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SCIENCE

A CLOSER LOOK

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American Museum of Natural History

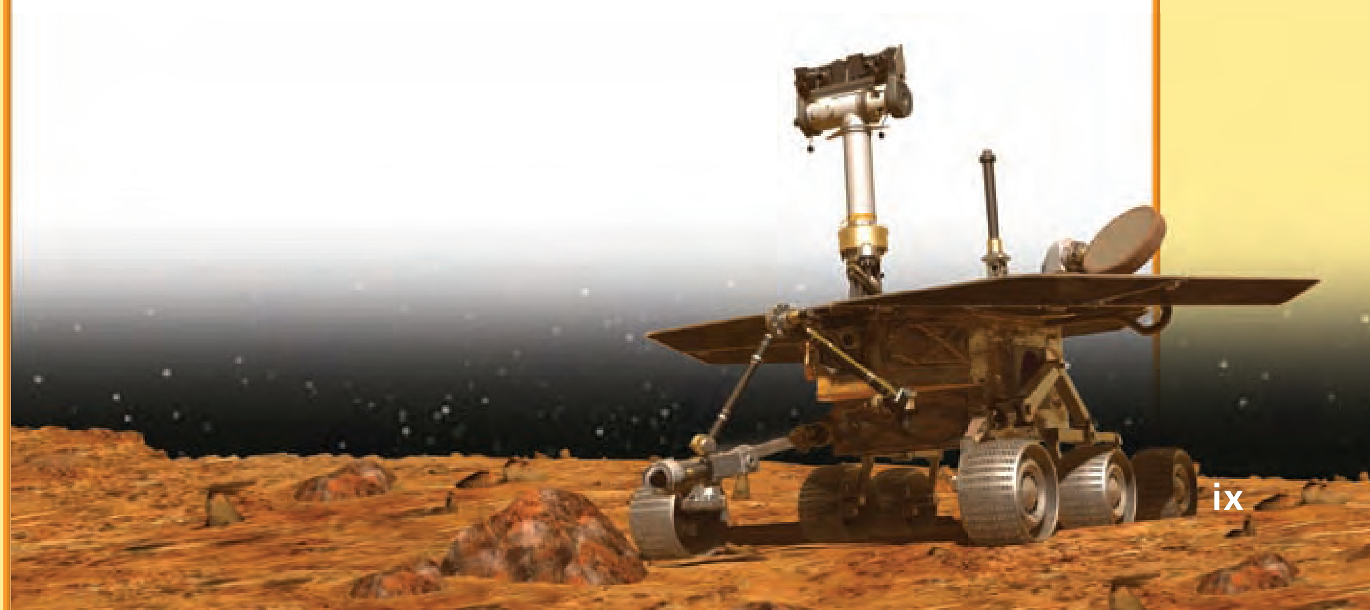
The American Museum of Natural History in New York City is one of the world's preeminent scientific, educational, and cultural institutions, with a global mission to explore and interpret human cultures and the natural world through scientific research, education, and exhibitions. Each year the Museum welcomes around four million visitors, including 500,000 school children in organized field trips. It provides professional development activities for thousands of teachers; hundreds of public programs that serve audiences ranging from preschoolers to seniors; and an array of learning and teaching resources for use in homes, schools, and community-based settings. Visit www.amnh.org for online resources.

Be a Scientist

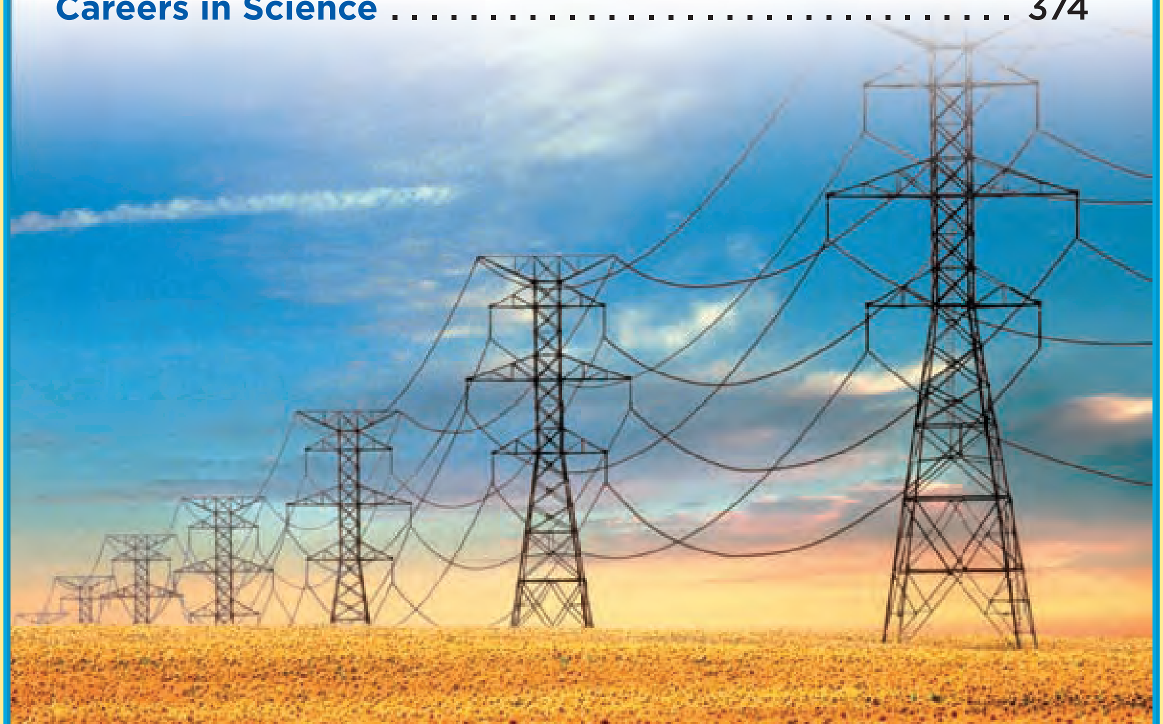
Scientific Method
Make Observations
Ask a Question
Form a Hypothesis
Test Your Hypothesis
Results Support Hypothesis
Results Do Not Support Hypothesis
Draw Conclusions / Ask Questions

Life Sciences

Earth and Space Sciences

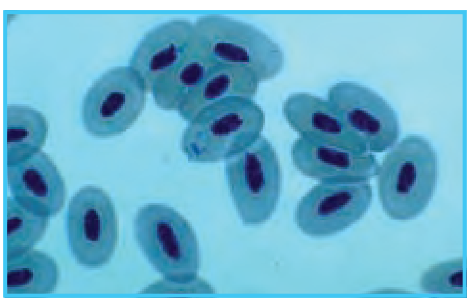


Physical Sciences



Activities and Investigations

Life Sciences



Earth and Space Sciences

Activities and Investigations

Physical Sciences

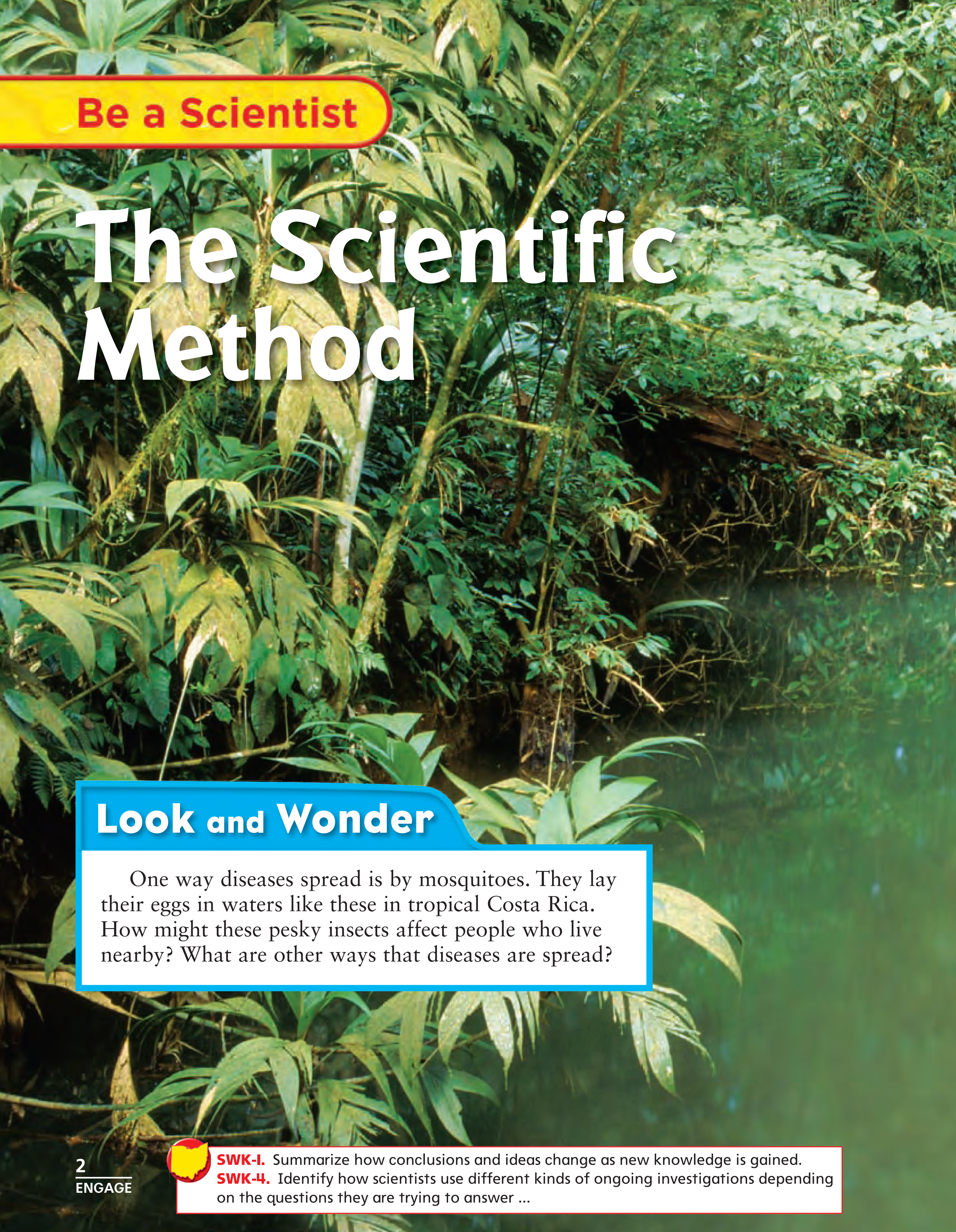
CHAPTER 6

Be a Scientist

Only female mosquitoes bite mammals.

Be a Scientist

The Scientific Method



Look and Wonder

One way diseases spread is by mosquitoes. They lay their eggs in waters like these in tropical Costa Rica. How might these pesky insects affect people who live nearby? What are other ways that diseases are spread?

SWK-1. Summarize how conclusions and ideas change as new knowledge is gained.
SWK-4. Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer ...

Explore

What do you know about disease?

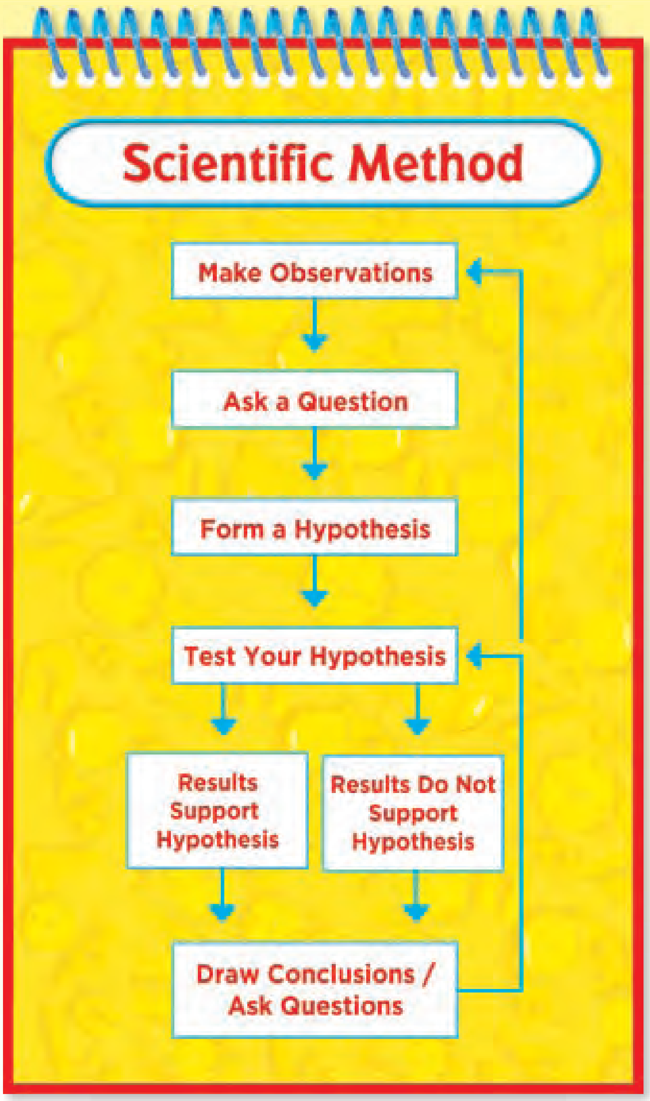
How do people get sick? Do other animals get sick too? What are some of the diseases that both people and other animals get? How do scientists study diseases?

Biologists are curious about the natural world and everything that lives in it. Susan Perkins and Liliana Dávolos are biologists at the American Museum of Natural History in New York City. They investigate organisms by looking at their cells under a microscope and analyzing them in the laboratory.

Liliana Dávolos

Susan Perkins

SWK-6. Identify a variety of scientific and technological work that people of all ages, backgrounds and groups perform.



What do scientists do?

Malaria is a serious disease that kills more than one million people every year. Malaria is caused by a parasite that infects red blood cells. A parasite is an organism that lives in or on a host.

Scientists have studied malaria in humans for many years, but humans aren't the only animals that get malaria. Birds, lizards, and other mammals also get malaria. Scientists are now studying malaria in different animals. "The more we understand about the organism that causes malaria, the more tools we have to fight the disease," Susan Perkins explains.

She and Liliana Dávolos use the scientific method to learn more about the malaria parasite. The scientific method is a process that scientists use to investigate and answer questions. This method helps them explain how things happen in the natural world.

Scientists don't always follow the steps of the scientific method in order, but they do make sure that they and others can reliably repeat their procedures. This way, the work can be checked by other scientists.

Fence lizards can catch malaria from sand flies.

Female mosquitoes need a blood meal before they can lay their eggs.

Susan and other scientists know that humans get malaria when they are bitten by mosquitoes that have the organism that causes malaria in them. They have also observed that lizards get the disease when they are bitten by sand flies with malaria parasites.

Susan has a question: "Does malaria transmitted between different organisms behave the same way inside different hosts?" She predicts the cells of malaria parasites in lizards and in sand flies will be similar to the malaria parasites that scientists have observed in mosquitoes and in humans. That is her hypothesis.

There are different types of variables in Susan's hypothesis. Her independent variable, the factor that changes, is the type of species. Her dependent variable, a factor that varies based on the independent variable, is the genes in the cells of the parasites. Controlled variables are factors that are not tested and remain constant.

Form a Hypothesis

1. Ask lots of "why" questions.
2. Look for connections between important variables.
3. Suggest possible explanations for these connections.

▶ **Make sure the explanations can be tested.**

Striped manakins can also catch malaria.

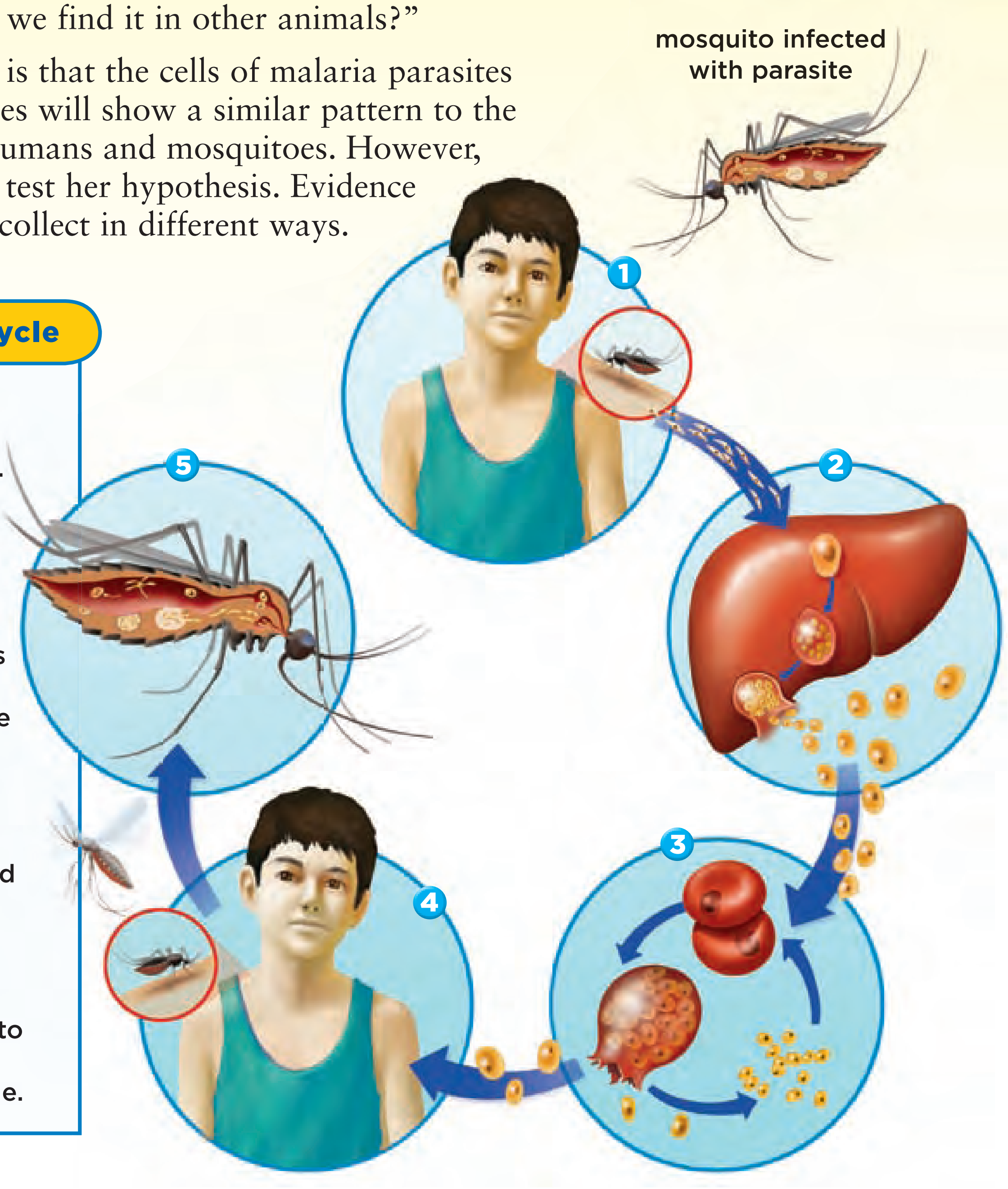
How do scientists test their hypothesis?

Scientists have made an interesting observation by studying certain genes from malaria parasites. The genes they are studying have directions for making ribosomes. Ribosomes are "factories" within cells that make proteins.

Most multicellular organisms have only one kind of ribosome. But some malaria parasites have two kinds of ribosomes. One kind of ribosome is observed when malaria parasites are living inside the mosquito. A different kind of ribosome is made once the malaria parasite enters a human.

This makes malaria passed between mosquitoes and humans very unusual! "This is an interesting pattern," Susan observes. "Can we find it in other animals?"

Susan's hypothesis is that the cells of malaria parasites in lizards and sand flies will show a similar pattern to the malaria parasites in humans and mosquitoes. However, she needs evidence to test her hypothesis. Evidence is data that scientists collect in different ways.



Malaria Parasite Cycle

Stage 1 A mosquito infected with parasite bites a healthy person.

Stage 2 The parasite travels to the liver and makes more parasites.

Stage 3 The parasites now infect the red blood cells, make more parasites, and the disease spreads throughout the body.

Stage 4 An uninfected mosquito bites the infected human and becomes infected.

Stage 5 That mosquito can now spread the disease to other people.

In this example, Susan traveled to California to get her evidence. She took two blood samples from fence lizards, which are common in California and easy to catch. One sample is used to see whether the lizard has malaria by looking for parasites under the microscope. If it does, she uses the second sample to look at the parasites' genes.

Back in the lab, Liliana helps analyze the blood samples Susan collected. They remove the parasites' genes from the lizards' blood so they can compare them to genes from parasites in other hosts. They also use powerful microscopes and computers to examine the malaria parasites.

Test Your Hypothesis

1. Think about the different kinds of data that could be used to test the hypothesis.
2. Choose the best method to collect this data:
   - **Perform an experiment** (in the lab)
   - **Observe the natural world** (in the field)
   - **Make a model** (on a computer)
3. Plan a procedure to collect this data.

▶ **Make sure the procedure can be repeated.**

Susan is taking blood samples from a fence lizard.

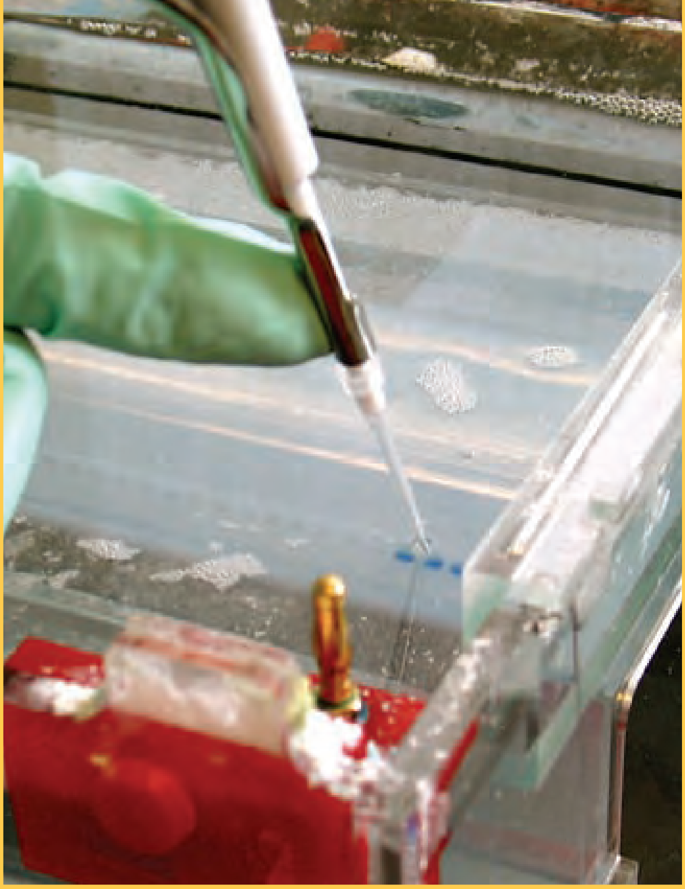
How do scientists analyze data?

Part of testing a hypothesis is arranging the data to look for patterns. Susan and Liliana collect genes from the malaria parasites found in lizards. They also collect genes from malaria parasites found in rodents. Just like humans and some other mammals, rodents are studied because they get malaria from mosquitoes.

Single genes are too small to see, so scientists use a special chemical process to make copies of them. Then they run the copied genes through a piece of gelatin, called a gel. The gel has tiny openings of different sizes called pores.

Susan and Liliana prepare the genes to run through the gel.

Susan and Liliana collect genes from the blood.


Liliana is testing the gene samples in the gel to determine their patterns.

Analyze the Data

1. Organize the data as a chart such as a table, graph, diagram, map, or group of pictures.
2. Look for patterns in the chart that show connections between important variables in the hypothesis being tested.

▶ **Make sure to check the data by comparing it to data from other sources.**

The pores separate pieces of the gene based on how large they are. The pieces of the gene form bands on the gel.

These bands form patterns that can be used to compare the genes. "It's a delicate process that can take several weeks," says Liliana.

Susan and Liliana found that all of the genes of the malaria parasite in the lizards have the same pattern. This is evidence that malaria parasites that infect lizards have only one kind of ribosome.

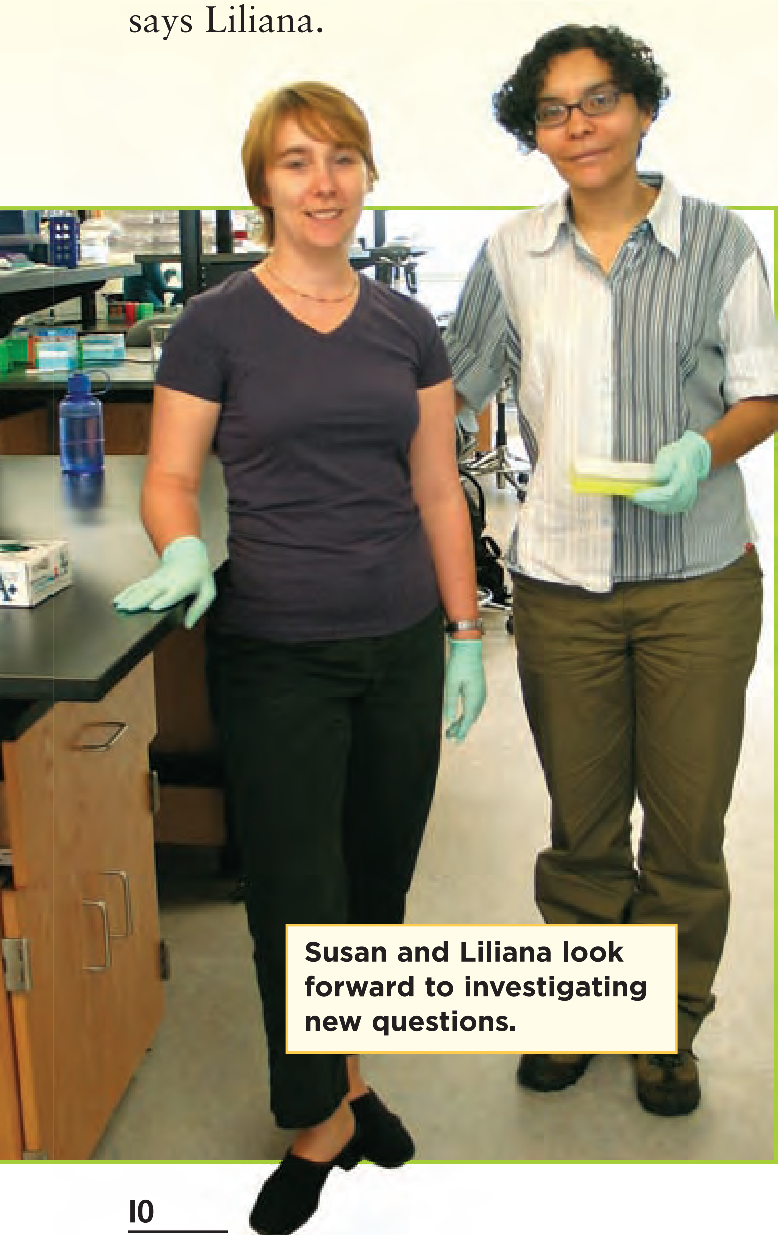
However, the genes of the malaria parasite in the rodent show different patterns. This is evidence that the malaria parasites that infect other organisms have different kinds of ribosomes.

The genes for the ribosomes of the malaria parasite show different patterns in the rodent and the fence lizards.

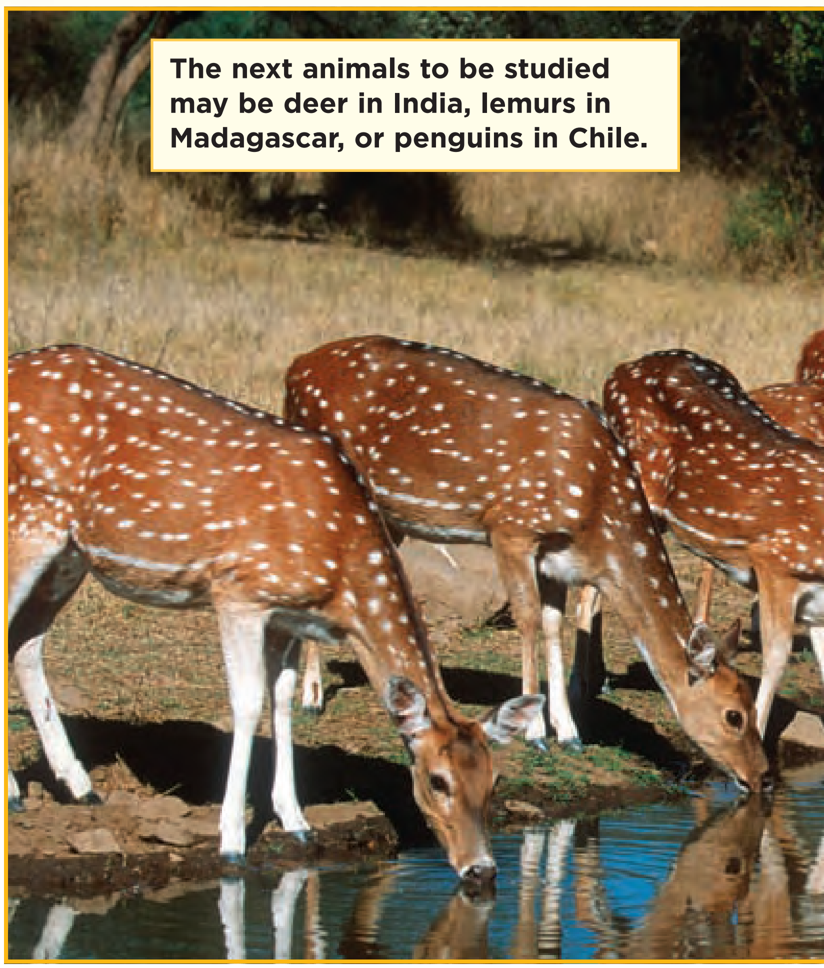
How do scientists draw conclusions?

Now Susan and Liliana see if their evidence supports their hypothesis. Do the malaria parasites transmitted between different groups of organisms behave the same way? No, they do not! The evidence shows that malaria parasites that infect mammals have two kinds of ribosomes and malaria parasites that infect lizards have only one.

The results of Susan and Liliana's work do not support their hypothesis. "We thought all malaria parasites would behave the way it does in humans. It came out differently," says Liliana.



Susan and Liliana look forward to investigating new questions.



The next animals to be studied may be deer in India, lemurs in Madagascar, or penguins in Chile.

When it comes to scientific research, disproving a hypothesis is as good as confirming one—in fact, it is often better! Susan and Liliana carefully check their data and procedures. Then they write up their results so that other scientists who study malaria can learn from their work.

Their results lead biologists to ask new questions. Is the way that malaria infects humans and other mammals unique? Why do those parasites have different kinds of ribosomes? How can these results lead to new tools to fight this disease? New questions are important because they lead to new hypotheses.

Draw Conclusions

1. Decide if the data clearly support the hypothesis.
2. If the results are not clear, rethink how the hypothesis was tested and make a new plan.
3. Write up the results to share with others.

▶ **Make sure to ask new questions.**

Liliana continues research on malaria parasites in the field.

Focus on Skills

Scientists use many skills as they work through the scientific method. Skills help them gather information and answer questions they have about the world around us. Here are some skills they use:

Observe Use your senses to learn about an object or event.

Form a Hypothesis Make a statement that can be tested to answer a question.

Communicate Share information with others.

Classify Place things with similar properties into groups.

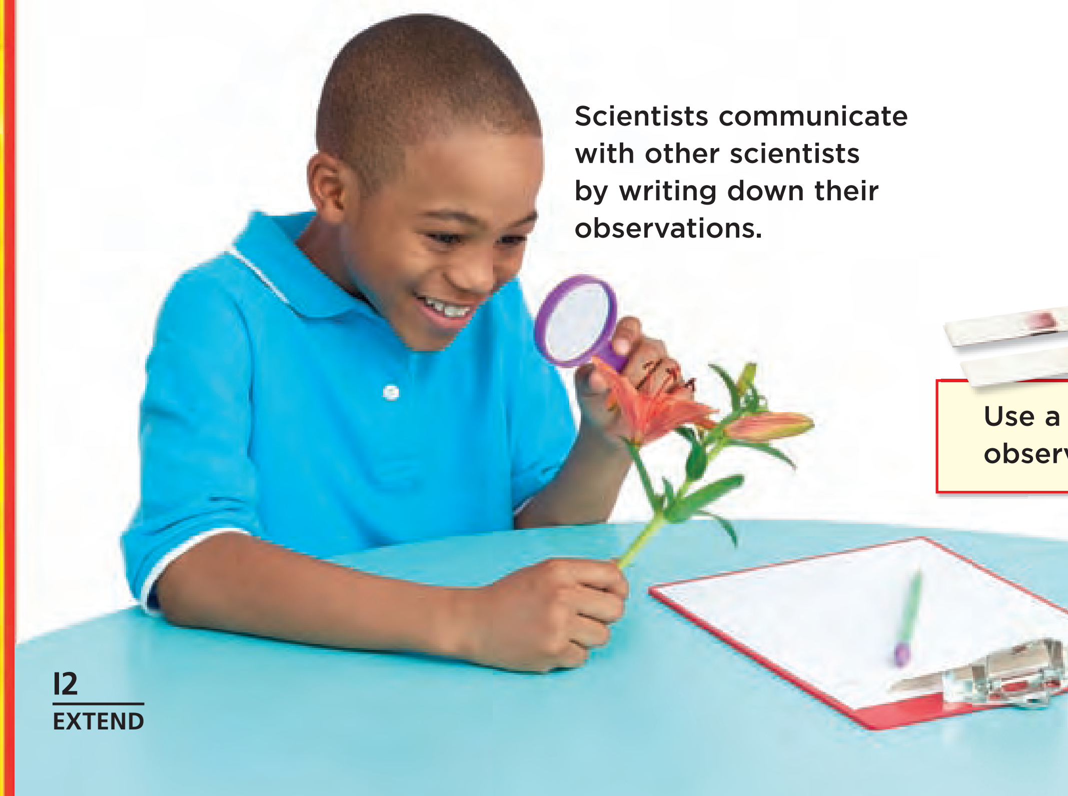
Use Numbers Order, count, add, subtract, multiply, and divide to explain data.

Make a Model Make something to represent an object or event.

Use spring scales to measure an object's weight.

Use a table to organize and interpret data.

Use a microscope to observe very small items.



Scientists communicate with other scientists by writing down their observations.

Scientists use experiments to test a hypothesis.

Use Variables Identify things that can control or change the outcome of an experiment.

Interpret Data Use information that has been gathered to answer questions or solve a problem.

Inquiry Skill Builder

In each chapter of this book, you will find an Inquiry Skill Builder. These features will help you build the skills you need to be a scientist.

Measure Find the size, distance, time, volume, area, mass, weight, or temperature of an object or event.

Predict State possible results of an event or experiment.

Infer Form an idea or opinion from facts or observations.

Experiment Perform a test to support or disprove a hypothesis.

Scientists use models to explain how an event happens.

Focus on Skills

Science and Technology:
The Design Process

Did you ever wonder how the products around you were created? Many of these products help meet a need or solve a problem. For example, cars help you get from one place to another faster than walking. Many of these products started with an idea that was developed into a final product. Scientists use a series of steps called the **design process** to bring about their ideas.

▶ Learn It

The first step of the **design process** is to think of possible solutions to your problem and sketch them. Then, pick one solution to try out, create a design, and build a *prototype,* or working model.

After you have built your prototype, you need to test your design. Testing ensures that your product accomplishes what it is designed to do. During the testing phase of the **design process**, data are collected through experimentation. Ask questions while you test your design. *Does the idea work? Can changes be made to make it better or easier to use?*

Scientists may also ask for feedback from other people, a process called *peer review*. Use your tests and feedback from your peers to modify your original design. Then, retest your model until you are satisfied that it solves the problem.

ST-2. Revise an existing design used to solve a problem based on peer review.

▶ Try It

Don noticed that most metal objects, such as a spoon or a nail, sink quickly. Yet he knew that large metal boats can carry heavy cargo across oceans and stay afloat. Don wondered how a metal boat could transport cargo across water. Can you **design** a metal boat that can hold cargo without sinking?

Materials **aluminum foil, paper clips, tank of water.**

1. Use a sheet of aluminum foil to make a boat. Experiment with different designs. Draw a picture of the boat in a chart.
2. Float the boat in a tank of water. Place the paper clips into the boat one at a time and record what happens. How many paper clips can the boat hold before it completely sinks?

	Picture	Number of clips	Observations
Boat Design #1			
Boat Design #2			

▶ Apply It

1. Compare your boat with a partner's. Do you notice any pattern between the design of the boat and the number of paper clips it will hold? Analyze each other's boat and suggest improvements.
2. Using a new piece of foil, change the design of your boat based on your partner's suggestions. Draw the new boat design in your chart. Repeat the test above and record your results. Did this boat hold more paper clips than the first?
3. Look at all of your classmates' boats. Which designs held the most paper clips? Did they have anything in common? Report your conclusions.

Safety Tips

In the Classroom

- Read all of the directions. Make sure you understand them. When you see "⚠ **Be Careful,**" follow the safety rules.
- Listen to your teacher for special safety directions. If you do not understand something, ask for help.

- Wash your hands with soap and water before an activity.
- Be careful around a hot plate. Know when it is on and when it is off. Remember that the plate stays hot for a few minutes after it is turned off.
- Wear a safety apron if you work with anything messy or anything that might spill.

- Clean up a spill right away, or ask your teacher for help.
- Dispose of things the way your teacher tells you to.
- Tell your teacher if something breaks. If glass breaks, do not clean it up yourself.

- Wear safety goggles when your teacher tells you to wear them. Wear them when working with anything that can fly into your eyes or when working with liquids.
- Keep your hair and clothes away from open flames. Tie back long hair, and roll up long sleeves.
- Keep your hands dry around electrical equipment.
- Do not eat or drink anything during an experiment.
- Put equipment back the way your teacher tells you to.
- Clean up your work area after an activity, and wash your hands with soap and water.

In the Field

- Go with a trusted adult—such as your teacher, or a parent or guardian.
- Do not touch animals or plants without an adult's approval. The animal might bite. The plant might be poison ivy or another dangerous plant.

Responsibility
Treat living things, the environment, and one another with respect.

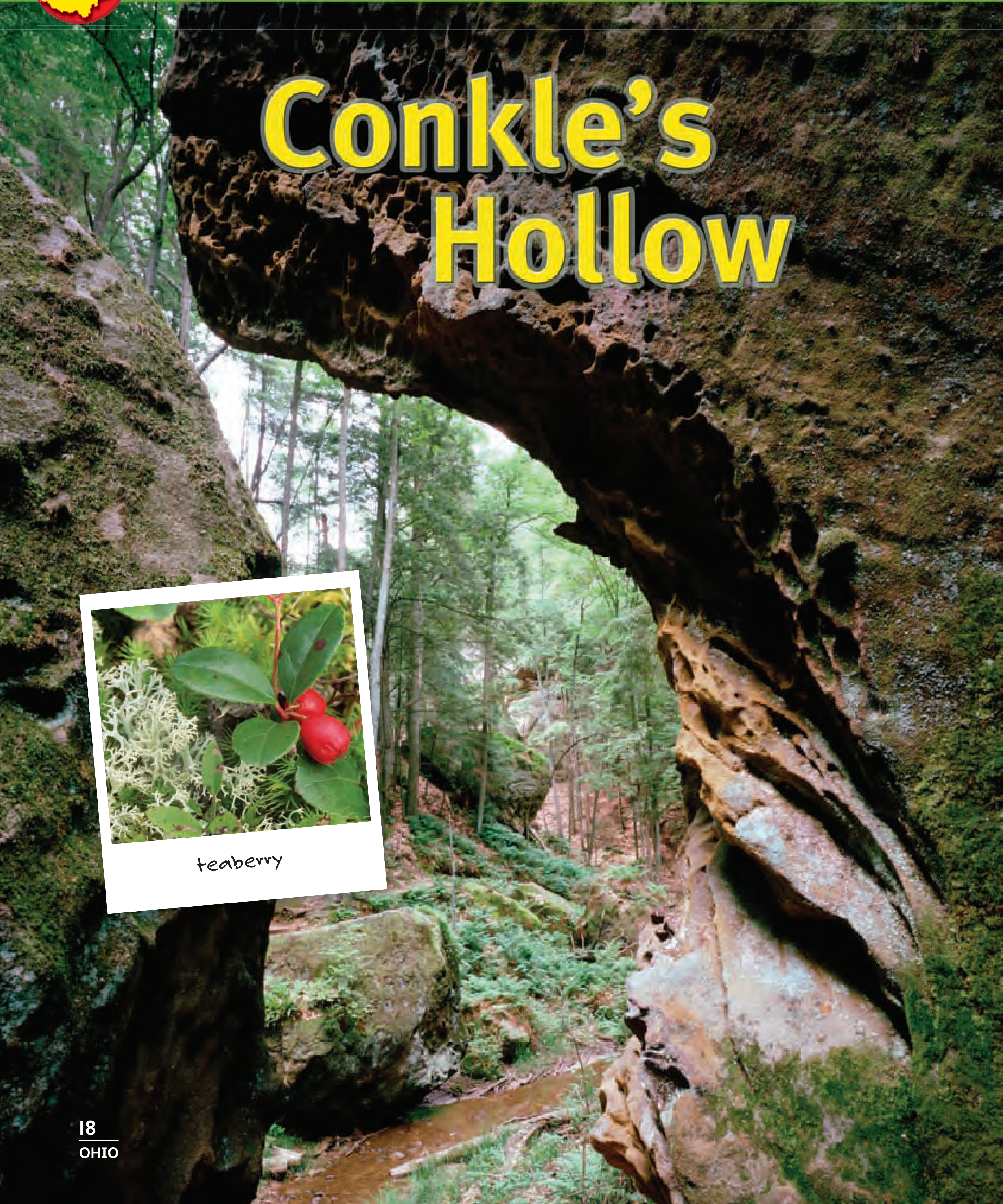
Ohio

Life Sciences

Watch out! Is this a snake? This caterpillar uses a disguise to fool would-be predators.

Spicebush swallowtail caterpillar, Ohio

Conkle's Hollow



teaberry

A Deep Valley in Ohio

Nestled in the Hocking Hills area of southeastern Ohio is a state nature preserve called Conkle's Hollow. Nature preserves are set up to protect habitats from being destroyed. The preserve includes a valley with steep sandstone cliffs that are almost 60 meters (200 feet) tall. Conkle's Hollow is one of the deepest valleys in Ohio. Trails winding down to the valley floor allow visitors to see many unique plant species.

Plants of Conkle's Hollow

The tall trees near the edges of the steep cliffs of Conkle's Hollow often prevent sunlight from reaching the valley floor. The shaded valley creates a microclimate that is cool and moist. A microclimate, such as that found in the valley in Conkle's Hollow, is a different climate from the area around it. Plants and animals that are adapted to live in certain climates may not be able to survive elsewhere. In Conkle's Hollow, the cool microclimate provides an environment where plants not normally found in Ohio can grow. Plants such as Canada yew, partridgeberry, and teaberry are found in the hollow. These plants are usually found in cooler climates north of Ohio, but the deep gorge in Conkle's Hollow provides a microclimate that allows them to thrive.

Think, Talk, and Write

Critical Thinking **Why does Conkle's Hollow contain many plants that are not found in other parts of Ohio?**

Ohio
A CLOSER LOOK

Main Idea

Conkle's Hollow is a deep valley where you can see many unique plants not normally found in Ohio.

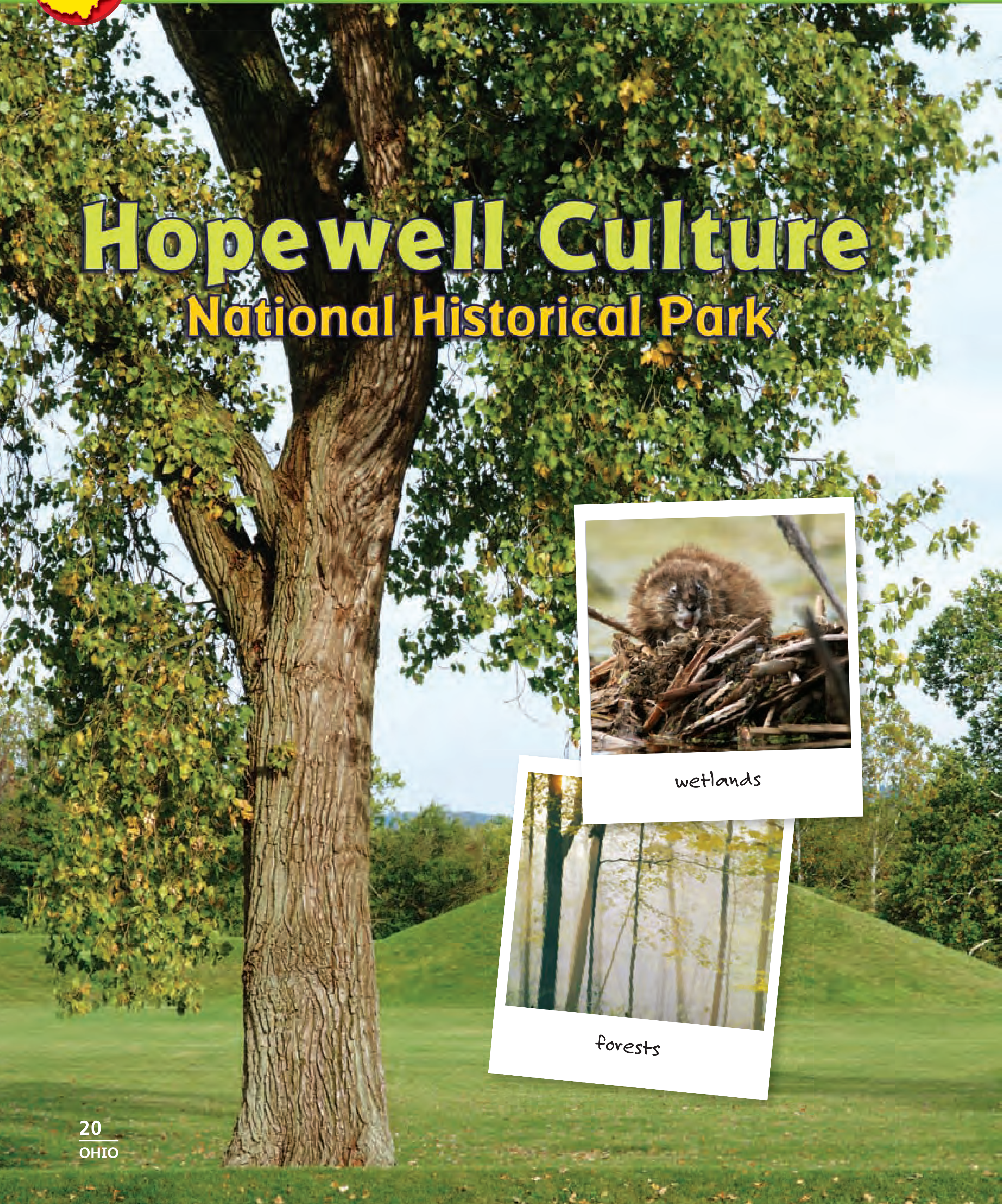
Activity

Communicate Every year many visitors come to see Conkle's Hollow.

- Create a poster encouraging people to visit Conkle's Hollow.
- Using the Internet, find pictures of Conkle's Hollow to place on your poster.

LS-4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.

Hopewell Culture
National Historical Park



wetlands

forests

Looking Back

The Ohio River Valley was home to the prehistoric Hopewell culture from 200 B.C. to A.D. 500. The term *Hopewell culture* is used to describe common beliefs and practices among different Native American groups from eastern North America. In the Hopewell culture, enclosures were built using materials from the earth, such as clay or sand. These enclosures were often in the shape of squares or circles. Many of these sites can still be seen today.

The Hopewell Culture National Historical Park is located in the Scioto River Valley near Chillicothe, Ohio. The purpose of the park is to preserve cultural and archeological resources. Natural resources found in the park are also preserved.

Wildlife at the Park

The park has a variety of ecosystems including forests, wetlands, and grasslands. These ecosystems support the needs of many plants and animals.

You can watch or listen to amphibians like American bullfrogs, red-backed salamanders, and northern spring peepers near the water or other moist areas. Birds, such as white-throated sparrows and eastern meadowlarks, can be seen and heard in the grasslands. Many fish species can be found in the Scioto River and several mammals and reptiles can be seen throughout the park.

Think, Talk, and Write

Critical Thinking How do you think the Hopewell lived off this land long ago?

Ohio
A CLOSER LOOK

Main Idea

Different animals live in different ecosystems to help them meet their needs.

Activity

Compare Research different ecosystems in the world.

- Make a poster showing the different plants and animals that live in the ecosystem you chose.
- Share your poster with your classmates. Determine if the plants and animals in your ecosystem could survive in the ecosystems that your classmates chose.

LS-4. Summarize that organisms can survive only in the ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.

CHAPTER 1

Living Organisms

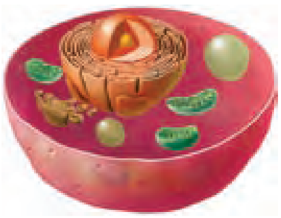
The Big Idea

How are living things similar?

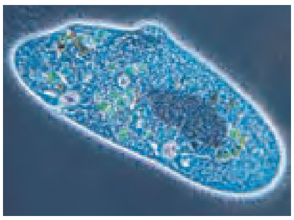
Euglena

Key Vocabulary

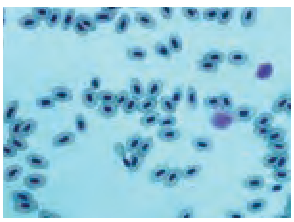
organism
any living thing that can carry out its life on its own (p. 26)



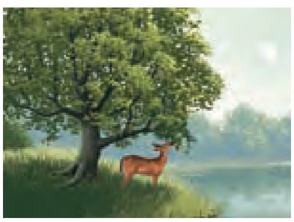
cell
the smallest unit of living matter (p. 26)



unicellular
one-celled organism (p. 27)



multicellular
many-celled organism (p. 27)



photosynthesis
the food-making process in green plants that uses sunlight (p. 44)

radial symmetry
all body parts of an organism are arranged around a central point (p. 52)

More Vocabulary

chlorophyll, p. 31

tissue, p. 32

organ, p. 32

organ system, p. 32

gymnosperm, p. 39

angiosperm, p. 39

xylem, p. 43

phloem, p. 43

cambium, p. 43

transpiration, p. 44

cellular respiration, p. 46

asymmetrical, p. 52

bilateral symmetry, p. 53

monotreme, p. 58

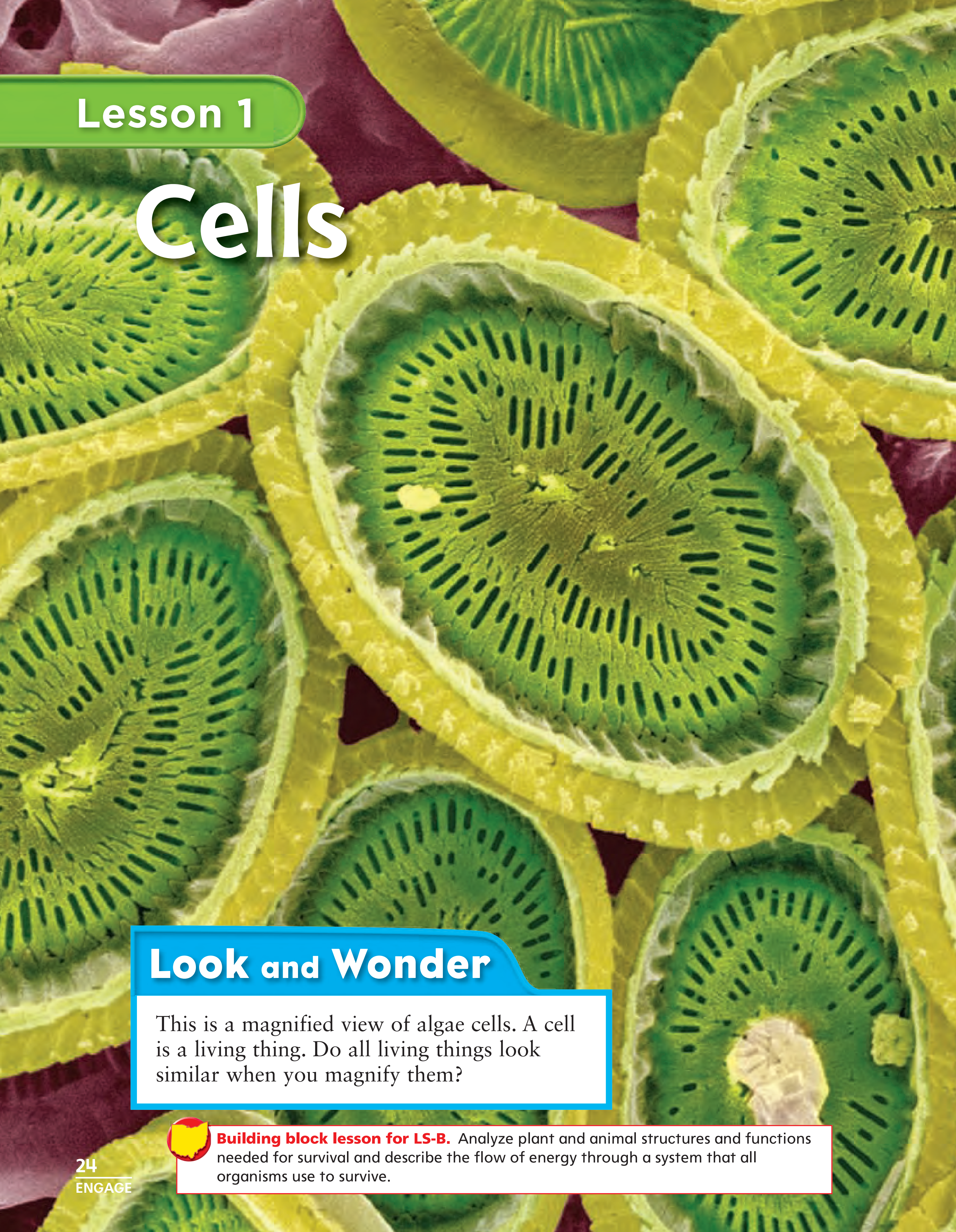
marsupial, p. 58

placental mammal, p. 58

LS-A. Differentiate between the life cycles of different plants and animals.
LS-B. Analyze plant and animal structures and functions needed for survival....

Lesson 1

Cells



Look and Wonder

This is a magnified view of algae cells. A cell is a living thing. Do all living things look similar when you magnify them?

Building block lesson for LS-B. Analyze plant and animal structures and functions needed for survival and describe the flow of energy through a system that all organisms use to survive.

Explore

Inquiry Activity

What are plants and animals made of?

Make a Prediction

Plants and animals are living things. Think about a plant and an animal you have seen. Do you think they are made of similar or different parts?

Test Your Prediction

1. **Observe** Look at the prepared slide of a plant leaf under the microscope. For help using the microscope, ask your teacher and look at page R5.
2. Draw what you see.
3. Look at the prepared slide of animal blood under the microscope.
4. Draw what you see. Compare your drawings.

Draw Conclusions

5. **Interpret Data** How were the plant slide and animal slide alike? How were they different?
6. **Communicate** Write a report explaining whether or not your observations supported your prediction.

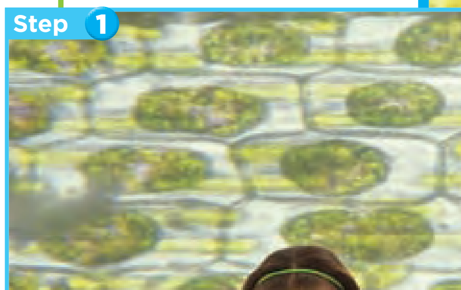
Explore More

Examine the drawings you made and think about the living things they came from. Mushrooms are also living things. What do you think a mushroom slide looks like? Make a prediction and plan an experiment to test it.

Materials

- microscope
- prepared slides of plant-leaf cells
- prepared slides of animal-blood cells

Step 1



Step 2

Step 3

SI-3. Use evidence and observations to explain and communicate the results of investigations.

Read and Learn

Main Idea LS-B

Living things are all made of the same basic building blocks—cells.

Vocabulary

organism, p. 26
cell, p. 26
unicellular, p. 27
multicellular, p. 27
chlorophyll, p. 31
tissue, p. 32
organ, p. 32
organ system, p. 32

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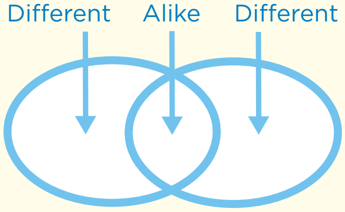
Reading Skill

Compare and Contrast



Technology SCIENCE QUEST

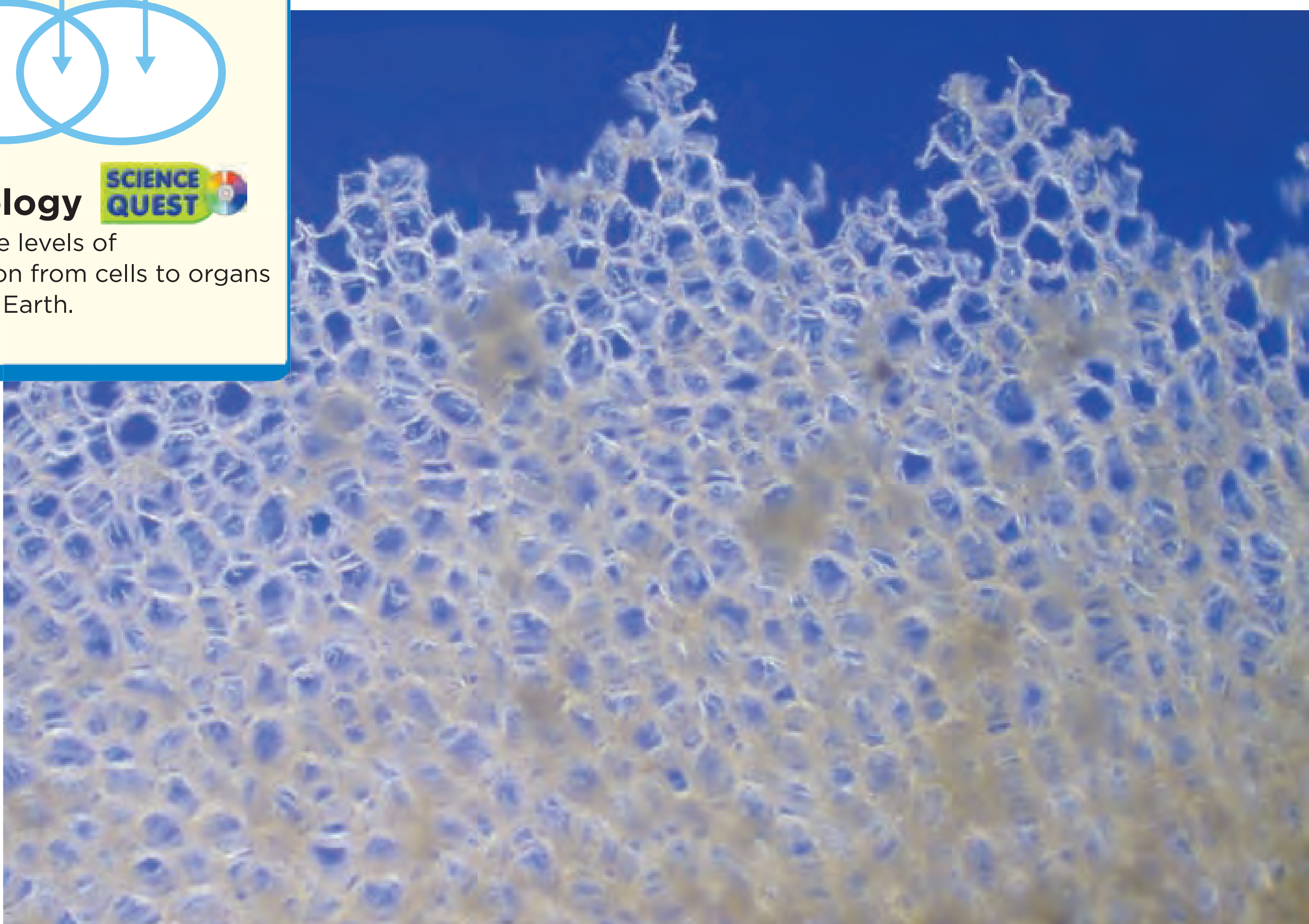
Explore the levels of organization from cells to organs with Team Earth.

What are cells?

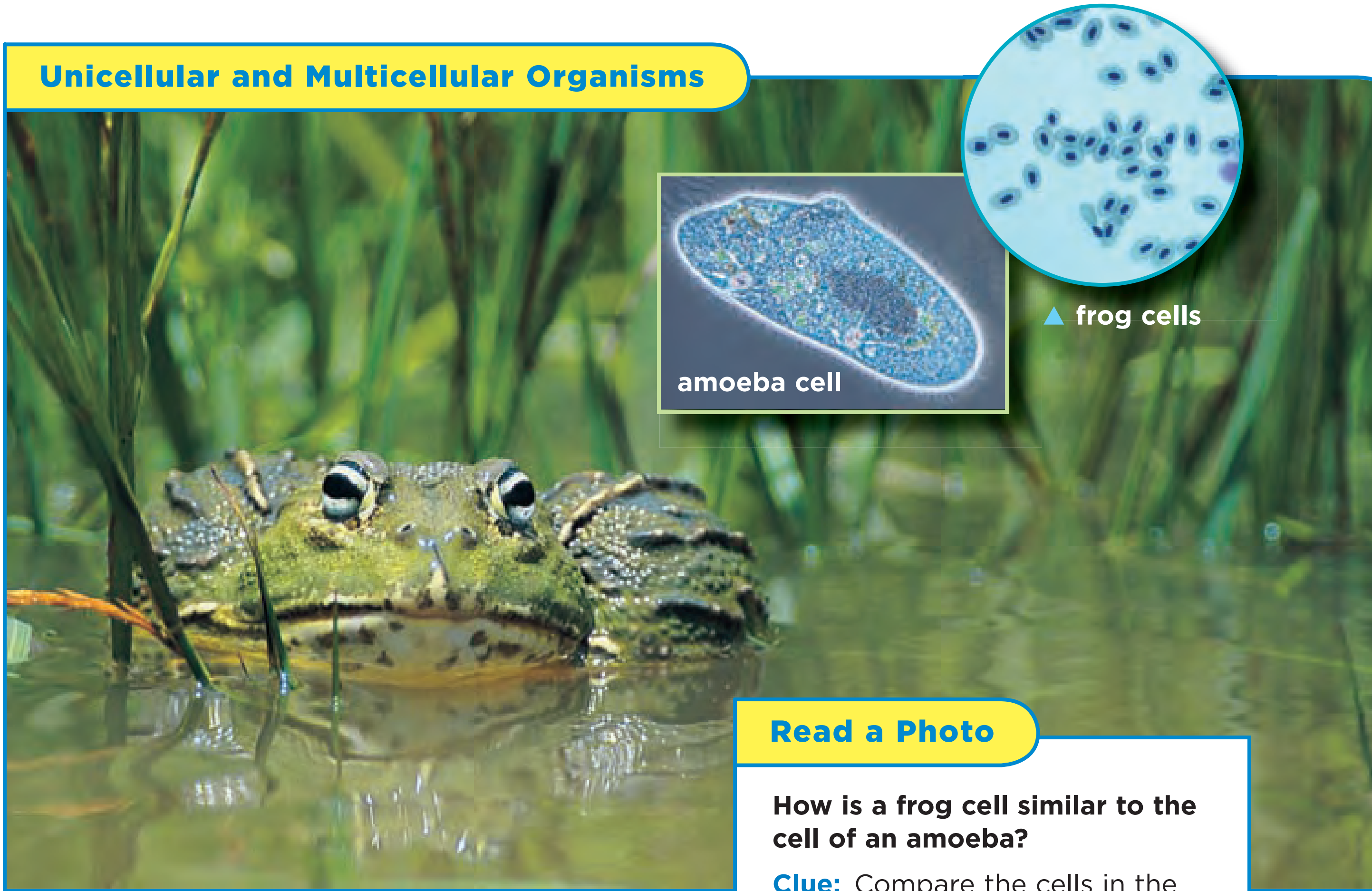
Earth is home to many different living things—big, small, strange, beautiful, and everything in between. You might think a microscopic amoeba and an 18.3-meter-long (60 foot) giant squid could have nothing in common. However, if you look closely through a microscope you will see how similar they are. A giant squid and an amoeba are both organisms (OR•guh•niz•uhmz). An **organism** is a living thing. They are made of the same tiny building blocks. From the smallest organism to the largest, they are all made of cells. A **cell** is the smallest unit of living things that can carry out the basic processes of life.

Where do cells come from? The simple answer is that cells come from other cells! Every cell in every living thing on Earth originally came from another cell. A cell divided, or split into two new cells, and so did the cell before that, and so on.

In 1665, English scientist Robert Hooke looked at a slice of cork in his microscope and saw many "little boxes" like these that he called cells.



Unicellular and Multicellular Organisms



Read a Photo

How is a frog cell similar to the cell of an amoeba?

Clue: Compare the cells in the photos. How are they alike? How are they different?

A **unicellular** (ew•nuh•SEL•yuh•luhr), or one-celled, organism is made of a single cell that carries out its life processes. Life processes include growing, responding to an environment, reproducing, and getting food. **Multicellular** (mul•ti•SEL•yuh•luhr), or many-celled, organisms are made of more than one cell. Multicellular organisms include frogs, trees, and you!

In multicellular organisms, every cell carries out its own life process. The cells also work together to take care of different functions for the organism. For example, all of your heart muscle cells carry out their own life processes, and they work together to keep your heart beating.

How plentiful are unicellular and multicellular organisms? More than $1\frac{1}{2}$ million kinds of organisms have been identified. That number is small compared to the estimated number of unicellular organisms that exist and have not been identified. Scientists estimate that there are more than 1 billion kinds of unicellular organisms!

Quick Check

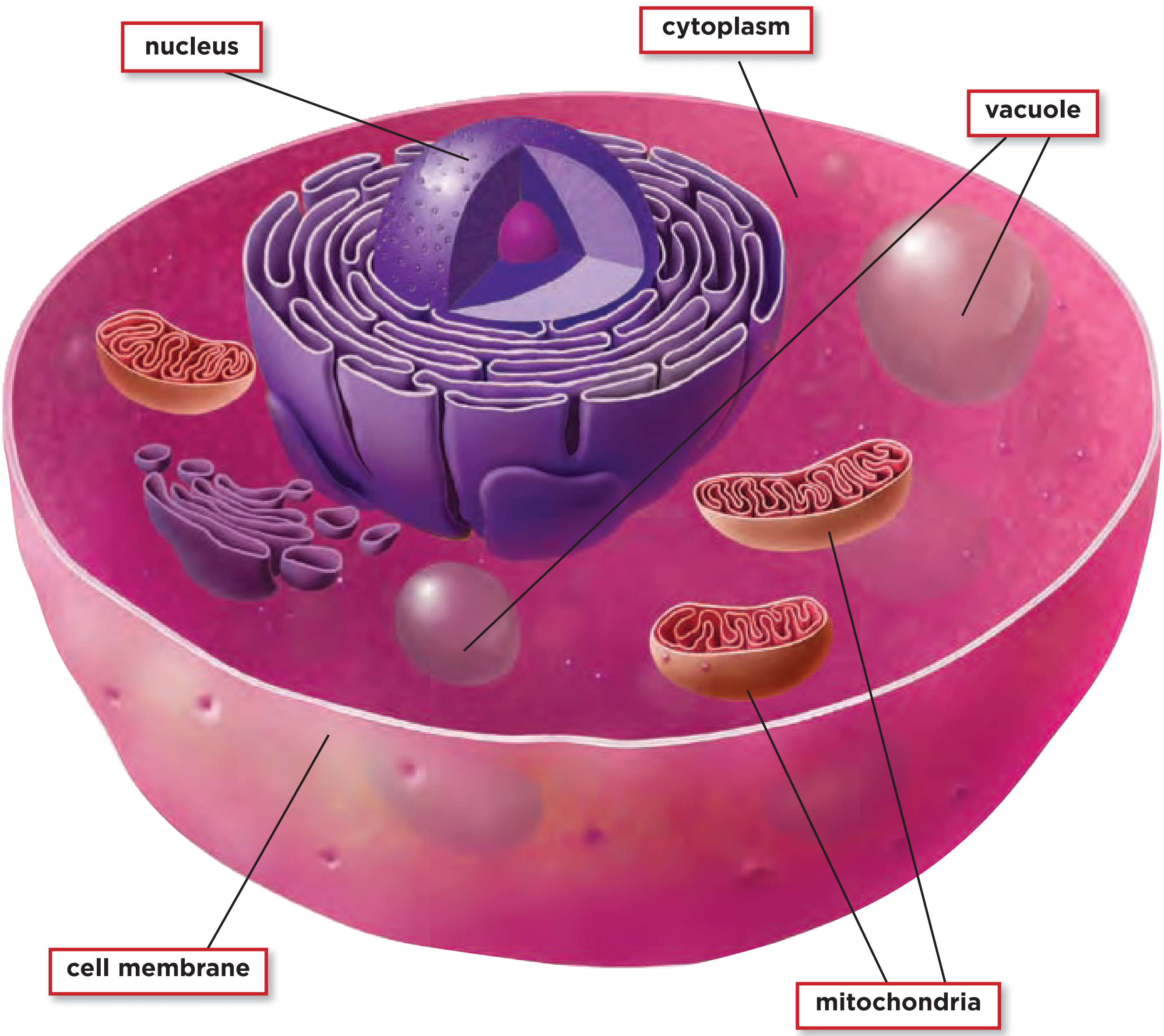
Compare and Contrast How are unicellular and multicellular organisms alike and different?

Critical Thinking Why do you think there are more unicellular organisms than multicellular organisms?

What is inside an animal cell?

All organisms are made of cells. Your own body has more than 200 different kinds of cells. Plant and animal cells have several basic structures, called *organelles* (OR•guh•nelz), that help them perform life processes. Organelles have functions that help keep the cell alive.

Animal Cell



Cell Membrane

Animal cells are surrounded by a flexible wrapping called a *cell membrane*. The cell membrane is a layer around the outside of the cell. It wraps around the cell in somewhat the same way your skin wraps around you. It gives the cell its shape.

The cell membrane controls what materials move into and out of the cell. Only certain substances are able to enter and leave the cell.

Cytoplasm

The cell membrane is filled with a gel-like liquid called *cytoplasm* (SYE•tuh•plaz•uhm). It occupies the region from the nucleus to the cell membrane. Cytoplasm is made mostly of water. A variety of organelles float in the cytoplasm.

The cytoplasm supports all the cell's structures. It is constantly moving through the cell in a stream-like motion. Some of the cell's life processes take place in the cytoplasm.

Nucleus

The *nucleus* (NEW•clee•uhs) is the cell's control center. It is a large, round organelle usually found in the center of the cell. It has a membrane with pores, or openings, that allow certain materials to pass in and out.

The nucleus contains the master plans for all the cell's activities. It sends signals to all other parts of the cell. Cells grow, move, and at some point may divide. These functions are controlled by a cell's nucleus.

Mitochondria

Mitochondria (mye•tuh•KON•dree•uh) are oval, membrane-covered organelles that supply energy for the cell. Each mitochondrion is a tiny power plant. They break down food, which releases energy for the cell to use.

Some cells are more active than others and require more energy. Cells that require a lot of energy, such as muscle cells, usually have a great many mitochondria.

Vacuoles

A *vacuole* (VAK•yew•ohl) is a membrane-covered structure used for storage. It can store water, food, and wastes. The nucleus can signal a vacuole to release whatever it is storing. Some animal cells have many small vacuoles and some may not have any vacuoles.

Quick Check

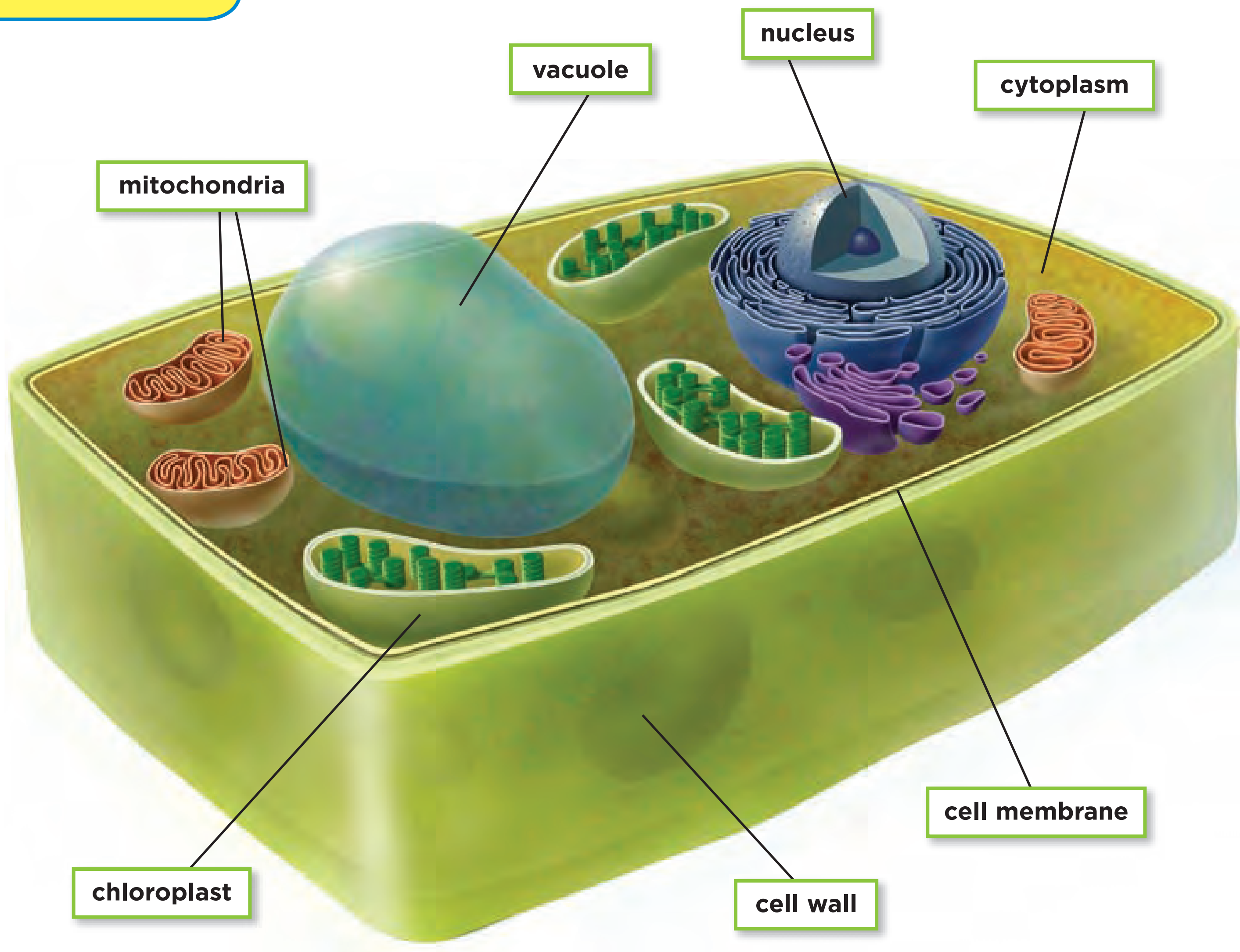
Compare and Contrast How is a mitochondrion similar to a tiny power plant?

Critical Thinking Do you think a cell would function without a nucleus? Explain your answer.

What is inside a plant cell?

Plant cells have many of the same structures and organelles as animal cells. However, plant cells often have a box-like shape and are a bit larger than animal cells. They also have some additional organelles that animal cells do not have.

Plant Cell



Read a Diagram

Which structures in plant and animal cells are the same? Draw a Venn diagram to answer the question.

Clue: Look for key differences between plant and animal cells.

Cell Wall

Plant cells have an additional outer covering around the outside of the cell. This layer is called the *cell wall*. The cell wall is a stiff structure outside the cell membrane. It provides the plant cell with strength and extra support.

Vacuole

Unlike animal cells, plant cells usually have one large, central vacuole. In plant cells this vacuole stores excess water and provides extra support. The extra water in the vacuoles of plant cells keeps the plant from drying out. When a plant needs extra water the vacuoles release the water they have stored into the cells.

Chloroplast

Plants make their own food in structures inside their cells called *chloroplasts* (KLOR•uh•plastz). A chloroplast is a green structure where the energy from sunlight is used to produce food for the plant. Chloroplasts are green because they contain a chemical called chlorophyll (KLOR•uh•fil). **Chlorophyll** is able to use the energy in sunlight.

Many plant cells are green because of the chlorophyll in their chloroplasts. Plant cells that lack chloroplasts are not green. Chloroplasts are mainly found in the cells of leaves and stems of plants.

Quick Lab

Plant and Animal Cells

1. **Make a Model** Put one plastic bag in a storage container. This is a plant cell. Use another plastic bag as an animal cell.
2. Using a spoon, carefully put gelatin in both bags until the bags are almost full.
3. Choose vegetables that look the most like the plant-cell and animal-cell organelles.
4. Place the vegetables that you have picked into the appropriate container and seal the bags.
5. Try to stack your models. How well do the plant cells stack compared to the animal cells?
6. **Communicate** Discuss with your classmates which vegetables you selected for your organelles and explain why.

Quick Check

Compare and Contrast Which cell has a stronger outer covering—a plant cell or an animal cell?

Critical Thinking A plant cell has a thick cell wall and large vacuoles. However, it does not seem to have chloroplasts. What part of the plant might this cell be from?

How are cells organized?

For unicellular organisms, organization is simple. The organism has only one cell that performs all life functions. Multicellular organisms are more specialized. Your own body contains many different cell types that have specific functions. Muscle cells, for example, specialize in movement. Red blood cells, on the other hand, carry oxygen to other cells.

In a complex organism like a salamander, organization starts at the cell level. Cells are the building blocks of the body. Similar cells working together at the same job, or function, form a **tissue** (TISH•ew). A group of tissues that work together to perform a specific function form an **organ** (OR•guhn). The salamander's heart, liver, brain, and skin are organs.

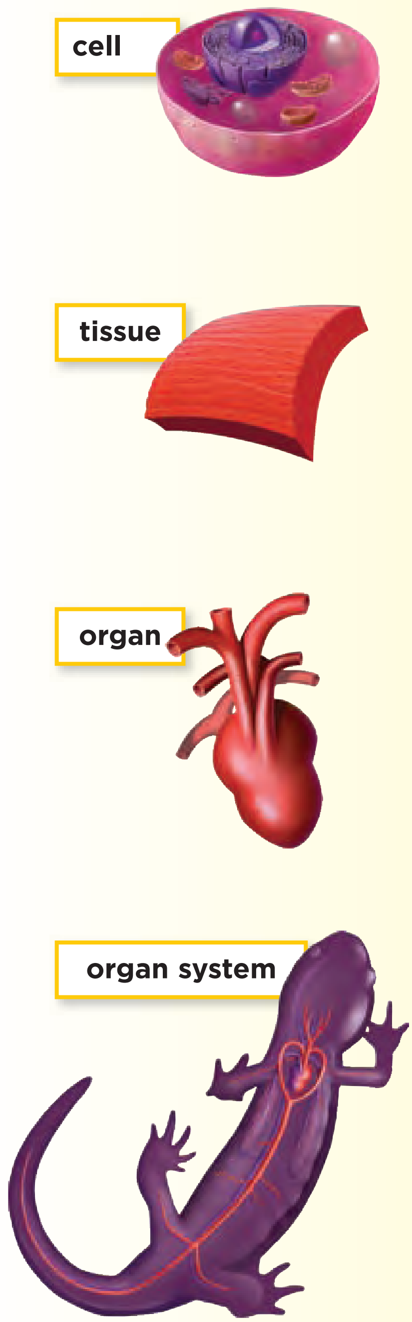
Organs that work together to perform a certain function make up an **organ system**. For example, the salamander's circulatory system includes its heart, blood, and blood vessels. These work together to bring food, oxygen, and other materials to the salamander's cells. Some organ systems work together with other organ systems. The digestive system sends food to the circulatory system. The blood vessels in the circulatory system bring this food to the salamander's cells. All of the cells, tissues, organs, and organ systems form an organism.

Quick Check

Compare and Contrast How do organs compare to organ systems?

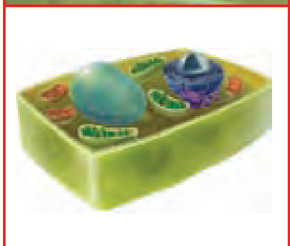
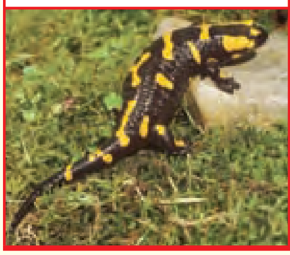
Critical Thinking How are complex organisms organized?

From Cells to Organisms



Lesson Review

Visual Summary

	**Cells** are the basic building blocks of all living things.
	Animal cells and plant cells share some **organelles**, but animal cells do not have cell walls, chloroplasts, or large vacuoles.
	Organisms can exist as single cells, or they can be organized into **tissues, organs,** and **organ systems**.

Make a FOLDABLES™ Study Guide

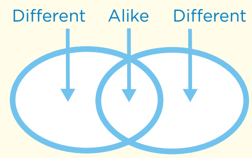
Make a Three-Tab Book. Use the titles shown. Tell about the topic on the inside of each tab.

Think, Talk, and Write

1. **Main Idea** What is the main difference between the ways unicellular and multicellular organisms are organized?

2. **Vocabulary** The cell's power plants are the _________.

3. **Compare and Contrast** How can you tell the difference between a typical plant cell and a typical animal cell?



4. **Critical Thinking** Do bigger organisms have bigger cells? What kind of test could you do to answer this question?

5. **Test Prep** **Which of the following exists in both plant and animal cells?**
   - **A** chloroplast
   - **B** cell wall
   - **C** mitochondrion
   - **D** chlorophyll

6. **Test Prep** **Which of the following is the cell's control center?**
   - **A** cytoplasm
   - **B** nucleus
   - **C** cell membrane
   - **D** vacuole

Math Link

Dividing Bacteria

A single unicellular bacterium divides every half hour. How many bacteria will exist after 3 hours?

Social Studies Link

The Plague

The Plague was a disease that killed many in the Middle Ages. Write a report on this disease. What kind of organism caused plague—unicellular or multicellular?

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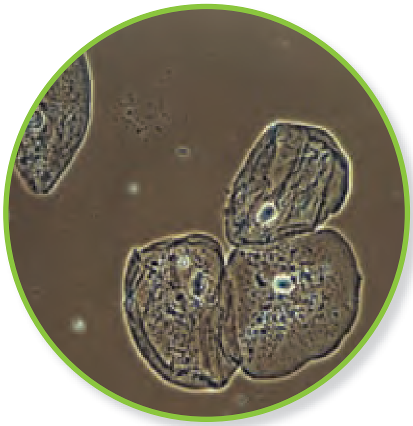
Focus on Skills

Inquiry Skill: Experiment

All living things are made up of cells. Every cell has a cell membrane. The cell membrane is a layer around the cell that lets substances in and out.

Substances move in or out of a cell depending on their concentrations, or amounts. Substances move from areas where they are crowded to areas where they are less crowded. For example, if a cell has a higher concentration of water than its environment, water will flow out of the cell until the concentration on the inside and outside is balanced. One way to learn more about how cell membranes work is by doing an **experiment**.



▶ Learn It

An **experiment** is a test that supports or does not support a hypothesis. To carry out an experiment you need to perform a test that examines the effects of one variable on another using controlled conditions. You can then use your data to draw a conclusion about whether or not the hypothesis has been supported.

In the following experiment, you will test the effects of various substances on a cell membrane. You will gather and analyze data to support or disprove the following hypothesis: If the concentration of a substance is higher outside the membrane, then the substance will move inside the membrane to balance the concentration.

▶ Try It

Materials **2 eggs, balance, 2 glass jars with lids, vinegar, spoon, 2 beakers, water, corn syrup**

1. Measure two eggs using a balance. Record the measurements in a chart.
2. Pour 200 mL of vinegar into two jars with lids. Carefully lower the two eggs into the jars of vinegar. Tighten the lids and leave the eggs inside for two days.
3. Use a spoon to carefully remove the eggs. Rinse the eggs under water.
4. Measure each egg and record the data in your chart.
5. Pour 200 mL of water into a beaker and 200 mL of corn syrup into another beaker. Carefully lower an egg into each beaker. Leave the eggs inside for one day.
6. Use the spoon to carefully remove the eggs. Rinse the eggs under water.
7. Measure each egg and record the data in your chart.

▶ Apply It

1. Now it is time to analyze your data and observations. Use your chart to compare the masses of the eggs.
2. Did the mass of both eggs change? Explain why the masses changed.
3. Did this **experiment** support or disprove the hypothesis?

	First Measurement	Second Measurement	Third Measurement
Egg #1			
Egg #2			

SI-I. Select and safely use the appropriate tools to collect data when conducting investigations.... **SI-3.** Use evidence and observations to explain and communicate the results of investigations. **SWK-2.** Develop descriptions, explanations and models using evidence to defend/support findings.

Lesson 2

Plants

Arizona wildflowers and cacti

Look and Wonder

Some cactus plants can survive for a year on the water they store in their roots and stems. What do cactus plants have in common with other vascular plants?

LS-I. Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis.

Explore

Inquiry Activity

How is water transported in vascular plants?

Form a Hypothesis

Vascular plants have vessels that transport food and water in the plant. How does the amount of leaves on a plant affect transport through a plant stem? Write your answer as a hypothesis in the form "If the number of the leaves on a plant decreases, then . . .

Test Your Hypothesis

1. Fill 3 plastic cups with water. Be sure that each cup has the same amount. Put 3 drops of food coloring in each cup of water.
2. Break all the leaves off one celery stalk. Remove all but one leaf on another stalk. Leave the third stalk intact. Place a celery stalk in each cup.
3. **Observe** On the following day, examine each cup. What happened to the water? Note any changes.
4. **Measure** Use a ruler to measure how far up the water traveled in each celery stalk.

Draw Conclusions

5. What are the independent and dependent variables in this experiment?
6. **Interpret Data** Did the amount of leaves affect the transport of water?
7. Did your results support your hypothesis?

Explore More

What other variables can affect the movement of water through a plant? How will adding sugar or salt affect water transport in a plant? Form a hypothesis and test it. Then analyze and write a report of your results.

Materials

- 3 plastic cups
- water
- blue food coloring
- 3 celery stalks with leaves
- ruler

SI-3. Use evidence and observations to explain and communicate the results of investigations. **SI-4.** Identify one or two variables in a simple experiment.

Read and Learn

Main Idea LS-I

Plants perform photosynthesis, which provides food and energy for most organisms.

Vocabulary

gymnosperm, p. 39
angiosperm, p. 39
xylem, p. 43
phloem, p. 43
cambium, p. 43
photosynthesis, p. 44
transpiration, p. 44
cellular respiration, p. 46

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Reading Skill

Draw Conclusions

Text Clues	Conclusions

Technology

SCIENCE QUEST

Explore photosynthesis and respiration with Team Earth.

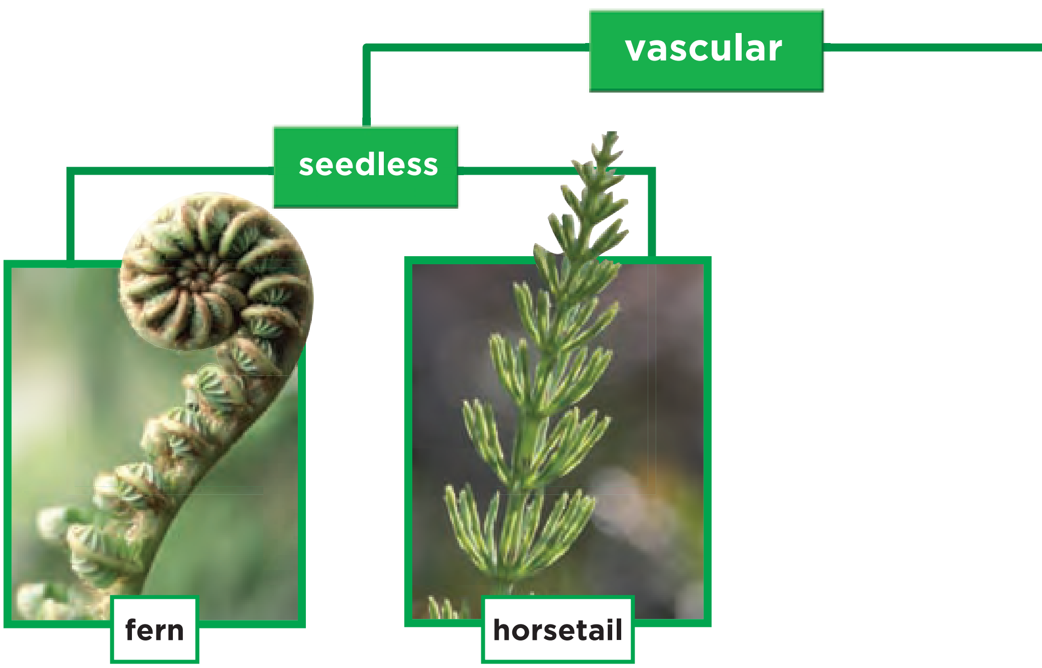
How are plants classified?

All plants need space, air, water, and sunlight. In most cases, plants can obtain air and sunlight directly from their environments. Transporting water and other nutrients can be more difficult.

Nonvascular plants are small and survive without a transport system. Mosses, for example, reach heights of a centimeter or less. Their parts are very close to the ground to absorb water directly.

Vascular plants do not have the same size limitations. Trees, for example, can grow to heights of more than 65 meters (200 feet). How do trees get water up to their higher branches and leaves? Inside a tree trunk there is a *vascular system*, which is a series of hollow tubes. These tubes can transport water and nutrients to the top of the tallest redwood tree where they are used by the plant.

Vascular plants are divided into seed plants and seedless plants. Seed plants, like pine trees and flowering plants, produce seeds. A *seed* contains an undeveloped plant, stored food, and a protective covering. The protective covering prevents the seed from drying out or getting damaged. The



undeveloped plant uses the stored food to grow and develop.

Seedless plants, like ferns, produce spores. A *spore* is a single cell that can develop into a new plant exactly like the plant that produced it. Spores have a tough outer covering. It protects them from drying out until they find the right conditions for growth.

There are two main types of seed plants: gymnosperms (JIM•nuh•spurmz) and angiosperms (AN•jee•uh•spurmz). A **gymnosperm** is a seed plant that does not produce a flower. They include pines, firs, and other cone-bearing trees. Gymnosperms have hard seeds that are uncovered.

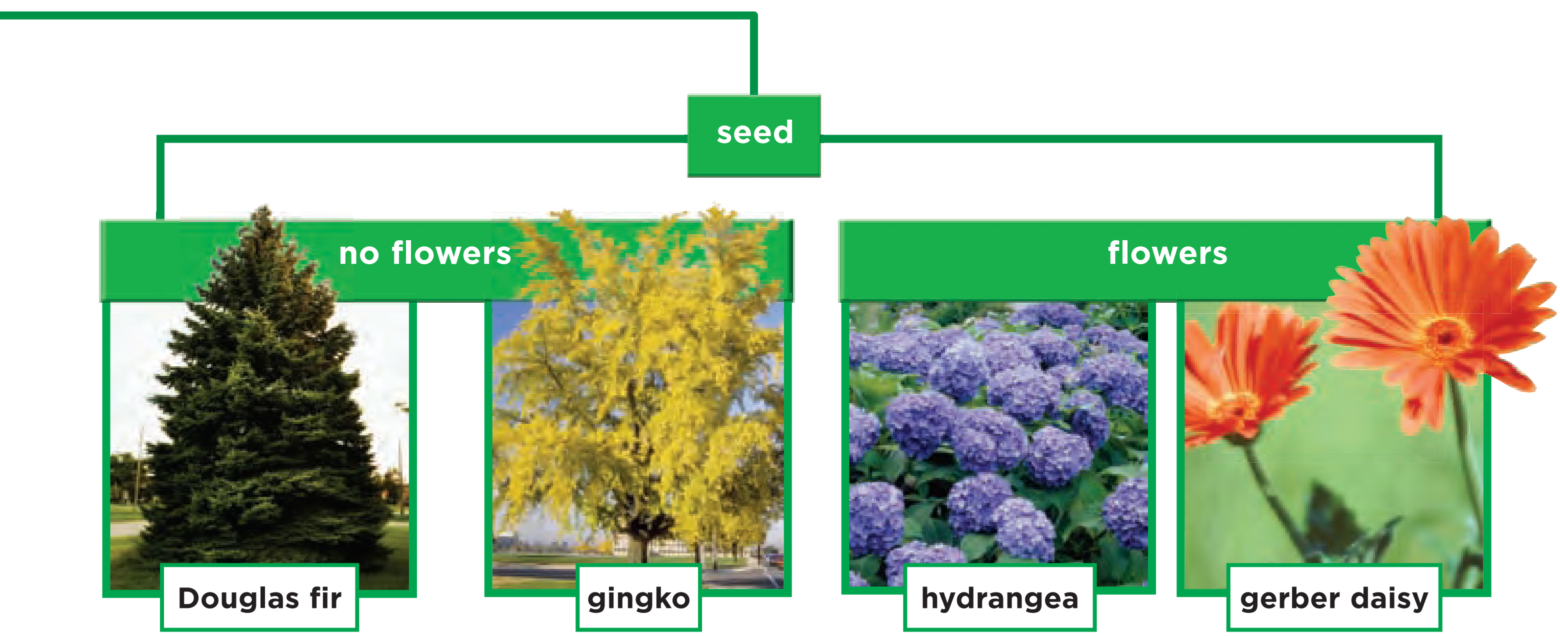
An **angiosperm** is a seed plant that produces flowers. All angiosperms have seeds that are covered by some kind of fruit. Some angiosperms have familiar fruits, like apples and plums. Other angiosperms, like grasses, have smaller and less-colorful fruits.

Angiosperms are the most plentiful of all plant types. There are about 250,000 different kinds of angiosperms. Some familiar angiosperm plants include tulips, maple trees, rose bushes, and corn.

Quick Check

Draw Conclusions A plant is 20 meters (65 feet) tall and it does not produce flowers. What conclusions can you draw about this plant?

Critical Thinking How is height an advantage for some vascular plants?



Quick Lab

Observe a Root

1. **Observe** Look at a carrot cut lengthwise. What structures do you see?
2. Look at a cross section of a carrot. Can you identify the epidermis, cortex, and inner transport layers?
3. Draw a diagram of the carrot in cross section. Label the parts.
4. **Infer** Is the carrot a fibrous root or a taproot?
5. Would it be easier to pull a plant with a taproot from the ground or a plant with a fibrous root system? Explain your answer.

What are roots?

Have you ever tried to dig up a plant? If so, then you might have hit a maze of stringy, cordlike roots. A *root* is the part of the plant that absorbs water and minerals, stores food, and anchors the plant.

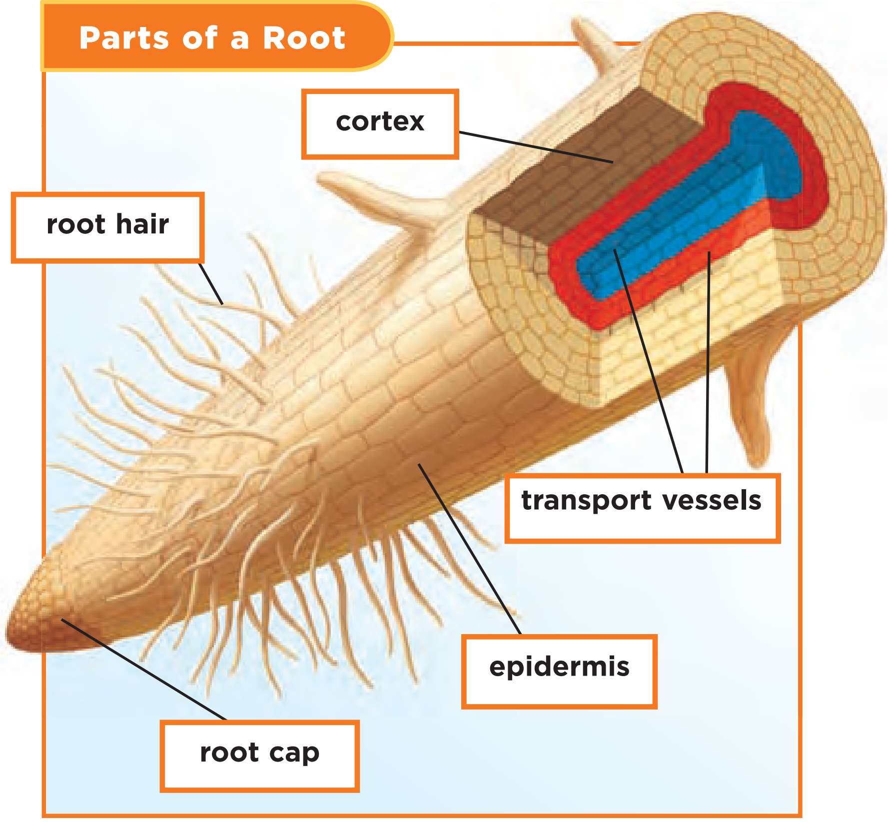
Roots absorb water using fuzzy root hairs. A *root hair* is a threadlike projection from a plant root. Each root hair is less than 1 millimeter (0.04 inches) in length, but together they soak up moisture like a sponge.

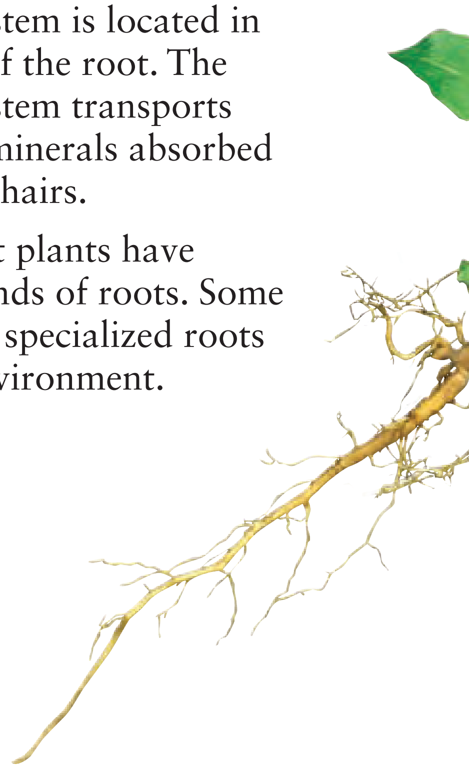
A typical root of a vascular plant is made of three different layers and a root cap. The *root cap* covers the tip of the root. It protects the root tip while it pushes into the ground.

The outer layer of a root and the whole plant is the *epidermis* (ep•i•DUR•mis). The epidermis of a root has root hairs and absorbs water. A *cortex* layer is located just under the epidermis. It is used to store food and nutrients. The vascular system is located in the center of the root. The vascular system transports water and minerals absorbed by the root hairs.

Different plants have different kinds of roots. Some plants have specialized roots for their environment.

Parts of a Root



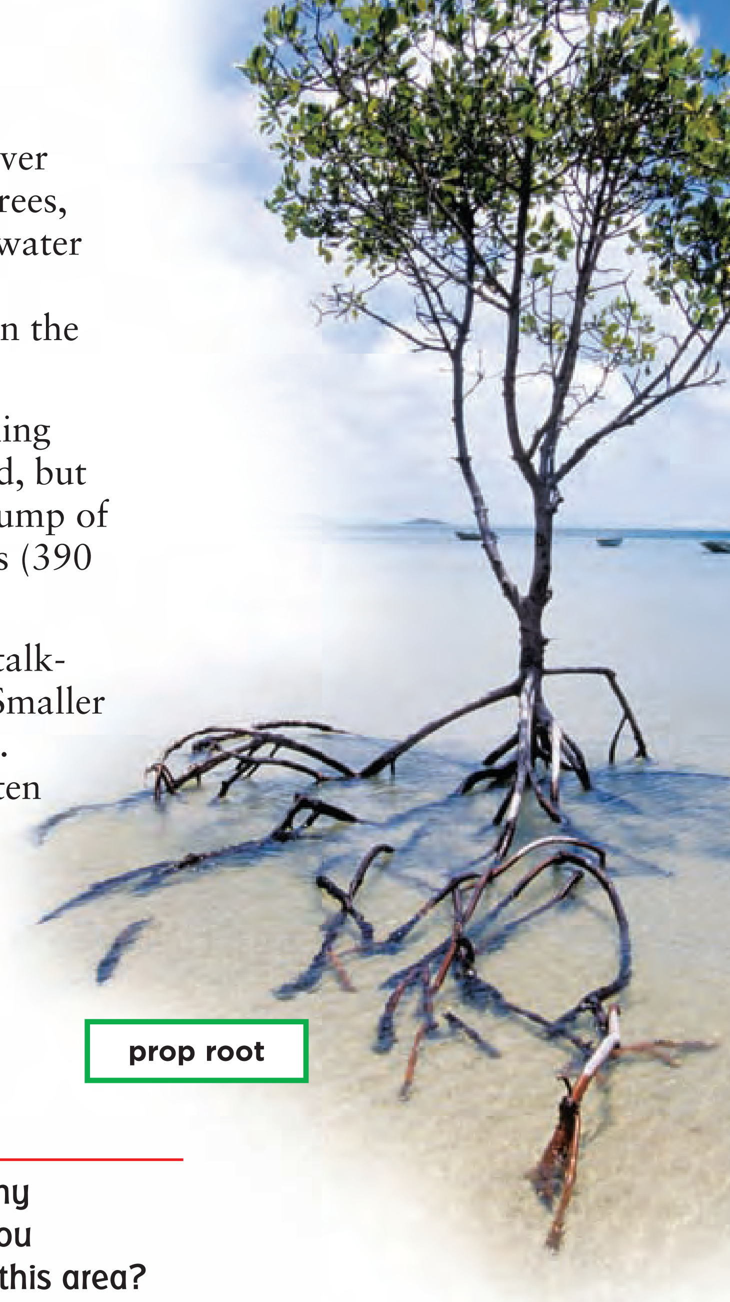


Aerial (AYR•ee•uhl) *roots* are roots that never touch the ground. They anchor the plant to trees, rocks, or other surfaces. Aerial roots absorb water from the air and rain, rather than soil. Many orchids have aerial roots. Some live high up in the rain forest attached to tree bark.

Fibrous (FYE•bruhs) *roots* are thin, branching roots. They do not grow deep into the ground, but they often cover a very wide area. A single clump of grass was found to have some 600 kilometers (390 miles) of fibrous roots.

Plants with *taproots* have a single, main stalk-like root that plunges deep into the ground. Smaller side roots often branch off of a main taproot. Pine trees and plants that live in dry areas often have taproots.

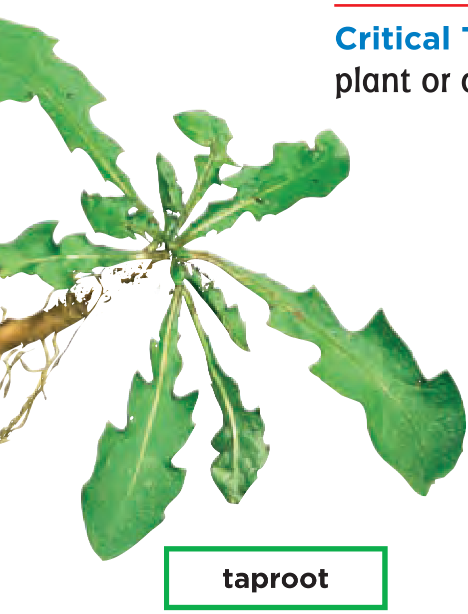
Prop roots usually grow at the bottom of a plant's stem. They prop up and support the plant so it cannot be knocked over. Corn plants and mangrove trees have prop roots.

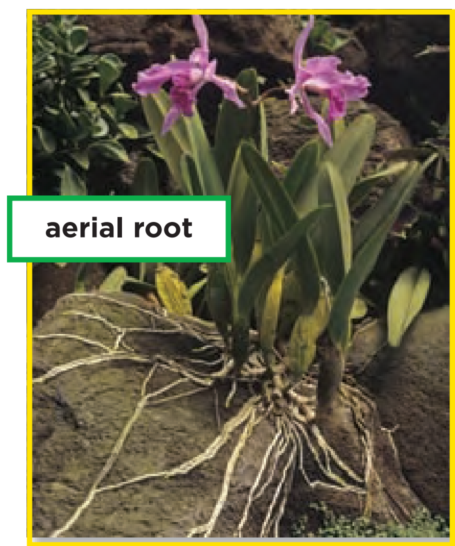


Quick Check

Draw Conclusions An area has many plants with taproots. Where would you expect to find underground water in this area?

Critical Thinking Would you expect a desert plant or a swamp plant to have more root hairs?



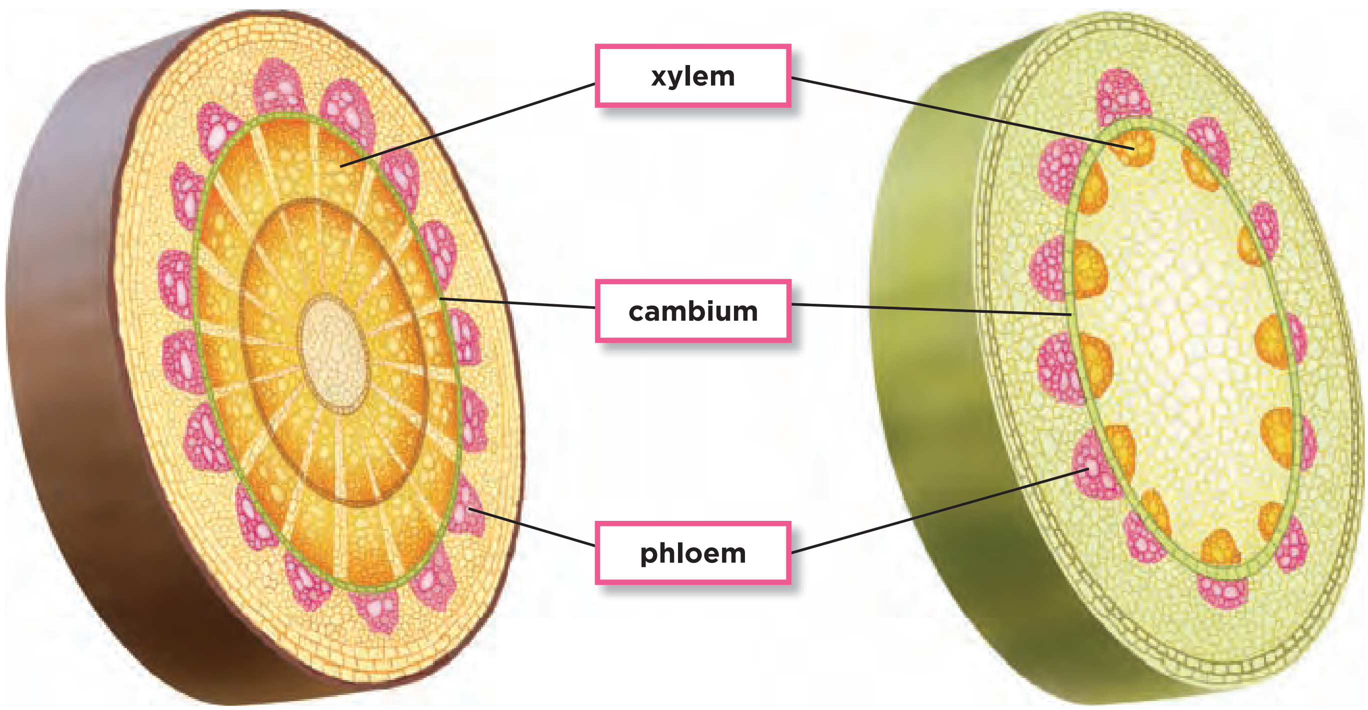


What are stems?

Each part of a plant has a special function. The plant's stem has two functions. First, it is a support structure. The stem of a tree, for example, must support the weight of the entire tree. Smaller plant stems support less weight, but most stems must be sturdy enough to support leaves, flowers, and branches.

Stems come in two basic forms—soft stems and woody stems. Soft stems are not as strong as woody stems. They are soft, green, and can bend. Their green color shows that their cells have chlorophyll and produce food. Shrubs and trees have woody stems. Woody stems are often covered with *bark*, a tough outer covering that serves as a protective layer. Woody stems do not contain chlorophyll.

Soft and Woody Stems



woody stem **soft stem**

Read a Diagram

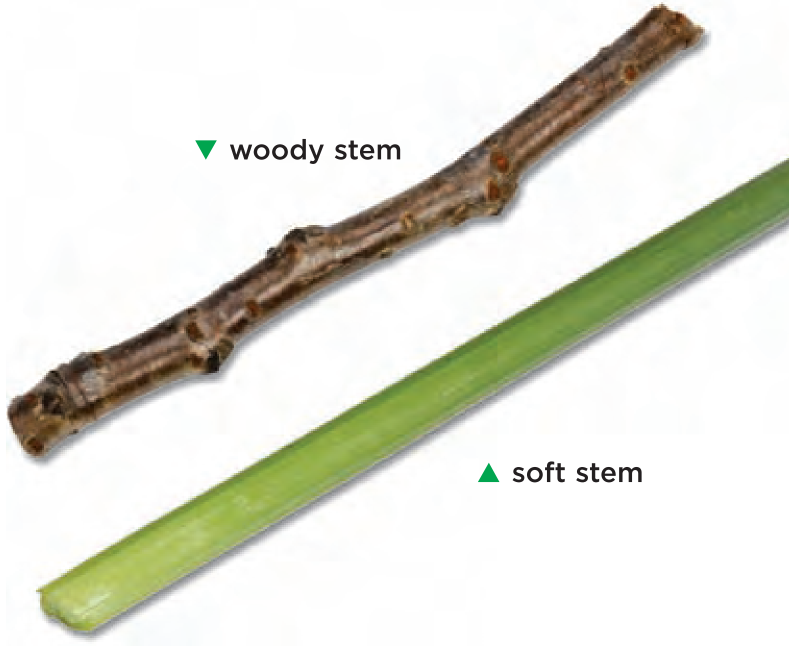
How are the xylem, phloem, and cambium arranged differently in the woody stem and the soft stem?

Clue: Compare the location and shape of the xylem, phloem, and cambium in each stem.

The stem's second function is to serve as a transport system for the plant. The transport system actually begins in the roots of the plant. Two kinds of cells make up the system. **Xylem** (ZYE•luhm) is a series of tubes that moves water and minerals up the stem. Xylem tissue conducts, or transports, in one direction only—up from the plant roots to the leaves.

Phloem (FLOH•em) moves sugars that are made in the plant's leaves to other parts of the plant. Phloem tissue is a two-way transport route. It flows both up and down in a plant. In a carrot, for example, sugars are brought down from the leaves of the plant to the taproot through the phloem. Phloem also transports sugars up from one part of a plant to another.

The xylem and phloem layers in a plant stem are separated by a layer called the **cambium** (KAM•bee•uhm). Xylem and phloem cells are produced in the cambium, then move inward. When they are alive in the cambium layer, xylem cells are not able to transport water. It is only after the cells die and become hollow that they are able to function as transport vessels.

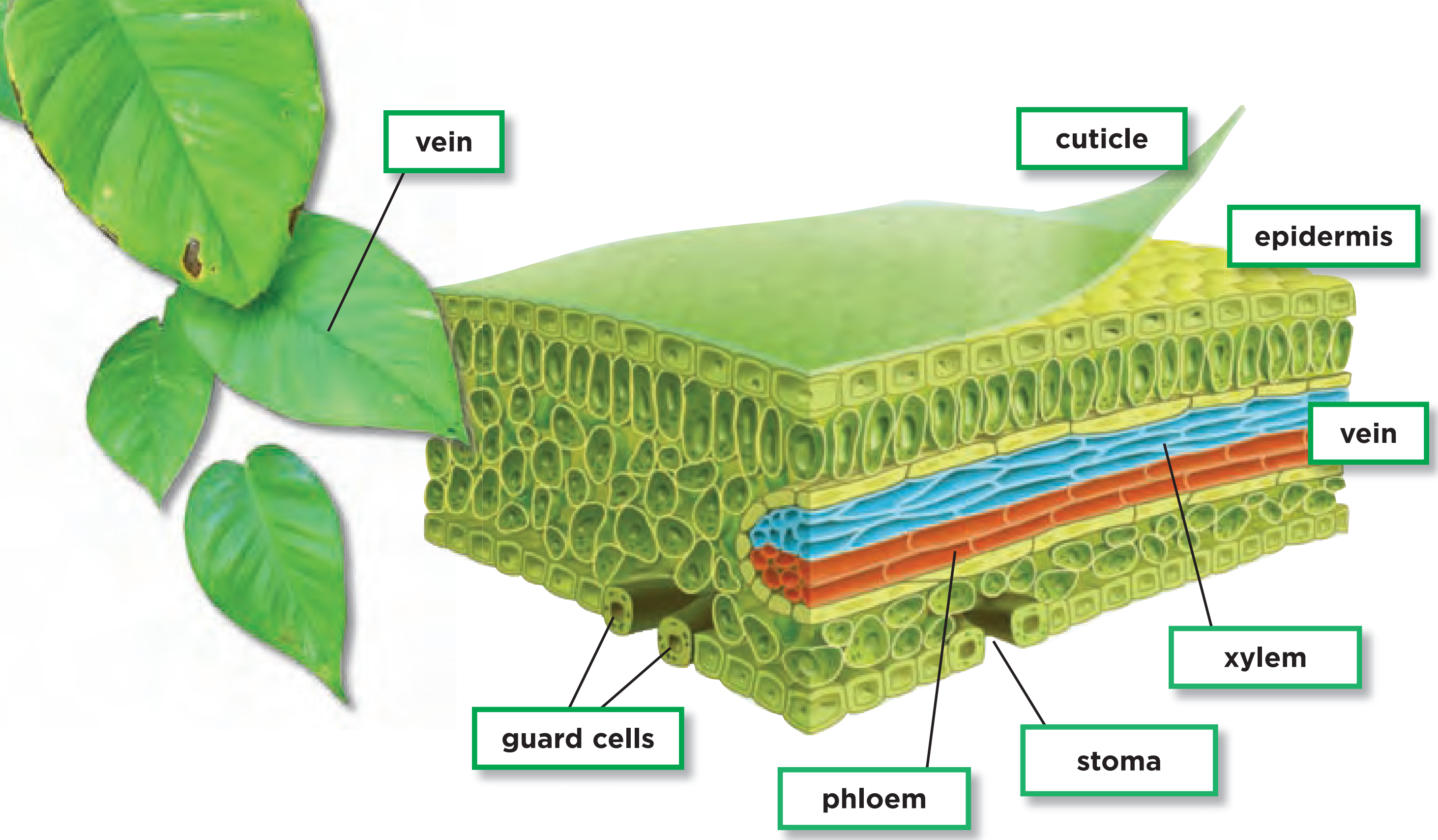


Quick Check

Draw Conclusions In how many directions does xylem move water and minerals?

Critical Thinking Why do most trees have woody stems?

Tree rings are formed by layers of xylem and phloem.



What are leaves?

The leaves of a plant have the important function of carrying out **photosynthesis** (foh•tuh•SIN•thuh•sis), or the process of making food. Cells within the leaf's epidermis make up the plant's main food factory. To perform photosynthesis, leaves need three raw materials: sunlight, water, and carbon dioxide from air. Each leaf is designed to obtain these materials.

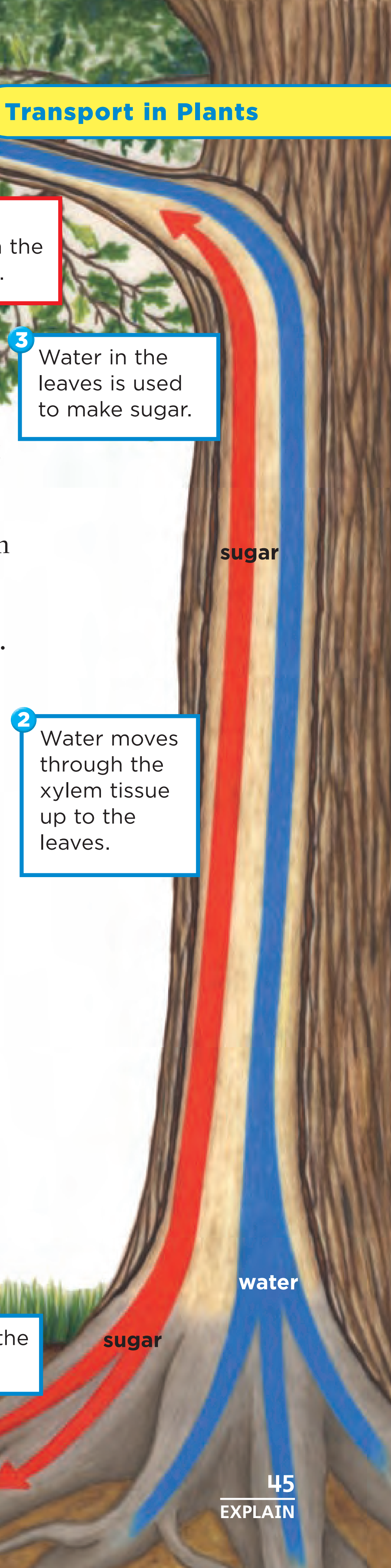
Many leaves are flat and broad. This allows the leaf to collect the most sunlight possible. Chlorophyll in the chloroplasts of the leaves traps the energy of sunlight.

Water enters the plant through its roots. It is transported up through the xylem tissue in the leaf veins. The top leaf surface also has a waxy *cuticle*, a waterproof layer that prevents moisture from evaporating.

Leaves get carbon dioxide from the air. Air enters and moves out of the plant through tiny pores on the underside of the leaves called *stomata* (STOH•muh•tuh). A single pore is called a *stoma*. Each stoma is controlled by guard cells. When the leaf has plenty of water, the guard cells swell and pull the stomata open. This allows water and air to leave the plant. The loss of water through a plant's leaves is called **transpiration** (tran•spuh•RAY•shuhn). When the plant is low on water, the guard cells shrink. This causes the stomata to close and prevents water from escaping.

As water evaporates from the leaves, more water is carried from the bottom of the plant to the top. Finally, water moves into the leaf, replacing the water that has evaporated.

Transport in Plants



Now the plant has all the raw materials for performing photosynthesis. Carbon dioxide and water enter the chloroplasts in the plant's cells. They combine in the presence of the trapped energy from sunlight. This reaction produces sugar and oxygen. The sugars are transported to all the plant's cells by the phloem tissue. Excess sugar is stored as starch, which the plant can break down for food. Most of the oxygen leaves the plant through the stomata as a waste product.

Scientists express what happens during photosynthesis by a chemical equation. This equation shows that the materials of photosynthesis react together and what they produce.

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} + \text{energy} \rightarrow \underset{\text{sugar}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

Quick Check

Draw Conclusions Suppose you did not water a plant for two weeks. What position would you expect the stomata of the plant to be in?

Critical Thinking Would you expect a rain forest tree or a desert cactus to have a thicker cuticle?

Read a Diagram

How does sugar produced in the leaves get to the roots?

Clue: Read the labels to find the answer.

How are photosynthesis and respiration related?

The most important source of energy for Earth is the Sun. Plants can use the Sun's energy to make fuel. The sugars produced during photosynthesis are used by most organisms for energy. The energy is released when the cells of organisms use oxygen to break down the sugars stored as starch in the process of **cellular respiration** (SEL•yuh•luhr res•puh•RAY•shuhn).

Cellular respiration occurs in the mitochondria of your cells. Here oxygen combines with stored sugars to release energy which your body uses to do work. Plants also perform cellular respiration. They take in oxygen from the air through their stomata and break down sugars for energy.

During cellular respiration, plant and animal cells produce carbon dioxide and water as waste products, which are then released back into the air. Plants use the released carbon dioxide and water to produce sugars during photosynthesis.

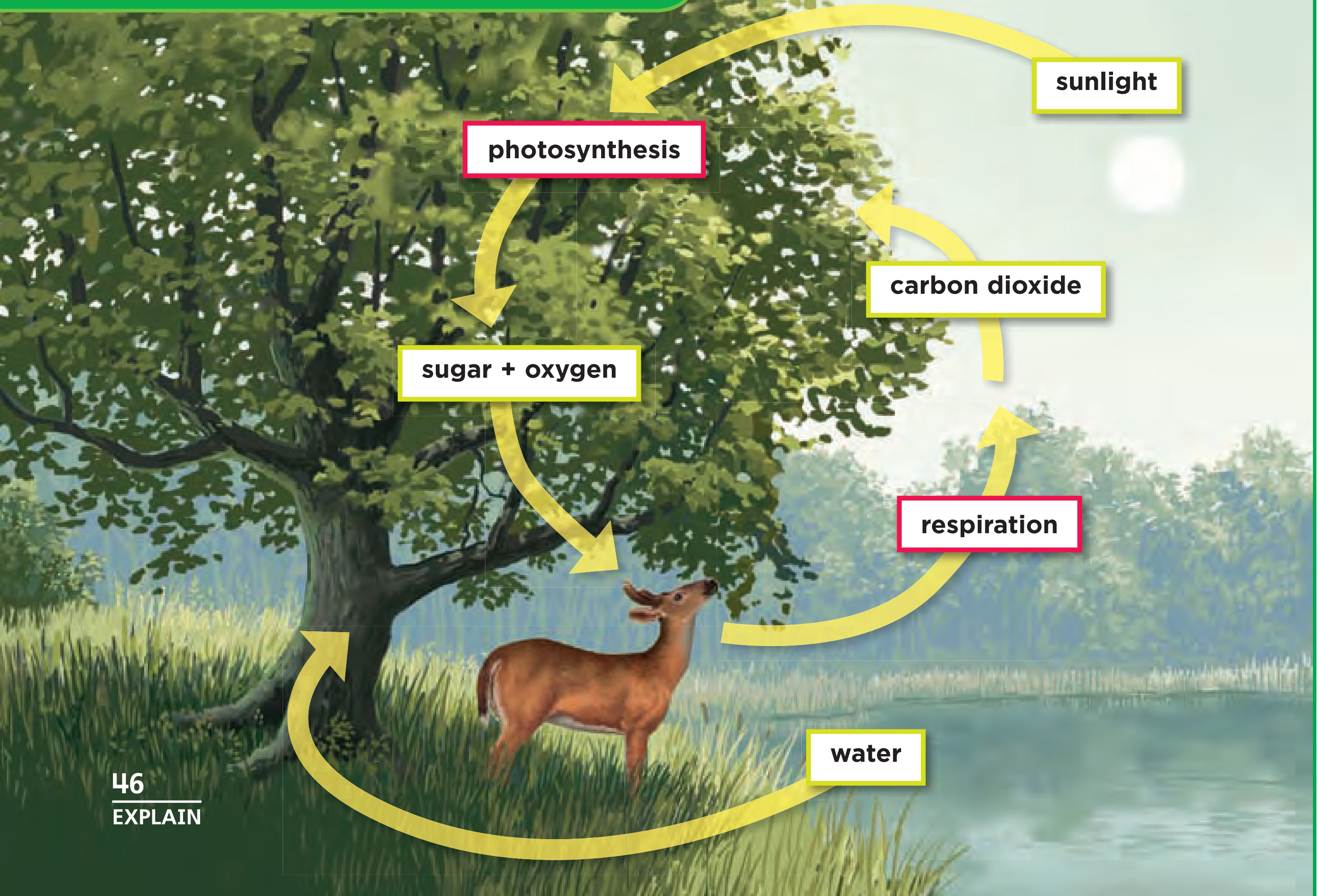
$$6O_2 + C_6H_{12}O_6 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

Quick Check

Draw Conclusions Do plants produce carbon dioxide? Explain.

Critical Thinking Is it easier for your body to store food or oxygen?

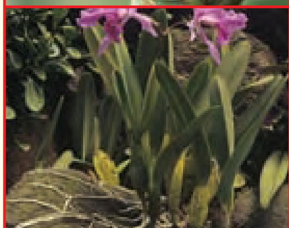
Photosynthesis and Respiration



Lesson Review

Visual Summary

Plants are divided into **vascular** and **nonvascular** plants. Vascular plants are divided into seed plants and seedless plants.

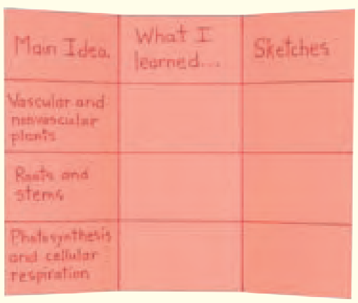


Roots anchor a plant and supply it with water and minerals. **Stems** support a plant and transport materials.

Leaves carry out the process of **photosynthesis**. Organisms burn the sugars produced in photosynthesis during **cellular respiration**.

Make a FOLDABLES™ Study Guide

Make a Trifold Book. Use the titles shown. Tell what you learned about each title.



Think, Talk, and Write

1. **Main Idea** Why do all plants need air, water, and sunlight?

2. **Vocabulary** Flowering plants are called ________.

3. **Draw Conclusions** An insect cannot survive in a covered jar, even though the jar contains food and water. When a plant is added to the jar, the insect can now survive. Explain.

Text Clues	Conclusions

4. **Critical Thinking** Animals depend on plants for food. Could plants make food without animals?

5. **Test Prep** **Which kind of plant produces fruit?**
   - **A** angiosperm
   - **B** nonvascular
   - **C** seedless
   - **D** gymnosperm

6. **Test Prep** **Which of the following is found inside the stem of a plant?**
   - **A** epidermis
   - **B** xylem
   - **C** root hairs
   - **D** leaves

Writing Link

Explanatory Writing

Aliens from another planet want to know how organisms on Earth obtain energy. Write a letter to the aliens explaining how organisms on Earth obtain energy.

Math Link

Energy Fractions

A plant uses $\frac{1}{10}$ of the Sun's energy it receives to make sugars. An animal that eats the plant uses about $\frac{1}{10}$ of the plant's stored energy. What fraction of the Sun's energy does the animal use?

Saving Water the Yucca Plant Way

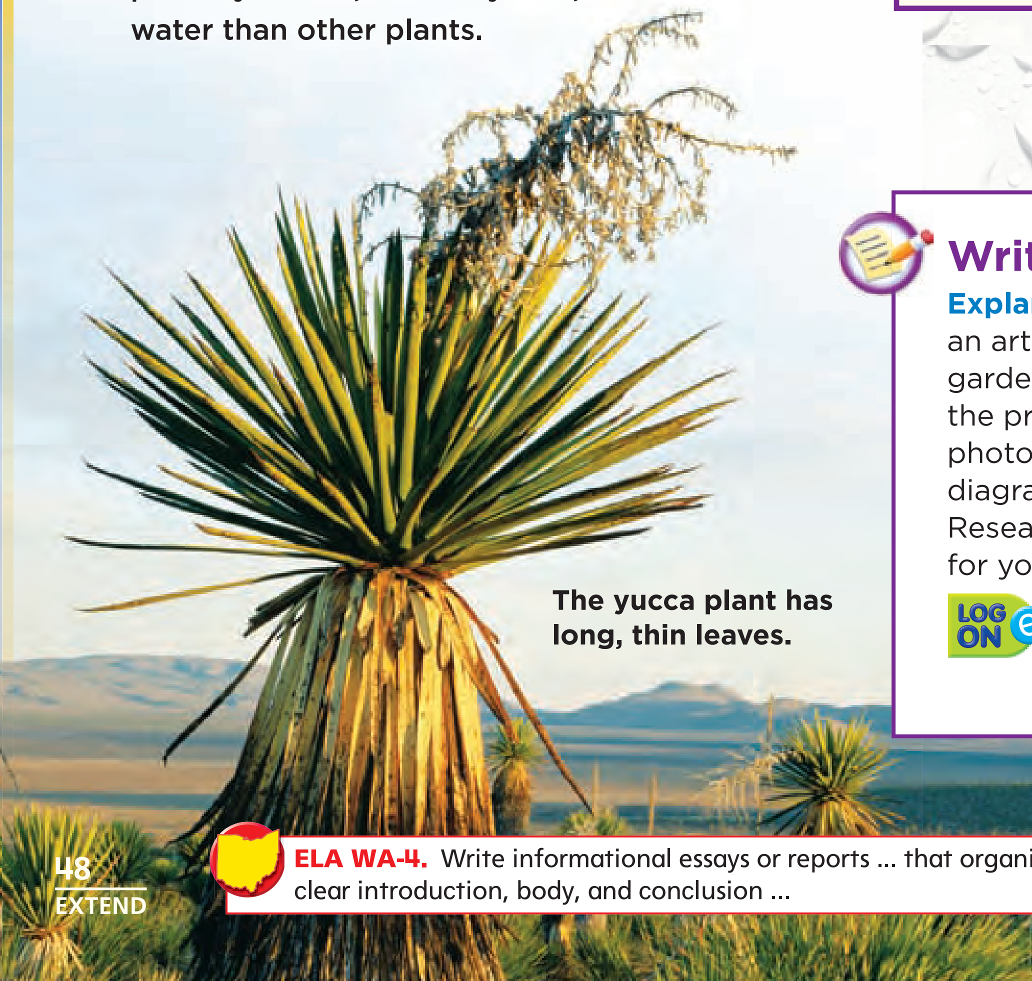
Yucca plants grow in the deserts of California and the southwest parts of North America. They have long, narrow leaves that are adapted to save water. Yuccas use a special kind of photosynthesis called CAM photosynthesis.

Most plants open their stomata during the day. They need carbon dioxide for photosynthesis. Yucca plants only open their stomata at night. This keeps the yucca from losing water through evaporation in the hot desert sun. During the day, the yucca plant uses its stored carbon dioxide to perform photosynthesis. Desert plants that use CAM photosynthesis, like the yucca, lose much less water than other plants.

Explanatory Writing

A good explanation

- develops the main idea with facts and supporting details
- lists what happens in an organized and logical way
- uses time-order words to make the description clear



The yucca plant has long, thin leaves.

Write About It

Explanatory Writing Write an article for young gardeners. Explain the process of CAM photosynthesis. Add a diagram to help explain. Research facts and details for your article.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA WA-4. Write informational essays or reports ... that organize information with a clear introduction, body, and conclusion ...

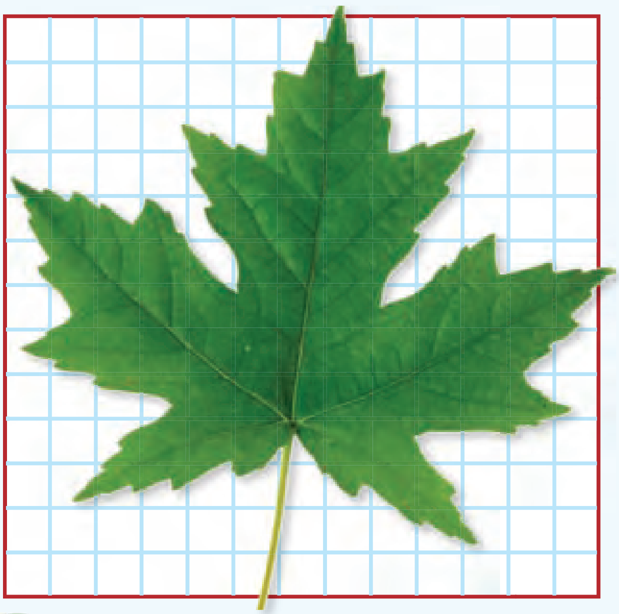
Leave It Be

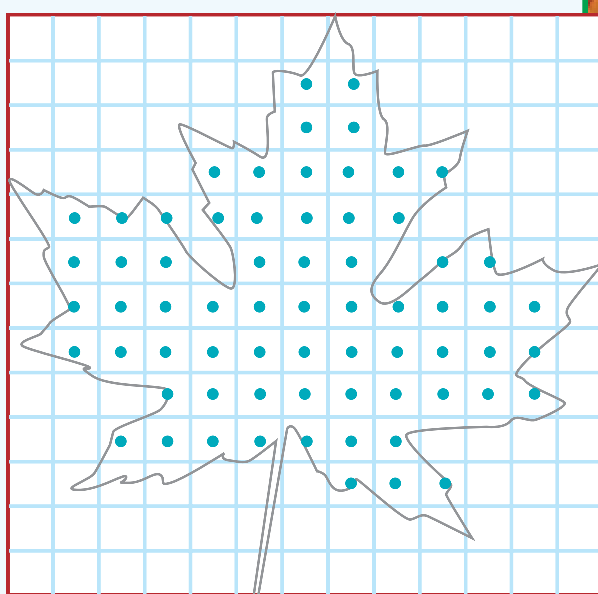
Some leaves, like a tiny pine needle, have a very small surface area. Others, like a maple leaf, have a large surface area. The surface area of leaves is directly connected to the amount of sugar and oxygen they produce. Therefore, one can assume that a single pine needle does not produce as much sugar and oxygen as a maple leaf. How can you find the surface area of a leaf?

Calculating Area

To find the area of an irregular figure

- trace the figure on graph paper
- count the number of whole square units
- count the number of partial square units and divide this number by 2
- add the two numbers





Solve It

1. Find a leaf. Calculate the area of your leaf.
2. Compare the area of your leaf to the area of the maple leaf in the example above.
3. Which produces more sugar and oxygen?

whole squares	+	partial squares	÷ 2	= area
43	+	24	÷ 2	= area
43	+	12		= 55

MA M-6. Use strategies to develop formulas for determining perimeter and area of triangles, rectangles, and parallelograms ...

Lesson 3

Animals

Christmas tree worm

Look and Wonder

These strange-looking organisms are actually animals. What characteristics do all animals have? How do you determine whether an organism is an animal?

Building block lesson for LS-3. Trace the organization of simple food chains and food webs ...

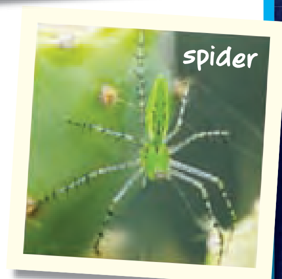
Explore

Inquiry Activity

How do you classify animals?

Purpose

A dichotomous key lists traits of organisms. It gives directions that lead you to an organism's identity. Create a dichotomous key to identify the animals shown.

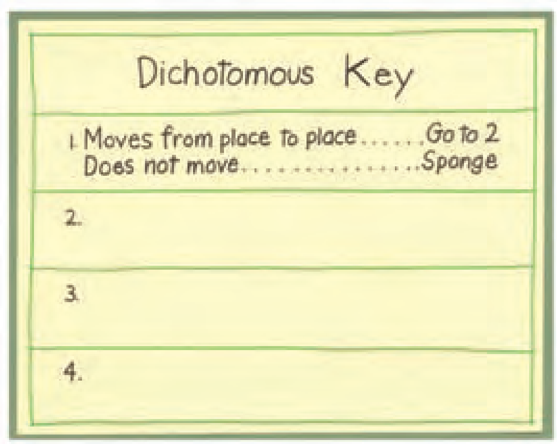


Procedure

1. **Observe** Look at the animals shown. What features do they have? How can you use these features to classify them?
2. Make a key. The key should include a series of yes or no questions that can help you identify the animals.
3. Start your key with a general question. Make each additional question eliminate at least one animal. For example, you might start by asking "Is this animal able to move by itself from place to place?" If the animal is a worm, you would answer "Yes," and move on. If the animal is a sponge, you would answer "No."
4. Keep writing questions until you can single out one animal in your key.
5. **Communicate** Exchange keys with a partner. Use their key to identify an animal.

Draw Conclusions

6. **Infer** Could you use your key to identify other animals? Explain.



Explore More

How would you change your key to make it more useful? Which questions would you change? Which questions would you keep the same?

SWK-I. Summarize how conclusions and ideas change as new knowledge is gained.

Read and Learn

Main Idea LS-3

Form, structure, and behavior can all be used to divide animals into classification groups.

Vocabulary

asymmetrical, p. 52
radial symmetry, p. 52
bilateral symmetry, p. 53
monotreme, p. 58
marsupial, p. 58
placental mammal, p. 58

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Reading Skill

Main Idea and Details

Main Idea	Details

What are simple invertebrates?

You learned that invertebrates are animals that do not have a backbone. They can live on land or in the water. Most lower invertebrates live in aquatic environments, which are filled with water or are moist. The lower invertebrates include sponges, *cnidarians* (nye•DAYR•ee•uhnz), and worms.

Sponges

Sponges are animals that have no true organization. Sponges are the only animals without real tissues or organs. They are also asymmetrical (ay•si•MET•ri cuhl). An **asymmetrical** body plan cannot be divided into mirror images.

The sponge body structure is arranged around a single tunnel-like canal. The tissue surrounding the canal is filled with lots of tiny pores, or holes. The word *pore* gives sponges their phylum name—*Porifera* (paw•RIF•uhr•uh). All members of the phylum Porifera live in water.

Cnidarians

Jellyfish, sea anemones, corals, and hydras are all cnidarians. Cnidarians are soft-bodied, aquatic creatures. Unlike sponges, they have radial symmetry (RAY•dee•uhl SIM•uh•tree). **Radial symmetry** is a body plan in which all body parts of an organism are arranged around a central point. An organism with radial symmetry has more than one line that divides the organism into two mirror images.


sea anemone

Cnidarians have a mouth, tentacles, muscle tissues, and stinger cells. When they hunt, their stingers shoot out like tiny harpoons. The poison inside these cells helps them capture other animals. Once stung, the dart-like stinger cells hold the victim while tentacles move it toward the animal's mouth.

Worms

There are three main worm groups: flatworms, roundworms, and segmented worms. All worms have bilateral symmetry (bye•LAT•uhr•uhl). **Bilateral symmetry** is a body plan in which an organism can be divided along only one plane of their body to produce two mirror images.

Flatworms, or *platyhelminthes* (plat•uh•HEL•minths), have a flat body and a head with simple eyes and a mouth. With only one body opening, undigested food must leave the flatworm's body through its mouth.

Roundworms, or *nematodes* (NEM•uh•tohdz), have simple digestive and nervous systems. Roundworms are some of the most abundant animals on Earth. Like flatworms, they often live inside the bodies of other animals.

Segmented worms, or *annelids* (AN•uh•lidz), have a body plan that is divided into sections, or segments. They have a two-way digestive system and organs, including a stomach, heart, and brain.

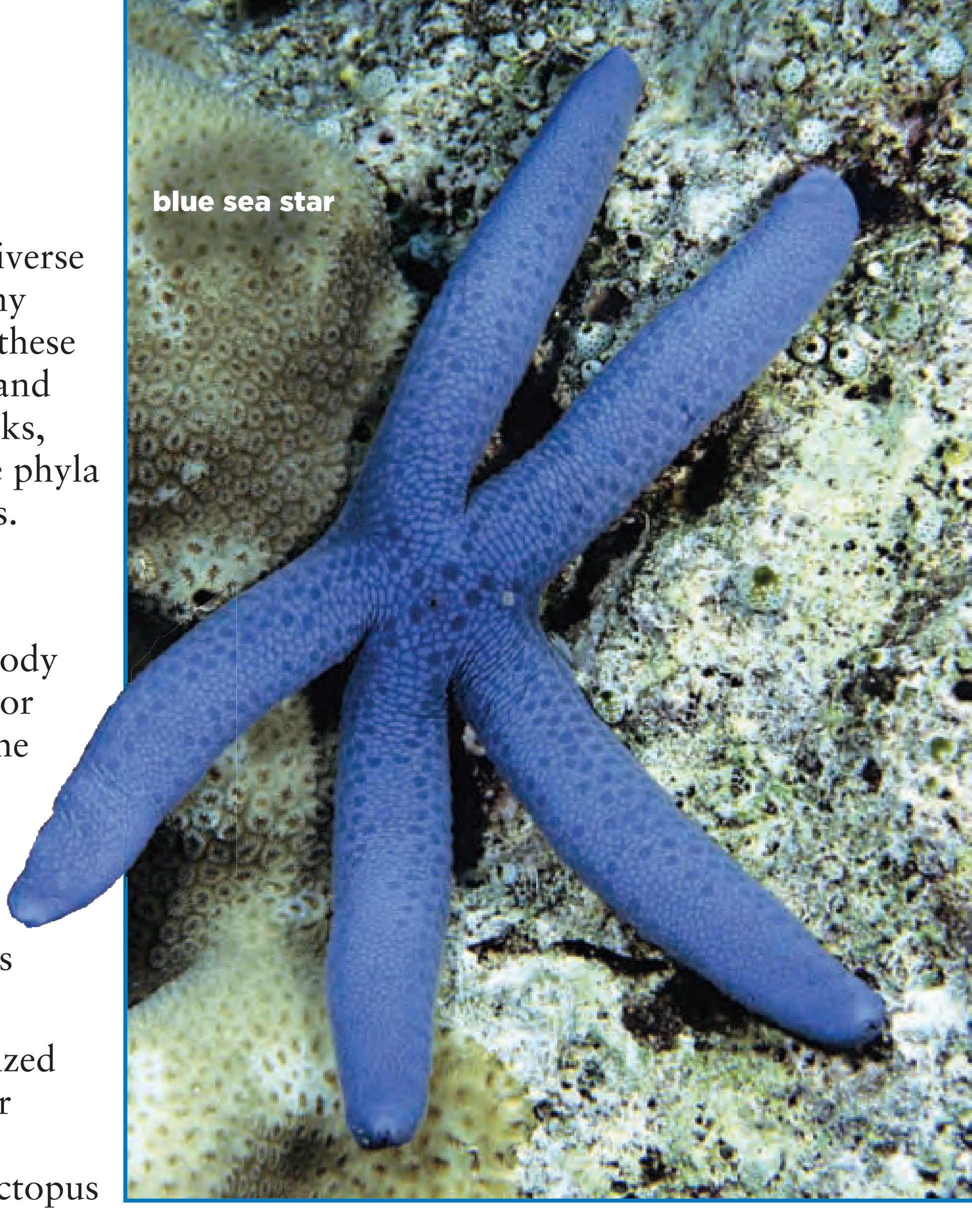
Quick Check

Main Idea and Details What are some lower invertebrates?

Critical Thinking Which characteristics do scientists use to classify cnidarians?

What are complex invertebrates?

Invertebrates include a very diverse group of animals that live in many different environments. Some of these animals have specialized organs and complex body structures. Mollusks, echinoderms, and arthropods are phyla with very different characteristics.



blue sea star

Mollusks

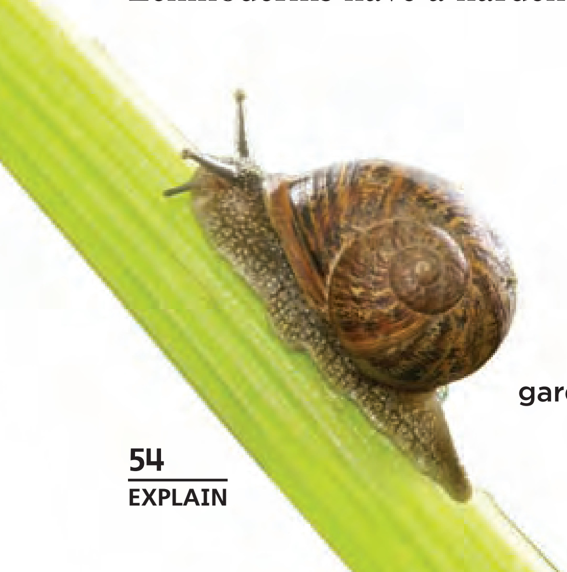
All mollusks share the same body plan. They have a muscular foot or tentacles, a fold of tissue called the *mantle*, and a mass of internal organs. They all have bilateral symmetry. Mollusks include snails, clams, and squids. Almost all mollusks have a shell, which is secreted by the mantle.

Mollusks have several specialized organs, including a heart, gills for breathing, and a well-developed nervous system. The squid and octopus have extremely good eyesight and a very large brain.

Echinoderms

Echinoderms include sea stars, sea urchins, and sea cucumbers. Echinoderms have a hardened skeleton located inside the body called an *endoskeleton* (en•doh•SKEH•luh•tun). Spines from the endoskeleton often poke through their thin, bumpy skin. Echinoderms usually have radial symmetry.

Echinoderms use a water pressure system that helps them feed, breathe, and move. Seawater enters the system and moves to different parts of the animal's body under pressure. The system ends in the echinoderm's many tube feet, which cling to surfaces like small suction cups.



garden snail

FACT Starfish are called sea stars.

Arthropods

Read a Photo

What do arthropods have in common?

Clue: Look at the basic body plan of both arthropods. What features do they share?

Arthropods

Arthropods are the most numerous animal group on Earth. More than half of the world's animal species are arthropods, including spiders, crabs, and insects. Arthropods have a very efficient body plan. They are small and light with a hard skeleton on the outside of the body called an *exoskeleton* (ek•so•SKEH•luh•tun). It provides strength and protection. All arthropods have bilateral symmetry.

Arthropods have a segmented body, with paired limbs on either side of their body. In some cases, these limbs are used as wings or claws. In other cases, their many legs help arthropods move quickly. Arthropods have simple but very efficient nervous systems and good sensory systems. If you have ever tried to swat a fly, you know just how quickly an arthropod can move!

Quick Check

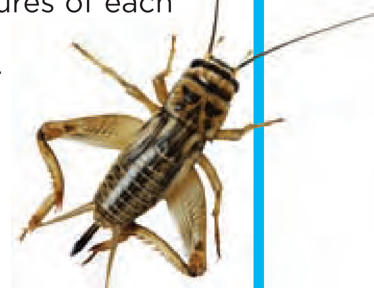
Main Idea and Details What body part do arthropods have that echinoderms do not have?

Critical Thinking Is the statement "the smaller the animal, the simpler the animal" generally true? Explain.

Quick Lab

Observe Insects

1. **Observe** Look at each insect with a hand lens. Draw what you see.
2. Compare the structures of each insect. Create a table to record your observations.
3. **Infer** Choose any two structures that you observed. What is special about these structures? How does the design of these structures help the insect survive?



What are vertebrates?

Recall that vertebrates are animals that have a backbone. They all have bilateral symmetry and endoskeletons.

Fish

There are three classes of fish: jawless fish, cartilaginous fish, and bony fish. Lamprey and hagfish are jawless fish. Instead of a true backbone, they have a flexible nerve cord. Without jaws, they are forced to suck in their food.

Sharks, skates, and rays are cartilaginous fish. They have skeletons made of cartilage rather than bone. *Cartilage* is the material that gives your ear its stiffness. They have paired fins and jaws.

Bony fish have a nerve cord covered by bone, not cartilage. Like sharks, they have jaws and paired fins. They have balloonlike swim bladders that allow them to easily go up or down in water. Bony fish also have moving flaps that push water into their gills. This allows them to get oxygen while not moving in the water.

tree frog

Amphibians

Frogs, salamanders, and other amphibians bridge the gap between land and water vertebrates. An amphibian is an animal that spends part of its life in the water and part of its life on land.

A frog begins its life in the water as a tadpole with gills. As it matures, the frog develops four legs and lungs for breathing air. Most adult amphibians do not leave the water for too long. Many frogs, for example, breathe through their skin as well as their

white-tip reef shark

lungs, so they need to stay moist at all times. They also return to the water to lay their eggs.

Reptiles

There are about 7,000 different kinds of reptiles. A reptile is a true land animal with one lung or two. They have thick, scaly, waterproof skin. Reptiles include lizards, snakes, turtles, alligators, and crocodiles.

Reptiles do not generate much body heat. Instead, reptiles stay warm by sunning themselves and taking advantage of heat in their environments. They are cold-blooded animals. This means they cannot automatically keep their body temperature steady.

Birds

Birds have several features that make them different from other vertebrates. Rather than four legs, birds have two legs and two wings. Birds have hollow bones to reduce their weight.

Feathers are a unique characteristic of birds. They are strong and incredibly light. Feathers help keep heat inside the bodies of birds. Birds are warm-blood animals that can keep their body temperatures constant. Their feathers are sturdy enough to hold up to the stresses and strains of flight. The world's fastest bird, the peregrine falcon, can fly at speeds of more than 322 kilometers per hour (200 miles per hour).

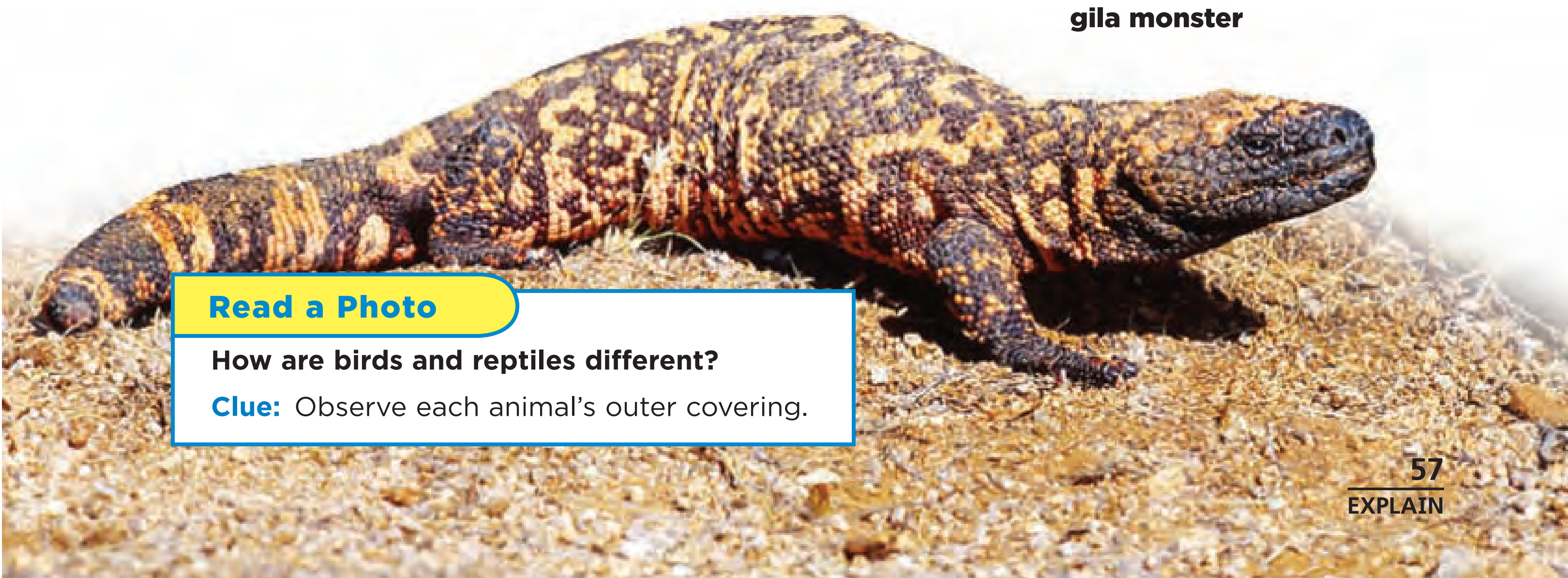
Quick Check

Main Idea and Details What are characteristics of vertebrates?

Critical Thinking Why do many reptiles hide at night and stay completely inactive?

Birds and Reptiles

hummingbird



gila monster

Read a Photo

How are birds and reptiles different?

Clue: Observe each animal's outer covering.

What are mammals?

Milk, hair, and large brains are the key characteristics of mammals. Mammals are unique because they produce milk to feed their young. Most mammals have hair or fur. Some mammals, like humans and whales, have little body hair. Like birds, mammals are warm-blooded. They generate their own body heat by burning food.

Mammals are divided into three subclasses: monotremes (MON•uh•treemz), marsupials (mahr•SEW•pee•uhlz), and placental mammals (pluh•SEN•tuhl). A **monotreme** is a mammal that lays eggs. After the young hatch, they are fed milk from their mothers. The duck-billed platypus and the spiny anteater are members of this group.

A **marsupial** is a pouched mammal. These mammals give birth to partially developed offspring. They carry their developing young in a pouch on the front of their bodies. Kangaroos and koala bears are marsupials. Most monotremes and marsupials are found in Australia.

Koala bears are marsupials.

A spiny anteater is a monotreme.

What do humans have in common with dogs, tigers, elephants, and whales? All are placental mammals. The young of a **placental mammal** develops within its mother. Placental mammals are born more mature than the offspring of marsupials.

A tiger is a placental mammal.

Quick Check

Main Idea and Details What characteristics are shared by all mammals?

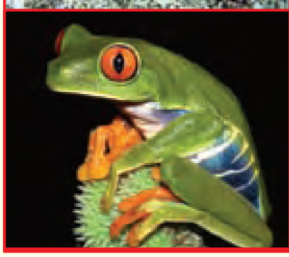
Critical Thinking Why do mammals need to consume more food than reptiles?

Lesson Review

Visual Summary

Invertebrates do not have a backbone. Porifera, cnidaria, and worms are **simple invertebrates**.

Mollusks, echinoderms, and arthropods are **complex invertebrates**.



All **vertebrates** have backbones. Fish, amphibians, reptiles, birds, and mammals are vertebrates.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. Tell what you learned about each topic on the tabs.

Think, Talk, and Write

1. **Main Idea** What is the main difference between vertebrates and invertebrates?

2. **Vocabulary** Snails, squid, and clams are all ________.

3. **Main Idea and Details** What characteristics identify birds?

Main Idea	Details

4. **Critical Thinking** Some scientists think dinosaurs were warm-blooded. How would this make dinosaurs more likely to be related to birds?

5. **Test Prep** **Which animal group has the least organized body plan?**
   - **A** flatworms
   - **B** mollusks
   - **C** porifera
   - **D** reptiles

6. **Test Prep** **Which of the following does not have bilateral symmetry?**
   - **A** worms
   - **B** fish
   - **C** mammals
   - **D** sponges

Math Link

Number of Beetles

Suppose about 350,000 different beetles were identified. If 1,900,000 total animals were identified, what percent are beetles?

Social Studies Link

Australian Mammals

Research marsupials and monotremes. Find out why these animals are found mostly in Australia.

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The Underground Life of Mole Rats

Some animals are cute, like pandas or koala bears. But this animal—the naked mole rat—is considered by many people to be quite ugly. It reminds most people of a pink, wrinkled, sausage with feet!

Mole rats spend most of their lives digging a maze of underground tunnels. The tunnels bring the mole rats closer to the plant roots they eat. The tunnels also offer protection from heat and other animals. A colony of mole rats can dig tunnels that would be several kilometers long if they were laid out in a straight line.

Scientists call this animal *Heterocephalus glaber*. Its scientific name is important because this animal is neither a mole nor a rat. It is actually related to porcupines, chinchillas, and guinea pigs. You would hardly recognize any family likenesses if you looked at these animals. That is why scientific names are important. You can learn a lot about an organism when you know its scientific name.

chinchilla

Descriptive Writing

A good description

- uses sensory words to describe how something looks, sounds, smells, tastes, and/or feels
- includes vivid details to help the reader experience what is being described

Write About It

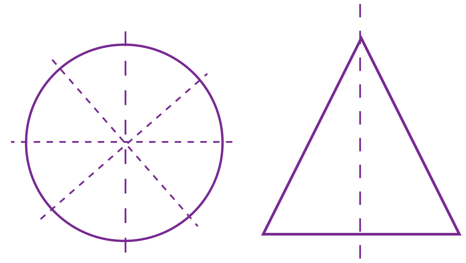
Descriptive Writing Find out the scientific name of an animal you think is cute or ugly. Write a description of the animal. Use words and details that appeal to the senses in your description.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA WR-12. Add and delete information and details to better elaborate on a stated central idea and to more effectively accomplish a purpose.

Math in Science

Animal Symmetry

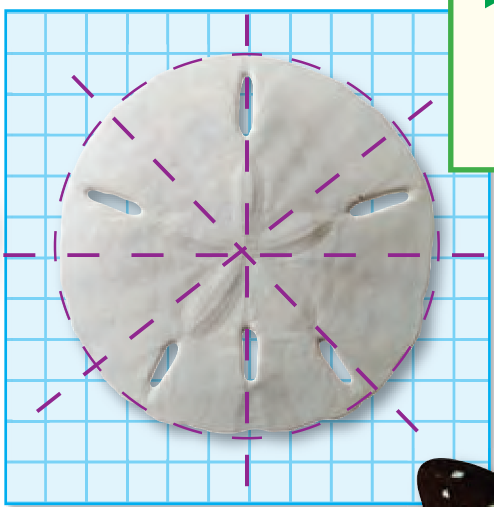


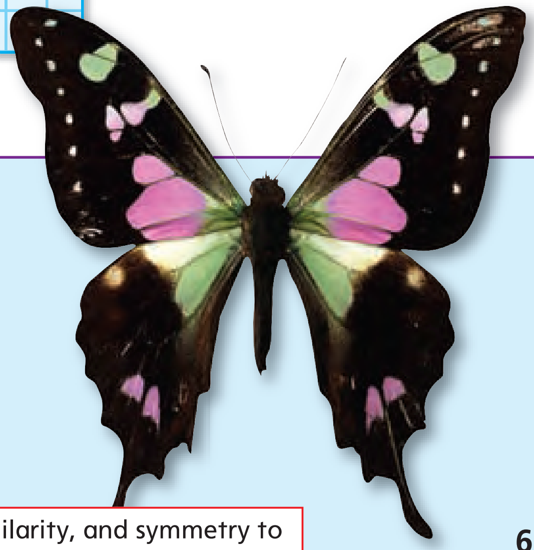
As you learned, most animals have symmetry. This means they have at least two sides that are mirror images. Animals can have bilateral symmetry or radial symmetry. A dog has bilateral symmetry because there is only one line of symmetry that divides it into mirror images. A sand dollar has radial symmetry because there is more than one line of symmetry that divides it into mirror images. You can use graph paper to determine which kind of symmetry a figure or an object has.

Line Symmetry

To find the symmetry of a figure

- trace the figure onto graph paper
- fold the graph paper in half to find the line of symmetry
- if the two halves of the figure match exactly, draw the line of symmetry





Solve It

1. Look at the picture of the butterfly. What kind of symmetry does it have?
2. Draw a figure with at least two lines of symmetry. Show all lines of symmetry.

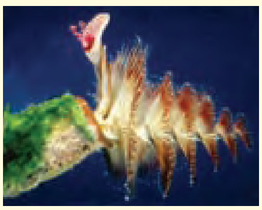
M GSS-F. Describe and use the concepts of congruence, similarity, and symmetry to solve problems.

CHAPTER 1 Review

Visual Summary

Lesson 1 Living things are all made of the same basic building blocks—cells.

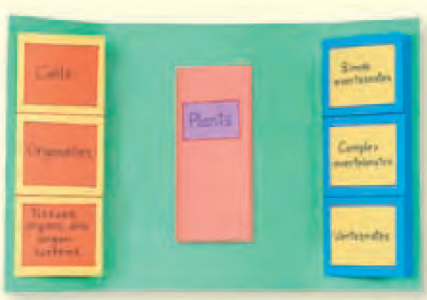
Lesson 2 Plants perform photosynthesis, which provides food and energy for most organisms.



Lesson 3 Form, structure, and behavior can all be used to divide animals into classification groups.

Make a FOLDABLES™ Study Guide

Assemble your lesson study guide as shown. Use your study guide to review what you have learned in this chapter.



Vocabulary

Fill in each blank with the best term from the list.

- **bilateral symmetry**, p. 53
- **cell**, p. 26
- **chlorophyll**, p. 31
- **organ system**, p. 32
- **organism**, p. 26
- **photosynthesis**, p. 44
- **transpiration**, p. 44

1. Any living thing is a(n) ________.

2. Many plant cells are green because of the ________ in their chloroplasts.
LS-B

3. ________ is the loss of water through a plant's leaves.
LS-B

4. A mammal that lays eggs is known as a(n) ________.
LS-A

5. The smallest unit of living things that can carry out the basic processes of life is a(n) ________.
LS-B

6. The leaves of a plant carry out ________ to make food for the plant.
LS-I

7. An animal that can be divided into two halves that are alike has ________.

8. Organs that work together to perform a certain function make up a(n) ________.
LS-B

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Skills and Concepts

Answer each of the following in complete sentences.

9. Draw Conclusions You are observing a cell under a high-power microscope. The cell has a stiff cell wall and a large, central vacuole. What can you conclude about this cell? Explain your answer.
LS-B

10. Classify What body plan describes the organism below?

11. Experiment You want to find out which of two types of plants grows fastest. Describe a simple experiment you could conduct to find the answer.
SI-C

12. Critical Thinking Do you think a lizard could survive in Antarctica? Explain why or why not.
LS-4

13. Descriptive Writing Describe the two types of plant stems.
LS-B

The Big Idea

14. How are all plants and animals similar?
LS-B

Performance Assessment

Light Up a Problem!

Your goal is to find out how much light plants need.

What to Do

1. Gather data on the amount of light plants need to produce the food they require to stay healthy. Use the Internet, reference books, or visit a plant nursery or florist shop to find information.
2. Design a chart that shows the amount of light needed for different plants. Include illustrations of the plants in your chart.

Analyze Your Results

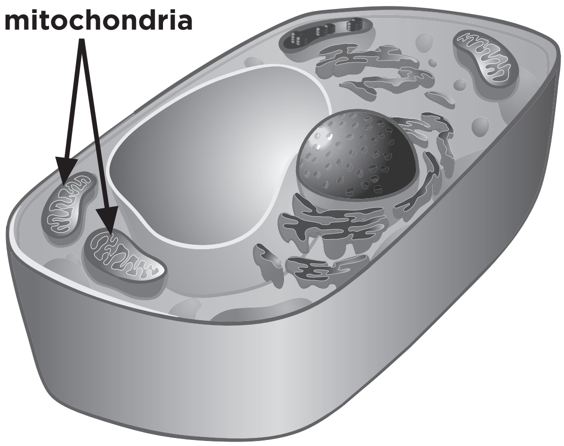
- Based on the information you have collected, explain whether different plants need similar or different amounts of light to stay healthy. Suggest places where each kind of plant might grow best.

Ohio Activity

There are many different reptiles native to Ohio. Research Ohio's turtles, lizards, and snakes by visiting **http://www.dnr.state.oh.us/wildlife/Resources/reptiles/reptiles.htm.** Make a list of the similarities and differences between three Ohio reptiles. Share your findings with your classmates.

Ohio Benchmark Practice

1 The diagram below shows the parts of a plant cell.



What is the function of the structures identified by the arrows?

A to control the activities of the cell
B to store water, food, and wastes
C to support the cell's structures
D to supply energy for the cell

LS–I

2 Which instrument would be **best** for studying animal-cell division?

A an electron microscope
B a compound light microscope
C a scanning electron microscope
D a magnifying glass

SI–I

3 Which would be the best way to determine if a plant stem is a cutting?

A Cover it with soil and do not water it.
B Examine its leaves for spores.
C Put it in a cup of water to see if it grows roots.
D Taste the stem's sap for bitterness.

LS–A

4 A student is looking at a cell through a microscope. She is trying to determine if the cell is an animal cell or a plant cell.

In your **Answer Document**, describe or draw what observation will tell her she is seeing a plant cell and what the function of this structure or organelle is. Be sure to label any drawings. (2 points)

SI–3

5 A student collected data on the root systems of plants. She observed that in dry, desertlike conditions, plants often had shallow, widespread root systems. She also observed that in areas with plentiful rainfall, many plants had deep roots. What is a valid conclusion that she might draw from her data?

A Root systems of plants perform similar functions.
B Root growth is influenced by the amount of precipitation.
C Roots are similar in shape and size.
D Root systems are affected by the average temperature of a region.

SI–3

6 Which factor determines a plant's ability to carry out photosynthesis?

A sunlight
B temperature
C oxygen
D minerals

LS–I

7 A student observed many flowering plants in her backyard. What conclusion can she draw about the types of plants there?

A The plants are gymnosperms.
B The plants are angiosperms.
C The plants are spores.
D The plants are seedless.
SI–3

8 This table shows the effect of fertilizer on the growth of sunflowers. The groups of flowers were grown in the same soil and had the same amount of water and sunlight.

Amount of Liquid Fertilizer per Week	1 ounce	2 ounces	3 ounces
Sunflower Height	10–12 inches	13–15 inches	16–17 inches

What is the dependent variable in this experiment?

A fertilizer
B height
C soil
D water and sunlight
SI–4

9 The Sun is the most important source of energy for Earth. It plays an important role in ecosystems. In your **Answer Document**, describe or draw one reason why the Sun is the most important source of energy and describe how plants use the Sun's energy. Be sure to label any drawings. (2 points)
LS–I

10 A student placed long-stemmed white flowers in blue water. The petals gradually turned blue. What hypothesis did he **most likely** set out to prove?

A Impurities in the water will stop photosynthesis.
B Plants need water to prevent wilting.
C Transpiration draws water into every plant cell.
D Plants give off oxygen.
SI–3

11 A student pulled a carrot from the ground. What is the large orange part that had been underground?

A fruit
B stem
C taproot
D chloroplast
LS–B

12 A student noticed that a shady pond had a low amount of algae. She also noticed that a pond that received full sunshine most of the day had a large quantity of algae. What conclusion might she draw from her observations?

A Algae are photosynthetic.
B Direct sunlight kills algae.
C Algae kill fish.
D Algae can only grow in the dark.
SI–3

CHAPTER 2

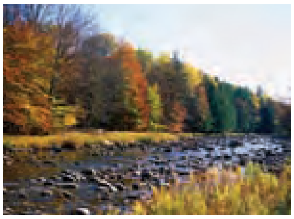
Ecosystems

The Big Idea

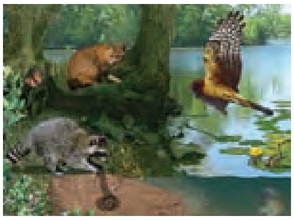
How do organisms interact?

Katmai National Park, Alaska

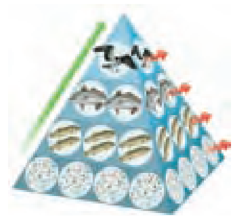
Key Vocabulary



ecosystem
all the living and nonliving things in an environment, including their interactions with each other (p. 70)



food web
the overlapping food chains in an ecosystem (p. 74)



energy pyramid
a diagram that shows the amount of energy available at each level of an ecosystem (p. 76)

carrying capacity
the maximum population size that an area can support (p. 85)

commensalism
relationship between two kinds of organisms that benefits one without harming the other (p. 89)

camouflage
an adaptation in which an animal protects itself against predators by blending in with the environment (p. 101)

More Vocabulary

population, p. 71

community, p. 71

food chain, p. 72

predator, p. 75

prey, p. 75

limiting factor, p. 84

habitat, p. 86

niche, p. 86

symbiosis, p. 88

mutualism, p. 88

parasitism, p. 90

adaptation, p. 96

protective coloration, p. 101

protective resemblance, p. 101

mimicry, p. 102

LS-C. Compare changes in an organism's ecosystem/habitat that affect its survival.

Lesson 1

Energy Flow in Ecosystems

Look and Wonder

A cheetah chasing prey can run 112 km/h (70 mph). That takes a lot of energy! How do organisms depend on one another for energy?

LS-I. Describe the role of producers in the transfer of energy entering ecosystems as sunlight.... **LS-2.** Explain how almost all kinds of animals' food can be traced back to plants. **LS-3.** Trace the organization of simple food chains and food webs....

Explore

Inquiry Activity

How do organisms in a food chain interact?

Purpose

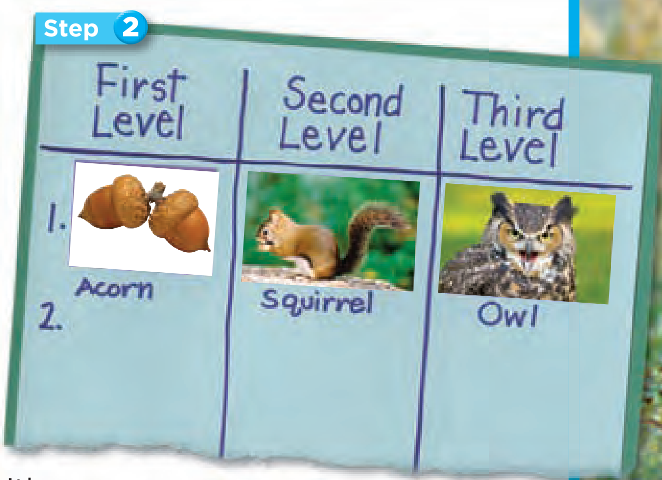
A food chain models how food energy is transferred from one organism to another. Producers make their own food. Herbivores consume producers. Carnivores consume herbivores. Create food chains using the list below.

PRODUCERS	HERBIVORES	CARNIVORES
algae	grasshopper	wolf
berries, flowering plants	deer	otter
shrubs	chipmunk	hawk
seeds, grass	squirrel	robin
acorn, oak tree	fish	owl

Materials

- blank note cards
- construction paper
- glue stick
- magazines
- markers
- scissors

Procedure



1. Make cards for the organisms listed in the chart above. Draw or glue a picture of an organism on each card.
2. Create a three-column chart on the paper. Label the columns as shown.
3. Use your organism cards to make five food chains. Place the organism cards on your chart under the correct columns.

Draw Conclusions

4. **Communicate** Compare your food chains with a classmate's food chains. Explain how they compared.
5. **Infer** Can food chains overlap? How does this affect the ecosystem?

Explore More

Research one of your food chains. What ecosystem is it part of? What other organisms are part of this ecosystem? How are these organisms connected to your food chain?

SI-2. Evaluate observations and measurements made by other people and identify reasons for any discrepancies.

Read and Learn

Main Idea LS-I, LS-2, LS-3

Food chains, food webs, and energy pyramids show the energy flow between organisms in an ecosystem.

Vocabulary

ecosystem, p. 70
population, p. 71
community, p. 71
food chain, p. 72
food web, p. 74
predator, p. 75
prey, p. 75
energy pyramid, p. 76

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Reading Skill

Sequence

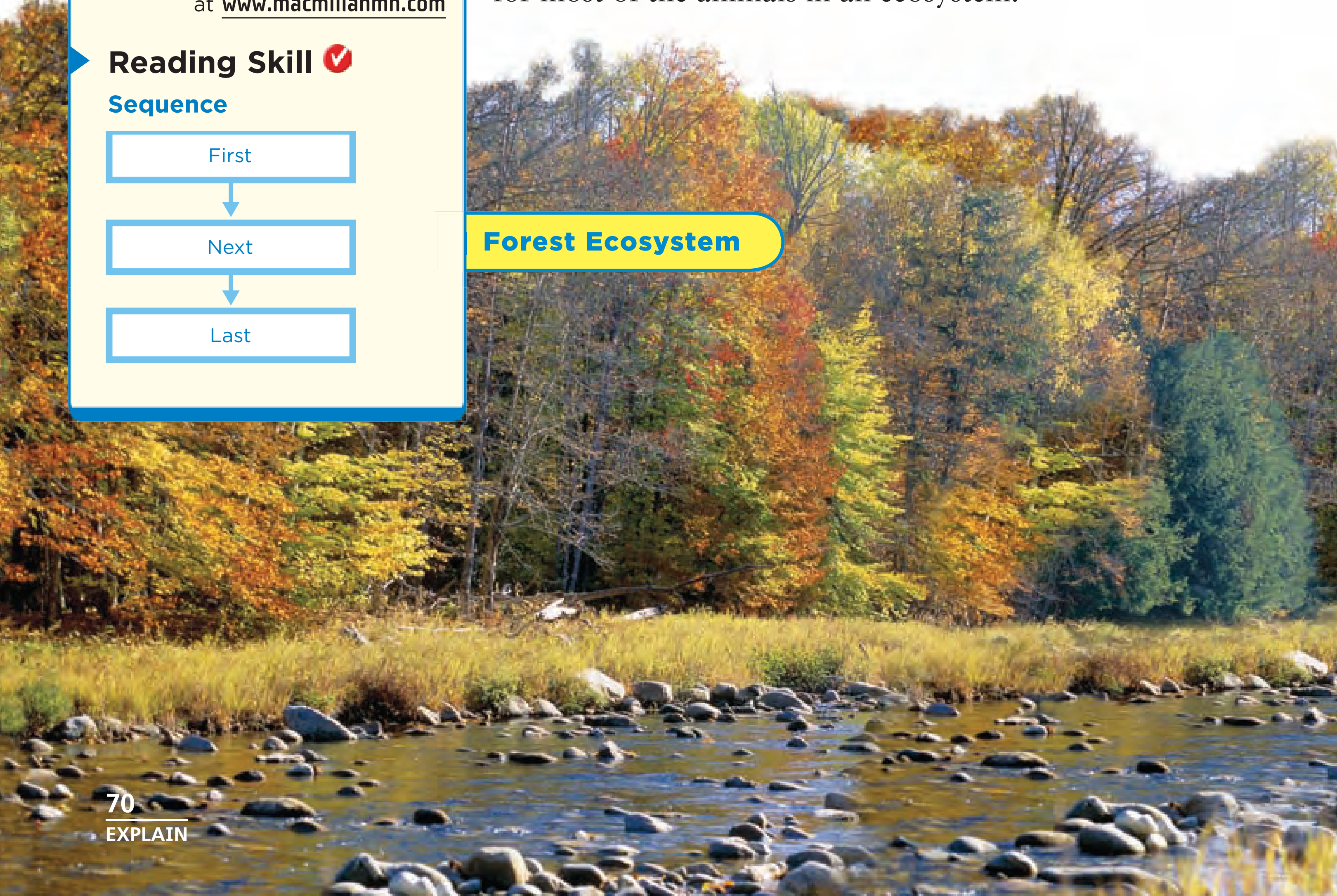
First → Next → Last

What is in an ecosystem?

You are on a hike in a beautiful forest. What do you see? Plants, including spruce trees, wildflowers, and grasses, grow along your path. Chipmunks scurry across the trail and birds fly overhead. These are some of the living things, or *biotic factors* (bye•OT•ik FAK•tuhrz), of the environment.

Plenty of nonliving things, or *abiotic factors* (ay•bye•OT•ik), are also in view. Fresh air fills your lungs. Rocks lie on the trail. Below you hear the gurgle of a nearby stream filled with water. Together, these biotic and abiotic factors make up the forest ecosystem (EK•oh•sis•tuhm). An **ecosystem** includes all living and nonliving things in an environment.

Biotic and abiotic factors in an ecosystem interact and supply the needs of living things. Recall that plants need abiotic factors to survive, including soil, sunlight, air, and water. Plants, in turn, provide food for most of the animals in an ecosystem.



Forest Ecosystem

The organisms in an ecosystem can be sorted into different populations (pop•yuh•LAY•shuhnz). A **population** includes all members of a single species. For example, all the blue spruce trees in a forest form a population. Each species forms its own population. The monarch, painted lady, and buckeye butterflies all form separate butterfly populations in an ecosystem.

Together, the many different populations make up a community (kuh•MYEW•ni•tee). A **community** includes all the living things in an ecosystem. In addition to plants and animals, a community also has bacteria, protists, and fungi. For example, the soil of a forest community has huge populations of molds and bacteria living in it. The living community of most ecosystems might include thousands of populations.

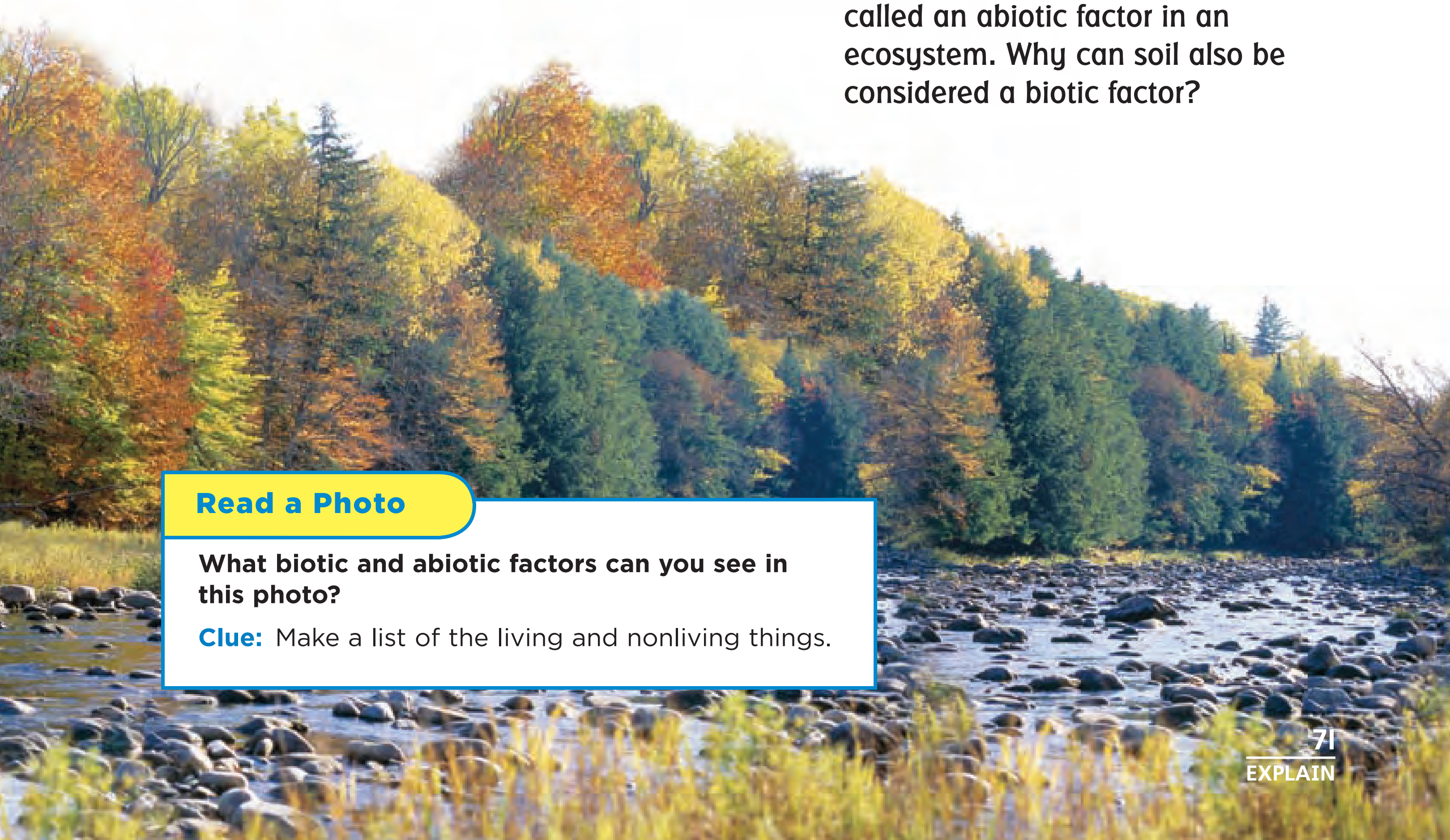
This fallen log is part of a tiny ecosystem that includes fungi, moss, and bacteria.

An ecosystem can be local or widespread. An entire forest that covers a huge area can be an ecosystem. But one fallen log in the middle of that forest can also make up an ecosystem.

Quick Check

Sequence List the parts that make up an ecosystem from the smallest to the largest.

Critical Thinking Soil is usually called an abiotic factor in an ecosystem. Why can soil also be considered a biotic factor?



Read a Photo

What biotic and abiotic factors can you see in this photo?

Clue: Make a list of the living and nonliving things.

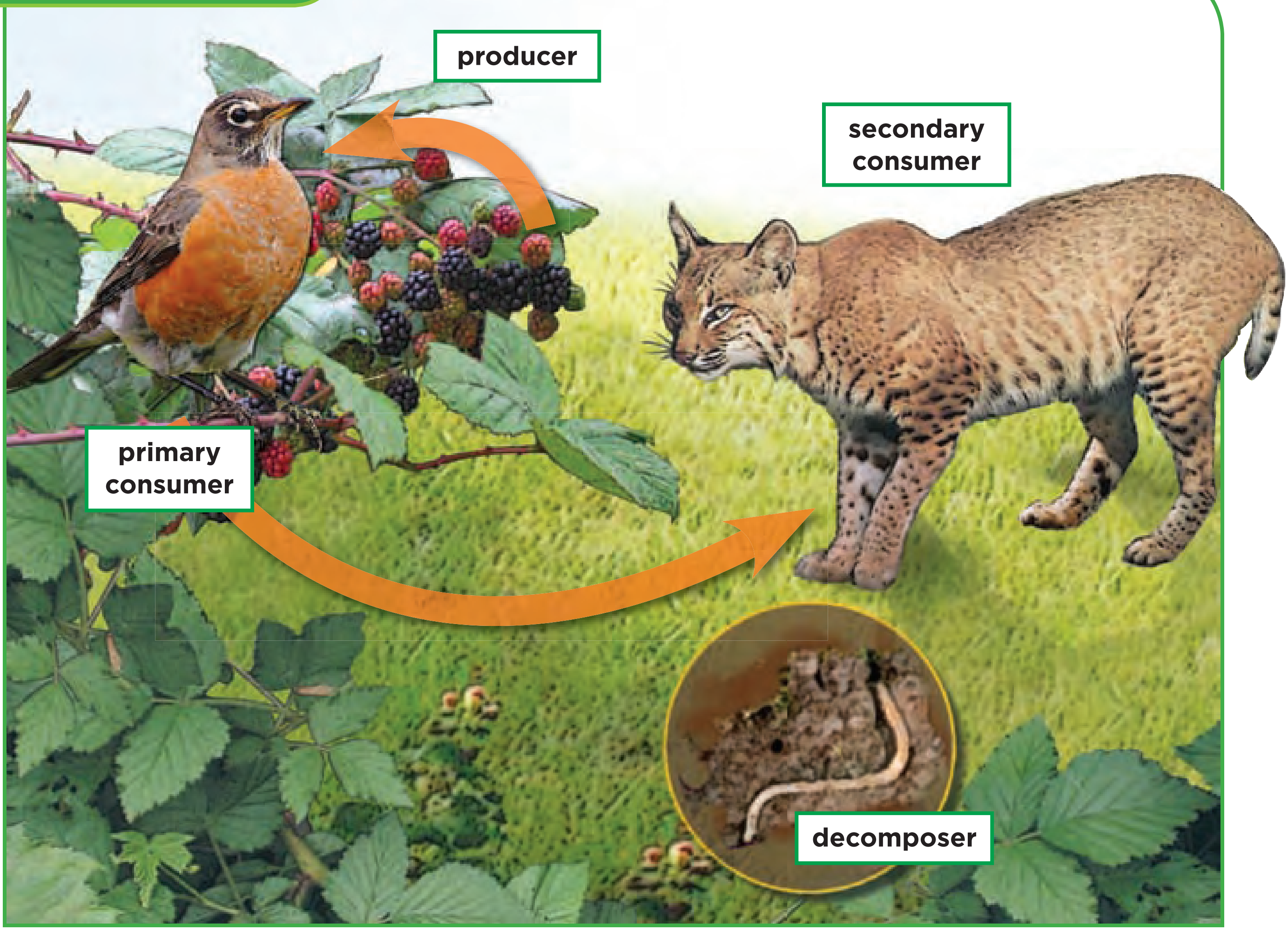
How are food chains alike?

The path that energy and nutrients follow in an ecosystem is called a **food chain**. Food chains model the feeding relationships between organisms in an ecosystem. Energy flows in one direction in food chains. Once energy is used by an organism, it leaves the organism's body as heat. It becomes unavailable for other organisms in the ecosystem.

The energy in a food chain starts with the Sun. It is the energy source for almost all organisms on Earth. *Producers* are organisms that use the Sun's energy to make sugar and oxygen. Producers are at the base of every food chain.

During photosynthesis, producers, such as plants and algae, build sugar molecules out of carbon dioxide and water. The sugar molecules are the original source of food for consumers. A *consumer* is any animal that eats plants or other animals.

Land Food Chain



Animals that eat producers directly are called herbivores. These consumers include squirrels, some birds, some insects, and grazing animals. Animals that eat other animals rather than producers are called *carnivores* (KAHR•nuh•vawrz). Bobcats and hawks are carnivores. Animals that eat both plants and other animals are called *omnivores* (OM•nuh•vawrz). Raccoons, woodpeckers, mice, and some crabs are omnivores.

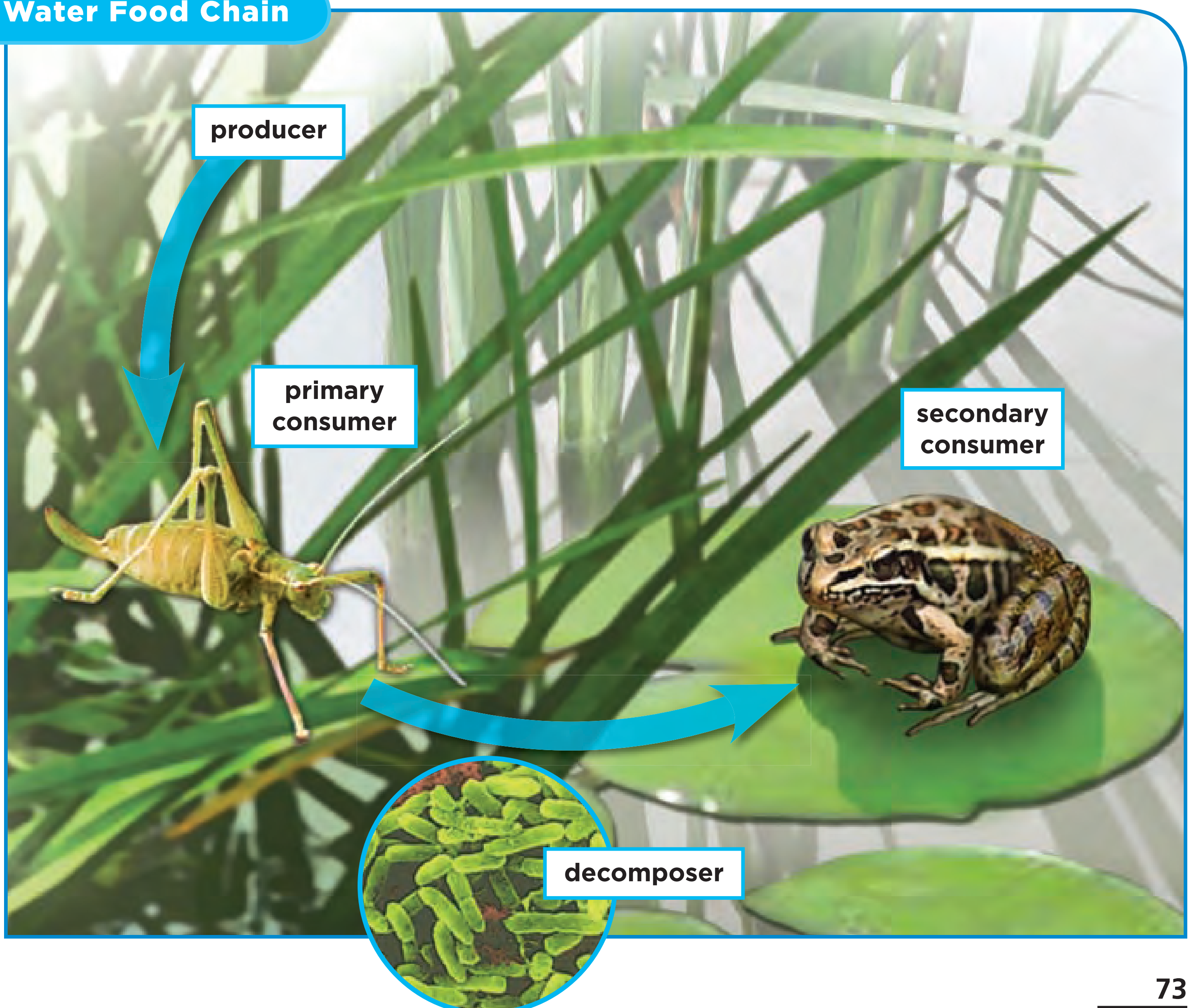
Finally, there are decomposers in a food chain. *Decomposers* break down dead or decaying plant and animal material. Decomposers include fungi, bacteria, termites, and many worm species. *Scavengers* are not included in these food chains. Scavengers are consumers that eat leftover bodies after they have started to rot. Common scavengers include vultures, raccoons, and some crabs.

Quick Check

Sequence What general pattern do all food chains follow?

Critical Thinking What is the fewest number of links a food chain could have? The greatest number?

Water Food Chain



What are food webs made of?

In most food chains, a single organism is not eaten by only one consumer. For example, a mouse may be eaten by a bobcat or a hawk. This makes the mouse a part of two separate food chains. These chains can be combined to form an even bigger food web.

A **food web** is a network of food chains that have some links in common. A food web may look complicated. But as you can see, food webs are just several food chains that are put together. How do you read a food web? As with food chains, arrows represent the energy flow from one organism to another. Arrows pointing to an organism show the living things that the organism eats. Arrows pointing away from an organism show the animals that eat that organism.

Forest and Salt Marsh Food Web

Read a Diagram

Can you name three separate food chains in the food web on these pages?

Clue: Follow a single set of arrows.

LOG ON *Science in Motion* Watch how organisms interact in food chains at www.macmillanmh.com

For example, arrows pointing to the hawk show that it hunts fish, frogs, mice, and small birds. A **predator** (PRED•uh•tuhr) is an animal that hunts other animals for food. Top carnivores are the highest-level predators in a food web. Arrows pointing away from the mouse show that it is hunted by hawks, raccoons, and bobcats. **Prey** (pray) are organisms that are eaten by other animals.

Predators are important in food webs and food chains. They limit the size of prey populations. When the number of prey animals is reduced, producers and other resources in an ecosystem are less likely to run out.

Quick Check

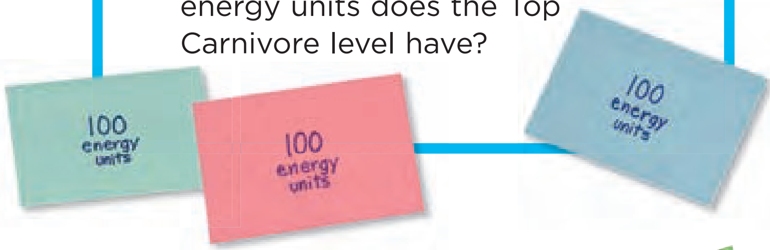
Sequence Describe the steps in constructing a food web.

Critical Thinking Can one organism be a consumer, omnivore, predator, and prey? Give an example that explains your answer.

Quick Lab

Energy Transfer

1. Make 100 energy cards. Each card represents 100 energy units.
2. Make an energy-level poster with four levels: Producers, Herbivores, Carnivores, and Top Carnivore.
3. Place 100 cards on the Producers. How many total energy units does this level have?
4. Continue to take 10% of the energy units from one level to the next level up to the Top Carnivore level. Use scissors if necessary.
5. **Draw Conclusions** How many energy units does the Top Carnivore level have?

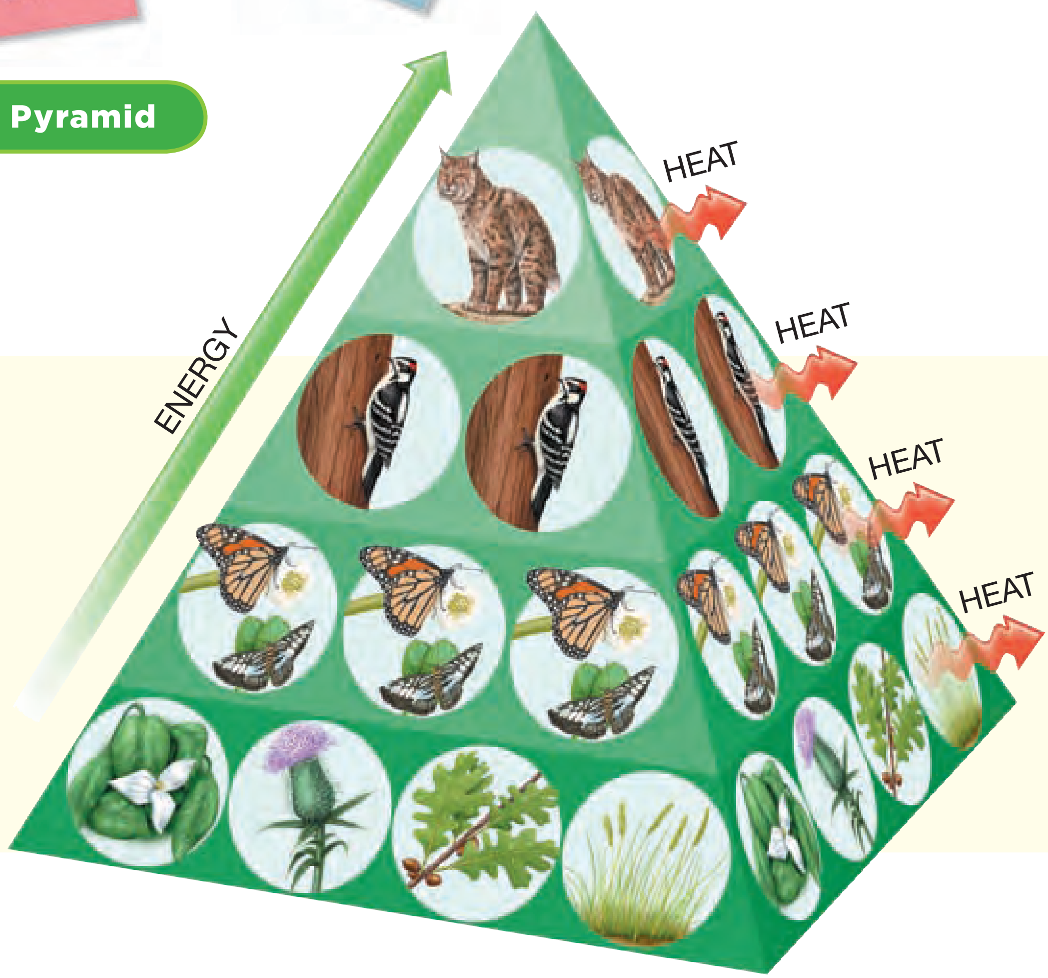


How do energy pyramids compare?

An **energy pyramid** (EN•uhr•jee) is a diagram that shows the amount of energy available at each level of an ecosystem. How much of the Sun's original energy actually gets used during photosynthesis? In fact, only about 10 percent of the Sun's energy gets turned into food energy by a producer.

When a producer is eaten, only about 10 percent of the food energy it contains gets turned into herbivore or omnivore tissue. The rest is utilized or transferred into heat energy. For example, a butterfly drinks nectar from flowers to obtain energy. The butterfly's body then uses the energy from the nectar to support its life processes, such

Land Food Pyramid



as respiration and digestion. If only 10 percent of plant tissue gets turned into butterfly tissue, 90 percent of the plant's energy is not used by the butterfly! This pattern continues with each level of an energy pyramid. When a bird eats the butterfly, it obtains even less energy. At each stage, about 90 percent of the available energy is not utilized. What does this mean? It means that most feeding patterns are not very efficient.

Energy pyramids illustrate that it takes a huge number of organisms to support an ecosystem. The bottom of the pyramid represents the producers. It is the largest level because it contains the most organisms, and therefore the most energy. There are fewer numbers of organisms and less available energy at each level of the pyramid.

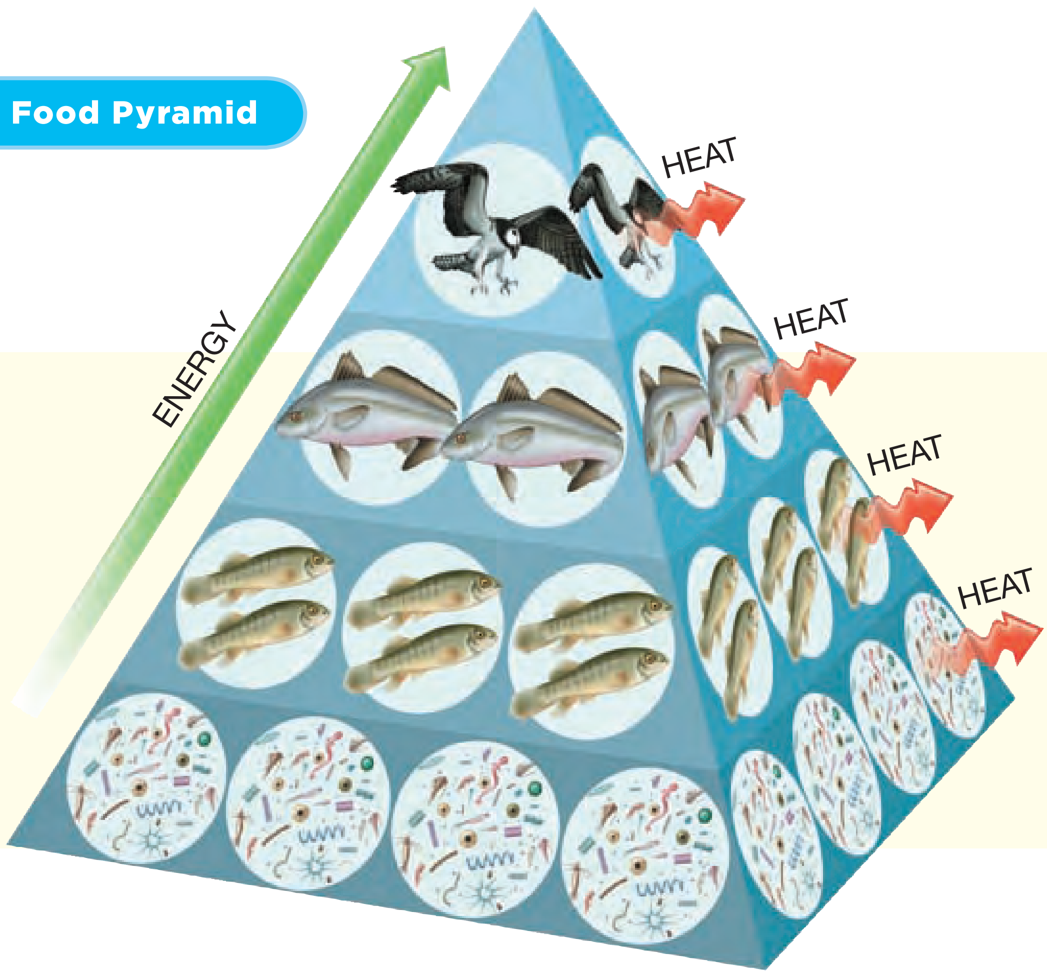
In any ecosystem the number of producers is greater than the number of herbivores. Similarly, there are many more herbivores than carnivores. In a forest, for example, there are more flowers than butterflies. There are many more butterflies and other insects than birds. There are many more birds than bobcats, the top carnivores.

Quick Check

Sequence Explain how energy is utilized in an energy pyramid.

Critical Thinking In a prairie ecosystem, would you expect a rabbit or a hawk population to be larger? Explain.

Water Food Pyramid



How does change affect a food web?

Most ecosystems stay in balance most of the time. What happens when a top carnivore is removed from a food web? What happens when a population in a food web increases in number? These changes set off a chain of events that affect all the organisms in a food web.

When top carnivores are removed from a food chain, prey populations are no longer controlled. Now prey organisms can reproduce without limits. When prey populations increase in number, more producers are required to supply them with energy. For example, if you removed the bobcat from the forest food web, the populations of birds, mice, and raccoons would increase. Soon there would be less grass, trees, and other producers to support these organisms.

Sometimes, a single population can grow out of control. For example, a *red tide* is a sudden explosive growth of single-celled algae in coastal areas. Red tides can occur when nutrient-rich deep water gets brought to the surface after a storm. With so many nutrients in the water, the algae keep reproducing. Toxins produced by the algae can cause the organisms that eat the algae, such as small fish, to die. This reduces the food energy available for predators who eat the fish.

Quick Check

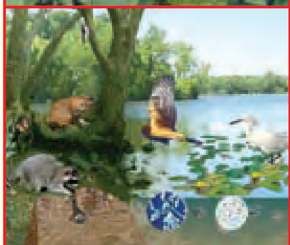
Sequence What occurs when a top carnivore is removed from a food web?

Critical Thinking What might happen if a population of producers was removed from a food web?

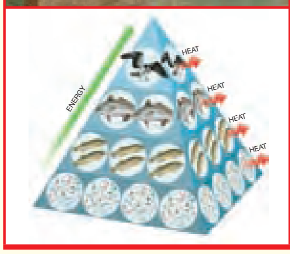
Lesson Review

Visual Summary

Producers, consumers, and decomposers all play important roles in **food chains**.



Food webs are networks of food chains that share common links.



Energy pyramids show the amount of energy available at each level of an ecosystem.

Make a FOLDABLES™ Study Guide

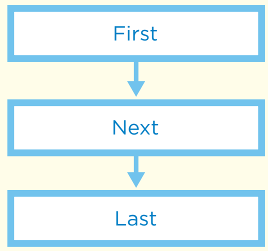
Make a Trifold Book. Use the titles shown. Tell about the topic on the inside of each fold.

Think, Talk, and Write

1. **Main Idea** How do producers and consumers obtain energy?

2. **Vocabulary** A consumer that hunts for its food is called a(n) ________.

3. **Sequence** Describe the events that take place as energy from the Sun travels through an energy pyramid.



4. **Critical Thinking** Where would you place decomposers on an energy pyramid? Explain.

5. **Test Prep** **A food web can be broken down into separate**
   - **A** producers.
   - **B** decomposers.
   - **C** food chains.
   - **D** food pyramids.

6. **Test Prep** **Which of the following is the largest group in an energy pyramid?**
   - **A** consumers
   - **B** producers
   - **C** carnivores
   - **D** herbivores

Writing Link

Your Food Chain

What food chains are you a part of? Describe what you ate for lunch today. Tell how the foods you ate link back to a food chain or food web.

Math Link

Food Pyramid

Suppose all the faces, or sides, of a food pyramid are triangles. How many sides, edges (where two sides meet), and vertices (where two or more edges meet) does it have?

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Two Desert Creatures

Fictional Narrative

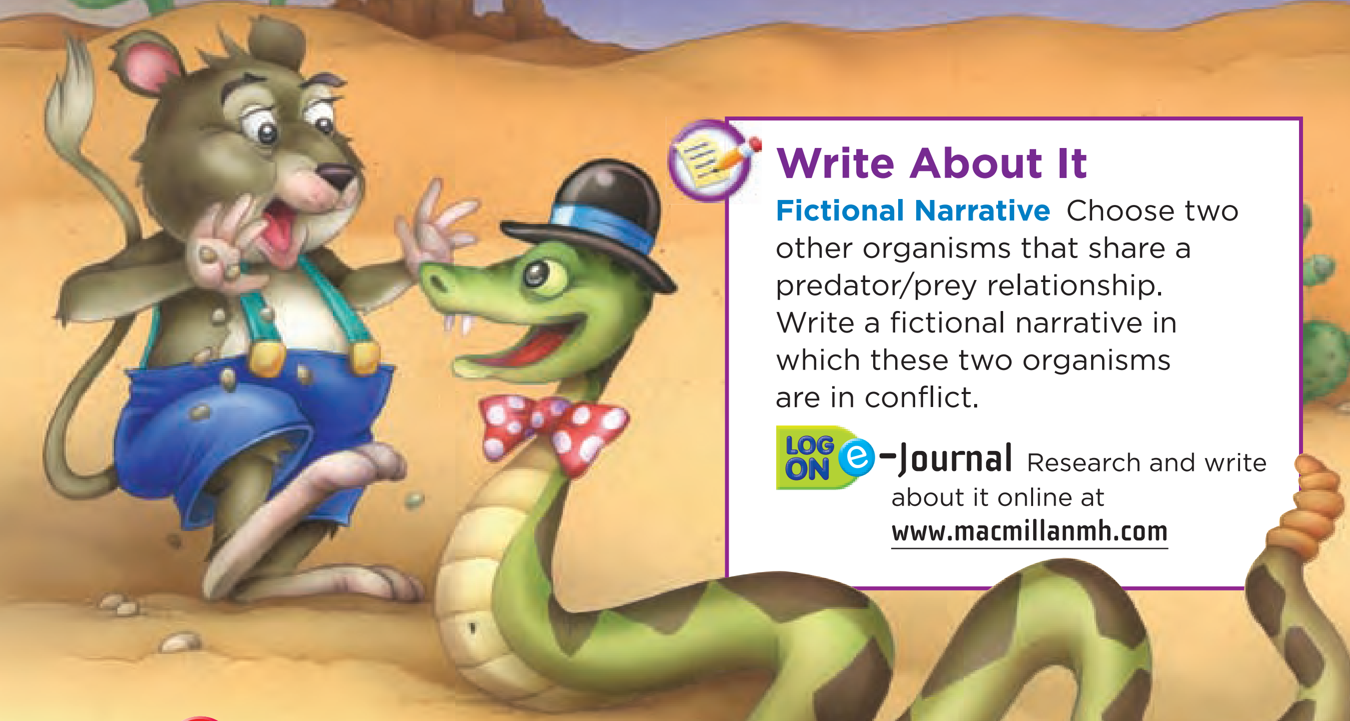
A good fictional story

- has an interesting beginning, middle, and end
- describes a setting that tells when and where the story takes place
- has a plot that centers around a problem or conflict
- has characters whose actions move the plot along

It was a cool night in the desert. The kangaroo rat crawled out of his underground burrow. He hopped on his long back legs to some nearby bushes. There he found some seeds on the ground. He was so busy stuffing seeds into his cheek pockets that he did not hear the soft rattling noise coming from behind him.

"Hello, furry friend," said the rattler. The moonlight shone on the brown diamond shapes along his back. "I'm very hungry. Are those seeds-s-s-s any good?"

"Stay back," screeched the kangaroo rat when he saw the snake slithering closer. "Don't be silly. I won't eat you, I just want some of your seeds-s-s-s," hissed the snake. But he quickly moved to within striking distance. The kangaroo rat tried to hop away, but it was too late.



Write About It

Fictional Narrative Choose two other organisms that share a predator/prey relationship. Write a fictional narrative in which these two organisms are in conflict.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA WA-I. Write narratives with a consistent point of view, using sensory details and dialogue to develop characters and setting.

Calculate How Much Energy Is Used

In the energy pyramid, only about ten percent of the available energy gets used as food energy at each level. This is an inefficient use of energy. You can calculate how much energy is used for food and how much energy is transferred to heat at each level to see exactly how inefficient it is.

Suppose that the Sun gave off 95,000 energy units. To calculate how many units of energy are available at the producer level, you must start by finding 10 percent of 95,000. You can see that 10 percent of 95,000 is 9,500. This is how much energy would be available at the producer level.

Calculate Percents

To calculate percents

- you write a percent as a decimal

  10% = 0.10

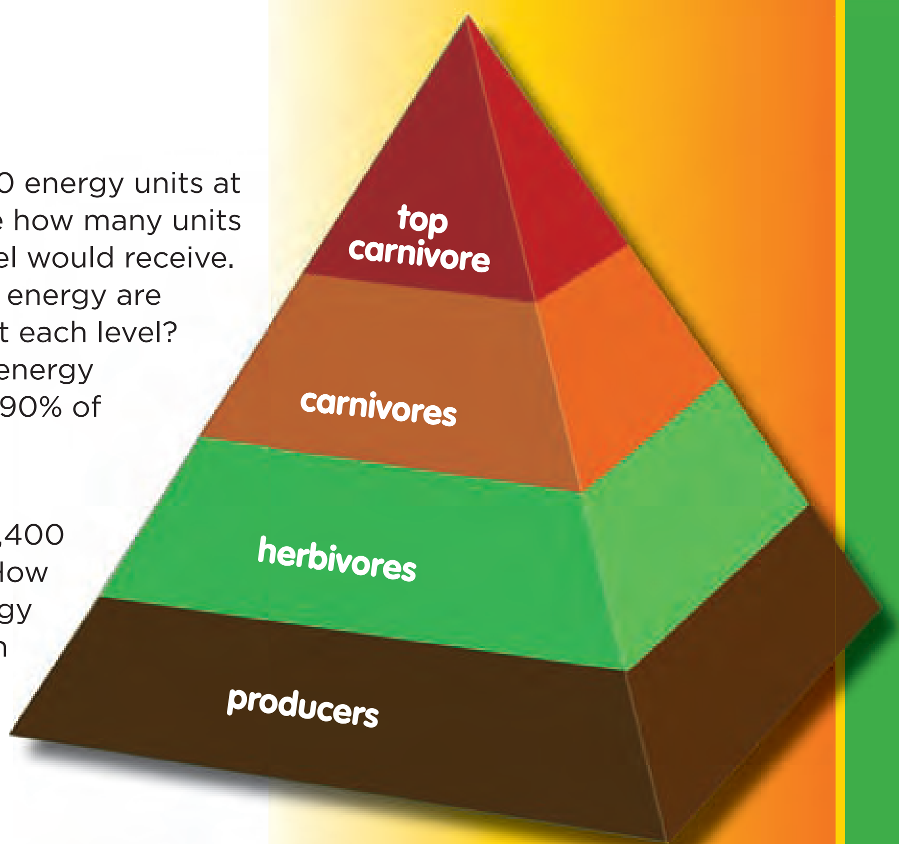
- multiply the decimal by the total number

  95,000 x 0.1 = 9,500

Solve It

1. Suppose that there are 9,500 energy units at the producer level. Calculate how many units of available energy each level would receive. How many units of available energy are transferred to heat energy at each level? **Hint**: To find out how much energy is transferred you must find 90% of available energy.

2. Suppose that a plant used 6,400 energy units from the Sun. How many units of available energy will a carnivore receive when it eats a herbivore? How many energy units did the plant transfer as heat?



MA NNSO-I. Use models and visual representation to develop the concept of ratio … and the concept of percent.…

Lesson 2

Interactions in Ecosystems

Look and Wonder

African jacana birds spend hours picking small insects and ticks off the backs of hippos. How does this relationship help both organisms survive?

LS-5. Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the ecosystem.

Explore

Inquiry Activity

What do organisms need to survive?

Make a Prediction

What do organisms need to survive? Do organisms in an aquatic environment need different things than organisms in land environments? Make a prediction.

Test Your Prediction

1. Make a water environment. Place gravel in one container. Fill the container with pond water. Add water plants and snails.
2. Make a land environment. Place gravel in the other container and cover it with a layer of soil. Add grass seeds and earthworms and cover them with additional soil. Water the seeds.
3. Cover each container with a lid. Place the containers in a well-lit place out of direct sunlight.
4. **Observe** Examine your containers for changes every day for a week. Do the organisms in each environment interact? Record your observations.

Draw Conclusions

5. What are the abiotic and biotic parts of water and land environments?
6. **Infer** How do the plants help the animals survive in the water environment? The land environment?
7. What would happen to each environment if the plants or animals were removed?

Explore More

What other factors affect an organism's survival? Try adding more plants or animals to your environments. Try placing your environments in the dark for a few days. How do the environments change?

SI-I. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others ...

Materials

- gravel
- 2 containers with lids
- pond water
- water plants
- water snails
- soil
- grass seed
- earthworms

Step 2

Step 3

Read and Learn

Main Idea LS-4, LS-5

Abiotic factors and interactions between organisms control the size of populations in a community.

Vocabulary

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Reading Skill

Infer

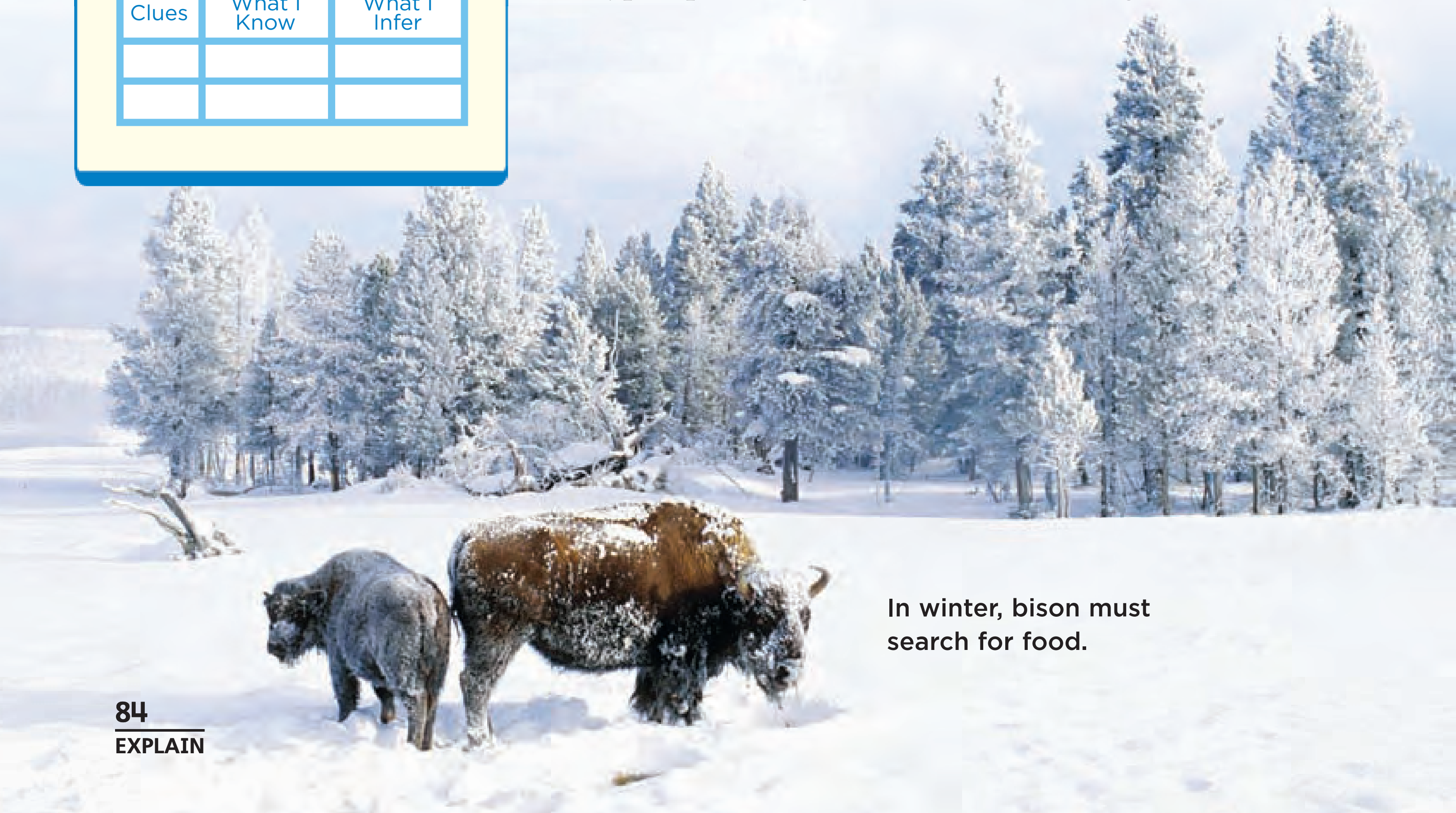
Clues	What I Know	What I Infer

Why do organisms compete?

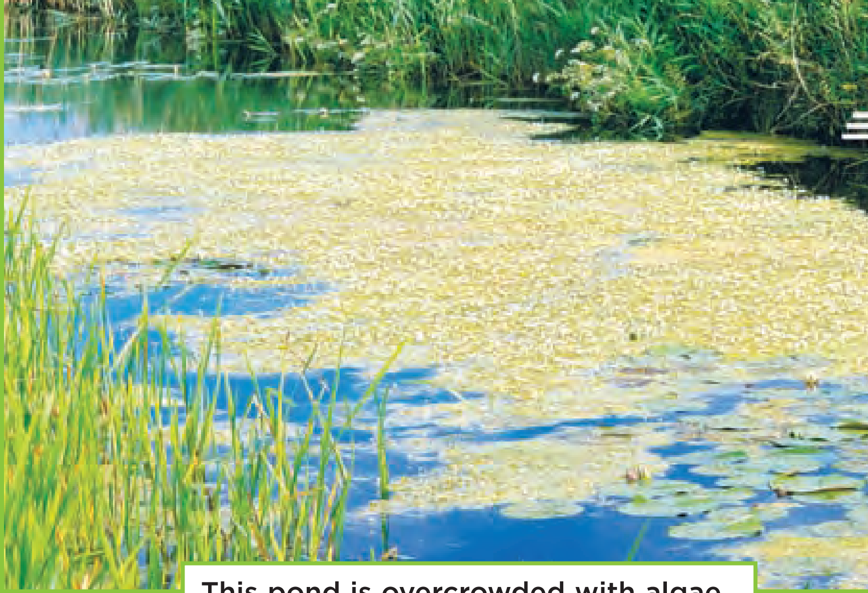
Life in an ecosystem is a constant struggle. Food, water, space, and other resources are restricted. Organisms struggle to get their share of each resource. This fight for limited resources is called *competition*.

Who competes in an ecosystem? Organisms within a population compete with one another. A fox must compete with other foxes to catch rabbits. Populations also compete. Foxes and hawks, for example, both eat rabbits. Since there is a limited number of rabbits, the two predator populations compete for food. The rabbits must also compete with other herbivore populations for their food.

Ultimately, the survival of populations comes down to resources. A **limiting factor** (LIM•i•ting FAK•tuhr) is any resource that restricts the growth of populations. A forest, for example, gets more rainfall and is much warmer in summer than winter. In summer, the forest can support many more populations than in winter. In this case, rainfall and temperature are limiting factors. Common abiotic limiting factors include water, temperature, weather, soil type, space to grow, shelter, and sunlight.



In winter, bison must search for food.



This pond is overcrowded with algae.

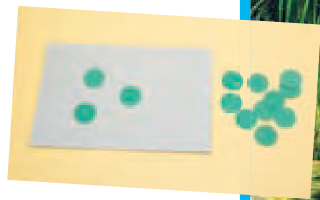
Biotic factors can also limit ecosystems. A prairie ecosystem has more producers than a desert ecosystem. As a result, the prairie can support more herbivores, which support more carnivores. In this case, the amount of available food is the biotic limiting factor for the desert ecosystem. With more available food, the prairie ecosystem can support more populations.

Together, biotic and abiotic factors determine the carrying capacity (KAR•ee•ing kuh•PAS•i•tee) for each population. The **carrying capacity** is the greatest number of individuals within a population that an ecosystem can support. For example, a rain forest can support a certain number of jaguars. If the jaguar population starts to rise, food becomes harder to find. Soon, some of the jaguars die and the population returns to its former level.

Overcrowding also limits growth. An algae population in a nutrient-rich pond may seem like it can grow indefinitely. But the algae will eventually get so thick that they start to use up the oxygen in the pond. Without enough oxygen for respiration, the algae and other organisms begin to die off.

Quick Lab

Limiting Factors



1. **Be Careful.** Use scissors to cut out twenty 2.5 cm (1 in.) circles. Each circle represents the range that the roots of the plant extend.
2. **Measure** Create an environment for these plants by making a 20 cm (8 in.) square box on your desk.
3. Toss 8 plants into the environment. If a plant does not touch another plant, it "survives." If the plant touches another plant, remove the plant and any plant that it touches. Record your results in a data table.
4. Increase the number of plants that you toss to 10, 12, 14, and so on. Record your results. Which number of plants tossed allows the most plants to survive?
5. **Infer** How can crowding be a limiting factor for a population?

Quick Check

Infer Compared to the surface, the bottom of the ocean is dark and has very few organisms. What might be a limiting factor in this ecosystem?

Critical Thinking Why is a sudden increase in a predator population usually temporary?

FACT Populations cannot grow indefinitely.

How do organisms avoid competition?

An organism avoids competition by having a specific territory and a unique role within its ecosystem. A **habitat** (HAB•i•tat) is the physical place where an organism lives and hunts for food. Some creatures have very small habitats. Pill bugs, for example, spend most of their time under and around a stump or rock. A bee's habitat is larger. It is not only the hive where the bee lives. It also includes the fields and forests where the bee searches for flowers.

A **niche** (nich) is the special role that an organism plays in a community. For example, two birds might live in the same location and eat the same food. But one bird is active at night while the other is active during the day. Therefore, the two birds occupy different niches.

In a similar way, two birds might share the same rain-forest habitat but eat different foods. One bird eats plants while the other eats insects. The two birds occupy two different niches in the community. For example, honeycreepers are a group of related birds found on the islands of Hawaii. These birds all share the same habitat, but are able to avoid competing with each other by eating different foods.

The **akiapolaau** removes insects from beneath tree bark.

The **iiwi** sips nectar from long, tube-shaped flowers.

Hawaiian Honeycreepers

The **Maui parrotbill** finds insects and grubs by crushing twigs.

The **Maui creeper** eats insects and grubs it finds on the leaves, branches, and bark of trees.

The **apapane** sips nectar from flowers high in the tree tops of the rain forest.

Read a Photo

Why does each honeycreeper have a uniquely shaped beak?

Clue: Compare the beak shapes with the methods for finding food. How would certain beaks help honeycreepers to obtain different foods?

Quick Check

Infer Two populations share the same food and habitat. What key difference could cause them to occupy different niches?

Critical Thinking What might happen to organisms when their habitats are destroyed?

How do organisms benefit from interactions?

Living things in an ecosystem depend on one another. For example, all animals in an ecosystem depend on plants and other producers for food. Plants depend on animals for carbon dioxide. These interlocking relationships are examples of interdependence. *Interdependence* is the reliance of organisms on other organisms for their survival. Some forms of interdependence are linked more closely than others. **Symbiosis** (sim•bye•OH•sis) is a relationship between two or more kinds of organisms that lasts over time.

These ants are defending an acacia tree from other insects.

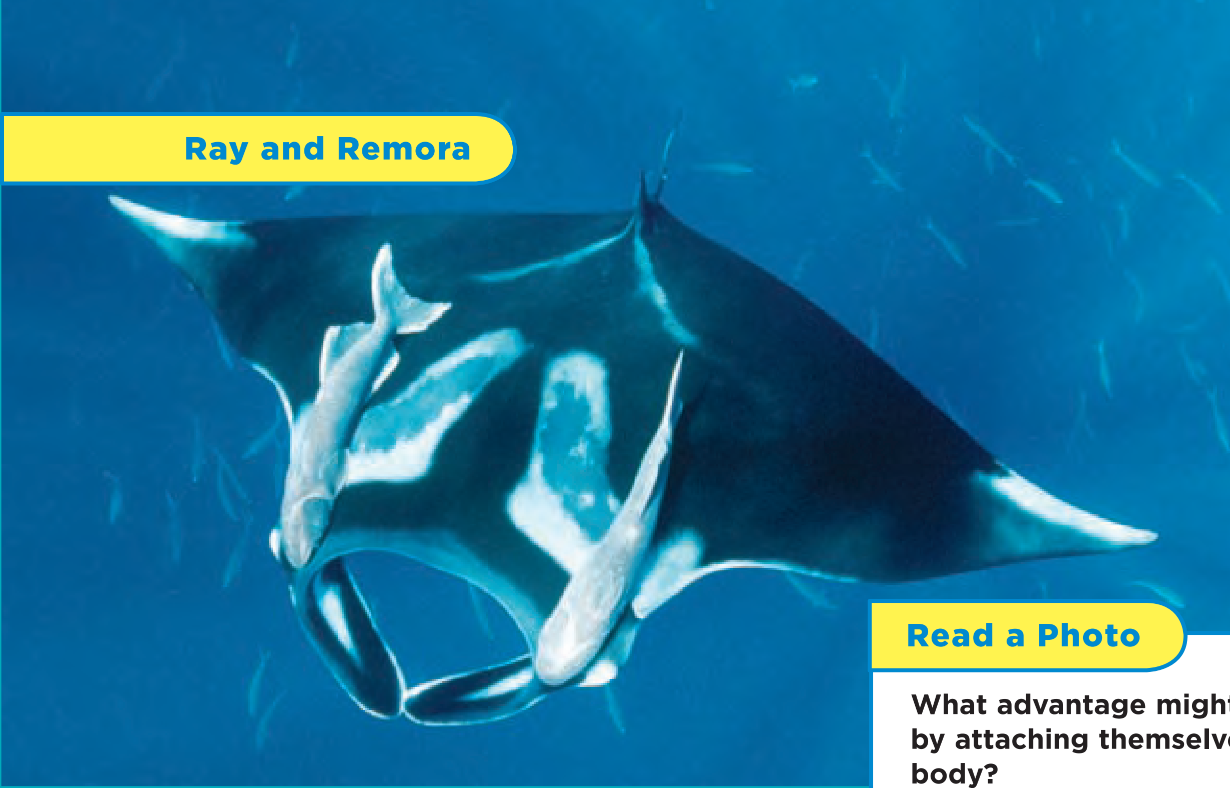
Mutualism

A symbiotic relationship that benefits both organisms is called **mutualism** (MYEW•chew•uh•liz•uhm). A pollinator and a flowering plant provide an example of mutualism. The pollinator, usually an insect or bird, gets sweet nectar from the flower. The plant gets its pollen transported to the pistil of another flower. Both organisms gain from the relationship.

A fascinating example of mutualism is seen in the relationship between ants and acacia trees. The tree provides a home and food for the ants. The ants in turn defend the tree against other insect pests. How successful is this relationship? Scientists used chemicals to get rid of the ants on an acacia. Without its ants, the tree soon died!

Another example of mutualism can be seen in lichens. A *lichen* is actually two different organisms—a fungus and an alga—that live together. The fungus provides the alga with a home and nutrients. As a result, the alga does not dry out. The alga, in turn, provides the fungus with food and oxygen.

British soldier lichen



Read a Photo

What advantage might remoras get by attaching themselves to a ray's body?

Clue: Remoras do not get any nutrition from the ray itself.

Commensalism

Remora are fish that attach themselves to the bodies of rays and sharks. The remora gets food scraps, transportation, and protection from the ray. What does the ray get from the remora? While the remora does not hurt the ray in any way, it does not help the ray either. A symbiotic relationship that benefits one organism without harming the other is called **commensalism** (kuh•MEN•suh•liz•uhm).

Other examples of commensalism include the growth of orchids on trees in the rain forest. Rather than root in the ground, orchids anchor themselves high in a tree. This situation helps the orchid. It does not hurt the tree, so it is an example of commensalism. Barnacles growing on the backs of whales are also commensal. The barnacles gain a home. The whales are not hurt by the barnacles.

Sometimes it is difficult to tell whether a relationship between organisms really is an example of commensalism. The clownfish, for example, lives among the tentacles of the sea anemone. It uses the anemone for protection. When chased by predators, the clownfish retreats to the anemone's tentacles. In this relationship, the clownfish is clearly helped by the anemone. However, it is hard to tell whether the anemone gains from the clownfish. Most scientists think that the relationship is an example of commensalism.

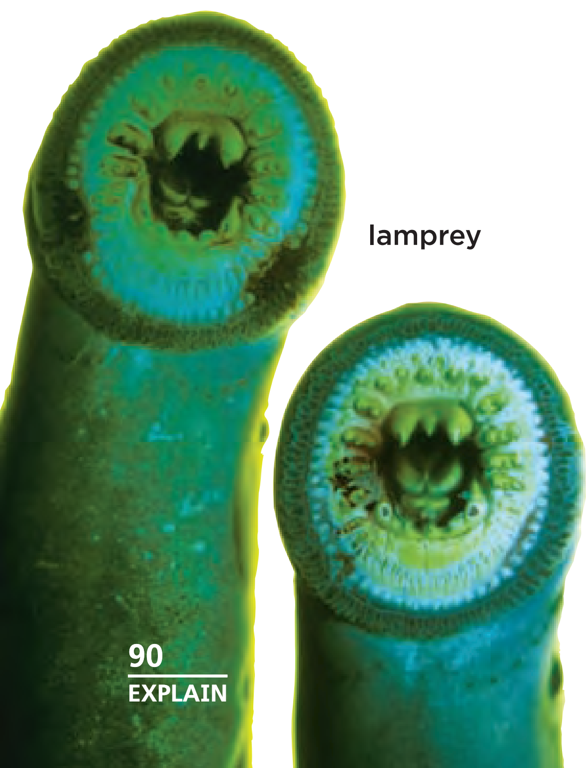
Quick Check

Infer How do algae and fungi benefit from living as a lichen?

Critical Thinking Oxpecker birds eat pests that bother rhinoceroses. Is this an example of mutualism or commensalism? Why?

▲ A magnified view of a wood tick on human skin.

▲ A magnified view of a tapeworm.



lamprey

What are parasites?

Some partnerships are harmful for individuals in the relationship. **Parasitism** (PAR•uh•sye•tiz•uhm) is a symbiotic relationship where one organism benefits and the other is harmed. A *parasite* lives in or on a host organism and benefits from the relationship. For example, ticks are parasites on dogs and other animals. Ticks use their host's body for a home and a food source. A tick attaches itself to a host and harms the host by taking in the host's blood. The tick's host gets no benefit from the relationship.

Some parasites are very harmful for the host organism. Millions of people around the world have parasites called tapeworms. These worms live inside a person's intestinal tract. Tapeworms more than 70 centimeters (2 feet) in length have been found in humans. Tapeworms can harm their hosts by causing fevers and digestive problems. Another dangerous parasite is a lamprey. Lampreys are parasitic fish. They use their suckerlike mouth to attach themselves to other fish. They harm their host by sucking out its blood and other body fluids.

Some parasites are protists, including the species of amoeba that causes a disease called *dysentery* (DIS•uhn•ter•ee). Dysentery amoebas enter the host's body through contaminated food or water. The protist that causes sleeping sickness in Africa lives in the bodies of cows and other large animals. When these animals are bitten by flies, the flies transfer the protists to humans, causing the disease.

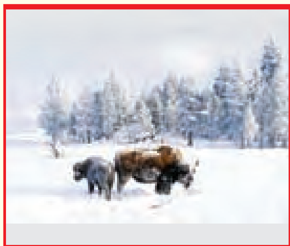
Quick Check

Infer Why do parasites often harm, but not kill, their hosts?

Critical Thinking How is a parasitic relationship like a predator-prey relationship?

Lesson Review

Visual Summary



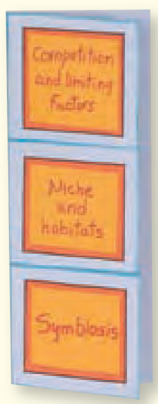
Competition and **limiting factors** control the size of populations in an ecosystem.

Organisms avoid competition by occupying different **niches** and **habitats**.

Mutualism, commensalism, and parasitism are examples of **symbiosis**.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. Tell about the topics on the inside of each tab.



Think, Talk, and Write

1. **Main Idea** How can biotic and abiotic factors affect the size of a population?

2. **Vocabulary** The role of an organism in the community is its ________.

3. **Infer** A predator population suddenly decreases even though the prey stays the same. Besides disease, what could explain this change?

Clues	What I Know	What I Infer

4. **Critical Thinking** How do humans change the abiotic factors in their habitat? Explain.

5. **Test Prep** **Which of the following determines the carrying capacity of a population in an ecosystem?**
   - **A** plants and animals
   - **B** abiotic limiting factors
   - **C** biotic limiting factors
   - **D** abiotic and biotic limiting factors

6. **Test Prep** **Which term represents all living things in an ecosystem?**
   - **A** a community
   - **B** a population
   - **C** a limiting factor
   - **D** a habitat

Writing Link

Personal Narrative

What niche do you occupy? Write a personal narrative that tells about your unique "niche."

Math Link

Determine Area

Suppose a wolf's habitat is a rectangle that measures 4.5 km on one side and 6.4 km on the other side. What is the area of this habitat?

Focus on Skills

Inquiry Skill: Predict

You just read about how some organisms get food by eating other organisms. Can anyone know in advance what effect this will have on the population size? When scientists have questions like that, they conduct simulations and study the results. Then they can **predict** what might happen in a similar situation.

▶ Learn It

When you **predict**, you state the possible results of an event or experiment. Then you conduct a test and interpret the results to determine if your prediction was correct.

It is important to record your predictions, as well as any measurements or observations you make during the test. Your observations and measurements provide written proof of whether or not your prediction was correct. In this activity, you will predict how population size will change.

▶ Try It

How many deer do you **predict** will survive in a population of wolves? Use what you have learned about predators and prey to write your prediction. Then use the model to see if your prediction was correct.

Materials **masking tape, 1—7.5 cm cardboard square, 100—2.5 cm construction paper squares, graph paper**

1. Use tape to mark off a 60 cm by 60 cm square. This square represents a meadow. Distribute 3 of the 2.5 cm paper deer squares in the meadow.

2. Toss the 7.5 cm cardboard wolf square in the meadow. Remove any deer that touch the wolf. In order to survive, the wolf must catch, or touch, 3 deer. If the wolf survives, it produces 1 offspring. If the wolf does not catch any deer, it starves.

Predator-Prey Results

Trial	Deer	Wolf	Deer Caught	Wolves Starved	Wolves surviving	New Baby Wolves	Deer left
1							
2							
3							
4							
5							
6							

3. Record your results in a data table. What happened to the wolf and deer in this trial?

4. At the start of the next trial, double the deer remaining from the first trial to represent new deer offspring. Disperse these new deer in the meadow.

5. If the entire deer population was caught by the wolf in the previous trial, then add 3 new deer to the meadow.

6. In each additional trial throw a wolf square once for each wolf. This includes any surviving wolves from previous trials and any of the offspring produced in previous trials. Record your results in your data table.

7. Repeat steps 1 through 6 for a total of 14 trials.

▶ Apply It

Predict the outcomes for 6 trials. Base your prediction on the pattern you observed during the first 14 trials. Then actually model trials 15 to 20. Were your predictions correct?

Graph the data for your 20 trials. Place the deer and wolf data on the same graph so that the interrelationship can be easily observed. Label the vertical axis "Number of Animals" and the horizontal axis "Trials." Use one color for the deer data and another for wolf data.

SWK-I. Summarize how conclusions and ideas change as new knowledge is gained.
SWK-2. Develop descriptions, explanations, and models using evidence to defend/support findings.

Lesson 3

Adaptation and Survival

Look and Wonder

These spiny bugs look very similar to the plant they are standing on. How does blending in with an environment help an organism?

LS-4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity, and waste disposal) ...
LS-5. Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem ...

Explore

Inquiry Activity

How do adaptations help animals survive in their environment?

Form a Hypothesis

Sow bugs are animals that live under logs, leaves, and rocks. Are sow bugs adapted to prefer damp or dry environments? Write your answer as a hypothesis in the form "If moisture in the sow bug's environment is increased, then . . ."

Test Your Hypothesis

1. **Observe** Place 15 sow bugs on the tray. Examine the sow bugs with the hand lens. Record your observations.
2. **Experiment** Tear four paper towels in half. Make sure they are the same size. Dampen two of the halves.
3. Move the sow bugs to the center of the tray. Place the moist paper towels in one end of the tray. Place the dry paper towels on the opposite side of the tray.
4. Watch the sow bugs for several minutes. Look for changes in their behavior.
5. After 10 minutes, count the sow bugs on each side of the tray. Record your results. ⚠ **Be Careful.** Wash your hands after handling sow bugs.

Draw Conclusions

6. Based on your observations, what traits help sow bugs survive in their environments?
7. What were the independent variable and dependent variable? What variables remained constant?
8. **Infer** Did your results support your hypothesis? Explain why or why not.

Explore More

Are sow bugs adapted to prefer dark or light environments? Form a hypothesis and test it. Then analyze and write a report of your results.

Materials

- sow bugs
- tray
- hand lens
- paper towels
- water

SI-I. Select and safely use the appopriate tools to collect data when conducting investigations ... **SI-3.** Use evidence and observations to explain and communicate the results of investigations.

Read and Learn

Main Idea LS-4, LS-5

Organisms have adaptations that help them survive in their environments.

Vocabulary

adaptation, p. 96
camouflage, p. 101
protective coloration, p. 101
protective resemblance, p. 101
mimicry, p. 102

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Reading Skill

Problem and Solution

Problem
↓
Steps to Solution
↓
Solution

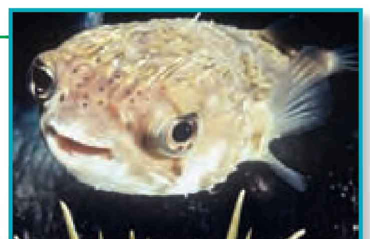
What is adaptation?

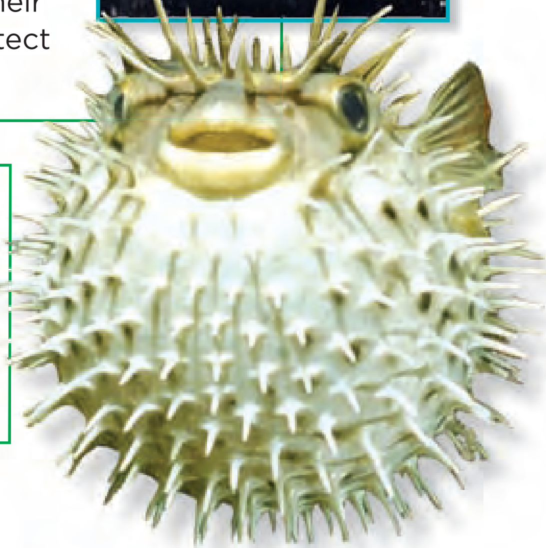
Survival in any ecosystem is a constant struggle. An **adaptation** (ad•uhp•TAY•shuhn) is any characteristic that helps an organism survive in its environment. Over time, organisms with successful adaptations survive more frequently than other organisms. Their offspring inherit these adaptations. Adaptations can be structural or behavioral.

Structural Adaptations

Structural adaptations are adjustments to internal or external physical structures. Fur color, long limbs, strong jaws, and the ability to run fast are structural adaptations. Some structural adaptations help organisms survive in certain environments. For example, ducks have webbed feet that help them survive in water. Cactuses have a thick, waxy cuticle that prevents water loss in their dry environment.

Other structural adaptations protect prey from predators or enable predators to hunt more successfully. Turtles have hard shells that protect them from predators. Predators such as sharks have an excellent sense of smell and sharp teeth. Both of these traits help sharks catch their prey.





Structural Adaptation When puffer fish are threatened, they fill their bodies with air or water. As they fill up, their spines are pushed out. Their spines and large size protect them from predators.

Structural Adaptation Many plants, such as roses and cactuses, have thorns or spines on their stems. These modified leaves protect the plant from herbivores.

Behavioral Adaptations

An adjustment in an organism's behavior is a *behavioral adaptation*. For example, wolves traveling in packs is a behavioral adaptation. Wolf packs can hunt large prey that one wolf alone could not capture. Many prey animals also travel in groups. Some fish swim in schools which protects them from predators. Symbiotic relationships are also behavioral adaptations.

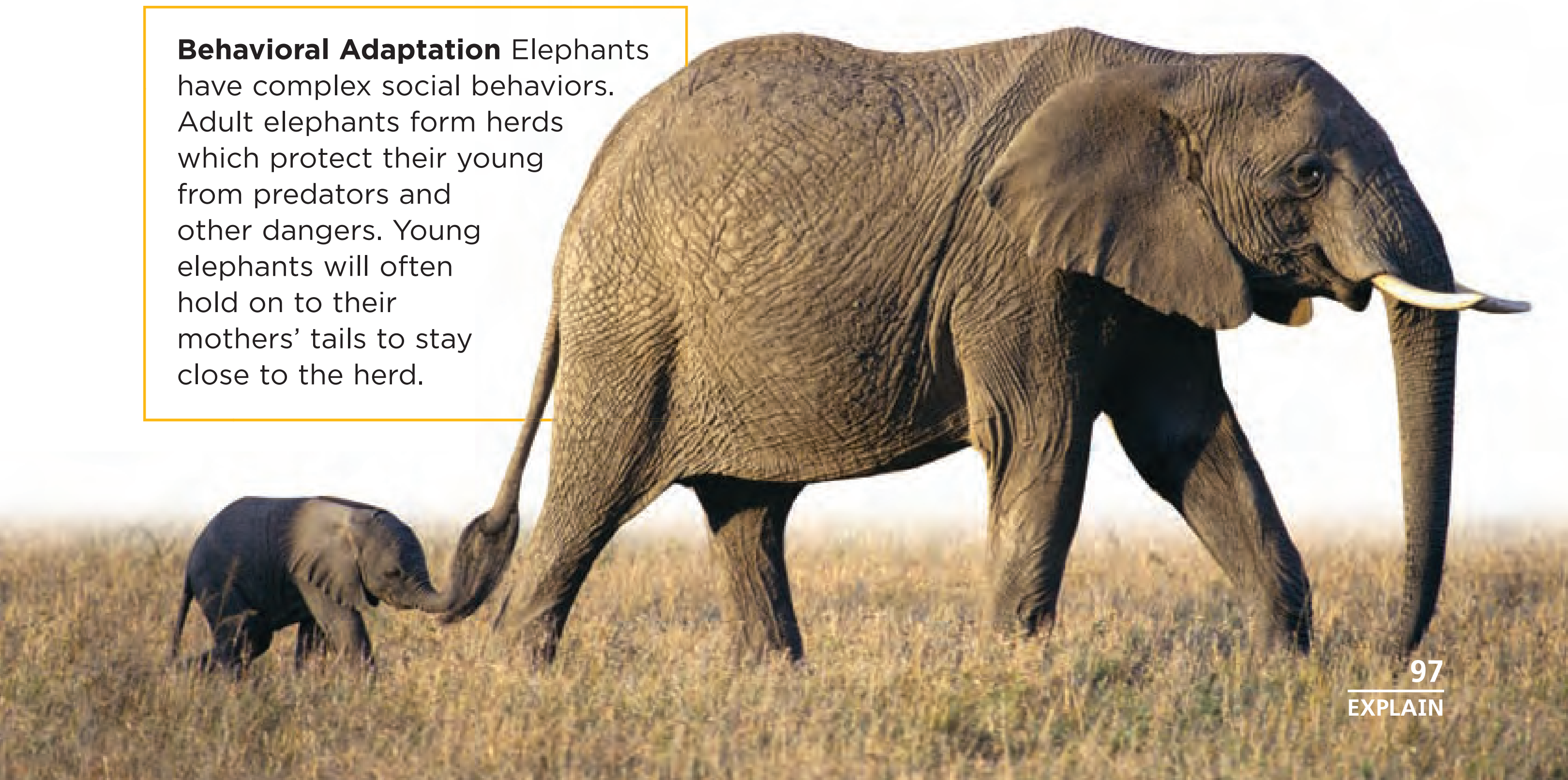
Some behavioral adaptations help animals survive seasonal changes in the climate. Many animals such as birds, butterflies, and fish migrate. *Migration* (mye•GRAY•shuhn) is a seasonal movement of animals to find food, reproduce in better conditions, or find a less severe climate. Other animals such as bats, snakes, turtles, and frogs hibernate to escape the cold. *Hibernation* (hye•ber•NAY•shuhn) is a period of inactivity during cold weather. The animals remain inactive until warmer temperatures return in spring.

Quick Check

Problem and Solution How do sea otters eat animals with shells?

Critical Thinking What structural and behavioral adaptations do humans have?

Behavioral Adaptation Sea otters eat shelled animals, such as crabs and clams. They crack open the shells using rocks. An otter will hold a rock on its stomach and smash the crab or clam against the rock.



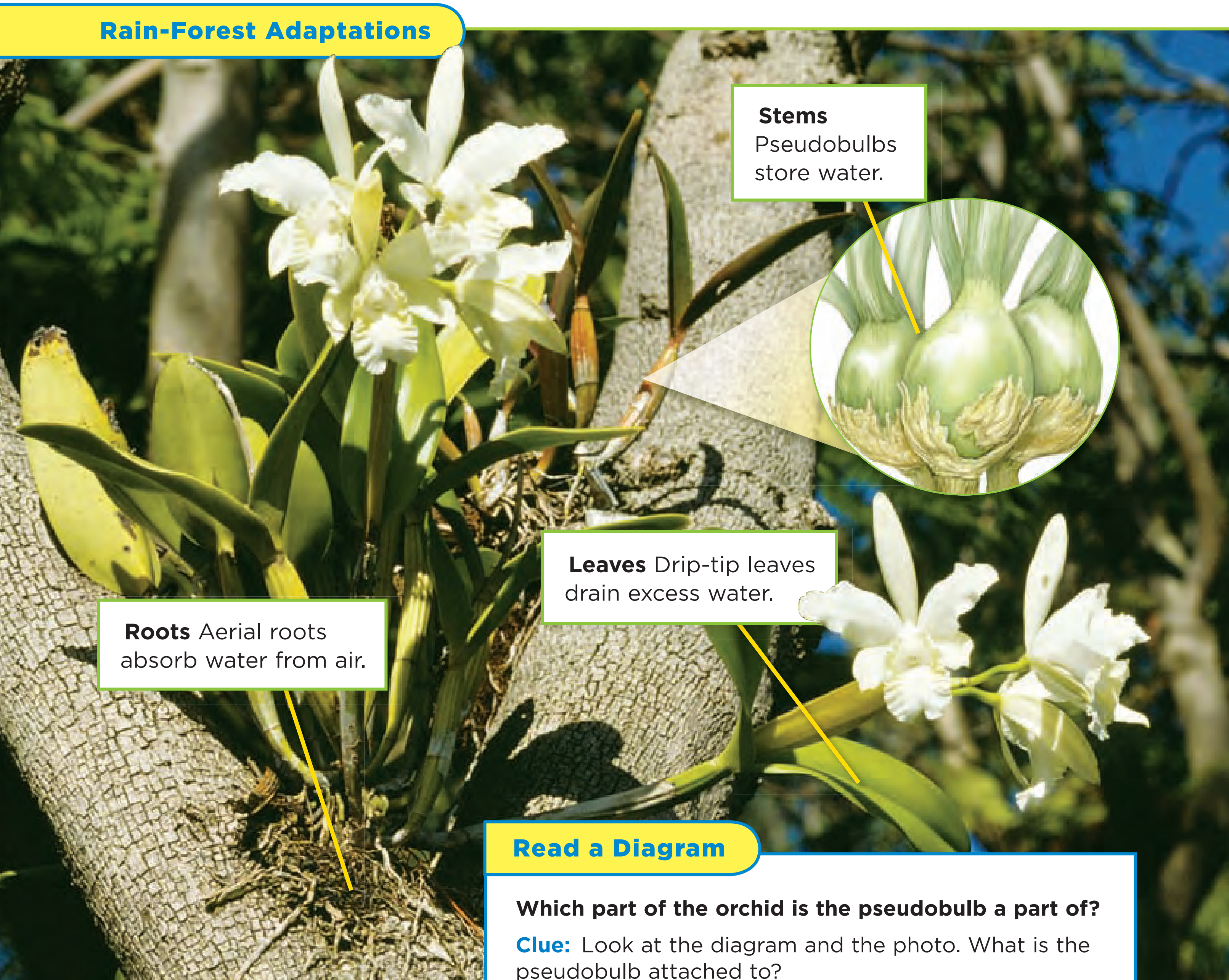
Behavioral Adaptation Elephants have complex social behaviors. Adult elephants form herds which protect their young from predators and other dangers. Young elephants will often hold on to their mothers' tails to stay close to the herd.

What are some plant adaptations?

Angiosperms have scented flowers that attract certain pollinators. They have leaves that catch sunlight and roots that soak up water. These and other adaptations help plants survive.

Some plants have specific structural adaptations to different environments. Rain-forest plants, like orchids, have adaptations that help them survive wet, hot temperatures. Orchid stems have storage organs called *pseudobulbs* (SEW•doh•bulbz). They store water for the plant. An orchid's aerial roots help secure it to a tree high in the rain forest. These roots also absorb water

Rain-Forest Adaptations



Read a Diagram

Which part of the orchid is the pseudobulb a part of?

Clue: Look at the diagram and the photo. What is the pseudobulb attached to?

from the moist air. Like many rain-forest plants, orchids have drip-tip leaves. These leaves are adapted to the constant wet conditions in a rain forest. Their tips drain excess water.

Plants, like cactuses, that live in hot and dry environments have thick, waxy stems that prevent water loss. They have very dense, shallow roots that soak up rain quickly. Plants that live in forests, like oak trees, lose their leaves in the winter. This helps them prevent water loss. Cold climate plants, such as moss, are able to complete their life cycle in a shortened growing season. Some aquatic plants, such as water lilies, have stomata on the top surface of the leaf instead of the bottom. This enables the stomata to take in and release carbon dioxide and oxygen.

Many plants have adaptations that defend them from herbivores. For example, some plants produce chemicals that give them a bad taste. When most herbivores eat the leaves, they do not like the taste and stop eating the plant. Other plants, such as milkweeds, produce chemicals that are poisonous to most animals. Both of these adaptations protect the plants from predators.

Quick Check

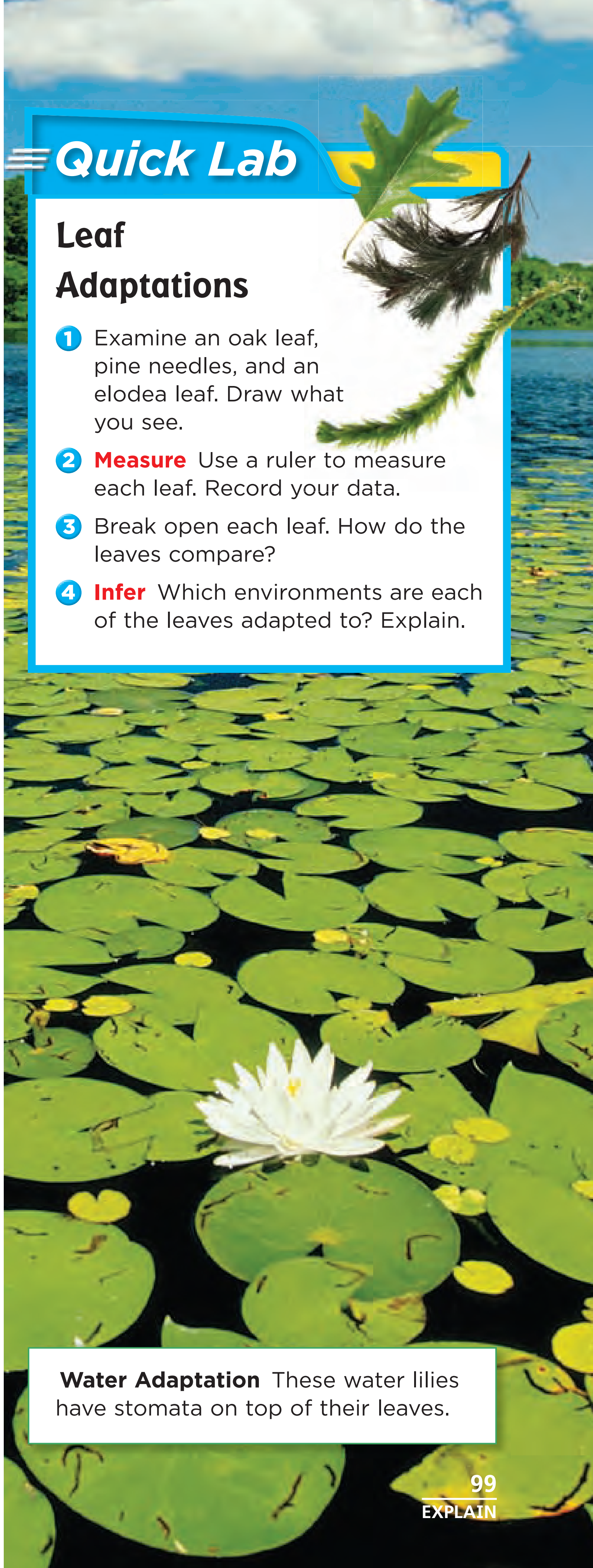
Problem and Solution How do water plants release oxygen and take in carbon dioxide?

Critical Thinking Why do adaptations always "fit" the environment? For example, why don't cactuses have drip-tip leaves?

Quick Lab

Leaf Adaptations

1. Examine an oak leaf, pine needles, and an elodea leaf. Draw what you see.
2. **Measure** Use a ruler to measure each leaf. Record your data.
3. Break open each leaf. How do the leaves compare?
4. **Infer** Which environments are each of the leaves adapted to? Explain.



Water Adaptation These water lilies have stomata on top of their leaves.

What are some animal adaptations?

Like plants, animals have adaptations that help them survive in specific environments. Animals that live in cold climates have thick fur and extra body fat that keep them warm. Desert animals are often active at night, or *nocturnal*. They stay in shelters or underground burrows during the day and avoid the heat. Nocturnal animals come out at night to search for food.

Animals that live in water also have adaptations. Aquatic animals are usually much more streamlined than land animals. This allows them to swim quickly through the water. Aquatic mammals can hold their breath for long periods of time. Other aquatic animals breathe underwater using gills.

Many animal adaptations develop because of predator and prey relationships. Prey have adaptations that enable them to avoid predators. Predators have adaptations that help them hunt and capture prey. Prey animals, such as gazelles, are able to run at speeds of up to 80 kilometers per hour (49.7 miles per hour). Some animals use chemicals to escape predators. When skunks are threatened, they spray a bad-smelling liquid. These adaptations help prey escape predators.

Predators also have adaptations that make them more efficient hunters. Owls, for example, have several adaptations that make them successful night hunters.

Head Owls have excellent hearing which helps them hunt. One of their ears is higher than the other. This increases their ability to distinguish where sounds are coming from and how far away a sound is.

Eyes Owls have large eyes which help them see tiny prey, such as mice, in the dark. Their eyes are positioned at the front of their head which gives them better vision.

Wings An owl's large, muscular wings help it swiftly hunt for prey. Special tips on the wing feathers muffle the sound of air rushing over the wings as the owl flies. This helps the owl fly silently.

Feet An owl's feet are also adapted for hunting. They have large talons, or claws, for accurately grabbing prey. This adaptation helps them pick up larger prey animals.

Camouflage

Some organisms increase their survival in an environment by blending in. Any coloring, shape, or pattern that allows an organism to blend in with its environment is called **camouflage** (KAM•uh•flahzh). Predators with camouflage can sneak up on prey. Camouflage also helps prey animals hide from predators.

Protective coloration (pruh•TEK•tiv kul•uh•RAY•shuhn) is a type of camouflage in which the color of an animal helps it blend in with its background. In winter, the arctic fox has a white coat that blends in with the snow. In summer, the fox's coat changes color to help it blend in with the plants that grow in the warm weather. Similarly, a tiger's stripes make it difficult to see in the grass. Stripes help a tiger conceal itself from its prey.

Some organisms go beyond protective coloration. Matching the color, shape, and texture of an environment is called **protective resemblance** (ri•ZEM•bluhns). The walking stick insect, for example, resembles a stick or a small branch.

This pipefish resembles the sea grass in its environment.

Quick Check

Problem and Solution How could you tell whether a rabbit comes from a cold weather or a warm weather environment?

Critical Thinking Many flowering plants have brightly colored flowers that are very noticeable. Why don't these plants use camouflage?

Protective coloration helps arctic hares blend in with their snowy environment.

What is mimicry?

Some animals have adapted to their environment by copying other well-adapted organisms. An adaptation in which an animal is protected against predators by its resemblance to an unpleasant animal is called **mimicry** (MIM•i•kree). The viceroy butterfly, for example, is protected from predators because it looks just like the bad-tasting, poisonous monarch butterfly.

Mimic organisms can look so much like a dangerous or unpleasant animal that their enemies stay away. The harmless robber fly resembles the dangerous bumblebee. The king snake mimics the coloring of the poisonous coral snake.

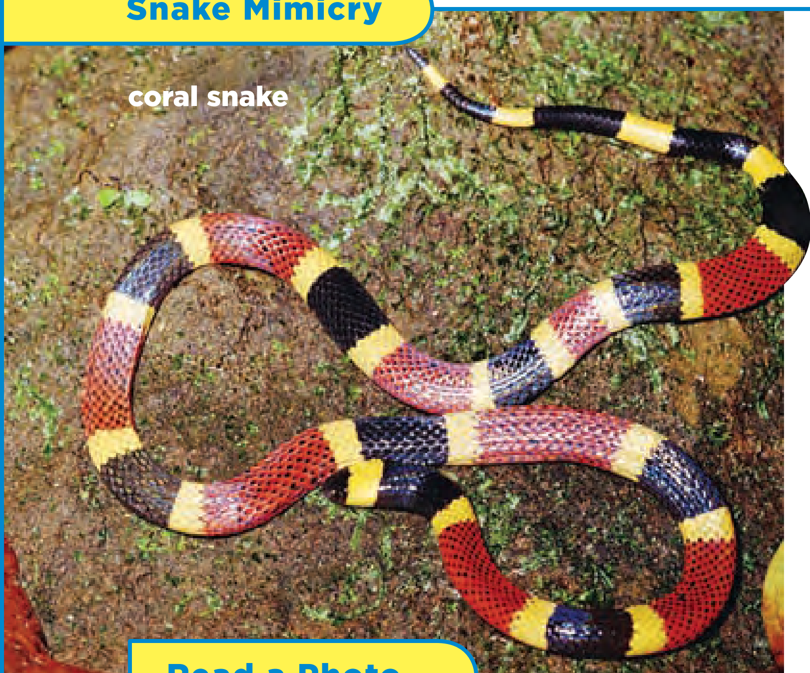
Predators also use mimicry. Instead of warning their prey, they use mimicry to deceive it. Some snapping turtles, for example, have the ability to wag a fleshy "lure" in their mouth. The lure looks like a worm. When fish come closer to try to eat the "worm," the turtles catch the fish.

Quick Check

Problem and Solution How do snapping turtles solve the problem of catching fish?

Critical Thinking How does mimicry increase an organism's chance of survival?

Snake Mimicry



Read a Photo

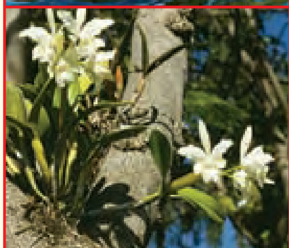
How can you tell a king snake from a coral snake?

Clue: Look for key differences in skin pattern.

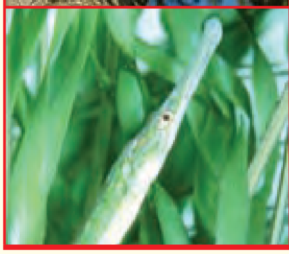
Lesson Review

Visual Summary

Adaptations are traits that help organisms survive in their environments.



Plant adaptations include variations in their leaves, flowers, stems, and roots that help them survive in different environments.



Animal adaptations include **camouflage** and **mimicry**.

Make a FOLDABLES™ Study Guide

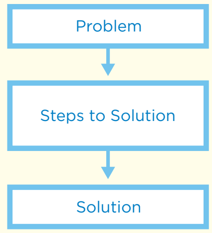
Make a Trifold Book. Use the titles shown. Tell what you learned about each topic.

Think, Talk, and Write

1. **Main Idea** What are structural and behavioral adaptations?

2. **Vocabulary** An organism imitating a harmful organism is called ________.

3. **Problem and Solution** How are aquatic animals able to survive in water?



4. **Critical Thinking** Can adaptations be both behavioral and structural? Explain.

5. **Test Prep** **Which of the following are adaptations for cold weather?**
   - **A** thick fur, big ears
   - **B** thick fur, body fat
   - **C** body fat, gills
   - **D** sleek shape, gills

6. **Test Prep** **Which of the following is a behavioral adaptation?**
   - **A** scaly skin
   - **B** sharp teeth
   - **C** hibernation
   - **D** camouflage

Writing Link

Fictional Narrative

Why does the giraffe have a long neck? How does its neck help the giraffe survive in its environment? Write a story about how the giraffe might have acquired this adaptation.

Art Link

Adaptation Art

Make a painting or drawing that illustrates an animal using camouflage, protective coloration, protective resemblance, or mimicry.

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Real World

Reading in Science

Meet Caroline Chaboo

Plants in the tropical forests of the Caribbean face many challenges. They endure pounding rain, drought, and 160-kilometer-per-hour (100-mile-per-hour) hurricane winds. Yet plants like the Sabal palm (*Sabal causarium*) have adapted to meet these challenges.

This tall, regal palm resists the power of the wind very well. Its root system holds the tree in place and prevents it from being knocked over by strong storms. The palm's long, flexible leaves also help it survive high winds.

The tree can live through hurricanes, but faces another obstacle—a plant-eating beetle. Caroline Chaboo is a scientist at the American Museum of Natural History. Caroline studies the relationships between plants and insects. She researches the tiny tortoise beetle (*Hemisphaerota palmarum*), which is found in the Dominican

Female tortoise beetles place their eggs within the tissues of the plant.

These scars were caused by tortoise beetles.

Republic. This beetle and its larvae feed on the leaves of the Sabal palm. They scrape the palm's leaves with their mandibles, or jaws. This produces long scars that cause the leaves to dry out and die. Since palm trees have few leaves, losing even one can harm the growth of the entire tree.

While the tortoise beetle weakens the palm, the tree itself does not die. Scientists have found that many plants produce proteins that serve as a defense against insects. Caroline is studying the Sabal palm to find out whether it too produces a natural pesticide against the beetles.

By studying the tortoise beetle and the Sabal palm, Caroline hopes to learn more about how plants and animals adapt to their habitats.

Write About It

Infer

1. How might a natural pesticide produced by the Sabal palm help other organisms?
2. Research tortoise beetles. What other plants do they eat? Write a report that tells how such a pesticide could help other plants.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

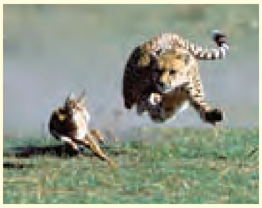
Infer

- Review the text to make inferences about information not stated explicitly.
- List the details that support the inferences you make.

American Museum of Natural History

CHAPTER 2 Review

Visual Summary



Lesson 1 Food chains, food webs, and energy pyramids show the energy flow between organisms in an ecosystem.

Lesson 2 Abiotic factors and interactions between organisms control the size of populations in a community.

Lesson 3 Organisms have adaptations that help them survive in their environments.

Make a FOLDABLES™ Study Guide

Assemble your lesson study guides as shown. Use your study guides to review what you have learned in this chapter.

Vocabulary

Fill in each blank with the best term from the list.

food web, p. 74	**habitat**, p. 86
camouflage, p. 101	**parasitism**, p. 90
ecosystem, p. 70	**prey**, p. 75
food chain, p. 72	**symbiosis**, p. 88

1. All living and nonliving things in an environment make up a(n) ________.
LS-4

2. A relationship where one organism benefits and the other is harmed is ________.
LS-5

3. An organism lives and hunts for food in its ________.
LS-4

4. Animals that are eaten by other animals are called ________.
LS-3

5. A network of food chains that have some links in common is a(n) ________.
LS-3

6. Some organisms blend in with their environment using ________.
LS-4

7. The path that energy and nutrients follow in an ecosystem is a(n) ________.
LS-3

8. Mutualism and commensalism are different types of ________.
LS-5

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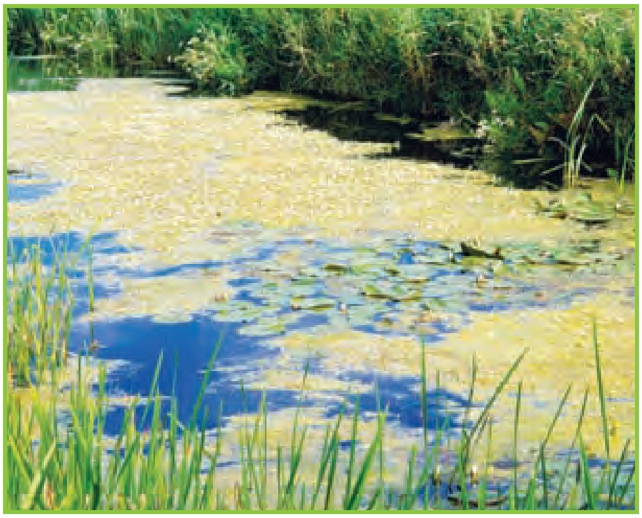
Skills and Concepts

Answer each of the following in complete sentences.

9. **Problem and Solution** Desert ecosystems are dry and often hot. What structural and behavioral adaptations do organisms living in a desert have to solve this problem?
LS-5

10. **Infer** How do the abiotic characteristics of this pond environment act as limiting factors in this environment?
LS-4



11. **Predict** A rabbit with brown fur lives in a snowy environment. What do you think will happen to the rabbit?
LS-4

12. **Critical Thinking** What would happen if an organism at the bottom of a food chain died off?
LS-3

13. **Fictional Narrative** Write a short story set in the future. Suppose that some people have settled, with their pets, on a new planet. Create an ecosystem for the planet. What adaptations will the humans and animals develop to live in the new planet's ecosystem?
LS-1, LS-4

The Big Idea

14. How do organisms interact?
LS-B

Performance Assessment

An Ecosystem in Action!

Create a skit about how animals in an ecosystem interact.

What to Do

1. Working with a group, choose an ecosystem in which to set your skit. What animals, plants, and other organisms live in this ecosystem?
2. Choose several animals from your ecosystem that interact with each other. They may be predator and prey, or they may compete for food. They may also interact through symbiosis.
3. Write a skit showing how the animals interact. Perform your skit for the class.

Ohio Activity

Food chains and webs show the producers and consumers in an environment. They are models of how energy flows through an ecosystem. Ohio has a variety of ecosystems, such as wetlands, lakes, and forests. Write a short story, skit, or poem about a food web that might be found in an Ohio ecosystem.

Ohio Benchmark Practice

1 A town used pesticides to control the mosquitoes in an area. Scientists later observed that the population of one type of bat had decreased. What conclusion can you draw from this information?

A The pesticide killed the bats.
B This type of bat ate mosquitoes.
C The air had become polluted as a result of the spraying.
D This type of bat had migrated south for the winter.

SI-3, LS-C

2 This table describes a simple food web.

Consumer	Food
snake	birds, toads, mice
toad	spiders, insects
bird	spiders, insects
mouse	grass, plants
grasshopper	grass, plants

Based on the table, which two animals listed below are in competition?

A snake and mouse
B grasshopper and toad
C bird and snake
D bird and toad

SI-3, LS-3

3 Which is an example of a plant adaptation for life in a desert?

A broad leaves and a deep taproot
B the ability to complete its life cycle in a shortened growing season
C thick, waxy stems and dense, shallow roots
D the production of chemicals that taste bad

LS-4

4 Producers have an important role in transferring energy in food chains. In your **Answer Document,** label and draw or describe the role of the producer in a land food chain. Include two examples of land producers to support your response. Explain a producer's position in a food chain. (4 points)

LS-B

5 Certain bacteria that live in the stomach of a cow help to break down and digest the plant matter that the cow eats. This is an example of

A commensalism.
B parasitism.
C mutualism.
D competition.

LS-4, LS-5

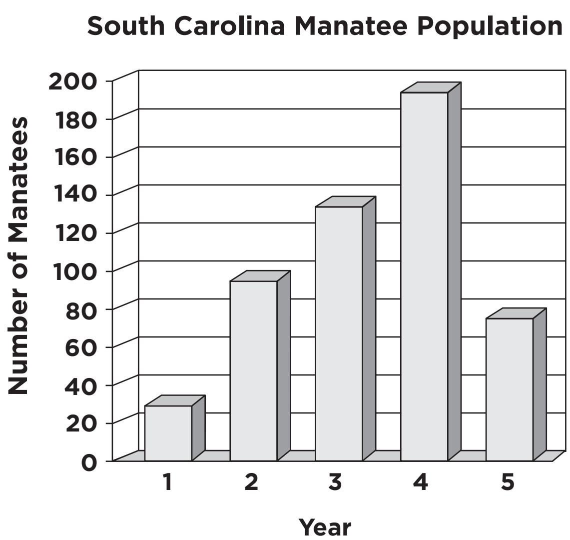
6 The zebra mussel was introduced into the Lake Erie ecosystem. Within a few years, the mussel population had soared, and it showed no sign of declining. What conclusion can you draw?

A The mussels have no natural predators in the lake.
B The mussels play a vital role in the lake's ecosystem.
C The mussels are in competition for very limited resources.
D The mussels are not adapted to fresh water.

SI-3, LS-5

7 Adaptations are characteristics that help an organism survive in its environment. Adaptations can be structural or behavioral. In your **Answer Document,** label and draw or describe the difference between structural adaptations and behavioral adaptations. Be sure to include one example of an adaptation. (2 points)
LS-5

8 Researchers in South Carolina tracked the manatee population for five years. The graph below represents the data they collected.



What conclusion is **best** supported by this graph?

A The population has not reached its carrying capacity.
B There were limiting factors in the manatees' environment.
C Limiting factors do not affect the size of the manatee population.
D The manatee population continued to increase in years 6 and 7.
SWK-2, LS-4

9 After a forest fire several kilometers away, a new species of bird migrated to a location inhabited by several populations of birds. Over time scientists noticed that the populations of the new species and the original birds remained constant. What might scientists conclude?

A The new birds preyed on the original birds.
B The new birds occupied the same niche as one of the other groups.
C The new birds occupied a different niche from the other birds.
D The new birds bred with the original birds.
SI-3, LS-4

10 Which combination in a plant creates the waste product of oxygen?

A sunlight and oxygen
B sunlight and carbon dioxide
C water and carbon dioxide
D nutrients and water
LS-B

11 What is the **best** description of a parasitic relationship?

A Neither partner benefits.
B Both partners benefit.
C One partner benefits while the other is not harmed.
D One partner benefits while the other is harmed.
LS-5

12 An organism that eats grain and small insects is

A an herbivore.
B a producer.
C prey.
D an omnivore.
LS-3

CHAPTER 3

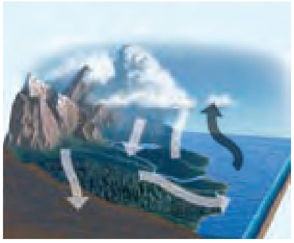
Ecosystems and Biomes

The Big Idea

How are ecosystems different?

Coral reef, Papua New Guinea

Key Vocabulary



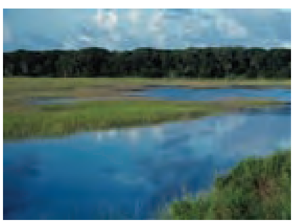
water cycle
the continuous movement of water between Earth's surface and the air, changing from liquid to gas to liquid (p. 114)

endangered species
a species that is in danger of becoming extinct (p. 129)

succession
the process of one ecosystem changing into a new and different ecosystem (p. 130)

pioneer species
the first species living in an otherwise lifeless area (p. 130)

climax community
the final stage of succession in an area, unless a major change happens (p. 131)

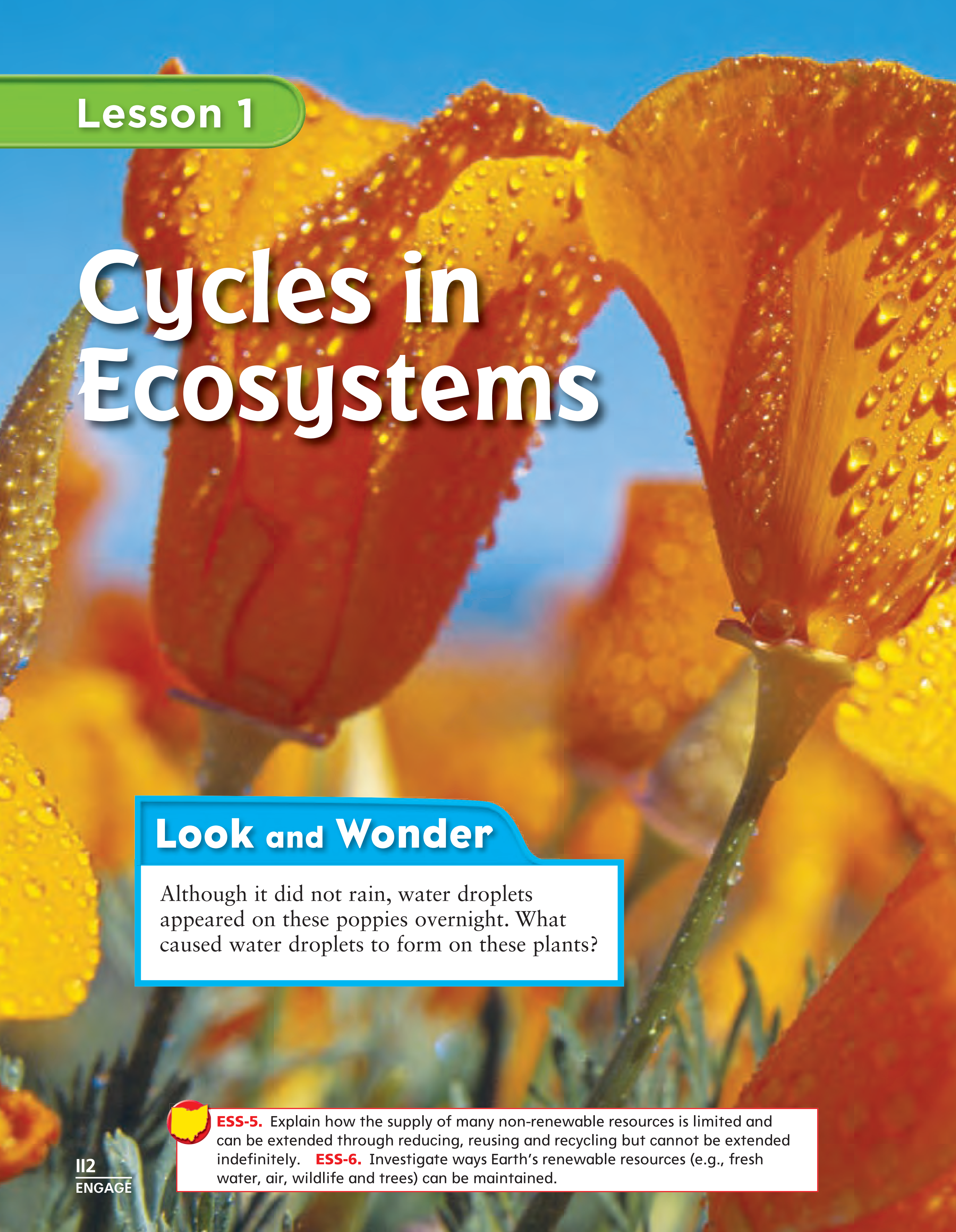


estuary
the boundary where a river feeds into an ocean (p. 156)

More Vocabulary

evaporation, p. 114
condensation, p. 114
precipitation, p. 114
watershed, p. 114
runoff, p. 114
groundwater, p. 114
carbon cycle, p. 116
nitrogen cycle, p. 118
compost, p. 120
extinct species, p. 128
threatened species, p. 129
primary succession, p. 130
pioneer community, p. 130
secondary succession, p. 132
biome, p. 138
desert, p. 139
tundra, p. 140
taiga, p. 141
tropical rain forest, p. 142
temperate rain forest, p. 142
deciduous forest, p. 143
grassland, p. 144
plankton, p. 150
nekton, p. 150
benthos, p. 150
intertidal zone, p. 154

LS-B. Analyze plant and animal structures and functions needed for survival....
LS-C. Compare changes in an organism's ecosystem/habitat that affect its survival.



Lesson 1

Cycles in Ecosystems

Look and Wonder

Although it did not rain, water droplets appeared on these poppies overnight. What caused water droplets to form on these plants?

ESS-5. Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely. **ESS-6.** Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained.

Explore

Inquiry Activity

How do water droplets form?

Form a Hypothesis

Water droplets occur when water changes from a gas to a liquid. Does temperature affect water droplet formation on an object? Write your answer as a hypothesis in the form "If the temperature of a glass is decreased, then . . ."

Test Your Hypothesis

1. Fill one glass completely with ice. In a separate glass, add a few drops of food coloring to some cold water and stir. Then pour the water into the glass that is full of ice.
2. Fill an empty glass with room-temperature water. Add a few drops of food coloring to the water and stir. Be sure to use the same amount of food coloring and water in each glass.
3. **Experiment** Sprinkle salt onto each saucer. Then put one glass on each saucer. Allow the glasses to sit for 30 minutes.
4. **Observe** What do you see on the sides of each glass?

Draw Conclusions

5. What does the color of the droplets indicate about where the water droplets came from?
6. **Use Variables** What were the independent and dependent variables in this experiment? Which variables were controlled?
7. **Infer** Why do you think water droplets formed where they did?

Explore More

What happened to the salt under the glass with water droplets? Plan and carry out an experiment that shows where the salt is.

Materials

- 2 glasses
- ice
- food coloring
- water
- spoon
- salt
- 2 saucers

Step 1

Step 3

SI-1. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others....

Read and Learn

Main Idea ESS-5, ESS-6

The important chemicals for life—water, carbon, nitrogen, and oxygen—are used and reused as they flow through ecosystems.

Vocabulary

water cycle, p. 114
evaporation, p. 114
condensation, p. 114
precipitation, p. 114
watershed, p. 114
runoff, p. 114
groundwater, p. 114
carbon cycle, p. 116
nitrogen cycle, p. 118
compost, p. 120

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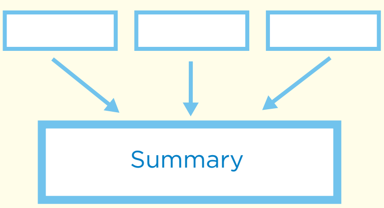
Reading Skill

Summarize



What is the water cycle?

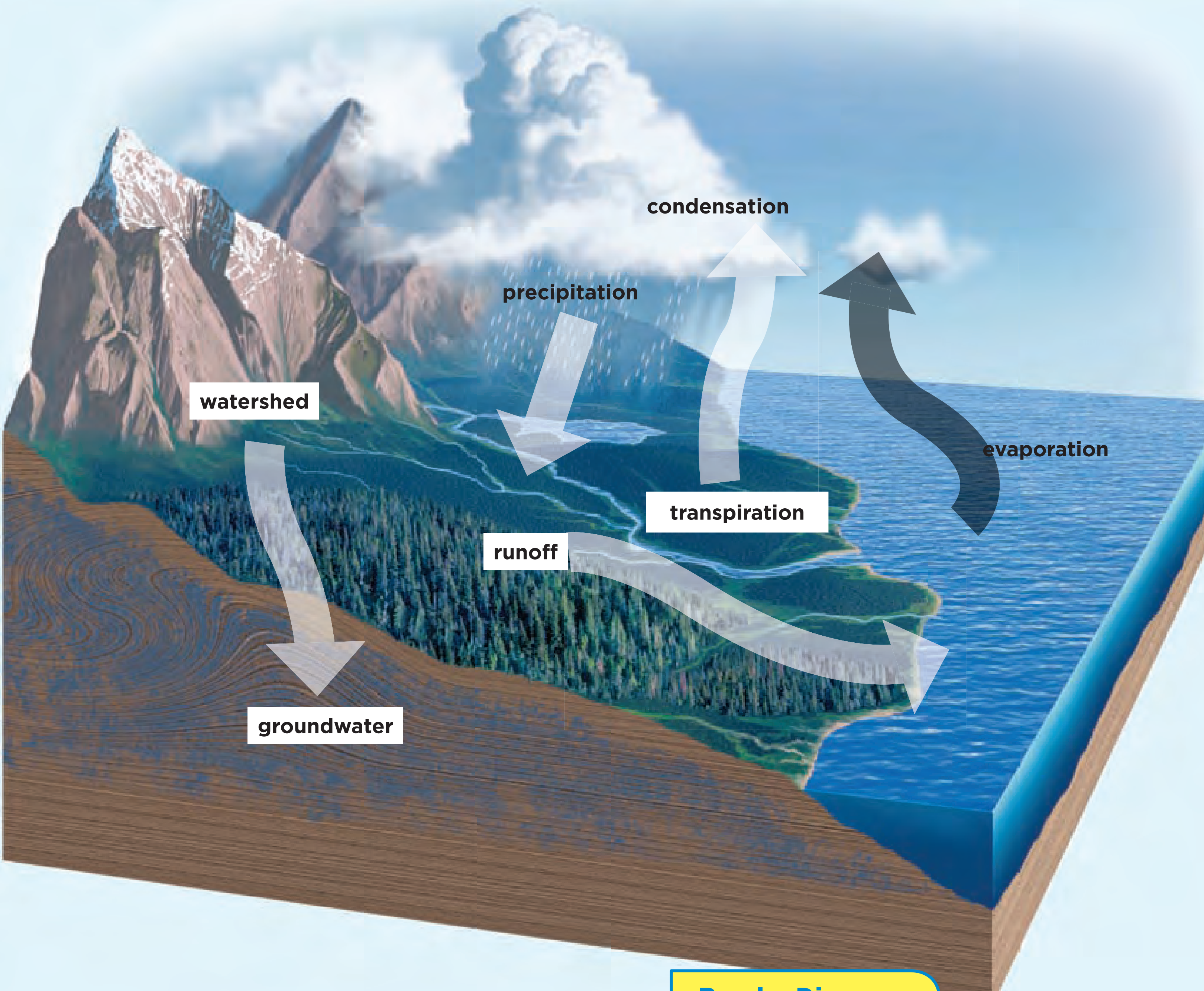
Water in your environment can seem to change every day. One day it is raining and the next day it is dry as a desert. Where did all the water go? All water on Earth is *recycled*, or reused, constantly. This continuous movement of water between Earth's surface and the air, changing from liquid to gas to liquid, is the **water cycle**.

The water cycle is driven by the Sun's energy. Water in oceans, seas, lakes, ponds, and streams absorbs the Sun's heat. The heat helps speed the evaporation (i•vap•uh•RAY•shuhn) of the water. **Evaporation** is the changing of a liquid into a gas. The evaporated water rises into the *atmosphere* and cools. As it cools, it condenses into water droplets. **Condensation** (kon•den•SAY•shuhn) is the changing of a gas into a liquid. The water droplets gather with dust particles and form clouds. In time, the condensed water may become too heavy and drop out of the clouds as precipitation (pri•sip•i•TAY•shuhn). **Precipitation** is any form of water that falls from the atmosphere and reaches the ground, such as rain, sleet, snow, or hail.

The water cycle continues as precipitation falls back to the surface of Earth. Some of the water that falls as precipitation collects on land and flows downhill. A **watershed** is an area from which water is drained. Precipitation that flows across the land's surface and is not absorbed will flow into rivers, lakes, and streams as **runoff**. Most of the water will flow from rivers to the ocean. Some of the water will settle underground and become **groundwater**. Groundwater is stored in tiny holes, or pores, in soil and rocks.

Plants and animals also play a role in the water cycle. Plant roots soak up groundwater. Excess water evaporates out of the plant's leaves through transpiration. Animals also take in water and return some water to the atmosphere through respiration.

Water Cycle



Quick Check

Summarize What are the stages of the water cycle?

Critical Thinking Which would you expect to have a higher rate of evaporation – hot water or cold water? Why do you think so?

Read a Diagram

During which steps of the water cycle does water exist as a gas?

Clue: If water is not in a liquid or solid state, then it must be a gas.

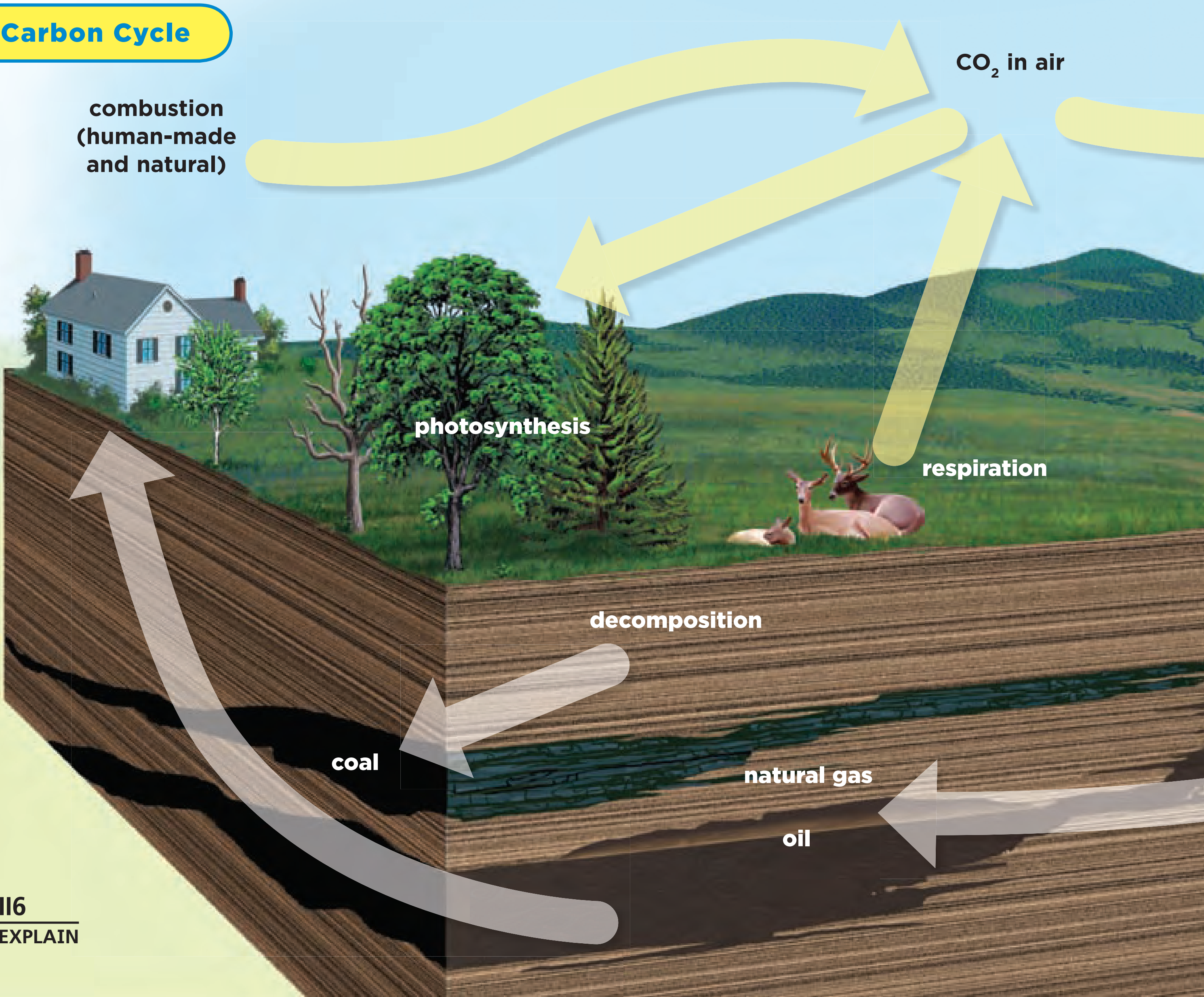
LOG ON *Science in Motion* Watch how the water cycle works at www.macmillanmh.com

What is the carbon cycle?

Carbon is an important element in every living thing. How important is carbon? About 18 percent of your body is carbon. Carbon in the atmosphere is plentiful as CO_2, or carbon dioxide gas. It is also present in rocks, such as limestone. However, your body cannot use these sources of carbon directly.

How do people and other living things get the carbon they need? The continuous exchange of carbon among living things is the **carbon cycle**. Plants and other photosynthetic organisms take in carbon dioxide from the air. They combine it with water to make sugars and other chemicals, such as fats and proteins. These carbon-rich chemicals are then eaten directly by herbivores or omnivores and indirectly by carnivores.

Carbon Cycle



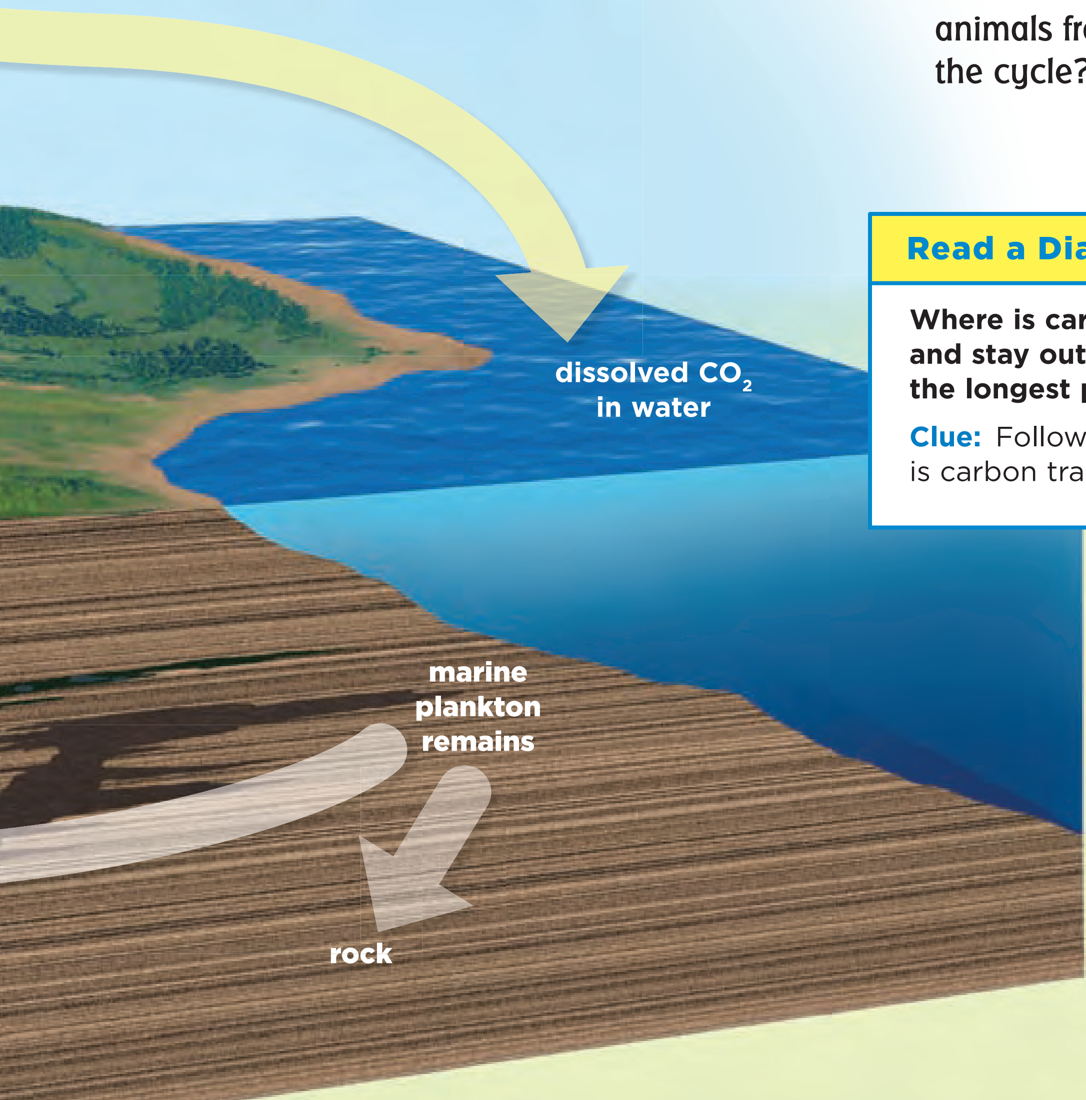
Both animals and plants burn carbon-rich foods for fuel during cellular respiration. The end product of cellular respiration, carbon dioxide, then returns to the atmosphere. Sometimes the carbon may not be recycled for a long period of time. The wood of a tree, for example, contains a large amount of carbon that will remain stored in a tree for as long as it lives. Carbon stored in plants and other organisms cannot be reused until they are eaten or decompose.

Decomposers, such as bacteria and insects, break down dead or decaying plants and animals. This breakdown releases some additional carbon dioxide to the atmosphere. Other decaying plant and animal materials go deep into the ground. Over a long period of time and under extreme pressure from the layers of Earth above, it may get turned into fossil fuels, such as oil, natural gas, and coal. The carbon in these materials is released back into the atmosphere as carbon dioxide when people burn them for energy.

Quick Check

Summarize Write a brief summary of the carbon cycle.

Critical Thinking Would removing animals from the carbon cycle stop the cycle? Explain.



Read a Diagram

Where is carbon likely to get trapped and stay out of the atmosphere for the longest period of time?

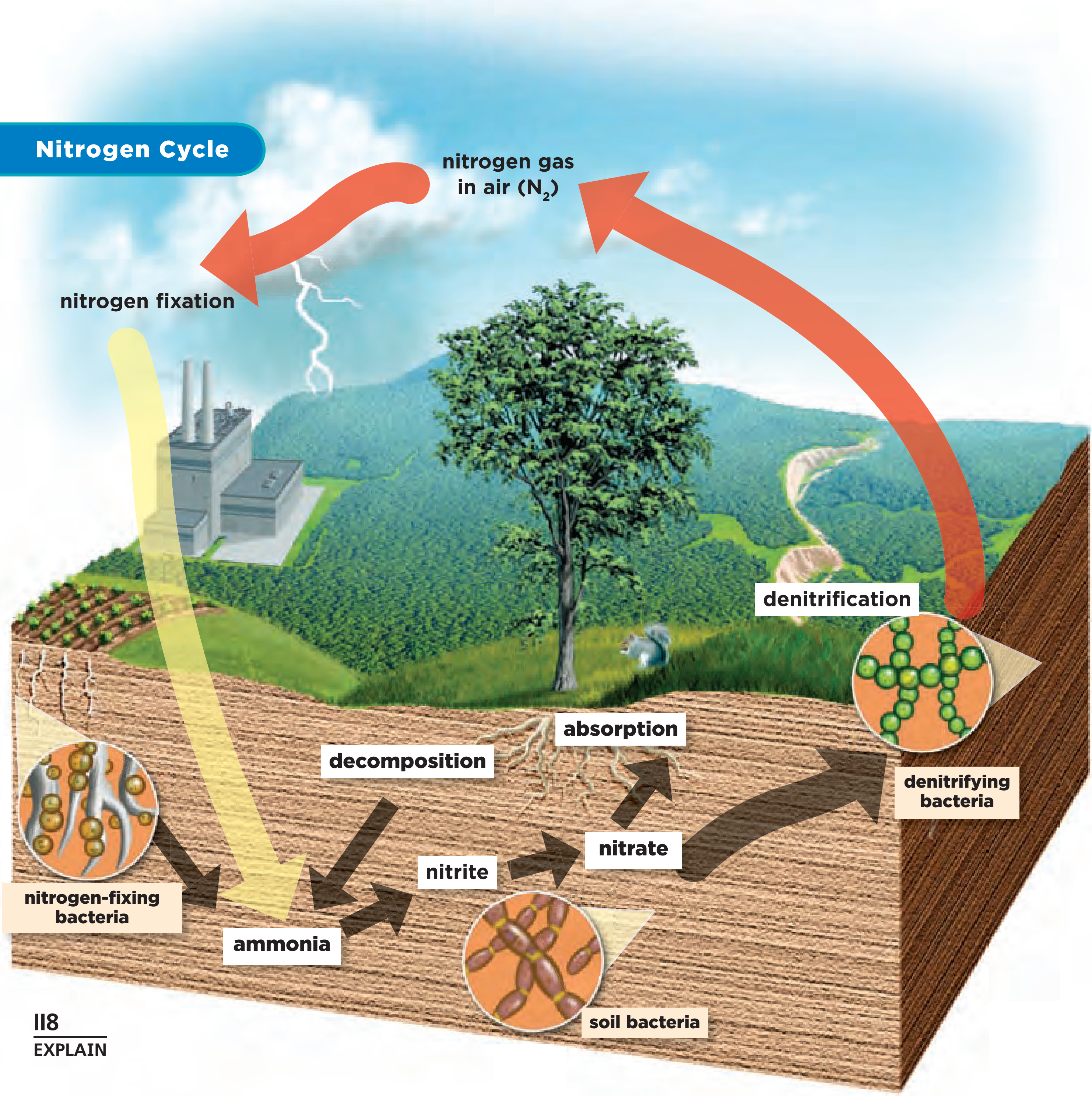
Clue: Follow each pathway. Where is carbon trapped for a long time?

What is the nitrogen cycle?

Nitrogen (NYE•truh•juhn) is another key element for all organisms. The proteins that make up the muscles, skin, nerves, bones, blood, and enzymes in your body contain nitrogen. Nitrogen is also a part of the genetic material in all cells.

Where do cells get nitrogen? The air is 78 percent nitrogen gas. But few living things can use nitrogen gas. Nitrogen must first be changed, or fixed into a form organisms can use. The continuous trapping of nitrogen gas into compounds in the soil and its return to the air is called the **nitrogen cycle**.

Nitrogen Cycle



Nitrogen can be fixed by volcanic activity, lightning, and combustion. It can also be fixed by certain bacteria. Different types of bacteria play important roles in the nitrogen cycle. *Nitrogen-fixing bacteria* live on the root nodules of *legumes* (LEG•yewmz), such as bean, pea, and peanut plants. These bacteria turn nitrogen gas into *ammonia* (uh•MOHN•yuh), a nitrogen-containing substance.

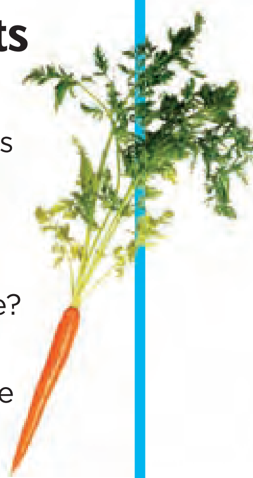
The ammonia is then changed into a form of nitrogen that can be used by plants. This is accomplished by two groups of bacteria that live in the soil. The first type of soil bacteria turn ammonia into a nitrogen-containing substance called *nitrite* (NYE•trite) A second type of soil bacteria turn the nitrite into *nitrate* (NYE•trayt), another substance that contains nitrogen.

As plants grow, they absorb nitrate from the soil. They use the nitrogen in nitrates to make proteins. Animals take in nitrogen when they eat plants or other plant-eating animals. Animals use the nitrogen to form compounds and then excrete substances containing nitrogen in their waste.

The nitrogen in animal waste and decayed plant and animal material returns to the soil. Decomposers then convert the nitrogen from these materials back into ammonia. How does nitrogen return to the atmosphere as a gas? *Denitrifying bacteria* (dee•NYE•truh•fye•ing) in the soil change some of the nitrates back into nitrogen gas and the cycle continues.

Quick Lab

Observe Legume Roots



1. Examine a legume plant. Clean off all dirt on the roots of the plant.
2. **Observe** Use a hand lens or microscope to examine the roots. What did you observe?
3. Use a hand lens to examine a carrot root. Compare these roots to the legume roots.
4. How are the legume roots similar to the other roots you observed? How are they different?
5. **Infer** Why are root nodules important in the nitrogen cycle?

Quick Check

Summarize Write a summary of the nitrogen cycle.

Critical Thinking Why do humans need soil bacteria?

How is matter recycled?

Just as nature recycles water, carbon, and nitrogen, we need to conserve and recycle natural resources. Some natural resources are *renewable resources*. For example, trees, which are used for wood and paper, can be replanted. Other natural resources, such as oil and metals, are *nonrenewable resources*. These resources cannot be replaced in the environment once they are used. We can reduce our uses of natural resources by recycling them. We can make new objects or materials out of old materials.

Repeated planting sometimes uses up nitrogen in the soil. To replenish worn-out soil, farmers and gardeners have three choices. They can add nitrogen by planting legumes, using nitrogen-rich fertilizers, or creating compost. **Compost** (KOM•pohst) is a mixture of dead organic material that can be used as fertilizer. Composting is a way to recycle nitrogen. It also reduces the amount of trash we make.

How does compost enrich soil? Decomposers break down decaying plant and animal materials in the compost. One product of the decomposition is the nitrogen-containing substance ammonia. Soil bacteria change ammonia into nitrites and nitrates. Compost replenishes the nitrogen used by plants as they grow.

Quick Check

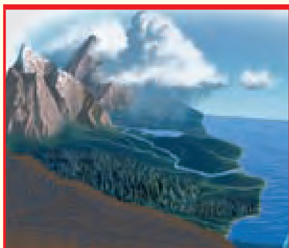
Summarize Write a summary of how compost replenishes soil.

Critical Thinking Compost is useful but it often has a bad smell. What might give compost its smell?

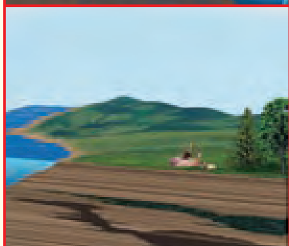
Decomposers, like these bark beetles, break down decaying materials in the compost.

Lesson Review

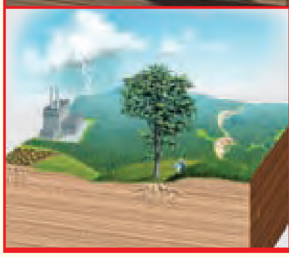
Visual Summary



The **water cycle** moves water from its liquid form to its gas form through evaporation, condensation, and precipitation.



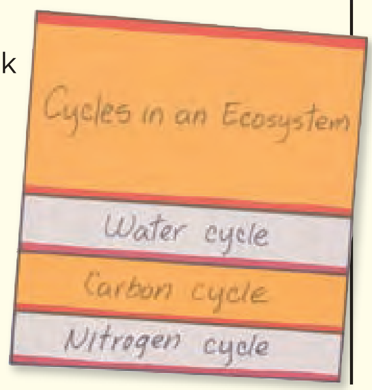
The **carbon cycle** moves carbon in an ecosystem by respiration, photosynthesis, and decomposition.



The **nitrogen cycle** moves nitrogen from a gas to living things and back to a gas again. Composting is a way to recycle nitrogen.

Make a FOLDABLES™ Study Guide

Make a Layered-Look Book. Use the titles shown. Tell about the cycle named on each layer.

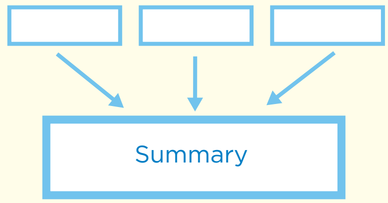


Think, Talk, and Write

1. **Main Idea** What roles do plants play in the water, carbon, and nitrogen cycles?

2. **Vocabulary** A gas turns into a liquid during ________.

3. **Summarize** Write a summary of things that get recycled in an ecosystem.



4. **Critical Thinking** A farmer's crops are less healthy than in previous years. What can the farmer do to get better crops?

5. **Test Prep** **Which of the following processes release carbon dioxide?**
   - **A** photosynthesis, respiration
   - **B** photosynthesis, burning oil
   - **C** respiration, decomposition
   - **D** photosynthesis, decomposition

6. **Test Prep** **Animals add nitrogen into the ecosystem when they**
   - **A** eat plants.
   - **B** excrete waste.
   - **C** breathe.
   - **D** burn sugars.

Writing Link

The Three Sisters

Research the "three sisters" planted by many Native American groups. These plants included corn, beans, and squash. Write a report about how this method of farming replenished soil naturally.

Art Link

Cycle Poster

Make a poster of one of the cycles described in this lesson. Use your imagination to illustrate the steps in the cycle.

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Be a Scientist

Materials

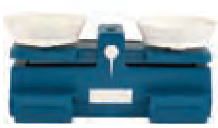
spray bottle

4 plants in pots

water

4 plastic bags

string



equal pan balance

light source

Structured Inquiry

How does water move in and out of plants?

Form a Hypothesis

Plants need water to survive. If a plant loses too much water it will wilt and eventually die. Plants lose water through transpiration, the evaporation of water from the leaves. As water evaporates, it pulls more water from the roots up through the xylem tissue. How does the amount of light a plant receives affect its transpiration rate? Write your answer as a hypothesis in the form "If the amount of light a plant receives is increased, then..."

Test Your Hypothesis

1. Use the spray bottle to water the four plants. Be sure to give all of the plants the same amount of water.
2. Place each of the plants' pots in a plastic bag and use the string to tie the bag securely around the stem of each plant.
3. **Measure** Weigh all four plants using the equal pan balance. Record their masses.
4. **Use Variables** Place two of the plants under the light source. Place the other two plants away from the light source.
5. **Record Data** After one hour weigh all four plants again. Record their masses and any changes you notice.
6. Return the plants to their original locations.
7. Repeat steps 5 and 6 after 24 hours and 48 hours. Record the masses and any observations.

Draw Conclusions

1. What are the independent variables and dependent variables in the investigation? Which variables are controlled?
2. **Interpret Data** Did the mass of any of the plants change? Did your data show a connection between the transpiration rates and the amount of light?
3. Did your results support your hypothesis? Why or why not?

Guided Inquiry

How is the water loss in plants affected by changes in the environment?

Form a Hypothesis

You have seen how light affects the rate of transpiration. What other variables affect the rate of transpiration? How about wind? Write your answer as a hypothesis in the form "If wind increases, then the rate of transpiration . . ."

Test Your Hypothesis

Design a plan to test your hypothesis. Then write out the materials, resources, and steps you need. Record your results and observations as you follow your plan.

Draw Conclusions

Did your results support your hypothesis? Why or why not? Present your results to your classmates.

Open Inquiry

What other conditions in the environment can affect the rate of transpiration? Come up with a question to investigate. For example, how does humidity affect the rate of transpiration? Design an experiment to answer your question. Your experiment must be organized to test only one variable, or item being changed.

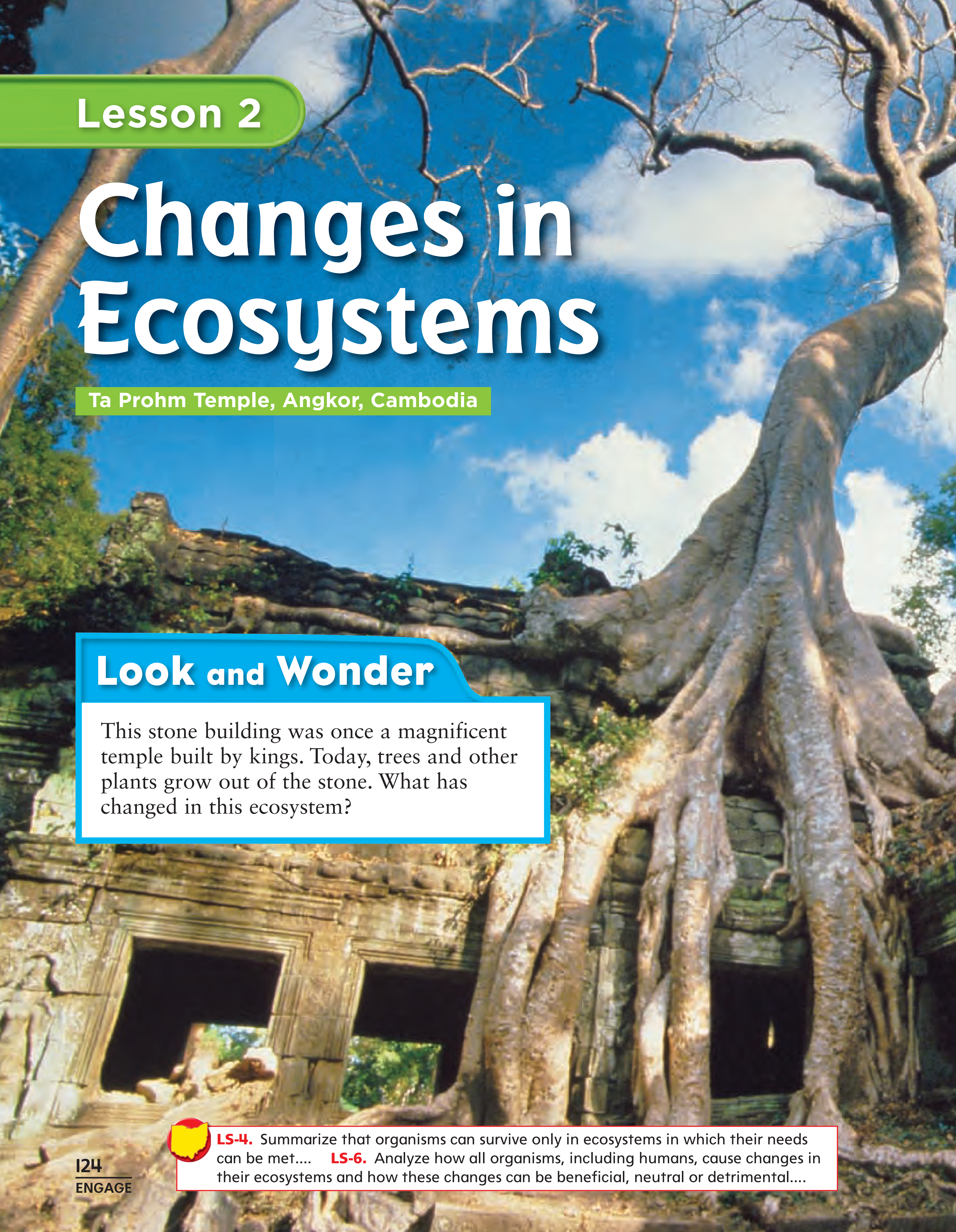
Remember to follow the steps of the scientific process.

Ask a Question
↓
Form a Hypothesis
↓
Test Your Hypothesis
↓
Draw Conclusions

SI-4. Identify one or two variables in a simple experiment.

Lesson 2

Changes in Ecosystems



Ta Prohm Temple, Angkor, Cambodia

Look and Wonder

This stone building was once a magnificent temple built by kings. Today, trees and other plants grow out of the stone. What has changed in this ecosystem?

LS-4. Summarize that organisms can survive only in ecosystems in which their needs can be met.... **LS-6.** Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental....

Explore

Inquiry Activity

What happens when ecosystems change?

Materials

- ruler

Make a Prediction

Each year a tree grows wider as a new layer of xylem forms an annual ring. Scientists often use tree rings to study changes in ecosystems. How did this tree's ecosystem change? Make a prediction.

Test Your Prediction

1. Count the number of tree rings on the tree-ring diagram. How old was this tree?
2. **Measure** Use the ruler to measure the width of each tree ring. Record your measurements.
3. **Interpret Data** Use the information provided in the chart to interpret your tree-ring data.

Step 1

Draw Conclusions

4. Which years had the thickest rings? The narrowest rings?
5. **Predict** What most likely happened to the tree in its eighth year?
6. **Infer** What types of ecosystem changes did this tree experience? How can you tell?

Step 3

Tree-Ring Data

Type of Ring	Event Affecting Tree
thick ring	good growing conditions: warm, plenty of precipitation
narrow ring	poor growing conditions: cold, drought
dark scars	fire
long, light scars	insect infestation or disease

Explore More

Have there been any fires, droughts, or floods in your community? Investigate using newspaper or Internet sources. Which parts of the environment have recovered better than others? Why?

SI-3. Use evidence and observations to explain and communicate the results of investigations. **SWK-4.** Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer....

Read and Learn

Main Idea LS-4, LS-6

Ecosystems can change naturally over time into a series of different living communities.

Vocabulary

- **extinct species**, p. 128
- **endangered species**, p. 129
- **threatened species**, p. 129
- **succession**, p. 130
- **primary succession**, p. 130
- **pioneer species**, p. 130
- **pioneer community**, p. 130
- **climax community**, p. 131
- **secondary succession**, p. 132

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Reading Skill

Cause and Effect

Cause → Effect
→
→
→
→

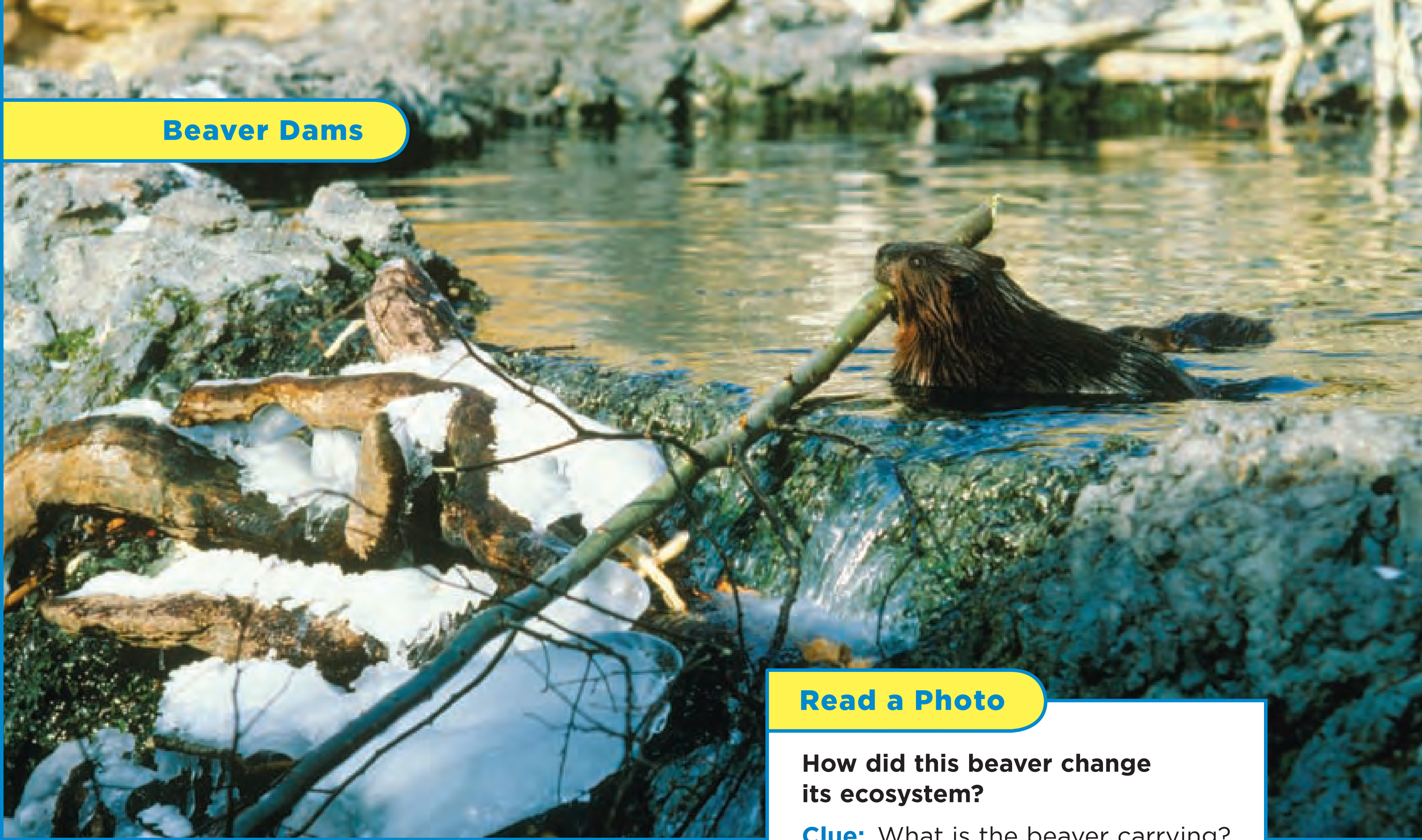
How can ecosystems change?

Most ecosystems are constantly changing. For example, an oak tree dies in a forest. Soon a new tree grows. Only this time the tree is a hickory, not an oak. Sometimes the balance of an ecosystem itself can change. Ecosystem changes can be caused by natural events or by human actions.

Natural events include natural disasters and changes caused by organisms. Earthquakes, floods, storms, volcanoes, droughts, and other natural disasters can drastically alter ecosystems. People can try to repair the damage from these disasters, but there is little or nothing anyone can do to prevent such events from occurring.

The second type of natural change is caused by organisms. Beavers, for example, build dams. They use mud, stones, and trees to create an artificial pond. Their dams can cause flooding, but the dams can also be beneficial by creating new habitats and food supplies. Large animals, like elephants, can cause changes by trampling trees and seedlings.

▼ A volcanic eruption causes lava to flow in Hawaii.



Beaver Dams

Read a Photo

How did this beaver change its ecosystem?

Clue: What is the beaver carrying?

Very small organisms can also change their ecosystems. Grasshoppers can sometimes rapidly reproduce and consume all of the plants in an area. Earthworms burrowing in the soil soften the ground, adding air and providing drainage. Aquatic organisms like coral change their ecosystem by building reefs, creating new habitats.

Humans cause ecosystem changes by shaping the environment to meet their needs. These changes often destroy or alter habitats and affect the organisms that live in those habitats. Trees are planted in a park. Forests get cut down to build homes. Pesticides can harm organisms for which they were not intended. Pollution can damage water, soil,and air quality.

FACT All ecosystems are in a constant state of change.

Humans also change ecosystems by introducing new species or removing species. Introduced plant and animal species can threaten native species. Without natural predators, introduced species can threaten or even kill off local species. For example, zebra mussels were introduced into the Great Lakes. They began to reproduce rapidly and reduced the number of local mussel species. This drastically altered the food webs in the lakes.

Quick Check

Cause and Effect How do humans affect ecosystems?

Critical Thinking Can a natural ecosystem change cause more damage than a change caused by people? Give an example.

Quick Lab

Extinction Game

Wild Atlantic sturgeon are endangered because of overfishing and pollution.

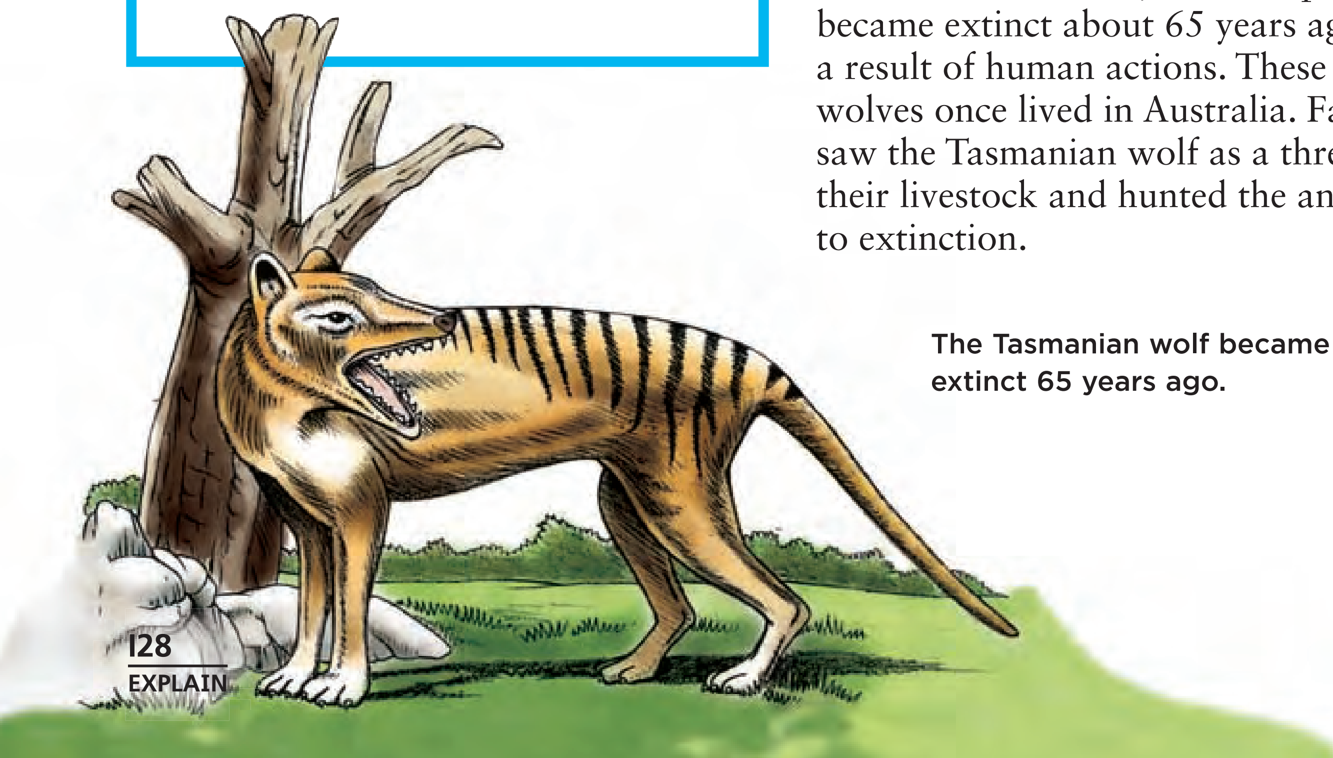
1. Count out 20 pennies to represent a school of sturgeon.
2. **Make a Model** Tape a piece of construction paper to your desk. Divide it into 6 sections. Sections 1 and 3 represent death. Sections 2, 4, and 6 represent life. Section 5 represents a new offspring.
3. Toss all 20 pennies onto the paper.
4. Remove any pennies that land in sections 1 and 3. Add a penny for any pennies that land in section 5. Record the new number of sturgeon in a data table.
5. Play the game for 20 rounds (years). After each round, record the number of sturgeon.
6. **Communicate** Did your school of sturgeon become extinct? If so, how many years did it take?

What happens when ecosystems change?

Some ecosystem changes are permanent. These changes affect the organisms within that ecosystem. Organisms must respond to changes in order to survive. Some respond by migrating to a place where they are more likely to survive. Recall that other organisms respond by adapting to the changes.

What happens when a species cannot respond to ecosystem changes? The individual members of that species begin to die. When the last member of a species dies, the species becomes an **extinct species** (ek•STINGT). Once a species becomes extinct it no longer exists on Earth. Some extinct organisms include all species of dinosaurs, the saber-toothed cat, and the dodo bird.

Thousands of species are expected to become extinct each year. Pollution, global warming, habitat destruction, and hunting all threaten organisms. The Tasmanian wolf, for example, became extinct about 65 years ago as a result of human actions. These wolves once lived in Australia. Farmers saw the Tasmanian wolf as a threat to their livestock and hunted the animal to extinction.



The Tasmanian wolf became extinct 65 years ago.

When a species is in danger of becoming extinct, it is called an **endangered species** (en•DAYN•juhrd). Endangered species today include the pitcher plant, the hawksbill sea turtle, the Karner blue butterfly, the flying squirrel, and many others. In some cases, such as the right whale, only a few hundred of these endangered organisms still exist.

Species with low numbers that could become endangered are called **threatened species**. The gray wolf, the manatee, and many others are threatened species. Each endangered and threatened organism is at risk for different reasons. Pollution, over-hunting or over-collecting, disease, and competition from newly introduced organisms can all cause a species to die out. The biggest threat to the survival of most organisms is habitat loss.

Quick Check

Cause and Effect What can cause an organism to become threatened or endangered?

Critical Thinking Why are at least two members of an endangered mammal species needed for that species to survive?

pitcher plant
habitat: pine forests, bogs, and stream banks in Alabama, Georgia, and North Carolina
status: endangered
main threats: overcollecting by humans, habitat loss

Karner blue butterfly
habitat: dry, sandy areas and open woods in Indiana, Wisconsin, Michigan, Minnesota, New York, and New Hampshire
status: endangered
main threats: habitat loss, over-collecting by humans

flying squirrel
habitat: coniferous and hardwood forests in Virginia and West Virginia
status: endangered
main threat: habitat loss

hawksbill sea turtle
habitat: coral reefs and shallow coastal areas of Atlantic, Pacific, and Indian oceans; nests in Hawaii and Florida
status: endangered
main threats: hunting, loss of nesting habitats, water pollution

How do ecosystems come back?

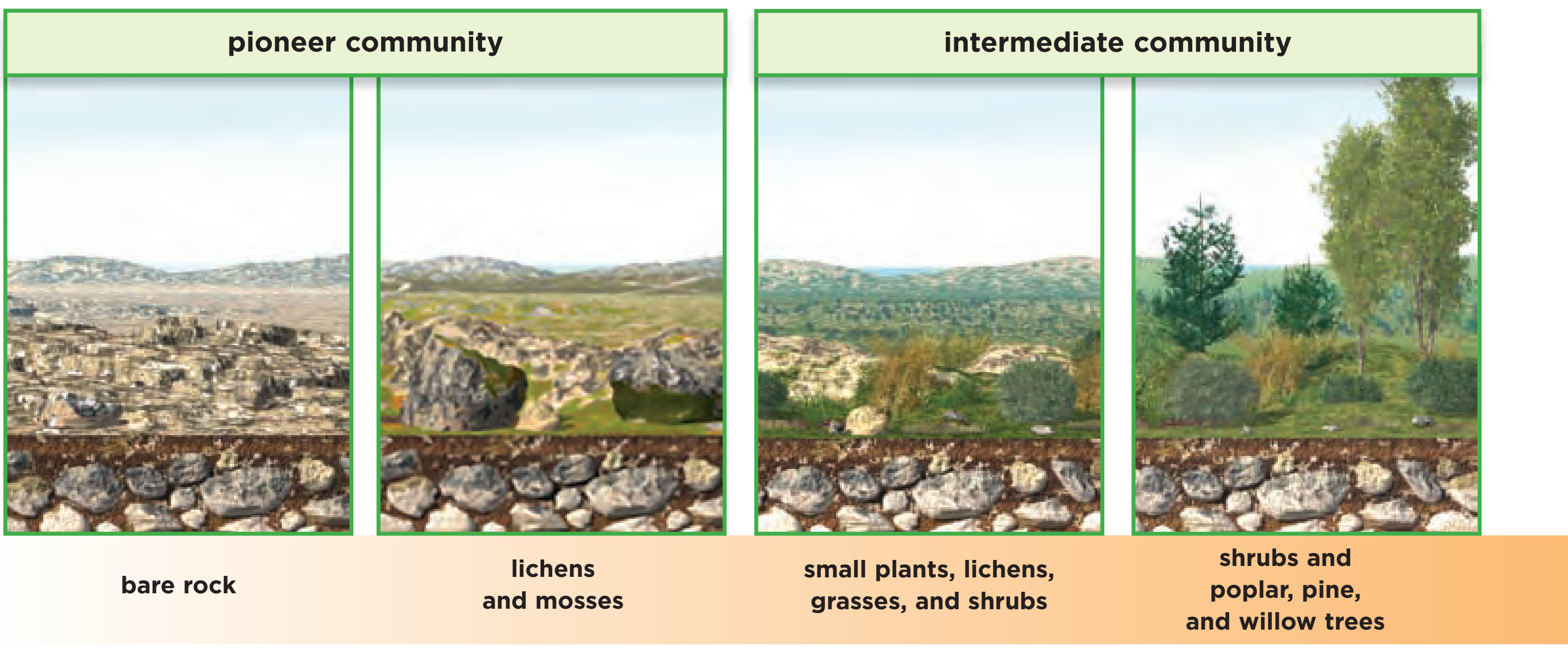
Over time, ecosystems can gradually change. The process of one ecosystem changing into a new and different ecosystem is called **succession** (suhk•SESH•uhn). During succession, an area is changed by a certain species that is then replaced by other species over time. **Primary succession** takes place in a community where few, if any, living things exist, or where earlier communities were wiped out.

Primary succession occurs in barren, lifeless areas that have little or no soil. At first, the ecosystem is little more than solid, bare rock. Particles of dust and seeds blow in from neighboring environments. Lichens and plants, such as mosses, begin growing on the rock. These first organisms are **pioneer species**, the first species living in an otherwise lifeless area. They tend to be hardy organisms with short life cycles. Along with microorganisms, the pioneer species make up the **pioneer community**, the first living community in an otherwise lifeless area.

As they grow, lichens and mosses break down the rock and form soil. When lichens and mosses die, bacteria and other decomposers break them down as well. The decaying material adds nutrients to the soil. The soil can now support the growth of larger plants. In addition to plants, insects, spiders, and other small organisms begin to colonize. Decaying material from these organisms creates thicker, richer soil.

Grasses, ferns, and shrubs begin to sprout in the richer soil. Changes

Stages of Primary Succession



in the plant species cause changes in the animal species of the community. Flowering plants attract pollinators to the area, such as insects, birds, and small mammals. These animals attract larger predators to the community. After many years, this community may become a grassland or prairie.

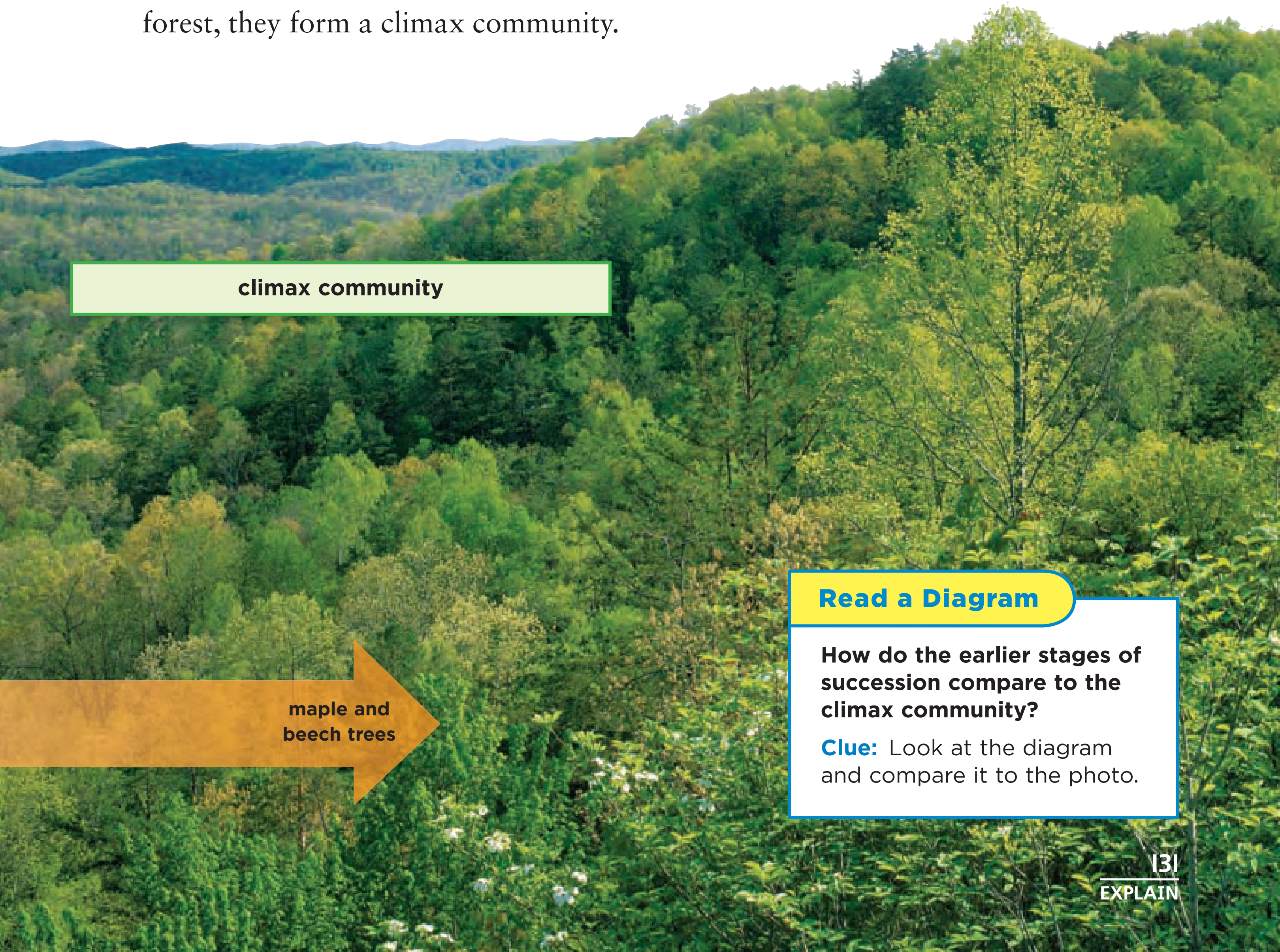
If there is enough moisture, small trees, such as poplars and grey birch, begin to grow. The leaves of these fast-growing trees block the Sun. This enables seedlings that need less sun to grow. Soon, pine trees that do not require as much sun start filling in the gaps. Eventually, the pine trees give way to the hardwoods—maple and beech trees. As these trees fill in the forest, they form a climax community.

A **climax community** is the final stage of succession. Unless the community is disturbed by some natural disaster or human activity, the climax community will remain.

Quick Check

Cause and Effect During succession, what causes larger plants to grow in place of mosses and lichens?

Critical Thinking A prairie is becoming a forest. Then a fire burns down the grassland. How does the fire affect the process of succession?



Read a Diagram

How do the earlier stages of succession compare to the climax community?

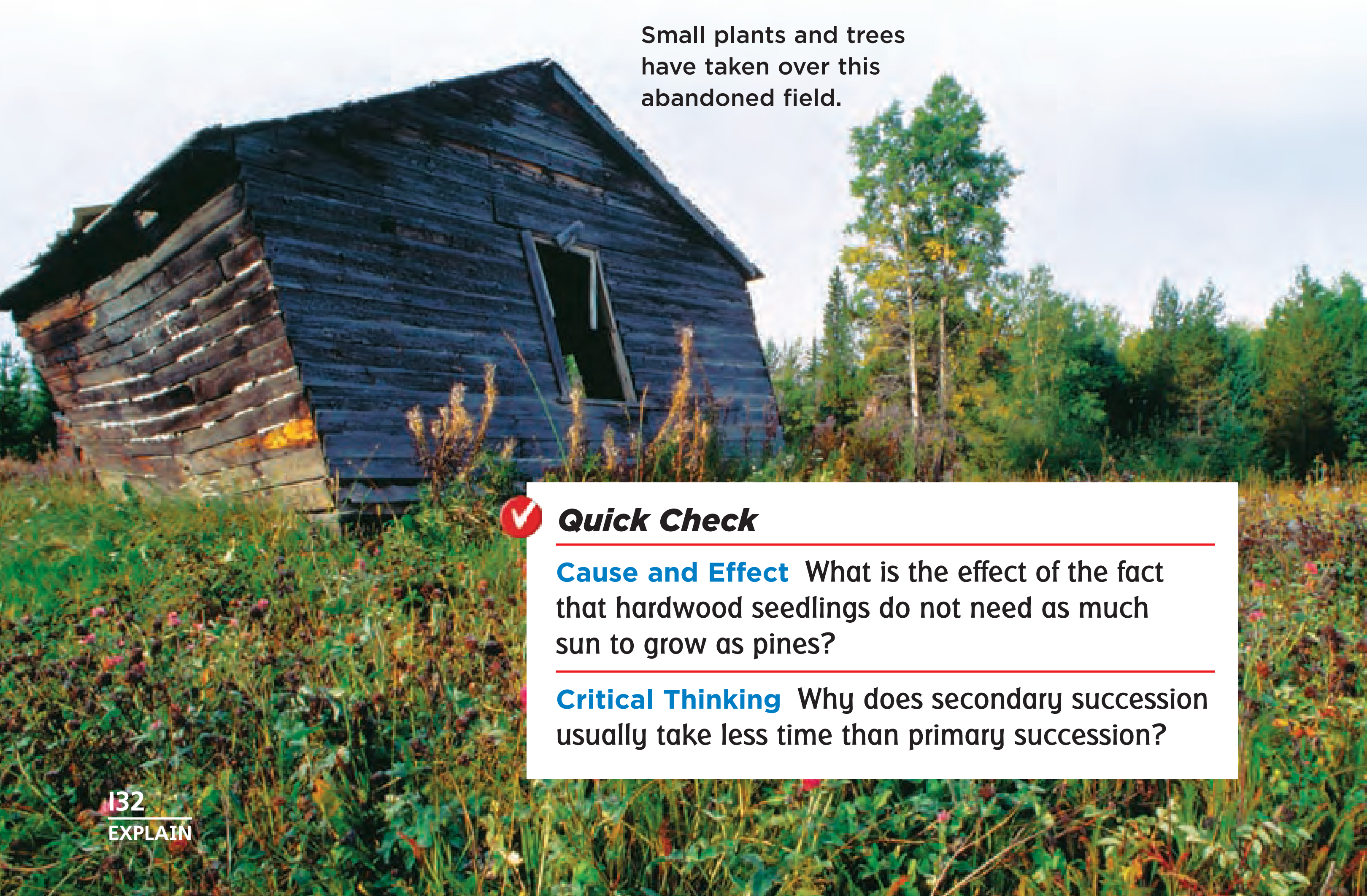
Clue: Look at the diagram and compare it to the photo.

What is secondary succession?

Secondary succession is the beginning of a new community where a community had already existed. Secondary succession can take place in a forest after a fire or logging has occurred. It can also take place in an abandoned farm field.

Secondary succession occurs faster than primary succession. The soil has already formed and some organisms might be present. For example, when a farm is abandoned, weeds and crabgrass begin to grow in the plowed field. After a couple of years, larger shrubs take over, as well as tree seedlings. For the next several years, the shrubs and seedlings compete for light, space, and resources. The tree seedlings finally win out and eventually the farm will become a pine forest.

From this point, the secondary succession process is similar to primary succession. After many years, the pine forest has a lower layer full of small hardwood seedlings. These seedlings take 40 or 50 years to take over and form the climax community.



Small plants and trees have taken over this abandoned field.

Quick Check

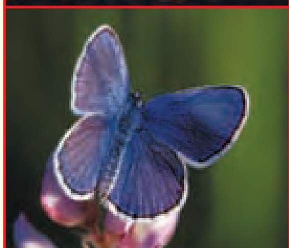
Cause and Effect What is the effect of the fact that hardwood seedlings do not need as much sun to grow as pines?

Critical Thinking Why does secondary succession usually take less time than primary succession?

Lesson Review

Visual Summary

Natural events and organisms can cause **ecosystem changes**. Human activity can also change ecosystems.

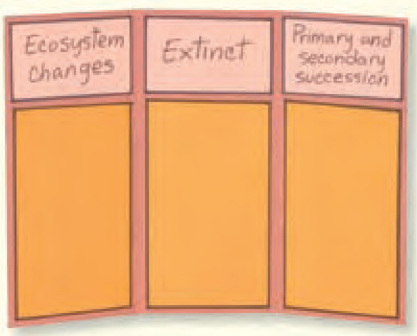


A variety of different things can cause organisms to become **extinct**. Most species become extinct from loss of habitat

Primary succession turns a barren, lifeless area into a living community. **Secondary succession** changes one living community into another.

Make a FOLDABLES™ Study Guide

Make a Trifold Book. Use the titles shown. Tell what you learned about each topic on the folds.



Think, Talk, and Write

1. **Main Idea** What can cause ecosystems to change?

2. **Vocabulary** One of the first organisms to live in an area is a(n) ________.

3. **Cause and Effect** Tell the causes and effects that result in a barren, lifeless ecosystem becoming a forest.

Cause	→	Effect
	→	
	→	
	→	
	→	

4. **Critical Thinking** How does primary succession affect food chains and food webs in an ecosystem?

5. **Test Prep** **Which list gives the correct order of primary succession?**
   A lichens, grasses, shrubs, pine, maple
   B lichens, maple, grasses, shrubs, pine
   C grasses, lichens, shrubs, pine, maple
   D grasses, lichens, pine, shrubs, maple

6. **Test Prep** **Which of the following is a pioneer species?**
   A lichen
   B pine tree
   C owl
   D soil

Writing Link

Endangered Species

Research an endangered species. Explain why this species is endangered. Tell how we might be able to prevent this animal from becoming extinct.

Math Link

Soil Collection

Soil in an ecosystem collects at a rate of $\frac{1}{6}$ of a centimeter every 10 years. At this rate, how long will it take for 2 centimeters of soil to collect?

Focus on Skills

Inquiry Skill: Interpret Data

Ecosystem changes can affect organisms. Scientists estimate that once there were more than 500,000 bald eagles in America. But by the 1960s, there were less than 450 nesting pairs. What happened? Scientists discovered particles of an insecticide called DDT in the eagles' eggshells. The United States outlawed the use of DDT in 1972. Did that help bring eagles back from the edge of extinction? Scientists learned the answer to that question by collecting and **interpreting data**.

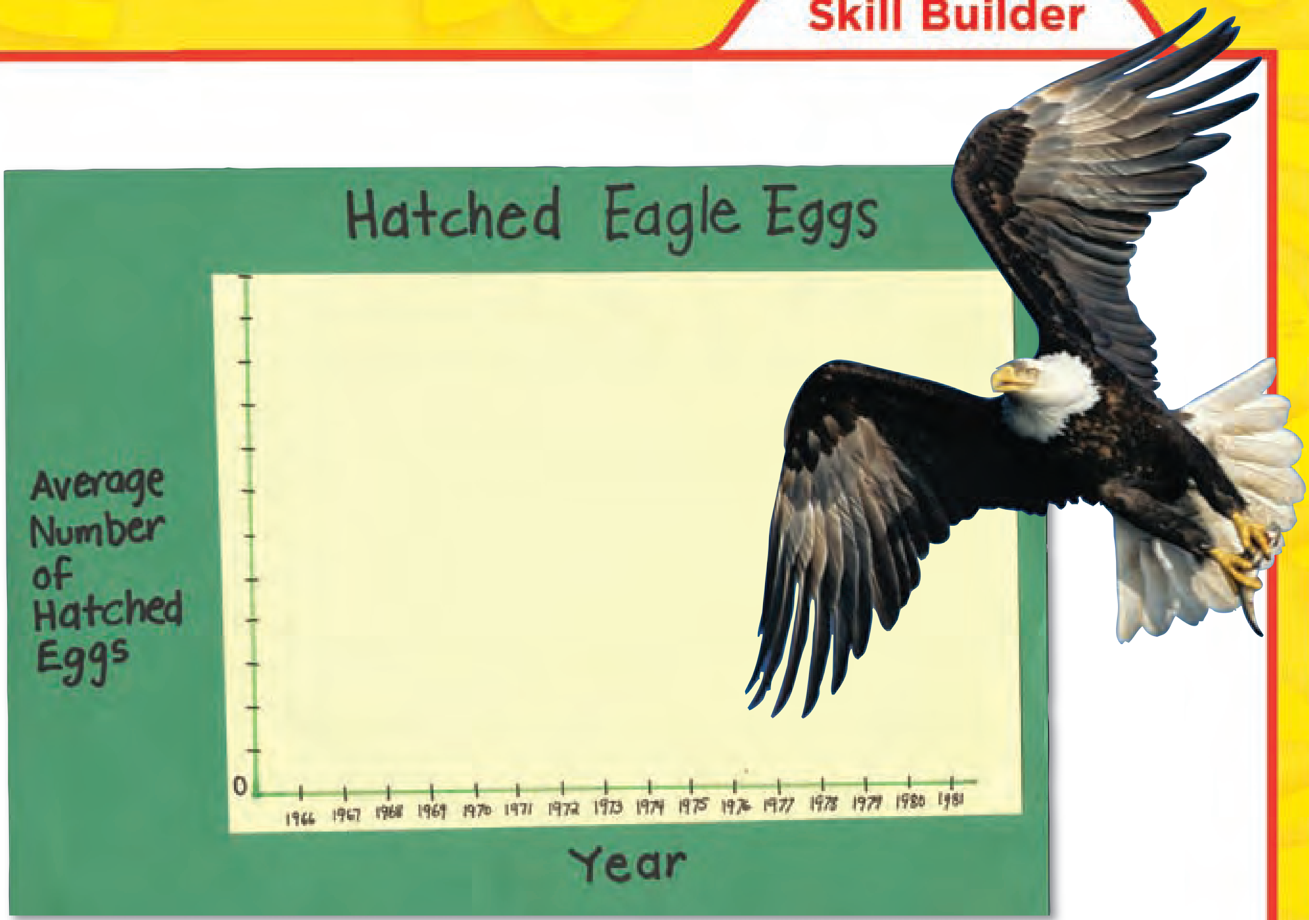
▶ Learn It

When you **interpret data**, you use information that has been gathered to answer questions or solve problems. It is much easier to interpret data that has been organized and placed on a table or graph. Tables and graphs allow you to quickly see similarities and differences in the data.

The table below shows data gathered about bald eagle eggs. It lists the average number of eggs that hatched in the wild during a 16-year period. It also lists the levels of pesticide found in the eggs during that time.

Bald Eagle–Hatching Data

Year	Average # Hatched	DDT in Eggs parts/million
1966	1.28	42
1967	.75	68
1968	.87	125
1969	.82	119
1970	.50	122
1971	.55	108
1972	.60	82
1973	.70	74
1974	.60	68
1975	.81	59
1976	.90	32
1977	.93	12
1978	.91	13
1979	.98	14
1980	1.02	13



▶ Try It

Study the table, then **interpret data** to answer these questions:

1. In which year did the amount of pesticide in eggshells begin to decline? Why?
2. Did the amount of pesticide continue in a steady decline?
3. Does the data supply evidence that insecticide in eggs and the numbers of young hatched are related?

▶ Apply It

1. Now use the data from the table to make two line graphs: one to show the average number of eggs that hatched and one to show the insecticide in the eggs. Do your graphs make it easier to **interpret data**? Why or why not?
2. Lay one graph carefully on top of the other so the years across the bottom line up. Hold the pages up to the light. How would this help someone understand the relationship between the eagle eggs that hatched and the amount of insecticide in the eggs?

SI-3. Use evidence and observations to explain and communicate the results of investigations.

Lesson 3

Biomes

Serengeti National Park, Tanzania, Africa

Look and Wonder

These gnu are grazing in an African grassland. Do the characteristics of an environment, such as soil, water, and temperature, affect the kinds of organisms that can live there?

LS-4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different organisms.

Explore

Inquiry Activity

How are soils different?

Make a Prediction

The nutrient content of soils can vary greatly. The amounts of nutrients in soils can influence the types of organisms that can live in certain places. Which type of soil has more nutrients? Make a prediction.

Test Your Prediction

1. ⚠ **Be Careful.** Wear your goggles and apron. Place a spoonful of sand in the plastic cup.
2. **Observe** Add hydrogen peroxide to the sand, drop by drop. Hydrogen peroxide is a chemical that bubbles when it reacts with nutrients.
3. **Communicate** Record the number of drops it takes until the sample starts bubbling.
4. Repeat steps 1 to 3 using soil instead of sand. Record your data.

Draw Conclusions

5. Which sample had more nutrients—sand or soil? Explain.
6. **Predict** Which would probably be better for growing plants—sand or soil? Explain.
7. **Infer** How might you classify the sand and soil—high in nutrients or low in nutrients?

Explore More

Collect other types of soil and test their nutrient levels using hydrogen peroxide. Which soil had the greatest amount of nutrients?

Materials

- goggles
- apron
- plastic spoons
- sand
- plastic cups
- hydrogen peroxide
- dropper
- soil

Step 1

Step 2

SI-1. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others....

Read and Learn

Main Idea LS-4

The six major land biomes on Earth are tundra, taiga, desert, rain forest, deciduous forest, and grassland.

Vocabulary

biome, p.138
desert, p.139
tundra, p.140
taiga, p.141
tropical rain forest, p.142
temperate rain forest, p.142
deciduous forest, p.143
grassland, p.144

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Reading Skill

Classify

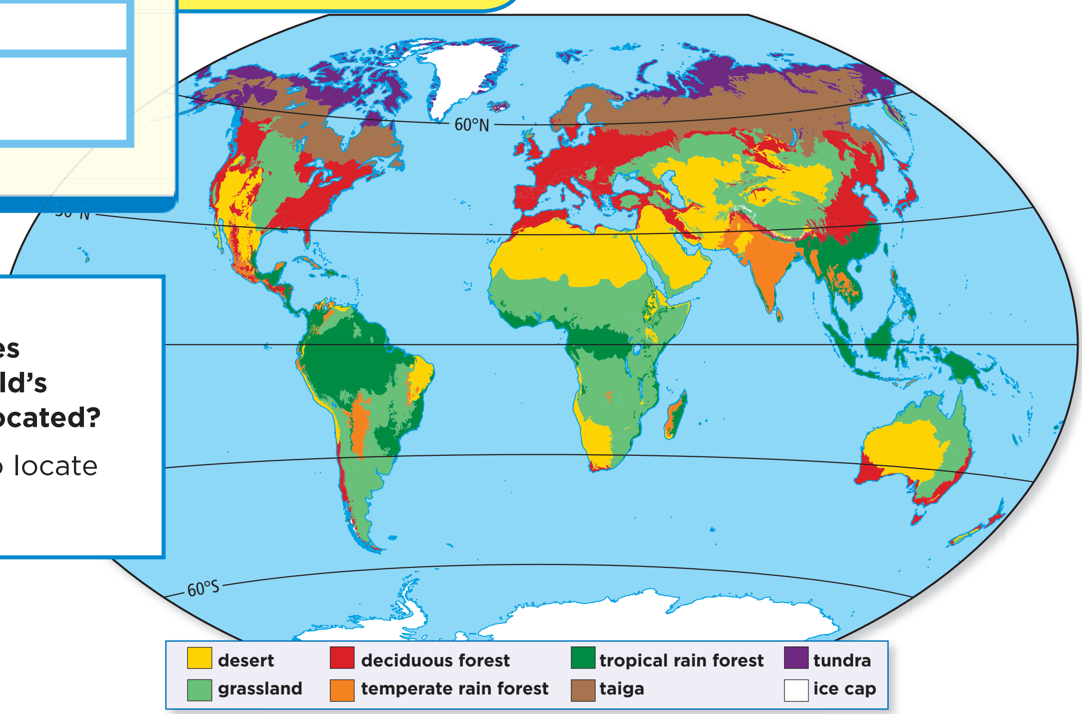
What are biomes?

Take a look out your window. If you live in Arizona you might see a dry desert. In Pennsylvania you might see a green forest. In Iowa the scene outside your window is likely to be a golden grassland. Each environment is a biome (BYE•ohm).

A **biome** is one of Earth's major land ecosystems with its own characteristic animals, plants, soil, and climate. A *climate* is an average weather pattern for a region. How is a biome different from other habitats? You can think of a biome as a set of habitats or ecosystems all grouped together into a kind of "super-ecosystem."

In all, there are six major land biomes: desert, tundra (TUN•druh), taiga (TYE•guh), rain forest, deciduous forest (di•SIJ•ew•uhs), and grassland. You can see how they are arranged on the map. For example, a desert stretches across the continent of Africa. A taiga covers the distance across Russia, a length of about 10,000 km (6000 miles). Each continent on Earth has a number of different biomes.

Global Biomes



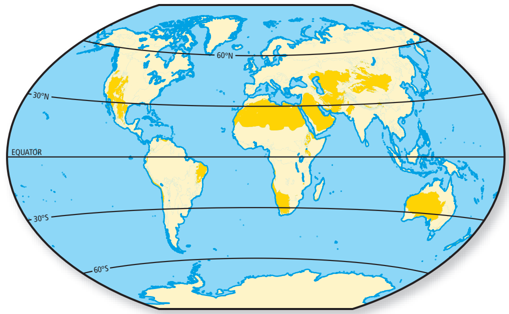
Read a Map

In which three places are most of the world's deciduous forests located?

Clue: Use the key to locate deciduous forests.

Desert

A **desert** is a sandy or rocky biome, with little precipitation and little plant life. The main characteristic of a desert is the lack of water. Deserts are treeless and extremely dry biomes. Some deserts, such as the ones in Asia, are cold, but many deserts are brutally hot. Desert soil is often rich in minerals, but poor in animal and plant decay.



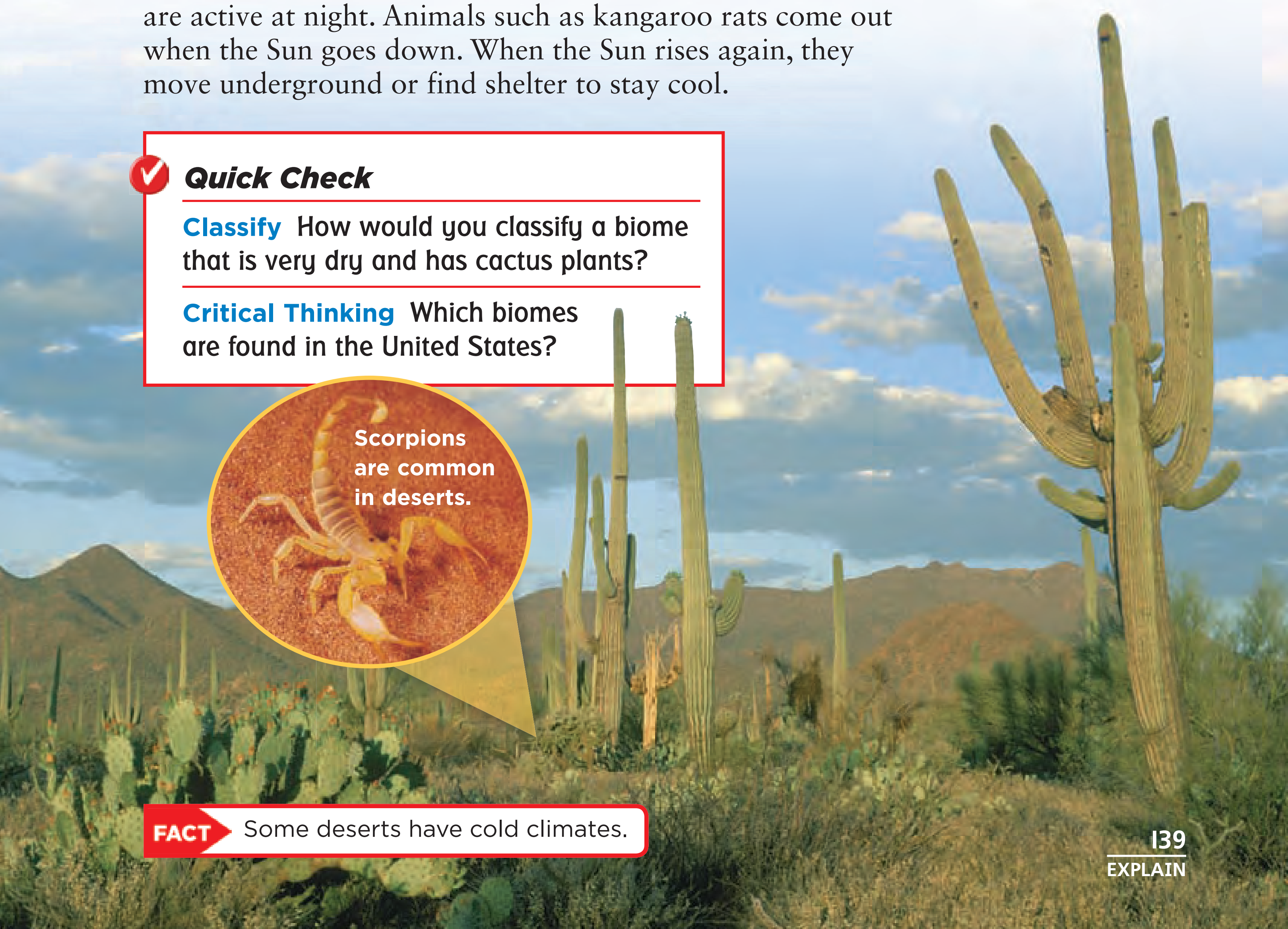
Plants and animals need special adaptations to survive in dry deserts. For example, cactus plants store water in their stems and branches. They also have thick, waxy cuticles that prevent water from evaporating. Other desert plants, like the mesquite, survive by having very long roots that reach moisture deep underground.

Only a few animals are active during the heat of the day in the desert. These include lizards and other reptiles that need the Sun's heat to warm their blood. Some insects and a few birds also are active during the day. Most desert animals are active at night. Animals such as kangaroo rats come out when the Sun goes down. When the Sun rises again, they move underground or find shelter to stay cool.

Quick Check

Classify How would you classify a biome that is very dry and has cactus plants?

Critical Thinking Which biomes are found in the United States?



Scorpions are common in deserts.

FACT Some deserts have cold climates.

What are some harsh biomes?

Some biomes are characterized by having extremely cold weather. The tundra and taiga are cold biomes found in the northern hemisphere.

Tundra

The **tundra** is a large, treeless biome where the ground is frozen all year. The layer of *permafrost*, or permanently frozen soil, prevents trees from growing. The soil is also poor in nutrients. During the six- to nine-month winter, most tundra locations get very little sunlight. Temperatures can drop to –94°F (–70°C).

In the short summer, it stays light almost all day and temperatures rise to above freezing. Because of the permafrost, poor soil, and short summers, tundra plants have shallow roots and short growing seasons. Mosses, lichens, and some grasses and shrubs are common here.

Very few animals have adapted to living in the tundra. Caribou, polar bears, musk ox, and arctic hares and foxes make their homes in the tundra. In the spring and summer, shallow, boggy pools form from the melted ice. These are perfect breeding grounds for millions of mosquitoes and the birds that feed on them.

This caribou is grazing on lichens in an Alaskan tundra.

Wolverines are found in taiga forests.

Taiga

Just south of the tundra lies the world's largest biome— the taiga. The **taiga** is a cool forest biome of conifers found in northern regions. Unlike the frozen tundra, the taiga is full of coniferous evergreen trees. Temperatures in the taiga are cold, but not as cold as those in the tundra. Soil in the taiga is low in minerals.

Many plants have adapted to life in the taiga. The taiga has a longer growing season than the tundra. During the summer months the ice melts, which makes it possible for trees and other plants to grow. The taiga is able to support pines, firs, spruces, and other conifers.

Many taiga animals, like the snowshoe rabbit, look much like animals that live farther south. Their coats are thicker for extra warmth, and during the winter, lighter-colored to match the snow. Many taiga animals have thick layers of fat that protect against the cold. Many hibernate to avoid the coldest winter months.

Quick Check

Classify How would you classify a cold, treeless biome with very little sunlight?

Critical Thinking How would you expect a desert rabbit to be different from a rabbit that lives in the taiga?

What are some forest biomes?

Does a jungle in South America have anything in common with a tree-filled park near your home? Yes; both are examples of forest biomes.

Rain Forests

tropical rain forest

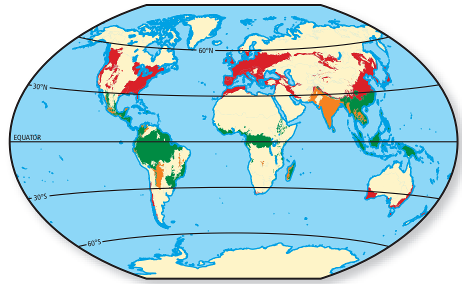
temperate rain forest

Read a Photo

How do tropical rain forests and temperate rain forests compare?

Clue: Look at the two photos. What similarities and differences do you see?

Rain Forest



The **tropical rain forest** is a hot, humid biome near the equator, with heavy rainfall and a wide variety of life. Although its soil is nutrient-poor, the tropical rain forest supports more organisms than any other place on Earth.

Tropical rain forests have four layers. Few plants can grow on the *forest floor*, because there is very little light. The forest floor is home to many insects, frogs, and mice. The *understory* is made up of tree trunks, shrubs, and vines. Leopards, jaguars, and other large mammals are found in this layer.

The next layer, the *canopy*, is thick with plant life. The leaves of canopy plants prevent sunlight from reaching the lower levels. Monkeys, bats, toucans, tree frogs, snakes, and insects live among the tree branches. The highest layer is the *emergent layer*. It is made up of the upper parts of large trees. Many birds nest in this part of the rain forest.

A **temperate rain forest** is a biome with a lot of rain, fog, and a cool climate. Temperate rain forests have mild winters and cool summers. They are dominated by large evergreen trees and epiphytes (EP•uh•fites). *Epiphytes* can be lichens or plants, such as mosses and some ferns, that grow on trees. The animals in this biome include cougars, black bears, bobcats, owls, reptiles, and many amphibians.

Deciduous Forest

The **deciduous forest** is a forest biome with four distinct seasons and deciduous trees. Deciduous trees are hardwoods whose leaves change color and fall off every autumn. Examples are oak, maple, beech, and hickory trees. The soil is rich in nutrients. In winter, the forest is a snowy, empty place. Many birds have migrated to warmer places. Other animals are hiding or hibernating.

In the spring and summer, ferns, shrubs, and saplings shoot up. The leaves on the trees begin to grow. Common forest birds return, including robins, woodpeckers, owls, and hawks. Squirrels, mice, rabbits, raccoons, skunks, porcupines, and other small mammals also populate the forest. Larger animals include white-tailed deer, foxes, and bears. A variety of insects live in the forest, including ants, beetles, and butterflies.

Quick Lab

Compare Leaves

1. **Observe** Compare the broad leaf and the succulent leaf. Which leaf is thicker? Which leaf would be better for catching sunlight? Record your observations.
2. Break open each leaf. Which leaf holds more water?
3. **Infer** Think about the characteristics of each leaf. Which leaf might have come from a forest? Which leaf might have come from a desert? Explain.

Quick Check

Classify How would you classify a biome that changes every season?

Critical Thinking Which biome has about the same weather all year long?

Deciduous forests provide habitats for chimpmunks.

What are grasslands?

The **grassland** is a biome where grasses, not trees, are the main plant life. American prairies are one kind of grassland. The African grassland is called a savanna. A temperate grassland has cold winters and hot summers. A grassland is wetter than a desert, but it is too dry for many trees to grow. Grassland soil is rich with nutrients. It is often used for growing crops such as wheat, oats, and corn.

Fires are common in this dry biome. The roots of the plants are deep, so the environment recovers quickly. New grass plants—and the grassland habitats—grow back.

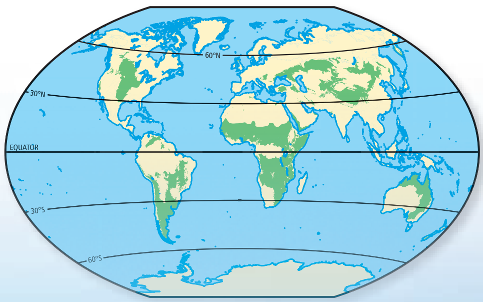
The grasses are the producers of the ecosystem. They provide a rich food source for all the herbivores. In tall grass prairies, bluestem and switchgrass grows to heights of 3 meters (10 feet). Down below, the roots of these plants can grow just as deep or deeper.

Grasslands are also filled with animal life. Insects, like grasshoppers, crickets, butterflies, and moths, live among the wildflowers of American prairies. Low in the grass, toads, worms, insects, spiders, mice, prairie dogs, snakes, and other small organisms make their homes. These small organisms are prey for birds and other predators.

Quick Check

Classify A grassland gets so dry that grasses cannot grow and soil blows away. How would you classify this biome?

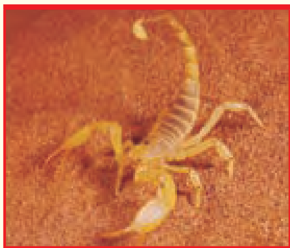
Critical Thinking What do you think could happen to a grassland if fires were prevented?



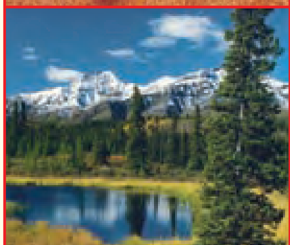
Bison roam the American prairie grasslands.

Lesson Review

Visual Summary



Earth can be divided into six major **biomes**. Desert biomes are dry and hot.

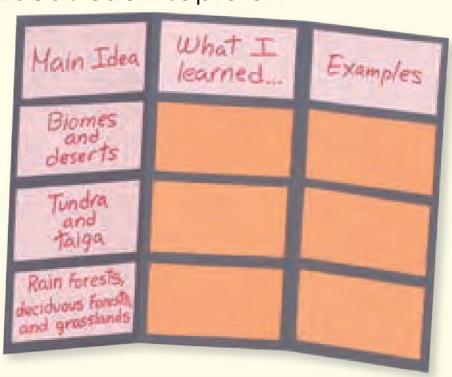


The **tundra** and **taiga** are cold biomes.

Forest biomes include **rain forests** and **deciduous forests**. Prairies and savannas are **grasslands**.

Make a FOLDABLES™ Study Guide

Make a Trifold Book. Use the titles shown. Tell about each topic on the folds.

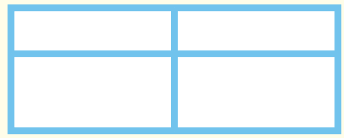


Think, Talk, and Write

1. **Main Idea** What are Earth's six major land biomes?

2. **Vocabulary** The biome just south of the tundra is the ________.

3. **Classify** How would you classify the biome where you live? Give reasons to support your classification.



4. **Critical Thinking** The Gobi Desert is dry, but its average temperature is around freezing. Should this region be classified as a different biome? Explain.

5. **Test Prep** **Which biome has permafrost?**
   - **A** deciduous forest
   - **B** grassland
   - **C** tundra
   - **D** taiga

6. **Test Prep** **Which biome has many epiphytes?**
   - **A** grassland
   - **B** rain forest
   - **C** desert
   - **D** tundra

Writing Link

Global Warming

Research and write a report on global warming. How might global warming change some of Earth's biomes?

Math Link

Temperature Ranges

Tundra temperatures may range from -70°C to 12°C. What is the total temperature range in degrees?

A Year in the Life of a Forest

Did you know that forests breathe?

Scientists can measure the gases in the forest air to gather data about the photosynthesis and respiration of the trees, animals, and other organisms that live there.

Take a look at the carbon dioxide data that scientists measured in the air from Howland Forest, a deciduous forest in Maine. Howland Forest has cold and snowy winters and hot and humid summers. How do these changes in seasons affect the amount of carbon dioxide in the air?

Spring

As the days become longer and warmer, activity in the forest increases. This increased activity results in higher levels of respiration, so the amount of carbon dioxide measured in the air starts to rise. The trees sprout new leaves and begin to photosynthesize.

Summer

Summer days are the longest and warmest of the year. Because the forest is so active, a lot of photosynthesis and respiration occurs. During the day, the amount of carbon dioxide is low. That's because the trees are taking in carbon dioxide and transforming it into food to store in their roots. During the night, the amount of carbon dioxide is high. All organisms in the forest, including the trees, are respiring and releasing carbon dioxide. These two processes together result in the different day and night carbon dioxide levels you see in the chart.

CO_2 Concentration (parts/million)

month	minimum CO_2	maximum CO_2
Jan	378	388
Feb	377	385
March	377	384
April	376	388
May	371	393
June	362	413
July	356	427
Aug	355	424
Sept	362	418
Oct	358	386
Nov	366	379
Dec	368	377

SWK-3. Explain why an experiment must be repeated by different people or at different times or places and yield consistent results before the results are accepted.

These photos show Howland Forest during all four seasons.

Fall

Shorter days mean fewer hours of sunlight. Trees begin to lose their leaves and the forest becomes less active. The forest is photosynthesizing and respiring less. Day and night carbon dioxide levels are similar.

Winter

Winter days are the shortest and coldest of the year. The forest is much less active. Most of the trees have lost their leaves, and there is no photosynthesis. Day and night carbon dioxide levels are very similar as all the life-forms continue to respire.

Write About It

Main Idea and Details

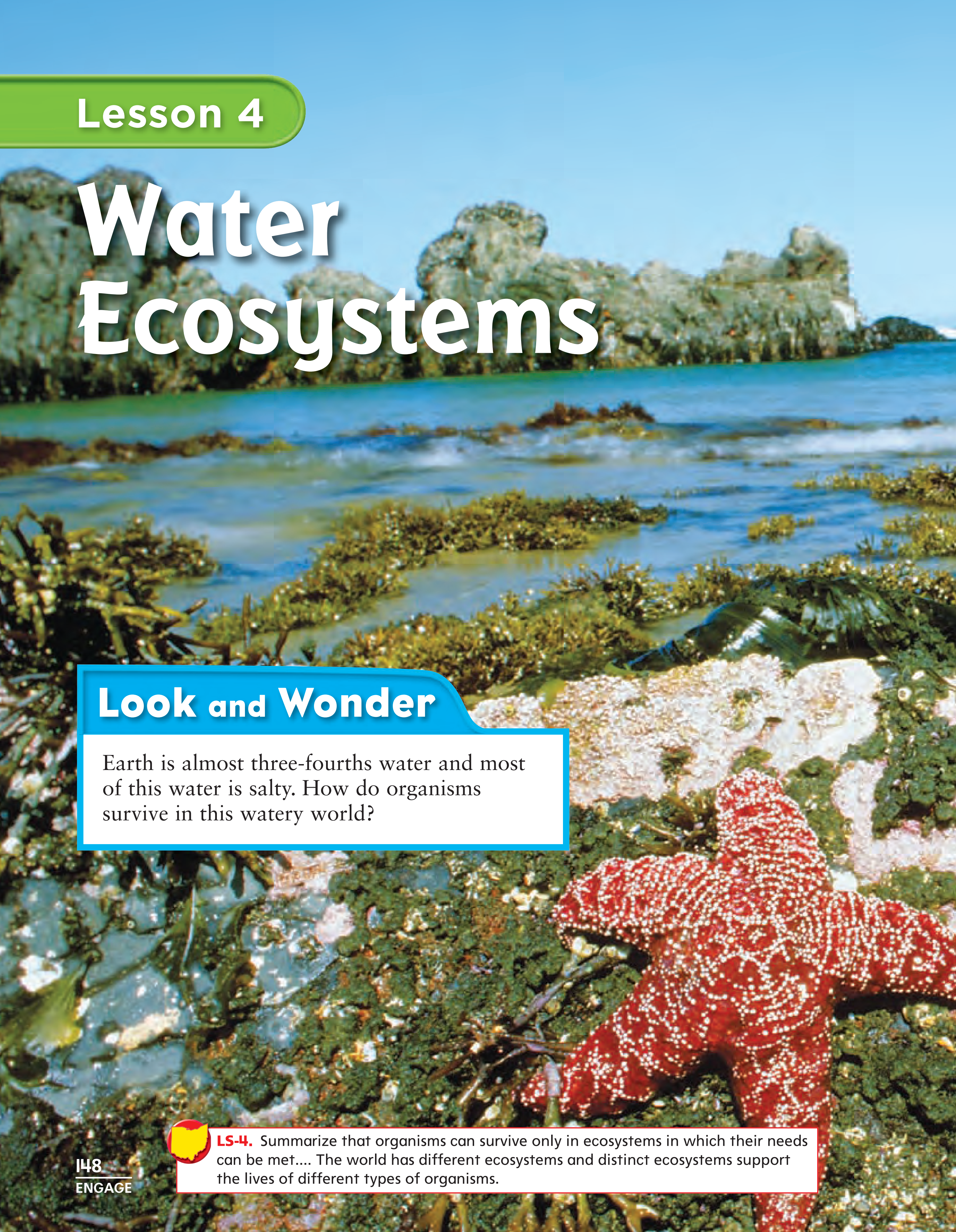
1. Tell how the levels of carbon dioxide change in Howland Forest throughout the year.
2. Research other biomes and explain how they change during the year.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

Main Idea and Details

- Look for the central point of a selection to find the main idea.
- Details are important parts of the selection that support the main idea.

American Museum of Natural History



Lesson 4

Water Ecosystems

Look and Wonder

Earth is almost three-fourths water and most of this water is salty. How do organisms survive in this watery world?

LS-4. Summarize that organisms can survive only in ecosystems in which their needs can be met.... The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.

Explore

Inquiry Activity

How does the ocean get salty?

Purpose

To make a model that shows how ocean water becomes salty.

Procedure

1. **Measure** In the plastic cup, mix 2 tablespoons of salt and a few drops of food coloring. Use the spoon to stir until it's well-mixed.
2. Pour 2 cups of soil into one side of the shallow baking pan.
3. Mix the salt with the soil in the pan.
4. Tip the pan so the side with the mixture in it is slightly off the table. Try not to knock any of the mixture to the other side.
5. As you hold the pan slightly off the table, slowly pour some water onto the mixture.
6. **Observe** Note the color of the water when it reaches the other side of the pan.

Draw Conclusions

7. How does the color of the water compare to the color of the dyed salt?
8. **Infer** How does this model resemble what happens as fresh water flows to the ocean?

Explore More

Are some oceans saltier than others? Research Earth's oceans to find out if some have more salt than others. Write a report that explains how some oceans become saltier than others.

Materials

- plastic cup
- salt
- blue food coloring
- plastic spoon
- soil
- shallow baking pan
- container of water

Step 1

Step 5

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.

Read and Learn

Main Idea LS-4

Water ecosystems include bodies of fresh water, salt water, and mixed water.

Vocabulary

plankton, p.150
nekton, p.150
benthos, p.150
intertidal zone, p.154
estuary, p.156

LOG ON e-Glossary
at www.macmillanmh.com

Reading Skill

Main Idea and Details

Main Idea	Details

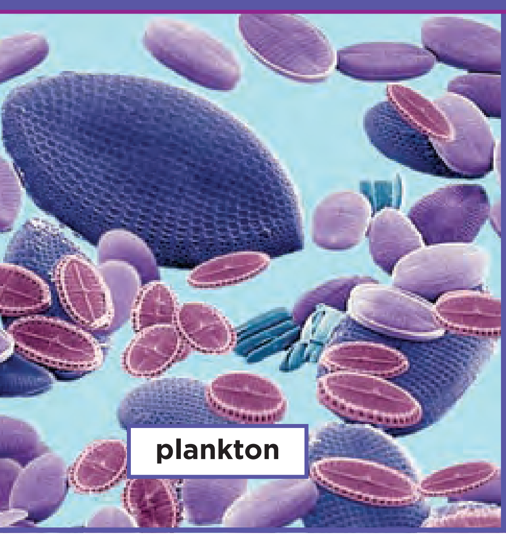
What are water ecosystems?

Most of Earth's surface is covered by water, but all water is not alike. About 97 percent of the world's water is salty ocean water. The other three percent is fresh water. Fresh water is water that does not contain salt, or is very low in salt. Fresh water is the water you drink.

Freshwater and saltwater ecosystems are organized in similar ways. The organisms in water ecosystems are divided into three main categories. **Plankton** (PLANGK•tuhn) are creatures that drift freely in the water. They are not able to swim. Some plankton, such as diatoms, are producers, and others are consumers, such as some animal larvae. The second group includes the larger, active swimmers in a body of water called **nekton** (NEK•ton). Fish, turtles, and whales are all nekton.

The third group, organisms that live on the bottom of a body of water, are called **benthos** (BEN•thahs). Many benthos are scavengers or decomposers because they feed on material that floats down from shallower water. Some benthos, such as oysters, fix themselves to one spot. Others, like worms, burrow in the sand. Many, like lobsters, walk about on the bottom of a body of water looking for food.

Saltwater Organisms


plankton


nekton


benthos

Like land ecosystems, biotic and abiotic factors determine the types of organisms that can survive in water ecosystems. Unlike land ecosystems, water is never a limiting factor. However, the amount of light, dissolved salt, and dissolved oxygen are important. They can all affect the types of organisms that can live in bodies of water.

Little sunlight is able to penetrate to the bottom of a body of water. The water gets cooler and darker away from the surface. Shallow water allows more light to penetrate. For this reason, producers that require light for photosynthesis are usually found on the surface or in very shallow water.

These same producers release oxygen during photosynthesis. Water can also pick up oxygen from the air. So surface and shallow water tend to have more dissolved oxygen than deeper water. The oxygen and nutrients from producers enable more organisms to live in the surface waters.

Quick Lab

Salt Water v. Fresh Water

1. Fill a cup with fresh water. Fill a cup with salt water. Label each cup. Place flowers in each cup.
2. **Observe** Examine each flower after two hours.
3. **Communicate** Did you see any changes to either flower? Explain your observations.

Quick Check

Main Idea and Details How does the amount of fresh water compare to the amount of salt water?

Critical Thinking Suppose you had a bottle containing ocean water and another with fresh water. How could you tell the two apart?

Freshwater Organisms


plankton


nekton


benthos

This river is a running-water ecosystem.

What are freshwater ecosystems?

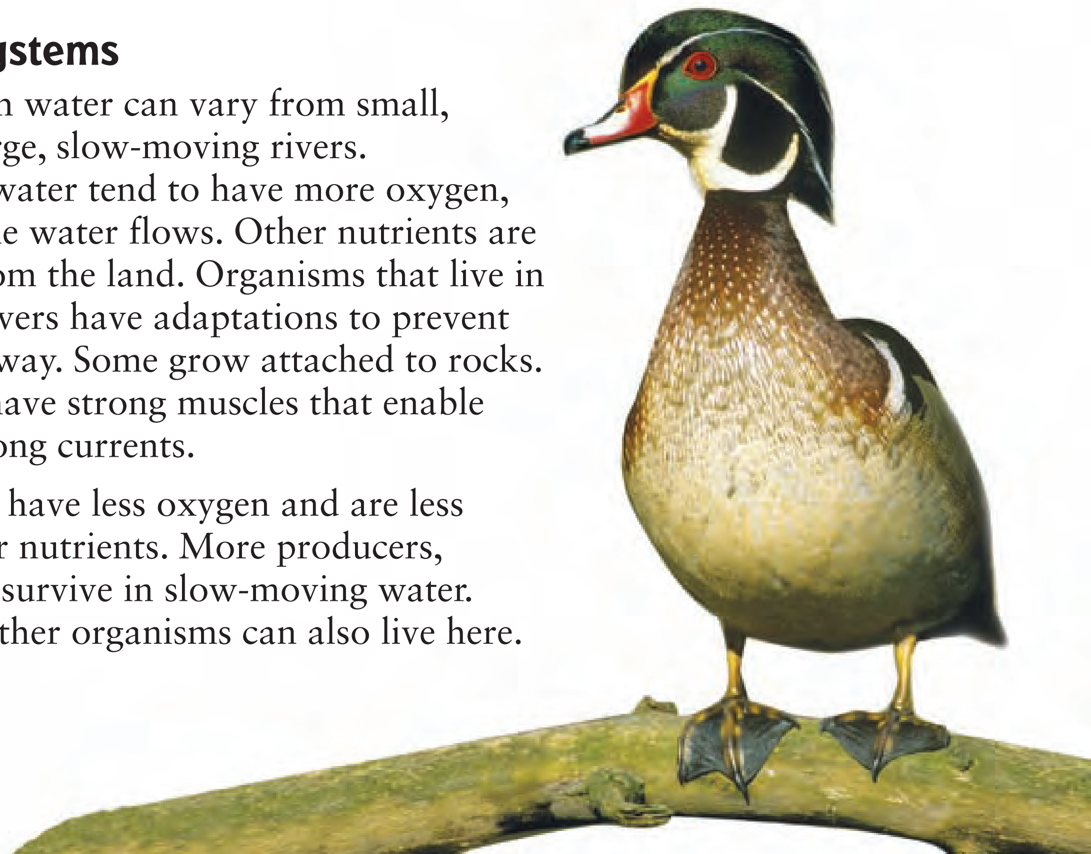
Not all freshwater ecosystems are alike. Rivers and streams are running-water ecosystems. Lakes and ponds are standing-water ecosystems. Swamps, bogs, and marshes are freshwater wetlands.

Running-Water Ecosystems

Moving bodies of fresh water can vary from small, fast-moving brooks to large, slow-moving rivers. Faster-moving bodies of water tend to have more oxygen, because air mixes in as the water flows. Other nutrients are washed into the water from the land. Organisms that live in fast-moving streams or rivers have adaptations to prevent them from being swept away. Some grow attached to rocks. Others, such as salmon, have strong muscles that enable them to swim against strong currents.

Slower-moving waters have less oxygen and are less dependent on the land for nutrients. More producers, such as algae, are able to survive in slow-moving water. Mussels, minnows, and other organisms can also live here.

▼ Wood ducks are common organisms in freshwater ecosystems.



Standing-Water Ecosystems

The typical freshwater lake or pond is divided into three zones. The shallow-water zone along the shore is where most of the organisms live. Cattails, sedges, arrowgrass, and other rooted plants grow here. These plants are home to a variety of microorganisms. They are eaten by animals such as insects, worms, tiny fish, insect larvae, and crustaceans. These animals are eaten by larger organisms that include frogs, birds, and small sunfish. Finally, top predators, such as herons, bass, and turtles, eat the smaller predators.

The open-water zone includes the water away from the shore. This zone may be too deep for rooted plants to survive. Algae and plankton float near the surface. Nekton, such as trout, whitefish, and pike are found here.

The third zone is below the open-water zone and includes the bottom. Very little light reaches the bottom, so producers cannot grow here. As a result, there is very little oxygen. Food must drift into this zone from other zones. Benthos, including worms and mollusks, are found in this zone.

Freshwater Wetlands

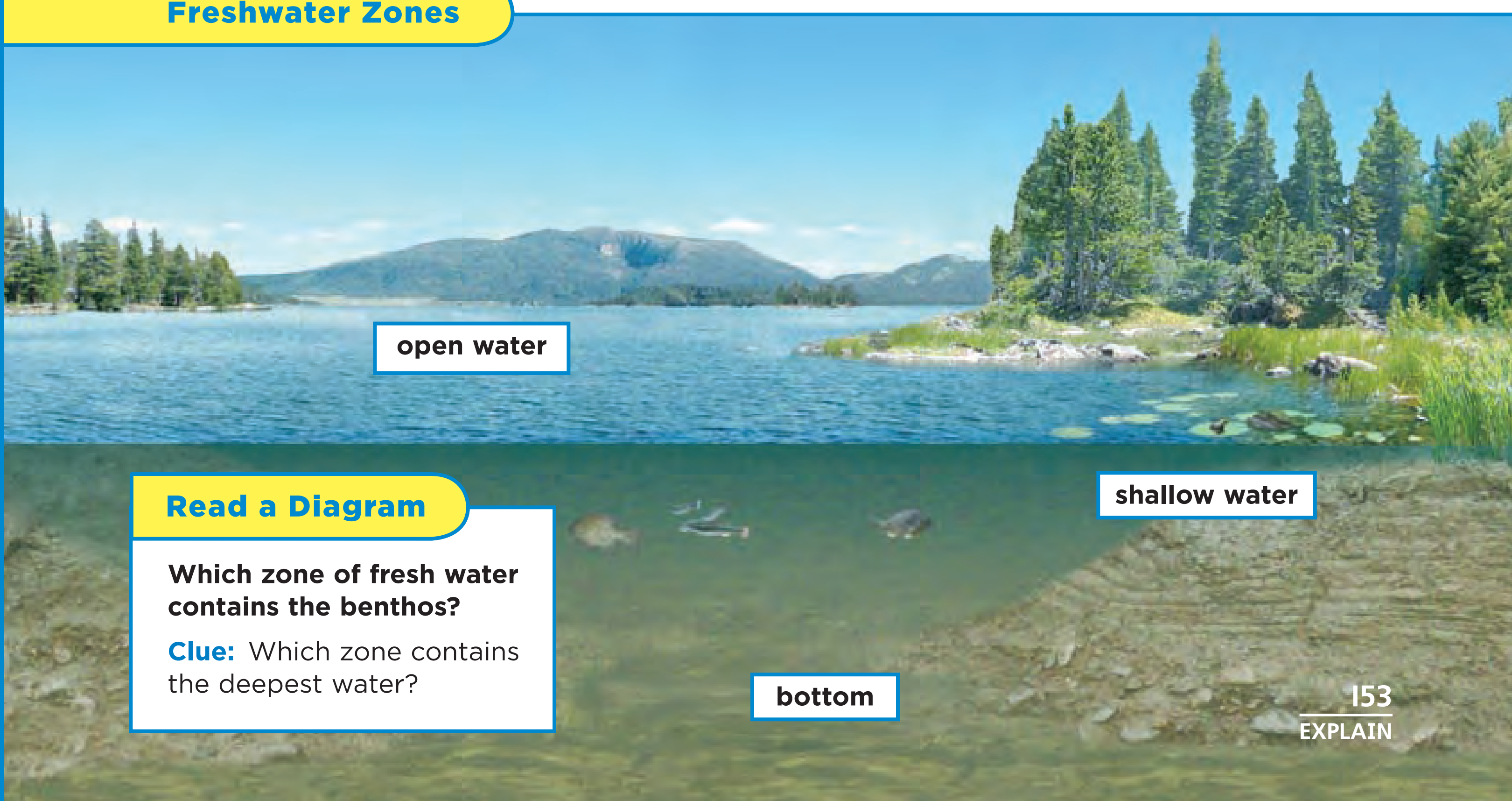
Wetlands, such as marshes, swamps, and bogs, are regions that are wet for most of the year. They are found in areas that lie between land and water. In order to survive here, plants must be adapted to water-soaked soil. Grasslike plants, moss, and some shrubs are found in wetlands. Beavers, muskrats, otters, birds, and fish live in wetlands.

Quick Check

Main Idea and Details Describe the zones of standing water. Give details about the organisms in each zone.

Critical Thinking Why is fast-moving water dependent on the land?

Freshwater Zones

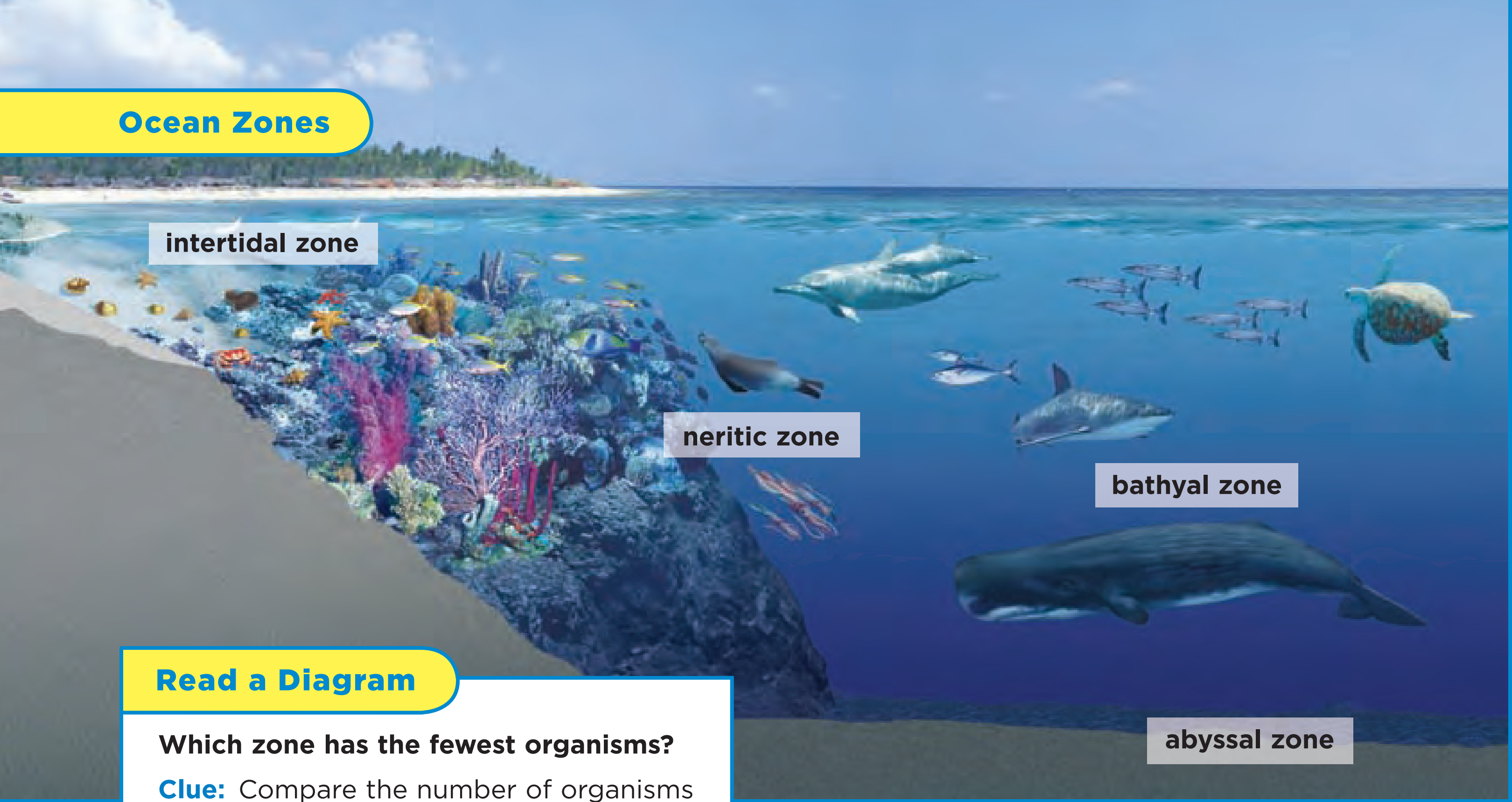


Read a Diagram

Which zone of fresh water contains the benthos?

Clue: Which zone contains the deepest water?

Ocean Zones



Read a Diagram

Which zone has the fewest organisms?

Clue: Compare the number of organisms in each zone.

What are ocean ecosystems?

Like pond and lake ecosystems, oceans are divided into zones. The shallowest part of the ocean ecosystem is called the **intertidal zone**. Every day, the pull of the Moon's gravity causes ocean tides to rise and fall over the intertidal zone. It is covered by water at high tide. At low tide the organisms of the intertidal zone are exposed to the air.

Beyond the intertidal zone is the *neritic zone* (nuh•RI•tik). The key resource in this zone is sunlight. Algae, kelp, and other producers grow in huge numbers near the surface water where sunlight can penetrate. These producers attract herbivores including small fish, animal-like plankton, shrimplike crustaceans, and some whales. These organisms in turn attract larger organisms: seals, sea turtles, jellyfish, and other large fish.

The third zone of the ocean is the *oceanic zone* (oh•shee•AN•ik). It is divided into the *bathyal zone* (BA•thee•uhl) and the *abyssal zone* (uh•BIS•uhl). The bathyal zone is home to many large consumers, such as sharks, but few producers.

Further down is the abyssal zone, where it gets darker and colder because the sunlight is completely blocked. Without light, producers cannot perform photosynthesis. Without producers, few consumers can survive. Organisms in this zone tend to be scavengers or decomposers. They live on nutrients that float down from other zones.

FACT Hydrothermal vents on the ocean floor support many organisms.

Intertidal Zone The intertidal zone is part of the sunlight zone. It can be rocky or sandy. Organisms such as crabs, clams, barnacles, sea stars, sea grasses, snails, and seaweeds live here. These organisms must be adapted to daily changes in temperature, moisture, and wave action.

Neritic Zone The neritic zone is also part of the sunlight zone. Coral reefs and kelp forests are important parts of the neritic zone. They provide habitats and food for many other organisms in this zone.

Bathyal Zone The bathyal zone can be divided into the twilight and dark zones. Little sunlight reaches these parts of the ocean. Many large organisms, like this octopus, make the dark zone their home. You will find sharks, squid, and many other large nekton in this zone.

Abyssal Zone The organisms in the abyssal zone, or the abyss, are well-adapted to its cold, dark conditions. Tube worms live in and around hydrothermal vents, cracks in the deep ocean floor. The heat and minerals from these vents support many organisms.

Quick Check

Main Idea and Details Which zone is home to the most producers? What feature does this location have that helps organisms survive?

Critical Thinking At a depth of 5 meters, which would you expect to have more organisms living in it – clear water or murky water? Explain your answer.

Where do salt and fresh water meet?

The boundary where fresh water feeds into salt water is called an **estuary** (ES•chew•er•ee). Estuaries are unique ecosystems that are part salt water and part fresh water. Like intertidal zones, estuaries change with the tides. When the tide comes in, estuary water becomes more salty. The tide also brings in nutrients from the land. When the tide runs out, the estuary becomes mostly fresh water and wastes are flushed out.

Estuaries usually contain salt marshes. These boggy areas are covered with grasses and other marsh plants. The marsh grasses and surrounding water provide habitats for a wide variety of organisms. Large numbers of shrimp, oysters, clams, and fish live in estuaries. Many ocean fish return to estuaries to lay their eggs. Countless insect larvae, young fish, and tiny crustaceans begin their lives in the calm, protected waters within an estuary. Larger organisms, including egrets, herons, frogs, turtles, muskrats, raccoons, otters, and bobcats feed on these smaller consumers.

Salt marshes within estuaries perform several special functions for a coastal region. They act like a sponge during storms to soak up excess water. The roots and stems of marsh plants also act as filters for river water. The grasses in salt marshes slow the water down and trap nutrients and pollution. The water that then flows into the ocean has been cleaned.

Quick Check

Main Idea and Details What are estuaries? Use details to explain how they help the environment.

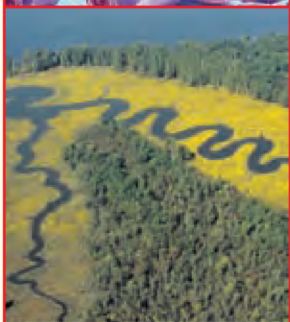
Critical Thinking A river empties into a freshwater lake. Is the place where the river and the lake meet an estuary? Why or why not?

Bobcats are one of the top carnivores in estuary ecosystems.

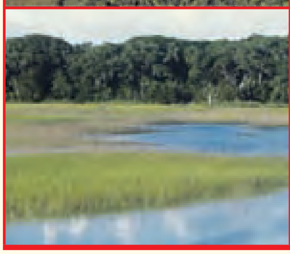
Lesson Review

Visual Summary

The organisms that live in fresh water and salt water are divided into **plankton**, **nekton**, and **benthos**.



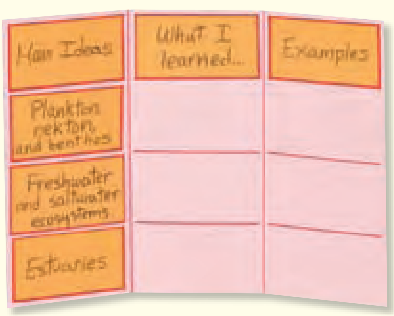
Freshwater ecosystems include standing water, running water, or wetlands. **Saltwater ecosystems** are divided into the intertidal zone, neritic zone, and oceanic zone.



Estuaries are rich ecosystems that exist where fresh water and salt water meet.

Make a FOLDABLES™ Study Guide

Make a Trifold Book. Use the titles shown. Tell what you learned about each topic.



Think, Talk, and Write

1. **Main Idea** Which water ecosystem contains most of the world's water?

2. **Vocabulary** The shallowest part of the ocean ecosystem is the ________.

3. **Main Idea and Details** Which freshwater ecosystems get a fresh supply of water every day? Which do not? Use details to support your answer.

Main Idea	Details

4. **Critical Thinking** Why are lakes and rivers more sensitive to pollution than the oceans?

5. **Test Prep** **Which of the following organisms are nekton?**
   - **A** whales, turtles, sharks
   - **B** sea stars, plankton, lobsters
   - **C** crabs, tube worms, algae
   - **D** rays, crabs, diatoms

6. **Test Prep** **Which of the following helps to clean the environment?**
   - **A** neritic zone
   - **B** benthos
   - **C** plankton
   - **D** estuary

Math Link

Ocean Fractions

The top 200 meters of 3,000-meter-deep ocean water are penetrated by sunlight. What fraction of the water is dark?

Art Link

Water Ecosystems

Make a poster that shows every water ecosystem, including streams, rivers, ponds, lakes, oceans, and estuaries.

LOG ON e-Review Summaries and quizzes online at www.macmillanmh.com

Persuasive Writing

A good persuasion

- clearly states the opinion of the writer on a specific topic
- uses convincing reasons to influence an audience to agree with that opinion
- asks the reader to take an important action

Keep Our Water Clean

Laura wanted people in her town to help clean up trash that had been dumped in the local stream. She wrote an e-mail to the mayor and asked him to put her message on the town Web site.

Laura_Email.com Send Cancel

Our supply of fresh water is limited to what we can get from streams, rivers, lakes, and under the ground. If we pollute these sources of water, we will run out of fresh water to use! I believe that adopting a local stream, creek, or watershed is one way you can protect your water.

Come this weekend and help clean up our stream. We will pick up the trash and plant trees and grasses that will keep the soil near the creek from washing away. We will also put up signs to remind people not to dump trash in our stream.

Don't take the water near you for granted. Take care of it!

Write About It

Persuasive Writing Write a letter to the mayor of your town. Explain a need that the students in your community have and why people should help. State your position clearly and support it with relevant facts and evidence organized in a logical way.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA WA-3. Write letters that state the purpose, make requests, or give compliments and use business letter format.

Understanding Earth's Water

Percents and Fractions

To convert a percent

- place the percent over a denominator of 100
- reduce the fraction to its simplest form

$15\% = \frac{15}{100} = \frac{3}{20}$

To find a fraction of a fraction

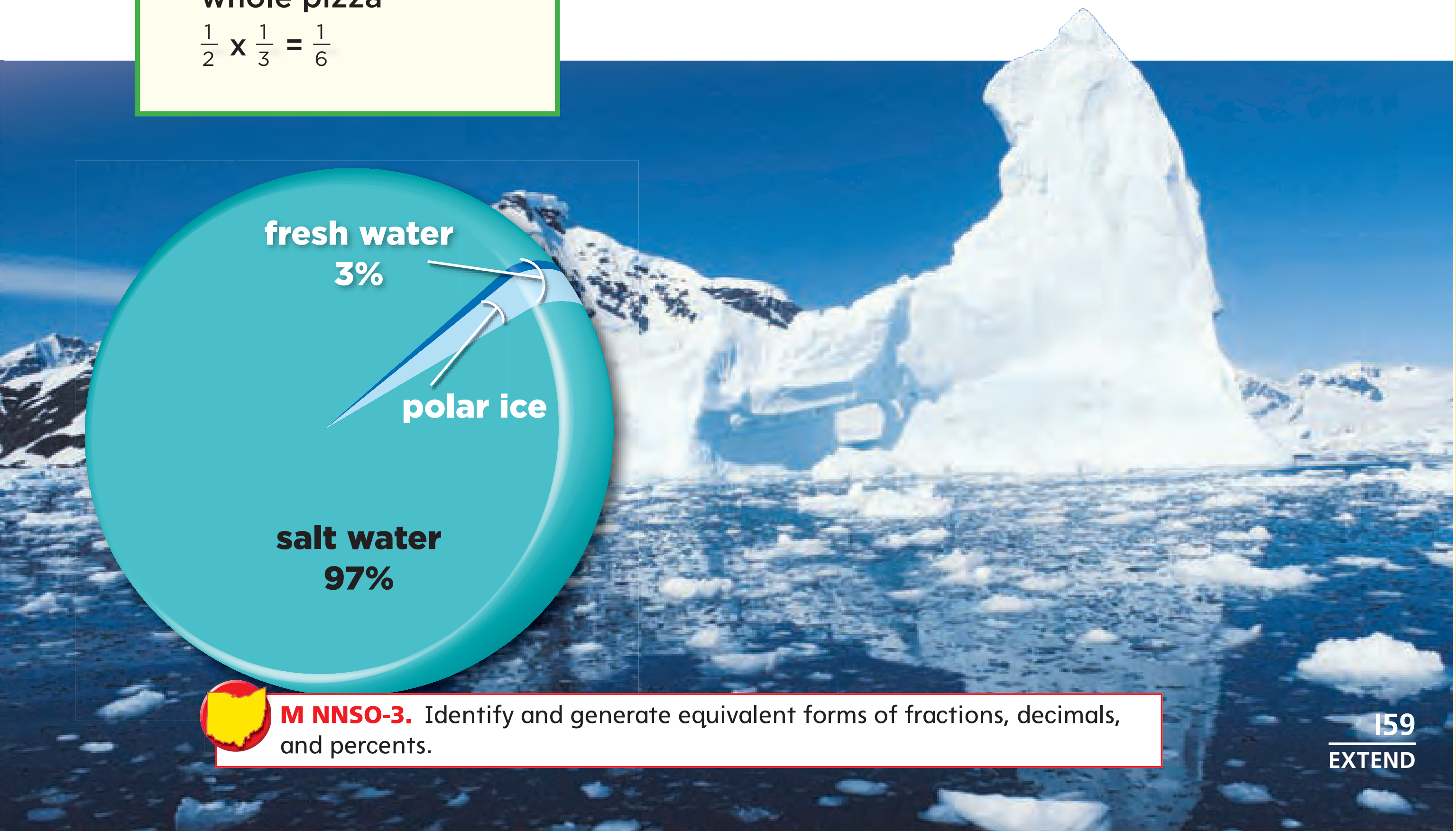
- multiply the two fractions. So if you ate $\frac{1}{3}$ of $\frac{1}{2}$ a pizza, you ate $\frac{1}{6}$ of the whole pizza

$\frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$

Most of the water on Earth is salt water. Just a small fraction of Earth's water is fresh. Most of that fresh water is frozen! It is trapped as polar ice. Polar ice is found around the North and South Poles. If you understand percents and fractions, you can figure out what part of Earth's water is polar ice.

Solve It

1. What fraction of Earth's water is salt water?
2. What fraction of Earth's water is fresh water?
3. Polar ice is about $\frac{3}{4}$ of the 3% of Earth's fresh water. What fraction of all of Earth's water is polar ice? Hint: Use your answer to question 2 to help you solve this. Then use a calculator to change your answer to a decimal. First divide the numerator by the denominator. Then multiply the answer by 100 to find out what percent of Earth's water is polar ice.



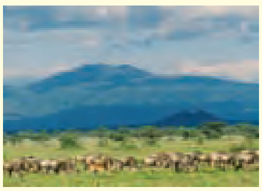
M NNSO-3. Identify and generate equivalent forms of fractions, decimals, and percents.

CHAPTER 3 Review

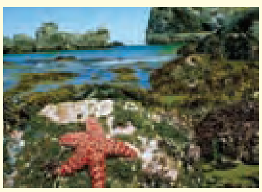
Visual Summary

Lesson 1 The important chemicals for life—water, carbon, nitrogen, and oxygen—are used and reused as they flow through ecosystems.

Lesson 2 Ecosystems can change naturally over time into a series of different living communities.



Lesson 3 The six major land biomes on Earth are tundra, taiga, desert, rain forest, deciduous forest, and grassland.



Lesson 4 Water ecosystems include bodies of fresh water, salt water, and mixed water.

Make a FOLDABLES™ Study Guide

Assemble your lesson study guide as shown. Use your study guide to review what you have learned in this chapter. Don't forget to include your Lesson 4 study guide in the back.

Vocabulary

Fill in each blank with the best term from the list.

biome, p. 138

compost, p. 120

deciduous forest, p. 143

estuary, p. 156

extinct species, p. 128

intertidal zone, p. 154

secondary succession, p. 132

water cycle, p. 114

1. A desert ecosystem is an example of a(n) _________.
LS-4
2. When its last member dies, a species becomes a(n) _________.
LS-4
3. Trees such as oak and maple grow in a(n) _________.
LS-4
4. The continuous movement of water between Earth's surface and the air is called the _________.
ESS-6
5. The beginning of a new community where another has already existed is called _________.
LS-6
6. The Moon's gravity causes constant changes to the ocean's _________.
LS-4, LS-5
7. A fertilizer made from dead plant and animal material is called _________.
LS-3
8. An ecosystem where fresh water meets salt water is called a(n) _________.
LS-4

LOG ON e-Review Summaries and quizzes online at www.macmillanmh.com

Skills and Concepts

Answer each of the following in complete sentences.

9. **Cause and Effect** Why does burning fossil fuels create carbon dioxide? ESS-5, LS-1

10. **Sequence** In the process of primary succession, what three stages would come before the one shown below? LS-4

11. **Interpret Data** In which biomes would you expect to find animals that require little water to survive?

Biome Annual Precipitation	
tundra	20 cm
desert	0.25 cm
rainforest	more than 250 cm
deciduous forest	80 cm

LS-4

12. **Critical Thinking** Why would you not expect to find algae in the abyssal zone of the ocean? LS-4

13. **Persuasive Writing** Write a speech to persuade your community to recycle. Explain why recycling is important. ESS-5

The Big Idea

14. How are ecosystems different? LS-C, LS-4

Performance Assessment

Succession in Action

What to Do

Identify a place where primary or secondary succession is taking place.

1. Write a short paragraph describing primary and secondary succession.
2. Think of an area you have visited or read about where succession is taking place. Observe or research the types of plants and animals that inhabit this place. Draw a diagram of your observations or research.
3. Write a report based on your observations and/or research. In your report, list the evidence that succession is taking place in the area you chose.

Analyze Your Results

- Make a prediction about what will happen to this area if it is not disturbed for 20 years.

Ohio Activity

Ohio is home to many different types of ecosystems, including wetlands, deciduous forests, and prairies. Research one of these ecosystems and find out what organisms live there. Plan a trip to the ecosystem. Be sure to include a list of what things you would need to pack if you stayed there for a week or longer. Share your plan with the rest of your class.

Ohio Benchmark Practice

1 **When humans burn many non-renewable fossil fuels, large amounts of carbon dioxide are released**

A into the water cycle.
B into the carbon cycle.
C into renewable resources.
D into nonrenewable resources.
ESS-5

2 **Why does every organism in an ecosystem rely upon producers?**

A Producers make their own food from sunlight.
B Producers eat consumers.
C Producers break down wastes.
D Producers recycle.
LS-B, LS-2

3 **The table below shows a list of threatened and endangered species in Ohio.**

Animal	Status
Lake Erie water snake	threatened
Piping plover	endangered
Bald eagle	threatened
Copperbelly water snake	threatened

In your Answer Document, name an animal that is in danger of becoming extinct, and include the difference between endangered and threatened species. Be sure to name two types of risks that organisms might face in their environment. (4 points)
LS-6, LS-4

4 **Which of the following is the best description of a pioneer species?**

A the first species to live in a barren area
B plants, such as trees, that form a climax community
C a species in danger of becoming extinct
D pollinators such as insects that attract large predators
LS-4

5 **The population of a particular species of butterfly is less than a quarter of what it was ten years ago. What might scientists conclude?**

A The population will increase over the next ten years.
B The butterfly has adapted to a new environment.
C The butterfly has become extinct.
D The butterfly's habitat may have been damaged.
LS-4, SWK-2

6 **Compared to plants that grow in the understory of a rain forest, plants in the canopy level require**

A less sunlight.
B no sunlight.
C more sunlight.
D the same amount of sunlight.
LS-4

7 An energy pyramid shows the amount of energy moving through a food web. Imagine an energy pyramid that has grass and flowers at the bottom, crickets in the middle, and birds at the top. Which conclusion can you draw based on the pyramid?

- **A** The food web has more birds than crickets.
- **B** The food chain has more flowers than blades of grass.
- **C** Crickets get most of the energy stored in plants.
- **D** Birds have the smallest amount of food energy available to them.

LS-B, LS-I

8 Scientists observe large shrubs growing in an area that was devastated by fire two years before. This is evidence of

- **A** a climax community.
- **B** primary succession.
- **C** a pioneer community.
- **D** secondary succession.

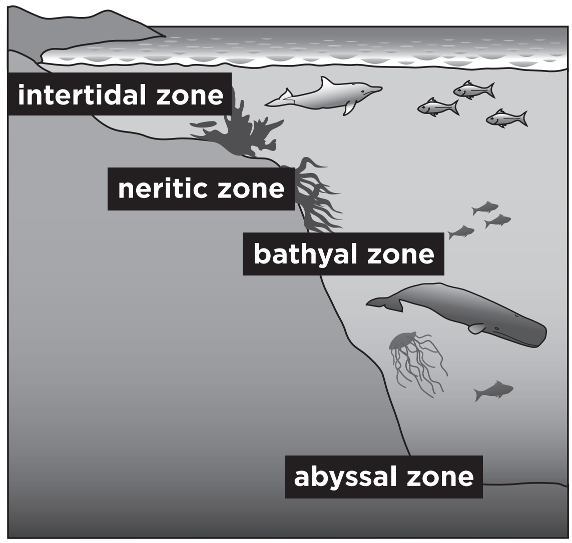
SI-3, LS-5

9 A scientist recorded the number of a certain type of fish in a freshwater lake over a period of ten years. During that time the average water temperature increased slightly each year, and the fish population decreased. Which is the independent variable in this investigation?

- **A** water temperature
- **B** type of fish
- **C** number of fish
- **D** water level

SI-4, LS-4

10 The diagram below shows ocean zones.



If an organism is adapted to daily changes in temperature, moisture, and water movement, it **most likely** lives in the

- **A** bathyal zone.
- **B** abyssal zone.
- **C** intertidal zone.
- **D** neritic zone.

SI-3, LS-4

11 Changes to an organism's ecosystem can be beneficial, neutral, or detrimental. In your **Answer Document,** describe one beneficial change in an organism's ecosystem and one detrimental change in an organism's ecosystem. (2 points)

LS-6

12 How are freshwater and ocean ecosystems similar?

- **A** They are limited by light, salt, and oxygen.
- **B** They support the same organisms.
- **C** They are divided into three zones.
- **D** They include fast-running and slow-moving ecosystems.

LS-4

Literature

National Wildlife Federation

Ranger Rick

Magazine Article

LS-5. Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including ... the availability of food and resources....

from *Ranger Rick*

Adventures in Eating

You just take a bite, chew, swallow, and that's that. Right? Well, dinner isn't always as cooperative as that. Some animals, like giraffes and anteaters, have special adaptations that help them succeed in their eating adventures!

How about dinner with a view? A giraffe uses its extra-long neck to stretch to the treetops. There, it munches on leaves—up to 34 kilograms (75 pounds) of them each day! Giraffes even eat the leaves of thorny acacia trees. The giraffe's long, flexible tongue weaves past the thorns, curls around a leaf, and tugs it free. If it grabs a thorn by mistake, thick, gooey saliva inside the giraffe's mouth and throat protects it from the sharp spines.

Giant anteaters have all the right tools to help them eat ants. Nose to the ground, the anteater sniffs out an ant nest. It makes a hole with a sharp claw, pokes in its long snout, and sticks out its tongue. This is no ordinary tongue. It is 2 feet long and covered with tiny spines and sticky saliva. It flicks in and out more than 150 times a minute, slithering through the tunnels where ants live and slurping as many as 30,000 of them a day.

Write About It

Response to Literature This article tells about different adaptations for eating. Research two more animals that have interesting adaptations. Write a report that explains how these adaptations help the animals eat. Compare these adaptations to the ones you read about in the article.

LOG ON e-Journal Write about it online at www.macmillanmh.com

Gardener

Think about a garden or park. Besides walkways and some playground equipment, what comes to mind? Chances are you will think about plants, such as trees, shrubs, grass, and flowers. The beauty of gardens and parks depends on the work of gardeners. These are people who plant seeds and then take care of the plants that grow. Do you like to work outdoors? Do you have a "green thumb"? If both your answers are "yes," then you might like a career as a gardener. As a high school graduate, you can get a job where you learn gardening skills as you work. Among the rewards of being a gardener is the enjoyment of the beauty you help to create.

▲ Gardeners work with many kinds of plants.

▼ This plant ecologist is observing pitcher plants.

Plant Ecologist

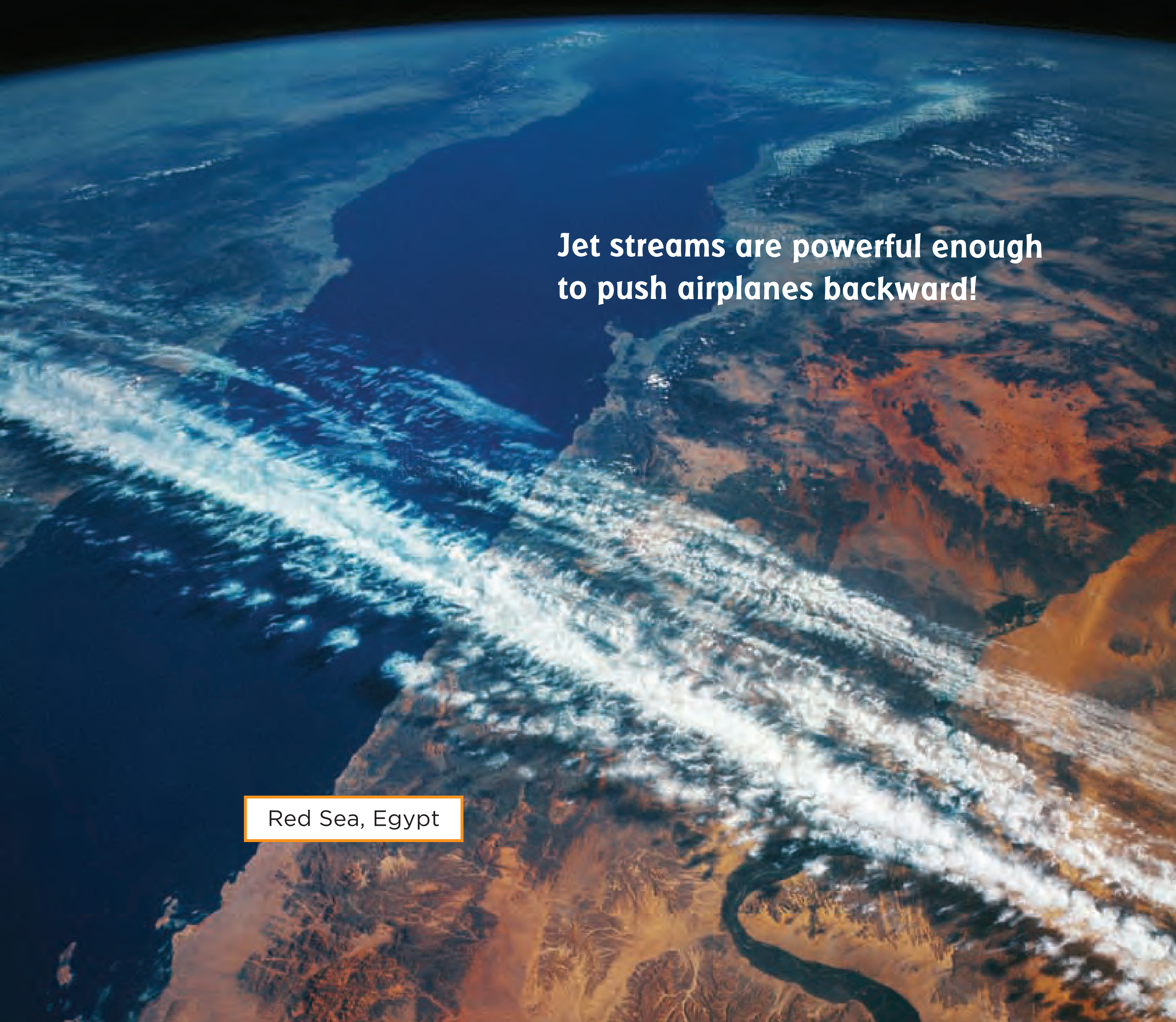
Do you have a strong love of nature, especially plants? If so, then you might want to become a plant ecologist. As a plant ecologist, you would do much of your work outdoors as well as in a laboratory. Plant ecologists study the interrelationships of plants and their environments. Their concerns include natural resources, the protection of endangered species, and conservation issues. For example, plant ecologists are concerned with wetland ecosystems. Many plants within that ecosystem are endangered, such as the pitcher plant. A bachelor of science degree is needed for a beginner in this field, after which you might do graduate work.

LOG ON e-Careers at www.macmillanmh.com

Ohio

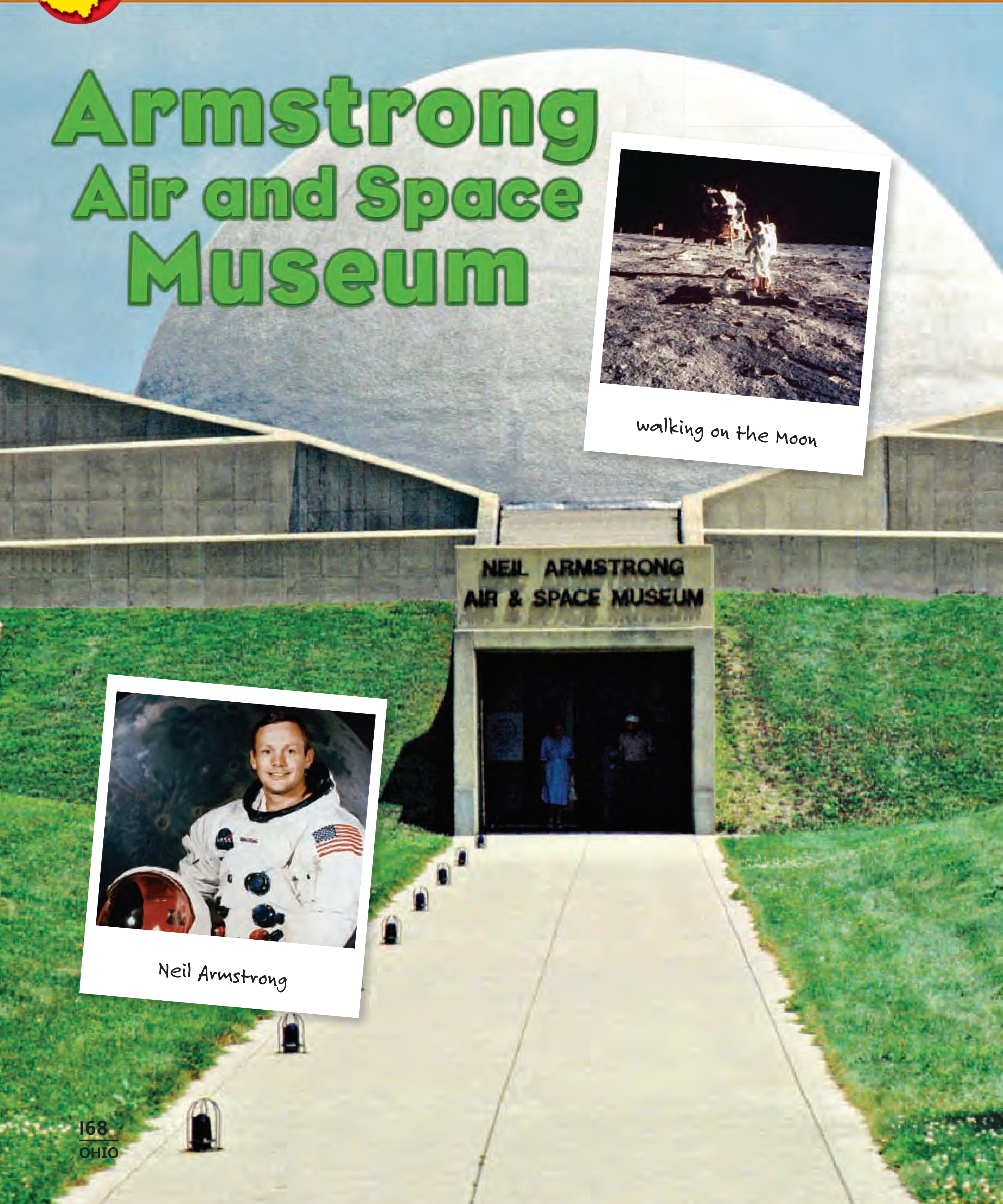
Earth and Space Sciences

Jet streams are powerful enough to push airplanes backward!



Red Sea, Egypt

Armstrong Air and Space Museum



walking on the Moon

Neil Armstrong

First in Flight

The Armstrong Air and Space Museum in Wapakoneta, Ohio, is named after astronaut Neil Armstrong. Located in his hometown, the museum honors Armstrong and many of Ohio's great accomplishments in space flight.

The Apollo program was developed in the early 1960s and its mission was to land a man on the Moon and return him safely to Earth. On July 21, 1969, Neil Armstrong became the first person to set foot on the Moon. The crew of *Apollo 11* collected rock samples and returned to Earth. These were the first samples taken from another planetary body. Since Neil Armstrong's first walk on the Moon, other astronauts have also walked there; however, the Moon is the only planetary body in space that astronauts have explored. Someday, astronauts may be able to walk on Mars.

Space Study

Not all missions to study our solar system involve sending people into space. Scientists can study space using satellites and space probes that do not carry crew members. *Voyager 2* is a space probe that contains cameras and other scientific instruments and has photographed Jupiter, Saturn, Neptune, and Uranus. It was launched in 1977 and is still exploring the solar system. The *Mars Pathfinder* was another probe. It included a rover called *Sojourner* that explored the surface of Mars and sent back photographs in 1997.

Think, Talk, and Write

Critical Thinking Why do you think astronauts have only been to the Moon?

ESS-2. Explain that Earth is one of several planets to orbit the sun, and that the moon orbits Earth.

Ohio

A CLOSER LOOK

Main Idea

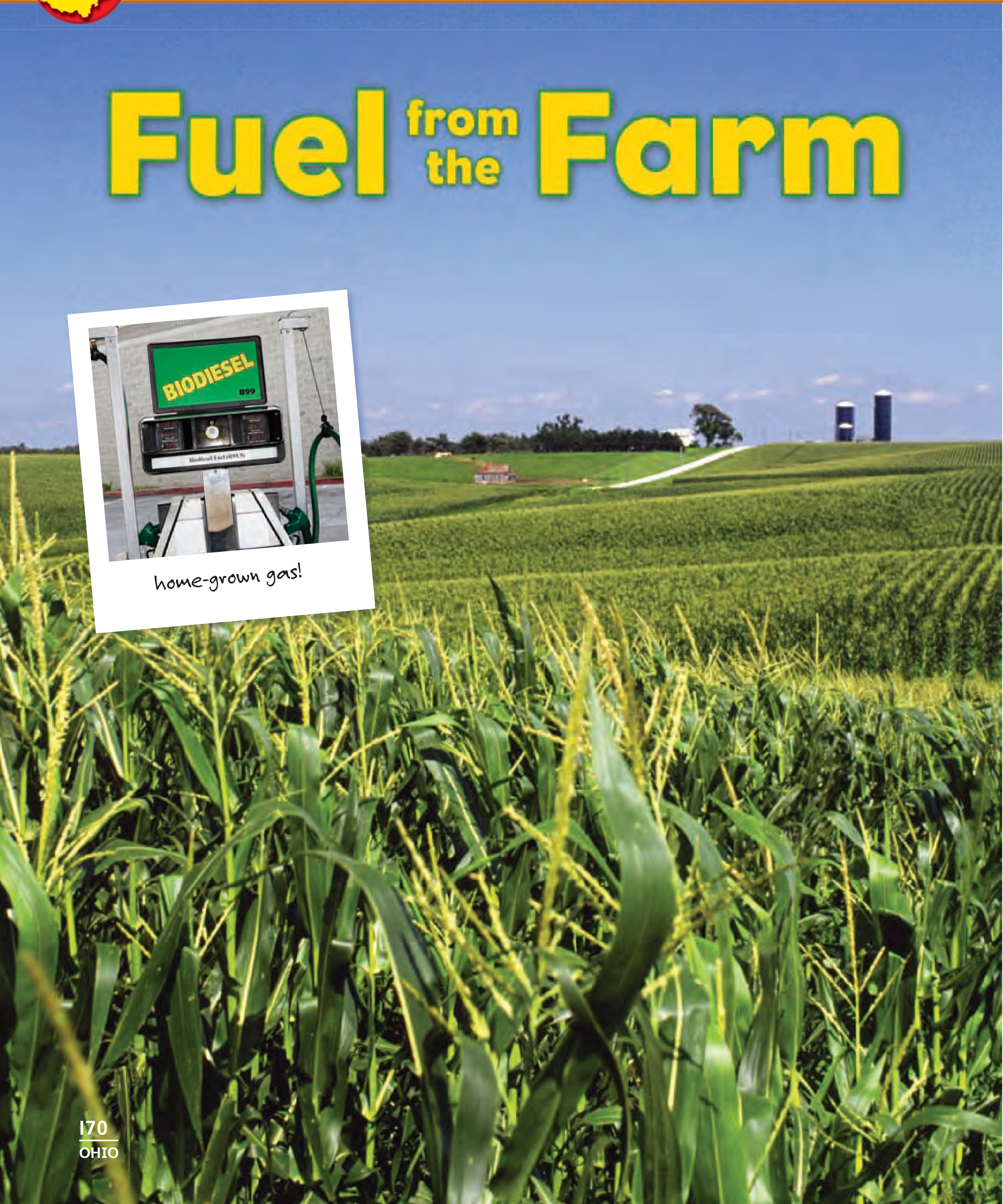
Astronauts have been to the Moon. Space probes and satellites can study and photograph other planets and moons.

Activity

Communicate Research human exploration in space.

- What spacecrafts have been sent to explore space?
- What have we learned about other planets and moons from these spacecrafts?
- Present your findings on a poster board to the rest of the class.

Fuel from the Farm



home-grown gas!

Corn-Powered Cars

Today, most cars and trucks are powered by fossil fuels. The Ohio Department of Agriculture in Reynoldsburg, Ohio, is trying to reduce our need for fossil fuels by changing what powers our vehicles. They're working on biofuels—alternative fuels that come from crops.

One biofuel is ethanol, an alcohol fuel. In Ohio ethanol is made from corn. When it is added to gasoline, it helps the gasoline to burn cleaner and cooler. Many cars already use some ethanol: Most fuel sold in Ohio is E10—a blend of 10 percent ethanol and 90 percent gasoline. Special cars, called Flexible Fuel Vehicles, can run on higher percentages of ethanol. Flexible Fuel Vehicles can use E85—a fuel with 85 percent ethanol and 15 percent gasoline. When using E85, these cars produce less pollution and don't use as much gasoline.

Soybeans at the Pump

Another alternative fuel made from crops grown in Ohio is biodiesel. Created from soybeans, biodiesel is an oil fuel that can be used in any diesel engine on the road today. Biodiesel is very similar to cooking oil. Like ethanol, the use of biodiesel results in less air pollution from vehicles.

Use of cleaner-burning fuels in cars and trucks means less air pollution and less impact on the environment. Because the fuels come from crops, they provide a renewable alternative to fossil fuels.

Think, Talk, and Write

Critical Thinking What are the possible disadvantages to using biofuels?

Ohio

A CLOSER LOOK

Main Idea

Biofuels are alternatives to fossil fuels made from plants.

Activity

Draw Conclusions
Research the costs of E85 ethanol fuel in your area and Flexible Fuel Vehicles that can operate on E85.

- Make a map showing where E85 can be purchased in your area.
- Make a list of the advantages and disadvantages of owning a Flexible Fuel Vehicle.

ESS-5. Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely.
ESS-6. Investigate ways Earth's renewable resources ... can be maintained.

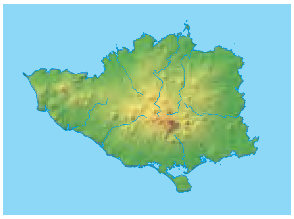
CHAPTER 4

Earth's Resources

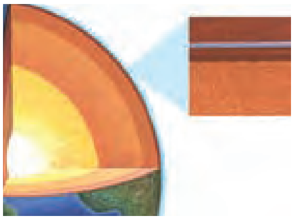
The Big Idea What are Earth's resources?

Planting saplings in a tree nursery

Key Vocabulary

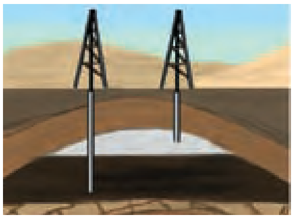


relief map
a map that uses shading to show elevations (p. 180)



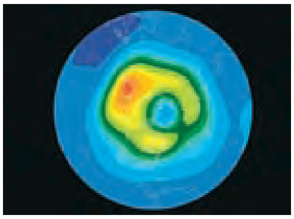
mantle
a nearly melted layer of hot rock below Earth's crust (p. 182)

soil horizon
any of the layers of soil from the surface to the bedrock (p. 189)



fossil fuel
a fuel formed from the decay of ancient forms of life (p. 199)

renewable resource
a resource that can be replanted or replaced in a short period of time (p. 203)



ozone
a gas that forms a layer in the atmosphere that screens out much of the Sun's ultraviolet rays (p. 220)

More Vocabulary

landform, p. 176

topographical map, p. 181

atmosphere, p. 182

hydrosphere, p. 182

crust, p. 182

outer core, p. 182

inner core, p. 182

soil, p. 188

humus, p. 189

topsoil, p. 189

pollution, p. 191

conservation, p. 192

fossil, 198

relative age, p. 200

absolute age, p. 200

era, p. 201

nonrenewable resource, p. 203

alternative energy source, p. 204

reservoir, p. 215

aquifer, p. 215

smog, p. 220

ESS-C. Describe Earth's resources including rocks, soil, water, air, animals and plants and the ways in which they can be conserved.

Lesson 1

Earth's Landforms

Look and Wonder

Looking down from above Earth's surface, you can see oceans, mountains, and rivers below. What do these features look like?

ESS-3. Describe the characteristics of Earth and its orbit about the sun....

Explore

Inquiry Activity

What are Earth's features?

Purpose

To examine and classify Earth's features.

Procedure

1. **Observe** Examine the photos.
2. List the features of Earth's surface that you can identify in these photos.
3. **Communicate** Describe how the features are similar and different.

Draw Conclusions

4. **Classify** Identify groups into which you could sort Earth's features.
5. **Infer** What processes might have produced one or more of the features you have identified?

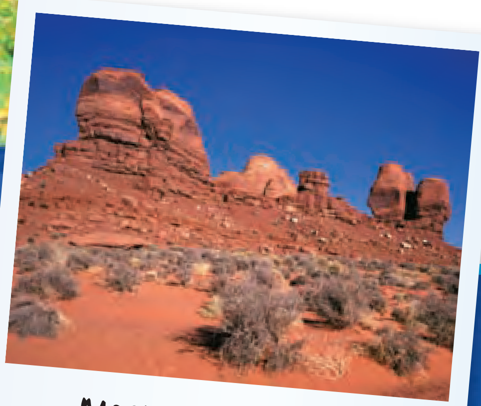
Explore More

Find photos of the Grand Canyon in Arizona. What do you think happens when water runs over rock for a long time? Form a hypothesis about how water was involved in forming the canyon. Design an experiment that would test your prediction.

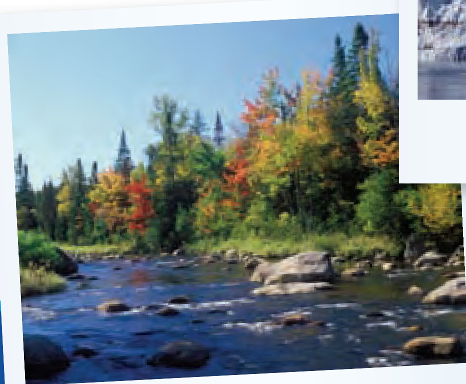
Cannon Beach, OR

Alaska Range, AK

Marjorie Glacier, AK



Monument Valley, AZ



Ausable River, NY

SI-3. Use evidence and observations to explain and communicate the results of investigations.

Read and Learn

Main Idea ESS-3

Each layer of Earth has its own features.

Vocabulary

landform, p. 176
relief map, p. 180
topographical map, p. 181
atmosphere, p. 182
hydrosphere, p. 182
crust, p. 182
mantle, p. 182
outer core, p. 182
inner core, p. 182

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Reading Skill

Classify

What are landforms?

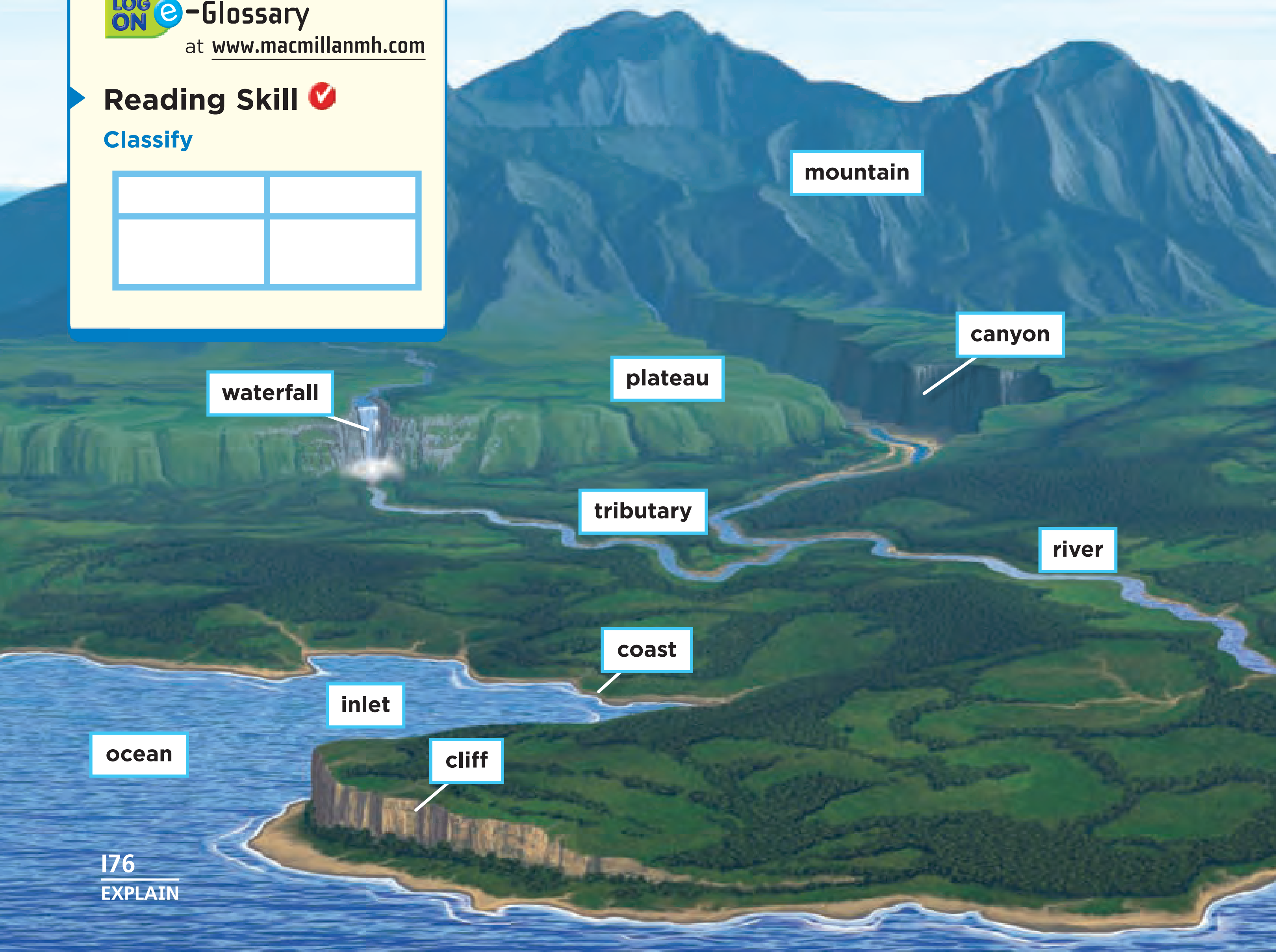
If you were to travel across the United States, what would you see? You might see sandy beaches or rocky shores. You would travel across hills, plateaus, mountains, deserts, and valleys. You would cross rivers and travel around lakes such as the Great Lakes. You might look into deep canyons.

All of these objects make up Earth's landforms. A **landform** is a physical feature on Earth's surface. Each landform has specific characteristics and each landform forms in a different way.

Quick Check

Classify What is the name for the land along the edge of a body of water?

Critical Thinking What are the landforms near you?

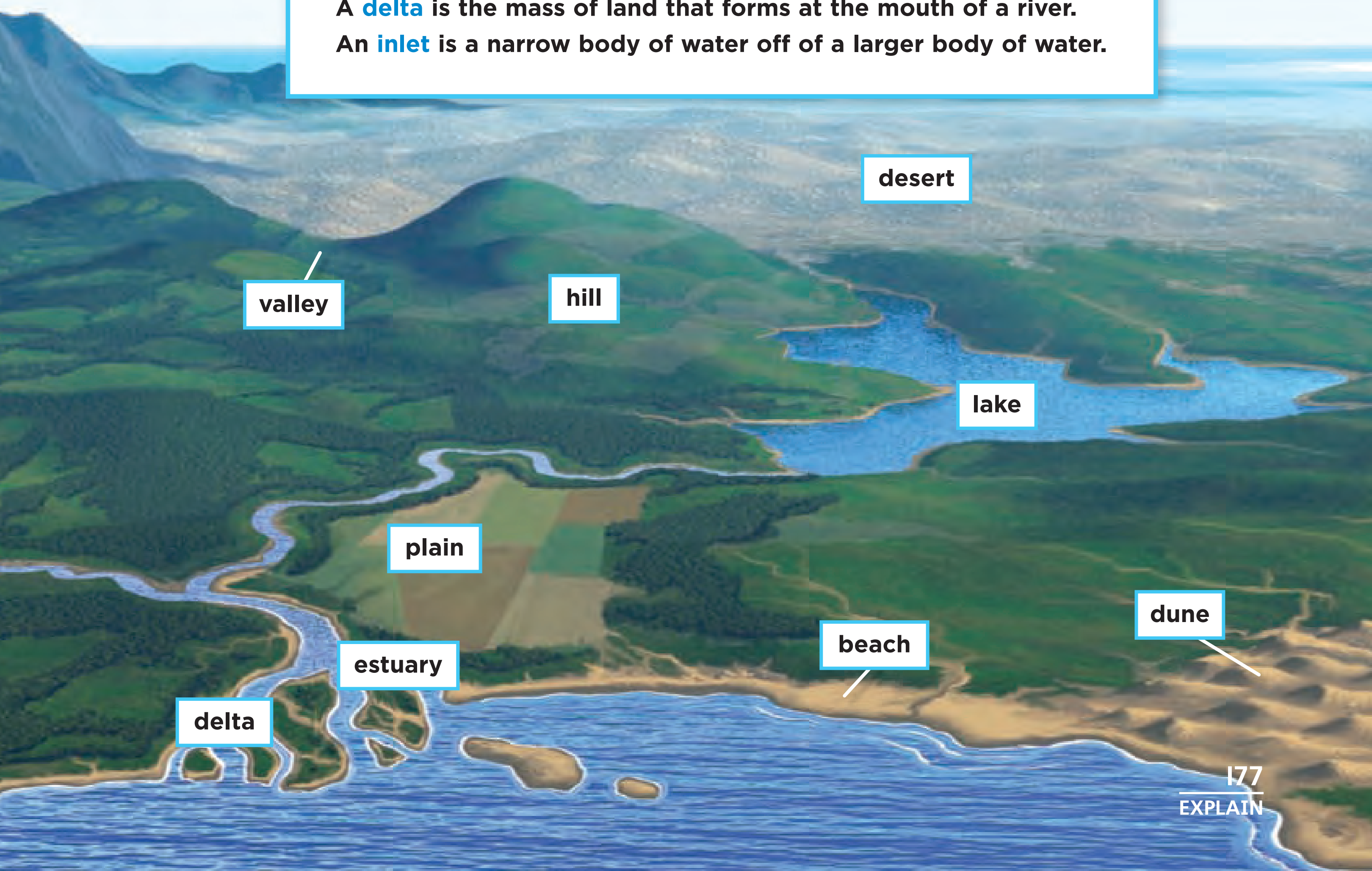


Earth's Land Features

A **mountain** is a landform that rises high above the ground.
A **hill** is lower and rounder than a mountain.
A **valley** is low land between hills or mountains.
A **canyon** is a deep valley with high, steep sides.
A **cliff** is a high, steep section of rock or soil.
A **plain** is a wide, flat area.
A **plateau** is flat land that is higher than the land around it.
A **desert** is an area with very little precipitation.
A **beach** is the land along the edge of a body of water.
A **dune** is a mound or ridge of sand.

Earth's Water Features

An **ocean** is a large body of salt water.
A **coast** is where a body of water meets land.
A **tributary** is a small river or stream.
A **river** is a natural body of moving water.
A **waterfall** is a natural stream of water falling from a high place.
A **lake** is a body of water surrounded by land.
An **estuary** is where river water and ocean water meet.
A **delta** is the mass of land that forms at the mouth of a river.
An **inlet** is a narrow body of water off of a larger body of water.



What are the features of the ocean floor?

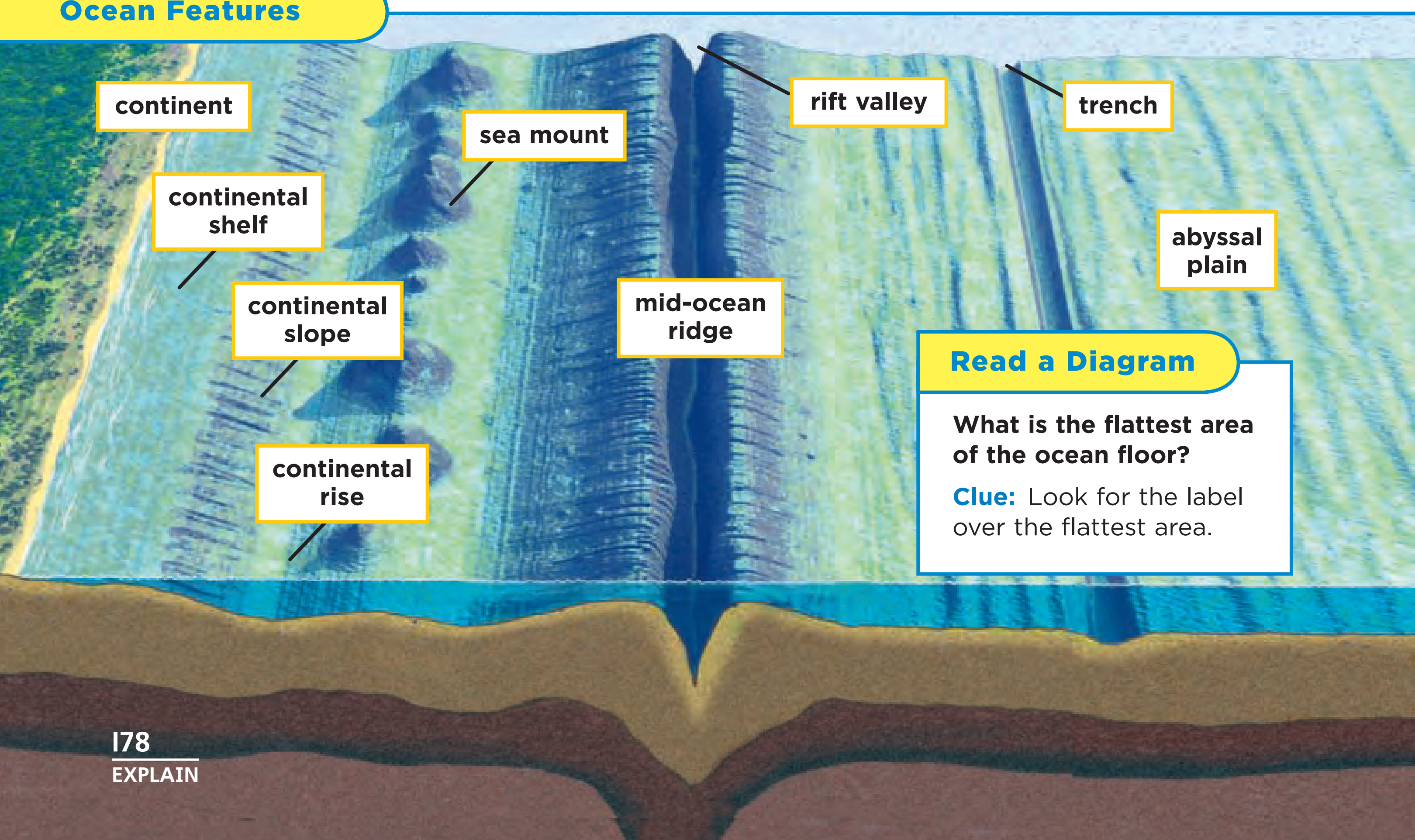
Although waves move over the surface of the ocean, the ocean's surface is mostly flat. However, if you could travel beneath the ocean's surface, you would find features on the ocean floor that look like mountains and valleys.

An ocean basin is a large underwater area between continents. Along the coast of a continent, the ocean floor is called the *continental shelf*. Here the ocean floor is covered by shallow water and gradually slopes down. A continental shelf ends at a point where a sharp slope begins. This sharp slope is called the *continental slope*.

A *submarine canyon* is a steep-sided valley in a continental slope. Submarine canyons often are found near the mouths of large rivers. At the end of a continental slope is another gradual downward slope called a *continental rise*.

The *abyssal plain* (uh•BIS•uhl playn) is a wide, flat area of ocean floor. Abyssal plains cover about 40% of the ocean floor.

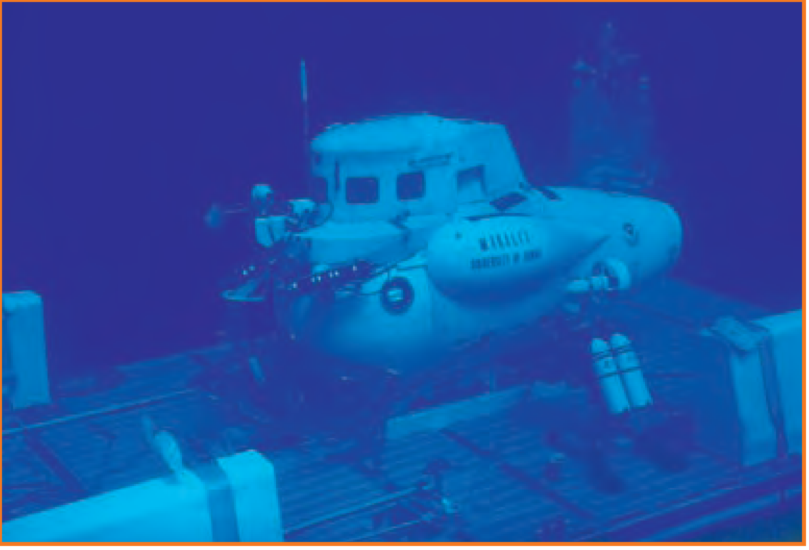
Ocean Features



Read a Diagram

What is the flattest area of the ocean floor?

Clue: Look for the label over the flattest area.



▲ This underwater vehicle explored the ocean around Hawaii.

Trenches are the deepest parts of the ocean floor. They are usually long and narrow. A *seamount* is an underwater mountain that rises from the ocean floor but stops before it reaches the surface of the ocean.

Mid-ocean ridges are underwater mountain ranges. An indentation called a *rift valley* occurs along the top of these mountains.

Scientists can tell the depth of the ocean floor by sending sounds into the ocean and waiting for the echo to come back. How do scientists know what the ocean floor looks like? Scientists use underwater vehicles to observe the ocean floor. These vehicles may carry cameras, instruments to measure the underwater environment, or mechanical arms to gather samples.

Quick Check

Classify Which ocean features are underwater mountains that do not reach the surface?

Critical Thinking How could rivers form submarine canyons?

Quick Lab

Mapping the Ocean Floor

1. Place soft clay in the bottom of a container to form features of the ocean floor.

2. Cover your container.
3. Exchange your container with another classmate.
4. **Measure** Gently drop a probe into each hole and measure how much of the probe sticks out of the hole. Record the depth of each square of the grid.

5. **Interpret Data** Use your probe measurements to figure out the height of the features, then draw and label them.
6. Remove the top of the container and compare your drawing to the ocean features.

How are Earth's features mapped?

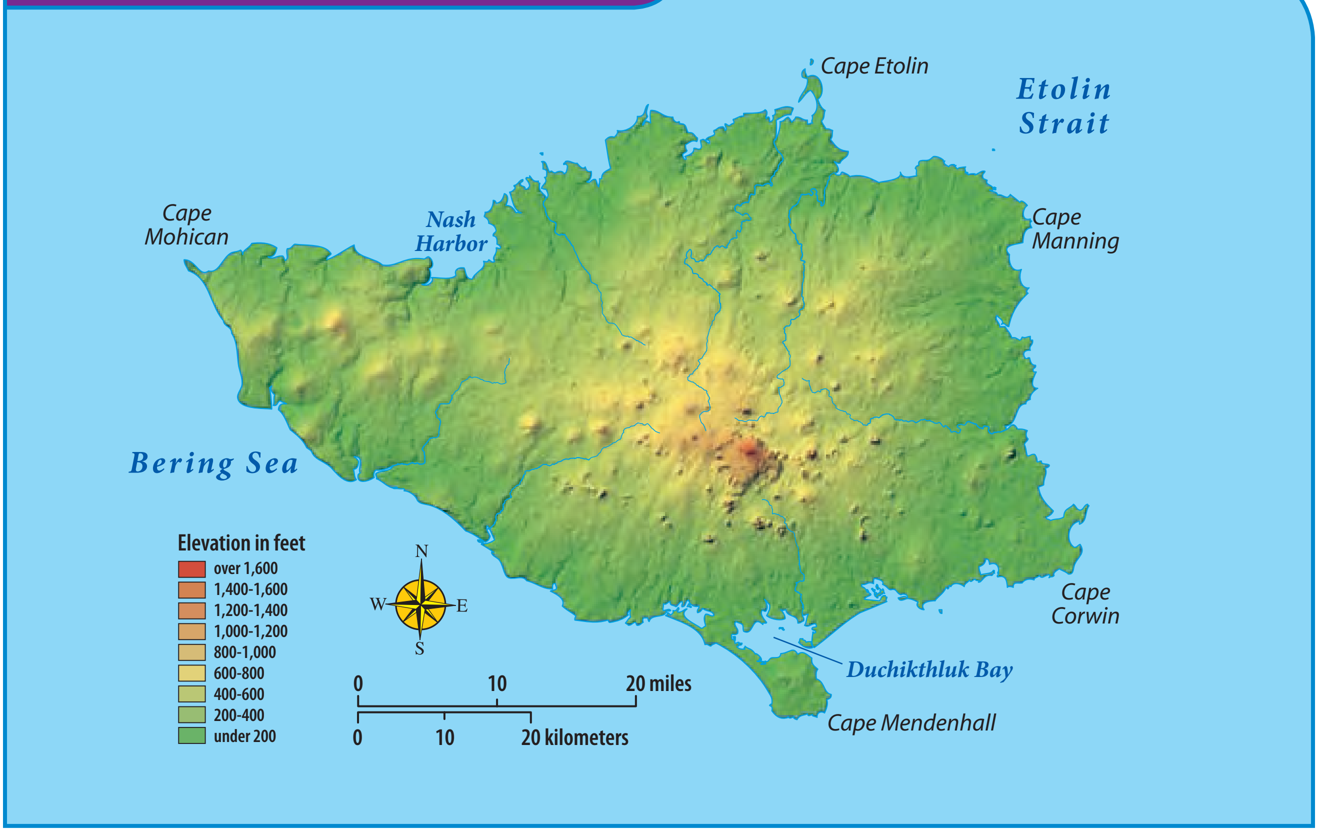
Earth's surface is uneven. Hills rise in one place, while valleys dip in another place. While some places are higher or lower than other places, maps of the surface are flat. How can a flat map show an uneven surface?

Relief Maps

A *surveyor* is a person who takes measurements of land. As the first step in making a map, a surveyor measures the elevation in a specific location. *Elevation* is the height of land above sea level. The surveyor may leave an object as a *benchmark,* or permanent reference point, for that elevation.

Mapmakers then use the surveyor's measurements to show changes in elevation on a map. One way to do this is to draw a shaded picture of the land. The shading makes a map look as if it has three dimensions: length, width, and height. The map, of course, really has only two dimensions: length and width. A map that uses shading to show elevations is called a **relief map**.

Relief Map of Nunivak Island, AK



Topographical Map of Nunivak Island, AK

Read a Map

What is the highest part of the island?

Clue: Look for close contour lines.

Topographical Maps

A map that uses lines to show elevation is called a **topographical map** (top•uh•GRAF•i•kuhl). Each *contour line* represents a different elevation. A number on the line gives the elevation. The number is usually in units of meters or feet.

In addition to elevation, contour lines can tell you how steep or gradual a slope is. Contour lines that are close together mean that elevation is changing rapidly and the slope of the land is very steep. Contour lines that are far apart mean that elevation is changing gradually.

Quick Check

Classify What kind of map uses shading to show elevations?

Critical Thinking While hiking, why would you avoid a route where a map shows contour lines that are very close together?

What are Earth's layers?

The air around you is Earth's atmosphere. The **atmosphere** (AT•muhs•feer) includes all of the gases around Earth.

All of Earth's liquid and solid water, including oceans, lakes, rivers, glaciers, and ice caps, makes up its **hydrosphere** (HYE•druh•sfeer). The hydrosphere covers about 70% of Earth's surface.

The rocky layer of Earth's surface is called the **crust**. The crust includes the continents and the ocean basins.

The layer of Earth's interior below the crust is called the **mantle** (MAN·tuhl). The mantle is divided into the upper and lower mantle. The top of the upper mantle is solid rock. The crust and the top of the upper mantle are the *lithosphere* (LITH•uh•sfeer).

The rest of the upper mantle is almost-melted rock. This layer is called the *asthenosphere*.

The lower mantle is solid rock. Below the lower mantle is the core, or the central part of Earth. The core is divided into the inner and outer core. The **outer core** is made of liquid metals, while the **inner core** is made of solid metals.

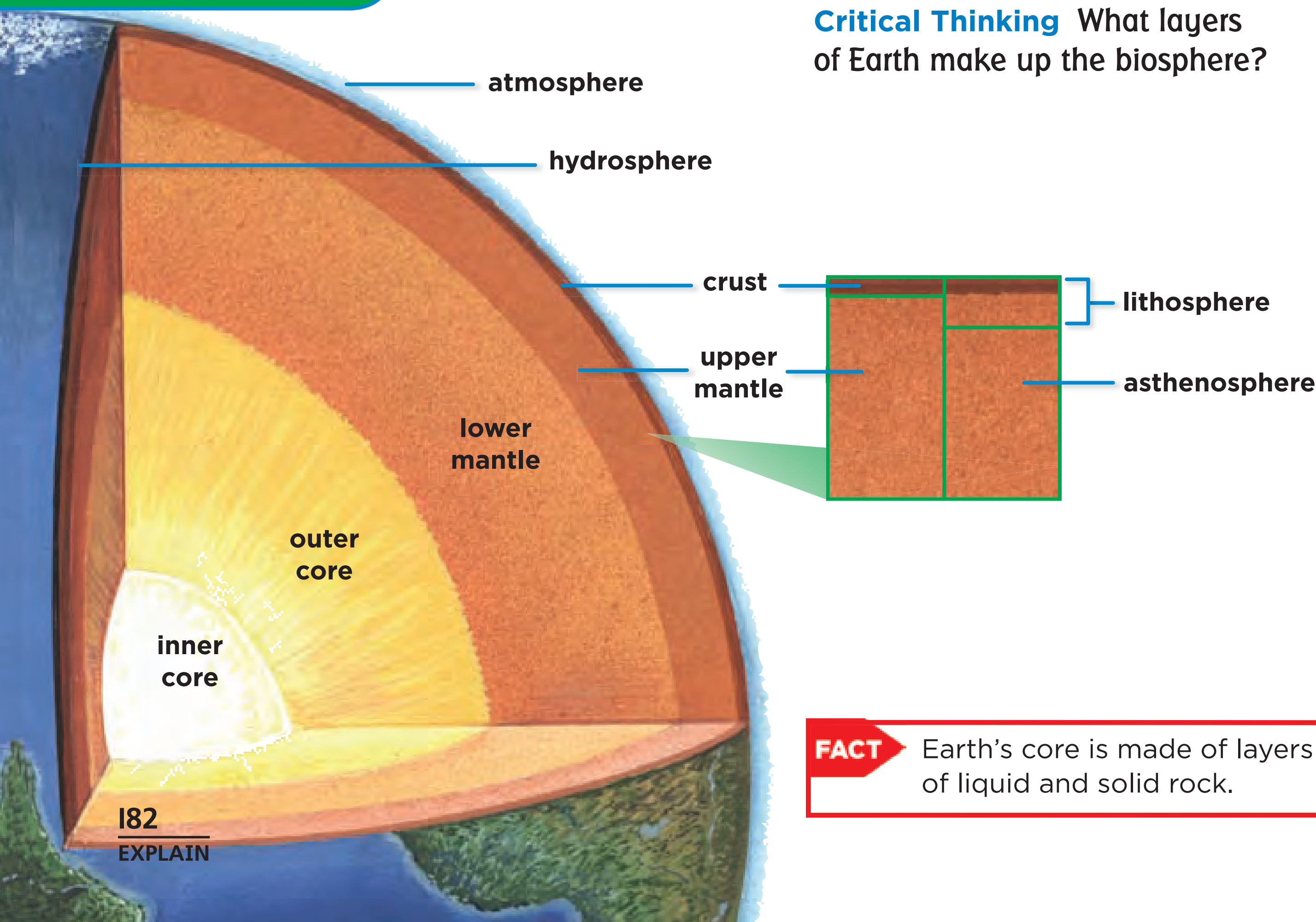
Earth's *biosphere* means the parts of Earth where living things are found. Organisms have been found from the lower atmosphere to the ocean floor.

Quick Check

Classify Is the lithosphere solid or liquid rock?

Critical Thinking What layers of Earth make up the biosphere?

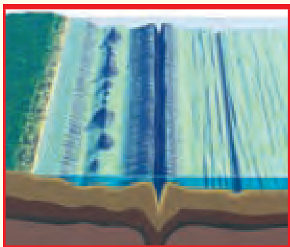
Earth's Layers



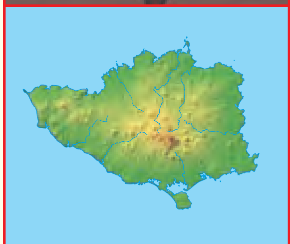
FACT Earth's core is made of layers of liquid and solid rock.

Lesson Review

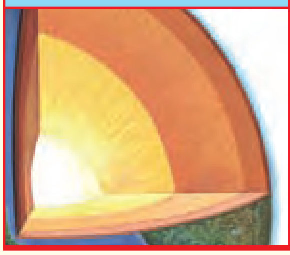
Visual Summary



Earth's surface and ocean floor are covered by landforms.



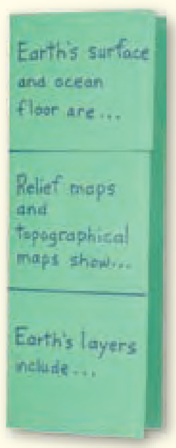
Relief maps and topographical maps show elevations on Earth's surface.



Earth's layers include the atmosphere, hydrosphere, crust, mantle, and core.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. Then write about what you have learned about those topics.



Think, Talk, and Write

1. **Main Idea** What are Earth's layers?
2. **Vocabulary** Mountains, valleys, deserts, and rivers are examples of ________.
3. **Classify** Which features of the ocean floor angle downward and which angle upward?

4. **Critical Thinking** How could a map showing elevation help you plan a hike?
5. **Test Prep** **What is an abyssal plain?**
   A an underwater mountain range
   B a steep-sided valley
   C a slope covered by shallow water
   D a wide, flat area of the ocean floor
6. **Test Prep** **What is the outermost solid layer of Earth called?**
   A hydrosphere
   B lithosphere
   C inner core
   D mantle

Writing Link

Explanatory Writing

Write about how a relief map is different from a topographical map. Give examples of circumstances under which you would want to use each type of map.

Social Studies Link

The Deepest Trench

The Marianas Trench in the Pacific Ocean is the deepest known trench in the ocean floor. Research the different depth measurements that have been taken and discuss how the depth measurements were made.

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Focus on Skills

Inquiry Skill: Make a Model

Models show the basic features of a structure or process. When scientists **make a model**, they simplify a process or structure that would otherwise be difficult to see and understand. Many scientists use laboratory materials or computers to make a model so they can explain an idea, an object, or an event.

Mt. Rainier

Learn It

What is the relationship between elevation and contour lines? Mapmakers use elevation measurements that are made by surveyors to make contour lines on maps. The surveyors use various instruments that can accurately measure distances. Telescopes, aerial photographs, and satellite images help them to get elevation measurements.

How can you understand the relationship between elevation and contour lines without those instruments? **Make a model** of a mountain and use it to make a topographical map to help you understand the relationship between contour lines and elevation.

Mt. Hood

Try It

Materials **soft clay, pencil, ruler, dental floss, graph paper**

1. **Make a Model** Form the clay into a mountain shape.
2. Using the pencil, poke a hole through the center of your mountain.
3. Measure the height of your mountain in centimeters.
4. Using the dental floss, cut a 1-centimeter slice off the top of the mountain.

5. Place the slice of mountain onto a piece of graph paper. Trace the edges of the slice and mark the location of the hole in the middle. Then put the slice to the side.

6. Cut the next 1-centimeter slice of mountain. Place it on the graph paper so the hole in the middle of the slice lines up with the spot you marked on the graph paper from the previous slice. Then trace the edges of this slice.

7. Cut, line up, and trace the rest of the slices of mountain. When you are finished with the bottom slice, put the clay mountain back together.

8. Is there a point on your topographical map where the lines are closer together? If there is, what does the mountain look like in this area?

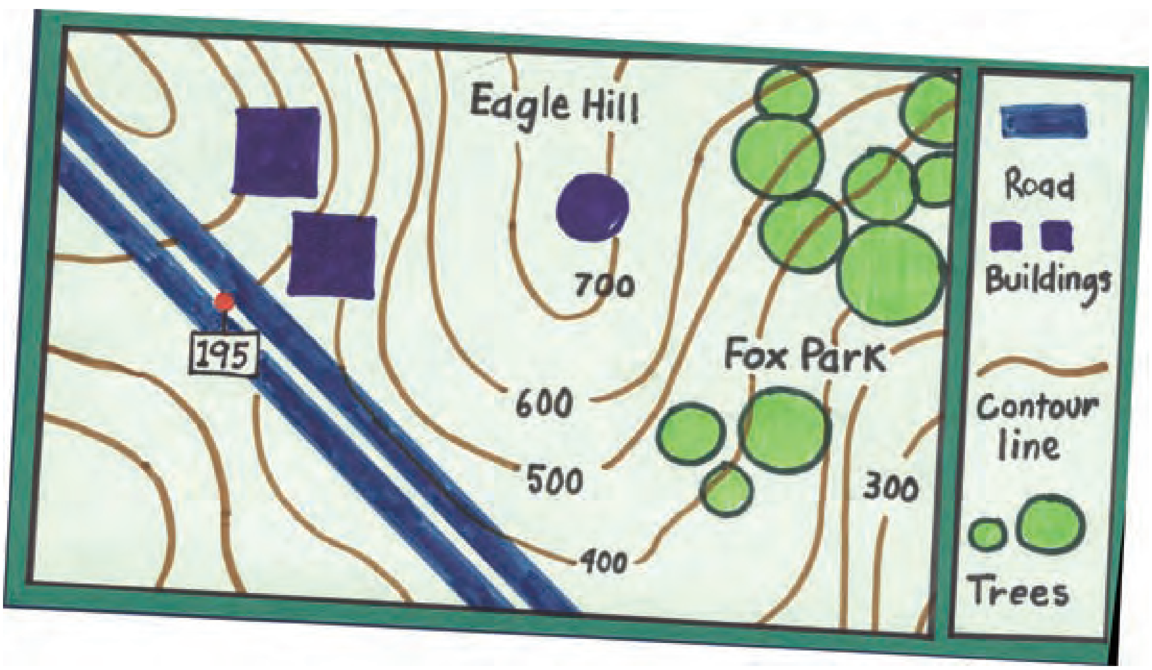
▶ Apply It

Now that you understand the relationship between elevation and contour lines, you can apply your understanding when reading topographical maps. The topographical map below shows a student's neighborhood with the contour lines measured in feet. Use the map to answer the following questions.

1. What is the lowest elevation on the map?

2. What is the highest elevation on the map?

3. The purple circle represents a school. What is its elevation?



SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.

Lesson 2

Soil

Look and Wonder

These young plants are growing in a field in Manitoba, Canada. Plants grow well in some types of soil but don't grow well in others. What is in soil that helps plants grow?

ESS-6. Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained.

Explore

Inquiry Activity

What is in soil?

Purpose

To examine the contents of a soil sample.

Procedure

1. **Observe** Use the toothpicks and hand lens to separate the contents of the soil sample.
2. **Record Data** Identify and list the different materials in the soil sample.

Draw Conclusions

3. **Classify** Does your soil sample contain nonliving things? What about once-living things?
4. Based on your observations, what are the contents of soil?

Materials

- toothpicks
- hand lens
- soil sample

Explore More

Collect and examine samples of soil from different places in your neighborhood. How do the contents of these samples compare with the one you studied in this activity? Do the additional samples change the conclusion you drew about the contents of soil?

SI-I. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others....

Read and Learn

Main Idea ESS-6

Soil is a natural resource made of a mixture of nonliving and once-living materials.

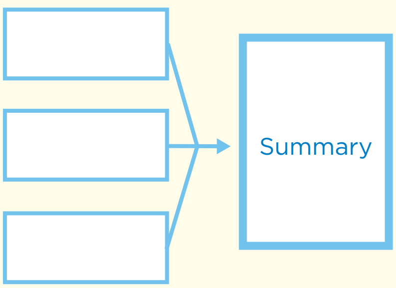
Vocabulary

soil, p. 188
soil horizon, p. 189
humus, p. 189
topsoil, p. 189
pollution, p. 191
conservation, p. 192

LOG ON e-Glossary at www.macmillanmh.com

Reading Skill

Summarize



What is soil?

If you watched the same rock over many years, you would see that as time passed, the rock weathered. Microscopic organisms would grow among the bits of rock. Some of these organisms would break down the rocks into chemicals that could nourish plants.

As the rock weathers, grasses would grow, followed by bushes and trees. Animals would come to eat the plants, and other animals would feed on the animals that fed on the plants. When the animals and plants die, their bodies add organic nutrients back to the soil. *Organic* means having to do with or coming from living things.

Soil is a mixture of bits of rock and bits of once-living parts of plants and animals. Soil covers most of Earth's landmasses. Without it, plants and animals would not be able to live on land.

Soil covers the ground in rain forests, grasslands, and deserts. The soils in these places look different, but they all started from rocks. As rocks weather, the soil forms in layers. If you dig a hole in the ground, you will see the layers as you dig deeper.

Soils in different locations look different, but they form in similar ways.

Soil Horizons

Each layer of soil is called a **soil horizon** (huh•RYE•zuhn). No matter where it is found, soil is divided into three horizons called A, B, and C.

The **A** horizon, which holds the most nutrients, contains humus (HYEW•muhs). **Humus** is the part of the soil that is made up of decayed organic materials. These materials are the remains of dead plants and animals that are decayed by microscopic organisms. Humus contains nutrients that feed plants. Humus also soaks up and holds water more easily than the bits of rock do.

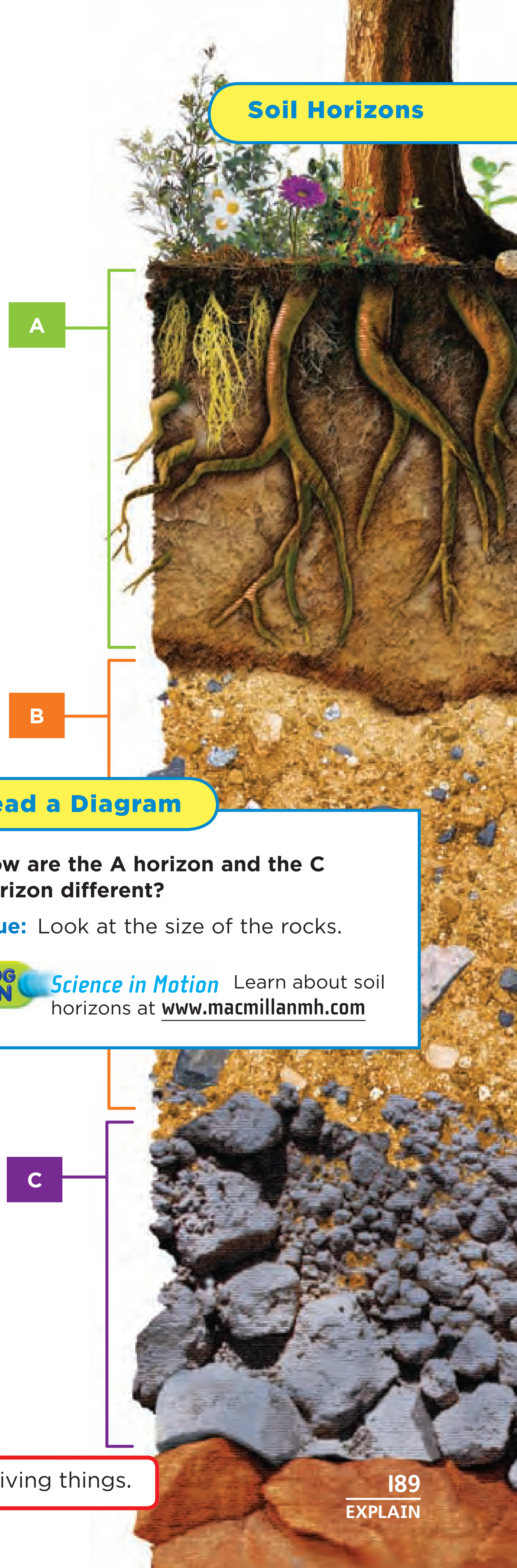
The soil in this horizon is called **topsoil**. Most plant roots grow in this soil. The roots absorb nutrients and water from humus.

The **B** horizon is called *subsoil*. You will find less humus in subsoil and lots of fine particles of rock, such as the particles that make up clay.

Next is the **C** horizon, which is made mostly of larger pieces of weathered rock. These soil horizons rest on solid, unweathered bedrock.

Different areas will have different depths of soil horizons. Some areas may not have one of these soil horizons.

Soil Horizons



Read a Diagram

How are the A horizon and the C horizon different?

Clue: Look at the size of the rocks.

LOG ON *Science in Motion* Learn about soil horizons at www.macmillanmh.com

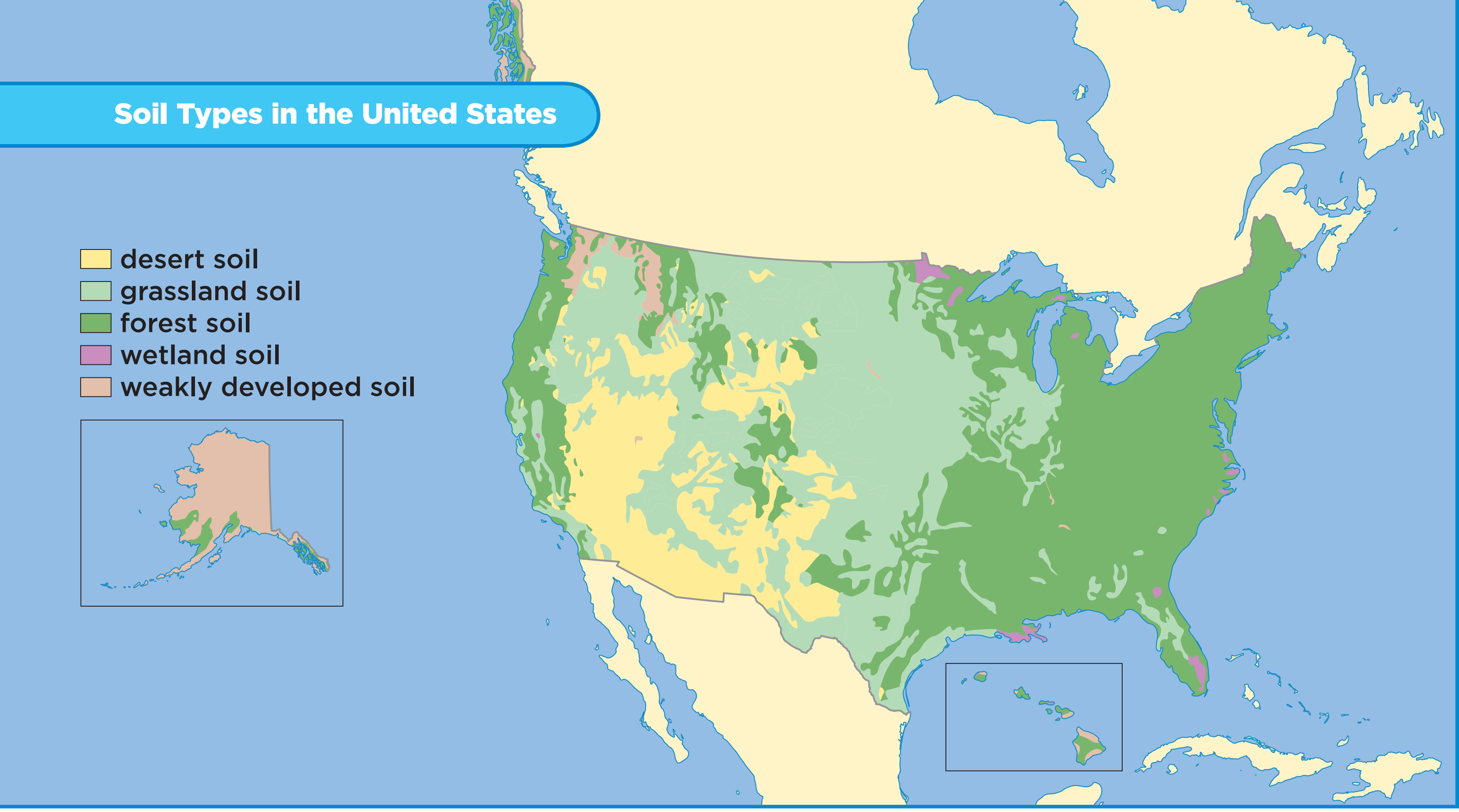
Quick Check

Summarize What are the main steps in the formation of soil?

Critical Thinking How could erosion change soil horizons and how plants grow in that soil?

FACT Soil only contains nonliving and once-living things.

Soil Types in the United States



How is soil used?

Soils in different places have different properties. Each type of soil supports different plant and animal life. Most of the United States is covered by three types of soil: forest soil, desert soil, and grassland and prairie soil.

The soil in a forest has a thin layer of topsoil with little humus. Frequent heavy rainfall carries minerals deep into the ground. Plants with shallow roots cannot reach these minerals. Crops with shallow roots do not grow well in such soil. Most of the forest soil in the United States is in the eastern third of the country.

Desert soil is sandy and does not hold much humus. Because desert areas receive little rain, plants have special adaptations to grow there. However, desert soil is rich in minerals since the minerals are not washed away by rain. Animals can sometimes be raised in areas with desert soil. Crops can only be grown if water for the plants is artificially piped to the area.

The grasslands and prairies of the United States are found between the Rocky Mountains and the country's eastern forests. Crops such as corn, wheat, and rye grow on land from Texas to North Dakota. The soil is rich in humus, which provides nutrients for crops. The humus holds water so minerals are not washed deep into the ground. Animals eat the grasses that grow naturally in this soil.

Soil is a resource. Like other resources, it can be used up, wasted, or spoiled. Soil can be eroded by flowing water and wind. Plant roots hold soil in place. If plants are removed, more soil may be eroded. This may change the type of plants that can grow in an area or make it difficult for any plants to grow.

The nutrients in soil are naturally removed by plants. The plants use the nutrients to grow and to build their body parts. The nutrients are normally replaced when plants die, fall to the ground, and decay. What happens when a farmer completely removes a crop from the land? Then there are no plants left behind to die and decay. The land becomes less able to support the growth of new crops.

Pollution (puh•LEW•shuhn) is the addition of harmful materials to soil, air, or water. Soil can be polluted by chemicals released onto the ground. It can also be polluted by chemicals used to kill insects and weeds. When people dump garbage on the ground, the garbage can also pollute soil.

Quick Check

Summarize What properties of soil are best for farming?

Critical Thinking How might insect pests be controlled without using chemicals that may pollute the soil?

Quick Lab

Soil Soaks Up Water

1. In a bowl, measure out topsoil and sand to make a soil mixture that you predict will hold water well.
2. ⚠ **Be Careful.** Using the point of a pen, punch an equal number of small holes in the bottom of three cups.
3. Fill one cup with topsoil, one cup with sand, and one cup with your mixture.

4. **Experiment** While holding the cup with the topsoil over a large measuring cup, pour 100 mL of water into the cup with soil. Allow the water to drain through the cup for 5 minutes.
5. Measure the water that passed through the soil.
6. Repeat steps 4 and 5 with the sand and with your mixture.
7. Calculate the amount of water that the soil soaked up.
8. **Interpret Data** Which type of soil holds the most water?

Farmers use chemicals to kill insects that eat crops, but these chemicals can pollute the soil that the crops need to grow.

How is soil conserved?

The preservation or protection of natural resources, including soil, is called **conservation** (kon•suhr•VAY•shuhn). Here are some methods of conserving soil:

Fertilizing Fertilizers containing one or more nutrients can be added to soil to replace nutrients used up by previous crops.

Crop Rotation Farmers can plant different crops on the same land in different years. They can choose crops that add the nutrients that have been removed by other crops.

Conserving Soil

Read a Photo

How does the method shown in the photograph conserve soil?

Clue: Look for patterns in the fields.

Strip Farming Plant roots help prevent soil from being washed or blown away. For this reason, farmers may plant grasses between rows of other crops.

Contour Plowing Rain water flows swiftly down hills and can carry away rich topsoil. Farmers can slow the speed with which water flows down the hill by contour plowing, or plowing furrows across the slope of a hill instead of plowing up and down the slope of the hill.

Terracing Terraces are flat shelves that are cut into a hillside. Crops are planted along each terrace. This also slows the speed of water flowing down a slope.

Wind Breaks Farmers plant tall trees along the edges of farmland to slow the speed of wind across the ground. Where there are trees, the wind is less likely to blow away topsoil.

Laws Governments may pass laws to stop the pollution of soil.

Individual Efforts You can avoid polluting soil with trash and help clean up land that has already been polluted.

Education You can help inform people of the value of soil and how to conserve it.

Quick Check

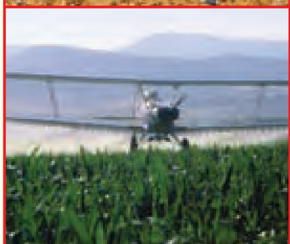
Summarize What methods are used to conserve soil?

Critical Thinking What might cause mountaintops to have little or no topsoil?

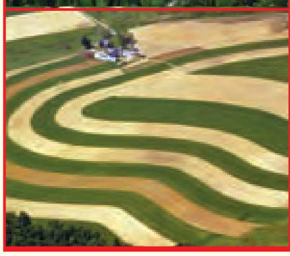
Lesson Review

Visual Summary

Soil is a mixture of bits of rock and bits of once-living parts of plants and animals.



Soil supports plant and animal life and can be polluted.



Soil can be conserved in many different ways.

Make a FOLDABLES™ Study Guide

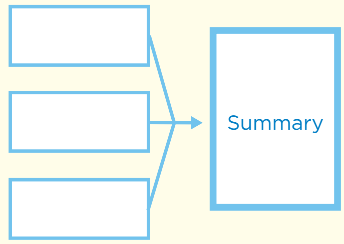
Make a Three-Tab Book. Use the titles shown. On the inside of each tab, summarize what you learned about that topic.

Think, Talk, and Write

1. **Main Idea** What is soil?

2. **Vocabulary** The part of soil that is made up of decayed organic materials is called ________ .

3. **Summarize** Describe the methods used to protect soil from erosion by water.



4. **Critical Thinking** Compare and contrast forest soil with desert soil.

5. **Test Prep** **What is the C horizon of soil made of?**
   - **A** clay
   - **B** humus
   - **C** bedrock
   - **D** large rocks

6. **Test Prep** **What is strip farming?**
   - **A** adding fertilizer to soil
   - **B** cutting shelves in hills
   - **C** planting grasses between crop rows
   - **D** planting trees around crops

Writing Link

Conserve Soil!

Make a leaflet or flyer designed to persuade your neighbors to conserve soil. Explain why the soil in your area should be conserved and suggest ways people can conserve it.

Social Studies Link

The Dust Bowl

Research the Dust Bowl of the 1930s. Write an essay describing the causes of the Dust Bowl and how it affected people in the United States.

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Be a Scientist

Materials

2 pans

potting soil

ruler

sand

grass seeds

2 measuring cups with water

Structured Inquiry

Which soil is better for plant growth?

Form a Hypothesis

Different types of soil are made of different materials. Sand is a type of soil made from small pieces of rocks. Potting soil is made from bits of sticks and leaves. How fast will grass seeds grow in potting soil compared to sand? Write your answer as a hypothesis in the form "If grass seeds are planted in potting soil and in sand, then . . ."

Test Your Hypothesis

1. Fill one pan with potting soil until the soil is 1 inch deep. Fill the other pan with sand until the sand is 1 inch deep.
2. Evenly scatter grass seeds over each pan.
3. Place the pans in the sunlight.
4. Every other day, pour the same amount of water on the seeds in both pans.
5. **Observe** What do the pans look like after three days? After one week?

Draw Conclusions

6. Why is it important to make sure the pans get the same amount of light and water?
7. **Infer** What differences between the potting soil and the sand may have affected the plant growth?

Guided Inquiry

What effect does pollution have on plants?

Form a Hypothesis

You now know the type of soil in which plants will grow faster. How fast will plants grow in polluted soil? Write your answer as a hypothesis in the form “If grass seeds are planted in soil and polluted soil, then . . .”

Test Your Hypothesis

Design an experiment to investigate how fast plants will grow in polluted soil compared to unpolluted soil. List the materials you need and the steps you will follow. Record your observations and results.

Draw Conclusions

Did your results support your hypothesis? Why or why not? Present your results to your classmates.

Open Inquiry

How efficient are conservation methods that slow down the flow of water over soil? Think of a question and design an experiment to answer it. Your experiment must be organized to test only one variable. Keep careful notes as you do your experiment so another group could repeat the experiment by following your instructions.

Remember to follow the steps of the scientific process.

Ask a Question
↓
Form a Hypothesis
↓
Test Your Hypothesis
↓
Draw Conclusions

ST-I. Investigate positive and negative impacts of human activity and technology on the environment.

Lesson 3

Fossils and Energy

Look and Wonder

These windmills are located near Palm Springs, CA. They turn moving air into energy that can be used to move objects or make electricity. How can a windmill move objects?

ESS-6. Investigate ways Earth's renewable resources ... can be maintained.
ESS-5. Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling....

Explore

Inquiry Activity

How can wind move objects?

Form a Hypothesis

How many paper clips do you think you can move with your breath using a windmill? Write your answer as a hypothesis in the form "If the speed of the wind against a windmill blade increases, then . . ."

Test Your Hypothesis

1. Wrap the 8-cm by 15-cm strip of paper around the pencil. Have a partner tape the edges of the paper together to form a tube.
2. Tape the 5-cm side of the 8-cm by 5-cm strips to the tube of paper near one end of the tube to make blades for the windmill. Space the strips so they are equally far apart.
3. Tie one paper clip to the string. Tape the other end of the string to the paper tube.
4. Hold the ends of the pencil and blow on the paper strips. What happens to the paper clip?
5. **Experiment** Now attach more paper clips to that one. How many paper clips did you add before your breath could no longer lift them?

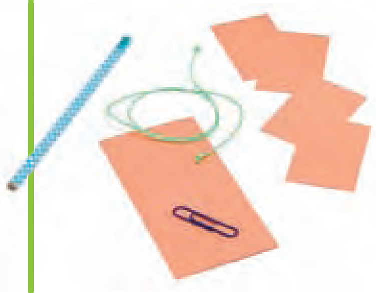
Draw Conclusions

6. How is the energy from your breath used to raise the paper clip?
7. **Infer** If you used larger rectangles for windmill blades, what do you think would happen to the number of paper clips you could lift?

Explore More

What result do you think you would get with different-shape blades? Think of a shape to test and come up with a design. Share your design with your classmates. Work together to find the best design.

Materials



- 8 cm by 15 cm strip of paper
- new pencil
- tape
- four 8 cm by 5 cm strips of paper
- paper clips
- string

Step 1

Step 3

SI-2. Revise an existing design used to solve a problem based on peer review.

Read and Learn

Main Idea ESS-6, ESS-5

Ancient organisms became fossils and fossil fuels. Fossil fuels are nonrenewable resources, so renewable sources of energy are also used.

Vocabulary

fossil, p. 198
fossil fuel, p. 199
relative age, p. 200
absolute age, p. 200
era, p. 201
nonrenewable resource, p. 203
renewable resource, p. 203
alternative energy source, p. 204

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Reading Skill

Fact and Opinion

Fact	Opinion

What are fossils?

Fossils (FOS•uhlz) are the remains or traces of ancient organisms preserved in soil or rock. Sometimes when an organism died its remains were covered with soil, sand, or some other sediment. Over many centuries, these sediments hardened over and around the organism's remains. Almost all fossils are found in sedimentary rock.

Scientists also can use fossils to learn more about ancient environments. Scientists know that modern animals that live in a warm climate have certain characteristics. What could scientists conclude if they examined fossils from Antarctica and saw that these fossils have characteristics of warm-climate animals? The scientists could conclude that Antarctica, which is now cold, was once much warmer.

Sometimes different characteristics are shown by comparisons of the bones of modern animals to fossilized bones. In the 1880s, the fossilized bones of an organism named *Smilodon* were discovered. *Smilodon* is a type of large cat popularly known as a saber-toothed cat because of its large fangs. The fossilized fangs are larger than the fangs of modern lions and tigers. Scientists generally agree that *Smilodon* used its fangs for hunting. However, scientists are not sure whether *Smilodon* used its fangs to grab or to bite prey.

Compare the teeth of the modern tiger (left) to the *Smilodon* skeleton (center) and *Smilodon* model (right).

Fossil Fuels

Millions of years ago, plants used the energy in sunlight to build their bodies. In the process, they stored the Sun's energy as sugars and starches. The plants eventually died and fell to the ground. Layers of sediment built up on top of this layer of dead plants.

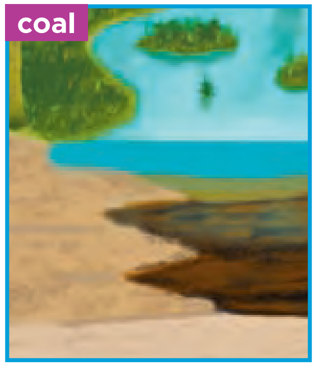
Over millions of years, pressure from the weight of the layers of sediment pressed the dead plants together and formed *peat*. As the peat hardened, it turned into a sedimentary rock called *bituminous coal* (bye•TEW•muh•nuhs kohl), or soft coal. As it was buried even deeper, this coal was changed into a metamorphic rock called *anthracite* (AN•thruh•site), or hard coal.

Bituminous coal and anthracite are types of fossil fuels. A **fossil fuel** is a material that formed from the decay of ancient organisms and is used today as a source of energy.

Sometimes, partly decayed parts of ocean organisms were buried deep under the ocean. There, a combination of the weight of rock, heat, and the action of bacteria turned the decayed materials into oil and natural gas. Oil and natural gas also are fossil fuels.

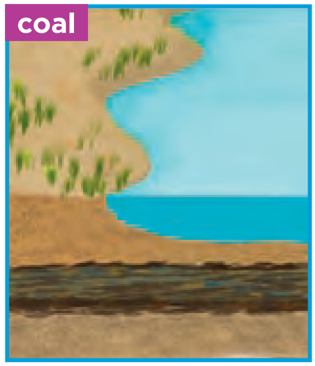
Over time, natural gas and oil fill up connected spaces between rocks. Natural gas is often found above oil. Today, in many parts of the world, oil and natural gas are pumped from deep beneath the ocean floor. Oil and natural gas also are now found beneath land that used to be covered by oceans.

How Fossil Fuels Are Formed

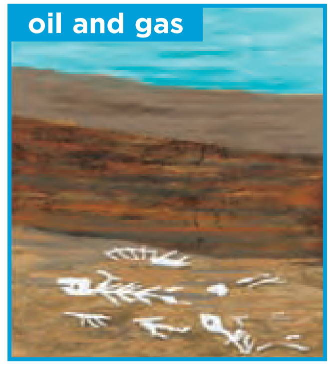


Dead organisms in a swamp form peat.

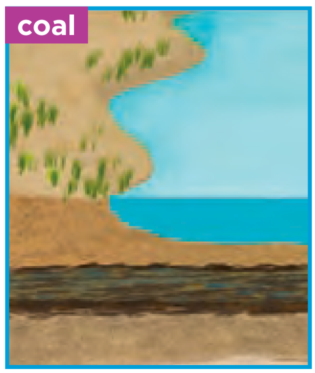
Dead organisms fall to the ocean floor.



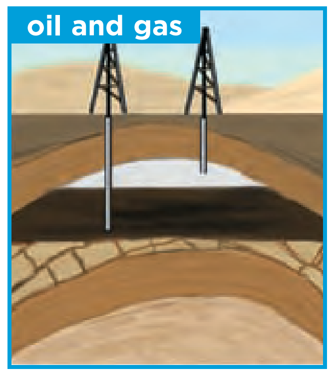
Peat is covered with layers of sediment.



The dead organisms are buried in sediment.



Pressure turns peat into coal.



Pressure forms oil and gas.

Quick Check

Fact and Opinion Most people like to hunt fossils. Is this an opinion?

Critical Thinking What happens to igneous rocks that makes finding fossils in them unlikely?

How old are fossils and fossil fuels?

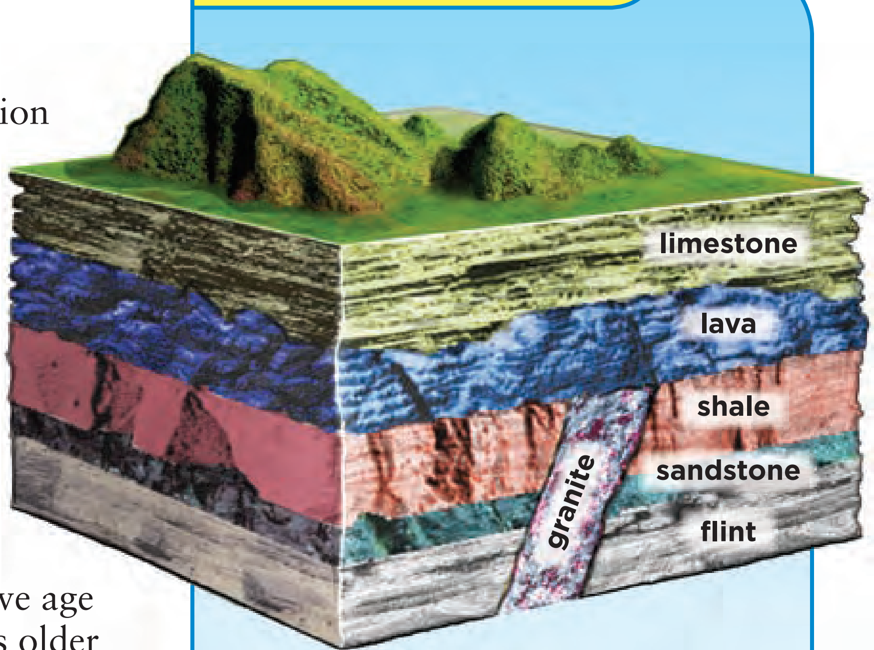
Fossils can provide information about whether an organism is older or younger than other organisms. In general, each layer of rock is older than the layer above it and younger than the layer below it. This is called the *law of superposition*.

If you found one fossil in a top layer of rock and another fossil in a lower layer, the relative age of the fossil in the lower layer is older than the fossil in the higher layer. The **relative age** of a rock is how old it is compared to another rock.

Although you know that the bottom fossil is older, how can you tell whether it is 50,000 years old, 500,000 years old, or 5,000,000 years old? The **absolute age** is the age of a fossil in years. To find the absolute age of a fossil, you have to find out the absolute age of the rock in which the fossil was found. Since the fossil formed when the rock formed, the fossil is the same age as the rock.

How can you tell how old a rock is? All rocks contain different elements. Some of these elements change into other elements in constant ways.

Law of Superposition



Read a Diagram

Which rock layer is older, the lava or the sandstone?

Clue: Compare the position of the layers.

For example, element A changes into element B over time. If half of element A changes into element B every 1 million years, after 1 million years have passed, the rock holds equal amounts of elements A and B.

The time it takes for the amount of an element to be cut in half is called the element's *half-life*. The half-life of element A is 1 million years. Different elements have different half-lives.

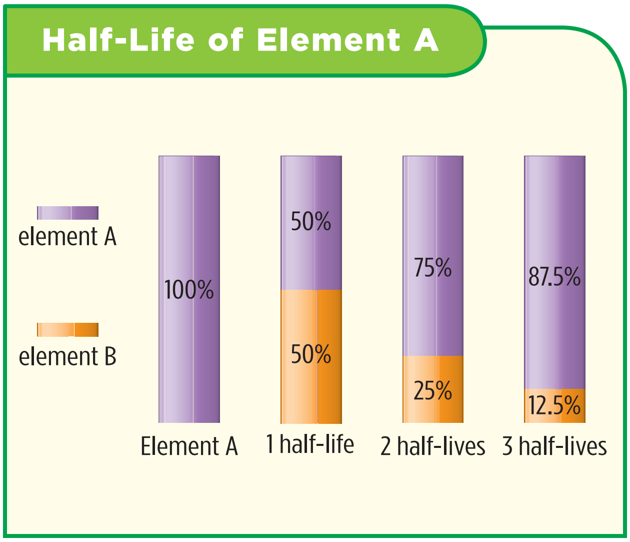
Geological Eras

PRECAMBRIAN

PALEOZOIC – AGE OF ANCIENT LIFE

CAMBRIAN | ORDOVICIAN | SILURIAN | DEVONIAN | CARBONIFEROUS | PERMIAN

(b) Phil Degginger



Scientists have used the relative and absolute ages of fossils to develop a history of Earth since its formation about 4.6 billion years ago. When describing the age of Earth, scientists use units called eras (EER•uhz). An **era** is a unit of time measured in millions of years. A geologic period divides an era into a smaller unit of time.

Fossil fuels formed during the Carboniferous period, which was between 350 million and 280 million years ago. During this time, the land was covered with swamps filled with large leafy plants. Over millions of years, these plants were buried and turned into fossil fuels. As the tectonic plates moved, the fossil fuels moved. Coal is now found in northern Europe, Asia, and midwestern and eastern North America.

Quick Lab

Half-Life of a Penny

1. **Record Data** Count the total number of pennies that you were given.
2. Place all of the pennies in a box so they are heads up.
3. **Experiment** Close the box and shake it to mix the pennies.
4. Open the box and remove all the pennies that have turned tails up. Set them aside.
5. Record the number of pennies remaining in the box.
6. Repeat steps 2–4 until one or no pennies remain in the box.
7. How many pennies were removed after each shake?
8. What is the “half-life” of a penny?

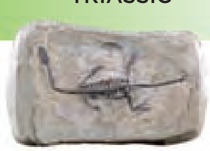
Quick Check

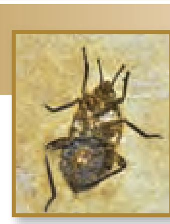
Fact and Opinion A fossil in a 2-million-year-old rock is 2 million years old. Is this a fact or an opinion?

Critical Thinking Could you tell the relative age of a fossil if layers of rock have been shifted by earthquakes?

MESOZOIC – AGE OF DOMINANT REPTILES | CENOZOIC – AGE OF DOMINANT MAMMALS

TRIASSIC | JURASSIC | CRETACEOUS | TERTIARY | QUATERNARY





(bl, br) Phil Degginger

How are fossil fuels used?

When fossil fuels are burned, they release energy from the sunlight that was stored in the dead plants and in the animals that ate them. People can either turn the stored energy into a different kind of energy or use it to do work.

For example, in a car, gasoline releases energy that runs the car's engine. The energy released from burning oil also is turned into heat energy and used to warm buildings. Natural gas can be burned in a stove to cook food or in a furnace to heat a home.

Electricity is a form of energy that people use every day. Electricity is used to light homes, schools, office buildings, and streets. It is used to run equipment from clocks and elevators to DVD players and computers.

Most of the electricity that people use is made in power plants. In a power plant, energy is used to make an electric generator move. As the generator moves, electricity is produced. The electricity then travels through wires to places where it is used, such as your home.

Coal power plants burn coal to produce electricity.

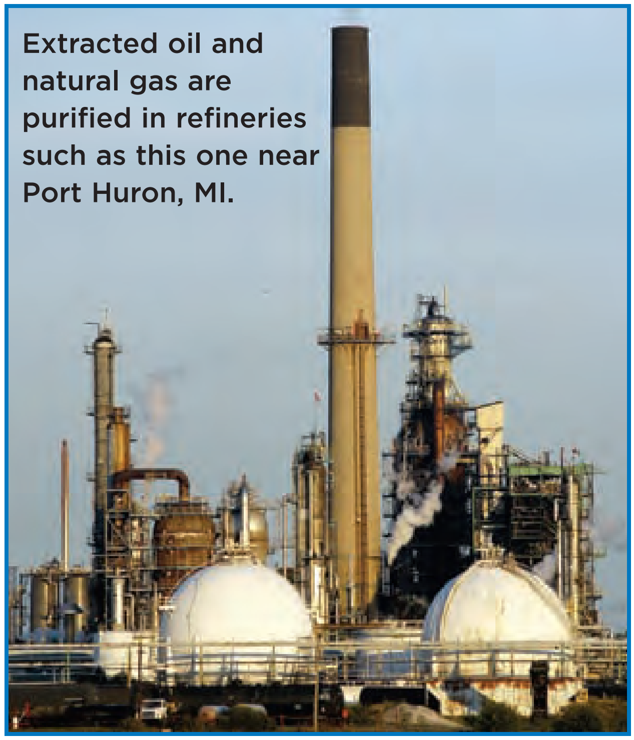
Drilling rigs extract oil and natural gas from underneath the ocean floor.

Power plants get the energy to run electric generators from sources such as coal, oil, and natural gas. However, these are nonrenewable resources (non•ri•NEW•uh•buhl). A **nonrenewable resource** is one that can be used up faster than it is made. It took millions of years to make the oil, natural gas, and coal that we use today, but we may use up these resources in only hundreds of years.

Renewable Resources

Earth also has renewable resources. A **renewable resource** is a living or nonliving resource that can be replaced naturally. Wind, water power, and sunlight are considered nonliving renewable energy sources.

Living renewable resources include such things as fish and forests. Living renewable resources must be treated with care. It is possible to use populations of living things faster than they can reproduce. Once completely gone, a living thing cannot be replaced.



Extracted oil and natural gas are purified in refineries such as this one near Port Huron, MI.

Quick Check

Fact and Opinion Fossil fuels are made from decayed plants and animals. Is this statement a fact or an opinion?

Critical Thinking Why are wind, water, and sunlight renewable energy sources?

How can the Sun, wind, and water make energy?

Our planet provides other sources of energy that could be used to make electricity, keep us moving, and keep us warm. Any source of energy other than fossil fuels is called an **alternative energy source** (awl•TUR•nuh•tiv EN•uhr•jee sawrs). Alternative energy sources include wind, moving water, and *solar energy*, or energy from the Sun.

The energy from these sources can be used to do work. Sunlight can heat water, air, or other materials. It can also be turned into electricity. The energy in wind and moving water can be used to move machines and make electricity.

Energy from Wind

Wind is simply air that is moving. The wind moves the blades of a windmill. The blades are attached to gears and shafts. The gears and shafts are attached to an electric generator.

When the blades of the windmill turn, the parts of the generator move and electricity is produced. Windmills are used to produce electricity in parts of California and Hawaii and in countries such as Denmark, Germany, Spain, and India.

Wind energy does not pollute the air we breathe. However, it can only be used where winds blow almost all the time. Some people are concerned that windmills might interfere with the habitats of migrating birds.

Energy from Moving Water

Water running through streams and rivers has energy. Waterwheels use energy from moving water to do work. Running or falling water turns a wheel,

Alternative Energy Sources

This windmill turns wind into wind power.

The dam helps make hydroelectric power from water.

and the turning wheel moves an axle. The axle can be connected to one of a number of different machines.

In a mill, the axle moves two large, round stones. When grain is put between the stones, the motion of the stones grinds the grain into a powder.

In a hydroelectric plant, running, falling, or flowing water spins a generator. The prefix *hydro* means "water." A hydroelectric plant is one that uses water to produce electricity.

Hydroelectric power plants do not pollute air or water. However, they can only be used where there is moving water. They may also disrupt the lives of animals that live in the water.

Solar Energy

Energy from the Sun is solar energy. Solar energy is a resource that will last as long as the Sun shines. How are light and heat energies from the Sun changed into energy people can use?

Fields of solar cells turn the sunlight that strikes them into electricity for homes. Some calculators are powered by solar cells that also change sunlight into electricity. Solar energy also can heat water for a house.

Solar energy will not run out. It does not cause pollution of any kind and it is available wherever the Sun shines. In order to be most effective, solar cells need to be located in areas where cloud-free days occur most of the year.

Quick Check

Fact and Opinion Solar energy will last as long as the Sun shines. Is this statement a fact or an opinion?

Critical Thinking If fossil fuels ran out, what would be the effect on the world's people?

Read a Photo

Which of these alternative energy sources uses water?

Clue: Look for water in the photos.

The turbine makes hydroelectric power from tides.

A solar panel captures solar power.

What are other sources of alternative energy?

Alternative energy sources also include energy in the nucleus of atoms, heat from inside Earth, and plant and animal materials that are used as fuel.

Nuclear Energy

Certain elements are made of atoms that can change into atoms of other elements. The change occurs in the center, or nucleus, of the atoms.

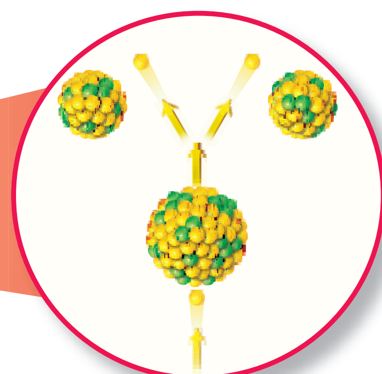
▼ A view inside a nuclear power plant.

When these changes occur, a great amount of heat energy is given off. This energy is called *nuclear energy* (NEW•klee•uhr). The heat makes steam and the steam moves the parts of an electric generator.

Electricity made by using nuclear energy is generally less expensive than electricity made by burning fossil fuels. Nuclear power plants do not pollute the atmosphere unless an accident occurs. However, accidents have occurred that have caused radioactive material to pollute the air.

Geothermal Energy

Heat produced inside Earth, or *geothermal energy* (jee•oh•THUR•muhl), causes volcanoes and hot springs. Hot springs contain water at Earth's surface that has been heated underground. Steam from hot springs can be piped to machines that spin generators. The hot water also can be piped into homes and buildings to heat them. Nearly all of the homes in the country of Iceland are heated by geothermal energy.



nuclear chain reaction


Geothermal power plants heat almost all the homes in Iceland.

Geothermal energy sources have to be tapped from underground. Only a few places on Earth are located where this kind of energy is easy to reach.

Biomass

Anything that burns can be used as an energy source. However, when nonrenewable resources such as coal, oil, and natural gas are burned, they are used up. *Biomass* (BYE•oh•mas) is made up of materials from living things. Wood, animal waste, and plant materials, such as cornstalks that are leftover parts of crops, are biomass.

Because trees and crops are living renewable resources, biomass does not run out. Trees can be replanted and crops can be grown again. However, biomass does not release as much energy as the burning of coal, oil, or natural gas. Growing plants for fuel also decreases the amount of land available for growing crops.

This biodiesel is made of 20 percent soybean oil and 80 percent diesel fuel. ▼

Quick Check

Fact and Opinion State one fact and one opinion about nuclear energy.

Critical Thinking How is location a drawback that is shared by wind, solar power, flowing water, and geothermal heat in terms of their uses as sources of energy?

How can we conserve energy?

You and your family use energy every day. You may not even realize that a certain activity uses energy. For example, when you turn on a light, you are using power. You also are using coal, oil, or natural gas because many power plants burn these fuels to produce electricity.

When you ride in a car, the gasoline that is burned in the car's engine comes from oil. When you take a shower, you may be using up natural gas or oil because many hot-water boilers burn natural gas or oil. If you feel cold at home, you may turn up a thermostat. When you do, a signal goes to a furnace, turning it on and burning more oil or natural gas.

For every way you use up energy, there is a way you can conserve it. How do you think you and your family can conserve energy?


Houses in this community in England are designed to be energy efficient.

Quick Check

Fact and Opinion Give your opinion about ways you could conserve energy.

Critical Thinking Explain how you could be using fossil fuels while watching a television show.

Guidelines for Energy Conservation


Turn off lights when you leave the room.


Turn off electronic equipment when you aren't using it.


Use water-conserving showerheads and take shorter showers.


Turn hot water off when you aren't using it.


Carpool or use public transportation whenever you can.


Turn the heat down or air conditioning up when you aren't home. Insulate windows and doors to prevent heat loss.

Lesson Review

Visual Summary

Fossils are the remains or evidence of past life and are used to shed light on Earth's history.

Fossil fuels have been produced from decayed living things, and are nonrenewable resources.

People can use sources of renewable energy or conserve nonrenewable energy resources.

Make a FOLDABLES Study Guide

Make a Trifold Book. Use the titles shown. In each column, write down a fact that you know.

Think, Talk, and Write

1. **Main Idea** What do people get from ancient organisms?

2. **Vocabulary** The main energy source for heating homes in Iceland is heat from inside Earth, or ________.

3. **Fact and Opinion** Describe one solution to the problem of decreasing oil supplies due to the use of cars.

Fact	Opinion

4. **Critical Thinking** How are relative age and absolute age different?

5. **Test Prep** **Which of the following is an alternative source of energy?**
   - **A** oil
   - **B** biomass
   - **C** natural gas
   - **D** coal

6. **Test Prep** **Which of the following is NOT a renewable resource?**
   - **A** plants
   - **B** solar energy
   - **C** coal
   - **D** animals

Math Link

Half-Life of a Jam Sandwich
The half-life of a jam sandwich is 5 minutes. How much of the sandwich is left after 15 minutes?

Art Link

Carboniferous Period
Research the plants and animals that lived during the Carboniferous period. Then draw a picture of their environment.

LOG ON e-Review Summaries and quizzes online at www.macmillanmh.com

Scientists dig for fossils in Dinosaur National Monument in Colorado and Utah.

So You Want to Be a Fossil Hunter

You should look for fossils in locations where fossils will be on the surface, such as craggy mountains and hills or steep canyons. Fossils can also be found along tall riverbanks or ocean shores.

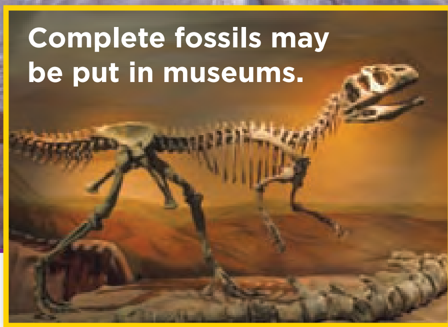
You should look for areas where the rocks are in layers. You may have to dig to find fossils in the layers. Look for patterns or different colors in the rocks that could be a plant leaf or an animal shell.

If you think you have found a fossil, record your location and the type of rock in the area. Next, take a photo of the fossil. After that, you may carefully use a stiff brush or small trowel to clean the dirt or rock away from the fossil without damaging it. To identify your fossil, compare the patterns and details in your fossil to reference materials.

Descriptive Writing

A good description

- uses sensory words to describe how something looks, sounds, smells, tastes, or feels
- includes vivid details to help the reader experience what is being described



Complete fossils may be put in museums.

Write About It

Descriptive Writing Select a fossil discovery and write a description of it. Use sensory words and specific details.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA WA-I. Write narratives with a consistent point of view, using sensory details and dialogue to develop characters and setting.

Math in Science

Converting Units

When people shop for a car, they often consider how much gas it uses to drive a certain distance. A fuel-efficient car travels a longer distance on a smaller amount of gas. This saves the driver money and also helps conserve oil. In the United States, we measure the amount of gas that a car uses in miles per gallon (mpg). Scientists and people in most other countries get the same information in kilometers per liter (kmpl).

Converting Units

To convert kmpl to mpg

- Multiply the number of kmpl by 2.352

$$\begin{array}{r} 12 \text{ kmpl} \\ \underline{\times\ 2.352} \\ 28.224 \text{ mpg} \end{array}$$

To convert mpg to kmpl

- Multiply the number of mpg by 0.425

$$\begin{array}{r} 40 \text{ mpg} \\ \underline{\times\ 0.425} \\ 17.000 \text{ kmpl} \end{array}$$

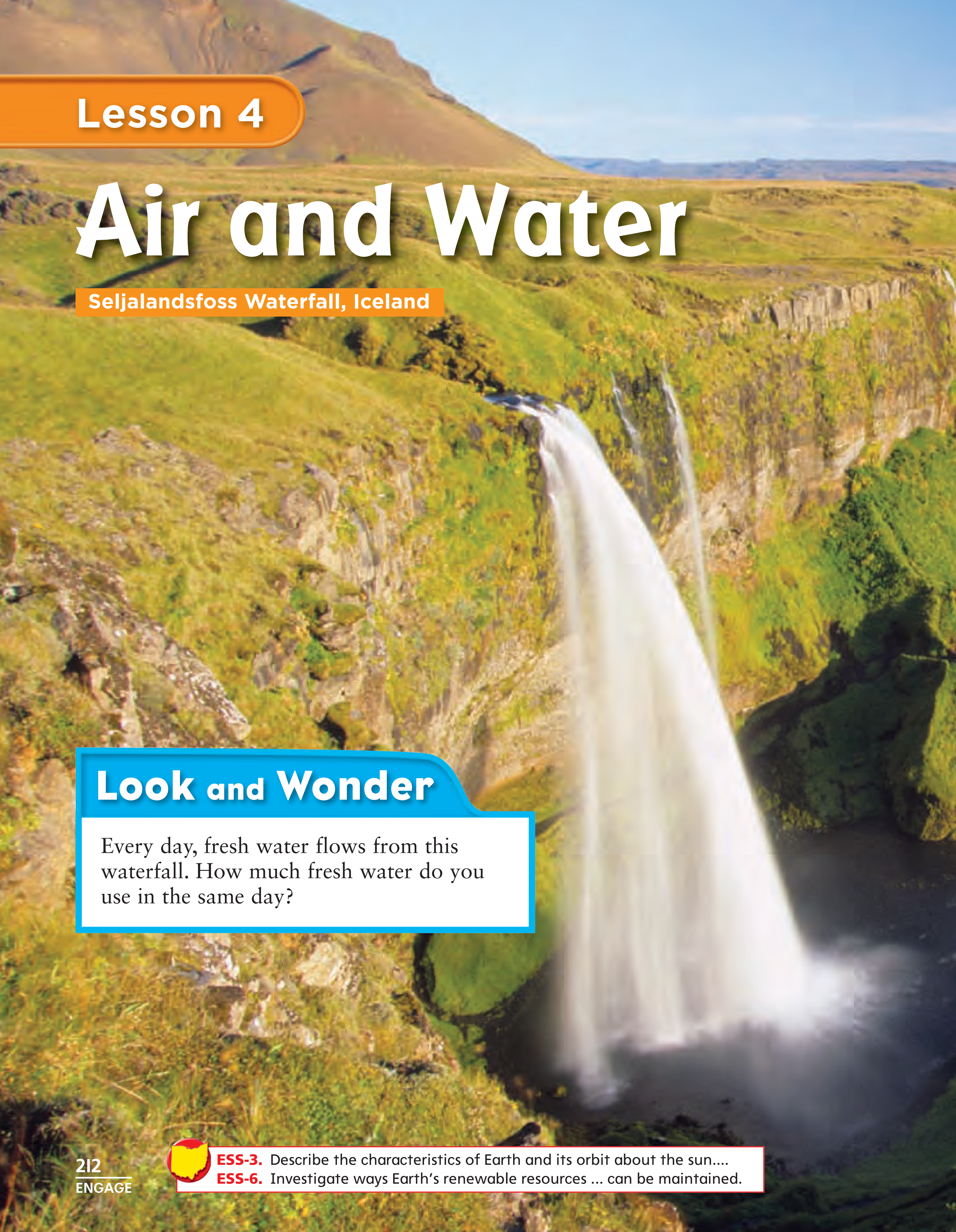
Solve It

1. Sam's car gets 25 mpg. Jasmine's car gets 29 mpg. Which car is more fuel-efficient?
2. Lori's car gets 36 mpg. Henry's car gets 9 kmpl. How much gas does Henry's car use in miles per gallon? Whose car is more fuel-efficient?
3. Maria drove 64 kilometers on 4 liters of gas. Jerry drove 80 miles on 4 gallons of gas. How many kilometers per liter of gas can each car drive? Whose car is more fuel-efficient?

M M-5: Make conversions within the same measurement system while performing computations. **PFA-4.** Create and interpret the meaning for equations and inequalities representing problem situations.

Lesson 4

Air and Water



Seljalandsfoss Waterfall, Iceland

Look and Wonder

Every day, fresh water flows from this waterfall. How much fresh water do you use in the same day?

ESS-3. Describe the characteristics of Earth and its orbit about the sun....
ESS-6. Investigate ways Earth's renewable resources ... can be maintained.

Explore **Inquiry Activity**

How much fresh water do you use?

Make a Prediction

How much water do you use in a day for a particular activity, such as brushing your teeth or washing your hands?

Test Your Prediction

1. Put the container in the sink.
2. Turn the water on and pretend to brush your teeth or wash your hands. Run the water as long as you would if you were really doing that activity. Once you are done, turn the water off.
3. **Measure** Using the measuring cup, scoop water out of the container into the sink. Keep track of each cup that you pour so you can estimate the total amount of fresh water you use for that activity.

Draw Conclusions

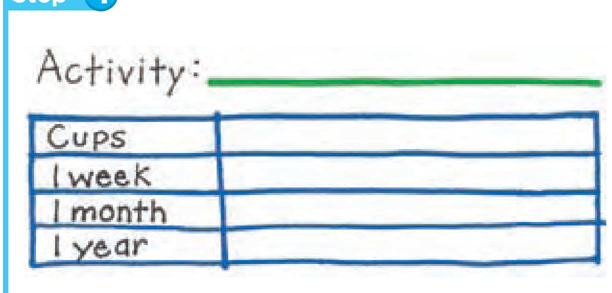
4. **Use Numbers** On a chart, figure out how many gallons of fresh water you use for the activity in a week, a month, and a year.
5. **Communicate** Discuss how much water you used with your classmates. Exchange data for the amount of water you used for your chosen activity. Whose use of water was closest to their prediction?
6. Design and complete tables or graphs to display the results of all of the data collected by the other students.

Materials

- container
- sink
- measuring cup

Step 2

Step 4



Explore More

Think of a way you can reduce the amount of water that you used. Predict how much water you can save. Redo the activity you chose using your new idea. Were you able to save water? Discuss your idea and its result with your classmates.

SWK-I. Summarize how conclusions and ideas change as new knowledge is gained.

Read and Learn

Main Idea ESS-3, ESS-6

Air and water are resources that support life on Earth.

Vocabulary

reservoir, p. 215
aquifer, p. 215
smog, p. 220
ozone, p. 220

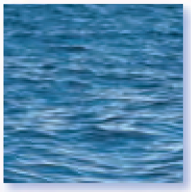
Reading Skill

Main Idea and Details

Main Idea	Details

What are sources of fresh water?

Many organisms on Earth need fresh water to survive. About 70 percent of Earth's surface is covered with water. However, about 97 percent of the water on Earth is salt water in the oceans. Roughly 2.3 percent of the fresh water on Earth is frozen at or near the North Pole and South Pole. Another 0.6 percent is liquid fresh water. Finally,



0.1 percent of Earth's water is present in the air as water vapor. If all the water on Earth were the size of this page, the amount of fresh water on Earth would be the size of this square.

What causes so much of the water on Earth to be salty? Water that falls as rain or snow is fresh water. As rain runs downhill, it picks up salts that are in soil and rocks. The flowing water runs into rivers. River water does not taste salty because it contains a very small amount of salts.

Usable Sources of Fresh Water

Rivers carry these salts into the ocean. Waves pick up salts from rocks and sand. Erupting volcanoes also add salts to the ocean. Each of these sources adds only a small amount of salt to the ocean. Since salts have been added for many millions of years, over time, the amount of salt in the ocean has slowly increased to its current concentration of 3.5 percent.

Because so much of the water on Earth is salty, fresh water is a limited resource. Most of the fresh water that people use is obtained from running water, standing water, and groundwater.

Running Water

Many cities and towns are built next to sources of running water, such as streams or rivers. Running water provides a source of fresh water for homes, farms, and businesses.

Standing Water

Bodies of standing fresh water, such as lakes and reservoirs (REZ•uhr•vwahrz), fill holes in the ground. A **reservoir** is an artificial lake that is built to store water. Reservoirs are usually made by building a dam across a river. Water is stored behind the dam and is released when it is needed.

Groundwater

Groundwater seeps into the ground through aquifers (AK•wuh•fuhrz). An **aquifer** is an underground layer of rock or soil that has pores and is capable of absorbing water. As water seeps through an aquifer, it eventually reaches a layer of rock that does not absorb water. Over the years, fresh water builds up on top of this rock.

Groundwater is most useful to people when it is close enough to the surface that it can be reached by drilling or digging into the ground. Groundwater is then pumped up through a well. As water is removed, the level of the water underground drops. In order for the water to reach that height again, more water must seep down to replace it.

Quick Check

Main Idea and Details What makes fresh water a limited resource?

Critical Thinking What are some reasons why one area of an ocean might be more salty?

Read a Diagram

What are ways people use artificial construction to get water?

Clue: Look for artificial construction.

How do we use water?

In the United States, about 408 billion gallons of water are used every day. How do we use this water?

The largest category of water use in the United States is thermoelectric power. In this case, water is mostly used to cool the equipment that makes the electricity. As this water is not directly used by people, these power plants often use salt water.

The largest use of fresh water in the United States is irrigation (ir•ri•GAY•shuhn). *Irrigation* means to supply with water by artificial means. Unless crops and plants are supplied by natural sources of fresh water, they need irrigation in order to grow.

Most of the time, households and businesses use water that is supplied by a water company. Some of this water also is used for fighting fires, in swimming pools, and in public buildings, such as schools.

▲ Farmers need water for their crops.

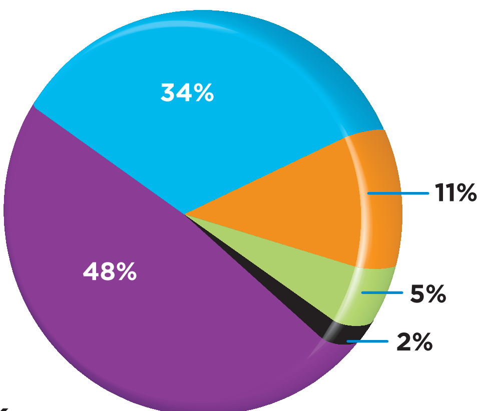
Some businesses have their own water sources. They may use water as part of making, washing, cooling, or transporting their product.

Some people have their own supply of fresh water. The source is usually a well. They can use this water in their house or for animals.

As water condenses in the sky or runs across the ground, it may pick up substances such as chemicals or harmful organisms that can pollute it. Polluted water cannot be used by people.

What are some signs that water might be contaminated? It might smell. It might be cloudy, have a strange color, or have dead fish in it. However, you can't always tell that water is polluted by looking at it.

Water Use in the United States



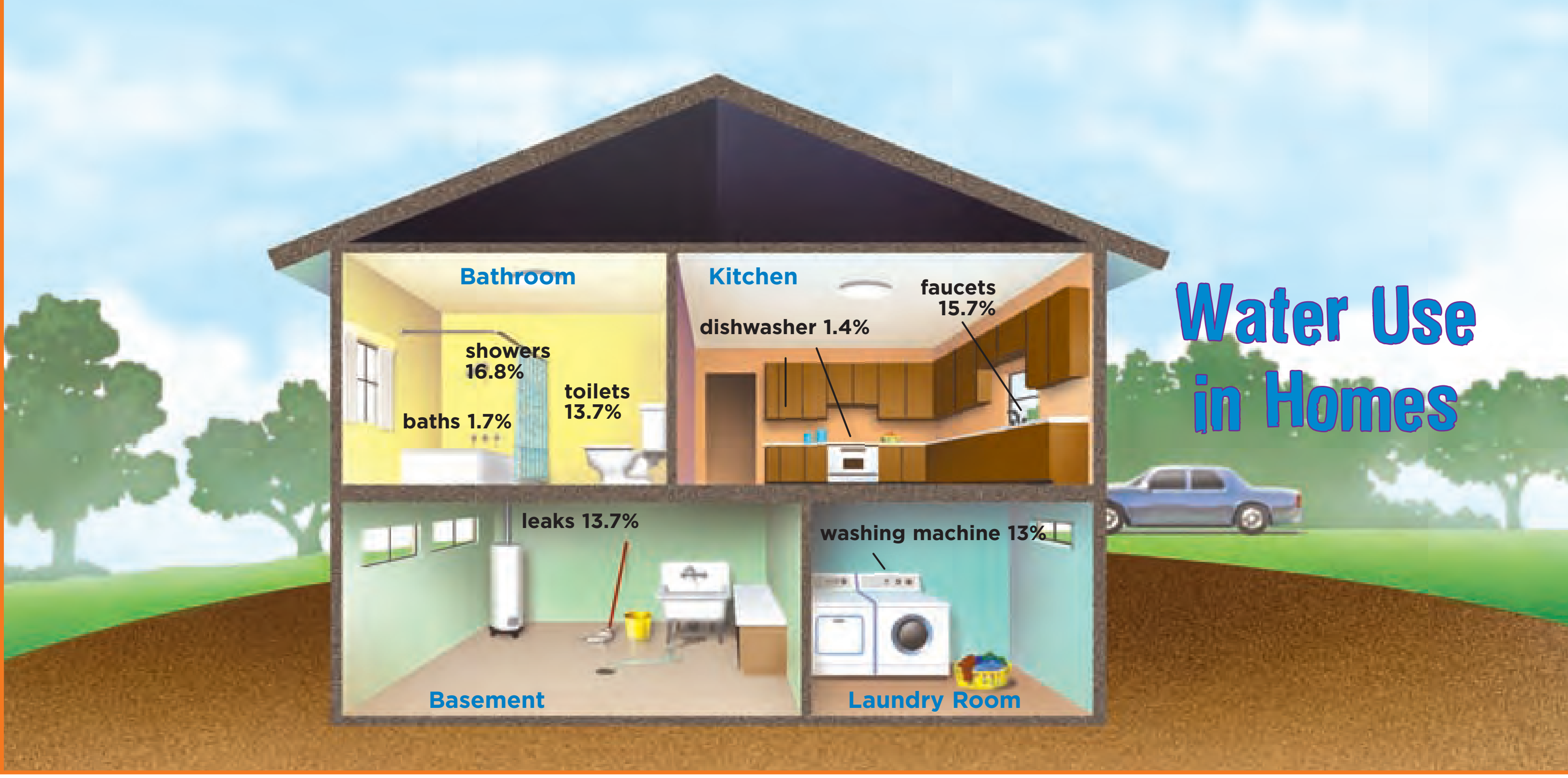
Key:

- thermoelectric power
- irrigation
- water company
- business
- wells

Read a Graph

What is the second-largest use of water in the United States?

Clue: Look for the second-largest piece of the pie chart.



Farmers and homeowners need to water plants so the plants will grow. Sometimes they also use chemicals to help their crops and lawns grow, or to kill specific types of plants. People also use chemicals to kill organisms that are harmful to plants. Some factories and mines produce wastes. If these chemicals or wastes reach a source of water, they can pollute it.

Polluted water from this sewage pipe is pouring into a reservoir.▼

Water washes over streets and driveways. The flowing water can pick up contaminants, such as salt used to melt ice and snow, spilled motor oil, and trash.

Watering lawns and gardens may use 50 percent to 70 percent of a household's water. Inside their homes, people use the largest amounts of water to take showers, flush toilets, wash clothes, and wash dishes. When they are done with these tasks, the water flows back into the pipes. However, the water now has wastes and household chemicals in it and will need to be cleaned before it can be used again by people.

Quick Check

Main Idea and Details How is water used and polluted?

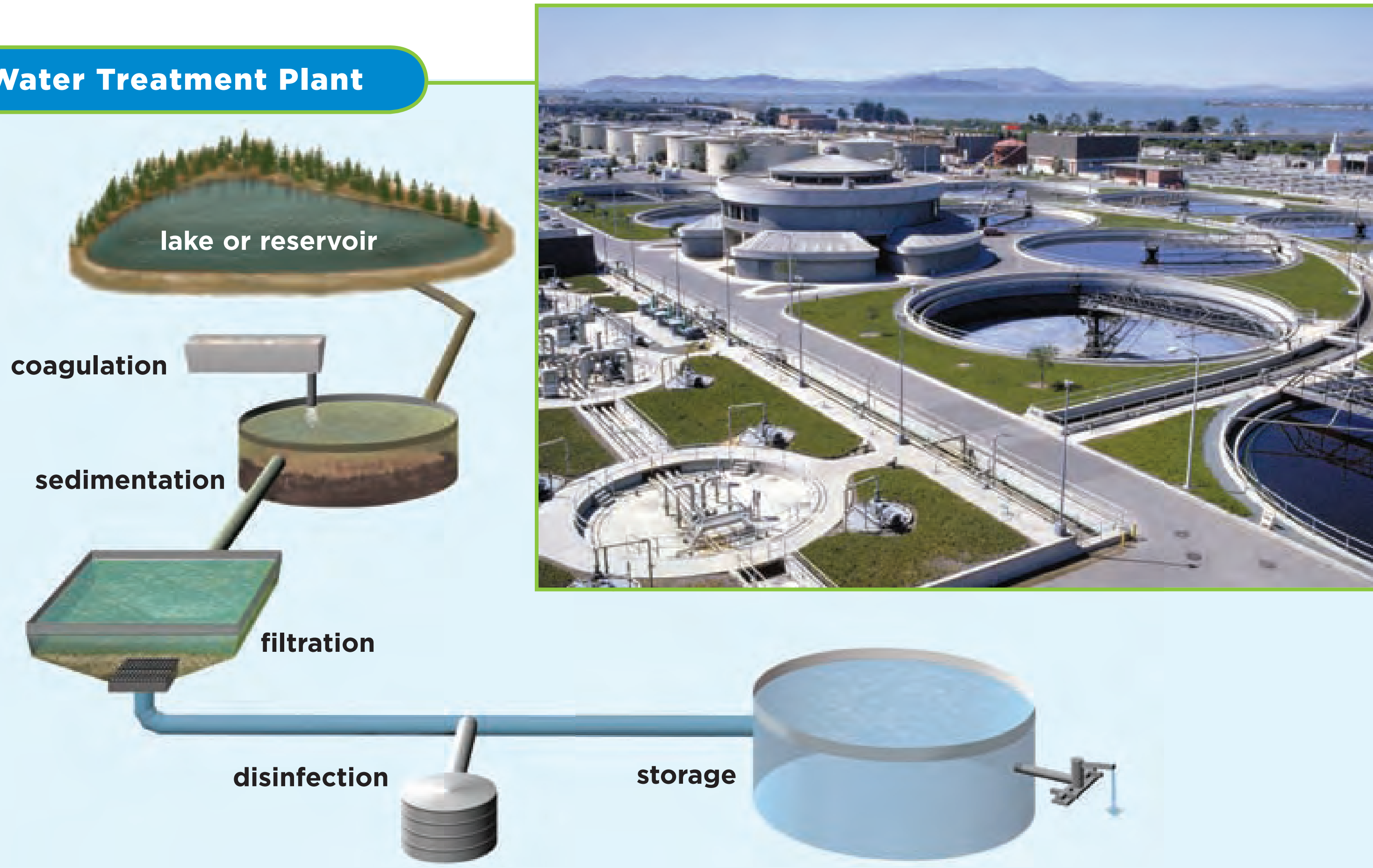
Critical Thinking Why do farmers and homeowners use products that can contaminate fresh water?

How do we clean, conserve, and protect water?

The water that flows to houses and businesses in most communities is treated, or cleaned, in a water treatment plant. There, water from a freshwater source, such as a lake or reservoir, runs through several tanks. In each tank, a different step takes place. The steps may vary depending on the source of your community's water.

First, sticky particles are added to the water to attract any dirt in it. This step is called *coagulation* (koh•ag•yuh•LAY•shuhn). In the next tank, as *sedimentation* (sed•uh•muhn•TAY•shuhn) takes place, the clumps of dirt and sticky particles fall to the bottom of the tank. Then the water passes through a series of filters, which are layers of sand, gravel, and charcoal. These filters remove remaining bits of soil or other particles from the water. After water leaves this tank, chlorine and other chemicals are added to the water to kill harmful bacteria. This step is called *disinfection* (dis•in•FEK•shuhn). The clean water is kept in a storage tank until it is released to the community.

Water Treatment Plant



Conserving Water

People can conserve water by reducing their use of water. Water conservation can be done by entire communities and by individuals. Sometimes water conservation efforts are aimed at larger areas, such as a river's watershed.

Protecting Water

In communities that have a limited supply of water, the local government may make regulations that stop people from watering lawns, filling swimming pools, and washing cars. People who break such regulations can be fined. These restrictions usually go into effect when natural sources of water, such as rain or snow, fall below the amount of water needed for people to use.

Local and state governments, as well as the United States government, have passed laws to protect our water supply. In 1974, Congress passed the Safe Drinking Water Act, which sets rules that communities must follow to keep drinking water clean and safe.

Three years later, Congress passed the Clean Water Act, which made it illegal to throw pollutants into surface waters. People or businesses that break this law can be fined.

Quick Check

Main Idea and Details What can you do to conserve water?

Critical Thinking How would you change the steps in a treatment plant if the water were heavily polluted?

Rules of Water Conservation

Use water-conserving showerheads and take shorter showers.

Don't leave water running when you aren't using it.

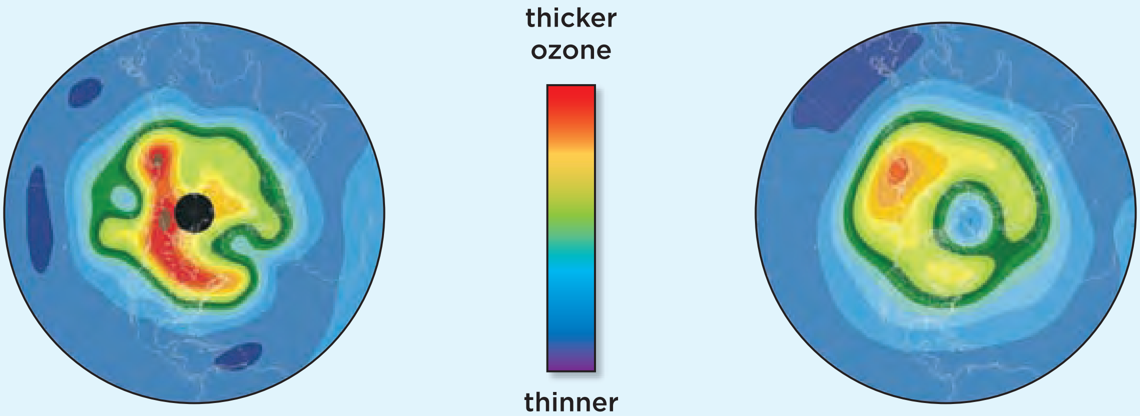
Wash dishes by hand. If you use a dishwasher, use a water-saving model and don't run it unless it is full.

Fix leaking pipes or faucets.

Use a water-saving washing machine and wash full loads of clothes.

Grow plants that don't require frequent watering and water your plants after dark so the water does not evaporate.

Changes in the Ozone Layer



Northern Hemisphere (1986) Northern Hemisphere (2006)

How do we use and pollute air?

You cannot see air, and if air is clean, you cannot smell it or taste it. If air does not move, you cannot feel it or hear it. However, air is all around you.

Earth's atmosphere holds the gases that living things need to stay alive. These gases are oxygen, carbon dioxide, and nitrogen. Plants and animals use oxygen to produce the energy they need. Plants take in carbon dioxide to make the foods they need to survive. Bacteria in soil turn nitrogen into chemicals that plants use to grow.

Sometimes particles of a pollutant build up in the air. These particles are produced when fossil fuels or trash are burned. Dust from plowed fields, construction sites, and mines also can put polluting particles into the air. Chemicals that are produced by factories can cause air pollution.

On certain days, you might see a yellow haze in the air over cities. This is a sign of a type of air pollution called smog. **Smog** is a type of air pollution that is caused by particles that are produced when fossil fuels are burned. Smog irritates eyes and can make breathing difficult. It is especially dangerous for people who have breathing problems such as asthma.

Air pollution does not only cause problems near the ground. About 30 kilometers above Earth's surface, there is a layer of a gas called **ozone** (OH•zohn). Ozone is a form of oxygen that protects living things on Earth's surface from dangerous energy from the Sun.

In recent years, chemicals in aerosol cans and air conditioners have escaped into the atmosphere. When these chemicals rise high up into the atmosphere, they set in motion chemical reactions that destroy ozone. When ozone is destroyed, harmful radiation from the Sun reaches Earth's surface more easily. Evidence suggests that this radiation can increase the chances of getting skin cancer.

Smoke from cars and trucks is a source of air pollution.

An *ozone hole* is a thinner area in the layer of gas. Compare the images of the ozone over the North Pole in 1986 and in 2006. What has happened to the thickness of the ozone layer?

In industrial areas, smoke and gases that pour into the air from factories can combine with rain to form acid rain. Acid rain has many harmful effects. It can kill trees and wear away stone buildings and statues.

Air can also be polluted by events in nature. Volcanic eruptions of gases, dust, and ash may stay for days, weeks, or months.

Quick Lab

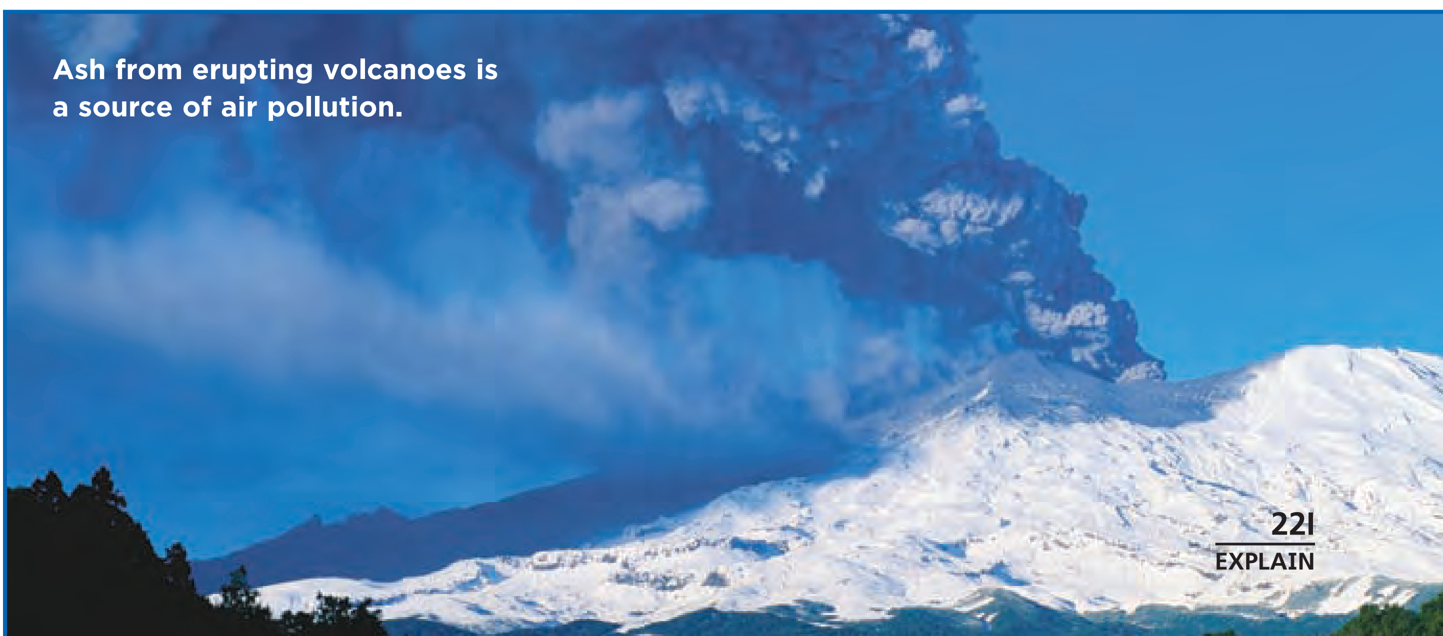
Dirty Air

1. Using a plastic knife, smear a thin layer of petroleum jelly on an index card.
2. Holding the edges of the index card, carefully place the card in a corner of the room.
3. **Observe** What does the index card look like after one day? After one week?
4. **Infer** How does the petroleum jelly help you track air pollution?
5. **Form a Hypothesis** Would you expect more air pollution near a road or away from a road? Why?

Quick Check

Main Idea and Details How is air pollution produced?

Critical Thinking Discuss how forest destruction would affect air pollution.



Ash from erupting volcanoes is a source of air pollution.

▲ Planting trees can lower carbon dioxide levels and reduce air pollution.

How do we protect air?

What can be done to prevent air pollution? The best way to prevent air pollution is to keep the pollutants from getting into the air.

Congress passed the Clean Air Act in 1963 and has added several updates to it. As a result of these laws, many pollutants are now banned and other pollutants are filtered out before they get into the air.

The chemicals that destroy ozone can no longer be used in aerosol cans. Factories must equip smokestacks with devices that trap pollutants before they can be set loose in the air. The exhaust systems of cars, buses, and trucks also are fitted with devices that limit the gases and soot that come out of exhaust pipes.

A park ranger measures air pollutants in Yellowstone National Park, WY.

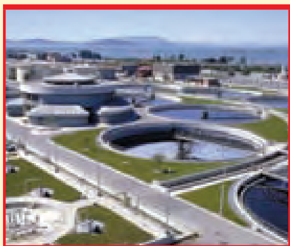
Quick Check

Main Idea and Details List three causes of air pollution.

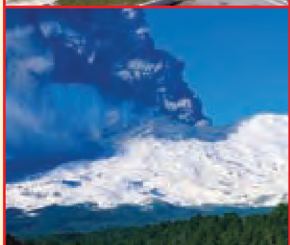
Critical Thinking List a benefit and cost of controlling air pollution.

Lesson Review

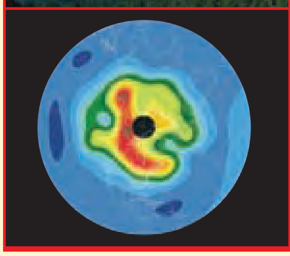
Visual Summary



Most organisms on Earth need clean fresh water to live.



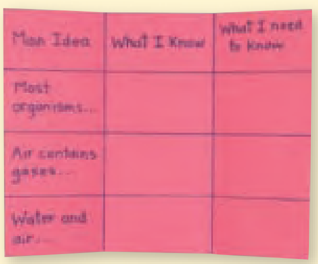
Air contains gases, such as oxygen, carbon dioxide, and nitrogen, that are needed by living things.



Water and air can be polluted or conserved.

Make a FOLDABLES™ Study Guide

Make a Folded Chart. Use the titles shown. In each box, write the main idea of what you learned.



Think, Talk, and Write

1. **Main Idea** Why are air and water important resources?

2. **Vocabulary** Dangerous radiation from the Sun is blocked by ________ in Earth's atmosphere.

3. **Main Idea and Details** List three ways you can conserve fresh water.

Main Idea	Details

4. **Critical Thinking** Some whales feed on krill, a small sea animal. Krill feed on green organisms called algae, which produce oxygen. Explain how killing the whales might affect Earth's atmosphere.

5. **Test Prep** **An aquifer is a(n)**
   - **A** body of surface water.
   - **B** body of underground water.
   - **C** form of precipitation.
   - **D** ocean.

6. **Test Prep** **Which gas do plants release into the air?**
   - **A** nitrogen
   - **B** carbon dioxide
   - **C** oxygen
   - **D** nitrates

Writing Link

The End of Trees

Write a science fiction story in which all the trees on Earth are destroyed by an event of your choosing. Describe how the end of trees affects the environment and all living things on Earth.

Health Link

Waterborne Diseases

Do research to identify a disease that is caused by polluted water. Write a report describing the type of pollution, the effects of the disease, and ways to prevent the pollution.

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Getting the Salt Out

Salts are removed from ocean water inside the Santa Catalina Island desalination plant.

SWK-6. Identify a variety of scientific and technological work that people of all ages, backgrounds and groups perform. **ELA RP-9.** List questions and search for answers within the text to construct meaning.

Why does California have water shortages when it is next to the Pacific Ocean? People cannot drink ocean water because of the salts in it.

The island of Santa Catalina lies off the coast of Southern California. It is completely surrounded by the Pacific Ocean. However, people on the island use water from the ocean all the time—to water crops, to take showers, and even to drink. How can they drink and use the salty ocean water? The water is transformed from salty to fresh at the Santa Catalina desalination plant. *Desalination* means "to remove salts."

At the desalination plant, ocean water is taken from an ocean water well. Once it is moved into the plant, salt and other impurities are removed from the water. The fresh water that is produced can now be used by people.

The Santa Catalina plant is one of the few desalination plants in the United States that produces water for public use. Desalination is an expensive process that uses a lot of energy. Despite its cost, there are desalination plant projects all over the world, including places like Saudi Arabia and Japan. Desalination is generally used when a community has so little access to fresh water that it is willing to pay a high price to get it. Scientists continue to research cheaper and more efficient ways to produce fresh water from ocean water.

Problem and Solution

- Identify the problem by looking for a conflict or an issue that needs to be resolved.
- Think about how the conflict or issue could be resolved.

Write About It

Problem and Solution

1. What is in ocean water that prevents people from using it directly from the ocean?
2. How do the people of Santa Catalina get fresh water?

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American Museum of Natural History

CHAPTER 4 Review

Visual Summary

Lesson 1 Each layer of Earth has its own features.

Lesson 2 Soil is a natural resource made of a mixture of nonliving material and once-living things.

Lesson 3 Ancient organisms became fossils and fossil fuels. Fossil fuels are nonrenewable resources, so renewable sources of energy are also used.

Lesson 4 Air and water are resources that support life on Earth.

Make a FOLDABLES™ Study

Assemble your lesson study guide as shown. Use your study guide to review what you have learned in this chapter.

Vocabulary

Fill in each blank with the best term from the list.

aquifer, p. 215
conservation, p. 192
crust, p. 182
landform, p. 176
outer core, p. 182
renewable resource, p. 203
smog, p. 220
topsoil, p. 189

1. Water power can be replaced naturally, so it is a(n) ________.
ESS-6
2. The ________ is the rocky layer of Earth's surface.
ESS-C
3. Most plant roots grow in ________.
ESS-6, ESS-C
4. The protection of natural resources is called ________.
ESS-5, ESS-6
5. An underground layer of rock or soil that can absorb water is a(n) ________.
ESS-C
6. A physical feature on Earth's surface is a(n) ________.
ESS-B
7. When fossil fuels are burned, the resulting particles can cause ________.
ESS-6
8. The layer of Earth's core that is made up of liquid metal is the ________.
ESS-B

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Skills and Concepts

Answer each of the following in complete sentences.

9. Fact and Opinion The atmosphere includes all of the gases around the Earth. Is this statement a fact or an opinion? Explain your answer.
ESS-3

10. Summarize Write a description of the soil horizons.
ESS-C

11. Classify Identify whether each of the following is a renewable or nonrenewable fuel resource: wind, oil, sunlight, coal, natural gas, tides, and waves.
ESS-5, ESS-6

12. Critical Thinking Why do you think that most households and businesses get water from water companies?
ESS-6

13. Explanatory Writing Explain how you can tell that this is an extrusive rock and not an intrusive rock.
ESS-C

The Big Idea

14. What are Earth's resources?
ESS-C

Performance Assessment

Alternatives for the Future

Create a brochure about an alternative energy source.

What to Do

1. Choose one alternative energy source. Review its advantages and disadvantages.
2. Do research to learn how this alternative energy source is used today.
3. Brainstorm ideas about how this alternative energy source may be used in the future.

Analyze Your Results

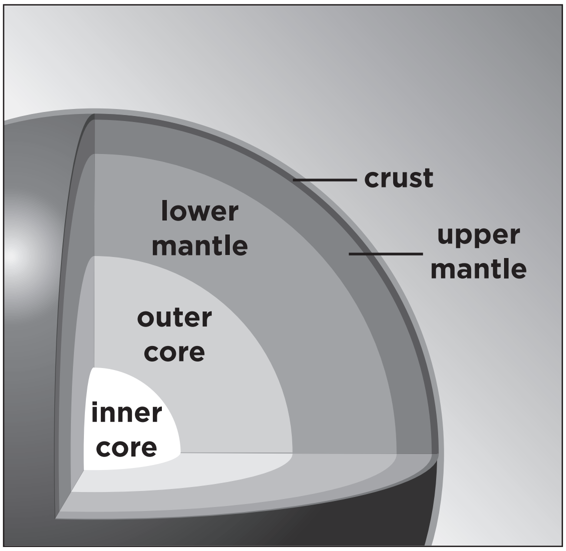
- Create a brochure to teach people about your alternative energy source. Use the information you have collected.

Ohio Activity

The landscape of Ohio is made up of many different features. Crossing the state, you would travel through areas with lakes, rolling hills, rivers, and streams, valleys, and plateaus. Using a landform map as a reference, make a three-dimensional map of Ohio using different colors of modeling clay. Use flags made from toothpicks and paper to identify each landform.

Ohio Benchmark Practice

1 The diagram below shows Earth's layers.



Which layer of Earth contains the continents and ocean basins?

A the outer core
B the lower mantle
C the crust
D the upper mantle

ESS-3

2 What is a moraine?

A a mound formed by materials deposited by a glacier
B a mixture of sand, gravel, rocks, and clay deposited by glaciers
C the ending point of a glacier
D the deep valley carved by a glacier

ESS-B

3 Which is not an alternative energy source?

A water
B wind
C air
D fossil fuels

ESS-5

4 In your **Answer Document**, describe which energy source uses leftover parts of crops and could also be considered recycling. Is this energy source renewable or nonrenewable? (2 points)

ESS-6

5 A student is investigating ways that farmers protect soil. He observes tall trees planted between farm fields. What method of conservation does he observe?

A terracing
B crop rotation
C contour plowing
D wind breaks

ESS-C

6 A scientist is investigating fields for placing many solar panels. She compiles the data shown in the table below.

Field	Days of Sunlight
Field A	117
Field B	300
Field C	279

What is the dependent variable in this investigation?

A the fields
B days of sunlight
C wind speed
D the Sun's angle

SI-4, ESS-6

7 How much of Earth's water is salt water?

A about 97 percent
B 2.3 percent
C 0.6 percent
D 0.1 percent

ESS-C, ESS-3

8 Which process would most likely cause a canyon to form?

A chemical weathering
B terminus
C deposition
D erosion

ESS-B

9 How much of Earth's surface is covered in water?

A about 95 percent
B exactly 23 percent
C nearly 50 percent
D around 70 percent

ESS-C

10 Which landform is the deepest part of the ocean floor?

A abyssal plain
B rift valley
C seamount
D trench

ESS-B

11 What makes up Earth's atmosphere?

A nothing
B only helium and hydrogen
C a mixture containing oxygen, nitrogen, and carbon dioxide
D a mixture of gases, including argon, mercury, and sodium

ESS-3

12 What is the layer above Earth that protects it from the harmful rays of the Sun?

A nitrogen
B carbon dioxide
C ozone
D aquifer

ESS-3

13 Which of the following is not a good way to conserve energy?

A While brushing teeth, turn off the water when not needed.
B Drive to a friend's house four blocks away.
C Turn off lights when leaving a room.
D Install a water-saving showerhead.

ESS-5

14 Where is 2.3 percent of Earth's fresh water?

A frozen at the poles
B trapped in trenches
C in reservoirs
D in irrigated fields

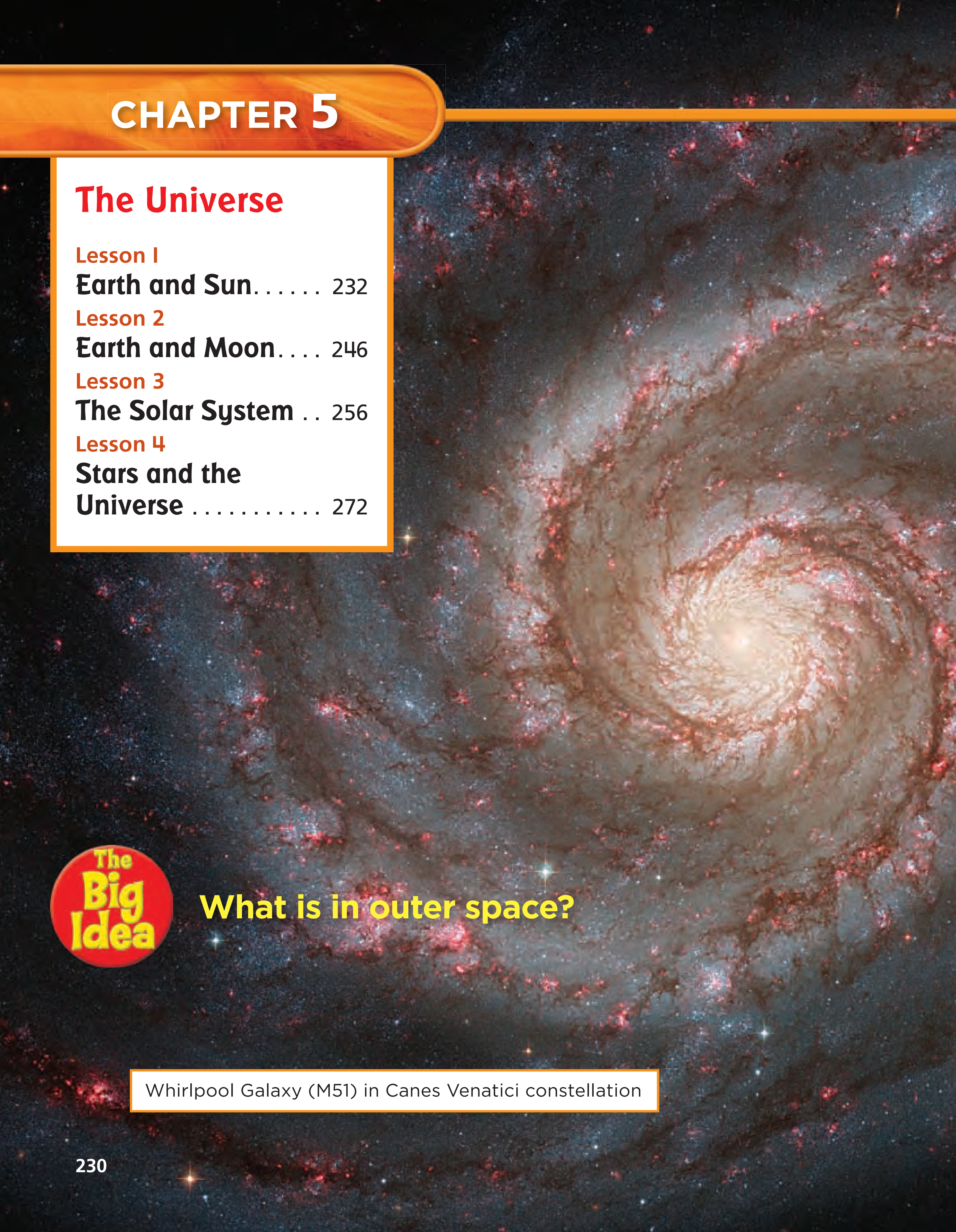
ESS-3

15 Most organisms need fresh water to survive, making water one of the most important resources on Earth. In your **Answer Document**, explain two ways in which humans use water and two methods of conserving water. (4 points)

ESS-C

CHAPTER 5

The Universe

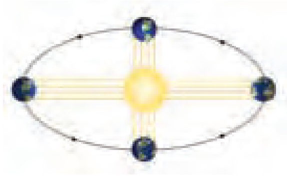


The Big Idea

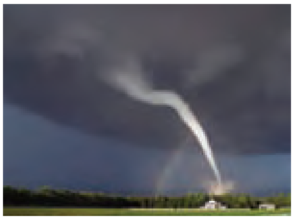
What is in outer space?

Whirlpool Galaxy (M51) in Canes Venatici constellation

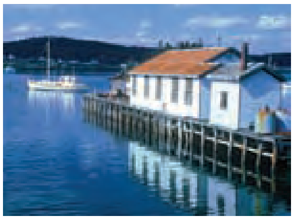
Key Vocabulary



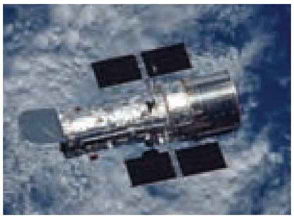
revolution
one complete trip around the Sun. Earth completes one revolution in 365 days (p. 236)



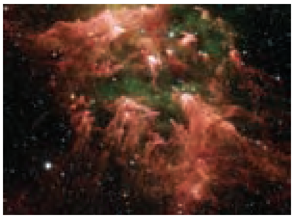
weather
what the lower atmosphere is like at any given place and time (p. 240)



tide
the regular rise and fall of the water level along a shoreline (p. 252)



satellite
a natural or artificial object in space that circles around another object (p. 264)



star
an object in space that produces its own energy, including heat and light (p. 274)

galaxy
a collection of billions of stars. Our Sun belongs to the Milky Way galaxy (p. 281)

More Vocabulary

gravity, p. 234

orbit, p. 235

inertia, p. 235

insolation, p. 238

troposphere, p. 240

air pressure, p. 241

rotation, p. 242

phase, p. 248

solar eclipse, p. 251

lunar eclipse, p. 251

telescope, p. 258

planet, p. 260

moon, p. 264

comet, p. 266

asteroid, p. 267

meteor, p. 267

nebula, p. 274

white dwarf, p. 275

supernova, p. 276

black hole, p. 276

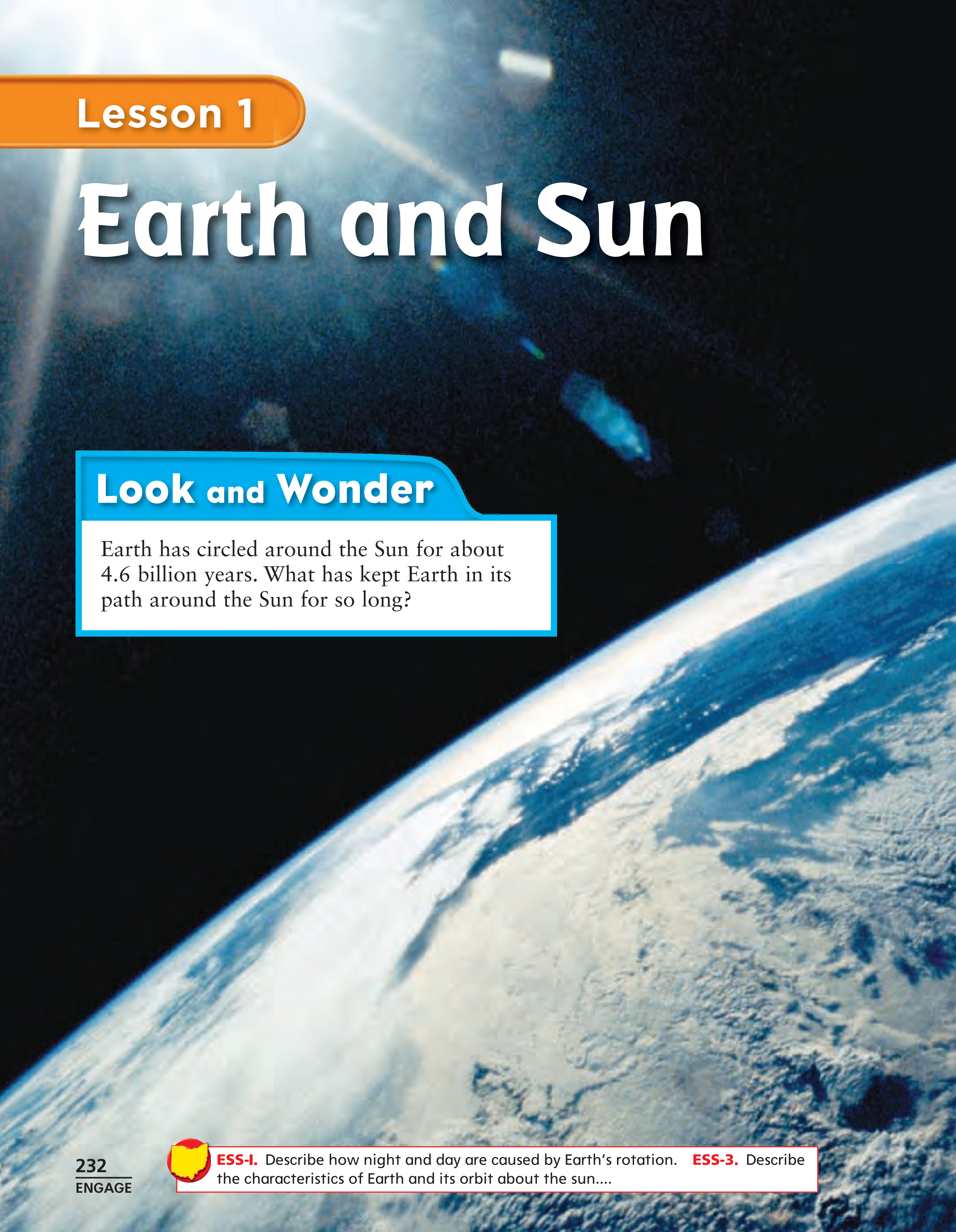
constellation, p. 278

light-year, p. 279

ESS-A. Explain the characteristics, cycles and patterns involving Earth and its place in the solar system.

Lesson 1

Earth and Sun



Look and Wonder

Earth has circled around the Sun for about 4.6 billion years. What has kept Earth in its path around the Sun for so long?

ESS-I. Describe how night and day are caused by Earth's rotation. **ESS-3.** Describe the characteristics of Earth and its orbit about the sun....

Explore

Inquiry Activity

What keeps Earth moving around the Sun?

Form a Hypothesis

If you let go of a ball being swung in a circle, in what direction will the ball travel? Write a hypothesis in the form "If I let go of a ball being swung in a circle at a particular point, then . . . "

Test Your Hypothesis

1. Place the tennis ball on the fabric and bring the four corners of the fabric together so they cover the ball. Then tie string around the four corners to form a pouch.
2. ⚠ **Be Careful.** While holding the other end of the string, lean forward and slowly spin the ball in a circle near your feet.
3. **Observe** Let go of the string. Watch the path that the ball takes.
4. **Record Data** Draw a diagram to show the path the ball took when you let it go.
5. Repeat the experiment, letting go of the ball at three different spots on the circle. Where does the ball go?

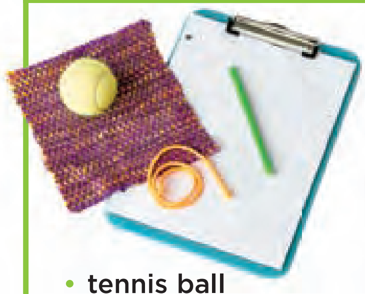
Draw Conclusions

6. Did the experiment support your hypothesis? Why or why not?
7. If this activity models the movement of Earth around the Sun, what do you, the ball, and the string represent?

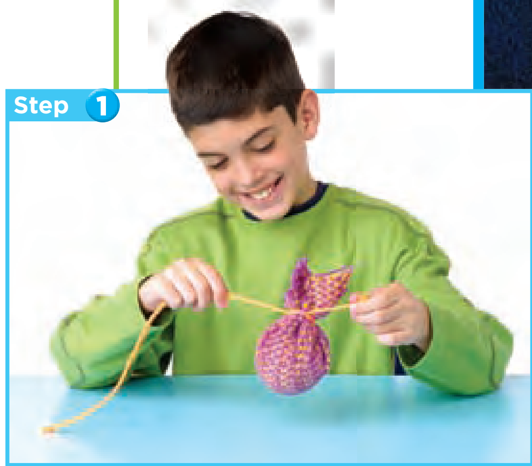
Explore More

What results would you expect if you repeated the experiment using a lighter ball? Form a hypothesis, do the experiment, record your data, and write a report.

Materials



- tennis ball
- fabric
- string
- graph paper



SI-5. Identify potential hazards and/or precautions involved in an investigation.

Read and Learn

Main Idea ESS-I, ESS-3

Gravity and inertia keep Earth in orbit around the Sun.

Vocabulary

- **gravity**, p. 234
- **orbit**, p. 235
- **inertia**, p. 235
- **revolution**, p. 236
- **insolation**, p. 238
- **troposphere**, p. 240
- **weather**, p. 240
- **air pressure**, p. 241
- **rotation**, p. 242

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Reading Skill

Fact and Opinion

Fact	Opinion

Technology SCIENCE QUEST

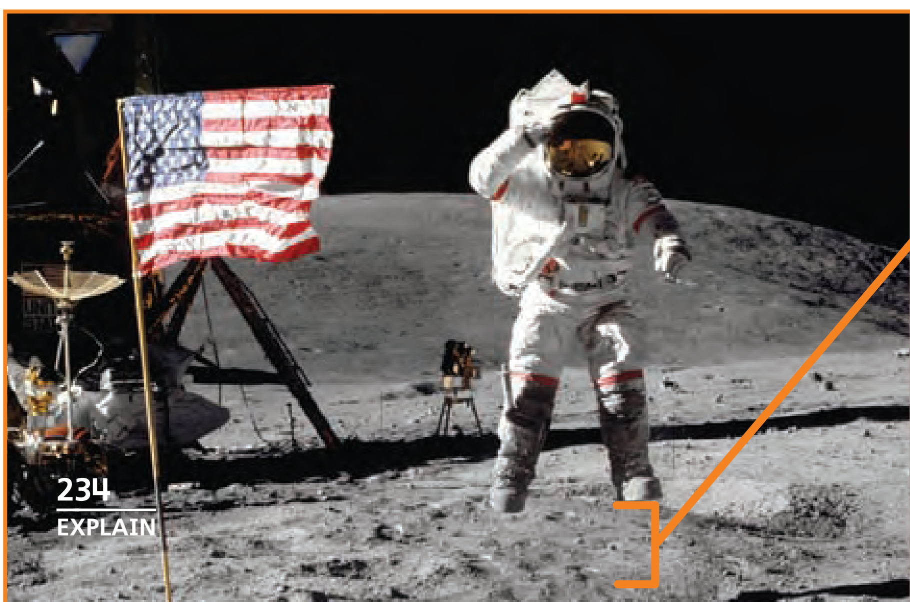
Explore gravity and orbits with Team Earth.

How does Earth orbit the Sun?

Each planet in the solar system is drawn toward the Sun by gravity. **Gravity** is a force of attraction, or pull, between any two objects. The strength of the pull of gravity is affected by the total mass of the two objects and by the distances between the objects. The strength of the pull of gravity decreases when the total mass of the two objects decreases and when the objects are farther apart.

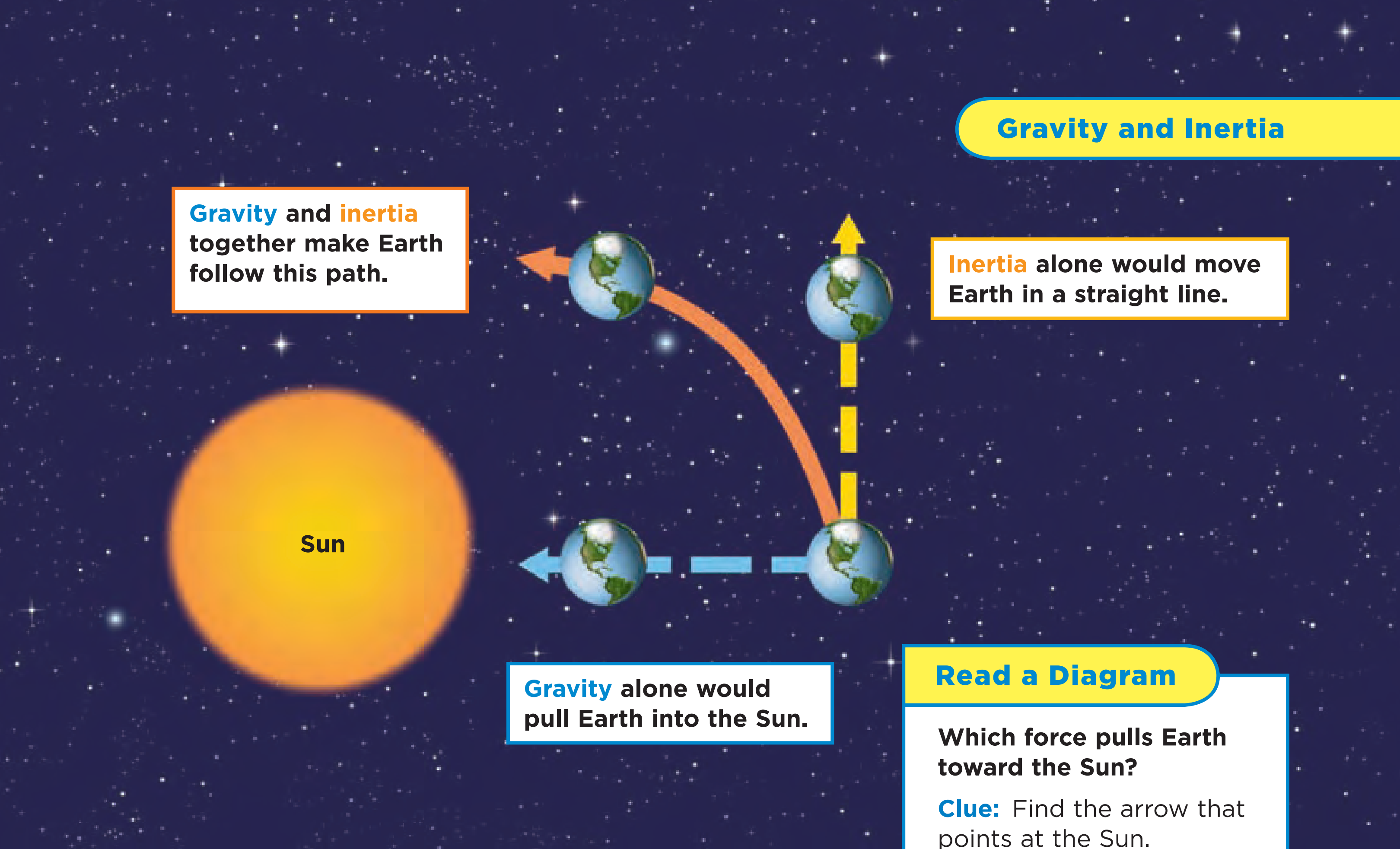
Compare the pull of gravity you feel on Earth to the pull of gravity you would feel on the Moon. Your mass stays the same no matter where you are. Earth's mass is greater than the Moon's mass. This means that the total mass of you and Earth is greater than the total mass of you and the Moon. The pull of gravity between you and Earth is stronger than the pull between you and the Moon. In fact, the Moon's gravity is about one sixth of Earth's gravity.

Two objects do not have to touch each other to produce a force of gravity between them. The pull of gravity between Earth and the Sun acts across about 150 million kilometers (93 million miles) of space. Gravity also acts across roughly 6 billion kilometers (4 billion miles) of space between the Sun and Pluto. Because the distance is farther between the Sun and Pluto, the pull of gravity between the Sun and Pluto is weaker than the pull of gravity between the Sun and Earth.



In this photo, you can see the height of astronaut John Young's jump on the Moon. He can jump higher on the Moon than on Earth because the Moon's gravity is about one sixth of Earth's gravity.

Gravity and Inertia



Read a Diagram

Which force pulls Earth toward the Sun?

Clue: Find the arrow that points at the Sun.

The planets are held in their orbits around the Sun by the force of gravity between each planet and the Sun. An **orbit** is a path one object takes around another object.

If gravity was the only force acting on a planet, the planet would be pulled into the Sun. What prevents this from happening? All objects have a property called *inertia*. **Inertia** is the tendency of a moving object to keep moving in a straight line.

As Earth orbits the Sun, it is pulled toward the Sun because of gravity. At the same time, Earth's inertia makes it move away from the Sun. As a result of the effects of gravity and inertia, Earth moves in a nearly circular orbit called an *ellipse*.

When Earth is closest to the Sun, it is about 147,000,000 kilometers (91,000,000 miles) away. When Earth is furthest from the Sun, it is about 152,000,000 kilometers (94,000,000 miles) away. This 5-million-kilometer (3-million-mile) difference shows that Earth's orbit is close to, but not quite, a perfect circle.

Quick Check

Fact and Opinion Astronauts can jump higher on the Moon than on Earth. Is this a fact or an opinion?

Critical Thinking In what direction would the planets travel if the Sun suddenly disappeared? Explain.

What causes seasons?

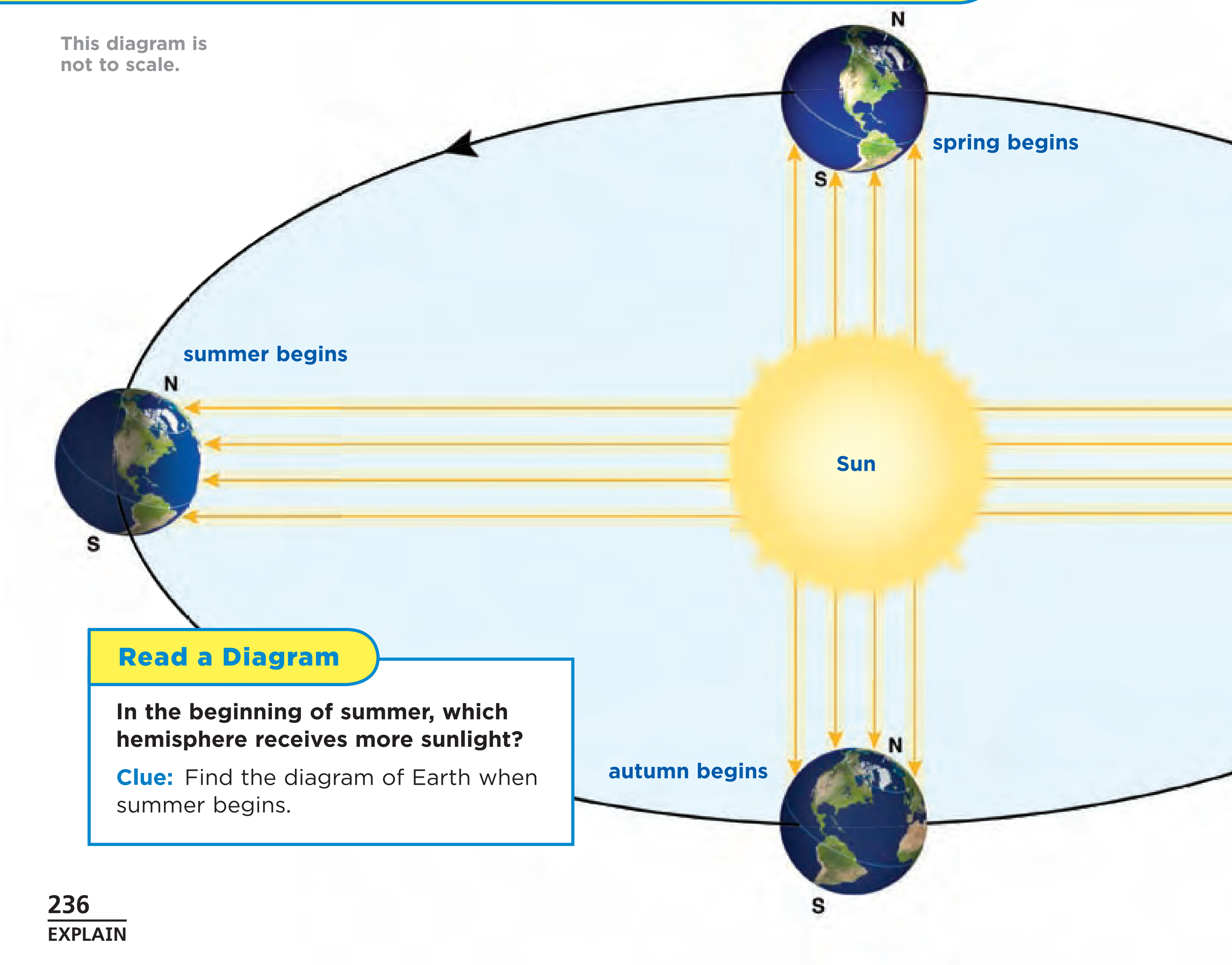
You probably feel like you are sitting still as you read this page, but you are actually rushing through space at 30 kilometers per second (19 miles per second). This is the speed at which Earth is moving around the Sun.

Earth's orbit is about 942,000,000 kilometers (585,000,000 miles) long. How long does it take Earth to make one revolution? A **revolution** is one complete trip around the Sun. Earth makes this trip in one year, or in $365\frac{1}{4}$ days.

During a year, you observe seasons changing on Earth. What causes the seasons to change? As Earth revolves around the Sun, sunlight strikes different parts of Earth at different angles. These changes in the angle of the sunlight cause the seasons.

The angle at which sunlight hits Earth changes during a year because Earth's axis is tilted about 23°. An *axis* is a straight line about which an object rotates. Earth's axis is an imaginary line that runs through Earth between its North and South poles.

How Seasons Change in the Northern Hemisphere During a Year



Read a Diagram

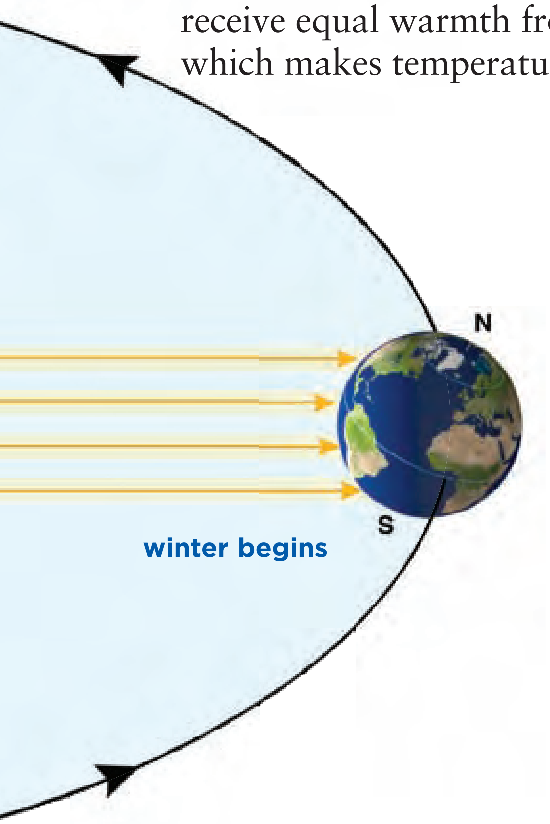
In the beginning of summer, which hemisphere receives more sunlight?

Clue: Find the diagram of Earth when summer begins.

As Earth revolves around the Sun, the tilted axis always points in the same direction. When the Northern Hemisphere is tilted away from the Sun, the ground does not receive much heat energy and temperatures are low. In the Northern Hemisphere, this is the beginning of winter.

At the same time, summer begins in the Southern Hemisphere. The Southern Hemisphere is angled toward the Sun, so the heat energy of the sunlight is more concentrated. The ground receives more heat energy and temperatures are warmer.

Because the tilt of Earth's axis always points in the same direction, the seasons in the Northern and Southern hemispheres are always opposite. In spring and in autumn, both hemispheres receive equal warmth from sunlight which makes temperatures mild.



FACT Earth is closer to the Sun in January than in July.

Quick Lab

Seasons and Earth's Tilt

1. Using modeling clay, make a sphere to represent Earth. Then make a base for the sphere.
2. ⚠ **Be Careful.** Push a toothpick through the sphere to represent Earth's axis. Use a pencil to draw a line around the center to represent the equator.

3. Hold the sphere so the toothpick is straight up and down, then tilt the sphere so the top of the toothpick is at an angle of about 23° and push the bottom of the toothpick into the base.
4. **Observe** Aim a flashlight at the sphere so the end of the toothpick points away from you. Describe how the light spreads over the sphere. What would the seasons be in the Northern and Southern Hemispheres?
5. **Observe** Now shine the flashlight so the end of the toothpick points toward you. Describe how the beam of light spreads over the sphere. What would the seasons be in the Northern and Southern Hemispheres?

Quick Check

Fact and Opinion Write a fact about why Earth's seasons change.

Critical Thinking When the season in the Northern Hemisphere is autumn, what season occurs in the Southern Hemisphere?

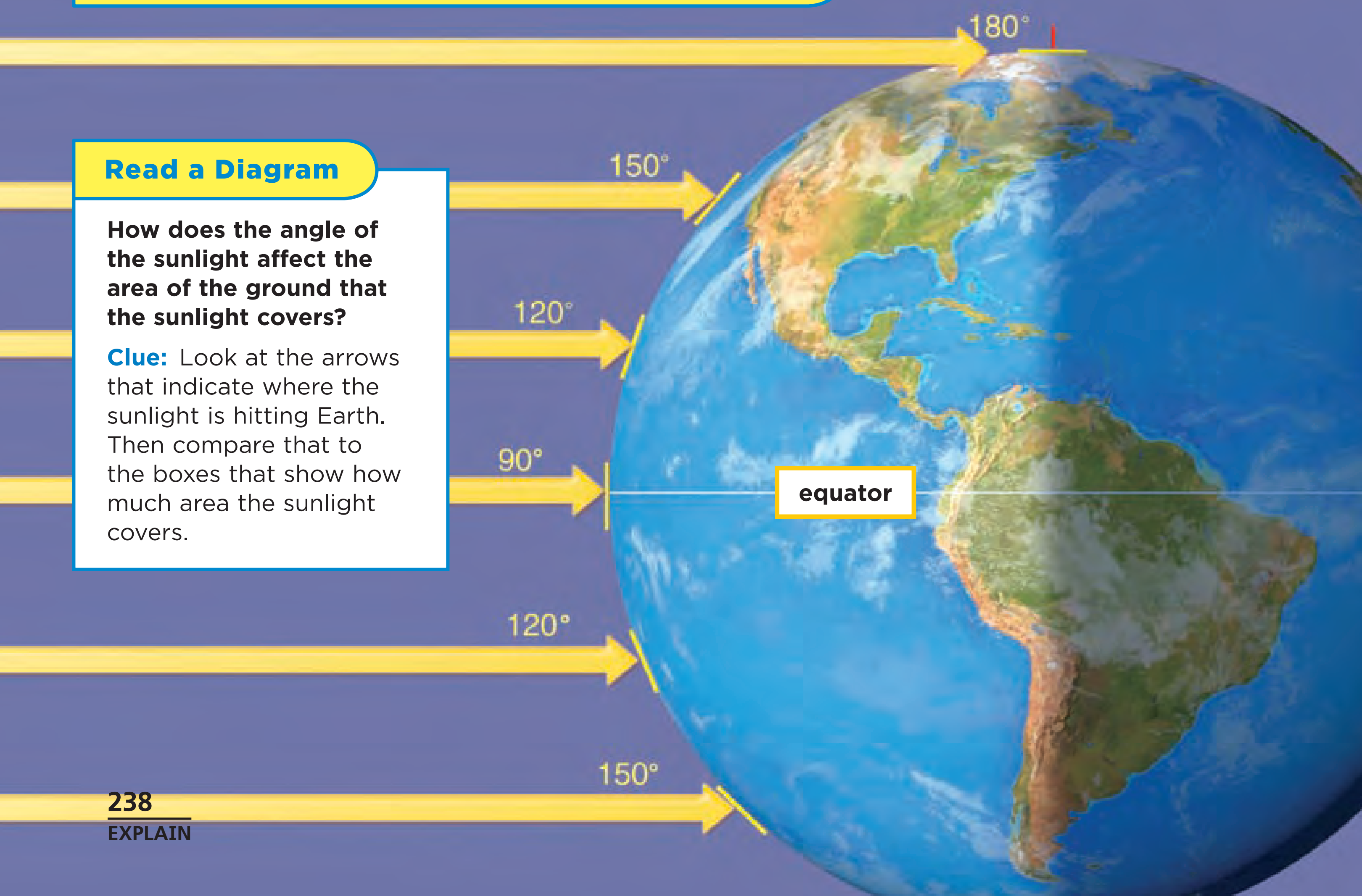
How does the Sun warm Earth?

On the first day of spring, the thermometer outside your window in New York City, NY, reads 41°F (5°C). Your friend lives in Miami, FL, about 2,080 kilometers (1,290 miles) to the south. She says that the temperature there is 72°F (22°C). What causes the temperature to be warmer in Miami than in New York City?

When sunlight shines on Earth, energy from the Sun warms Earth's surface. The solar energy that reaches a planet is called **insolation** (in•suh•LAY•shuhn). However, insolation does not warm all places on Earth equally.

One reason for the difference in temperature has to do with Earth's shape. Earth is shaped like a sphere, or a ball. An imaginary line called the *equator* (ee•KWAY•tuhr) runs around Earth's middle. Sunlight strikes with the most vertical angle at or near the equator.

Angles of Sunlight on the First Day of Spring



Read a Diagram

How does the angle of the sunlight affect the area of the ground that the sunlight covers?

Clue: Look at the arrows that indicate where the sunlight is hitting Earth. Then compare that to the boxes that show how much area the sunlight covers.

If you think of sunlight as a beam of light, the beam shines on Earth in a circle at the equator. Since Earth's surface is curved, the same beam will strike Earth at a wider angle above or below the equator.

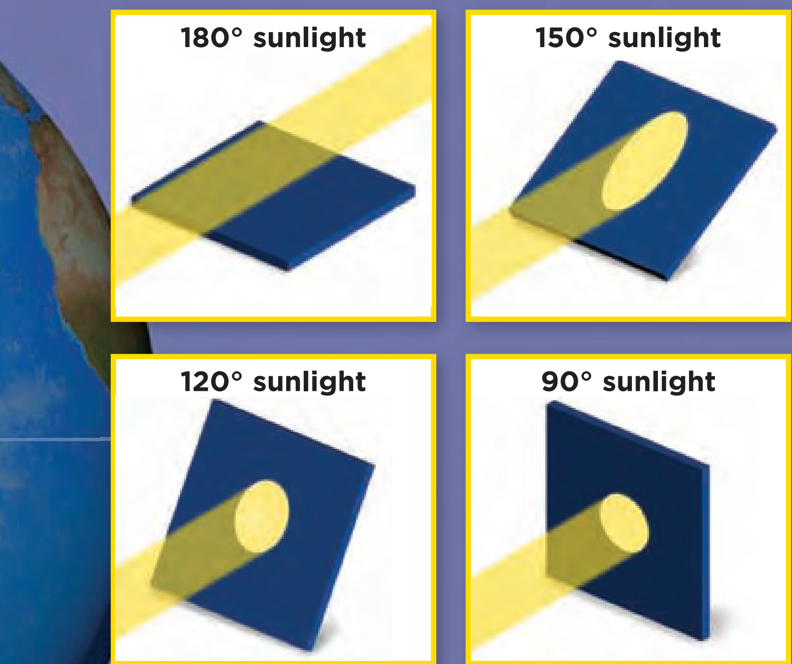
The beam of sunlight always has the same amount of heat energy. However, a beam that warms Earth in an oval covers a greater area of Earth's surface than a beam that warms Earth in a circle. The heat energy of the sunlight is spread over a greater area.

Because the area is larger but the heat energy in the sunlight is the same, each part of that area receives less energy. Areas that are farther north or south of the equator receive less heat energy from sunlight than areas that are closer to the equator. Because New York City is farther away from the equator than Miami, it receives less of the Sun's heat energy.

Quick Check

Fact and Opinion Miami is warmer than New York. Is this a fact or an opinion?

Critical Thinking On what part of Earth is sunlight the least concentrated?



▲ New York (top) is generally cooler than Miami (bottom). Part of the reason for this is that New York receives less heat energy from sunlight than Miami.

What are the layers of the atmosphere?

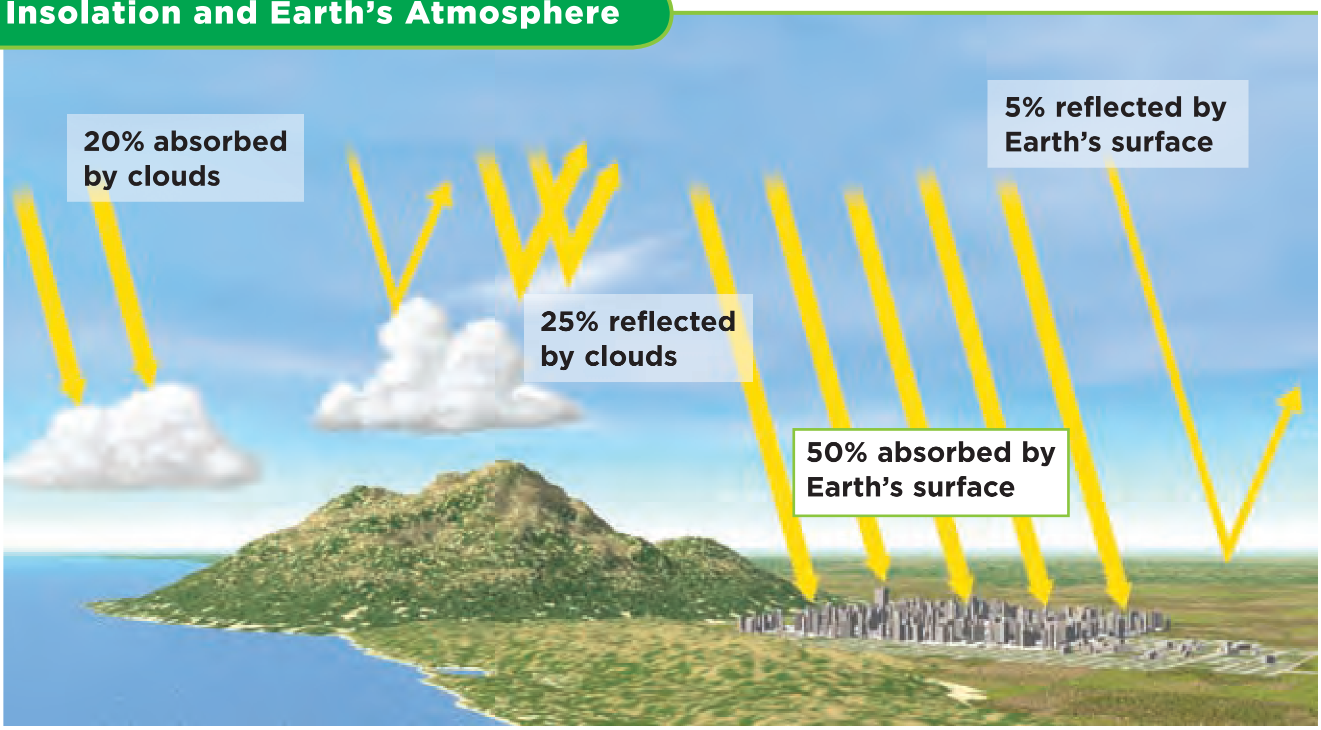
When energy from the Sun hits Earth, about 50 percent of the insolation is absorbed by Earth's surface and about 5 percent of energy from insolation is reflected by Earth's surface. What happens to the rest of the energy?

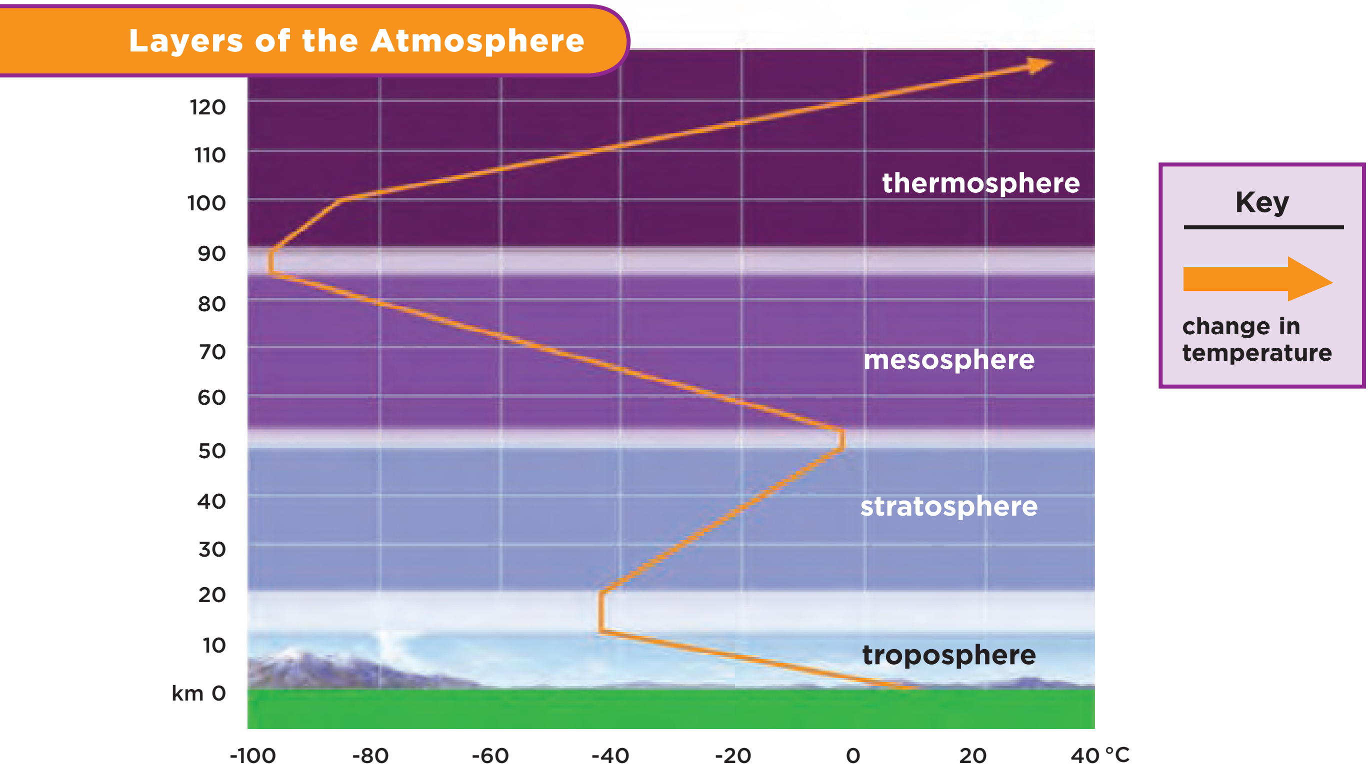
The atmosphere forms five layers of gases around Earth. The layer of gases closest to Earth's surface is called the **troposphere** (TROP•uh•sfeer). The troposphere is between 8 and 18 kilometers (5 to 11 miles) thick. The depth of the troposphere is greatest at the equator and smallest at the poles.

Weather is the condition of the troposphere at a particular time and place. Almost all weather occurs in the troposphere. Weather can be hot or cold, wet or dry, calm or stormy, and sunny or cloudy. Clouds may absorb or reflect about 45 percent of the Sun's energy.

Above the troposphere are the stratosphere, mesosphere, thermosphere, and exosphere. As the height above Earth increases, the number of particles of gas in the atmosphere decreases. The exosphere begins at about 640 kilometers (400 miles) and ends at about 10,000 kilometers (6,200 miles) above Earth's surface. The particles of gas in the exosphere are very far apart.

Insolation and Earth's Atmosphere





The particles of gas press on Earth's surface and on everything they surround. The force put on a given area by the weight of the air above it is called **air pressure** or atmospheric pressure. At sea level, the average air pressure is 1.04 kilograms per square centimeter (1.04 kg/cm^2), or 14.7 pounds per square inch (14.7 lb/in.^{2}).

You can think of this as the weight of a column of air pressing on a patch of Earth's surface about the size of your thumbnail. You do not feel this weight because atmospheric pressure pushes in all directions and these pushes balance each other.

Even though air looks empty, it contains a mixture of gases, such as nitrogen and oxygen. You can tell that air takes up space because it fills up blimps, balloons, and car or bike tires.

FACT Air exerts air pressure in all directions.

Air takes up space in a basketball.

Quick Check

Fact and Opinion Write a fact about how much of the Sun's energy is absorbed by Earth's surface?

Critical Thinking Are there particles of gas in space?

What causes day and night?

You are moving through space at 30 kilometers per second (19 miles per second) as Earth revolves. You are also spinning in a circle at about 1,600 kilometers per hour (1,000 miles per hour) as Earth rotates. One **rotation** is a complete spin on the axis. Earth makes one rotation every day, or 24 hours.

At any point in time, half of Earth's surface faces the Sun and is in daylight. The other half of Earth's surface faces away from the Sun and is in darkness.

The tilt of Earth's axis affects the length of the day. If the axis was not tilted, day and night would each be 12 hours long. Instead, there are more hours of daylight and fewer hours of night during the summer.

Shouldn't you feel movement as Earth revolves and rotates? You don't feel these motions because you are carried along with Earth. It is as if you had your eyes closed as you sped down a perfectly smooth highway in a car. As you sat in the car, you would not feel the motion of the car and would not be able to tell that you were moving.

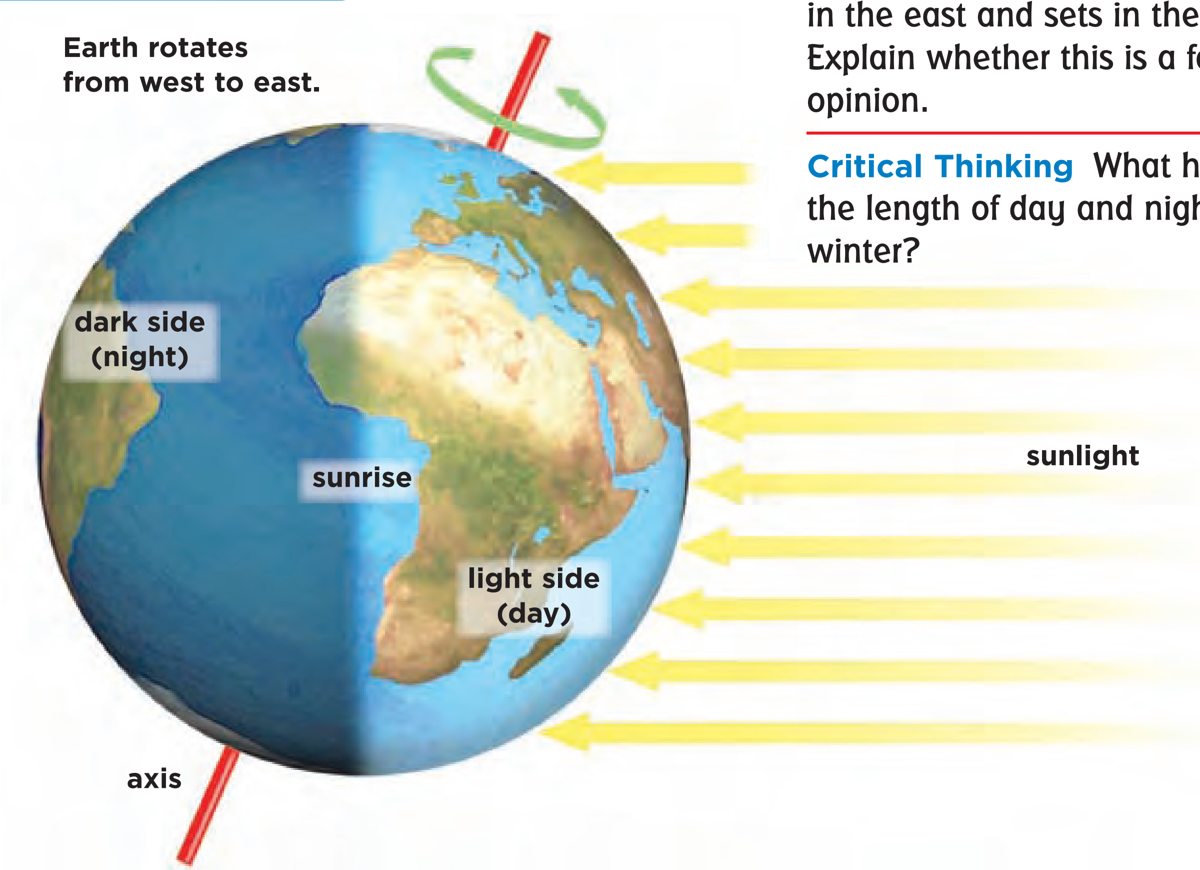
If you watch objects in the sky, such as the Sun, they appear to rise in the east and set in the west. This is the apparent motion of these objects, but is not the real motion. As Earth rotates from west to east, objects in the sky appear to move in the direction opposite of Earth's movement.

Quick Check

Fact and Opinion The Sun rises in the east and sets in the west. Explain whether this is a fact or an opinion.

Critical Thinking What happens to the length of day and night during winter?

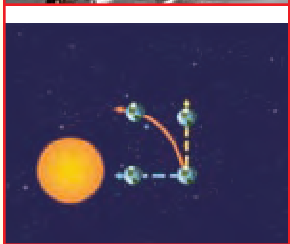
Earth's Rotation



Lesson Review

Visual Summary

The pull of gravity depends on the masses of two objects and the distance between them.

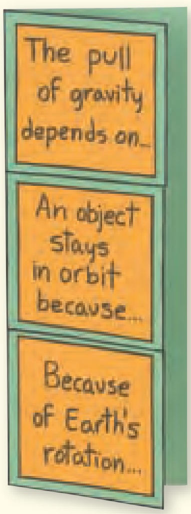


An object stays in orbit because of gravity and inertia.

Because of Earth's rotation, half of Earth's surface is in daylight and half is in darkness.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. On the inside of each tab, write a fact about the title.



Think, Talk, and Write

1. **Main Idea** What factors affect the strength of the pull of gravity between two objects?
2. **Vocabulary** The tendency of a moving object to keep moving in a straight line is called ________.
3. **Fact and Opinion** Earth's day is 24 hours long. Is this a fact or an opinion?

Fact	Opinion

4. **Critical Thinking** Which movement of Earth causes day and night?
5. **Test Prep** **What is the angle at which sunlight strikes the equator on the first day of spring?**
   - **A** 180°
   - **B** 150°
   - **C** 120°
   - **D** 90°
6. **Test Prep** **How much time does Earth take to complete one revolution?**
   - **A** one day
   - **B** one week
   - **C** one month
   - **D** one year

Math Link

Calculating Earth's Mass
The Sun's mass is roughly 330,000 times Earth's mass. If you made a model of the Sun with a mass that was 1,000 kilograms, what would Earth's mass be?

Health Link

Weightlessness
Research and write about how human beings in space are affected by the lack of gravity and how astronauts deal with these effects.

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Inquiry Skill: Use Numbers

When scientists **use numbers**, they add, subtract, multiply, divide, count, or put numbers in order to explain and analyze data.

The orbits of each planet in the solar system have different radii. This means each planet takes a different amount of time to revolve around the Sun. As the radius of the planet's orbit increases, the revolution time increases. What would your age be if you lived on a different planet?

▶ Learn It

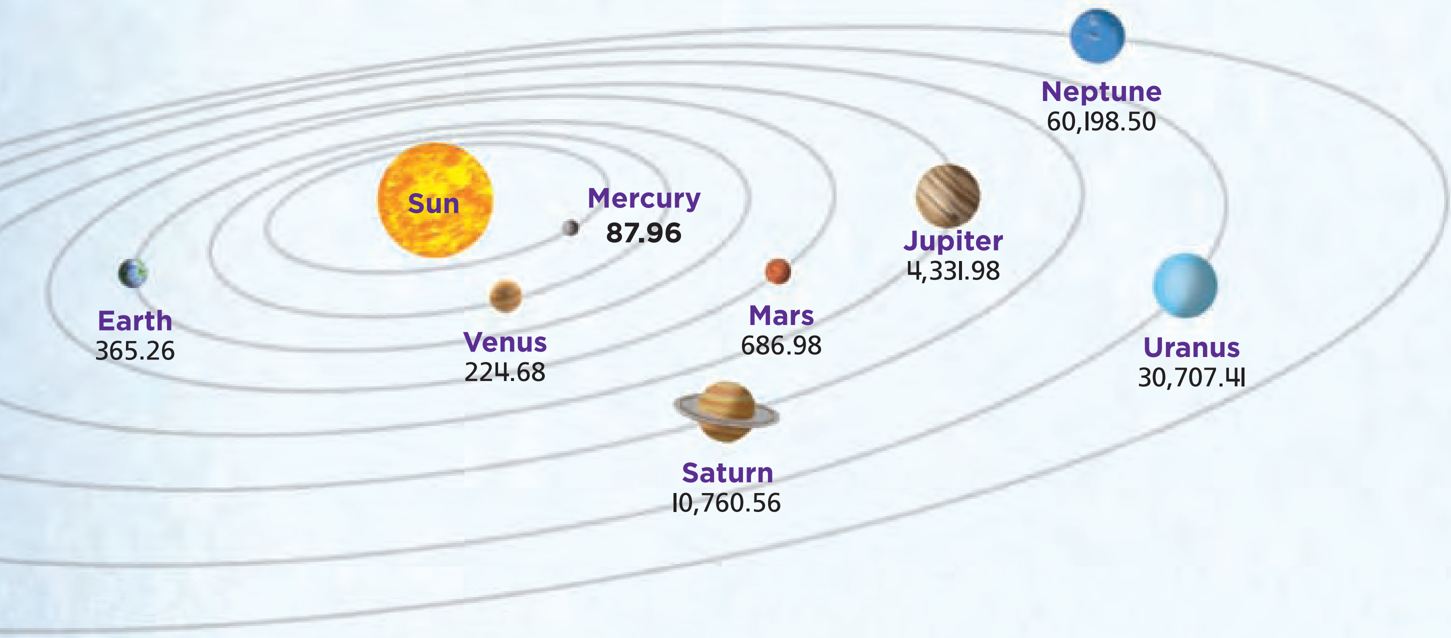
The diagram of the planets shows the time each planet takes to revolve around the Sun in Earth days or years. Scientists **use numbers** to compare the revolution time of the other planets in our solar system to that of Earth. You can do that by dividing the revolution time of a planet by the revolution time of Earth.

For example, it takes Earth $365\frac{1}{4}$ days to travel around the Sun. Mars takes 687 days to complete its revolution. If you divide the length of time it takes Mars to make a revolution by the length of time it takes Earth to make a revolution, you get 1.88. Mars takes almost twice as long as Earth to complete one revolution.

If you were 62 years old in Earth years, how old would you be in Mars years? The ratio of Mars's revolution to Earth's is 1.88. Divide your age by the Earth-planet ratio to calculate your age on a specific planet.

Planet	Revolution (days)	Earth-Planet Ratio	Age on Planet
Mercury			
Venus			
Earth	365	1	62
Mars	687	1.88	33
Jupiter			
Saturn			
Uranus			
Neptune			

Number of Days Each Planet Takes to Revolve Around the Sun



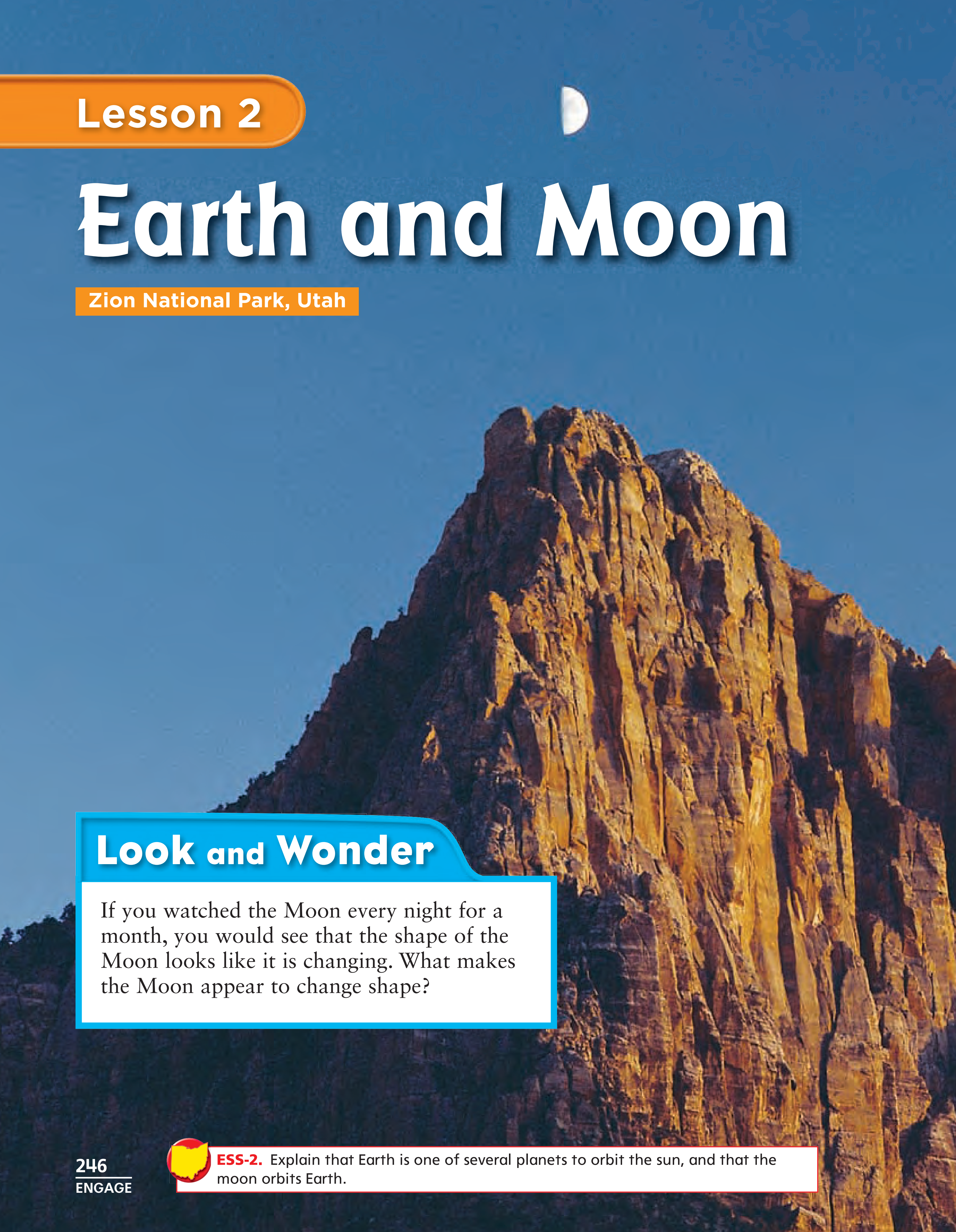
Try It

1. Make a chart with titles like the one shown. Record the revolution data from the diagram on your chart.
2. **Use Numbers** Calculate the Earth-planet ratio for all of the planets.
3. If you were 6 years old in Earth years, how old would you be in Mars years?

Apply It

1. **Use Numbers** Now calculate how old you would be if you lived on each of the planets.
2. On which planet would you be the oldest in that planet's years? On which planet would you be the youngest?
3. What can you infer about the revolution time of the planet and the age you would be on that planet?

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.



Lesson 2

Earth and Moon

Zion National Park, Utah

Look and Wonder

If you watched the Moon every night for a month, you would see that the shape of the Moon looks like it is changing. What makes the Moon appear to change shape?

ESS-2. Explain that Earth is one of several planets to orbit the sun, and that the moon orbits Earth.

Explore

Inquiry Activity

What makes the Moon appear to change shape?

Purpose

To model changes in the appearance of the Moon as seen from Earth.

Procedure

1. **Make a Model** You represent an observer on Earth. A classmate uses a lamp to represent the Sun. A classmate with a ball represents the Moon.
2. Face the classmate with the lamp. Have your other classmate hold the ball directly between you and the lamp.
3. **Observe** Have your classmate turn the lamp on. How much of the surface of the ball is lit? Record what you see.
4. **Observe** Have your classmate with the ball move one eighth of the way around you. Turn to face the ball and record what you see.
5. Repeat step 4 until your classmate returns to the starting position.

Materials

- lamp
- large ball

Draw Conclusions

6. What causes the changes in the Moon's appearance as seen from Earth?
7. What happened to the shape of the ball that represented the Moon during this experiment?

Explore More

Mark one side of the ball. Repeat the procedure while keeping the marked side toward the light. How much sunlight do the marked and unmarked sides receive?

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.

Read and Learn

Main Idea ESS-2

The Moon is Earth's natural satellite.

Vocabulary

phase, p. 248

solar eclipse, p. 251

lunar eclipse, p. 251

tide, p. 252

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Reading Skill

Sequence

First → Next → Last

Craters, rills, maria, and mountains can be seen on the Moon's surface.

How does the Moon appear?

On July 20, 1969, astronaut Neil Armstrong was the first person to walk on the Moon. Armstrong sent this message back to Earth: "The surface is fine and powdery . . . like much of the high desert of the United States."

The Moon has no atmosphere. Because there is no atmosphere, there are no winds and there is no weather on the Moon. There is no air to block radiation from the Sun or for astronauts to breathe. Temperatures can reach as high as 253°F (123°C) and drop below –451°F (–233°C).

How did Earth's visitors to the Moon survive? They wore spacesuits to protect them from the changes in temperature and from radiation. They also carried containers of oxygen to breathe.

The craters on the Moon's surface were made over billions of years as rocks traveling through space hit the Moon. Vast plains cover other parts of the Moon. Early astronomers called these plains *maria*, a Latin word meaning "seas." Valleys, or *rills*, cut grooves in the Moon's surface. In other places, mountains rise thousands of meters.

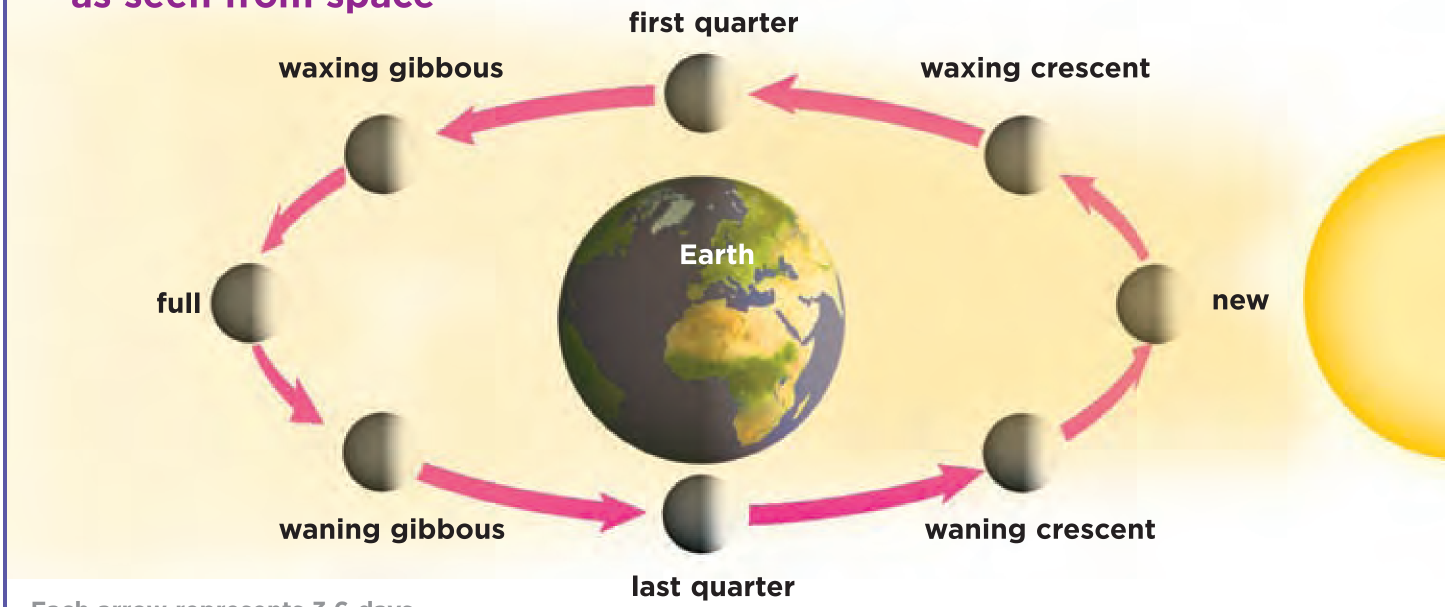
Phases of the Moon

From Earth, you can only see the parts of the Moon's surface that are lit by sunlight. If you looked at the Moon from out in space, you would see that the side of the Moon that faces the Sun is always lit by sunlight. As the Moon revolves around Earth, different amounts of light reflect from the Moon's surface and the Moon appears to change shape.

During a full-moon phase, an observer on Earth can see the entire half of the Moon that is lit by sunlight. During a new-moon phase, the lit side of the Moon is facing away from an observer on Earth. A **phase** of the Moon is the appearance and shape of the Moon as you see it at a particular time. The phase depends on the location of the Moon in relation to Earth and the Sun. The time from one phase of the Moon until the next time the Moon reaches the same phase is 29.5 days.

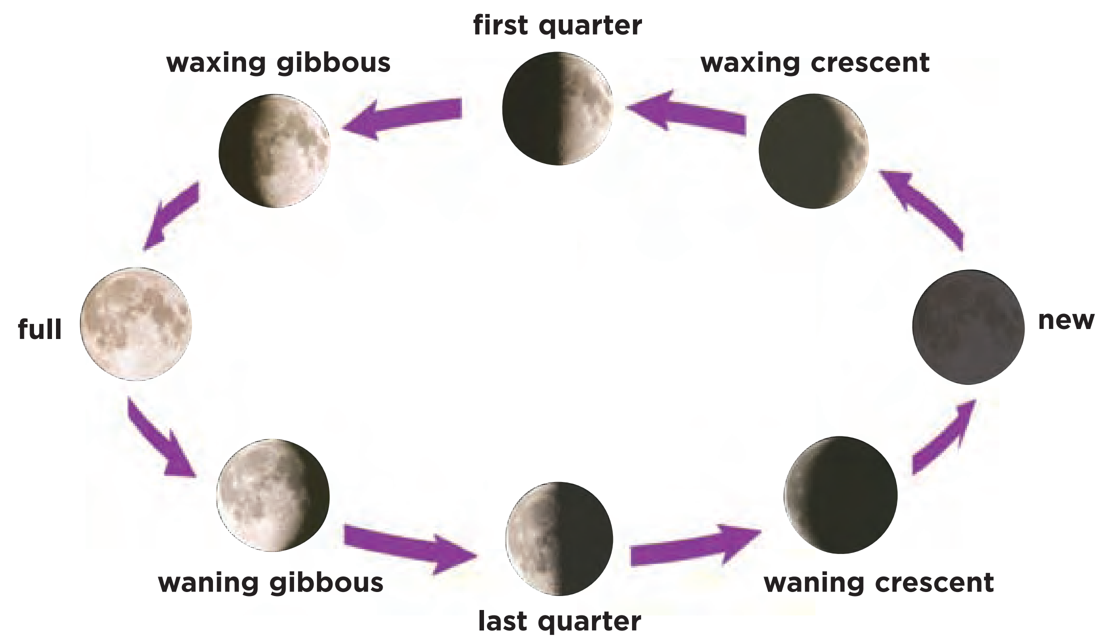
Phases of the Moon

as seen from space



Each arrow represents 3.6 days.

as seen from Earth



Each arrow represents 3.6 days.

Quick Check

Sequence Starting with a full moon, what are the phases of the Moon during a month?

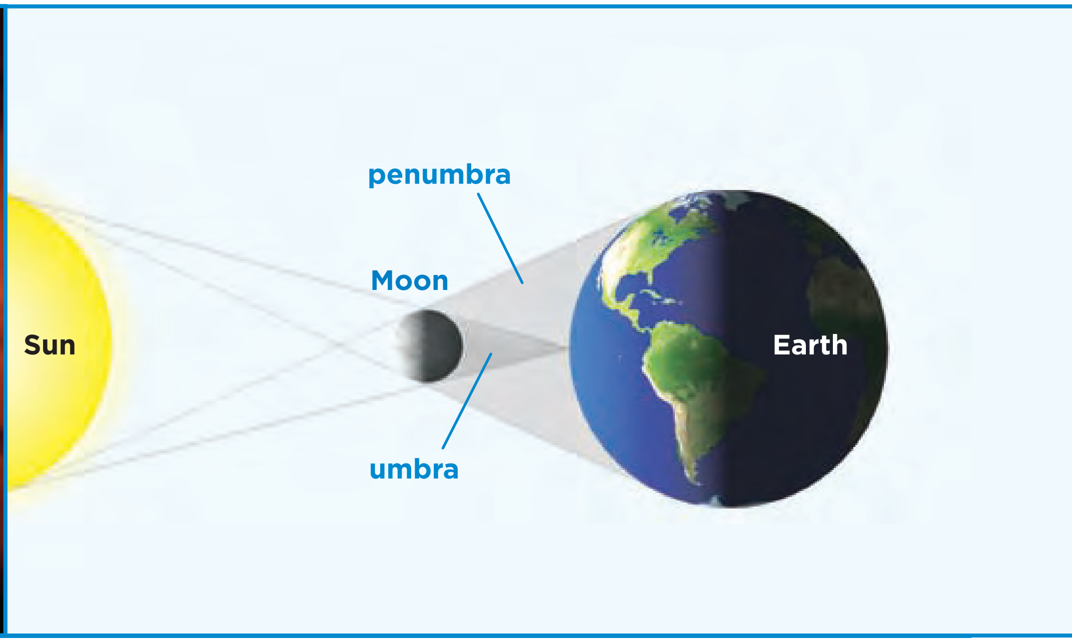
Critical Thinking How does the Moon change during the waxing and waning phases?

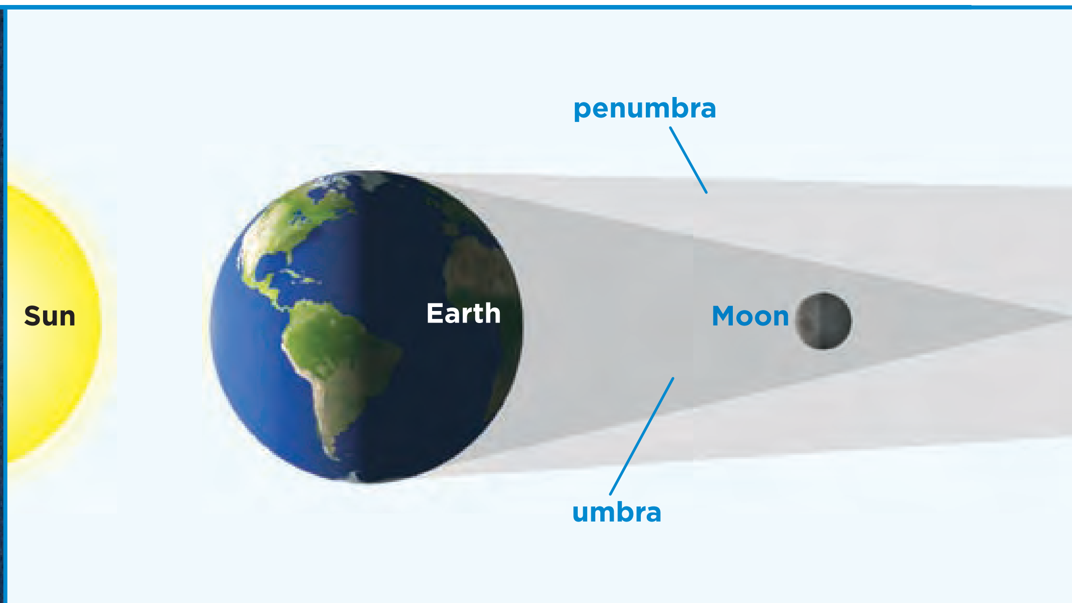
FACT The phases of the Moon are caused by the revolution of the Moon around Earth.

What causes eclipses?

What is happening when a dark shadow seems to move in front of the Sun or when the Moon dims or changes color? These events are called *eclipses*. An eclipse occurs when one object moves in front of another object in space.

Eclipses





Read a Diagram

What is the location of the Moon during lunar and solar eclipses?

Clue: Look at the diagrams of the two eclipses.

A **solar eclipse** occurs when the Moon passes directly between the Sun and Earth. When this happens, the Moon casts a shadow on Earth. People on Earth see darkness move across the Sun. A solar eclipse can only occur during a new-moon phase.

A **lunar eclipse** occurs when the Moon moves into Earth's shadow and is no longer reached by direct sunlight. This happens when Earth is between the Sun and the Moon. Lunar eclipses happen only during full-moon phases.

A full moon and a new moon occur once a month, but eclipses happen more rarely. What makes eclipses occur less frequently? The Moon's orbit moves above and below a straight line between Earth and the Sun. Because of these differences in its orbit, the Moon rarely travels exactly between Earth and the Sun.

Look at the way the Sun, the Moon, and Earth line up in lunar and solar eclipses. In both cases, there is an area where the light from the Sun is completely blocked. This area is called the *umbra*. Around the umbra, there is an area where light is not completely blocked. This is called the *penumbra*.

In solar eclipses, the shadow of the Moon causes the umbra and penumbra. If you are on Earth in the umbra during a solar eclipse, darkness covers the entire face of the Sun. This is called a *total solar eclipse*. If you are on Earth in the penumbra during a solar eclipse, darkness covers only part of the Sun. This is called a *partial solar eclipse*.

Quick Lab

Eclipses

1. **Make a Model** You will represent Earth using a large ball. One classmate will use a flashlight to model the Sun. Another classmate will use a tennis ball to represent the Moon.

2. Begin by facing the classmate with the lamp. Rotate the Moon through one month of revolution around Earth.
3. What positions of the Moon, Earth, and Sun produce eclipses?

In lunar eclipses, Earth's shadow causes the umbra and penumbra. Lunar eclipses may also be total or partial depending on whether or not the Moon is in the umbra or penumbra.

Quick Check

Sequence In a solar eclipse, what are the positions of the Sun, the Moon, and Earth?

Critical Thinking What would you see if you were on the Moon's surface during a lunar eclipse?

What causes the tides?

The pull of gravity between the Moon and Earth and between the Sun and Earth causes a bulge in the surface of Earth. On the part of Earth's surface that is rocky, we do not notice this pull. However, the pull can be seen in the oceans and other large bodies of water. This pull causes the **tide**, or the rise and fall of the ocean's surface.

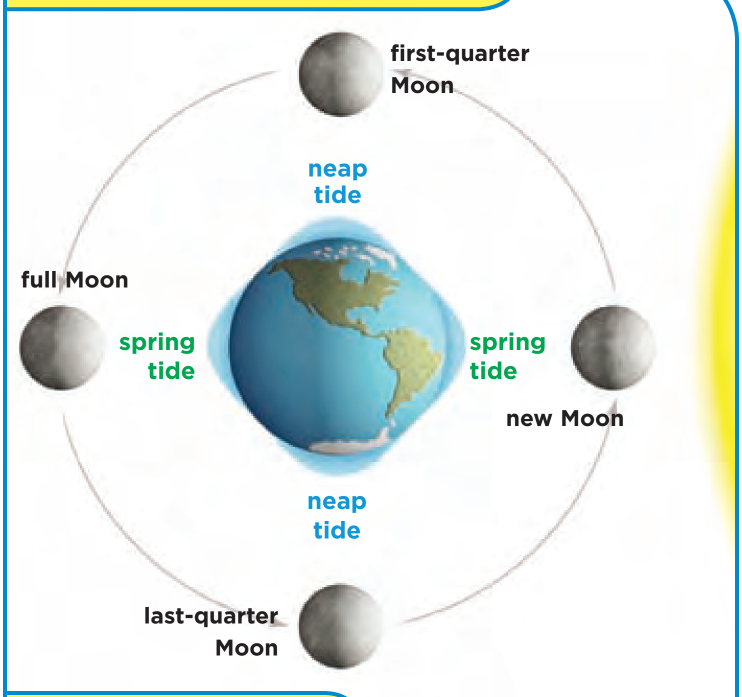
The pull of gravity causes ocean water to bulge on the side of Earth facing the Moon. A matching bulge occurs on the side of Earth that is opposite the Moon. This causes high tides at both locations. Low tides occur halfway between high tides. As Earth rotates, these bulges move across the oceans. Most oceans have two high tides and two low tides every day.

About twice a month, near the new- and full-moon phases, the Sun and the Moon line up and pull in the same direction. This causes higher high tides and lower low tides, called *spring tides*. The tides with the smallest range between high and low tides occur between these two spring tides. These more moderate tides are called *neap tides*. They take place when the Sun and the Moon pull in different directions and their pulls partly cancel each other. Neap tides occur during the first-quarter and last-quarter moon phases.

low tide

high tide

Tides During One Month



Read a Diagram

During which phases of the Moon do the strongest tides occur?

Clue: The strongest tides are caused when gravity from the Sun and from the Moon pull together on Earth.

LOG ON *Science in Motion* Watch how gravity causes tides at www.macmillanmh.com

Quick Check

Sequence When do the weakest tides occur?

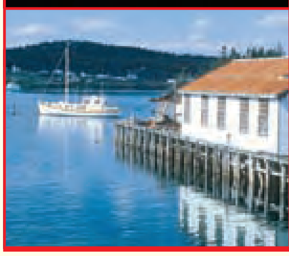
Critical Thinking What makes spring tides and neap tides occur twice a month?

Lesson Review

Visual Summary

Earth's Moon goes through eight phases during one month.

Eclipses are a darkening or hiding of the Sun, a planet, or a moon by another object in space.



Tides on Earth are caused by the pull of gravity from the Moon and the Sun.

Make a FOLDABLES™ Study Guide

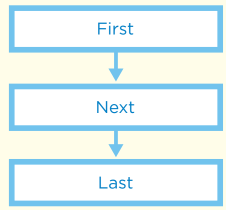
Make a Trifold Book. On each page, summarize what you have learned.

Think, Talk, and Write

1. **Main Idea** What makes Earth's Moon a natural satellite?

2. **Vocabulary** During a(n) ________ the Moon passes through Earth's shadow.

3. **Sequence** Draw the phases of the Moon beginning with the new moon.



4. **Critical Thinking** How did astronauts survive as they explored the Moon?

5. **Test Prep** **When the Moon is completely in the umbra during a lunar eclipse, this is called a ________**
   - **A** total solar eclipse.
   - **B** partial lunar eclipse.
   - **C** total lunar eclipse.
   - **D** partial solar eclipse.

6. **Test Prep** **Which pair of moon phases are opposites?**
   - **A** new and full
   - **B** waxing crescent and first quarter
   - **C** full and waning gibbous
   - **D** waxing gibbous and last quarter

Math Link

Diameter of Earth and the Moon

The diameter of Earth is 12,760 kilometers across, while the diameter of the Moon is 3,475 kilometers across. Convert these distances into miles and feet.

Social Studies Link

What Is a Blue Moon?

"Once in a blue Moon" is an expression meaning an event that rarely happens. Research the meaning of the phrase "blue Moon" and explain how it could relate to this expression.

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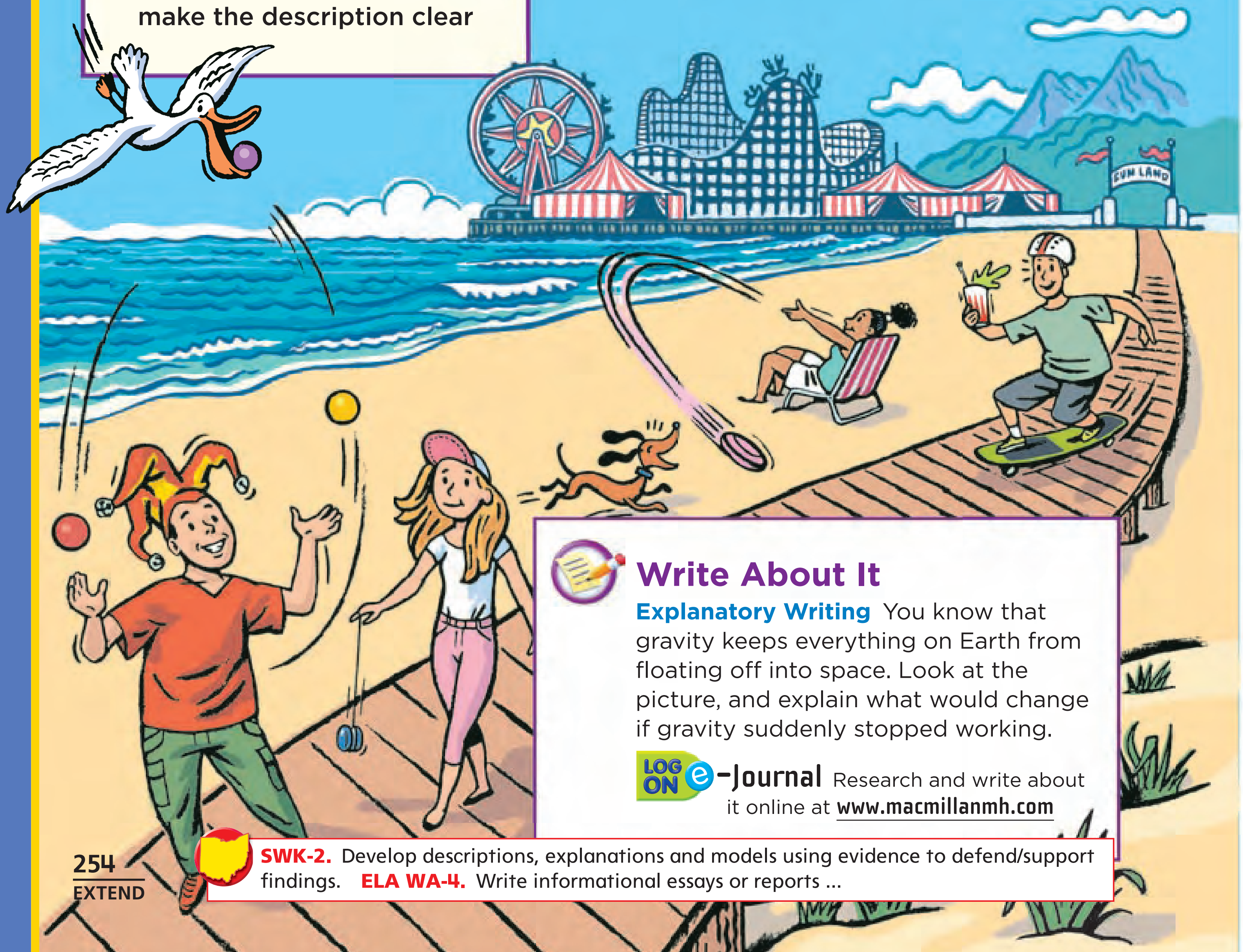
What Would Happen If Gravity Went Away?

Explanatory Writing

A good explanation

- develops the main idea with facts and supporting details
- lists what happens in an organized and logical way
- uses time-order words to make the description clear

If gravity went away in my room, the first thing I would do would be to tie my furniture to the floor to keep it from floating around. Then, I would gather all my small toys and put them in a box so I'd know where to find them. Finally, I would practice somersaults and walk on the ceiling.



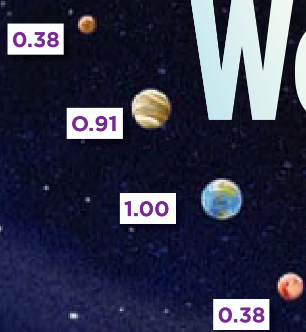
Write About It

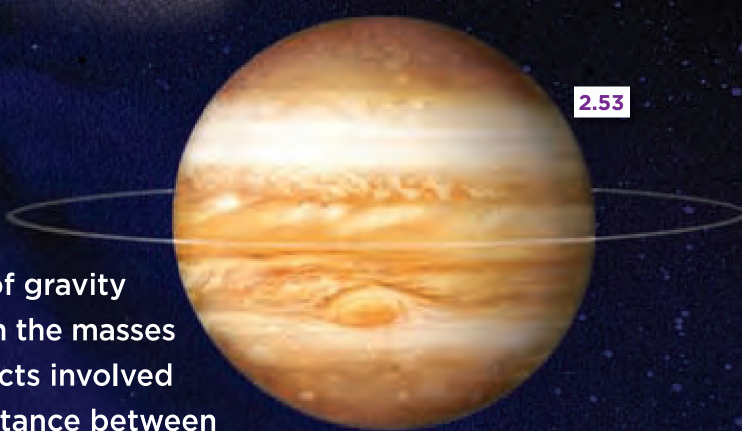
Explanatory Writing You know that gravity keeps everything on Earth from floating off into space. Look at the picture, and explain what would change if gravity suddenly stopped working.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings. **ELA WA-4.** Write informational essays or reports ...

Weight on Other Planets



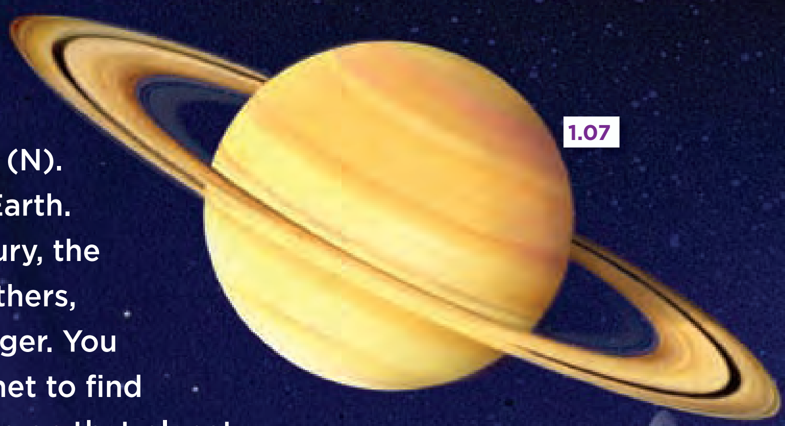


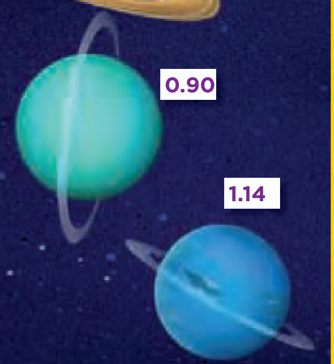
Multiply Decimals

To multiply decimals

- ▶ multiply as with whole numbers
- ▶ count the number of decimal places in each factor
- ▶ add the total number of decimal places
- ▶ move the decimal point that many places to the left in the product

The force of gravity depends on the masses of the objects involved and the distance between them. On other planets, the weight of an object would not be the same as it is on Earth. Weight is measured in newtons (N). A 1-kg object weighs 9.8 N on Earth. On some planets, such as Mercury, the pull is much weaker, while on others, such as Jupiter, it is much stronger. You can use the gravity of each planet to find the weight an object would have on that planet.





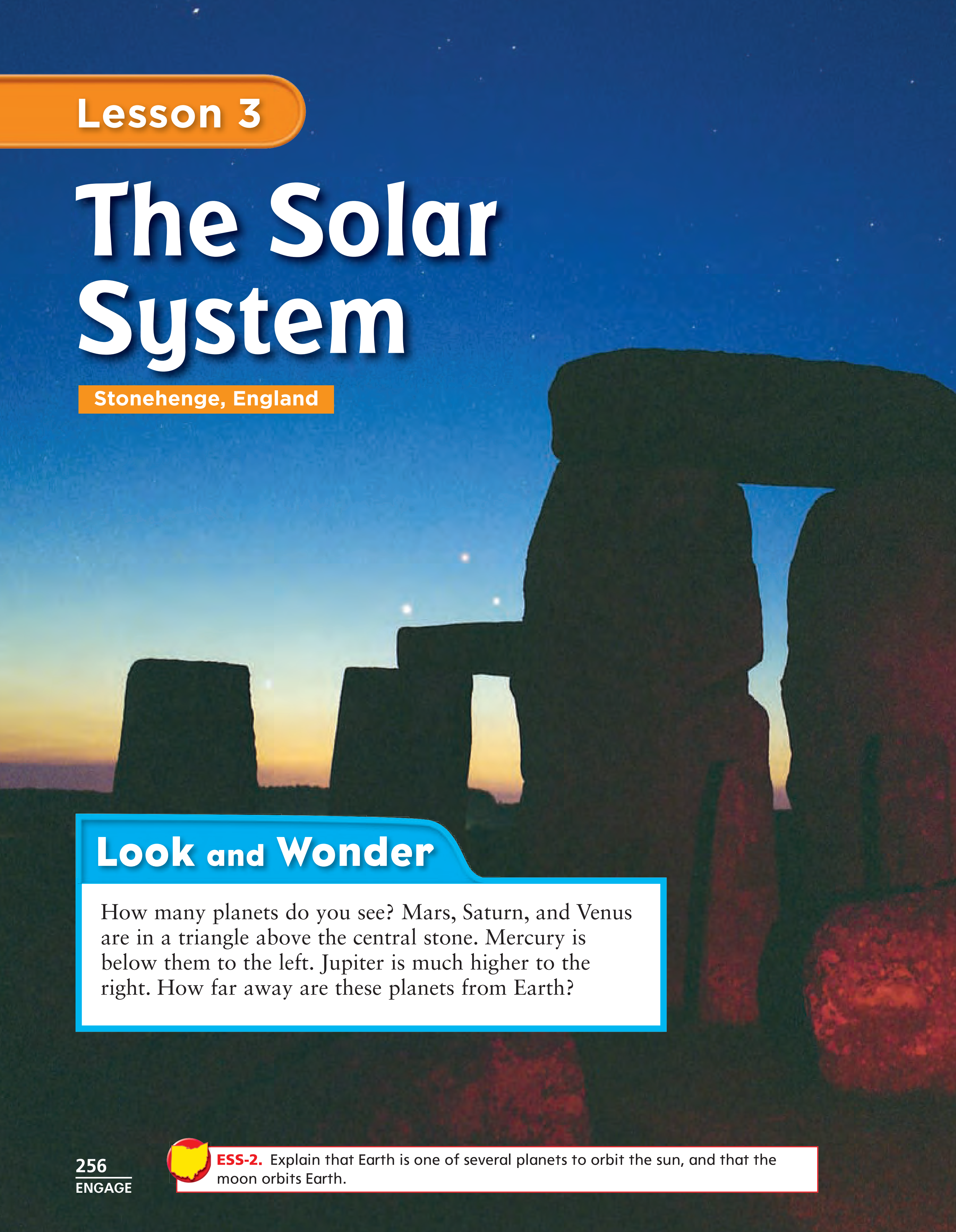
Solve It

1. *Spirit,* the Mars Exploration Rover, weighs 1700 newtons on Earth. How much would it weigh on Mars?
2. An astronaut weighs 910 newtons on Earth. How many newtons would the astronaut weigh on Venus?
3. If a dog weighs 290 newtons on Earth, how much would the dog weigh on each planet?

M NNSO-3. Identify and generate equivalent forms of fractions, decimals, and percents. **M-5.** Make conversions within the same measurement system while performing computations.

Lesson 3

The Solar System



Stonehenge, England

Look and Wonder

How many planets do you see? Mars, Saturn, and Venus are in a triangle above the central stone. Mercury is below them to the left. Jupiter is much higher to the right. How far away are these planets from Earth?

ESS-2. Explain that Earth is one of several planets to orbit the sun, and that the moon orbits Earth.

Explore

Inquiry Activity

How far apart are the planets?

Purpose

To make a model that shows the distances between the planets using Astronomical Units (AU), where one AU equals the average distance between Earth and the Sun. This distance is about 149,591,000 kilometers (92,960,000 miles).

Procedure

1. Let the length of each paper towel equal 1 Astronomical Unit. Using the information on the chart, roll out the number of paper towels you need to show the distance from the Sun to Neptune.
2. **Make a Model** Mark the location of the Sun at one end. Then measure the distance that each planet would be from the Sun and draw the planet on the paper towel.

Draw Conclusions

3. **Interpret Data** Compare the distances between Mercury and Mars, Mars and Jupiter, and Jupiter and Neptune. Which are farthest apart?
4. **Infer** What can you conclude about the distances between the planets in the solar system?

Explore More

Your model has all of the planets in a line. How could you make a model to show the positions of the planets at a specific time? Write instructions that others can follow to make the model.

Materials

- paper towels
- markers
- ruler
- masking tape

Step 1

Distances of the Planets from the Sun

planet	distance in AU
Mercury	0.4
Venus	0.7
Earth	1
Mars	1.5
Jupiter	5.2
Saturn	9.5
Uranus	19.2
Neptune	30

Step 2

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.

Read and Learn

Main Idea ESS-2

Our solar system is made up of the Sun, the eight planets and their moons, and comets, asteroids, and meteoroids.

Vocabulary

telescope, p. 258
planet, p. 260
moon, p. 264
satellite, p. 264
comet, p. 266
asteroid, p. 267
meteor, p. 267

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Reading Skill

Infer

Clues	What I Know	What I Infer

Technology SCIENCE QUEST

Explore gravity and orbits with Team Earth.

How do we observe objects in space?

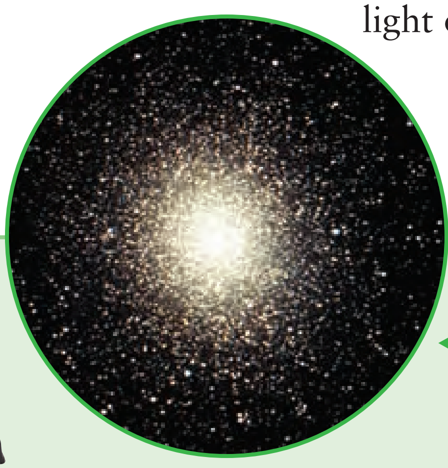
Until January 7, 1610, people observed the night sky using only their eyes. On that date, an Italian astronomer named Galileo Galilei looked at the sky through a telescope for the first time. A **telescope** is an instrument that makes distant objects seem larger and nearer.

Optical Telescopes

Galileo used an optical telescope, which uses lenses or mirrors to see objects by gathering visible light. Among the objects Galileo saw were four moons revolving around the planet Jupiter. At that time, most people believed that all of the objects in the solar system revolved around Earth.

Looking through an optical telescope makes a dim object such as a star seem brighter. It can also make objects appear larger so more details can be seen. When the diameter of the light-gathering lens or mirror is increased, more light is gathered and planets appear larger. Today's optical telescopes have lenses and mirrors many times larger than those of Galileo's telescope. Modern optical telescopes can magnify images of more distant planets and look farther into space.

However, observers on Earth have to look into space through Earth's atmosphere. As you learned, the air in Earth's atmosphere has different densities. As light from distant stars travels through the air, the changes in density make the faint light of stars appear fuzzy.



This large globular cluster was seen through an optical telescope.

Telescopes in Space

In 1990, the *Hubble Space Telescope* was placed into orbit around Earth. Objects that are billions of trillions of kilometers from Earth can be seen through the *Hubble Space Telescope*. The *Hubble Space Telescope* was named after astronomer Edwin Powell Hubble, who studied galaxies.

Placing telescopes in space allows scientists to see into space while avoiding Earth's atmosphere. The *Hubble Space Telescope* and other space telescopes gather more than visible light from objects in space. For example, they can detect the heat that is given off by a star.

◀ This supernova was seen by the *Hubble Space Telescope.*

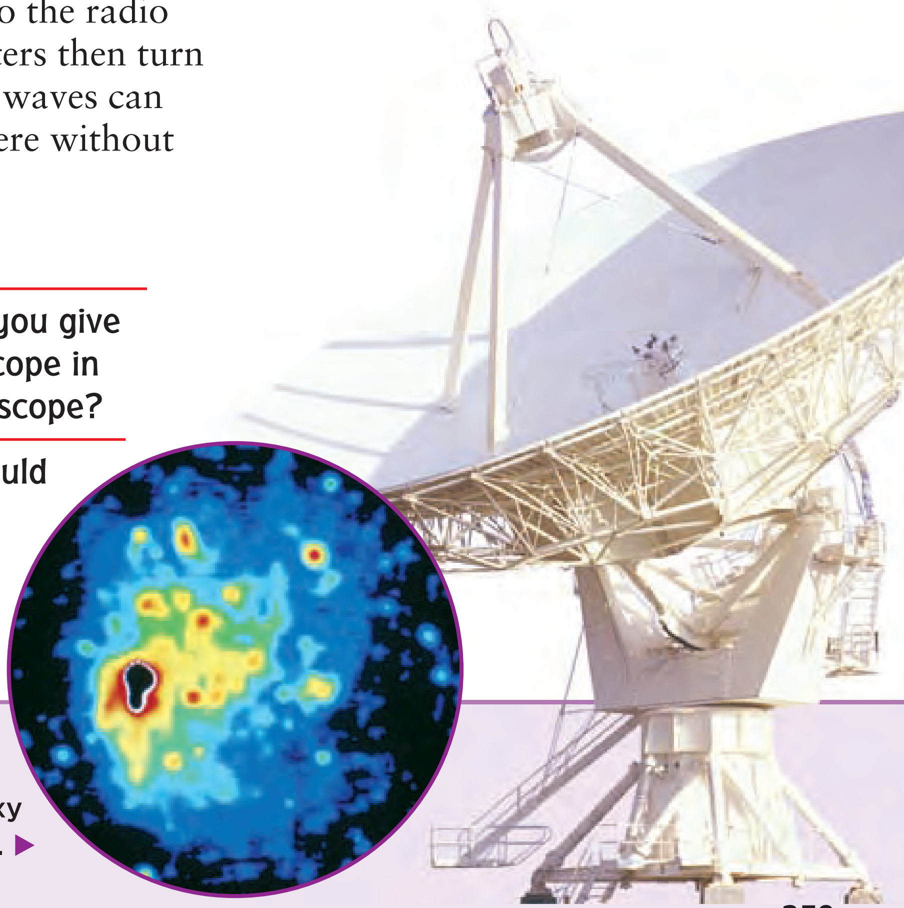
Radio Telescopes

Back on Earth, radio telescopes record data from radio waves given off by objects in space. Groups, or arrays, of dishes focus the radio waves so the radio data can be recorded. Computers then turn the data into an image. Radio waves can pass through Earth's atmosphere without interference.

Quick Check

Infer What reasons could you give for placing an optical telescope in orbit instead of a radio telescope?

Critical Thinking How would Galileo's observation of Jupiter's moons affect the idea that everything revolved around Earth?



This image of an irregular galaxy was made by a radio telescope. ▶

What are planets?

A *solar system* is a star and the objects that orbit around it. In our solar system, there are eight planets orbiting the Sun. A **planet** is a large object that orbits a star.

From nearest to farthest from the Sun, the planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The planets travel in elliptical, nearly circular orbits around the Sun.

The *inner planets* are closer to the Sun than the asteroid belt and have surfaces made of rock. These planets are Mercury, Venus, Earth, and Mars. The *outer planets* are beyond the asteroid belt and have surfaces made of gases. These planets are Jupiter, Saturn, Uranus, and Neptune.

Pluto was once known as the ninth planet. Pluto's elongated orbit and small size were different from the other planets. Because of this, scientists debated whether Pluto should be classified as a planet.

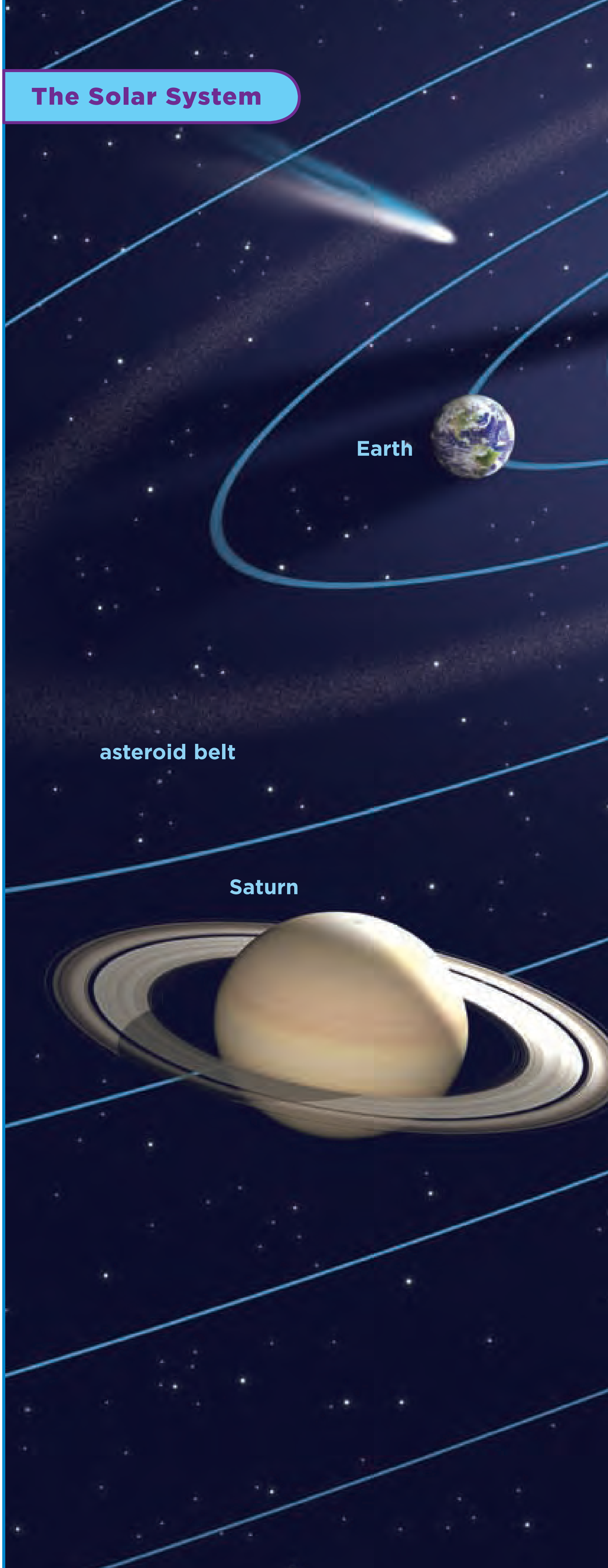
In August 2006, the International Astronomical Union officially reclassified Pluto as a dwarf planet. Other dwarf planets include Ceres, which is found in the asteroid belt, and 2003 UB313, which is larger than Pluto and even farther from the Sun.

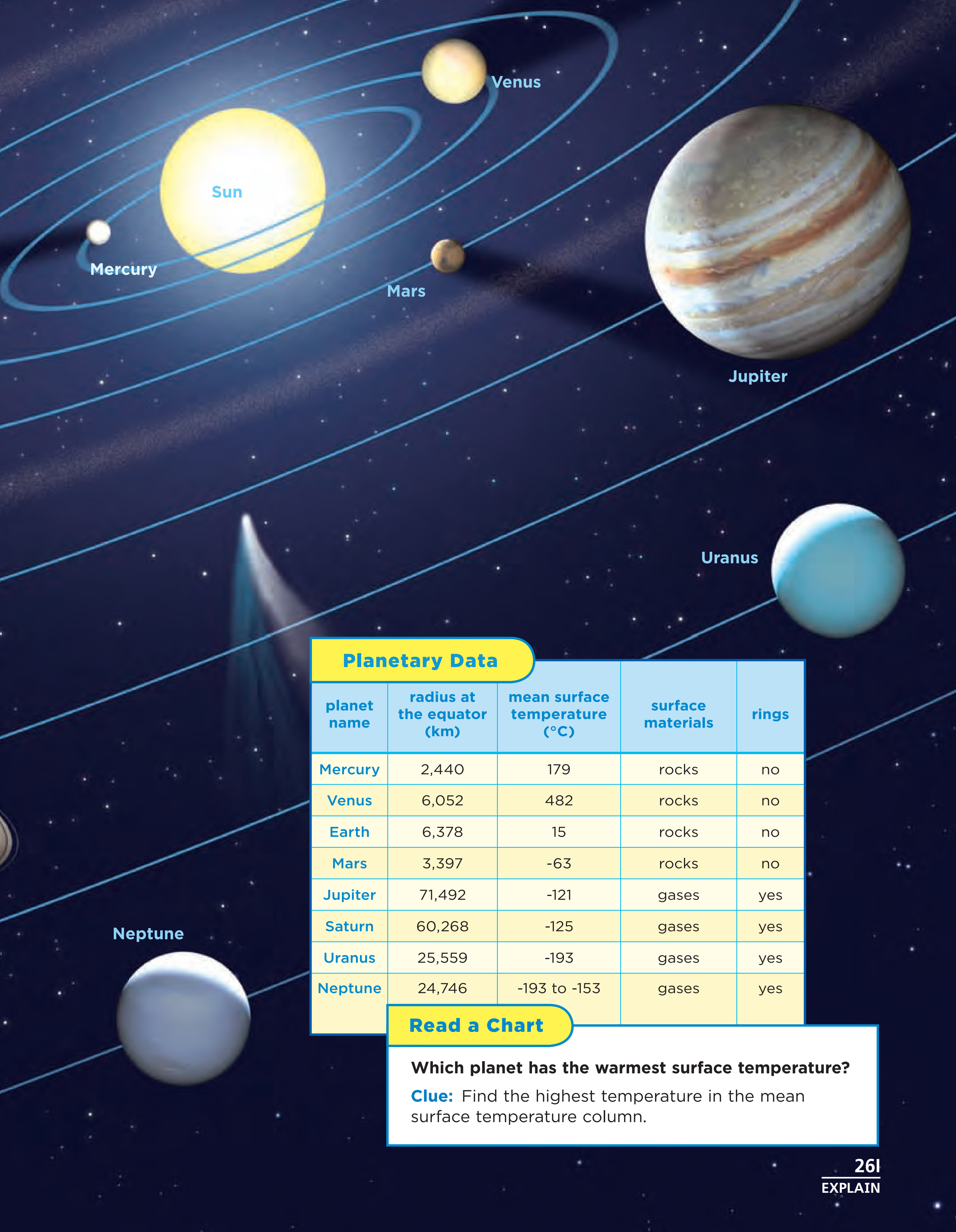
Quick Check

Infer How do the surface materials of the inner and outer planets differ?

Critical Thinking What other objects are in a solar system?

The Solar System





Planetary Data

planet name	radius at the equator (km)	mean surface temperature (°C)	surface materials	rings
Mercury	2,440	179	rocks	no
Venus	6,052	482	rocks	no
Earth	6,378	15	rocks	no
Mars	3,397	-63	rocks	no
Jupiter	71,492	-121	gases	yes
Saturn	60,268	-125	gases	yes
Uranus	25,559	-193	gases	yes
Neptune	24,746	-193 to -153	gases	yes

Read a Chart

Which planet has the warmest surface temperature?

Clue: Find the highest temperature in the mean surface temperature column.

How do the planets compare?

Each planet has unique features. By studying these features, you can learn more about the differences in the surfaces and atmospheres of the planets.

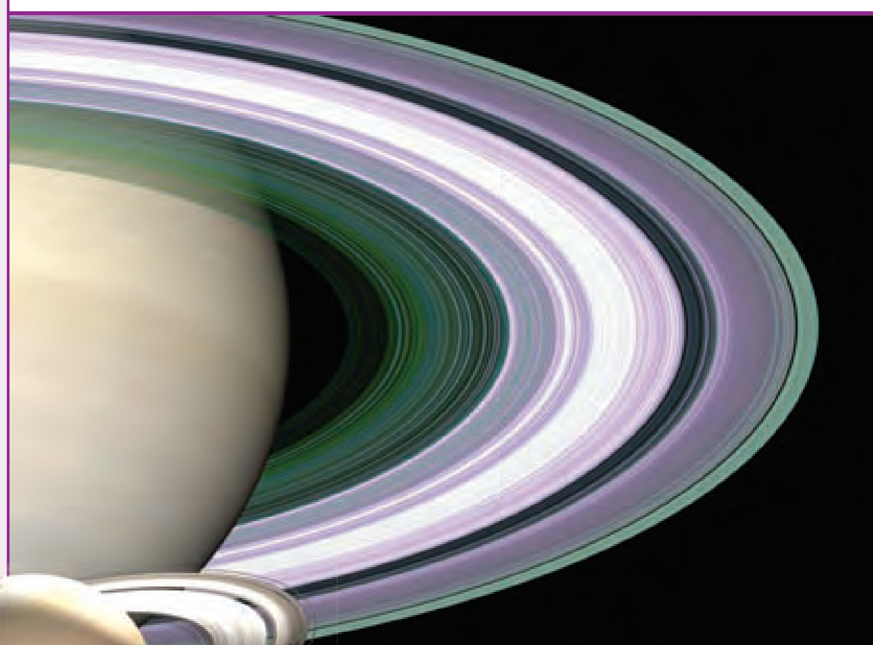
Jupiter's Great Red Spot

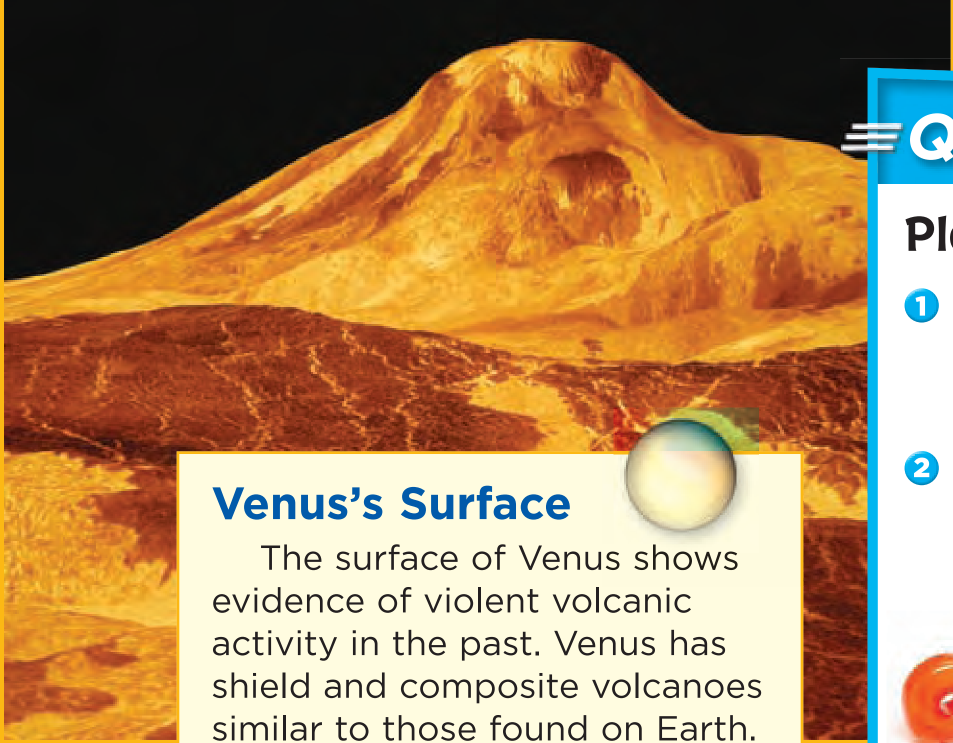
The Great Red Spot is a huge storm that has been blowing continuously for over 400 years. Its winds can reach speeds of about 435 kilometers per hour (270 miles per hour). This storm has a diameter of 24,800 kilometers (15,400 miles), which is almost twice the diameter of Earth. Scientists believe that a combination of sulfur and phosphorus in the atmosphere gives this storm its color.

Saturn's Rings

Saturn's rings were first observed by Galileo in 1610. The rings are made of pieces of ice and rock. Some of these pieces are as small as a grain of sand, while others are as large as a house. Scientists think the rings may be pieces of comets, asteroids, or moons that broke apart near Saturn and were pulled into orbit around it.

Until 1977, scientists thought Saturn was the only planet with rings. As scientists observed the outer planets, they also found faint rings around Jupiter, Uranus, and Neptune.





Venus's Surface

The surface of Venus shows evidence of violent volcanic activity in the past. Venus has shield and composite volcanoes similar to those found on Earth. Long rivers of lava have been seen on Venus.

Mars's Rocks

These dark boulders are volcanic rock fragments that have been found on Mars. These rocks look similar to rocks found near lava flows on Earth. On Earth, these types of rocks only form in the presence of water.

Quick Lab

Planet Sizes

1. **Use Numbers** Using a scale of 2,000 kilometers = 1 centimeter, find the diameter of each of the planets in centimeters.
2. **Make a Model** Using a ruler and scissors, cut circles out of poster board to show the sizes of the planets. Then label each planet.

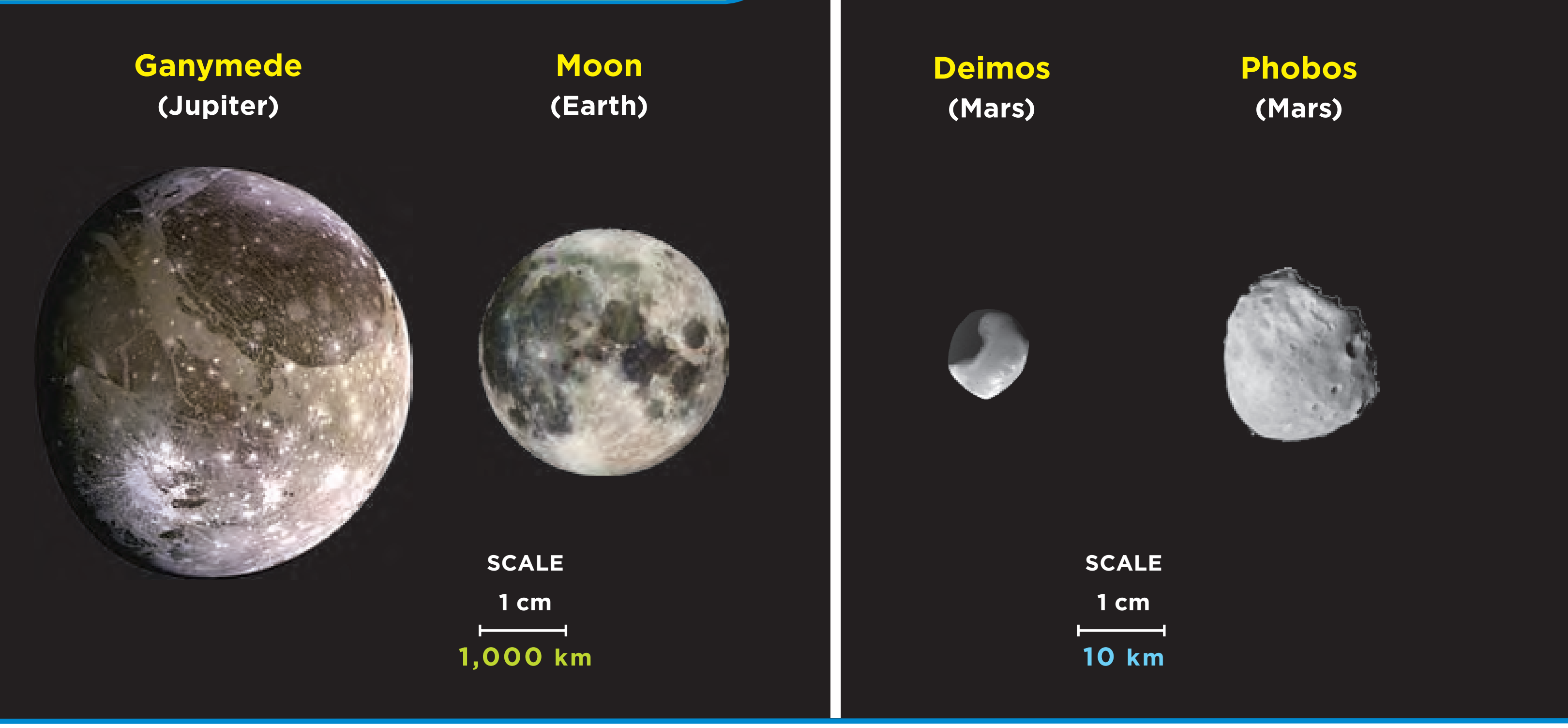
3. Arrange the planets in order from nearest to farthest from the Sun.
4. How do the sizes of the inner and outer planets compare?

Quick Check

Infer What could the fact that there are volcanoes on Venus mean about the interior of the planet?

Critical Thinking How do winds form on Jupiter?

Various Moons of the Solar System



How do the moons compare?

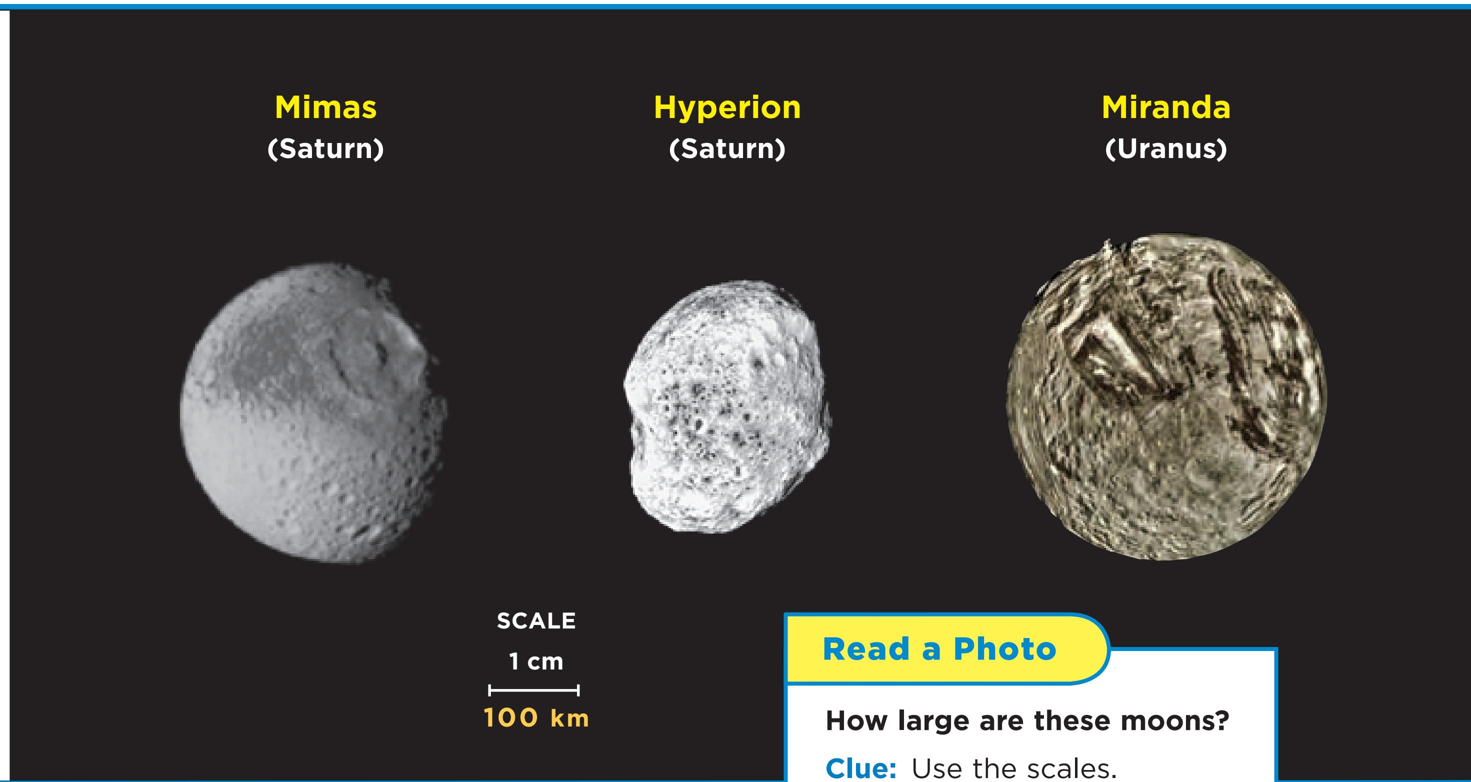
A **moon** is a natural object that orbits a planet. Different planets have different numbers and sizes of moons.

The inner planets have fewer moons than the outer planets. Mercury and Venus do not have moons. Earth has one moon and Mars has two.

With at least 63 moons, Jupiter has the most moons of any planet in the solar system. Saturn has 47 moons. Astronomers have discovered 27 moons around Uranus and 13 moons orbiting Neptune. As astronomers observe the outer planets with better telescopes and with space probes, they continue to find more moons.

Moons are also called *satellites*. A **satellite** is an object in space that circles around another object. While moons are natural satellites, people also put objects into space that orbit Earth or other planets. These objects are called *artificial satellites*. They include weather and communications satellites and space probes that orbit planets to observe their surfaces.

The size of the moons in the solar system varies. Some of the moons are only a few kilometers wide. Jupiter's Ganymede is the largest moon in the solar system. Ganymede is larger in diameter than Pluto and Mercury. Earth's Moon is also larger than Pluto, and is visible without a telescope. Ganymede is the only other moon that may be seen without a telescope.



Read a Photo

How large are these moons?

Clue: Use the scales.

Forming Craters

Sometimes small objects in space collide with large objects. When this happens, the impact often forms a crater, or a bowl-shaped hole, on the large object. Many moons have craters on their surfaces. Craters vary in size because the objects that hit a moon are different sizes and travel at different speeds.

On Earth's Moon, the impact of an object knocks the surface material away so the rock underneath is exposed. The surface material piles around the edges of the crater. This makes the Moon's craters distinct and easy to see from Earth.

Ganymede's surface is made of ice and rock. The dark rock is about 4 billion years old. The light-colored rock is somewhat younger. Craters are seen on both types of rock, which means that objects have been hitting Ganymede for at least 4 billion years. Unlike those on the Moon, craters on Ganymede are flat. This may be because flowing ice on Ganymede's surface smooths out their edges.

Deimos, Mars's smaller moon, is composed of carbon-rich rock and ice. Deimos's surface has craters that have been partially filled in by loose rock.

Quick Check

Infer How are a moon and an artificial satellite different?

Critical Thinking What happens when objects in space collide with Earth?

What are asteroids, comets, and meteors?

Different types of small objects are present in space. These objects include comets, asteroids, and meteors.

Comets

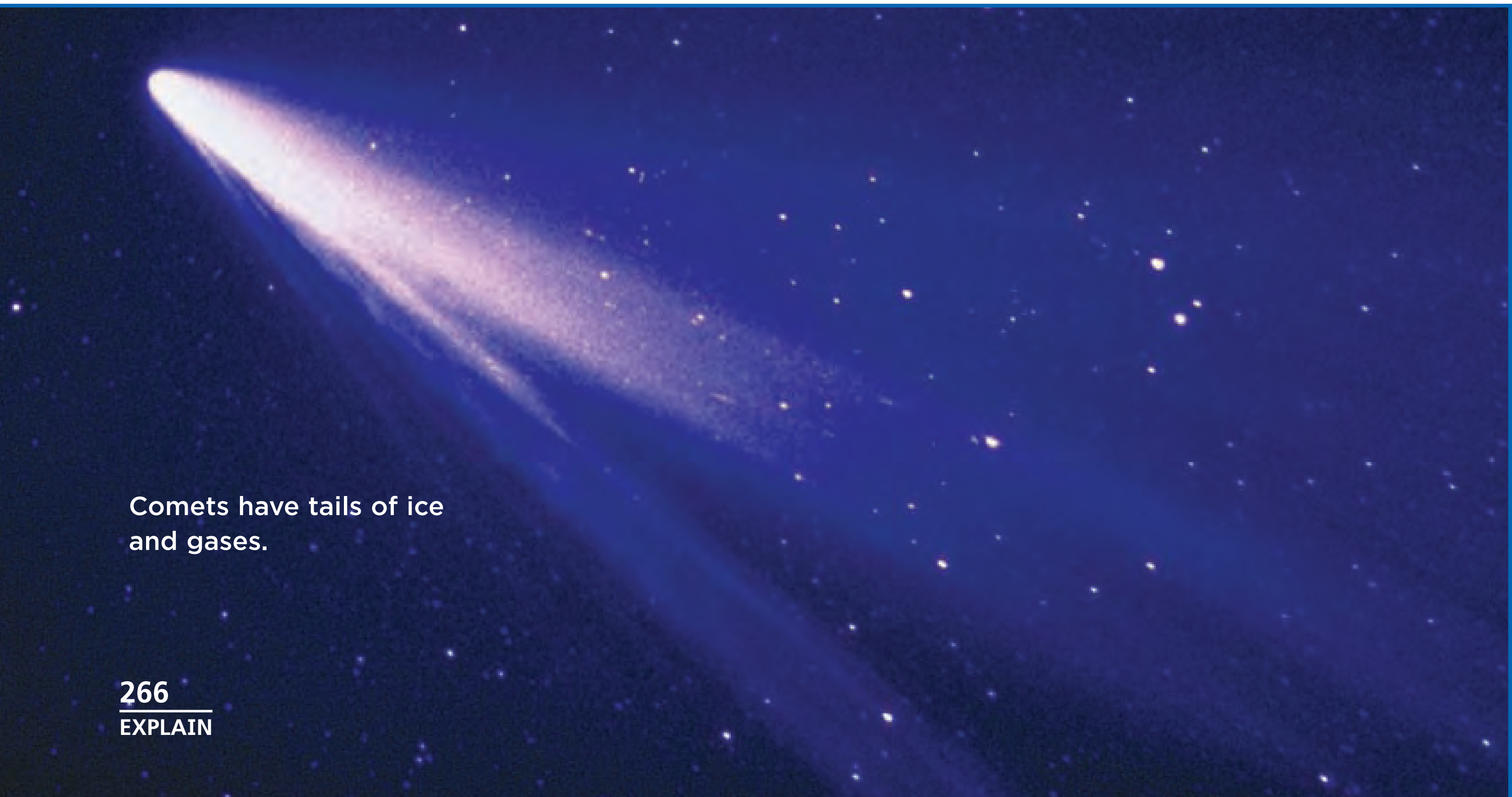
A **comet** is a mixture of frozen gases, ice, dust, and rock that moves in an elliptical orbit around the Sun. Comets are thought to be bits of material left over from the formation of the solar system about 4.6 billion years ago.

When a comet is farther away from the Sun, the gases and ice in the comet are frozen. As the comet moves toward the Sun, the core of the comet, or the *nucleus*, warms up. Some of the ice and dust in the core form a cloud, or *coma*, around the nucleus. Together, the nucleus and coma make up the *head* of the comet.

As the comet gets closer to the Sun, radiation from the Sun pushes some of the coma away from the comet. This material forms a glowing tail that may stretch millions of kilometers behind the head. Sometimes two tails will form. One tail is made of ice and one is made of gases.

Heat energy moves out from the Sun in every direction. As a comet moves around the Sun, the head stays closest to the Sun and the tail trails out behind it. No matter where the comet is in its path around the Sun, the comet's tail always points away from the Sun.

Comets orbit around the Sun, but the amount of time that their orbits take is different. Halley's Comet was the first comet whose return was predicted. It gets close to Earth about every 76 years, most recently in 1986. The next time it will be near Earth is in 2061.



Comets have tails of ice and gases.

The Leonids are a meteor shower that occurs every year in mid-November.

Asteroids

An **asteroid** is a rock that revolves around the Sun. Most of the thousands of asteroids in the solar system are located between Mars and Jupiter in the asteroid belt. Many asteroids have irregular shapes and look like potatoes. Some asteroids are less than 2 kilometers (1 mile) wide, while others can be up to 800 kilometers (500 miles) wide!

Ida is a heavily cratered, irregularly shaped asteroid.

Meteors

The solar system is full of other small objects. In space, these objects are called *meteoroids*. If an object crosses paths with Earth and enters Earth's atmosphere, it is called a **meteor**. Most meteors burn up before they reach the ground. When a meteor lands on the ground, it is called a *meteorite*.

Quick Check

Infer As scientists identify materials in comets, what might they infer about the materials that existed as the solar system formed?

Critical Thinking Draw the location of the tail and head of a comet as it moves around the Sun.

How do we explore the solar system?

Exploration of other worlds started in 1959 when a Soviet rocket carrying scientific instruments landed on the Moon. Since then, we have sent space probes to orbit and land on all of the planets in the solar system. A *space probe* is a vehicle carrying instruments that is sent from Earth to explore an object in space.

The first space probe to visit a planet arrived at Venus in 1965. In 1969, the United States sent the first astronauts to the Moon. An astronaut is a person who travels in a space vehicle. The Moon is the only place in space that astronauts have explored.

In 2004, two small robot cars, or rovers, landed on Mars. The rovers, named *Spirit* and *Opportunity*, drove over the Martian surface. Cameras took pictures of soil, pebbles, and rocks. Instruments aboard the rovers examined the Martian surface and found evidence that liquid water may once have existed on Mars. As far as we know, liquid water is required to support life.

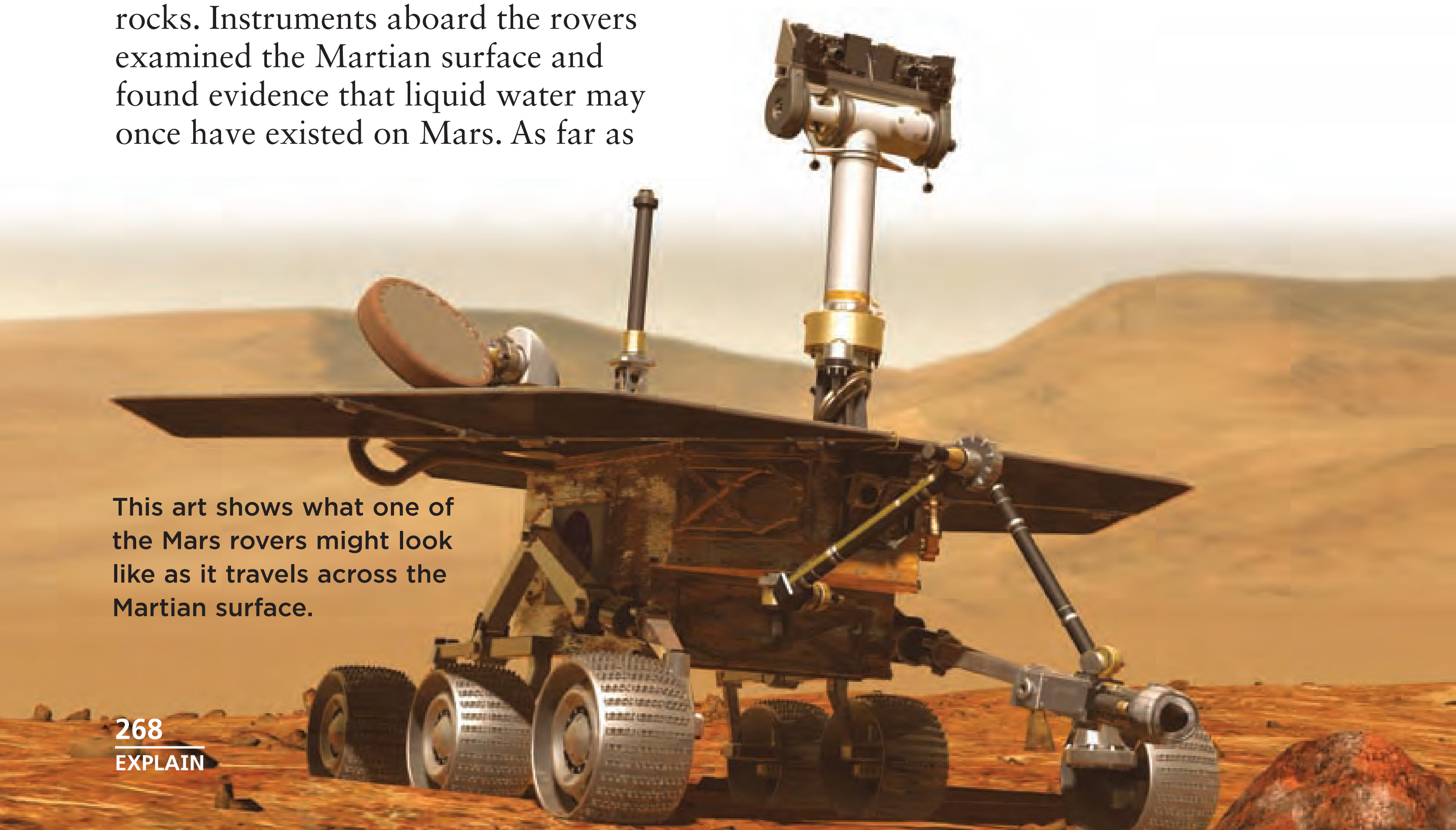
NASA is planning a mission to use rovers to collect Martian soil and bring it back to Earth. NASA may also use airplanes and balloons to study the atmosphere on Mars.

Other space probes have observed comets and asteroids. The *New Horizons* space probe launched in January 2006 and should reach the dwarf planet Pluto in 2015. This space probe will analyze Pluto's surface, geology, and atmosphere. Another space probe called *Dawn* will explore Ceres.

Quick Check

Infer What might be inferred from the discovery that liquid water may once have existed on Mars?

Critical Thinking Design your own spaceship that is capable of carrying astronauts to the Moon.



This art shows what one of the Mars rovers might look like as it travels across the Martian surface.

Lesson Review

Visual Summary

The solar system is made up of the Sun, the planets and their moons, asteroids, meteoroids, and comets.

The planets and moons in the solar system vary in size and surface material.

Space probes are sent to objects in the solar system to gather information about them.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. On each tab, summarize what you have learned.

Think, Talk, and Write

1. **Main Idea** What are planets?

2. **Vocabulary** A mixture of frozen gases, ice, dust, and rock that orbits the Sun is a(n) ________.

3. **Infer** If you knew that probes that traveled to Venus were crushed after a few hours, what could you infer about atmospheric pressure on Venus?

Clues	What I Know	What I Infer

4. **Critical Thinking** If you land on the closest planet to the Sun, where are you?

5. **Test Prep** **What is the largest planet in the solar system?**
   - **A** Earth
   - **B** Mars
   - **C** Saturn
   - **D** Jupiter

6. **Test Prep** **Which was the first planet to be explored by a space probe?**
   - **A** Mercury
   - **B** Venus
   - **C** Jupiter
   - **D** Mars

Writing Link

Science Fiction

Read *The War of the Worlds* by H. G. Wells. Write a report about the novel. Discuss how much of the story is based on fact and how much is fiction.

Art Link

Planet Surfaces

Research the surface features of one of the inner planets. Then draw an illustration of what the planet's surface might look like.

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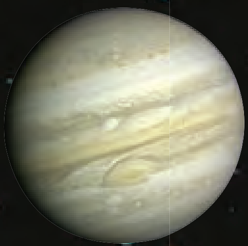
Voyager Discoveries

In 1977 NASA launched the Voyager Interstellar Mission to explore Jupiter, Saturn, Uranus, Neptune, and their moons. Each of the mission's trips had to be very precisely planned. Speeds and distances had to be accurately calculated. The two Voyager spacecraft had to be close enough to each planet to collect data and to get a boost from that planet's gravity in order to be propelled toward their next destination. At the same time, the spacecraft had to be far enough away from the planets that they would not go into orbit around them. All of NASA's careful planning worked. The Voyager mission has provided scientists with new and closer looks at our farthest neighbors.



Jupiter—1979

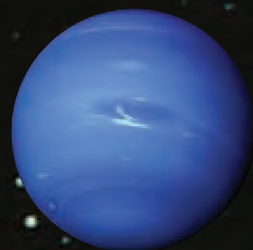
Images show Jupiter's rings. Volcanic activity is observed on Io, one of Jupiter's moons. Scientists observed that Triton, another moon, has a thin atmosphere.

Saturn—1980

Scientists get a close look at Saturn's rings. The rings contain structures that look like spokes or braids.

Uranus—1986

Scientists discover dark rings around Uranus. They also see ten new moons. Voyager sends back detailed images and data on the planet, its moons, and dark rings.



Neptune—1989

Large storms are seen on the planet. One of these storms is Neptune's Great Dark Spot. Scientists thought Neptune was too cold to support this kind of weather.

After observing these planets, the Voyager spacecraft kept traveling. They are the first human-made objects to go beyond the heliosphere. The heliosphere is the region of space reached by the energy of our Sun. It extends far beyond the most distant planets in the solar system.

Write About It

Cause and Effect

1. What caused the Voyager spacecraft to be propelled from one planet toward the next?
2. How did scientists benefit from the Voyager missions?

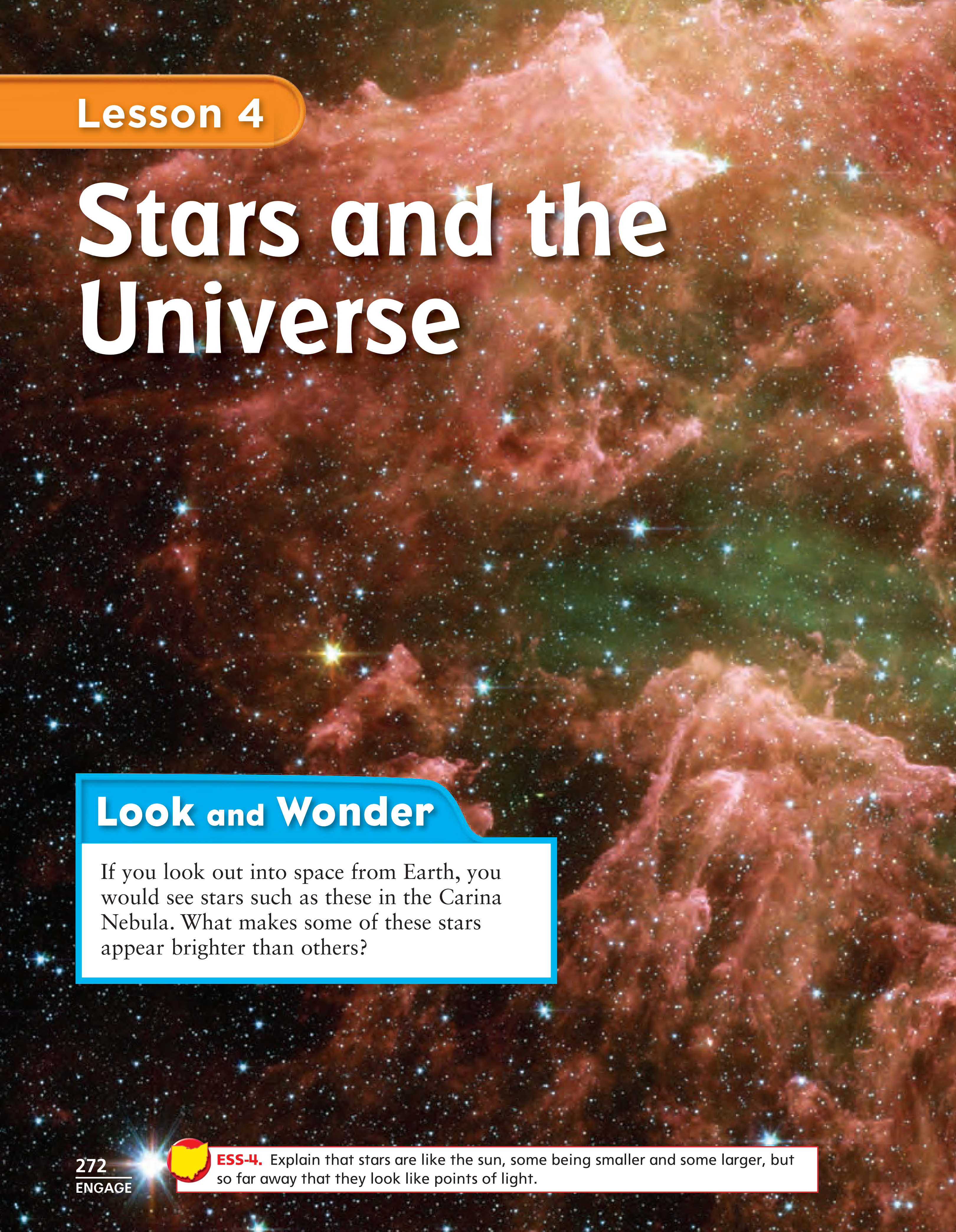
LOG ON e-Journal Research and write about it online at www.macmillanmh.com

Cause and Effect

- Look for the reason why something happens to find a cause.
- An effect is what happens as a result of a cause.

SI-3. Use evidence and observations to explain and communicate the results of investigations. **ELA RA-2.** Identify, distinguish between, and explain examples of cause and effect in informational text.

American Museum of Natural History



Lesson 4

Stars and the Universe

Look and Wonder

If you look out into space from Earth, you would see stars such as these in the Carina Nebula. What makes some of these stars appear brighter than others?

ESS-4. Explain that stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.

Explore

Inquiry Activity

How does distance affect how bright a star appears?

Form a Hypothesis

If one star gives off more light than another star, but they appear to be the same brightness to an observer, what does this mean about the distance of the stars from the observer? Write your answer as a hypothesis in the form "If one star gives off more light than another star but both appear to be the same brightness to an observer, then . . ."

Procedure

1. Cover the front of one flashlight with a few layers of tissue paper. Place a rubber band around the paper.
2. **Make a Model** Let each flashlight represent a star. Place a strip of masking tape on the floor. Have two classmates stand behind the tape and turn the flashlights on.
3. Select the flashlight that appears brighter and have the classmate holding it slowly move away from you. When do the two stars appear to have the same brightness? Measure the distance.

Draw Conclusions

4. **Infer** What factors affect how bright a star looks to an Earth observer?
5. **Communicate** Did your classmates see the stars as having the same brightness at different distances? What might that mean about individual observations of stars?

Explore More

Two stars give off the same amount of light, but one star looks dimmer. Form a hypothesis and use models to test your prediction. Collect data and communicate your results.

Materials

- 2 flashlights
- tissue paper
- rubber band
- masking tape
- meterstick

Step 2

SI-6. Explain why results of an experiment are sometimes different....

Read and Learn

Main Idea ESS-4

Stars are organized into systems such as galaxies and solar systems.

Vocabulary

star, p. 274
nebula, p. 274
white dwarf, p. 275
supernova, p. 276
black hole, p. 276
constellation, p. 278
light-year, p. 279
galaxy, p. 281

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Reading Skill

Problem and Solution

Problem
↓
Steps to Solution
↓
Solution

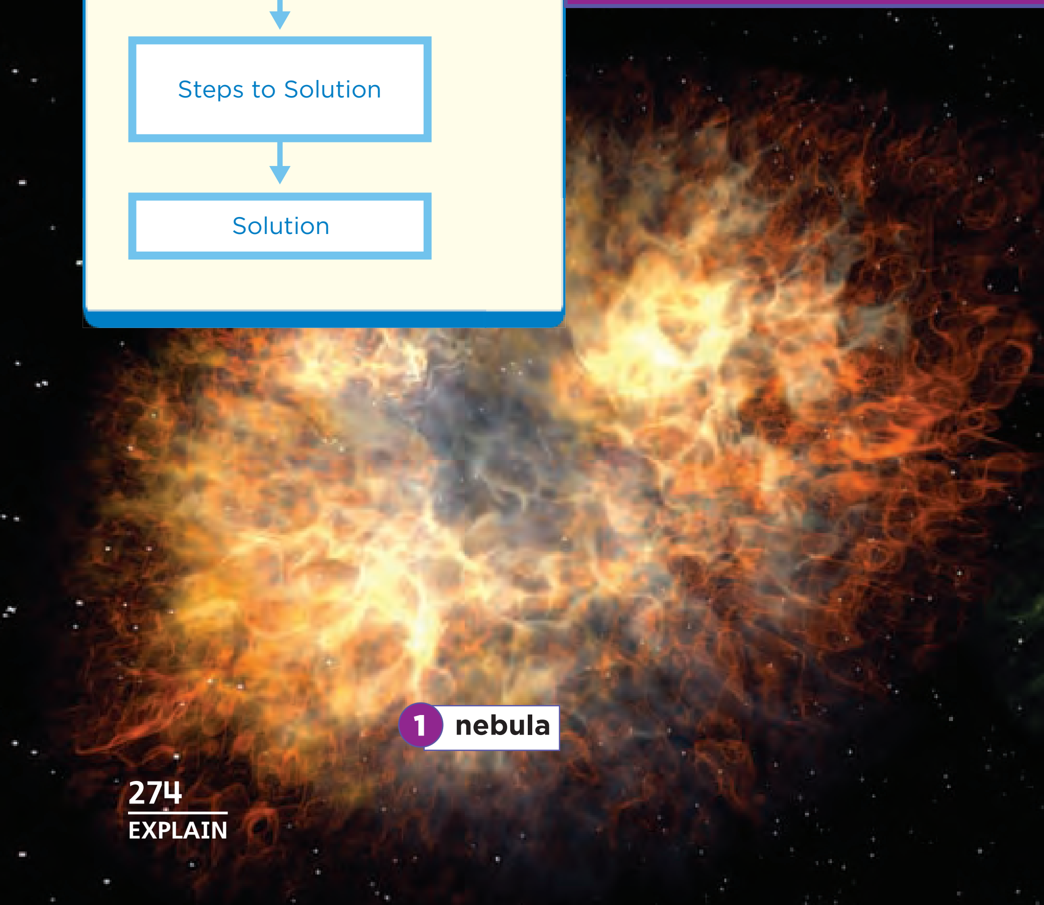
How do stars form?

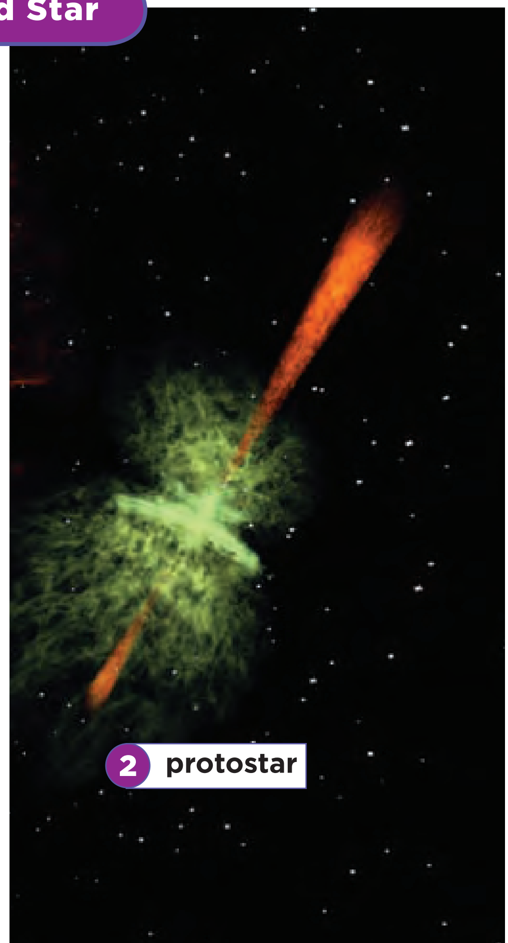
Stars form when matter comes together and starts to give off energy. A **star** is an object that produces its own energy, including heat and light. Stars can go through stages, or cycles, between their beginning and ending. Different kinds of stars have different cycles. The cycle of a star depends on how much hydrogen the star contains. A star's cycle ends when it stops giving off energy.

All stars form out of a nebula. A **nebula** is a huge cloud of gases and dust. Gravity pulls the mass of the nebula, most of which is hydrogen atoms, closer together. As the hydrogen atoms move closer, they collide with each other.

The collisions produce heat and the temperature in the cloud begins to rise. When the temperature reaches at least 10,000,000°C (18,000,000°F), hydrogen atoms begin combining together to form atoms of helium. This process gives off tremendous amounts of heat and light. The spinning cloud has become a *protostar*, or beginning star.

Stages of a Medium-Sized Star


1 nebula


2 protostar

The Sun, and other stars like it, started with a medium amount of hydrogen. That hydrogen is the fuel that produces energy in the Sun. For a few billion years, hydrogen continues to combine to form helium and the star increases in temperature.

Eventually the heat forces the hydrogen on the edge of the star to expand into space. As the expanding hydrogen moves further away from the center of the star, it cools and turns red.

At this stage in its cycle, the star has become a *red giant*. A red giant is many times larger than the original star. In the star's core, the temperature has risen to about 100,000,000°C (180,000,000°F). Helium atoms now combine to form atoms of carbon.

Eventually all the helium is gone and the star can no longer combine helium to form carbon. Now the star begins to cool and shrink, becoming a white dwarf. A **white dwarf** is a small and very dense star that shines with a cooler white light. The white dwarf stage is the end of a medium-sized star's cycle.

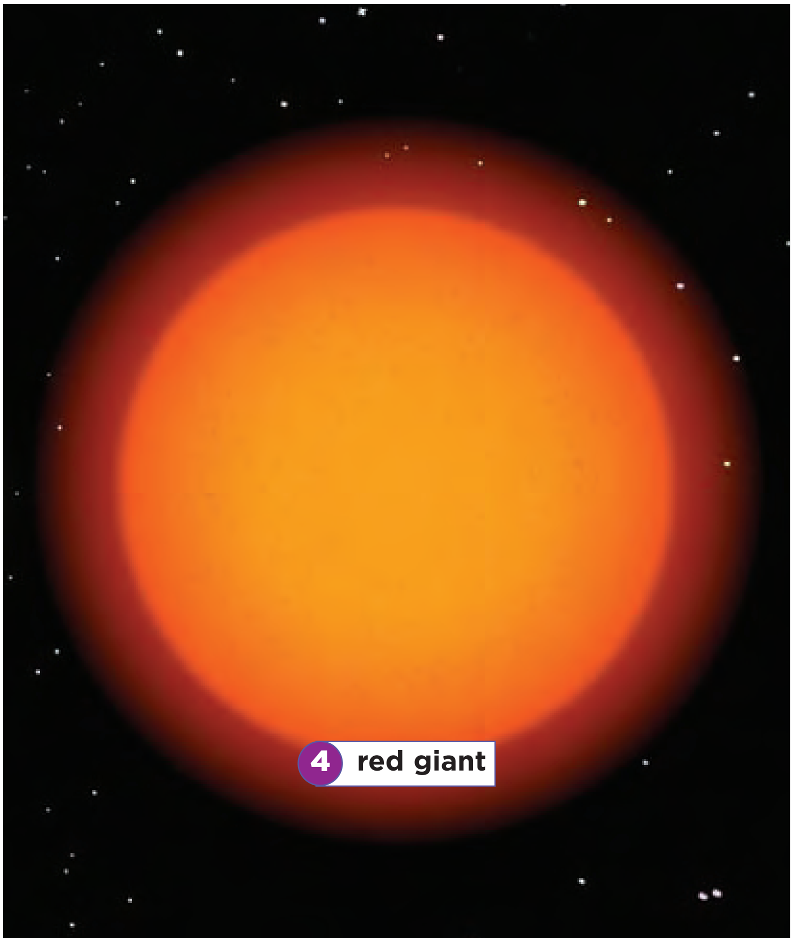
About 10 billion years pass during this cycle. Since the Sun is about 5 billion years old, it is about halfway through its cycle.

Quick Check

Problem and Solution What data could you use to find out the stage of a star's cycle?

Critical Thinking Contrast a protostar and a white dwarf.

3 star



4 red giant

5 white dwarf

What happens to larger stars?

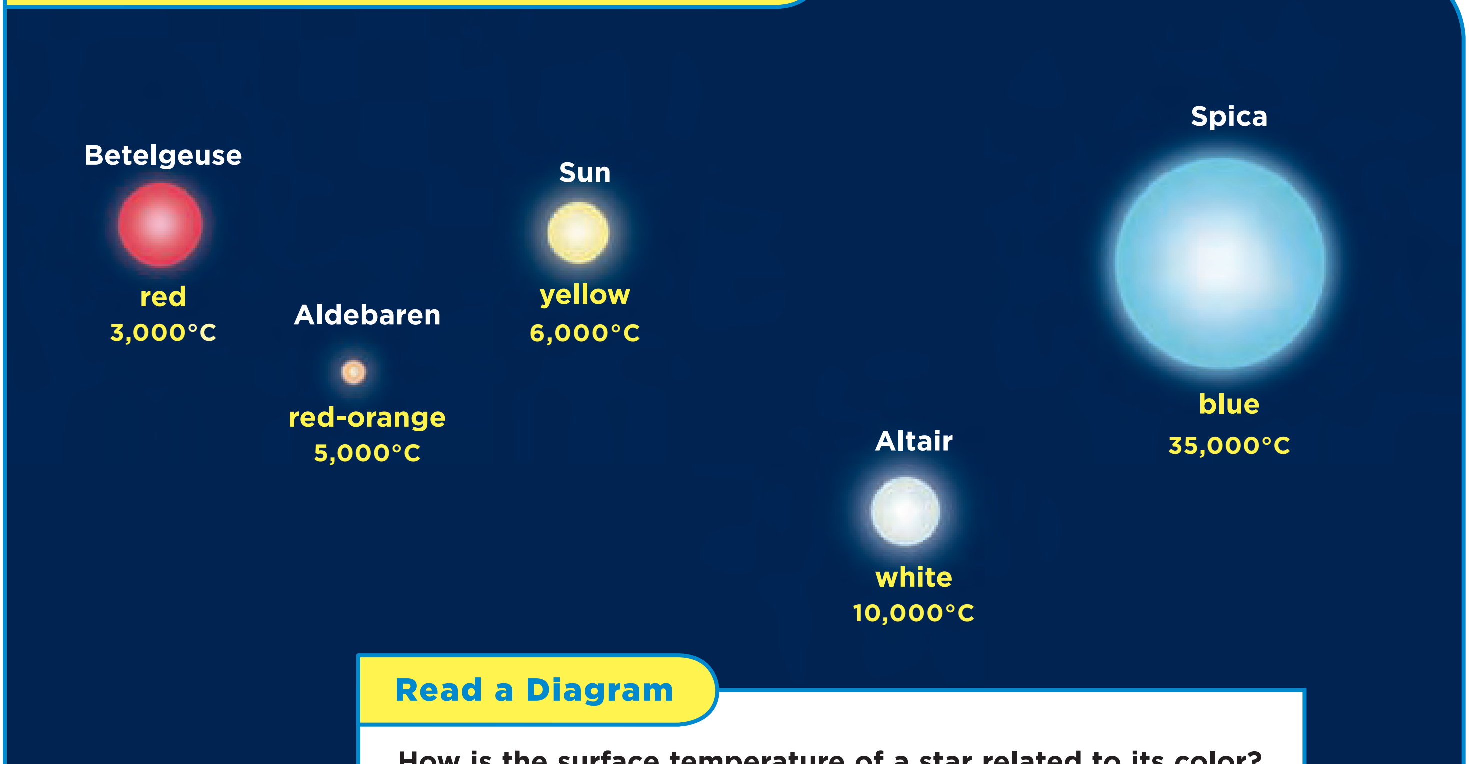
Stars that start off with greater amounts of hydrogen end their cycle differently. After they become red giants, the temperature of the core of these stars increases to about 600,000,000°C (1,080,000,032°F). At this temperature, their atoms combine to form atoms of iron.

Eventually the iron core produces more energy than gravity can hold together and the star explodes. The exploding star is called a **supernova**. Supernovas shine brightly for days or weeks and then fade away. A supernova will form a new nebula.

If a star is very massive, it may end its cycle as a black hole. A **black hole** is an object that is so dense and has such powerful gravity that nothing can escape from it, not even light. Stars are characterized by their size, color, and temperature. The Sun is a medium-sized yellow star whose surface temperature is about 6,000°C (10,832°F).

Giant stars have diameters that are 10 to 100 times that of the Sun. Super giants may have diameters that are 1000 times that of the Sun. Neutron stars are the smallest stars.

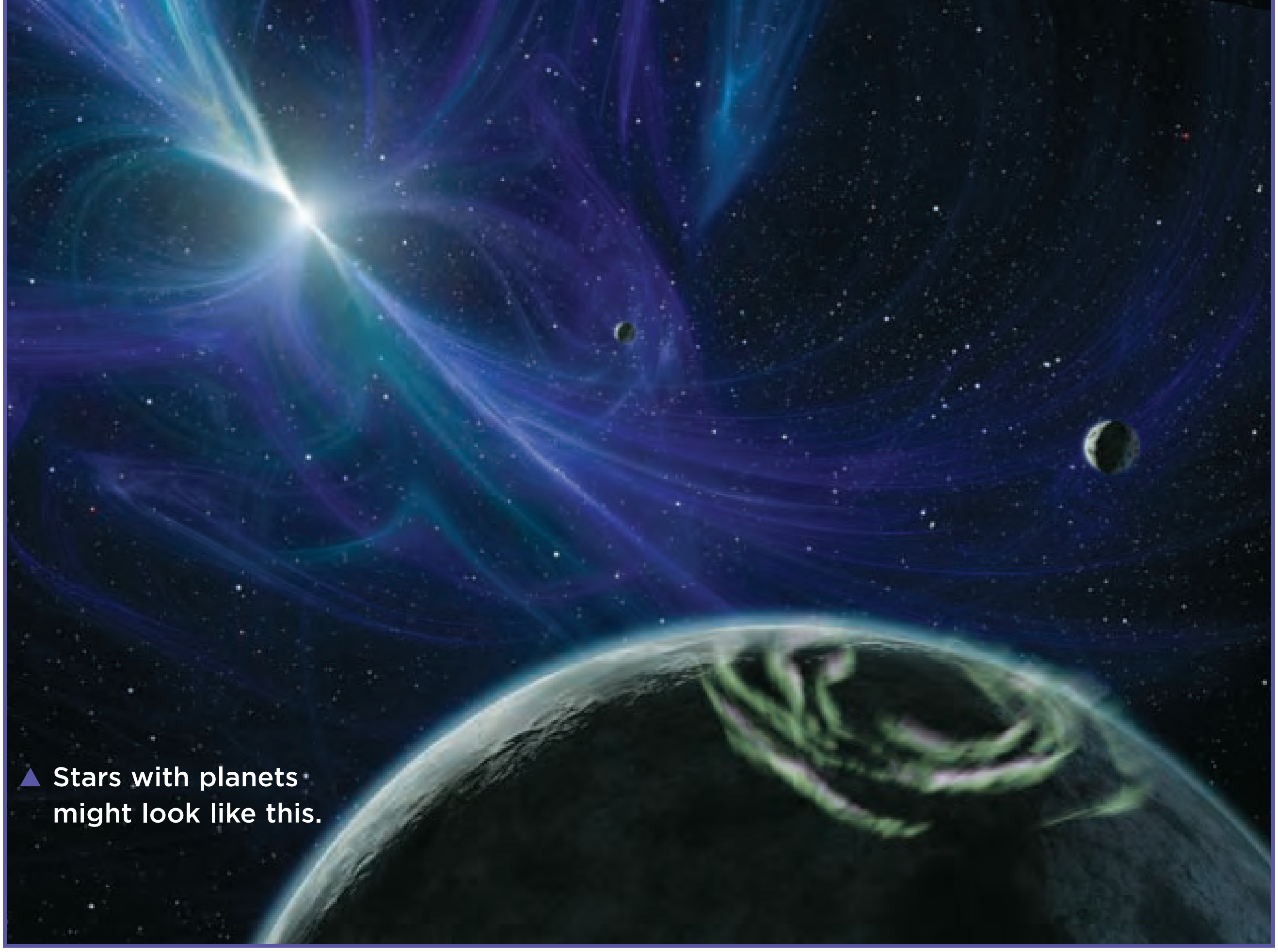
Color and Surface Temperatures of Stars



Read a Diagram

How is the surface temperature of a star related to its color?

Clue: Look for a pattern in the temperatures and colors.



▲ Stars with planets might look like this.

Planets around distant stars are too dim, small, and far away to be seen even through a telescope. How are these planets discovered? Remember that gravity causes all objects to pull on all other objects. When scientists observe a star whose motion is not smooth, they infer that another source of gravity is present.

By measuring the motion of the star, astronomers can calculate the mass and distance from the star of the possible planet. Using such methods, astronomers have discovered what may be more than 160 planets beyond our solar system.

Most of these planets are probably gas giants. However, scientists have reported finding what may be a rocky planet orbiting a red dwarf. Scientists calculated that the planet was five times more massive than Earth and three times farther from its star than Earth is from the Sun. Temperatures on its surface were thought to be about –364°F (–220°C).

Astronomers found this planet by analyzing data of the star's brightness for changes that indicated that a planet passed in front of the star. This method is called *gravitational microlensing*.

Quick Check

Problem and Solution How can astronomers discover planets around distant stars that they cannot see?

Critical Thinking What may happen to massive stars at the end of their cycles?

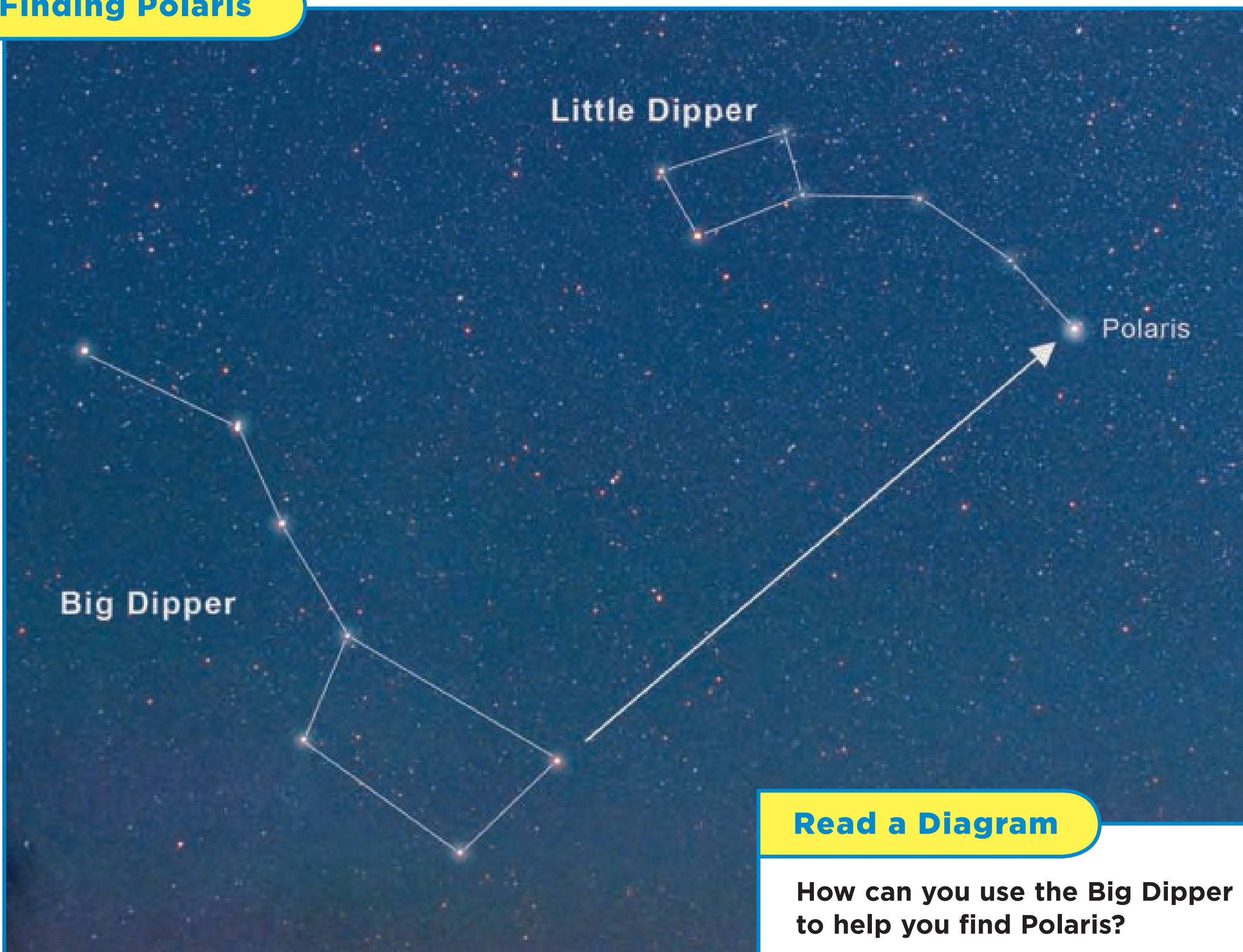
What are constellations?

When people in ancient cultures looked at the night sky, they saw patterns called **constellations** in the stars. Constellations were often named after animals, characters from stories, or familiar objects. Some constellations have been very useful to both ancient and modern travelers.

For example, if you can see either the Big Dipper or the Little Dipper in the night sky, you can follow the line that their stars make to find Polaris, the North Star. If you travel in the direction of Polaris, you will be moving north. If you ever become lost in the woods or at sea, look for Polaris in the night sky. It will help guide you to safety.

The ancient Greeks divided the sky into 12 sections. They named some constellations after characters from Greek myths, such as Orion, a hunter, and Hercules, a hero.

Finding Polaris



Read a Diagram

How can you use the Big Dipper to help you find Polaris?

Clue: Look at the stars in the bowl of the Big Dipper.

The Greeks named other constellations after animals, such as Taurus, the bull, or Ursa Major, the big bear.

The ancient Chinese divided the sky into four major regions. The name of each region included a color, an animal, and a direction. For example, the western region was called the White Tiger of the West. Within each of these four major regions are seven smaller areas.

Star Distance

How far away are the stars in the constellations? After the Sun, the next closest star to Earth is called Proxima Centauri. It is about 40,000,000,000,000 kilometers (24,800,000,000,000 miles) away. Because stars are so far from Earth, writing their distance in kilometers becomes awkward.

To simplify the writing of such distances, astronomers use a unit called a *light-year*. A **light-year** is the distance that light travels in a year, or about 9.5 billion kilometers (5.9 billion miles). Proxima Centauri is 4.2 light-years from Earth.

Greek constellations

Chinese constellations

Quick Check

Problem and Solution How could you travel using the stars as a guide?

Critical Thinking What animals, characters, and objects would you choose to name constellations after?

Types of Galaxies

Messier 81
spiral galaxy

NGC 1300
barred spiral galaxy

M32
ovoid elliptical galaxy

ESO 510-G13
disc-shaped elliptical galaxy

NGC 1427A
irregular galaxy

NGC 7673
irregular galaxy

What are star systems?

If you look at the night sky through a small telescope, you can see individual stars and some of the planets in our solar system. If you look carefully, you might see hazy patches of faint light. These hazy patches are galaxies. A **galaxy** is a huge, very distant collection of stars.

Each galaxy holds billions of stars. The universe is full of galaxies, and each galaxy varies in size and shape. The three basic shapes of galaxies are spiral, elliptical, and irregular.

Spiral galaxies are shaped like a pinwheel with many arms. They are fairly flat with a bulge in the middle.

Our solar system is in an arm of a spiral galaxy called the *Milky Way*. The individual stars that you see in the sky are part of the Milky Way galaxy.

Some spiral galaxies only have two arms. These are called *barred spiral galaxies*. The arms of this kind of galaxy spread out from a bar of stars that cut across the center of the galaxy.

Elliptical galaxies are rounded. They can be shaped like an egg or a thick pancake. They do not have arms.

Irregular galaxies do not have distinct shapes. They may look like clouds or blobs.

Star Clusters

Some stars in a galaxy form clusters. These clusters range in size from a few hundred stars to more than 100,000 stars. *Globular clusters* are shaped like a sphere. They hold 100,000 or more stars. If you looked at a star cluster without a telescope, the star cluster would look as if it were a single star.

Binary Stars

Sometimes when you aim a telescope at what looks like a single star, you discover two points of light instead of one. This happens when two stars form near each other and rotate around each other. These two stars are called *binary stars*. The prefix *bi-* means "two."

How would a blinking star indicate a binary star? An apparently single star blinks because it has a dim partner star that regularly comes between it and an observer on Earth. When this happens, the dimmer star blocks the brighter star's light from reaching Earth. It's as if you repeatedly passed your hand between your eyes and a lighted bulb. The bulb would appear to blink each time your hand passed in front of it.

Quick Check

Problem and Solution You want to demonstrate a way of identifying a binary star without using a telescope. What do you do?

Critical Thinking What would a spiral galaxy look like if viewed from the side?

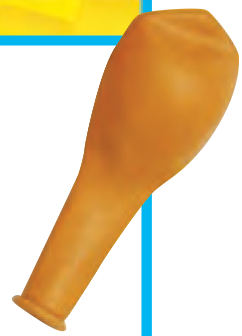
How did the universe form?

Astronomers have found evidence that the universe is expanding like ripples made by a stone dropped in a pond. The universe includes all matter and energy, including everything from the tiniest parts of atoms to the tremendous explosions of dying stars.

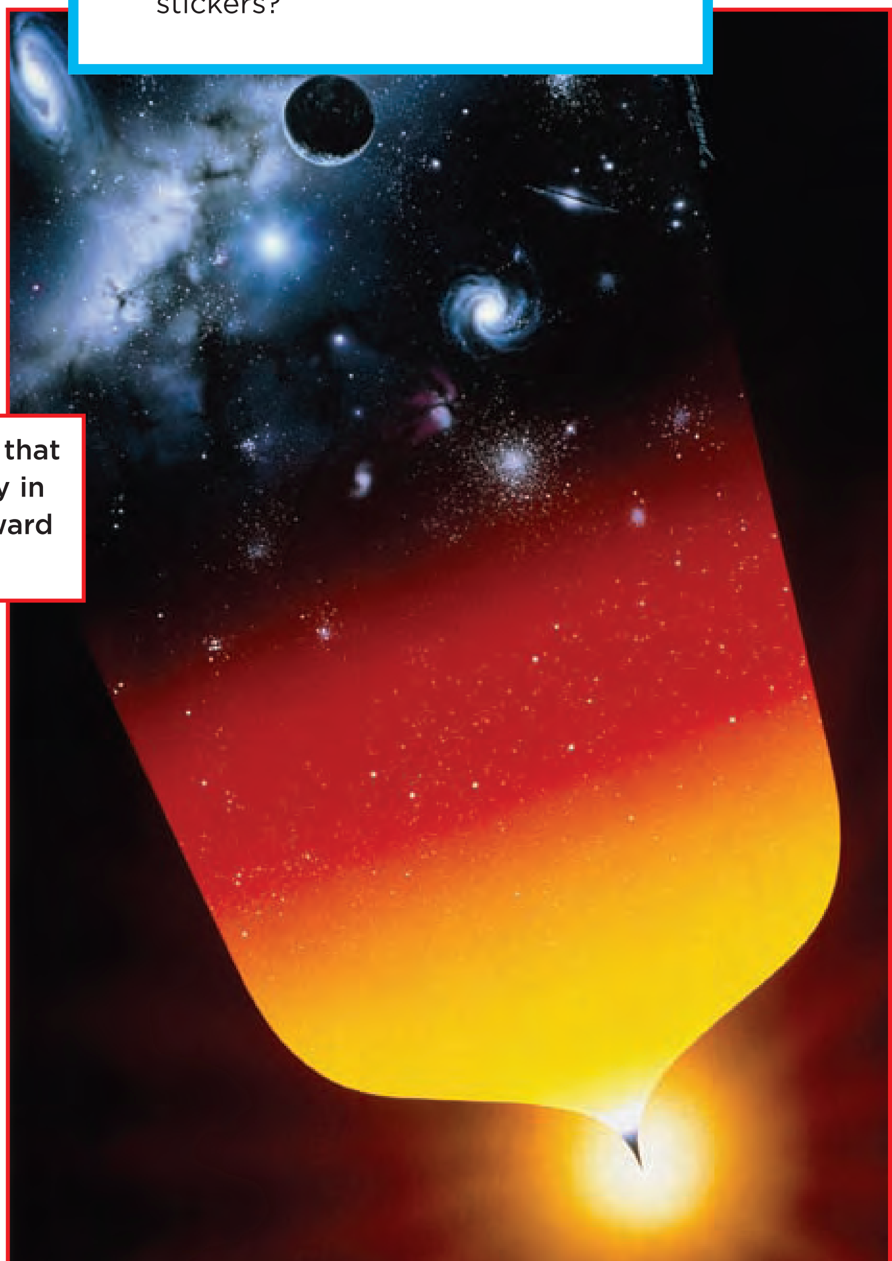
If the universe is expanding in all directions, it had to have started at a single point. That point was like the spot where a rock drops into a pond, sending ripples outward. The *big bang theory* states that the universe started with a big bang at a single point and has been expanding ever since. Evidence suggests that the big bang happened about 13.7 billion years ago.

Quick Lab

Expanding Universe



1. **Make a Model** Blow the balloon up a little. The balloon represents the universe shortly after the big bang. Place stickers on it to represent galaxies.
2. **Observe** Blow the balloon half-full of air. What happens to the size of the stickers? To the distance between the stickers?
3. **Observe** Blow the balloon full of air. What happens to the size of the stickers? To the distance between the stickers?



The big bang theory states that all of the matter and energy in the universe exploded outward from a single point.

Quick Check

Problem and Solution How can you tell from the direction of the universe's expansion that the universe began at a single point?

Critical Thinking Which is older, the universe or the Sun?

Lesson Review

Visual Summary

Stars produce their own light and heat.

The Sun is one of many different kinds of stars that make up the Milky Way galaxy.

Ancient cultures saw different constellations in the night sky.

Make a FOLDABLES™ Study Guide

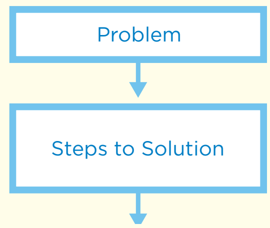
Make a Trifold Book. Use the titles shown. Then summarize what you have learned.

Think, Talk, and Write

1. **Main Idea** How are stars organized?

2. **Vocabulary** An object so dense that nothing can escape from it, not even light, is a(n) ________.

3. **Problem and Solution** What could you test to determine the stage of a star's cycle?



4. **Critical Thinking** What can you infer about the mass of a star whose cycle ends as a white dwarf?

5. **Test Prep** **What is a supernova?**
   - **A** a small star
   - **B** a giant star
   - **C** an exploding star
   - **D** a nebula

6. **Test Prep** **What is a huge, distant family of stars?**
   - **A** a galaxy
   - **B** a planet
   - **C** a universe
   - **D** a constellation

Writing Link

Discovering Galaxies

Edwin Powell Hubble was an American astronomer who discovered galaxies outside of the Milky Way. Research and write about Hubble's Law and how it relates to the big bang theory.

Social Studies Link

Supernovas

Research the supernovas that have been seen in the last thousand years. Pick one supernova and describe the last time it was seen.

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Be a Scientist

Materials

newspaper

pan

cocoa powder

ruler

plastic spoon

white flour

3 rubber bands

3 marbles of different sizes

Structured Inquiry

How do craters form?

Form a Hypothesis

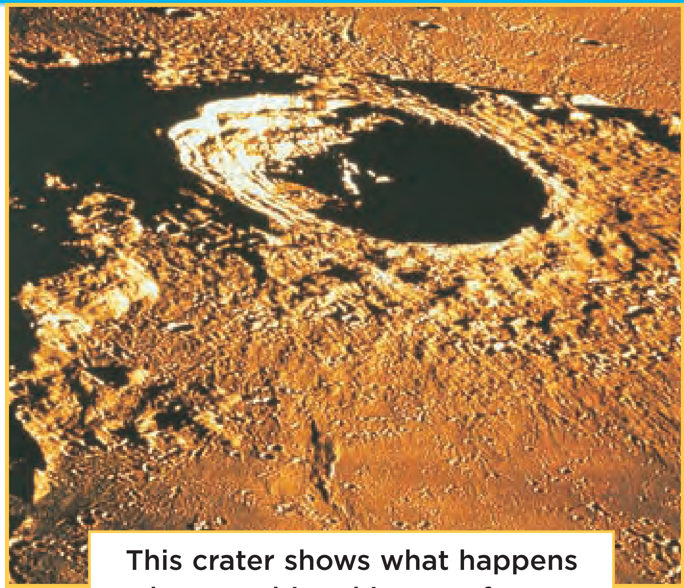
You know that craters form when an object in space hits another object. Does the size of an object affect the size of the crater it forms? Write your answer as a hypothesis in the form "If a larger object hits, then . . ."

Test Your Hypothesis

1. Cover the floor with newspaper and place a pan on the paper.
2. **Make a Model** Fill the pan with cocoa powder to about 1 cm. Gently tap the pan until the cocoa powder is smooth. Using the spoon, shake white flour on top to represent topsoil.
3. By wrapping a cut rubber band around each marble, measure the diameter of three marbles of different sizes.
4. Drop the largest marble from 20 cm above the pan. Measure the diameter of the crater and record your data.
5. Repeat step 4 for the other 2 marbles. Make sure each marble falls in a different area of the pan.

Draw Conclusions

6. **Analyze Data** How does the diameter of the crater compare to the diameter of the marble?
7. What did you see at the crater sites? Why did this happen?
8. How is this model similar to what happens when an object hits the surface of the Moon?
9. What are the controlled, independent, and dependent variables?



This crater shows what happens when an object hits a surface.

Guided Inquiry

How does height affect crater size?

Form a Hypothesis

You now know the effect that objects of different sizes have on crater formation. What happens when similar-sized objects hit from different heights? Write your answer as a hypothesis in the form "If an object hits from a greater height, then . . ."

Test Your Hypothesis

Design an experiment to test your hypothesis. Write out the materials you need and the steps you will take. Record your results and observations.

Draw Conclusions

What were your independent and dependent variables? Did your experiment support your hypothesis?

Open Inquiry

What effect does the surface material have on crater formation? Think of a question and design an experiment to answer it. Your experiment must be organized to test only one variable. Keep careful notes as you do your experiment so another group could repeat the experiment by following your instructions.

Remember to follow the steps of the scientific process.

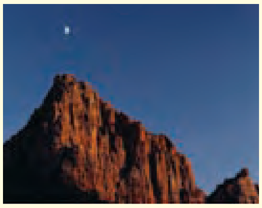
Ask a Question
↓
Form a Hypothesis
↓
Test Your Hypothesis
↓
Draw Conclusions

SWK-5. Keep records of investigations and observations that are understandable weeks or months later. **SI-4.** Identify one or two variables in a simple experiment.

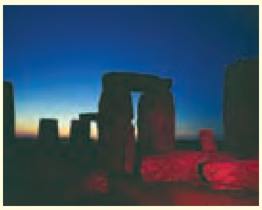
CHAPTER 5 Review

Visual Summary

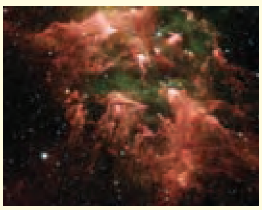
Lesson 1
Gravity and inertia keep Earth in orbit around the Sun



Lesson 2
The Moon is Earth's natural satellite.



Lesson 3
Our solar system is made up of the Sun, the eight planets and their moons, and comets, asteroids, and meteoroids.



Lesson 4
Stars are organized into systems such as galaxies and solar systems.

Make a FOLDABLES™ Study Guide

Assemble your lesson study guide as shown. Use your study guide to review what you have learned in this chapter.

Vocabulary

Fill in each blank with the best term from the list.

air pressure, p. 241
asteroid, p. 267
galaxy, p. 281
lunar eclipse, p. 251
nebula, p. 274
orbit, p. 235
planet, p. 260
rotation, p. 242
tide, p. 252

1. Gravity and inertia keep Earth moving around the Sun in its ________.
   ESS-3
2. When the Moon moves into Earth's shadow, a(n) ________ occurs.
   ESS-2
3. A large object that orbits a star is called a(n) ________.
   ESS-2
4. The force put on a given area by the weight of the air above it is called ________.
   ESS-3
5. Every 24 hours, Earth makes a complete ________, or spin on its axis.
   ESS-I
6. A rock that revolves around the Sun is called a(n) ________.
   ESS-2
7. A huge, distant collection of stars is called a(n) ________.
   ESS-4
8. The rise and fall of the ocean's surface is called the ________.
   ESS-A

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Skills and Concepts

Answer each of the following in complete sentences.

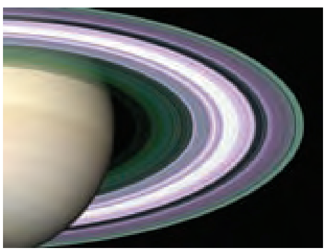
9. **Infer** What is the relationship between the universe, galaxies, solar systems, stars, and planets? How do Earth, Moon, and Sun fit into this picture?
ESS-2

10. **Fact and Opinion** Write a paragraph using facts to explain how the revolution of Earth causes the seasons.
ESS-3

11. **Main Idea and Details** How does Earth's shape affect its temperature?
ESS-3

12. **Critical Thinking** You observe a small, white, very dense star with a telescope. Identify this star and explain whether this star is older or younger than the Sun.
ESS-4

13. **Explanatory Writing** What two planets are shown below? Explain how you know which planets they are.
ESS-2



The Big Idea

14. What is in outer space?
ESS-A

Performance Assessment

Moon Music

Your goal is to analyze facts and opinions in songs about the Moon.

1. Research and write down the lyrics of a song about the Moon.
2. Write down any statements made about the Moon in your song. Identify each as either fact or opinion.

Analyze Your Results

- Why do you think so many songs have been written about the Moon? Why is the Moon's true nature often misunderstood?

Ohio Activity

Ohio is home to 24 astronauts. To become an astronaut, an individual must work hard and complete a great deal of education. Research at least two astronauts from Ohio, and investigate how these men or women became astronauts. Also, explore the job duties of astronauts. Report your findings to the class.

Ohio Benchmark Practice

1 **What factor or factors cause Earth's change of seasons?**

A Earth's rotation around the Sun
B the Sun's rotation around Earth
C Earth's tilted axis and revolution around the Sun
D Earth's rotation and revolution around the Sun

ESS-3

2 **A space probe lands on a planet that is dark and cold. In your Answer Document, describe what can you infer about this planet from this evidence. Also include what could be inferred if the space probe finds evidence that liquid water may have existed on the planet. (2 points)**

SI-3

3 **When do spring tides occur?**

A during spring
B during a third-quarter moon
C when the Moon and the Sun line up
D when the Moon and the Sun pull in different directions

ESS-2

4 **A weather map shows a cold front over Columbus, Ohio. In which direction will it most likely move?**

A from west to east
B from east to west
C It is impossible to predict
D from south to north

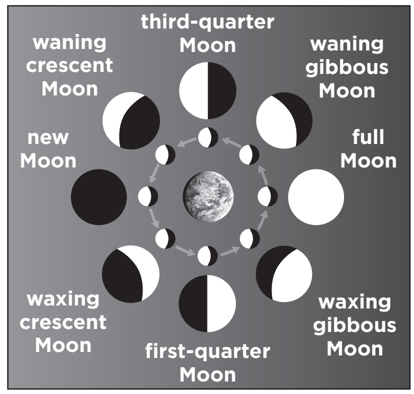
ESS-D

5 **Which phrase best describes the solar system?**

A the Sun and the objects that orbit it
B Earth, the Sun, and the Moon
C Earth and the objects that orbit it
D eight planets and their moons

ESS-2

6 **The diagram below shows the phases of the Moon. If the new moon is seen on a given day, approximately when will the full moon occur?**



A one week later
B two weeks later
C three weeks later
D four weeks later

ESS-2

7 **What would you use to determine if another star is similar to the Sun?**

A a space telescope
B an optical telescope
C binoculars
D a space probe

SI-1, ESS-4

8 **In about 5 billion years, the Sun will grow much larger than its current size. It will become which type of star?**

A a white dwarf
B a protostar
C a constellation
D a red giant

ESS-4

9 **When Galileo saw four moons revolving around Jupiter, which scientific belief was challenged?**

A that life exists on other planets
B that all objects in the solar system revolved around Earth
C that Earth was flat
D that there were no other planets

SI-6, ESS-2

10 **Which type of weather will a cold front most likely bring?**

A stormy weather
B no change in the weather
C hot and humid weather
D light rain, then sunshine

ESS-D

11 **Which best describes what happens to air pressure as you climb a mountain?**

A Air pressure decreases.
B Air pressure increases.
C Air pressure remains the same.
D Air pressure decreases and then increases.

ESS-3

12 **This table shows the time it takes for the five planets to revolve around the Sun.**

Mercury	88 days
Venus	225 days
Mars	687 days
Jupiter	4,333 days
Neptune	60,190 days

Where would Earth fit into this table?

A between Mercury and Venus
B between Venus and Mars
C between Mars and Jupiter
D between Jupiter and Neptune

ESS-2

13 **All of these orbit the Sun in our solar system except**

A asteroids.
B comets.
C dwarf planets.
D meteors.

SI-5

14 **In your Answer Document, draw or describe a difference and a similarity between the Sun and another star. Name the beginning and end stages of a medium-sized star like the Sun. (4 points)**

ESS-4

15 **At which angle does sunlight strike the equator on the first day of spring?**

A 180°
B 150°
C 120°
D 90°

ESS-A, ESS-3

Literature

TIME FOR KIDS

Magazine Article

This diamond mine is in the Republic of Botswana, Africa.

from *Time for Kids*

The Many Sides of Diamonds

Diamonds are famed for their beauty. Diamonds are also the hardest and one of the most useful substances on Earth.

Most diamonds are shaped too strangely or are too small to be made into jewelry. These stones are still valuable. They are used in making thousands of products, from eyeglasses to computer chips. Workers cut, grind, or shape building materials using tools with diamond edges. Dentists use diamond-tipped drills.

After diamonds are mined, they may be used in various industries or to make jewelry.

Diamonds may be colorless, white, gray, blue, yellow, orange, red, green, pink, brown, or black.

Write About It

Response to Literature This article describes the formation and use of diamonds. Research additional information about the history of industrial diamonds, how they are formed, and how they are used. Write a report about industrial diamonds. Include facts and details from this article and from your research.

LOG ON e-Journal Write about it online at www.macmillanmh.com

Weather Observer

There is an old saying that if you do not like the weather now, wait and it will change. How do people know what the weather will change to? After you finish high school, you might enjoy working as a weather observer. As a weather observer, you would collect data about weather conditions. You would be trained to use instruments that measure temperature, humidity, and air pressure. You would read radar scans and satellite photographs. The weather forecasts meteorologists make depend on data collected by weather observers.

Weather observers collect data.

▲ Astronomers observe stars and planets.

Astronomer

Are you interested in looking for planets around distant stars or watching solar systems form? Astronomers study the stars and learn about the other planets and suns in the universe. As an astronomer, you would use telescopes and satellites to gather data about other solar systems. Then you would interpret that data to find out what the stars and planets are made of and how old they are. To be an astronomer, you need to be good at math and physics, have strong computer skills, and obtain a doctoral degree in astronomy. After that, you might say the sky's the limit!

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Ohio

Physical Sciences

Rockets travel at speeds near 11 kilometers per second (7 miles per second) to leave Earth's atmosphere.

Rock and Roll Hall of Fame

Les Paul and his invention

Rock and Roll

On the shore of Lake Erie in Cleveland, Ohio, is a giant glass pyramid that houses a museum of musical legends. The Rock and Roll Hall of Fame honors the individuals who have made major contributions to rock-and-roll music. In 1988, the Rock and Roll Hall of Fame inducted musician and inventor Les Paul.

While much has changed in rock and roll since its early days, one thing that has not changed is Les Paul's invention, the solid body electric guitar. Les Paul built the first solid body electric guitar in 1941. His design became one of the first commercially available electric guitars and has changed little since its introduction in 1952.

The Solid Body Electric Guitar

The solid body electric guitar uses electromagnets called *magnetic pickups*. The magnetic pickups are bar magnets wrapped with wire coils. They are mounted under the strings at the body end of the guitar.

When the guitar strings vibrate, they interrupt the electrical field created by the magnetic pickups. This interruption in the electrical field is sent to the guitar amplifier as an electric signal. The amplifier then powers the speakers. What we hear through the speakers is the vibration of the guitar strings.

Think, Talk, and Write

Critical Thinking What would we hear if the electric guitar were not hooked to an amplifier?

PS-3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.

Ohio

A CLOSER LOOK

Main Idea

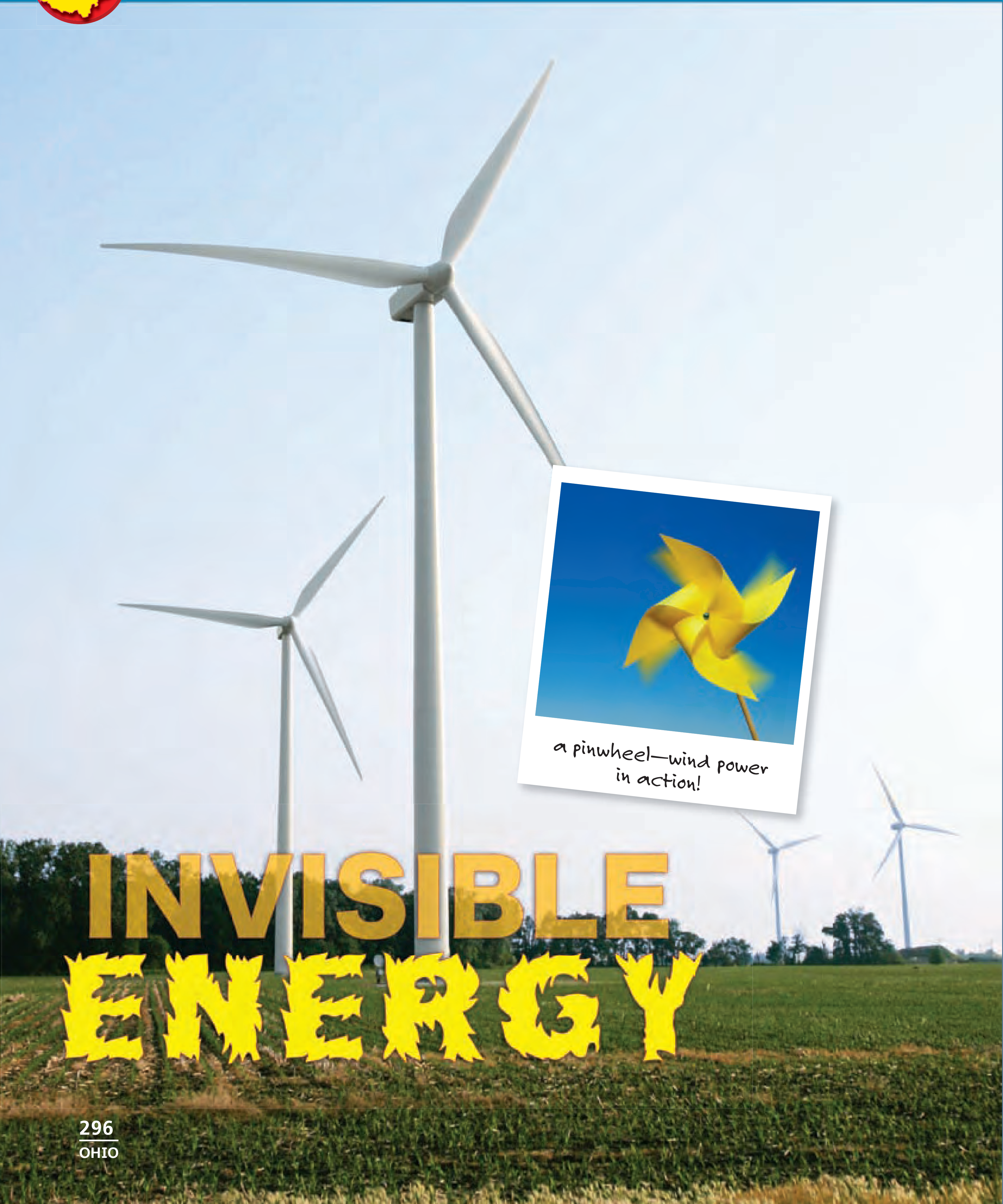
Electromagnets convert motion (vibration) to electrical energy.

Activity

Diagram Construct a simple circuit tracing the flow of energy from the vibrating strings to the sound produced by the speakers.

- What is the role of the amplifier?
- How does the speaker transmit sound to your ears?

INVISIBLE ENERGY



a pinwheel—wind power in action!

The Power of Wind

Right now, most of our electricity comes from burning fossil fuels. Coal, oil, and natural gas are all burned to move turbines that are connected to electric generators. These generators produce electricity. Many scientists believe we will soon run out of fossil fuels. Some people are studying *alternative energy*—ways of generating electricity that do not rely on fossil fuels.

One alternative energy source is wind. A wind turbine looks like a giant pinwheel that is more than 100 meters tall. It can convert wind energy into electricity. As wind blows, the rotor blades spin. The spinning rotor blades are connected to an electric generator. Electricity is generated as long as there is enough wind to keep the rotor blades spinning.

"Farming" for Electricity

The city of Bowling Green in northwest Ohio is home to the state's first wind farm. The "farm" consists of four large wind turbines. Together, these turbines can generate enough electricity to power nearly 2,400 homes. More turbines may be added in the future to provide even more electricity.

The success of wind farms like this one is making people look seriously at alternative energy. Wind power currently provides only about 1 percent of the electricity used in the United States. Many scientists are hopeful, however, that one day up to 20 percent of our electricity could come from the power of wind.

Think, Talk, and Write

Critical Thinking Are there places where wind power can't be used?

P-3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.

Ohio

A CLOSER LOOK

Main Idea

Wind power can be an alternative to fossil fuels.

Activity

Draw Conclusions

Research the wind patterns for the entire state of Ohio.

- Draw a map of Ohio and mark the areas of highest and lowest winds.
- Determine the best and worst locations for wind farms. Mark the locations on your map.

CHAPTER 6

Using Energy

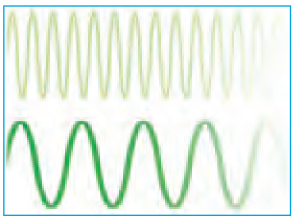
The Big Idea

What forms does energy take?

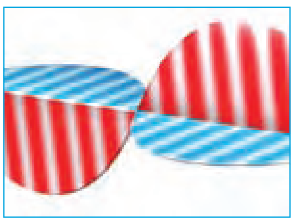
Key Vocabulary

thermal conductivity
the ability of a material to transfer thermal energy (p. 308)

sound wave
a series of rarefactions and compressions traveling through a substance (p. 317)



frequency
the number of times an object vibrates per second (p. 320)



wavelength
the distance from one peak to the next on a wave (p. 330)

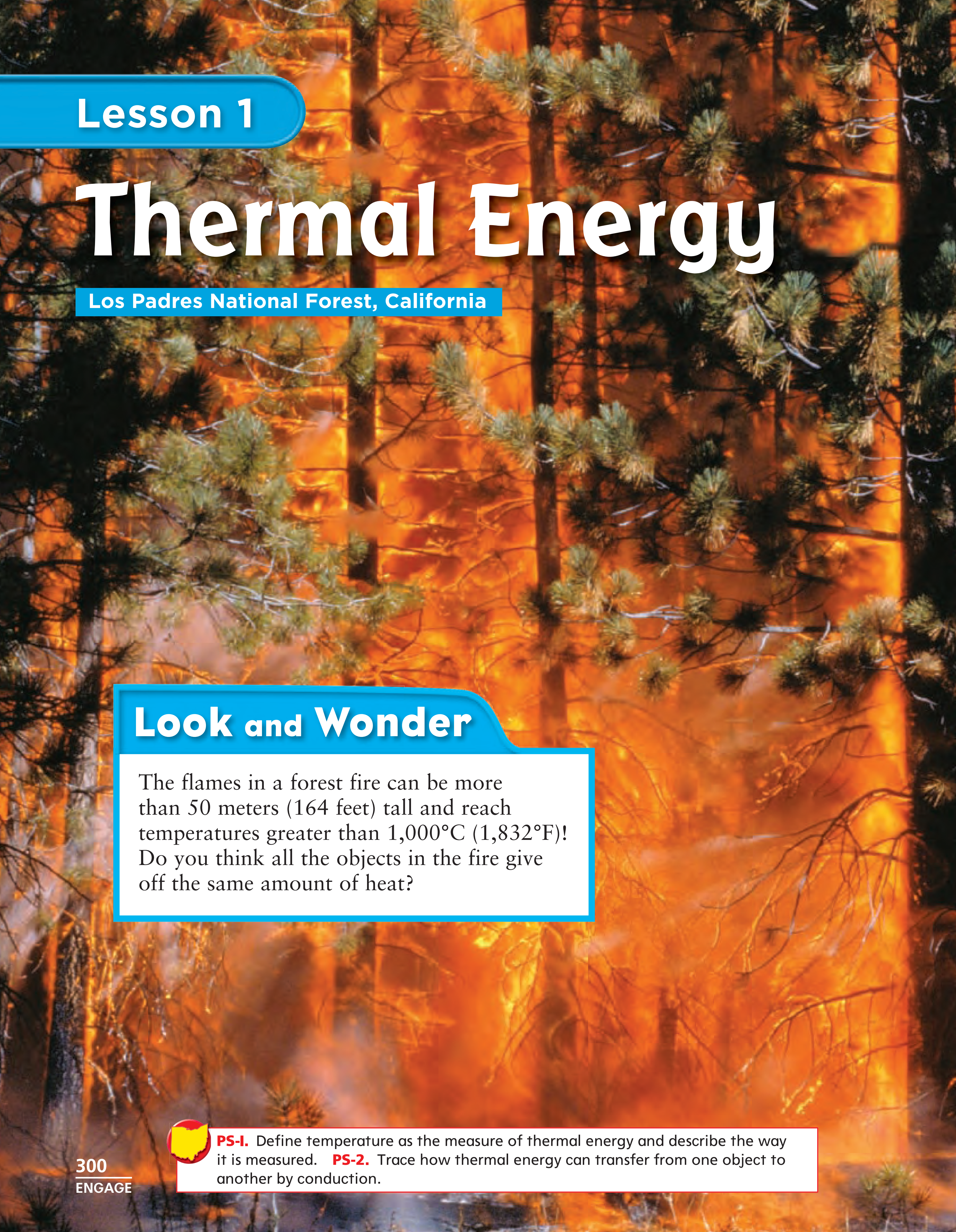
electricity
the movement of electrons (p. 346)

electromagnet
an electric circuit that produces a magnetic field (p. 360)

More Vocabulary

energy, p. 302
thermal energy, p. 304
heat, p. 304
temperature, p. 304
conduction, p. 306
convection, p. 306
radiation, p. 306
medium, p. 317
absorption, p. 319
pitch, p. 320
amplitude, p. 322
echolocation, p. 324
photon, p. 331
translucent, p. 332
image, p. 334
refraction, p. 335
prism, p. 336
spectrum, p. 336
electromagnetism, p. 338
atom, p. 344
proton, p. 345
neutron, p. 345
electron, p. 345
static electricity, p. 346
grounding, p. 347
electric current, p. 348
circuit, p. 348
resistor, p. 348
magnetism, p. 358
magnetic field, p. 359
generator, p. 362
alternating current, p. 362
magnetic levitation, p. 364

PS-D. Summarize the way changes in temperature can be produced and thermal energy transferred. **PS-E.** Trace how electrical energy flows through a simple electrical circuit and...can produce...magnetic forces. **PS-F.** Describe the properties of light and sound energy.



Lesson 1

Thermal Energy

Los Padres National Forest, California

Look and Wonder

The flames in a forest fire can be more than 50 meters (164 feet) tall and reach temperatures greater than 1,000°C (1,832°F)! Do you think all the objects in the fire give off the same amount of heat?

PS-1. Define temperature as the measure of thermal energy and describe the way it is measured. **PS-2.** Trace how thermal energy can transfer from one object to another by conduction.

Explore

Inquiry Activity

Which becomes hotter?

Form a Hypothesis

If you mix the same amount of water or oil into ice water, which one will warm the ice water more? Write your answer as a hypothesis in the form "If the same amount of room-temperature water and oil is added to ice water, then…"

Test Your Hypothesis

1. Pour 100 mL of ice water (but don't include any ice) into 2 cups. Pour 100 mL of room-temperature water and cooking oil into 2 different cups. Record the temperature of each.
2. **Experiment** Mix a cup of ice water into the cup of room-temperature water and stir for two minutes. Record its temperature. Repeat this process for the cooking oil.
3. **Use Numbers** Subtract the starting temperature of the ice water from the final temperature of each mixture. This gives you the temperature change of the ice water for each experiment.

Draw Conclusions

4. **Interpret Data** How do the temperature changes compare? Was your hypothesis correct? Explain.
5. **Infer** Based on your answers in step 4, is heat the same thing as temperature? Explain.

Explore More

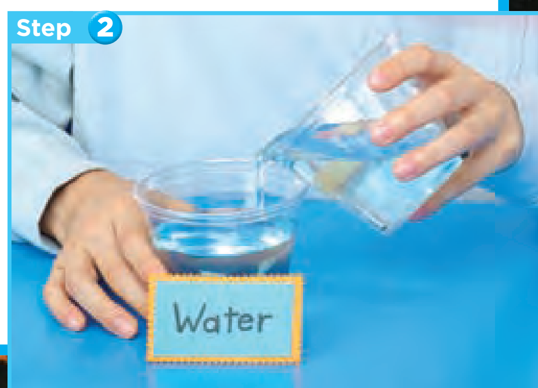
Which would cool faster starting at the same high temperature, 100 mL of cooking oil or 100 mL of water? Write a hypothesis. Then design an experiment to test it.

Materials

- ice
- water
- graduated cylinder
- plastic cups
- cooking (corn) oil
- thermometer

Step 1

Step 2



SI-1. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others....

Read and Learn

Main Idea PS-I, PS-2

Energy flows between objects when they have different temperatures.

Vocabulary

energy, p. 302
thermal energy, p. 304
heat, p. 304
temperature, p. 304
conduction, p. 306
convection, p. 306
radiation, p. 306
thermal conductivity, p. 308

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Reading Skill ✔
Draw Conclusions

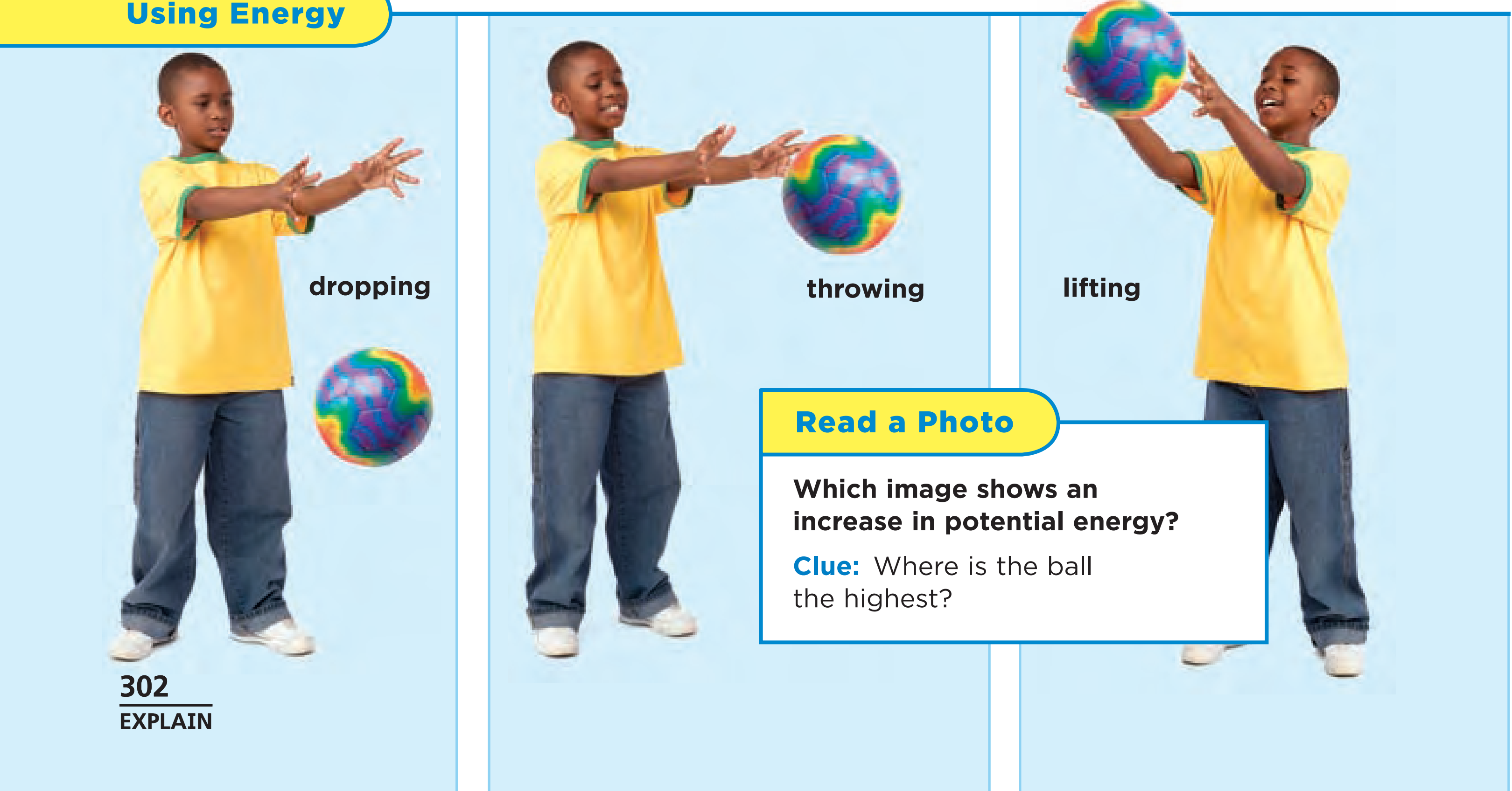
Text Clues	Conclusions

What are energy and work?

When you feel tired you may say, "I don't have any energy." But what is *energy*? **Energy** is the ability to perform work or to change an object. When you are low on energy, you probably cannot do much work. *Work* is the measurement of the energy used to perform a task. Work is equal to the force used times the distance the force was applied. The units of both work and energy are the units of force times the unit of distance: newton-meters (N·m). If you lift a box that weighs 10 newtons onto a shelf that is 1.5 meters high, you are performing 15 N·m of work. Newton-meters are also known as joules (J). In describing how you lifted and moved the box, you could also say that you used 15 J of energy.

There are many things that seem like work but are not. For instance, do you think it is work to hold a ball over your head? Lifting it there is definitely work, but just holding it there is not. Why? A force must be applied over a distance in order to qualify as work. When you lift the ball, you are applying a force over a distance. When you are holding the ball you are still applying a force, but the ball is not moving, so the distance equals zero.

Using Energy



Read a Photo

Which image shows an increase in potential energy?

Clue: Where is the ball the highest?

Forms of Energy

There are many forms that energy can take. All forms of energy have one thing in common—they can perform work! When a spring is stretched, it has energy, but it is not moving. It has the potential to do work. *Potential energy* (puh•TEN•shuhl) is energy that is stored in the position, or structure, of an object. When you release the spring, it moves. *Kinetic energy* (ki•NET•ik) is the energy of a moving object.

There are different forms of potential and kinetic energy. There is potential energy in the links between atoms and molecules. This is chemical energy. Magnetic energy is another form of potential energy; it acts like gravity, pulling objects together, but it can also push some objects apart. Electricity is related to the kinetic energy of electrons. Sound is the kinetic energy of particles as they move in waves. Thermal energy is a form of kinetic energy within a material.

We can detect many forms of energy with our senses. A fire, for example, generates light energy you can see, sound energy you can hear, and thermal energy you can feel.

Quick Check

Draw Conclusions A weight lifter lifts a barbell above her head and holds it there. What can you conclude about the work she is doing?

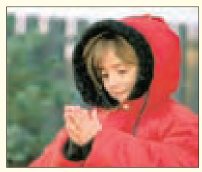
Critical Thinking What potential and kinetic energies exist when you dive into water?

Types of Energy

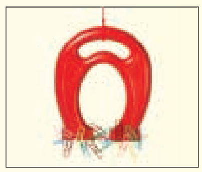
Electricity produced during a storm

Sound produced by a stereo

Light produced by a lightbulb



Thermal energy produced by friction



Magnetism produced by a magnet

Chemical energy produced by a battery

Can any of the examples above represent more than one type of energy? Explain.

Magnets do work by pulling objects together.

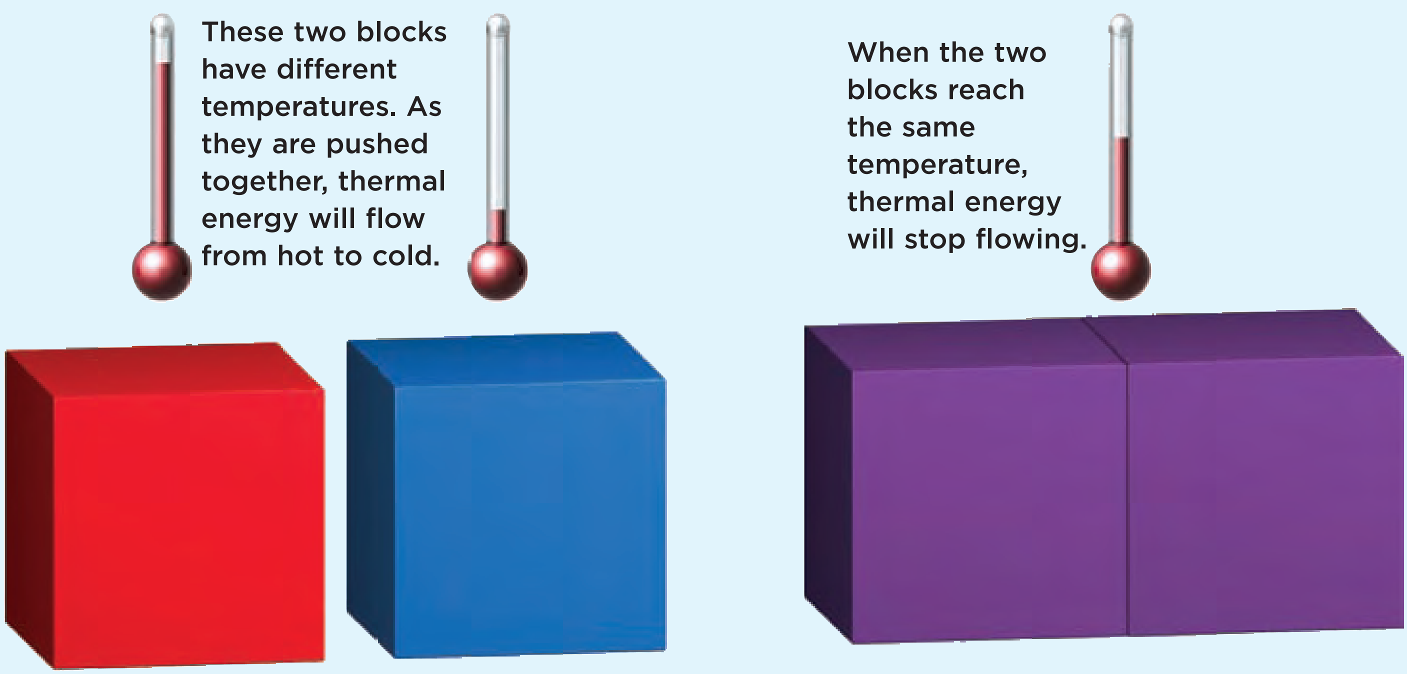
Thermal energy in hot cocoa can burn your tongue.

What is thermal energy?

Have you ever taken a sip of hot cocoa and burned your tongue? Ouch! Energy in the hot drink flows into your tissues and damages them. The energy that causes such a burn is thermal energy. **Thermal energy** is the energy due to the motion of particles in matter. **Heat** is the flow of thermal energy between objects due to a difference in temperature. Your tongue is cooler than the drink, so thermal energy flows from the drink into your tongue.

Thermal energy moves from an object with a higher temperature to an object with a lower temperature. But what is temperature? **Temperature** is a measurement of the average kinetic energy of particles in an object. All the particles in an object are moving with kinetic energy. Objects with a higher temperature have particles that are moving faster. Objects with a lower temperature have particles that do not move as fast.

When a hot object touches a cold object, the particles in each object bump into each other. During these collisions, the particles from the hot object pass on some of their energy to the particles in the cold



The soup has a higher temperature, but the lake's greater mass releases more thermal energy than the soup.

object. The cold object is now warmer, and the hot object is now cooler. When thermal energy moves from one object to another, the temperature of each object changes. It will continue to flow until both objects are at the same temperature.

When two things rub together, they can get warm. This is because friction between objects changes kinetic energy into thermal energy. Particles in the objects bump into one another as they are rubbed together. Each bump causes the particles to move faster, and the temperatures of the objects rise.

We often measure temperature by using a thermometer. When a thermometer touches an object, thermal energy will flow either into or out of the thermometer. When the thermometer and the object are at the same temperature thermal energy will stop flowing. The thermometer then gives the temperature of the object in units of degrees Celsius (°C) or degrees Fahrenheit (°F). Many thermometers work by measuring the way liquids expand or contract with temperature.

Keep in mind, though, that temperature and thermal energy are not the same thing. Thermal energy is the total energy of the particles in a material. Temperature is a measure of the average kinetic energy of the particles. A small bowl of steaming soup has a higher temperature than a cool lake. The lake, though, has more thermal energy because it has many more particles.

Quick Check

Draw Conclusions Two objects have been touching for hours. What can you conclude about their temperatures? Explain.

Critical Thinking How could a typical liquid thermometer measure its own temperature?

FACT Thermal energy, heat, and temperature are not the same.

How does energy travel?

You're stirring some hot cocoa. Suddenly, you notice that the spoon is too hot to hold! The cocoa warmed the spoon, and the spoon is warming your fingers! How did the energy get from the cocoa to your fingers?

Thermal energy has moved from the cocoa to the spoon and then to your fingers. **Conduction** (kuhn•DUK•shuhn) is the passing of thermal energy through a material while the material itself stays in place. It occurs between objects that are touching.

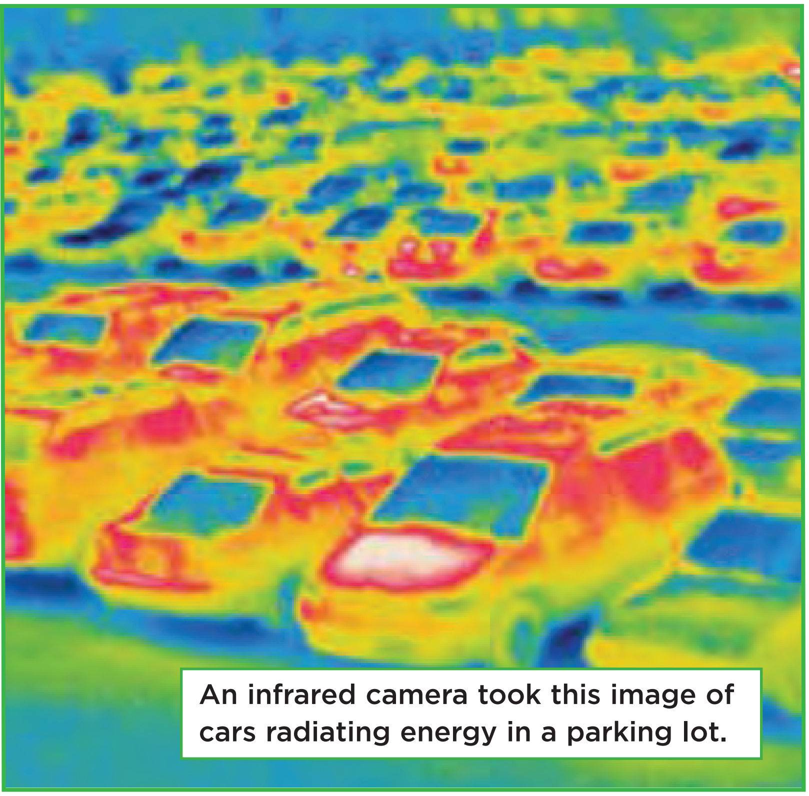
Inside the cocoa, thermal energy spreads as warm and cool parts of the cocoa move around. **Convection** (kuhn•VEK•shuhn) is the flow of thermal energy through a liquid or gas, caused by hot parts rising and cool parts sinking. As hot and cool parts of the liquid move, they cause currents. The currents spread thermal energy throughout the material. Remember that convection causes many of the weather patterns of Earth.

Earth's surface is warmed by radiation from the Sun. **Radiation** (ray•dee•AY•shuhn) is the transfer of energy through *electromagnetic rays* (i•lek•troh•mag•NET•ik rayz). These rays include visible light, X rays, and radio waves. Matter is not needed to transmit radiation. Electromagnetic rays can travel through empty space. Otherwise, energy from the Sun could not warm Earth!

Transmitting Energy

In conduction, energy transfers directly from the stove to the pan to the eggs.

In convection, hotter water rises as colder water falls.



An infrared camera took this image of cars radiating energy in a parking lot.

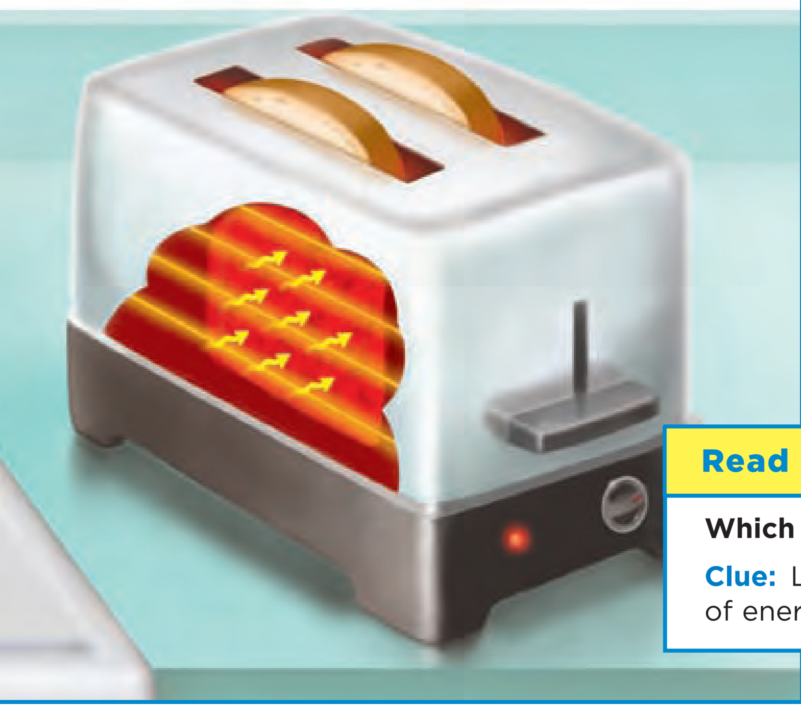
Infrared Rays

Hot objects radiate energy. The electromagnetic rays they produce are called *infrared rays* (in•fruh•RED). You cannot see infrared rays.

You can feel infrared rays, however, when you stand in the Sun. Cooks use infrared rays when they broil food in an oven. A red-hot coil gives off infrared radiation to cook foods quickly. Infrared rays heat the surface of an object more than its center.

Some snakes and other animals have special sensory organs to "see" infrared rays. Scientists have built special instruments and cameras so that you can do the same. Computers can artificially color the images that these cameras take. You can use infrared cameras to take pictures of objects even in the middle of the night.

In radiation, electromagnetic rays carry energy from the hot wires to the toast.



Quick Check

Draw Conclusions How is thermal energy transferred in a pot of water on a stove top?

Critical Thinking How could a large, hot surface move the air above it?

Read a Diagram

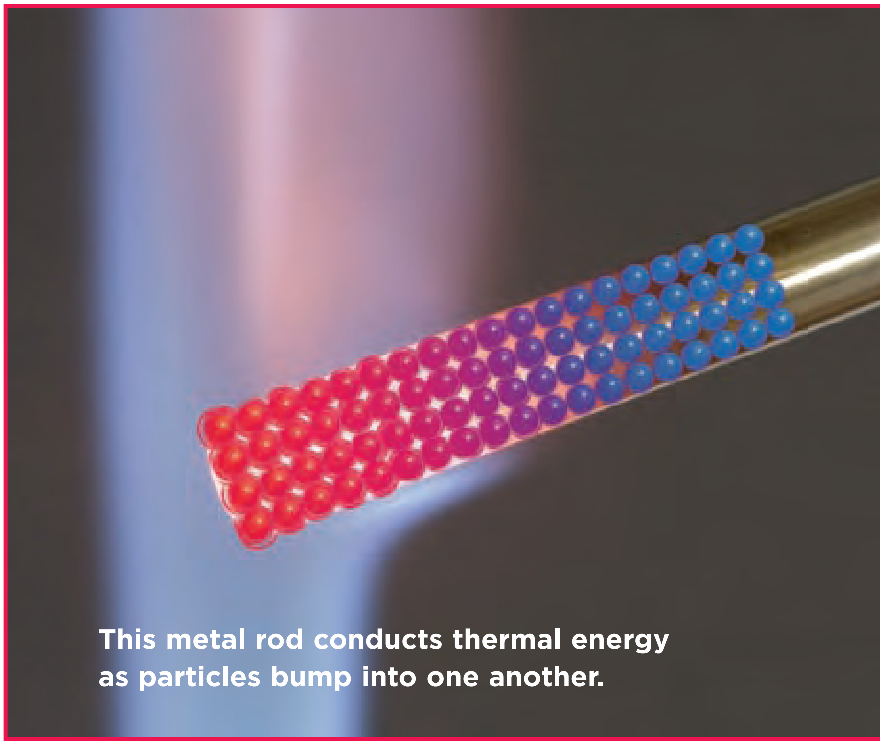
Which method moves both energy and matter?

Clue: Look at the arrows that show the transfer of energy.

What is thermal conductivity?

When thermal energy travels, it does not always travel at the same speed. Radiation will carry thermal energy at the speed of light (300,000,000 m/s)! Convection currents can be measured like wind speed, and are rarely faster than 56 m/s (125 mph). Conduction typically carries thermal energy much slower than either of the other two methods. Why?

In conduction, particles bump into other particles and transfer energy. Thermal energy can only move from one side of an object to another by moving through all the particles in between. This exchange of thermal energy takes time.



This metal rod conducts thermal energy as particles bump into one another.

The ability of a material to transfer thermal energy is called **thermal conductivity** (kon•duk•TIV•i•tee). If a material conducts energy easily, we say it is a good *thermal conductor*. If a material conducts energy poorly, it is a good *thermal insulator*. Most metals are good thermal conductors, and most nonmetals are good thermal insulators.

In materials, thermal conductivity is usually highest in solids and lowest in gases. Solids are better conductors than liquids. Liquids are better conductors than gases. Why? The closer particles are together, the more particles can bump into each other and transfer energy. Particles are closest in solids.

Conductivity

material	how many times better than air it conducts heat
oak wood	6
water	23
brick	25
glass	42
stainless steel	534
aluminum	8,300
copper	15,300
silver	16,300
diamond	35,000 or more

Read a Table

Which material from the table would be the best thermal insulator?

Clue: It has the lowest thermal conductivity.

Heat Capacity

Not all materials change temperature at the same rate. A gram of cooking oil warms more than a gram of water with the same amount of thermal energy. We say that oil has a lower *heat capacity* (kuh•PAS•i•tee) than water. Materials with low heat capacity change temperature more quickly.

A material's heat capacity partly depends on the forces between its particles. Water molecules are strongly attracted to one another. This is why water has a high heat capacity. Every substance has its own unique heat capacity.

Quick Check

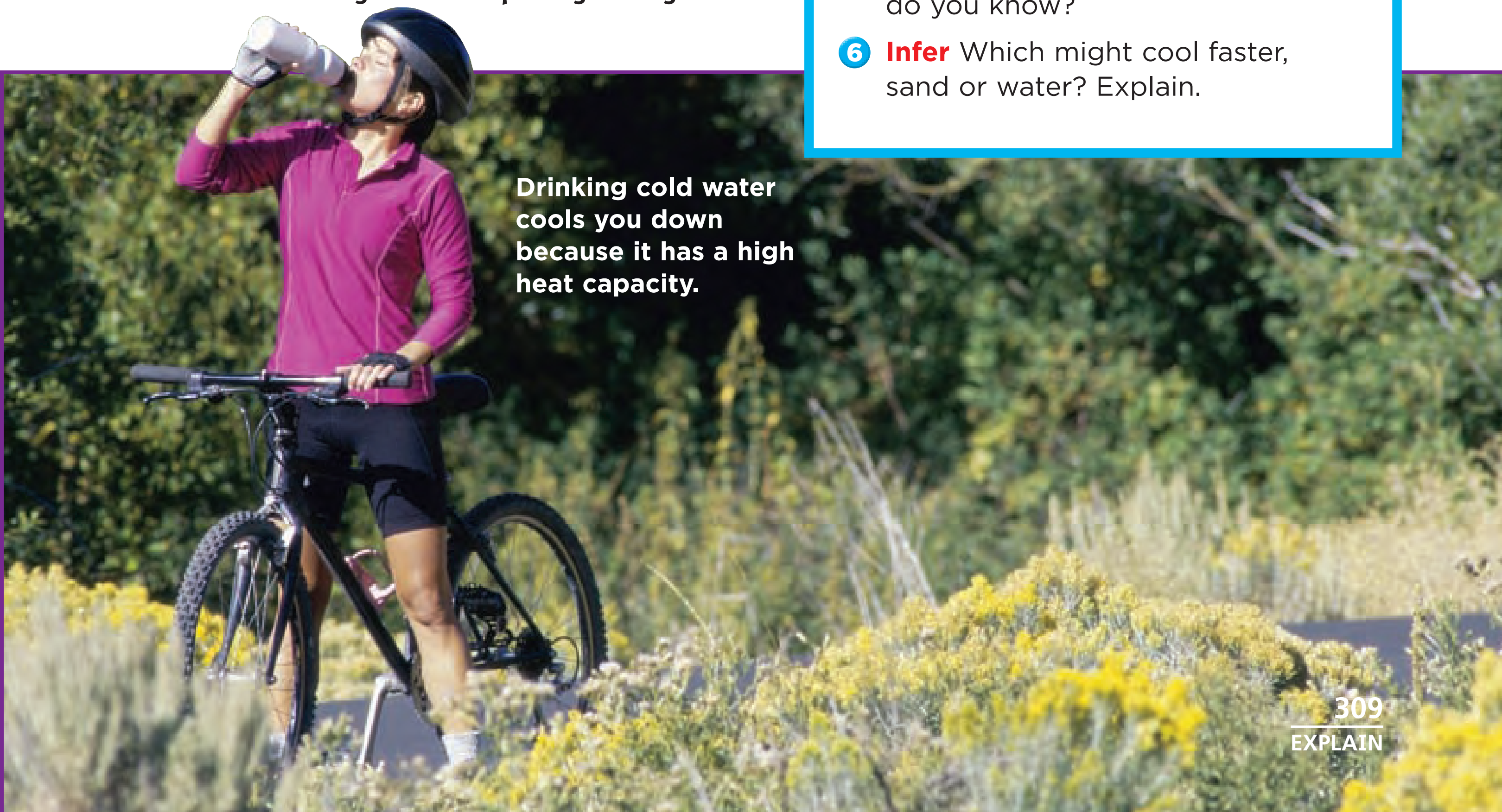
Draw Conclusions Animal fur traps air within it. Would it be a good insulator? Why or why not?

Critical Thinking Would you want a fireplace built from a material with low or high heat capacity? Why?

Quick Lab

Thermal Differences

1. Fill one cup with water and the other with sand. Place a thermometer in each material. Record the temperatures.
2. **Predict** Which material do you think will increase in temperature more rapidly when placed under a lamp?
3. Arrange a lamp so that it shines evenly on both cups. Every minute for ten minutes, measure and record the temperatures.
4. Graph your data for each material as temperature versus time.
5. Was your prediction correct? How do you know?
6. **Infer** Which might cool faster, sand or water? Explain.



Drinking cold water cools you down because it has a high heat capacity.

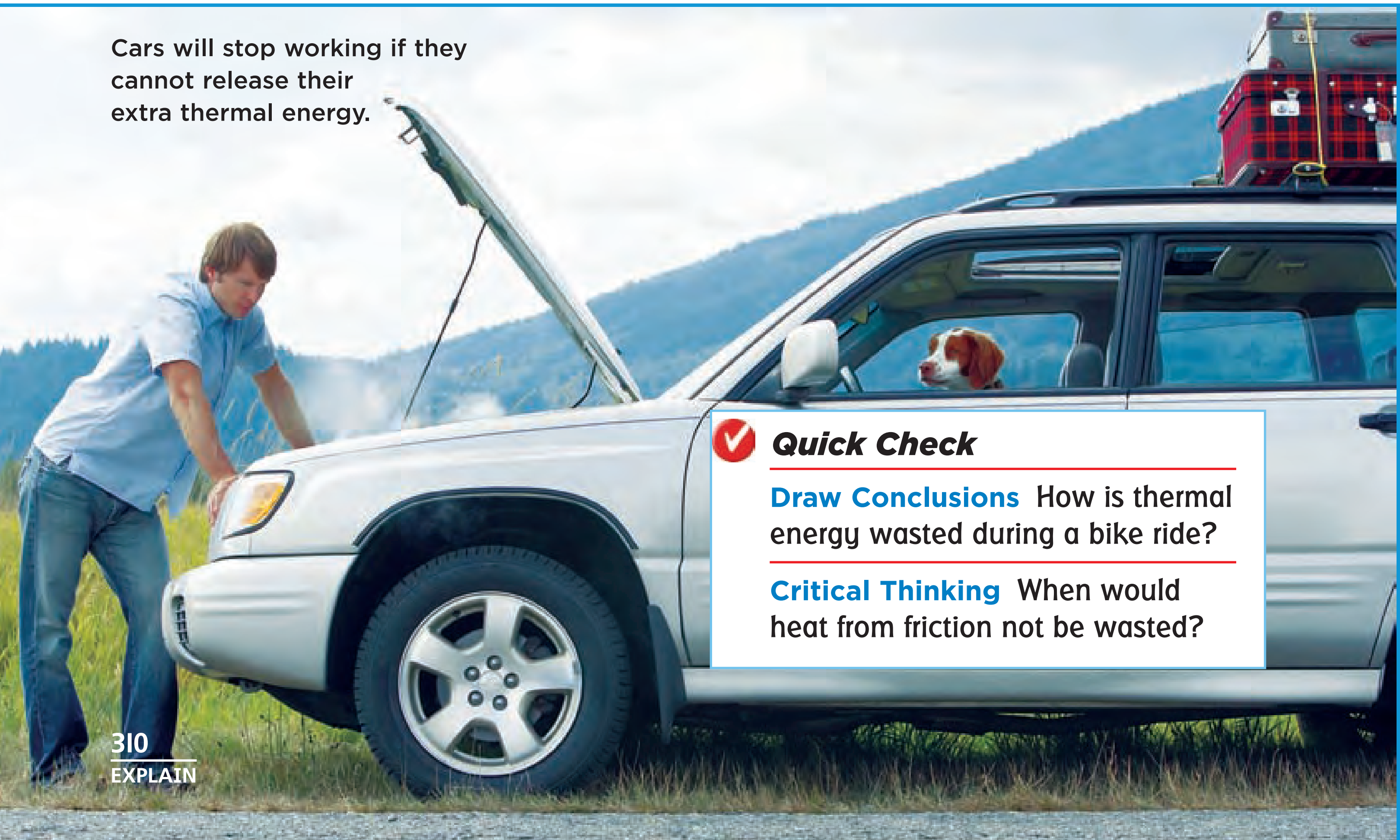
Can thermal energy be waste?

Besides keeping you warm, thermal energy has many uses. Many chemical reactions require thermal energy in order to occur. For example, the thermal energy released from chemical reactions powers the engine in a fossil-fuel-burning car. Metals are often heated to make them harder and more brittle. Infrared cameras are used in night-vision goggles to allow you to view objects without visible light.

Yet, thermal energy can also be an unwanted waste product. Over time, thermal energy generated by friction causes many machines to break. For instance, friction and thermal energy wear down car parts, and those parts must then be replaced. Also, friction often lowers the efficiency of machines. The energy that is lost to friction becomes thermal energy. This energy is hard to use to perform work. It is often considered to be wasted.

When energy changes form or performs work it will often waste thermal energy. Electrical energy heats electrical wires when electrons move through them. Muscles are heated when chemical reactions release energy from food. Although it can be very useful, thermal energy is the most common waste product from work.

Water absorbs the thermal energy caused by the friction of a saw cutting stone.



Cars will stop working if they cannot release their extra thermal energy.

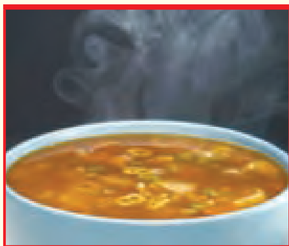
Quick Check

Draw Conclusions How is thermal energy wasted during a bike ride?

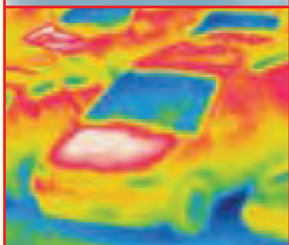
Critical Thinking When would heat from friction not be wasted?

Lesson Review

Visual Summary



Heat is the flow of thermal energy from a warmer object to a cooler one.

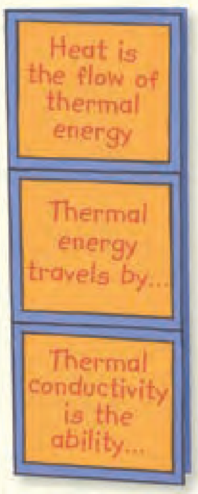


Thermal energy travels by **conduction, convection,** and **radiation**.

Thermal conductivity is the ability of a material to conduct thermal energy.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. Under each tab, summarize what you learned about that topic.



Think, Talk, and Write

1. **Main Idea** A candle is placed on a steel block and begins to melt. How do you know whether the candle or the steel block is hotter?

2. **Vocabulary** The ability of a material to transfer thermal energy is called ________.

3. **Draw Conclusions** An infrared image of a house shows that the roof is brighter than the rest of the house. What does this mean?

Text Clues	Conclusions

4. **Critical Thinking** Why is water a material used to cool hot machinery?

5. **Test Prep** **The transfer of thermal energy by direct contact is called**
   A conduction.
   B convection.
   C radiation.
   D insulation.

6. **Test Prep** **Which is most responsible for winds on Earth?**
   A conduction
   B convection
   C radiation
   D insulation

Writing Link

Writing a Story
You live on a planet where no materials are good conductors. Write a story about your life on this planet.

Math Link

Heating Gold
It takes 128 J of energy to raise the temperature of 1 kg of gold from 20°C to 21°C. A heat source supplies 1,536 J. How much gold can it heat from 20°C to 21°C?

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Focus on Skills

Inquiry Skill: Form a Hypothesis

You know that thermal energy flows from warmer to cooler objects until they both reach the same temperature. How is that temperature affected by the amount of each object?

Scientists use observations or theories to help them **form a hypothesis**. When you form a hypothesis, you make a testable statement about what you think is logically true.

▶ Learn It

A hypothesis is a statement about the effect of one variable on another. It should be based on observations or collected data. For example, when you drink hot chocolate, you might notice that it cools faster when you add ice to it. Based on this observation, you might **form a hypothesis** like "If increasingly colder substances are added to hot chocolate, then it will cool faster."

A hypothesis is tested by conducting an experiment. In this experiment, you will test how much hot water cools when room-temperature water is added. Think about observations you have made in the past involving temperature changes. Write a hypothesis in the form "If increasingly larger amounts of room-temperature water are added to hot water, then..."

Try It

Materials **graduated cylinder, hot and room-temperature water, cups, thermometer, stopwatch**

In this activity, you will observe how water temperatures change in order to test your **hypothesis**.

1. Use the graduated cylinder to pour 25 mL of room-temperature water into one cup and record its temperature on a chart like the one shown.
2. Pour 75 mL of hot water into a different cup and record its temperature on the chart.
3. Add the room-temperature water to the hot water and start the timer on the stopwatch. Place a thermometer in the water and observe its temperature after two minutes. Record the new temperature of the hot water.
4. Repeat steps 1 to 3 with 50 mL, 75 mL, and 100 mL of room-temperature water. You are changing this variable in order to test your hypothesis.

Apply It

1. Subtract the final temperature of the hot water from its starting temperature for each trial. Record your results on your chart.
2. Use the data in your chart to form a graph. On the horizontal axis plot the amount of room-temperature water added to the hot water. On the vertical axis plot the change in temperature of the hot water.
3. Was your **hypothesis** correct? How do you know?
4. Did the results of the first three trials make it easier to understand what would happen the last time? Why or why not?

Water Added	Added Water's Temperature	Hot Water's Starting Temperature	Hot Water's Ending Temperature	Hot Water's Temperature Change
25 mL				
50 mL				
75 mL				
100 mL				

SWK-I. Summarize how conclusions and ideas change as new knowledge is gained.

Lesson 2

Sound

Look and Wonder

A cloud forms as this jet breaks the sound barrier and creates a sonic boom. What do you think you might feel if you were near a sonic boom?

PS-6. Describe and summarize observations of the transmission, reflection, and absorption of sound. **PS-7.** Describe that changing the rate of vibration can vary the pitch of a sound.

Explore

Inquiry Activity

What makes sound?

Form a Hypothesis

When you pluck the rubber band on the "instrument" shown, it makes sound. How will this sound depend on the way you pluck the rubber band? Write your answer as a hypothesis in the form "If the rubber band is plucked with increasing force, then the sound..."

Test Your Hypothesis

1. **Be Careful.** Wear goggles. Make a rubber-band "instrument" as shown. Poke a small hole in the bottom of the cup with a toothpick. Tie one end of a cut rubber band to the toothpick. Thread the toothpick through the hole in the cup. Tie the stretched rubber band to the ruler and tape the ruler to the cup.
2. **Observe** Wrap one hand around the cup while you pluck the rubber band. What do you hear and feel? Record your observations.
3. Pluck the rubber band both gently and forcefully. Record how the sound is affected. Repeat your actions to verify your results.

Draw Conclusions

4. **Interpret Data** Based on your observations, was your hypothesis correct? Explain.
5. **Infer** How do you think your rubber-band "instrument" made sound? Use your observations from step 2 to help you.

Explore More

How will stretching the plucked rubber band affect whether the pitch is high or low? Write out your hypothesis. Then carry out experiments to test it.

Materials

- goggles
- paper cup
- toothpick
- rubber band
- wood or plastic ruler
- masking tape

Step 1

Step 2

SI-5. Identify potential hazards and/or precautions involved in an investigation.

Read and Learn

Main Idea PS-6, PS-7

Sounds are produced by vibrating objects.

Vocabulary

- **sound wave**, p. 317
- **medium**, p. 317
- **absorption**, p. 319
- **frequency**, p. 320
- **pitch**, p. 320
- **amplitude**, p. 322
- **echolocation**, p. 324

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Reading Skill

Fact and Opinion

Fact	Opinion

How is sound produced?

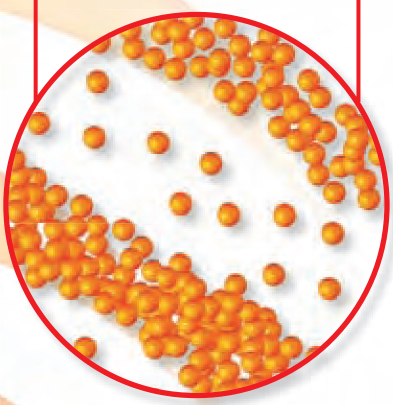
Have you ever noticed the sound from a low-flying jet rattling the dishes in the kitchen? Perhaps you've noticed something similar when someone plays a stereo system too loudly. What causes objects to shake when there are loud sounds nearby?

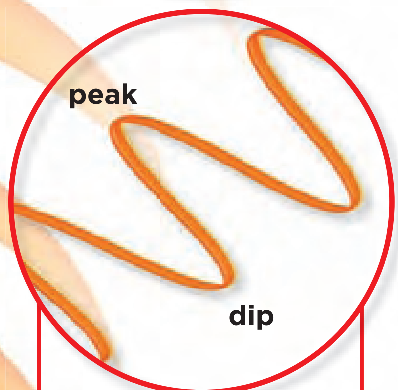
When an object makes sound, it vibrates back and forth. The vibrations of a drum alternately squeeze air particles and then spread them out. This creates regions of air that have many particles, called *compressions* (kuhm•PRESH•uhnz), and regions of air that have few particles, called *rarefactions* (rayr•uh•FAK•shuhnz). The compressions and rarefactions move through the air, carrying sound energy. Each region of the air is only moved back and forth. Drums do not create a steady wind.

Sound waves vibrate in the same direction that they travel.

Vibrations caused by the helicopter blades produce loud sound waves.

The density of the air, but not the air itself, moves.





The density of the air can be shown as a series of peaks and dips.

A series of rarefactions and compressions traveling through a substance is called a **sound wave**. The substance through which the wave travels is called the **medium** for the wave. As with all waves, sound waves carry energy. When they pass through a medium, the medium is not permanently moved. Energy, however, is permanently moved from one place to another.

Sound waves vibrate the medium in the same direction that the energy moves. They are called *longitudinal* (lon•ji•TEW•duh•nuhl) waves. We can also represent sound waves as a series of peaks and dips. The peaks represent the high density of air in compressions. The dips indicate the low density of air in rarefactions. Remember that air does not move up and down like the peaks and dips.

When sound waves hit an object, it can start vibrating. The object is moved by the energy of the wave. This is how sound from a loud airplane or stereo rattles dishes. You can literally feel the vibrations caused by such loud sounds.

Quick Check

Fact and Opinion Should homes be built next to airports? Support your opinion with facts.

Critical Thinking Describe the density of air in a room when music is played.

How does sound travel?

Could you hear sounds in space? No, space is a *vacuum* (VAK•yew•uhm), a region that contains few or no particles. Since space has few particles, there is no medium for sound to travel through. You could not hear a radio, even if it were playing next to you!

Sound can travel through solids, liquids, and gases. In fact, sound tends to travel with the greatest speeds in solids and the slowest speeds in gases. In steel, for example, sound travels at almost 6,000 m/s. In air, though, sound only travels at about 343 m/s.

These differences in the speed of sound are due to how far apart the particles are. The collision of particles is what carries sound energy. In a solid, the particles are close together. They collide quickly and move sound rapidly. In gases, particles are far apart. Collisions are less frequent, so sound travels more slowly.

FACT Sound cannot travel through outer space.

The temperature of the medium also affects the speed of sound. In warmer air, particles move faster. As a result, they collide more often. With more collisions, the particles in warmer air transmit sound faster.

Water is a good medium for sounds like dolphin songs.

Changing How Sound Travels

Have you ever been in a sound-proof room? Such rooms are often used by musicians. When a sound wave hits soft, thick, or uneven materials, the energy of the wave is absorbed. **Absorption** (ab•SAWRP•shuhn) is the transfer of energy when a wave disappears into a surface. Absorbed sound waves become kinetic or thermal energy on that surface.

Have you ever heard an echo? When sound waves hit a flat, firm surface much of their energy bounces back. Echoes are sound waves that have reflected back at the speaker. Reflection is the bouncing of a wave off a surface. Whenever a sound wave reflects off a surface, at least some of it is absorbed. Echoes are never as loud as the original sound wave.

The walls of this room are made to absorb sound.

Quick Lab

Sound Carriers

1. **Predict** Will you be able to hear the sound from a radio better through air, water, or wood?
2. Put a radio on a wooden table. Put your ear on the other side of the table and listen. Now lift your head. Record your observations.
3. Fill a plastic bag with water. Hold the bag against your ear. Then hold the radio against the other side of the bag. How loud is the radio? Move your ear away from the bag. How loud is the radio now? Record your observations.
4. Rate wood, air, and water as sound mediums from worst to best.
5. **Infer** Foam is less dense than wood or water, but more dense than air. How well do you think foam will carry sound?

Quick Check

Fact and Opinion A friend says echoes are scary because they sound softer than regular voices. Which part of this statement is fact, and which is opinion?

Critical Thinking How would putting your ear to the floor let you hear a sound sooner than you would hear it in the air?

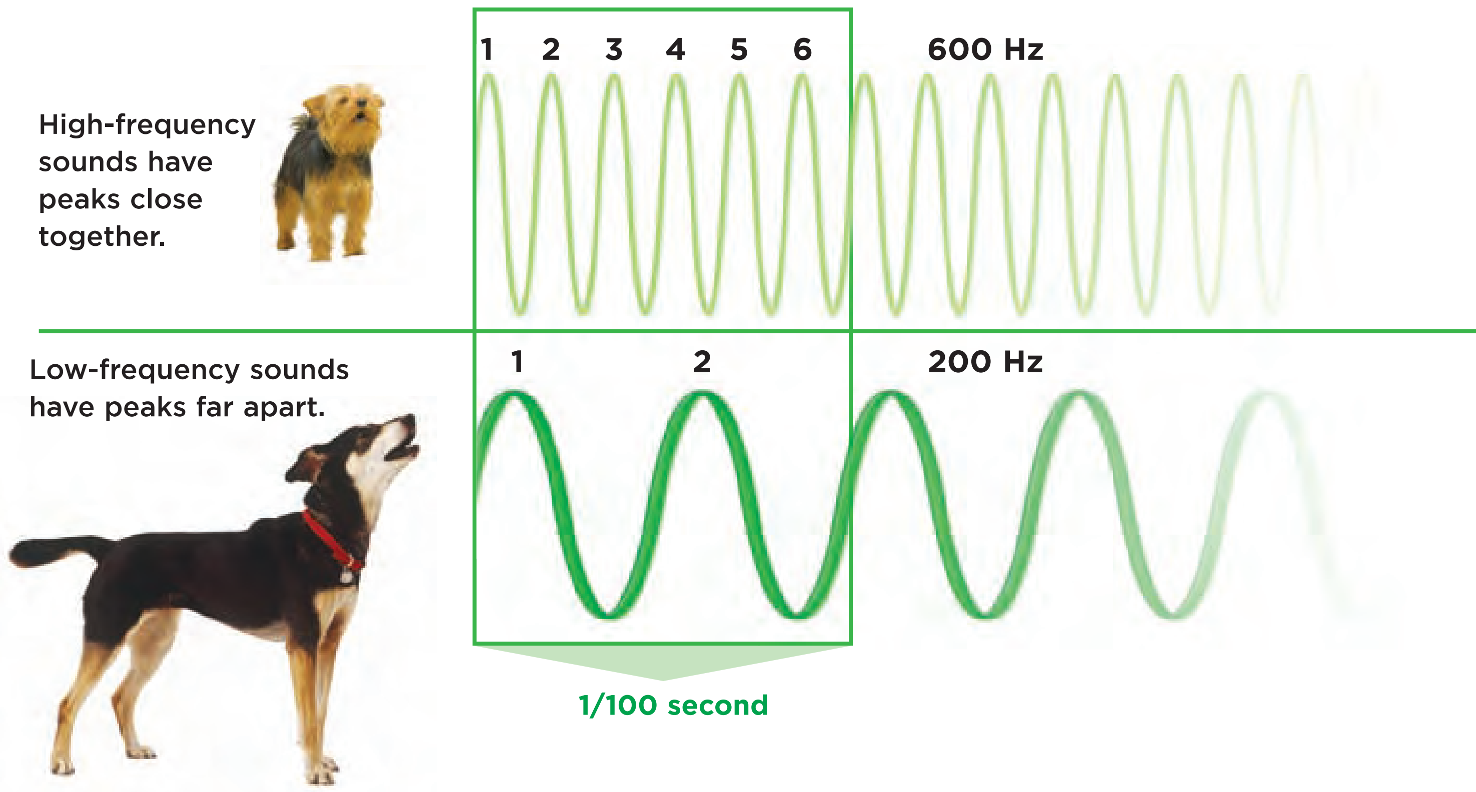
What is pitch?

How high can you sing? How low can you sing? What is changing when you go from singing a high note to a low note? The sound wave that reaches your ears is different. The series of peaks and dips in the wave get closer together the higher you sing. **Frequency** (FREE•kwuhn•see) is the number of times an object vibrates per second. Its units are cycles per second (1/s) or hertz (Hz). High notes have a greater frequency than low notes.

Musical notes like the ones you sing are defined by their pitch. **Pitch** is how high or low a sound is, and is related to frequency. In music, pitch is often given a letter name of "C," "D," "E," "F," "G," "A," or "B." The series repeats itself so that the eighth note is "C" again. A series of eight notes is called an *octave* (OK•tiv).

If the first "A" you sing is at a frequency of 55 Hz, the "A" in the next octave will be 110 Hz. You will hear that the second A is twice as high in pitch as the first. The third "A" will in turn sound three times as high in pitch as the first "A." Its frequency, however, will not be 165 Hz, but 220 Hz! The frequency doubles for every octave.

Pitch and frequency are two different ways to describe sound waves. Pitch is the way our ears perceive frequency. It is closely related to the number of peaks in a sound wave, but is not the same thing as frequency.



Doppler Effect

Read a Photo

Would a train's whistle sound higher or lower in pitch than normal?

Clue: Is the train moving toward or away from you?

Changing Pitch

To make a sound higher in pitch, you increase the number of times it vibrates each second. On a string instrument, shortening the string increases pitch. On a wind instrument, shortening the tube increases pitch. A shorter tube produces a higher pitch because the air inside vibrates faster.

You can increase the frequency of a sound wave by moving toward it. How? Frequency is just the number of peaks of a wave per second. If you move toward a wave, you will hear the peaks quicker than if you were standing still. If you move away from a wave, the peaks arrive at your ear more slowly and the pitch is lower.

A change in frequency due to moving away or toward a wave is called the *Doppler effect* (DOP•luhr i•FEKT). Any movement can cause a Doppler effect, but only fast speeds will change a pitch enough to be heard by your ears.

The pitch of a trombone changes with the length of its tubes.

Quick Check

Fact and Opinion A classmate says that higher notes are irritating because they vibrate your ear faster. Which part of that statement is fact and which is opinion?

Critical Thinking How do you think you change the pitch of your voice?

What is volume?

Pretend you are in a room when someone turns up the volume on a radio too much. Is it easy to hear other noises? What makes a sound so loud?

The height of a sound wave is called its *amplitude* (AM•pli•tewd). The **amplitude** is how dense the air is in the compressions or rarefactions compared to normal air. The loudness, or volume, of a sound depends on the amplitude of the sound's waves.

Scientists measure the volume of sounds with decibels (dB). A 20 dB noise has 10 times more energy than a 10 dB noise. A 30 dB noise has 100 times more energy than a 10 dB noise.

Our ears hear things in a different way. A 30 dB noise sounds twice as loud as a 20 dB noise, and four times as loud as a 10 dB noise. Sounds above 85 decibels damage your hearing. Wear earplugs if you are near loud sounds!

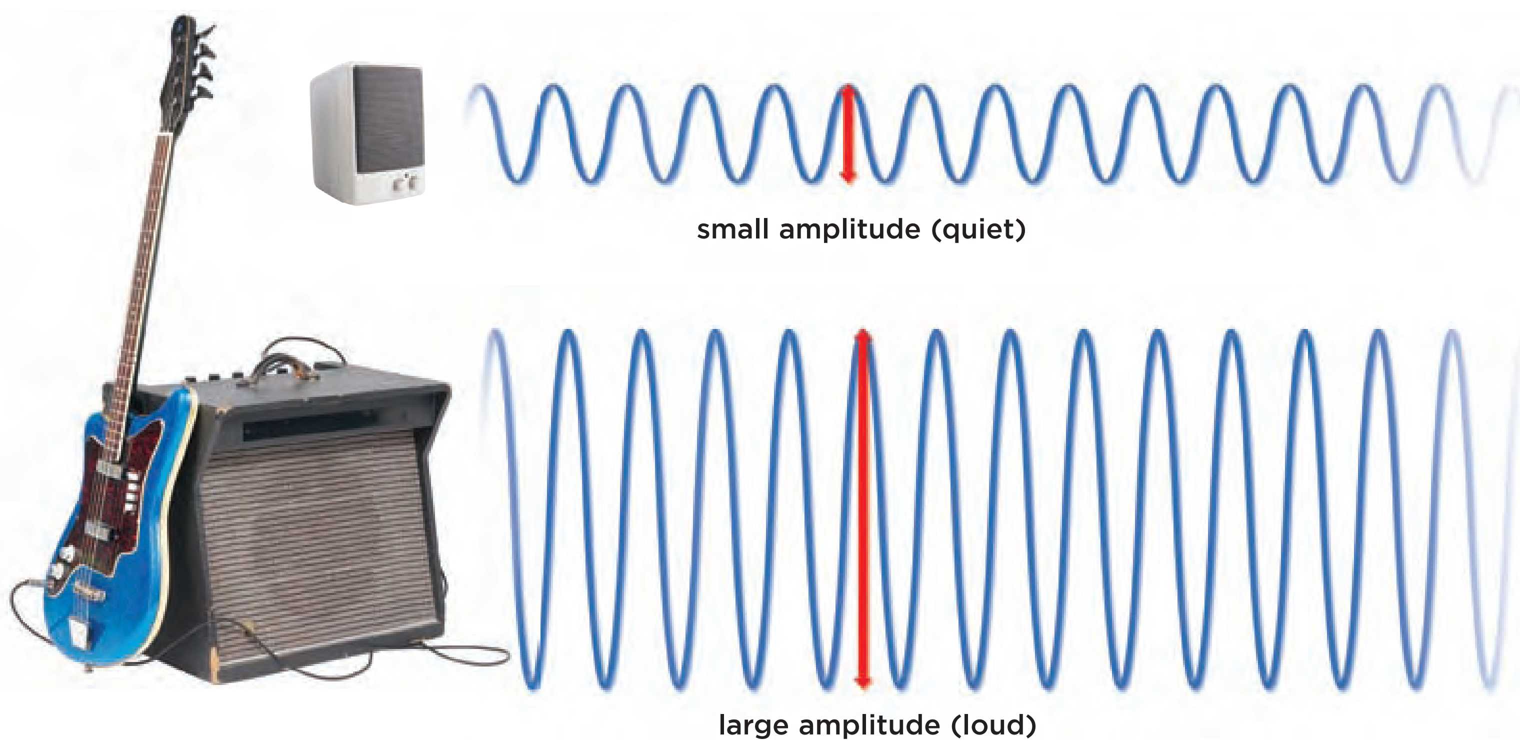
Volume of Sounds

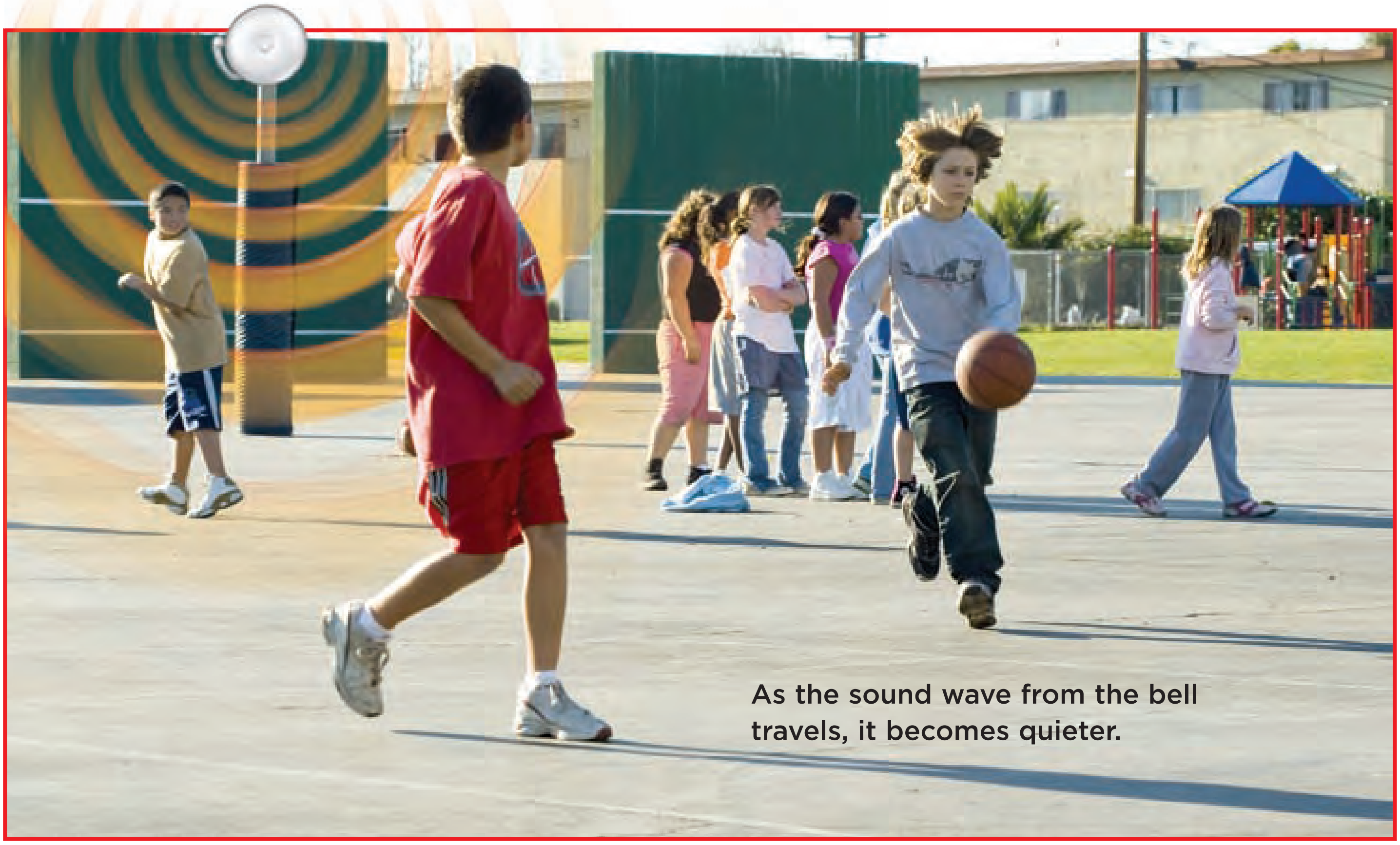
decibel level	sound
180 dB	rocket engine at 30 m (98 feet)
130 dB	threshold of pain, train horn at 10 m (33 feet)
120 dB	rock concert
110 dB	chainsaw at 1 m (3.3 feet)
100 dB	jackhammer at 2 m (6.6 feet)
85 dB	threshold of damaging hearing
80 dB	vacuum cleaner at 1 m
60 dB	normal conversation
50 dB	rainfall
30 dB	theater (without talking)
10 dB	human breathing at 3 m (10 feet)
0 dB	threshold of human hearing (with healthy ears)

Read a Table

Could the sound from a rocket engine 30 m away cause pain in your ears?

Clue: Compare the volume for the rocket engine and the threshold of pain.




As the sound wave from the bell travels, it becomes quieter.

Changing Volume

You can make sounds louder by using more energy. For example, you can pluck a string harder, use more air in your voice, or hit a drum with more force. The extra energy increases the density of the particles in the compressions. Also, the rarefactions will be less dense than before.

Changing the medium of a sound wave will also change its amplitude. A wave in a dense material will have a smaller amplitude than in air. The wave, however, will have the same amount of energy. Even though the amplitude is smaller there are more particles moving in the wave.

The volume of a sound will be smaller the farther you travel from its origin. Why? Think of ripples in a pond. At their center, the ripples are high, but as they expand outward they get smaller. The same amount of energy in the wave is being spread out over a larger and larger area. So as you move away from the origin of a sound, the energy in the wave at any point gets smaller. Less energy means less volume, and you hear the difference.

Quick Check

Fact and Opinion Listening to loud music damages your hearing. Is that statement fact or opinion?

Critical Thinking You hear the sound of a drum as 45 dB, then 55 dB, then 65 dB. How might this be happening?

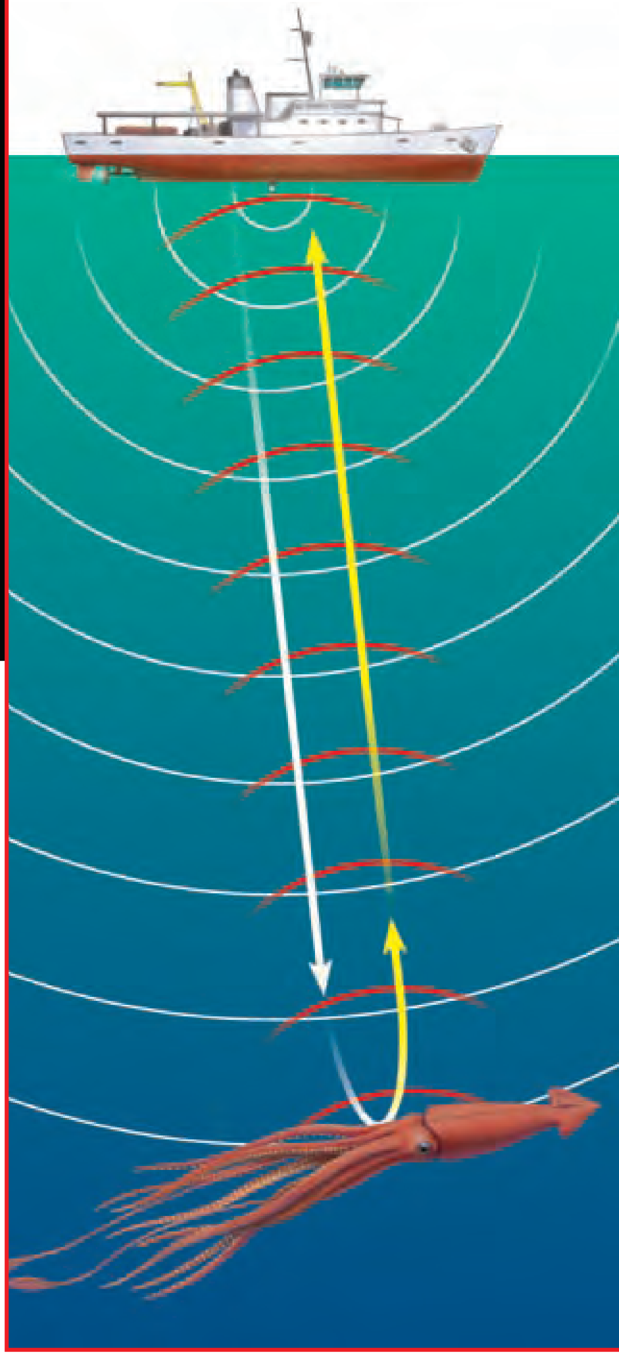
Bats use echoed sound to locate insects.

What is echolocation?

Echoes can be put to good use. Some bats, for example, make sounds that echo off of their prey. The returning echoes tell the bat where the prey is located. Finding food or other objects in this manner is known as **echolocation**. Whales and dolphins, too, use echolocation to orient themselves and to find food.

Scientists have developed a system called *sonar* that works like echolocation does for animals. Sonar stands for "sound navigation and ranging." It is used under water to find objects. The sonar system sends out sound waves that reflect off of objects. It then detects the reflected sound waves. The return time and direction of the sonar echoes are used to calculate the location of the object.

Boats use sonar to find objects under water.



Quick Check

Fact and Opinion Dolphins are cuter than whales when using echolocation. Is this fact or opinion?

Critical Thinking Could sonar work on land? Why or why not?

Lesson Review

Visual Summary

Vibrating objects produce **sound waves** in a **medium**.

Sounds may be **transmitted, absorbed,** or **reflected** by materials or objects.

As the **frequency** of a sound wave increases, the **pitch** becomes higher.

Make a FOLDABLES™ Study Guide

Make a Folded Chart. Use the title shown. Fill in the chart with information you learned about each topic.

Think, Talk, and Write

1. **Main Idea** How could a stereo playing loudly rattle dishes?

2. **Vocabulary** The number of compressions that pass by in a given time is called a sound wave's ________.

3. **Fact and Opinion** Should you wear earplugs while using a vacuum cleaner? Support your opinion with facts.

Fact	Opinion

4. **Critical Thinking** Is there more energy in a 30 dB or 40 dB sound wave? Why?

5. **Test Prep** **At what volume do sounds start damaging hearing?**
   A 10 decibels
   B 65 decibels
   C 85 decibels
   D 150 decibels

6. **Test Prep** **An echo is an example of a sound wave being**
   A transmitted.
   B absorbed.
   C reflected.
   D surfed.

Math Link

Finding Frequencies
A particular "C" note has a frequency of 33 Hz. What will be the frequency of a "C" note 5 octaves higher than that note?

Music Link

Why would guitars have a top made of thin wood? Why would they have a big, hollow body? Write out your ideas.

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Be a Scientist

Materials

scissors

10 straws

ruler

masking tape

Structured Inquiry

How can you change a sound?

Form a Hypothesis

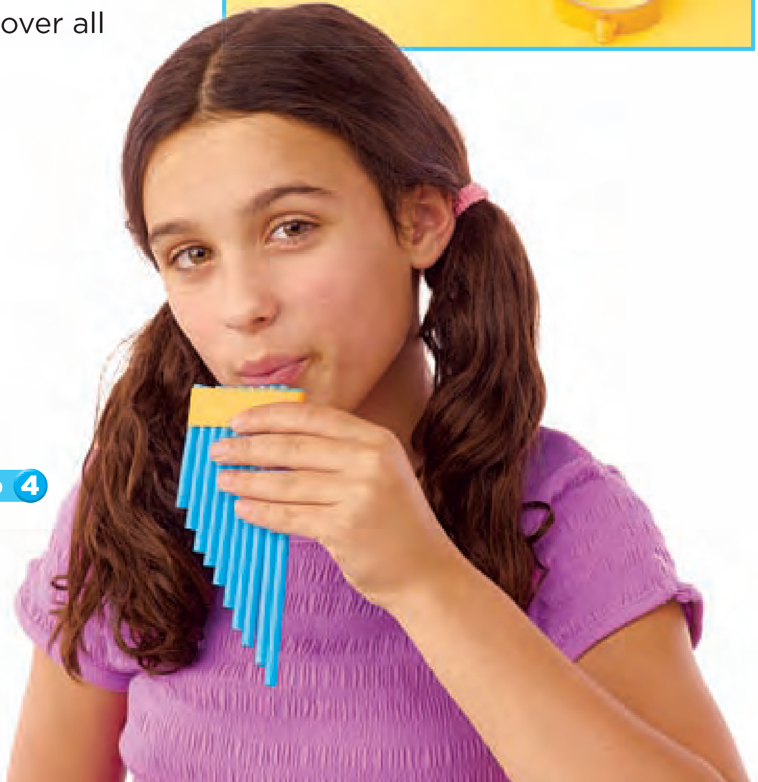
Increasing or decreasing the number of vibrations in a second changes the pitch of a sound. For example, on a guitar, the highest notes are played when the strings vibrate the fastest. For instruments that have tubes, the length of each tube determines how quickly air inside it vibrates.

How does the length of tubes affect the pitch of sounds they make? Write your answer as a hypothesis in the form "If the tube of a wind instrument is shortened, then the pitch... "

Test Your Hypothesis

1. **Make a Model** Use scissors to cut a straw to a length of 15 cm.
2. Cut the next straw to be 1 cm shorter than the last one. Repeat this procedure until all of the straws are cut. The last straw should be 6 cm long.
3. Lay the straws on the table. Place a piece of tape over all of the straws.
4. **Experiment** Hold the instrument to your mouth and blow across the straws to create sound.

Step 2



Step 4

Draw Conclusions

5 **Observe** What do the shortest and longest pipes sound like? Was your hypothesis correct? Why or why not?

6 **Infer** Would the 12-cm straw sound identical to the 6-cm straw if it was cut in half? Why or why not?

Guided Inquiry

How are pitch and tension related?

Form a Hypothesis

How do you think tension in a rubber band would affect the sound it makes? Write your answer as a hypothesis in the form "If the tension in a rubber band is increased, then the pitch of the sound will…"

Test Your Hypothesis

⚠ **Be Careful.** Wear goggles. Design an experiment to investigate the effect that tension in a rubber band has on the pitch of its sound. Write out the materials you need and the steps you will follow. Record your results and observations.

Draw Conclusions

Did your results support your hypothesis? Why or why not?

Open Inquiry

What other variables might affect the pitch of sounds? For example, how is sound affected by different mediums? Determine the materials needed for your investigation. Your experiment must be written so that another group can complete the experiment by following your instructions.

Remember to follow the steps of the scientific process.

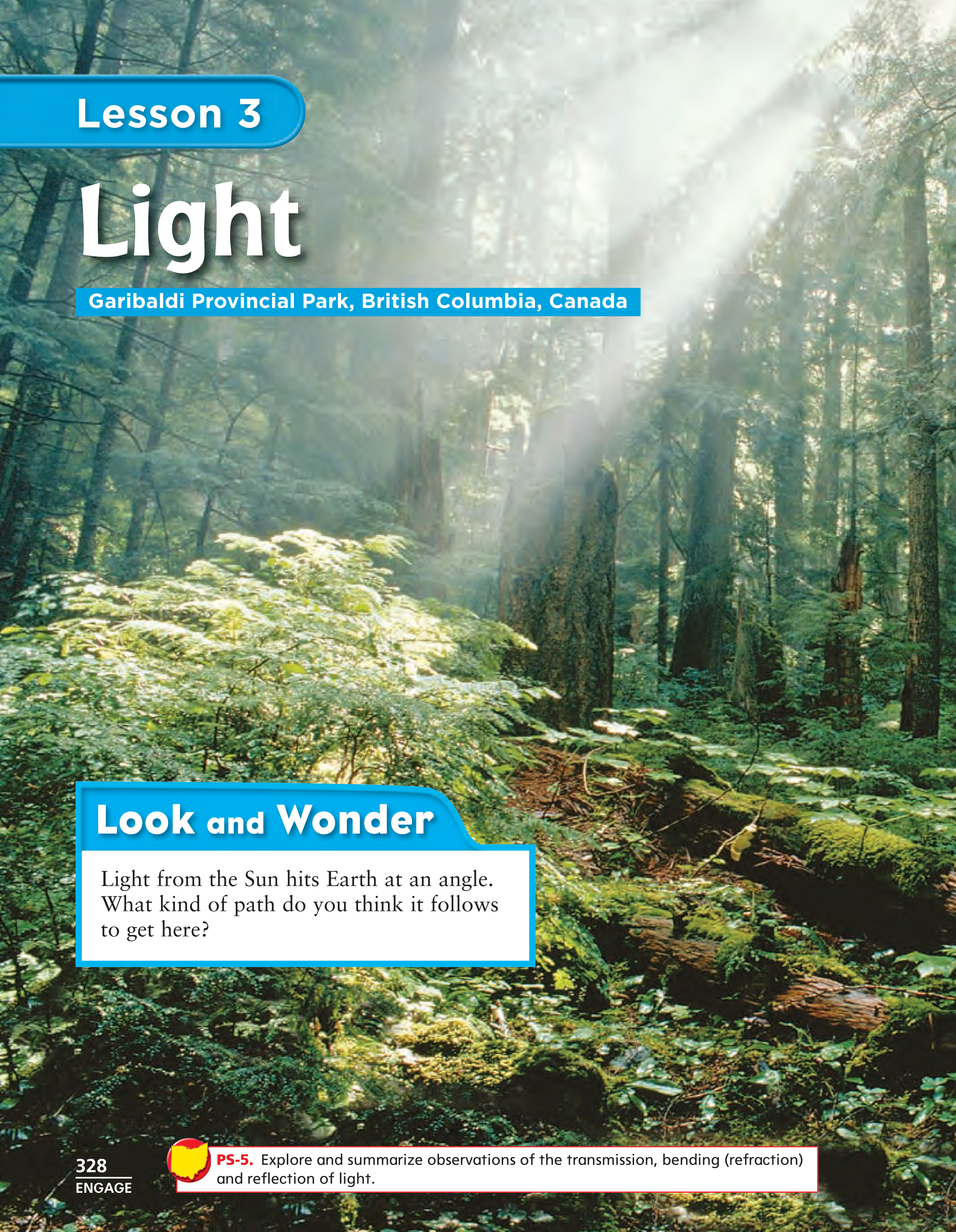
Ask a Question
↓
Form a Hypothesis
↓
Test Your Hypothesis
↓
Draw Conclusions

SI-4. Identify one or two variables in a simple experiment.

Lesson 3

Light

Garibaldi Provincial Park, British Columbia, Canada



Look and Wonder

Light from the Sun hits Earth at an angle. What kind of path do you think it follows to get here?

PS-5. Explore and summarize observations of the transmission, bending (refraction) and reflection of light.

Explore

Inquiry Activity

What path does the light follow?

Form a Hypothesis

When you look in a mirror, you see light that travels to the mirror, bounces off, and travels to your eye. How does the angle of the light hitting the mirror compare to the angle of the light bouncing to your eye? Write your answer as a hypothesis in the form "If the angle at which light strikes a mirror decreases, then . . . "

Test Your Hypothesis

1. Using two pieces of tape, form a large letter *T*. Place the mirror upright on the top of the *T*. Stick each pencil, point down, into an eraser so that they can stand up on their own.
2. **Experiment** Place a pencil on the left side of the *T*. Place your head on the right side. Move your head until the pencil appears to be in the center of the mirror at the top of the *T*. Now place the second pencil so that it completely blocks your view of the first pencil in the mirror.
3. **Measure** Move the mirror and place a protractor on the top of the *T*. Find the angle between the top left of the *T* and the first pencil. This is your independent variable. Find the angle between the top right of the *T* and the second pencil. This is your dependent variable.
4. Repeat steps 2 and 3 three more times, moving the first pencil farther from the *T* each time.

Draw Conclusions

5. **Interpret Data** Look at the angles you measured. Was your hypothesis correct? Why or why not?

Explore More

What would happen if one pencil was close to the mirror while another was far away? Would the angles change? Write a hypothesis and carry out an experiment to test it.

Materials

- masking tape
- flat mirror
- 2 pencils
- 2 erasers
- protractor

SI-I. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others....

Read and Learn

Main Idea PS-5

Light travels as waves but can also be described as particles.

Vocabulary

wavelength, p. 330
photon, p. 331
translucent, p. 332
image, p. 334
refraction, p. 335
prism, p. 336
spectrum, p. 336
electromagnetism, p. 338

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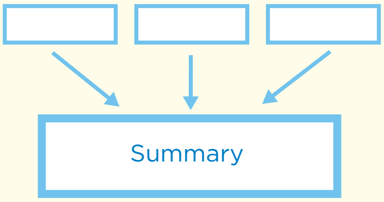
Reading Skill ✔

Summarize



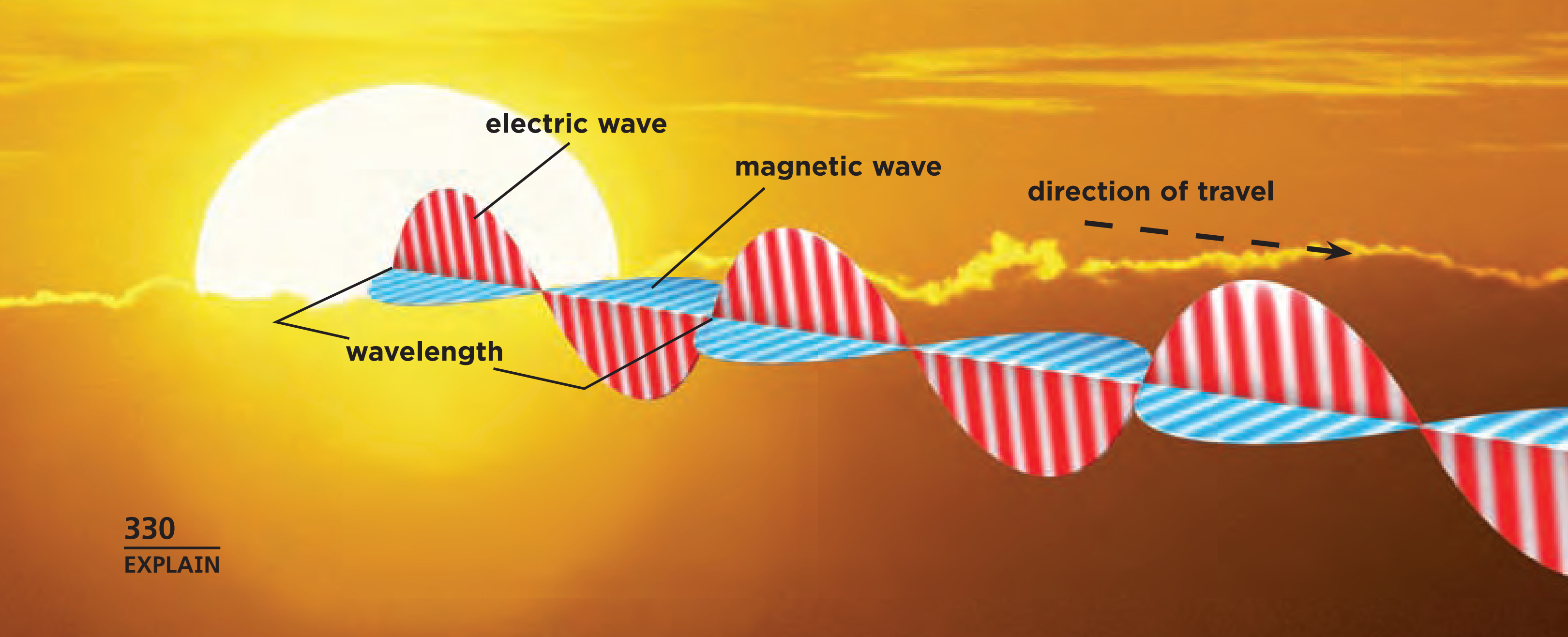
What is light?

Light from the Sun travels more than 90 million miles to Earth in only $8\frac{1}{3}$ minutes! Light is made of vibrating electric and magnetic energy. This energy travels as a wave—it has both frequency and amplitude. Light waves vibrate in the direction perpendicular to the direction of their motion. They are called *transverse* (trans•VURS) waves.

Light does not depend on compressions or rarefactions. In fact, light waves can travel with or without a medium. In a vacuum, light travels very fast—about 300,000 km/s (186,000 mile/s). Light travels slightly slower through mediums like air, water, or glass. The speed of light is so fast that some scientists think that nothing travels faster. The speed of light may be the speed limit of our universe.

We often wish to know the wavelength (WAYV•lengkth) of light. **Wavelength** is the distance between one peak and the next in a wave. When you multiply the wavelength of a wave by its frequency, you get the speed of that wave.

Light is a wave made from electric and magnetic energy.



Light Is Also a Particle

Although light is a wave of energy, it is also a particle. How can something be both a wave and a particle? Scientists were confused about that question for a very long time. They performed many experiments and found that light has properties of both waves and particles, so they had to conclude it was both.

Light is like a particle in several ways. It travels in straight lines called *light rays*. Light does not have mass like a particle, but it does have momentum like a particle. When light hits an object, it acts just like a tiny particle. Light can even change the direction of atoms and other small particles. When light hits camera film, it produces little dots instead of forming an image all at once. Over time, those points will eventually add up and form the original image.

Particles of light are called photons (FOH•tonz). A **photon** is a tiny bundle of energy by which light travels. The energy of a single photon is very small: a photon of red light has only about 0.0000000000000000003 J of energy! Each photon also acts like a wave with a frequency. If a photon has a higher frequency, it also has more energy.

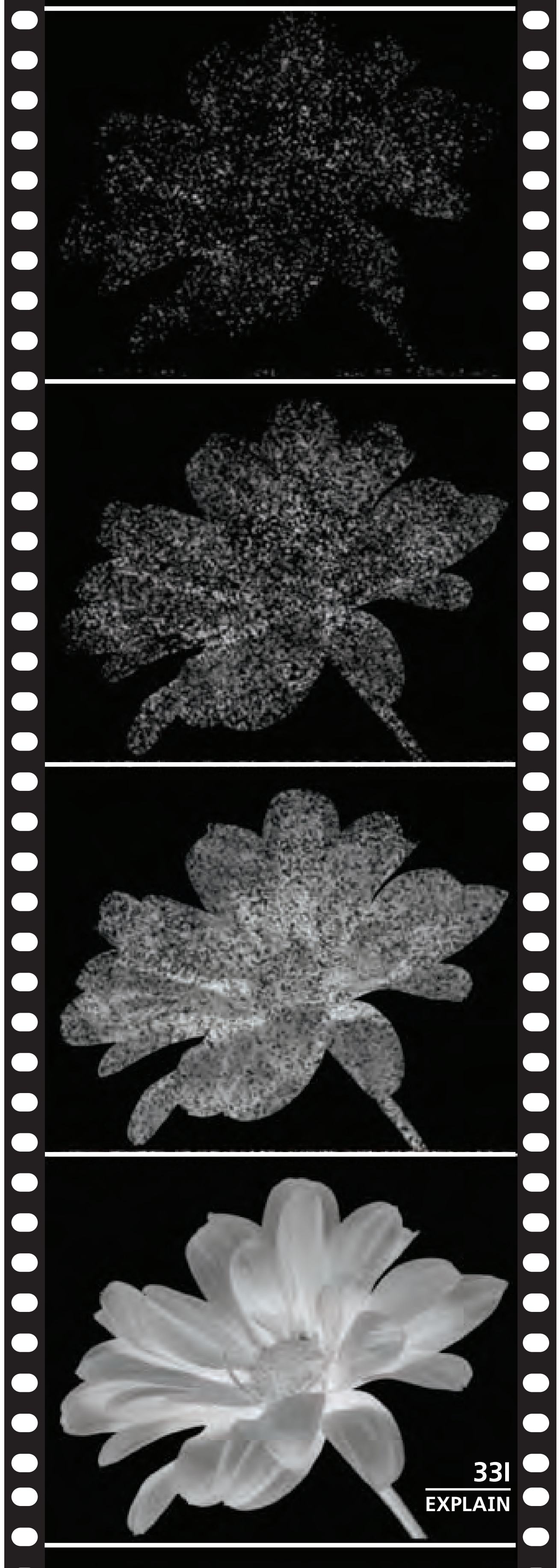
Quick Check

Summarize What properties of particles does light have?

Critical Thinking How could you find the wavelength of light if you knew its speed and frequency?

FACT Light is both a wave and a particle.

Photons hit a piece of film individually. When enough of them have hit, the image the camera took appears.



How does light make shadows?

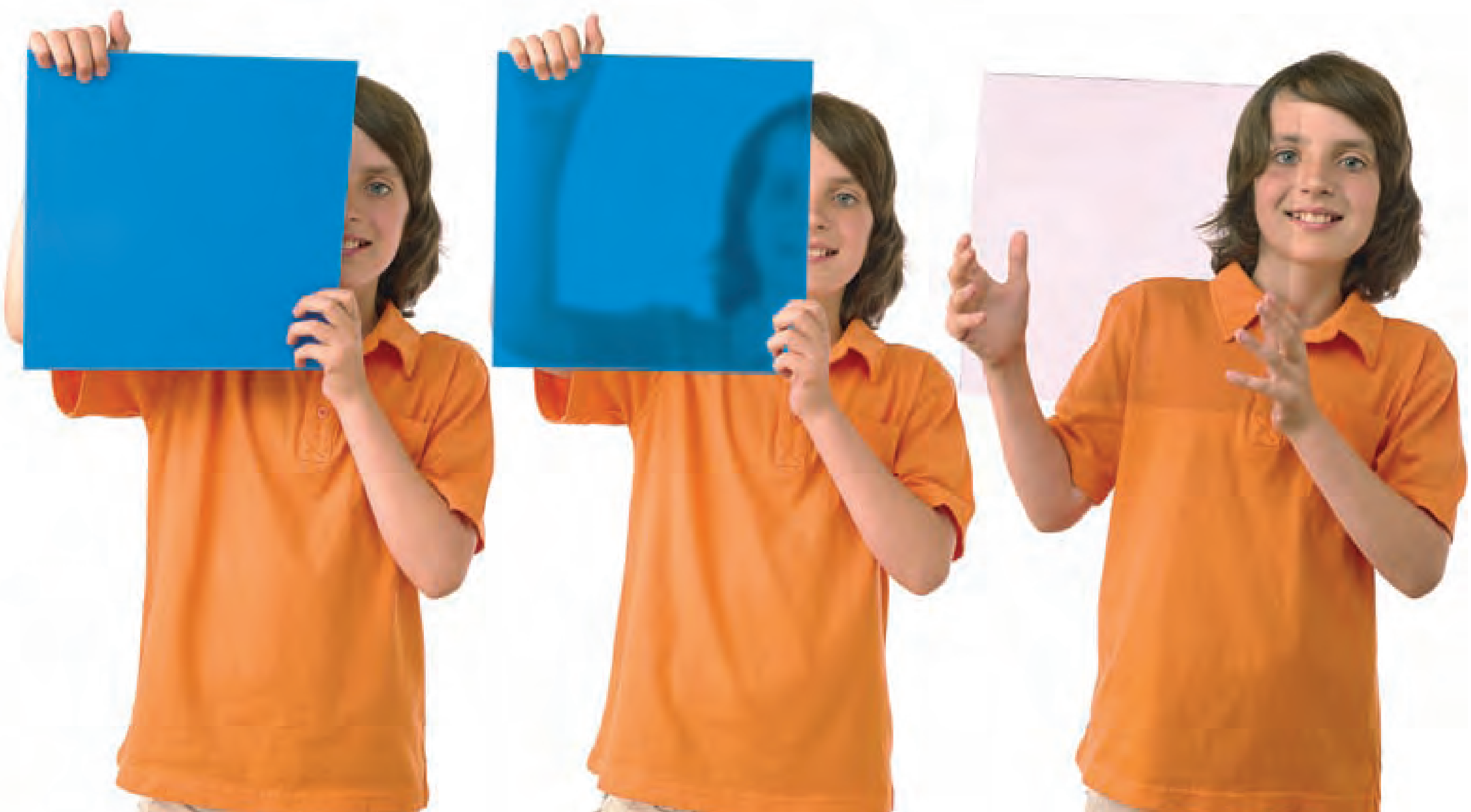
When light strikes an object's surface, photons can bounce off at random angles. This is called *scattering* (SKAT•uhr•ing) light. We see objects because light has scattered off them and entered our eyes.

Sometimes when light hits an object, a photon is absorbed. When photons are absorbed by objects, those objects gain energy. This energy is usually transformed into heat. Darker objects absorb more light than lighter objects.

Light may also pass through objects. Objects that allow most light through are called *transparent* (trans•PAYR•uhnt). Objects that blur light as it passes through are called **translucent** (trans•LEW•suhnt). If an object allows little to no light through, it is called *opaque* (oh•PAYK).

Whether an object is opaque, translucent, or transparent depends on its material, its thickness, and the color of light. Thicker objects have more particles to absorb photons so they are more likely to be opaque. Some objects will be opaque, transparent, or translucent in only one color of light.

Opaque and translucent objects block light. The area behind these objects is darker—they have a shadow! Shadows are just the absence of light.



Opaque objects let little to no light pass through.

Translucent objects blur light that passes through.

Transparent objects allow almost all light through.

When an object is between a light source and another object, it will cast a shadow on the other object. Light sources can be natural (like the Sun) or artificial (like a flashlight).

You cast shadows on the ground when the Sun shines. Have you ever seen how long your shadow is at sunrise? The Sun is low in the sky. Light from the Sun travels toward you at a small angle. At such a small angle, it takes a long distance for the light to hit the ground behind you. As the Sun rises, the angle of the sunlight increases and your shadow becomes shorter.

Shadows depends on the angle and distance between a light source and an object, and between the object and the place where the shadow is cast. Drawing light rays helps you trace the outline of a shadow. The closer a light source is to an object, the larger the shadow an object will cast.

Quick Check

Summarize What are the ways in which light interacts with matter?

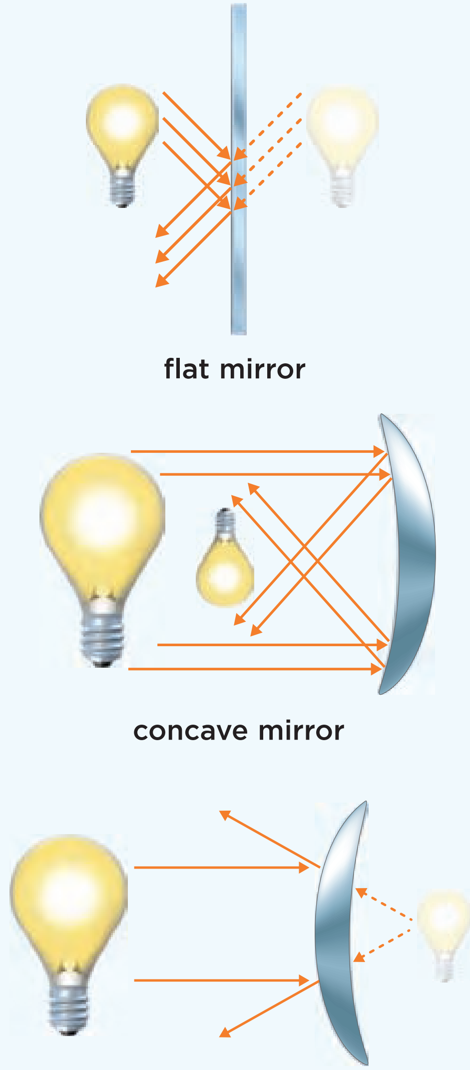
Critical Thinking What makes a white shirt cooler than a dark one on a sunny day?

How does light bounce and bend?

When you look into a mirror, you see an image. An **image** is a "picture" of the light source that light makes bouncing off a shiny surface. Light reflects off a mirror like sound echoes off a cliff. The image in a mirror is clear because most of the light wave reflects the same way off the mirror's smooth surface. Reflection is just the organized scattering of a wave.

When light hits a mirror, it obeys the *law of reflection*: the angle of an incoming light ray equals the angle of the reflected light ray. An image in a flat mirror appears to be behind the mirror. The distance to the image is equal to the distance the light traveled from the object to the mirror.

This girl's image is enlarged and reflected by a curved mirror.



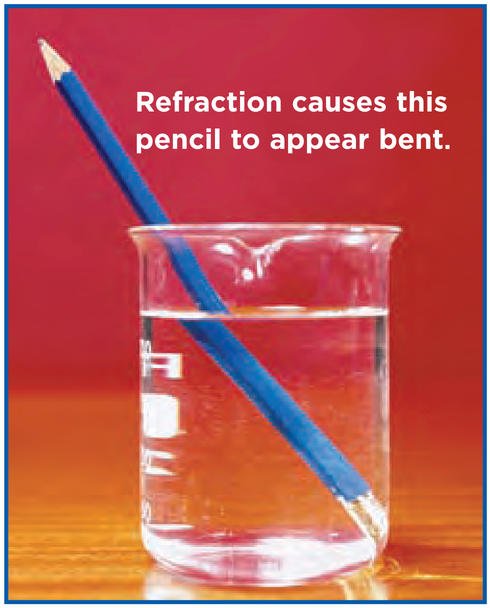
Reflected images may appear behind the mirror (faded bulbs) or be projected in front of the mirror (bright bulbs).

Mirrors can also be made with curved surfaces. If they curve in, they are *concave* (kon•KAYV). If they curve out, they are *convex* (kon•VEKS). Curved mirrors can form many kinds of images. They may be upright or upside down. They may also be enlarged or reduced. Convex mirrors always produce images that are upright and reduced.

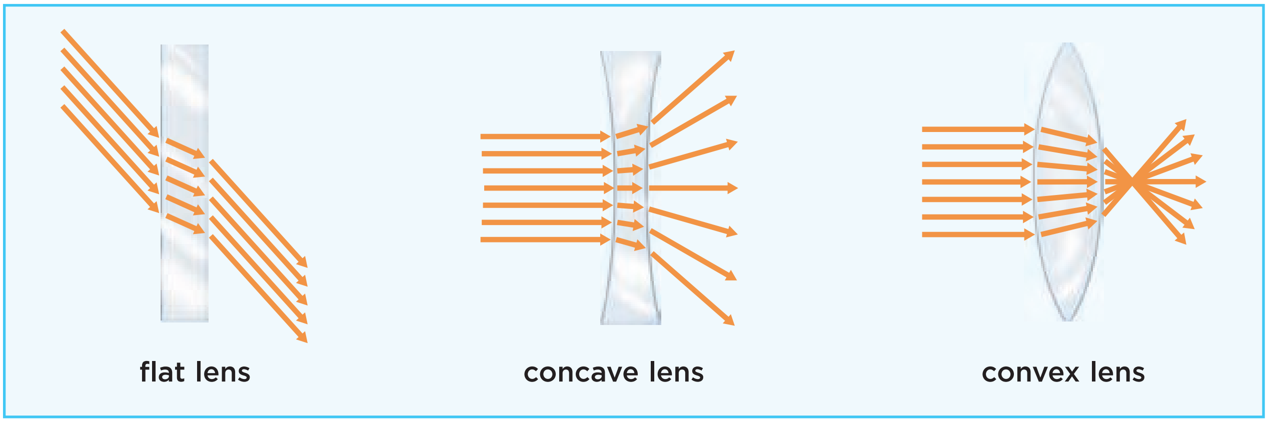
Light Can Bend

When you place an object in a glass of water, it appears to bend. Yet, if you pull the object out it is still straight. How can this be? It is the light from the object that is bending!

When light changes mediums it also changes speed. When waves change speed, they refract. **Refraction** (ri•FRAK•shuhn) is the bending of waves as they pass from one substance into another. Refraction is not very noticeable with sound waves. With light waves, however, you see it easily.



Refraction causes this pencil to appear bent.



Rays entering a denser medium bend to make a steeper angle with the surface. Rays leaving a denser medium bend in the opposite direction.

Lenses use refraction to shape images. Convex lenses work like concave mirrors and concave lenses work like convex mirrors.

Lenses are used in eyeglasses to make objects appear in focus. We also use lenses in cameras and telescopes to change the size of the image we see. The size and location of the image depend on where the object and lenses are in relation to each other.

Eyeglasses focus light to help your vision.

Quick Check

Summarize What properties do images have if they are formed by concave lenses or convex mirrors?

Critical Thinking How is bouncing a basketball to a friend a model of how light reflects from a surface?

Why do we see colors?

When sunlight hits raindrops in the sky, a rainbow appears. Where do these colors come from? Actually, the colors are already in the sunlight that produces the rainbow.

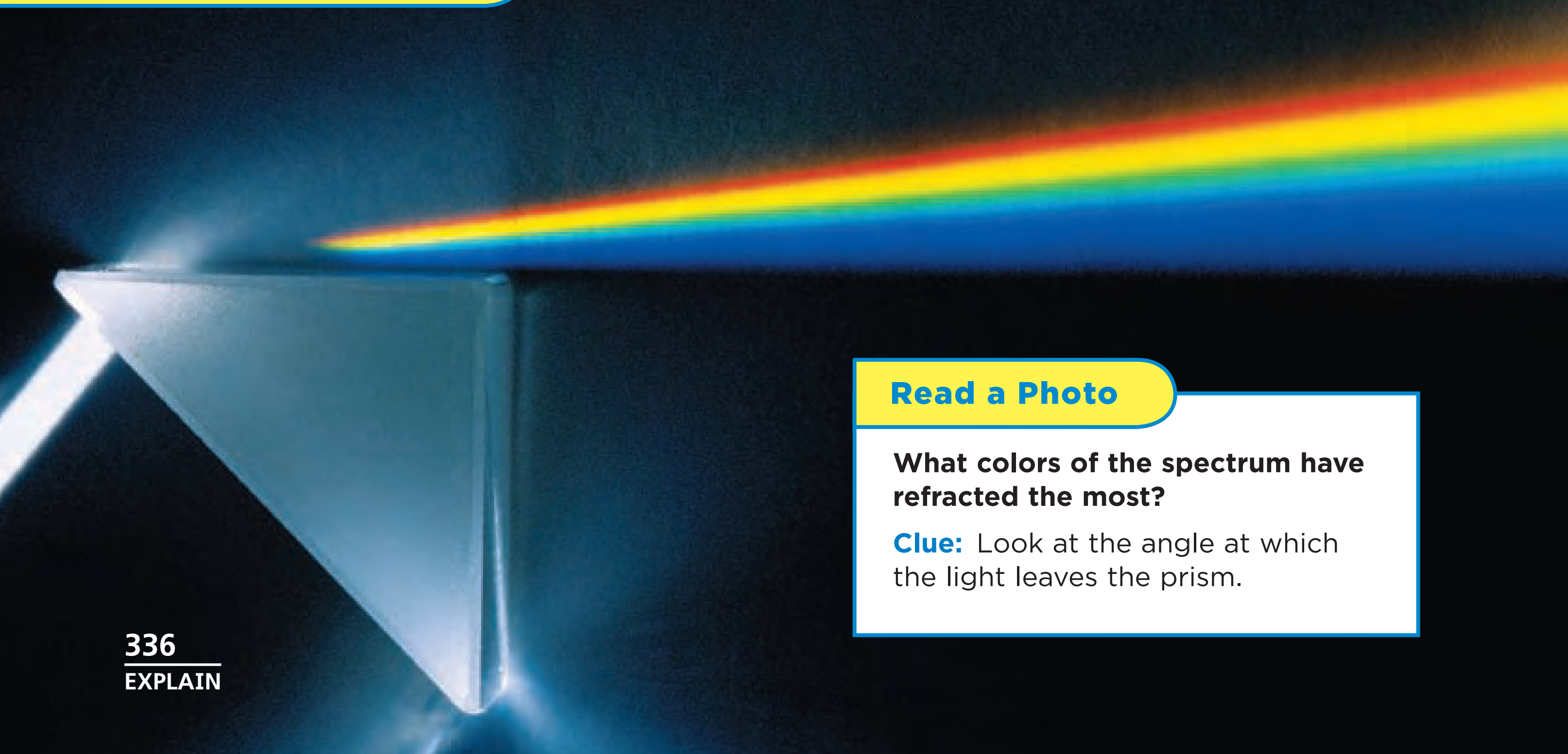
Our eyes see light waves with different wavelengths as different colors. Visible light waves with longer wavelengths look red. Visible light waves with shorter wavelengths look violet. All the colors in between have wavelengths in the middle of those two. White light, like the kind from the Sun, is actually just a collection of many different wavelengths mixed together.

Different wavelengths of light will reflect and refract at different angles. This is why when white light is refracted by raindrops in the sky, it is spread out into a rainbow. You can also separate light using a prism (PRIZ•uhm). A **prism** is a cut piece of clear glass (or plastic) in the form of a triangle or other geometric shape. The band of color in a rainbow, or from light passing through a prism, is called a **spectrum** (SPEK•truhm).

Opaque objects are the color of light that they scatter.

Translucent objects are the color of light that passes through them.

Creating a Spectrum



Read a Photo

What colors of the spectrum have refracted the most?

Clue: Look at the angle at which the light leaves the prism.

Overlapping Colors

Whether an object scatters, absorbs, or transmits light may depend on the wavelength of the light. When light hits an opaque object it is scattered and/or absorbed. Opaque objects appear the color of light that they scatter. They absorb all other colors of light.

When light hits a translucent object, some colors are absorbed and others pass through. Translucent objects appear the color of the light that passes through them. They absorb all other colors of light.

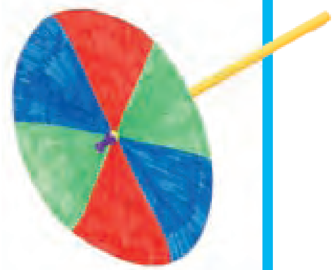
The picture on a color television is made up of red, green, and blue dots of light. Why are these colors used? We can create any color of light by mixing red, green, and blue light in the right amounts. For this reason, red, green, and blue are called the primary colors of light. If mixed equally, red, green, and blue light produce white light.

When equal parts of red, green, and blue light rays are mixed, they form white light.

When equal parts of magenta, cyan, and yellow materials are mixed, they absorb all light and appear black.

Quick Lab

Mixing Colors



1. Divide a paper plate into six sections. Color two sections red, two sections blue, and two sections green.
2. Mount the plate on a pencil using a thumbtack.
3. **Observe** Roll the pencil between your palms to spin the wheel. What color do you see? Why?

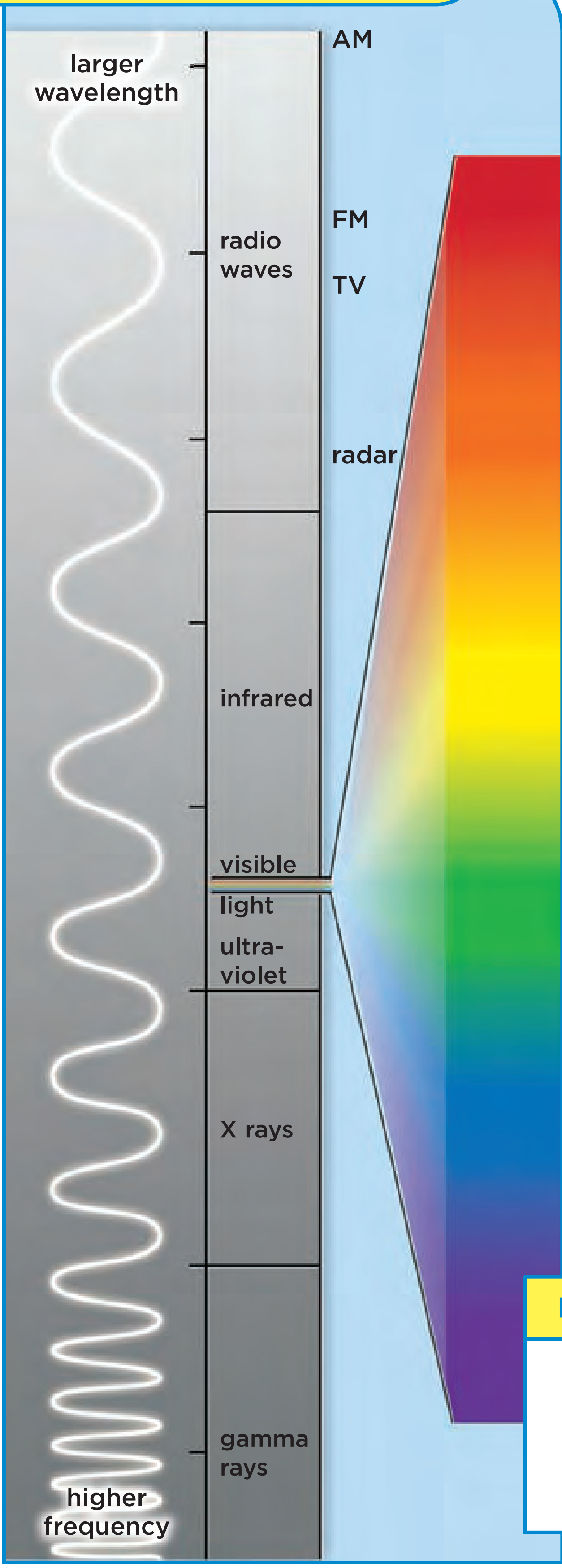
Magenta, cyan, and yellow are often used to create color by scattering. For instance, we want a part of a picture on a page to look blue when white light strikes it. We could mix equal amounts of magenta and cyan paint. Magenta scatters only red and blue. Cyan scatters only blue and green. When the two are mixed, magenta absorbs cyan's green, and cyan absorbs magenta's red. Together they only scatter blue, the color they share.

Quick Check

Summarize What colors are made by mixing red, green, and blue light two at a time in equal amounts?

Critical Thinking What would happen if you shined yellow light on a blue opaque object?

Electromagnetic Spectrum



Is all light visible?

The way in which electric and magnetic forces interact is called **electromagnetism** (i•lek•troh•MAG•ni•tiz•uhm). You know that light is made of electric and magnetic waves that can move through space. Light is just a form of electromagnetic radiation.

Scientists know of many forms of electromagnetic radiation besides visible light. All travel at the speed of light and can move through a vacuum. They differ, however, in wavelength and energy. Together, they make up the electromagnetic spectrum.

What single source could produce all forms of electromagnetic radiation? If you said the Sun, you're right! Most of the radiation from the Sun is infrared, visible and ultraviolet light. Solar flares, however, give off all forms of electromagnetic radiation when they erupt.

Quick Check

Summarize What forms of electromagnetic radiation does the Sun give off?

Critical Thinking Why would exposure to X rays be more dangerous than radio waves?

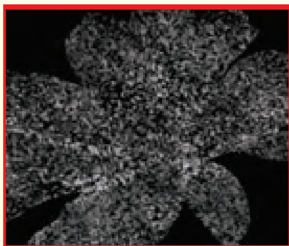
Read a Diagram

Do radio or gamma-ray photons have more energy?

Clue: Higher frequency photons have more energy.

Lesson Review

Visual Summary



Light travels as **electromagnetic** waves, but can also be thought of as particles called **photons**.

Light **reflects** off surfaces and **refracts** when entering a new material.

The color of light depends on its **wavelength**.

Make a FOLDABLES Study Guide

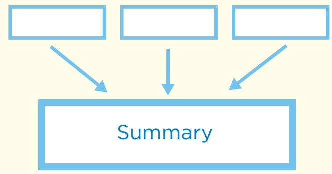
Make a Trifold Table. Use the titles shown. Summarize what you have learned in the boxes provided.

Think, Talk, and Write

1. **Main Idea** What enables light to move through empty space?

2. **Vocabulary** A material or object that blocks light completely is ________.

3. **Summarize** How does light act like a wave?



4. **Critical Thinking** How does light change when it enters a new medium?

5. **Test Prep** **The law of reflections states that incoming and outgoing angles are**
   - **A** always the same.
   - **B** never the same.
   - **C** always large.
   - **D** always small.

6. **Test Prep** **Which kind of light has a wavelength shorter than green light?**
   - **A** red light
   - **B** radio waves
   - **C** X rays
   - **D** yellow light

Math Link

Solar Energy

Some infrared photons have half the frequency of blue-light photons. How many blue-light photons would it take to equal the energy in 5,000 of these infrared photons?

Art Link

Photography

Colored transparent windows, called filters, can be placed over the lens of a camera. How could these colors be used? Write down your ideas.

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How We Use Lasers

Expository Writing

A good exposition

- develops the main idea with facts and supporting details
- summarizes information from a variety of sources
- uses transition words to connect ideas
- draws a conclusion based on the facts and information

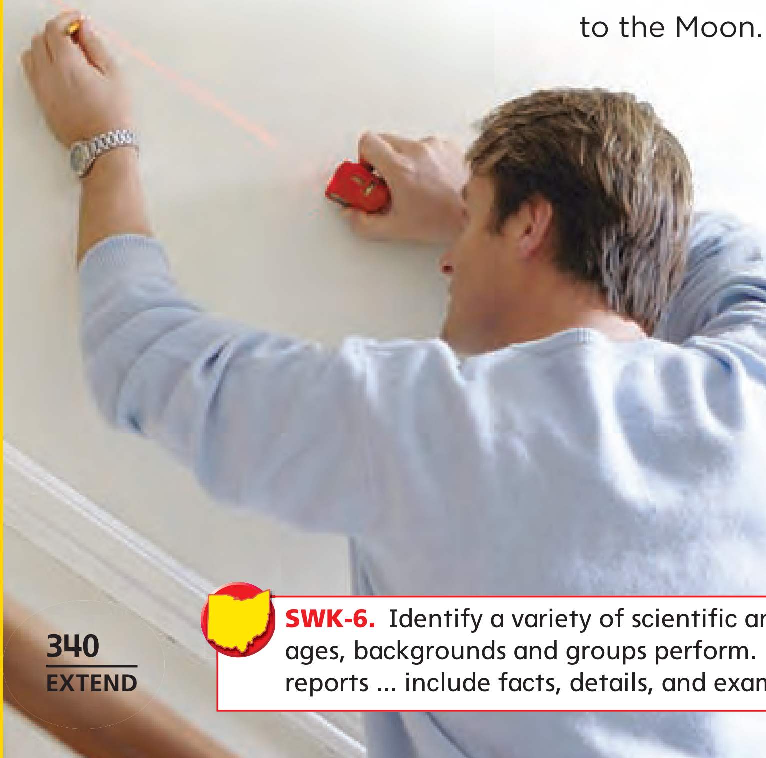
Lasers play a role in almost all aspects of our lives. Laser shows amaze audiences. Lasers read compact discs (CDs). Laser light carries television signals along optical fibers.

Lasers play an important role in business and industry, too. Bar code scanners help stores keep track of purchases. Laser beams can focus a huge amount of energy on a single spot. They can cut metal very precisely. Jewelers use lasers to cut diamonds because they are so precise.

Lasers have changed the face of medicine. A laser can cut out diseased parts without hurting healthy areas of the body. It can destroy diseased cells by heating them. It can join cells together for healing. Most delicate eye surgery is done with lasers. Dentists use lasers to remove decay from teeth, bond teeth, and whiten teeth.

Engineers and surveyors use lasers to measure distances more accurately than ever before. Lasers have been used to measure the distance from Earth to the Moon.

Lasers can be used to align objects or measure distances. ▼



Write About It

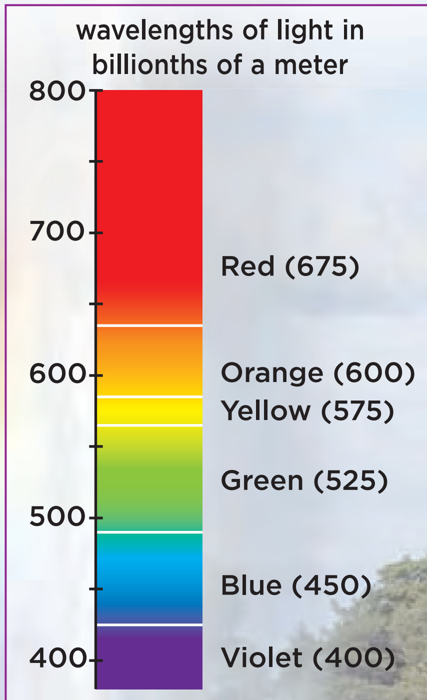
Expository Writing Find out more about one of the uses of lasers. Write an expository essay giving important information about this use. Support your main idea with facts and details. Reach a conclusion at the end.

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

SWK-6. Identify a variety of scientific and technological work that people of all ages, backgrounds and groups perform. **ELA WA-4.** Write informational essays or reports ... include facts, details, and examples to illustrate important ideas.

Graphing Wavelengths of Light

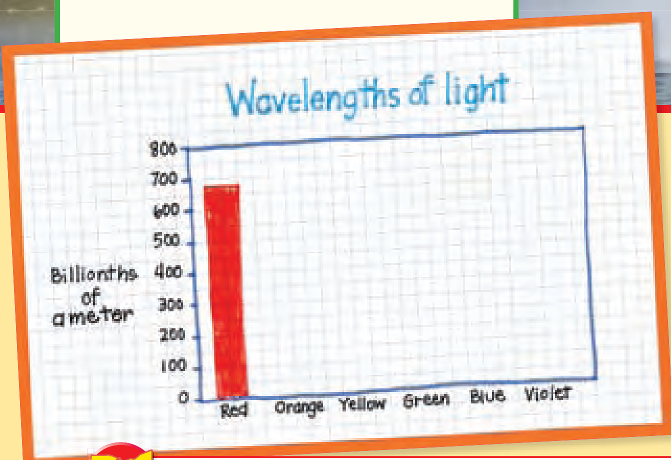
Have you ever looked at a rainbow and wondered about the colors? Why do they always appear in the same order? It's because the colors show up in order of wavelength, with the longest wavelength on the outside. Use the information in the table to find out the order of the colors in a rainbow.



Make a Bar Graph

To make a bar graph using data

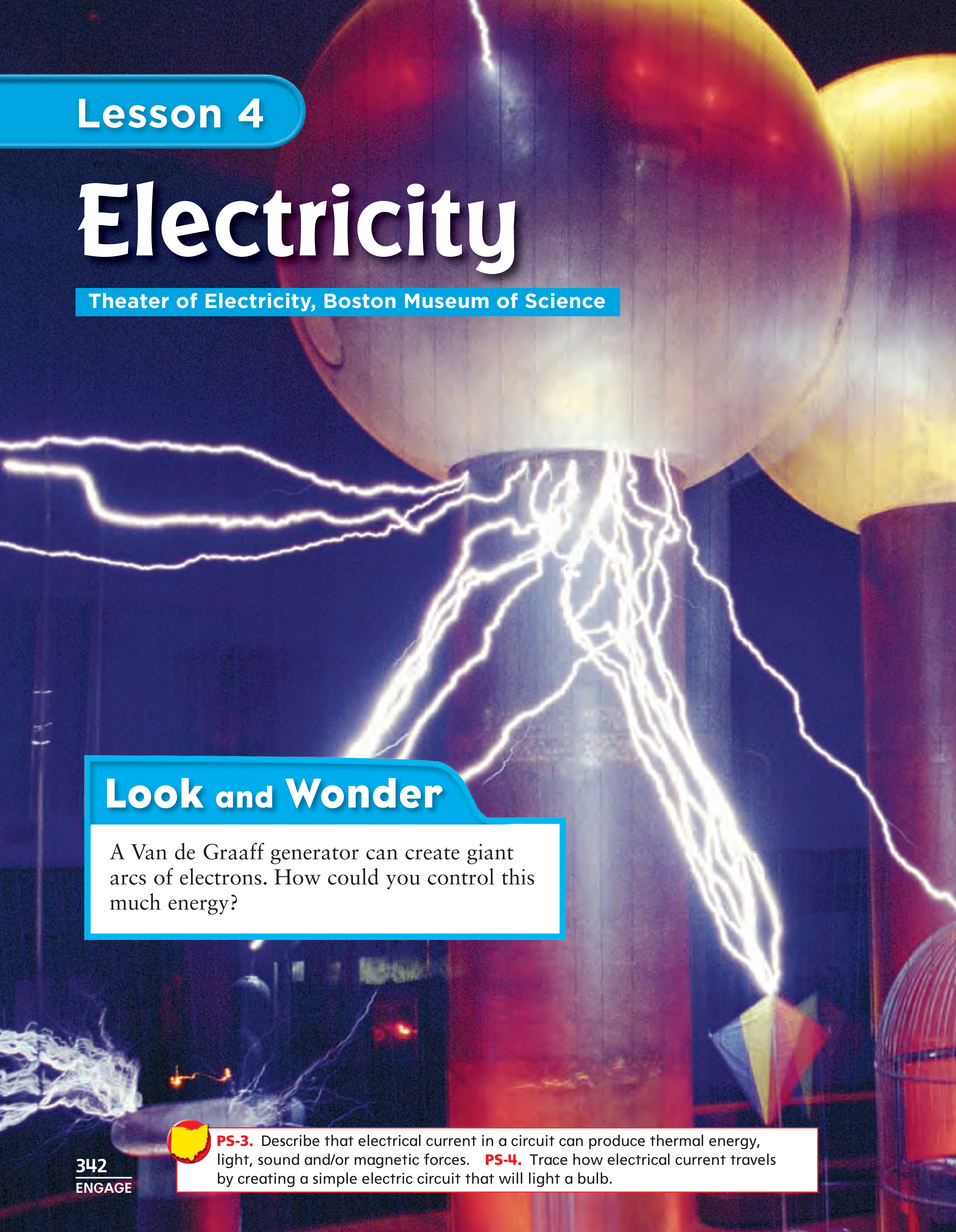
- have each axis represent one variable
- if an axis has numbers, use even increments (for example: 350, 400, 450, 500...) and label the units
- use your data to draw a bar of the correct height for each point on the horizontal axis



Solve It

1. Which color has the longest wavelength? What is it?
2. What is the difference in wavelength between yellow and orange light?
3. Make a bar graph using the colors and wavelengths listed in the chart.

M DAP-2. Select and use a graph that is appropriate for the type of data to be displayed ...



Lesson 4

Electricity

Theater of Electricity, Boston Museum of Science

Look and Wonder

A Van de Graaff generator can create giant arcs of electrons. How could you control this much energy?

PS-3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces. **PS-4.** Trace how electrical current travels by creating a simple electric circuit that will light a bulb.

Explore

Inquiry Activity

Which bulbs does each switch control?

Purpose

A bulb will light if there is an unbroken path through it from one end of a battery to the other. You will examine several different electrical paths with switches. You will then predict which light bulbs will be lit when a switch is opened or closed.

Procedure

1. Assemble the electric circuit as shown in the diagram, and leave all the switches open.
2. **Predict** Examine the top switch. When it closes, which bulbs will have an unbroken path from one end of a battery to another? Which bulbs will light when the switch closes? Record your prediction.
3. **Experiment** Close the top switch and record your observations. Then open the switch.
4. Repeat steps 2 and 3 for the other switches.

Draw Conclusions

5. **Interpret Data** Look at the observations you wrote down. How many of your predictions were correct? For any that were incorrect, explain what was wrong in your thinking.

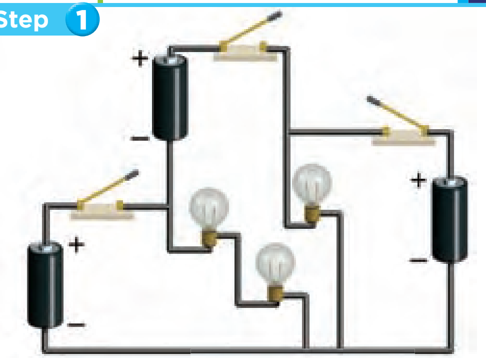
Explore More

Which switch should be closed to provide the most light from a single bulb? What if you could close more than one switch? Design a procedure to test which closed switches produce the most light. Follow your procedure and record your results.

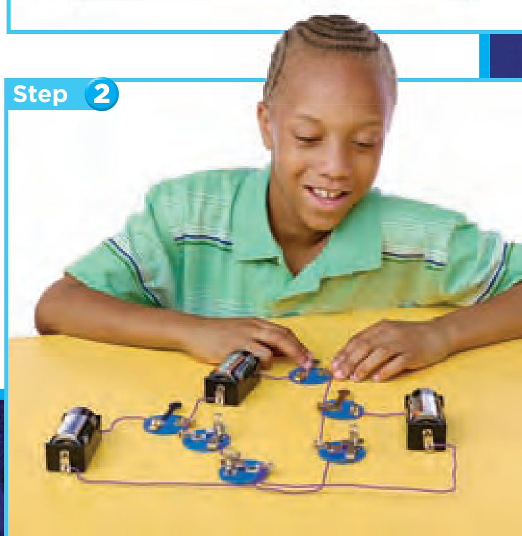
Materials

- three switches
- three 1.5-volt light-bulbs and stands
- three 1.5-volt batteries and stands
- insulated wire with stripped leads

Step 1



Step 2



SI-6. Explain why results of an experiment are sometimes different....

Read and Learn

Main Idea PS-3, PS-4

All matter is made of elements.

Vocabulary

matter, p. 344
element, p. 344
atom, p. 344
nucleus, p. 345
proton, p. 345
neutron, p. 345
electron, p. 345
electricity, p. 346
static electricity, p. 346
grounding, p. 347
electric current, p. 348
circuit, p. 348
resistor, p. 348

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Reading Skill

Sequence

First
↓
Next
↓
Last

What makes up matter?

Almost everything in the world around you is matter. **Matter** is anything that has mass and volume. All matter is made of the same set of building blocks: the chemical elements (EL•uh•muhnts). An **element** is a material that cannot be broken down into anything simpler.

The ancient Greek philosopher Aristotle believed all matter is made of the elements earth, air, water, and fire. Modern scientists know that Aristotle's elements are not true elements. Fire is not matter. Air and earth are made up of many different materials, not just one. Water can be broken down into simpler substances: hydrogen and oxygen. Hydrogen and oxygen, however, cannot be broken down into simpler substances by using chemical reactions. This tells us that hydrogen and oxygen are elements.

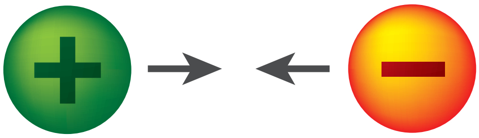
Smaller and Smaller

If you cut a piece of an element in half, will it still be an element? Yes, the two halves have the same properties as the original element. What if you kept cutting it in half, again and again? Eventually, you would have the smallest piece of element possible. John Dalton proposed in 1803 that elements are made of tiny particles. He believed that these particles could not be cut into smaller pieces. Today, we know that Dalton's particles do exist—we call them atoms (AT•uhmz). An **atom** is the smallest unit of an element that retains the properties of that element.

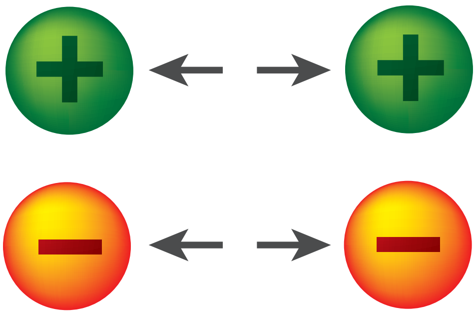
Matter is made of elements just like these models are made of the same building blocks.

Electrical Charge

Some particles have a negative electrical charge. Others have a positive electrical charge.



Opposite charges attract each other. Like charges repel each other.



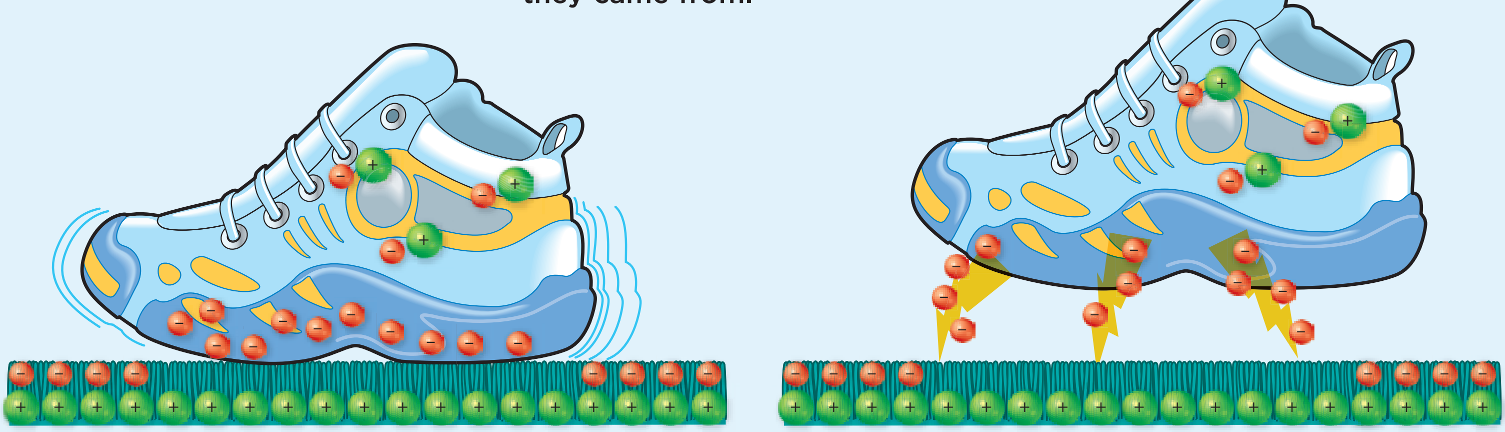
What is static electricity?

Have you ever shocked yourself by touching a doorknob on a cold, dry day? A spark jumps to your finger! Lightning during a thunderstorm is a larger version of this spark. Both are examples of electricity. **Electricity** is the movement of electrons. Its energy is measured in joules (J). We use units called volts (V) to measure how strongly electrons will move.

You have already learned that the protons and electrons that make up atoms have charges. A negative electrical charge is shown as a minus sign (–). A positive electrical charge is shown as a plus sign (+). Particles with opposite charges are attracted to each other. Particles with the same charge are repelled from each other. When two objects rub against each other, electrons are sometimes knocked off one object and onto the other. This causes static electricity. **Static electricity** is the buildup of charged particles.

Static Electricity

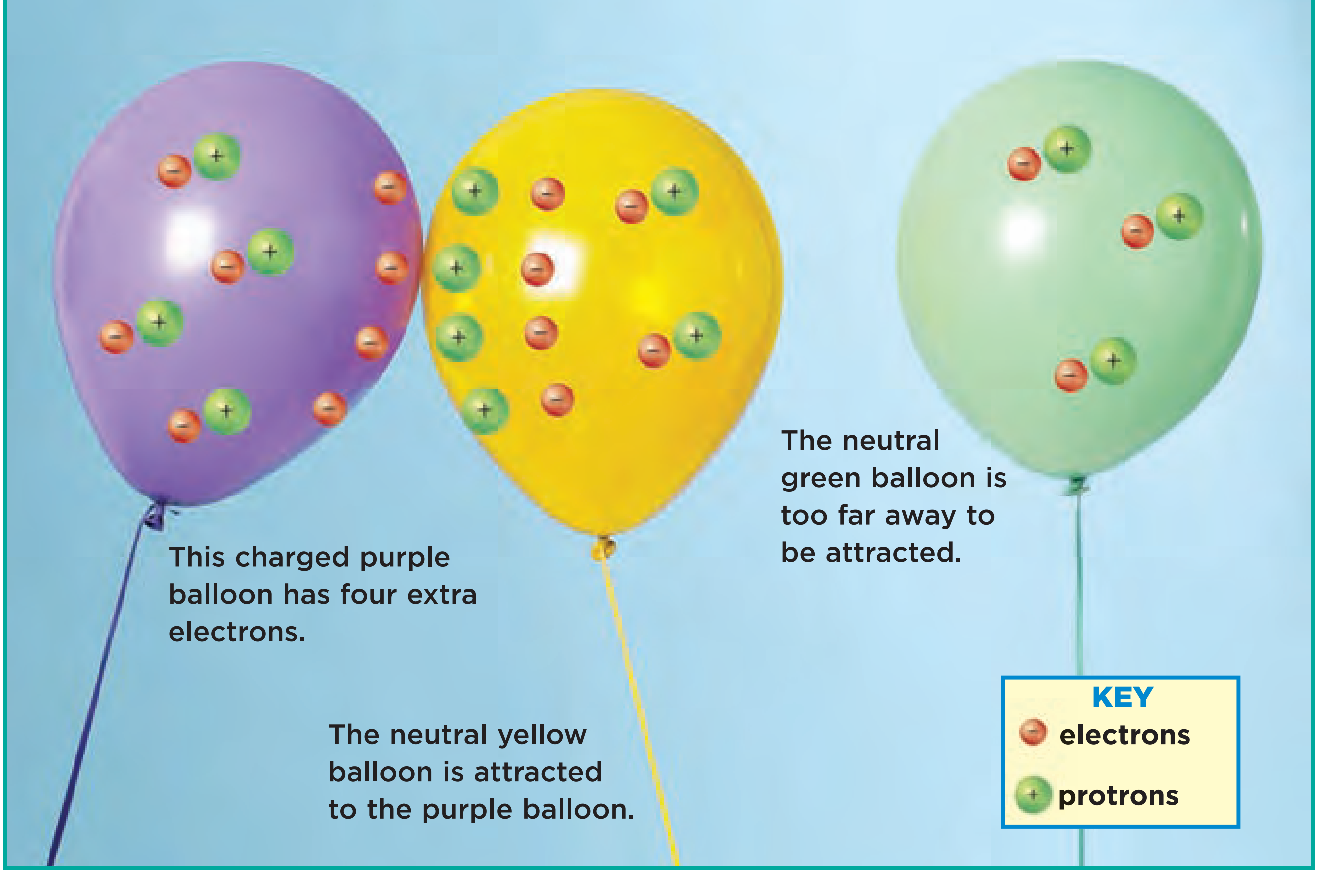
A buildup of electrons on a shoe will discharge back to the carpet they came from.



Read a Diagram

Does the shoe have an overall charge?

Clue: Count the number of protons and electrons.



The attractive force between electrons and protons is strong. Static electricity causes electrons to jump through the air toward nearby protons. A spark is formed. The electrons have been discharged and returned to the protons. The objects are now neutral. A neutral object has equal numbers of protons and electrons.

Two oppositely charged objects will stick together; this is called *static cling*. It happens often when clothes rub together in a tumble dryer. Charged objects can also attract neutral objects. How? When a charged object nears a neutral object, it pulls on one type of charge and pushes on the other. Then the neutral object will act like it is slightly charged on one side and attract the charged object.

When static electricity forms on a good electrical conductor, like a metal, the charges can move freely. Like charges will push on each other and spread themselves out. When static electricity forms on an electrical insulator, charges cannot move freely.

Earth is a large neutral conductor. You can protect objects from static electricity (including lightning) by grounding them to Earth with a wire. **Grounding** occurs when a conductor shares its excess charge with a much larger conductor. Instead of building up static electricity, grounded objects pass their charge onto Earth. The charges then can spread out so that they are barely noticed.

Quick Check

Sequence What happens when a balloon with excess electrons is brought closer to a wall?

Critical Thinking What would happen if two oppositely charged conductors touched?

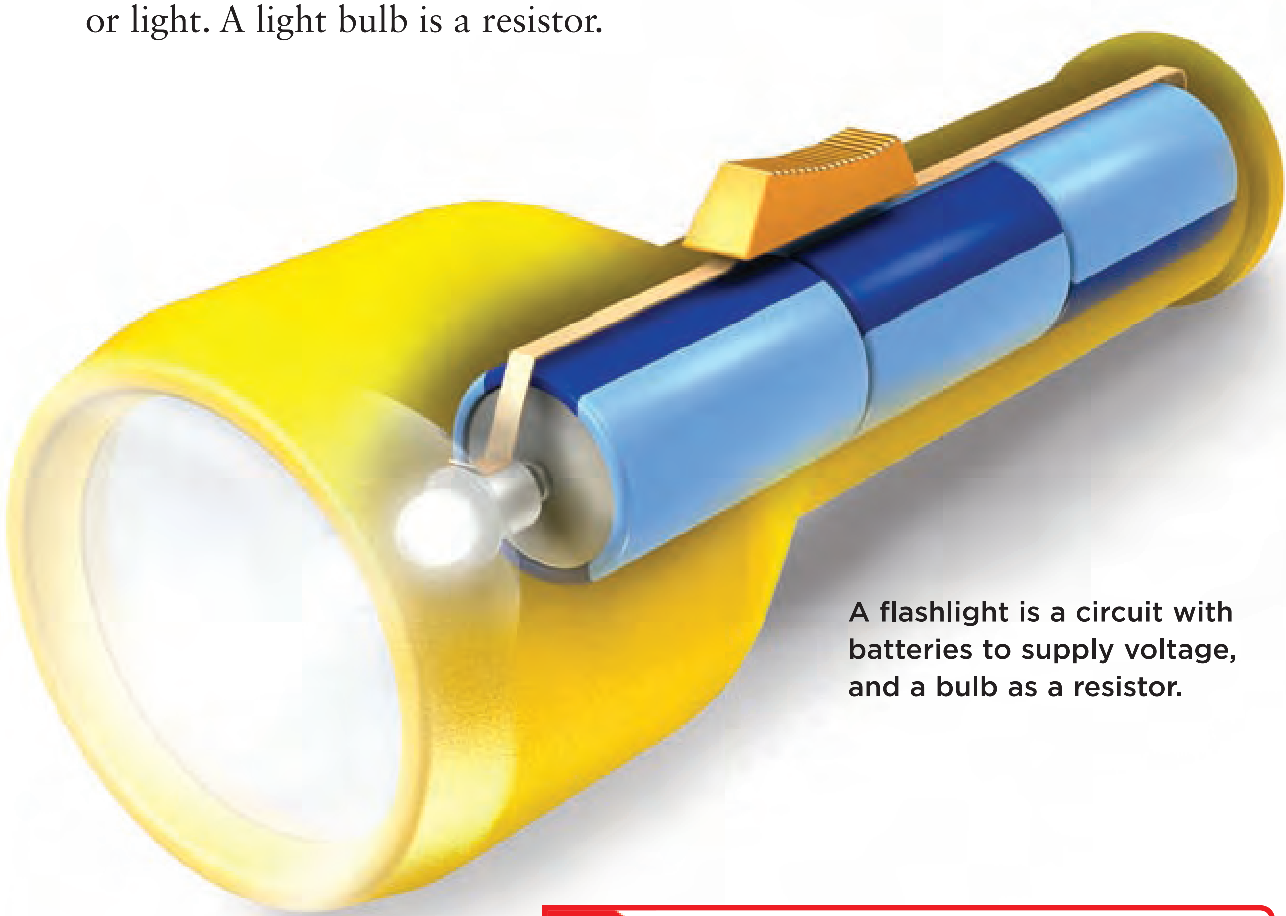
How can electricity flow?

When you're in the dark, a flashlight comes in handy. A flow of electricity causes the bulb to light. A flow of electricity through a conductor is called an **electric current**.

A **circuit** (SUR•kit) is formed when an electric current passes through an unbroken path of conductors. Often the path of a circuit consists of wires. Circuits must also have a device to move electrons along the path. Such devices increase the volts of electrons in the circuit and are called *voltage sources*. Batteries are an example of a voltage source.

A *switch* is a device that can open or close the path. When the switch is closed, the voltage pushes on the electrons in the circuit. This causes electrons to move. Protons feel a force in the opposite direction. Protons, however, are not free to move.

Electricity does not flow the same way through every part of a circuit. An object in an electrical circuit that resists the flow of electrons is called a **resistor** (ri•ZIS•tuhr). Resistance is measured in units called *ohms* (Ω). Electrons lose energy when moving through a resistor. This energy can be transformed into heat or light. A light bulb is a resistor.



A flashlight is a circuit with batteries to supply voltage, and a bulb as a resistor.

FACT Electrons may not travel far in a circuit.

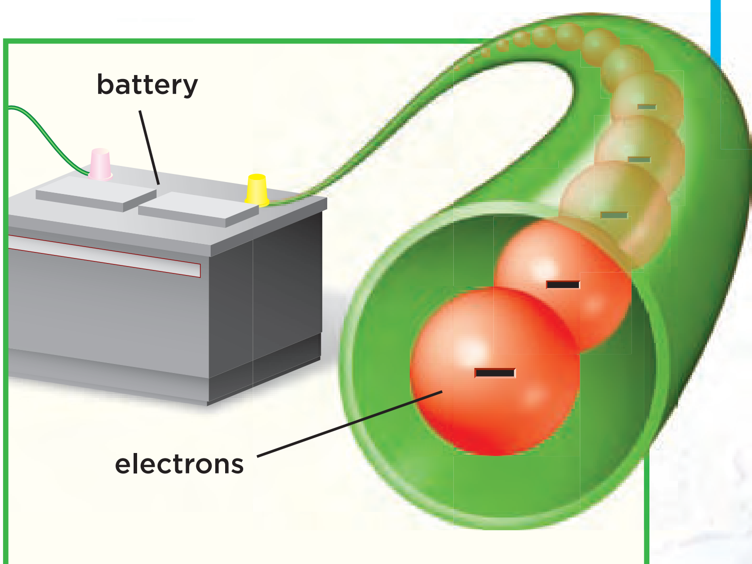
Electric current in a circuit travels fast—almost at the speed of light. Electrons, however, travel just a few millimeters per second. Why? Electrons only need to move far enough to push another electron. That electron then pushes another and so on.

The amount of electric charge moving in a circuit is measured in units called *amperes* or *amps* (A). There are about six billion billion electrons moving every second in one amp of current. Even currents as small as 0.05 A can seriously hurt you, so be careful!

Quick Check

Sequence How does energy change form in a flashlight?

Critical Thinking How is the resistance of a resistor like friction?



Electricity flows in a wire like water flows in a pipe.

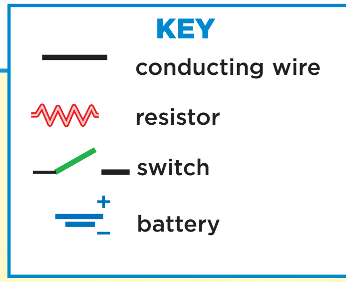
Quick Lab

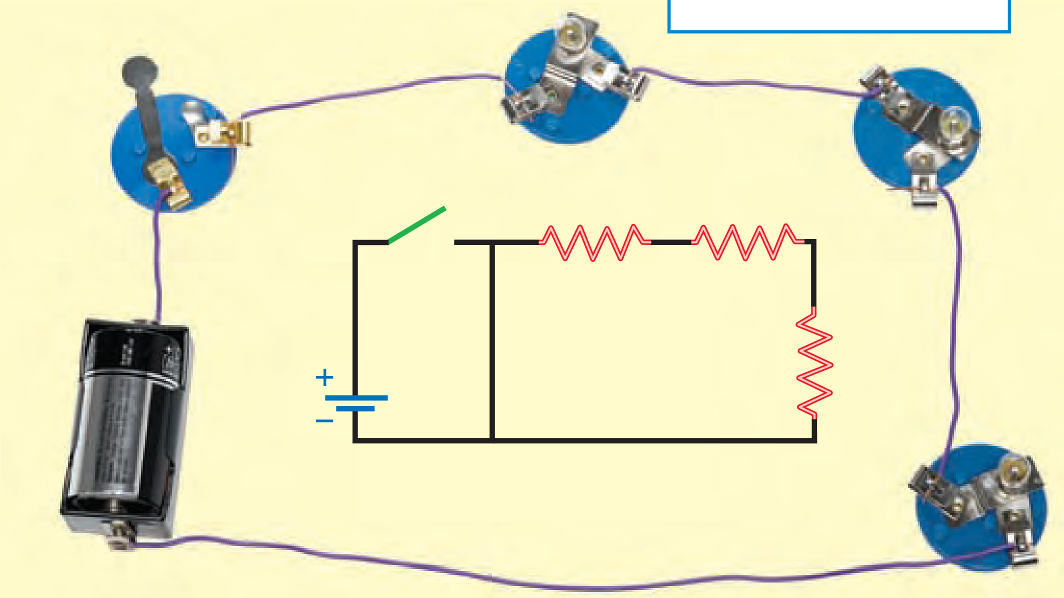
Measuring Electric Current

1. Build a flashlight circuit using a battery, a switch, and a light bulb.
2. **Observe** Close the switch and record your findings.

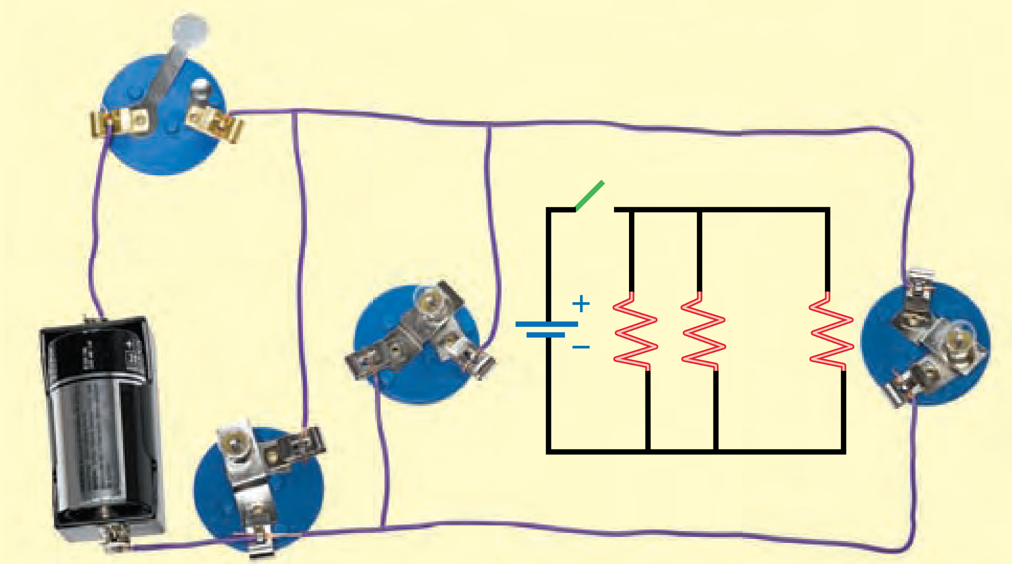
3. Open the circuit and add another battery. Make sure the positive end of one battery touches the negative end of the other.
4. Close the switch again. Is the light bulb the same brightness as before? Why?
5. **Infer** When was there more electricity flowing through the circuit? How do you know?

Circuit Diagrams





A series circuit only has one path through which electricity can flow.



A parallel circuit has more than one path through which electricity can flow.

Read a Diagram

Which bulbs will be brightest when the switches are closed?

Clue: Which paths have the least resistance?

What kinds of circuits are there?

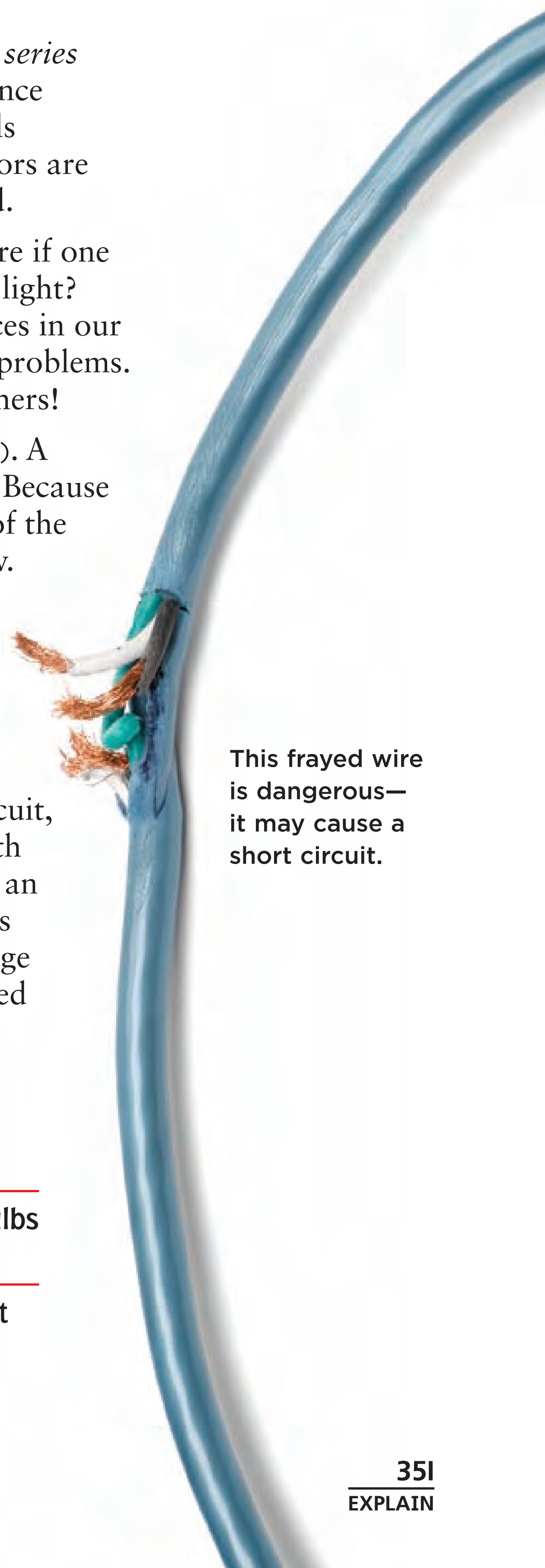
Look at the circuits in the photograph. The illustrations next to them are called *circuit diagrams*. Can you match the parts of the photo to the parts of the diagram?

If there is only one conductive path it is called a *series circuit* (SEER•eez). In this type of circuit, the resistance increases with each resistor added. Electricity travels through all the resistors one after another. As resistors are added, the energy each resistor receives is decreased.

Did you ever have a string of holiday lights where if one bulb was taken out, none of the other bulbs would light? Light strings like this are a series circuit. If appliances in our homes were wired in series circuits, it would cause problems. Turning off one appliance would turn off all the others!

Circuits in your house are in parallel (PAR•uh•lel). A *parallel circuit* has more than one conductive path. Because there is more than one path, the overall resistance of the circuit is smaller, which causes more current to flow.

Electricity flows through all paths in a parallel circuit at the same time. The smaller the resistance of the path, the more current flows through it. What happens if one of the paths is broken? The current flows through the remaining paths.



This frayed wire is dangerous—it may cause a short circuit.

If a conductor accidentally forms a path in a circuit, it can short that circuit. A *short circuit* is a path with little or no resistance that connects the two ends of an electrical source. The tiny resistance in short circuits causes large currents to flow across them. These large currents can damage appliances, or start fires. Frayed wires are a common cause of short circuits.

Quick Check

Sequence What happens to the brightness of bulbs each time one is added into a series circuit?

Critical Thinking How would the electric current compare for two identical bulbs in a series circuit versus in a parallel circuit?

▲ Breakers protect circuits from too much current.

GFI outlets are often used in bathrooms.

How can you use electricity safely?

Plugging too many appliances into a power strip dangerously heats wires. Each time an appliance is plugged in, another branch is added to the parallel circuit. This increases the current. Adding too many appliances leads to currents large enough to start fires.

To protect against large currents, homes have fuses or breakers. A *fuse* is a wire that breaks if too much current flows through it. A *breaker* is a switch that opens when it detects too much current. Homes have separate fuses or breakers for different circuits.

Delicate electronics, like computers, are often plugged into surge protectors. Surge protectors prevent sudden spikes in current from entering electronics and damaging them.

In bathrooms and kitchens, outlets have small buttons saying "test" and "reset." These are part of a *ground fault interrupter* (in•tuh•RUP•tuhr) (GFI). A GFI is sensitive to changes in current. It will turn an outlet off if a short circuit forms. It will also turn the outlet off if electricity starts to flow through water.

The electrical energy that comes to your home through power lines is dangerous. Never reach up into power lines to get a toy that is stuck there. If you touch two power lines at the same time, or one power line and the ground, it can be deadly.

▼ Never go near fallen power lines.

Quick Check

Sequence How might an electrical fire start?

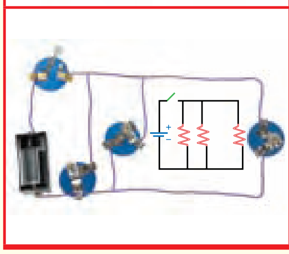
Critical Thinking How is a fuse like a switch? How is it different?

Lesson Review

Visual Summary

Static electricity is a buildup of electric charge.

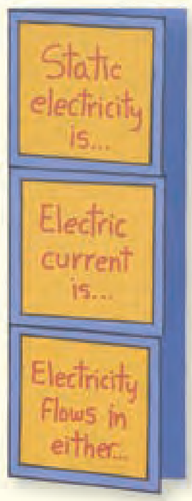
Electric current is a flow of electricity through a conductor.



Electricity flows in either **series** or **parallel circuits**.

Make a FOLDABLES™ Study Guide

Make a Three-Tab Book. Use the titles shown. Summarize what you have learned about each topic under the tab.

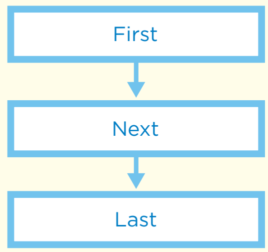


Think, Talk, and Write

1. **Main Idea** Why will a comb rubbed with wool pick up bits of paper?

2. **Vocabulary** When a conductor shares its excess charge with a much larger conductor it is called ________.

3. **Sequence** What happens as objects rub together and form sparks?



4. **Critical Thinking** Do electrons from a battery reach a bulb before it lights?

5. **Test Prep** **Adding branches to a parallel circuit**
   - **A** increases current.
   - **B** decreases current.
   - **C** keeps current the same.
   - **D** reverses the direction of current.

6. **Test Prep** **Which protects a home from high currents?**
   - **A** on/off switches
   - **B** resistors
   - **C** circuit breakers
   - **D** electrical sources

Math Link

Lighting with Lightning

A small lightning bolt produces about 500,000,000 J of energy. A lightbulb uses 100 J/s. How many hours could the lightning bolt keep the bulb lit?

History Link

Discovering Electricity

Benjamin Franklin performed many important experiments with electricity. Research and summarize those experiments.

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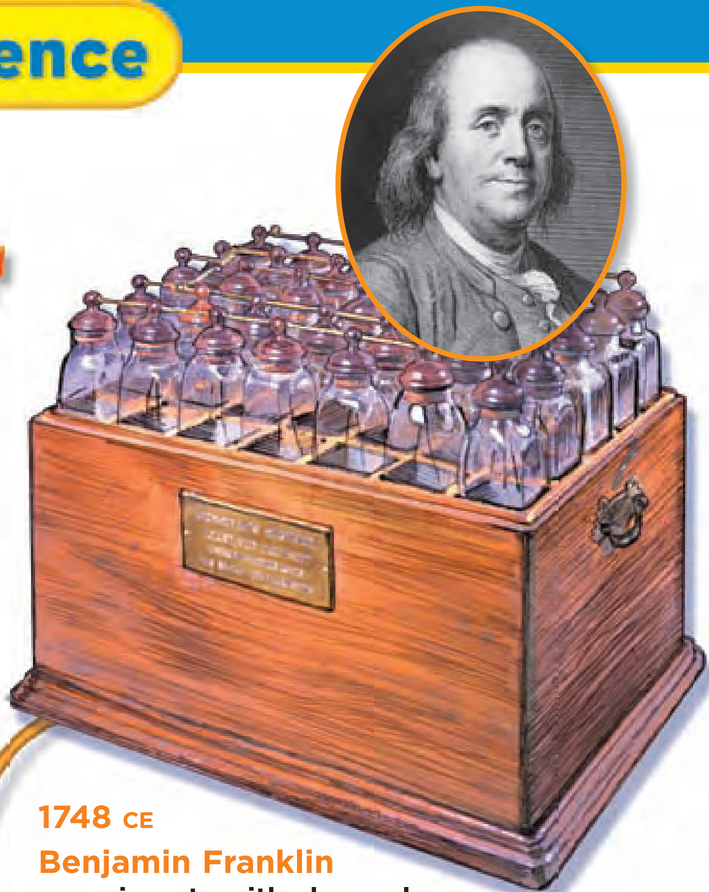
Building a Better Battery

You find them in cars, in flashlights, and in radios. They're batteries: devices that store chemical energy and provide electricity. Over the years, batteries have changed from the inside out. They all have a basic structure in common, however. Positive and negative electrodes attach to wires, and an electrolyte provides the medium through which current can flow.



1748 CE

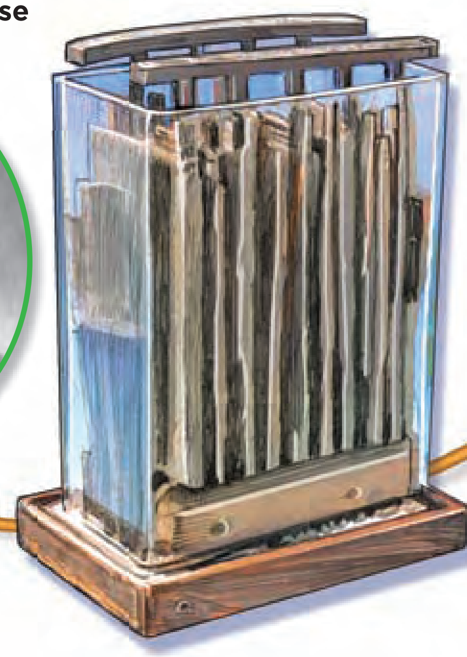
Benjamin Franklin **experiments with charged glass plates. He calls his device a *battery* because the shock it produces feels like a beating.**

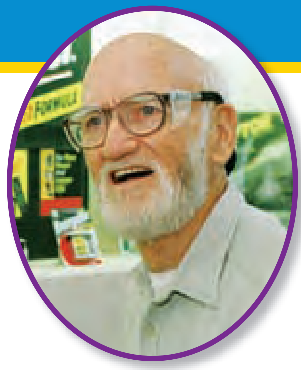
1800 CE

Alexander Volta, an Italian nobleman, conducts experiments with battery designs. He uses copper and zinc discs separated by cloth soaked in salt water. This "cell" produces a steady current of electricity. Many such cells stacked together form a *voltaic pile battery.*

1859 CE

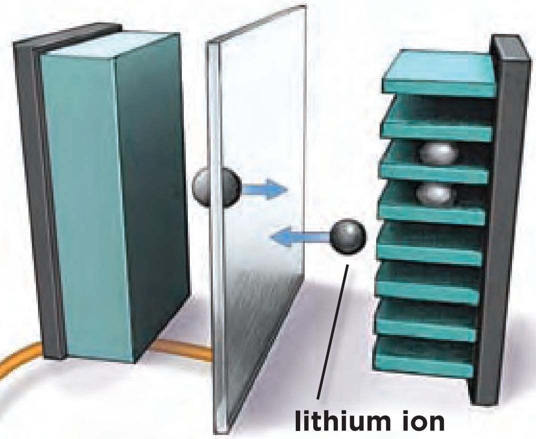
French physicist Raymond Gaston Planté takes two lead electrodes, separates them with rubber, and places them in a solution of sulfuric acid and water. This *wet-cell* battery uses its liquids as electrolytes. The battery is rechargeable, and cars today still use lead-acid batteries.





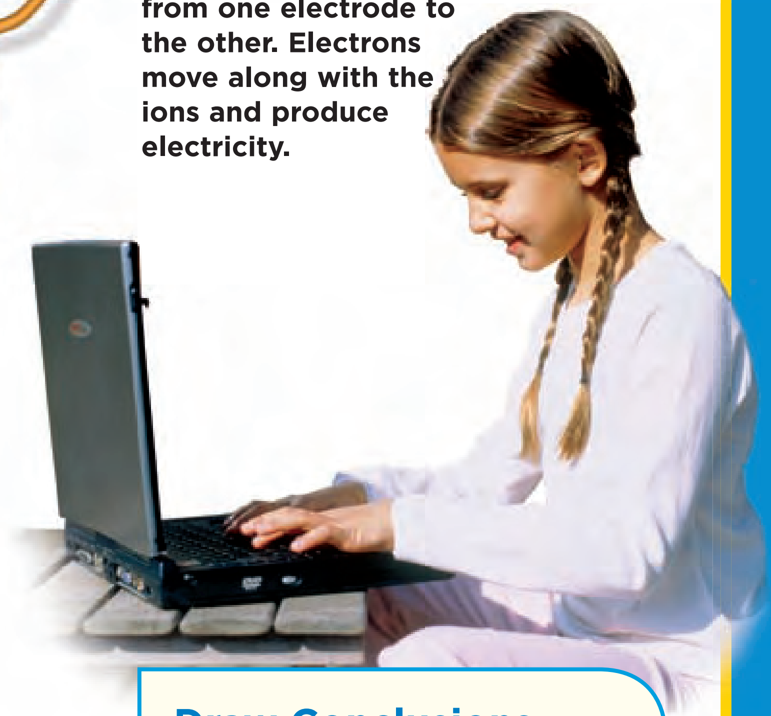
1959 CE

American researcher Lewis Urry uses powdered zinc and manganese dioxide to build a battery that provides more energy and lasts longer. Newer versions of this "alkaline battery" are used today to power devices like flashlights and remote controls.



Today, many companies make lithium-ion batteries. The lithium ions travel from one electrode to the other. Electrons move along with the ions and produce electricity.

Today's batteries are getting smaller and longer-lasting. They are also used in many new devices. Laptop computers need batteries that are lightweight and powerful. Lithium-ion batteries provide laptops with the energy they need for hours and can then be recharged.



Draw Conclusions

- Use information in the text and background knowledge.
- Support your conclusions with information found in the text.

Write About It

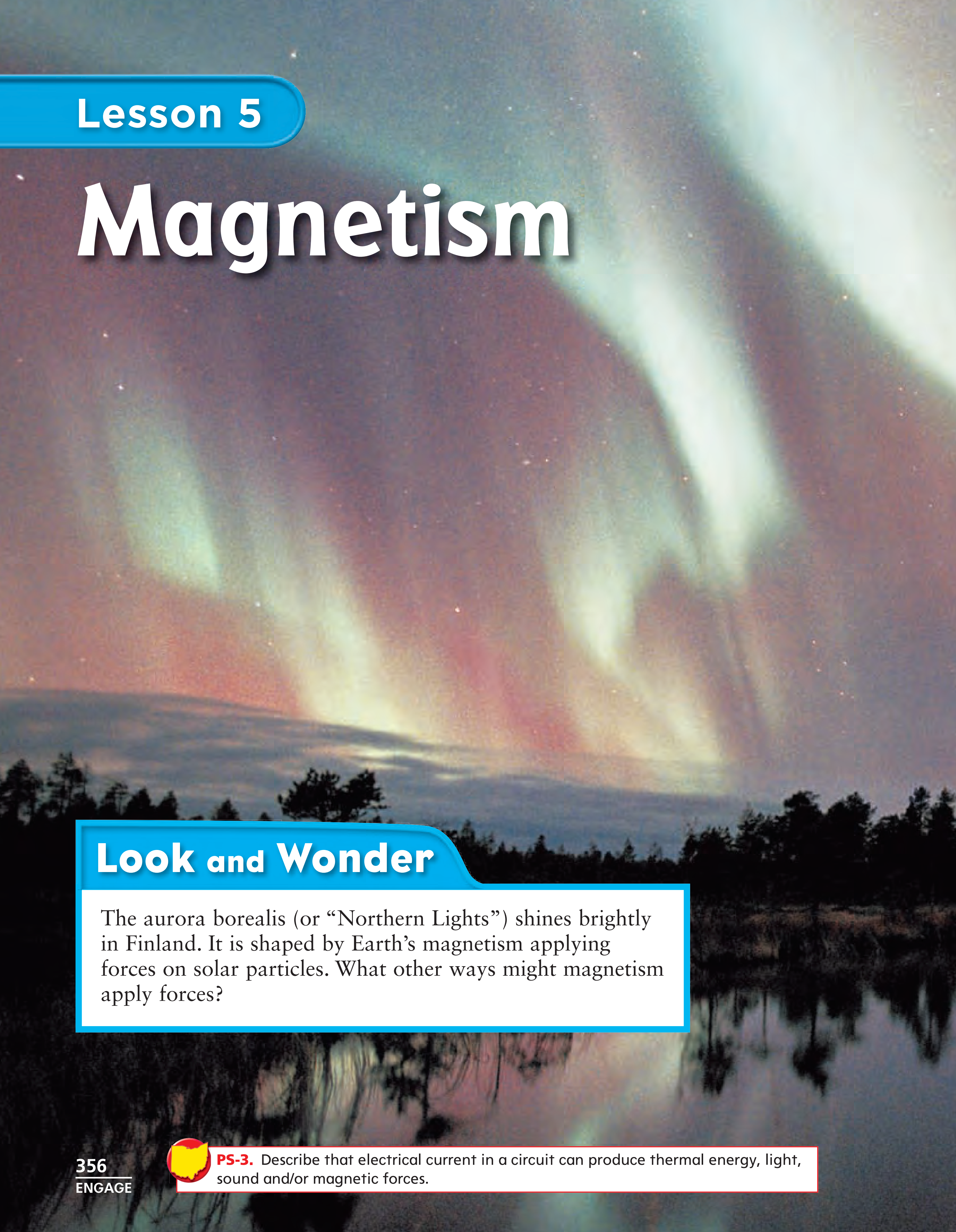
Draw Conclusions

1. What makes batteries useful?
2. What is the electrolyte in a lead-acid battery?

LOG ON e-Journal Research and write about it online at www.macmillanmh.com

ELA RP-5. Make inferences based on implicit information in texts, and provide justifications for those inferences.

American Museum of Natural History



Lesson 5

Magnetism

Look and Wonder

The aurora borealis (or "Northern Lights") shines brightly in Finland. It is shaped by Earth's magnetism applying forces on solar particles. What other ways might magnetism apply forces?

PS-3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.

How do magnets apply forces?

Make a Prediction

Magnets push and pull on other magnets. Where on a bar magnet do you think the strongest forces are felt? Write down your prediction.

Test Your Prediction

1. **Observe** Lay a sealed bag containing iron filings over a bar magnet. Do the iron filings form a pattern? Draw a sketch.
2. **Experiment** Hang one magnet from a meterstick. Take another magnet and move it toward the hanging magnet. Watch how it moves. Record your observations. Repeat for each side of the bar magnet.
3. Place a compass at 0 cm of a meterstick lying flat on a table. Align the meterstick west-east. Move a bar magnet from the 100-cm mark toward the compass. Record at what distance the compass first starts to move. Repeat for each side of the bar magnet.

Draw Conclusions

4. **Interpret Data** Look at all of your observations. Which support your prediction and which disprove your prediction? Explain. Was your prediction correct? Why or why not?

Explore More

Suppose you put two bar magnets in a line, the north pole of one touching the south pole of the other. Where do you think this double magnet would be strongest? Design an experiment to test your prediction and report on how accurate it was.

Materials

- bag
- iron filings
- 2 bar magnets
- string
- meterstick
- books
- compass

Step 2

Step 3

SI-3. Use evidence and observations to explain and communicate the results of investigations.

Read and Learn

Main Idea PS-3

Magnets have north and south poles that apply forces to other magnets and magnetic materials.

Vocabulary

magnetism, p. 358
magnetic field, p. 359
electromagnet, p. 360
generator, p. 362
alternating current, p. 362
magnetic levitation, p. 364

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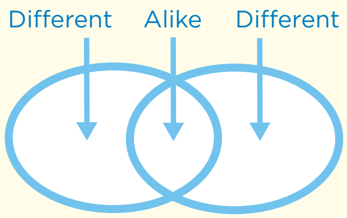
Reading Skill

Compare and Contrast



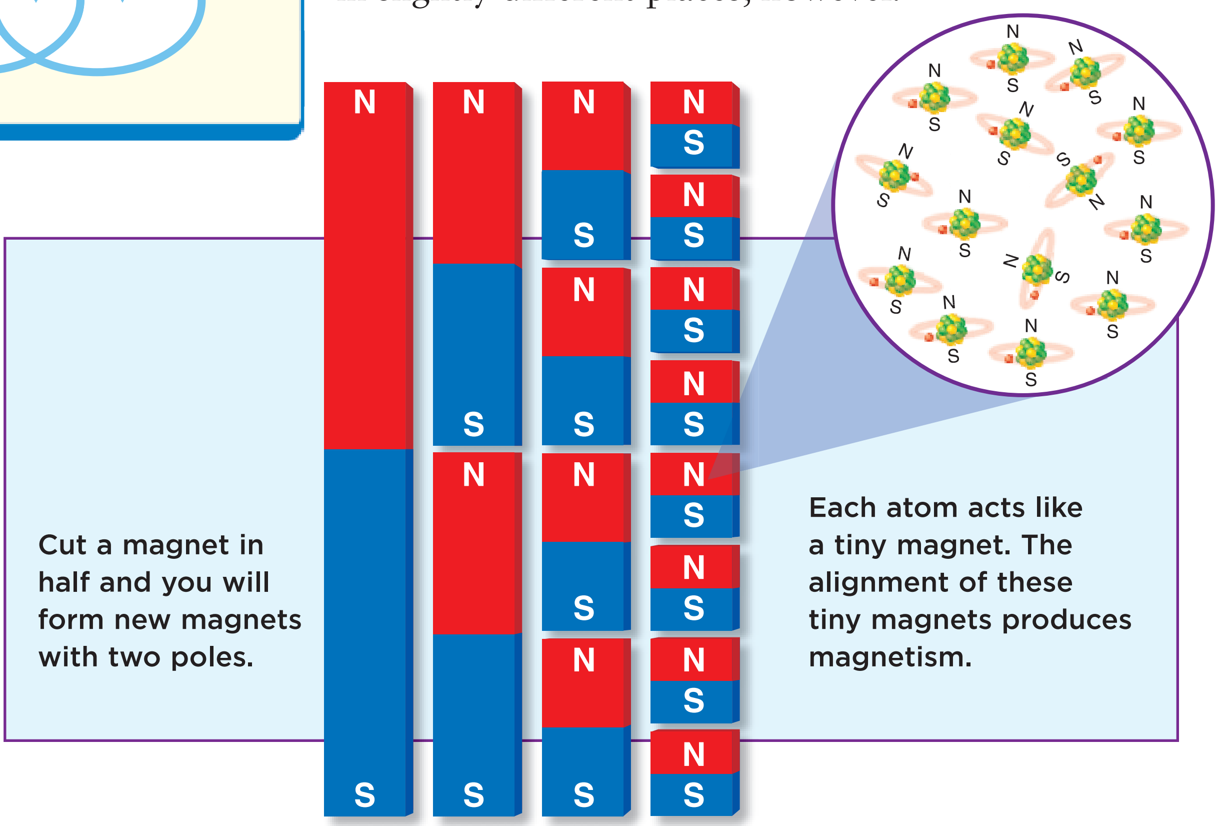
What is magnetism?

You're hiking in a forest. The trees are so thick that you can't see the Sun. How could you tell which way to go? Pull out your compass! Its needle tells you which direction is north. You're on your way!

How does a compass point north? The needle inside a compass is a magnet. **Magnetism** (MAG•ni•tiz•uhm) is the ability of an object to push or pull on another object that has the magnetic property. Magnets will also apply forces to certain metals like iron or nickel.

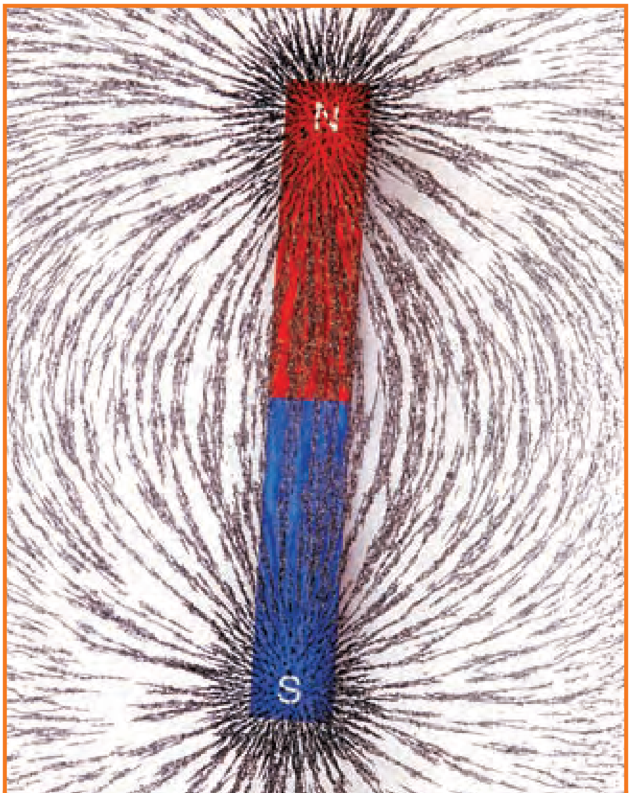
Magnets have two poles: north (N) and south (S). Like poles repel one another; different poles attract. You may notice that this is similar to what happens with electric charges. Magnetic poles always exist in north-south pairs. If you cut a magnet in half, each half will form a new magnet with two poles.

Are the pole names familiar? Earth has a North and South pole. Is Earth magnetic? Yes! Compass needles point toward Earth's North Pole. The geographic North Pole and magnetic north pole are in slightly different places, however.

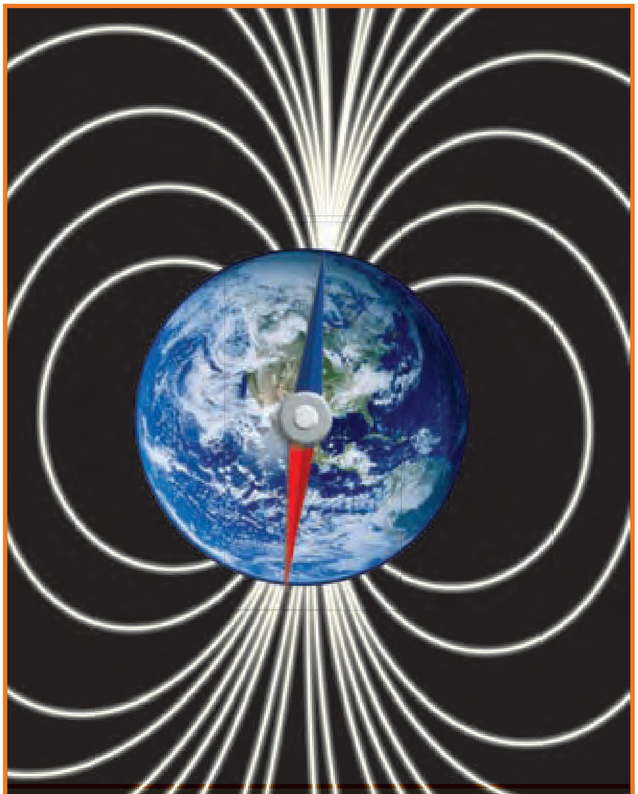


Cut a magnet in half and you will form new magnets with two poles.

Each atom acts like a tiny magnet. The alignment of these tiny magnets produces magnetism.



The closer together magnetic field lines are, the stronger the magnetic force.



Earth's magnetic field is like the field of a large permanent bar magnet.

Forming Magnets

Atoms also act like magnets. This magnetism comes from the properties and movement of electrons. In most materials, the north and south poles of atoms point in random directions. The forces from the random poles cancel each other out.

If the poles of many of the atoms line up in the same direction, a *permanent magnet* is formed. The forces from the aligned poles of the atoms add up and give a magnet its strength. The bar magnets you have used are permanent magnets.

Iron, nickel, cobalt, and a few other metals are attracted to magnets. Their atoms can line up to match the alignment of magnets. They will then act like weak magnets.

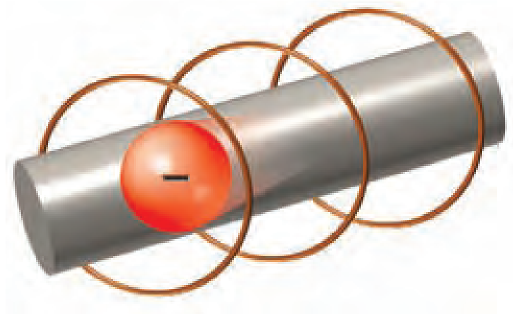
When small pieces of these metals are sprinkled over a magnet, they form lines. These lines are the directions of the magnetic forces around a magnet, and are called the **magnetic field**. The closer together these lines appear, the stronger the magnetic forces are in that area. The magnetic forces around Earth are similar to those of a bar magnet.

Quick Check

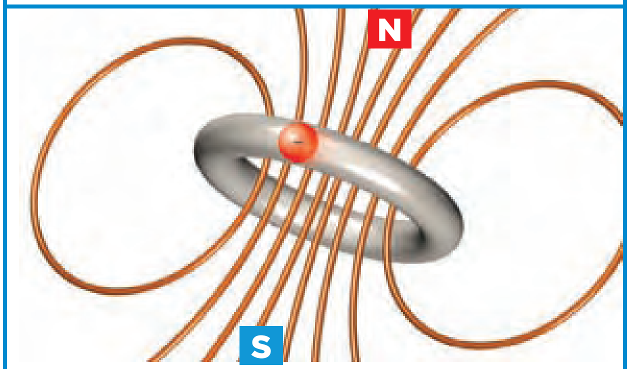
Compare and Contrast How is Earth like or unlike a bar magnet?

Critical Thinking How could you make a piece of iron into a permanent magnet?

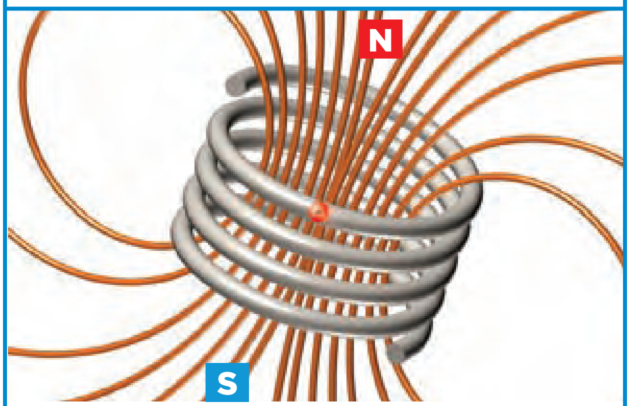
Electromagnetism



Electrons moving in a wire produce a magnetic field.



A loop of electric current will have north and south magnetic poles.



The magnetic field of a coil is like that of a bar magnet.

Read a Diagram

Which electromagnet has the strongest magnetic field?

Clue: Look at the magnetic field lines.

What are electromagnets?

What do doorbells, television sets, and electric motors have in common? They all use electromagnets. An **electromagnet** (i•LEK•troh•mag•nit) is an electric circuit that produces a magnetic field. The moving electrons in electricity generate magnetic fields. When the current stops, the magnetic field disappears.

The simplest electromagnet is a straight wire. The magnetic field circles around the wire when current is flowing. When you wrap a wire into a loop, you increase the strength of the magnetic field. Many loops together can make a coil. The magnetism from each loop adds up to make the coil a stronger electromagnet. The shape of its magnetic field is like a bar magnet's.

Placing a rod of iron in a coil will magnetize the iron. This adds to the strength of the electromagnet's magnetic field. Increasing the current also strengthens the field.

An iron rod in an electromagnet's coil is pulled toward the center of the coil. If you try to pull it out, it will spring back. This action is used in a number of devices, such as doorbells.

A *voice coil* operates audio speakers. The voice coil sits in a permanent magnetic field. Current changes in the coil alter its magnetic field. This causes the forces of the permanent magnet to move it back and forth. The coil is connected to a cone of paper or metal. The coil's vibrations make the cone move back and forth, creating sound waves in the air.

If several voice coils were placed in a circle, changes in electric current would cause them to rotate back and forth. Something very similar happens in electric motors. An axle is attached to many coils which are between two permanent magnets. Forces between the permanent magnets and the coils acting as electromagnets cause the coils to rotate. Electric motors are used in many devices, from ceiling fans to cars.

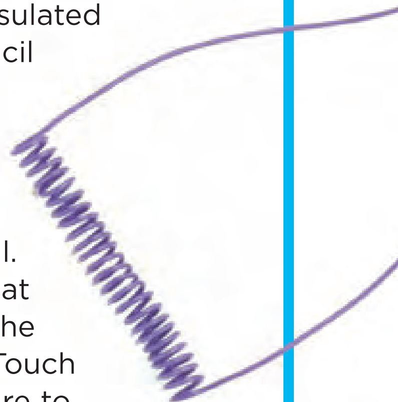
Quick Check

Compare and Contrast How are electromagnets and permanent magnets alike and different?

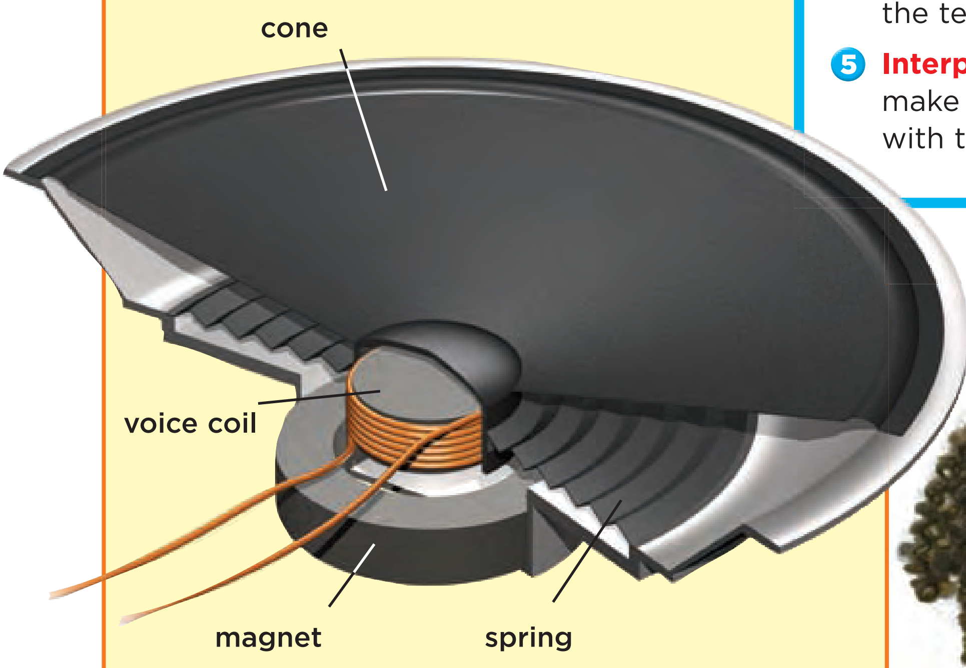
Critical Thinking How could a coil of wire and an iron rod be turned into a doorbell?

Quick Lab

Building an Electromagnet



1. Coil a length of insulated wire around a pencil 25 times. Remove the pencil.
2. **Observe** Place a compass right under the wire coil. Turn the coil so that it is crosswise to the compass needle. Touch the ends of the wire to a battery. Write down what you observe.
3. Hold the ends of the wire to the battery and try to pick up small steel paper clips with the coil. What's the largest chain of paper clips you can lift?
4. Repeat steps 2 and 3 with a nail inserted into the coil. Then repeat the test with a longer coil.
5. **Interpret Data** How would you make the strongest electromagnet with the materials you used?



A voice coil vibrates next to a permanent magnet to create sound in a speaker.

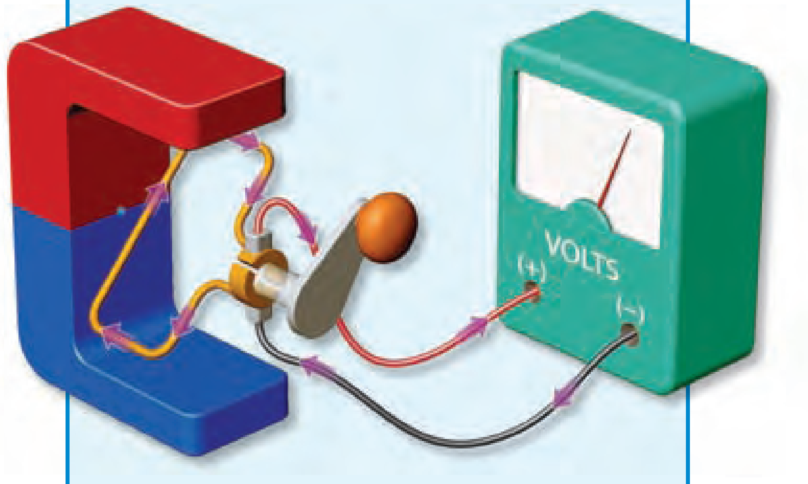
How can magnets produce electricity?

What would happen if you turned the axle of an electric motor by hand? You would be using the electric motor as a generator (JEN•uh•ray•tuhr). A **generator** is a device that creates electric current by spinning an electric coil between the poles of a magnet.

Energy is used to turn the axle of the generator. As the coil moves through the magnetic field, forces push on its electrons and create an electric current. Wires attached to the loop allow the current to flow as the loop rotates.

Whenever a loop moves past the pole of a magnet, the direction of the magnetic forces changes. This causes changes in the direction of the electric current. Electric current that rapidly changes directions is called **alternating current** (AWL•tuhr•nayt•ing).

In real generators, there are several coils of wire that spin past many magnets. U.S. generators produce alternating current that changes direction 120 times each second.



A simple generator has a metal coil in a magnetic field. As the coil rotates, an electric current is formed.

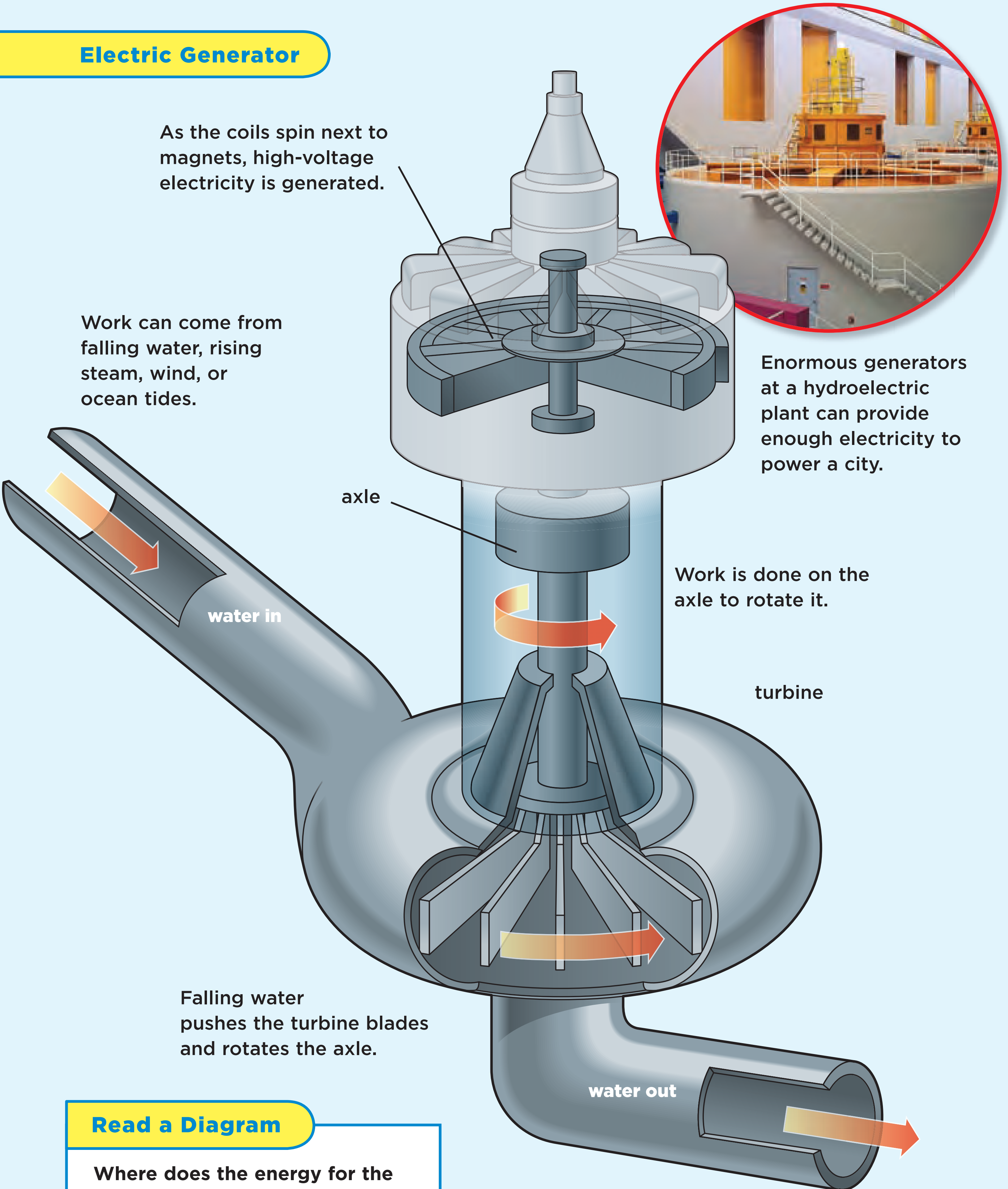

Devices called transformers use magnetism to lower the voltage to the 120 V used in homes.

Quick Check

Compare and Contrast What are the similarities and differences between electric motors and generators?

Critical Thinking What would happen in a generator if the permanent magnet rotated instead of the coils?

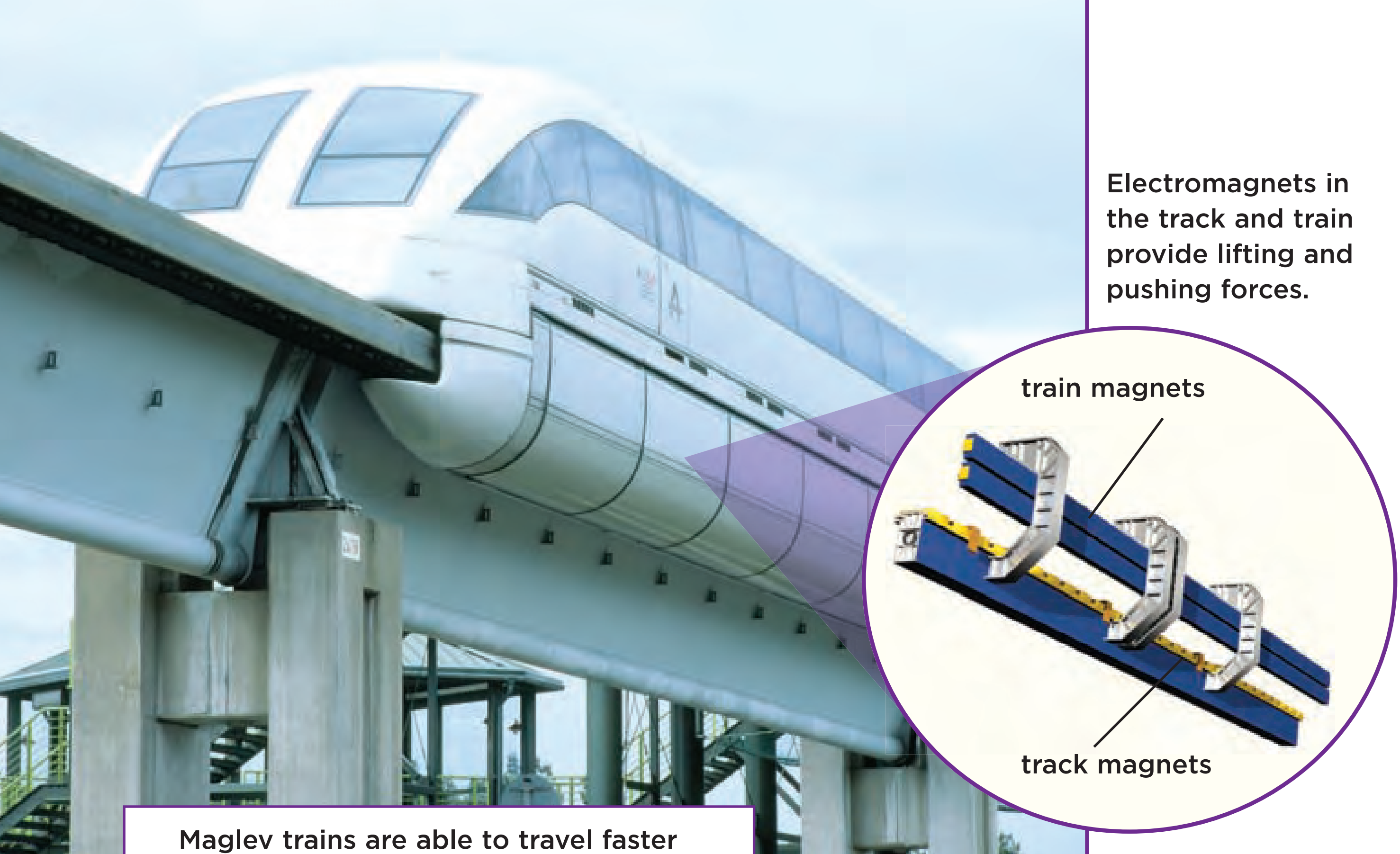
Electric Generator



Read a Diagram

Where does the energy for the electricity come from?

Clue: Look at the "water in" and "water out" labels.



Electromagnets in the track and train provide lifting and pushing forces.

Maglev trains are able to travel faster than 400 km per hour (310 mph).

What is magnetic levitation?

Have you ever seen the magic trick where a magician floats someone in midair? That's just an illusion, but magnets can accomplish the real thing! When two like poles of magnets face each other they feel a pushing force. If you balance this pushing force against the force of gravity you have magnetic levitation (lev•i•TAY•shuhn). **Magnetic levitation** is the lifting of an object by means of magnetic forces.

Scientists and engineers have designed trains that use magnetic levitation (*maglev* for short) to travel on a track. Electromagnets in the track and in the train have alternating north and south poles. By aligning the right type of poles in the track and in the train, electromagnets push the train a few centimeters above the track. The train moves forward by switching the poles in the track back and forth.

Maglev trains have no touching parts between the track and the train. This means there is little to no friction, though still air resistance. With so little energy lost to friction, maglev trains may be able to provide very efficient means of traveling from city to city.

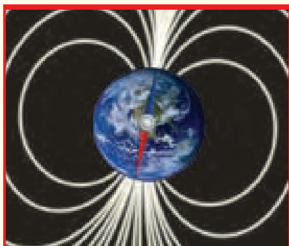
Quick Check

Compare and Contrast How is magnetic levitation similar to and different from buoyancy?

Critical Thinking How would electromagnetic poles be arranged in order to levitate a bar magnet?

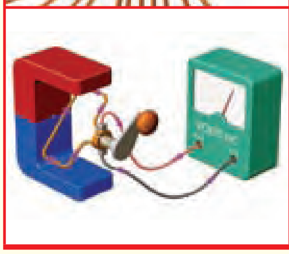
Lesson Review

Visual Summary



Magnets have north and south poles and can apply forces on one another.

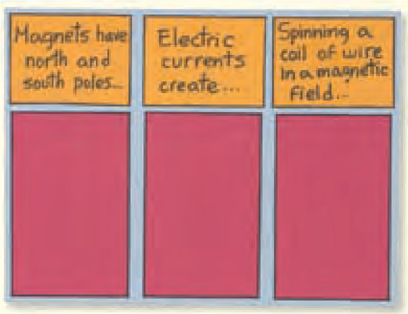
Electric currents create **electromagnets**.



Spinning a coil of wire in a magnetic field can **generate** electricity.

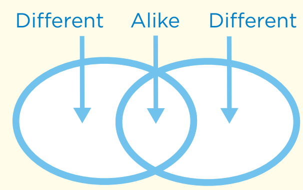
Make a FOLDABLES™ Study Guide

Make a Folded Chart. Use the titles shown. Summarize what you have learned in the boxes.



Think, Talk, and Write

1. **Main Idea** What happens when a bar magnet is cut in half?
2. **Vocabulary** Electric current that rapidly changes direction is called ________.
3. **Compare and Contrast** How are electric doorbells and speakers similar and different?



4. **Critical Thinking** How could heating a bar magnet reduce its magnetism?
5. **Test Prep** **All of these increase the strength of an electromagnet EXCEPT**
   - **A** increasing the number of loops.
   - **B** adding an iron rod in the middle.
   - **C** increasing the resistance.
   - **D** increasing the electric current.
6. **Test Prep** **Which energy conversion happens in electric motors?**
   - **A** radiant to electrical
   - **B** heat to mechanical
   - **C** nuclear to electrical
   - **D** electrical to kinetic

Math Link

Electromagnetic Forces

An electromagnetic coil can pick up 114 kg of iron. A strong bar magnet can pick up 33 kg of iron. What is the simplified ratio of their strengths?

Social Studies Link

Geography

Orienteering is a sport where you find your way to a location as fast as possible. Research and write a report on how magnetism is used in orienteering.

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Be a Scientist

Materials


wire with leads


3-inch nail

battery


battery holder


compass

Structured Inquiry

How are electric current and electromagnets related?

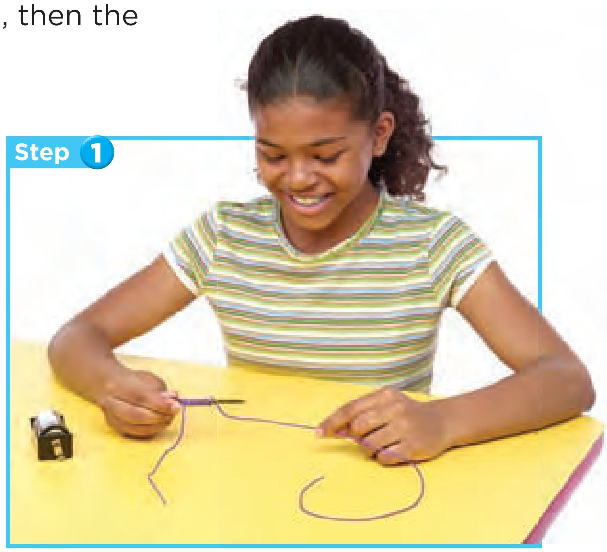
Form a Hypothesis

A magnetic field is produced when a current is flowing in a circuit. An electromagnet can be produced in this way. Electromagnets produce a magnetic field similar to bar magnets. When the current stops, the magnetic field disappears.

Each electromagnet has a north and a south pole. A compass needle also has a north and south pole. The compass needle will point to the appropriate poles of other magnets. How do you think the direction of electric current affects the poles of the electromagnet? Write a hypothesis in the form "If the direction of electric current is reversed, then the poles on an electromagnet…"

Test Your Hypothesis

1. Coil the wire around the nail 35 times clockwise toward the flat end. Leave about 10 cm of straight wire at both ends.
2. Find the straight part of the wire near the flat side of the nail. Connect that end of the wire to the positive side of the battery.
3. Lay the compass on the flat end of the nail. Press the unconnected wire to the negative side of the battery. Record what happens.
4. Find the wire from the flat end of the nail. Disconnect it from the positive side of the battery and connect it to the negative side. Keep the compass on the flat end of the nail. Press the other end of the wire to the positive side of the battery. Record what happens.


Step 1


Step 2

Draw Conclusions

5 **Infer** Where did the compass point in step 3 and step 4? What do you think happened to the poles of the electromagnet?

6 **Communicate** Draw a picture of the electromagnet before and after the current was reversed. Mark to which side of the battery the wires were connected. Label the poles of the electromagnet as north or south.

Guided Inquiry

How is an electromagnet affected by the direction of its coils?

Form a Hypothesis

Are the poles of an electromagnet only dependent on electric current? How does the direction in which a coil is wound affect an electromagnet? Write your answer as a hypothesis in the form "If the direction in which a coil is wound is reversed, then the poles of the electromagnet…"

Test Your Hypothesis

Design an experiment to investigate the effect changing the direction of coils will have on an electromagnet. Write out the materials you need and the steps you will follow. Record your observations.

Draw Conclusions

Did your results support your hypothesis? Explain.

Open Inquiry

What can you learn about electromagnets? For example, how are electromagnets used in electric motors? Determine the materials needed for your investigation. Your experiment should be written so that another group can complete it by following your instructions.

Remember to follow the steps of the scientific process.

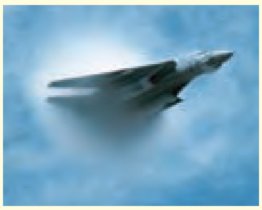
Ask a Question
↓
Form a Hypothesis
↓
Test Your Hypothesis
↓
Draw Conclusions

SWK-2. Develop descriptions, explanations and models using evidence to defend/support findings.

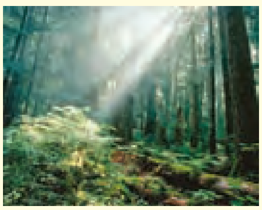
CHAPTER 6 Review

Visual Summary

Lesson 1 Thermal energy flows between objects when they have different temperatures.



Lesson 2 Sounds are produced by vibrating objects.



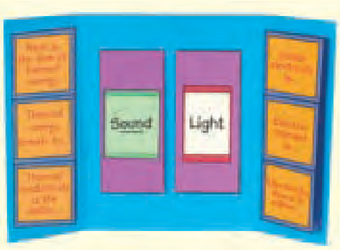
Lesson 3 Light travels as waves, but can also be described as particles.

Lesson 4 Electricity is a form of energy and can flow in a circuit.

Lesson 5 Magnets have north and south poles that apply forces to other magnets and magnetic materials.

Make a FOLDABLES™ Study Guide

Assemble your lesson study guide as shown. Don't forget to include your Lesson 5 study guide in the back.



Vocabulary

Fill in each blank with the best term from the list.

amplitude, p. 322	**photon**, p. 331
circuit, p. 348	**pitch**, p. 320
conduction, p. 306	**refraction**, p. 335
electromagnet, p. 360	**static electricity**, p. 346
generator, p. 362	**temperature**, p. 304

1. A tiny bundle of energy by which light travels is called a(n) ________.
PS-5

2. An unbroken path of conductors carrying an electric current is a(n) ________.
PS-4

3. An electric circuit that produces a magnetic field is a(n) ________.
PS-3

4. The average energy of molecules in an object is its ________.
PS-C

5. A musical note will sound high or low depending on its ________.
PS-7

6. When solid objects touch, thermal energy can pass through ________.
PS-2

7. The height of a wave is called its ________.
PS-F

8. The bending of waves as they pass from one substance to another is called ________.
PS-5

9. Lightning can result after a large buildup of ________.
PS-E

10. A hydroelectric dam creates electricity when water powers its ________.
PS-3

Skills and Concepts

Answer each of the following in complete sentences.

11. Compare and Contrast What are the similarities and differences between thermal energy and temperature?
PS-I

12. Summarize How are the colors created in the rainbow below?
PS-5

13. Form a Hypothesis Suppose that the lights in one room of your house went out but were still on in another room. Form a hypothesis to explain this. Tell how you might test your hypothesis.
SI-I

14. Critical Thinking What would be the advantages and disadvantages of using magnetic levitation to run a public transportation system?
PS-3

15. Expository Writing Write a paragraph explaining how echolocation works and provide an example.
PS-6

The Big Idea

16. What forms does energy take? Define each one and give an example of how we use it in our everyday lives.
PS-D, PS-E, PS-F

Performance Assessment

Space Waves

Find out about the different kinds of waves that form the electromagnetic spectrum. These include:

radio waves	microwaves
infrared waves	visible waves
ultraviolet rays	X rays
gamma rays	cosmic rays

1. Use reference books or the Internet to research the characteristics of each.

2. Make a chart comparing and contrasting them. Your chart should compare wavelength, frequency, and two other variables, and provide an example of each kind of wave.

Analyze Your Results

- Write a paragraph about your results based on your chart.

Ohio Activity

Ohio power companies use several different resources to generate electricity. Investigate the power company that supplies electricity to your home, school, or nearest city. Create a pie chart comparing the different sources of power used to generate electricity. Your pie chart may include sources of power such as coal, nuclear, wind, solar, and hydroelectric.

Ohio Benchmark Practice

1 **Which statement about reflection is false?**

A Lenses in eyeglasses use reflection to make objects appear in focus.
B Incoming and reflected angles are equal.
C Lighter colors reflect more than darker colors.
D Reflection is like an organized scattering of light.

PS-F

2 **Heating by conduction is most effective in a**

A gas.
B liquid.
C solid.
D vacuum.

PS-D

3 **Temperature is best described as the**

A average kinetic energy of an object's particles.
B average thermal conductivity in an object.
C total amount of thermal energy in an object.
D total amount of potential energy in an object's particles.

PS-I

4 **Sound waves are longitudinal waves because they**

A vibrate a medium at a right angle.
B vibrate a medium in the same direction that the energy moves.
C move in all directions from a vibrating object.
D look, when they are seen, like a series of peaks and valleys.

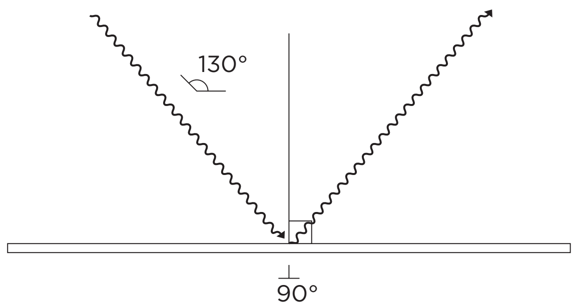
PS-F

5 **The pitch of a sound is related to**

A amplitude.
B frequency.
C speed.
D wavelength.

PS-7

6 **The diagram below shows a ray of light striking a mirror.**



Which of these terms best describes the mirror?

A concave
B convex
C opaque
D transparent

PS-5

7 **Which statement best describes the role of a resistor in an electric circuit?**

A A resistor supplies electrons to a circuit.
B A resistor opens and closes an electric circuit.
C A resistor changes electrical energy to other forms of energy.
D A resistor connects each part of an electric circuit to the next.

PS-E

8 **Which describes what happens when a thermometer is placed in a container of cold water?**

- **A** The thermometer displays a higher temperature.
- **B** Thermal energy flows out of the thermometer.
- **C** Thermal energy flows into the thermometer.
- **D** Nothing happens.

PS-D

9 **The table below compares the thermal conductivity of some common materials.**

Thermal Conductivity	Material
high	silver, gold, copper
medium	iron, steel, lead
low	rubber, wood, marble

Your friend wants to make a cup that will keep hot liquids warm for as long as possible. In your Answer Document, recommend a material to use and justify your recommendation. (2 points)

PS-D

10 **Electrical current in a circuit can be converted into all of the following EXCEPT**

- **A** thermal energy.
- **B** magnetism.
- **C** chemical energy.
- **D** sound energy.

PS-E

11 **Light rays reflect off a concave mirror in the same way that light rays**

- **A** refract through a convex lens.
- **B** reflect off a convex mirror.
- **C** refract through a concave lens.
- **D** refract through a flat lens.

PS-5

12 **Which describes what happens when a sound wave hits a soft, thick surface?**

- **A** echolocation
- **B** rarefaction
- **C** transmission
- **D** absorption

PS-6

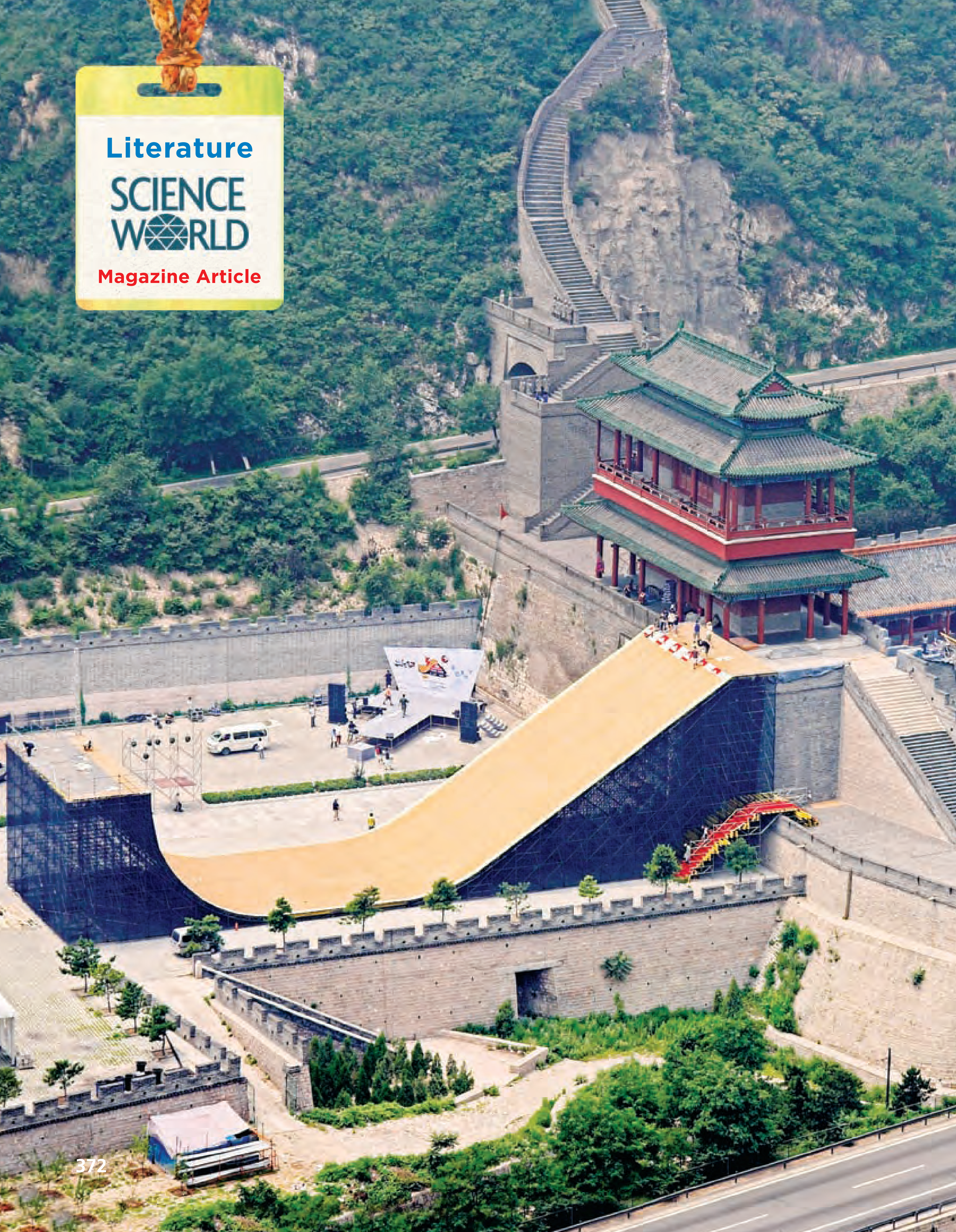
13 **Series and parallel circuits are two types of electrical circuits. In your Answer Document, describe or draw the path of electricity in a parallel circuit and in a series circuit in order to light a lightbulb. Identify one similarity and one difference between the two types of electrical circuits. Be sure to label any drawings. (4 points)**

PS-E

Literature

SCIENCE WORLD

Magazine Article



from *Science World*

The Great Jump in China

This daredevil even managed a spin while airborne.

During a hot day in July, Danny Way rolled into the record books. He became the first person to leap across the Great Wall of China . . . on a skateboard!

Way began his wall-jumping roll from the top of a towering J-shaped ramp. “The higher up he is, the more gravitational potential energy (stored energy due to height) he’ll have,” says Louis Bloomfield, a physicist at the University of Virginia. When Way descended, that stored energy converted into energy of motion, or kinetic energy, and gave him maximum speed.

Why the need for speed? When Way blasted off the ramp and up into the air, gravity pulled him downward. With more upward speed he could fight gravity’s tug longer to gain big air.

Way also needed forward speed to cross the 21-meter-wide (70-foot-wide) wall. That’s why his takeoff ramp sloped gradually up toward the wall. The gentle angle shot him both upward and forward onto a ramp on the other side.

Danny Way standing on the Great Wall of China.

Write About It

Response to Literature This article describes how an athlete used a ramp to jump over a large object. If you were a professional athlete, what other kinds of devices might you use? Write a fictional narrative describing one of these devices and its uses.

LOG ON **e-Journal** Write about it online at www.macmillanmh.com

Mechanical Engineer

If you like to take things apart to find out how they work, you are in good company—that of mechanical engineers. They design, build, and operate many types of machines, such as those that run refrigerators, elevators, automobiles, and electric generators. Mechanical engineers also develop robots. Robotic machines do many kinds of jobs, from heavy manufacturing to delicate heart surgery. To qualify for a career in robotics, start developing your math, science, and computer skills while you are in school. In college and graduate school, you would specialize in mechanical engineering.

▼ **Mechanical engineers build all types of machines—including some that go into space.**

▲ **An auto mechanic uses tools, including computers, to fix cars.**

Auto Mechanic

Have you ever been in a car that broke down? If so, then it was probably an auto mechanic who came to the rescue. Auto mechanics do not only make repairs. They also service cars to keep them in good running condition. To make repairs, an auto mechanic uses hand tools, such as pliers and screwdrivers, power tools, such as pneumatic wrenches and welding equipment, and computers. Auto mechanics need to be good problem solvers, too. If you want to become an auto mechanic, the more you learn about automobiles, the better. Some schools offer training programs which allow you to earn a mechanic's certificate along with your high school diploma.

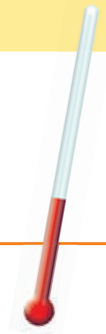
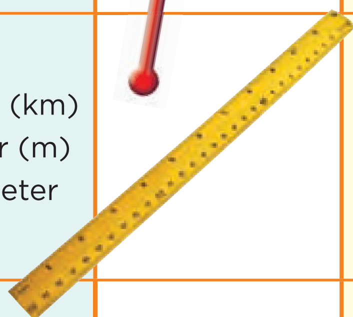
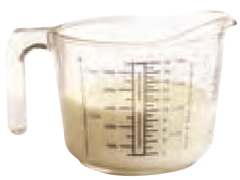
LOG ON e-Careers at www.macmillanmh.com

Reference

Science Handbook

Measurements

Units of Measurement

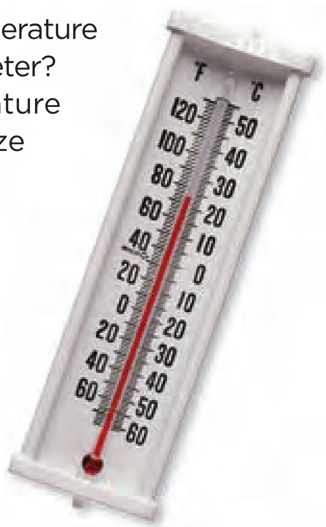
Table of Measurements		
International System of Units (SI)		**Customary Units**
Temperature Water freezes at 0°C (degrees Celsius) and boils at 100°C		**Temperature** Water freezes at 32°F (degrees Fahrenheit) and boils at 212°F
Length and Distance 1,000 meters (m) = 1 kilometer (km) 100 centimeters (cm) = 1 meter (m) 10 millimeters (mm) = 1 centimeter (cm)		**Length and Distance** 5,280 feet (ft) = 1 mile (mi) 3 feet (ft) = 1 yard (yd) 12 inches (in.) = 1 foot (ft)
Volume 1,000 milliliters (mL) = 1 liter (L) 1 cubic centimeter (cm^3) = 1 milliliter (mL)		**Volume** 4 quarts (qt) = 1 gallon (gal) 2 pints (pt) = 1 quart (qt) 2 cups (c) = 1 pint (pt) 8 fluid ounces (oz) = 1 cup (c)
Mass 1,000 grams (g) = 1 kilogram (kg)		**Mass (and Weight)** 2,000 pounds (lb) = 1 ton (T) 16 ounces (oz) = 1 pound (lb)
Weight 1 kilogram (kg) weighs 9.81 newtons (N)		

Making Measurements

Temperature

You use a thermometer to measure temperature. A thermometer is made of a thin tube with a liquid inside that is usually red in color. When the liquid inside the tube gets warmer, it expands and moves up the tube. When the liquid gets cooler, it contracts and moves down the tube.

1. Look at the thermometer shown here. It has two scales—a Fahrenheit scale and a Celsius scale.
2. What is the temperature on the thermometer? At what temperature does water freeze on each scale?



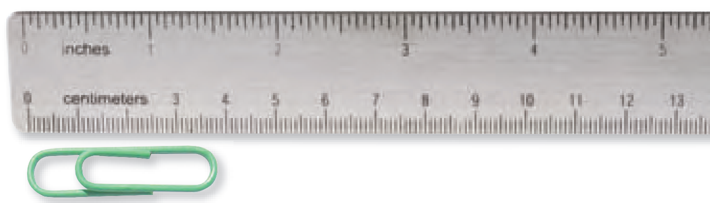
Time

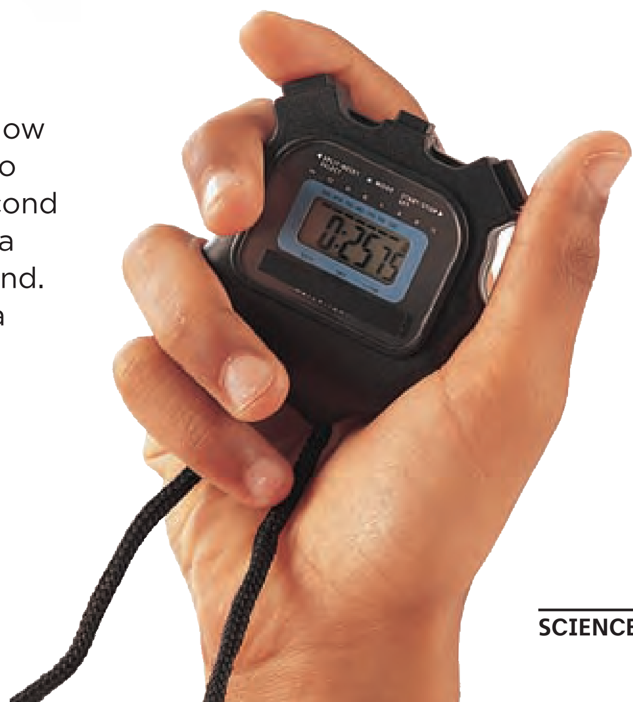
You use timing devices to measure how long something takes to happen. Two timing devices are a clock with a second hand and a stopwatch. A clock with a second hand is accurate to one second. A stopwatch is accurate to parts of a second.

Length

1. Look at the ruler below. Each centimeter is divided into 10 millimeters. Estimate the length of the paper clip.
2. The length of the paper clip is about 3 centimeters plus 8 millimeters. You can write this length as 3.8 centimeters.

Try estimating the length of some objects found in your classroom. Then measure the length of the objects with a ruler. Compare your estimates with accurate measurements.





Measurements

Measuring Mass, Weight, and Volume

Mass

Mass is the amount of matter that makes up an object. You can use a balance to measure mass. To find the mass of an object, you balance or compare it with masses you know.

1. Place the balance on a level surface. Check that the two pans are empty, clean, and balanced with each other. The pointer should point to the middle mark. If it does not, move the slider to the right or left until the pans are balanced.
2. Gently place the object you want to measure in the left pan. The left pan will then move lower.
3. Now add masses to the right pan until both pans are balanced again. Add and get the total mass in the right pan. This total is the mass of the object in grams.

Weight

You use a spring scale to measure weight. Weight equals the amount of gravity pulling down on the mass of an object. Therefore weight is a force. Weight is measured in newtons (N).

1. To find the weight of your object, hold the spring scale by the top. Determine the weight of the empty plastic cup. Add the object to the cup.
2. Subtract the first measurement from the second, and the difference is the weight of the rock.

Volume

1. You can use a beaker or graduated cylinder to find the volume of a liquid.
2. You can also find the volume of a solid such as a rock. Add water to a beaker or graduated cylinder. Gently slide the object down into the beaker. To find the volume of the rock, subtract the starting volume of the liquid from the new volume. The difference is equal to the volume of the rock.

Collecting Data

Microscopes

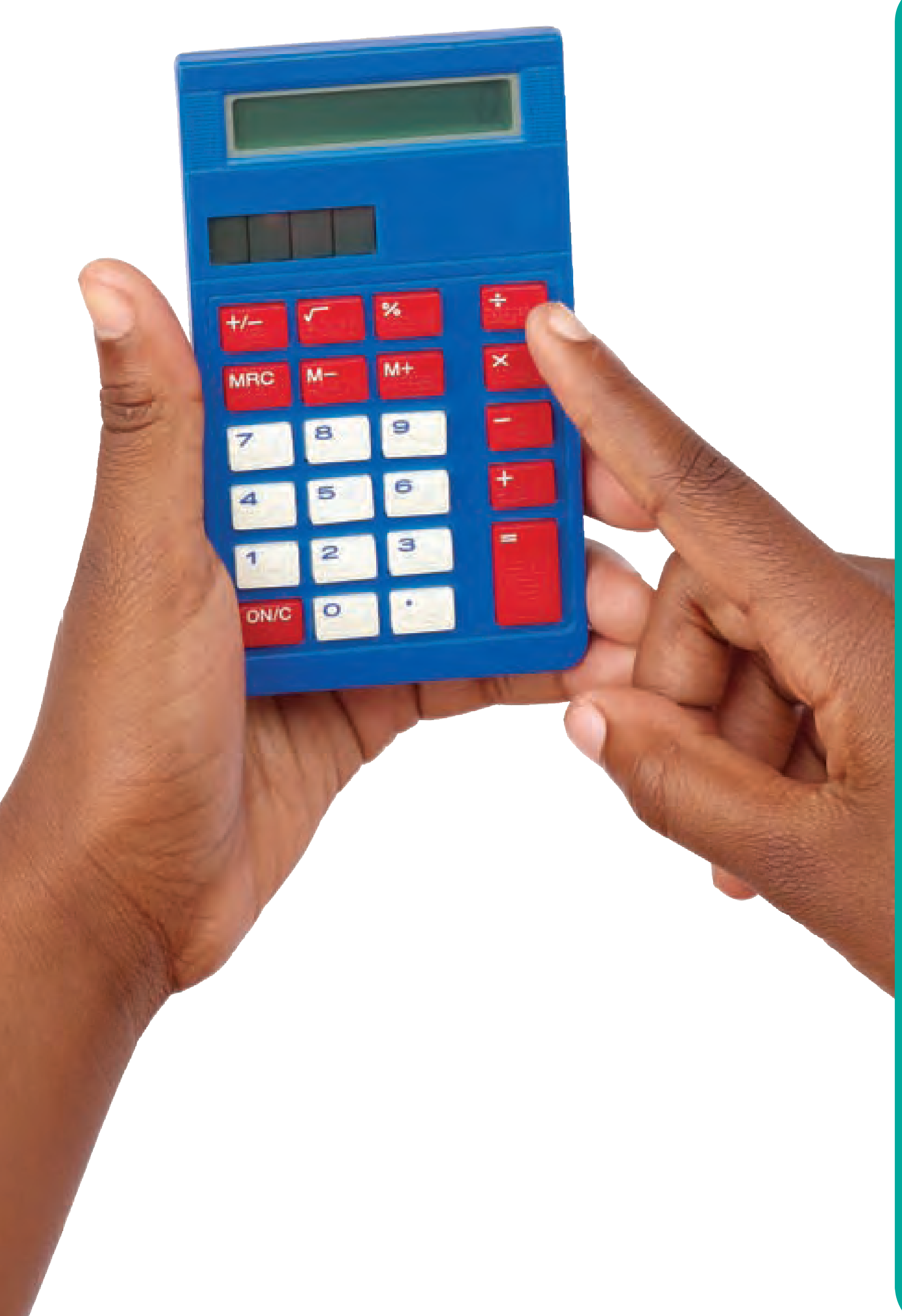
1. Look at the photograph to learn the different parts of your microscope.
2. Always carry a microscope with both hands. Hold the arm of the microscope with one hand, and put your other hand beneath the base. Place the microscope on a flat surface.
3. Move the mirror so that it reflects light from the room up toward the stage. Never point the mirror directly at the Sun or a bright light. ⚠ **Be careful.** Bright light can cause permanent eye damage.
4. Place a small piece of newspaper on a slide. Put the slide under the stage clips. Be sure that the area you are going to examine is over the hole in the stage.
5. Look through the eyepiece. Turn the focusing knob slowly until the newspaper comes into focus.
6. Draw what you see through the microscope.
7. Look at other objects through the microscope. Try a piece of leaf, a human hair, or a pencil mark.

Other Lenses

You use a hand lens to magnify an object, or make the object look larger. With a hand lens, you can see more detail than you can without the lens. Look at a few grains of salt with a hand lens and draw what you see. Binoculars are a tool that makes distant objects appear closer. In nature, scientists use binoculars to look at animals without disturbing them. These animals may be dangerous to approach or frightened at the approach of people. Cameras can act like binoculars or they can be used to see things up close. Cameras have the advantage of making a record of your observations. Cameras can make a record on film or as data on a computer chip.

Use Calculators

Sometimes after you make measurements, you have to analyze your data to see what they mean. This might involve doing calculations with your data. A handheld calculator helps you do calculations quickly and accurately, and can also be used to verify your own calculations.



Hints

- Make sure the calculator is on and previous calculations have been cleared.
- To add a series of numbers, press the + sign after you enter each number. After you have entered the last number, press the = sign to find the sum.
- If you make a mistake while putting numbers in, press the clear entry key. You can then enter the correct number.
- To subtract, enter the first number, then the – sign. Then enter the number you want to subtract. Then press the = sign for the difference.
- To multiply, enter the first number, then the × sign and enter the second number you want to multiply by. Then press the = sign for the product.
- To divide, enter the number you want to divide, press the ÷ sign and enter the number you want to divide by. Then press the = sign for the quotient.
- You can also find averages and percents with a calculator, and verify your own work.

Use Computers

A computer has many uses. You can write a paper on a computer. You can use programs to organize data and show your data in a graph or table. The Internet connects your computer to many other computers and databases around the world. You can send the paper you wrote to a friend in another state or another country. You can collect all kinds of information from sources near and far. Best of all, you can use a computer to explore, discover, and learn. You can also get information from computer disks that can hold large amounts of information. You can fit the information found in an entire encyclopedia set on one disk.

One class used computers to work on a science project. They were able to collect data from students in another state who were working on a similar project, and share their data with them. They were also able to use the Internet to write to local scientists and request information. The students collected and stored their data, moved paragraphs around, changed words, and made graphs. Then they were able to print their report to share their discoveries with others.

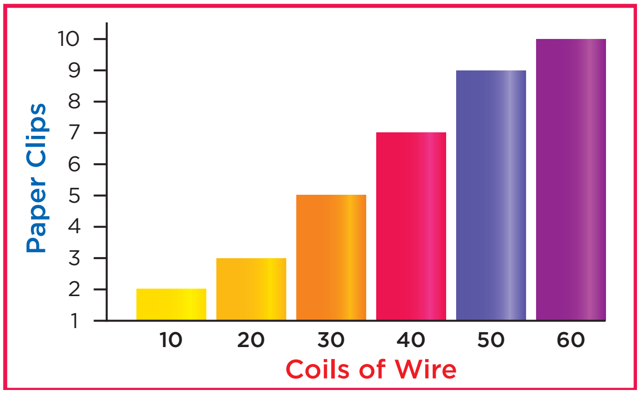
Organizing Data

Use Graphs

When you do an experiment in science, you collect information, or data. To find out what your data means, you can organize it into graphs. There are several different kinds of graphs. You can choose a type of graph that best organizes your data and makes it easier for you and for others to understand the data presented.

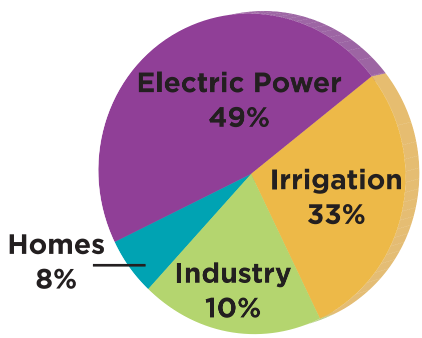
Bar Graphs

A bar graph uses bars to show information. For example, what if you performed an experiment to test the strength of a nail electromagnet and the number of coils of wire wrapped around it? This graph shows that increasing the number of coils increases the strength of the electromagnet.



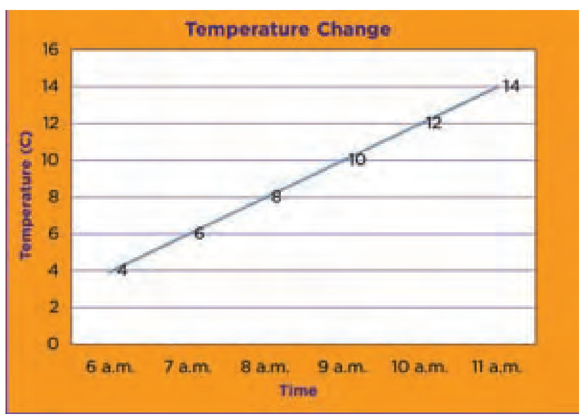
Circle Graphs

A circle graph is used to show how a complete set of data is divided into parts. This circle graph shows how water is used in the United States. In a circle graph, all the data must add up to 100.



Line Graphs

A line graph shows information by connecting dots plotted on a graph. A line graph is often used to show changes that occur over time. For example, this line graph shows the relationship between temperature and time for a particular morning.



Use Tables and Maps

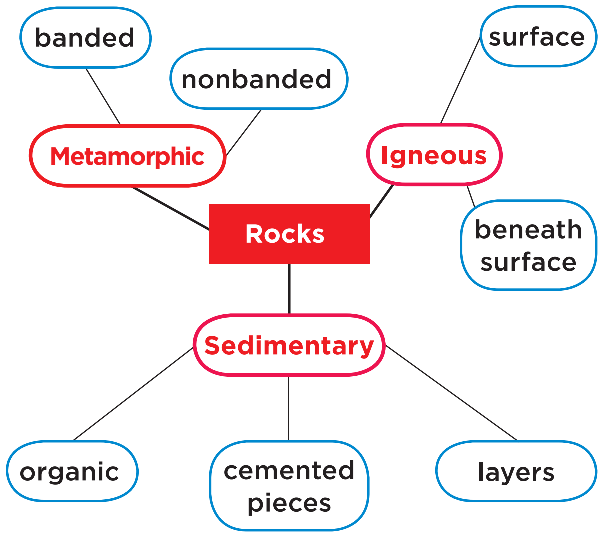
Tables

Tables help you organize data during experiments. Most tables have columns that run up and down, and rows that run horizontally. The columns and rows have headings that tell you what kind of data goes in each part of the table. The table here shows a record of the conductivity of several different kinds of substances.

Material	Thermal Conductivity
Aluminum	109.0
Copper	385.0
Wood	0.1
Packing foam	0.01

Idea Maps

This kind of map shows how ideas or concepts are connected to each other. Idea maps help you organize information about a topic. The idea map shown here connects different ideas about rocks.



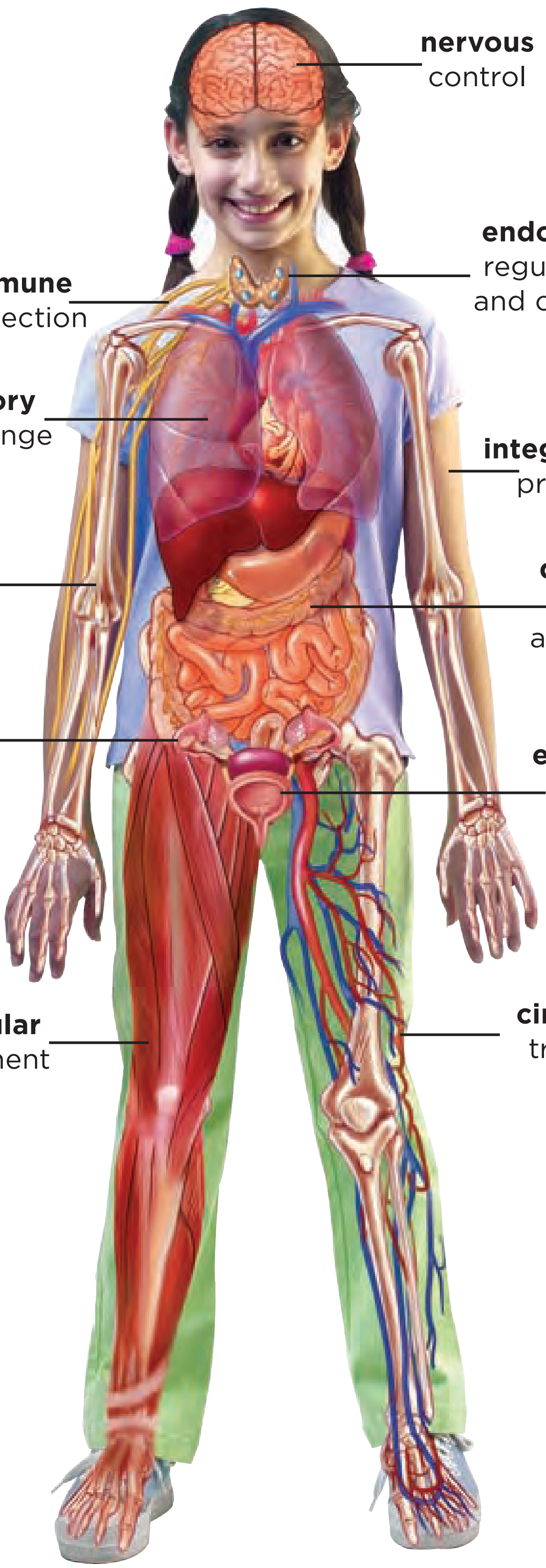
Maps

A map is a drawing that shows an area from above. Maps help you learn about a location. You are probably most familiar with road maps, which are often used to plan ways to travel from one place to another. Other kinds of maps show terrain. Hills and valleys, for example, can be shown on some types of maps. A good map also has a legend that shows the scale it was made to, and also a compass point that shows the direction of north and sometimes other directions as well.

Human Body Systems

Organization of the Human Body

Like all organisms, humans are made up of cells. In fact, the human body is made of trillions of cells. These cells are organized into tissues, a group of similar cells that perform a specific function. The cardiac muscle in your heart is an example of tissue. Tissues, in turn, form organs. Your heart and lungs are examples of organs. Finally, organs work together as part of organ systems. For example, your heart and blood vessels are part of the circulatory system. The organ systems in the human body all function together to keep the body healthy.



The Skeletal and Muscular Systems

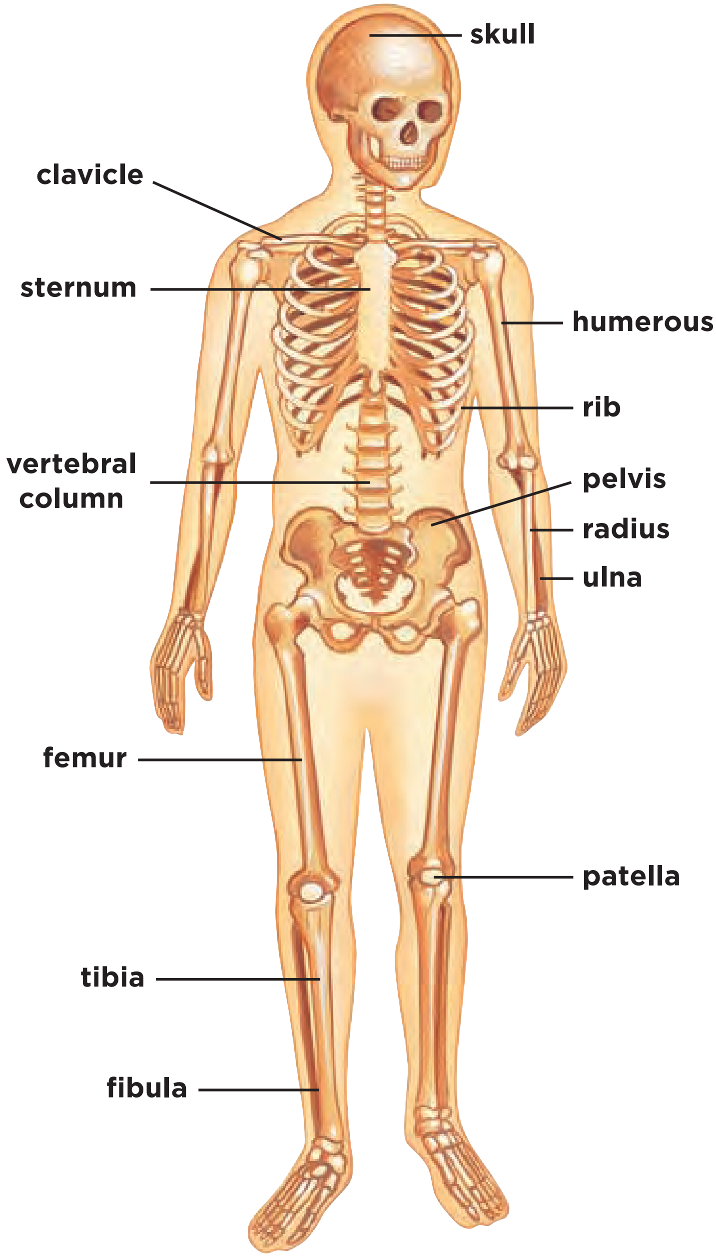
The body has a supporting frame called a skeleton, which is made up of bones. The skeleton gives the body its shape, protects organs in the body, and works with muscles to move the body.

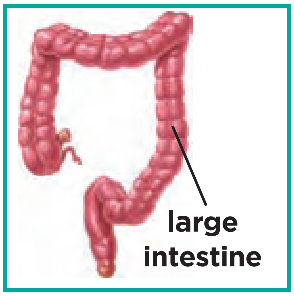
Each of the 206 bones of the skeleton is the size and shape best fitted to do its job. For example, long and strong leg bones support the body's weight.

Three types of muscles make up the body—skeletal muscle, cardiac muscle, and smooth muscle. Cardiac muscles are found only in the heart. These muscles contract to pump blood throughout the body.

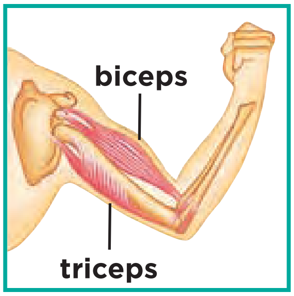
Smooth muscles make up internal organs such as the intestines, as well as blood vessels.

The muscles that are attached to and move bones are called skeletal muscles. Skeletal muscles pull bones to move them. Most muscles work in pairs to move bones.

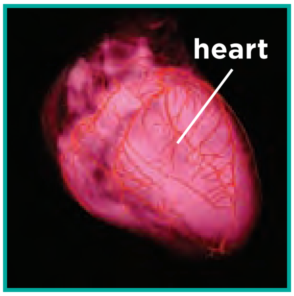




smooth muscle



skeletal muscles



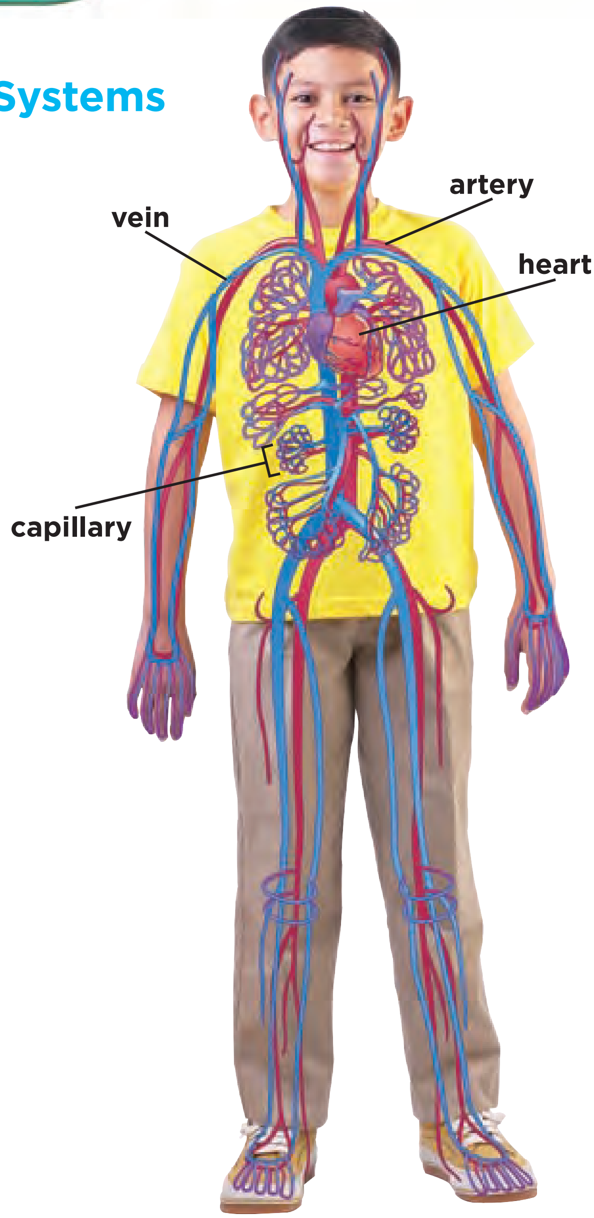
cardiac muscle

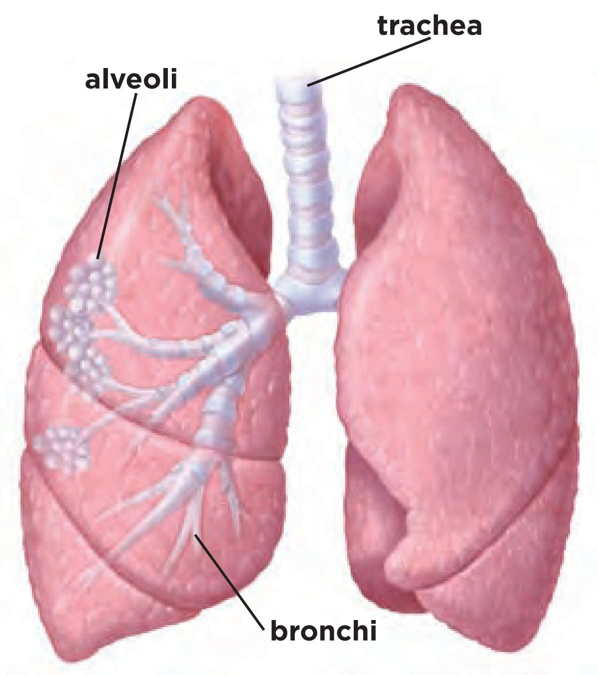
Human Body Systems

The Circulatory and Respiratory Systems

The circulatory system consists of the heart, blood vessels, and blood. Circulation is the flow of blood through the body. Blood is a liquid that contains red blood cells, white blood cells, and platelets. Red blood cells carry oxygen and nutrients to cells. They also carry CO_2 and cellular wastes away from the cells. White blood cells work to fight germs that enter the body. Platelets are cell fragments that help make the blood clot.

The heart is a muscular organ about the size of a fist. Arteries carry blood away from the heart. Some arteries carry blood to the lungs, where red blood cells pick up oxygen. Other arteries carry oxygen-rich blood from the lungs to all other parts of the body. Veins carry blood from other parts of the body back to the heart. Blood in most veins carries the wastes released by cells and has little oxygen. Blood flows from arteries to veins through narrow vessels called capillaries.



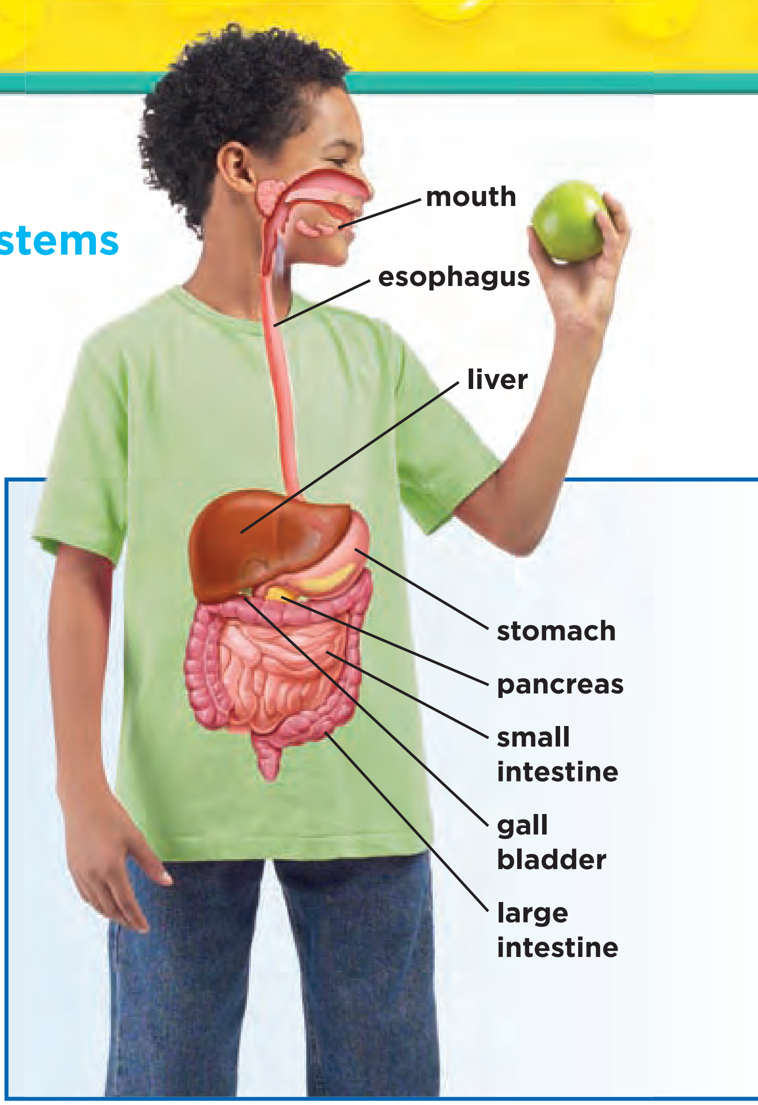


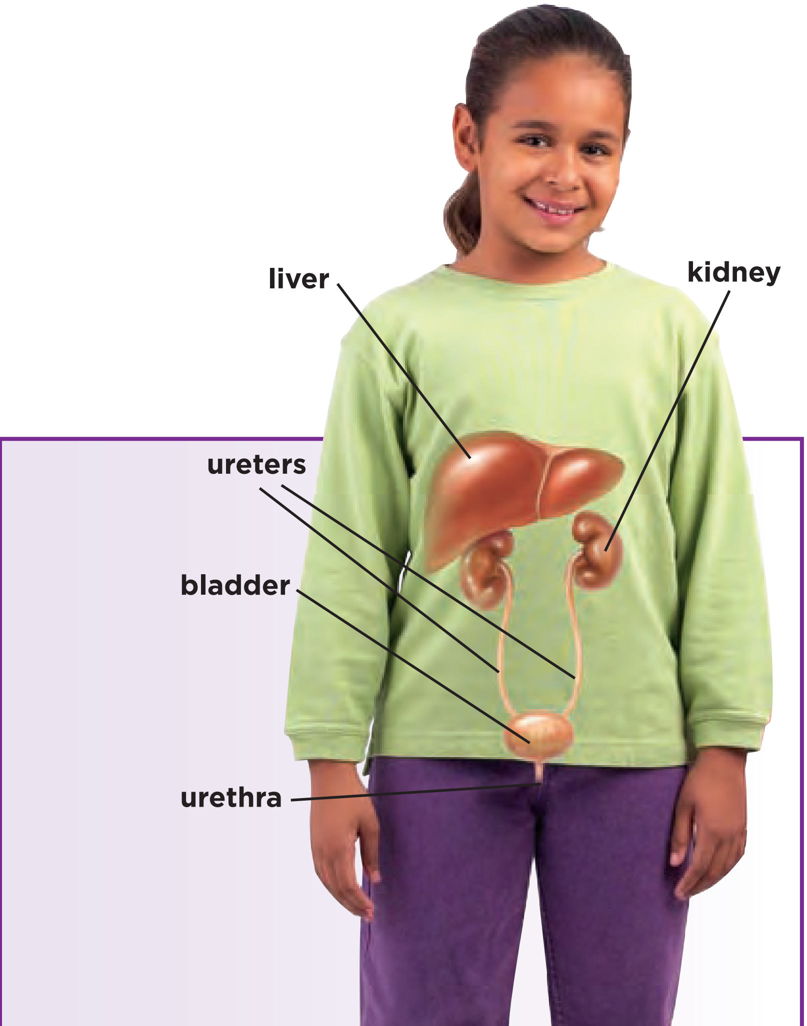
The process of getting and using oxygen in the body is called respiration. When a person inhales, air is pulled into the nose or mouth. The air travels down into the trachea. In the chest the trachea divides into two bronchial tubes. One bronchial tube branches into smaller tubes called bronchioles. At the end of each bronchiole are tiny air sacs called alveoli. The alveoli exchange carbon dioxide for oxygen.

The Digestive and Excretory Systems

Digestion is the process of breaking down food into simple substances the body can use. Digestion begins when a person chews food. Chewing breaks the food down into smaller pieces and moistens it with saliva. Food passes through the esophagus and into the stomach. The stomach mixes digestive juices with food before passing it on to the small intestine.

Digested food is absorbed in the small intestine. The walls of the small intestine are lined with villi, which are fingerlike projections. Digested food is absorbed through the surface of the villi. From the villi the blood transports nutrients to every part of the body. Water is absorbed from undigested food in the large intestine.





Excretion is the process of removing waste products from the body. The liver filters nitrogen wastes from the blood and converts them into urea. Urea is then carried by the blood to the kidneys for excretion. Each kidney contains more than a million nephrons. Nephrons are structures in the kidneys that filter blood.

The skin takes part in excretion when a person sweats. Glands in the inner layer of skin produce sweat. Sweat is mostly water. There is also a tiny amount of urea and mineral salts in sweat.

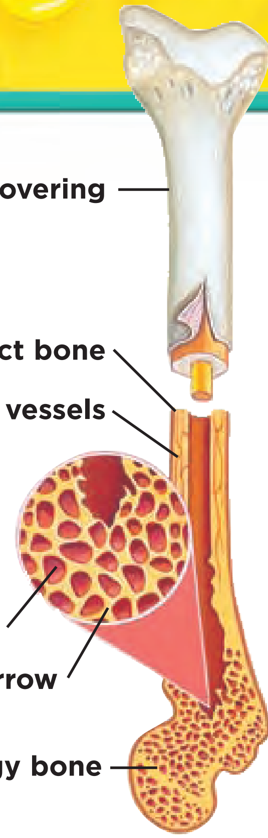
Human Body Systems

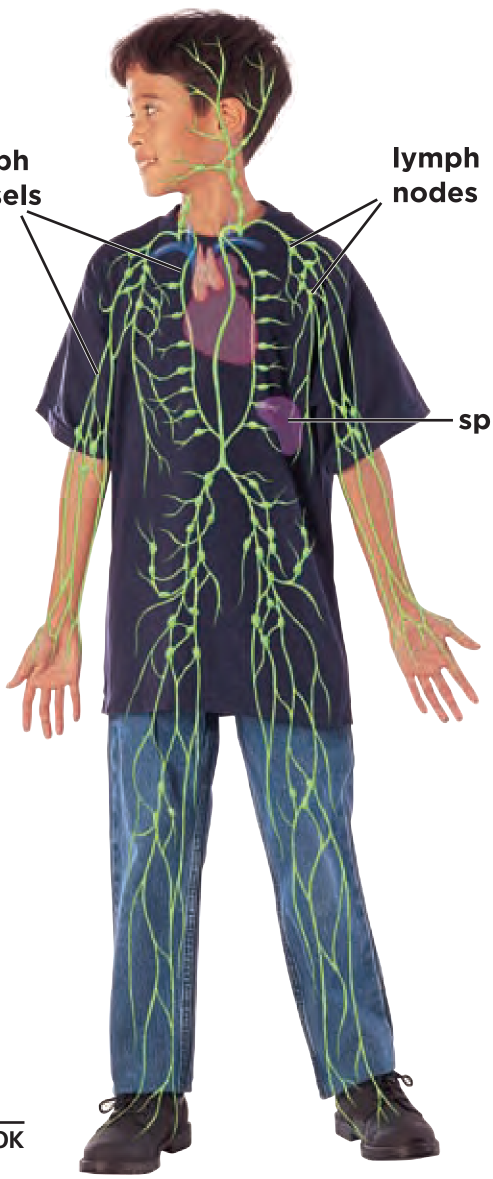
The Immune System

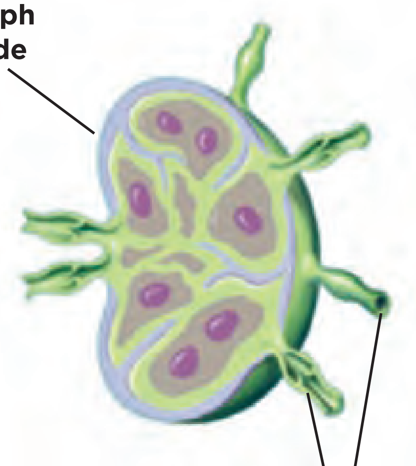
The immune system helps the body fight disease. A soft tissue known as red marrow fills the spaces in some bones. Red marrow makes new red blood cells, platelets that stop a cut from bleeding, and germ-fighting white blood cells.

There are white blood cells in the blood vessels and in the lymph vessels. Lymph vessels are similar to blood vessels. Instead of blood, they carry lymph. Lymph is a straw-colored fluid that surrounds body cells.

Lymph nodes filter out harmful materials in lymph. Like red marrow, they also produce white blood cells to fight infections. Swollen lymph nodes in the neck are a clue that the body is fighting germs.



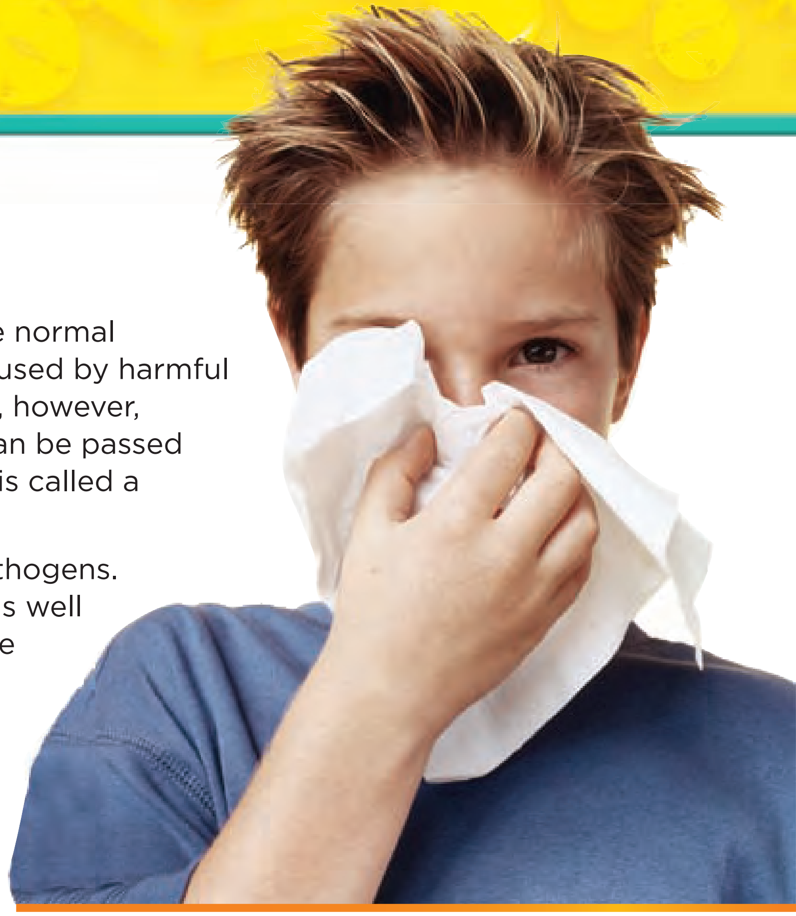




Communicable Diseases

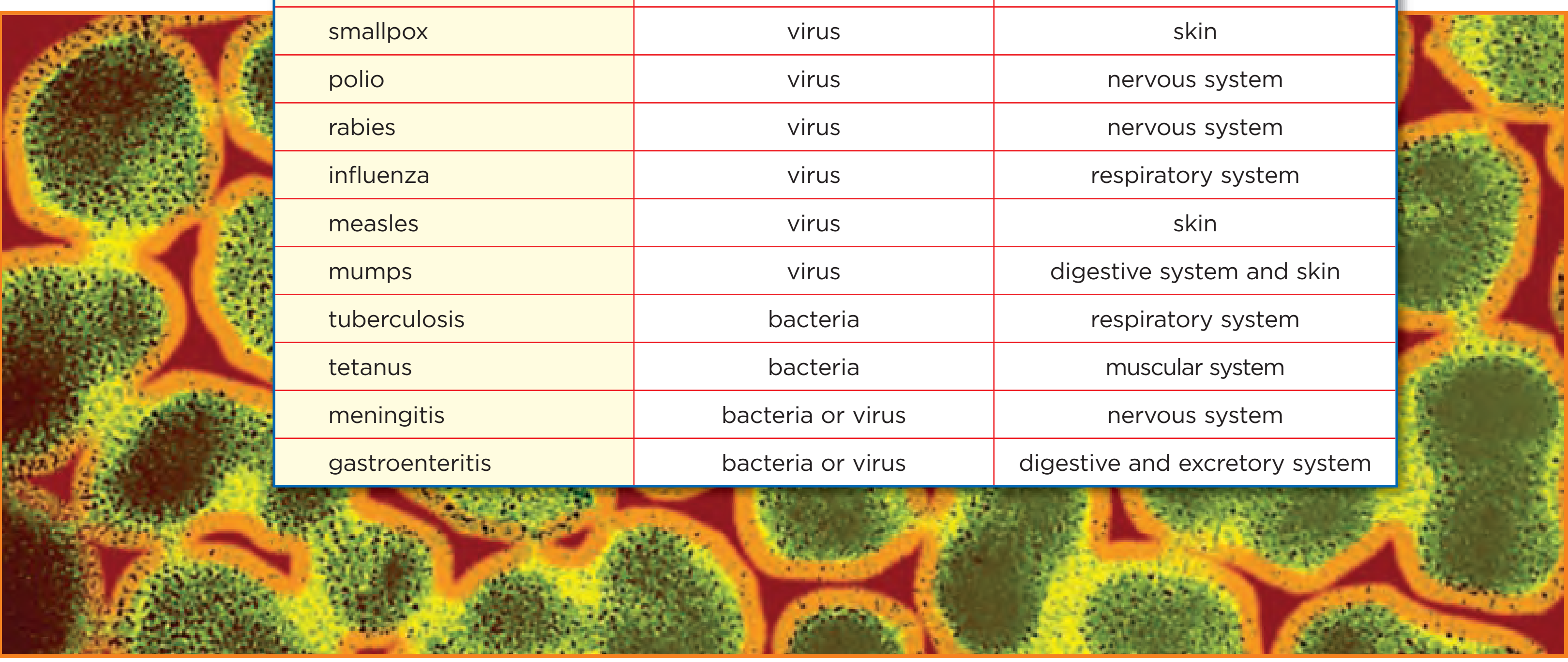
A disease is anything that interferes with the normal functions of the body. Some diseases are caused by harmful materials in the environment. Many diseases, however, are caused by microscopic organisms and can be passed from person to person. This type of disease is called a communicable or infectious disease.

Disease-causing organisms are called pathogens. Pathogens include many types of bacteria, as well as viruses. Diseases caused by pathogens are also called communicable diseases, because they can be passed from one person to another. Pathogens must enter the body before they can cause an illness. Once these invaders enter the body, the immune system works very hard to fight them off.



Human Infectious Diseases

Disease	Caused by	Organ System Affected
common cold	virus	respiratory system
chicken pox	virus	skin
smallpox	virus	skin
polio	virus	nervous system
rabies	virus	nervous system
influenza	virus	respiratory system
measles	virus	skin
mumps	virus	digestive system and skin
tuberculosis	bacteria	respiratory system
tetanus	bacteria	muscular system
meningitis	bacteria or virus	nervous system
gastroenteritis	bacteria or virus	digestive and excretory system



Human Body Systems

The Nervous System

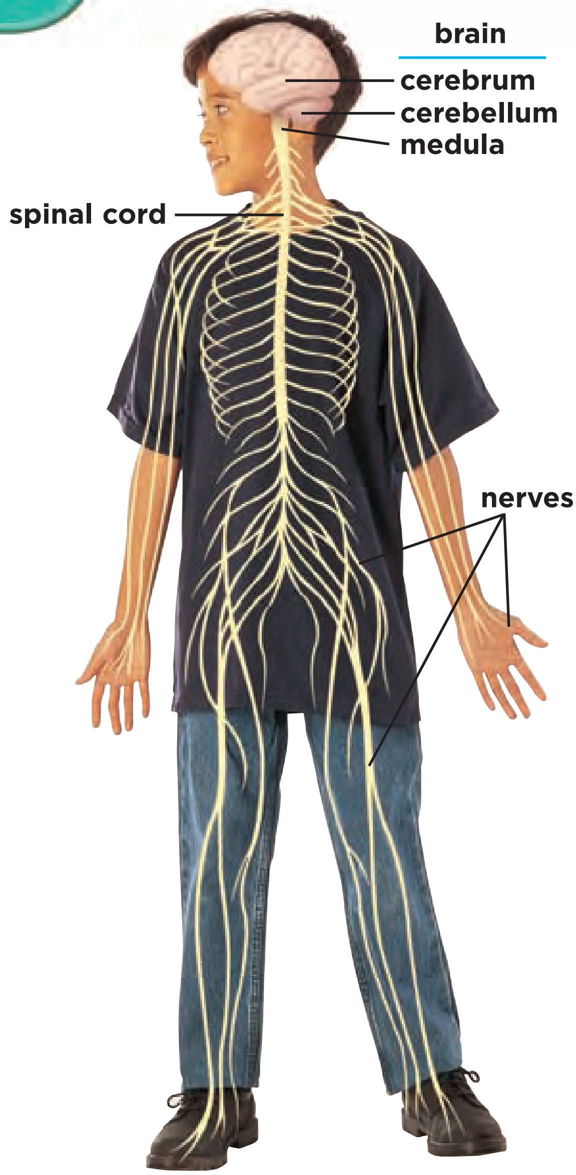
The nervous system has two parts. The brain and the spinal cord make up the central nervous system. All other nerves make up the outer, or peripheral, part of the nervous system.

The largest part of the human brain is the cerebrum. A deep groove separates the right half, or hemisphere, of the cerebrum from the left half. Both the right and left hemispheres of the cerebrum contain control centers for the senses. The cerebrum is the part of the brain where thought occurs.

The cerebellum lies below the cerebrum. It coordinates the skeletal muscles so they work smoothly together. It also helps in keeping balance.

The brain stem connects to the spinal cord. The lowest part of the brain stem is the medulla. It controls heartbeat, breathing, blood pressure, and the muscles in the digestive system.

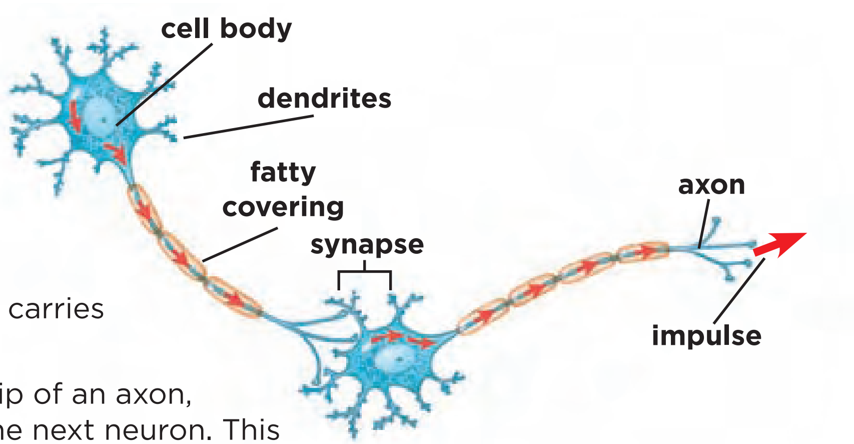
The spinal cord is a thick band of nerves that carries messages to and from the brain. Nerves branch off from your spinal cord to all parts of your body. The spinal cord also controls reflexes. A reflex is a quick reaction that occurs without waiting for a message to and from the brain. For example, if you touch something hot, you pull your hand away without thinking about it.



Parts of a Neuron

The nerves in the nervous system are made up of nerve cells called neurons. Each neuron has three main parts—a cell body, dendrites, and an axon. Dendrites are branching nerve fibers that carry impulses, or electrical signals, toward the cell body. An axon is a nerve fiber that carries impulses away from the cell body.

When an impulse reaches the tip of an axon, it must cross a tiny gap to reach the next neuron. This gap between neurons is called a synapse.



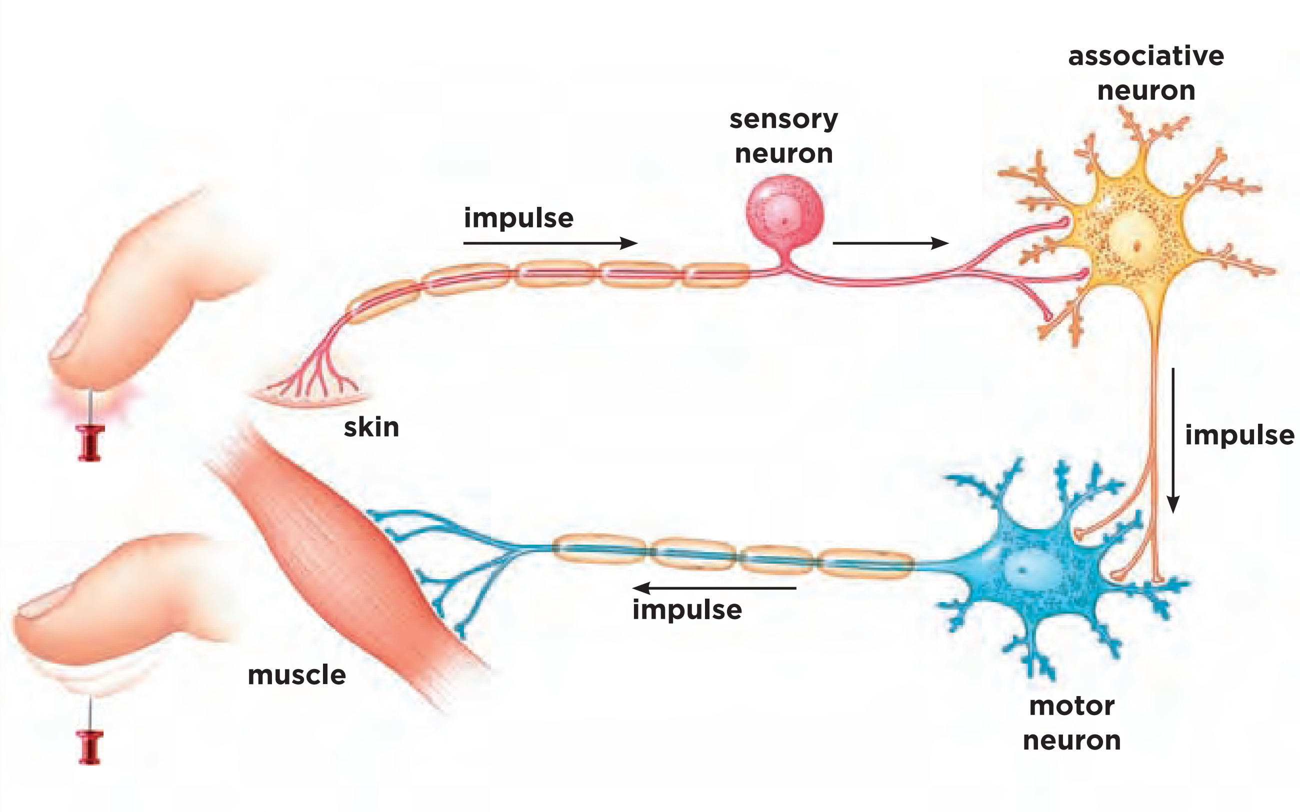
Stimulus and Response

The nervous system, the skeletal system, and the muscular system work together to help you adjust to your surroundings. Anything in the environment that requires your body to adjust is called a stimulus (plural: stimuli). A reaction to a stimulus is called a response.

As you learned, nerve cells are called neurons. There are three kinds of neurons: sensory, associative, and motor. Each kind does a different job to help your body respond to stimuli. Sensory neurons receive stimuli from your body and the environment. Associative neurons connect the sensory neurons to the motor neurons. Motor neurons carry signals from the central nervous system to the organs and glands.

In addition to responding to external stimuli, your body also responds to internal changes. Your body regulates its internal environment to maintain a stable condition for survival. This is called a steady-state condition.

Nerve Response

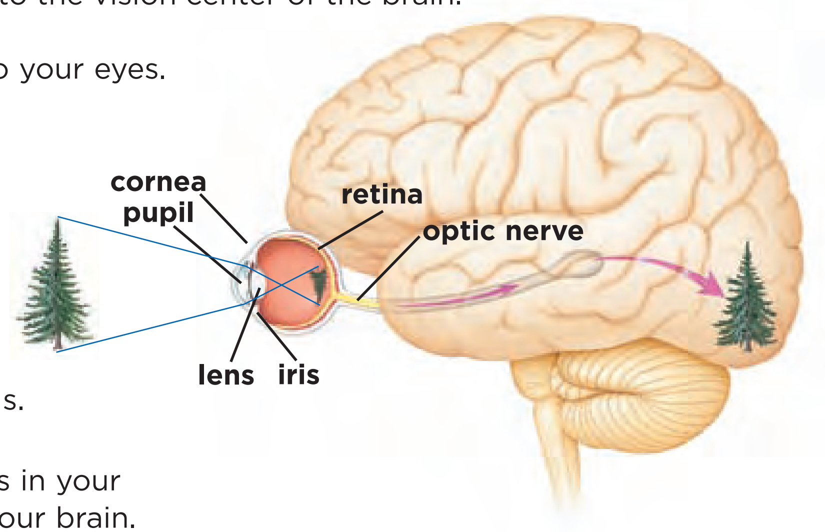


The Senses

Sense of Sight

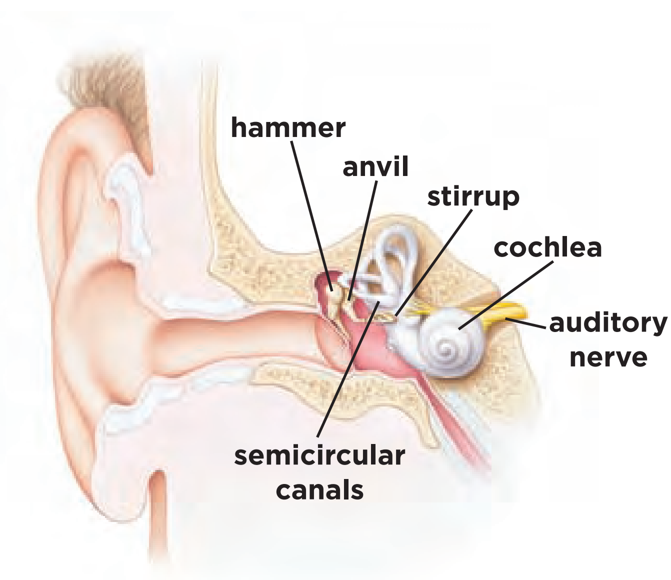
Light reflected from an object enters your eye and falls on the retina. Receptor cells change the light into electrical signals, or impulses. These impulses travel along the optic nerve to the vision center of the brain.

1. Light reflects off the tree and into your eyes.
2. The light passes through your cornea and the pupil in your iris.
3. The lens bends the light so that it hits your retina.
4. Receptor cells on your retina change the light into electrical signals.
5. The impulses travel along neurons in your optic nerve to the seeing center of your brain.



Sense of Hearing

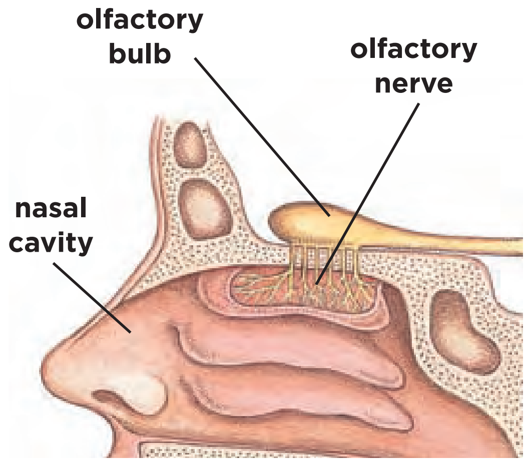
Sound waves enter your ear and cause the eardrum to vibrate. Receptor cells in your ear change the sound waves into impulses that travel along the auditory nerve to the hearing center of the brain.



1. Your outer ear collects sound waves.
2. They travel down your ear canal.
3. The eardrum vibrates.
4. Three tiny ear bones vibrate.
5. The cochlea vibrates.
6. Receptor cells inside your cochlea change.
7. The impulses travel along your auditory nerve to the brain's hearing center.

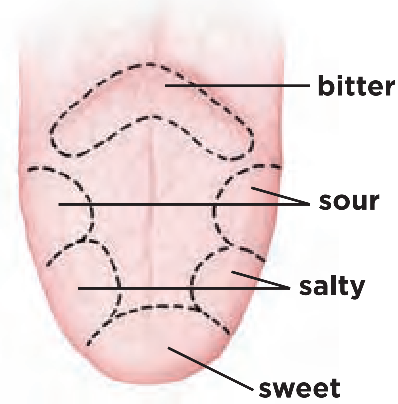
Sense of Smell

The sense of smell is really the ability to detect chemicals in the air. When you breathe, chemicals dissolve in mucus in the upper part of your nose or nasal cavity. When the chemicals come in contact with receptor cells, the cells send impulses along the olfactory nerve to the smelling center of the brain.



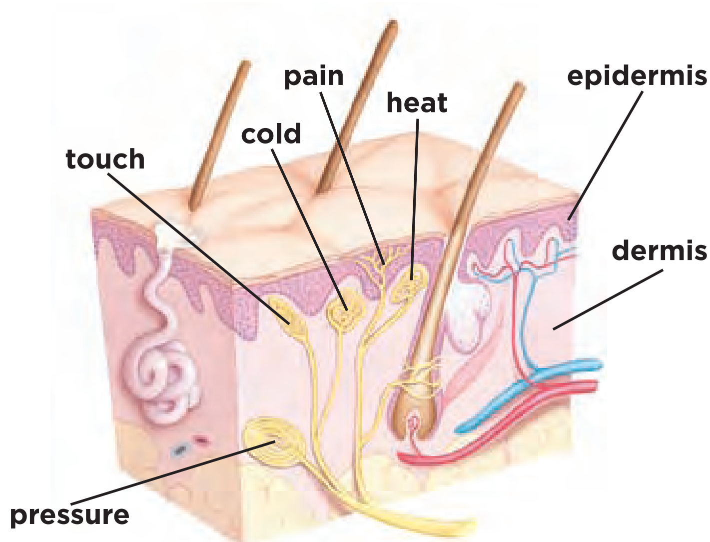
Sense of Taste

When you eat, chemicals in the food dissolve in saliva. Saliva carries the chemical to taste buds on the tongue. Inside each taste bud are receptors that can sense the four main tastes—sweet, sour, salty, and bitter. The receptors send impulses along a nerve to the taste center of the brain. The brain identifies the taste of the food, which is usually a combination of the four main taste categories.



Sense of Touch

Receptor cells in the skin help a person tell hot from cold, wet from dry. These can also tell the light touch of a feather or the pressure of stepping on a stone. Each receptor cell sends impulses along sensory nerves to the spinal cord. The spinal cord then sends the impulses to the touch center of the brain.

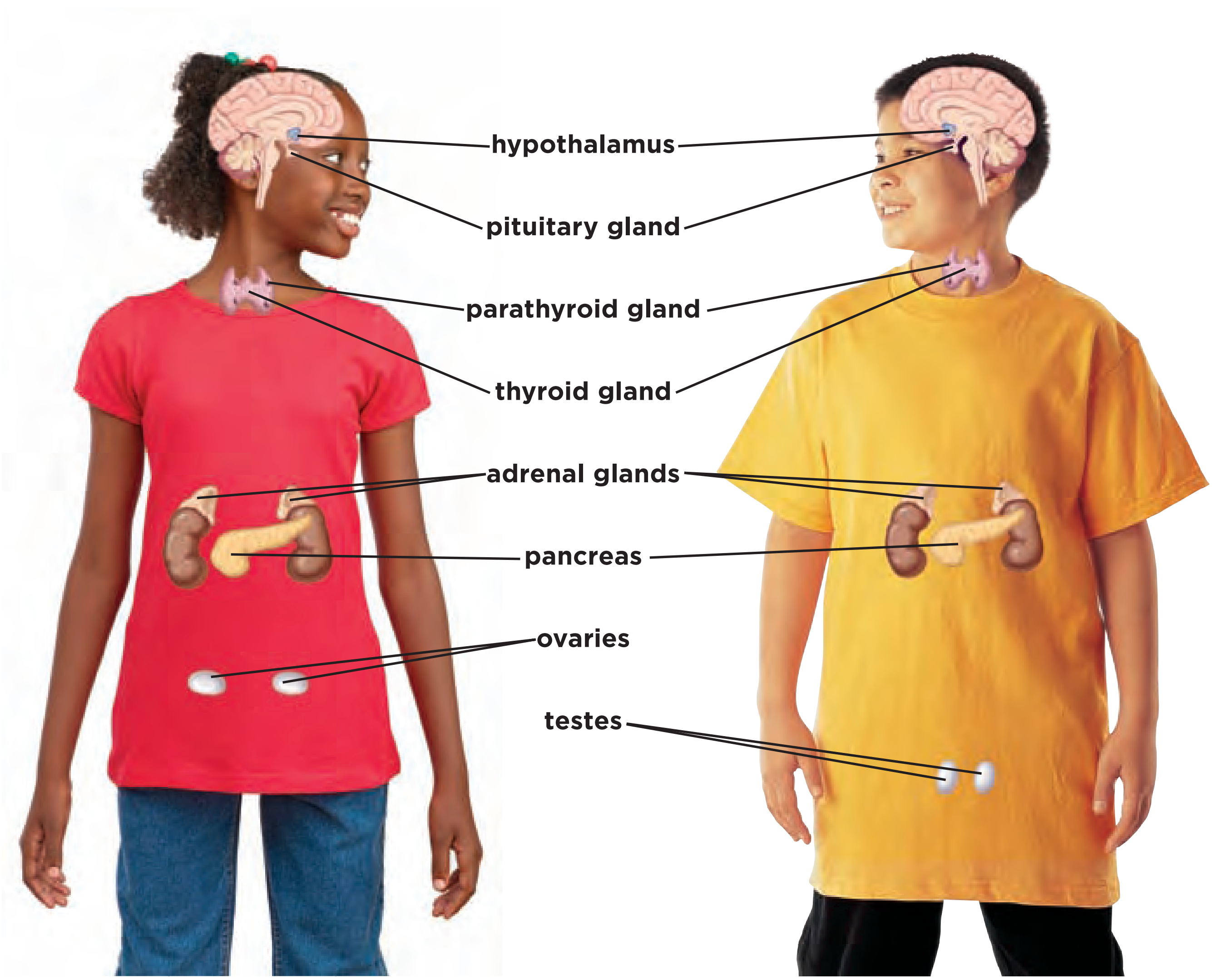


The Endocrine System

Hormones are chemicals that control body functions. An organ that produces hormones is called an endocrine gland.

The endocrine glands are scattered around the body. Each gland makes one or more hormones. Every hormone seeks out a target organ or organ system, the place in the body where the hormone acts. Changing levels of different hormones communicate important messages to target organs and organ systems.

The endocrine glands help to maintain a constant healthy condition in your body. These glands can turn the production of hormones on or off whenever your body produces too little or too much of a particular hormone.



FOLDABLES™

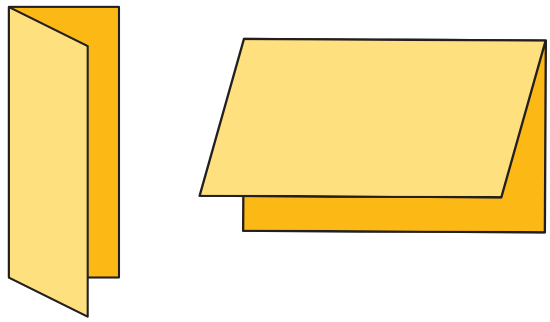
by Dinah Zike

Folding Instructions

The following pages offer step-by-step instructions to make the Foldables study guides.

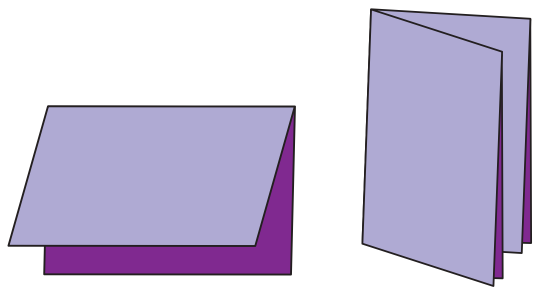
Half-Book

1. Fold a sheet of paper ($8\frac{1}{2}$" x 11") in half.
2. This book can be folded vertically like a hot dog or …
3. … it can be folded horizontally like a hamburger



Folded Book

1. Make a Half-Book.
2. Fold in half again like a hamburger. This makes a ready-made cover and two small pages inside for recording information.

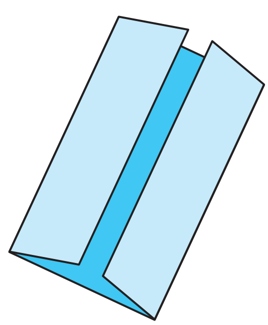


Pocket Book

1. Fold a sheet of paper ($8\frac{1}{2}$" x 11") in half like a hamburger.
2. Open the folded paper and fold one of the long sides up two inches to form a pocket. Refold along the hamburger fold so that the newly formed pockets are on the inside.
3. Glue the outer edges of the two-inch fold with a small amount of glue.

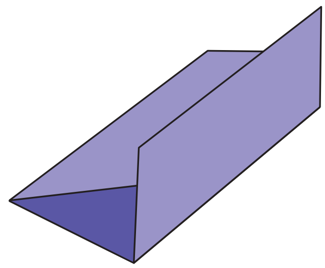
Shutter Fold

1. Begin as if you were going to make a hamburger, but instead of creasing the paper, pinch it to show the midpoint.
2. Fold the outer edges of the paper to meet at the pinch, or midpoint, forming a Shutter Fold.



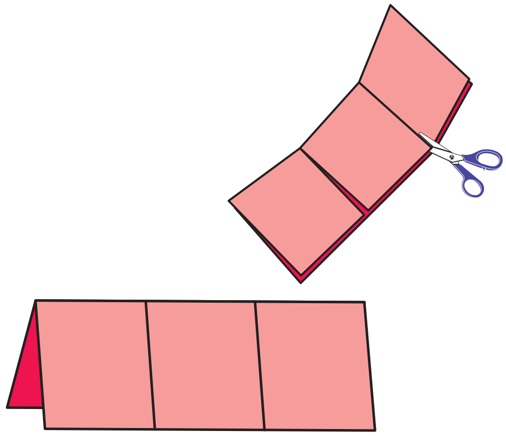
Trifold Book

1. Fold a sheet of paper ($8\frac{1}{2}$" x 11") into thirds.
2. Use this book as is, or cut into shapes.



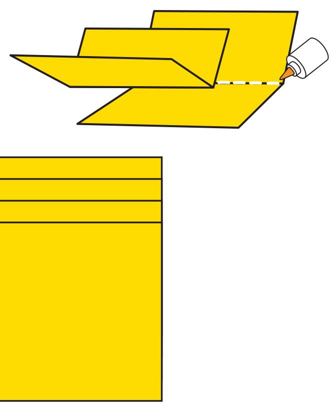
Three-Tab Book

1. Fold a sheet of paper like a hot dog.
2. With the paper horizontal and the fold of the hot dog up, fold the right side toward the center, trying to cover one half of the paper.
3. Fold the left side over the right side to make a book with three folds.
4. Open the folded book. Place one hand between the two thicknesses of paper and cut up the two valleys on one side only. This will create three tabs.



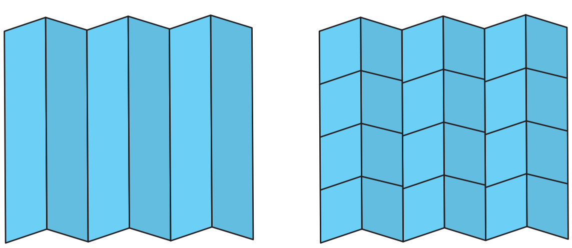
Layered-Look Book

1. Stack two sheets of paper ($8\frac{1}{2}$" x 11") so that the back sheet is one inch higher than the front sheet.
2. Bring the bottoms of both sheets upward and align the edges so that all of the layers or tabs are the same distance apart.
3. When all the tabs are an equal distance apart, fold the papers and crease well.
4. Open the papers and glue them together along the valley, or inner center fold, or staple them along the mountain.



Folded Table or Chart

1. Fold the number of vertical columns needed to make the table or chart.
2. Fold the horizontal rows needed to make the table or chart.
3. Label the rows and columns.



Glossary

Use this glossary to learn how to pronounce and understand the meanings of Science Words used in this book. Page numbers tell you where to find words in the book.

A

absolute age (ab′sə·lüt′ āj) A rock's age in years. (p. 200)

absorption (ab·sôrp′shən) The transfer of energy when a wave disappears into a surface. (p. 319)

adaptation (ad′əp·tā′shən) A characteristic that helps an organism to survive in its environment. (p. 96)

air pressure (âr presh′ər) The force put on a given area by the weight of the air above it. (p. 241)

alternating current (ôl′tər·nāt·ing kûr′ənt) Electric current that changes directions many times per second. (p. 362)

alternative energy source (ôl·tûr′nə·tiv en′ər·jē sôrs) A source of energy other than the burning of a fossil fuel. (p. 204)

amplitude (am′pli·tüd′) The height of a sound wave, which determines its volume. (p. 322)

angiosperm (an′jē·ə·spûrm′) A seed plant that produces flowers. (p. 39)

aquifer (ak′wə·fər) An underground layer of rock or soil filled with water. (p. 215)

asteroid (as′tə·roid′) One of many small, rocky objects between Mars and Jupiter. (p. 266)

asymmetrical (ā′si·met′ri·kəl) Cannot be divided into mirror images. (p. 52)

atmosphere (at′məs·fîr′) The layers of gases that surround Earth. (p. 182)

atom (at′əm) The smallest unit of an element that has the properties of that element. (p. 344)

B

benthos (ben′thos) Organisms that live on the bottom in aquatic ecosystems. (p. 150)

Pronunciation Key

The following symbols are used throughout the Macmillan/McGraw-Hill Science Glossaries.

a	**a**t	e	**e**nd	o	h**o**t	u	**u**p	hw	**wh**ite	ə	**a**bout
ā	**a**pe	ē	m**e**	ō	**o**ld	ū	**u**se	ng	so**ng**		tak**e**n
ä	f**a**r	i	**i**t	ôr	**f**o**r**k	ü	r**u**le	th	**th**in		penc**i**l
â	c**a**re	ī	**i**ce	oi	**oi**l	ů	p**u**ll	<u>th</u>	**th**is		lem**o**n
ô	l**a**w	îr	p**ier**ce	ou	**ou**t	ûr	t**ur**n	zh	mea**s**ure		circ**u**s

′ = primary accent; shows which syllable takes the main stress, such as **kil** in **kilogram** (kil**′** ə gram′).

′ = secondary accent; shows which syllables take lighter stresses, such as **gram** in **kilogram**.

bilateral symmetry (bī·lat′ər·əl sim′ə·trē) A body plan in which an organism can be divided along only one plane of its body to produce two mirror images. (p. 53)

biome (bī′ōm) One of Earth's large ecosystems, with its own kind of climate, soil, plants, and animals. (p. 138)

black hole (blak hōl) An object whose gravity is so strong that light cannot escape it. (p. 276)

C

cambium (kam′bē·əm) The layer in plants that separates the xylem from the phloem. (p. 43)

camouflage (kam′ə·fläzh′) An adaptation in which an animal protects itself against predators by blending in with the environment. (p. 101)

carbon cycle (kär′bən sī′kəl) The continuous exchange of carbon dioxide and oxygen among living things. (p. 116)

carrying capacity (kar′ē·ing kə·pas′i·tē) The maximum population size that an ecosystem can support. (p. 85)

cell (sel) The smallest unit of living matter. (p. 26)

cellular respiration (sel′yə·lər res′pə·rā′shun) The process in which energy is released from food (sugar) inside a cell. (p. 46)

chlorophyll (klôr′ə·fil′) A green chemical in plant cells that allows plants to use the Sun's energy to make food. (p. 31)

circuit (sûr′kit) A loop formed when electric current passes through an unbroken path of conductors. (p. 348)

climax community (klī′maks kə·mū′ni·tē) The final stage of succession in an area, unless a major change happens. (p. 131)

comet (kom′it) A mixture of ice, frozen gases, rock, and dust left over from the formation of the solar system. (p. 266)

commensalism (kə·men′sə·liz·əm) A relationship between two kinds of organisms that benefits one without harming the other. (p. 89)

community (kə·mū′ni·tē) All the living things in an ecosystem. (p. 71)

compost (kom′pōst) A mixture of dead plant material that can be used as fertilizer. (p. 120)

condensation (kon′den·sā′shən) The changing of a gas into a liquid. (p. 114)

conduction (kən·duk′shən) The passing of heat through a material while the material itself stays in place. (p. 306)

conservation (kon′sər·vā′shən) Saving, protecting, or using natural resources wisely. (p. 192)

constellation (kon′stə·lā′shən) Any of the patterns formed by groups of stars in the night sky. To people in the past, these patterns looked like pictures of animals or people. (p. 278)

convection (kən·vek′shən) The flow of heat through a liquid or gas, caused by hot parts rising and cooler parts sinking. (p. 306)

crust (krust) The rocky surface that makes up the top of the lithosphere and includes the continents and the ocean floor. (p. 182)

D

deciduous forest (di·sij′ü·əs fôr′ist) A forest biome with many kinds of trees that lose their leaves each autumn. (p. 143)

desert (dez′ər t) A sandy or rocky biome, with little precipitation and little plant life. (p. 139)

E

echolocation (ek′ō·lō·kā′shə n) Finding an object by using reflected sound. (p. 324)

ecosystem (ēk′ō·sis′tə m) All the living and nonliving things in an environment, including their interactions with each other. (p. 70)

electric current (i·lek′trik kûr′ə nt) A flow of electricity through a conductor. (p. 348)

electricity (i·lek·tris′i·tē) The movement of electrons. (p. 346)

electromagnet (i·lek′trō·mag′nit) An electric circuit that produces a magnetic field. (p. 360)

electromagnetism (i·lek′trō·mag′ni·tiz′ə m) The way electric and magnetic forces interact. (p. 338)

electron (i·lek′tron) A particle in the space outside the nucleus of an atom that carries one unit of negative electric charge. (p. 345)

element (el′ə·mə nt) A pure substance that cannot be broken down into any simpler substances through chemical reactions. (p. 344)

endangered species (en·dān′jə rd spē′shēz) A species that is in danger of becoming extinct. (p. 129)

energy (en′ə r·jē) The ability to perform work or change an object. (p. 302)

energy pyramid (en′ə r·jē pir′ə·mid′) A diagram that shows the amount of energy available at each level of an ecosystem. (p. 76)

era (îr′ə) Long stretches of time used to measure Earth's geological history. (p. 201)

estuary (es′chü·er·ē′) The boundary where a freshwater ecosystem meets a saltwater ecosystem. (p. 156)

evaporation (i·vap′ə·rā′shə n) The change of a liquid into a gas below the boiling point. (p. 114)

extinct species (ek·stingkt′ spē′shēz) A species that has died out completely. (p. 128)

F

food chain (füd chān) The path that energy and nutrients follow in an ecosystem. (p. 72)

food web (füd web) The overlapping food chains in an ecosystem. (p. 74)

fossil (fos′əl) Any remains or imprint of living things from the past. (p. 198)

fossil fuel (fos′əl fū′əl) A fuel formed from the decay of ancient forms of life. (p. 199)

frequency (frē′kwən·sē) The number of times an object vibrates per second. (p. 320)

G

galaxy (gal′ək·sē) A collection of billions of stars. (p. 281)

generator (jen′ə·rā′tər) A device that creates electric current by spinning an electric coil between the poles of a magnet. (p. 362)

grassland (gras'land') A biome where grasses, not trees, are the main plant life. (p. 144)

gravity (grav′i·tē) The force of attraction between any two objects due to their mass. (p. 234)

grounding (ground′ing) Connecting an object to Earth with a conducting wire to prevent the buildup of static electricity. (p. 347)

groundwater (ground′wô′tər) Precipitation that seeps into the ground and is stored in tiny holes, or pores, in soil and rocks. (p. 114)

gymnosperm (jim′nə·spûrm′) A seed plant that does not produce flowers. (p. 39)

H

habitat (hab′i·tat) The place where a plant or animal lives and grows. (p. 86)

heat (hēt) The flow of thermal energy between objects due to a difference in temperature. (p. 304)

humus (hū′məs) Decayed plant or animal material in soil. (p. 189)

hydrosphere (hī′drə·sfîr′) Earth's water, whether found on continents or in oceans, including the fresh water in ice, lakes, rivers, and underground. (p. 182)

I

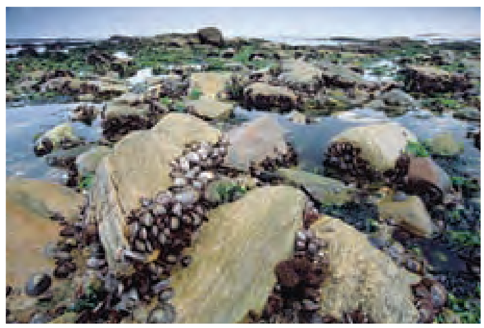
image (im′ij) A "picture" of the light source that light rays make in bouncing off a polished, shiny surface. (p. 334)

inertia (i·nûr′shə) The tendency of a moving object to keep moving in a straight line or of any object to resist a change in motion. (p. 235)

inner core (in′ər kôr) A solid layer of iron and nickel inside Earth. (p. 182)

insolation (in′sə·lā′shən) The amount of the Sun's energy that reaches Earth. (p. 238)

intertidal zone (in′tər·tī′dəl zōn) The shallowest part of the ocean ecosystem, where the ocean floor is covered and uncovered as the tide goes in and out. (p. 154)



K

kinetic energy (ki·net′ik en′ər·jē) The energy of a moving object. (p. 302)

L

landform (land′fôrm′) A physical feature on Earth's surface. (p. 176)

light-year (līt′yîr′) The distance light travels in a year. (p. 279)

limiting factor (lim′it·ing fak′tər) Anything that controls the growth or survival of a population. (p. 84)

lunar eclipse (lü′nər i·klips′) A situation that occurs when the Sun, Earth, and Moon are in a straight line and Earth's shadow falls across the Moon. (p. 251)

M

magnetic field (mag·net′ik fēld) A region of magnetic force around a magnet, represented by lines. (p. 359)

magnetic levitation (mag·net′ik lev′i·tā′shən) The lifting of an object by means of magnetic forces. (p. 364)

magnetism (mag′ni·tiz′əm) The ability of an object to push or pull on another object that has the magnetic property. (p. 358)

mantle (man′təl) A nearly melted layer of hot rock below Earth's crust. (p. 182)

marsupial (mär·sü′pē·əl) A mammal in which the female has a pouch where offspring develop after birth. (p. 58)

matter (mat′ər) Anything that has mass and takes up space. (p. 344)

medium (mē′·dē·əm) Substance through which a wave travels. (p. 317)

meteor (mē′tē·ər) A chunk of rock from space that travels through Earth's atmosphere. (p. 267)

mimicry (mim′i·krē) An adaptation in which an animal is protected against predators by its resemblance to another, unpleasant animal. (p. 102)

monotreme (mon′ə·trēm′) A mammal that lays eggs. (p. 58)

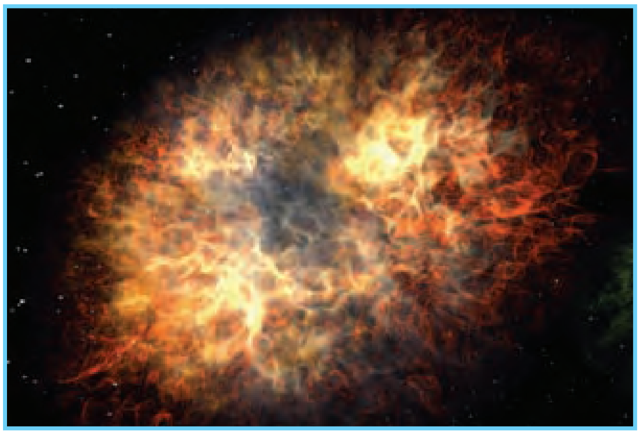
moon (mün) A natural object that orbits a planet. (p. 264)

multicellular (mul′ti·sel′yə·lər) Many-celled organism. (p. 27)

mutualism (mū′chü·ə·liz′əm) A relationship between two kinds of organisms that benefits both. (p. 88)

N

nebula (neb′ye·lə) A huge cloud of gas and dust in space that is the first stage of star formation. (p. 274)



nekton (nek′ton) Organisms that swim through the water in aquatic ecosystems. (p. 150)

neutron (nüū′tron) A particle in the nucleus of an atom that has no net electric charge. (p. 345)

niche (nich) The role of an organism in an ecosystem. (p. 86)

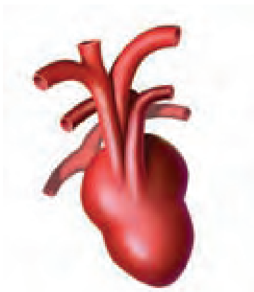
nitrogen cycle (nī′trə jən sī′kəl) The continuous trapping of nitrogen gas into compounds in the soil and its return to the air. (p. 118)

nonrenewable resource (non′ri·nü′ə·bəl rē′sôrs′) A resource that cannot be replaced within a short period of time or at all. (p. 203)

nucleus (nü′klē·əs) The center of an atom that has most of its mass. (p. 345)

O

orbit (ôr′bit) The path one object travels around another object. (p. 235)



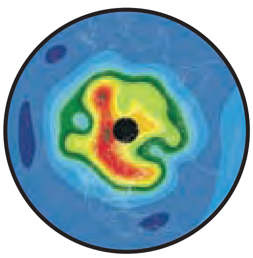
organ (ôr′gən) A group of tissues working together to do a certain job. (p. 32)

organ system (ôr′gən sis′təm) A group of organs that work together to do a certain job. (p. 32)

organism (ōr′gə·niz·əm) An y living thing that can carry out its life on its own. (p. 26)

outer core (ou′tər kôr) A liquid layer of iron and nickel below Earth's mantle. (p. 182)

ozone (ō′zōn) A form of oxygen gas that makes a layer in the atmosphere that screens out much of the Sun's ultraviolet rays. (p. 220)



P

parasitism (par′ə·sī·tiz′əm) A relationship in which one organism lives in or on another organism and benefits from that relationship while the host organism is harmed by it. (p. 90)

phase (fāz) The appearance of the shape of the Moon at a particular time. (p. 248)

phloem (flō′em) The tissue through which food from the leaves moves throughout the rest of a plant. (p. 43)

photon (fō′ton) A tiny bundle of energy through which light travels. (p. 331)

photosynthesis (fō′tə sin′thə sis) The food-making process in green plants that uses sunlight. (p. 44)

pioneer community (pī′ə·nîr′ cə·mü′ni·tē) The first community living in a lifeless area. (p. 130)

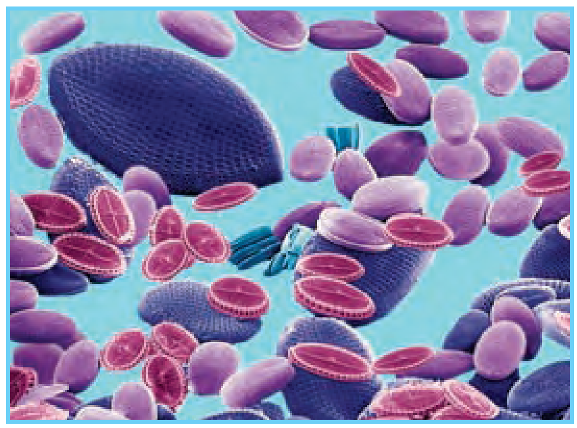
pioneer species (pī′ə·nîr′ spē′shēz) The first species living in an otherwise lifeless area. (p. 130)

pitch (pich) How high or low a sound is. (p. 320)

placental mammal (plə·sen′təl mam′əl) A mammal whose young develops within the mother. (p. 58)

planet (plan′it) A large object that orbits a star and does not produce its own light. (p. 260)

plankton (plangk′tən) Organisms that float on the water in aquatic ecosystems and are unable to swim. (p. 150)



pollution (pə·lü′shən) The addition of harmful substances to the environment. (p. 191)

population (pop′yə·lā′shən) All the members of one species in an area. (p. 71)

potential energy (pə·ten′shəl en′ər·jē) Energy stored in the position or structure of an object. (p. 302)

precipitation (pri sip′i tā′shə n) Any form of water that falls from the atmosphere and reaches the ground. (p. 114)

predator (pred′ə tə r) An animal that hunts other animals for food. (p. 75)

prey (prā) A living thing that is hunted for food. (p. 75)

primary succession (prī′mer·ē sə k·sesh′ə n) The beginning of a community where few, if any, living things exist, or where earlier communities were wiped out. (p. 130)

prism (priz′ə m) A cut piece of clear glass (or plastic) with two opposite sides in the shape of a triangle or other geometric shape. (p. 336)

protective coloration (prə·tek′tiv kul′ə·rā′shə n) A type of camouflage in which the color of an animal blends in with its background, protecting the animal against predators. (p. 101)

protective resemblance (prə·tek′tiv ri·zem′blə ns) A type of camouflage in which the color and shape of an animal blends in with its background, protecting it against predators. (p. 101)

proton (prō′ton) A particle in the nucleus of an atom that carries one unit of positive electric charge. (p. 345)

R

radial symmetry (rā′dē·ə l sim′ə·trē) A body plan in which all body parts of an organism are arranged around a central point. (p. 52)

radiation (rā′dē·ā′shə n) The transfer of heat through electromagnetic rays. (p. 306)

refraction (ri·frak′shə n) The bending of waves as they pass from one substance into another. (p. 335)

relative age (rel′ə·tiv āj) The age of one rock or fossil as compared to another. (p. 200)

relief map (ri·lēf′ map) A map that shows the elevation of an area using colors or shading. (p. 180)

renewable resource (ri·nü′ə·bə l rē′sôrs′) A resource that can be replanted or replaced naturally in a short period of time. (p. 203)

reservoir (rez′ə r·vwär′) A storage area for fresh water. (p. 215)

resistor (ri·zis′tə r) An object in an electrical circuit that resists the flow of electrons. (p. 348)

revolution (rev′ə·lü′shə n) One complete trip of one object around another object. (p. 236)

rotation (rō·tā′shə n) A complete spin on an axis. (p. 242)

runoff (run′ôf′) Precipitation that flows across the land's surface or falls into rivers and streams. (p. 114)

S

satellite (sat′ə·līt) A natural or artificial object in space that circles around another object. (p. 264)

secondary succession (sek′ən der′ē sək·sesh′ən) The beginning of a new community where an earlier community already exists. (p. 132)

smog (smog) A type of air pollution formed by particles produced by burning fossil fuels. (p. 220)

soil (soil) A mixture of bits of rock and bits of once-living plants and animals. (p. 188)

soil horizon (soil hə·rī′zən) Any of the layers of soil from the surface to the bedrock. (p. 189)

solar eclipse (sō′lər i·klips′) A blocking of the Sun's light that happens when Earth passes through the Moon's shadow. (p. 251)

sound wave (sound wāv) A series of rarefactions and compressions traveling through a substance. (p. 317)

spectrum (spek′trəm) A band of colors produced when light goes through a prism. (p. 336)

star (stär) An object in space that produces its own energy, including heat and light. (p. 274)

static electricity (stat′ik i·lek·tris′i·tē) The buildup of charged particles. (p. 346)

succession (sək·sesh′ən) The process of one ecosystem changing into a new and different ecosystem. (p. 130)

supernova (sü′pər·nō′və) A star that has produced more energy than gravity can hold together and explodes. (p. 276)

symbiosis (sim′bī·ō′sis) A relationship between two kinds of organisms over time. (p. 88)

T

taiga (tī′gə) A cool forest biome of conifers in the upper northern hemisphere. (p. 141)

telescope (tel′ə·skōp′) An instrument that makes distant objects appear closer and larger. (p. 258)

temperate rain forest (tem′pər·it rān fôr′ist) A biome with a lot of rain and a cool climate. (p. 142)

temperature (tem′pər·ə·chər) A measurement of the average energy of particles in an object. (p. 304)

thermal conductivity (thûr′məl kon′duk·tiv′i·tē) The ability of a material to transfer heat. (p. 308)

thermal energy (thûr′məl en′ər·jē) The energy due to the motion of particles in matter. (p. 304)

threatened species (thret′ənd spē′shēz) A species that is in danger of becoming endangered. (p. 129)

tide (tīd) The regular rise and fall of the water level along a shoreline. (p. 252)

tissue (tish′ü) A group of similar cells that work together at the same job. (p. 32)

topographical map (top′ə·graf′i·kəl map) A map that shows the elevation of an area of Earth's surface using contour lines. (p. 181)

topsoil (top′soil′) The dark, top layer of soil, rich in humus and minerals, in which organisms live and most plants grow. (p. 189)

translucent (trans·lü′sənt) Blurring light as it passes through. (p. 332)

transpiration (tran′spə·rā′shən) The loss of water through a plant's leaves. (p. 44)

tropical rain forest
(trop′i·kəl rān fôr′ist) A hot, humid biome near the equator, with much rainfall and a wide variety of life. (p. 142)

troposphere (trop′ə·sfîr′) The atmospheric layer of gases that is closest to Earth's surface. (p. 240)

tundra (tun′drə) A large, treeless plain in the arctic regions, where the ground is frozen all year. (p. 140)

U

unicellular (ū′nə·sel′yə·lər) One-celled organism. (p. 27)

V

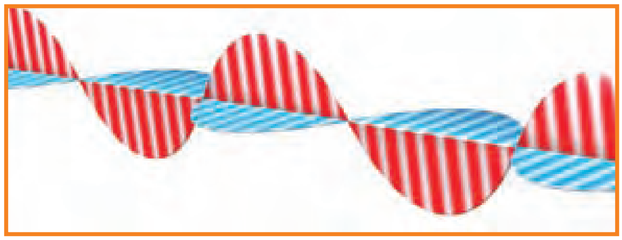
vacuum (vak′ū·əm) A space which contains little or no matter. (p. 318)

W

water cycle (wô′tər sī′kəl) The continuous movement of water between Earth's surface and the air, changing from liquid to gas to liquid. (p. 114)

watershed (wô′tər·shed′) Area from which water is drained; a region that contributes water to a river or river system. (p. 114)

wavelength (wāv′lengkth) The distance from one peak to the next on a wave. (p. 330)



weather (weth′ər) What the troposphere is like at any given place and time. (p. 240)

white dwarf (hwīt dwôrf) A star that can no longer turn helium into carbon; it cools and shrinks, becoming very small and dense. (p. 275)

work (wûrk) The measurement of the energy used to perform a task. (p. 302)

X

xylem (zī′ləm) The tissue through which water and minerals move up through a plant. (p. 43)

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Note: Page references followed by an asterisk (*) indicate activities.

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Science Content Standards

Ohio Science Benchmarks – Grades 3-5

Earth and Space Sciences (ESS)

A. Explain the characteristics, cycles and patterns involving Earth and its place in the solar system.

B. Summarize the processes that shape Earth's surface and describe evidence of those processes.

C. Describe Earth's resources including rocks, soil, water, air, animals and plants and the ways in which they can be conserved.

D. Analyze weather and changes that occur over a period of time.

Life Sciences (LS)

A. Differentiate between the life cycles of different plants and animals.

B. Analyze plant and animal structures and functions needed for survival and describe the flow of energy through a system that all organisms use to survive.

C. Compare changes in an organism's ecosystem/habitat that affect its survival.

Physical Sciences (PS)

A. Compare the characteristics of simple physical and chemical changes.

B. Identify and describe the physical properties of matter in its various states.

C. Describe the forces that directly affect objects and their motion.

D. Summarize the way changes in temperature can be produced and thermal energy transferred.

E. Trace how electrical energy flows through a simple electrical circuit and describe how the electrical energy can produce thermal energy, light, sound and magnetic forces.

F. Describe the properties of light and sound energy.

Science and Technology (ST)

A. Describe how technology affects human life.

B. Describe and illustrate the design process.

Scientific Inquiry (SI)

A. Use appropriate instruments safely to observe, measure, and collect data when conducting a scientific investigation.

B. Organize and evaluate observations, measurements and other data to formulate inferences and conclusions.

C. Develop, design and safely conduct scientific investigations and communicate the results.

Scientific Ways of Knowing (SWK)

A. Distinguish between fact and opinion and explain how ideas and conclusions change as new knowledge is gained.

B. Describe different types of investigations and use results and data from investigations to provide the evidence to support explanations and conclusions.

C. Explain the importance of keeping records of observations and investigations that are accurate and understandable.

D. Explain that men and women of diverse countries and cultures participate in careers in all fields of science.

Grade Level Indicators – Grade 5

Earth and Space Sciences (ESS)

The Universe

1. Describe how night and day are caused by Earth's rotation.
2. Explain that Earth is one of several planets to orbit the sun, and that the moon orbits Earth.
3. Describe the characteristics of Earth and its orbit about the sun (e.g., three–fourths of Earth's surface is covered by a layer of water [some of it frozen], the entire planet surrounded by a thin blanket of air, elliptical orbit, tilted axis and spherical planet).
4. Explain that stars are like the sun, some being smaller and some larger, but so far away that they look like points of light.

Earth Systems

5. Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely.
6. Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained.

Life Sciences (LS)

Diversity and Interdependence of Life

1. Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis.
2. Explain how almost all kinds of animals' food can be traced back to plants.
3. Trace the organization of simple food chains and food webs (e.g., producers, herbivores, carnivores, omnivores and decomposers).
4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.
5. Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the ecosystem.
6. Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental (e.g., beaver ponds, earthworm burrows, grasshoppers eating plants, people planting and cutting trees and people introducing a new species).

Physical Sciences (PS)

Nature of Energy

1. Define temperature as the measure of thermal energy and describe the way it is measured.
2. Trace how thermal energy can transfer from one object to another by conduction.
3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.
4. Trace how electrical current travels by creating a simple electric circuit that will light a bulb.
5. Explore and summarize observations of the transmission, bending (refraction) and reflection of light.
6. Describe and summarize observations of the transmission, reflection, and absorption of sound.
7. Describe that changing the rate of vibration can vary the pitch of a sound.

Sciences and Technology (ST)

Understanding Technology

1. Investigate positive and negative impacts of human activity and technology on the environment.

Abilities To Do Technological Design

2. Revise an existing design used to solve a problem based on peer review.
3. Explain how the solution to one problem may create other problems.

Scientific Inquiry (SI)

Doing Scientific Inquiry

1. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others (e.g., thermometers, timers, balances, spring scales, magnifiers, microscopes and other appropriate tools).
2. Evaluate observations and measurements made by other people and identify reasons for any discrepancies.
3. Use evidence and observations to explain and communicate the results of investigations.
4. Identify one or two variables in a simple experiment.
5. Identify potential hazards and/or precautions involved in an investigation.
6. Explain why results of an experiment are sometimes different (e.g., because of unexpected differences in what is being investigated, unrealized differences in the methods used or in the circumstances in which the investigation was carried out, and because of errors in observations).

Scientific Ways of Knowing (SWK)

Nature of Science

1. Summarize how conclusions and ideas change as new knowledge is gained.
2. Develop descriptions, explanations and models using evidence to defend/support findings.
3. Explain why an experiment must be repeated by different people or at different times or places and yield consistent results before the results are accepted.
4. Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer (e.g., observations of things or events in nature, data collection and controlled experiments).

Ethical Practices

5. Keep records of investigations and observations that are understandable weeks or months later.

Science and Society

6. Identify a variety of scientific and technological work that people of all ages, backgrounds and groups perform.

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