%$

So, $\frac{13}{20} = 65\%$.

This also can be solved as a proportion.

Example Express $\frac{13}{20}$ as a percent.

Step 1 Write a proportion.

$$\frac{13}{20} = \frac{x}{100}$$

Step 2 Find the cross products. 1300 = 20x

Step 3 Divide each side by 20. $\frac{1300}{20} = \frac{20x}{20}$ 65% = x

Practice Problem In one year, 73 of 365 days were rainy in one city. What percent of the days in that city were rainy?

Solve One-Step Equations

A statement that two things are equal is an equation. For example, A = B is an equation that states that A is equal to B.

An equation is solved when a variable is replaced with a value that makes both sides of the equation equal. To make both sides equal the inverse operation is used. Addition and subtraction are inverses, and multiplication and division are inverses.

Example 1 Solve the equation x - 10 = 35.

Step 1 Find the solution by adding 10 to each side of the equation.

$$x - 10 = 35$$

 $x - 10 + 10 = 35 + 10$
 $x = 45$

Step 2 Check the solution.

$$x - 10 = 35$$

 $45 - 10 = 35$
 $35 = 35$

Both sides of the equation are equal, so x = 45.

Example 2 In the formula a = bc, find the value of c if a = 20 and b = 2.

a = bc**Step 1** Rearrange the formula so $\frac{a}{b} = \frac{bc}{b}$ the unknown value is by itself on one side of the $\frac{a}{b} = c$ equation by dividing both sides by b. $\frac{a}{b} = c$ **Step 2** Replace the variables *a* and *b* with the values that $\frac{20}{2} = c$ are given. 10 = *c* **Step 3** Check the solution. a = bc $20 = 2 \times 10$ 20 = 20

Both sides of the equation are equal, so c = 10 is the solution when a = 20 and b = 2.

Practice Problem In the formula h = gd, find the value of *d* if g = 12.3 and h = 17.4.



Use Statistics

The branch of mathematics that deals with collecting, analyzing, and presenting data is statistics. In statistics, there are three common ways to summarize data with a single number—the mean, the median, and the mode.

The **mean** of a set of data is the arithmetic average. It is found by adding the numbers in the data set and dividing by the number of items in the set.

The **median** is the middle number in a set of data when the data are arranged in numerical order. If there were an even number of data points, the median would be the mean of the two middle numbers.

The **mode** of a set of data is the number or item that appears most often.

Another number that often is used to describe a set of data is the range. The **range** is the difference between the largest number and the smallest number in a set of data.

A **frequency table** shows how many times each piece of data occurs, usually in a survey. **Table 2** below shows the results of a student survey on favorite color.

Table 2 Student Color Choice						
Color	Tally	Frequency				
red		4				
blue	╫╫	5				
black		2				
green		3				
purple	 	7				
yellow	+++++	6				

Based on the frequency table data, which color is the favorite?

Example The speeds (in m/s) for a race car during five different time trials are 39, 37, 44, 36, and 44.

To find the mean:

Step 1 Find the sum of the numbers.

39 + 37 + 44 + 36 + 44 = 200

Step 2 Divide the sum by the number of items, which is 5.

$$200 \div 5 = 40$$

The mean is 40 m/s.

To find the median:

Step 1 Arrange the measures from least to greatest. 36, 37, 39, 44, 44

Step 2 Determine the middle measure. 36, 37, <u>39</u>, 44, 44

The median is 39 m/s.

To find the mode:

Step 1 Group the numbers that are the same together. 44, 44, 36, 37, 39

Step 2 Determine the number that occurs most in the set.

<u>44, 44</u>, 36, 37, 39

The mode is 44 m/s.

To find the range:

- **Step 1** Arrange the measures from largest to smallest. 44, 44, 39, 37, 36
- **Step 2** Determine the largest and smallest measures in the set.

<u>44, 44, 39, 37, 36</u>

Step 3 Find the difference between the largest and smallest measures.

44 - 36 = 8

The range is 8 m/s.

CONTENTS

Practice Problem Find the mean, median, mode, and range for the data set 8, 4, 12, 8, 11, 14, 16.



Use Geometry

The branch of mathematics that deals with the measurement, properties, and relationships of points, lines, angles, surfaces, and solids is called geometry.

Perimeter The **perimeter** (*P*) is the distance around a geometric figure. To find the perimeter of a rectangle, add the length and width and multiply that sum by two, or 2(l + w). To find perimeters of irregular figures, add the length of the sides.

Example 1 Find the perimeter of a rectangle that is 3 m long and 5 m wide.

- **Step 1** You know that the perimeter is 2 times the sum of the width and length. P = 2(3 m + 5 m)
- **Step 2** Find the sum of the width and length. P = 2(8 m)
- **Step 3** Multiply by 2. P = 16 m

The perimeter is 16 m.

Example 2 Find the perimeter of a shape with sides measuring 2 cm, 5 cm, 6 cm, 3 cm.

Step 1 You know that the perimeter is the sum of all the sides.

P = 2 + 5 + 6 + 3

Step 2 Find the sum of the sides.

$$P = 2 + 5 + 6 + 3$$

 $P = 16$

The perimeter is 16 cm.

Practice Problem Find the perimeter of a rectangle with a length of 18 m and a width of 7 m.

Practice Problem Find the perimeter of a triangle measuring 1.6 cm by 2.4 cm by 2.4 cm.

Area of a Rectangle The **area** (*A*) is the number of square units needed to cover a surface. To find the area of a rectangle, multiply the length times the width, or $l \times w$. When finding area, the units also are multiplied. Area is given in square units.

Example Find the area of a rectangle with a length of 1 cm and a width of 10 cm.

- **Step 1** You know that the area is the length multiplied by the width. $A = (1 \text{ cm} \times 10 \text{ cm})$
- **Step 2** Multiply the length by the width. Also multiply the units. $A = 10 \text{ cm}^2$

The area is 10 cm².

Practice Problem Find the area of a square whose sides measure 4 m.

Area of a Triangle To find the area of a triangle, use the formula:

$$A = \frac{1}{2}(\text{base} \times \text{height})$$

The base of a triangle can be any of its sides. The height is the perpendicular distance from a base to the opposite endpoint, or vertex.

Example Find the area of a triangle with a base of 18 m and a height of 7 m.

- **Step 1** You know that the area is $\frac{1}{2}$ the base times the height. $A = \frac{1}{2}(18 \text{ m} \times 7 \text{ m})$
- **Step 2** Multiply $\frac{1}{2}$ by the product of 18 \times 7. Multiply the units.

$$A = \frac{1}{2}(126 \text{ m}^2)$$

 $A = 63 \text{ m}^2$

The area is 63 m².

Practice Problem Find the area of a triangle with a base of 27 cm and a height of 17 cm.



Circumference of a Circle The diameter (d) of a circle is the distance across the circle through its center, and the **radius** (r) is the distance from the center to any point on the circle. The radius is half of the diameter. The distance around the circle is called the **circumference** (C). The formula for finding the circumference is:

 $C = 2\pi r \text{ or } C = \pi d$

The circumference divided by the diameter is always equal to 3.1415926... This nonterminating and nonrepeating number is represented by the Greek letter π (pi). An approximation often used for π is 3.14.

Example 1 Find the circumference of a circle with a radius of 3 m.

Step 1 You know the formula for the circumference is 2 times the radius times π . C = $2\pi(3)$

- **Step 2** Multiply 2 times the radius. $C = 6\pi$
- **Step 3** Multiply by π . C = 19 m

The circumference is 19 m.

Example 2 Find the circumference of a circle with a diameter of 24.0 cm.

- **Step 1** You know the formula for the circumference is the diameter times π . $C = \pi(24.0)$
- **Step 2** Multiply the diameter by π . C = 75.4 cm

The circumference is 75.4 cm.

Practice Problem Find the circumference of a circle with a radius of 19 cm.

Area of a Circle The formula for the area of a circle is: $A = \pi r^2$

Example 1 Find the area of a circle with a radius of 4.0 cm.

Step 1 $A = \pi (4.0)^2$

- **Step 2** Find the square of the radius. $A = 16\pi$
- **Step 3** Multiply the square of the radius by π . $A = 50 \text{ cm}^2$

The area of the circle is 50 cm².

Example 2 Find the area of a circle with a radius of 225 m.

Step 1 $A = \pi (225)^2$

- **Step 2** Find the square of the radius. $A = 50625\pi$
- **Step 3** Multiply the square of the radius by π . A = 158962.5

The area of the circle is 158,962 m².

Example 3 Find the area of a circle whose diameter is 20.0 mm.

Step 1 You know the formula for the area of a circle is the square of the radius times π , and that the radius is half of the diameter. $A = \pi (20.0)^2$

$$A = \pi \left(\frac{20.0}{2}\right)^2$$

- **Step 2** Find the radius. $A = \pi (10.0)^2$
- **Step 3** Find the square of the radius. $A = 100\pi$
- **Step 4** Multiply the square of the radius by π . $A = 314 \text{ mm}^2$

The area is 314 mm².

CONTENTS

Practice Problem Find the area of a circle with a radius of 16 m.



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Volume The measure of space occupied by a solid is the **volume** (*V*). To find the volume of a rectangular solid multiply the length times width times height, or $V = l \times w \times h$. It is measured in cubic units, such as cubic centimeters (cm³).

Example Find the volume of a rectangular solid with a length of 2.0 m, a width of 4.0 m, and a height of 3.0 m.

- **Step 1** You know the formula for volume is the length times the width times the height. $V = 2.0 \text{ m} \times 4.0 \text{ m} \times 3.0 \text{ m}$
- **Step 2** Multiply the length times the width times the height.
 - $V = 24 \text{ m}^3$

The volume is 24 m³.

Practice Problem Find the volume of a rectangular solid that is 8 m long, 4 m wide, and 4 m high.

To find the volume of other solids, multiply the area of the base times the height.

Example 1 Find the volume of a solid that has a triangular base with a length of 8.0 m and a height of 7.0 m. The height of the entire solid is 15.0 m.

Step 1 You know that the base is a triangle, and the area of a triangle is $\frac{1}{2}$ the base times the height, and the volume is the area of the base times the height.

 $V = \left[\frac{1}{2} (b \times h)\right] \times 15$

Step 2 Find the area of the base.

$$V = \left[\frac{1}{2} (8 \times 7)\right] \times 15$$
$$V = \left(\frac{1}{2} \times 56\right) \times 15$$

Step 3 Multiply the area of the base by the height of the solid.

 $V = 28 \times 15$ $V = 420 \text{ m}^3$

The volume is 420 m³.

Example 2 Find the volume of a cylinder that has a base with a radius of 12.0 cm, and a height of 21.0 cm.

Step 1 You know that the base is a circle, and the area of a circle is the square of the radius times π , and the volume is the area of the base times the height. $V = (\pi r^2) \times 21$

$$V = (\pi T^2) \times 21$$

 $V = (\pi 12^2) \times 21$

Step 2 Find the area of the base.

$$V = 144\pi \times 2^{\circ}$$
$$V = 452 \times 21$$

Step 3 Multiply the area of the base by the height of the solid. $V = 9490 \text{ cm}^3$

The volume is 9490 cm³.

Example 3 Find the volume of a cylinder that has a diameter of 15 mm and a height of 4.8 mm.

Step 1 You know that the base is a circle with an area equal to the square of the radius times π . The radius is one-half the diameter. The volume is the area of the base times the height.

$$V = (\pi r^2) \times 4.8$$
$$V = \left[\pi \left(\frac{1}{2} \times 15\right)^2\right] \times 4.8$$
$$V = (\pi 7.5^2) \times 4.8$$

Step 2 Find the area of the base.

$$V = 56.25\pi \times 4.8$$

 $V = 176.63 \times 4.8$

Step 3 Multiply the area of the base by the height of the solid. V = 847.8

The volume is 847.8 mm³.

Practice Problem Find the volume of a cylinder with a diameter of 7 cm in the base and a height of 16 cm.



Science Applications

Measure in SI

The metric system of measurement was developed in 1795. A modern form of the metric system, called the International System (SI), was adopted in 1960 and provides the standard measurements that all scientists around the world can understand.

The SI system is convenient because unit sizes vary by powers of 10. Prefixes are used to name units. Look at **Table 3** for some common SI prefixes and their meanings.

Table 3 Common SI Prefixes						
Prefix	Symbol	Me	aning			
kilo-	k	1,000	thousand			
hecto-	h	100	hundred			
deka-	da	10	ten			
deci-	d	0.1	tenth			
centi-	с	0.01	hundredth			
milli-	m	0.001	thousandth			

Example How many grams equal one kilogram?

- **Step 1** Find the prefix *kilo* in **Table 3**.
- **Step 2** Using **Table 3**, determine the meaning of *kilo*. According to the table, it means 1,000. When the prefix *kilo* is added to a unit, it means that there are 1,000 of the units in a *"kilo*unit."
- **Step 3** Apply the prefix to the units in the question. The units in the question are grams. There are 1,000 grams in a kilogram.

Practice Problem Is a milligram larger or smaller than a gram? How many of the smaller units equal one larger unit? What fraction of the larger unit does one smaller unit represent?

Dimensional Analysis

Convert SI Units In science, quantities such as length, mass, and time sometimes are measured using different units. A process called dimensional analysis can be used to change one unit of measure to another. This process involves multiplying your starting quantity and units by one or more conversion factors. A conversion factor is a ratio equal to one and can be made from any two equal quantities with different units. If 1,000 mL equal 1 L then two ratios can be made.

$$\frac{1,000 \text{ mL}}{1 \text{ L}} = \frac{1 \text{ L}}{1,000 \text{ mL}} = 1$$

One can covert between units in the SI system by using the equivalents in **Table 3** to make conversion factors.

Example 1 How many cm are in 4 m?

Step 1 Write conversion factors for the units given.From Table 3, you know that 100 cm = 1 m.The conversion factors are

$$\frac{100 \text{ cm}}{1 \text{ m}} \text{ and } \frac{1 \text{ m}}{100 \text{ cm}}$$

Step 2 Decide which conversion factor to use. Select the factor that has the units you are converting from (m) in the denominator and the units you are converting to (cm) in the numerator.

<u>100 cm</u> 1 m

Step 3 Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. There are 400 cm in 4 m.

$$4 \text{m} \times \frac{100 \text{ cm}}{1 \text{m}} = 400 \text{ cm}$$

Practice Problem How many milligrams are in one kilogram? (Hint: You will need to use two conversion factors from **Table 3.**)



Table 4 Unit System E	quivalents
Type of Measurement	Equivalent
Length	1 in = 2.54 cm
	1 yd = 0.91 m
	1 mi = 1.61 km
Mass	1 oz = 28.35 g
and	1 lb = 0.45 kg
Weight*	1 ton (short) = 0.91 tonnes (metric tons)
	1 lb = 4.45 N
Volume	$1 \text{ in}^3 = 16.39 \text{ cm}^3$
	1 qt = 0.95 L
	1 gal = 3.78 L
Area	$1 \text{ in}^2 = 6.45 \text{ cm}^2$
	$1 \text{ yd}^2 = 0.83 \text{ m}^2$
	$1 \text{ mi}^2 = 2.59 \text{ km}^2$
	1 acre $=$ 0.40 hectares
Temperature	$^{\circ}C = (^{\circ}F - 32)$
	1.8
	K = °C + 273

*Weight is measured in standard Earth gravity.

Convert Between Unit Systems Table 4

gives a list of equivalents that can be used to convert between English and SI units.

Example If a meterstick has a length of 100 cm, how long is the meterstick in inches?

Step 1 Write the conversion factors for the units given. From **Table 4**, 1 in = 2.54 cm.

 $\frac{1 \text{ in}}{2.54 \text{ cm}}$ and $\frac{2.54 \text{ cm}}{1 \text{ in}}$

- **Step 2** Determine which conversion factor to use. You are converting from cm to in. Use the conversion factor with cm on the bottom.
 - 1 in 2.54 cm

Step 3 Multiply the starting quantity and units by the conversion factor. Cancel the starting units with the units in the denominator. Round your answer based on the number of significant figures in the conversion factor.

$$100\,\mathrm{cm} imesrac{1\,\mathrm{in}}{2.54\,\mathrm{cm}}=39.37\,\mathrm{ir}$$

The meterstick is 39.4 in long.

CONTENTS

Practice Problem A book has a mass of 5 lbs. What is the mass of the book in kg?

Practice Problem Use the equivalent for in and cm (1 in = 2.54 cm) to show how $1 \text{ in}^3 = 16.39 \text{ cm}^3$.

Precision and Significant Digits

When you make a measurement, the value you record depends on the precision of the measuring instrument. This precision is represented by the number of significant digits recorded in the measurement. When counting the number of significant digits, all digits are counted except zeros at the end of a number with no decimal point such as 2,050, and zeros at the beginning of a decimal such as 0.03020. When adding or subtracting numbers with different precision, round the answer to the smallest number of decimal places of any number in the sum or difference. When multiplying or dividing, the answer is rounded to the smallest number of significant digits of any number being multiplied or divided.

Example The lengths 5.28 and 5.2 are measured in meters. Find the sum of these lengths and record your answer using the correct number of significant digits.

Step 1 Find the sum.

5.28 m	2 digits after the decimal
+ 5.2 m	1 digit after the decimal
10.48 m	

Step 2 Round to one digit after the decimal because the least number of digits after the decimal of the numbers being added is 1.

The sum is 10.5 m.

Practice Problem How many significant digits are in the measurement 7,071,301 m? How many significant digits are in the measurement 0.003010 g?

Practice Problem Multiply 5.28 and 5.2 using the rule for multiplying and dividing. Record the answer using the correct number of significant digits.

Scientific Notation

Many times numbers used in science are very small or very large. Because these numbers are difficult to work with scientists use scientific notation. To write numbers in scientific notation, move the decimal point until only one non-zero digit remains on the left. Then count the number of places you moved the decimal point and use that number as a power of ten. For example, the average distance from the Sun to Mars is 227,800,000,000 m. In scientific notation, this distance is 2.278×10^{11} m. Because you moved the decimal point to the left, the number is a positive power of ten.

Example Earth is 149,600,000 km from the Sun. Express this in scientific notation.

- Step 1 Move the decimal point until one non-zero digit remains on the left. 1.496 000 00
- Step 2 Count the number of decimal places you have moved. In this case, eight.
- **Step 3** Show that number as a power of ten, 10⁸.
- The Earth is 1.496 imes 10⁸ km from the Sun.

Practice Problem How many significant digits are in 149,600,000 km? How many significant digits are in 1.496 \times 10⁸ km?

Practice Problem Parts used in a high performance car must be measured to 7×10^{-6} m. Express this number as a decimal.

Practice Problem A CD is spinning at 539 revolutions per minute. Express this number in scientific notation.



Math Skill Handbook

Make and Use Graphs

Data in tables can be displayed in a graph—a visual representation of data. Common graph types include line graphs, bar graphs, and circle graphs.

Line Graph A line graph shows a relationship between two variables that change continuously. The independent variable is changed and is plotted on the *x*-axis. The dependent variable is observed, and is plotted on the *y*-axis.

Example Draw a line graph of the data below from a cyclist in a long-distance race.

Table 5 Bicycle Race Data				
Time (h)	Distance (km)			
0	0			
1	8			
2	16			
3	24			
4	32			
5	40			

- **Step 1** Determine the *x*-axis and *y*-axis variables. Time varies independently of distance and is plotted on the *x*-axis. Distance is dependent on time and is plotted on the *y*-axis.
- **Step 2** Determine the scale of each axis. The *x*-axis data ranges from 0 to 5. The *y*-axis data ranges from 0 to 40.
- **Step 3** Using graph paper, draw and label the axes. Include units in the labels.
- **Step 4** Draw a point at the intersection of the time value on the *x*-axis and corresponding distance value on the *y*-axis. Connect the points and label the graph with a title, as shown in **Figure 20.**

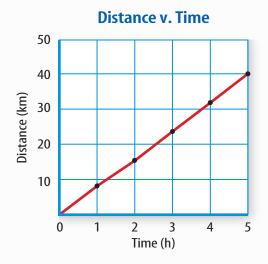


Figure 20 This line graph shows the relationship between distance and time during a bicycle ride.

Practice Problem A puppy's shoulder height is measured during the first year of her life. The following measurements were collected: (3 mo, 52 cm), (6 mo, 72 cm), (9 mo, 83 cm), (12 mo, 86 cm). Graph this data.

Find a Slope The slope of a straight line is the ratio of the vertical change, rise, to the horizontal change, run.

Slope =
$$\frac{\text{vertical change (rise)}}{\text{horizontal change (run)}} = \frac{\text{change in } y}{\text{change in } x}$$

- **Example** Find the slope of the graph in **Figure 20.**
- **Step 1** You know that the slope is the change in *y* divided by the change in *x*. Slope $= \frac{\text{change in } y}{\text{change in } x}$
- **Step 2** Determine the data points you will be using. For a straight line, choose the two sets of points that are the farthest apart. Slope $= \frac{(40-0) \text{ km}}{(5-0) \text{ hr}}$
- **Step 3** Find the change in *y* and *x*. Slope $= \frac{40 \text{ km}}{r^{\text{b}}}$
- **Step 4** Divide the change in *y* by the change in *x*. Slope $= \frac{8 \text{ km}}{h}$

The slope of the graph is 8 km/h.

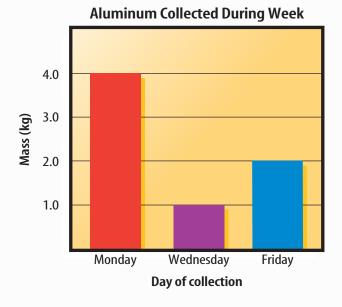


Math Skill Handbook

Bar Graph To compare data that does not change continuously you might choose a bar graph. A bar graph uses bars to show the relationships between variables. The *x*-axis variable is divided into parts. The parts can be numbers such as years, or a category such as a type of animal. The *y*-axis is a number and increases continuously along the axis.

Example A recycling center collects 4.0 kg of aluminum on Monday, 1.0 kg on Wednesday, and 2.0 kg on Friday. Create a bar graph of this data.

- **Step 1** Select the *x*-axis and *y*-axis variables. The measured numbers (the masses of aluminum) should be placed on the *y*-axis. The variable divided into parts (collection days) is placed on the *x*-axis.
- **Step 2** Create a graph grid like you would for a line graph. Include labels and units.
- **Step 3** For each measured number, draw a vertical bar above the *x*-axis value up to the *y*-axis value. For the first data point, draw a vertical bar above Monday up to 4.0 kg.



Practice Problem Draw a bar graph of the gases in air: 78% nitrogen, 21% oxygen, 1% other gases.

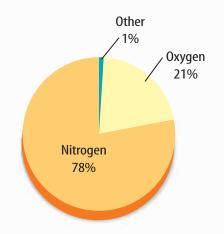
Circle Graph To display data as parts of a whole, you might use a circle graph. A circle graph is a circle divided into sections that represent the relative size of each piece of data. The entire circle represents 100%, half represents 50%, and so on.

Example Air is made up of 78% nitrogen, 21% oxygen, and 1% other gases. Display the composition of air in a circle graph.

Step 1 Multiply each percent by 360° and divide by 100 to find the angle of each section in the circle.

$$78\% \times \frac{360^{\circ}}{100} = 280.8^{\circ}$$
$$21\% \times \frac{360^{\circ}}{100} = 75.6^{\circ}$$
$$1\% \times \frac{360^{\circ}}{100} = 3.6^{\circ}$$

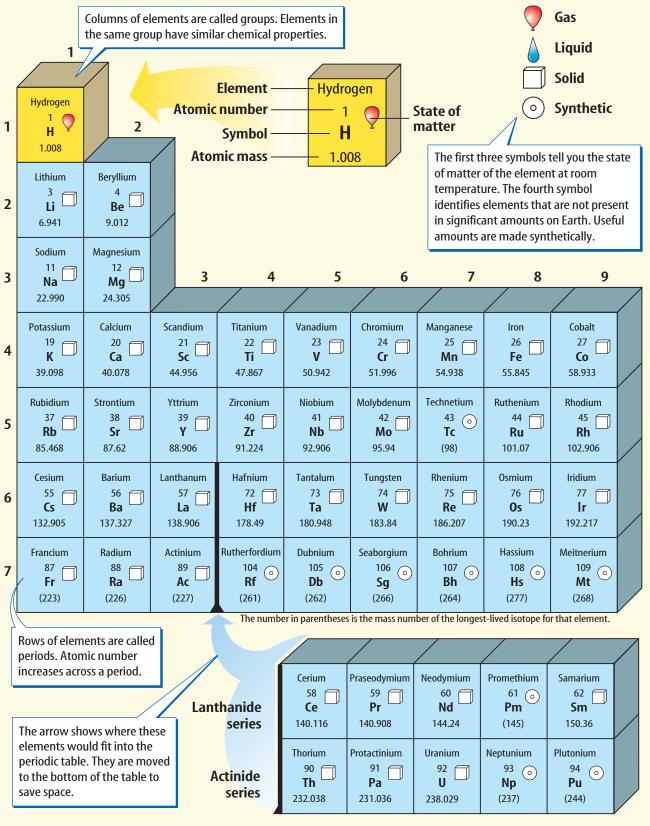
- **Step 2** Use a compass to draw a circle and to mark the center of the circle. Draw a straight line from the center to the edge of the circle.
- **Step 3** Use a protractor and the angles you calculated to divide the circle into parts. Place the center of the protractor over the center of the circle and line the base of the protractor over the straight line.



Practice Problem Draw a circle graph to represent the amount of aluminum collected during the week shown in the bar graph to the left.







CONTENTS

Metal Metalloid Nonmetal								18 Helium	
			13	14	15	16	17	² He	
The color of an								4.003	
tells you if the e metal, nonmet			Boron 5 B 10.811	Carbon 6 C	Nitrogen 7 N 14.007	Oxygen 8 Q 0 15.999	Fluorine 9 7 F 18.998	Neon 10 Ne 20.180	
10	11	12	Aluminum 13 AI 26.982	Silicon 14 Si 28.086	Phosphorus 15 P 30.974	Sulfur 16 5 32.065	Chlorine 17 Cl 35.453	Argon 18 Ar 39.948	
Nickel 28 Ni 58.693	Copper 29 Cu 63.546	Zinc 30 Zn 65.409	Gallium 31 Ga 69.723	Germanium 32 Ge 72.64	Arsenic 33 As 74.922	Selenium 34 Se 78.96	Bromine 35 Br 79.904	Krypton 36 Kr 83.798	
Palladium 46 Pd 106.42	Silver 47 Ag 107.868	Cadmium 48 Cd 112.411	Indium 49 In 114.818	Tin 50 Sn 118.710	Antimony 51 Sb 121.760	Tellurium 52 Te 127.60	lodine 53 I 126.904	Xenon 54 Xe 131.293	
Platinum 78 Pt 195.078	Gold 79 Au 196.967	Mercury 80 Hg 200.59	Thallium 81 TI 204.383	Lead 82 Pb 207.2	Bismuth 83 Bi 208.980	Polonium 84 Po (209)	Astatine 85 At (210)	Radon 86 Rn (222)	
	Inununium 111 Uuu (272)	Ununbium * 112 Uub (285)	are temperari	Ununquadium * 114 Uuq (289) Einal names will b	a colortod whee	** 116		** 118	

★ The names and symbols for elements 111–114 are temporary. Final names will be selected when the elements' discoveries are verified.
 ★★ Elements 116 and 118 were thought to have been created. The claim was retracted because the experimental results could not be repeated.

									\square
Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium	
63	64	65	66	67	68	69	70	71	
Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
151.964	157.25	158.925	162.500	164.930	167.259	168.934	173.04	174.967	
Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium	
95	96	97 💿	98	99 o	100	101	102 o	103 <u></u>	
Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	
(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)	





Use and Care of a Microscope

Eyepiece Contains magnifying _ lenses you look through.

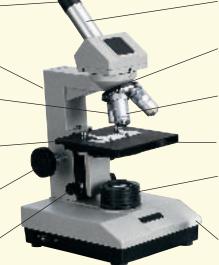
Arm Supports the body tube.

Low-power objective Contains the lens with the lowest power — magnification.

Stage clips Hold the microscope_slide in place.

Coarse adjustment Focuses the, image under low power.

Fine adjustment Sharpens the image under high magnification.



Body tube Connects the eyepiece to the revolving nosepiece.

- **Revolving nosepiece** Holds and turns the objectives into viewing position.
- **High-power objective** Contains the lens with the highest magnification.
- **Stage** Supports the microscope slide.
- **Light source** Provides light that passes upward through the diaphragm, the specimen, and the lenses.
- **Base** Provides support for the microscope.

Caring for a Microscope

- 1. Always carry the microscope holding the arm with one hand and supporting the base with the other hand.
- **2.** Don't touch the lenses with your fingers.
- The coarse adjustment knob is used only when looking through the lowest-power objective lens. The fine adjustment knob is used when the high-power objective is in place.
- **4.** Cover the microscope when you store it.

Using a Microscope

- Place the microscope on a flat surface that is clear of objects. The arm should be toward you.
- 2. Look through the eyepiece. Adjust the diaphragm so light comes through the open-ing in the stage.
- Place a slide on the stage so the specimen is in the field of view. Hold it firmly in place by using the stage clips.

4. Always focus with the coarse adjustment and the low-power objective lens first. After the object is in focus on low power, turn the nosepiece until the high-power objective is in place. Use ONLY the fine adjustment to focus with the high-power objective lens.

Making a Wet-Mount Slide

- Carefully place the item you want to look at in the center of a clean, glass slide. Make sure the sample is thin enough for light to pass through.
- 2. Use a dropper to place one or two drops of water on the sample.
- **3.** Hold a clean coverslip by the edges and place it at one edge of the water. Slowly lower the coverslip onto the water until it lies flat.
- If you have too much water or a lot of air bubbles, touch the edge of a paper towel to the edge of the coverslip to draw off extra water and draw out unwanted air.

Reference Handbooks

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Diversity of Life: Classification of Living Organisms

Archaebacteria and Kingdom Eubacteria—contain organisms is used today. Two kingdoms—Kingdom Archaebacteria and Kingdom Eubacteria—contain organisms that do not have a nucleus and that lack membrane-bound structures in the cytoplasm of their cells. The members of the other four kingdoms have a cell or cells that contain a nucleus and structures in the cytoplasm, some of which are surrounded by membranes. These kingdoms are Kingdom Protista, Kingdom Fungi, Kingdom Plantae, and Kingdom Animalia.

Kingdom Archaebacteria

one-celled; some absorb food from their surroundings; some are photosynthetic; some are chemosynthetic; many are found in extremely harsh environments including salt ponds, hot springs, swamps, and deep-sea hydrothermal vents

Kingdom Eubacteria

one-celled; most absorb food from their surroundings; some are photosynthetic; some are chemosynthetic; many are parasites; many are round, spiral, or rod-shaped; some form colonies

Kingdom Protista

Phylum Euglenophyta one-celled; photosynthetic or take in food; most have one flagellum; euglenoids

Kingdom Eubacteria Bacillus anthracis **Phylum Bacillariophyta** one-celled; photosynthetic; have unique double shells made of silica; diatoms

Phylum Dinoflagellata one-celled; photosynthetic; contain red pigments; have two flagella; dinoflagellates

Phylum Chlorophyta one-celled, manycelled, or colonies; photosynthetic; contain chlorophyll; live on land, in freshwater, or salt water; green algae

Phylum Rhodophyta most are many-celled; photosynthetic; contain red pigments; most live in deep, saltwater environments; red algae

Phylum Phaeophyta most are many-celled; photosynthetic; contain brown pigments; most live in saltwater environments; brown algae

Phylum Rhizopoda one-celled; take in food; are free-living or parasitic; move by means of pseudopods; amoebas



Amoeba

CONTENTS

Phylum Zoomastigina one-celled; take in food; free-living or parasitic; have one or more flagella; zoomastigotes

Phylum Ciliophora one-celled; take in food; have large numbers of cilia; ciliates

Phylum Sporozoa one-celled; take in food; have no means of movement; are parasites in animals; sporozoans



Phylum Myxomycota Slime mold



Phylum Oomycota *Phytophthora infestans*

Phyla Myxomycota and Acrasiomycota

one- or many-celled; absorb food; change form during life cycle; cellular and plasmodial slime molds

Phylum Oomycota many-celled; are either parasites or decomposers; live in freshwater or salt water; water molds, rusts and downy mildews

Kingdom Fungi

Phylum Zygomycota many-celled; absorb food; spores are produced in sporangia; zygote fungi; bread mold

Phylum Ascomycota one- and many-celled; absorb food; spores produced in asci; sac fungi; yeast

Phylum Basidiomycota many-celled; absorb food; spores produced in basidia; club fungi; mushrooms

Phylum Deuteromycota members with unknown reproductive structures; imperfect fungi; *Penicillium*

Phylum Mycophycota organisms formed by symbiotic relationship between an ascomycote or a basidiomycote and green alga or cyanobacterium; lichens



Lichens

CONTENTS

Kingdom Plantae

Divisions Bryophyta (mosses), Anthocerophyta (hornworts), Hepaticophyta (liverworts), Psilophyta (whisk ferns) many-celled nonvascular plants; reproduce by spores produced in capsules; green; grow in moist, land environments

Division Lycophyta many-celled vascular plants; spores are produced in conelike structures; live on land; are photosynthetic; club mosses

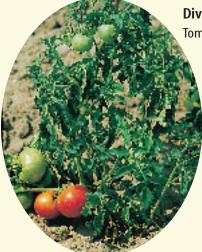
Division Arthrophyta vascular plants; ribbed and jointed stems; scalelike leaves; spores produced in conelike structures; horsetails

Division Pterophyta vascular plants; leaves called fronds; spores produced in clusters of sporangia called sori; live on land or in water; ferns

Division Ginkgophyta deciduous trees; only one living species; have fan-shaped leaves with branching veins and fleshy cones with seeds; ginkgoes

Division Cycadophyta palmlike plants; have large, featherlike leaves; produces seeds in cones; cycads

Division Coniferophyta deciduous or evergreen; trees or shrubs; have needlelike or scalelike leaves; seeds produced in cones; conifers



Division Anthophyta Tomato plant **Division Gnetophyta** shrubs or woody vines; seeds are produced in cones; division contains only three genera; gnetum

Division Anthophyta dominant group of plants; flowering plants; have fruits with seeds

Kingdom Animalia

Phylum Porifera aquatic organisms that lack true tissues and organs; are asymmetrical and sessile; sponges

Phylum Cnidaria radially symmetrical organisms; have a digestive cavity with one opening; most have tentacles armed with stinging cells; live in aquatic environments singly or in colonies; includes jellyfish, corals, hydra, and sea anemones

Phylum Platyhelminthes bilaterally symmetrical worms; have flattened bodies; digestive system has one opening; parasitic and free-living species; flatworms



Division Bryophyta Liverwort



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REFERENCE HANDBOOKS C +

(tr)G.R. Roberts, (I)Ralph Reinhold/Earth Scenes, (br)Scott Johnson/Animals Animals

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Phylum Chordata

Phylum Nematoda round, bilaterally symmetrical body; have digestive system with two openings; free-living forms and parasitic forms; roundworms

Phylum Mollusca soft-bodied animals, many with a hard shell and soft foot or footlike appendage; a mantle covers the soft body; aquatic and terrestrial species; includes clams, snails, squid, and octopuses

Phylum Annelida bilaterally symmetrical worms; have round, segmented bodies; terrestrial and aquatic species; includes earthworms, leeches, and marine polychaetes

Phylum Arthropoda largest animal group; have hard exoskeletons, segmented bodies, and pairs of jointed appendages; land and aquatic species; includes insects, crustaceans, and spiders

Phylum Echinodermata marine organisms; have spiny or leathery skin and a water-vascular system with tube feet; are radially symmetrical; includes sea stars, sand dollars, and sea urchins

Phylum Chordata organisms with internal skeletons and specialized body systems; most have paired appendages; all at some time have a notochord, nerve cord, gill slits, and a post-anal tail; include fish, amphibians, reptiles, birds, and mammals



Cómo usar el glosario en español:

- 1. Busca el término en inglés que desees encontrar.
- El término en español, junto con la definición, se encuentran en la columna de la derecha.

Pronunciation Key

Use the following key to help you sound out words in the glossary.

a b a ck (BAK)	ew f oo d (FEWD)
ay d a y (DAY)	yoo p u re (PYOOR)
ahfa ther (FAH thur)	yew few (FYEW)
ow flower (FLOW ur)	uh comm a (CAH muh)
ar c ar (CAR)	\mathbf{u} (+ con)rub (RUB)
eless (LES)	shsh elf (SHELF)
eelea f (LEEF)	chnature (NAY chur)
ih tr i p (TRIHP)	ggift (GIHFT)
\mathbf{i} (i + con + e) idea (i DEE uh)	jgem (JEM)
oh	ingsing (SING)
awsoft (SAWFT)	zhvision (VIH zhun)
ororbit (OR buht)	k cake (KAYK)
oycoin (COYN)	s seed, cent (SEED, SENT)
oo foot (FOOT)	zzone, raise (ZOHN, RAYZ)
00	

English

aggression: forceful behavior, such as fighting, used by an animal to control or dominate another animal in order to protect their young, defend territory, or get food. (p. 142)

amniotic egg: egg covered with a shell that provides a complete environment for the embryo's development; for reptiles, a major adaptation for living on land. (p. 91)

anus: opening at the end of the digestive tract through which wastes leave the body. (p. 25)

appendages: jointed structures of arthropods, such as legs, wings, or antennae. (p. 48)

agresión: comportamiento violento, como la lucha, manifestado por un animal para controlar o dominar a otro animal con el fin de proteger a sus crías, defender su territorio o conseguir alimento. (p. 142)

Español

- **huevo amniótico:** huevo cubierto por un cascarón coriáceo que proporciona un ambiente completo para el desarrollo del embrión; para los reptiles, una gran adaptación para vivir en la tierra. (p. 91)
- **ano:** apertura al final del tracto digestivo a través de la cual los desechos salen del cuerpo. (p. 25)
- **apéndices:** estructuras articuladas de los artrópodos, como las patas, alas o antenas. (p. 48)

В

- **behavior:** the way in which an organism interacts with other organisms and its environment; can be innate or learned. (p. 134)
- **bilateral symmetry:** body parts arranged in a similar way on both sides of the body, with each half being nearly a mirror image of the other half. (p. 13)
- **comportamiento:** forma en la que un organismo interactúa con otros organismos y su entorno; puede ser innato o aprendido. (p. 134)

simetría bilateral: disposición de las partes del cuerpo de manera similar a ambos lados de éste, de tal forma que cada mitad es una imagen especular de la otra. (p. 13)



carnivore/endoskeleton

carnívoro/endoesqueleto

carnivore: animal that eats only other animals or the remains of other animals; mammal having large, sharp canine teeth and strong jaw muscles for eating flesh. (pp. 9, 115)

- **cartilage:** tough, flexible tissue that joins vertebrae and makes up all or part of the vertebrate endoskeleton. (p. 73)
- **chordate:** animal that has a notochord, a nerve cord, pharyngeal pouches, and a postanal tail present at some stage in its development. (p. 72)
- **closed circulatory system:** blood circulation system in which blood moves through the body in closed vessels. (p. 40)
- **conditioning:** occurs when the response to a stimulus becomes associated with another stimulus. (p. 138)
- **contour feathers:** strong, lightweight feathers that give birds their coloring and shape and that are used for flight. (p. 108)
- **courtship behavior:** behavior that allows males and females of the same species to recognize each other and prepare to mate. (p. 143)
- **crop:** digestive system sac in which earthworms store ingested soil. (p. 44)
- **cyclic behavior:** behavior that occurs in repeated patterns. (p. 146)

- **carnívoro:** animal que se alimenta exclusivamente de otros animales o de los restos de otros animales; mamífero con caninos largos y afilados y músculos fuertes en la mandíbula que le sirven para alimentarse de carne. (pp. 9, 115)
- **cartílago:** tejido resistente y flexible que conecta a las vértebras y constituye todo o parte del endoesqueleto de los vertebrados. (p. 73)
- **cordado:** animal que posee notocordio, un cordón nervioso, bolsas faríngeas y que presenta cola postnatal en alguna etapa de su desarrollo. (p. 72)
- sistema circulatorio cerrado: sistema circulatorio sanguíneo en el cual la sangre se mueve a través del cuerpo en vasos cerrados. (p. 40)
- **condicionamiento:** ocurre cuando la respuesta a un estímulo llega a estar asociada con otro estímulo. (p. 138)
- **plumas de contorno:** plumas fuertes y ligeras que dan a las aves su colorido y forma y que son usadas para volar. (p. 108)
- **comportamiento de cortejo:** comportamiento que permite que los machos y hembras de la misma especie se reconozcan entre sí y se preparen para el apareamiento. (p. 143)

buche: saco del sistema digestivo en el que los gusanos de tierra almacenan el suelo ingerido. (p. 44)

- **comportamiento cíclico:** comportamiento que ocurre en patrones repetidos. (p. 146)
- D

down feathers: soft, fluffy feathers that provide an insulating layer next to the skin of adult birds and that cover the bodies of young birds. (p. 108)

plumón: plumas suaves y esponjadas que proporcionan una capa aislante junto a la piel de las aves adultas y que cubren los cuerpos de las aves jóvenes. (p. 108)

E

- **ectotherm:** vertebrate animal whose internal temperature changes when the temperature of its environment changes. (p. 75)
- endoskeleton: supportive framework of bone and/or cartilage that provides an internal place for muscle attachment and protects a vertebrate's internal organs. (p. 73)
- ectotérmico: animal vertebrado cuya temperatura interna cambia cuando cambia la temperatura de su ambiente. (p. 75)
- endoesqueleto: estructura ósea y/o cartilaginosa de soporte que proporciona un medio interno para la fijación de los músculos y que protege a los órganos internos de los vertebrados. (p. 73)



endotherm/imprinting

endotérmico/impronta

endotherm: vertebrate animal with a nearly constant internal temperature. (pp. 75, 108)

estivation: inactivity in hot, dry months. (p. 85)

- **exoskeleton:** thick, hard, outer covering that protects and supports arthropod bodies and provides places for muscles to attach. (p. 48)
- endotérmico: animal vertebrado con una temperatura interna casi constante. (pp. 75, 108)
- estivación: inactividad durante los meses cálidos y secos. (p. 85)
- **exoesqueleto:** cubierta externa, dura y gruesa que protege y soporta el cuerpo de los artrópodos y proporciona lugares para que los músculos se fijen. (p. 48)

fin: structure used by fish for steering, balancing, and movement. (p. 77)

- **free-living organism:** organism that does not depend on another organism for food or a place to live. (p. 22)
- **aleta:** estructura parecida a un abanico usada por los peces para mantener la dirección, equilibrio y movimiento. (p. 77)
- **organismo de vida libre:** organismo que no depende de otro para alimentarse o para tener un lugar en donde vivir. (p. 22)

G

F

gestation period: period during which an embryo develops in the uterus; the length of time varies among species. (p. 119)

gills: organs that exchange carbon dioxide for oxygen in the water. (p. 38)

gizzard: muscular digestive system structure in which earthworms grind soil and organic matter. (p. 44)

- **periodo de gestación:** periodo durante el cual un embrión se desarrolla en el útero; este periodo varía de una especie a otra. (p. 119)
- **agallas:** órganos que intercambian dióxido de carbono y oxígeno en el agua. (p. 38)
- **molleja:** estructura muscular del sistema digestivo en la que los gusanos de tierra muelen el suelo y materia orgánica. (p. 44)

herbivore: animal that eats only plants or parts of plants; mammals with large premolars and molars for eating only plants. (pp. 9, 115)

hermaphrodite (hur MA fruh dite): animal that produces both sperm and eggs in the same body. (p. 16)
hibernation: cyclic response of inactivity and slowed metabolism that occurs during periods of cold temperatures and limited food supplies. (pp. 85, 147)

- **herbívoro:** animal que se alimenta exclusivamente de plantas o de partes de las plantas; mamífero con premolares y molares grandes que se alimenta exclusivamente de plantas. (pp. 9, 115)
- **hermafrodita:** animal que produce óvulos y espermatozoides en el mismo cuerpo. (p. 16)
- hibernación: respuesta cíclica de inactividad y disminución del metabolismo que ocurre durante periodos de bajas temperaturas y suministro limitado de alimento. (pp. 85, 147)

imprinting: occurs when an animal forms a social attachment to another organism during a specific period following birth or hatching. (p. 137)

impronta: ocurre cuando un animal forma un vínculo social con otro organismo durante un periodo específico después del nacimiento o eclosión. (p. 137)



impro

innate behavior/nerve cord

comportamiento innato/cordón nervioso

- **innate behavior:** behavior that an organism is born with and does not have to be learned, such as a reflex or instinct. (p. 135)
- **insight:** form of reasoning that allows animals to use past experiences to solve new problems. (p. 139)
- **instinct:** complex pattern of innate behavior, such as spinning a web, that can take weeks to complete. (p. 136)

invertebrate: animal without a backbone. (p. 12)

comportamiento innato: comportamiento con el que nace un organismo y que no necesita ser aprendido, tal como los reflejos o los instintos. (p. 135)

comprensión: forma de razonamiento que permite a los animales usar experiencias pasadas para solucionar problemas nuevos. (p. 139)

instinto: patrón complejo de comportamiento innato, como tejer una telaraña, que puede durar semanas para completarse. (p. 136)

- **invertebrado:** animal que no posee columna vertebral. (p. 12)
- **mammals:** endothermic vertebrates that have hair, teeth specialized for eating certain foods, and mammary glands; in females, mammary glands produce milk for feeding their young. (p. 114)

- **mantle:** thin layer of tissue that covers a mollusk's body organs; secretes the shell or protects the body of mollusks without shells. (p. 38)
- **marsupial:** a mammal with an external pouch for the development of its immature young. (p. 118)
- **medusa (mih DEW suh):** cnidarian body type that is bell-shaped and free-swimming. (p. 17)
- **metamorphosis:** process in which many insect species change their body form to become adults; can be complete (egg, larva, pupa, adult) or incomplete (egg, nymph, adult). (p. 50)
- **migration:** instinctive seasonal movement of animals to find food or to reproduce in better conditions. (p. 148)
- **molting:** shedding and replacing of an arthropod's exoskeleton. (p. 48)
- **monotreme:** a mammal that lays eggs with tough, leathery shells and whose mammary glands do not have nipples. (p. 118)

- mamíferos: vertebrados endotérmicos que poseen pelo y dientes especializados para comer cierto tipo de alimentos y cuyas hembras tienen glándulas mamarias que producen leche para alimentar a sus crías. (p. 114)
- **glándulas mamarias:** glándulas productoras de leche que las hembras de los mamíferos usan para alimentar a sus crías. (p. 114)
- manto: capa delgada de tejido que recubre los órganos corporales de los moluscos; secreta el caparazón o protege el cuerpo de los moluscos sin caparazón. (p. 38)
- **marsupial:** mamífero con una bolsa externa para el desarrollo de sus crías inmaduras. (p. 118)
- **medusa:** tipo corporal de los cnidarios con forma de campana y nado libre. (p. 17)
- **metamorfosis:** proceso a través del cual muchas especies de insectos cambian su forma corporal para convertirse en adultos; puede ser completa (huevo, larva, pupa, adulto) o incompleta (huevo, ninfa, adulto). (p. 50)
- **migración:** movimiento estacional instintivo de los animales para encontrar alimento o para reproducirse en mejores condiciones. (p. 148)
- **muda:** muda y reemplazo del exoesqueleto de un artrópodo. (p. 48)
- **monotrema:** mamífero que pone huevos con cascarón coriáceo y resistente y cuyas glándulas mamarias carecen de pezones. (p. 118)
- **nerve cord:** tubelike structure above the notochord that in most chordates develops into the brain and spinal cord. (p. 73)
- **cordón nervioso:** estructura en forma de tubo sobre el notocordio que en la mayoría de los cordados se desarrolla en el cerebro y en la médula espinal. (p. 73)



Μ

mammary glands: milk-producing glands of female mammals used to feed their young. (p. 114)

notochord/radula

notocordio/rádula

notochord: firm but flexible structure that extends along the upper part of a chordate's body. (p. 72)

notocordio: estructura firme pero flexible que se extiende a lo largo de la parte superior del cuerpo de un cordado. (p. 72)

- **omnivore:** animal that eats plants and animals or animal flesh; mammals with incisors, canine teeth, and flat molars for eating plants and other animals. (pp. 9, 115)
- **open circulatory system:** blood circulation system in which blood moves through vessels and into open spaces around the body organs. (p. 38)
- omnívoro: animal que se alimenta de plantas y animales; mamífero con incisivos, caninos y molares planos que se alimenta de plantas y otros animales. (pp. 9, 115)
- sistema circulatorio abierto: sistema circulatorio sanguíneo en el que la sangre se mueve a través de vasos y entra en espacios abiertos alrededor de los órganos corporales. (p. 38)

Ρ

0

- **pharyngeal pouches:** in developing chordates, the paired openings found in the area between the mouth and digestive tube. (p. 73)
- **pheromone (FER uh mohn):** powerful chemical produced by an animal to influence the behavior of another animal of the same species. (p. 143)
- **placenta:** an organ that develops from tissue of the embryo and tissues that line the inside of the uterus and that absorbs oxygen and food from the mother's blood. (p. 119)
- **placental:** a mammal whose offspring develop inside the female's uterus. (p. 119)
- **polyp (PAH lup):** cnidarian body type that is vaseshaped and is usually sessile. (p. 17)
- **postanal tail:** muscular structure at the end of a developing chordate. (p. 72)
- **preening:** process in which a bird rubs oil from an oil gland over its feathers to condition them. (p. 108)

- **bolsas faríngeas:** en los cordados en desarrollo, las aperturas pareadas que se encuentran en el área entre la boca y el tubo digestivo. (p. 73)
- **feromona:** químico potente producido por un animal para influir en el comportamiento de otro animal de la misma especie. (p. 143)
- **placenta:** órgano que se desarrolla a partir de tejido embrionario y de los tejidos que cubren la pared interna del útero y que absorbe oxígeno y alimentos de la sangre de la madre. (p. 119)
- **placentario:** mamífero cuyas crías se desarrollan en el útero de la hembra. (p. 119)
- **pólipo:** tipo corporal de los cnidarios con forma de jarro y usualmente sésil. (p. 17)
- **cola postnatal:** estructura muscular en el extremo de un cordado en desarrollo. (p. 72)
- **acicalamiento:** proceso mediante el cual las aves acondicionan sus alas frotándoles grasa producida por una glándula sebácea. (p. 108)

R

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radial symmetry: body parts arranged in a circle around a central point. (p. 13)

- **radula (RA juh luh):** in gastropods, the tonguelike organ with rows of teeth used to scrape and tear food. (p. 39)
- simetría radial: disposición de las partes del cuerpo circularmente alrededor de un punto central. (p. 13)
- **rádula:** órgano de los gasterópodos en forma de lengua con filas de dientecillos usado para raspar y desgarrar alimentos. (p. 39)

reflex/umbilical cord

reflejo/cordón umbilical

- **reflex:** simple innate behavior, such as yawning or blinking, that is an automatic response and does not involve a message to the brain. (p. 135)
- **reflejo:** comportamiento innato simple, como bostezar o parpadear, que constituye una respuesta automática y no requiere el envío de un mensaje al cerebro. (p. 135)

S

U

CONTENTS

- **scales:** thin, hard plates that cover a fish's skin and protect its body. (p. 77)
- **sessile (SE sile):** describes an organism that remains attached to one place during most its lifetime. (p. 15)
- **setae (SEE tee):** bristlelike structures on the outside of each body segment that helps segmented worms move. (p. 43)
- **social behavior:** interactions among members of the same species, including courtship and mating, getting food, caring for young, and protecting each other. (p. 140)
- **society:** a group of animals of the same species that live and work together in an organized way, with each member doing a specific job. (p. 141)
- **spiracles (SPIHR ih kulz):** openings in the abdomen and thorax of insects through which air enters and waste gases leave. (p. 49)
- **stinging cells:** capsules with coiled triggerlike structures that help cnidarians capture food. (p. 18)

- escamas: placas duras y delgadas que cubren la piel de los peces y protegen su cuerpo. (p. 77)
- **sésil:** organismo que permanece adherido a un lugar durante la mayor parte de su vida. (p. 15)
- **cerdas:** estructuras en forma de cilios presentes en la parte externa de cada segmento corporal y que ayudan a los gusanos segmentados a moverse. (p. 43)
- **comportamiento social:** interacciones entre los miembros de la misma especie, incluyendo el cortejo y el apareamiento, la obtención de alimento, el cuidado de las crías y la protección de unos a otros. (p. 140)
- **sociedad:** grupo de animales de la misma especie que vive y trabaja conjuntamente de forma organizada, con cada miembro realizando una tarea específica. (p. 141)
- **espiráculos:** aperturas del abdomen y tórax de los insectos a través de las cuales entra aire y salen gases de desecho. (p. 49)
- **cnidocitos:** cápsulas con estructuras enrolladas en forma de gatillo y que ayudan a los cnidarios a capturar su alimento. (p. 18)
- **tentacles (TEN tih kulz):** armlike structures that have stinging cells and surround the mouths of most cnidarians. (p. 18)
 - **tube feet:** hydraulic, hollow, thin-walled tubes that end in suction cups and enable echinoderms to move. (p. 58)
- **tentáculos:** estructuras en forma de brazo, que poseen cnidocitos y rodean la boca de la mayoría de los cnidarios. (p. 18)
- **pie tubular:** tubos hidráulicos de pared delgada que terminan en copas de succión y que permiten moverse a los equinodermos. (p. 58)

umbilical cord: connects the embryo to the placenta; moves food and oxygen from the placenta to the embryo and removes the embryo's waste products. (p. 119) **cordón umbilical:** conecta al embrión con la placenta, lleva nutrientes y oxígeno de la placenta al embrión y retira los productos de desecho de éste. (p. 119)

vertebrae/water-vascular system	vértebra/sistema vascular acuoso
(V
 vertebrae: backbones that are joined by flexible cartilage and protect a vertebrate's spinal nerve cord. (p. 73) vertebrate: animal with a backbone. (p. 12) 	 vértebra: huesos de la espalda unidos por cartílago flexible y que protegen la médula espinal de los vertebrados. (p. 73) vertebrado: animal que posee columna vertebral. (p. 12)
(w
water-vascular system: network of water-filled canals that allows echinoderms to move, capture food, give off wastes, and exchange carbon dioxide and	sistema vascular acuoso: red de canales llenos de agua que permiten a los equinodermos moverse, cap- turar alimento, eliminar sustancias de desecho e

oxygen. (p. 58)

turar alimento, eliminar sustancias de desecho e intercambiar dióxido de carbono y oxígeno. (p. 58)

Glossary/Glosario



Aardvark

Italic numbers = illustration/photo Bold numbers = vocabulary term lab = indicates a page on which the entry is used in a lab act = indicates a page on which the entry is used in an activity

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