

**HOLT** CALIFORNIA   
**Earth**  
**Science**

**Interactive Reader  
and Study Guide**



**HOLT, RINEHART AND WINSTON**

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SECTION 1 **Thinking Like a Scientist**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What qualities do all good scientists have?
- Why is it important for scientists to be ethical?
- What are ways you can think like a scientist every day?

**What Makes a Good Scientist?**

You may notice things that happen throughout the day. Why does the firetruck sound like it has a higher pitch just as it passes by? How do clouds form? When you observe things around you and ask questions, you are acting like a scientist.

There are several features that all good scientists have. Scientists are curious. They do not like to accept facts without proof. Scientists are also open-minded, creative, and ethical.

It is important for scientists not to give up. The inventor Thomas Edison once said that he never failed. Instead, he just found 10,000 ways that did not work. ✓

**CURIOSITY**

Scientists are curious about the world around them. An example of a scientist whose curiosity led her to make important discoveries is Jane Goodall.

Jane Goodall wanted to know about where chimpanzees lived, what they ate, and how they behaved. She has spent years studying chimpanzees. Her studies have helped other scientists to know more about chimpanzees and other primates.



Jane Goodall has studied chimpanzees for more than 40 years. Her curiosity has helped her, and other scientists, to learn a lot about chimpanzees.

**STUDY TIP**

**Summarize** As you read, keep a list of the different features that good scientists have. When you are finished reading, write a paragraph or two telling why each feature is important to a good scientist.

**READING CHECK**

**1. Identify** Name three qualities that good scientists have.

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**TAKE A LOOK**

**2. Describe** How did Jane Goodall’s curiosity help scientists learn about chimpanzees?

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**SECTION 1** Thinking Like a Scientist *continued*

**READING CHECK**

**3. Define** What does *skepticism* mean? Give an example of a time when you were skeptical.

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**TAKE A LOOK**

**4. Explain** How did Rachel Carson show the quality of skepticism?

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**SKEPTICISM**

**Skepticism** is the practice of questioning accepted ideas or claims. All good scientists are skeptical. They look for proof before they believe new information. ✓

Skepticism helped scientist Rachel Carson to discover a major threat to the environment. Rachel Carson was a biologist in the 1950s. At that time, many new chemicals were being used to kill insects.

The companies that made the chemicals said that the chemicals would hurt only insects. Carson was skeptical. She wanted proof that the chemicals wouldn't hurt other living things.

Carson did a lot of research on the chemicals. She found that some of the chemicals were harmful to birds. Because of her work, a chemical called DDT was banned from use. Many kinds of birds were saved from harm by her work.



Rachel Carson helped save bald eagles and other birds. She showed skepticism by questioning the claims of chemical makers.

**OPEN-MINDEDNESS**

Keeping an open mind means being willing to consider new ideas. This can be hard to do. Most people have a very hard time believing in ideas that are different from what they believe. Scientists should be open to new ideas, even if the ideas are different from what the scientists are used to.

Sometimes, considering a different idea can help a scientist to make an important new discovery. A famous astronomer, Nicolaus Copernicus, lived in the 1400s. At that time, most scientists believed that the Earth was the center of the universe. But Copernicus studied the stars very closely. Based on his observations, he realized that Earth revolved around the sun.

**Say It**

**Investigate** Find out more about Copernicus or another scientist whose unpopular ideas changed science. Present your findings to your class or a small group.

**SECTION 1** Thinking Like a Scientist *continued*

**CREATIVITY**

Another feature scientists have is creativity. They use their imaginations to think about the world in new ways. For example, Andy Michael is a scientist who uses his imagination to connect earthquakes to music! ✓

Andy Michael is a scientist who studies earthquakes. He also plays the trombone. He realized that the stress building up inside the Earth is like the beat in a song. He wrote a song called “Earthquake Quartet #1.” He used the music to show how stress builds up in the Earth before an earthquake.

Writing earthquake music helped Michael think about earthquakes in a new way. His ideas have helped scientists learn more about earthquakes.



Andy Michael used his creativity to write “Earthquake Quartet #1.” Writing music helped him think about earthquakes in new ways.

**ETHICAL RESPONSIBILITY AND HONESTY**

*Ethics* are rules about right and wrong. Scientists have a duty to be ethical. Being ethical means they must not cause people or animals unnecessary harm. It also means that scientists must be honest about their work. They must not make up data or copy other people’s work.

**READING CHECK**

**5. Describe** Think of some talents that you have. How can you use your talents to help you learn science?

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*Critical Thinking*

**6. Explain** Why is it unethical for a person to take credit for someone else’s idea?

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**SECTION 1** Thinking Like a Scientist *continued* **Say It**

**Discuss** Think of a scientist you know or have read about. What has he or she studied? What qualities do you especially admire? Discuss your ideas in a group.

**Who Can Be a Scientist?**

What do you think of when someone talks about a scientist? Do you picture a man who has crazy white hair and who wears thick glasses? Is he also wearing a white lab coat? This is a common image of a scientist, but it is not what most scientists are like.

There are scientists all over the world. They have very different backgrounds. Some are a lot like you. The pictures below show some famous scientists from around the world.



- A** Mae Jemison was a scientist on the space shuttle. Now, she is using space technology to help people in West Africa.
- B** David Ho is a researcher who has developed new treatments for the virus that causes AIDS.
- C** Stephen Hawking is a physicist who has taught us about black holes in space.

**SECTION 1** Thinking Like a Scientist *continued*

**How Can You Be Like a Scientist?**

Why is it important for you to learn science? Learning science increases your **scientific literacy**. When you have scientific literacy, you understand how science works. You also understand the role of science in society. ✓

Even if you do not become a scientist, you can still think like a scientist. Thinking like a scientist can help you in your daily life. Science teaches you how to ask questions and find answers.

Science also helps you make careful observations. It teaches you to think carefully about information. Science can help you decide if the information is true. Even if you are not a scientist, being skeptical and asking questions can help you know when to believe someone else’s claims.

**READING CHECK**

**7. Define** What is scientific literacy?

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**TAKE A LOOK**

**8. Analyze Claims** The advertisement makes many claims about the product. Pick one claim and explain how you can figure out if it is true.

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**SECTION 1** Thinking Like a Scientist *continued*

 **READING CHECK**

**9. List** What are two ways that you can help yourself to think critically?

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 **READING CHECK**

**10. Describe** Give an example of how a person's opinion or beliefs may affect how they interpret information.

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### Critical Thinking

**11. Brainstorm** Name a science topic that interests you. What are two ways you can learn more about the topic?

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### CRITICAL THINKING

Scientists have good critical-thinking skills. When you think critically about something, you think in a clear and logical way. You can do this by gathering information, asking questions, and making educated guesses. You should also try not to let your feelings or beliefs get in the way of your thinking. 

The key to critical thinking is studying the information. You should think about the following things when you decide whether the information makes sense:

1. Is the person who is giving you the information trying to sell you something or make you believe something?
2. How was the information gathered?
3. Was the research done scientifically?
4. Are there any other sources that back up the information?
5. How may your opinion or beliefs affect how you interpret information? 

You should think critically about information from all sources. This includes information from the TV, the Internet, and newspapers and magazines.

### How Does Science Affect Your Life?

Science is not limited to the laboratory or the classroom. Science is a process. It is a way of thinking about the world.

Scientists can affect your daily life by their discoveries. Many scientists work to improve the lives of others. Mario Molina is an example of such a scientist. He has worked hard to protect Earth's ozone layer.

When Molina was a student in the 1970s, he studied chemicals called CFCs. Molina discovered that CFCs can damage Earth's ozone layer. The ozone layer protects living things on Earth from the sun's harmful rays.

Molina warned leaders and other scientists about his discovery. It took a long time for people to believe him. He worked for many years teaching others about the connection between CFCs and damage to the ozone. Finally, in the 1990s, the use of CFCs was banned in most of the world.

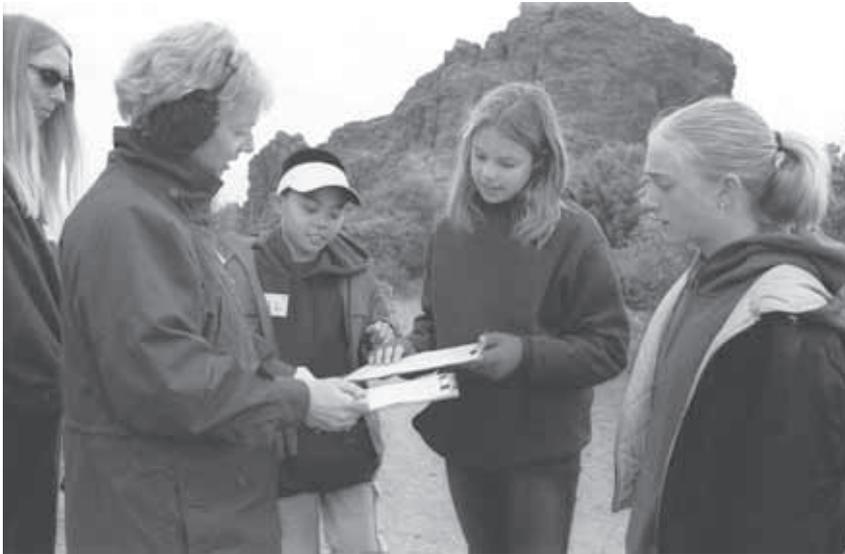
**SECTION 1** Thinking Like a Scientist *continued***How Can You Learn More About Science?**

Learning science does not stop when you leave the classroom. You can read about science topics that interest you. Try going to a museum or a zoo or on a nature hike.

You can enter a science fair. You can also join a science club. Your library and teachers are great resources to find out about other opportunities. Some more ways to learn more about science are described below.

**SPECIAL SCIENCE PROGRAMS**

You can learn about science by being part of a special science program. These programs can offer exciting, hands-on activities. Students interested in the ocean can explore tide pools or go whale watching. They can even explore the ocean by using an ROV, or remotely operated vehicle.



These students are learning to think like scientists by taking part in a special science program.

**TAKE A LOOK**

**12. Predict** What is one thing that these students may be learning about?

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**COLLABORATING WITH OTHERS**

Your class can participate in science projects that connect classrooms around the world. One such project is the JASON Project.

Each year, the scientists working on the project lead students, teachers, and other scientists on a virtual two-week research trip. Students talk online with researchers and do online experiments. They also keep notes in their online journals and share their observations with others.

# Section 1 Review

## SECTION VOCABULARY

**scientific literacy** the understanding of the methods of scientific inquiry, the scope of scientific knowledge, and the role of science in society

**skepticism** a habit of mind in which a person questions the validity of accepted ideas

**1. Explain** Why is it important for scientists to be skeptical?

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**2. List** What are five qualities that all good scientists have? For each quality, include an example from a scientist you know or have read about.

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**3. Analyze** What are three questions you can ask yourself if you want to think critically about new information?

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**4. Infer** Why is it important for scientists not to give up easily?

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**5. Explain** Why is it hard for most people to be open-minded?

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# Scientific Methods in Earth Science

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are the steps used in scientific methods?
- How is a hypothesis tested?
- Why do scientists share their findings with others?



California Science Standards

6.7.a, 6.7.d

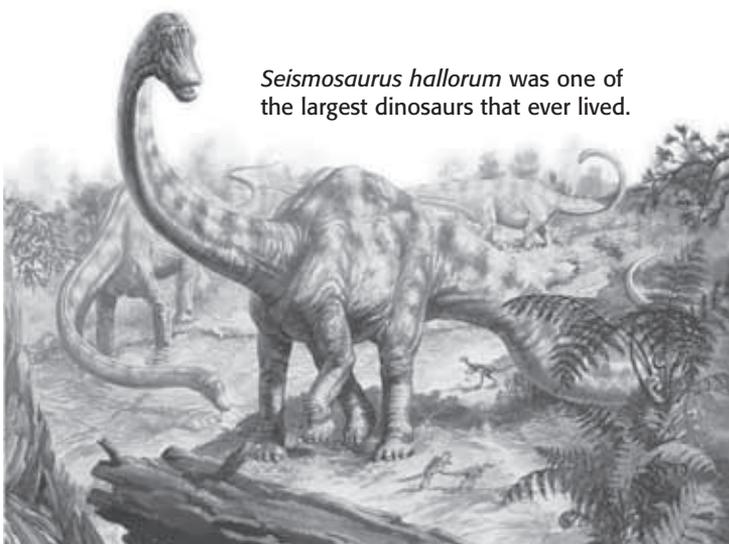
## How Do Scientists Learn About the World?

Imagine you are standing in a thick forest. Suddenly, you hear a booming noise, and you feel the ground begin to shake. You notice a creature's head looming over the treetops.

The creature's head is so high that its neck must be 20 m long! Then, the whole animal comes into view. Now you know why the ground is shaking. The giant animal is *Seismosaurus hallorum*, the "earthquake lizard."

This description of *Seismosaurus hallorum* is not just from imagination. Since the 1800s, scientists have gathered information about dinosaurs and their environment. Using this knowledge, scientists can recreate what dinosaurs may have been like hundreds of millions of years ago.

How do scientists piece all the information together? How do they know if they have discovered a new species of dinosaur? Asking these questions is the first step in using scientific methods to learn more about the world.



*Seismosaurus hallorum* was one of the largest dinosaurs that ever lived.

## STUDY TIP

**Outline** As you read this section, make a chart showing the ways that David Gillette used the steps in scientific methods to learn more about the dinosaur bones he studies.

## Math Focus

**1. Make Comparisons** When a *Seismosaurus* held its head up as high as it could, it could have been 25 m tall. How many times taller than you was *Seismosaurus*?

**SECTION 2** Scientific Methods in Earth Science *continued*

## What Are Scientific Methods?

**Scientific methods** are a series of steps that scientists use to answer questions and to solve problems. Although each question is different, scientists can use the same methods to find answers. ✓

**READING CHECK**

**2. Define** What are scientific methods?

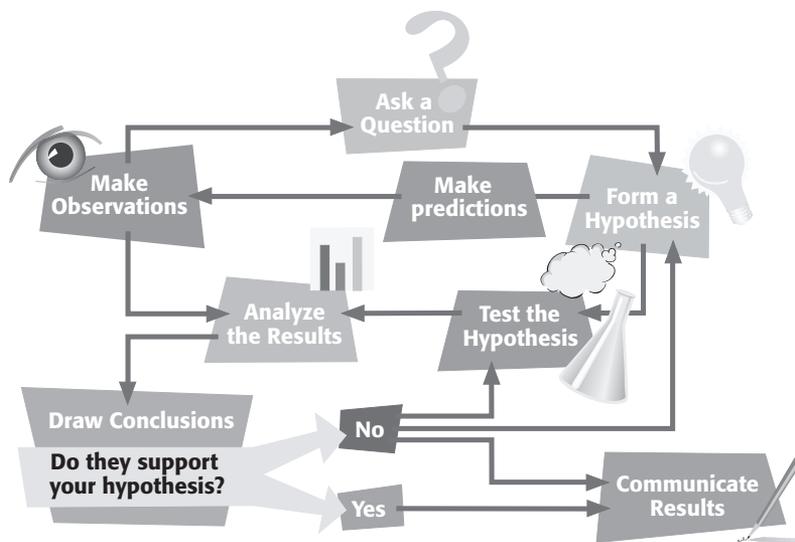
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Scientific methods have several steps. Scientists may use all of the steps or just some of them. They may even repeat some of the steps.

The goal of scientific methods is to come up with reliable answers and solutions. These answers and solutions must be able to stand up to the skepticism of other scientists.



## TAKE A LOOK

**3. Use Models** Starting with “Ask a question,” trace two different paths through the figure to “Communicate results.” Use a colored pen or marker to trace your paths.

## Why Is It Important to Ask a Question?

Asking a question helps scientists focus on the most important things they want to learn. The question helps to guide the research that the scientist does.

David D. Gillette is a scientist who studies fossils. In 1979, he studied some bones from New Mexico. He knew they came from a dinosaur, but he did not know which kind.

Gillette began his study by asking, “What kind of dinosaur did these bones come from?” We will use a table to follow Gillette as he tried to answer his question by using scientific methods.

Step in scientific methods	How did David Gillette apply this step?
Asking questions	He wondered what kind of dinosaur the bones came from.

**SECTION 2** Scientific Methods in Earth Science *continued*

## How Do Scientists Form a Hypothesis?

When scientists want to investigate a question, they form a hypothesis. A **hypothesis** (plural, *hypotheses*) is a possible answer to a question. It is sometimes called an educated guess.

The hypothesis is a scientist’s best answer to the question. But a hypothesis can’t be just any answer. The hypothesis must be tested to see if it is true.

From his observations and knowledge about dinosaurs, Gillette formed a hypothesis about the bones. He said that the bones came from a new kind of dinosaur that had not been discovered yet. To test his hypothesis, Gillette had to do a lot of research.

Step in scientific methods	How did David Gillette apply this step?
Forming a hypothesis	He thought that the bones came from a new kind of dinosaur.

## Why Do Scientists Make Predictions?

Before scientists test a hypothesis, they make predictions. A prediction is a guess based on a hypothesis.

Most predictions are stated in an if-then form. For example, Gillette could make this prediction based on his hypothesis: “If the bones are from a dinosaur that has not been discovered, then some of the bones will not match any dinosaur bones that have been studied before.”

Scientists may make many predictions based on one hypothesis. After predictions are made, scientists do experiments to see which, if any, of the predictions are true. If a prediction turns out to be true, it suggests that the hypothesis may also be true.

Step in scientific methods	How did David Gillette apply this step?
Making predictions	

**CALIFORNIA STANDARDS CHECK**

**6.7.a** Develop a hypothesis.

**4. Hypothesize** Imagine you are given a small cardboard box. It is heavy. When you shake it, there is a metallic clinking sound. Form a hypothesis about what is in the box. What are some ways you can test your hypothesis without opening the box?

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**TAKE A LOOK**

**5. Identify** In the table, fill in the prediction that David Gillette made based on his hypothesis.

**SECTION 2** Scientific Methods in Earth Science *continued*

## How Do Scientists Test a Hypothesis?

To see if an idea can be proven scientifically, scientists must test the hypothesis. They do this by gathering data. **Data** (singular, *datum*) are any pieces of information gathered through observation or experimentation. Scientists then use the data to see if the hypothesis is correct. ✓

**READING CHECK**

**6. Define** What are data?

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### TESTING WITH EXPERIMENTS

To test a hypothesis, a scientist may perform a controlled experiment. A **controlled experiment** tests only one factor, or variable, at a time. All other variables remain constant. By changing only one variable, scientists can see the results of changing just one thing.

During experiments, scientists must keep accurate records of everything that they do and observe. This includes failed attempts, too. Accurate record keeping is needed for overcoming the skepticism of other scientists.

## Critical Thinking

**7. Compare and Contrast** What is the difference between a controlled experiment and observation?

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### TESTING WITHOUT EXPERIMENTS

Sometimes, it is not possible to do a controlled experiment. In such cases, scientists depend on observation to test their hypotheses. By observing nature, scientists can collect large amounts of data. If the data support a hypothesis, the hypothesis is probably correct.

To test his hypothesis, Gillette took hundreds of measurements of bones. He compared his measurements with the measurements of bones from known dinosaurs. He also visited museums and talked with other scientists.



To test his hypothesis, Gillette took hundreds of measurements of the sizes and shapes of the bones.

## TAKE A LOOK

**8. Identify** In the table, fill in the way that David Gillette tested his hypothesis.

Step in scientific methods	How did David Gillette apply this step?
Testing hypotheses	

**SECTION 2** Scientific Methods in Earth Science *continued*

## How Do Scientists Analyze Results?

When scientists finish collecting data, they must analyze the results. Analyzing results helps scientists explain their observations. Their explanations are based on the evidence they collected. ✓

To arrange their data, scientists often make tables and graphs. Gillette organized his data in a table that showed the sizes and shapes of his dinosaur bones. When he analyzed his results, he found that the mystery dinosaur's bones did not match the bones of any known dinosaur.

**READING CHECK**

**9. Explain** Why do scientists analyze their data?

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	Hip bone of <i>Diplodocus</i>	Hip bone of <i>Apatosaurus</i>	Hip bone of unknown dinosaur
Top view			
Side view			

**TAKE A LOOK**

**10. Explain** Why did David Gillette include bones from *Diplodocus* and *Apatosaurus* when he analyzed his results?

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**TAKE A LOOK**

**11. Identify** In the table, fill in the way that David Gillette analyzed his results.

Step in scientific methods	How did David Gillette apply this step?
Analyzing results	

**SECTION 2** Scientific Methods in Earth Science *continued*

### What Are Conclusions?

After analyzing results from experiments, scientists must decide if the results agree with, or support, the hypotheses. This is called *drawing conclusions*. Finding out that a hypothesis is not true can be as valuable as finding out that a hypothesis is true.

What happens if the results do not support the hypothesis? Scientists may repeat the investigation to check for mistakes. Sometimes scientists repeat experiments hundreds of times.

Another option is to look at the original question in a different way. A scientist can then ask another question and make a new hypothesis.

From all his work, Gillette concluded that the bones found in New Mexico were from an unknown dinosaur. From his data, he learned that the new dinosaur was about 35 m long and had a mass of 30 to 70 metric tons. The dinosaur definitely fits the name Gillette gave it—*Seismosaurs hallorum*, or the “earthquake lizard.”

### Critical Thinking

**12. Infer** How can finding out that a hypothesis is not true be useful for a scientist?

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### TAKE A LOOK

**13. Identify** In the table, fill in David Gillette’s conclusions about his dinosaur bones.

Step in scientific methods	How did David Gillette apply this step?
Drawing conclusions	

### Why Do Scientists Share Their Findings?

After finishing a study, scientists share their results with others. They write reports and give presentations. They can also put their results on the Internet.

Sharing information allows others the chance to repeat the experiments for themselves. If other scientists get different results, more studies must be done to find out if the differences are significant. ✓

In many cases, the results of an investigation are reviewed year after year as new evidence is found. In the case of *Seismosaurus*, the debate still continues. Some wonder if *Seismosaurus* is a new genus. Other scientists believe it belongs to the genus *Diplodocus*. The best way to resolve this issue is to find another set of bones from *Seismosaurus* to study.

### READING CHECK

**14. Describe** Why is it important for scientists to share their results?

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# Section 2 Review

6.7.a, 6.7.d 

## SECTION VOCABULARY

<p><b>controlled experiment</b> an experiment that tests only one factor at a time by using a comparison of a control group with an experimental group</p> <p><b>data</b> any pieces of information acquired through observation or experimentation</p>	<p><b>hypothesis</b> a testable idea or explanation that leads to scientific investigation</p> <p><b>scientific methods</b> a series of steps followed to solve problems</p>
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**1. Describe** How can a scientist test a hypothesis if she or he cannot do a controlled experiment?

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**2. Explain** Why is it important for scientists to ask questions?

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**3. Apply Procedures** You observe that your tongue sticks to a very cold ice pop when you lick it. You ask yourself, “Why does my tongue stick to the ice pop?” Make a hypothesis about why your tongue sticks to the ice pop.

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**4. Identify** How could you share the results of an experiment with the rest of your class? Give two ways.

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**5. Infer** Why might a scientist need to repeat a step in scientific methods?

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SECTION 3 **Safety in Science**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- Why should you follow safety rules when learning science?
- What are the six elements of safety?
- What should you do if there is an accident?

**STUDY TIP**

**Summarize** As you read this section, underline the important ideas. When you have finished reading, use the ideas you underlined to write a summary of the section.

**READING CHECK**

**1. Describe** Why should you follow directions in science?

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**Why Are Safety Rules Important?**

All safety rules have two purposes. Safety rules help prevent accidents. They also help prevent injuries if an accident does happen.

**PREVENTING ACCIDENTS**

To be safe while doing science activities, it is a good idea to learn some safety rules. The most important safety rule is to follow directions. The directions of a science activity are made to help you prevent accidents. Following directions will also make your work easier, which will help you get better results. ✓

**PREVENTING INJURIES**

If an accident takes place, you or someone nearby can get hurt. Following safety rules after an accident can help prevent injuries. For example, you should never touch or try to clean up a spilled chemical unless you know how to do it safely. If you are using chemicals in a lab, you should learn how to use them safely.

**TAKE A LOOK**

**2. Identify** In the table, fill in the way that each safety rule can help prevent accidents or injuries.

Safety rule	How it prevents accidents or injuries
Wear goggles when working in the lab.	
Throw away broken glass in a specially labeled container.	
Tell your teacher if a chemical spills in the lab.	

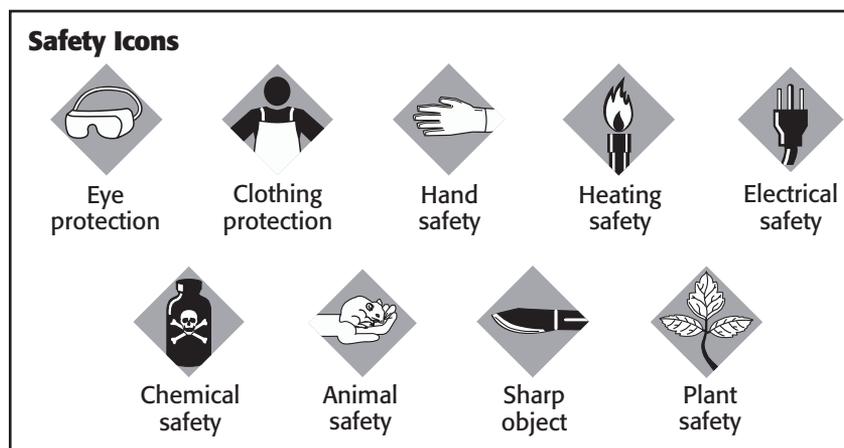
**SECTION 3** Safety in Science *continued***What Are the Elements of Safety?**

Safety has many parts. To be safe, you need to recognize safety symbols. You also need to follow directions, be neat, use equipment correctly, and clean up after experiments.

**SAFETY SYMBOLS**

Signs and symbols have special meanings when they are used in science. Some of these symbols are safety symbols. They tell you what to do to prevent injuries or accidents.

Look at the safety symbols in the figure below. Each symbol tells you something important. For example, the “animal safety” symbol tells you to be careful when using animals in experiments. You should follow your teacher’s directions about how to handle the animals. You should always wash your hands carefully after touching animals.

**TAKE A LOOK**

**3. Investigate** Look around your classroom for safety symbols like the ones in the figure. Give two examples of places where safety symbols are found in your classroom.

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**READING AND FOLLOWING DIRECTIONS**

If you want to bake cookies, you use a recipe. The recipe provides all the directions on how to make cookies. When scientists work in a lab, they also follow directions.

Before starting a science activity, read the directions very carefully. If you do not understand them, ask your teacher to explain them. If you can’t finish some of the directions, you should stop your experiment and ask your teacher for help.

When you read, understand, and follow directions, you will get better results. You will also reduce the chance of having an accident.

**SECTION 3** Safety in Science *continued*

**NEATNESS**

Before starting any experiment, you should clear your work area of anything you don't need for the lab. Some objects can get in the way and can cause an accident. Long hair and loose clothing can get in the way, too. They should be tied back.

During an experiment, keep your table or desk clean. Gather all the equipment you need for the activity before you start. Arrange your equipment and materials so that they are easy to find and pick up.

Label your materials clearly. Some lab materials look alike and can get mixed up if they are not labeled.

As you collect data, you should record your findings carefully in your data table or notebook. Neatly recorded data are easier to read and analyze.

**TAKE A LOOK**

**4. Explain** In the table, fill in the blank spaces with things you should do in a lab experiment, and the reasons for doing them.

<b>What to do</b>	<b>Why to do it</b>
Tie back loose hair and clothing.	
	This will keep your books or backpack from getting in the way during the activity.
Gather all of your equipment before you start the activity.	
	This will prevent materials that look alike from getting mixed up.

**USING PROPER SAFETY EQUIPMENT**

Goggles, gloves, and aprons are all pieces of safety equipment that you may use. Some of the safety symbols tell you what safety equipment you need.

For example, when you see the symbol for eye protection, you must put on safety goggles. Your goggles should be clean and fit properly. Your teacher can help you adjust them for a proper fit. ✓

The chemicals that you use may not always be dangerous. However, you should always wear aprons, goggles, and protective gloves whenever you use chemicals.

You should wear protective gloves when handling animals, too. Different gloves are available for different uses. For example, if you are handling warm or hot objects, you should wear heat-resistant gloves.

 **READING CHECK**

**5. Identify** Why is it important to wear goggles during lab activities?

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**SECTION 3** Safety in Science *continued*

**PROPER CLEANUP PROCEDURES**

At the end of a science activity, you must clean up your work area. Put caps back on bottles or jars. Return everything to its proper place. Spills and accidents are less likely to happen when everything is put away correctly. ✓

Wash your glassware and check for chips and cracks. If you find any damaged glassware, notify your teacher. It should be carefully thrown away in a special container.

If you have extra chemicals, follow your teacher’s directions for throwing them away. Once your work area is clear, you should wipe it with a wet paper towel. Finally, wash your hands carefully with soap and water.

 **READING CHECK**

**6. Explain** Why is it important to clean up correctly after a lab activity?

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**What Should You Do If There Is an Accident?**

Even when all the safety rules are followed, accidents may still happen. If an accident happens, try to remain calm. Panicking may make the situation worse. You may be scared, but staying in control will help keep you and others safe.

Being prepared and having a plan of action will help you do the right things if an emergency happens.

**THINGS TO KNOW BEFORE AN ACCIDENT**

Take a look around your classroom or work area. Find out where these things are:

- the fire extinguisher
- the emergency shower and eyewash station
- the first-aid kit
- all the exits from the room
- a phone that you can use to call for help

Find out when and how to use the fire extinguisher, the emergency shower, and the eyewash station. Find out what phone number you can call in case there is an emergency. Make sure that the number is clearly written on or near the phone.

*Critical Thinking*

**7. Identify** Why is it important to plan ahead for an accident?

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**SECTION 3** Safety in Science *continued*

## Critical Thinking

**8. Design a Plan** You are heating water on a hot plate. You suddenly notice that some papers near the hot plate have caught fire. What should you do? What could you have done to prevent this accident?

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### STEPS TO FOLLOW AFTER AN ACCIDENT

If an accident happens, follow these steps:



**Step 1: Remain calm.**

Try to stay calm and figure out what happened. Look around you for clues, but do not touch anything.



**Step 2: Secure the area.**

Make sure that no one (including you!) is in danger. If other students are coming over to see what happened, tell them to stay away so that they don't get hurt.



**Step 3. Tell your teacher.**

If an accident happens, you must tell your teacher. Tell your teacher, even if the accident is small. Explain exactly what happened. Give your teacher details, such as where the accident happened, what chemicals were spilled, or if glass was broken. If you can't find your teacher, call for help.



**Step 4. Help your teacher.**

Ask your teacher if there is anything you can do to help. If not, stay out of your teacher's way.

### CARING FOR INJURIES

If an accident happens, someone may need first aid. **First aid** is emergency care for someone who has been hurt. Find the first-aid kit in your classroom. Become familiar with the items in it, such as bandages and protective gloves.

If an accident happens, you can help your teacher give first aid to someone who is hurt. However, you should not try to give first aid to someone unless you have first-aid training.

# Section 3 Review

## SECTION VOCABULARY

**first aid** emergency medical care for someone who has been hurt or who is sick

**1. Define** Write your own definition of first aid.

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**2. Apply Concepts** Fill in the table below to show that you understand safety symbols.

Safety symbol	What does it mean?	Where might you see it?
	eye protection	
		near a chemical storage closet
		
	electrical safety	
		in a lab activity using chemicals that could burn you

**3. Identify** Name four pieces of safety equipment in your classroom. Write down where each is located.

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**4. List** What should you do if an accident happens? List four steps.

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SECTION 1 **Tools and Measurement**



California Science Standards

6.7.b

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do tools help scientists?
- How do scientists measure length, area, mass, volume, and temperature?

**STUDY TIP**

**Compare** As you read this section, make a table that compares how scientists measure length, area, mass, volume, and temperature. Include the tools and units of measurement that scientists use.

**What Tools Do Scientists Use?**

Scientists collect and record a lot of information, or data. To gather and study the data, scientists use many tools. A *tool* is anything that helps a person do a job.

Different tools help scientists gather different kinds of data. Some tools help scientists see things. Some tools help scientists analyze, or examine, information. Some tools help scientists take measurements.

**TOOLS FOR SEEING OBJECTS**

Scientists can use tools to help them see objects clearly. Different tools help scientists study objects of different sizes. If the objects are very small, scientists may use a microscope or a magnifying glass to study them. If the objects are very far away, scientists may use a telescope or binoculars to study them. ✓

**READING CHECK**

**1. Identify** What are two tools that scientists can use to see things that are very small?

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\_\_\_\_\_

A telescope is a tool that can help you see things, such as the moon, that are very far away.



**TOOLS FOR EXAMINING DATA**

The measurements that scientists collect from experiments are called *data* (singular, *datum*). Scientists analyze, or examine, data using many different tools. Calculators can help scientists do calculations quickly. Graphs and charts are tools that can help scientists see patterns in data. Computers are very important tools for collecting, storing, and studying data. ✓

**READING CHECK**

**2. List** Give three tools that scientists use to examine data.

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**SECTION 1** Tools and Measurement *continued*

**TOOLS FOR MEASURING OBJECTS**

During an experiment, scientists record what is happening. They measure the changes that happen to the objects in the experiment. To make these measurements, scientists use many different tools.



A **balance** is a tool that is used to measure mass.



A **meterstick** is a tool that is used to measure length.



A **thermometer** is a tool that is used to measure temperature.

A **graduated cylinder** is a tool that is used to measure volume.



**CALIFORNIA STANDARDS CHECK**

**6.7b** Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.

**Word Help:** appropriate correct for the use; proper

**Word Help:** technology tools, including electronic products

**Word Help:** computer an electronic device that stores, retrieves, and calculates data

**Word Help:** data facts or figures; information

**3. Identify** List the tools that you should use to make the following measurements:  
mass:

\_\_\_\_\_

temperature:

\_\_\_\_\_

length:

\_\_\_\_\_

**How Do Scientists Measure Objects?**

Scientists make many measurements as they collect data. It is important for scientists to be able to share their data with other scientists. Therefore, scientists use units of measurement that are known to all other scientists. One system of measurement that most scientists use is called the International System of Units.

**THE INTERNATIONAL SYSTEM OF UNITS**

The *International System of Units*, or *SI*, is a system of measurement that scientists use when they collect data. This system of measurement has two benefits. First, scientists around the world can easily share and compare their data because all measurements are made in the same units. In addition, SI units are based on the number 10. This makes it easy to change from one unit to another.

It is important to learn the SI units that are used for different types of measurements. You will use SI units when you make measurements in the science lab.

**Critical Thinking**

**4. Predict Consequences**  
What could happen if all scientists used different systems of measurement to record their data?

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**SECTION 1** Tools and Measurement *continued*

**LENGTH**

*Length* is a measure of how long an object is. The SI unit for length is the **meter** (m). Centimeters (cm) are used to measure small distances. There are 100 cm in 1 m. Micrometers ( $\mu\text{m}$ ) are used to measure very small distances. There are 1 million  $\mu\text{m}$  in 1 m. Kilometers (km) are used to measure large distances. There are 1,000 meters in 1 km. ✓

✓ **READING CHECK**

**5. Identify** What is the SI unit for length?

\_\_\_\_\_

<b>Length</b>	SI unit: meter (m) other units: kilometer (km) centimeter (cm) micrometer ( $\mu\text{m}$ )	1 cm = 0.01 m 1 km = 1,000 m 1 m = 1,000,000 $\mu\text{m}$ 1 m = 100 cm 1 m = 0.001 km
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**AREA**

**Area** is a measure of how much surface an object has. For most objects, area is calculated by multiplying two lengths together. For example, you can find the area of a rectangle by multiplying its length by its width. Area is measured in square units, like square meters ( $\text{m}^2$ ) or square centimeters ( $\text{cm}^2$ ). ✓

✓ **READING CHECK**

**6. Explain** How can you find the area of a rectangle?

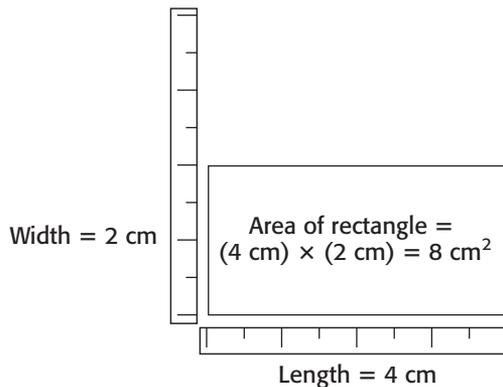
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**Math Focus**

**7. Calculate** What is the area of a rectangle that has a width of 7 cm and a length of 4 cm?

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<b>Area</b>	square meter ( $\text{m}^2$ ) square centimeter ( $\text{cm}^2$ )	1 $\text{cm}^2$ = 0.0001 $\text{m}^2$ 1 $\text{m}^2$ = 10,000 $\text{cm}^2$
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**MASS**

**Mass** is the amount of matter in an object. The SI unit for mass is the kilogram (kg). The masses of large objects, such as people, are measured using kg. The masses of smaller objects, such as an apple or a thumbtack, are measured in grams (g) or milligrams (mg). There are 1,000 g in 1 kg. There are 1 million mg in 1 kg.

<b>Mass</b>	SI unit: kilogram (kg) other units: gram (g) milligram (mg)	1 g = 0.001 kg 1 mg = 0.000001 kg 1 kg = 1,000 g 1 kg = 1,000,000 mg
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**Math Focus**

**8. Convert** How many mg are there in 1 g?

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**SECTION 1** Tools and Measurement *continued*

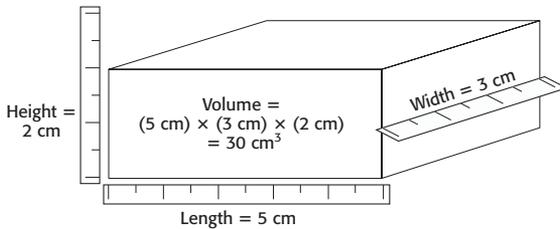
**VOLUME**

**Volume** is the amount of space an object takes up. You can find the volume of a box-shaped object by multiplying its length, width, and height together. You can find the volume of objects with many sides by measuring how much liquid they can push out of a container. ✓

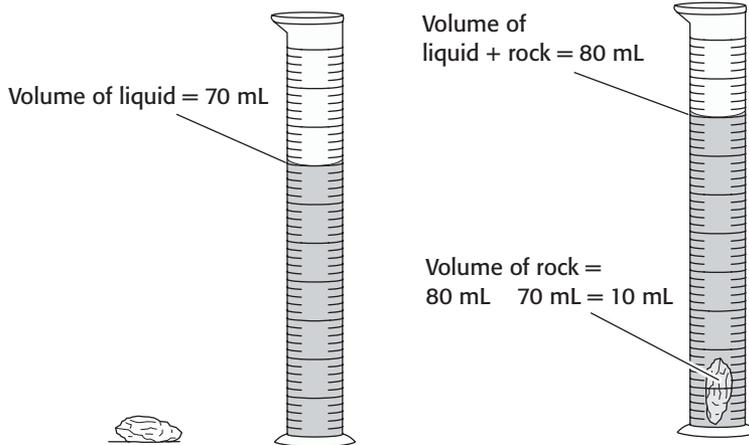
Volume is most often measured in cubic units. For example, very large objects can be measured in cubic meters (m<sup>3</sup>). Smaller objects can be measured in cubic centimeters (cm<sup>3</sup>). There are 1 million cm<sup>3</sup> in 1 m<sup>3</sup>.

The volume of a liquid is sometimes given in units of liters (L) or milliliters (mL). One mL has the same volume as one cm<sup>3</sup>. There are 1,000 mL in 1 L. There are 1,000 L in one m<sup>3</sup>.

<b>Volume</b>	cubic meter (m <sup>3</sup> )	1 cm <sup>3</sup> = 0.000001 m <sup>3</sup>
	cubic centimeter (cm <sup>3</sup> )	1 L = 0.001 m <sup>3</sup>
	liter (L)	1 mL = 1 cm <sup>3</sup>
	milliliter (mL)	1 mL = 0.001 L
		1 m <sup>3</sup> = 1,000 L



You can find the volume of a box-shaped object by multiplying its length, width, and height together. This box has a volume of 30 cm<sup>3</sup>.



You can find the volume of a more complicated object, such as this rock, by measuring how much liquid it pushes out of the way. The graduated cylinder has 70 mL of liquid in it before the rock is added.

The rock made the volume of material in the cylinder go up to 80 mL. The rock pushed 10 mL of liquid out of the way. The volume of the rock is 10 mL. Because 1 mL = 1 cm<sup>3</sup>, the volume of the rock can also be written as 10 cm<sup>3</sup>.

**READING CHECK**

**9. Define** What is volume?

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**Math Focus**

**10. Calculate** What is the volume of a cube with 5 m-long sides?

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**TAKE A LOOK**

**11. Explain** How do you know that the rock in the figure has a volume of 10 mL?

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**SECTION 1** Tools and Measurement *continued*



**Discuss** Where have you seen volume, mass, or temperature measurements outside of science class? In a small group, talk about different places that these measurements are found.

**READING CHECK**

**12. Explain** Why do scientists measure temperature in K or °C instead of °F?

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\_\_\_\_\_

**TEMPERATURE**

**Temperature** is a measure of how hot or cold an object is. The SI unit for temperature is the Kelvin (K). However, most people are more familiar with other units of temperature. For example, most people in the United States measure temperatures using degrees Fahrenheit (°F). Scientists often measure temperatures using degrees Celsius (°C).

It is easy to change measurements in °C to K. To change a temperature measurement from °C to K, you simply add 273 to the measurement. For example,  $200\text{ }^{\circ}\text{C} = 200 + 273 = 473\text{ K}$ . It is more complicated to change measurements in K or °C into °F. That is why scientists do not measure temperatures in °F. ✓

<b>Temperature</b>	SI unit: Kelvin (K) other units: degrees Celsius (°C)	$0^{\circ}\text{C} = 273\text{ K}$ $100^{\circ}\text{C} = 373\text{ K}$
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**SCIENTIFIC NOTATION**

Scientists often work with numbers that are very big or very small. These numbers have a lot of zeros or decimal places. Instead of writing out many zeroes, scientists use scientific notation to simplify the numbers.

*Scientific notation* is a way to represent a number by using a different number multiplied by a power of 10. The power of 10 shows how many zeroes or decimal places the number has. For example, light moves through space at a speed of 300,000,000 m/s. This number has eight zeroes in it. To write the speed of light in scientific notation, you would write  $3 \times 10^8\text{ m/s}$ .

Power of 10	What it means	Example of scientific notation
$10^6$	1,000,000	$7,000,000 = 7 \times 10^6$
$10^5$	100,000	$200,000 = 2 \times 10^5$
$10^4$	10,000	$10,000 = 1 \times 10^4$
$10^3$	1,000	$3,000 = 3 \times 10^3$
$10^2$	100	$800 = 8 \times 10^2$
$10^1$	10	$60 = 6 \times 10^1$
$10^{-1}$	0.1	$0.5 = 5 \times 10^{-1}$
$10^{-2}$	0.01	$0.04 = 4 \times 10^{-2}$
$10^{-3}$	0.001	$0.009 = 9 \times 10^{-3}$

**Math Focus**

**13. Convert** Write the number 5,000,000 in scientific notation.

\_\_\_\_\_

# Section 1 Review

6.7.b 

## SECTION VOCABULARY

**area** a measure of the size of a surface or a region  
**mass** a measure of the amount of matter in an object  
**meter** the basic unit of length in the SI (symbol, m)

**temperature** a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object  
**volume** a measure of the size of a body or region in three-dimensional space

**1. Describe** You can find the volume of a box-shaped object by multiplying its length, width, and height together. How can you measure the volume of an object if it is not shaped like a box?

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**2. Identify** What are two units that scientists use to measure temperature?

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**3. Explain** Why do scientists use scientific notation?

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**4. List** Give two tools that you can use to see something that is far away.

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**5. Calculate** What is the area of a room that is 10 m long and 12 m wide?

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**6. Identify** Give one example of a tool that scientists use to find patterns in their data.

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**7. List** Give three units that can be used to describe volume.

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SECTION 2 **Models in Science**



California Science Standards

6.7.b, 6.7.c, 6.7.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do scientists use models?
- What are scientific theories and laws?

**STUDY TIP**

**Compare** As you read, make a table to show the features of physical models and mathematical models.

**What Are Models?**

Why do scientists use crash-test dummies to learn how safe cars are? By using crash-test dummies, scientists can learn how to make cars safer without putting real people in danger. A crash-test dummy is a model of a person. A **model** is something scientists use to represent an object or event in order to make it easier to study.

Scientists use models to study things that are very small, like atoms, or things that are very large, like Earth. Some scientists use models to predict things that haven't happened yet, or to study events that happened long ago. Some models, like crash-test dummies, allow scientists to study events without affecting or harming the things they are studying. ✓

**READING CHECK**

**1. Identify** Give two reasons scientists use models.

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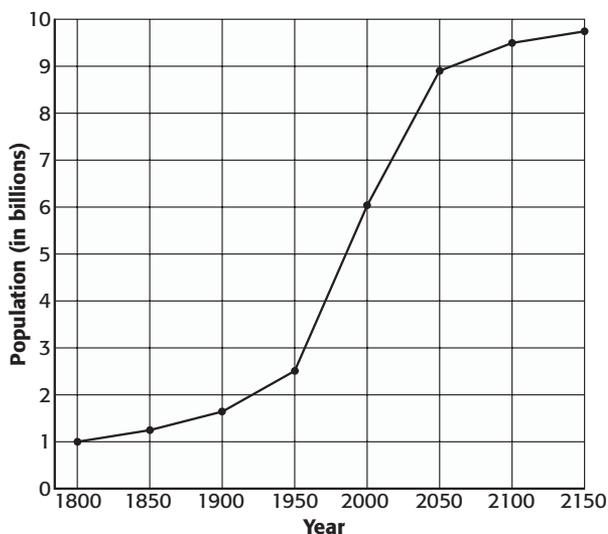
**Math Focus**

**2. Read a Graph** In about what year did the world's population reach 6 billion people?

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This graph shows how the population of the world is changing with time. Notice that it has predictions for the population of the world in the future. Scientists used a model to make these predictions.

**World Population 1800 to 2150**



Models can come in many forms. Many models are objects that you can see and touch. Other models are made up of data and mathematical equations. Some models are made up of both objects and data.

**SECTION 2** Models in Science *continued*

**PHYSICAL MODELS**

*Physical models* are models that you can see or touch. Many physical models look like the things they represent. For example, a globe is a physical model of Earth. Other physical models may look different from the things they represent. For example, a map is a physical model of Earth. A map can show more details about Earth's surface than a globe can. However, a flat map looks very different from the round Earth! ✓]

**MATHEMATICAL MODELS**

A *mathematical model* is made up of mathematical equations and data. Some mathematical models are simple. These models help you to calculate things such as how far a car will travel in an hour. Other models are more complicated. These models can have many different parts related by complicated equations. ✓]

Many mathematical models contain so much data that a person would need hundreds of years to sort through it all. Scientists use computers to help them build and use these models. Because computers can deal with large amounts of data, they can solve many mathematical equations at once. Some computers can solve 30 trillion ( $3 \times 10^{13}$ ) equations in only one second!



The model in this picture was produced by a computer. The computer combined huge amounts of data into a model that can predict changes in Earth's climate. Without computers, scientists would not be able to use complicated models like this.

✓ **READING CHECK**

**3. Define** What is a physical model?

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\_\_\_\_\_

✓ **READING CHECK**

**4. Define** What is a mathematical model?

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**TAKE A LOOK**

**5. Explain** How do computers help scientists make models?

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**SECTION 2** Models in Science *continued*

## Critical Thinking

**6. Analyze** A crash-test dummy is a model of a person. Give two ways that a crash-test dummy is like a person, and two ways that they are different.

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### LIMITS OF MODELS

Models are very useful for scientists. However, models are not exactly like the things they represent. For example, a globe is a model of Earth. It shows the shape of Earth and the locations of oceans and land. However, it does not show the living things on Earth, or what Earth looks like inside. When you use a model, make sure that you know how it is different from the thing it represents.

Models are not perfect, but all models can change. Models can change if a scientist finds new data or thinks about ideas in a new way. Scientists are always working to make models better. For example, scientists can use technology, such as computers, to make their models more accurate.

### HOW SCIENTISTS USE MODELS

Scientists often use models to study repeating patterns in nature. For example, the model in the figure on the previous page can help scientists predict repeating weather events, such as hurricanes.

### How Do Scientists Explain Natural Events?

Many of the events that happen in the natural world form patterns. For example, the moon looks different every night, but it looks the same again about every month. Scientists study these patterns to learn more about how the world works. Scientists study how the moon changes to learn about its movements through space.

Scientists use their observations about the natural world to develop scientific laws and theories. A scientific **law** is a statement or equation that can predict what will happen in certain situations. A **theory** is a scientific explanation that connects and explains many observations.

### TAKE A LOOK

**7. Identify** Fill in the blank boxes in the table with the terms *scientific theory* and *scientific law*.

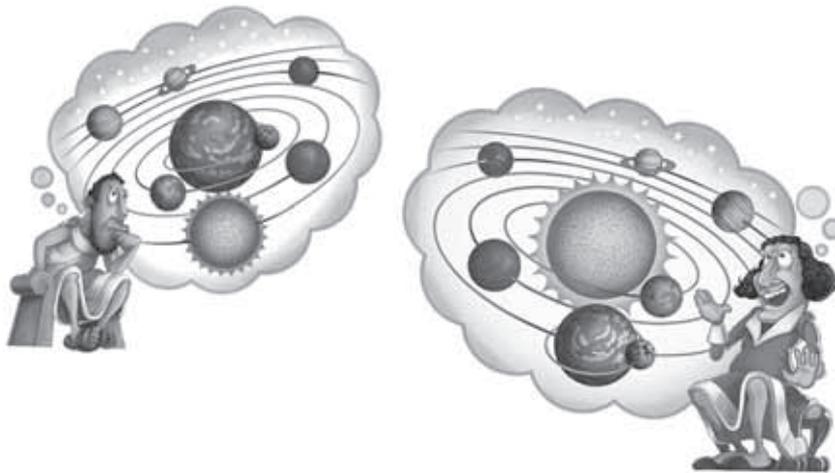
Name	What it is
	an explanation that connects and explains evidence and observations
	a statement or equation that predicts what will happen in a certain situation

**SECTION 2** Models in Science *continued*

**THEORIES AND OBSERVATIONS**

Scientific theories are based on observations. They explain all of the observations about a topic that scientists have at a certain time. However, scientists are always discovering new information. This new information may show that a theory is incorrect. When this happens, the theory must be changed so that it explains the new information. Sometimes, scientists have to develop a totally new theory to explain the new and old information. ✓

For thousands of years, people believed that Earth was at the center of the solar system. They observed stars moving in a circle in the sky. This evidence seemed to support the theory that Earth was at the center of the solar system.



When the telescope was invented, scientists were able to make more detailed observations about the solar system. They saw that planets moved in ways that did not fit the theory of an Earth-centered solar system. Therefore, they developed a new theory about the shape of the solar system. This theory states that the sun is at the center of the solar system. All of the evidence that scientists have been able to collect supports this theory. Therefore, scientists now accept that this theory is correct.

**THEORIES AND LAWS**

Many people think that scientific theories become scientific laws, but this is not true. Actually, many scientific laws provide evidence to support scientific theories.

In 1665, Sir Isaac Newton discovered the *law of universal gravitation*. This law states that all objects in the universe attract each other with a force called *gravity*. Gravity holds the planets in their orbits as they travel around the sun. Scientists used this law to support the theory of a sun-centered solar system.

**READING CHECK**

**8. Explain** What must scientists do if new information shows that a theory is incorrect?

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**TAKE A LOOK**

**9. Identify** Why did scientists change their theory about the shape of the solar system?

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# Section 2 Review

6.7.b, 6.7.c, 6.7.e



## SECTION VOCABULARY

**law** a descriptive statement or equation that reliably predicts events under certain conditions

**model** a pattern, plan, representation, or description designed to show the structure or workings of an object, system, or concept

**theory** a system of ideas that explains many related observations and is supported by a large body of evidence acquired through scientific investigation

**1. Identify** How are scientific theories related to observations and evidence?

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**2. Explain** Why do scientists use models?

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**3. Describe** What effect can new observations have on a scientific theory?

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**4. List** Give one example of a physical model and one example of a mathematical model.

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**5. Summarize** How is a scientific theory different from a scientific law?

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SECTION 3 Mapping Earth's Surface

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is a map?
- How are maps made?



California Science Standards

6.7.b, 6.7.f

**What Is a Map?**

A **map** is a model that shows the features of an object. Most of the maps that people use show the features of Earth's surface. Some maps show all of Earth's surface. Other maps show only part of Earth's surface. Maps can show natural features, such as rivers. They can also show features made by people, such as roads. Although maps can show different things, all maps of Earth's surface have one thing in common: they all show directions.



**Discuss** Read this section quietly to yourself. In a small group, try to figure out anything you didn't understand.

**FINDING DIRECTIONS ON EARTH**

Earth's shape is similar to a sphere. However, a true sphere has no top, bottom, or sides that can be used as reference points. *Reference points* are certain locations that never change. They can be used to define directions. ✓

Unlike a true sphere, Earth has two reference points. They are located where Earth's axis of rotation passes through Earth's surface. The reference points are called the North Pole and the South Pole. The North and South Poles are known as *geographic poles*. Since these poles never move, they are used as references points to define directions on Earth.



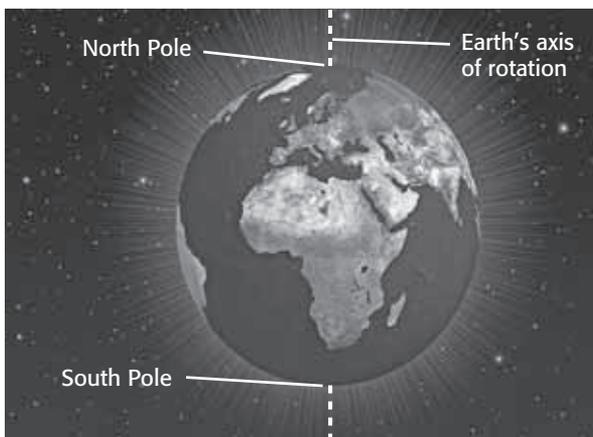
**1. Define** What are reference points?

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The North Pole and the South Pole can be used as reference points to define directions on Earth.



**TAKE A LOOK**

**2. Identify** What are two reference points on Earth?

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**SECTION 3** Mapping Earth's Surface *continued*

**USING A COMPASS TO FIND DIRECTIONS**

Earth's core produces a field that makes Earth act as a giant magnet. Earth has two *magnetic poles* located near the geographic poles. A *compass* is a tool that uses the Earth's natural magnetism to show direction. The needle on a compass points to the magnetic pole that is near the North Pole. Therefore, a compass can show you which direction is north. ✓

✓ **READING CHECK**

**3. Identify** What does the needle on a compass point to?

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**How Do People Find Specific Locations on Earth?**

All of the houses and buildings in your neighborhood have addresses that give their locations. These addresses may include a street name and a number. You can tell someone exactly where you live by giving them your address. In a similar way, you can use latitude and longitude to give an "address" for any place on Earth.

**LATITUDE**

The **equator** is a circle halfway between the North and South Poles. It divides Earth into two *hemispheres*, or halves—the Northern Hemisphere and the Southern Hemisphere. *Lines of latitude*, or *parallels*, are imaginary lines on Earth's surface that are parallel to the equator. ✓

**Latitude** is the distance north or south from the equator. Latitude is measured in degrees. The equator represents 0° latitude. The North Pole is 90° north latitude and the South Pole is 90° south latitude. North latitudes are in the Northern Hemisphere and south latitudes are in the Southern Hemisphere.

✓ **READING CHECK**

**4. Define** What are parallels?

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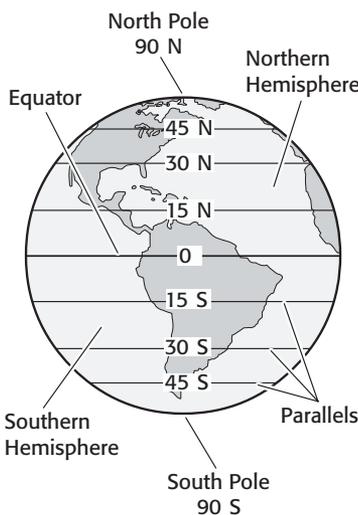
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**TAKE A LOOK**

**5. Describe** Which parallel is farther from the equator: 10°N latitude or 10°S latitude?

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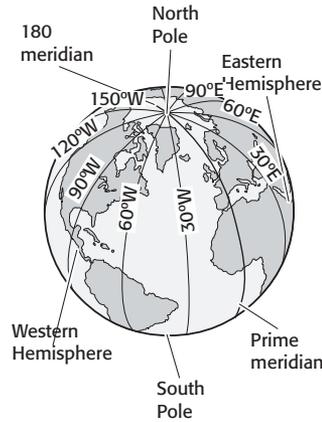


**SECTION 3** Mapping Earth's Surface *continued*

**LONGITUDE**

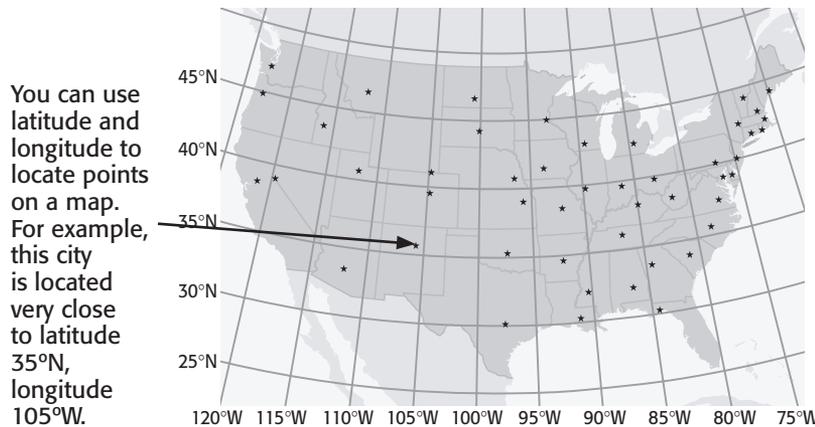
*Lines of longitude, or meridians, are imaginary lines that link the geographic poles. Lines of longitude are similar to the lines on a basketball. The lines all touch at the poles. They are farthest apart at the equator. The **prime meridian** is the line that represents 0° longitude. **Longitude** is the distance east or west of the prime meridian. Like latitude, longitude is measured in degrees.*

The prime meridian does not circle the whole globe. It runs from the North Pole, through Greenwich, England, to the South Pole. On the other side of the globe, the 180° meridian runs from the North to the South Pole. Together, the prime meridian and the 180° meridian split Earth into Western and Eastern Hemispheres.



**USING LATITUDE AND LONGITUDE**

Lines of latitude and longitude cross to form a grid. This grid is shown on maps and globes. You can use the lines of latitude and longitude to tell someone the location of any point on Earth's surface. First, find the point on a map like the one below. Then, estimate the latitude and longitude of the point, using the lines closest to it.



You can use latitude and longitude to locate points on a map. For example, this city is located very close to latitude 35°N, longitude 105°W.

*Critical Thinking*

**6. Apply Concepts** A friend asks you what the distance is between 80°E longitude and 90°E longitude. What else do you need to know in order to answer your friend's question? Explain why you need this piece of information.

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**TAKE A LOOK**

**7. Identify** Where do all lines of longitude meet?

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**TAKE A LOOK**

**8. Read a Map** Circle the city on the map that is closest to latitude 45°N, longitude 100°W.

**SECTION 3** Mapping Earth's Surface *continued*

## How Is Information Shown on Maps?

The information on a map is in the form of symbols. To read a map, you must understand the symbols on the map. Maps can show many different kinds of information. Almost all maps contain five pieces of information: a title, an indicator of direction, a scale, a legend, and a date. ✓

**READING CHECK**

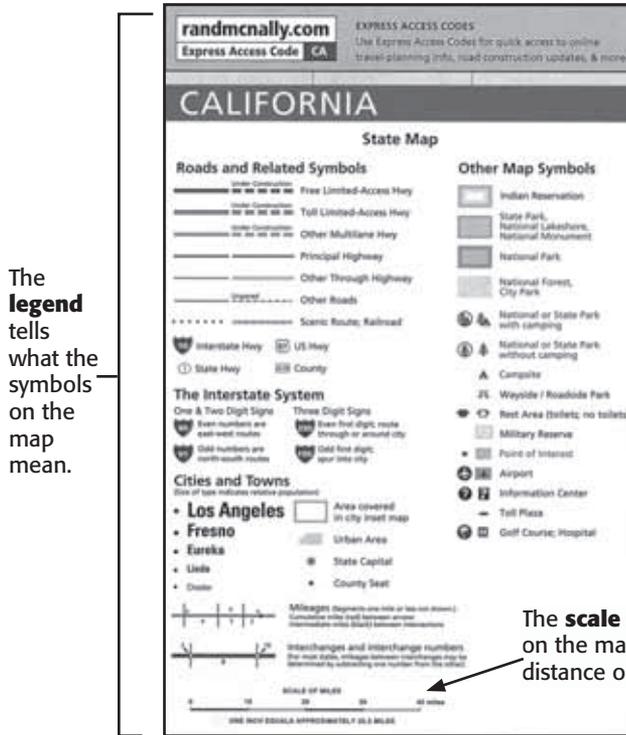
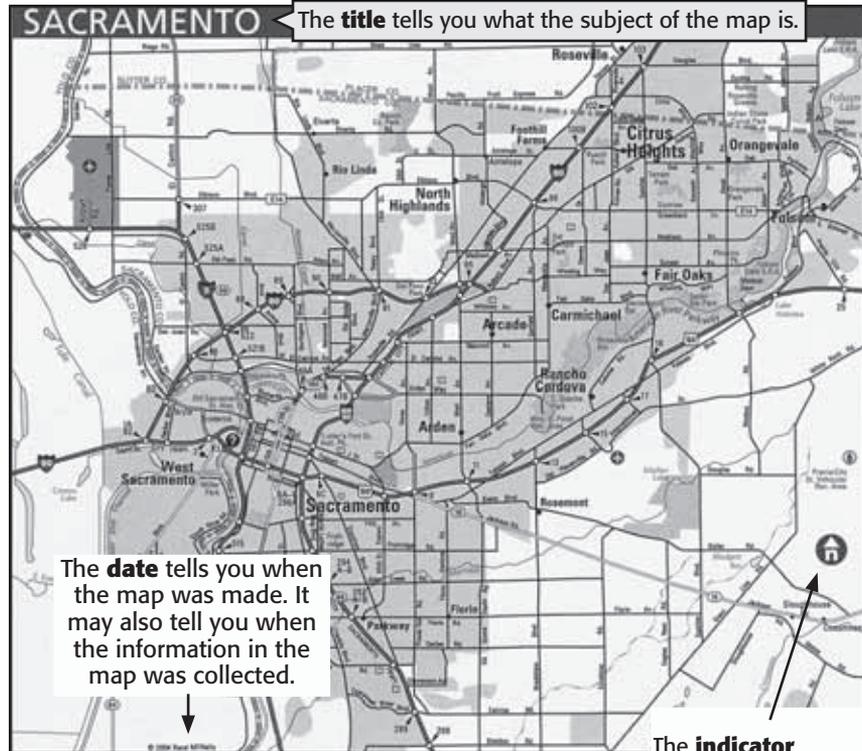
**9. Describe** How is information shown on a map?

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**TAKE A LOOK**

**10. Identify** What is the subject of the map in the figure?

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The legend tells what the symbols on the map mean.

The indicator of direction can show which way is north or give other information about the location of the map. It can be an arrow pointing north, like this one, a compass rose, or a latitude and longitude grid.

The scale shows how a distance on the map is related to the distance on the Earth.

**Math Focus**

**11. Use Models** How far is Arcade from Rio Linda? Use a ruler and the map's scale to find out. Give your answer in km.

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**SECTION 3** Mapping Earth's Surface *continued*

**How Are Maps Made?**

The information used to make maps today comes from remote sensing. **Remote sensing** is a way to gather information about an object without actually touching or seeing the object. ✓

Today, most maps are made from photographs. Cameras on low-flying airplanes take the photographs. However, mapmakers are beginning to use new equipment that can be carried on both airplanes and satellites.

**READING CHECK**

**12. Define** What is remote sensing?

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**PASSIVE REMOTE SENSING**

All things on Earth's surface give off radiation, such as heat or light. *Passive* remote-sensing equipment records the radiation given off by objects. A satellite collects the data and changes it to numbers. These numbers are then sent to a computer. The computer changes the numbers into a picture of the Earth's surface.

**ACTIVE REMOTE SENSING**

*Active* remote-sensing equipment makes its own radiation, mostly in the form of microwaves. It sends out the radiation toward Earth's surface. The radiation bounces off Earth's surface and travels back to the sensing equipment. The strength of the signal that bounces back can be used to produce an image of Earth's surface. ✓

Microwaves can travel through clouds and water. Therefore, active remote-sensing equipment can be used to map areas that are difficult to see.

**READING CHECK**

**13. Compare** How is active remote sensing different from passive remote sensing?

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This picture of downtown San Francisco, California, was made using remote-sensing equipment.

**SECTION 3** Mapping Earth's Surface *continued*

**GLOBAL POSITIONING SYSTEM**

Satellites can keep you from getting lost. The *global positioning system* (GPS) can help you find where you are on Earth. GPS is a system of satellites that travel around the Earth. The satellites send radio waves to receivers on Earth. The receivers calculate the latitude, longitude, and elevation of a certain place. ✓

**READING CHECK**

**14. Identify** What is GPS?

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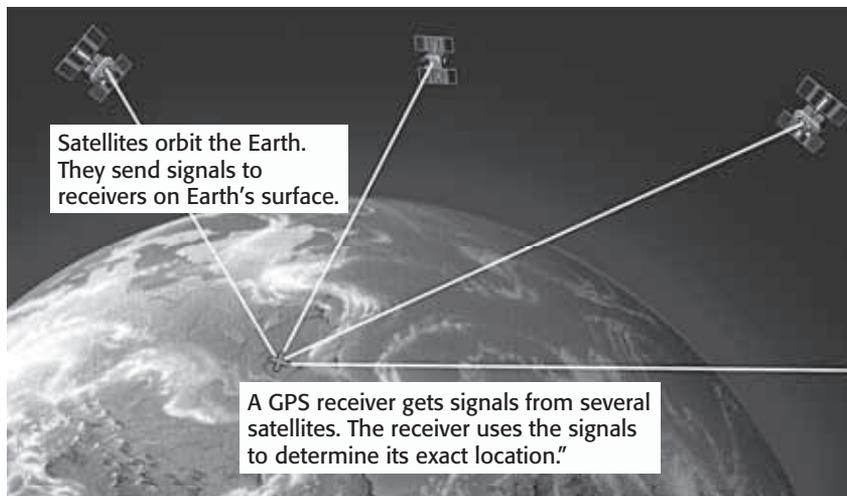
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**TAKE A LOOK**

**15. Describe** What do GPS satellites do?

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GPS is very common in people's lives today. Mapmakers use GPS to check the location of boundary lines between countries. Airplane and boat pilots use GPS for navigating. GPS receivers are even put into cars and watches!

**GEOGRAPHIC INFORMATION SYSTEMS**

A geographic information system (GIS) is a computerized system that shows information about an area. A GIS allows scientists to combine a lot of information into one model. A GIS organizes information in layers. Scientists can compare the layers in order to answer questions. The figure on the next page shows how scientists use GIS to combine information and find safe places for bears to live. ✓

**READING CHECK**

**16. Define** What is a GIS?

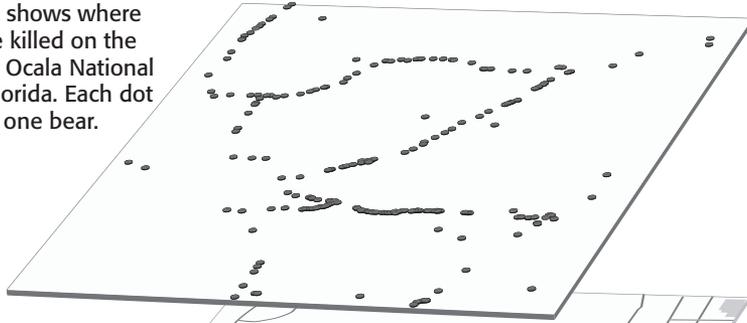
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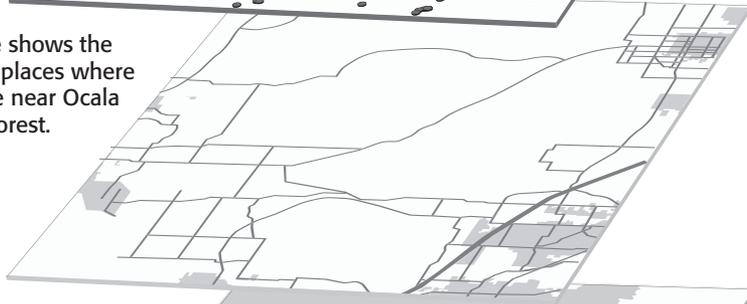
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**SECTION 3** Mapping Earth's Surface *continued*

This image shows where bears were killed on the roads near Ocala National Forest in Florida. Each dot represents one bear.



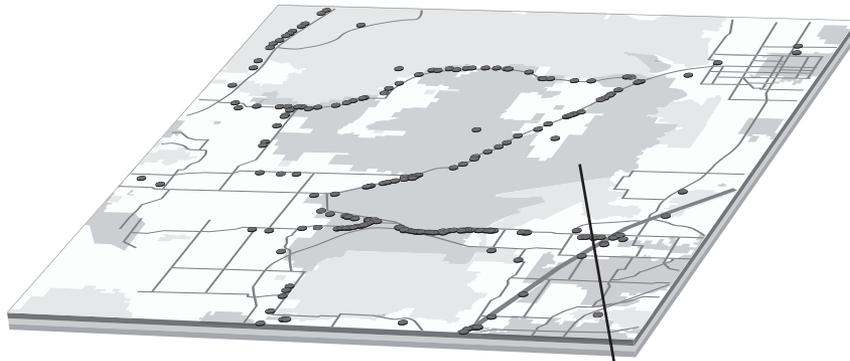
This image shows the roads and places where people live near Ocala National Forest.



This image shows where parks are found near Ocala National Forest.



Scientists used GIS to combine the information in the images above. They used the information to learn where bears could safely live



Safe place for bears to live.

 **Say It**

**Discuss** In a small group, talk about some different problems that scientists can use GIS to solve.

**TAKE A LOOK**

**17. Color** On the maps, color the parks using green. Color the places where bears can live using purple.

# Section 3 Review

 6.7.b, 6.7.f 

## SECTION VOCABULARY

**equator** the imaginary circle halfway between the poles that divides the Earth into the Northern and Southern Hemispheres

**Wordwise** The root *equ* means “even” or “equal.” Other examples are *equal*, *equidistant*, and *equality*.

**latitude** the distance north or south from the equator; expressed in degrees

**longitude** the angular distance east or west from the prime meridian; expressed in degrees

**map** a representation of the features of a physical body such as Earth

**prime meridian** the meridian, or line of longitude, that is designated as 0° longitude

**remote sensing** the process of gathering and analyzing information about an object without physically being in touch with the object

**1. Explain** How can you use a compass to find direction on Earth?

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**2. Compare** Fill in the table below to compare latitude and longitude.

Name	What it is	Measured in	Distance apart
latitude		degrees	always the same
longitude	distance east or west of the prime meridian		

**3. List** What are five pieces of information that are found on all maps?

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**4. Apply Concepts** Why would a mapmaker use active remote sensing instead of passive remote sensing?

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# Maps in Earth Science

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is a topographic map?
- What is a geologic map?



California Science Standards

6.7.f

## What Is a Topographic Map?

If you were going hiking in the wilderness, you would want to take a compass and a map. Because there are no roads in the wilderness, you would not take a road map. Instead, you would take a topographic map.

A **topographic map** is a map that shows the surface features, or *topography*, of an area. Topographic maps show natural features, such as rivers and lakes. They show some features made by people, such as bridges. Topographic maps also show elevation. **Elevation** is the height of an object above the surface of the sea. The elevation at sea level is 0 m. ✓



**Compare** After you read this section, make a chart comparing the features of topographic maps and geologic maps.



**1. Define** What is elevation?

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## CONTOUR LINES

How can a flat map show elevations? Contour lines are used to show elevation on a topographic map. *Contour lines* are lines that connect points on a map that are the same elevation. Each contour line on a map shows a different elevation. Here are some rules for using contour lines:

- Contour lines never cross. All points on a contour line are at the same elevation.
- The space between contour lines depends on the slope of the ground. Contour lines that are close together show a steep slope. Contour lines that are far apart show a gentle slope.
- Contour lines that cross a valley or stream are V-shaped. The V points toward the area of higher elevation, or upstream.
- The tops of hills, mountains, and depressions (dips) are shown by closed circles. Depressions are marked with short, straight lines inside the circle. The lines point toward the center of the depression.

## Critical Thinking

**2. Explain** Why can two contour lines never cross?

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**SECTION 4** Maps in Earth Science *continued***CONTOUR INTERVALS AND RELIEF**

Each contour line represents a certain elevation. The difference in elevation between any two contour lines is called the *contour interval*. For example, a map with a contour interval of 20 m has contour lines drawn at 0 m, 20 m, 40 m, and so on. The contour interval of a map is usually given in or near the map's legend. The contour interval on a map is based on the relief in the area. ✓

**READING CHECK**

**3. Define** What is a contour interval?

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**Math Focus**

**4. Calculate** A map has index contours at 250 m, 500 m, and 750 m. What is the contour interval?

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**Relief** is the difference in elevation between the highest and lowest points in the area on the map. Mountains have high relief. They are usually mapped with large contour intervals. Plains have low relief. They are usually mapped with small contour intervals.

**INDEX CONTOURS**

The many contour lines on a map can make it hard to read. An index contour is used to make reading the map easier. An *index contour* is a darker, heavier contour line that is labeled with an elevation. In most maps, every fifth contour line is an index contour. So, for example, a map with a contour interval of 20 m may have index contours at 0 m, 100 m, 200 m, and so on.

**COLORS**

Topographic maps use colors and symbols to show different features of Earth's surface. Buildings, bridges, and railroads are shown by special symbols drawn in black. Contour lines are brown. Major roads are red. Bodies of water are blue. Wooded areas are shaded in green. Cities are shaded in gray or red. ✓

**READING CHECK**

**5. Identify** How do topographic maps show information?

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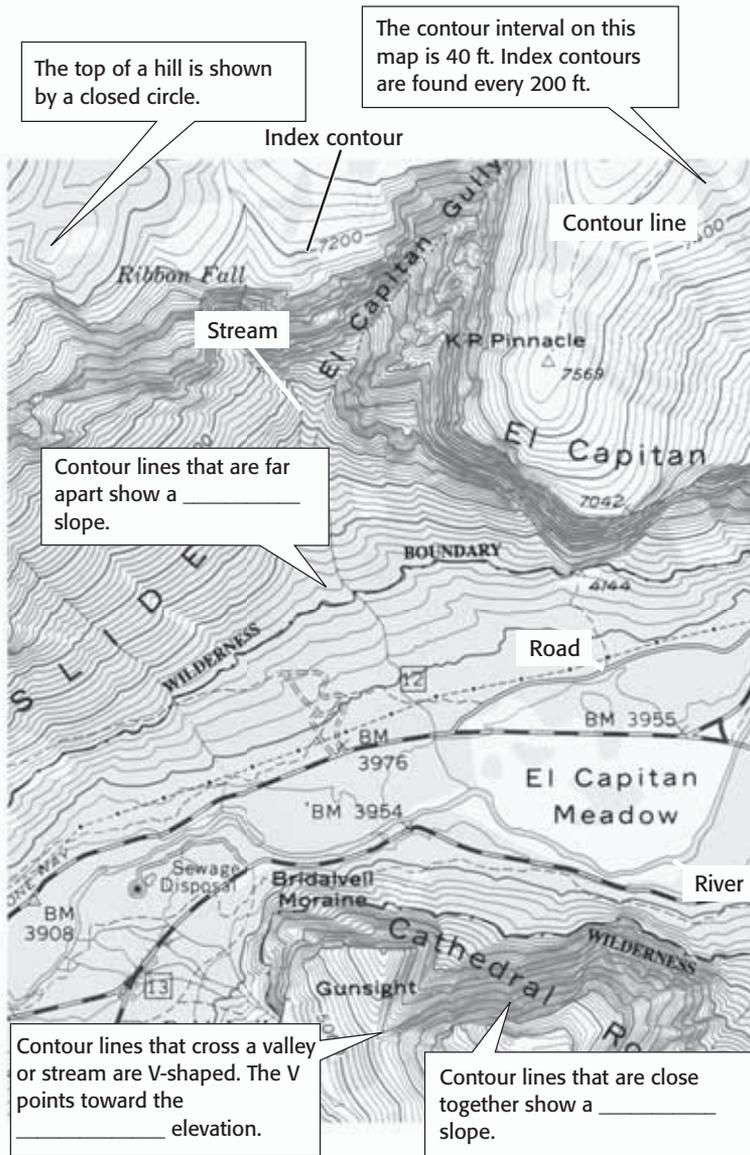
Topographic maps contain a lot of information. This information can be confusing at first. However, if you practice, you will be able to read topographic maps more easily. When you look at a topographic map, ask yourself these questions to help you read the map:

- What area does the map show?
- What is the contour interval of the map?
- What is the relief of the area in the map?
- What kinds of features are shown on the map?

The map on the next page is an example of a topographic map. You can use it to become more familiar with reading topographic maps.

**SECTION 4** Maps in Earth Science *continued*

**Topographic Map of El Capitan**



Building		Lake or pond	
Highway		Railroad track	
Trail		Stream	
Depression		Contour interval = 40 ft	

**CALIFORNIA STANDARDS CHECK**

**6.7.f** Read a topographic map and a geologic map for evidence provided on the maps and construct and interpret a simple scale map.

**Word Help: evidence**  
information showing whether an idea or belief is true or valid

**Word Help: construct**  
to build; to make from parts

**Word Help: interpret**  
to tell or explain the meaning of

**6. Read a Map** On the figure, circle the areas that have the steepest slope. Make a box around the areas that have the gentlest slope.

**TAKE A LOOK**

**7. Identify** Fill in the blanks in the figure to explain how to use contour lines.

**SECTION 4** Maps in Earth Science *continued*

## What Is a Geologic Map?

**Geologic maps** show the geologic features in a given area. *Geologic features* include different types of rocks and rock structures, such as folded, tilted, or broken rocks. Geologic maps present a history of the rocks in a certain area.

To make a geologic map, scientists walk over the area. They record the rock and structures they see on a base map. A *base map* is often a topographic map. Geologists use this map to find hills, valleys, and other features. They then use these topographic features to help record the location of geologic features. ✓

**READING CHECK**

**8. Explain** How do scientists make a geologic map?

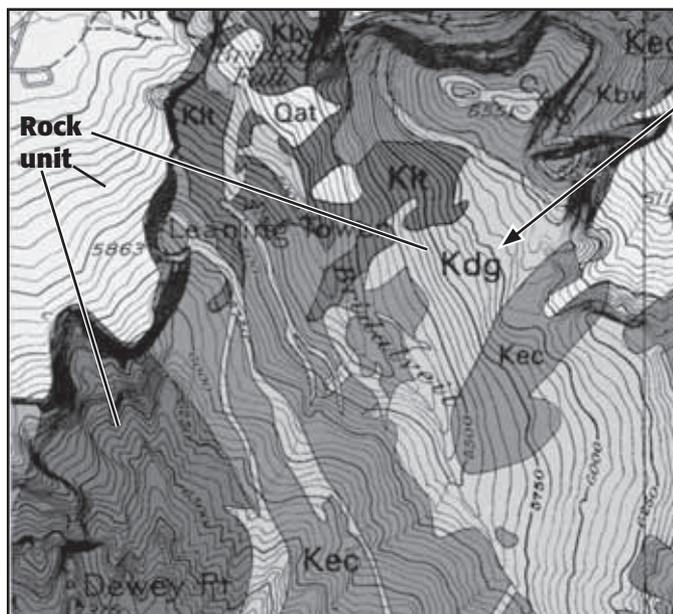
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### ROCK UNITS

Rocks of a certain type and age range are called a *geologic unit*. On a geologic map, different geologic units are identified by different colors. If some geologic units are of similar age, they are colored in different shades of the same color.



On geologic maps, different rock units are shown by different colors. Rock units are also labeled with letters. There is usually one capital letter followed by lowercase letters. The capital letter indicates the age of the rock. The lowercase letters indicate the type of rock or name of the rock unit.

### TAKE A LOOK

**9. Color** On the map, shade the different rock units with different colors. Make sure to make a legend explaining your colors.

### OTHER STRUCTURES

Besides rock units, other features can be shown on geologic maps. *Contact lines* show places where two geologic units meet. The shape of the contact line can show where rock has been folded. Other symbols show if rocks have been tilted. *Faults*, or breaks in rock, can also be shown on geologic maps.

# Section 4 Review

6.7.f



## SECTION VOCABULARY

**elevation** the height of an object above sea level

**geologic map** a map that records geologic information, such as rock units, structural features, mineral deposits, and fossil localities

**relief** the difference between the highest and lowest elevations in a given area; the variations in elevation of a land surface

**topographic map** a map that shows the surface features of Earth

**1. Define** What are contour lines?

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**2. Explain** What is the relationship between the relief of an area and the contour interval on a map of the area?

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**3. Describe** What do the colors on a geologic map represent?

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**4. Identify** Give three features that are shown on topographic maps.

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**5. Identify** Give three features that are shown on geologic maps.

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**6. Calculate** The highest point on a topographic map is marked as 345 m. The lowest contour interval is at 200 m. What is the relief of the area in the map?

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**7. Describe** How is the top of a mountain shown on a topographic map?

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SECTION 1 **The Earth System**



California Science Standards

6.1.b, 6.4.a, 6.4.b, 6.4.d, 6.5.a, 6.5.b

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the parts of the Earth system?
- How does energy move through the atmosphere, hydrosphere, and biosphere?

**STUDY TIP**

**Compare** In your notebook, make a chart showing the features of the atmosphere, biosphere, geosphere, and hydrosphere.

**READING CHECK**

**1. Identify** What are the four parts of the Earth system?

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**TAKE A LOOK**

**2. Define** Fill in the blank spaces in the table.

**What Are the Parts of the Earth System?**

What do the sky and the ground have in common? Like all other parts of Earth, they are always changing. Some parts of Earth change slowly. Other parts change very quickly. All of these changes are important in shaping the Earth system.

Scientists divide Earth into four parts: the geosphere, the hydrosphere, the atmosphere, and the biosphere. The *geosphere* is the mostly solid, rocky part of Earth. The *hydrosphere* is the part of Earth that is water. The *atmosphere* is the mixture of gases that surrounds Earth. The *biosphere* is the part of Earth where life is found. ✓

Energy and matter move through and between the four parts of the Earth system. This movement of energy and matter is what makes life on Earth possible.

Part of the Earth system	Definition
	the part of Earth that is water
Atmosphere	
	the part of Earth where life is found
Geosphere	

**SECTION 1** The Earth System *continued*

## What Are the Parts of the Geosphere?

The geosphere is the rocky part of Earth. It includes all of the rock on Earth’s surface and all of the rock inside Earth. The geosphere is made up of layers.

### LAYERS IN THE GEOSPHERE

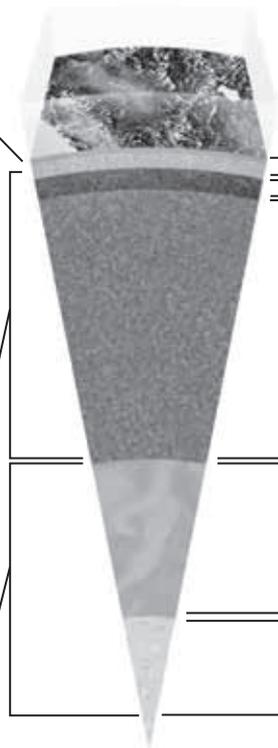
Different parts of the geosphere are made of different materials. The geosphere can be divided into three layers based on composition: the crust, the mantle, and the core. The **crust** is the thin, outermost layer of Earth. The **mantle** is the layer of hot, solid rock beneath the crust. The **core** is the central part of Earth. ✓

Another way to think about the parts of the geosphere is to divide it into five layers based on physical features: the lithosphere, the asthenosphere, the mesosphere, the outer core, and the inner core.

**Crust** The crust is the thin, outermost layer of Earth. It is between 5 km and 70 km thick. Even though it is very thin compared with the rest of Earth, it is still too thick for people to drill or dig through. Even the deepest holes that people have drilled reach only a small part of the way through the crust.

**Mantle** The mantle is about 2,900 km thick. Even though it is very hot, the rock in the mantle is solid. Most of the rock in the mantle can flow like soft chewing gum.

**Core** The core has a radius of 3,400 km. It is made of iron and nickel.



**Lithosphere** The lithosphere is the outer, rigid layer of Earth. It is between 15 km and 300 km thick. It contains all of the crust and a little bit of the mantle. The lithosphere is broken into several large pieces called tectonic plates. The tectonic plates move very slowly over Earth’s surface.

**Asthenosphere** The asthenosphere is the solid layer of mantle that lies beneath the lithosphere. It can flow and move like putty.

**Mesosphere** The mesosphere is the solid layer of the mantle between the asthenosphere and the core.

**Outer Core** The outer core is made of liquid iron and nickel.

**Inner Core** The inner core is made of solid iron and nickel.

✓ **READING CHECK**

**3. List** What are the three layers of the Earth, based on composition?

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## Critical Thinking

**4. Infer** Where do you think the thickest crust on Earth is found?

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## TAKE A LOOK

**5. Identify** What is the main difference between the inner core and the outer core?

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**SECTION 1** The Earth System *continued*



**CALIFORNIA STANDARDS CHECK**

**6.4.a** Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.

**Word Help: major**  
of great importance or large scale

**Word Help: source**  
the thing from which something else comes

**Word Help: energy**  
what makes things happen

**Word Help: phenomenon**  
any facts or events that can be sensed or described scientifically

**Word Help: cycle**  
a repeating series of changes

**6. Explain** How does the sun cause convection currents in the ocean?

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## What Are the Features of the Hydrosphere?

Earth's hydrosphere is made up of the water in, on, and around Earth. The hydrosphere includes all of the oceans, lakes, rivers, glaciers, and polar icecaps on Earth. Clouds, rain, and snow are also part of the hydrosphere. Even water that is found in rocks deep underground is part of the hydrosphere.

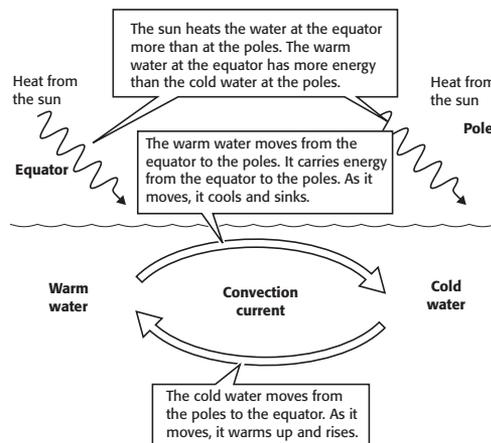
### GLOBAL OCEAN

Most of the water on Earth is found in the oceans. This water is sometimes called the *global ocean*. The global ocean holds more than 97% of all of the water on Earth. People cannot use ocean water for drinking, because it is too salty.

### ENERGY FLOW IN THE OCEAN

The water in the oceans moves because the temperature of the water is different in different places. When the temperature of water changes, its density also changes. Cold, dense water sinks. Warmer, less-dense water rises. A **convection current** forms when matter moves because of differences in density. In the ocean, convection currents help to move energy from one place to another.

The sun is the main source of energy for convection in the ocean. Energy from the sun heats ocean water. However, not all parts of Earth get the same amount of energy from the sun. Therefore, the temperature of ocean water can be very different from place to place. For example, the ocean water near the equator is warm, but the water near the poles can be close to freezing.

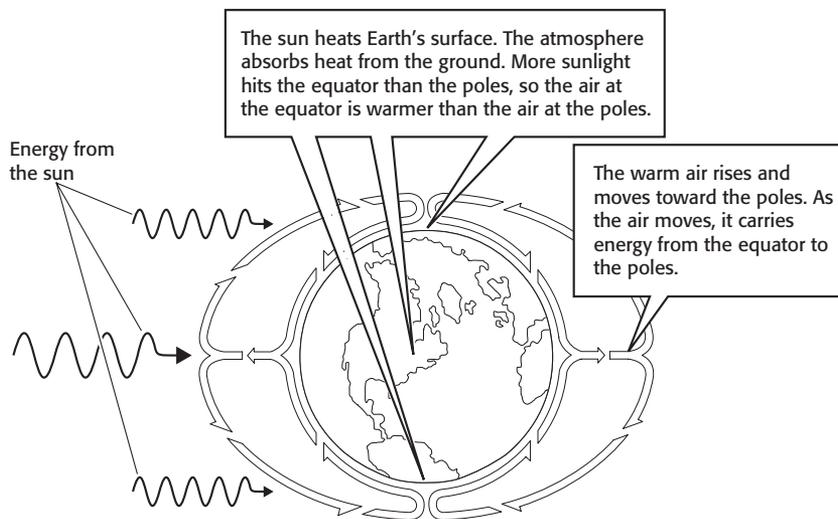


**SECTION 1** The Earth System *continued***What Is the Atmosphere?**

The atmosphere is the mixture of gases that surrounds Earth. The atmosphere reaches out from the surface of Earth for about 500 km. However, most of the gases in the atmosphere are found within about 8 km to 12 km of Earth's surface.

**LAYERS IN THE ATMOSPHERE**

Earth's atmosphere is made up of four layers. The *troposphere* is the layer that is closest to Earth's surface. It is the layer in which people live. Most weather happens in the troposphere. The *stratosphere* is the layer that is right above the troposphere. The *mesosphere* is the coldest layer of the atmosphere. The *thermosphere* is the uppermost layer of the atmosphere. ✓

**ENERGY FLOW IN THE ATMOSPHERE**

The sun is the main source of energy for Earth's surface. The energy from the sun heats Earth's surface unevenly. The atmosphere absorbs energy from Earth's surface. Since the surface is heated unevenly, the atmosphere is, too. The uneven heating makes the air in the atmosphere move.

The movement of the air helps move heat energy through the atmosphere. The term **convection** is used to describe the transfer of energy by the movement of matter. Convection is an important way that energy flows through the atmosphere, just as it is in the hydrosphere.

**READING CHECK**

**7. Draw** In the space above, draw a picture of the four layers of the atmosphere. Label each layer.

**TAKE A LOOK**

**8. Identify** On the figure, draw an arrow showing the main direction that energy moves in the atmosphere.

**SECTION 1** The Earth System *continued*

**Critical Thinking**

**9. Apply Concepts** Why are the upper parts of the atmosphere not part of the biosphere?

\_\_\_\_\_

\_\_\_\_\_

**READING CHECK**

**10. Explain** Why are most living things found near Earth's surface?

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**What Is the Biosphere?**

The biosphere is made up of *organisms*, or living things, and the parts of Earth where life is found. The biosphere includes Earth's surface, the lower part of the atmosphere, and most of the hydrosphere. Scientists continue to find life in new places. Therefore, the boundaries of the known biosphere are always changing.

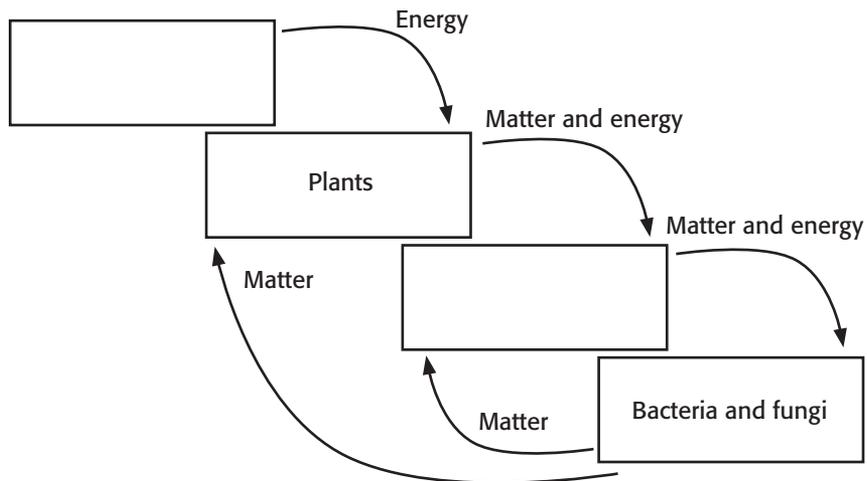
**FACTORS NEEDED FOR LIFE**

The biosphere has many factors that living things need in order to survive. For example, most living things need liquid water and a certain range of temperatures in order to survive. Therefore, most living things are found near Earth's surface. ✓

**MATTER AND ENERGY FLOW**

Most of the energy that flows through the biosphere comes from sunlight. Plants use the energy in sunlight to change chemicals, such as carbon dioxide, into food, such as sugar. The plants use some of the energy in the food to grow. Animals and other living things get energy by eating plants or by eating living things that have eaten plants. Both matter and energy are transferred when living things eat other living things.

The transfer of matter and energy does not stop when a living thing dies. Living things such as some bacteria and fungi break down the remains of dead organisms into simple materials. These materials then can be used by other organisms. The bacteria and fungi get their energy from the remains of the dead organisms they break down.



**TAKE A LOOK**

**11. Identify** Fill in the blank boxes in the figure to show how matter and energy flow in the biosphere.

# Section 1 Review

6.1.b, 6.4.a, 6.4.b, 6.4.d, 6.5.a, 6.5.b



## SECTION VOCABULARY

**convection** the movement of matter due to differences in density; the transfer of energy due to the movement of matter

**Wordwise** The prefix *con-* means “with” or “together.” The root *vect* means “to carry.”

**convection current** any movement of matter that results from differences in density; may be vertical, circular, or cyclical

**core** the central part of the Earth below the mantle

**crust** the thin and solid outermost layer of the Earth above the mantle

**mantle** the layer of rock between the Earth’s crust and core

**1. Identify** How does heat flow through the atmosphere and the hydrosphere?

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**2. Compare** Give two differences between the mantle and the core.

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**3. Explain** How does energy flow in the biosphere?

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**4. Describe** How does matter flow in the biosphere?

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**5. Identify** What is the main source of energy for convection in the atmosphere and the oceans?

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**6. Compare** How is the lithosphere different from the asthenosphere?

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**7. Explain** Why are water and air at the equator warmer than water and air at the poles?

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SECTION 2 **Heat and Energy**



6.3.a, 6.3.c, 6.3.d

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is temperature?
- What is heat?
- How does heat move from place to place?

**STUDY TIP**

**Discuss** Read this section quietly to yourself. When you finish reading, talk about the section with a partner. Work together to figure out the parts that you don't understand.

**READING CHECK**

**1. Explain** How does the speed of a particle affect its kinetic energy?

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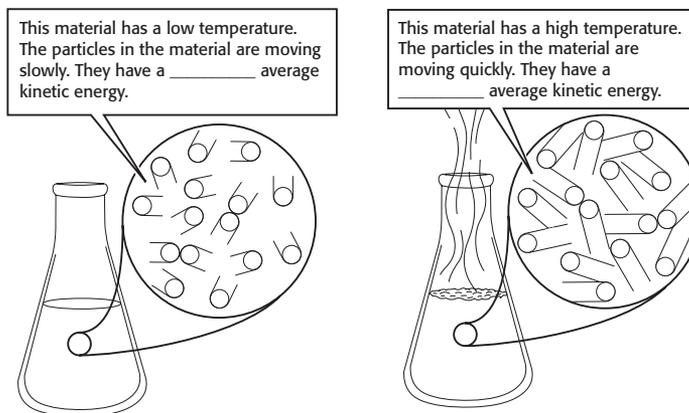
**What Is Temperature?**

What makes an object have a certain temperature? The answer to that question has to do with the tiny particles that make up the object.

All matter is made up of tiny particles. These particles are always moving, even though we can't see them move. When particles are moving, they have a kind of energy called *kinetic energy*. The faster the particles move, the more kinetic energy they have. ✓

The particles in an object are all moving at different speeds and in different directions. We can't measure the kinetic energy of each particle by itself. However, we can measure the average kinetic energy of all of the particles in an object.

The average kinetic energy of these tiny particles is what gives an object its temperature. The **temperature** of an object is a measure of the average kinetic energy of all of the particles in the object. The temperature of an object does not depend on the size of the object. If the particles in an object have a lot of kinetic energy, the object will have a high temperature.



**TAKE A LOOK**

**2. Identify** Fill in the blank lines in the figure to describe the amount of kinetic energy in the particles.

**SECTION 2** Heat and Energy *continued*

**What Is Heat?**

What do you think of when you think about heat? Most people think of something that has a high temperature. However, heat also has to do with objects that have low temperatures. In science, **heat** is the energy that is transferred between objects that are at different temperatures. ✓

Why do some objects feel hot or cold? Heat moves from one object to another when their temperatures are different. Heat always moves from the object with a higher temperature to the object with a lower temperature. When you touch something that feels cold, heat moves from your body into the object. When you touch something that feels hot, heat moves from the object into your body.

**READING CHECK**

**3. Define** What is heat?

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**HEAT AND THERMAL ENERGY**

If heat is transferred energy, what kind of energy is being transferred? The answer is thermal energy.

**Thermal energy** is the total kinetic energy of the particles that make up a substance. Thermal energy is measured in joules (J).

The amount of thermal energy in a substance depends partly on its temperature. Something at a high temperature usually has more thermal energy than something at a lower temperature.

Thermal energy also depends on the number of particles in a substance. At the same temperature, objects made of many particles have more thermal energy than objects made of few particles.

*Critical Thinking*

**4. Compare** How is thermal energy different from temperature?

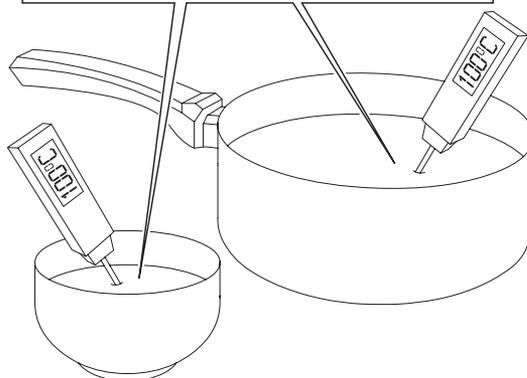
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The soup in the bowl has the same temperature as the soup in the pan. However, there is less soup in the bowl than in the pan. Therefore, the soup in the pan has more thermal energy than the soup in the bowl.



**TAKE A LOOK**

**5. Explain** The soup in the bowl and the soup in the pan have the same temperature. Why does the soup in the pan have more thermal energy than the soup in the bowl?

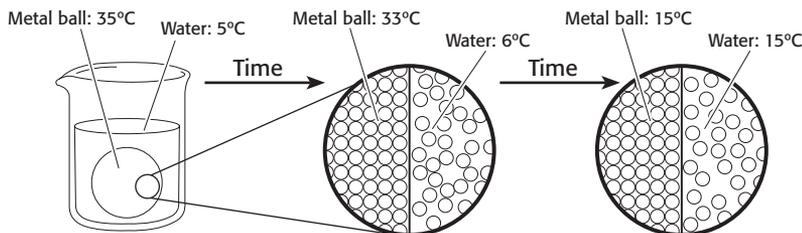
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**SECTION 2** Heat and Energy *continued*

**REACHING THE SAME TEMPERATURE**

When two objects with different temperatures touch, heat flows between them. The heat flows from the warmer object to the cooler object. Heat flows until both objects have the same temperature.



1. A hot metal ball is placed in a beaker of cold water. The ball starts out with a temperature of 35°C. The water starts out with a temperature of 5°C.
2. As soon as the ball enters the water, heat begins to move from the \_\_\_\_\_ into the \_\_\_\_\_. The temperature of the water begins to rise, and the temperature of the ball begins to drop.
3. In time, the ball and the water reach the same temperature. The ball has become cooler, and the water has become warmer. Heat stops moving between the ball and water.

**TAKE A LOOK**

**6. Identify** Fill in the blank spaces to show the direction that thermal energy moves between the ball and the water.

**Math Focus**

**7. Calculate** By how many degrees did the temperature of the metal ball decrease when it transferred its thermal energy to the water?

\_\_\_\_\_

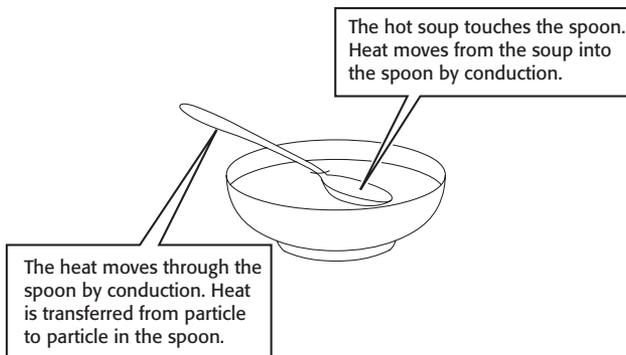
**How Does Heat Move?**

Heat can move between objects in three main ways: conduction, convection, and radiation. During conduction, heat moves through matter, but the matter does not move. During convection, matter moves and carries heat with it. During radiation, no matter is needed to move the heat from place to place.

**CONDUCTION**

**Conduction** happens when heat moves from one object to another through direct contact. Imagine that you place a metal spoon into a bowl of hot soup. The particles in the rounded end of the spoon touch the particles in the soup. Heat moves from the soup into the spoon by conduction.

After a while, the handle of the spoon will get hot, even though it is not touching the soup. This is because the metal in the spoon can conduct heat from the rounded end to the handle.



**Critical Thinking**

**8. Apply Concepts** What will happen to the temperature of the soup when the spoon is placed into the bowl? Explain your answer.

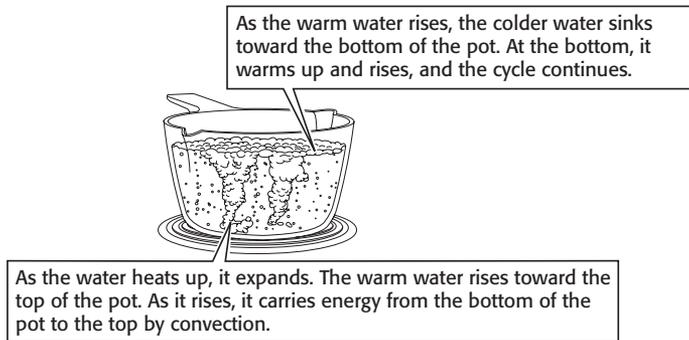
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**SECTION 2** Heat and Energy *continued*

**CONVECTION**

**Convection** happens when matter carries heat from one place to another. For example, when you boil water in a pot, the temperature of the water near the hot burner increases. The particles in the hot water move farther apart. The hot water rises. As it rises, the hot water carries heat from the bottom of the pot to the top. ✓

In many cases, convection occurs because of thermal expansion. *Thermal expansion* happens when the volume of a substance increases because its temperature increases. Thermal expansion is what causes hot air to rise above cold air in the atmosphere. It is also what causes warm water to rise above colder water in the oceans. Thermal expansion can even cause rocks in the geosphere to move!



**READING CHECK**

**9. Define** What is convection?

\_\_\_\_\_

\_\_\_\_\_

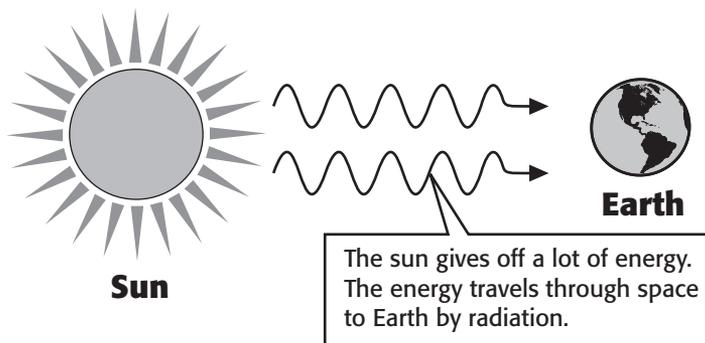
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**TAKE A LOOK**

**10. Identify** On the figure, draw arrows showing how the warm and cold water moves in the pot.

**RADIATION**

**Radiation** happens when energy, such as heat, moves in waves between one object and another. Energy can move between objects by radiation even if there is no matter to carry the energy. For example, the sun produces a lot of energy. This energy travels to Earth by radiation through outer space. Even though there is almost no matter in outer space, the energy can travel to Earth by radiation.



**TAKE A LOOK**

**11. Compare** How is radiation different from both convection and conduction?

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**SECTION 2** Heat and Energy *continued*

## How Can Heat Affect Matter?

What is the difference between ice and water? You probably answered that ice is a solid and water is a liquid. The chemicals that make up the water are the same as the chemicals that make up the ice. The difference between the ice and the water is the *state*, or physical form, that the matter is in. In general, substances can be in three different states: solid, liquid, or gas. ✓

Remember that matter is made of tiny particles. The state of a substance depends on the speed of its particles and on the attractions between them. The figure below shows how the particles in solids, liquids, and gases are different.



Particles of a solid have a strong attraction between them. The particles are closely locked in position and can only vibrate.

Particles of a liquid are more loosely connected than those of a solid and can collide with and move past one another.

Particles of a gas move fast enough that they overcome the attractions between them. The particles move independently and collide frequently.

One way to change matter from one state to another is to add heat. When heat moves into an object, the object's temperature goes up. The particles in the substance move faster. This can make a solid turn into a liquid or a liquid turn into a gas.

You can also change a substance's state by causing it to lose heat. When you put a glass of water in the freezer, heat moves from the water into the much colder freezer. The particles in the water move more and more slowly. After a while, they move so slowly that the water turns from a liquid into a solid.

Change of state	Description
Condensing	A gas turns into a liquid.
Freezing	A liquid turns into a solid.
Melting	A solid turns into a liquid.
Evaporating	A liquid turns into a gas.

**READING CHECK**

**12. Identify** What are the three states of matter?

\_\_\_\_\_

\_\_\_\_\_

**CALIFORNIA STANDARDS CHECK**

**6.3.a** Students know energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects.

**Word Help: energy**  
what makes things happen

**13. Apply Concepts** Why does the ice in a glass of soda melt?

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# Section 2 Review

6.3.a, 6.3.c, 6.3.d 

## SECTION VOCABULARY

<p><b>conduction</b> the transfer of energy as heat through a material</p> <p><b>convection</b> the movement of matter due to differences in density; the transfer of energy due to the movement of matter</p> <p><b>heat</b> the energy transferred between objects that are at different temperatures</p>	<p><b>radiation</b> the transfer of energy as electromagnetic waves</p> <p><b>temperature</b> a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object</p> <p><b>thermal energy</b> the kinetic energy of a substance's atoms</p>
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**1. Explain** How is temperature related to kinetic energy?

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**2. Explain** Why does an ice cube feel cold when you touch it?

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**3. Describe** You place a hot glass rod in a cup filled with a cold liquid. Describe what will happen to the rod and the liquid with time.

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**4. Apply Concepts** Why does the energy from the sun travel to Earth by radiation instead of by convection or conduction?

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**5. Compare** How is convection different from conduction?

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CHAPTER 3 Earth's Systems and Cycles

SECTION 3 **The Cycling of Energy**



California Science Standards

6.3.a, 6.3.c, 6.3.d, 6.4.a, 6.4.b, 6.4.c, 6.4.d

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- Where does the heat on Earth come from?
- How does heat move through the atmosphere, hydrosphere, and geosphere?

**STUDY TIP**

**Compare** As you read this section, make a chart comparing the ways that heat moves through Earth's systems.

**READING CHECK**

**1. Identify** What are three ways heat can move?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**How Does Energy Move from Place to Place?**

Imagine that you are playing outside on a warm, sunny day. You see some clouds start to form in the sky. All of a sudden, a strong wind starts to blow, and the air feels much cooler. Soon, you hear thunder. It starts to rain. Why did the weather change so quickly? The answer has to do with how heat moves through Earth's atmosphere.

Remember that heat can be carried from one place to another in three ways: by radiation, by convection, or by conduction. During radiation, heat moves in the form of waves. During convection, matter moves from place to place and carries heat with it. During conduction, heat moves by heat flow. **Heat flow** means the transfer of heat from a warmer object to a cooler object. ✓

Radiation, conduction, and convection are all important in moving heat through Earth's systems. Where does this heat come from? The sun is the main source of heat for Earth's systems. However, the inside of Earth also gives a little bit of heat to Earth's systems. The heat from the sun and from the inside of Earth moves through the geosphere, hydrosphere, biosphere, and atmosphere.

**TAKE A LOOK**

**2. Recall** Fill in the table to compare the three different ways that heat can move from place to place.

Type of heat transfer	How heat moves	Example
Radiation		
Conduction		
Convection		

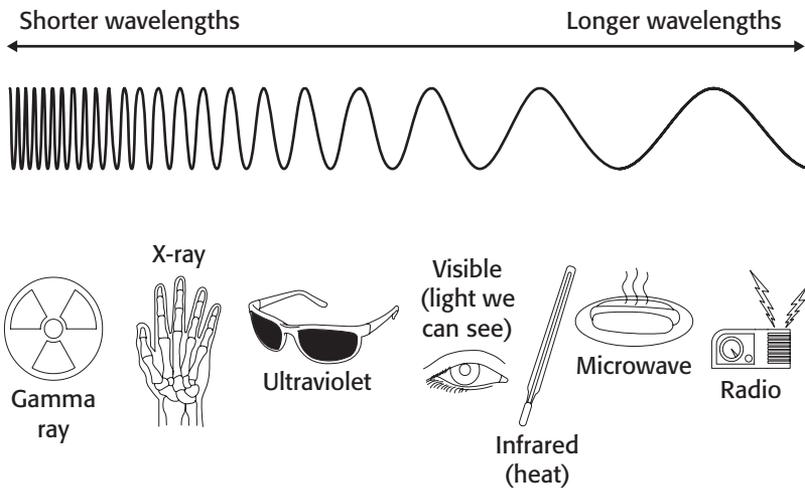
**SECTION 3** The Cycling of Energy *continued*

**How Does the Sun’s Energy Get to Earth?**

Earth is almost 150 million kilometers from the sun. However, the sun provides 99% of the energy on Earth. How does energy from the sun travel to Earth? The answer is radiation. Remember that energy can travel by radiation, even when there is no matter around to transmit the energy.

**ELECTROMAGNETIC SPECTRUM**

Most of the energy that the sun gives off is light that you can see. However, the sun also gives off energy that you can’t see. All of the energy from the sun travels in waves. These waves are called *electromagnetic radiation*. Electromagnetic radiation includes many different *wavelengths*, or kinds, of energy. Together, all of these wavelengths are called the **electromagnetic spectrum**.



The electromagnetic spectrum is made up of many different wavelengths of electromagnetic radiation. Most of the energy that the sun gives off is visible light that we can see. Other kinds of electromagnetic radiation are X-rays, microwaves, and radio waves.

**EARTH AND ENERGY FROM THE SUN**

The energy from the sun travels through space by radiation. Some of the energy can pass through Earth’s atmosphere and reach Earth’s surface. The energy from the sun is the main force that drives the water cycle. The energy from the sun makes life on Earth possible.

Earth’s geosphere, hydrosphere, atmosphere, and biosphere absorb a lot of the energy that Earth gets from the sun. As Earth’s systems absorb the light energy, some of it turns into heat. Heat can move through Earth’s systems by convection and conduction.

**CALIFORNIA STANDARDS CHECK**

**6.4.b** Students know solar energy reaches Earth through radiation, mostly in the form of visible light.

**Word Help: energy**  
what makes things happen

**Word Help: visible**  
that can be seen

**3. Identify** In what form is most of the energy that Earth gets from the sun?

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**Say It**

**Discuss** You may have heard or seen the terms “X-ray,” “infrared,” and “ultraviolet” in other places. In a small group, talk about the ways that these words are used in everyday speech.

**SECTION 3** The Cycling of Energy *continued*

## How Does Convection Move Energy Through Earth's Systems?

Remember that convection happens when moving matter carries heat from one place to another. Convection happens when matter is heated unevenly. Most of the heat that moves through Earth's systems moves by convection. Convection moves energy in the hydrosphere, atmosphere, and geosphere. ✓

**READING CHECK**

**4. Identify** What is the main way that energy moves through the atmosphere, hydrosphere, and geosphere?

\_\_\_\_\_

### Critical Thinking

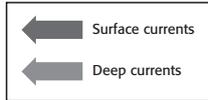
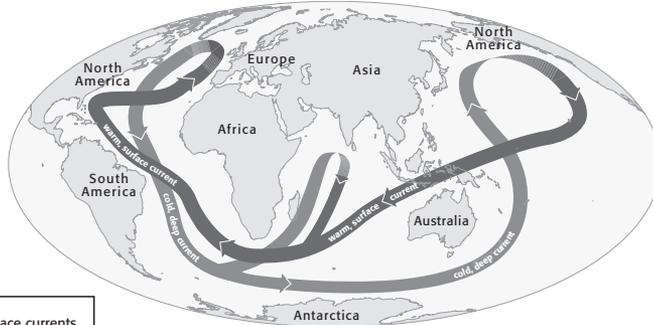
**5. Predict Consequences** Would there still be convection in the oceans if the Earth stopped getting energy from the sun? Explain your answer.

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### CONVECTION IN THE HYDROSPHERE

Most of the convection in the hydrosphere happens in the oceans. Remember that convection in the oceans happens when ocean water is colder in some places than in other places. The colder water is denser than the warmer water. The difference in density produces a convection current in the ocean.

In the ocean, convection can cause currents. *Currents* are bodies of water that move like rivers on the ocean surface or far below it. Currents can move water over thousands of miles, but the journey can take a thousand years or more!



Convection in the oceans moves heat from place to place. Convection produces currents on the surface and in the deep water. These currents can move water and energy for thousands of miles.

### CONVECTION IN THE ATMOSPHERE

Convection in the atmosphere, just like convection in the oceans, happens because of uneven heating. The sun heats Earth's surface. The ground warms up the air by conduction. Then, the warm air rises and moves across Earth's surface. As it rises and moves, it loses some of its heat and gets cooler. The cooler air sinks toward Earth. ✓

The movement of air by convection can cause winds. It also helps transfer heat from one place to another on Earth's surface.

**READING CHECK**

**6. Explain** Why does convection happen in the atmosphere?

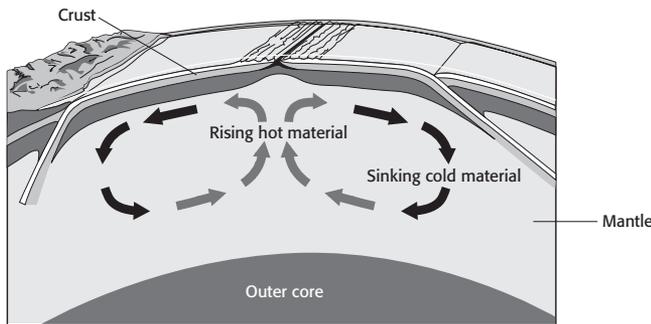
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**SECTION 3** The Cycling of Energy *continued*

**CONVECTION IN THE GEOSPHERE**

Earth may seem very solid and rigid to you. However, inside Earth, solid rock is flowing slowly from place to place. Energy from inside Earth heats up the rock in Earth’s mantle. The rock in the mantle is under a lot of pressure, so it does not melt. Instead, the heated rock acts like soft taffy or chewing gum. It is still solid, but it moves slowly from place to place.

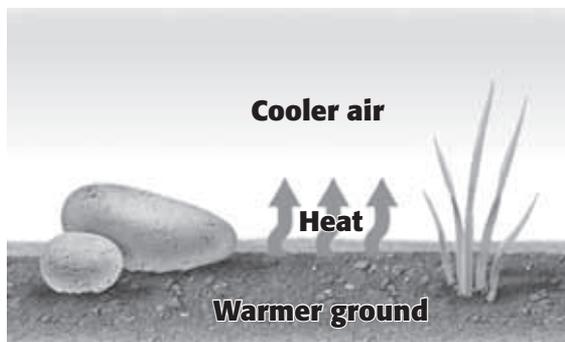
As the rock heats up, it rises toward Earth’s surface. At the same time, cooler, denser rock sinks deeper into the mantle. This movement produces convection currents like those in the ocean. In this way, heat from inside Earth moves to Earth’s surface. Scientists think that convection currents in the mantle make tectonic plates move.



Convection in the geosphere moves \_\_\_\_\_ and matter from the inside of Earth to the surface.

**How Does Conduction Move Energy Through Earth’s Systems?**

Conduction happens when heat moves between objects that are touching. Heat moves from the warmer object to the cooler object. Heat can move by conduction between the geosphere and the atmosphere where the air touches the ground.



Radiation from the sun warms the ground. If the ground is warmer than the air, heat can move from the ground into the air by conduction. Conduction happens only within a few centimeters of Earth’s surface, where air particles are touching the ground.

**CALIFORNIA STANDARDS CHECK**

**6.4.c** Students know heat from Earth’s interior reaches the surface primarily through convection.

**Word Help:** primarily mainly

**7. Explain** How does heat move from inside Earth to Earth’s surface?

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**TAKE A LOOK**

**8. Identify** Fill in the blank line in the figure.

**TAKE A LOOK**

**9. Explain** How does energy move from the geosphere to the atmosphere?

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# Section 3 Review

6.3.a, 6.3.c, 6.3.d, 6.4.a, 6.4.b, 6.4.c, 6.4.d



## SECTION VOCABULARY

<p><b>electromagnetic spectrum</b> all of the frequencies or wavelengths of electromagnetic radiation</p>	<p><b>heat flow</b> another term for heat transfer, the transfer of energy from a warmer object to a cooler object</p>
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1. **List** What are three ways that heat can move from one place to another?

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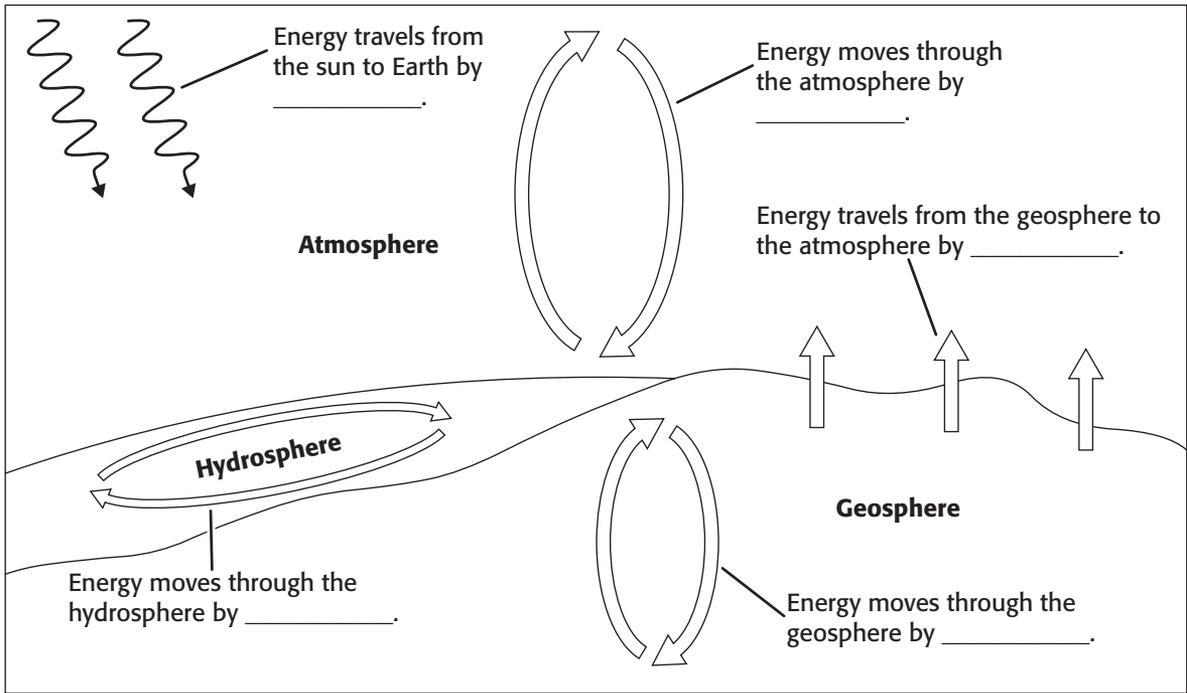


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2. **Identify** On the figure below, fill in the blanks with the terms *radiation*, *conduction*, and *convection* to show how energy moves in Earth's systems. Hint: You may need to use some of the terms more than once.



3. **Apply Concepts** Will heat move from the ground to the atmosphere by conduction if the air is warmer than the ground? Explain your answer.

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**CHAPTER 3** Earth's Systems and Cycles

**SECTION 4** **The Cycling of Matter**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is the rock cycle?
- What is the water cycle?
- How do nitrogen, carbon, and phosphorus move through Earth's systems?



**California Science Standards**

6.4.a, 6.5.a, 6.5.b

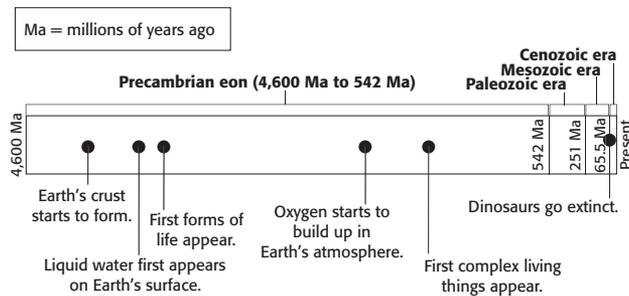
**How Fast Does Earth Change?**

You probably know people who recycle. Did you know that Earth also recycles? Not very much new matter comes into the Earth system. Therefore, the matter that is already here has to be recycled. Water, carbon, nitrogen, phosphorus, and even rocks move through cycles on Earth.

As matter moves through the parts of Earth, the matter changes. Some of the changes happen very fast. For example, floods can move a lot of rock from one place to another in only a few days. On the other hand, some of the changes happen very slowly. For example, it can take millions of years for a tall mountain to form. Because Earth is so old, even these very slow changes have affected Earth a great deal.



**Compare** As you read, make a chart comparing the ways that carbon, nitrogen, and phosphorus move through Earth's systems.



Earth is 4.6 billion years old. This timeline shows when some important events happened on Earth. Human-like animals did not appear on Earth until about 4 million years ago.

**Math Focus**

**1. Calculate** For what fraction of Earth's history have human-like animals existed? Show your work.

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**What Are the Different Kinds of Rocks?**

Rocks can look very different from each other. In many cases, they look different because they form in different ways. Scientists put rocks into three groups based on how they form. *Sedimentary rocks* form when pieces of rock stick together to form a hard rock. *Igneous rocks* form when melted rock cools and hardens. *Metamorphic rocks* form when rock changes because of heat or pressure.

**SECTION 4** The Cycling of Matter *continued*

**SEDIMENTARY ROCKS**

What do sand, clay, and pebbles have in common? They all form when large rocks are broken into smaller pieces. Small pieces of rock that are moved from place to place are called *sediment*. Sediment can be moved by wind, water, ice, and gravity. ✓

**READING CHECK**

**2. Define** What is sediment?

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Sedimentary rocks can be grouped based on what they are made of and how they form. Some sedimentary rocks form when sediment is buried and put under pressure. The pressure causes the sediment pieces to stick together. In time, the sediment hardens and forms a rock. Sedimentary rocks that form when sediment hardens under pressure are called *clastic sedimentary rocks*.

Other sedimentary rocks form when chemicals form mineral crystals. For example, many kinds of chemicals are dissolved in ocean water. If the water evaporates, some of the chemicals will form mineral crystals. Sedimentary rock that forms when minerals that are dissolved in water form crystals are called *chemical sedimentary rocks*.

Some sedimentary rocks are made of pieces of dead organisms. For example, many animals that live in the ocean have hard shells. When the animals die, their shells fall to the ocean floor. The shells can be buried. In time, pressure can cause the pieces to stick together and form a rock. Sedimentary rocks that form from pieces of dead organisms are called *organic sedimentary rocks*.

**Critical Thinking**

**3. Compare** How are clastic sedimentary rocks different from organic sedimentary rocks?

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**TAKE A LOOK**

**4. Describe** How does halite form?

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Sandstone is a kind of clastic sedimentary rock. It is made of sand that has stuck together and hardened.

Halite is a kind of chemical sedimentary rock. It forms when seawater evaporates.

Coquina is a kind of organic sedimentary rock. It is made of the shells of tiny sea creatures.

**SECTION 4** The Cycling of Matter *continued*

**IGNEOUS ROCKS**

Igneous rock forms when melted rock cools and hardens. Igneous rocks can be grouped based on the size of the crystals in the rock. When melted rock cools slowly, large crystals can form. Igneous rocks made of large crystals are called *coarse-grained* igneous rocks.

If melted rock cools quickly, only very small crystals can form. Sometimes, the melted rock cools so fast that no crystals can form. Igneous rocks made of tiny crystals or no crystals at all are called *fine-grained* igneous rocks. ✓

Igneous rocks can also be grouped by the types of minerals in them. Some igneous rocks, such as granite, are made of mostly light-colored minerals. Most of these light-colored rocks are found on Earth’s crust, in the continents. Other igneous rocks are made of mostly dark-colored minerals. These dark-colored rocks are found mainly in Earth’s mantle and in the crust under the oceans.



Granite is a kind of igneous rock. It has very large crystals, so it is coarse-grained. It is made mostly of light-colored minerals.



Basalt is a kind of igneous rock. It has very small crystals, so it is fine-grained. It is made of dark-colored minerals.

**METAMORPHIC ROCKS**

Metamorphic rock forms when one kind of rock changes into another kind of rock because of heat or pressure. Most metamorphic rocks form deep within Earth’s crust. At these depths, temperature and pressure can be much higher than they are at Earth’s surface.

Metamorphic rocks can be put in groups based on how the minerals in them are related. In *foliated* metamorphic rocks, the minerals form bands or stripes within the rock. In *nonfoliated* metamorphic rocks, the minerals do not form bands or stripes. The picture at the top of the next page shows examples of metamorphic rocks.

**READING CHECK**

**5. Identify** What is the main factor that affects whether an igneous rock is fine-grained or coarse-grained?

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**TAKE A LOOK**

**6. Infer** Where would you be most likely to find granite, in Earth’s mantle or Earth’s continents? Explain your answer.

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**SECTION 4** The Cycling of Matter *continued*

**TAKE A LOOK**

**7. Explain** Why is marble considered a nonfoliated metamorphic rock?

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Gneiss is a kind of metamorphic rock. The minerals form stripes in the rock, so it is a foliated metamorphic rock.



Marble is a kind of metamorphic rock. The minerals do not form stripes in the rock, so it is a nonfoliated metamorphic rock.

**How Do Rocks Change from One Kind to Another?**

There are many ways that rocks can change. The **rock cycle** is made up of all of the ways that rocks can change from one kind to another. Some of the processes that can change the form of a rock are melting, cooling, heating, increasing pressure, weathering, and erosion. *Weathering* happens when rock is broken into smaller pieces. *Erosion* happens when sediment is moved from one place to another. ✓

**READING CHECK**

**8. Identify** Give three ways that rock can change from one form to another.

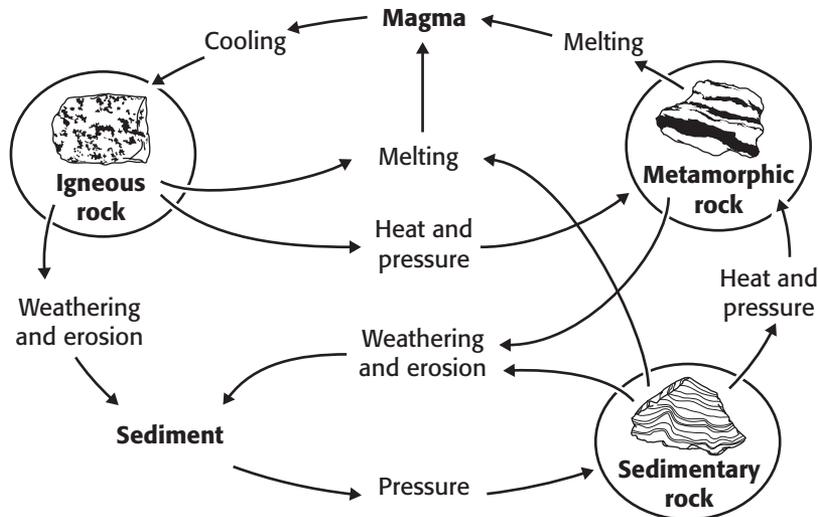
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**HOW ROCK MOVES THROUGH THE ROCK CYCLE**

Rocks can take many different paths through the rock cycle. The path that a rock takes depends on the forces that act on the rock. These forces change, depending on where the rock is located. For example, metamorphic rock usually forms deep beneath Earth's surface, where pressure and temperature are high.



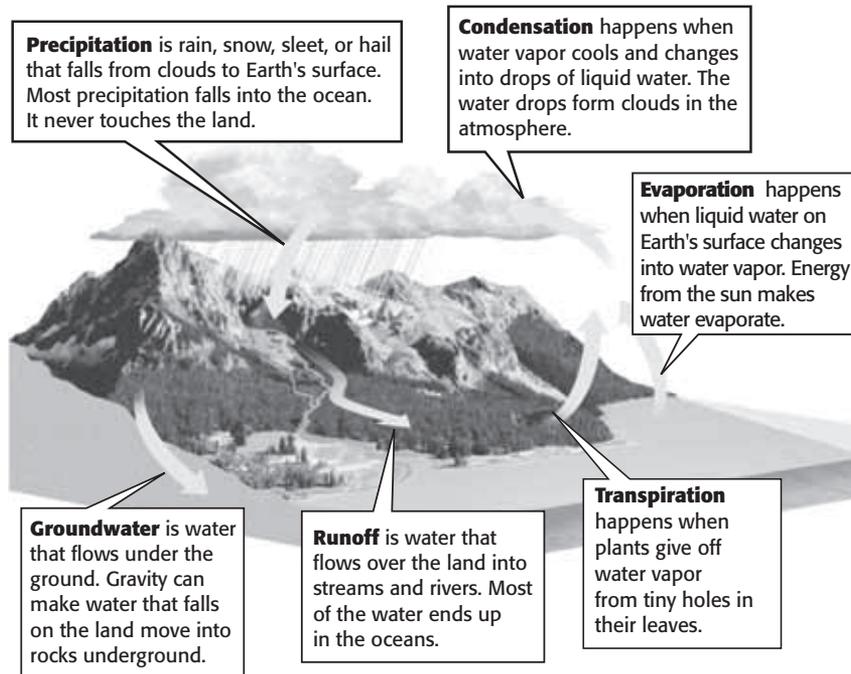
**TAKE A LOOK**

**9. Use Models** Find two paths through the rock cycle that lead from sedimentary rock to igneous rock. Use a colored pen or marker to trace both paths on the figure.

**SECTION 4** The Cycling of Matter *continued*

## How Does Water Move Through Earth's Systems?

The **water cycle** is the constant movement of water between the atmosphere, the land, and the oceans. Most of the energy that drives the water cycle comes from the sun. For example, the sun's energy can turn liquid water in the oceans into water vapor, a gas that enters the atmosphere. The figure below shows some of the ways that water moves through the water cycle.



## Critical Thinking

**10. Predict Consequences**  
Imagine that evaporation stopped happening on Earth. What could happen to the water cycle? Explain your answer.

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## Say It

**Discuss** In a small group, talk about the ways that precipitation, runoff, and groundwater can affect people.

## How Do Elements Move Through Earth's Systems?

Many chemical elements, such as carbon, nitrogen, and phosphorus, are important for life on Earth. These elements are constantly moving from one place to another. They move between living things and nonliving things through many different processes.

**SECTION 4** The Cycling of Matter *continued*

**CALIFORNIA STANDARDS CHECK**

**6.5.b** Students know matter is transferred over time from one organism to others in the food web and between organisms and the physical environment.

**Word Help: transfer**  
to carry or cause to pass from one thing to another

**11. Identify** Give one way that carbon can move from the atmosphere into living things. Give one way that carbon can move from living things into the atmosphere?

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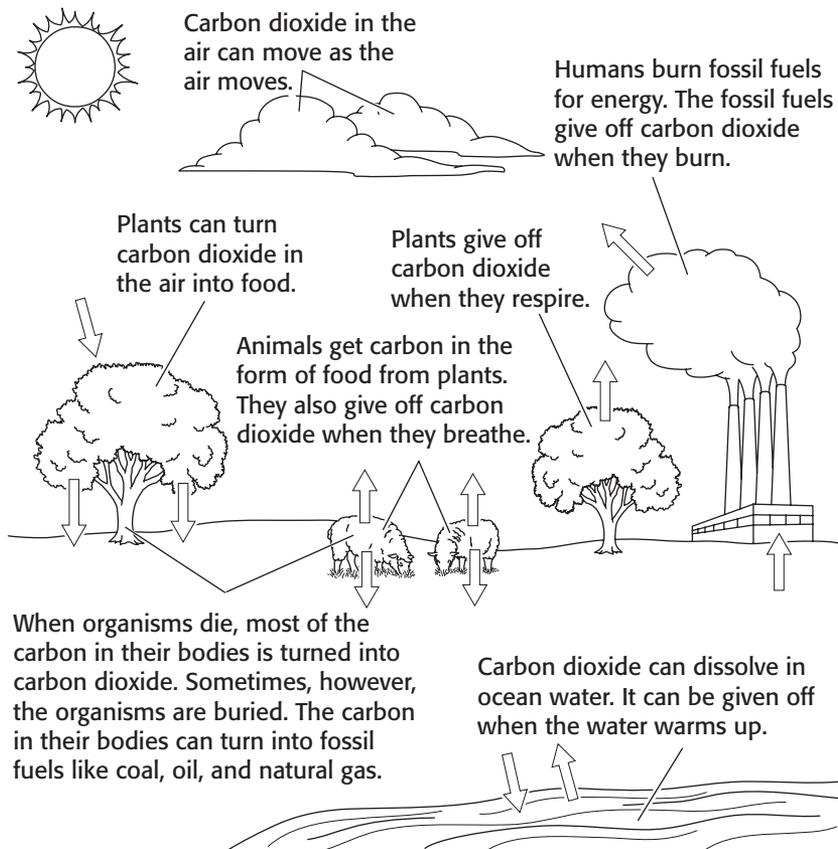
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**CARBON CYCLE**

Carbon is an important part of many of the chemicals that make up living things. However, carbon is not found only in living things. It is also found in the atmosphere, the land, and water. The **carbon cycle** is the way that carbon moves between living things and nonliving things.

Some parts of the carbon cycle happen fairly quickly. For example, plants can turn carbon dioxide from the atmosphere into food. Other organisms get food from plants. When plants and other organisms break down the food, the carbon dioxide moves back into the atmosphere. This process takes as little as a day or two.

In contrast, some parts of the carbon cycle happen very slowly. For example, dead plants and tiny sea creatures can be buried by sediment before they decay. After millions of years, the remains can turn into fossil fuels such as coal, oil, and natural gas. The carbon in the organisms is stored in the fossil fuels. People can burn fossil fuels for energy. When people burn the fossil fuels, the carbon in them moves back into the environment.



**TAKE A LOOK**

**12. Explain** How does the carbon in fossil fuels get into the atmosphere?

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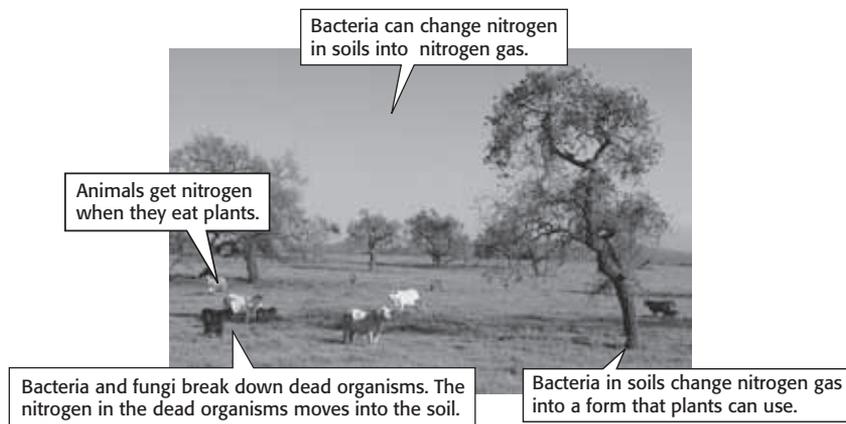
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**SECTION 4** The Cycling of Matter *continued*

**NITROGEN CYCLE**

The movement of nitrogen through the Earth system is called the **nitrogen cycle**. Nitrogen can be found in several different forms. In the atmosphere, nitrogen is mainly found as a gas. However, most living things cannot use nitrogen gas as a nutrient. Special bacteria change the nitrogen gas into a form of nitrogen that plants can use. Other organisms get their nitrogen from plants.

When organisms die, the nitrogen in them can be returned to the environment. Bacteria can change the nitrogen in dead organisms back into nitrogen gas. The nitrogen gas then can move into the atmosphere. ✓



**READING CHECK**

**13. Explain** Why are bacteria important in the nitrogen cycle? Give two reasons.

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**PHOSPHORUS CYCLE**

Like carbon and nitrogen, phosphorus is found in living things. Phosphorus is also found in soil, rock, and water. Plant roots can take up phosphorus from the soil. Animals take in phosphorus when they eat the plants. When the animals and plants die, the phosphorus in their bodies moves back into the soil.

**OTHER CYCLES IN NATURE**

Rock, water, carbon, nitrogen, and phosphorus move through the Earth in cycles. Many other forms of matter also move in cycles through Earth's systems. In fact, almost all of the elements that living things need to survive are cycled through Earth's systems. When living things die, every element in their bodies is recycled.

Every cycle in nature is connected to every other cycle. For example, water can carry nitrogen and carbon through the environment. Living things are also important in keeping the cycles moving.

*Critical Thinking*

**14. Summarize** Why does matter on Earth have to be recycled in order for living things to survive?

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# Section 4 Review

6.4.a, 6.5.a, 6.5.b



## SECTION VOCABULARY

**carbon cycle** the movement of carbon from the nonliving environment into living things and back

**nitrogen cycle** the process in which nitrogen circulates among the air, soil, water, plants, and animals in an ecosystem

**rock cycle** the series of processes in which rock forms, changes from one type to another, is destroyed, and forms again by geologic processes

**water cycle** the continuous movement of water between the atmosphere, the land, and the oceans

**1. Describe** How does water move from the oceans into groundwater? Use some of the steps in the water cycle in your answer.

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**2. Identify** What is the main feature that scientists use to put rocks into three main groups?

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**3. Identify Relationships** Give two ways that human beings contribute to the carbon cycle.

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**4. Summarize** What are the steps in the nitrogen cycle?

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**5. Apply Concepts** Give three reasons why living things are important in moving matter through cycles.

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**CHAPTER 4** Material Resources

**SECTION 1** Natural Resources

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is the difference between a renewable resource and a nonrenewable resource?
- How can you protect natural resources?



**California Science Standards**

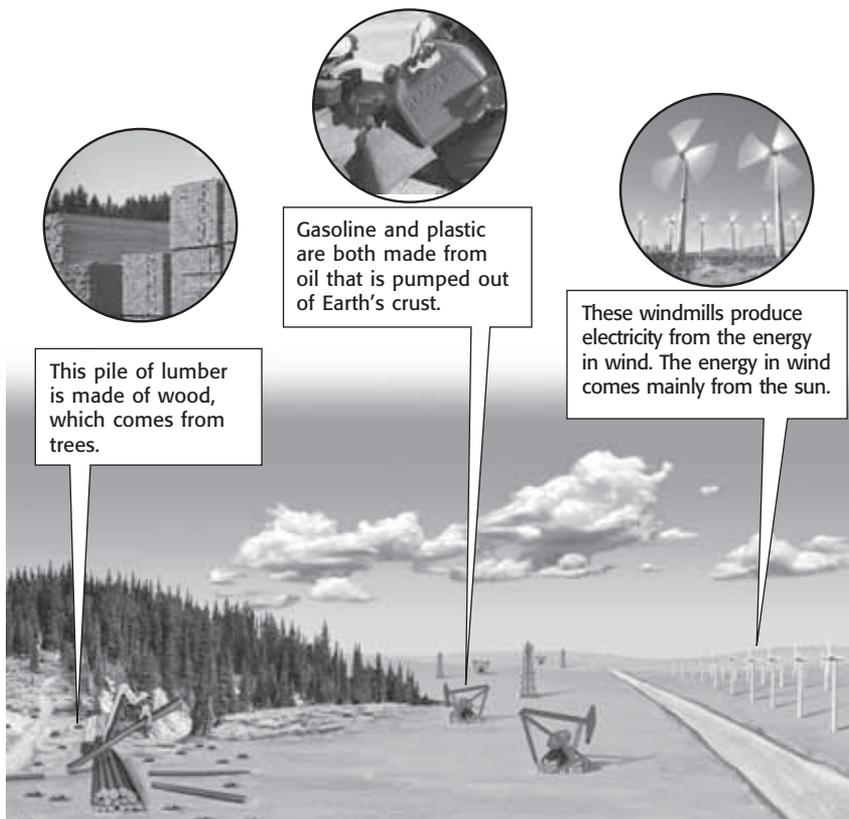
**6.6.b**

**What Are Earth's Resources?**

Earth provides what you need to survive. You breathe air from Earth's atmosphere. You drink water from Earth's rivers, lakes, and aquifers. You eat food from Earth's plants and animals.

A **natural resource** is any material from Earth that is used by people. Air, soil, fresh water, petroleum, rocks, minerals, forests, and wildlife are examples of natural resources. The figure below shows some examples of natural resources. ✓

**Examples of Natural Resources**



**STUDY TIP**

**Summarize** After you read this section, make a chart giving the definitions of renewable and nonrenewable resources. In the chart, include two examples of each kind of resource.

**READING CHECK**

**1. Define** In your own words, write a definition of *natural resource*.

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**TAKE A LOOK**

**2. Identify** Give two examples of natural resources that are not shown in the figure.

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**SECTION 1** Natural Resources *continued*

### What Types of Resources Exist on Earth?

Natural resources can be grouped based on how fast they can be replaced. Some natural resources are nonrenewable. Others are renewable.

#### NONRENEWABLE RESOURCES

Some resources, such as coal, petroleum, and natural gas, take millions of years to form. A **nonrenewable resource** is a resource that is used much faster than it can be replaced. *Renew* means “to begin again.” When nonrenewable resources are used up, people can no longer use them. ✓

**READING CHECK**

**3. Define** What is a nonrenewable resource?

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#### RENEWABLE RESOURCES

Some natural resources, such as trees and fresh water, can grow or be replaced quickly. A **renewable resource** is a natural resource that can be replaced as fast as it is used.

Many renewable resources are only renewable if people do not use them too fast. For example, wood is usually considered a renewable resource. However, if people cut down trees faster than the trees can grow back, wood is no longer a renewable resource. Some renewable resources, such as the sun, will never be used up, no matter how fast people use them.

### TAKE A LOOK

**4. Explain** Describe how some renewable resources can become nonrenewable resources.

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Fresh water and trees are both renewable resources. However, they can be used up if people use them too quickly.

**SECTION 1** Natural Resources *continued*

## How Can We Protect Natural Resources?

Whether the natural resources you use are renewable or nonrenewable, you should be careful how you use them. In order to *conserve* natural resources, you should try to use them only when you have to. For example, leaving the water running while you are brushing your teeth wastes clean water. Turning the water off while you brush your teeth saves water so that it can be used in the future.

The energy we use to heat our homes, drive our cars, and run our computers comes from natural resources. Most of these resources are nonrenewable. If we use too much energy now, we might use up these resources. Therefore, reducing the amount of energy you use can help to conserve natural resources. You can conserve energy by being careful to use it only when you need to. The table shows some ways you can conserve energy.

Instead of...	You can...
...leaving the lights on all the time	...turn them off when you're not in the room
...running the washing machine when it is only half full	...run it only when it is full
...using a car to travel everywhere	...walk, ride a bike, or use public transportation when you can

Recycling is another important way that you can help to conserve natural resources. **Recycling** means using things that have been thrown away to make new objects. Fewer natural resources are used to make objects from recycled materials than from materials that aren't recycled. Recycling also helps to conserve energy. For example, it takes less energy to recycle an aluminum can than to make a new one.

Conserving resources also means taking care of them even when you are not using them. For example, it is important to keep our drinking water clean. Polluted water can harm the living things, including humans, that need water in order to live.

## Critical Thinking

**5. Explain** Why is it important to conserve all natural resources, even if they are renewable resources?

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## TAKE A LOOK

**6. Brainstorm** Fill in the blank spaces in the table with some other ways you can conserve natural resources.

## READING CHECK

**7. Identify** How does recycling conserve natural resources?

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# Section 1 Review

6.6.b



## SECTION VOCABULARY

**natural resource** any natural material that is used by humans, such as water, petroleum, minerals, forests, and animals

**nonrenewable resource** a resource that forms at a rate that is much slower than the rate at which the resource is consumed

**recycling** the process of recovering valuable or useful materials from waste or scrap

**Wordwise** The prefix *re-* means “again.” The root *cycl* means “circle” or “wheel.”

**renewable resource** a natural resource that can be replaced at the same rate at which the resource is consumed

**1. Identify** What is the difference between a renewable resource and a nonrenewable resource?

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**2. List** Give four ways to conserve natural resources.

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**3. Explain** Why is wood usually considered a renewable resource? When would it be considered a nonrenewable resource?

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**4. Describe** What does it mean to conserve natural resources?

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**5. Explain** Why are coal, oil, and natural gas considered nonrenewable resources, even though they come from living things that can reproduce?

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# Rock and Mineral Resources

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are minerals?
- What are rocks?
- How are rock and mineral resources used?



California Science Standards

6.6.b, 6.6.c

## How Are Rocks Different from Minerals?

A **mineral** is a naturally formed, inorganic solid that forms crystals and is always made of the same elements. Let's look at each part of this definition more closely.

- Minerals form naturally. For example, most diamonds form far underground. These diamonds are minerals. However, some diamonds are made by people. These diamonds are not minerals, because they did not form naturally.
- Minerals are solids. For example, frozen water, or ice, in a glacier is considered a mineral because it is solid. However, liquid water in a stream is not a mineral. ✓
- Minerals form by inorganic processes. In other words, they are not formed from living things. For example, coal is not a mineral because it forms from the remains of plants.
- Minerals are crystals. *Crystals* are solids whose particles are lined up in a repeating pattern. For example, volcanic glass is not a mineral because the particles in it are not lined up in a pattern.
- Minerals are always made of the same elements. For example, every sample of the mineral fluorite contains the same elements: calcium and fluorine. In many cases, the elements in minerals are valuable natural resources.

A *rock* is a natural material that makes up most of the solid part of Earth. Most rocks are made from one or more minerals. Rocks can also be made from solid materials that are not minerals. For example, a rock can contain coal or volcanic glass, neither of which are minerals.



**Describe** After you read this section, make a chart showing the uses of different rock and mineral resources.



**1. Explain** Why is the salt dissolved in ocean water not considered a mineral?

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**SECTION 2** Rock and Mineral Resources *continued*

### How Do Minerals Form?

Minerals form in many different ways. The table below shows five ways that minerals can form.

#### TAKE A LOOK

**3. Identify** Give three minerals that form by metamorphism and three minerals that form by reaction.

Metamorphism:

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Reaction:

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Process	Description	Examples of minerals that form this way
Evaporation	When a body of salt water dries up, minerals are left behind.	gypsum, halite
Metamorphism	High temperatures and pressures deep underground can cause the minerals in rock to change into different minerals.	garnet, graphite, magnetite, talc
Deposition	When water carries dissolved materials into lakes and seas, minerals form and sink to the bottom.	calcite, dolomite
Reaction	Water underground can be heated by hot rock. The hot water can dissolve some minerals and deposit other minerals in their place.	gold, copper, sulfur, pyrite, galena
Cooling	Melted rock can cool slowly under Earth's surface. As the melted rock cools, minerals form.	mica, feldspar, quartz

### How Are Minerals Removed from Earth?

People mine many kinds of rocks and minerals from the ground and make them into objects we need. Some kinds of rocks and minerals have more useful materials in them than others. An **ore** is a rock or mineral that contains enough useful materials for it to be mined at a profit.

There are two ways of removing ores from Earth: surface mining and subsurface mining. The type of mining that people use depends on how close the ore is to the surface. ✓

 **READING CHECK**

**4. Explain** What determines the type of mining that people use to remove an ore from Earth's crust?

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#### SURFACE MINING

People use surface mining to remove ores that are near Earth's surface. Open-pit mining is used to remove gold and copper from the ground. Explosives break up the overlying rock and ore. Then, trucks haul the ore from the mine to a processing plant.

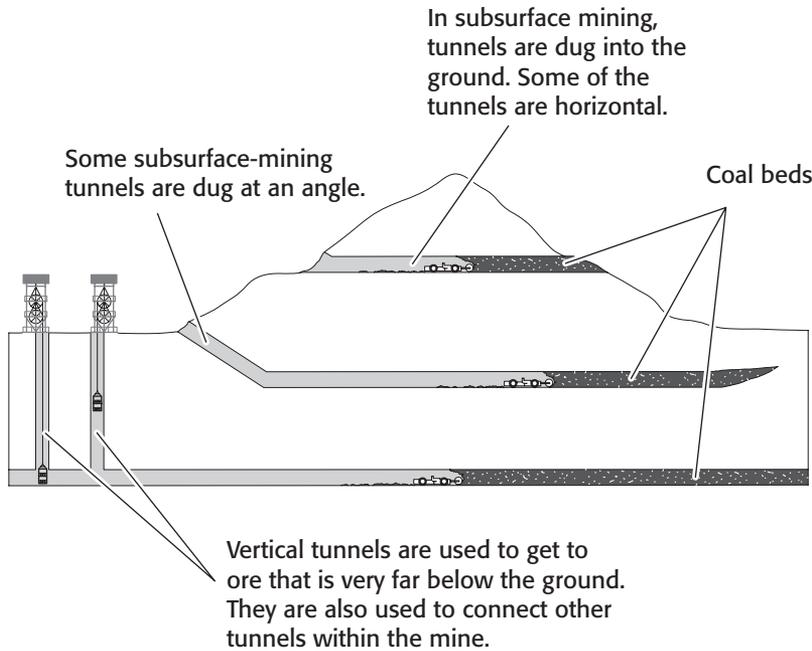
Quarries are open mines that are used to remove sand, gravel, and crushed rock. The layers of rock near the surface are removed and used to make buildings and roads.

Strip mines are often used to mine coal. The coal is removed in large pieces. These pieces are called *strips*.

**SECTION 2** Rock and Mineral Resources *continued*

**SUBSURFACE MINING**

People use subsurface mining to remove ores that are deep underground. Iron, coal, and salt can be mined in subsurface mines. ✓



**READING CHECK**

**5. List** Give three resources that can be mined using subsurface mining.

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**TAKE A LOOK**

**6. Identify** What are three kinds of tunnels used in subsurface mining?

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**RESPONSIBLE MINING**

Mining can help us get the resources we need, but it can also create problems. Mining may destroy or harm the places where plants and animals live. The wastes from mining can be poisonous. They can pollute water. ✓

One way to reduce these problems is to return the land to its original state after mining is finished. This is called *reclamation*. Since the mid-1970s, laws have required the reclamation of land used for mining. Another way to reduce the problems with mining is to use less of the resources that are mined.

**READING CHECK**

**7. Describe** What are two problems with mining?

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**SECTION 2** Rock and Mineral Resources *continued*

**CALIFORNIA STANDARDS CHECK**

**6.6.c** Students know the natural origin of the materials used to make common objects.

**8. Identify** Give two uses for the mineral silver and two uses for the mineral bauxite.

Silver:

\_\_\_\_\_

Bauxite:

\_\_\_\_\_

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## What Are Rocks and Minerals Used For?

The table shows how some common minerals are used.

Mineral	Uses
Copper	electrical wire, plumbing, coins
Diamond	jewelry, cutting tools, drill bits
Galena	lead in batteries, ammunition
Bauxite	aluminum cans, foil, appliances, utensils
Gold	jewelry, computers, spacecraft, dentistry

Mineral	Uses
Gypsum	wallboard, plaster, cement
Halite	table salt, road salt, water softener
Quartz	glass, silicon for computer chips
Silver	photography, electronic products, jewelry
Sphalerite	zinc for jet aircraft, paints

### METALS

Many minerals contain metals. Many of the features of metals make them useful in aircraft, automobiles, computers, and spacecraft. Some of these features are listed below.

- Metals have shiny surfaces.
- Light cannot pass through metals.
- Heat and electricity can pass through metals easily.
- Metals can be rolled into sheets or stretched into wires.

Some metals react easily with air and water. For example, iron can react with oxygen in the air to produce rust. Other metals do not react very easily. For example, gold does not react with very many chemicals. Therefore, it is used in many spacecraft.

### NONMETALS

Many minerals also contain nonmetals. Some important features of nonmetals are listed below.

- Nonmetals have shiny or dull surfaces.
- Light can pass through some kinds of nonmetals.
- Heat and electricity cannot pass through nonmetals easily.

Nonmetals are very important. For example, the mineral calcite is used to make cement. Sand is made of small pieces of rocks and minerals. It contains silica, which is used to make computer chips and glass.

 **Say It**

**Discuss** In a small group, talk about some of the ways that metals and nonmetals are used in everyday objects.

# Section 2 Review

## SECTION VOCABULARY

<p><b>mineral</b> a naturally formed, inorganic solid that has a definite chemical structure</p>	<p><b>ore</b> a natural material whose concentration of economically valuable minerals is high enough for the material to be mined profitably</p>
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**1. Identify** What are five features of minerals?

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**2. Describe** Fill in the spaces in the table to describe metals and nonmetals.

Type of material	Main features	Common objects made from it
Metal	has shiny surfaces does not transmit light transmits heat and electricity easily can be rolled into sheets or stretched into wires	
Nonmetal		

**3. List** What are three ways minerals can form?

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**4. Apply Concepts** Are minerals renewable resources or nonrenewable resources? Explain your answer.

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SECTION 3 **Using Material Resources**



California Science Standards

6.6.b, 6.6.c

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What resources come from Earth?
- What resources come from living things?
- How can we use resources wisely?

**STUDY TIP**

**Ask Questions** As you read this section, write down any questions that you think of. Then, talk about your questions with the class.

**What Resources Come from Earth?**

Earth’s resources are found in Earth’s atmosphere, crust, and oceans. They also come from the organisms that live on Earth. Earth’s resources can be divided into two categories: energy resources and material resources. Energy resources are natural resources that humans use to produce energy. **Material resources** are natural resources that humans eat, drink, or use to make objects.

**RESOURCES FROM THE ATMOSPHERE**

The air around us contains oxygen gas, which almost all living things need to survive. Other valuable resources are also found in Earth’s atmosphere. For example, nitrogen gas in the atmosphere is used to make fertilizer. Argon gas is used in light bulbs. ✓

**READING CHECK**

**1. Identify** Give two resources that are found in Earth’s atmosphere.

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**ROCK AND MINERAL RESOURCES**

Rocks and minerals are used to make many of the objects that we use every day. The table below shows some of the ways that people use different minerals.

Mineral	Uses
Iron	making steel; cars and other vehicles; cooking utensils
Aluminum	cars, buildings, and aircraft; food and drink containers
Copper	electrical wires; computers; money
Platinum	jewelry; cars and other vehicles; electrical wires
Calcite	cement; fertilizer; building stone
Salt	food; clearing ice from roads; source of the element chlorine

**TAKE A LOOK**

**2. Infer** What is the most likely reason that copper and platinum are used in electrical wires, but salt is not?

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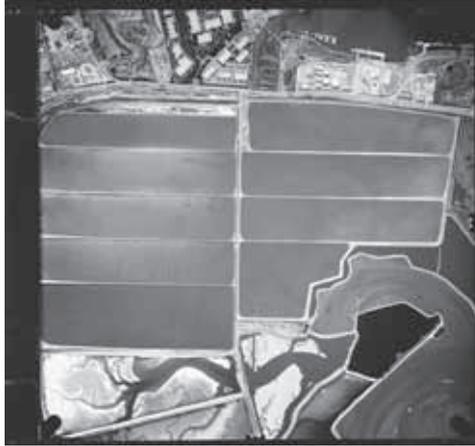
The figure on the top of the next page shows how people get salt out of sea water.

**SECTION 3** Using Material Resources *continued*



Ocean water has salt in it. Most of the salt is the chemical sodium chloride. In its solid form, sodium chloride forms the mineral halite.

People pump ocean water into large ponds. The water evaporates. The salt is left behind as crystals.



The salt is used for flavoring food and to keep food from going bad. It can also be used to help melt ice on roads.

**Math Focus**

**3. Calculate** One kilogram of ocean water has about 35 g of salt in it. One pound of salt has a mass of about 455 g. How many kilograms of ocean water would have to evaporate to produce one pound of salt?

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**PETROLEUM**

**Petroleum** is a mixture of liquid chemicals that is found in Earth’s crust. You may know that gasoline and other fuels are made from petroleum. Petroleum can also be used to make many other products, such as tar, wax, and plastic. ✓

**What Resources Come from Living Things?**

Many of the products we use are made with resources from Earth. Many other products are made with resources from living things.

**PLANT RESOURCES**

People use resources from plants in many different ways. Farming provides us with plants for food and drinks, and also with food for animals. Cotton produces fibers that can be woven into cloth or braided into ropes or baskets. Trees supply fruit and nut crops, as well as wood for lumber, paper, and fuel. The sap of some trees can be used to make products such as rubber and maple syrup.

**READING CHECK**

**4. Identify** List three ways that people use petroleum products in their everyday lives.

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**SECTION 3** Using Material Resources *continued*

**CALIFORNIA STANDARDS CHECK**

**6.6.c** Students know the natural origin of the materials used to make common objects.

**5. Identify** Give three everyday objects that are made from plant resources, and three everyday objects that are made from animal resources.

Plant Resources:

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Animal Resources:

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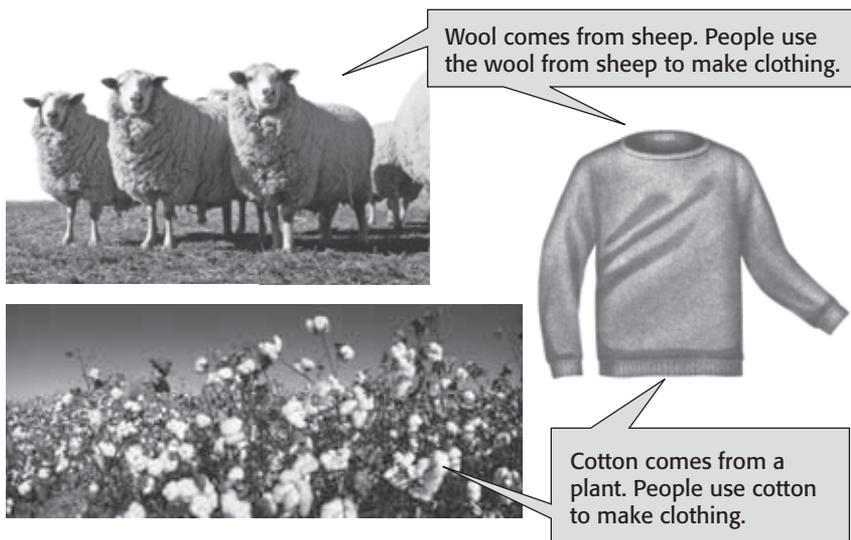
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**ANIMAL RESOURCES**

People also use resources from animals. Animals provide transportation for people and for cargo. They help farmers till the soil and plant crops. People use animals for food and clothing. Fur from sheep, goats, and llamas can be made into fabric. The skin from some animals can be used for leather. Animal wastes can be used for fertilizer and cooking fuel.

**Resources from Plants and Animals**



Wool comes from sheep. People use the wool from sheep to make clothing.

Cotton comes from a plant. People use cotton to make clothing.

**What Are the Costs of Material Resources?**

Using natural resources has many costs. Most natural resources must be removed from rock, water, or the air before they can be used. Then, the resources have to be made into the products we need. The products have to be shipped from place to place. Plant and animal resources may need special care. Using natural resources can harm the environment. ✓

**READING CHECK**

**6. Describe** What are two costs related to using material resources?

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**ECONOMIC COSTS**

It costs money to get natural resources from Earth and from living things. Companies will only make a product if they can sell it for more than it costs them to make it. If it becomes too expensive to get a natural resource for a product, a cheaper resource must be used instead.

The figure on the next page shows how trees can be made into paper. Each step costs money. For example, companies have to pay people to do the work in each step.

**SECTION 3** Using Material Resources *continued*

The paper can be made into many different products.

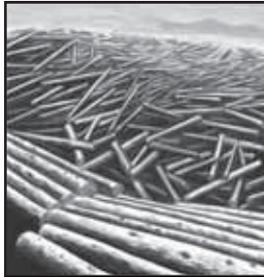


People cut down trees to get wood. Wood is a material resource.



**Say It**

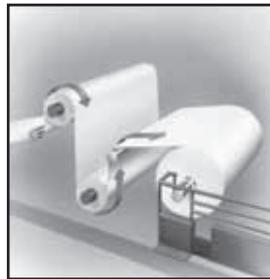
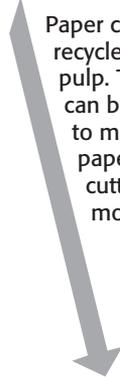
**Discuss** In a small group, talk about ways that the costs of using material resources can be reduced.



The wood from the cut trees is cut into small chips.



Paper can be recycled into pulp. The pulp can be used to make fresh paper without cutting down more trees.



The pulp is spread out, pressed, and dried to form paper. The paper is stored in large rolls.



The wood chips are ground and mixed with water and other materials. This forms a pulp.



**TAKE A LOOK**

**7. Explain** How does recycling paper reduce the cost of using some material resources?

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**ENVIRONMENTAL COSTS**

Often, the price of an item in a store is only based on how much money it costs to make the item. However, using natural resources also has environmental costs. For example, trees are cut down to make paper. The trees may come from old-growth forests. Cutting down trees can harm the places where other plants and animals live. The machines that are used to make the paper can pollute the air and water.

Some communities have passed laws that require companies to protect the environment. These laws can require that companies produce less pollution. They may also require companies to restore the land used for mining or to replant trees that were cut down.

**Critical Thinking**

**8. Analyze Relationships** Why does protecting the environment sometimes cause products to cost more money?

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# Section 3 Review

6.6.b, 6.6.c 

## SECTION VOCABULARY

<b>material resource</b> a natural resource that humans use to make objects or to consume as food and drink	<b>petroleum</b> a liquid mixture of complex hydrocarbon compounds; used widely as a fuel source <b>Wordwise</b> The root <i>petr</i> means “rock.” Another example is <i>petrify</i> .
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**1. Identify** Give two resources that come from the atmosphere and describe how each is used.

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**2. Describe** How is petroleum used as a material resource?

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**3. List** Give four rock or mineral resources and explain how each is used.

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**4. Describe** What are three environmental costs of producing paper?

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**5. Identify** Give two examples of renewable material resources and two examples of nonrenewable material resources.

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**CHAPTER 5** Energy Resources

**SECTION 1** **Fossil Fuels**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the different kinds of fossil fuels?
- How do fossil fuels form?
- What are the problems with using fossil fuels?



**California Science Standards**

6.3.b, 6.6.a, 6.6.b

**What Are Fossil Fuels?**

How do plants and animals that lived hundreds of millions of years ago affect your life today? If you turned on the lights or traveled to school in a car or bus, you probably used some of the energy from plants and animals that lived long ago.

*Energy resources* are natural resources that people use to produce energy, such as heat and electricity. Most of the energy we use comes from fossil fuels. A **fossil fuel** is an energy resource made from the remains of plants and tiny animals that lived long ago. The different kinds of fossil fuels are petroleum, coal, and natural gas. ✓

Fossil fuels are an important part of our everyday life. When fossil fuels burn, they release a lot of heat energy. Power plants use the energy to produce the electricity we use. Cars use the energy to move.

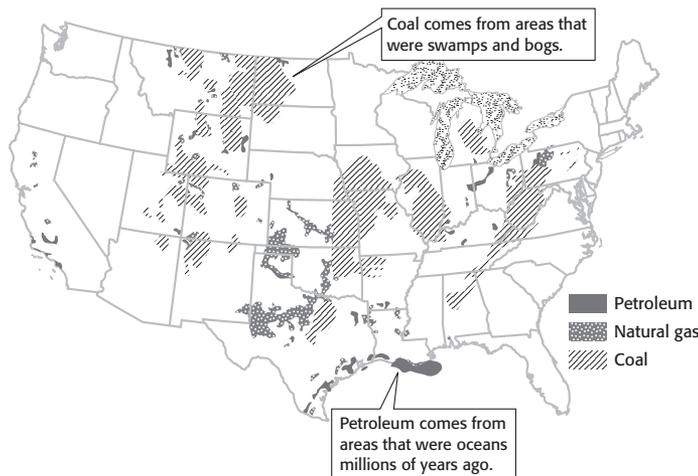
However, there are also some problems with using fossil fuels. Fossil fuels are nonrenewable, which means that they cannot be replaced once they have been used. Also, when they burn, they release pollution.

**STUDY TIP**

**Compare** In your notebook, make a table to show the similarities and differences between different kinds of fossil fuels.

**READING CHECK**

**1. Identify** Where do we get most of the energy we use?



**TAKE A LOOK**

**2. Describe** In general, where are the natural gas deposits in the United States?

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**SECTION 1** Fossil Fuels *continued*

### What Is Natural Gas?

A *hydrocarbon* is a compound that contains the elements carbon, hydrogen, and oxygen. **Natural gas** is a mixture of hydrocarbons that are in the form of gases. Natural gas includes methane, propane, and butane, which can be separated from one another.

Most natural gas is used for heating. Your home may be heated by natural gas. Your kitchen stove might run on natural gas. Some natural gas is used for creating electrical energy, and some cars are able to run on natural gas, too. ✓

**READING CHECK**

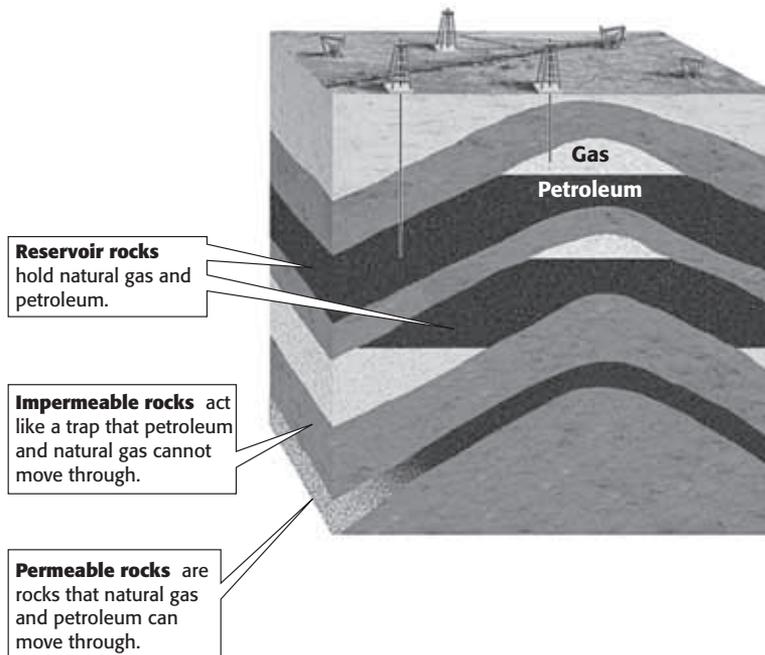
**3. Identify** What is most natural gas used for?

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### HOW NATURAL GAS FORMS

When tiny sea creatures die, their remains settle to the ocean floor and are buried in sediment. The sediment slowly becomes rock. Over millions of years, the remains of the sea creatures turn into natural gas.

The formation of natural gas is always happening. Some of the sea life that dies today will become natural gas millions of years from now.



### TAKE A LOOK

**4. Infer** Is reservoir rock permeable or impermeable? Explain your answer.

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### PROBLEMS WITH NATURAL GAS

Natural gas can be dangerous because it burns very easily. It can cause fires and explosions. Like other fossil fuels, natural gas causes pollution when it burns. However, it does not cause as much pollution as other fossil fuels.

**SECTION 1** Fossil Fuels *continued***What Is Petroleum?**

**Petroleum** is a mixture of hydrocarbons that are in the form of liquids. It is also known as crude oil. At a *refinery*, petroleum is separated into many different products, including gasoline, jet fuel, kerosene, diesel fuel, and fuel oil. ✓

Petroleum products provide more than 40% of the world's energy, including fuel for airplanes, trains, boats, ships, and cars. Petroleum is so valuable that it is often called "black gold."

**HOW PETROLEUM FORMS**

Petroleum forms the same way natural gas does. Tiny sea creatures die and then get buried in sediment, which turns into rock. The organisms eventually become petroleum or natural gas, which is stored in permeable rock within Earth's crust.

**PROBLEMS WITH PETROLEUM**

Petroleum can be harmful to animals and their environment. For example, in June 2000, the carrier ship *Treasure* sank off the coast of South Africa and spilled more than 400 tons of oil into the ocean. The oil covered penguins and other sea creatures, making it hard for them to swim, breathe, and eat.



Burning petroleum causes smog. **Smog** is a brownish haze that forms when sunlight reacts with pollution in the air. Smog can make it hard for people to breathe. Many cities in the world have problems with smog.

 **READING CHECK**

**5. Describe** What form is petroleum found in naturally?

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**Math Focus**

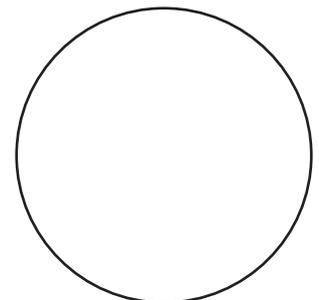
**6. Make a Graph** Use the information below to show where the world's crude oil comes from.

Middle East: 66%

North America and South America: 15%

Europe and Asia: 12%

Africa: 7%



**SECTION 1** Fossil Fuels *continued*

### What Is Coal?

**Coal** is a solid fossil fuel that is made of partly decayed plant material. Coal was once the main source of energy in the United States. Like other fossil fuels, coal releases heat when it is burned. Many people used to burn coal in stoves to heat their homes. Trains in the 1800s and 1900s were powered by coal-burning steam locomotives. Coal is now used in power plants to make electricity.

### HOW COAL FORMS

When swamp plants die, they sink to the bottom of the swamp. If they do not decay completely, coal can start to form. Coal forms in several different stages.

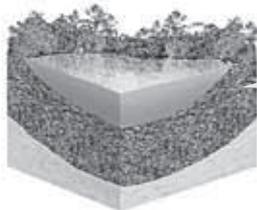
### TAKE A LOOK

**7. Identify** Name the three types of coal.

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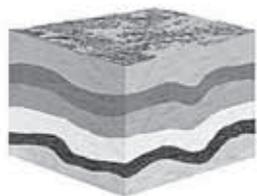
**Stage 1: Formation of Peat**  
Dead swamp plants that have not decayed can turn into **peat**, a crumbly brown material made mostly of plant material and water. Dried peat is about 60% carbon. In some parts of the world, peat is dried and burned for fuel. Peat is not coal, but it can turn into coal.



**Stage 2: Formation of Lignite**  
If sediment buries the peat, pressure and temperature increase. The peat slowly changes into a type of coal called **lignite**. Lignite coal is harder than peat. Lignite is about 70% carbon.



**Stage 3: Formation of Bituminous Coal**  
If more sediment is added, pressure and temperature force more water and gases out of the lignite. Lignite slowly changes into **bituminous** coal. Bituminous coal is about 80% carbon.



**Stage 4: Formation of Anthracite**  
If more sediment accumulates, temperature and pressure continue to increase. Bituminous coal slowly changes into **anthracite**. Anthracite coal is the hardest type of coal. Anthracite coal is about 90% carbon.

### TAKE A LOOK

**8. Identify** Which kind of coal contains the most carbon?

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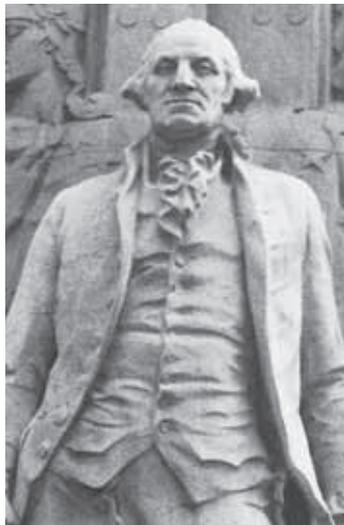
**SECTION 1** Fossil Fuels *continued*

**PROBLEMS WITH COAL**

Mining coal can create environmental problems. When coal is mined from Earth’s surface, people remove the layers of soil above the coal. This can harm the plants that need soil to grow and the animals that need soil for shelter. If the land is not restored after mining, wildlife habitats can be destroyed for years.

Coal that is on Earth’s surface can cause pollution. Water that flows through coal can pick up poisonous metals. That water can then flow into streams and lakes and pollute water supplies.

When coal is burned without pollution controls, sulfur dioxide is released. Sulfur dioxide can combine with the water in the air to produce sulfuric acid. Sulfuric acid is one of the acids in acid precipitation. **Acid precipitation** is rain, sleet, or snow that has a high concentration of acids, often because of air pollutants. Acid precipitation is also called “acid rain.” Acid precipitation can harm wildlife, plants, and buildings.



In 1935, this statue had not been damaged by acid precipitation.



By 1994, acid precipitation had caused serious damage to the statue.

	<b>CALIFORNIA STANDARDS CHECK</b>
<p><b>8.3.b</b> Students know different natural <u>energy</u> and material <u>resources</u>, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.</p>	
<p><b>Word Help: energy</b> what makes things happen</p>	
<p><b>Word Help: resource</b> anything that can be used to take care of a need</p>	
<p><b>9. Classify</b> Are fossil fuels renewable or nonrenewable resources? Explain your answer.</p>	
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*Critical Thinking*

**10. Infer** What do you think is the reason that fossil fuels are still used today, even though they create many environmental problems?

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# Section 1 Review

6.3.b, 6.6.a, 6.6.b



## SECTION VOCABULARY

**acid precipitation** rain, sleet, or snow that has a high concentration of acids

**coal** a fossil fuel that forms underground from partially decomposed plant material

**fossil fuel** a nonrenewable energy resource formed from the remains of organisms that lived long ago; examples include oil, coal, and natural gas

**natural gas** a mixture of gaseous hydrocarbons located under the surface of Earth, often near petroleum deposits; used as a fuel

**petroleum** a liquid mixture of complex hydrocarbon compounds; used widely as a fuel source

**Wordwise** The root *petr* means "rock." Another example is *petrify*.

**smog** photochemical haze that forms when sunlight acts on industrial pollutants and burning fuels

**1. Compare** How are petroleum and natural gas different?

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**2. Compare** Fill in the table to compare the different kinds of fossil fuels.

Kind of fossil fuel	What it is	How it forms
Coal		
	a mixture of gases containing carbon, hydrogen, and oxygen	

**3. Summarize** What are some of the problems with using fossil fuels for energy?

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SECTION 2 **Alternative Energy**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are some kinds of alternative energy?
- What are the benefits of alternative energy?
- What are the problems with alternative energy?



California Science Standards

6.3.b, 6.6.a, 6.6.b

**What Is Alternative Energy?**

What would your life be like if you couldn't turn on the lights, microwave your dinner, take a hot shower, or ride the bus to school? We get most of the energy we use for heating and electricity from fossil fuels. However, fossil fuels can be harmful to the environment and to living things. In addition, they are nonrenewable resources, so we cannot replace them when they are used up.

Many scientists are trying to find alternative energy sources. *Alternative energy sources* are sources of energy that are not fossil fuels. Some sources can be converted easily into usable energy. Others are not as easy to use.



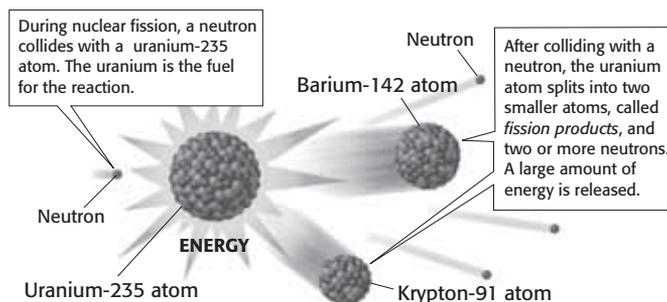
**Compare and Contrast** In your notebook, make a chart to show each kind of alternative energy source and its benefits and problems.

**What Is Nuclear Energy?**

One kind of alternative energy source is nuclear energy. **Nuclear energy** is the energy that is released when atoms come together or break apart. Nuclear energy can be obtained in two main ways: fission and fusion. ✓

**FISSION**

*Fission* happens when an atom splits into two or more lighter atoms. Fission releases a large amount of energy. This energy can be used to generate electricity. All nuclear power that people use is generated by fission.



**1. List** What are the two ways in which nuclear energy is produced?

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**TAKE A LOOK**

**2. Identify** What are the fission products in the figure?

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**SECTION 2** Alternative Energy *continued*

**FISSION'S BENEFITS AND PROBLEMS**

One benefit of fission is that it does not cause air pollution. In addition, mining the fuel for nuclear power is less harmful to the environment than mining other energy sources, such as coal. ✓

However, nuclear power has several problems. The fission products created in nuclear power plants are dangerous. They must be stored for thousands of years. Nuclear fission plants can release harmful radiation into the environment. Also, nuclear power plants must release extra heat from the fission reaction. This extra heat is not used to make electricity. The extra heat can harm the environment.

**READING CHECK**

**3. Explain** Why is nuclear energy called a "clean" energy source?

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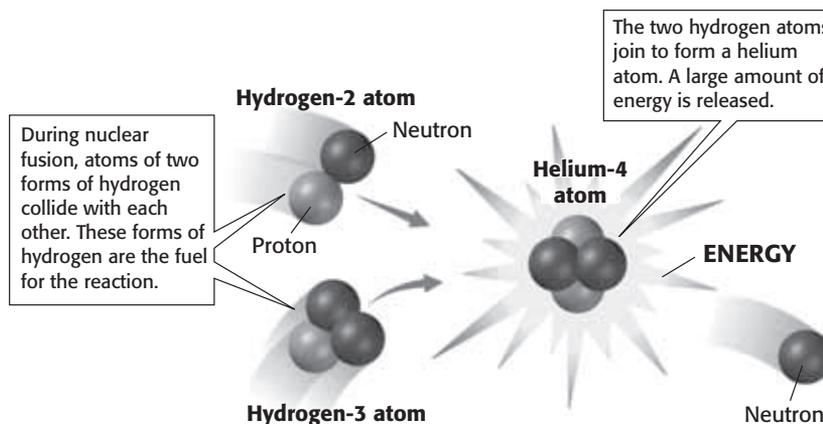
**FUSION**

*Fusion* happens when two or more atoms join to form a heavier atom. This process occurs naturally in the sun. Fusion releases a lot of energy.

**TAKE A LOOK**

**4. Identify** How many protons and how many neutrons are there in the helium-4 nucleus?

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**FUSION'S BENEFITS AND PROBLEMS**

Fusion has two main benefits. First, fusion does not create a lot of dangerous wastes. Second, the fuels used in fusion are renewable.

The main problem with fusion is that it can take place only at high temperatures. The reaction is difficult to control and keep going. Right now, people cannot control fusion reactions or use them to create usable energy. ✓

**READING CHECK**

**5. Describe** What is the main problem with fusion?

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**SECTION 2** Alternative Energy *continued*

### How Can Wind Provide Electricity?

*Wind* is air that is moving. Moving air contains energy. People can use windmills to turn the energy in wind into electricity. The electricity that is produced by windmills is called **wind power**. Large groups of windmills can make a lot of electricity.

Like all energy sources, wind power has benefits and problems. Since the wind can't be used up, wind energy is renewable. Wind power does not cause air pollution. However, in many areas, the wind isn't strong or regular enough to generate enough electricity for people to use.



These windmills near Livermore, California, produce electricity.

### Critical Thinking

**6. Infer** In most cases, people use a large number of windmills to create electricity. What do you think is the reason a lot of windmills are used, instead of just one or two?

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### TAKE A LOOK

**7. Explain** Based on what you see in the figure, what do you think is the reason windmills are not used in cities or other crowded areas?

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### What Are Fuel Cells?

What powers a car? You probably thought of gasoline. But not all cars are powered by gasoline. Some cars are powered by fuel cells. *Fuel cells* change chemical energy into electrical power. The **chemical energy** is released when hydrogen and oxygen react to form water.

Fuel cells have been used in space travel since the 1960s. They have provided space crews with electrical energy and drinking water. Today, fuel cells are used to create electrical energy in some buildings and ships. ✓

The only waste product of fuel cells is water, so they do not create pollution. Fuel cells are also more efficient than engines that use gasoline. However, not very many cars today use fuel cells. The hydrogen and oxygen used in fuel cells can be expensive to make and to store. Many people hope that we will be able to use fuel cells to power cars in the future.

 **READING CHECK**

**8. Explain** How could fuel cells give space crews electricity and water?

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**SECTION 2** Alternative Energy *continued*

 **Say It**

**Share Experiences** Have you ever used an object that was powered by sunlight? In a small group, talk about the different ways that sunlight can be used for energy.

**How Can We Use Sunlight for Power?**

Most forms of energy originally come from the sun. For example, the fossil fuels we use today were made from plants. The plants got their energy from the sun. The heat and light that Earth gets from the sun is **solar energy**. This type of energy is a renewable resource.

People can use solar energy to create electricity. *Photovoltaic cells*, or solar cells, can change sunlight into electrical energy. Solar energy can also be used to heat buildings.

Solar energy does not produce pollution and is renewable. The energy from the sun is free. However, some climates don't have enough sunny days to be able to use solar energy all the time. Also, even though sunlight is free, solar cells and solar collectors are expensive to make.

 **CALIFORNIA STANDARDS CHECK**

**6.6.a** Students know the utility of energy sources is determined by factors that are involved in converting these sources to useful forms and the consequences of the conversion process.

**Word Help: utility**  
usefulness

**Word Help: factor**  
a condition or event that brings about a result

**Word Help: consequence**  
the effect, or result, of an action or process

**Word Help: conversion**  
a change from one form to another

**9. Compare** What are hydroelectric energy's problems and benefits?

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**How Can Running Water Provide Electricity?**

Water wheels have been used since ancient times to help people do work. Today, the energy of falling water is used to generate electrical energy. **Hydroelectric energy** is electrical energy produced from moving water.

Hydroelectric energy causes no air pollution and is considered renewable. Hydroelectric energy is generally not very expensive to produce.

However, hydroelectric energy can be produced only in places that have a lot of fast-moving water. In addition, building a dam and a power plant to generate hydroelectric energy can be expensive. Dams can harm wildlife living in and around the river. Damming a river can cause flooding and erosion.



This dam in California can create electricity because a lot of water moves through it every day.

**SECTION 2** Alternative Energy *continued*

### How Can Plants Be Used for Energy?

Plants store energy from the sun. Leaves, wood, and stems contain stored energy. Even the dung of plant-eating animals has a lot of stored energy. These sources of energy are called biomass. **Biomass** is organic matter that can be a source of energy.

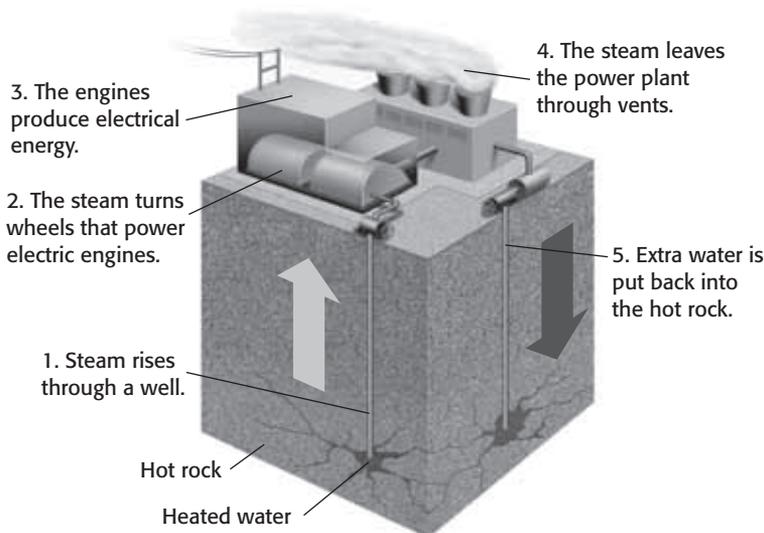
Biomass is commonly burned in its solid form to release heat. However, biomass can be changed into a liquid form. The sugar and starch in plants can be made into alcohol and used as fuel. Alcohol can be mixed with gasoline to make a fuel called **gasohol**.

Biomass is not very expensive. It is available almost everywhere. Since biomass grows quickly, it is considered a renewable resource. However, people must be careful not to use up biomass faster than it can grow back.

### What Is Geothermal Energy?

**Geothermal energy** is energy produced by the heat within Earth. This heat makes solid rocks get very hot. If there is any water contained within the solid rock, the water gets hot, too. The hot water can be used to generate electricity and to heat buildings. ✓

Geothermal energy is considered renewable because the heat inside Earth will last for millions of years. Geothermal energy does not create air pollution or harm the environment. However, this kind of energy can be used only where hot rock is near the surface.



### Critical Thinking

**10. Infer** What would happen if biomass were used at a faster rate than it was produced?

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### READING CHECK

**11. List** What are two uses for water that has been heated by hot rock?

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### TAKE A LOOK

**12. Describe** On the figure, draw arrows showing the path that the steam takes as it moves through the power plant.

# Section 2 Review

6.3.b, 6.6.a, 6.6.b



## SECTION VOCABULARY

**biomass** organic matter that can be a source of energy

**chemical energy** the energy released when a chemical compound reacts to produce new compounds

**gasohol** a mixture of gasoline and alcohol that is used as a fuel

**geothermal energy** the energy produced by heat within Earth

**hydroelectric energy** electrical energy produced by the flow of water

**nuclear energy** the energy released by a fission or fusion reaction; the binding energy of the atomic nucleus

**solar energy** the energy received by Earth from the sun in the form of radiation

**wind power** the use of a windmill to drive an electric generator

**1. Explain** Why is solar energy considered a renewable resource?

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**2. Identify** When would biomass *not* be considered a renewable resource?

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**3. Apply Concepts** Which place is *most likely* to be able to use geothermal energy: a city near a volcano or a city near a waterfall? Explain your answer.

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**4. Identify** Why is wind a useful energy source in some places, but not in others?

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**5. Analyze** Which alternative energy source do you think would be most useful for the place where you live? Explain your answer.

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# Earth's Structure

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are the layers inside Earth?
- How do scientists study Earth's interior?
- What is the evidence for continental drift?



California Science Standards

6.1.a, 6.1.b

## What Is Earth's Interior Made Of?

Earth is made of three main layers. Each layer is made of different materials with different properties. Scientists think about Earth's layers in two ways: by their chemical makeup and by their physical properties.

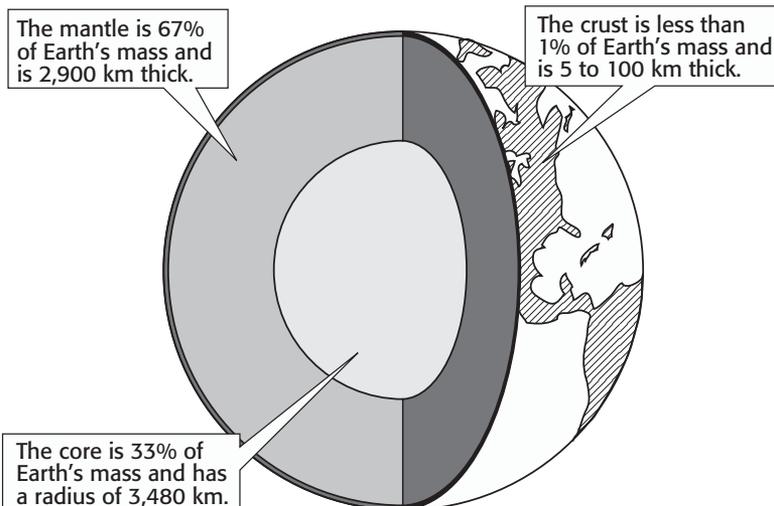
### COMPOSITIONAL LAYERS

Scientists divide Earth into three layers based on chemical makeup. In the very center of Earth is the core. The **core** is a thick sphere made of iron and nickel. The next layer is the mantle. The **mantle** is a thick layer that is made of hot, solid rock. The outermost layer of Earth is called the **crust**. The crust is the thinnest of Earth's layers.

There are two main kinds of crust: continental crust and oceanic crust. *Continental crust* forms the continents. It is thicker than oceanic crust. Continental crust can be up to 70 km thick. *Oceanic crust* is found beneath the oceans. It contains more iron than continental crust. Most oceanic crust is less than 7 km thick. ✓

### STUDY TIP

**Summarize** As you read, make a chart showing the features of Earth's layers. Make sure you include the compositional layers and the physical layers.



### READING CHECK

**1. Compare** How is oceanic crust different from continental crust?

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### Math Focus

**2. Calculate** How many times thicker is Earth's mantle than the thickest part of Earth's crust?

\_\_\_\_\_

**SECTION 1** Earth's Structure *continued*

**EARTH'S PHYSICAL STRUCTURE**

Scientists also divide Earth into five layers based on physical properties. The outer layer is the **lithosphere**. It is a cool, rigid layer that includes all of the crust and a small part of the upper mantle. The lithosphere is divided into pieces called *tectonic plates*. These plates move slowly over Earth's surface. ✓

The **asthenosphere** is found beneath the lithosphere. It is a layer of hot, solid rock that flows very slowly, like chewing gum. Beneath the asthenosphere is the *mesosphere*, which is the lower part of the mantle. The mesosphere flows more slowly than the asthenosphere.

There are two physical layers in Earth's core. The outer layer is the *outer core*. It is made of liquid iron and nickel. At the center of Earth is the *inner core*, which is a ball of solid iron and nickel. The inner core is solid because it is under very high pressure.

**READING CHECK**

**3. Define** What is the lithosphere?

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**CALIFORNIA STANDARDS CHECK**

**6.1.b** Students know Earth is composed of several layers; a cold, brittle lithosphere; a hot, convecting mantle; and a dense, metallic core.

**Word Help: layer**  
a separate or distinct portion of matter that has thickness

**Word Help: core**  
center

**4. Describe** What are the five layers of Earth, based on physical properties?

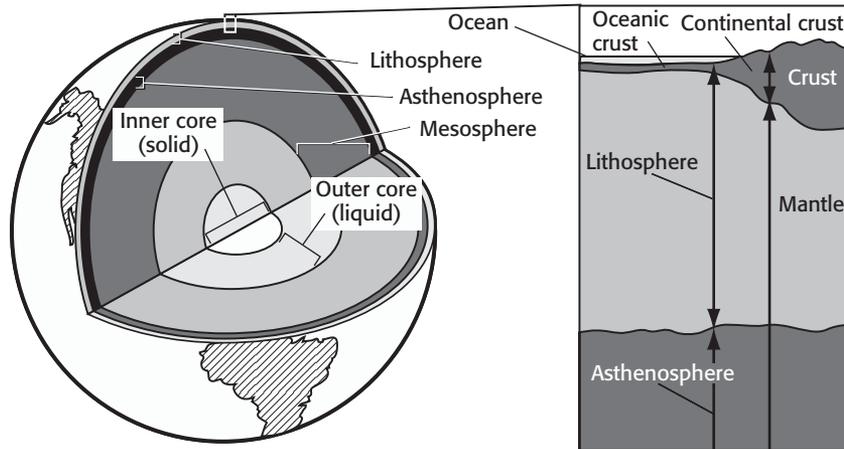
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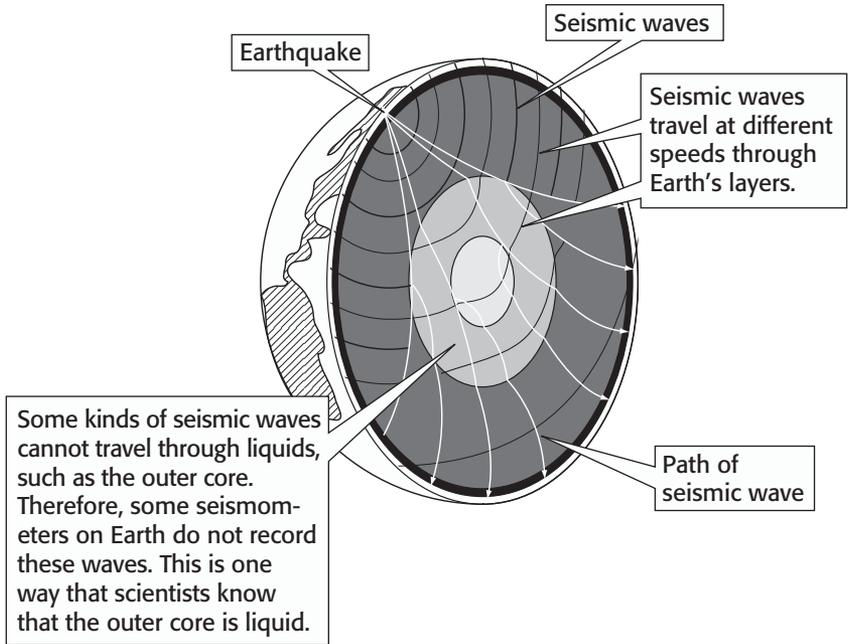
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**How Do Scientists Study the Inside of Earth?**

Much of what scientists know about Earth's layers comes from studying earthquakes. Earthquakes create vibrations called *seismic waves*. Scientists detect the waves using instruments called *seismometers*. Seismic waves travel at different speeds through the different layers of Earth. Therefore, by studying the data from seismometers, scientists can learn about the layers inside Earth.

**SECTION 1** Earth's Structure *continued*



**TAKE A LOOK**

**5. Explain** What is one way that scientists know the outer core is liquid?

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\_\_\_\_\_

**What Is Continental Drift?**

Remember that the lithosphere is broken into pieces called tectonic plates that move slowly over Earth's surface. The continents move over Earth's surface along with the plates. Sometimes, the continents are joined together. At other times, such as today, they are broken apart. This slow movement of continents over Earth's surface is called **continental drift**. ✓

**READING CHECK**

**6. Define** What is continental drift?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**EVIDENCE FOR CONTINENTAL DRIFT**

Look at the map of the continents on the next page. Can you see that South America and Africa seem to fit together, like the pieces of a puzzle? Continental drift can explain why this is so. South America and Africa were once part of a single continent. They have since broken apart and moved to their current locations.

Evidence for continental drift can also be found in fossils. For example, many of the same fossils have been found along the matching coastlines of South America and Africa. The organisms that formed these fossils could not have traveled across the Atlantic Ocean. Therefore, the two continents must once have been joined together.

Other evidence comes from similar rock types and mountain ranges on different continents. The locations of similar fossils and mountain ranges are shown on the map on the next page.

**SECTION 1** Earth's Structure *continued*

## Critical Thinking

**7. Infer** Which continent was once joined with Greenland? How do you know?

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**CALIFORNIA STANDARDS CHECK**

**6.1.a** Students know evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and midocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.

**Word Help: evidence**  
information showing whether an idea or belief is true or valid

**Word Help: derive**  
to figure out by reasoning

**Word Help: distribution**  
the relative arrangement of objects or organisms in time or space

**8. Explain** How do fossils indicate that the continents have moved with time?

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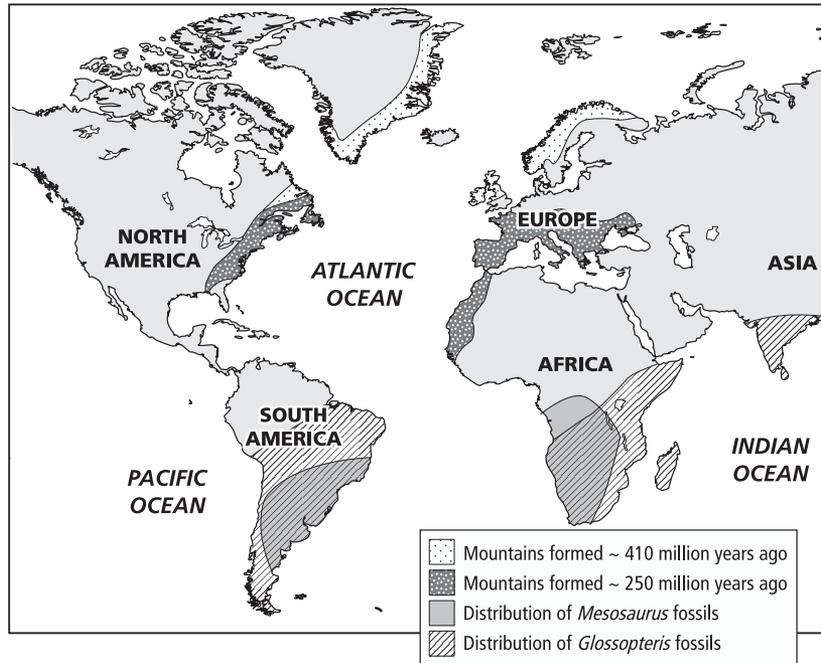
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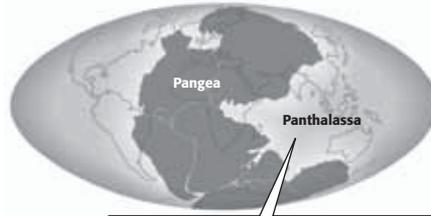
Similar fossils and rocks are found on widely separated continents. For example, *Glossopteris* and *Mesosaurus* fossils are found in Africa and in South America. These fossils and rocks indicate that, at one time, all of the continents were joined together.

### BREAKUP OF PANGAEA

About 245 million years ago, all of the continents were joined into a single *supercontinent*. This supercontinent was called *Pangaea*. The word *Pangaea* means “all Earth” in Greek. About 200 million years ago, *Pangaea* began breaking apart. It first separated into two large landmasses called Laurasia and Gondwana. The continents continued to break apart and slowly move to where they are today.

As the continents moved, some of them collided. These collisions produced many of the landforms that we see today, such as mountain ranges and volcanoes.

**SECTION 1** Earth's Structure *continued*



About 245 million years ago, the supercontinent Pangea existed. It was surrounded by a huge sea called *Panthalassa*, which is Greek for "all sea."



By about 135 million year ago, Pangea had split into two smaller continents. These continents were called Laurasia and Gondwana.



By about 65 million years ago, Laurasia and Gondwana had split into several smaller continents. These continents looked similar to the continents that exist today.

**TAKE A LOOK**

**9. Describe** How were the locations of the continents 65 million years ago different from the locations of the continents today? Give two ways.

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**What Is Sea-Floor Spreading?**

*Mid-ocean ridges* are mountain systems found deep in Earth's oceans. They form a continuous chain that is 50,000 km long. The chain wraps around Earth like the seams of a baseball. Mid-ocean ridges are the sites of intense volcanic activity. ✓

At a mid-ocean ridge, melted rock rises through cracks in the sea floor. As the melted rock cools and hardens, it forms new crust. The newly formed crust pushes the older crust away from the mid-ocean ridge. This process is called **sea-floor spreading**.

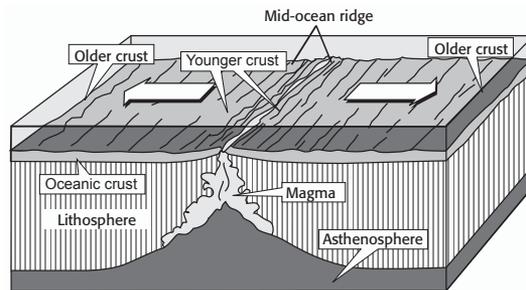
**READING CHECK**

**10. Define** What is a mid-ocean ridge?

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Sea-floor spreading produces new oceanic lithosphere at mid-ocean ridges. The oldest oceanic crust is found far from the ridges, and the youngest crust is found very close to the ridges.

**TAKE A LOOK**

**11. Identify** Does the oceanic lithosphere get older or younger as you move closer to the mid-ocean ridge?

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**SECTION 1** Earth's Structure *continued*

**SEA-FLOOR SPREADING AND MAGNETISM**

In the 1960s, scientists studying the ocean floor discovered an interesting property of mid-ocean ridges. Using a tool that can record magnetism, they found magnetic patterns on the sea floor! The pattern on one side of a mid-ocean ridge was a mirror image of the pattern on the other side of the ridge. What caused the rocks to have these magnetic patterns?

Throughout Earth's history, the north and south magnetic poles have switched places many times. This process is called *magnetic reversal*. This process, together with sea-floor spreading, can explain the patterns of magnetism on the sea floor. ✓

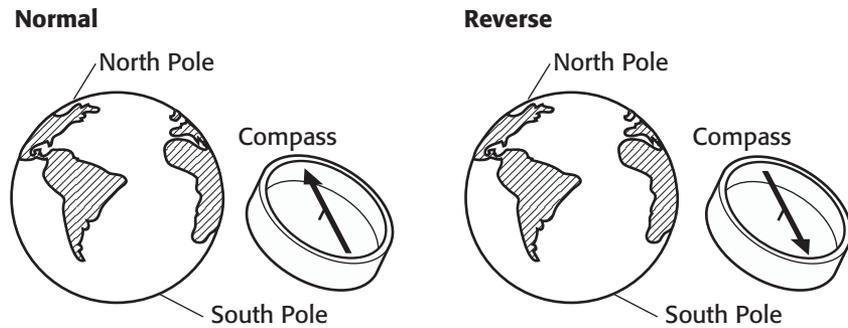
**READING CHECK**

**12. Define** What is a magnetic reversal?

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During times of normal polarity, such as today, a compass needle points toward the North Pole. During times of reverse polarity, a compass needle points toward the South Pole.

As ocean crust forms from melted rock, magnetic minerals form. These minerals act as compasses. As they form, they line up with Earth's magnetic north pole. When the melted rock cools, the minerals are stuck in place.

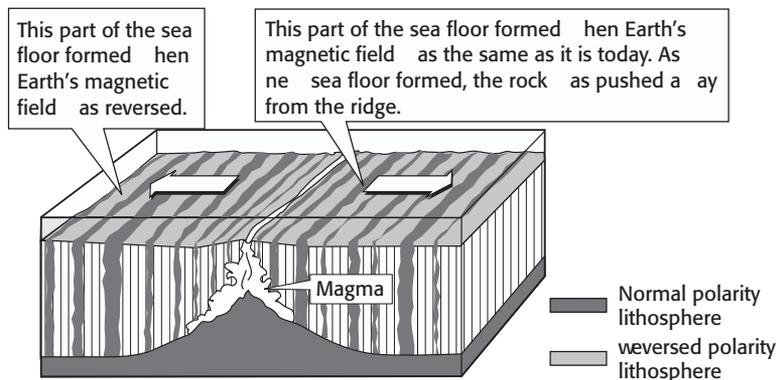
After Earth's magnetic field reverses, these minerals point to Earth's magnetic south pole. However, new rock that forms will have minerals that point to the magnetic north pole. Therefore, the ocean floor contains "stripes" of rock whose magnetic minerals point to the north or south magnetic poles.

**TAKE A LOOK**

**13. Describe** How are the "stripes" of magnetism on each side of the ridge related?

\_\_\_\_\_

\_\_\_\_\_



# Section 1 Review

## SECTION VOCABULARY

<p><b>asthenosphere</b> the soft layer of the mantle on which the tectonic plates move</p> <p><b>continental drift</b> the hypothesis that states that the continents once formed a single landmass, broke up, and drifted to their present locations</p> <p><b>core</b> the central part of the Earth below the mantle</p> <p><b>crust</b> the thin and solid outermost layer of the Earth above the mantle</p>	<p><b>lithosphere</b> the solid, outer layer of Earth that consists of the crust and the rigid upper part of the mantle</p> <p><b>Wordwise</b> The root <i>lith</i> means “stone.”</p> <p><b>mantle</b> the layer of rock between the Earth’s crust and core</p> <p><b>sea-floor spreading</b> the process by which new oceanic lithosphere (sea floor) forms as magma rises to Earth’s surface and solidifies at a mid-ocean ridge</p>
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**1. Describe** What are the features of each of the three compositional layers of Earth?

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**2. Identify** Give three pieces of evidence that support the idea of continental drift.

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**3. Compare** How is the crust different from the lithosphere? How are they the same?

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**4. Explain** How do the parallel magnetic “stripes” near mid-ocean ridges form?

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SECTION 2 **The Theory of Plate Tectonics**



California Science Standards

6.1.b, 6.1.c, 6.1.e, 6.4.c

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is the theory of plate tectonics?
- What are the three types of tectonic plate boundaries?

**STUDY TIP**

**Compare** As you read, make a table showing the features of the three kinds of plate boundaries.

**READING CHECK**

**1. Define** What are tectonic plates?

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**TAKE A LOOK**

**2. Identify** Give the name of one plate that contains mostly oceanic lithosphere and of one plate that contains mostly continental lithosphere.

Oceanic: \_\_\_\_\_

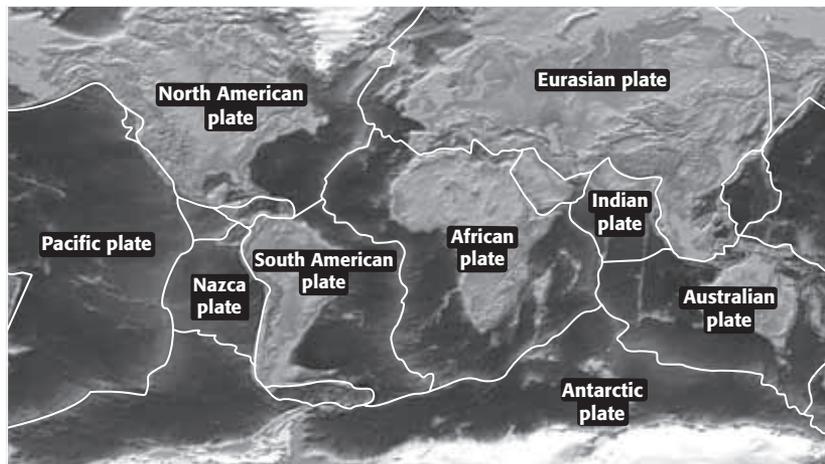
Continental: \_\_\_\_\_

**What Is the Theory of Plate Tectonics?**

As scientists learned more about sea-floor spreading and magnetic reversals, they formed a theory to explain how continents move. This theory, known as plate tectonics, explains how many of the features on Earth’s surface form.

The theory of **plate tectonics** states that Earth’s lithosphere is broken into many pieces that move slowly over the asthenosphere. These pieces are called **tectonic plates**. There are 12 large plates and many smaller ones. ✓

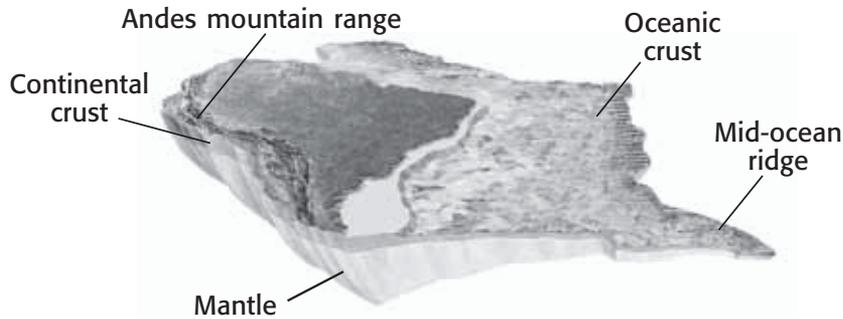
Tectonic plates can contain different kinds of lithosphere. Some plates contain mostly oceanic lithosphere. Others contain mostly continental lithosphere. Some contain both continental and oceanic lithosphere. The figure below shows Earth’s tectonic plates.



Tectonic plates move very slowly—only a few centimeters per year. Scientists can detect this motion only by using special equipment, such as global positioning systems (GPS). This equipment is sensitive enough to pick up even small changes in a continent’s location.

**SECTION 2** The Theory of Plate Tectonics *continued***STRUCTURE OF A TECTONIC PLATE**

The tectonic plates that make up the lithosphere are like pieces of a giant jigsaw puzzle. The figure below shows what a single plate might look like if it were separated from the other plates. Notice that the plate contains both continental and oceanic crust. It also contains some mantle material.



This figure shows what the South American plate might look like if it were lifted off the asthenosphere. Notice that the plate is thickest where it contains continental crust and thinnest where it contains oceanic crust.

**TAKE A LOOK**

**3. Compare** Which type of crust is thicker, oceanic crust or continental crust?

**What Happens Where Tectonic Plates Touch?**

The places where tectonic plates meet are called *boundaries*. Earthquakes and volcanoes are more common at tectonic plate boundaries than at other places on Earth. Other features, such as mid-ocean ridges and ocean trenches, are found only at plate boundaries.

There are three types of boundaries between plates: divergent boundaries, convergent boundaries, and transform boundaries. The kinds of features that are found at a plate boundary depend on what kind of plate boundary it is.

**DIVERGENT BOUNDARIES**

A *divergent boundary* forms where plates are moving apart. Most divergent boundaries are found beneath the oceans. Mid-ocean ridges form at these divergent boundaries. Because the plates are pulling away from each other, cracks form in the lithosphere. Melted rock can rise through these cracks. When the melted rock cools and hardens, it becomes new lithosphere. ✓

**READING CHECK**

**4. Describe** What features are found at most divergent boundaries?

**SECTION 2** The Theory of Plate Tectonics *continued*

**Critical Thinking**

**5. Infer** Why do continent-continent convergent boundaries produce very tall mountain ranges?

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**CONVERGENT BOUNDARIES**

A *convergent boundary* forms where plates are moving together. There are three different types of convergent boundaries:

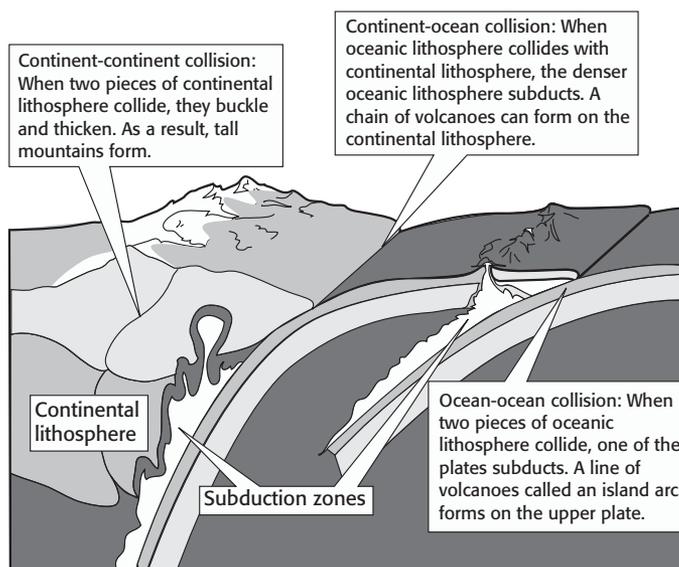
- **Continent-Continent Boundaries** These form when continental lithosphere on one plate collides with continental lithosphere on another plate. Continent-continent convergent boundaries can produce very tall mountain ranges, such as the Himalayas.
- **Continent-Ocean Boundaries** These form when continental lithosphere on one plate collides with oceanic lithosphere on another plate. The denser oceanic lithosphere sinks underneath the continental lithosphere in a process called *subduction*. Subduction can cause a chain of mountains, such as the Andes, to form along the plate boundary.
- **Ocean-Ocean Boundaries** These form when oceanic lithosphere on one plate collides with oceanic lithosphere on another plate. One of the plates subducts beneath the other. A series of volcanic islands, called an *island arc*, can form along the plate boundary.

**TAKE A LOOK**

**6. Identify** At what two types of convergent boundaries do subduction zones form?

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**TRANSFORM BOUNDARIES**

A *transform boundary* forms where plates slide past each other horizontally. Most transform boundaries are found near mid-ocean ridges. The ridges are broken into *segments*, or pieces. Transform boundaries separate the segments from one another.

**SECTION 2** The Theory of Plate Tectonics *continued*

## Why Do Tectonic Plates Move?

Scientists do not know for sure what causes tectonic plates to move. However, they have three main hypotheses to explain plate movements: convection, slab pull, and ridge push.

Scientists used to think that convection in the mantle was the main force that caused plate motions. Remember that *convection* happens when matter carries heat from one place to another. Convection happens in the mantle as rock heats up and expands. As it expands, it becomes less dense and rises toward Earth’s surface. ✓

As the hot material rises, cold, dense lithosphere sinks into the mantle at subduction zones. The rising hot material and the sinking cold material form *convection currents*. Until the 1990s, many scientists thought that these convection currents pulled the tectonic plates over Earth’s surface.

Today, most scientists think that slab pull is the main force that causes plate motions. During subduction, oceanic lithosphere at the edge of a plate sinks into the mantle. The oceanic lithosphere sinks because it is colder and denser than the mantle. As the lithosphere at the edge of the plate sinks, it pulls the rest of the plate along with it. This process is called *slab pull*.

Another possible cause of plate motions is ridge push. At mid-ocean ridges, new oceanic lithosphere forms. This new lithosphere is warmer and less dense than the older lithosphere farther from the ridge. Therefore, it floats higher on the asthenosphere than the older lithosphere. As gravity pulls the new lithosphere down, the plate slides away from the mid-ocean ridge. This process is called *ridge push*.

Driving Force	Description
Slab pull	Cold, sinking lithosphere at the edges of a tectonic plate pulls the rest of the plate across Earth’s surface.
Ridge push	Gravity pulls newly formed lithosphere downward and away from the mid-ocean ridge. The rest of the plate moves because of this force.
Convection currents	Convection currents are produced when hot material in the mantle rises toward the surface and colder material sinks. The currents pull the plates over Earth’s surface.

 **READING CHECK**

**7. Define** What is convection?

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## Critical Thinking

**8. Compare** How is slab pull different from ridge push?

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# Section 2 Review

6.1.b, 6.1.c, 6.1.e, 6.4.c 

## SECTION VOCABULARY

**plate tectonics** the theory that explains how large pieces of the Earth's outermost layer, called tectonic plates, move and change shape

**tectonic plate** a block of lithosphere that consists of the crust and the rigid, outermost part of the mantle

1. **Define** Write your own definition for *tectonic plate*.

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2. **Identify** What are the three main types of plate boundaries?

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3. **Describe** How fast do tectonic plates move?

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4. **List** Give three processes that may cause tectonic plates to move.

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5. **Explain** Why does oceanic lithosphere sink beneath continental lithosphere at convergent boundaries?

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6. **Describe** What is a transform boundary?

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7. **Identify** Give two features that are found only at plate boundaries, and give two features that are found most commonly at plate boundaries.

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## Deforming Earth's Crust

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What happens when rock is placed under stress?
- What are three kinds of faults?
- How do mountains form?



California Science Standards

6.1.a, 6.1.d

## What Is Deformation?

In the left-hand figure below, the girl is bending the spaghetti slowly and gently. The spaghetti bends, but it doesn't break. In the right-hand figure, the girl is bending the spaghetti quickly and with a lot of force. Some of the pieces of spaghetti have broken.



How can the same material bend in one situation but break in another? The answer is that the stress on the material is different in each case. *Stress* is the amount of force per unit area that is placed on an object. ✓

In the left-hand picture, the girl is slowly putting a small amount of stress on the spaghetti. The spaghetti bends under the small amount of stress. In the right-hand picture, the girl is quickly putting a lot of stress on the spaghetti. The spaghetti breaks under this large amount of stress.

Rocks can also bend or break under stress. When a rock is placed under stress, it *deforms*, or changes shape. When a small amount of stress is put on a rock slowly, the rock can bend. However, if the stress is very large or is applied quickly, the rock can break.



**Learn New Words** As you read, underline words that you don't understand. When you learn what they mean, write the words and their definitions in your notebook.



### READING CHECK

1. **Define** What is stress?

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**SECTION 3** Deforming Earth's Crust *continued*

## What Happens When Rock Layers Bend?

**Folding** happens when rock layers bend under stress. Folding causes rock layers to look bent or buckled. The bends are called *folds*.

Scientists assume that all rock layers start out as horizontal layers. Therefore, when scientists see a fold, they know that deformation has happened. ✓

All folds have a hinge and two limbs. *Limbs* are the sides of a fold. The *hinge* is the place where the two limbs meet.

**READING CHECK**

**2. Explain** How do folds indicate that deformation has happened?

\_\_\_\_\_

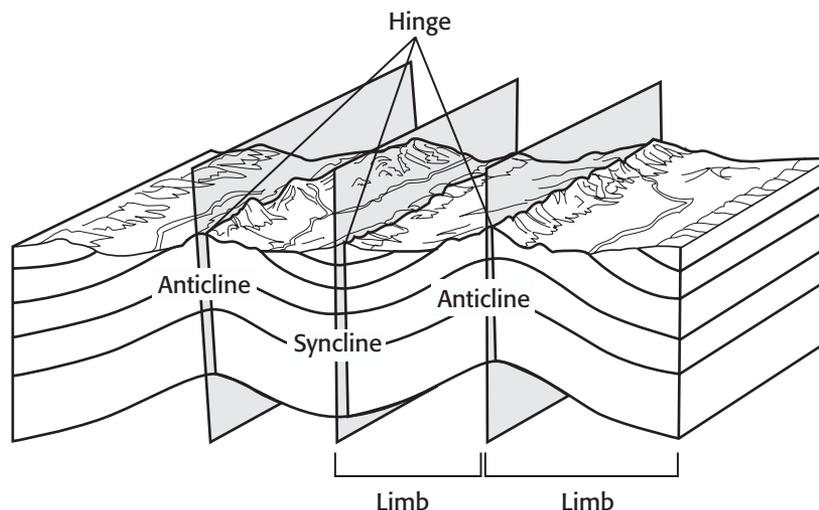
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### TYPES OF FOLDS

Two of the most common types of folds are synclines and anticlines. In a *syncline*, the oldest rocks are found on the outside of the fold. Most synclines are U-shaped. In an *anticline*, it is the youngest rocks that are found on the outside of the fold. Most anticlines are  $\cap$ -shaped. The figure below shows two anticlines and a syncline.



### TAKE A LOOK

**3. Color** The rock layers in the picture are oldest at the bottom and youngest at the top. Color each rock layer with a different color to help you see where the oldest and youngest rocks are in anticlines and synclines.

### SHAPES OF FOLDS

Folds can have many shapes. *Symmetrical* folds, like the ones in the figure above, have two limbs that are bent the same amount. *Asymmetrical* folds have limbs that are bent by different amounts. For example, an *overturned fold* has one limb that is tilted more than 90 degrees. In a *recumbent* fold, the limbs are bent so much that it looks like the fold is lying on its side.

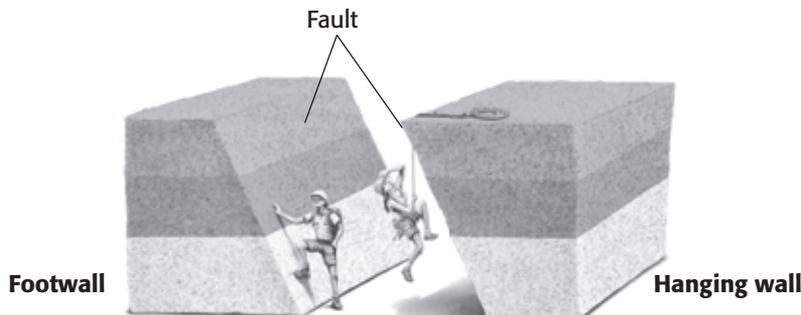
**SECTION 3** Deforming Earth's Crust *continued*

**What Happens When Rock Layers Break?**

When rock is put under so much stress that it can no longer bend, it may break. The crack that forms when rocks break and move past each other is called a **fault**. The blocks of rock that are on either side of the fault are called *fault blocks*. When fault blocks move suddenly, they can cause earthquakes. ✓

When a fault forms at an angle, one fault block is called the *hanging wall*, and the other is called the *footwall*. The figure below shows the difference between the hanging wall and the footwall.

Scientists classify faults by how the fault blocks have moved along the fault. There are three main kinds of faults: normal faults, reverse faults, and strike-slip faults.



The footwall is the fault block that is below the fault. The hanging wall is the fault block that is above the fault.

**NORMAL FAULTS**

In a *normal fault*, the hanging wall moves down, or the footwall moves up, or both. Normal faults form where tectonic plate motions cause tension. *Tension* is stress that pulls rock apart. Therefore, normal faults are common along divergent boundaries, where Earth's crust stretches. The figure at the top of the next page shows a normal fault. ✓

**REVERSE FAULTS**

In a *reverse fault*, the hanging wall moves up, or the footwall moves down, or both. Reverse faults form where tectonic plate motions cause compression. *Compression* is stress that pushes rock together. Therefore, reverse faults are common along convergent boundaries, where two plates collide. The figure on the top of the next page shows a reverse fault.

**READING CHECK**

**4. Define** Write the definition of a fault in your own words.

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**TAKE A LOOK**

**5. Compare** How is the hanging wall different from the footwall?

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**READING CHECK**

**6. Explain** Why are normal faults common along divergent boundaries?

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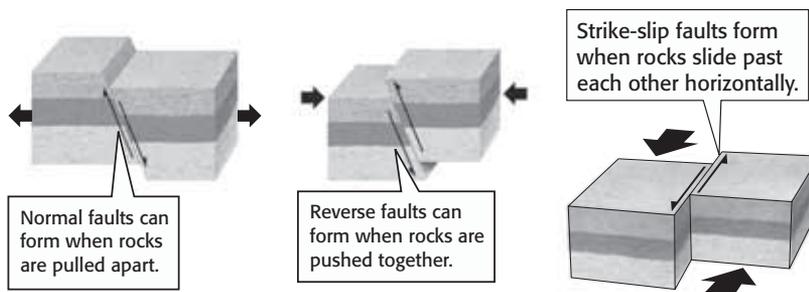


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**SECTION 3** Deforming Earth's Crust *continued*

**TAKE A LOOK**

**7. Identify** Label the hanging walls and the footwalls on the normal and reverse faults.



**STRIKE-SLIP FAULTS**

In a *strike-slip fault*, the fault blocks move past each other horizontally. Strike-slip faults form when rock is under shear stress. *Shear stress* is stress that pushes different parts of the rock in different directions. Therefore, strike-slip faults are common along transform boundaries, where tectonic plates slide past each other.

**RECOGNIZING FAULTS**

Faults produce many features that you can see on Earth's surface. For example, faulting causes rock layers to move relative to one another. Therefore, layers of different kinds of rock that are next to each other can indicate a fault. In addition, rocks can grind against each other when a fault forms. This grinding can produce grooves and scrapes on the surface of the rock. ✓

**READING CHECK**

**8. Describe** Give two features that can indicate the presence of a fault.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Some faults are many kilometers long. These faults can produce very large features on Earth's surface. For example, streams may flow in different directions when they cross a fault. Structures made by people, such as fences and roads, can also be disturbed by a fault.

Another feature that can indicate faulting is a scarp. A *scarp* is a row of cliffs that forms on a fault. Scarps form when one fault block is raised above the other fault block, as in a reverse fault. Some scarps are very small, but others may be tens of meters high.

**SECTION 3** Deforming Earth's Crust *continued*

**How Do Mountains Form?**

As tectonic plates move over Earth's surface, the edges of the plates grind against each other. This produces a lot of stress in Earth's lithosphere. Over very long periods of time, the movements of the plates can form mountains. Mountains can form in three main ways: through folding, faulting, and volcanism.

**FOLDED MOUNTAINS**

*Folded mountains* form when rock layers are squeezed together and pushed upward. Folded mountains usually form at convergent boundaries, where continents collide. For example, the Appalachian Mountains formed hundreds of millions of years ago when North America collided with Europe.

**FAULT-BLOCK MOUNTAINS**

*Fault-block mountains* form when tension makes the lithosphere break into many normal faults. Along these faults, pieces of the lithosphere drop down compared with other pieces. This produces fault-block mountains. The Tetons are an example of a fault-block mountain range.

**VOLCANIC MOUNTAINS**

*Volcanic mountains* form when melted rock erupts onto Earth's surface. Most major volcanic mountains are found at convergent boundaries.

Volcanic mountains can form on land or on the ocean floor. Volcanoes on the ocean floor can grow so tall that they rise above the surface of the ocean. These volcanoes form islands, such as the Hawaiian Islands.

Most of Earth's active volcanoes are concentrated around the edge of the Pacific Ocean. This area is known as the *Ring of Fire*.

Type of Mountain	Description
Folded	
Fault-block	
Volcanic	

*Critical Thinking*

**9. Apply Concepts** Why does it take a very long time for most mountains to form?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**READING CHECK**

**10. Identify** What kind of stress forms fault-block mountains?

\_\_\_\_\_

**TAKE A LOOK**

**11. Describe** Fill in the table with the features of each kind of mountain. Include where the mountains form and what they are made of.

# Section 3 Review

6.1.a, 6.1.d 

## SECTION VOCABULARY

<b>fault</b> a break in a body of rock along which one block slides relative to another	<b>folding</b> the bending of rock layers due to stress
---	---

1. **Compare** How are folding and faulting similar? How are they different?

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---

2. **Describe** Fill in the spaces in the table to describe the three main kinds of faults.

Kind of fault	Description	Kind of stress that produces it
Normal		
	Hanging wall moves up; footwall moves down.	
		shear stress

3. **Identify** Name two kinds of asymmetrical folds.

---



---

4. **Explain** Why are strike-slip faults common at transform boundaries?

---



---

5. **Infer** Why are fault-block mountains probably uncommon at transform boundaries?

---



---



---

6. **Define** What is the Ring of Fire?

---

# California Geology

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How have plate movements affected California?
- What features in California are the result of plate movements?



California Science Standards

6.1.f

## How Has Plate Tectonics Affected California?

Much of California's landscape is a result of plate tectonics. Compression along the plate boundaries has produced many of the rugged mountains in California. The steep, rocky coastlines in central and northern California are also a result of compression.

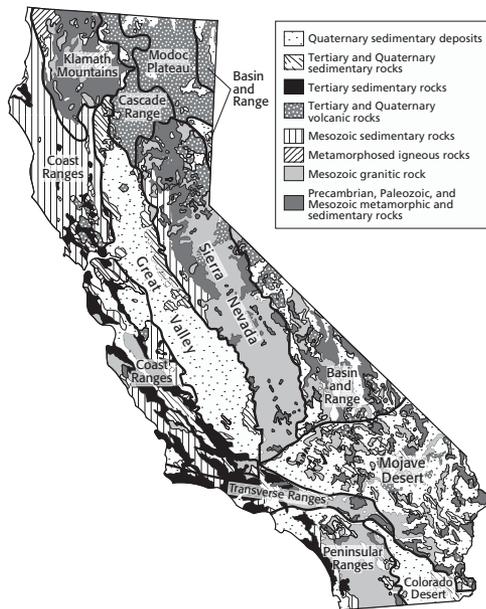
The main plate boundary in California, the San Andreas fault system, runs in a northwest-southeast direction. Many major river valleys and mountain ranges run parallel to this fault, as you can see in the figure below. The Transverse Ranges in southern California are an exception to this trend. The motion along the faults in southern California has caused these mountains to run in an east-west direction. ✓

## STUDY TIP

**Organize** As you read this section, create a time line of the geologic events that are discussed.

## READING CHECK

**1. Describe** In which direction do most of the geologic features in California run?



This geologic map of California shows many of the features of the California landscape. Notice that many of the features run in a northwest-southeast direction, parallel to the San Andreas fault system.

## TAKE A LOOK

**2. Identify** What is the main kind of rock that is found in the Coast Ranges?

**SECTION 4** California Geology *continued*

## How Did California Form?

The area that we know as California has been an active plate boundary for more than 225 million years. Before then, the western coast of North America stopped at Nevada and the eastern deserts of California. Most of what is now California was then either part of a distant plate or did not yet exist.

When Pangaea began to break up, the North American plate moved west. The western edge of North America became an active convergent boundary. A long period of subduction began. This subduction lasted from about 160 million to 100 million years ago. It started to “build” the area that we know today as California. ✓

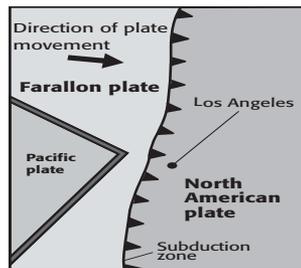
**READING CHECK**

**3. Identify** What kind of plate boundary started to form California when Pangaea began to break up?

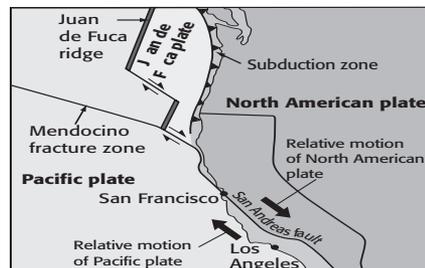
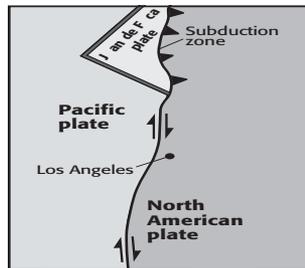
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### ANCIENT PLATE BOUNDARIES

Three major tectonic plates have affected California’s geology: the North American, the Farallon, and the Pacific plates. The interactions of these plates produced many of the features that are found in California today. The figures below show how these plates have interacted over time.



About 30 million years ago, the Farallon plate was subducting underneath the North American plate. About 25 million years ago, the Pacific plate first touched the North American plate.



**TAKE A LOOK**

**4. Identify** What is the only remaining piece of the Farallon plate?

\_\_\_\_\_

By 10 million years ago, almost all of the Farallon plate had been subducted. The plate boundary between the Pacific plate and the North American plate became a transform boundary.

Today, most of California’s coastline is a transform boundary. The small Juan de Fuca plate is all that is left of the Farallon plate.

**SECTION 4** California Geology *continued***How Did California's Volcanic Mountains Form?**

As an oceanic plate subducts, it heats up and releases water into the mantle rock around it. The mantle rock begins to melt. The melted rock rises toward the surface, where it can erupt to form mountains. The subduction of the Farallon plate produced California's well-known volcanic mountain ranges, the Sierra Nevada and the Cascade Mountains.

**SIERRA NEVADA MOUNTAINS**

As the Farallon plate subducted beneath the North American plate, large amounts of melted rock were produced. Some of the melted rock rose to the surface and erupted to form volcanoes. However, most of the melted rock remained below Earth's surface. Between about 210 million and 100 million years ago, it cooled and hardened below the ground.

As the melted rock cooled and hardened, it produced a large mass of granite below the ground. This mass of granite is called the *Sierra Nevada batholith*. A **batholith** is a large mass of igneous rock that forms underground.

The Sierra Nevada batholith formed hundreds of millions of years ago. Over time, the rock above the batholith was removed by weathering and erosion. Today, only the batholith remains. It is exposed at the surface in the Sierra Nevada mountain range.



The rocks in the Sierra Nevada mountains formed when melted rock cooled and hardened over hundreds of millions of years. This cooled rock makes up the Sierra Nevada batholith, which was once located far underground. Today, weathering and erosion have removed the overlying rock. Only the rock of the batholith is left.

**Investigate and Share**

Learn more about how one of California's mountain ranges formed. Share what you learn with a small group or with your class.

**Math Focus**

**5. Calculate** How long did it take for the melted rock to cool and harden?

\_\_\_\_\_

**TAKE A LOOK**

**6. Describe** Why is the Sierra Nevada batholith found above the ground today, even though it formed far beneath the ground?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**SECTION 4** California Geology *continued*

**CASCADE MOUNTAINS**

Today, the Juan de Fuca plate is subducting beneath the North American plate. This convergent boundary stretches from northern California to British Columbia, Canada. It is known as the *Cascadia subduction zone*.

Many active volcanoes are found along the Cascadia subduction zone. These volcanoes form the Cascade Mountains. They include Mount St. Helens, in Washington, and Mount Shasta and Lassen Peak, in California.



**CALIFORNIA STANDARDS CHECK**

**6.1.f.** Students know how to explain major features of California geology (including mountains, faults, volcanoes) in terms of plate tectonics.

**Word Help: major**  
of great importance or large scale

**Word Help: feature**  
the shape or form of a thing; characteristic

**7. Identify** Name four mountain ranges in California that formed as a result of plate tectonics.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**How Did Other Mountains in California Form?**

When a tectonic plate subducts, parts of the plate can be scraped off and become attached to the plate above it. This process is called *accretion*. Accretion can form mountain chains parallel to the plate boundary.

The chunks of Earth’s crust that are added to the edge of the continent are called **accreted terranes**. Geologists can identify accreted terranes because the rocks in the terranes are different from the surrounding rocks. For example, rocks from an accreted terrane may be a different age. They may be made of rocks from deep in the ocean or even of rocks from the mantle. In addition, many accreted terranes are surrounded by faults.

The Coast and Transverse mountain ranges in California probably formed by accretion. The Central Valley, Los Angeles Basin, and Ventura Basin separate some of these mountain ranges.

**GOLD ORES FROM ACCRETION**

Most of the California’s gold is found in the western foothills along the Sierra Nevada range. The rocks that contain the gold are thought to be accreted terranes that originally formed near volcanic vents in the ocean.

**TAKE A LOOK**

**8. Describe** Fill in the blank spaces in the table.

Type of mountain	How it forms	Examples in California
Volcanic	Magma forms at a convergent plate boundary. It erupts to form volcanoes or cools to form batholiths.	
Accreted terrane		Coast Ranges, Transverse Ranges

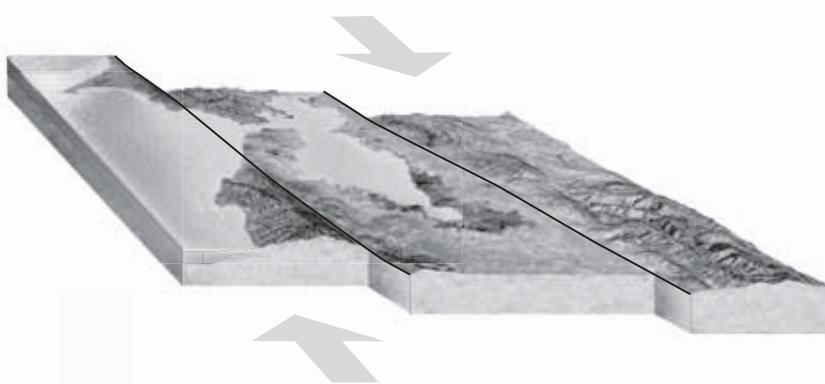
**SECTION 4** California Geology *continued*

**How Do Transform Faults Affect California?**

The San Andreas fault system in California is the most famous transform boundary in the world. The San Andreas is the dividing line between the Pacific plate to the west and the North American plate to the east. Most of California is located on the North American plate. The San Andreas fault system is more than 1,000 km long. It includes many smaller faults that branch off or join the main fault. ✓

**PLATE MOVEMENT ALONG THE FAULT SYSTEM**

Scientists consider the San Andreas fault to be the boundary between the Pacific and North America plates. However, not all of the plate motion takes place on the San Andreas fault itself. For example, in southern California, most plate motion happens on other faults in the fault system. Therefore, it is better to think of the boundary between the Pacific and North American plates as a region, rather than as a single line.



Movement in the San Andreas fault system takes place along several faults. Therefore, the boundary between the Pacific plate and the North American plate can be hard to define.

The Pacific and North American plates have been moving along the San Andreas fault system for about 25 million years. Over the last 16 million years, the total movement along the fault has been about 315 km.

In southern California, the San Andreas fault system bends to the east. Because of this bend, the Pacific and North American plates are colliding as they slide past each other. The collision produces a lot of compression. This compression causes the crust to be pushed up. The San Bernardino and San Gabriel mountains are some of the mountains that have been produced by this compression.

**READING CHECK**

**9. Identify** Which two plates are separated by the San Andreas fault system?

\_\_\_\_\_

\_\_\_\_\_

**TAKE A LOOK**

**10. Explain** Why can it be hard to define the exact boundary between the Pacific plate and the North American plate?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# Section 4 Review

## SECTION VOCABULARY

**accreted terrane** a piece of lithosphere that becomes part of a larger landmass when tectonic plates collide at a convergent boundary

**batholith** a large mass of igneous rock in Earth's crust that, if exposed at the surface, covers an area of at least 100 km<sup>2</sup>

**1. Define** Write your own definition for *accreted terrane*.

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**2. Identify** What kind of plate boundary is found along most of the coast of California?

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**3. Explain** How are Lassen Peak and Mount Shasta related to subduction?

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**4. Infer** What kind of fault is probably most common in the northern San Andreas fault system? Explain your answer.

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**5. Apply Concepts** How is the stress in the southern part of the San Andreas fault system different from the stress in the northern part?

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**6. Describe** How have the tectonic plate boundaries in California changed over the last 225 million years?

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# What Are Earthquakes?

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- Where do most earthquakes happen?
- What makes an earthquake happen?
- What are seismic waves?



California Science Standards

6.1.a, 6.1.d, 6.1.e, 6.3.a

## What Is an Earthquake?

Have you ever been in an earthquake? An **earthquake** is a movement or shaking of the ground. Earthquakes happen when huge pieces of the Earth's crust move suddenly and give off energy. This energy travels through the ground and makes it move.



**Outline** As you read, create an outline of this section. Use the headings in the section to guide you.

## Where Do Most Earthquakes Happen?

Most earthquakes happen at places where two tectonic plates touch. Tectonic plates are always moving. Where two plates touch, they may be moving toward each other, moving away from each other, or sliding past each other.

The movements of the plates can break the rocky crust in many places. A place where the crust is broken is called a *fault*. Earthquakes happen when rock breaks and slides along a fault. ✓

A place in the crust where a lot of faults are found is called a *fault zone*. Most fault zones, such as the San Andreas Fault Zone, are found at plate boundaries. But some fault zones are in the middle of plates.



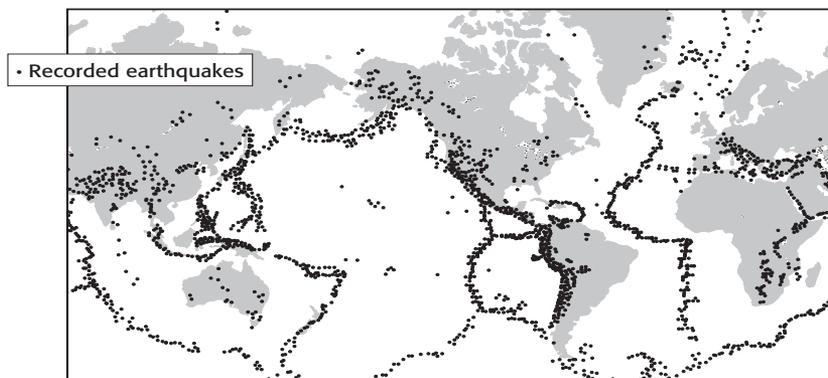
**1. Define** What is a fault?

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### Earthquakes and Plate Boundaries



## TAKE A LOOK

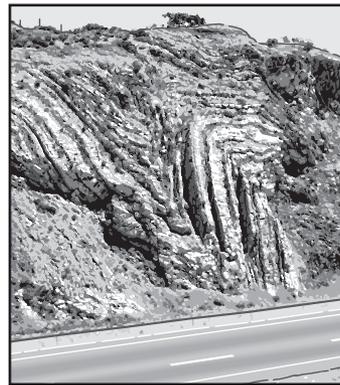
**2. Infer** Use the earthquake locations to help you figure out where the tectonic plate boundaries are on the map. Use a colored pen or marker to draw tectonic plate boundaries on the map.

**SECTION 1** What Are Earthquakes? *continued*

### Why Do Earthquakes Happen?

As tectonic plates move, pressure builds up on the rock near the edges of the plates. When a rock is put under pressure, it deforms, or changes shape. Rock can deform in two main ways.

One kind of deformation is called plastic deformation. *Plastic deformation* happens when rock bends and folds like clay. When the pressure is taken away, the rock stays folded.



**Folded Layers of Rock**

### TAKE A LOOK

**3. Explain** How do you know that the rock layers in the figure were once under a lot of pressure?

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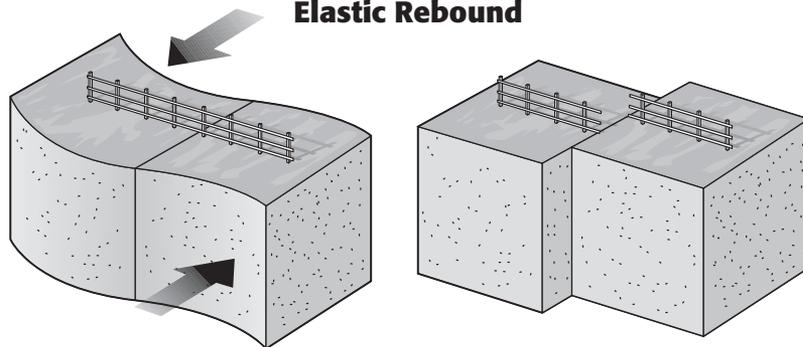


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A second kind of deformation is called elastic deformation. *Elastic deformation* happens when rock bends a little bit under pressure but returns to its original size and shape when the pressure stops.

Earthquakes happen when rock breaks under pressure. When the rock breaks, it snaps back to almost the same size and shape as before the earthquake. This snap back is called **elastic rebound**. When the rock breaks and rebounds, it gives off energy. This energy causes the ground to shake.

### Elastic Rebound



1. Forces push rock in opposite directions. The rock deforms elastically. It does not break.

2. If enough force is placed on the rock, it breaks. The rock slips along the fault. Energy is released.

 **CALIFORNIA STANDARDS CHECK**

**6.1.e** Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.

**Word Help:** major of great importance or large scale

**4. Explain** How does the movement of tectonic plates cause earthquakes?

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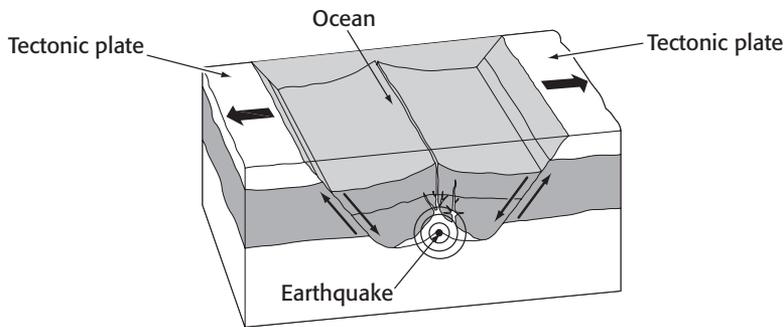
**SECTION 1** What Are Earthquakes? *continued*

## How Do Earthquakes Happen at Divergent Boundaries?

A *divergent boundary* is a place where two tectonic plates are moving away from each other. As the plates pull apart, the crust stretches. The crust breaks into pieces along faults. The pieces are called *fault blocks* because they are blocks of rock that move along faults. ✓

Most of the crust at divergent boundaries is thin, so the earthquakes tend to be shallow. Most earthquakes at divergent boundaries are no more than 20 km deep. ✓

### Earthquakes at Divergent Boundaries



✓ **READING CHECK**

**5. Define** What is a fault block?

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✓ **READING CHECK**

**6. Explain** Why do most earthquakes at divergent boundaries happen at shallow depths?

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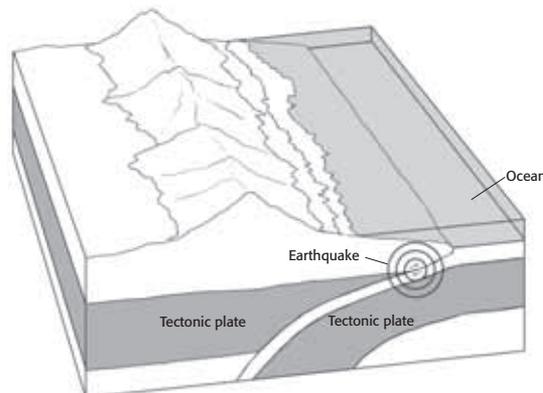
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## How Do Earthquakes Happen at Convergent Boundaries?

A *convergent boundary* is a place where two tectonic plates collide. When two plates come together, both plates may crumple up to form mountains. Or one plate can *subduct*, or sink, underneath the other plate and into the mantle.

The earthquakes that happen at convergent boundaries can be very strong because so much pressure is produced. When one plate subducts under another, earthquakes can happen inside the sinking plate at depths of up to 700 km. ✓

### Earthquakes at Convergent Boundaries



✓ **READING CHECK**

**7. Explain** Why are most earthquakes at convergent boundaries very strong?

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**TAKE A LOOK**

**8. Identify** Draw arrows on the figure to show the directions in which the two tectonic plates are moving.

**SECTION 1** What Are Earthquakes? *continued*

## How Do Earthquakes Happen at Transform Boundaries?

A *transform boundary* is a place where two tectonic plates slide past each other. As the plates move past each other, pressure builds up on the rock. Eventually, the rock breaks along a fault.

The rock will break only if it is brittle. Rocks far below Earth’s surface are generally not brittle. Therefore, most earthquakes at transform boundaries happen in the upper 50 km of the crust. ✓

**READING CHECK**

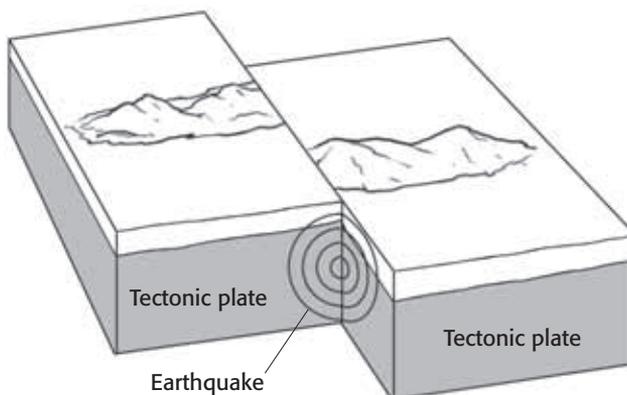
**9. Identify** How deep can earthquakes occur at transform boundaries?

\_\_\_\_\_

**TAKE A LOOK**

**10. Identify** Draw arrows showing the directions that the tectonic plates in the figure are moving.

**Earthquakes at Transform Boundaries**



## How Does Earthquake Energy Travel?

When an earthquake occurs, a lot of energy is given off. This energy travels through the Earth in the form of waves called **seismic waves**.

There are two kinds of seismic waves. *Body waves* are seismic waves that travel through the inside of Earth to the surface. *Surface waves* are seismic waves that travel through the top part of Earth’s crust. ✓

**READING CHECK**

**11. List** What are the two kinds of seismic waves?

\_\_\_\_\_

\_\_\_\_\_

**BODY WAVES**

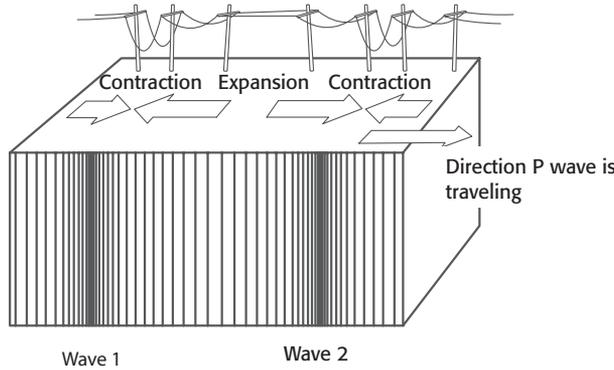
There are two kinds of body waves: P waves and S waves. *P waves* are the fastest kind of seismic wave. P waves cause rock to move back and forth. P waves can move through solids, liquids, and gases.

Another kind of wave, an *S wave*, can cause the rock to move horizontally from side to side. S waves can also cause the rock to move up and down. S waves travel more slowly than P waves. They can travel only through solids.

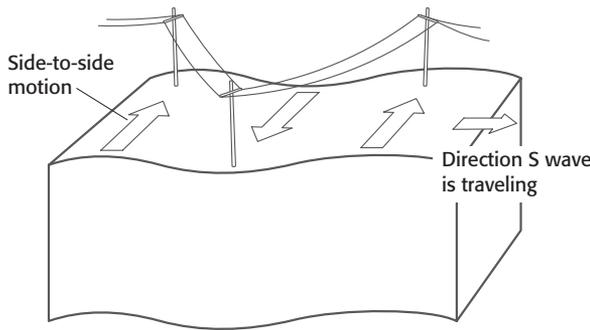
**SECTION 1** What Are Earthquakes? *continued*

**SURFACE WAVES**

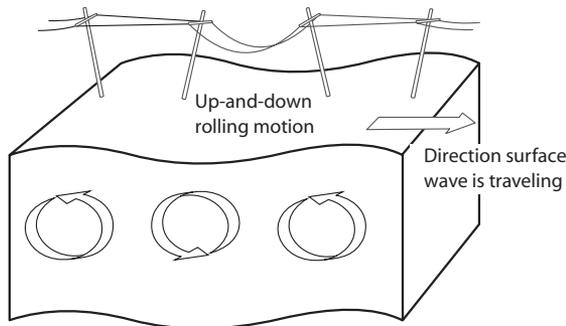
Surface waves travel along the top of Earth's crust. Only the very top part of the crust moves when a surface wave passes. Surface waves travel much more slowly than body waves, but they cause a lot more damage. ✓



**P waves** are body waves that squeeze and stretch rock.



**S waves** are body waves that can move rock from side to side.



**Surface waves** can move the ground up and down in a circular motion.

**READING CHECK**

**12. Compare** Which kind of seismic waves travel the most slowly?

\_\_\_\_\_

**TAKE A LOOK**

**13. Compare** How are the motions of P waves and S waves different?

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**Critical Thinking**

**14. Infer** What do you think is the reason that surface waves usually cause the most damage?

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

# Section 1 Review

6.1.a, 6.1.d, 6.1.e, 6.3.a



## SECTION VOCABULARY

**earthquake** a movement or trembling of the ground that is caused by a sudden release of energy when rocks along a fault move

**elastic rebound** the sudden return of elastically deformed rock to its undeformed shape

**seismic wave** a wave of energy that travels through the Earth, away from an earthquake in all directions

**1. Compare** What is the difference between an earthquake and a fault?

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**2. Compare** Give two ways that P waves are different from S waves.

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**3. Identify** Where do most earthquakes happen?

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**4. Describe** What causes an earthquake to happen?

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**5. Explain** What is the main difference between body waves and surface waves?

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**6. Apply Concepts** Why are some earthquakes stronger than others?

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**7. Infer** Why do few earthquakes happen in Earth's mantle?

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SECTION 2 Earthquake Measurement

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do scientists know exactly where an earthquake happened?
- How are earthquakes measured?
- What affects the intensity of an earthquake?



California Science Standards

6.1.g

**How Do Scientists Study Earthquakes?**

Scientists who study earthquakes use an important tool called a seismometer. A *seismometer* records the vibrations that are caused by seismic waves. When the waves from an earthquake reach a seismometer, it records them as lines on a chart called a *seismogram*.

Remember that earthquakes happen when rock in Earth’s crust breaks. The rock breaks in just one area, even though the earthquake can sometimes be felt many miles away.

The place inside the Earth where the rock first breaks is called the earthquake’s **focus**. The place on Earth’s surface that is right above the focus is called the **epicenter**. Scientists can use seismograms to find the epicenter of an earthquake. ✓



**Ask Questions** Read this section quietly to yourself. As you read, write down questions that you have. Discuss your questions in a small group.



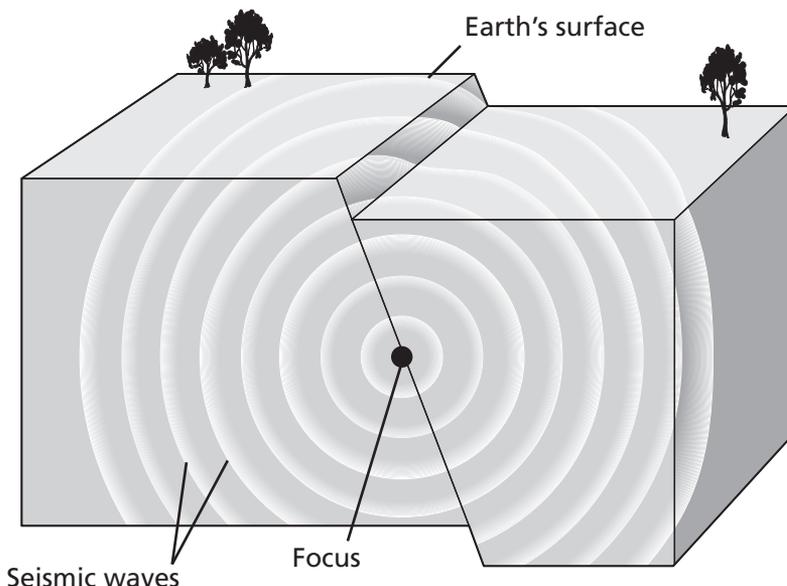
**1. Explain** What is the difference between the epicenter of an earthquake and the focus of the earthquake?

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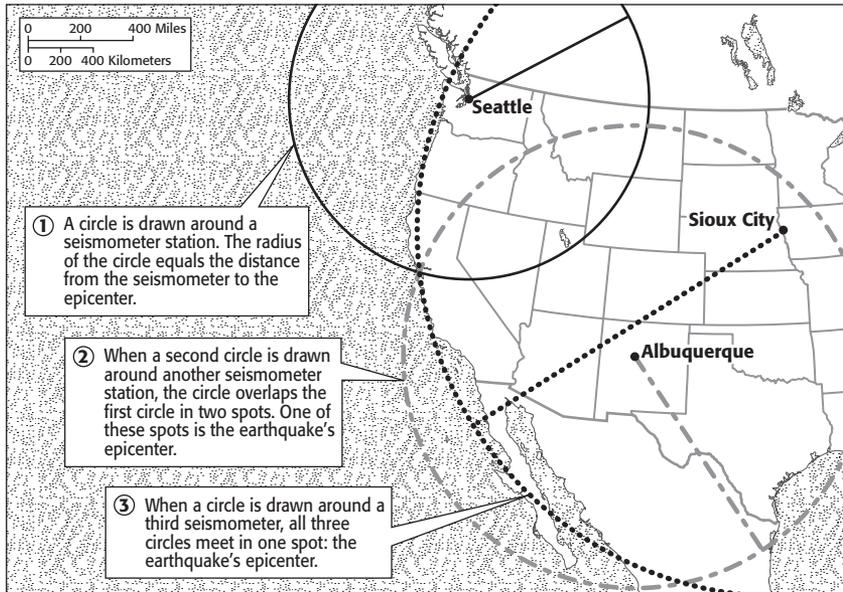
**TAKE A LOOK**

**2. Identify** On the figure, mark the epicenter of the earthquake with a star.

**SECTION 2** Earthquake Measurement *continued*

## How Do Scientists Know Where an Earthquake Happened?

Scientists can use seismograms to figure out how far each seismometer is from the epicenter of an earthquake. Then they can find the epicenter by using the steps below.



### TAKE A LOOK

**3. Identify** On the map, draw a star at the earthquake's epicenter.

### READING CHECK

**4. Define** What is magnitude?

\_\_\_\_\_

\_\_\_\_\_

### Math Focus

**5. Multiply** How much stronger is a magnitude 6.0 earthquake than a magnitude 4.0 earthquake? Show your work.

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## What Is Earthquake Magnitude?

The strength of an earthquake is called its **magnitude**. Scientists use two different scales to measure magnitude. One scale is called the Richter magnitude scale. It measures how much ground movement an earthquake causes. ✓

Scientists prefer to use another scale, *the moment magnitude scale*. Unlike the Richter scale, this scale is based on the size of the area involved in the earthquake. The moment magnitude scale gives a more accurate measurement of the strength of an earthquake.

The Richter magnitude scale and the moment magnitude scale can be used to compare the magnitudes of different earthquakes. When the magnitude of an earthquake goes up by one unit, the strength of the earthquake goes up ten times. For example, an earthquake with a magnitude of 5.0 is ten times stronger than an earthquake with a magnitude of 4.0.

**SECTION 2** Earthquake Measurement *continued***What Is Earthquake Intensity?**

The **intensity** of an earthquake is a measure of how much damage it caused and how much it was felt by people. Scientists in the United States use the Modified Mercalli intensity scale to compare the intensities of different earthquakes. ✓

Intensity	Description of effects
I	generally is not felt by people
II	is felt by only a few people
III	is felt by most people indoors
IV	is felt by many people; causes dishes to rattle
V	is felt by nearly everyone; breaks or tips over some objects
VI	is felt by everyone; causes some damage to buildings
VII	causes some damage to many buildings
VIII	causes a lot of damage to ordinary buildings
IX	causes much damage to earthquake-resistant buildings
X	destroys many buildings; bends railroad tracks
XI	destroys almost all buildings; breaks bridges
XII	causes total destruction

The effects of an earthquake can be very different from place to place. One earthquake can have many different intensity values, even though it has only one magnitude. Many things can affect the intensity of an earthquake.

Factor	How it affects intensity
Size of the earthquake	Intensity is higher in larger earthquakes.
Distance from the epicenter	Areas that are closer to the epicenter have higher intensities.
Local geology	Areas with hard rock in the ground have lower intensities than areas on soft or wet soil.
Building features	Short buildings made of wood or steel are not damaged as much as taller buildings made of brick or concrete.

**INTENSITY MAPS**

Scientists can measure the intensities of an earthquake in different areas. They can use the measurements to make an intensity map of an earthquake.

An intensity map shows which areas had the most damage from the earthquake. By looking at intensity maps for past earthquakes, scientists can figure out which areas are likely to be damaged in future earthquakes.

 **READING CHECK**

**6. Define** What is intensity?

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**Critical Thinking**

**7. Explain** Why is it that an earthquake can have many intensity values, even though it has only one magnitude?

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# Section 2 Review

6.1.g 

## SECTION VOCABULARY

**epicenter** the point on Earth’s surface directly above an earthquake’s starting point, or focus

**focus** the point along a fault at which the first motion of an earthquake occurs

**intensity** in Earth science, the amount of damage caused by an earthquake

**magnitude** a measure of the strength of an earthquake

**1. Explain** What is the difference between a seismometer and a seismogram?

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**2. Compare** Fill in the chart below to show the differences between an earthquake’s magnitude and its intensity.

Feature	What does it measure?	What scale is used to measure it?
Magnitude		
Intensity		

**3. Describe** How is the focus of an earthquake related to the epicenter?

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**4. Infer** An area that is far from the epicenter of an earthquake generally has a lower intensity than an area closer to the epicenter. Why is this so?

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**5. Apply Concepts** Which city would most likely be the epicenter of an earthquake: San Francisco, California, or St. Paul, Minnesota? Explain your answer.

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# Earthquakes and Society

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Can scientists predict when earthquakes will happen?
- Why do some buildings survive earthquakes better than others?
- How can you prepare for an earthquake?



California Science Standards

6.1.g, 6.2.d

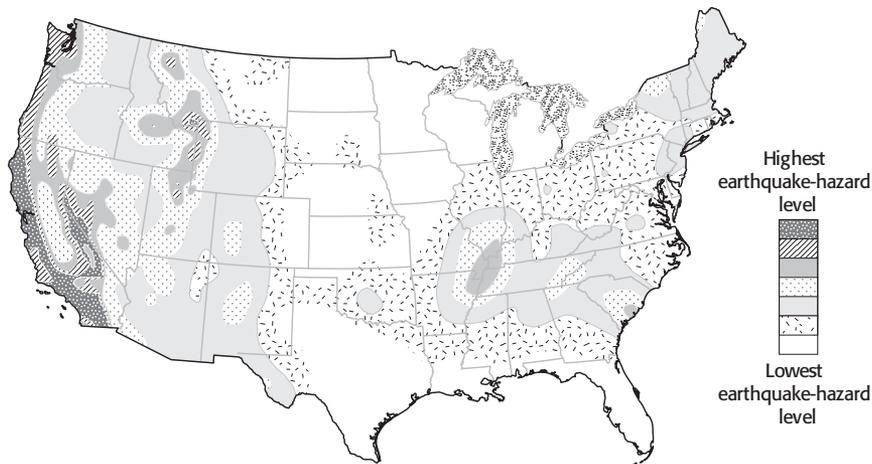
## What Is Earthquake Hazard?

*Earthquake hazard* is a measure of how likely it is that an area will have a damaging earthquake in the future. Scientists figure out the earthquake-hazard level by looking at the history of earthquakes in an area. Areas that have had many large earthquakes in the past have higher earthquake-hazard levels than areas without many earthquakes.



**Concept Map** As you read, underline the main ideas in this section. After you have read the section, create a Concept Map using your underlined ideas.

### Earthquake Hazard Map of the Continental United States



Look at the map in the figure above. Notice that California has the highest earthquake-hazard level in the country. The San Andreas Fault Zone runs through most of California, and a lot of earthquakes happen there. As a result, California has a high earthquake-hazard level.

## TAKE A LOOK

**1. Identify** Which parts of California have the highest earthquake-hazard level?

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**SECTION 3** Earthquakes and Society *continued*

### Can Scientists Predict Earthquakes?

Scientists can't predict earthquakes. But by looking at how often earthquakes have happened in the past, they can estimate where and when an earthquake will happen.

Look at the table below. It shows the number of earthquakes of different sizes that happen every year. There are a lot more weak earthquakes than strong earthquakes every year.

Kind of earthquake	Magnitude on the Richter scale	Average number every year
Great	8.0 and higher	1
Major	7.0 to 7.9	18
Strong	6.0 to 6.9	120
Moderate	5.0 to 5.9	800
Light	4.0 to 4.9	6,200
Minor	3.0 to 3.9	49,000
Very minor	2.0 to 2.9	365,000

### Math Focus

**2. Calculate** About how many times more light earthquakes than strong earthquakes happen every year?

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Scientists can guess when an earthquake will happen by looking at how many earthquakes have happened in the past. For example, if only a few strong earthquakes have happened recently in a fault zone, scientists can predict that a strong earthquake is likely to happen soon.

### What Is the Gap Hypothesis?

Some faults are very active. That is, they have a lot of earthquakes every year. These faults sometimes have very strong earthquakes. A part of an active fault that hasn't had a strong earthquake in a long time is called a **seismic gap**.

The *gap hypothesis* says that if an active fault hasn't had a strong earthquake in a long time, it is likely to have one soon. In other words, it says that earthquakes are more likely to happen in seismic gaps because pressure builds up in these places.

### Critical Thinking

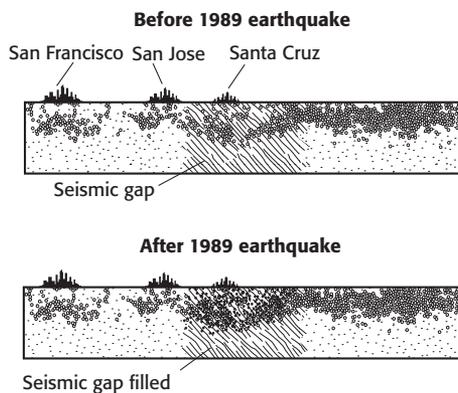
**3. Apply Concepts** What do you think is the reason that strong earthquakes are more likely to happen in seismic gaps?

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- **Earthquakes before the 1989 earthquake**  
In 1988, seismologists found a seismic gap in the San Andreas Fault. The pictures show a side view of the fault and the locations of earthquakes on the fault.
- **1989 earthquake and aftershocks**  
Seismologists predicted that there was a 30% chance of a strong earthquake in the seismic gap within 30 years. In 1989, a magnitude 6.0 earthquake happened at Loma Prieta, California. Many seismologists think that the gap hypothesis helped to predict this earthquake.

**SECTION 3** Earthquakes and Society *continued*

## How Do Earthquakes Affect Buildings?

Have you ever seen pictures of a city after a strong earthquake? You may have noticed that some buildings survive without very much damage. Other buildings, however, are totally destroyed.

Buildings that are damaged in an earthquake can be dangerous to the people in or near them. The damage can also be useful, though. Engineers can study it to learn how to make buildings that can better survive earthquakes.

### Critical Thinking

**4. List** Give three factors that can affect how much a building will be damaged in an earthquake.

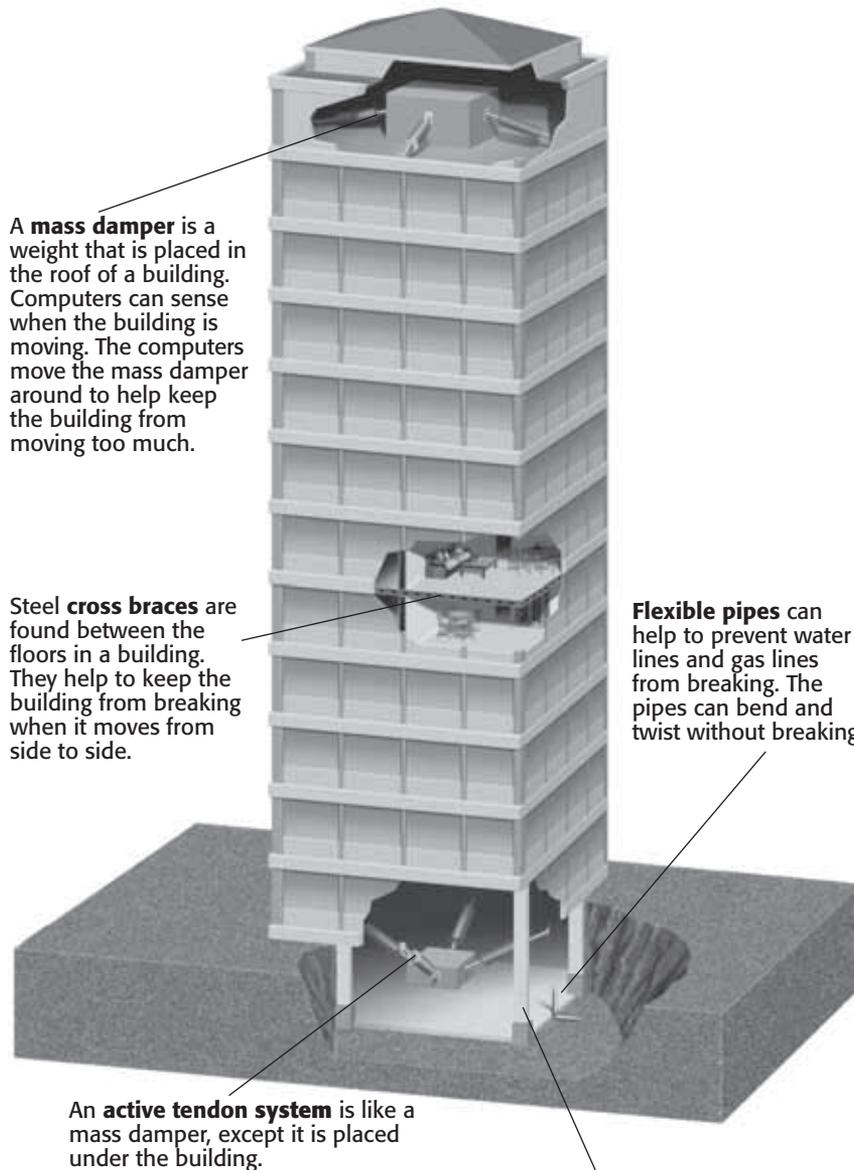
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A **mass damper** is a weight that is placed in the roof of a building. Computers can sense when the building is moving. The computers move the mass damper around to help keep the building from moving too much.

Steel **cross braces** are found between the floors in a building. They help to keep the building from breaking when it moves from side to side.

**Flexible pipes** can help to prevent water lines and gas lines from breaking. The pipes can bend and twist without breaking.

An **active tendon system** is like a mass damper, except it is placed under the building.

**Base isolators** can absorb energy during an earthquake. They keep seismic waves from moving through the building. Base isolators are made of rubber, steel, and lead.

### TAKE A LOOK

**5. Compare** How is a mass damper different from an active tendon system?

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**SECTION 3** Earthquakes and Society *continued*

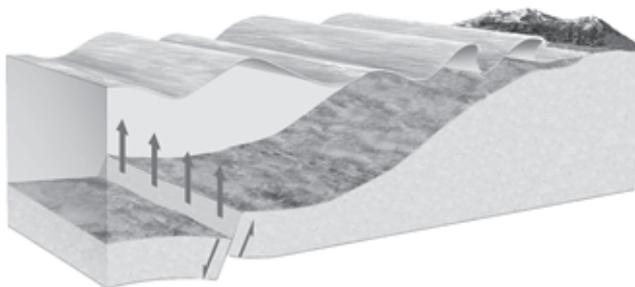
### What Are Tsunamis?

Earthquakes can affect water as well as land. A **tsunami** is a series of very long water waves. Tsunamis are often called “tidal waves.” Tsunamis can form when a strong earthquake happens on the sea floor. They can travel up to 800 km/h, from one side of the ocean to the other. ✓

**READING CHECK**

**6. Identify** What is one thing that can cause a tsunami?

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An earthquake on the ocean floor causes a tsunami. A lot of water is lifted up by the earthquake. As the water moves toward the shore, it creates huge waves that flood the land.

### TAKE A LOOK

**7. Compare** What happens to the size of the waves as a tsunami moves closer to shore?

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**CALIFORNIA STANDARDS CHECK**

**6.2.d** Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

**8. Infer** How can a tsunami change wildlife habitats?

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### How Do Tsunamis Cause Damage?

Out in the ocean, tsunami waves are fast but not very tall. When they come close to shore, they slow down and get much taller. When a tsunami hits, it floods the land. The water has a lot of energy and can smash or wash away almost anything in its path.

In December 2004, a very strong earthquake in the Indian Ocean caused a huge tsunami to hit part of Asia. The tsunami killed more than 280,000 people. It also destroyed people’s homes and businesses.



A tsunami on December 26, 2004, caused widespread destruction in Asia.

**SECTION 3** Earthquakes and Society *continued*

**How Can You Prepare for an Earthquake?**

If you live in a place with a high earthquake-hazard level, you and your family should have an earthquake plan. If you plan ahead and practice your plan, you will be better prepared for an earthquake. ✓

**How Can You Make an Earthquake Plan?**

**YOUR SAFE HOME**

Put heavy things near the floor so that they do not fall during an earthquake. Keep electrical wires and other things that can start a fire away from things that can burn.

**SAFE PLACES IN YOUR HOME**

Make sure you know a safe place in each room in your home. Safe places are areas that are far from windows and heavy objects that can fall or break. ✓

**A PLAN TO MEET OTHERS**

Talk to your family, friends, or neighbors and set up a place where you all will meet after an earthquake. If you all know where to meet each other, it will be easy to make sure that everyone is safe.

**AN EARTHQUAKE KIT**

Your earthquake kit should have things that you may need after an earthquake. Remember that your electricity may not work after an earthquake. It may be difficult to find clean water to drink.

What Should Be in an Earthquake Kit?
Water
A fire extinguisher
A small radio with batteries
Medicines
Food that won't go bad
A flashlight with batteries
Extra batteries
A first-aid kit

 **READING CHECK**

**9. Explain** Why is it important to make and practice an earthquake plan?

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 **READING CHECK**

**10. Identify** Think of your home. Write down a safe place in your home where you can go during an earthquake.

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**TAKE A LOOK**

**11. List** List four foods that are good to put in an earthquake kit.

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**SECTION 3** Earthquakes and Society *continued*

### What Should You Do During an Earthquake?

If you are inside when an earthquake happens, crouch or lie face down under a table or a desk. Make sure you are far from any windows or heavy objects that can break or fall. Cover your head with your hands. ✓

If you are outside during an earthquake, lie face down on the ground. Make sure you are far from buildings, power lines, and trees. Cover your head with your hands.

If you are in a car or bus, you should ask the driver to stop. Everyone should stay inside the car or bus until the earthquake is over.

If you are near the shore when an earthquake happens, you should try to get to high ground in case there is a tsunami. If there is no high ground, try to get to the top of a building or tree.

**READING CHECK**

**12. List** Look around your classroom. List two safe places that you can go in case of an earthquake.

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### Say It

**Share Experiences** Have you ever been in an earthquake or heard about an earthquake that happened somewhere else? In a small group, talk about what it was like.



If you are inside during an earthquake, you should crouch under a table or a desk.

### What Should You Do After an Earthquake?

Being in an earthquake can be scary. After an earthquake happens, people are often confused about what happened. They may not know what to do or where to go. If you can stay calm, you can help to keep yourself and others safe.

After an earthquake, look around you. If you are near something dangerous, like a power line or broken glass, get away as quickly as you can. Never go into a building after an earthquake until a parent, teacher, police officer, or firefighter tells you it is safe. ✓

Always remember that there could be aftershocks. Aftershocks are weak earthquakes that sometimes happen after a large earthquake. Even though they are weaker than the main earthquake, they can still be strong and damaging.

**READING CHECK**

**13. Identify** Who should you ask if you want to know whether it is safe to go back into a building after an earthquake?

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# Section 3 Review

## SECTION VOCABULARY

<p><b>seismic gap</b> an area along a fault where relatively few earthquakes have occurred recently but where strong earthquakes have occurred in the past</p>	<p><b>tsunami</b> a large ocean wave caused by an earthquake or other disturbance such as a volcanic eruption or a meteorite impact</p>
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**1. Identify** What is the relationship between earthquakes and tsunamis?

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**2. Graphic Organizer** Fill in the chart below to show what you should do during an earthquake.

If you are...	Then you should...
...inside a building,	
	...lie face down on the ground with your hands on your head, far from power lines or fire hazards.
...in a car or bus,	
...at the beach,	

**3. Identify** How do engineers know how to make a building more likely to survive an earthquake?

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**4. Identify Relationships** What is the relationship between the strength of an earthquake and how often it occurs?

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**5. Infer** In most cases, you should stay inside a car or a bus in an earthquake. When might it be better to leave a car or bus during an earthquake?

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# Why Volcanoes Form



California Science Standards

6.1.d, 6.1.e

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do volcanoes form?
- What causes magma to form?
- Where do most volcanoes form?



### Summarize in Pairs

Read this section quietly to yourself. With a partner, take turns explaining what you learned. Work together to figure out things that you or your partner didn't understand.



**1. List** What three things control whether or not a rock will melt?

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**2. Explain** Why do pressure have to be low in order for magma to form?

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\_\_\_\_\_

## What Is a Volcano?

When you think of a volcano, what comes into your mind? Most people think of a steep mountain with smoke coming out. In fact, a **volcano** is any place where gas, ash, and melted rock come out of the ground. A volcano can be a tall mountain, or it can be a small hole in the ground.

## How Do Volcanoes Form?

At many tectonic plate boundaries, the rock that is just below the surface melts. The melted rock, or **magma**, is less dense than the solid rock, so it rises toward the surface. When the magma gets to Earth's surface, it erupts and forms a volcano. Whether or not a rock melts depends on three things: temperature, pressure, and fluid. ✓

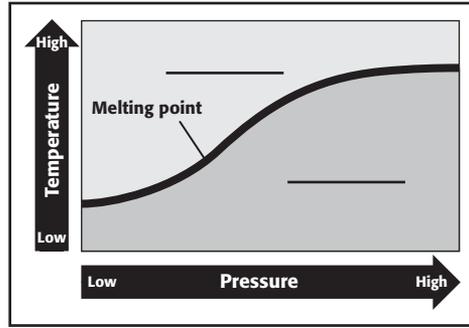
### TEMPERATURE

If a rock gets hot enough, parts of it will melt. On Earth's surface, few places are hot enough for rocks to melt. Deep underground, temperatures can be very high. In many cases, however, heat alone is not enough to make a rock melt. In order for the rock to melt, the pressure on it must drop, or water or other fluids must be added to it.

### PRESSURE

Magma takes up more space than solid rock. This means that rock must be able to expand in order to melt. In many places deep underground, hot rock cannot melt because it is under too much pressure. Near Earth's surface, however, the pressure is low because not much rock is pushing down from above. As solid rock rises to the surface, the decreasing pressure allows the rock to melt. ✓

**SECTION 1** Why Volcanoes Form *continued*

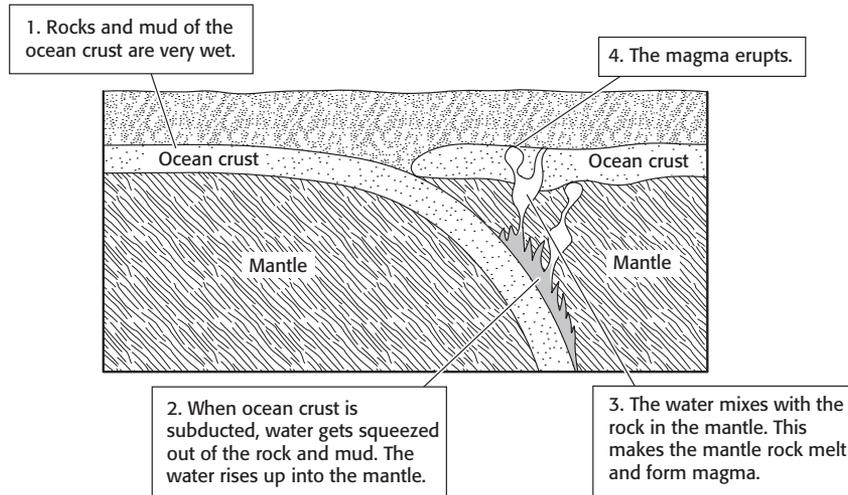


**TAKE A LOOK**

**3. Identify** The graph shows what happens to rock as pressure and temperature change. Fill in the blank spaces on the graph with the following words: melted rock and solid rock.

**FLUIDS**

Rock that has fluids like water in it can melt more easily than dry rock. Therefore, when fluids are added to rocks that are already very hot, the rocks can melt. The illustration below shows how this can happen.

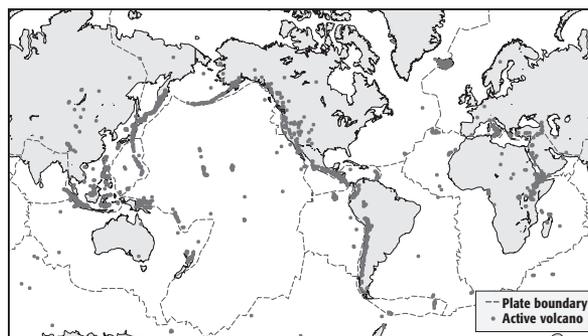


**TAKE A LOOK**

**4. Identify** Draw a volcano in the proper place on the diagram.

**Where Do Volcanoes Form?**

Look at the map below. It shows the locations of many of the volcanoes in the world. Can you see that most volcanoes are found in chains? The chains of volcanoes seem to break up the Earth's crust into pieces. The pieces are *tectonic plates*. Most volcanoes form at tectonic plate boundaries. ✓



**READING CHECK**

**5. Identify** Where do most volcanoes form?

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**SECTION 1** Why Volcanoes Form *continued*

**WHERE PLATES MOVE APART**

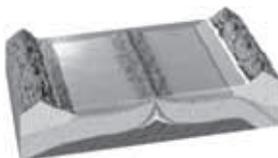
At divergent boundaries, plates move away from each other. The crust stretches and gets thinner, so the pressure decreases on the mantle rocks below. This causes parts of the mantle to melt. Magma flows up through cracks called *fissures* and out onto the land or on the ocean floor. When the magma erupts underwater, it forms a long mountain chain called a mid-ocean ridge. ✓

**READING CHECK**

**6. Explain** What causes the rocks in the mantle at divergent boundaries to melt?

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Volcanoes form at divergent boundaries, where tectonic plates pull apart.

**WHERE PLATES COME TOGETHER**

At convergent boundaries, two plates move toward each other and one plate sinks beneath the other. This process is called *subduction*. As the sinking plate dives deeper into the mantle, fluids get squeezed out of it. The fluids make the rock above melt and form magma. This magma rises to the surface and erupts to form volcanoes.



Volcanoes form at convergent boundaries, where one plate sinks beneath another.

**TAKE A LOOK**

**7. Explain** Draw arrows on the divergent boundary and convergent boundary to show which ways the plates are moving.

**IN THE MIDDLE OF A PLATE**

Most volcanoes form at the edges of tectonic plates, but some form in the middle. These volcanoes form where columns of hot rock called *mantle plumes* rise up through the mantle and crust. When the hot rock gets near the surface, it can melt and then erupt to form a volcano.

Areas on Earth's surface that have volcanoes like these are called *hot spots*. As the plate moves over a mantle plume, a chain of volcanic mountains can form.



Volcanoes form in the middle of a plate where the plate moves over a column of hot rock called a mantle plume.

*Critical Thinking*

**8. Infer** Hawaii is a chain of volcanoes in the middle of the Pacific Ocean. How did the Hawaiian island chain form?

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# Section 1 Review

6.1.d, 6.1.e 

## SECTION VOCABULARY

**magma** liquid rock produced under Earth's surface; igneous rocks can form when magma cools and solidifies

**volcano** a vent or fissure in the Earth's surface through which magma and gases are expelled

**1. Explain** How are volcanoes and magma related?

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**2. List** Name three things that can cause rock to melt and form magma.

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**3. Describe** What causes magma to form at a divergent plate boundary?

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**4. Describe** What causes magma to form at a convergent plate boundary?

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**5. Compare** How are hot spot volcanoes different from volcanoes in other places?

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**6. Apply Concepts** Why do most volcanoes form at plate boundaries?

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**7. Explain** Give one reason that a very hot rock might not melt.

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SECTION 2 **Types of Volcanoes**



California Science Standards

6.1.d, 6.1.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- Why are there different kinds of volcanoes?
- What are the parts of a volcano?
- How do types of lava differ?

**STUDY TIP**

**Color** When you come to an illustration, use crayons or colored pencils to color it in. Use a different color for each part of the drawing. Include a legend.

**Why Are Volcanoes Different from Each Other?**

You have probably noticed that not all volcanoes look the same. Some are tall and steep. Others are low and wide. The type of volcano that forms depends on the type of lava it is made of.

**Lava** is magma that has reached Earth’s surface. Lava at different places on the Earth is made up of different materials. In some places, lava is thin and runny, like water. In other places, lava is thick and stiff. Because there are different types of lava, there are different types of volcanoes.



**CALIFORNIA STANDARDS CHECK**

**6.1.d** Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.

**1. Describe** Use the illustration to describe how magma inside a volcano becomes a lava flow outside.

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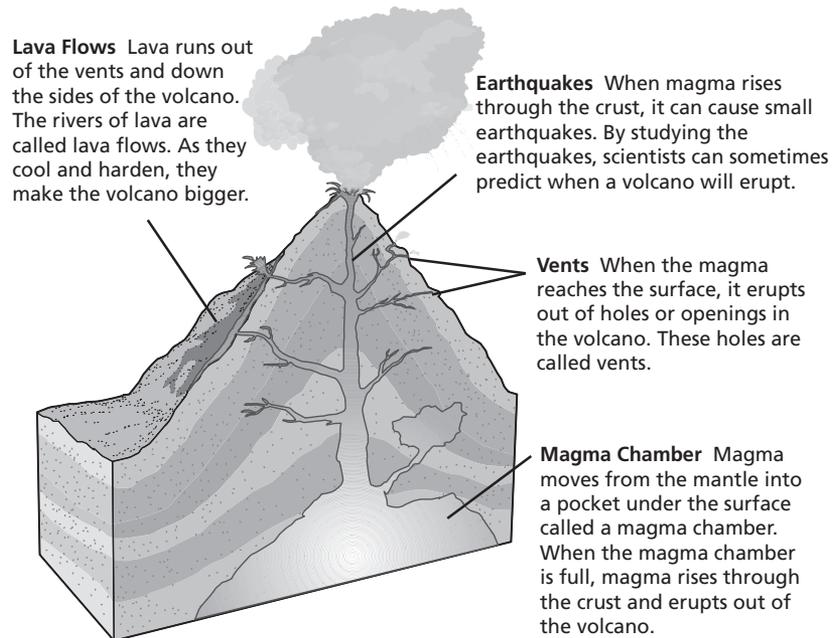
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**What Are the Parts of a Volcano?**

There are some features that most volcanoes have in common: a magma chamber, vents, and lava flows. In addition, most volcanoes experience earthquakes.



**SECTION 2** Types of Volcanoes *continued*

**What Kind of Lava Forms at Hot Spots?**

Most of the magma that erupts at hot spots forms when parts of Earth’s mantle melt. Magma that comes from the mantle is mafic. **Mafic** is a word that describes rock, magma, or lava that has a lot of iron and magnesium but not much silica in it. Most mafic rocks are dark in color. ✓



**Aa** is lava that forms a thick, brittle crust as it cools. The crust is torn into sharp pieces as lava moves underneath it.



**Pahoehoe** is lava that forms a thin, flexible crust as it cools. The crust wrinkles as the lava moves underneath it.



**Blocky lava** is cool, stiff lava that does not travel very far from the volcano. Blocky lava usually oozes from a volcano and forms piles of rocks with sharp edges.



**Pillow lava** is lava that erupts under water. As it cools, it forms rounded lumps that look like pillows. Pillow lava is common at hot spots and divergent boundaries.

✓ **READING CHECK**

**2. Define** What is mafic rock?

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**What Kinds of Volcanoes Form at Hot Spots?**

Because mafic lava is so runny, it can travel a long distance before it hardens. As a result, mafic volcanoes tend to be very wide and not very steep. Mafic volcanoes are rarely explosive. ✓

**SHIELD VOLCANOES**

If mafic lava erupts from the same place for thousands of years, lava flows build up. A wide, tall mountain called a *shield volcano* can form. From the side, a shield volcano looks like a knight’s shield. Most hot-spot volcanoes are shields for two reasons: mafic lava is very runny, and the volcano erupts over and over, for a very long period of time.

✓ **READING CHECK**

**3. Explain** Why are mafic volcanoes so wide?

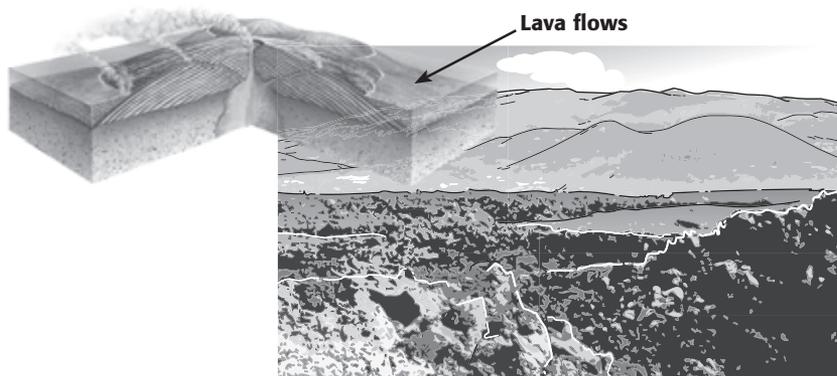
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Mauna Kea is a shield volcano in Hawaii. Its base is on the sea floor, but its top pokes above the ocean. If you measured the height of Mauna Kea from the sea floor all the way to the top of the volcano, it would be taller than Mount Everest!

Shield volcanoes form when many layers of mafic lava build up over time.

**TAKE A LOOK**

**4. Identify** On the illustration, draw and label arrows pointing to the magma chamber and the vents.

**SECTION 2** Types of Volcanoes *continued*

### What Kinds of Volcanoes Form at Divergent Boundaries?

Like the lava at hot spots, most of the lava that erupts at divergent boundaries comes from the mantle. As the tectonic plates move apart, part of the mantle melts. Magma rises up and fills the space between the plates. Some of it erupts on the surface. Like hot-spot lava, the lava at divergent boundaries is mafic. ✓

**READING CHECK**

**5. Compare** How is lava at divergent boundaries similar to lava at hot spots?

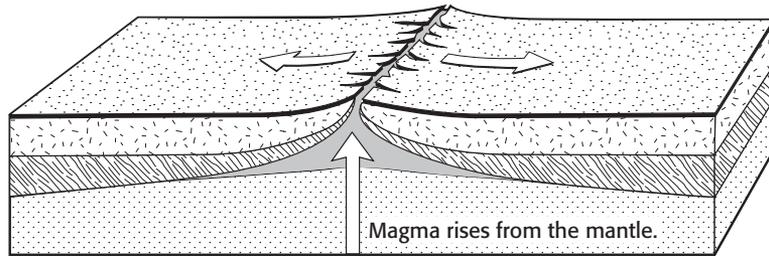
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#### MID-OCEAN RIDGE

Most divergent boundaries are on the ocean floor. When the mafic lava erupts, it forms a long chain of undersea volcanoes known as the *mid-ocean ridge*.

Although mafic lava is thin and runny, it does not travel very far underwater, because it hardens quickly. The reason mid-ocean ridges are wide and low is because the plates are moving apart. As soon as lava erupts and hardens, it begins moving away from the vent.



At mid-ocean ridges, magma moves upward from the mantle. The magma erupts as lava. It then cools and hardens to form new ocean floor. The plates keep moving apart and more lava erupts. This process is called sea-floor spreading.

#### ICELAND

Iceland is part of the mid-ocean ridge that runs down the center of the Atlantic Ocean. But it is also a hot spot. There is a mantle plume beneath the mid-ocean ridge under Iceland. Iceland is not deep underwater like the rest of the mid-ocean ridge because there are so many volcanic eruptions.

### Critical Thinking

**6. Infer** Iceland has an area of 100,000 km<sup>2</sup>. The Big Island of Hawaii is only 10,000 km<sup>2</sup>. Explain why Iceland is so much bigger.

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The Krafla volcano in Iceland has erupted 29 times in the last few thousand years.

**SECTION 2** Types of Volcanoes *continued*

**What Kind of Lava Forms at Convergent Boundaries?**

The lava that erupts at convergent boundaries comes from melted crust as well as melted mantle. Some of the lava is mafic, but some of it is felsic. **Felsic** is a word that describes rocks, magma, and lava that have a lot of silica but not very much iron and magnesium in them. Most felsic rocks are light in color. Felsic magma and lava are thick and sticky. ✓

**What Kinds of Volcanoes Form at Convergent Boundaries?**

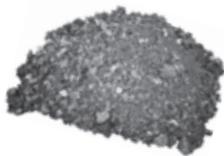
Have you ever shaken a can of soda and then opened it? The foamy soda probably exploded out of the can. Felsic magma does the same thing when it gets near Earth’s surface.

The low pressure near the surface causes the gas and water trapped in the magma to form bubbles. The bubbles cannot get out because the magma is thick and sticky. When the pressure inside the bubbles gets too high, the magma explodes. ✓

When a volcano explodes, a lot of material is given off. Gas, ash, and even large chunks called *pyroclastic rocks* can be blown out of the volcano. Ash and dust can race down the side of a volcano like a river, forming a *pyroclastic flow*. Pyroclastic flows are very dangerous. They can be as hot as 700°C and can move at 200 km/h. A pyroclastic flow can destroy everything in its path.



**Volcanic bombs** are large blobs of lava that harden in the air.



**Lapilli** are small bits of lava that harden before they hit the ground. Lapilli are usually about the size of pebbles.



**Volcanic ash** forms when gases trapped in magma or lava form bubbles. When the bubbles explode, they create millions of tiny pieces.

**Volcanic blocks** are large pieces of solid rock that come out of a volcano.



✓ **READING CHECK**

**7. Compare** Name one way that the lava at convergent boundaries is different from the lava at hot spots.

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\_\_\_\_\_

✓ **READING CHECK**

**8. Explain** Why does felsic magma explode when it gets near the surface?

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**Math Focus**

**9. Multiply** How fast can pyroclastic flows move in miles per hour?  
1 km = 0.62 mi

\_\_\_\_\_

**SECTION 2** Types of Volcanoes *continued*

**TAKE A LOOK**

**10. Apply Concepts** At what kind of tectonic plate boundary do you think the Philippines are located?

\_\_\_\_\_



Pyroclastic flows associated with the 1991 eruption of Mount Pinatubo in the Philippines had temperatures that reached 750°C.

**COMPOSITE VOLCANOES**

Many of the volcanoes that form at convergent boundaries are composite volcanoes. *Composite volcanoes* are made of layers of different materials. Some layers are made of mafic lava flows. Other layers are made of ash, dust, and other pyroclastic materials. Composite volcanoes are also called *stratovolcanoes* because they are made of strata, or layers. ✓

Unlike shield volcanoes, most composite volcanoes have very steep sides. Composite volcanoes can erupt many times, but there may be hundreds of years between eruptions.

**READING CHECK**

**11. Explain** Why are composite volcanoes also called stratovolcanoes?

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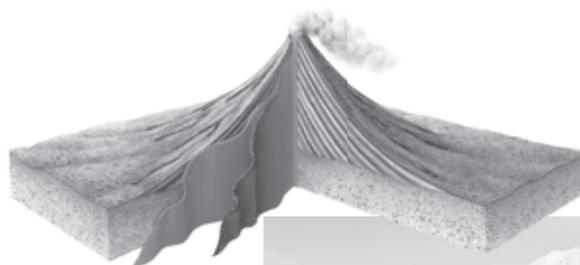
**TAKE A LOOK**

**12. Explain** How can you tell that Mount Fuji is a composite volcano rather than a shield volcano?

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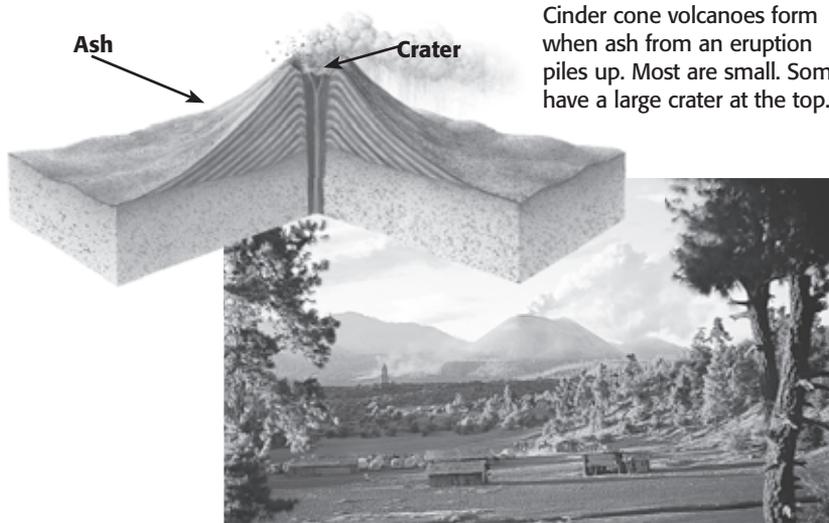
Mount Fuji is a composite volcano in Japan. It has erupted many times.

**SECTION 2** Types of Volcanoes *continued*

**CINDER CONES**

Sometimes lava and ash come out of small vents and spray out into the air. Pieces of lava harden in the air and then rain down onto the ground. These hardened pieces of lava are called *cinders*. The cinders and ash build up around the vent and form a small, steep volcano called a *cinder cone*.

Many cinder cones form at convergent boundaries, but they can form at hot spots also. In fact, some shield volcanoes have cinder cones on their sides. Unlike shield volcanoes and composite volcanoes, most cinder cones erupt only once. ✓



Paracutín is a cinder cone volcano in Mexico. It formed in a farmer's cornfield in 1943. It erupted for nine years. At the end of all that time, it was only 400 m tall.

**READING CHECK**

**13. Explain** Why are cinder cones smaller than shield volcanoes?

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# Section 2 Review

6.1.d, 6.1.e 

## SECTION VOCABULARY

**felsic** describes magma, lava, or igneous rock that is rich in feldspars and silica and that is generally light in color

**lava** magma that flows onto Earth's surface; the rock that forms when lava cools and solidifies

**mafic** describes magma, lava, or igneous rock that is rich in magnesium and iron and that is generally dark in color

**1. Compare** What is the difference between lava and magma?

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**2. Explain** Why are there different types of volcanoes?

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**3. Contrast** Fill in the chart below to show the differences between mafic and felsic lava.

Type of lava	Where it forms	What it is like	How it erupts
mafic	hot spots and divergent boundaries		flows in rivers
felsic		thick and sticky	

**4. Explain** Why are shield volcanoes wider than composite volcanoes and not as steep?

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**5. Describe Relationships** Describe one way that earthquakes and volcanoes are related.

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# Effects of Volcanic Eruptions

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do volcanic eruptions affect humans and wildlife?
- How can a volcanic eruption affect global temperature?
- What are the benefits of volcanic eruptions?



California Science Standards

6.2.d

## What Are Some Harmful Effects of Volcanoes?

A volcanic eruption can hurt or kill humans and other living things. A volcano's blast can destroy buildings and trees. An eruption can also cause large changes in the environment.

Pyroclastic flows can race down the side of a volcano and burn or bury everything in their path. Snow on top of a tall volcano can melt and cause dangerous floods. Volcanic ash can mix with water and create fast-moving mudflows called **lahars**.

Ash from a volcano can make it hard for people and animals to breathe. It can also damage or ruin crops by covering their leaves. Ash and gas from a volcano can mix into the air and travel all around the world. The ash in the air can block sunlight and make the world cooler for several years.



**List** As you read, make a list of the effects of volcanic eruptions. Using a colored pencil, underline harmful effects in red and helpful effects in green.

## TAKE A LOOK

**1. Identify** What is a likely harmful effect of the volcanic eruption shown in the picture?

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**SECTION 3** Effects of Volcanic Eruptions *continued*

**What Are Some Helpful Effects of Volcanoes?**

Although volcanoes can cause damage, they can also be very useful. For example, volcanic rocks, like other rocks, break down to form soil. The soil that forms from volcanic rocks contains nutrients that many plants need in order to grow. Many farmers rely on volcanic soil to grow enough food. ✓

**READING CHECK**

**2. Explain** Why is volcanic soil good for growing plants?

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**Critical Thinking**

**3. Apply Concepts** Explain why a divergent boundary, such as the one in Iceland, would be a good source of geothermal energy.

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**RENEWABLE ENERGY**

Volcanoes can also give people a clean, renewable energy source. When magma rises toward the surface, it heats up the rocks around it. Water underground heats up when it flows through cracks in the hot rock.

People can pump the hot water out of the rocks and use it to make electricity or to heat buildings. This kind of energy is called *geothermal energy*.

There is a very large geothermal energy power plant in Santa Rosa, California, called the Geysers. The Geysers is the largest geothermal energy plant in the world! San Francisco gets some of its electricity from the Geysers.

**USES FOR VOLCANIC MATERIALS**

Rocks from volcanoes can be used to build large buildings. The early Romans used volcanic ash from Mount Vesuvius to make cement. Some of the buildings they made are still standing today!

Volcanic materials can be used for many other things. Volcanic ash is used in cat litter, soaps, cleaners, and polishes. Pumice, a volcanic rock, can be added to soil to help air and water move through it more easily. Pumice is even used to filter drinking water.

**Say It**

**Break Down Words** In a group, break down the word *geothermal* into two parts. Discuss what you think the two parts mean. If you are having trouble, look them up in a dictionary.

# Section 3 Review

## SECTION VOCABULARY

<p><b>lahar</b> a mudflow that forms when volcanic ash and debris mix with water during a volcanic eruption</p>	
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**1. Describe** How can a lahar affect wildlife?

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**2. Compare** Fill in the chart below with examples of helpful and harmful effects of volcanic eruptions.

Type of effect	Examples
Helpful	
Harmful	

**3. Explain** How can a volcanic eruption in one part of the world cause the temperature to change in another part of the world?

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**4. Describe** How did the early Romans use volcanic ash?

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**5. Explain** What can geothermal energy be used for?

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SECTION 1 **Weathering**



**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is weathering?
- What causes mechanical weathering?
- What causes chemical weathering?

**STUDY TIP**

**Compare** Make a chart showing the ways that mechanical weathering and chemical weathering can happen.

**READING CHECK**

**1. Define** What is mechanical weathering?

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\_\_\_\_\_

**What Is Weathering?**

Have you ever wondered how large rocks turn into smaller rocks? **Weathering** is the process in which rocks break down. There are two main kinds of weathering: mechanical weathering and chemical weathering.

**What Is Mechanical Weathering?**

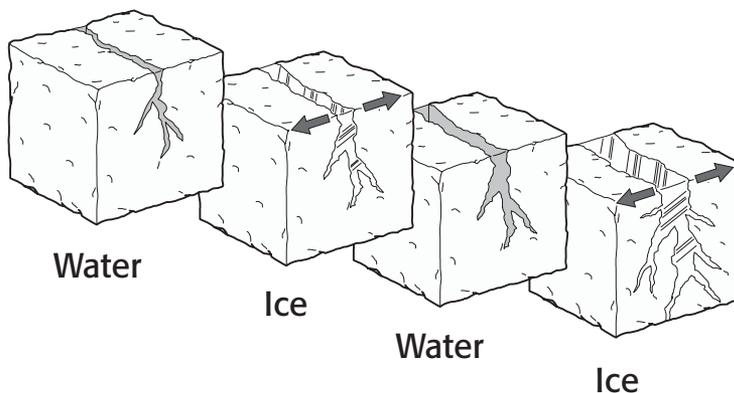
**Mechanical weathering** happens when rocks are broken into pieces by physical means. There are many ways that mechanical weathering can happen. ✓

**ICE WEDGING**

Ice wedging is one kind of mechanical weathering. *Ice wedging* breaks rock into pieces during cycles of freezing and thawing.

The cycle of ice wedging starts when water seeps into cracks in a rock. As the water freezes, it expands. The ice pushes against the sides of the cracks. This causes the cracks to widen. When the ice melts, the water seeps further into the cracks. As the cycle repeats, the cracks get bigger. Finally, the rock breaks apart.

**Ice Wedging**



**Critical Thinking**

**2. Infer** Would ice wedging happen if water did not expand as it froze? Explain your answer.

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**SECTION 1** Weathering *continued*

**ABRASION**

As you scrape a large block of chalk against a board, tiny pieces of the chalk rub off on the board. The large piece of chalk wears down and becomes smaller. The same process happens with rocks. **Abrasion** is a kind of mechanical weathering that happens when rocks are worn away by contact with other rocks. Abrasion happens whenever one rock hits another. Water, wind, and gravity can cause abrasion.



Water can cause abrasion by moving rocks and causing them to hit each other. The rocks in this river are rounded because of abrasion.

Wind can cause abrasion when it blows sand against rocks. This rock has been shaped by blowing sand.

Gravity can cause abrasion by making rocks grind against each other as they slide downhill. As the rocks grind against each other, they are broken into smaller pieces.

**EXFOLIATION**

Abrasion or other kinds of weathering can remove layers of rock from a large body of rock. When the layers of rock are removed, they no longer press down on the rest of the rock. Therefore, there is less pressure on the rest of the rock. The lower pressure on the rest of the rock allows it to expand.

When the rock expands, sheets of rock can peel away from the surface of the rock. **Exfoliation** is a kind of mechanical weathering that happens when sheets of rock peel away from a larger rock because pressure is removed.

**PLANT GROWTH**

Have you ever seen sidewalks and streets that are cracked because of tree roots? As plants grow, their roots get larger. The roots can make cracks in rock wider. In time, an entire rock can split apart. Roots don't grow fast, but they are very powerful!

	<p><b>CALIFORNIA STANDARDS CHECK</b></p>
<p><b>6.2.a</b> Students know water running downhill is the <u>dominant process</u> in shaping the landscape, including California's landscape.</p>	
<p><b>Word Help: dominant</b> having the greatest effect</p>	
<p><b>Word Help: process</b> a set of steps, events, or changes</p>	
<p><b>3. Explain</b> How does running water cause abrasion?</p>	
<p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>	

 **Say It**

**Explore Meanings** In a small group, look up the word *exfoliate* in the dictionary. Talk about where the word comes from and the different ways it can be used.

**SECTION 1** Weathering *continued*

**ANIMALS**

Did you know that earthworms cause a lot of weathering? They tunnel through the soil and move pieces of rock around. This motion breaks some of the rocks into smaller pieces. It also exposes more rock surfaces to weathering. ✓

Any animal that burrows in the soil causes mechanical weathering. Ants, worms, mice, coyotes, and rabbits are just a few of the animals that can cause weathering. The mixing and digging that animals do can also cause chemical weathering, another kind of weathering.

✓ **READING CHECK**

**4. Describe** How can earthworms cause weathering?

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\_\_\_\_\_  
\_\_\_\_\_

**What Is Chemical Weathering?**

Rocks can be broken down by chemical means. **Chemical weathering** happens when rocks break down because of chemical reactions.

Water, acids, and air can all cause chemical weathering. They react with the chemicals in the rock. The reactions can break the bonds in the minerals that make up the rock. When the bonds in the minerals are broken, the rock can be worn away. ✓

✓ **READING CHECK**

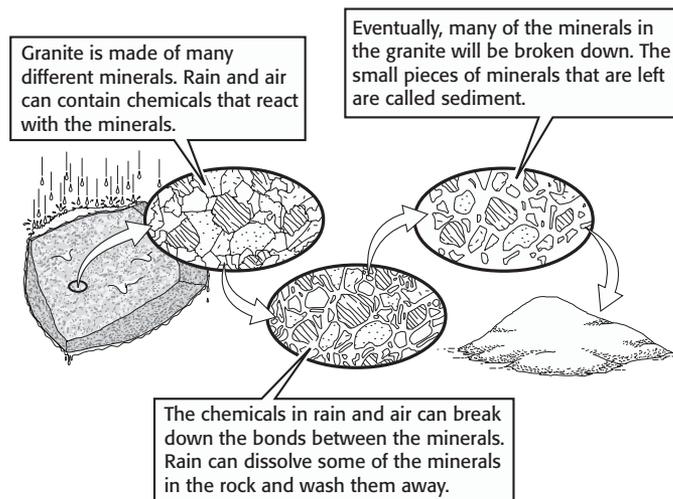
**5. List** What are three things that can cause chemical weathering?

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\_\_\_\_\_  
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**WATER**

If you drop a sugar cube into a glass of water, the sugar cube will dissolve after a few minutes. In a similar way, water can dissolve some of the chemicals that make up rocks. Even very hard rocks, such as granite, can be broken down by water. However, this process may take thousands of years or more.

**Chemical Weathering in Granite**



**TAKE A LOOK**

**6. Infer** What do you think is the reason it takes a very long time for granite to break down?

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\_\_\_\_\_  
\_\_\_\_\_

**SECTION 1** Weathering *continued*

**ACID PRECIPITATION**

Precipitation, such as rain and snow, always contains a little bit of acid. However, sometimes precipitation contains more acid than normal. Rain, sleet, or snow that contains more acid than normal is called **acid precipitation**.

Acid precipitation forms when small amounts of certain gases mix with water in the atmosphere. The gases come from natural sources, such as volcanoes. They are also produced when people burn fossil fuels, such as coal and oil. ✓

The acids in the atmosphere fall back to the ground in rain and snow. Acids can dissolve materials faster than plain water can. Therefore, acid precipitation can cause very rapid weathering of rock.

**READING CHECK**

**7. Identify** What are two sources of the gases that produce acid precipitation?

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**ACIDS IN GROUNDWATER**

In some places, water flows through rock underground. This water, called *groundwater*, may contain weak acids. When the groundwater touches rock, a chemical reaction takes place. The chemical reaction dissolves the rock. Over a long period of time, huge caves can form where rock has been dissolved.



This cave was formed when acids in groundwater dissolved the rock.

**TAKE A LOOK**

**8. Explain** Caves like the one in the picture are not found everywhere. What do you think controls where a cave forms?

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**SECTION 1** Weathering *continued*

**ACIDS FROM LIVING THINGS**

All living things make weak acids in their bodies. When the living things touch rock, some of the acids are transferred to the surface of the rock.

The acids react with chemicals in the rock and weaken it. The different kinds of mechanical weathering can more easily remove rock in these weakened areas. ✓

The rock may also crack in the weakened areas. Even the smallest crack can expose more of the rock to both mechanical weathering and chemical weathering.

 **READING CHECK**

**9. Explain** How can acids from living things cause mechanical weathering?

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**AIR**

Have you ever seen a rusted car or building? Metal reacted with something to produce rust. What did the metal react with? In most cases, the answer is air.

The oxygen in the air can react with many metals. These reactions are examples of a kind of chemical weathering called *oxidation*. This common form of chemical weathering is what causes rust. Rocks can rust if they have a lot of iron in them.

Many people think that rust forms only when metal gets wet. In fact, oxidation can happen even without any water around. However, when water is present, oxidation happens much more quickly.

Oxidation can cause rocks to weaken. Oxidation changes the metals in rocks into different chemicals. These chemicals are more easily broken down than the metals were.

**TAKE A LOOK**

**10. Describe** Fill in the blank spaces in the table to describe how different factors cause chemical weathering.

<b>Factor</b>	<b>How does it cause chemical weathering?</b>
Water	
Acid precipitation	
Acids in groundwater	
Acids from living things	
Air	

# Section 1 Review

## SECTION VOCABULARY

<p><b>abrasion</b> the grinding and wearing away of rock surfaces through the mechanical action of other rock or sand particles</p> <p><b>acid precipitation</b> rain, sleet, or snow that contains a high concentration of acids</p> <p><b>chemical weathering</b> the process by which rocks break down as a result of chemical reactions</p>	<p><b>exfoliation</b> the process by which sheets of rock peel away from a large body of rock because pressure is removed</p> <p><b>mechanical weathering</b> the process by which rocks break down into smaller pieces by physical means</p> <p><b>weathering</b> the natural process by which atmospheric and environmental agents, such as wind, rain, and temperature changes, disintegrate and decompose rocks</p>
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1. **List** What are three things that can cause abrasion?

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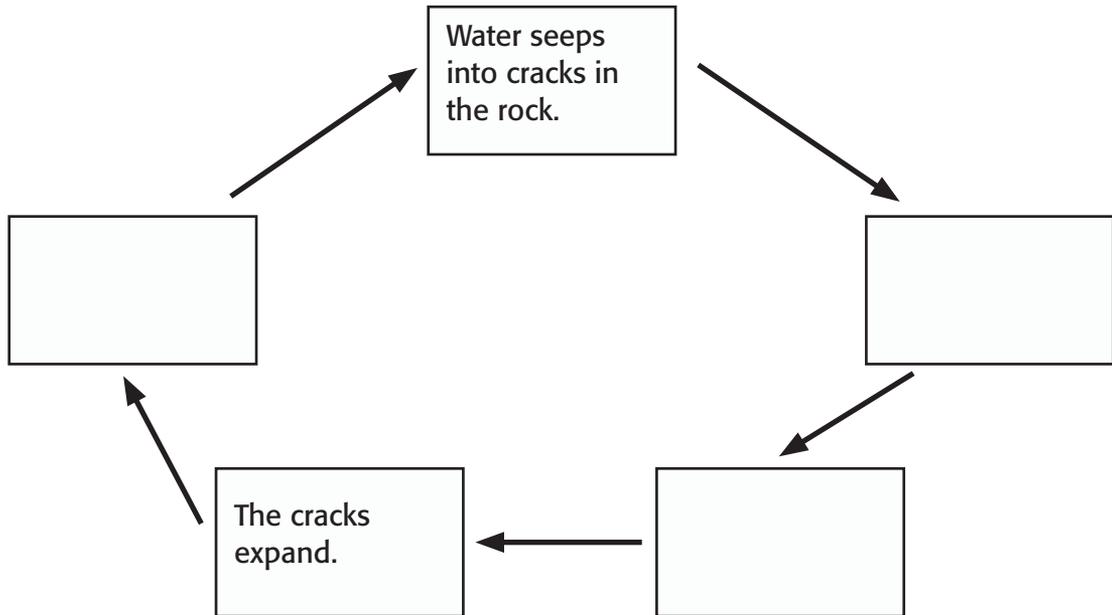


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2. **Explain** Fill in the spaces to show the steps in the cycle of ice wedging.



3. **Identify** How can acids cause chemical weathering?

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CHAPTER 9 Weathering and Soil Formation

SECTION 2 Rates of Weathering



California Science Standards

6.2.c

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is differential weathering?
- What factors affect how fast rock weathers?

**STUDY TIP**

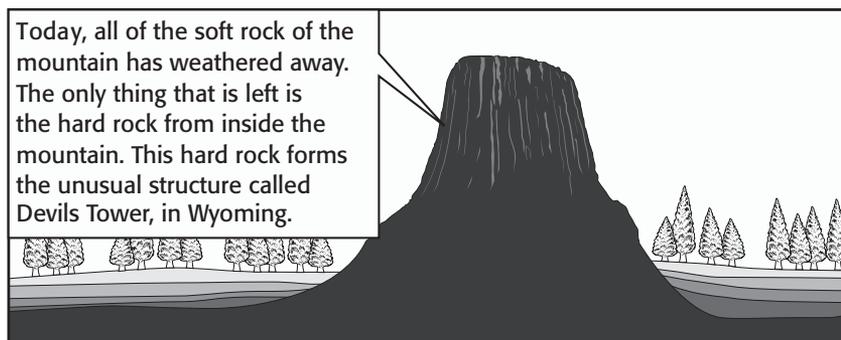
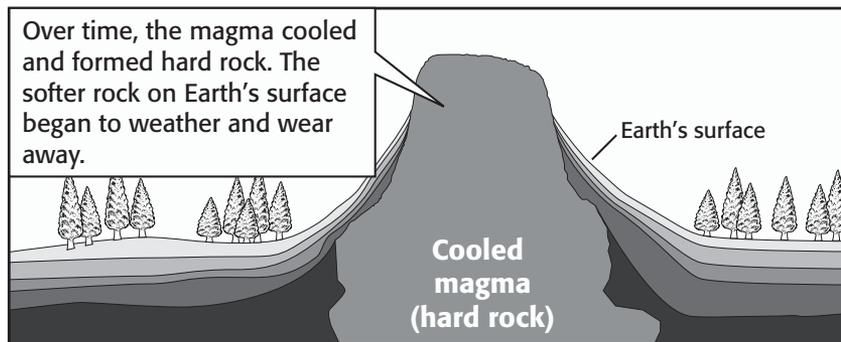
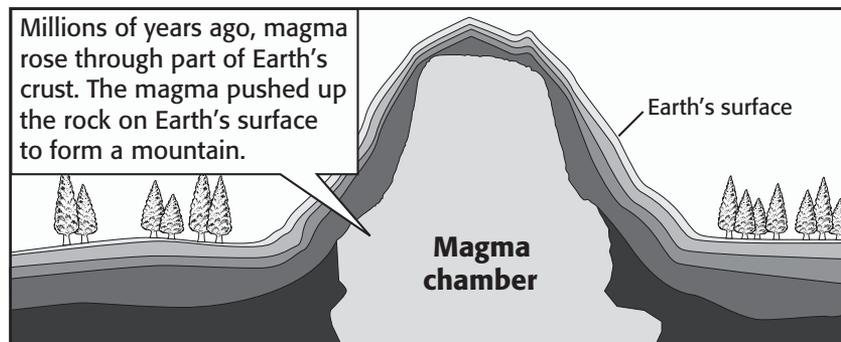
**Apply Concepts** After you read this section, think about how the different factors that control weathering can affect objects that you see every day.

**Say It**

**Discuss** In a small group, share your ideas about how some different landscape features formed because of differential weathering.

**What Is Differential Weathering?**

Hard rocks, such as granite, weather more slowly than softer rocks, such as limestone. **Differential weathering** happens when softer rock weathers away and leaves harder, more resistant rock behind. The figures below show an example of how differential weathering can shape the landscape.



**TAKE A LOOK**

**1. Infer** Imagine that the rock on the outside of the mountain was much harder than the cooled magma. How might Devils Tower look today?

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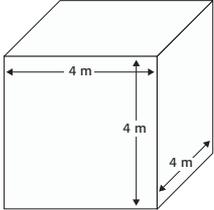
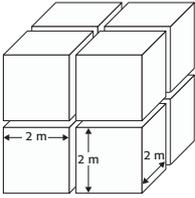
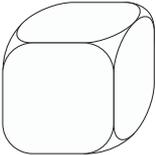
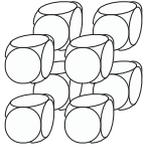
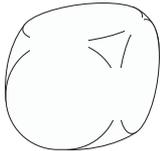
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**SECTION 2** Rates of Weathering *continued*

## How Does a Rock's Surface Area Affect Weathering?

Most chemical weathering takes place only on the outer surface of a rock. Therefore, rocks with a lot of surface area weather faster than rocks with a little surface area. However, if a rock has a large surface area as well as a large volume, it takes longer for the rock to wear down. The figure below shows how the surface area and volume of a rock affect how fast it wears down.

<p>Imagine a rock in the shape of a cube. Each side of the rock is 4 m long. The volume of the cube is <math>4\text{ m} \times 4\text{ m} \times 4\text{ m} = 64\text{ m}^3</math>. Each face of the rock has an area of <math>4\text{ m} \times 4\text{ m} = 16\text{ m}^2</math>. Because there are eight faces on the rock, it has a surface area of <math>8 \times 16\text{ m}^2 = \underline{\hspace{2cm}}\text{ m}^2</math>.</p>  <p>Cube with 4 m sides: volume = <math>64\text{ m}^3</math>, surface area = <math>\underline{\hspace{2cm}}\text{ m}^2</math></p>	<p>Now imagine eight smaller rocks that are shaped like cubes. Each small rock's side is 2 m long. The volume of each small rock is <math>2\text{ m} \times 2\text{ m} \times 2\text{ m} = 8\text{ m}^3</math>. The total volume of all 8 rocks is <math>8 \times 8\text{ m}^3 = 64\text{ m}^3</math>, the same as the large rock. Each face of each small rock has an area of <math>2\text{ m} \times 2\text{ m} = 4\text{ m}^2</math>. Each small rock has eight faces, and there are eight rocks total. Therefore, the total surface area of all eight small rocks is <math>8 \times 8 \times 4\text{ m}^2 = \underline{\hspace{2cm}}\text{ m}^2</math>. This is twice as big as the surface area of the large rock.</p>  <p>Eight cubes with 2 m sides: volume = <math>64\text{ m}^3</math>, surface area = <math>\underline{\hspace{2cm}}\text{ m}^2</math></p>
<p>Over time, the rock weathers. Its volume and surface area get smaller.</p> 	<p>In the same amount of time, the smaller rocks weather more and become much smaller. They lose a larger fraction of their volume than the larger rock.</p> 
<p>More time passes. The large rock is weathered even more. It is now much smaller than it was before it was weathered.</p> 	<p>In the same amount of time, the small rocks have completely worn away. They took much less time to wear away than the large rock. Even though their volume was the same, they had more surface area than the large rock. The large surface area allowed them to wear away more quickly.</p>

### Critical Thinking

**2. Explain** Why does most chemical weathering happen only on the outer surface of a rock?

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### Math Focus

**3. Calculate** Determine the surface areas of the large cube and the eight smaller cubes. Write these values in the blank lines on the figure.

### TAKE A LOOK

**4. Apply Concepts** Why do the edges and corners of the cubes weather faster than the faces?

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**SECTION 2** Rates of Weathering *continued*

## How Does Climate Affect Weathering?

The rate of weathering in an area is affected by the climate of that area. *Climate* is the average weather conditions of an area over a long period of time. Some features of climate that affect weathering are temperature, moisture, elevation, slope, and living things.

### TEMPERATURE

Temperature is a major factor in both chemical and mechanical weathering. Cycles of freezing and thawing increase the chance that ice wedging will take place. Areas in the world that have many freezes and thaws have faster mechanical weathering than other regions do. In addition, many chemical reactions happen faster at higher temperatures. These reactions can break down rock quickly in warm areas. ✓

 **READING CHECK**

**5. Identify** What is one way that temperature affects mechanical weathering?

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### MOISTURE

Water can interact with rock as precipitation, as running water, or as water vapor in the air. Water can speed up many chemical reactions. For example, oxidation can happen faster when water is present.

Water is also important in many kinds of mechanical weathering. For example, ice wedging cannot happen without water. Abrasion is also faster when water is present.

### ELEVATION, SLOPE, AND LIVING THINGS

Factor	How the factor affects weathering
Elevation	Rocks at high elevations are exposed to low temperatures and high winds. They can weather very quickly. Rocks at sea level can be weathered by ocean waves.
Slope	The steep sides of mountains and hills make water flow down them faster. Fast-moving water has more energy to break down rock than slow-moving water. Therefore, rocks on steep slopes can weather faster than rocks on level ground.
Living things	Organisms in the soil can produce acid, which causes chemical weathering. Plant roots and burrowing animals can move soil and rocks. Weathering may happen faster in places with many living things.

## TAKE A LOOK

**6. Explain** Why do rocks on the sides of mountains weather faster than rocks on level ground?

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# Section 2 Review

## SECTION VOCABULARY

<p><b>differential weathering</b> the process by which softer, less weather resistant rocks wear away at a faster rate than harder, more weather resistant rocks do</p>	
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**1. Identify** What are five factors that affect how fast weathering happens?

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**2. Explain** Why does it take less time for small rocks to wear away than it does for large rocks to wear away?

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**3. Describe** Imagine a rock on a beach and a rock on the side of a mountain. How would the factors that control weathering be different for these two rocks?

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**4. Apply Concepts** Two rivers run into the ocean. One river is very long. The other is very short. Which river probably drops the smallest rock pieces near the ocean? Explain your answer.

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SECTION 3 **From Bedrock to Soil**



California Science Standards

6.5.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is soil?
- How do the features of soil affect the plants that grow in it?
- What is the effect of climate on soil?

**STUDY TIP**

**Summarize in Pairs** Read this section quietly to yourself. Then, talk about the material with a partner. Together, try to figure out the parts that you didn't understand.

**READING CHECK**

**1. Explain** Why are different soils made of different chemicals?

\_\_\_\_\_

\_\_\_\_\_

**Where Does Soil Come From?**

What do you think of when you think of soil? Most people think of dirt. However, soil is more than just dirt. **Soil** is a loose mixture of small mineral pieces, organic material, water, and air. All of these things help to make soil a good place for plants to grow.

Soils are made from weathered rocks. The rock that breaks down and forms a soil is called the soil's **parent rock**. Different parent rocks are made of different chemicals. Therefore, the soils that form from these rocks are also made of different chemicals. ✓

**Bedrock** is the layer of rock beneath soil. In some cases, the bedrock is the same as the parent rock. In these cases, the soil remains in place above its parent rock. Soil that remains above its parent rock is called *residual soil*.

The material in soil is easily moved. Therefore, not very many soils are residual soils. Soil can be carried away from its parent rock by wind, water, ice, or gravity. Soil that has been moved away from its parent rock is called *transported soil*.

The soil is weathered from bedrock.	The soil is carried in from another place.
The bedrock is the same as the parent rock.	The bedrock is not the same as the parent rock.

\_\_\_\_\_

\_\_\_\_\_

**TAKE A LOOK**

**2. Identify** Fill in the blanks with the terms *residual soil* and *transported soil*.

**SECTION 3** From Bedrock to Soil *continued*

## What Are the Properties of Soil?

Some soils are great for growing plants. However, plants cannot grow in some other soils. Why is this? To better understand how plants can grow in soil, you must know about the properties of soil. These properties include soil composition, soil texture, and soil fertility. ✓

### SOIL COMPOSITION

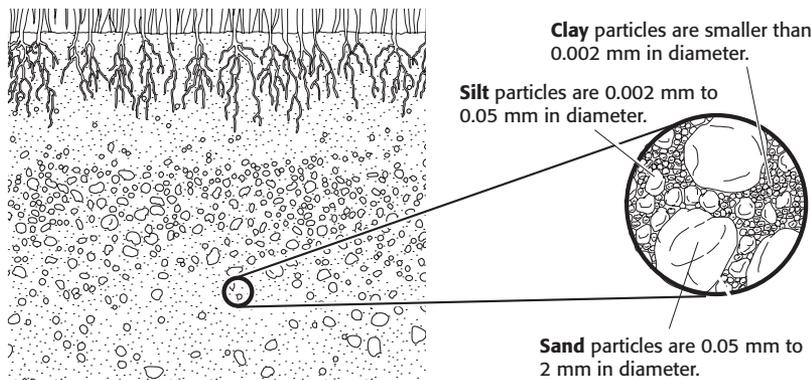
Soil is made up of mineral fragments, organic material, water, and air. Different soils have different amounts of these materials. For example, some soils contain more water or air than other soils do. *Soil composition* describes the kinds and amounts of different materials in the soil.

The composition of a soil can affect the kinds of plants that grow in it. For example, dark-colored soil is often rich in organic material. More kinds of plants can grow in dark-colored soil than in soil that has less organic matter.

### SOIL TEXTURE

Soil is made of particles of different sizes. Some particles, such as sand, are fairly large. Other particles are so small that they cannot be seen without a microscope. *Soil texture* describes the amounts of soil particles of different sizes that a soil contains.

Soil texture affects the consistency of soil and how easily water can move into the soil. *Consistency* describes how easily a soil can be broken up for farming. For example, soil that contains a lot of clay can be hard, which makes breaking up the soil difficult. Most plants grow best in soils that can be broken up easily.



Soil contains particles of many different sizes. However, all of the particles are smaller than 2 mm in diameter.

✓ **READING CHECK**

**3. Identify** What are three properties of soil?

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	<b>CALIFORNIA STANDARDS CHECK</b>
<p><b>6.5.e</b> Students know the number and type of organisms an ecosystem can support depends on the <u>resources</u> available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.</p>	
<p><b>Word Help:</b> <u>resource</u> anything that can be used to take care of a need</p>	
<p><b>4. Explain</b> How can soil composition affect the plants that can grow in soil?</p>	
<hr/> <hr/> <hr/> <hr/>	

## Math Focus

**5. Calculate** How many times larger is the biggest silt particle than the biggest clay particle?

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**SECTION 3** From Bedrock to Soil *continued*

**SOIL FERTILITY**

Plants need to get nutrients from soil in order to grow. Some soils are rich in nutrients. Other soils may have few nutrients or may be unable to give the nutrients to plants. The ability of soil to hold nutrients and to supply nutrients to plants is called *soil fertility*.

Many of the nutrients in a soil come from its parent rock. Other nutrients come from **humus**. Humus is the organic material that forms in soil from the remains of plants and animals. These remains are broken down into nutrients by decomposers, such as bacteria and fungi. It is humus that gives dark-colored soils their color. ✓

**READING CHECK**

6. **Define** What is humus?

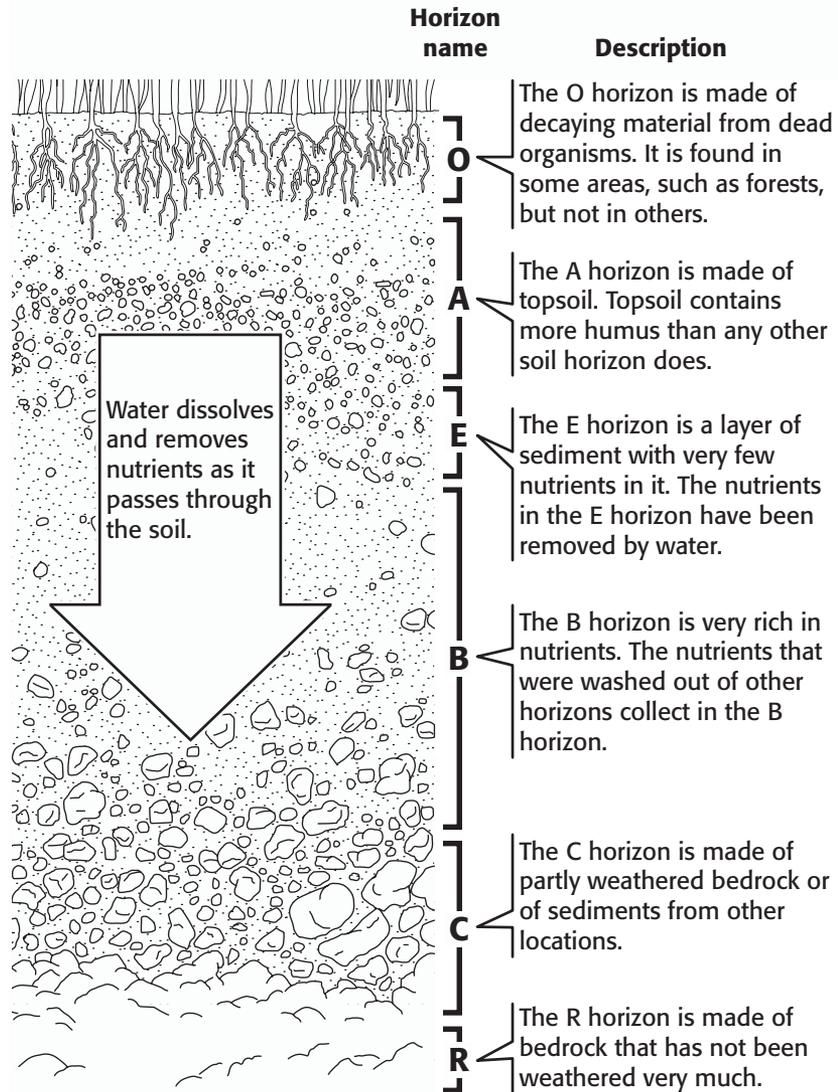
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**What Are the Different Layers in Soil?**

Most soil forms in layers. The layers are horizontal, so soil scientists call them *horizons*.



**TAKE A LOOK**

7. **Infer** Name a kind of environment where an O horizon would probably not be found.

\_\_\_\_\_

8. **Identify** Which three soil horizons probably have the most nutrients?

\_\_\_\_\_

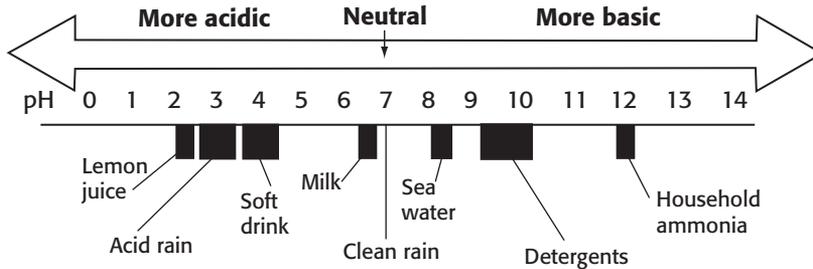
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**SECTION 3** From Bedrock to Soil *continued*

**Why Is the pH of a Soil Important?**

The *pH scale* is used to measure how acidic or basic something is. The scale ranges from 0 to 14. A pH of 7 is a *neutral* pH. Soil that has a pH below 7 is *acidic*. Soil that has a pH above 7 is *basic*.



The pH of a soil affects how nutrients dissolve in the soil. Many plants are unable to get certain nutrients from soils that are very acidic or basic. The pH of a soil therefore has a strong effect on soil fertility. Most plants grow best in soil with a pH of 5.5 to 7.0. A few plants grow best in soils with higher or lower pH.

Soil pH is determined partly by the soil’s parent rock. Soil pH is also affected by the acidity of rainwater, the use of fertilizers, and the amount of chemical weathering. ✓

**How Does Climate Affect Soil?**

Soil types vary from place to place. The kinds of soils that develop in an area depend on its climate. The different features of these soils affect the number and kinds of organisms that can survive in different areas.

**TROPICAL CLIMATES**

Tropical rain forests receive a lot of direct sunlight and rain. Because of these factors, plants grow year-round. The heat and moisture also cause dead organisms to decay easily. This decay produces a lot of rich humus in the soil.

Even though a lot of humus can be produced in tropical rain forests, their soils are often poor in nutrients. One reason for this is that tropical rain forests have heavy rains. The heavy rains in this climate zone can remove, or *leach*, nutrients from the topsoil. The rainwater carries the nutrients deep into the soil, where the plants can’t reach them. In addition, the many plants that grow in tropical climates can use up the nutrients in the soil. ✓

**TAKE A LOOK**

**9. Identify** Which is more acidic, lemon juice or a soft drink?

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**READING CHECK**

**10. List** What are three things that affect soil pH?

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**READING CHECK**

**11. Explain** Why are many tropical soils poor in nutrients?

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**SECTION 3** From Bedrock to Soil *continued*

**DESERTS AND ARCTIC CLIMATES**

Deserts and arctic climates receive little rainfall. Therefore, the nutrients in the soil are not leached by rainwater. However, the small amount of rain in these climates makes weathering happen more slowly. As a result, soil forms slowly.

Few plants and animals live in deserts and arctic climates. Therefore, most soils there contain very little humus.

Sometimes, desert soils can become harmful, even to desert plants. Groundwater can seep into the desert soil. The groundwater often contains salt. When the water evaporates, the salt is left in the soil. The salt can build up in the soil and harm plants.

*Critical Thinking*

**12. Apply Concepts** As in deserts, groundwater in arctic climates can contain salt. Salt does not build up in arctic soils as quickly as in desert soils. What do you think is the reason for this?

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**TEMPERATE FORESTS AND GRASSLANDS**

Most of the continental United States has a temperate climate. Because the temperature changes often, mechanical weathering happens quickly in temperate climates. Thick layers of soil can build up.

Temperate areas get a medium amount of rain. The rain is enough to weather rock quickly, but it is not enough to remove nutrients from the soil.

Temperate soils are very productive. Many different kinds of plants can grow in them. Therefore, they contain a lot of humus. The large amount of humus makes the soils very rich in nutrients. The most fertile soils in the world are found in temperate climates. For example, the Midwestern part of the United States is often called the “breadbasket” because of the many crops that grow there.

Type of climate	Description of climate	Features of the soil in this climate
Tropical climates	warm temperatures a lot of rain many living things	
Deserts and arctic climates	very little rain few living things	
Temperate forests and grasslands	medium amount of rain temperature changes often	

**TAKE A LOOK**

**13. Describe** Fill in the chart to show the features of soils in different climates.

# Section 3 Review

## SECTION VOCABULARY

<p><b>bedrock</b> the layer of rock beneath soil</p> <p><b>humus</b> dark, organic material formed in soil from the decayed remains of plants and animals</p>	<p><b>parent rock</b> a rock formation that is the source of soil</p> <p><b>soil</b> a loose mixture of rock fragments, organic material, water, and air that can support the growth of vegetation</p>
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**1. Summarize** What are three properties of soil?

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**2. Compare** What climate feature do arctic climates and desert climates share that makes their soils similar?

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**3. Analyze** How can flowing water affect the fertility of soils?

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**4. Identify** How does soil pH affect plant growth?

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**5. Explain** What determines a soil's texture?

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**6. Apply** If the soil in your yard is mostly clay, how can you change its properties to make it better for growing plants?

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SECTION 4 **Soil Conservation**



California Science Standards

6.2.a, 6.5.e, 6.6.b

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- Why is soil important?
- How can farmers conserve soil?

**STUDY TIP**

**Compare** Create a chart that shows the similarities and differences between the ways that farmers can help conserve soil.

**READING CHECK**

**1. Explain** Why is soil important for animals?

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**TAKE A LOOK**

**2. Identify** In the table, fill in the reasons that nutrients, habitat, and water storage are important.

**Why Is Soil Important?**

You have probably heard about endangered plants and animals. Did you know that soil can be endangered, too? Soil can take many years to form. It is not easy to replace. Therefore, soil is considered a nonrenewable resource.

Soil is important for many reasons. Soil provides nutrients for plants. If the soil loses its nutrients, plants will not be able to grow. Soil also helps to support plant roots so the plants can grow well.

Animals get their energy from plants. The animals get energy either by eating plants or by eating animals that have eaten plants. If plants are unhealthy because the soil has few nutrients, then animals will be unhealthy, too.

Soil also provides a home, or *habitat*, for many living things. Bacteria, insects, mushrooms, and many other organisms live in soil. If the soil disappears, so does the habitat for these living things. ✓

Soil is very important for storing water. Soil holds water that plants can use. Soil also helps to prevent floods. When rain falls, the soil can soak it up. The water is less likely to run over the land and cause floods.

What does soil provide?	Why is it important?
Nutrients	
Habitat	
Water storage	

If we do not take care of soils, we could lose them. In order to keep our soils from being lost, we need to conserve them. Soil conservation means protecting soils from erosion and nutrient loss. **Soil conservation** can help to keep soils fertile and healthy.

**SECTION 4** Soil Conservation *continued*

**How Can Soil Be Lost?**

Soil loss is a major problem around the world. One cause of soil loss is soil damage. Soil can be damaged if it is overused. Overused soil can lose its nutrients and become infertile. Plants can't grow in infertile soil.

Plants help to hold water in the soil. If plants can't grow somewhere because the soil is infertile, the area can become a desert. This process is known as *desertification*.

**EROSION**

Another cause of soil loss is erosion. **Erosion** happens when wind, water, or gravity transports soil and sediment from one place to another. If soil is not protected, it can be exposed to erosion.

Plant roots help to keep soil in place. They prevent water and wind from carrying the soil away. If there are no plants, soil can be lost through erosion.

**How Can Farmers Help to Conserve Soil?**

Farming can cause soil damage. However, farmers can prevent soil damage if they use certain methods when they plow, plant, and harvest their fields.

**CONTOUR PLOWING**

Water that runs straight down a hill can carry away a lot of soil. Farmers can plow their fields in special ways to help slow the water down. When the water moves more slowly down a hill, it carries away less soil. *Contour plowing* means plowing a field in rows that run across the slope of a hill.



Contour plowing helps water to run more slowly down hills. This reduces erosion because \_\_\_\_\_

	<b>CALIFORNIA STANDARDS CHECK</b>
<p><b>6.2.a</b> Students know water running downhill is the <u>dominant process</u> in shaping the landscape, including California's landscape.</p>	
<p><b>Word Help: dominant</b> having the greatest effect</p>	
<p><b>Word Help: process</b> a set of steps, events, or changes</p>	
<p><b>3. Describe</b> How do plant roots prevent erosion?</p>	
<p>_____</p>	

**TAKE A LOOK**

**4. Identify** Fill in the blank line in the figure to explain how contour plowing reduces erosion.

**SECTION 4** Soil Conservation *continued*

**Critical Thinking**

**5. Infer** What do you think is the reason farmers use terraces only on very steep hills?

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**TERRACES**

On very steep hills, farmers can use terraces to prevent soil erosion. *Terraces* change one very steep field into many smaller, flatter fields.



Terraces keep water from running downhill very quickly.

**NO-TILL FARMING**

In no-till farming, farmers leave the stalks from old crops lying on the field while the newer crops grow. The old stalks protect the soil from rain and help reduce erosion.



The stalks left behind in no-till farming reduce erosion by protecting the soil from rain.

**CALIFORNIA STANDARDS CHECK**

**6.5.e** Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

**Word Help: resource** anything that can be used to take care of a need

**6. Apply Concepts** How can crop rotation affect the number of plants that soil can support?

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**COVER CROPS**

*Cover crops* are crops that are planted between harvests of a main crop. Cover crops can help to replace nutrients in the soil. They can also prevent erosion by providing cover from wind and rain.

**CROP ROTATION**

If the same crop is grown year after year in the same field, the soil can lose certain nutrients. To slow this process, a farmer can plant different crops in the field every year. Different crops use different nutrients from the soil. Some crops used in crop rotation can replace soil nutrients.

# Section 4 Review

6.2.a, 6.5.e, 6.6.b



## SECTION VOCABULARY

**erosion** the process by which wind, water, ice, or gravity transports soil and sediment from one location to another

**soil conservation** a method to maintain the fertility of soil by protecting the soil from erosion and nutrient loss

**1. Explain** Why is soil a nonrenewable resource?

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**2. Describe** How is weathering different from erosion?

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**3. Identify** What are two causes of soil loss?

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**4. Explain** How does no-till farming help to reduce erosion?

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**5. List** What are five ways that farmers can help to conserve soil?

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**6. Apply** Many gardeners put mulch, which is usually shredded bark or straw, around their plants in the fall. How do you think this helps conserve soil?

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SECTION 1 **Shoreline Erosion and Deposition**



6.2.a, 6.2.c, 6.3.a

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is a shoreline?
- How do waves shape shorelines?

**STUDY TIP**

**Summarize** Read this section quietly to yourself. With a partner, talk about what you learned. Together, try to figure out the answers to any questions that you have.

**READING CHECK**

**1. Compare** How is wave erosion different from wave deposition?

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**How Do Waves Form?**

Waves form when wind blows over the surface of the ocean. Strong winds produce large waves. The waves move toward land. When waves crash into the land over a long time, they can break rock down into smaller pieces. These pieces are called *sand*.

A **shoreline** is a place where the land and the water meet. Most shorelines contain sand. The motion of waves helps to shape shorelines. During *erosion*, waves remove sand from shorelines. During *deposition*, waves add sand to shorelines. ✓

**WAVE TRAINS**

Waves move in groups called *wave trains*. The waves in a wave train are separated by a period of time called the *wave period*. You can measure the wave period by counting the seconds between waves breaking on the shore. Most wave periods are 10 s to 20 s long.

When a wave reaches shallow water, the bottom of the wave drags against the sea floor. The bottom slows down. As the water gets shallower, the wave gets taller. The wave gets so tall, it can't support itself. It begins to curl, fall over, and break. Breaking waves are called *surf*.



Waves travel in groups called wave trains. The time between one wave and the next is the wave period.

**TAKE A LOOK**

**2. Identify** On the figure, label the wave train.

**SECTION 1** Shoreline Erosion and Deposition *continued*

**POUNDING SURF**

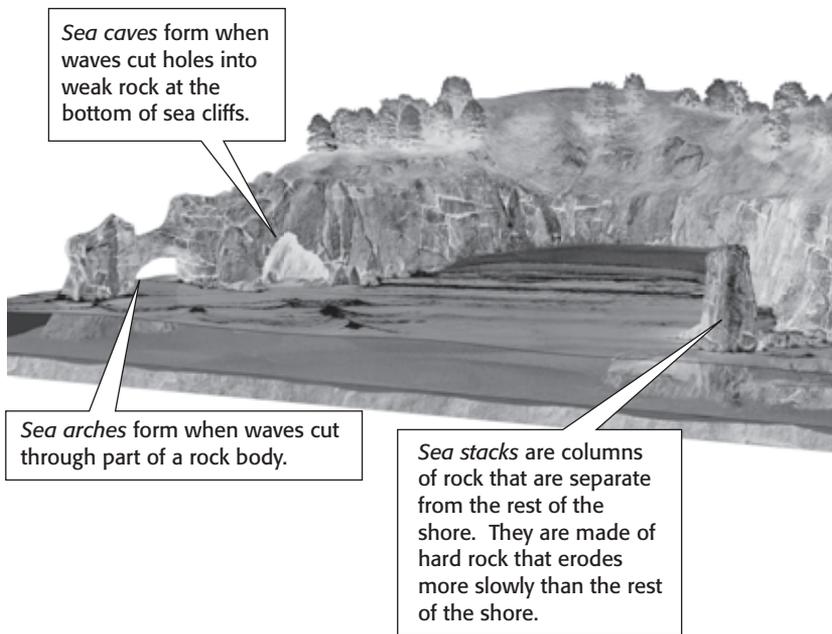
The energy in waves is constantly breaking rock into smaller and smaller pieces. Crashing waves can break solid rock and throw the pieces back toward the shore. Breaking waves can enter cracks in the rock and break off large boulders. Waves also pick up fine grains of sand. The loose sand wears down other rocks on the shore. ✓

**What Are the Effects of Wave Erosion?**

Wave erosion can produce many features along a shoreline. For example, *sea cliffs* form when waves erode rock to form steep slopes. As waves strike the bottom of the cliffs, the waves wear away soil and rock and make the cliffs steeper.

How fast sea cliffs erode depends on how hard the rock is and how strong the waves are. Cliffs made of hard rock, such as granite, erode slowly. Cliffs made of soft rock, such as shale, erode more quickly.

During storms, large, high-energy waves can erode the shore very quickly. These waves can break off large chunks of rock. Many of the features of shorelines are shaped by storm waves. The figures below and at the top of the next page show some of these features.



**READING CHECK**

**3. Identify** Give two ways that waves can break rock into smaller pieces.

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*Critical Thinking*

**4. Identify Relationships** When may a storm not produce high-energy waves?

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**TAKE A LOOK**

**5. Compare** How is a sea stack different from a sea arch?

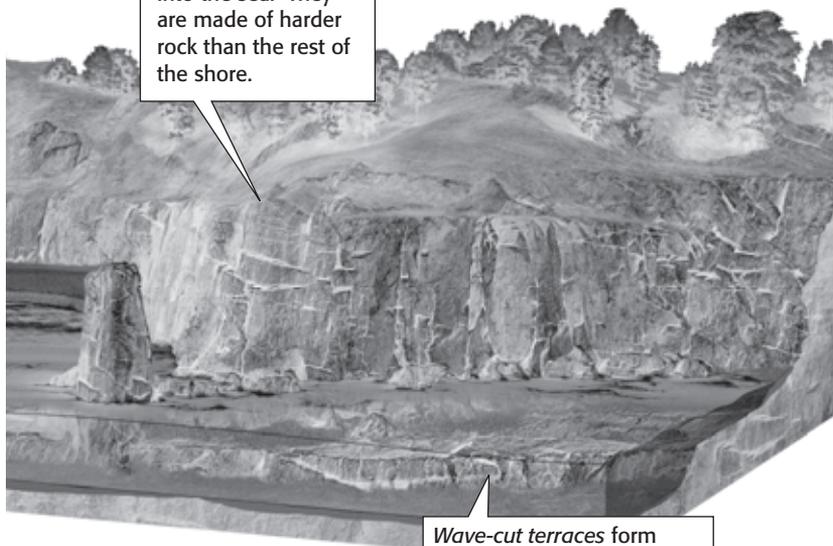
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**SECTION 1** Shoreline Erosion and Deposition *continued*

Headlands are finger-shaped bodies of rock that stick out into the sea. They are made of harder rock than the rest of the shore.



Wave-cut terraces form when sea cliffs are worn back from the shore. This produces a nearly flat platform beneath the water at the base of the cliff.

**TAKE A LOOK**

**6. Define** What is a headland?

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**What Are the Effects of Wave Deposition?**

Waves carry many materials, such as sand, shells, and small rocks. When the waves deposit these materials on the shoreline, a beach forms. A **beach** is any area of shoreline that is made of material deposited by waves. Some beach material is deposited near oceans by rivers and moves down the shoreline by the action of waves.

**CALIFORNIA STANDARDS CHECK**

**6.2.c** Students know beaches are **dynamic** systems in which the sand is supplied by rivers and moved along the coast by the action of waves.

**Word Help:** dynamic  
active

**7. Define** Write your own definition for *beach*.

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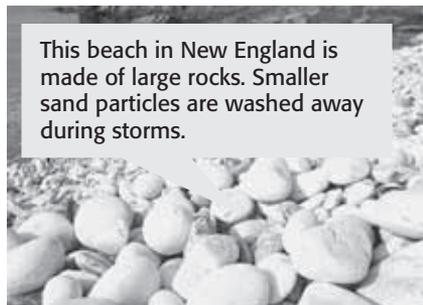
**BEACH MATERIALS**

Many people think that all beaches are made of sand. However, beaches may be made of many materials, not just sand. The size and shape of beach material depend on how far the material traveled before it was deposited. They also depend on how the material is eroded. For example, beaches in stormy areas may be made of large rocks because smaller particles are removed by the waves.

**SECTION 1** Shoreline Erosion and Deposition *continued***BEACH COLOR**

The color of a beach depends on the particles deposited there. Many beaches are light-colored because light-colored sand is the most common beach material. Most light-colored sand is made of the mineral quartz, which comes from eroded sandstone. Many Florida beaches are made of quartz sand. On many tropical beaches, the sand is white. It is made of finely ground white coral. ✓

Beaches can also be black or dark-colored. Black-sand beaches are found in Hawaii. Their sands are made of eroded lava from volcanoes. This lava is rich in dark-colored minerals, so the sand is also dark-colored. The figures below show some examples of beaches from across the United States.

**READING CHECK**

**8. Identify** What mineral is most light-colored sand made of?

\_\_\_\_\_

**TAKE A LOOK**

**9. Explain** Why are some beaches made mostly of larger rock pieces, instead of sand?

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**CALIFORNIA BEACHES**

California has both rocky and sandy beaches. Many rocky beaches are found where mountains or cliffs meet the ocean. Many sandy beaches form on the edges of gently sloping land. Most sandy beaches get some of their sand from rivers.

The materials that make up California beaches also vary. Materials from different sources have different colors and compositions. For example, the sand at Shelter Cove in Humboldt County is grey because it is made of eroded shale. The white sand at Carmel is made of light-colored quartz and feldspar. The dark sand near Santa Cruz contains dark grains of magnetite from igneous rock.

**SECTION 1** Shoreline Erosion and Deposition *continued*

**BEACH SIZE**

The amount of sand on a beach can change with the seasons. In California, beaches can become narrower in winter. Large waves from winter storms erode sand away from the beaches. The eroded sand can be trapped in areas away from the shore. Small waves return the sand to the beaches during the summer. ✓

**READING CHECK**

**10. Explain** Why do some beaches in California get smaller in the winter?

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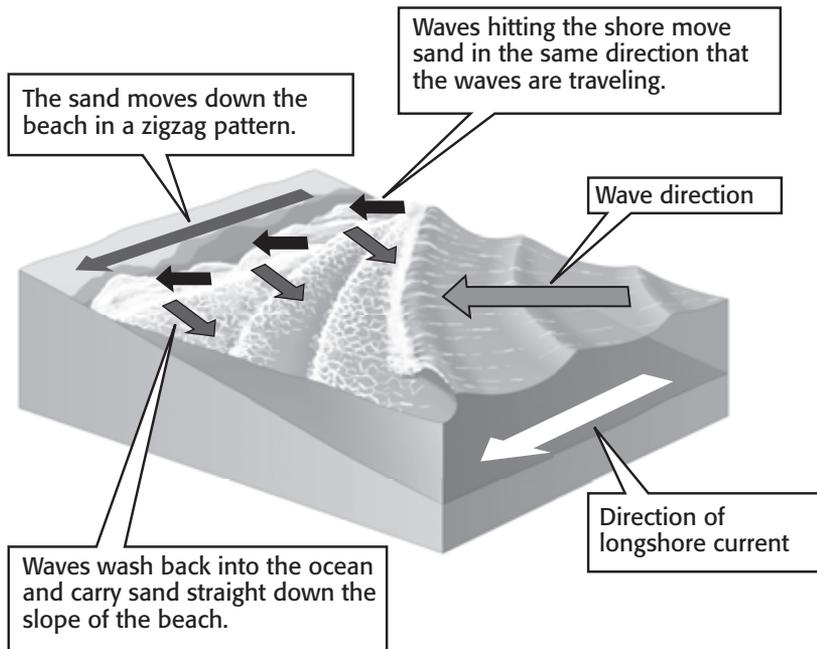
**SHORE CURRENTS**

After waves crash on the beach, the water glides back to the ocean. It flows underneath the incoming waves. This kind of water movement is called **undertow**. Undertow carries sand and pieces of rock away from the shore.

**LONGSHORE CURRENTS**

In some cases, water travels parallel to the shoreline very near the shore. This current is called a **longshore current**.

Longshore currents form when waves hit the shore at an angle instead of head-on. The waves wash sand onto the shore at the same angle that the waves are moving. However, when the waves wash back into the ocean, they move sand directly down the slope of the beach. This causes the sand to move in a zigzag pattern, as shown in the figure below.



**TAKE A LOOK**

**11. Infer** Why don't longshore currents form in places where waves hit the shore head-on?

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\_\_\_\_\_  
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**SECTION 1** Shoreline Erosion and Deposition *continued*

**OFFSHORE DEPOSITS**

Longshore currents can carry beach material offshore. This process can produce landforms in open water. These landforms include sandbars, barrier spits, and barrier islands.

A *sandbar* is a ridge of sand, gravel, or broken shells that is found in open water. Sandbars may be completely underwater or they may stick above the water. ✓

A *barrier spit* is a sandbar that sticks above the water and is connected to the shoreline. A *barrier island* is a long, narrow island that forms parallel to the shoreline. Most barrier islands are made of sand.

**READING CHECK**

**12. Define** What is a sandbar?

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\_\_\_\_\_



Cape Cod, Massachusetts, is an example of a barrier spit. Barrier spits form when sandbars are connected to the shoreline.

**TAKE A LOOK**

**13. Identify** What is a barrier spit?

\_\_\_\_\_

\_\_\_\_\_

**CALIFORNIA ISLANDS**

California is different from many other states because it has offshore islands. For example, the Channel Islands are found off the southern California coast. They formed millions of years ago. They were once part of the mainland. Now they are separated from the mainland by the Santa Monica and San Pedro Channels. The Channel Islands protect the coastline. They reduce the erosion of coastal cliffs by storm waves.

# Section 1 Review

6.2.a, 6.2.c, 6.3.a



## SECTION VOCABULARY

**beach** an area of the shoreline that is made up of deposited sediment

**longshore current** a water current that travels near and parallel to the shoreline

**shoreline** the boundary between land and a body of water

**undertow** a subsurface current that is near shore and that pulls objects out to sea

**1. Compare** How is a longshore current different from undertow?

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**2. Explain** Where does the energy to change the shoreline come from? Explain your answer.

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**3. Identify** Give two examples of different-colored beach sand and explain why each kind is a certain color.

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**4. Explain** How do longshore currents move sand?

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**5. List** Give five landforms that are produced by wave erosion.

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# Wind Erosion and Deposition

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How can wind erosion shape the landscape?
- How can wind deposition shape the landscape?



California Science Standards

6.2.a, 6.7.e

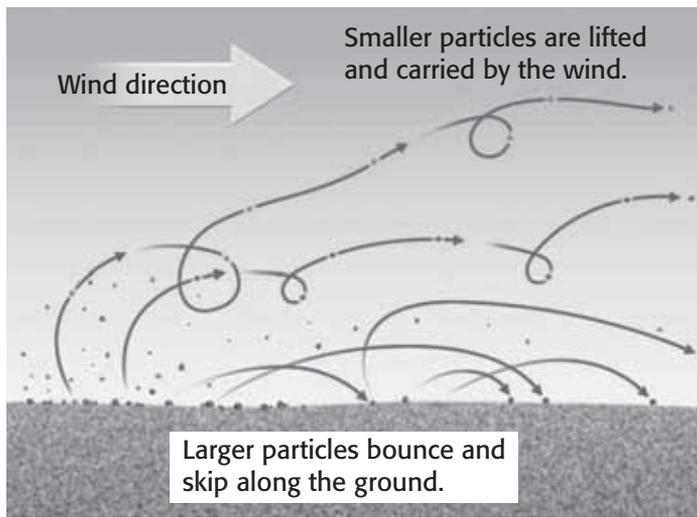
## How Can Wind Erosion Affect Rocks?

Wind can move soil, sand, and small pieces of rock. Therefore, wind can cause erosion. However, some areas are more likely to have wind erosion than other areas. For example, plant roots help to hold soil and rock in place. Therefore, areas with few plants, such as deserts and coastlines, are more likely to be eroded by wind. These areas also may be made of fine, loose rock particles. Wind can move these particles easily. ✓

Wind can shape rock pieces in three ways: saltation, deflation, and abrasion.

### SALTATION

Wind moves large grains of soil, sand, and rock by saltation. **Saltation** happens when sand-sized particles skip and bounce along in the direction that the wind is moving. When moving sand grains hit one another, some of the grains bounce up into the air. These grains fall back to the ground and bump other grains. These other grains can then move forward.



## STUDY TIP

**Learn New Words** As you read this section, underline words you don't understand. When you figure out what they mean, write the words and their definitions in your notebook.

## READING CHECK

**1. Explain** How do plant roots help to prevent wind erosion?

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## TAKE A LOOK

**2. Apply Concepts** Why can't the wind lift and carry large particles?

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**SECTION 2** Wind Erosion and Deposition *continued*

**DEFLATION**

Wind can blow tiny particles away from larger rock pieces during deflation. **Deflation** happens when wind removes the top layers of fine sediment or soil and leaves behind larger rock pieces. ✓

Deflation can form certain land features. It can produce *desert pavement*, which is a surface made of pebbles and small, broken rocks. In some places, the wind can scoop out small, bowl-shaped areas from fine sediment. These areas are called *deflation hollows*.

**READING CHECK**

**3. Define** What is deflation?

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**ABRASION**

Wind can grind and wear down rocks by abrasion. **Abrasion** happens when rock or sand wears down larger pieces of rock. Abrasion happens in areas where there are strong winds, loose sand, and soft rocks. The wind blows the loose sand against the rocks. The sand acts like sandpaper to erode, smooth, and polish the rocks.

**TAKE A LOOK**

**4. Complete** Fill in the blank spaces in the table.

Process	Description
	Large particles bounce and skip along the ground.
Deflation	
Abrasion	

**What Landforms Are Produced by Wind Deposition?**

Wind can carry material over long distances. The wind can carry different amounts and sizes of particles depending on its speed. Fast winds can carry large particles and may move a lot of material. However, all winds eventually slow down and drop their material. The heaviest particles fall first.

Barriers, such as plants and rocks, cause the wind to slow down. As it slows, the wind deposits particles on top of the barrier. As the dropped material builds up, the barrier gets larger. The barrier causes the wind to slow down even more. More and more material builds up on the barrier until a mound forms. The sand completely buries the original barrier.

A mound of wind-deposited sand is called a **dune**. Dunes are common in sandy deserts and along sandy shores of lakes and oceans.

*Critical Thinking*

**5. Infer** What do you think is the reason that fast winds can carry larger particles than slower winds?

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**SECTION 2** Wind Erosion and Deposition *continued*

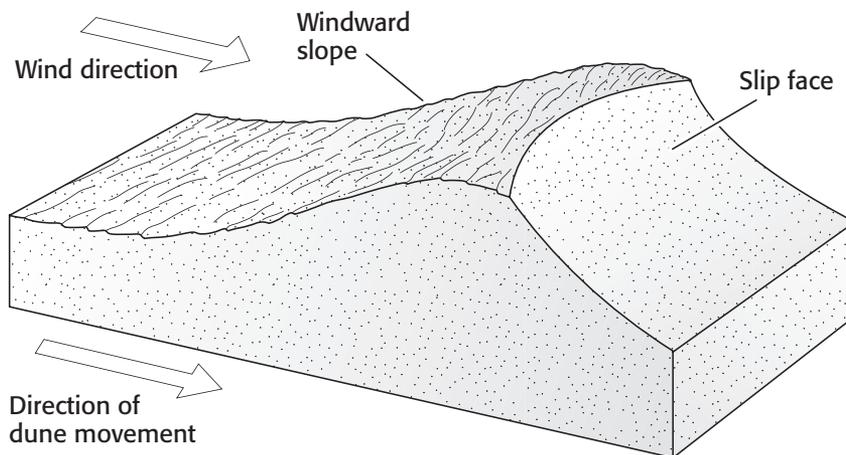
**CALIFORNIA DUNES**

There are many formations of dunes in California. They are found in coastal and desert areas. People use these areas for activities such as camping.

One major coastal dune system is the Monterey Bay Dunes, which covers 40 square miles. The largest desert sand-dune system in the state is the Algodones. The Algodones are in southeast California. They cover 1,000 square miles.

**THE MOVEMENT OF DUNES**

Wind conditions affect a dune's shape and size. In general, dunes move in the same direction the wind is blowing. A dune has one gently sloped side and one steep side. The gently sloped side faces the wind. It is called the *windward slope*. The wind constantly moves sand up this side. As sand moves over the top of the dune, the sand slides down the steep side. The steep side is called the *slip face*. ✓



The wind blows sand up the windward slope of the dune. The sand moves over the top of the dune and falls down the steep slip face. In this way, dunes move across the land in the direction that the wind blows.

**Math Focus**

**6. Calculate** How many times larger is the Algodones sand-dune system than the Monterey Bay Dunes?

\_\_\_\_\_

**READING CHECK**

**7. Identify** In what direction do dunes generally move?

\_\_\_\_\_  
\_\_\_\_\_

**TAKE A LOOK**

**8. Compare** How is the windward slope of a dune different from the slip face?

\_\_\_\_\_  
\_\_\_\_\_

# Section 2 Review

6.2.a, 6.7.e 

## SECTION VOCABULARY

**abrasion** the grinding and wearing away of rock surfaces through the mechanical action of other rock or sand particles

**deflation** a form of wind erosion in which fine, dry soil particles are blown away

**dune** a mound of wind-deposited sand that moves as a result of the action of wind

**saltation** the movement of sand or other sediments by short jumps and bounces that is caused by wind or water

**1. Identify** Give two land features that can form because of deflation.

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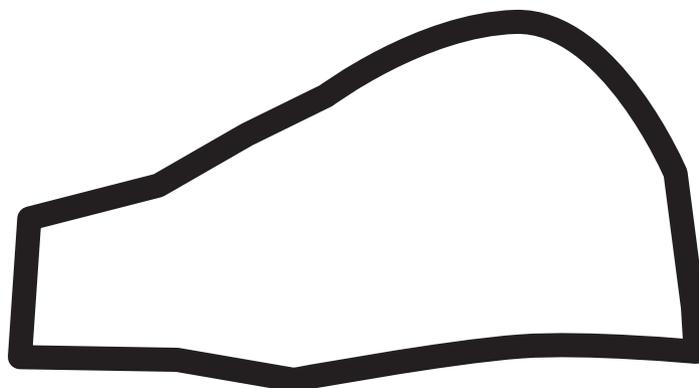
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**2. Describe** What areas are most likely to be affected by wind erosion? Give two examples.

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**3. Label** The figure shows a drawing of a sand dune. Label the windward slope and the slip face. Add an arrow to show the direction of the wind.



**4. Explain** How do dunes form?

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**5. Apply Concepts** Wind can transport particles of many different sizes. What sized particles are probably carried the farthest by the wind?

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## CHAPTER 10 Agents of Erosion and Deposition

## SECTION

## 3

## Erosion and Deposition by Ice

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are glaciers?
- How do glaciers affect the landscape?



California Science Standards

6.2.a

**What Are Glaciers?**

A **glacier** is a huge piece of moving ice. The ice in glaciers contains most of the fresh water on Earth. Glaciers are found on every continent except Australia.

There are two kinds of glaciers: continental and alpine. *Continental glaciers* are ice sheets that can spread across entire continents. *Alpine glaciers* are found on the tops of mountains. Both continental and alpine glaciers can greatly affect the landscape. ✓

Glaciers form in areas that are so cold that snow stays on the ground all year round. For example, glaciers are common in polar areas and on top of high mountains. In these areas, layers of snow build up year after year. Over time, the weight of the top layers pushes down on the lower layers. The lower layers change from snow to ice.

**HOW GLACIERS MOVE**

Glaciers can move in two ways: by sliding and by flowing. As more ice builds up on a slope, the glacier becomes heavier. The glacier can start to slide downhill, the way a skier slides downhill. Glaciers can also move by flowing. The solid ice in glaciers can move slowly, like soft putty or chewing gum.

Thick glaciers move faster than thin glaciers. Glaciers on steep slopes move faster than those on gentler slopes.



This is McBride Glacier in Alaska.



**Compare** As you read, make a table comparing the landforms that glaciers can produce.



**1. Identify** What are the two kinds of glaciers?

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**TAKE A LOOK**

**2. Define** What is a glacier?

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**SECTION 3** Erosion and Deposition by Ice *continued*

### Critical Thinking

#### 3. Identify Relationships

How is erosion by glaciers an example of water shaping the landscape?

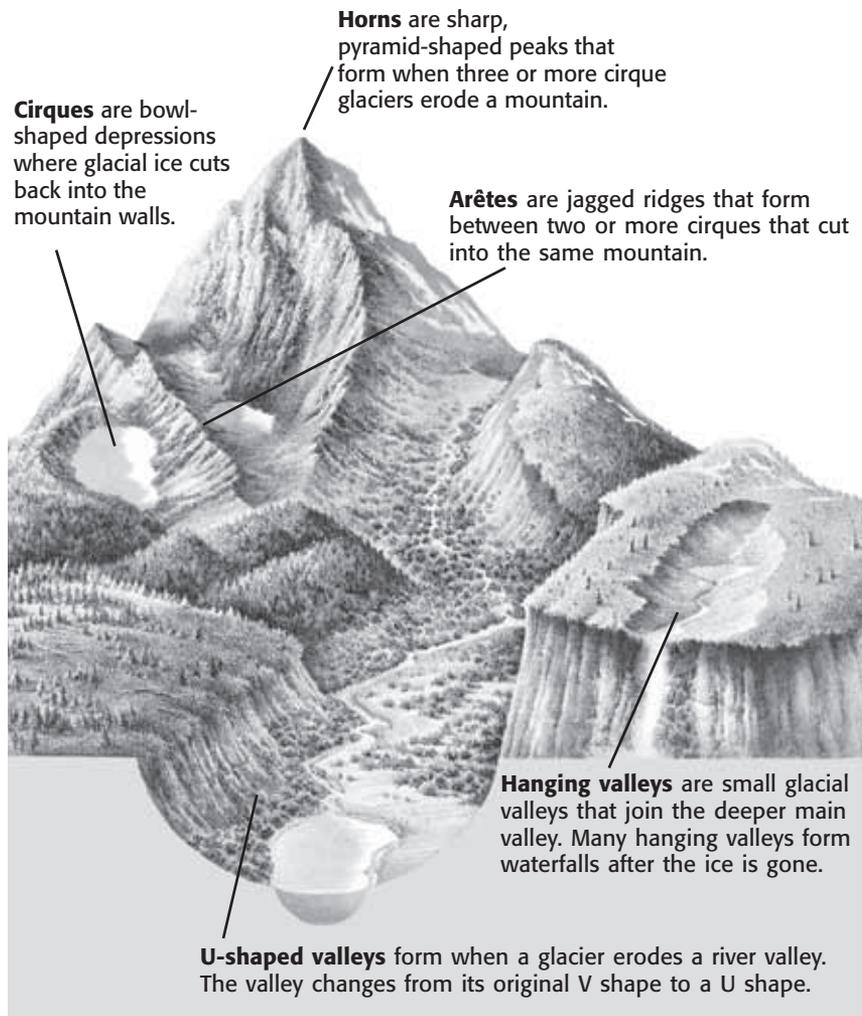
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### How Do Glaciers Affect the Landscape?

Glaciers can produce many different features as they move over Earth's surface. As a glacier moves, it can pick up and carry the rocks in its path. Glaciers can carry rocks of many different sizes, from dust all the way up to boulders. These rocks can scrape grooves into the land below the glacier as the glacier moves.

Continental glaciers tend to flatten the land that they pass over. However, alpine glaciers can produce sharp, rugged landscapes. The figure below shows some of the features that alpine glaciers can form.



### TAKE A LOOK

4. Explain How are horns, cirques, and arêtes related?

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### GLACIAL DEPOSITS

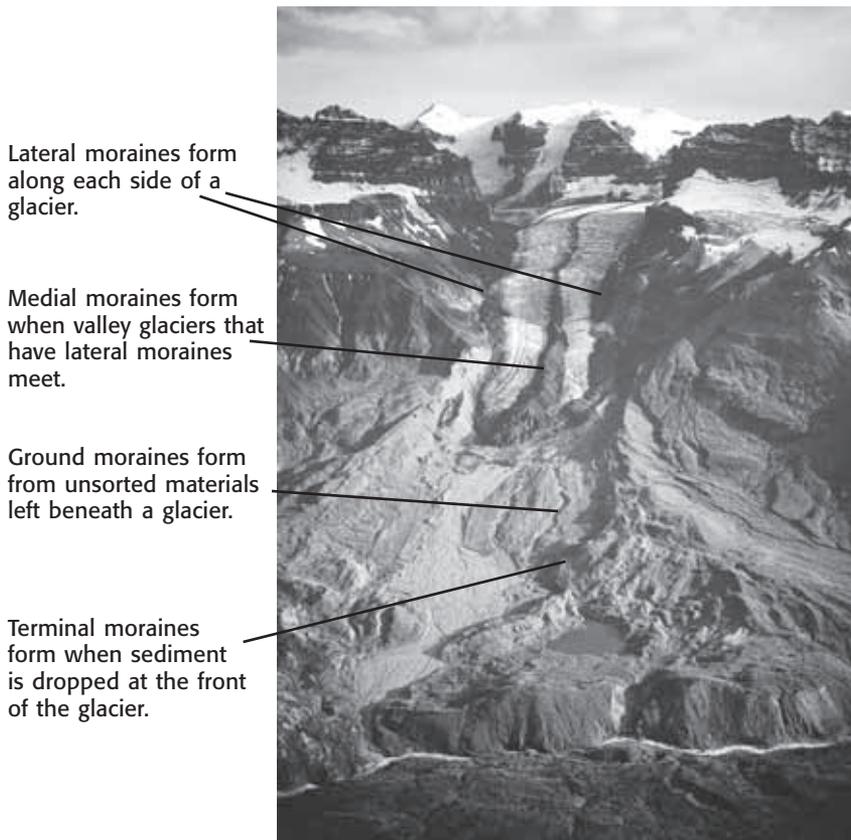
As a glacier melts, it drops all of the material that it is carrying. The material that is carried and deposited by glaciers is called **glacial drift**. There are two kinds of glacial drift: till and stratified drift.

**SECTION 3** Erosion and Deposition by Ice *continued*

**TILL DEPOSITS**

**Till** is unsorted rock material that is deposited by melting glacial ice. It is called “unsorted” because the rocks are of all different sizes. Till contains fine sediment as well as large boulders. When the ice melts, it deposits this material onto the ground. ✓

The most common till deposits are *moraines*. Moraines form ridges along the edges of glaciers. There are many types of moraines. They are shown in the figure below.



**STRATIFIED DRIFT**

When a glacier melts, the water forms streams that carry rock material away from the glacier. The streams deposit the rocks in different places depending on their size. The rocks form a sorted deposit called **stratified drift**. The large area where the stratified drift is deposited is called an *outwash plain*. ✓

In some cases, a block of ice is left in the outwash plain as the glacier melts. As the ice melts, sediment builds up around it. The sediment forms a bowl-shaped feature called a *kettle*. Kettles can fill with water and become ponds or lakes.

**READING CHECK**

**5. Explain** Why is till considered to be unsorted?

\_\_\_\_\_

\_\_\_\_\_

**Say It**

**Learn New Words** Look up the words *lateral*, *medial*, and *terminal* in a dictionary. In a group, talk about why these words are used to describe different kinds of moraines.

**READING CHECK**

**6. Define** Write your own definition for *stratified drift*.

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# Section 3 Review

## SECTION VOCABULARY

**glacial drift** the rock material carried and deposited by glaciers

**glacier** a large mass of moving ice

**stratified drift** a glacial deposit that has been sorted and layered by the action of streams or meltwater

**till** unsorted rock material that is deposited directly by a melting glacier

1. **List** Give two kinds of glacial drift.

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2. **Identify** What are four kinds of moraines?

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3. **Compare** How are continental glaciers different from alpine glaciers?

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4. **Explain** How do glaciers form?

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5. **Describe** How does a kettle form?

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6. **Infer** How can a glacier deposit both unsorted and sorted material?

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# Erosion and Deposition by Mass Movement

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is mass movement?
- How does mass movement shape Earth's surface?
- How can mass movement affect living things?



California Science Standards

6.2.d

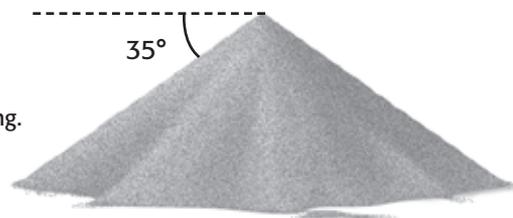
## What Is Mass Movement?

Gravity can cause erosion and deposition. Gravity makes water and ice move. It also causes rock, soil, snow, or other material to move downhill in a process called **mass movement**.

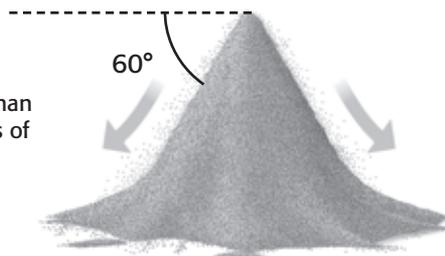
### ANGLE OF REPOSE

Particles in a sand pile move downhill. They stop when the slope of the pile becomes stable. The *angle of repose* is the steepest angle, or slope, at which the loose material no longer moves downhill. If the slope of a pile of material is larger than the angle of repose, mass movement happens. ✓

The slope of this pile of sand is equal to the sand's angle of repose. The sand pile is stable. The sand particles are not moving.



The slope of this pile of sand is larger than the angle of repose. Therefore, particles of sand move down the slope of the pile.



The angle of repose can be different in different situations. The composition, size, weight, and shape of the particles in a material affect its angle of repose. The amount of water in a material can also change the material's angle of repose.

## STUDY TIP

**Ask Questions** As you read this section, write down any questions you have. Talk about your questions in a small group.

## READING CHECK

**1. Define** What is the angle of repose?

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## TAKE A LOOK

**2. Explain** Why are sand particles moving downhill in the bottom picture?

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**SECTION 4** Erosion and Deposition by Mass Movement *continued*



**CALIFORNIA STANDARDS CHECK**

**6.2.d** Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

**3. Describe** How can landslides affect wildlife habitats?

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## What Are the Kinds of Mass Movement?

Mass movement can happen suddenly and quickly. Rapid mass movement can be very dangerous. It can destroy or bury everything in its path.

### LANDSLIDES

A **landslide** happens when a large amount of material moves suddenly and rapidly downhill. Landslides can carry away or bury plants and animals and destroy their habitats. Several factors can make landslides more likely.

- Heavy rains can make soil wet and heavy, which makes the soil more likely to move downhill.
- Tree roots help to keep land from moving. Therefore, *deforestation*, or cutting down trees, can make landslides more likely.
- Earthquakes can cause rock and soil to start moving.
- People may build houses and other buildings on unstable hillsides. The extra weight of the buildings can cause a landslide. ✓

The most common kind of landslide is a *slump*. Slumps happen when a block of material moves downhill along a curved surface.

### ROCK FALLS

A **rock fall** happens when loose rocks fall down a steep slope. Many such slopes are found on the sides of roads that run through mountains. Gravity can cause the loose and broken rocks above the road to fall. The rocks in a rock fall may be many different sizes.

### MUDFLOWS

A **mudflow** is a rapid movement of a large amount of mud. Mudflows can happen when a lot of water mixes with soil and rock. The water makes the slippery mud flow downhill very quickly. A mudflow can carry away cars, trees, houses, and other objects that are in its path. ✓

Mudflows are common in mountain regions when a long dry season is followed by heavy rain. Mudflows may also happen when trees and other plants are cut down. Without plant roots to hold soil in place and help water drain away, large amounts of mud can quickly form.

 **READING CHECK**

**4. Identify** Give three factors that can make landslides more likely.

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 **READING CHECK**

**5. Define** What is a mudflow?

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**SECTION 4** Erosion and Deposition by Mass Movement *continued*

**CREEP**

Not all mass movement is fast. In fact, very slow mass movement is happening on almost all slopes. **Creep** is the name given to this very slow movement of material downhill. Even though creep happens very slowly, it can move large amounts of material over a long period of time. ✓

Many factors can affect creep. Water can loosen soil and rock so that they move more easily. Plant roots can cause rocks to crack and can push soil particles apart. Burrowing animals, such as moles and gophers, can loosen rock and soil particles. All of these factors may make creep more likely.

Type of mass movement	Description
Landslide	Material moves suddenly and rapidly down a slope.
Rock fall	
Mudflow	
	Material moves downhill very slowly.

**How Does Mass Movement Affect Land Use?**

Mass movement can cause serious property damage, injury, and even death. Therefore, people need to consider mass movement when they decide how to use land. For example, when people build roads through mountains, rock falls may happen on the sides of the roads. People may put metal fences on the sides of the road to prevent rocks from damaging cars on the road.

Many of the short-term effects of sudden, large mass movements are harmful to people and to other organisms. However, the long-term effects of mass movements may be helpful. For example, minerals and rocks may be exposed at the surface after a landslide. The minerals and rocks can be used by people or can break down to form new, rich soil. ✓

 **READING CHECK**

**6. Compare** How is creep different from the other kinds of mass movement that are mentioned in this section?

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\_\_\_\_\_

**TAKE A LOOK**

**7. Describe** Fill in the blank spaces in the table.

 **READING CHECK**

**8. Explain** How can mass movements be helpful?

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\_\_\_\_\_

\_\_\_\_\_

# Section 4 Review

6.2.d



## SECTION VOCABULARY

**creep** the slow downhill movement of weathered rock material

**landslide** the sudden movement of rock and soil down a slope

**mass movement** the movement of a large mass of sediment or a section of land down a slope

**mudflow** the flow of a mass of mud or rock and soil mixed with a large amount of water

**rock fall** the rapid mass movement of rock down a steep slope or cliff

**1. List** What are four kinds of mass movement?

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**2. Explain** Why is it important for people to think about mass movement when they decide how to use land?

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**3. Identify Relationships** How is mass movement related to the angle of repose?

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**4. Identify** What force causes mass movements?

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**5. Compare** How are landslides different from mudflows?

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**6. List** Give four things that can affect a material's angle of repose.

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**CHAPTER 11** Rivers and Groundwater

**SECTION 1** **The Active River**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How does moving water change the surface of Earth?
- What is the water cycle?
- Which factors affect the rate of stream erosion?



**California Science Standards**

6.2.a, 6.2.b, 6.4.a

**What Is Erosion?**

Six million years ago, the Colorado River began carving through rock to form the Grand Canyon. Today, the river has carved through 1.6 km (about 1 mi) of rock!

Before the Grand Canyon was formed, the land was flat. Then the rock in the area began to lift upward because of plate tectonics. As Earth’s crust lifted upward, water began running downhill. The moving water cut into the rock and started forming the Grand Canyon.

Over millions of years, water cut into rock through the process of erosion. During **erosion**, wind, water, ice, and gravity move soil and rock from one place to another. Water is the main force in forming the Grand Canyon and in changing the Earth’s landscape. ✓

**STUDY TIP**

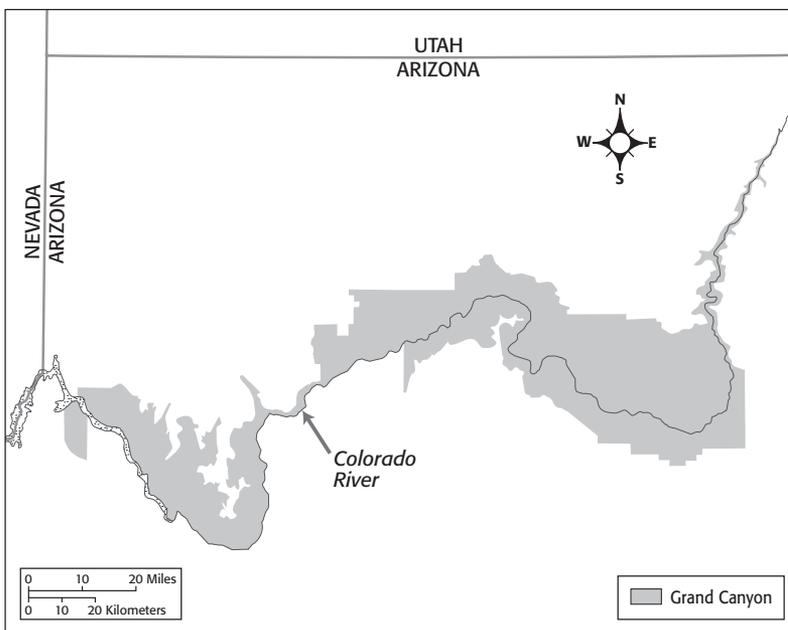
**Make A List** As you read, make a list of the different ways in which water can change the landscape of Earth.

**READING CHECK**

**1. Identify** What formed the Grand Canyon?

\_\_\_\_\_

\_\_\_\_\_



Six million years ago, the Colorado River started flowing through northern Arizona. Today, it has carved the Grand Canyon, which is about 1.6 km deep and 446 km long.

**Math Focus**

**2. Calculate** How long is the Grand Canyon in miles? Show how you got your answer.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**SECTION 1** The Active River *continued*

**CALIFORNIA STANDARDS CHECK**

**6.4.a** Students know the sun is the **major** source of **energy** for **phenomena** on Earth's surface; it powers winds, ocean currents, and the water cycle.

**Word Help: major**  
of great importance or large scale

**Word Help: energy**  
what makes things happen

**Word Help: phenomena**  
any facts or events that can be sensed or described scientifically

**3. Explain** How does the sun help the water cycle work?

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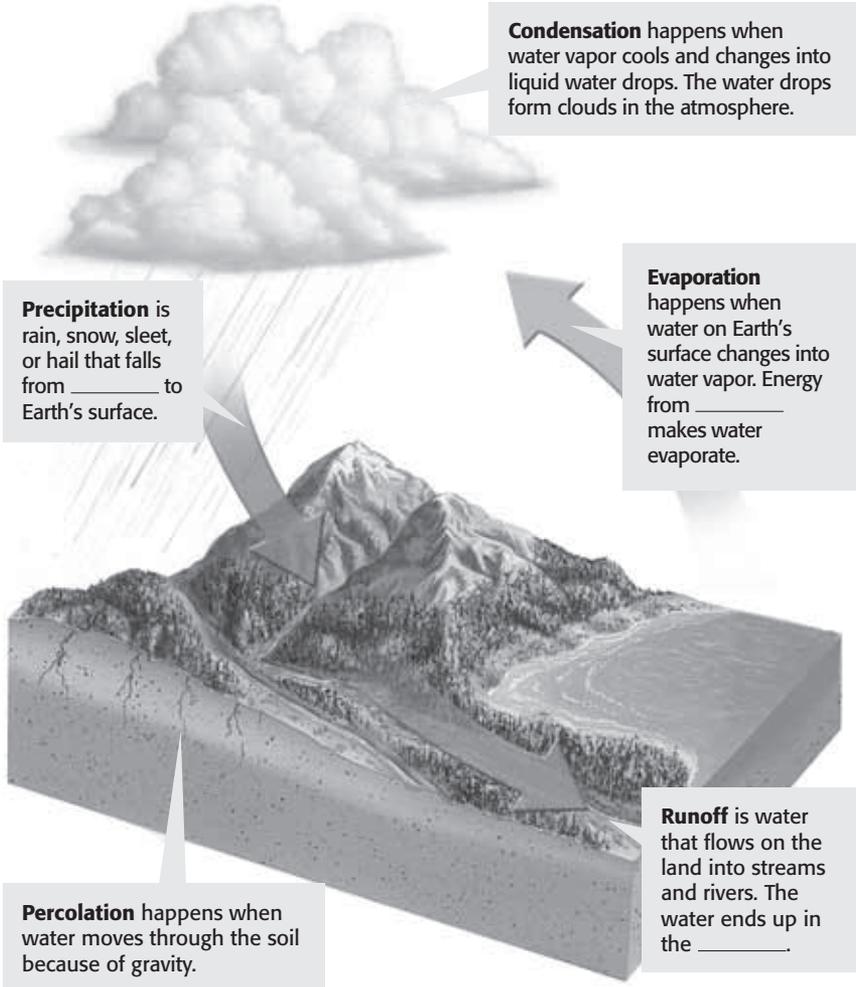
\_\_\_\_\_

**How Does the Water Cycle Work?**

Have you ever wondered where the water in rivers comes from? It is part of the water cycle. The **water cycle** is the nonstop movement of water between the air, the land, and the oceans. The major source of energy that drives the water cycle is the sun.

In the water cycle, water comes to Earth's surface from the clouds in the form of rain, snow, sleet, or hail. The water moves downward through the soil or flows over the land. Water that flows over the land collects in streams and rivers and flows to the oceans.

Energy from the sun changes the water on Earth's surface into a gas that rises up to form clouds. The gas is called *water vapor*. The water vapor moves through the atmosphere until it falls to Earth's surface again.



**TAKE A LOOK**

**4. Identify** In the figure, fill in the blank lines with the correct words.

**SECTION 1** The Active River *continued*

**What Is a River System?**

What happens when you turn on the shower in your family’s bathroom? When water hits the shower floor, the individual drops of water join together to form small streams. The small streams join together to form larger streams. The larger streams carry the water down the drain.

The water in your shower is like the water in a river system. A *river system* is a group of streams and rivers that drain an area of land. A *river* is a stream that has many tributaries. A **tributary** is a stream that flows into a lake or a larger stream. ✓

**READING CHECK**

**5. Define** What is a river system?

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**How Do River Systems Work?**

River systems are divided into areas called watersheds. A **watershed** is the land that is drained by a river system. Many tributaries join together to form the rivers in a watershed.

The largest watershed in the United States is the Mississippi River watershed. It covers over one third of the United States. It has hundreds of tributaries. The Mississippi River watershed drains into the Gulf of Mexico.

Watersheds are separated from each other by an area of higher ground called a **divide**. All of the rivers on one side of a divide flow away from it in one direction. All of the rivers on the other side of the divide flow away from it in the opposite direction. The Continental Divide separates the Mississippi River watershed from the watersheds in the western United States.



**TAKE A LOOK**

**6. List** Name three rivers that are tributaries to the Mississippi River.

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**SECTION 1** The Active River *continued*

### What Is a Stream Channel?

A stream forms as water wears away soil and rock to make a channel. A **channel** is the path that a stream follows. As more soil and rock are washed away, the channel gets wider and deeper.

Over time, tributaries flow into the main channel of a river. The main channel has more water in it than the tributaries. The larger amount of water makes the main channel longer and wider. ✓

**READING CHECK**

**7. Explain** Why is the main channel of a river longer and wider than the channels of its tributaries?

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### What Causes Stream Erosion?

*Gradient* is a measure of the change in height over a certain distance. Gradient can be used to measure how steep a stream is. The left-hand picture below shows a stream with a high gradient. The water in this stream is moving very fast. The fast-moving water easily washes away rock and soil.

A river that is flat, as in the right-hand picture, has a low gradient and flows slowly. The slow water washes away less rock and soil.

### TAKE A LOOK

**8. Explain** How does the gradient of a stream affect how much erosion it causes?

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\_\_\_\_\_



This stream has a large gradient. It flows very fast.



This stream has a small gradient. It flows very slowly.

The amount of water that flows in a stream during a certain amount of time is called the *discharge*. The discharge of a stream can change. A large rainfall or a lot of melted snow can increase the stream's discharge.

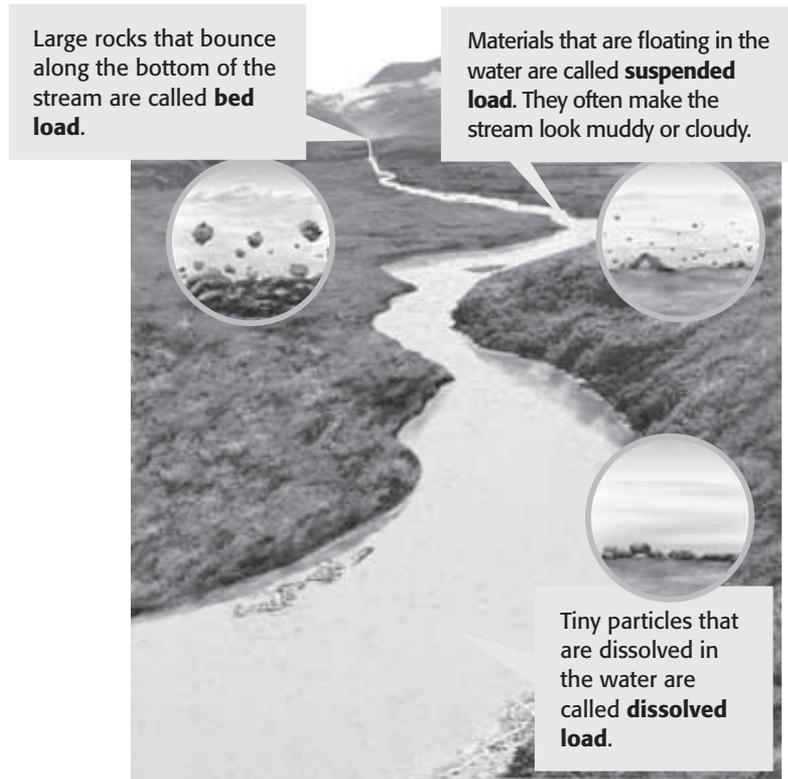
When the discharge of a stream gets bigger, the stream can carry more sediment. The larger amount of water will flow fast and erode more land.

**SECTION 1** The Active River *continued*

## How Does a Stream Carry Sediment?

A stream's **load** is the material carried in the stream's water. A fast-moving stream can carry large rocks. The large rocks speed up the stream's erosion by knocking away more rock and soil.

A slow-moving stream carries smaller rocks in its load. The smaller particles erode less rock and soil. The stream also carries material that is dissolved in the water.



	<p><b>CALIFORNIA STANDARDS CHECK</b></p>
<p><b>6.2.b.</b> Students know that rivers and streams are <u>dynamic</u> systems that <u>erode</u>, <u>transport</u> sediment, change course, and flood their banks in natural and recurring patterns.</p>	
<p><b>Word Help: <u>dynamic</u></b> active; tending toward change</p>	
<p><b>Word Help: <u>erode</u></b> to wear away</p>	
<p><b>Word Help: <u>transport</u></b> to carry from one place to another</p>	
<p><b>9. Identify</b> How does a stream carry material from one place to another? Give three ways.</p> <p>_____</p> <p>_____</p> <p>_____</p>	

## How Do Scientists Describe Rivers?

All rivers have different features. These features can change with time. Many factors, such as weather, surroundings, gradient, and load, control the changes in a river. Scientists use special terms to describe rivers with certain features.

**SECTION 1** The Active River *continued*

**YOUTHFUL RIVERS**

Youthful rivers are fast-flowing rivers with steep gradients. They often flow over rapids and waterfalls. Youthful rivers make narrow, deep channels for the water to flow in. The picture below shows a youthful river.



**TAKE A LOOK**

**10. Describe** What features of this river tell you that it is a youthful river?

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\_\_\_\_\_

\_\_\_\_\_

**MATURE RIVERS**

Mature rivers erode rock and soil to make wide channels. Many tributaries flow into a mature river, so mature rivers carry large amounts of water. The picture below shows a mature river bending and curving through the land. The curves and bends are called *meanders*. ☑



**READING CHECK**

**11. Explain** Why do mature rivers carry a lot of water?

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\_\_\_\_\_

**TAKE A LOOK**

**12. Identify** Label the meanders on this picture of a mature river.

**SECTION 1** The Active River *continued***REJUVENATED RIVERS**

Rejuvenated rivers form where land has been raised up by plate tectonics. This gives a river a steep gradient. Therefore, rejuvenated rivers flow fast and have deep channels. As shown in the picture below, steplike gradients called *terraces* usually form along the sides of rejuvenated rivers.

**TAKE A LOOK**

**13. Identify** Label the terraces on this picture of a rejuvenated river.

**OLD RIVERS**

Old rivers have very low gradients. Instead of widening and deepening its channel, an old river deposits soil and rock along its channel. Since very few tributaries flow into an old river, the river does not quickly erode land. Old rivers have wide, flat floodplains and many meanders. In the picture below, a bend in an old river's channel has eroded into a lake. This is called an *oxbow lake*.

*Critical Thinking*

**14. Infer** Very few tributaries flow into an old river. Do you think it will have a large or a small discharge?

# Section 1 Review

6.2.a, 6.2.b, 6.4.a



## SECTION VOCABULARY

**channel** the path that a stream follows

**divide** the boundary between drainage areas that have streams that flow in opposite directions

**erosion** the process by which wind, water, ice, or gravity transports soil and sediment from one location to another

**load** the materials carried in a stream

**tributary** a stream that flows into a lake or into a larger stream

**water cycle** the continuous movement of water between the atmosphere, the land, and the oceans

**watershed** the area of land that is drained by a river system

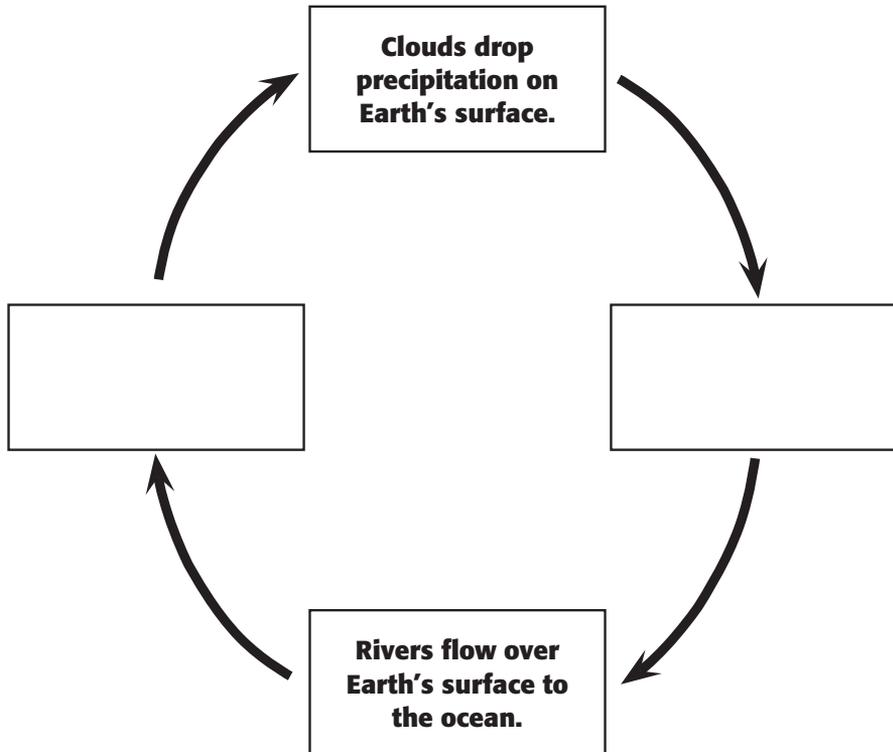
**1. Explain** Why do most rivers have wider channels than most streams?

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**2. Show a Sequence** Fill in the Process Chart to show what happens in the water cycle.



**3. Identify** What is the main source of energy for the water cycle?

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**4. Describe** How do rivers change Earth's surface?

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CHAPTER 11 Rivers and Groundwater

SECTION 2

# Stream and River Deposits

### BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What types of deposits are caused by streams?
- Why do floods happen?
- How do floods from rivers and streams affect humans?



California Science Standards

6.2.a, 6.2.b, 6.2.d

## How Do Rivers and Streams Rebuild Land?

Earlier, you learned that rivers and streams erode rock and soil. However, rivers also carry this loose rock and soil to new places. Rivers can help to form new land through deposition. **Deposition** is the process in which material is laid down, or dropped.

The rock and soil that a river erodes from the land move downstream in the river's load. When the flow of water slows down, the river deposits, or drops, some of its load. Material, such as rock and soil, that is deposited by rivers and streams is called *sediment*. ✓

In a river, erosion happens on the outside of a bend, where the water flows quickly. Deposition happens on the inside of a bend where the water flows more slowly.



**Graphic Organizer** In your notebook, create a table to compare the different landforms created by stream deposits.



**1. Define** What is sediment?

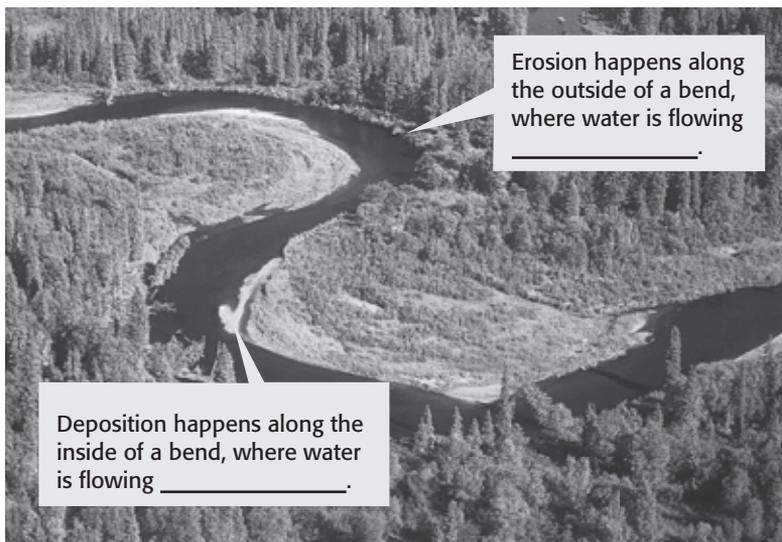
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### TAKE A LOOK

**2. Identify** Fill in the blanks in the figure with the correct words.

**SECTION 2** Stream and River Deposits *continued*

### What Are Deltas and Alluvial Fans?

Rivers deposit their loads of rocks and soil when their flow of water slows down. When a river enters the ocean, it flows much more slowly. Therefore, it deposits its load into the ocean.

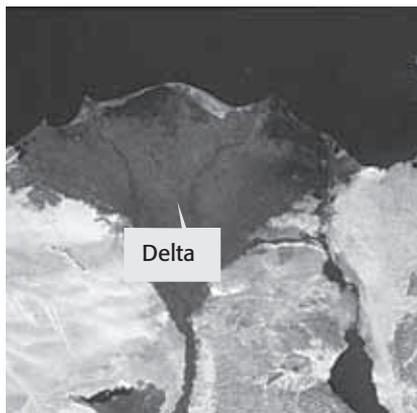
When the river enters the ocean, it deposits its load in a fan-shaped pattern called a **delta**. The river deposits form new land and build new coastline.

Rivers and streams can also deposit their loads on dry land. When a fast-moving stream flows from a mountain onto flat land, the stream slows down quickly. As it slows down, the stream deposits its rocks and soil in a fan-shaped pattern known as an **alluvial fan**.



#### Say It

**Investigate** Learn about a place in the world where people live on a delta. Give a short talk to your class about the place you studied.



### Why Do Rivers and Streams Flood?

Rivers and streams are always changing. Rivers and streams have different amounts of water in them in different seasons. If there is a lot of rain or a lot of snow melting, a stream will have a lot of water in it.

Floods are natural events that happen with the change of seasons. A *flood* happens when there is too much water for the channel to hold. The stream flows over the sides of its channel. ✓

During a flood, the land along the sides of the stream is covered in water. The stream drops its sediment on this land. This area is called a **floodplain**. Floodplains are good areas for farming because flooding brings new soil to the land.

**READING CHECK**

**3. Explain** What is a flood?

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**SECTION 2** Stream and River Deposits *continued*

**What Are the Effects of Floods?**

Floods are powerful and can cause a lot of damage. They can ruin homes and buildings. They can also wash away land where animals and people live.

In 1993, when the Mississippi River flooded, farms and towns in nine states were damaged. Floods can cover roads and carry cars and people downstream. They can also drown people and animals. ✓

Floods sometimes happen very fast. After a very heavy rainstorm, water can rush over the land and cause a *flash flood*. Flash floods can be hard to predict and are dangerous.



Floodwater can flow strongly enough to move cars. These people were trapped in their car in a flash flood.

Humans try to control flooding by building barriers. One kind of barrier is called a dam. A *dam* is a barrier that can guide floodwater to a reservoir.

Another barrier that people build is called a levee. A *levee* is a wall of sediment on the side of a river. The barrier helps keep the river from flooding the nearby land. ✓

**READING CHECK**

**4. List** List three ways that floods can be harmful to people and animals.

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**TAKE A LOOK**

**5. Explain** Why can a flash flood be dangerous to people driving in cars?

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**READING CHECK**

**6. Identify** What do people do to try to protect themselves from a flood?

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# Section 2 Review

6.2.a, 6.2.b, 6.2.d 

## SECTION VOCABULARY

<p><b>alluvial fan</b> a fan-shaped mass of material deposited by a stream when the slope of the land decreases sharply</p> <p><b>delta</b> a fan-shaped mass of material deposited at the mouth of a stream</p>	<p><b>deposition</b> the process in which material is laid down</p> <p><b>floodplain</b> an area along a river that forms from sediments deposited when the river overflows its banks</p>
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**1. Explain** Why do floods happen?

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**2. Compare** Complete the table to describe the features of different kinds of stream deposits.

Type of Deposit	How is it formed?	Where is it formed?	When is it formed?
Alluvial fan			
Delta			
Floodplain			

**3. Explain** How can a flood be both helpful and harmful to people?

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**4. Compare** How are dams and levees different?

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**5. Explain** What causes floods?

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CHAPTER 11 Rivers and Groundwater

SECTION 3 Using Water Wisely

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How does California get its water supply?
- Why should people in California conserve water?
- How can people protect their water supply?



California Science Standards

6.6.b

**Where Is Fresh Water Found?**

Although the Earth is covered with oceans, lakes, and rivers, only 3% of the Earth’s water is fresh water. Most of that 3% is frozen in the polar icecaps. Therefore, people must take care of and protect their water resources.

Some of the Earth’s fresh water is found in streams and lakes. However, a large amount of water is also found underground. Rainwater and water from streams move through the soil and into the spaces between rocks underground. The water found inside the underground rocks is called *groundwater*. The rock layer that stores groundwater is called an **aquifer**. ✓

Groundwater is found beneath the Earth’s surface. The upper surface of groundwater is called the **water table**. The water table is the top of an aquifer. When there is less water in the aquifer, the water table will be lower.

**STUDY TIP**

**Summarize** As you read, underline the important ideas in this section. When you are finished reading, write a one- or two-paragraph summary of the section, using the underlined ideas.

**READING CHECK**

**1. Define** What is groundwater?

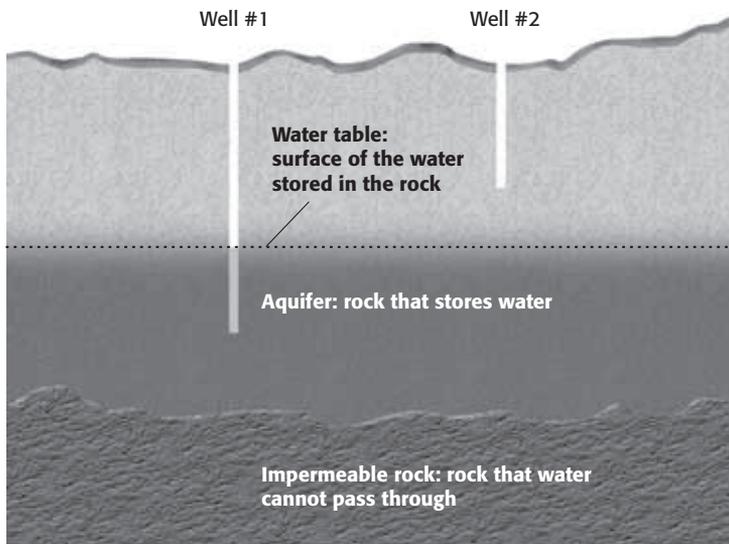
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**TAKE A LOOK**

**2. Identify** Two people drilled wells to try to get water out of the ground. The white bars in the figure show where the two people drilled their wells. Which of the wells will probably produce water? Explain your answer.

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**SECTION 3** Using Water Wisely *continued*

### Where Does Water in California Come From?

People in California get some of their water from aquifers. The shaded areas on the map below show the state's aquifers. However, the aquifers in California can't supply enough water for all the people who live there. Many of these aquifers are polluted. In others, *overdraft* occurs. That means more water is being taken out than is being replaced by rain. ✓

**READING CHECK**

**3. Explain** Why can't all of the water in California's aquifers be used for drinking?

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**TAKE A LOOK**

**4. Identify** On the map, draw an arrow showing where most of the rain in California falls. Draw another arrow showing where most of the water in California is used.

**Aquifers in California**



People in California also get their water from sources besides aquifers. Surface water, such as the water in rivers, is collected and stored in reservoirs for people to use.

In California, most of the rain falls in the area north of Sacramento. But most of the state's water is used by the people and farmland south of Sacramento. The California Aqueduct is a system of channels that is used to move water from Northern California to Southern California. Some water in California also comes from Oregon, Colorado, and Mexico. ✓

**READING CHECK**

**5. Explain** Why does California need to get some of its water from other states and countries?

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**SECTION 3** Using Water Wisely *continued*

**How Is Water in California Used?**

California is the largest producer of crops in the United States. Up to 50% of the state’s water supply is used to support the farming industry. The water supply is also used to generate power and energy for use by the state. Businesses and households use the remaining water supply.

**What Is Water Pollution?**

**Water pollution** is any waste material or harmful substance that is found in water. Water pollution can make water unsafe for organisms to live in, drink, or touch.

Most water pollution comes from the waste of cities, factories, and farms. Surface water and groundwater can become so polluted that they can kill organisms. ✓

**Where Does Water Pollution Come From?**

Water pollution can come from just one source or from many sources. Most of these sources are created by humans.

Pollution from a single place can be traced back to its source, and the problem can be corrected. However, when pollution comes from many sources, people must work together to figure out how to correct the problem.

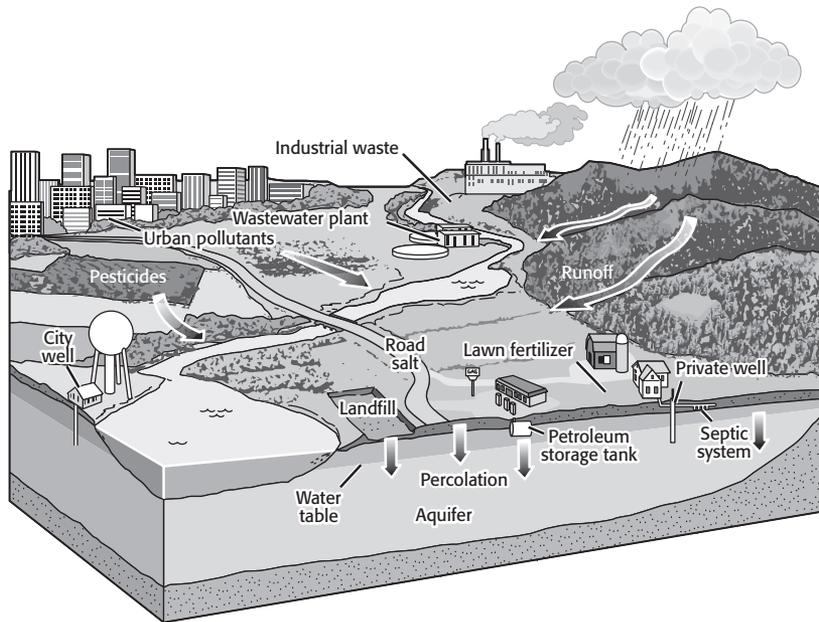
**READING CHECK**

**6. Describe** Why is water pollution harmful?

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**TAKE A LOOK**

**7. Identify** List four sources of groundwater pollution.

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**SECTION 3** Using Water Wisely *continued*

### How Do Laws Help Keep Water Clean?

In 1969, the Cuyahoga River in Cleveland, Ohio, was so polluted with oil that it caught on fire. To try to prevent such shocking events from happening again, Congress passed the Clean Water Act of 1972.



**Investigate** Learn more about one of the laws that help to protect our water supply. Share what you find out with your class or a small group.

The goal of the Clean Water Act of 1972 was to make all surface water clean enough for swimming and fishing by 1983. Although this goal was not reached, many states have passed tougher water-quality standards. The number of clean lakes and rivers has also increased.

The table below shows some of the laws that have been passed to help protect our water supply.

Name of the act	What the act did
Clean Water Act of 1972	
Marine Protection, Research, and Sanctuaries Act of 1972	strengthened laws against dumping chemicals and waste into the oceans
Drinking Water Act of 1975	helped to protect groundwater and surface water from pollution
Oil Pollution Act of 1990	required that all ships that carry oil near the United States have two layers of metal in their hulls

### TAKE A LOOK

**8. Identify** Fill in the blank box in the table to describe the Clean Water Act of 1972.

Although some of their goals have not been met, these and many other laws have improved the quality of water in the United States. However, people, businesses, and governments will have to continue to cooperate in order to maintain a clean water supply.

### How Can Water Be Conserved?

Water is a limited natural resource. There is only a certain amount of water on Earth. In order to have enough clean water, we must conserve it. **Conservation** is the protection and smart use of natural resources. Everyone can conserve water. ✓



**9. Define** What is conservation?

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When farmers water their crops, a large amount of water is lost through evaporation and runoff. Drip irrigation, in which water is placed directly on the plant's roots, loses less water. Many other industries conserve water by recycling it to be used again.

**SECTION 3** Using Water Wisely *continued*

**What Can You Do?**

Individual families can conserve water also. Toilets and shower heads that work with less water are good choices for conservation. If you have to water your lawn, water it at night and use a drip watering system.

Some people use an idea called xeriscaping. *Xeriscaping* is landscaping in a way that conserves water. This method uses plants that are local and used to the weather in an area, so they easily survive without extra water.



Each person can do his or her part to conserve water. Simple choices, such as taking shorter showers and turning off the water when you brush your teeth, are helpful. If everyone tries to conserve water, we can make a big difference.

<b>Things You Can Do to Conserve Water</b>
•
•
•
•
•

**CALIFORNIA STANDARDS CHECK**

**6.6.b** Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

**Word Help: energy**  
what makes things happen

**Word Help: resource**  
anything that can be used to take care of a need

**10. Draw Conclusions** Why is it important for people to try to conserve water?

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**TAKE A LOOK**

**11. Brainstorm** With your class, talk about ways that you can conserve water. Write down five of those ways in the table.

# Section 3 Review

6.6.b



## SECTION VOCABULARY

**aquifer** a body of rock or sediment that stores groundwater and allows the flow of groundwater

**Wordwise** the root *aqui-* means “water;” the suffix *-fer* means “to carry”

**conservation** the preservation and wise use of natural resources

**water pollution** waste matter or other material that is introduced into water and that is harmful to organisms that live in, drink, or are exposed to the water

**water table** the upper surface of underground water

**1. Explain** Why is it important to protect our water from pollution?

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**2. Analyze** Why does Northern California transport water to Southern California?

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**3. Describe** How can farmers and other industries conserve water?

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**4. Infer** How can watering your lawn at night help to conserve water?

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**5. List** What are four laws that help to protect our water supply?

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**6. Identify** Name four sources of water pollution.

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**CHAPTER 12** Exploring the Oceans

**SECTION 1** **Earth's Oceans**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What affects the salinity of ocean water?
- What affects the temperature of ocean water?
- How does density affect ocean currents?



**California Science Standards**

6.3.c, 6.4.d

**What Is the Global Ocean?**

Earth has more liquid water on its surface than any other planet in the solar system. In fact, 71% of Earth's surface is covered by liquid water. Most of Earth's water is found in its oceans. There are five main oceans on Earth. However, the oceans are all connected to each other. Therefore, scientists often refer to all the oceans on Earth as the *global ocean*.

The continents divide the global ocean into the five main oceans. The largest ocean is the *Pacific Ocean*. The *Atlantic Ocean* is the second largest ocean. It has half the volume of the Pacific Ocean. The *Indian Ocean* is the third largest ocean. The *Southern Ocean* extends from the coast of Antarctica to 60°S latitude. The *Arctic Ocean* is the smallest ocean. Much of its surface is covered by ice. The figure below shows where these oceans are found. ✓

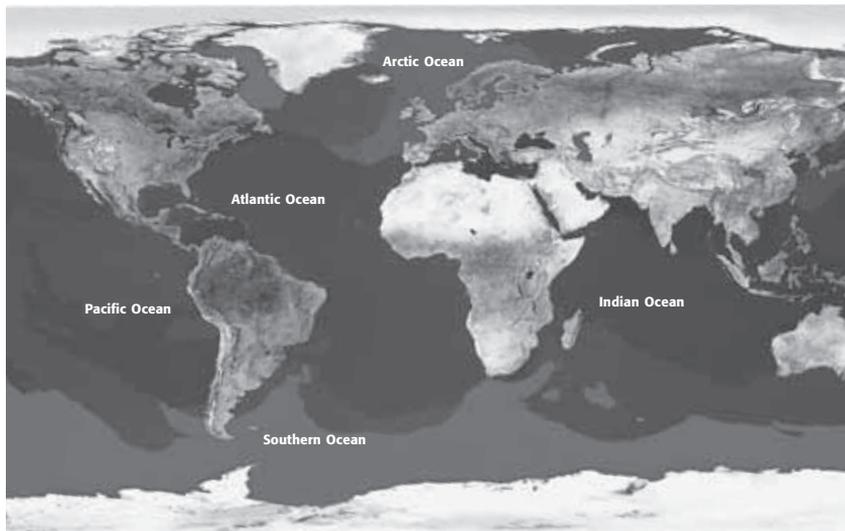
**STUDY TIP**

**Ask Questions** As you read this section, write down any questions you have. After you read, discuss your questions in a small group.

**READING CHECK**

**1. Describe** What divides the global ocean into five parts?

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**TAKE A LOOK**

**2. Identify** What are the five main oceans?

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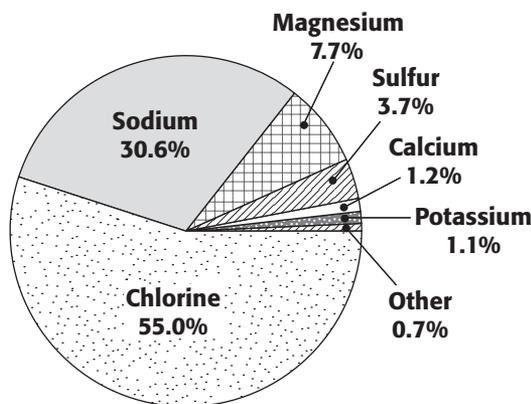
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**SECTION 1** Earth's Oceans *continued*

### Why Is Ocean Water Salty?

Ocean water is different from the water that we drink. People cannot use ocean water for drinking because it is salty.

Most of the salt in the ocean is the same kind of salt we use on our food. This type of salt is called sodium chloride. It is a compound made from the elements sodium, Na, and chlorine, Cl. Ocean water also contains other dissolved solids, including magnesium and calcium, which make the water taste salty.



This graph shows the amounts of different kinds of solids in ocean water.

### Math Focus

**3. Read a Graph** Which two elements make up most of the dissolved solids in sea water?

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Salts have collected in the ocean for billions of years. As rivers and streams flow toward the ocean, they dissolve minerals from rocks and soil. The rivers carry the dissolved minerals to the ocean. At the same time, liquid water in the oceans evaporates to form water vapor. As the water evaporates, it leaves behind the salts that were dissolved in it. ✓

**READING CHECK**

**4. Identify** Where does most of the salt in the ocean come from?

\_\_\_\_\_

\_\_\_\_\_

### What Is Salinity?

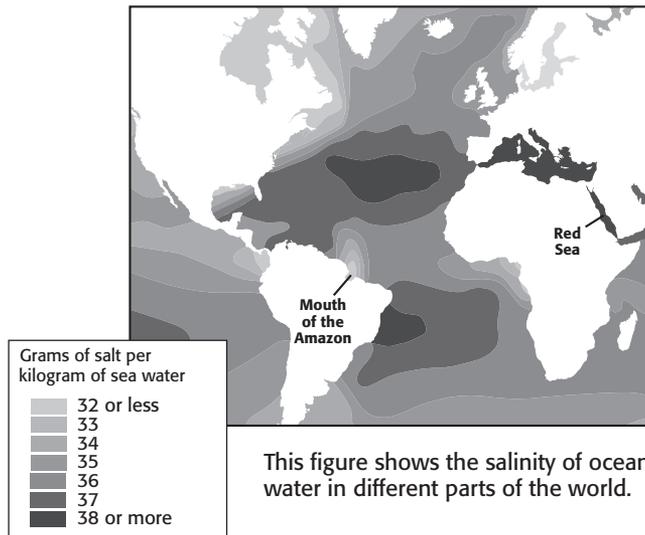
**Salinity** is a measure of the amount of solid material that is dissolved in a certain amount of liquid. It is usually measured as grams of dissolved solids per kilogram. On average, ocean water has 35 g/kg of dissolved solids in it. This means that 1 kg of ocean water has about 35 g of solids dissolved in it. If you evaporated 1 kg of ocean water, 35 g of solids would remain.

**SECTION 1** Earth's Oceans *continued*

**EFFECTS OF LOCATION ON SALINITY**

Some parts of the ocean are saltier than others. Most oceans in hot, dry climates have high salinities. In these areas, the hot weather causes water to evaporate quickly. Salt is left behind. For example, the Red Sea in the Middle East is very salty. The climate there is very hot and dry. ✓

Some parts of the ocean are less salty than others. Along the coastlines, fresh water from streams and rivers runs into the ocean. As fresh water mixes with ocean water, the salinity of the ocean water decreases. For example, the salinity of the ocean waters near the Amazon River is much lower than the salinity in other parts of the ocean.



**READING CHECK**

**5. Explain** Why do oceans in hot, dry climates tend to have high salinity?

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**TAKE A LOOK**

**6. Infer** The Gulf of Mexico is located between Mexico and Florida. Why is the ocean water in the Gulf of Mexico less salty than in other places?

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**EFFECTS OF WATER MOVEMENT ON SALINITY**

The movement of water also affects salinity. Slow-moving ocean water tends to have higher salinity than fast-moving water. Parts of the ocean with slow-moving water, such as gulfs, bays, and seas, often have high salinities. Parts of the ocean without currents are likely to have higher salinities as well. ✓

**What Affects Ocean Temperatures?**

The temperature of ocean water decreases as depth increases. However, the temperature change is not uniform. Scientists can divide the water in the ocean into three layers based on how temperature changes. These three layers are the surface zone, the thermocline, and the deep zone.

**READING CHECK**

**7. Describe** How does water movement affect salinity?

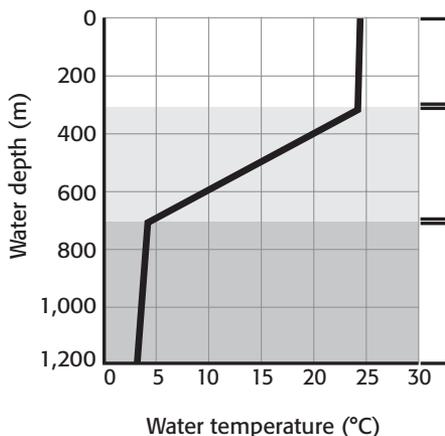
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**SECTION 1** Earth's Oceans *continued*

**Ocean Temperature and Depth**



**Surface zone** The surface zone extends to about 300 m below the surface. Sunlight heats the top 100 m. Convection currents mix the heated water with the cooler water below.

**Thermocline** The thermocline extends to between 700 m and 1,000 m below the surface. Temperature decreases quickly as depth increases.

**Deep zone** The deep zone is the deepest layer of the ocean. The temperature in the deep zone is only about 2°C.

**TAKE A LOOK**

**8. Identify** How does warm water mix with cool water in the surface zone?

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*Critical Thinking*

**9. Predict Consequences**  
 What would happen to the water temperature in the surface zone if convection currents did not form there? Explain your answer.

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 \_\_\_\_\_  
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**SURFACE ZONE**

The *surface zone* is the top layer of ocean water. It is heated by energy from the sun. As the ocean water is heated, it becomes less dense and rises above denser, cooler water. Convection currents form as the water moves. These currents can move heat within the surface zone to a depth of 100 m to 300 m. Therefore, the water temperature within the surface zone is fairly uniform.

**THERMOCLINE**

The **thermocline** is the layer of the ocean just beneath the surface zone. Within the thermocline, the temperature of the water decreases a lot as depth increases. This is because the sun cannot heat the water below the surface zone. In addition, the warm water of the surface zone cannot mix easily with the water below.

The depth of the thermocline is different in different places. It can extend from 100 m to almost 1,000 m below the surface of the ocean.

**DEEP ZONE**

The *deep zone* is the layer below the thermocline. In the deep zone, the temperature of the water is about 2°C. This very cold water is very dense. It moves slowly across the ocean floor and forms the deep ocean currents.

**SECTION 1** Earth's Oceans *continued*

**CHANGES IN SURFACE TEMPERATURE**

The temperature of water at the surface of the ocean is different in different places. Surface water along the equator is warmer than water at the poles. This is because more sunlight reaches the equator than the poles. Water near the surface at the equator can be up to 30°C. In the polar oceans, water at the surface can be as cold as -1.9°C. ✓

The temperature of water at the surface of the ocean can also change during different times of year. Many areas receive more sunlight in the summer than in the winter. In these areas, the surface water in the oceans is warmer in the summer.

**READING CHECK**

**10. Explain** Why is surface water warmer at the equator than at the poles?

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**Why Does Ocean Water Move?**

Salinity and temperature both affect the density of ocean water. The large amount of solids dissolved in ocean water make it more dense than fresh water. The higher the salinity of ocean water, the higher its density.

Temperature can have a large effect on the density of ocean water. In fact, water temperature has a larger effect on the density of ocean water than salinity does. Cold water is denser than warm water. Therefore, cold water will sink below warm water in the oceans.

The differences in density in the ocean cause water to circulate in convection currents. These currents distribute heat, water, and dissolved materials throughout the oceans.

**CALIFORNIA STANDARDS CHECK**

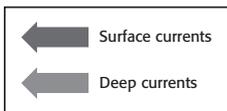
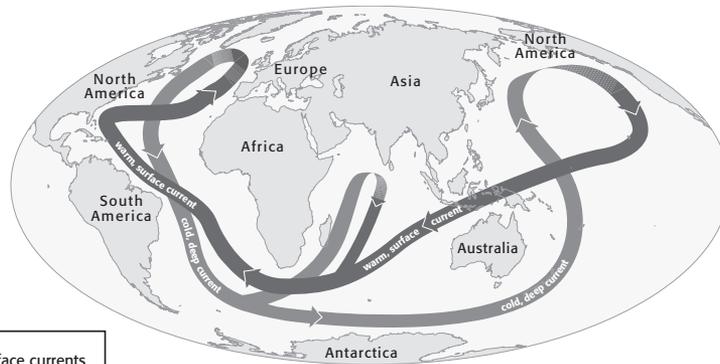
**6.4.d** Students know convection currents distribute heat in the atmosphere and oceans.

**Word Help: distribute**  
to spread out over an area

**11. Describe** How does heat move in Earth's oceans?

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The density of ocean water varies because of differences in temperature and salinity. These differences cause the water to move in currents. Cold, dense water moves from the poles toward the equator. Warm, less dense water moves from the equator to the poles. The currents move heat throughout the oceans.

# Section 1 Review

6.3.c, 6.4.d 

## SECTION VOCABULARY

**salinity** a measure of the amount of dissolved salts in a given amount of liquid

**thermocline** a layer in a body of water in which water temperature drops with increased depth faster than it does in other layers

**Wordwise** The root *therm* means “heat.” The root *clino* means “slope.” Other examples are *incline*, *decline*, and *thermometer*.

**1. Explain** Why do scientists call the ocean water on Earth the global ocean?

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**2. Identify** What are two factors that can affect salinity?

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**3. Identify Relationships** How does salinity affect the density of ocean water?

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**4. Explain** Why does the temperature in the thermocline decrease quickly with depth?

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**5. Describe** How do temperature and salinity differences produce convection currents?

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**6. List** What are the three temperature layers of ocean water?

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**CHAPTER 12** Exploring the Oceans

**SECTION 2** **The Ocean Floor**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the features of the ocean floor?
- How do the features of the ocean floor form?



**California Science Standards**

6.1.a, 6.1.d, 6.1.e

**How Do Scientists Study the Ocean Floor?**

The ocean floor can be as far as 11,000 m below the surface of the ocean. People cannot survive at such great depths without a lot of special equipment. Scientists sometimes use such equipment to travel to the ocean floor. However, scientists can also study the ocean floor from the surface of the ocean. They can even study the ocean floor from outer space!



**Compare** As you read, make a chart showing the similarities and differences between the different ways that scientists study the ocean floor.

**STUDYING THE OCEAN FLOOR WITH SONAR**

*Sonar* stands for **sound navigation and ranging**. Sonar instruments on a ship send pulses of sound down into the ocean. The sound moves through the water, bounces off the ocean floor, and returns to the ship. The deeper the water, the longer it takes for the sound to return to the ship. ✓

Scientists use sonar to determine how deep the ocean floor is. They know how fast sound travels in ocean water (about 1,500 m/s). They measure how long it takes for the sound to return to the ship. Then, they use this information to figure out how deep the ocean floor is.



**1. Identify** What is sonar?

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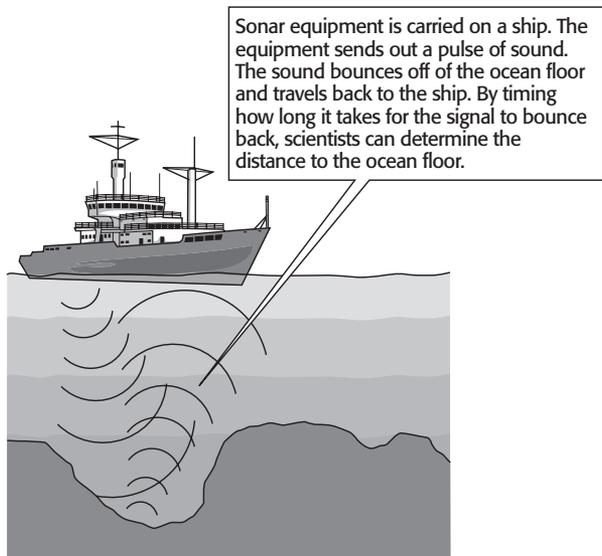
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**Math Focus**

**2. Calculate** The ship sends out a sonar signal. It picks up the return signal 4 s later. About how deep is the ocean floor? The speed of sound in ocean water is about 1,500 m/s. Show your work.

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**SECTION 2** The Ocean Floor *continued*

**STUDYING THE OCEAN FLOOR WITH SHIPS**

People cannot survive the high pressures on the ocean floor. Therefore, in order to explore the deep zone, scientists had to build an underwater vessel that can survive under high pressures. This vessel is called *Deep Flight*. Future models of *Deep Flight* may be able to carry scientists to 11,000 m below the ocean’s surface. ✓

Scientists can also use Remotely Operated Vehicles, or ROVs, to explore the ocean floor directly. These ROVs can explore parts of the ocean floor that are too dangerous for people to travel to.

**READING CHECK**

**3. Explain** Why did scientists have to build a special ship to explore the deep zone?

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*Critical Thinking*

**4. Infer** The *Deep Flight* and other deep-ocean vessels have very thick windows and walls. Why do you think this is?

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The *Deep Flight* is a vessel that can carry scientists deep beneath the ocean surface.

**STUDYING THE OCEAN FLOOR BY DRILLING**

Scientists involved in the Integrated Ocean Drilling Program (IODP) use drilling to study the ocean floor. Scientists use special equipment to cut cores, or long tubes of rock and sediment, from the ocean floor. The layers of rock and sediment in the cores can tell scientists about the history of Earth. ✓

**READING CHECK**

**5. Describe** How do scientists in the IODP study the ocean floor?

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**STUDYING THE OCEAN FLOOR USING SATELLITES**

*Geosat* was once a top-secret military satellite. Today, scientists use *Geosat* to study the ocean floor indirectly. Underwater features, such as mountains and trenches, affect the height of the ocean surface. Scientists can use *Geosat* to measure the height of the water on the ocean surface. They can use these measurements to make detailed maps of the ocean floor.

**SECTION 2** The Ocean Floor *continued*

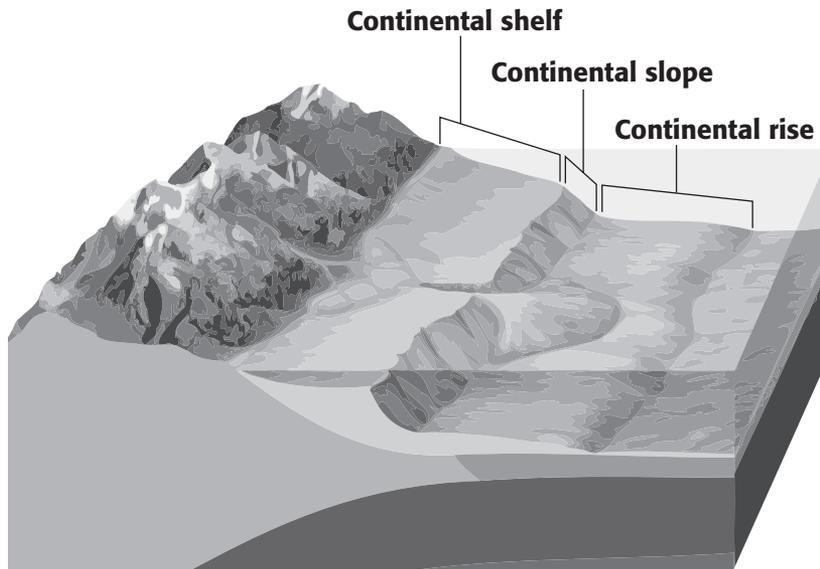
**What Are the Features of the Ocean Floor?**

Because most of the ocean floor is covered by kilometers of water, it has not been thoroughly explored. However, scientists do know that many of the features of the ocean floor are caused by plate tectonics.

**THE MAJOR REGIONS OF THE OCEAN FLOOR**

Scientists divide the ocean floor into two major regions: the continental margin and the deep-ocean basin. The *continental margin* is the edge of a continent that is covered by ocean water. The *deep-ocean basin* begins at the edge of the continental margin and extends under the deepest parts of the ocean. ✓

There are three main parts of the continental margin: the continental shelf, the continental slope, and the continental rise. The figure below shows where these parts are found.



The deep-ocean basin includes the abyssal plain, mid-ocean ridges, and ocean trenches. The **abyssal plain** is the flat, almost level part of the ocean basin. The abyssal plain is covered by layers of sediment. Some of the sediment comes from land. Some of it is made of the remains of dead sea creatures. These remains settle to the ocean floor when the creatures die.

**READING CHECK**

**6. Identify** What are the two major regions of the ocean floor?

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**TAKE A LOOK**

**7. Arrange** Write the names of the three parts of the continental margin in order from shallowest to deepest.

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**SECTION 2** The Ocean Floor *continued*

**PLATE TECTONICS AND OCEAN FLOOR FEATURES**

Convection within Earth causes tectonic plates to move. When the plates touch, they can slide past each other, collide with each other, or move away from each other. Remember that the movement of tectonic plates creates features, such as mountains, on land. Tectonic movements can also form features on the ocean floor. These features include seamounts, mid-ocean ridges, and ocean trenches.

**CALIFORNIA STANDARDS CHECK**

**6.1.e** Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.

**Word Help: major**  
of great importance or large scale

**8. Infer** What would the ocean floor look like if plate tectonics did not happen?

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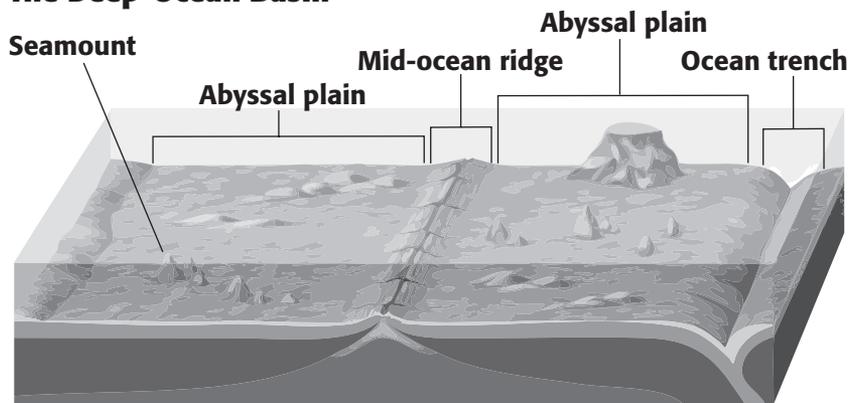


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**The Deep-Ocean Basin**



**SEAMOUNTS**

A volcanic mountain on the ocean floor is called a *seamount*. Some seamounts form when magma pushes its way between tectonic plates and erupts to form a mountain. Other seamounts form far away from the edges of tectonic plates. These areas are called *hot spots*. At these locations, magma rises from within Earth and breaks through a tectonic plate. ✓

As lava continues to erupt at a seamount, the mountain gets taller. If it gets tall enough to rise above the ocean's surface, it is called a volcanic island. The islands of the state of Hawaii are volcanic islands.

**READING CHECK**

**9. Define** What is a seamount?

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**SECTION 2** The Ocean Floor *continued*

**MID-OCEAN RIDGES**

A long mountain chain that forms on the floor of the ocean is a **mid-ocean ridge**. Mid-ocean ridges form where tectonic plates move apart. This motion produces a crack in the ocean floor called a *rift*. Magma rises through the rift and cools to form new rock. The ridge is built up from this new rock. ✓

Most mid-ocean ridges are far below the ocean surface. However, Iceland is one place on Earth where the mid-ocean ridge has risen above the ocean’s surface.

 **READING CHECK**

**10. Identify** Where do mid-ocean ridges form?

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**OCEAN TRENCHES**

Long, narrow valleys in the deep-ocean basins are called **ocean trenches**. Trenches form where tectonic plates are moving together. As the plates move toward each other, one plate sinks under the other plate in a process called *subduction*. ✓

Subduction causes pressure to increase on the plate that is sinking. Water and other fluids are squeezed out of the rock and sediments on this plate. These fluids cause mantle rock to melt and form magma. The magma rises to the surface and erupts to form a chain of volcanoes.

Ocean trenches are some of the deepest places on Earth. For example, the Marianas Trench in the Pacific Ocean is nearly 11,000 m deep.

 **READING CHECK**

**11. Define** Write your own definition for *ocean trench*.

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Feature	What it is	Where it is found
Seamount		
	flat part of the ocean basin, covered in sediment	in the deep-ocean basins
		where plates move apart
Ocean trench	long, narrow valley on the ocean floor	

**TAKE A LOOK**

**12. Describe** Fill in the table to compare the different features of the ocean floor.

# Section 2 Review

6.1.a, 6.1.d, 6.1.e



## SECTION VOCABULARY

**abyssal plain** a large, flat, almost level area of the deep-ocean basin

**mid-ocean ridge** a long, undersea mountain chain that forms along the floor of the major oceans

**ocean trench** a long, narrow, and steep depression on the ocean floor that forms when one tectonic plate subducts beneath another plate; trenches run parallel to volcanic island chains or to the coastlines of continents; also called a trench or a deep-ocean trench

**1. List** Name four ways that scientists study the ocean floor.

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**2. Describe** How do plate movements form ocean trenches?

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**3. Identify** Where does the sediment on the abyssal plain come from? Give two sources.

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**4. Explain** How do mid-ocean ridges form?

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**5. Explain** How can scientists map the ocean floor using the satellite *Geosat*?

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SECTION 3 Resources from the Ocean

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the living resources from the ocean?
- What are the nonliving resources from the ocean?



**California Science Standards**

6.6.a, 6.6.b, 6.6.c

**What Are the Living Resources of the Ocean?**

People have been harvesting plants and animals from the ocean for thousands of years. Today, harvesting food from the ocean is a multi-billion-dollar industry. As the population of humans on Earth has grown, the demand for these resources has increased. However, the availability of these resources has not increased as much.

Harvesting fish from the ocean can harm the environment. Usually, fish can reproduce faster than people can catch them. However, new technology, such as drift nets, has allowed people to catch more fish in less time. This may allow people to take fish faster than they can reproduce. This could cause the population of fish in the oceans to decrease. Also, other animals, such as dolphins and turtles, can be caught in fishing nets.

Recently, laws have been passed that regulate fishing more strictly. These laws are designed to help reduce the amount of damage fishing causes to the environment. As a result of these laws, people have begun to raise fish and other types of seafood, such as shellfish and seaweed, in farms near the shore.



New technology, such as these drift nets, allows people to catch more fish in less time. However, other animals, such as dolphins and turtles, can sometimes get caught in the nets.



**Summarize** As you read, make a chart describing the resources that people use from the ocean.



**CALIFORNIA STANDARDS CHECK**

**6.6.b** Students know different natural energy and material resources, including air, soil, rocks, minerals, petroleum, fresh water, wildlife, and forests, and know how to classify them as renewable or nonrenewable.

**Word Help: resource** anything that can be used to take care of a need

**1. Explain** Why can fish be considered to be a renewable resource? When would fish not be considered a renewable resource?

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**SECTION 3** Resources from the Ocean *continued*

## What Are the Nonliving Resources of the Ocean?

Fish and other seafood are important resources that people take from the oceans. However, people also take many nonliving resources from the oceans. These resources include energy resources and material resources.

### FRESH WATER

Fresh water is often considered a renewable resource. However, in parts of the world where the climate is dry, fresh water is limited. In these parts of the world, ocean water is desalinated to provide fresh drinking water. **Desalination** is the process of removing salt from sea water. ✓

Most desalination plants heat ocean water to cause the water to evaporate. The water vapor, which is not salty, is collected and condensed into liquid fresh water. Another method of desalination involves passing the ocean water through a membrane to leave the salts behind. However, no matter what process is used, desalination is expensive and can be slow.

✓ **READING CHECK**

**2. Define** What is desalination?

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## Critical Thinking

**3. Infer** Why can't tidal energy be used everywhere?

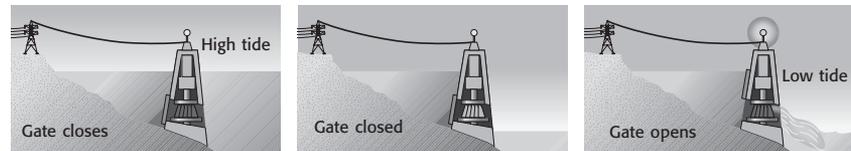
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### TIDAL ENERGY

The ocean is constantly moving as tides come in and go out. People can use the motion of the water to generate electricity. Energy that is generated from the movement of tides is called *tidal energy*. Tidal energy is clean, inexpensive, and renewable. However, it can only be used in certain parts of the world.



- 1 As the tide rises, water enters a bay behind a dam. The gate closes when high tide reaches its peak.
- 2 The gate remains closed as the tide falls.
- 3 At low tide, the gate opens, and water rushes through the dam. The water moves turbines, which generate electricity.

### TAKE A LOOK

**4. Explain** Why is tidal energy considered to be renewable?

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**SECTION 3** Resources from the Ocean *continued***OIL AND NATURAL GAS**

Oil and natural gas are considered the most valuable resources in the ocean. Oil and natural gas form from the remains of tiny plants and animals. These remains take millions of years to turn into oil and natural gas. Therefore, oil and gas are nonrenewable resources.

Many deposits of oil and natural gas are found in rock near the continental margins. In order to obtain these resources, engineers must drill wells through the rock. About one-fourth of the world's oil is now obtained from wells in rock beneath the oceans.

Oil is refined by manufacturers to make gasoline. Gasoline powers vehicles and generators that make electricity. Oil is also used to make plastic and other products. ✓

**MINERALS**

Many different kinds of minerals can be found on the ocean floor. These minerals are commonly in the form of nodules. *Nodules* are potato-shaped lumps of minerals that form from chemicals dissolved in ocean water.

Nodules can be made of many different kinds of minerals. Most nodules contain the element manganese. Manganese can be used to make certain kinds of steel. Some nodules contain the valuable metals iron, copper, nickel, or cobalt. Some contain phosphorus, which can be used in fertilizer.

Nodules can be very large. They may contain a large amount of valuable minerals. However, they form in the very deep parts of the ocean. For this reason, they are difficult to mine. ✓



Minerals can be found on the ocean floor in the form of nodules. These nodules are difficult to mine because they are found in very deep water.



**Discuss** In a small group, talk about different ways that you use resources from the ocean every day.



**5. List** Give two ways that people use oil or natural gas.

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**6. Explain** Why are nodules hard to mine?

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# Section 3 Review

6.6.a, 6.6.b, 6.6.c



## SECTION VOCABULARY

<b>desalination</b> a process of removing salt from ocean water	
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1. **List** Name two living resources from the ocean.

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2. **Define** Write your own definition for desalination.

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3. **Describe** How can the tides can be used to generate electricity?

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4. **Identify** Give five minerals that may be found in nodules.

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5. **List** Give four nonliving ocean resources.

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6. **Infer** Why are people starting to farm the oceans instead of harvesting wild organisms?

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SECTION 4 **Ocean Pollution**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the different types of pollution in the ocean?
- How can we preserve ocean resources?



California Science Standards

6.6.a

**What Pollutes the Ocean?**

Many human activities produce pollution that can harm the oceans. Some of this pollution comes from a specific source. Pollution that can be traced to one source is called **point-source pollution**. However, some pollution comes from many sources. Pollution that cannot be traced to a single source is called **nonpoint-source pollution**. ✓



**Summarize** As you read, underline the main ideas in each paragraph. When you finish reading, write a short summary of the section using the ideas you underlined.

**TRASH DUMPING**

People dump trash in many places, including the ocean. In the 1980s, scientists became alarmed by the kinds of trash that were washing up on beaches. Bandages, vials of blood, and other medical wastes were found among the trash.

The Environmental Protection Agency (EPA) found that hospitals in the United States were dumping medical wastes into the oceans. Much of this waste is now buried in sanitary landfills. However, dumping trash in the ocean is still common in many countries.

Trash thrown into the ocean can affect the organisms that live there. It also affects the organisms, such as people, that depend on the ocean for food. For example, most plastic material that is thrown into the ocean does not break down for thousands of years. Animals can mistake plastic material for food and choke on it.



**1. Define** Write your own definition for nonpoint-source pollution.

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Marine animals, such as this bird, can choke on plastic trash that is thrown into the oceans.

**TAKE A LOOK**

**2. Describe** How can trash harm the organisms that live in the oceans? Give two ways.

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**SECTION 4** Ocean Pollution *continued*

**SLUDGE DUMPING**

*Raw sewage* is all of the liquid and solid wastes that are flushed down toilets and poured down drains. In most places, raw sewage is collected and sent to a treatment plant. The treatment removes solid waste and cleans the raw sewage. The solid waste that remains is called *sludge*. ✓

In many places, people dump sludge into the ocean. Currents can stir up the sludge and move it closer to shore. The sludge can pollute beaches and kill ocean life. Many countries have banned sludge dumping. However, it still happens in many parts of the world.

✓ **READING CHECK**

**3. Compare** How is raw sewage different from sludge?

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**OIL SPILLS**

Oil is used by most of the world as an energy source. However, oil is only found in certain places around the world. Therefore, large tankers must transport billions of barrels of oil across the oceans. Sometimes, the tankers break open and the oil spills out of them.

Oil spills can cause many problems for the environment. Oil is poisonous to plants and animals. It is also very hard to clean up oil spills, so their effects can last for a long time. ✓

In 1990, the Oil Pollution Act was passed. This law states that all oil tankers that travel in United States waters must have two hulls. If the outer hull of a ship is damaged, the inner hull can keep oil from spilling into the ocean.

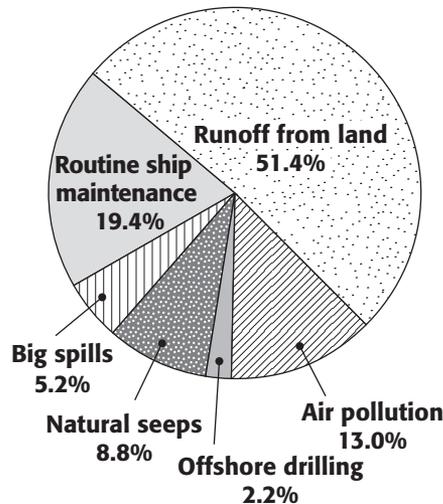
The Oil Pollution Act may help to prevent large oil spills. However, as the figure below shows, big spills only cause about 5% of the oil pollution in the ocean. Most of the oil in the ocean comes from nonpoint-source pollution on land.

✓ **READING CHECK**

**4. Explain** Why can the effects of an oil spill last a long time?

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**Math Focus**

**5. Read a Graph** What are the three largest sources of oil pollution in the oceans?

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**SECTION 4** Ocean Pollution *continued*

**NONPOINT-SOURCE POLLUTION**

Nonpoint-source pollution is pollution that comes from many sources instead of a single place. Most ocean pollution is nonpoint-source pollution. Things that people do on land can pollute rivers. The rivers can carry the pollution into the oceans. ✓

Nonpoint-source pollution is hard to control because it enters the water in many different ways. However, there are things that people can do to help reduce nonpoint-source pollution. For example, we can throw away chemicals, such as used motor oil, properly instead of washing them down the drain.

**READING CHECK**

**6. Explain** How can human activities on land cause ocean pollution?

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Oil and gasoline can leak out of cars and trucks and onto the streets. Rain can wash the oil and gasoline into rivers, which carry them to the oceans.



Boats and other watercraft can leak oil, gasoline, and other chemicals into the water.



People use chemicals to help their lawns grow. Rain can wash the chemicals into rivers, which carry them to the oceans.

**TAKE A LOOK**

**7. Identify** Give three examples of nonpoint-source pollution.

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**How Can We Protect Our Ocean Resources?**

People have begun to take steps to save and protect our ocean resources. From international treaties to volunteer cleanups, efforts to conserve and protect ocean resources are making a difference around the world.

**SECTION 4** Ocean Pollution *continued*

### Critical Thinking

**8. Infer** Why do countries need to work together to reduce ocean pollution?

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### NATIONS TAKE NOTICE

In the 1970s and 1980s, ocean pollution was very bad. Many countries realized that they would need to work together to reduce ocean pollution. In 1989, 64 countries signed a treaty that bans the dumping of many harmful materials into the ocean.

Many other treaties and laws have also been passed to help protect the oceans. For example, Congress passed the Clean Water Act in 1972. This law gave the Environmental Protection Agency more control over the trash that is dumped into the ocean.

Another law, the U.S. Marine Protection, Research, and Sanctuaries Act, was also passed in 1972. This law forbids people from dumping harmful materials into the oceans. These laws have helped to reduce the pollution entering the oceans. However, waste dumping and oil spills still happen.

### CITIZENS TAKE CHARGE

Citizens of many different countries have demanded that their governments do more to prevent ocean pollution. They have also begun to take the matter into their own hands. For example, people began to organize beach cleanups. Millions of tons of trash have been gathered from beaches. Also, people are helping to spread the word about the problems with dumping wastes into the oceans.

**READING CHECK**

**9. Explain** How can individual people help to reduce ocean pollution?

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During a beach cleanup, many people work together to remove trash from a beach. This helps make the beach safer for people, other animals, and plants.

# Section 4 Review

6.6.a



## SECTION VOCABULARY

**nonpoint-source pollution** pollution that comes from many sources rather than from a single, specific site

**point-source pollution** pollution that comes from a specific site

**1. Compare** How is point-source pollution different from nonpoint-source pollution?

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**2. Describe** Fill in the table below to describe different sources of ocean pollution.

Type of pollution	Description
Trash dumping	
Oil spills	
Chemical leaks	

**3. Infer** Most of the trash in the United States is buried instead of being dumped into the oceans. However, there is still trash in the oceans. Why is this?

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**4. Identify** What type of pollution is most ocean pollution?

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**5. Describe** Why is nonpoint-source pollution hard to control?

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**6. List** Give two United States laws that protect ocean resources.

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CHAPTER 13 The Movement of Ocean Water

SECTION 1 **Currents**



California Science Standards

6.3.c, 6.4.a, 6.4.d

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What factors affect ocean currents?
- Why are ocean currents important?

**STUDY TIP**

**Summarize** As you read, make a diagram showing the types of ocean currents and the factors that affect them.

**What Are Surface Currents?**

Imagine that you are stranded on an island. You write a note and put it into a bottle. You throw the bottle into the ocean to communicate with the outside world. Can you predict where the bottle will end up? If you understand ocean currents, you can! The oceans contain many streamlike movements of water called *ocean currents*. There are two main kinds of ocean currents: surface currents and deep currents.

**Surface currents** are horizontal, streamlike movements of water that are found at or near the surface of the ocean. Surface currents can be up to several hundred meters deep. They can be as long as several thousand kilometers. Three factors affect surface currents: global winds, the Coriolis effect, and continental deflections. ✓

**READING CHECK**

**1. Define** Write your own definition for *surface current*.

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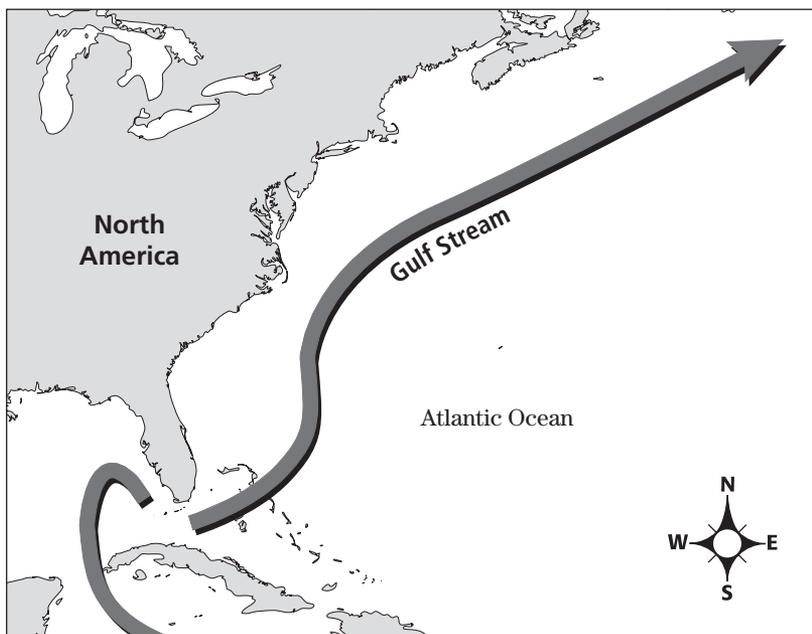
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**TAKE A LOOK**

**2. Read a Map** In what direction does the Gulf Stream flow?

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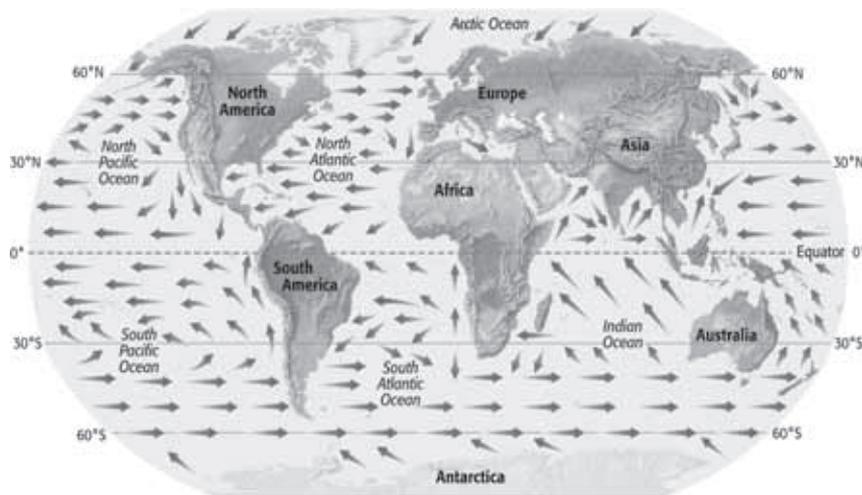
The Gulf Stream is one of the largest surface currents in the world. Every year, it transports at least 25 times as much water as all of the rivers on Earth combined!

**SECTION 1** Currents *continued*

**GLOBAL WINDS**

Have you ever blown across a bowl of hot soup? You may have noticed that your breath pushes the soup across the surface of the bowl. In much the same way, winds that blow across the surface of Earth’s oceans push water across Earth’s surface. This process causes surface currents in the ocean. ✓

Many winds blow across Earth’s surface, but they do not all blow in the same direction. Near the equator, the winds blow mostly east to west. Between 30° and 60° north and south latitudes, the winds blow mostly west to east.



Winds are important in producing surface currents. The winds near Earth’s surface do not all blow in the same direction.

The sun causes winds to blow, and winds cause surface currents to form. Therefore, the major source of the energy that powers surface currents is the sun. The sun heats air near the equator more than it heats air at other latitudes. As a result, the air near the equator is warmer and less dense than the surrounding air. The warm air rises and produces an area of low pressure. Cooler air rushes into this area of low pressure, producing wind.

**CONTINENTAL DEFLECTIONS**

If Earth’s surface were covered only with water, surface currents would travel across the oceans in a uniform pattern. However, water does not cover all of Earth’s surface. Continents cover about one-third of Earth’s surface. When surface currents meet continents, the currents *deflect*, or change direction. The figure on the top of the next page shows this process.

**READING CHECK**

**3. Explain** How do winds cause surface currents?

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	<p><b>CALIFORNIA STANDARDS CHECK</b></p>
<p><b>6.4.a</b> Students know the sun is the major source of energy for phenomena on Earth’s surface; it powers winds, ocean currents, and the water cycle.</p>	
<p><b>Word Help: major</b> of great importance or large scale</p>	
<p><b>Word Help: source</b> the thing from which something else comes</p>	
<p><b>Word Help: energy</b> what makes things happen</p>	
<p><b>Word Help: phenomenon</b> (plural, <i>phenomena</i>) any facts or events that can be sensed or described scientifically</p>	
<p><b>4. Explain</b> How does the sun power surface currents?</p>	
<p>_____</p> <p>_____</p> <p>_____</p>	

**SECTION 1** Currents *continued*

**TAKE A LOOK**

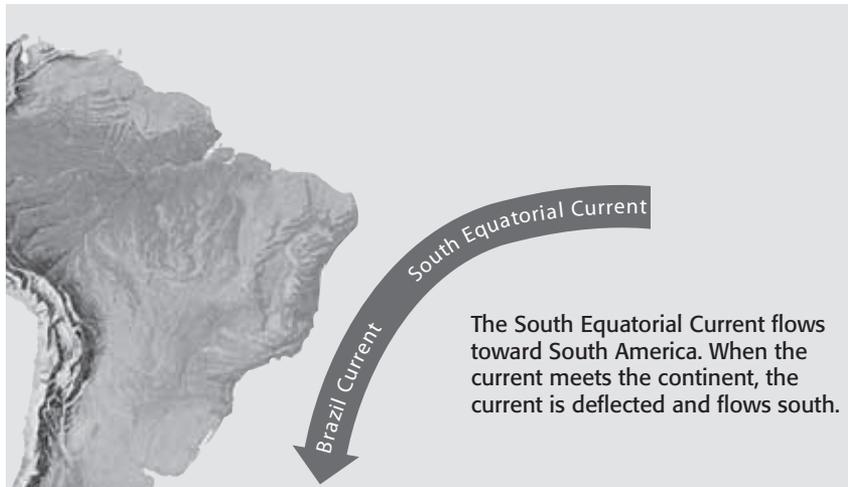
**5. Predict Consequences**

What would probably happen to the South Equatorial Current if South America were not there?

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**THE CORIOLIS EFFECT**

Earth's rotation also affects the paths of surface currents. If Earth did not rotate, surface currents would flow in straight lines. However, because Earth does rotate, the currents travel along curved paths. This deflection of moving objects from a straight path because of Earth's rotation is called the **Coriolis effect**.

**READING CHECK**

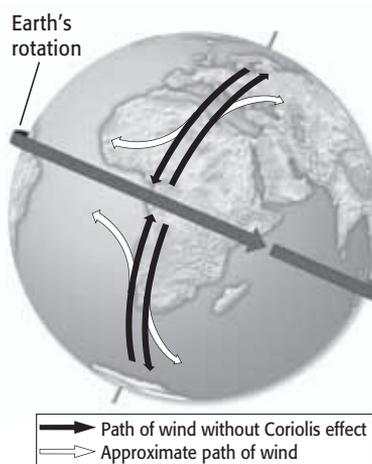
**6. Describe** How does Earth's rotation affect the paths of surface currents?

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As Earth rotates, places near the equator travel faster than places closer to the poles. This difference in speed causes the Coriolis effect. Wind or water moving from the poles to the equator is deflected to the west. Wind or water moving from the equator to the poles is deflected east. The figure below shows examples of these paths.



The Coriolis effect causes wind and water to move along curved paths.

**TAKE A LOOK**

**7. Apply Concepts**

A surface current starts at the equator near the west coast of Africa and begins moving north. In which direction will the current end up moving?

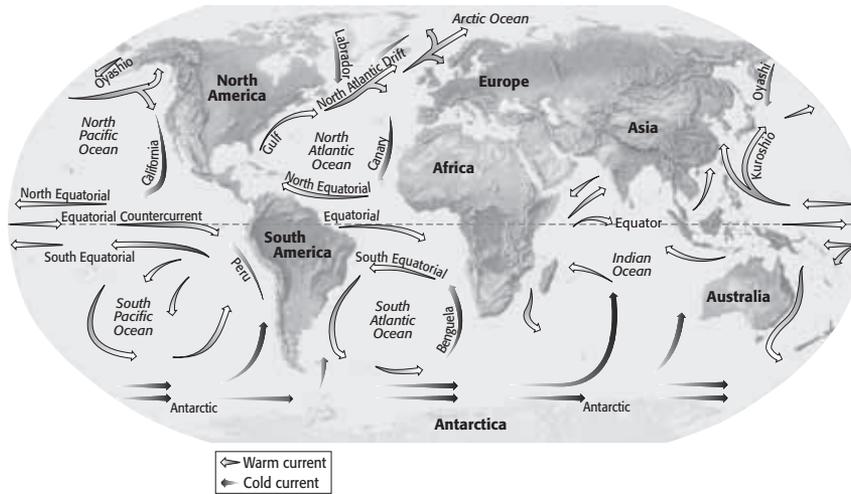
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The Coriolis effect is most noticeable for objects that travel very fast or travel over long distances. Over short distances or with slow moving objects, the rotation of the Earth does not make much of a difference.

**SECTION 1** Currents *continued*

**HOW SURFACE CURRENTS DISTRIBUTE HEAT**

Surface currents help to move heat from one part of Earth to another. Water near the equator absorbs heat energy from the sun. Then, warm-water currents carry the heat from the equator to other parts of the ocean. The heat from the warm-water currents moves into colder water or into the atmosphere. This transfer of energy through the movement of matter is called *convection*.



This map shows Earth’s major surface currents. Surface currents help to distribute heat across Earth’s surface.

**TAKE A LOOK**

**8. Identify** Which surface current carries warm water along the equator toward the west coast of South America?

\_\_\_\_\_

**What Are Deep Currents?**

Not all ocean currents are found at the surface. Movements of ocean water far below the surface are called **deep currents**. Unlike surface currents, deep currents are not controlled by wind. The movements of deep currents are controlled by differences in water density. ✓

*Density* is the amount of matter in a given space or volume. The density of ocean water is affected by salinity and temperature. *Salinity* is a measure of the amount of salts or solids dissolved in a liquid. Water with a high salinity is denser than water with a low salinity. Cold water is denser than warm water.

**READING CHECK**

**9. Compare** How are deep currents different from surface currents? Give two ways.

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**SECTION 1** Currents *continued*

### Critical Thinking

**10. Infer** Why do most deep currents form near the poles?

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### HOW DEEP CURRENTS FORM

Deep currents form when the density of ocean water increases, causing it to sink toward the bottom of the ocean. There are three main ways that the density of ocean water can increase.

- Temperature can decrease when heat moves from warm water to cold air or water.
- Salinity can increase when ocean water freezes.
- Salinity can increase when ocean water evaporates.

The figure below shows how these three processes can affect density.

### TAKE A LOOK

**11. Explain** How does freezing cause ocean water to become denser?

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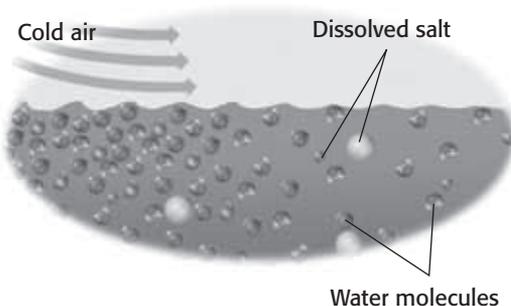
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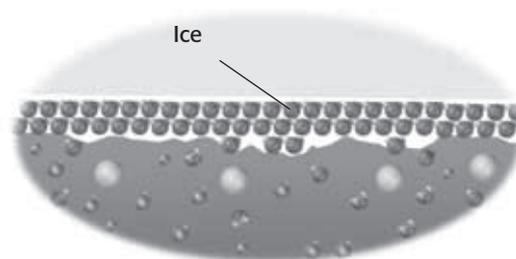
#### Decreasing Temperature

Near the poles, heat moves from ocean water into the colder air. The water becomes colder. The particles in the water slow down and move closer together. The volume of the water decreases, which makes the water denser.



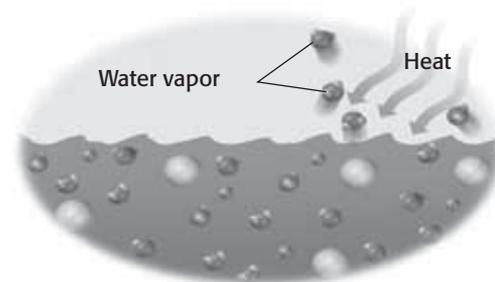
#### Increasing Salinity Through Freezing

When ocean water freezes, the salt in the ocean water does not become part of the ice. The salt remains in the water that has not frozen. This process increases the salinity of the water, and the water becomes denser.



#### Increasing Salinity Through Evaporation

When ocean water evaporates, the salt in the water remains in the liquid. This process increases the salinity of the water, and the water becomes denser.

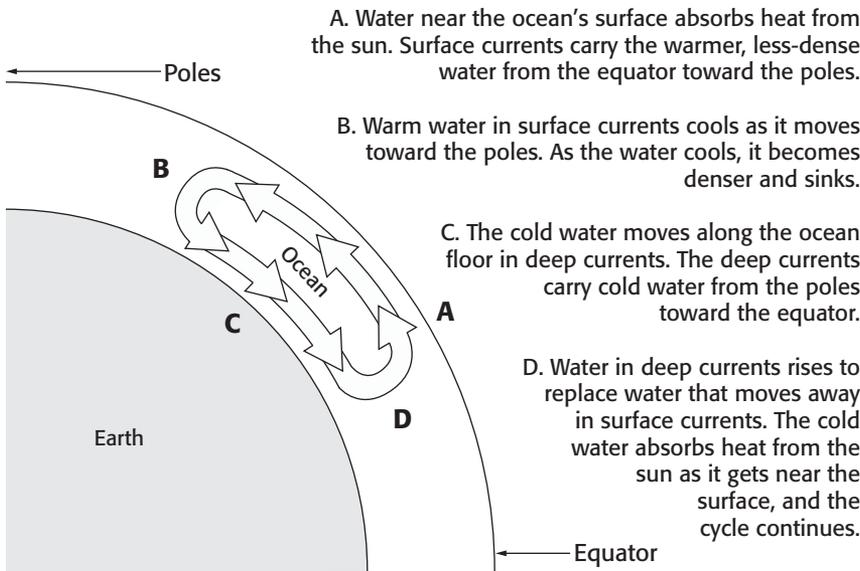


There are several main deep currents in the ocean. The deepest and densest water in the ocean is the Antarctic Bottom Water, which forms near Antarctica. North Atlantic Deep Water is less dense and forms in the North Atlantic Ocean. Water that is less dense stays above denser water. Therefore, North Atlantic Deep Water stays on top of Antarctic Bottom Water when the two meet.

**SECTION 1** Currents *continued*

## How Do Convection Currents Affect Earth?

Remember that convection is the transfer of heat as matter moves. Both surface currents and deep currents transfer energy. Therefore, they are also called **convection currents**. Convection currents carry heat from the equator toward the poles. The figure below shows a model of how convection currents work.



**CALIFORNIA STANDARDS CHECK**

**6.4.d** Students know convection currents **distribute** heat in the atmosphere and oceans.

**Word Help:** **distribute** to spread out over an area

**12. Explain** Why are surface and deep currents considered convection currents?

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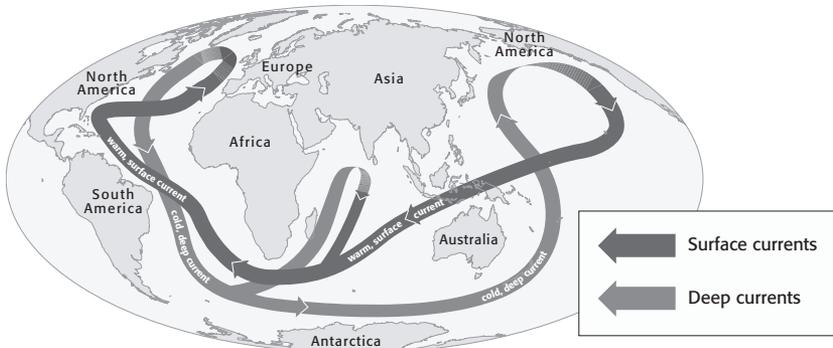
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## Why Are Ocean Currents Important?

Deep currents and surface currents are like highways that molecules of water travel on. However, currents carry more than just water around Earth. Materials in the water also move within currents.

Remember that convection currents carry heat throughout the oceans. Ocean currents also carry oxygen and nutrients. Deep currents transport oxygen from the surface to the deep ocean. As water rises to the surface, nutrients from deep in the ocean are brought to the surface along with the water.



This map shows the main paths of global ocean circulation.

## TAKE A LOOK

**13. Identify** Name three things that ocean currents transport.

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# Section 1 Review

6.3.c, 6.4.a, 6.4.d



## SECTION VOCABULARY

**convection current** any movement of matter that results from differences in density; may be vertical, circular, or cyclical

**Coriolis effect** the curving of the path of a moving object from an otherwise straight path due to the Earth's rotation

**deep current** a streamlike movement of ocean water far below the surface

**surface current** a horizontal movement of ocean water that is caused by wind and that occurs at or near the ocean's surface

**1. Define** Write your own definition for *convection current*.

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**2. Identify** What is the main source of power for surface currents in the ocean?

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**3. List** Give three ways that the density of ocean water can increase.

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**4. Describe** What are three factors that control the path that a surface current may take?

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**5. Infer** Deep currents carry oxygen from the surface to the deep ocean. What is the most likely reason that there is more oxygen in water near the surface?

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**6. Predict Consequences** If there were no continents on Earth, what paths would the ocean's surface currents take? Explain your answer.

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**CHAPTER 13** The Movement of Ocean Water

**SECTION 2** **Currents and Climate**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do surface currents affect climate?
- How do changes in surface currents affect climate?



**California Science Standards**

6.4.e

**How Do Surface Currents Affect Earth?**

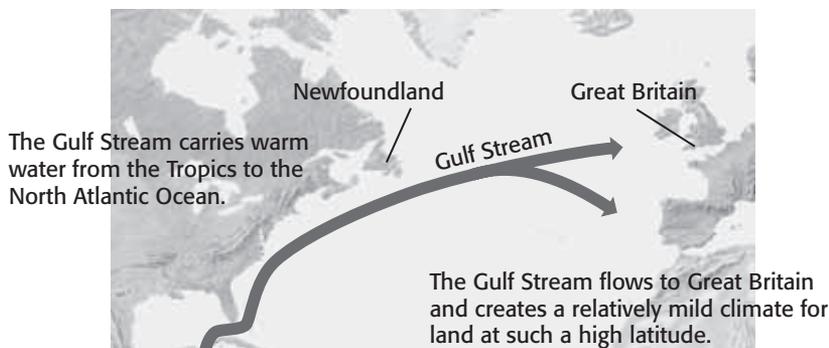
Surface currents can have a large impact on climate. The temperature of the water at the surface of the ocean affects the air above it. Warm water can heat air and produce warmer air temperatures. Cold water can absorb heat and produce cooler air temperatures.



**Summarize in Pairs** Read this section quietly to yourself. Then, talk about the section with a partner. Together, try to answer any questions that you have.

**WARM-WATER CURRENTS AND CLIMATE**

Surface currents can make coastal areas warmer than inland areas at the same latitude. For example, Great Britain and Newfoundland, Canada, are located at about the same latitude. However, the Gulf Stream flows close to Great Britain. The warm water of the Gulf Stream warms the air around Great Britain. As a result, Great Britain has a milder climate than Newfoundland.



**TAKE A LOOK**

**1. Explain** Why is Great Britain's climate milder than Newfoundland's?

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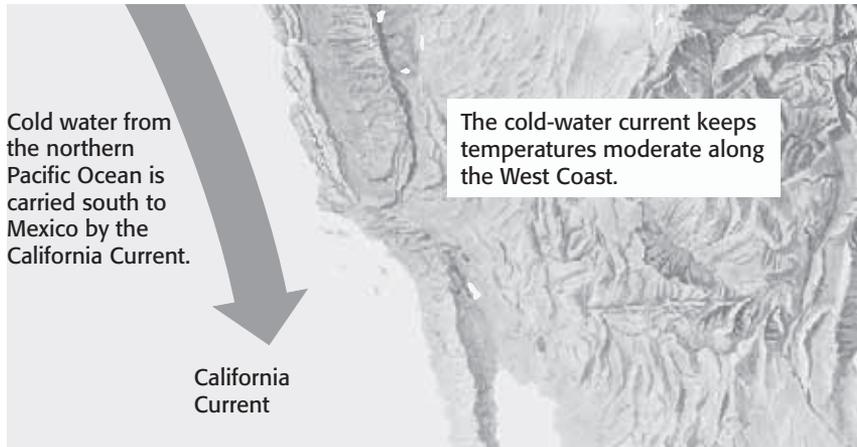
**COLD-WATER CURRENTS AND CLIMATE**

Cold-water currents also affect coastal areas. Coastal areas near cold currents tend to have cooler climates than inland areas at the same latitude. For example, the California Current is a cold-water current that flows near the West Coast of the United States. As a result, the climate along the West Coast is usually cooler than the climate of areas further inland. The figure on the top of the next page shows the location of the California Current.

**SECTION 2** Currents and Climate *continued*

**TAKE A LOOK**

**2. Identify** In which direction does the California Current flow?



**How Do El Niño and La Niña Affect Climate?**

Every 2 to 12 years, the South Pacific trade winds move less warm water to the western Pacific than usual. As a result, surface-water temperatures along the west coast of South America rise. Over time, this warming spreads westward. This periodic change in the location of warm and cool surface waters is called **El Niño**. El Niño events can last a year or longer.

Sometimes, El Niño is followed by La Niña. **La Niña** happens when surface-water temperatures in the eastern Pacific become unusually cool.

**EL NIÑO, LA NIÑA, AND WEATHER PATTERNS**

Both El Niño and La Niña change the way the ocean and atmosphere interact. Changes in the weather during El Niño show how the atmosphere, ocean, and weather patterns are related. Scientists can predict the changes in the weather on land that might be caused by El Niño by studying the atmosphere and the ocean.

**STUDYING AND PREDICTING EL NIÑO AND LA NIÑA**

To study El Niño and La Niña, scientists collect data with buoys anchored to the ocean floor along the equator. The buoys record data about water temperature, air temperature, currents, and winds. The data sometimes show that the South Pacific trade winds are weaker than usual. The data may also show that the surface-water temperatures in the oceans have increased. Either of these changes can tell scientists that El Niño is likely to happen.

*Critical Thinking*

**3. Apply Concepts** El Niño happens when there is warmer water near the west coast of South America. Why do scientists collect information about air temperatures in order to help them predict El Niño and La Niña?

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**SECTION 2** Currents and Climate *continued*

**EFFECTS OF EL NIÑO**

El Niño can have a major effect on weather patterns. Flash floods and mudslides may happen in areas of the world that usually receive little rain, such as Peru and the southern United States. Other areas of the world, such as Indonesia and Australia, may receive less rain than usual.



**Discuss** You may have heard news reports about the effects of El Niño. In a small group, talk about some of the effects of El Niño that you heard about on the news.

**How Does Upwelling Affect Climate?**

Ocean **upwelling** happens when warm surface water is replaced by cold, nutrient-rich water from the deep ocean. Upwelling is caused by local winds. These winds blow toward the equator along the northwest coast of South America and west coast of North America. The winds cause the local surface currents to move away from the shore. The warm surface water is then replaced by cold deep water. ✓

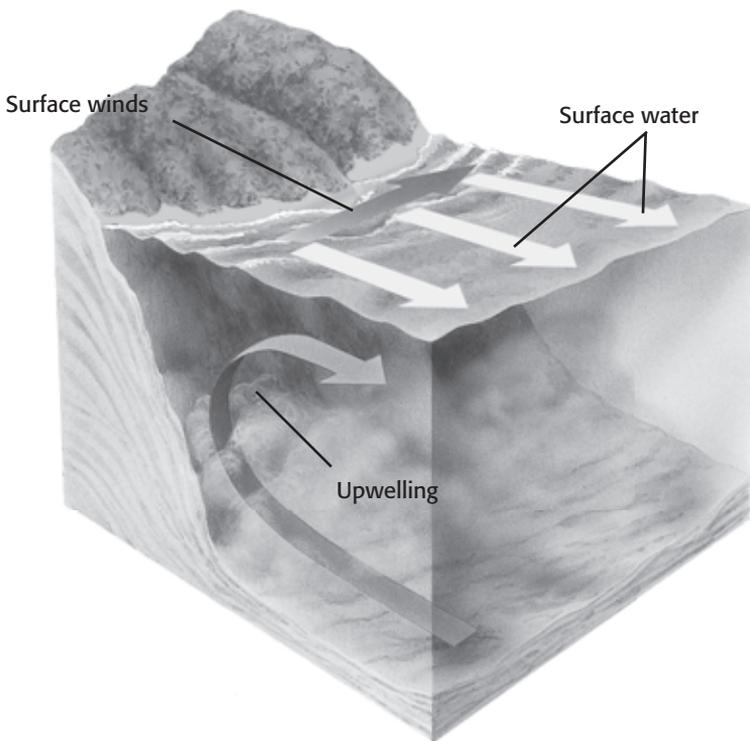
Upwelling is important for ocean life. Nutrients support the growth of plankton, which is the base of the food chain in the ocean. On the California coast, upwelling is usually strongest from March to September. El Niño can interrupt the process of upwelling and reduce the diversity of organisms near the ocean’s surface.

**READING CHECK**

**4. Define** What is upwelling?

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**TAKE A LOOK**

**5. Explain** How do winds cause upwelling?

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Upwelling can happen along coastlines when the wind conditions are right. Winds can blow surface water away from the shore. Then, deep, nutrient-rich water can rise toward the surface.

# Section 2 Review

## SECTION VOCABULARY

**El Niño** a change in the surface water temperature in the Pacific Ocean that produces a warm current

**La Niña** a change in the eastern Pacific Ocean in which the surface water temperature becomes unusually cool

**upwelling** the movement of deep, cold, and nutrient-rich water to the surface

**1. Explain** Why do surface-water temperatures on the west coast of South America rise during El Niño?

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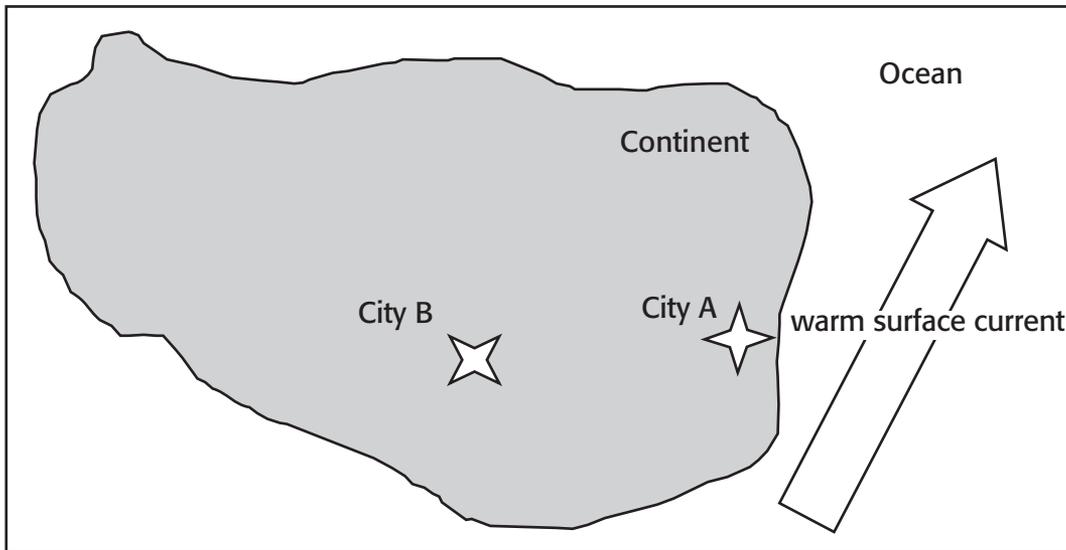


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**2. Apply Concepts** City A and city B are the same height above sea level. Based on the figure below, make a prediction about the average temperature in city A compared to city B. Explain your answer.




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**3. Explain** Why is upwelling important for marine life?

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**CHAPTER 13** The Movement of Ocean Water

**SECTION 3** **Waves and Tides**

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do waves form?
- What are the parts of a wave?
- What causes tides?



**California Science Standards**

6.3.a

**How Does a Wave Form?**

A **wave** is any disturbance that carries energy through matter or empty space. Waves in the ocean carry energy through water.

**WAVE FORMATION**

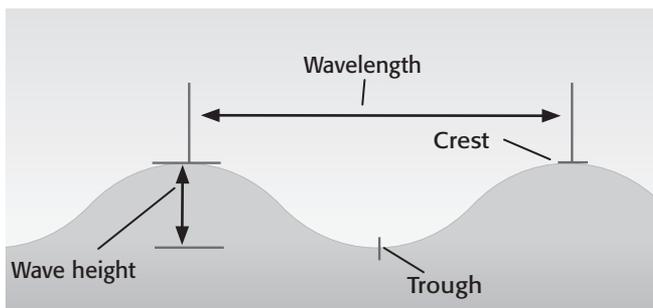
Ocean waves form when energy is transferred from a source to the ocean water. Most ocean waves form as wind blows across the water’s surface and transfers energy to the water. However, some waves form when energy from an earthquake or meteorite impact is transferred to the ocean water. ✓

Ocean waves can travel at different speeds. They can be very small or extremely large. The size and speed of a wave depend on the amount of energy the wave carries.

**PARTS OF A WAVE**

Waves are made up of two main parts: crests and troughs. A *crest* is the highest point of a wave. A *trough* is the lowest point of a wave. The distance between one crest and the next, or one trough and the next, is the *wavelength* of the wave. The distance in height between the crest and the trough is called the *wave height*.

**Parts of a Wave**



**STUDY TIP**

**Compare** As you read, make a chart describing the causes and features of high tides, low tides, spring tides, and neap tides.

**READING CHECK**

**1. Identify** Give two sources of energy that can cause ocean waves.

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**TAKE A LOOK**

**2. Define** Write your own definition for *wavelength*.

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**SECTION 3** Waves and Tides *continued*

## Critical Thinking

### 3. Predict Consequences

People who own boats often leave the boats anchored a short distance away from the shore. The boats stay in about the same place over many days. What would happen to these boats if waves caused water to move horizontally?

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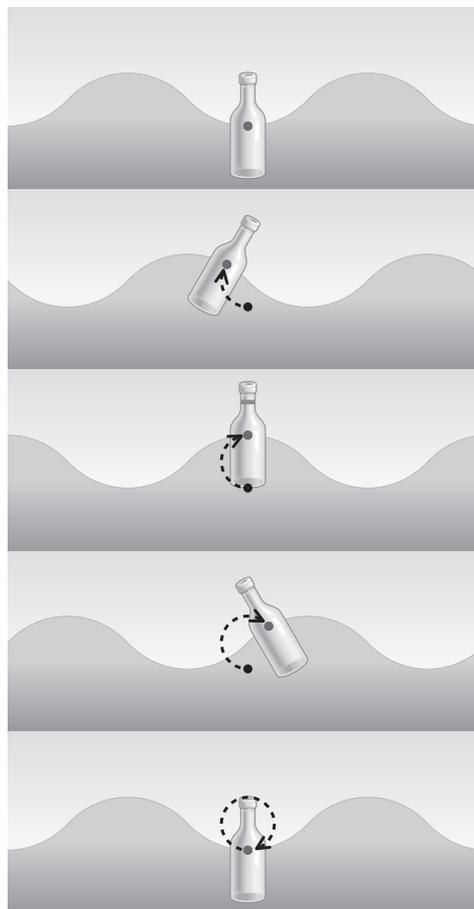
## TAKE A LOOK

**4. Describe** What is the shape of the path that the bottle takes as the wave passes by it?

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### WAVE MOVEMENT

If you have ever watched ocean waves, you may have noticed that water seems to move across the ocean's surface. However, this movement is only an illusion. The energy in the wave causes the water to rise and fall in circular movements. The water does not move horizontally very much. The figure below shows how waves can move energy without moving water horizontally.



The bottle shows the circular motion of matter when a wave moves in the ocean. The energy in the wave makes matter near the surface move in circular motions. The matter does not move horizontally.

### WAVE ENERGY

The size of a wave is related to the amount of energy it is carrying. When the wind begins to blow over the water, small waves called *ripples* form. If the wind keeps blowing, the ripples receive more energy and grow into larger waves. Large waves form when the wind blows in the same direction for a long time. When this happens, a lot of energy is transferred to the water.

Surface wave energy decreases as water depth increases. This means that most waves affect only the top of the water. Deeper water is not affected by the energy of surface waves.

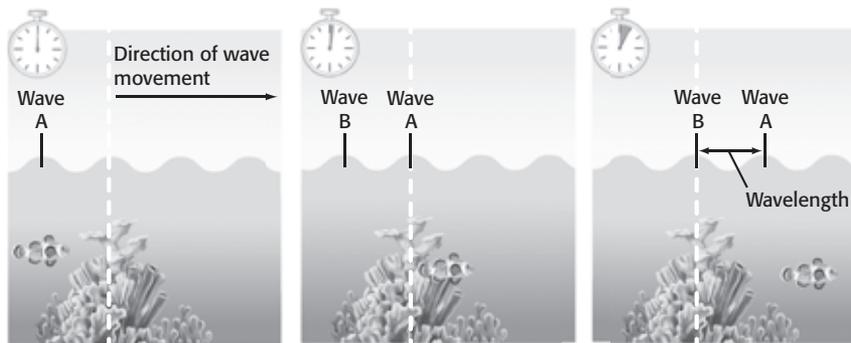
**SECTION 3** Waves and Tides *continued*

**WAVE SPEED**

Waves travel at different speeds. To calculate wave speed, scientists must know the wavelength and the wave period. *Wave period* is the time between the passage of two wave crests or troughs at a fixed point. Dividing wavelength by wave period gives you wave speed, as shown below.

$$\frac{\text{Wavelength (m)}}{\text{Wave period (s)}} = \text{Wave speed (m/s)}$$

Increasing the wave period, the time between wave crests, will decrease the wave speed. Decreasing the wave period will increase the wave speed. The figure below shows how the period of a wave can be measured.



1. The waves are moving from left to right. The reef is a fixed point because it is not moving. The dotted line marks the center of the reef.

2. The timer begins running as the crest of wave A passes the center of the reef.

3. The timer stops when the crest of wave B passes the center of the reef. The time that the timer recorded, 5 s, is the wave period.

**WAVES REACHING THE SHORE**

When waves reach water shallower than one-half their wavelength, they begin to interact with the ocean floor. As waves begin to touch the ocean floor, the waves transfer energy from the wave to the ocean floor. As a result, the water at the bottom of the waves slows down. However, the water at the top of wave continues to travel at the original speed. Eventually, the wave crest crashes onto the shore as a *breaker*. ✓

The energy of the wave is transferred to the beach environment at the shore. The energy of the wave and the angle at which the wave hits the shore determine how much energy is transferred to the shore.

**Math Focus**

**5. Calculate** A water wave has a speed of 5 m/s. If its wavelength is 50 m, what is its wave period? Show your work.

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**TAKE A LOOK**

**6. Identify** What part of wave B is passing the reef when the timer is stopped?

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**READING CHECK**

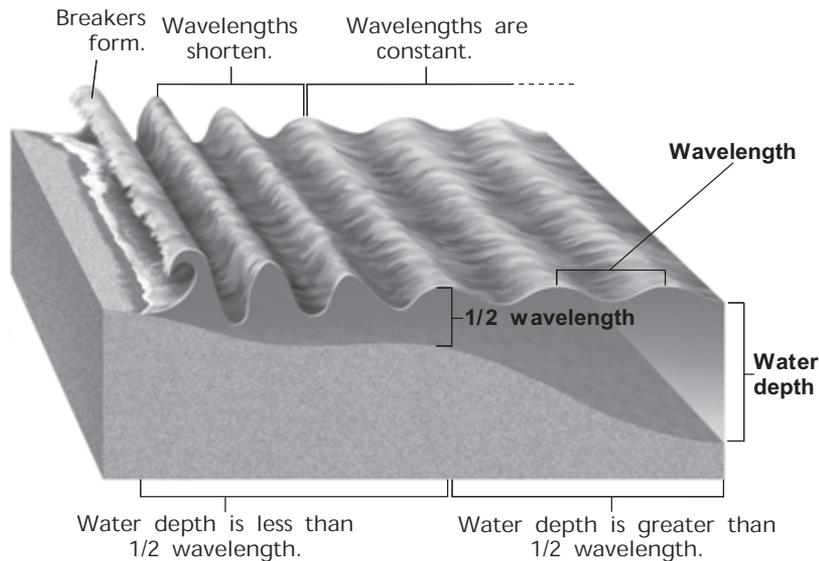
**7. Describe** What happens to a wave's energy as the wave moves close to the shore?

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**SECTION 3** Waves and Tides *continued*



**TAKE A LOOK**

**8. Describe** What are breakers?

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As the wave moves toward the shore, wave height increases. Breakers form when wave crests crash onto the shore.

**What Are Tides?**

Wind and earthquakes can move ocean water and produce waves. Other forces can also move ocean water in regular patterns, such as tides. **Tides** are daily changes in the level of the ocean water. Both the sun and the moon influence the level of tides. ✓

**READING CHECK**

**9. Define** Write your own definition for *tides*.

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**WHY TIDES HAPPEN**

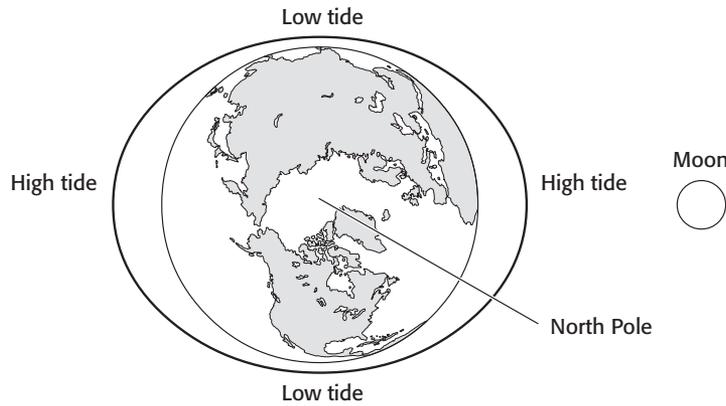
The moon's gravity pulls on every particle on Earth. However, the moon's gravity doesn't pull on every particle with the same strength. The moon's gravitational pull on Earth decreases with distance from the moon. Therefore, the pull on some parts of Earth is stronger than on other parts.

The difference in the moon's pull is more noticeable in liquids than in solids because liquids can move more easily. Therefore, the effects of the moon's pull on the oceans is more noticeable than on the land.

**WHERE TIDES HAPPEN**

The part of Earth that faces the moon is pulled toward the moon with the greatest force. Therefore, the water on the side of Earth that faces the moon bulges toward the moon. The water on Earth's opposite side is pulled toward the moon the least. Therefore, it bulges away from the moon. The figure at the top of the next page shows these bulges.

**SECTION 3** Waves and Tides *continued*



**TAKE A LOOK**

**10. Explain** Why does the water on the side of Earth that is farthest from the moon bulge outward?

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Water bulges toward the moon on the side of Earth that faces the moon. Water bulges away from the moon on Earth's far side. As a result, these two sides of Earth experience high tide. In this image, the sizes and locations of Earth, the oceans, and the moon are not drawn to scale.

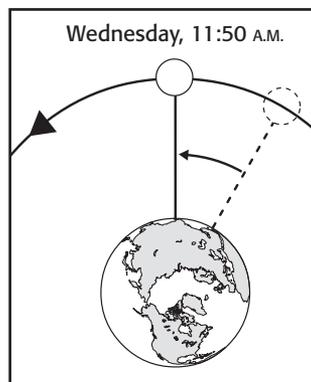
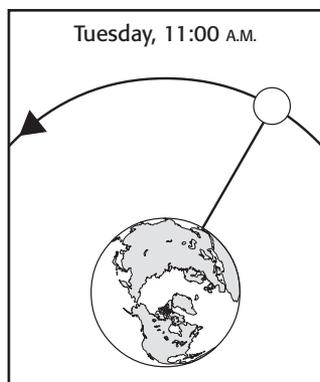
**HIGH TIDES AND LOW TIDES**

The bulges that form in the oceans because of the moon's pull are called *high tides*. In high-tide areas, the water level is higher than average sea level. In areas between high tides, *low tides* form. In low-tide areas, the water level is lower than average sea level because the water is pulled toward high-tide areas.

Remember that Earth rotates on its axis. As a result, high tides happen in different places on Earth at different times of day. However, because Earth's rotation is predictable, the tides are also predictable. Many places on Earth experience two high tides and two low tides every day. ✓

**TIMING THE TIDES**

The moon revolves around Earth much more slowly than Earth rotates. As the figure below shows, a place that is facing the moon takes 24 h and 50 min to rotate to face the moon again. Therefore, high and low tides at that place happen 50 min later each day.



High and low tides happen about 50 min later each day at a given place. This happens because Earth rotates faster than the moon orbits Earth. If Earth rotated at the same speed as the moon orbits Earth, tides would not alternate between high and low.

**READING CHECK**

**11. Describe** Why are the tides predictable?

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**SECTION 3** Waves and Tides *continued*

**How Do Tides Vary?**

The sun and the moon affect the tides. Even though the sun is bigger than the moon, it is much farther away from Earth than the moon is. Therefore, the sun's effect on tides is less than the moon's. The combined forces of the sun and the moon on Earth produce different tidal ranges. A *tidal range* is the difference between levels of ocean water at high tide and low tide. ✓

**READING CHECK**

**12. Explain** Why does the sun affect the tides less than the moon does?

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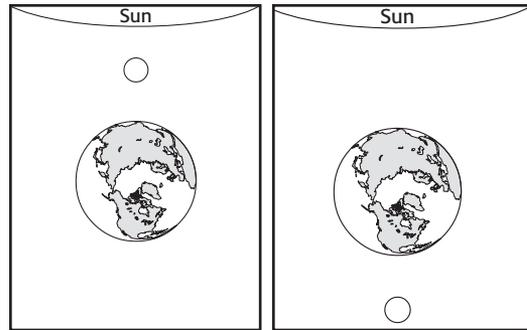
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**SPRING TIDES**

Tides that have the largest daily tidal range are **spring tides**. Spring tides happen when the sun, Earth, and the moon are aligned, as shown in the figures below. Spring tides happen during the new-moon and full-moon phases, or every 14 days. During these times, the pull of the sun and moon produces one pair of very large tidal bulges.

Spring tides happen when the sun, the moon, and Earth are aligned. This can happen in two ways. One way is when the moon is between Earth and the sun, as shown in the left-hand figure. The other way is when Earth is between the moon and the sun, as shown in the right-hand figure.



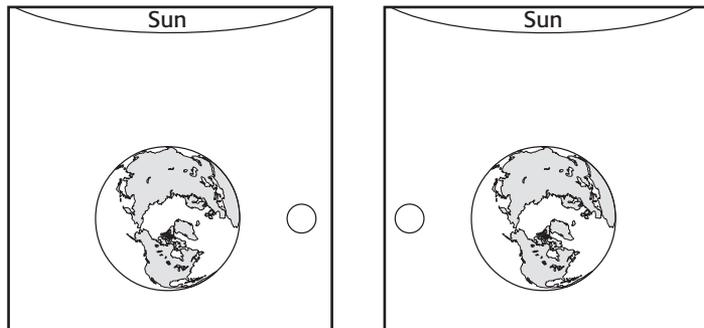
**TAKE A LOOK**

**13. Describe** Draw an oval around Earth in each picture to show where the tides are highest and where they are lowest during spring tides.

**NEAP TIDES**

Tides that have the smallest daily tidal range are called **neap tides**. Neap tides happen when the sun, Earth, and the moon form a 90° angle, as shown in the figures below. They happen halfway between the spring tides, during the first-quarter and third-quarter phases of the moon. During these times, the pull of the sun and moon produces smaller tidal bulges.

Neap tides happen when the sun, the moon, and Earth form a 90° angle.



# Section 3 Review

## SECTION VOCABULARY

<p><b>neap tide</b> a tide of minimum range that occurs during the first and third quarters of the moon</p>	<p><b>tide</b> the periodic rise and fall of the water level in the oceans and other large bodies of water</p>
<p><b>spring tide</b> a tide of increased range that occurs two times a month, at the new and full moons</p>	<p><b>wave</b> a periodic disturbance in a solid, liquid, or gas as energy is transmitted through a medium</p>

**1. Describe** How do ocean waves form?

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**2. Identify Relationships** How does the length of time that wind blows over water affect the amount of energy in a wave? Explain your answer.

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**3. Calculate** A wave has a wave period of 20 s and a wavelength of 100 m. What is its speed? How would the speed change if the wave period increased?

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**4. Summarize** What causes tides?

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**5. Explain** Why is the moon’s pull more noticeable in liquids than in solids?

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**6. Apply Ideas** If you have a calendar that shows only the phases of the moon, can you predict when spring tides and neap tides will happen? Explain your answer.

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SECTION 1 **Characteristics of the Atmosphere**



6.4.b, 6.4.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is Earth’s atmosphere made of?
- How do air pressure and temperature change as you move away from Earth’s surface?
- What are the layers of the atmosphere?

**STUDY TIP**

**Define** When you come across a word you don’t know, circle it. When you figure out what it means, write the definition in your notebook

**READING CHECK**

1. **List** Which two gases make up most of Earth’s atmosphere?

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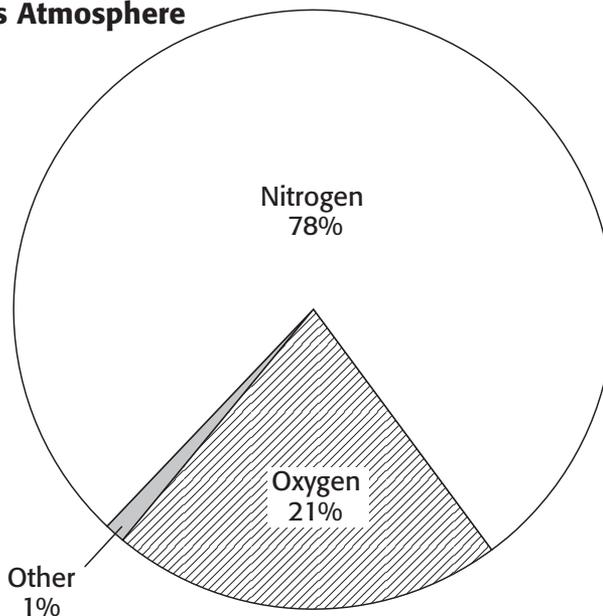
**What Is Earth’s Atmosphere Made Of?**

An **atmosphere** is a layer of gases that surrounds a planet or moon. On Earth, the atmosphere is often called just “the air.” When you take a breath of air, you are breathing in atmosphere.

The air you breathe is made of many different things. Almost 80% of it is nitrogen gas. The rest is mostly oxygen, the gas we need to live. There is also water in the atmosphere. Some of it is invisible, in the form of a gas called *water vapor*. ✓

Water is also found in the atmosphere as water droplets and ice crystals, like those that make up clouds. The atmosphere contains tiny solid bits, or particles, too. These particles are things like dust and dirt from continents, salt from oceans, and ash from volcanoes.

**Gases in Earth’s Atmosphere**



**Math Focus**

2. **Analyze Data** About how many times more nitrogen than oxygen is there in Earth’s atmosphere?

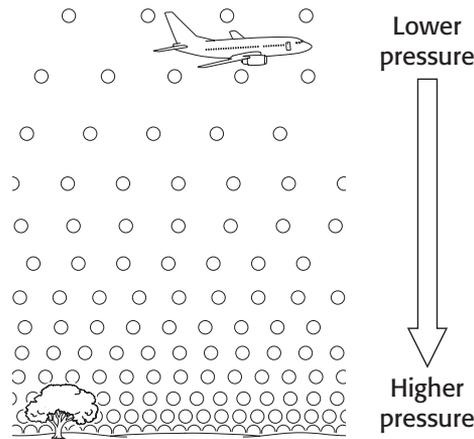
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**SECTION 1** Characteristics of the Atmosphere *continued*

### Why Does Air Pressure Change with Height?

**Air pressure** is how much the air above you weighs. It is a measure of how hard air molecules push on a surface. We don't normally notice air pressure, because our bodies are used to it.

As you move up from the ground and out toward space, there are fewer gas molecules pressing down from above. Therefore, the air pressure drops. The higher you go, the lower the air pressure gets. ✓



✓ **READING CHECK**

**3. Explain** Why does air pressure drop as you move away from Earth's surface?

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**TAKE A LOOK**

**4. Compare** How is the air pressure around the tree different from the air pressure around the plane?

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### Why Does Air Temperature Change with Height?

Like air pressure, air temperature changes as you move higher in the atmosphere. Air pressure always gets lower as you move higher, but air temperature can get higher or lower. The air can get hotter or colder. ✓

Air temperature depends on a number of things, including the gases that are present in the atmosphere. There are different layers of the atmosphere. Each layer is made of a different combination of gases. Some gases absorb energy from the sun better than others. When a gas absorbs energy from the sun, the air temperature goes up.

✓ **READING CHECK**

**5. Summarize** What is the main idea of this paragraph?

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### What Are the Four Layers of the Atmosphere?

There are four layers of the atmosphere: **troposphere**, **stratosphere**, **mesosphere**, and **thermosphere**. You cannot actually see these different layers. The atmosphere is divided into layers based on how each layer's temperature changes. The table on the next page shows the features of the different layers of the atmosphere.

**SECTION 1** Characteristics of the Atmosphere *continued*

### Critical Thinking

**6. Explain Events** How do you think scientists found out that there are four layers of the atmosphere?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



### Say It

**Make Up a Memory Trick** In groups of two or three, make up a sentence to help you remember the order of the layers of the atmosphere. The words in the sentence should start with T, S, M, and T. For example, "Tacos Sound Mighty Tasty." A sentence like this is called a *mnemonic*.

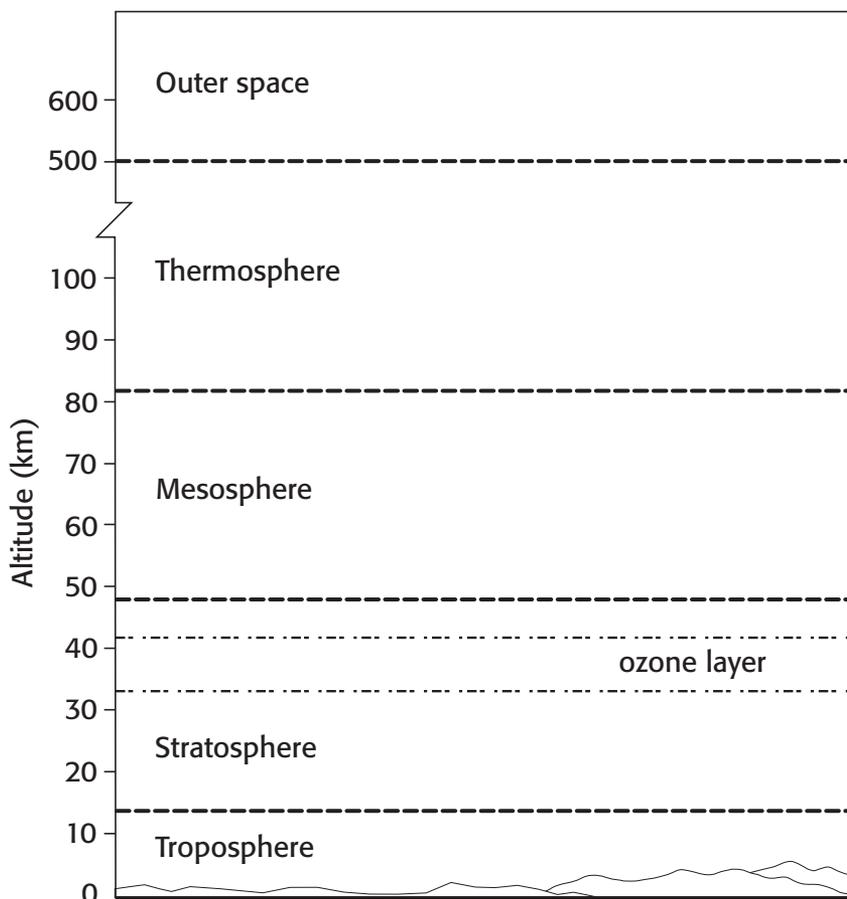
Layer	How temperature and pressure change as you move higher	Important features
Troposphere	temperature decreases ↓ pressure decreases ↓	densest layer where most of the atmosphere is where weather happens where clouds are
Stratosphere	temperature increases ↑ pressure decreases ↓	gases are arranged in layers contains the ozone layer
Mesosphere	temperature decreases ↓ pressure decreases ↓	has the lowest temperature
Thermosphere	temperature increases ↑ pressure decreases ↓	has the highest temperature

### TAKE A LOOK

**7. Identify** At what altitude does the mesosphere end and the thermosphere begin?

\_\_\_\_\_

**8. Identify** Sketch clouds in the proper place in the figure.



# Section 1 Review

## SECTION VOCABULARY

**air pressure** a measure of the force with which air molecules push on a surface

**atmosphere** a mixture of gases that surrounds a planet or moon

**mesosphere** the layer of the atmosphere between the stratosphere and the thermosphere and in which temperature decreases as altitude increases

**stratosphere** the layer of the atmosphere that is above the troposphere and in which temperature increases as altitude increases

**thermosphere** the uppermost layer of the atmosphere, in which temperature increases as altitude increases

**troposphere** the lowest layer of the atmosphere, in which temperature decreases as altitude increases

**1. Define** In your own words, explain what air pressure is.

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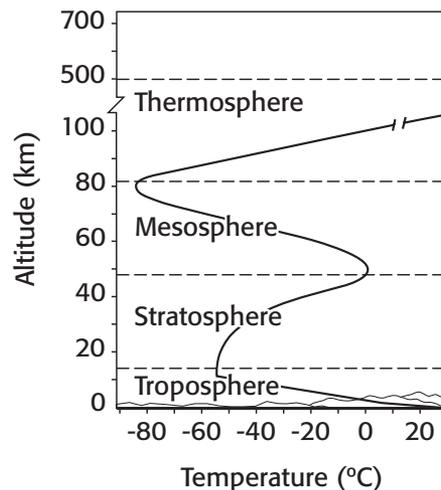
**2. Explain** Why does air temperature change as you move up from the Earth's surface?

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**3. Graph Data** The graph below shows how the temperature changes as you move up through the atmosphere. On the graph, draw a curve showing how the pressure changes.



**4. Identify Relationships** How does the sun affect air temperatures?

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CHAPTER 14 The Atmosphere

SECTION 2 Atmospheric Heating

 **California Science Standards**  
 6.3.a, 6.3.c, 6.3.d, 6.4.a, 6.4.b, 6.4.d

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

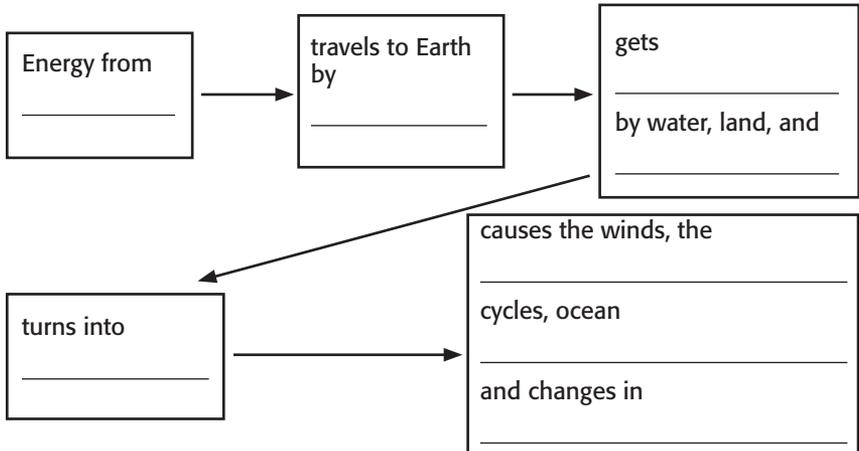
- How does energy travel from the sun to Earth?
- What are the differences between radiation, conduction, and convection?
- Why is Earth’s atmosphere as warm as it is?

**STUDY TIP**

**Outline** In your notebook, write an outline of this chapter. Use the questions in bold to make your outline. As you read, fill in information about each question.

**How Does Energy Travel from the Sun to Earth?**

Most of the heat energy on Earth’s surface comes from the sun. Energy travels from the sun to Earth by **radiation**, which means that it travels through space as waves. As solar energy (energy from the sun) is absorbed by air, water, and land, it turns into heat energy. This energy from the sun causes winds, the water cycle, ocean currents, and changes in the weather.



**TAKE A LOOK**

**1. Summarize** Use the information in the text to fill in the blanks in the graphic organizer.

**READING CHECK**

**2. Explain** What is radiation?  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**THE ELECTROMAGNETIC SPECTRUM**

All energy that travels in waves is radiation. The waves that make up all forms of radiation are called *electromagnetic waves*. These waves travel through space at very high speeds—about 300,000 km/s. ✓

Almost all of the energy that reaches Earth from the sun is in the form of electromagnetic waves. The **electromagnetic spectrum** is made of all the types of electromagnetic waves.

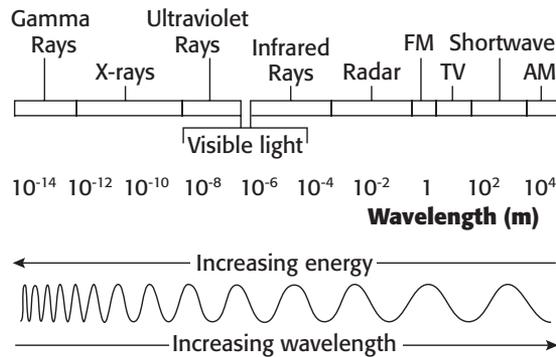
**SECTION 2** Atmospheric Heating *continued*

**WAVELENGTHS**

Different types of electromagnetic radiation have different wavelengths. A *wavelength* is the distance from any point on a wave to the same point on the next wave.

Visible light is made of light with different wavelengths. People see the different wavelengths as different colors. Ultraviolet rays, X rays, and gamma rays have shorter wavelengths than the wavelengths of visible light. Infrared and radio waves have wavelengths longer than those of visible light.

**The Electromagnetic Spectrum**



**Math Focus**

**3. Build Models** In the space below, use a ruler to draw a wave that has a wavelength of 1 cm. Label the beginning and the end of one wavelength.

**TAKE A LOOK**

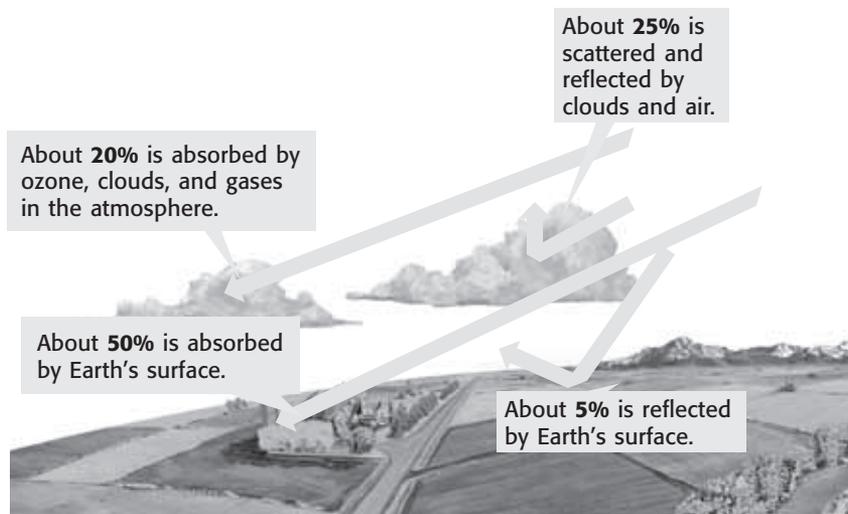
**4. Identify Relationships** Which types of radiation have wavelengths shorter than visible light?

\_\_\_\_\_

\_\_\_\_\_

**What Happens to Radiation from the Sun?**

Not all of the radiation from the sun reaches Earth's surface. Much of it gets absorbed by the atmosphere. Some of it is scattered and reflected by clouds and gases.



**TAKE A LOOK**

**5. Identify** How much of the sunlight that gets to Earth is absorbed by Earth's surface?

\_\_\_\_\_

**6. Summarize** What happens to the sunlight that is not absorbed by Earth's surface?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**SECTION 2** Atmospheric Heating *continued*

### How Is Heat Transferred by Contact?

Once sunlight is absorbed by Earth’s surface, it is *converted*, or changed, into heat energy. Then, the heat can be transferred to other objects and moved to other places. When a warm object touches a cold object, heat moves from the warm object to the cold one. This movement of heat is called **thermal conduction**.

When you touch the sidewalk on a hot, sunny day, heat energy is conducted from the sidewalk to you. The same thing happens to air molecules in the atmosphere. When they touch the warm ground, the air molecules heat up. ✓

**READING CHECK**

**7. List** Name two ways that air gets heated.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### How Is Heat Energy Transferred by Motion?

If you have ever watched a pot of water boil, you have seen convection. In **convection**, warm material, such as air or water, moves from one place to another.

When you turn on the stove under a pot of water, the water closest to the stove heats up. When it heats up, the water’s density decreases. The warm water near the stove is not as dense as the cool water near the air. So the cool water sinks while the warm water rises.

As it rises, the warm water begins to cool. When it cools, its density increases again. It becomes denser than the layer below, so it sinks back to the stove top. This cycle causes a circular movement called a *convection current*.

Convection currents also move heat through the atmosphere. In fact, most heat energy in the atmosphere is transferred by convection. Air close to the ground is heated by conduction from the ground. It becomes less dense than the cooler air above it. Then, it starts to convect. The warmer air rises while the cooler air sinks. The ground warms up the cooler air by conduction, and the warm air rises again. ✓

**READING CHECK**

**8. Explain** How is most heat energy in the atmosphere transferred from one place to another?

\_\_\_\_\_

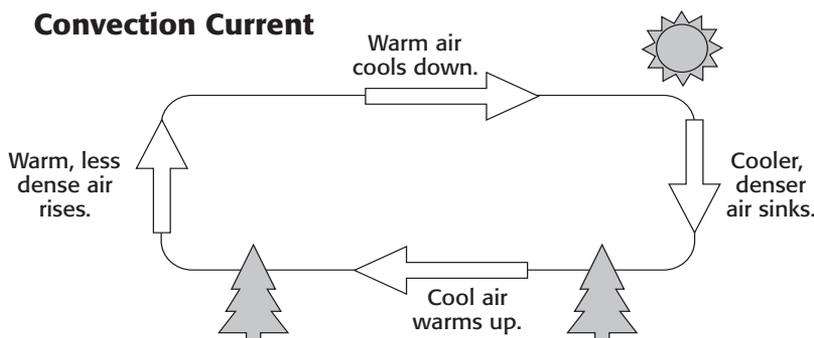
**TAKE A LOOK**

**9. Describe** In a convection current, what happens after cool air sinks?

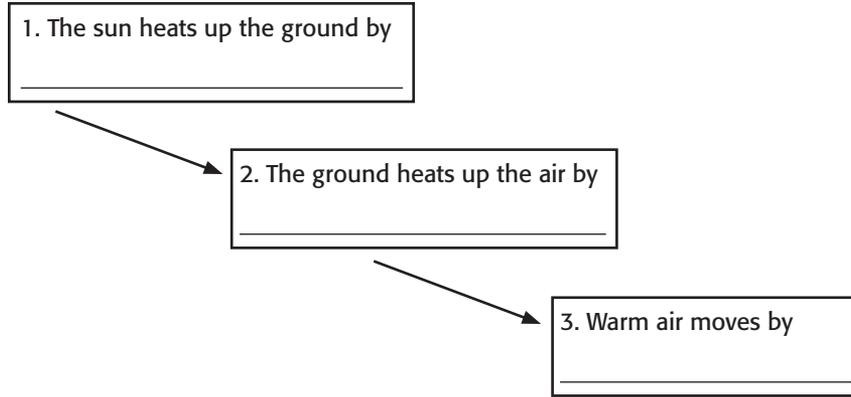
\_\_\_\_\_

\_\_\_\_\_

**Convection Current**



**SECTION 2** Atmospheric Heating *continued*



**TAKE A LOOK**

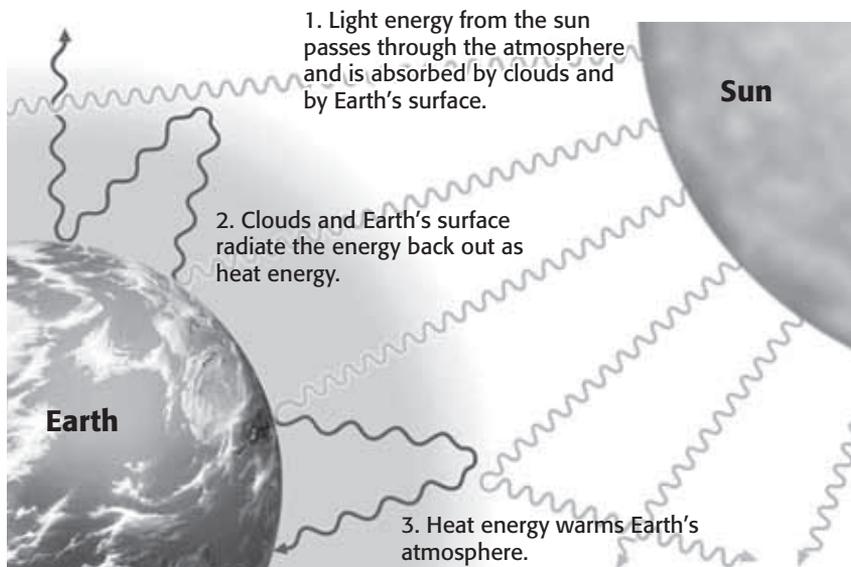
**10. Sequence** Fill in the blanks in the boxes to show how heat moves in Earth's atmosphere.

**Why Doesn't All the Heat in the Atmosphere Escape Back Out into Space?**

A gardener who needs to keep plants warm uses a glass building called a greenhouse. Light travels through the glass into the building, and the energy is absorbed by the air and plants inside. The energy is converted to heat, which cannot travel back through the glass as easily as light came in. Much of the heat energy stays trapped within the greenhouse, keeping the air inside warmer than the air outside.

Earth's atmosphere acts like the glass walls of a greenhouse. Sunlight travels through the atmosphere easily, but heat does not. Gases in the atmosphere, such as water vapor and carbon dioxide, absorb heat energy coming from Earth and radiate it back to Earth's surface. This is known as the **greenhouse effect**. ✓

**The Greenhouse Effect**



**READING CHECK**

**11. List** Name two gases in Earth's atmosphere that absorb heat.

\_\_\_\_\_

\_\_\_\_\_

**TAKE A LOOK**

**12. Identify** On the drawing, label the light coming from the sun with an **L**. Label the heat energy that is trapped by Earth's atmosphere with an **H**.

**SECTION 2** Atmospheric Heating *continued*

### Critical Thinking

**13. Apply Concepts** How will global warming affect the amount of water vapor in the atmosphere? Explain your answer.

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 **Say It**

**Predict** How might global warming affect your community? What can you do to slow global warming? In groups of two or three, discuss how global warming might affect your lives.

### TAKE A LOOK

**14. Explain** What is one possible reason that Earth is getting warmer?

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### Why Doesn't Earth Get Hotter and Hotter?

Every day, Earth receives more energy from the sun. If none of this energy could escape, Earth would get hotter and hotter. However, much of the energy does eventually get radiated back out into space. The balance between energy coming in and energy going out is known as the *radiation balance*.

### What Is Global Warming?

Many scientists are worried that Earth has been getting warmer over the past hundred years. This increase in temperatures all over the world is called **global warming**.

Scientists think that human activities may be causing global warming. When we burn fossil fuels, we release greenhouse gases, such as carbon dioxide, into the atmosphere. Because greenhouse gases trap heat in the atmosphere, adding more of them can make Earth even warmer. Global warming can have a strong effect on weather and climate.



This photo shows traffic on the Golden Gate bridge. Cars burn fossil fuels and produce greenhouse gases.

# Section 2 Review

6.3.a, 6.3.c, 6.3.d, 6.4.a, 6.4.b, 6.4.d



## SECTION VOCABULARY

<p><b>convection</b> the transfer of thermal energy by the circulation or movement of a liquid or gas</p> <p><b>electromagnetic spectrum</b> all of the frequencies or wavelengths of electromagnetic radiation</p> <p><b>global warming</b> a gradual increase in average global temperatures</p>	<p><b>greenhouse effect</b> the warming of the surface and lower atmosphere of the Earth that occurs when water vapor, carbon dioxide, and other gases absorb and reradiate thermal energy</p> <p><b>radiation</b> the transfer of energy as electromagnetic waves</p> <p><b>thermal conduction</b> the transfer of energy as heat through a material</p>
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**1. Explain** Explain how energy gets from the sun to Earth. Use at least one of the vocabulary words in the box above.

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**2. Compare** Fill in the table below to name and describe the three ways energy is transferred in Earth’s atmosphere.

Type of energy transfer	How energy is transferred
	Energy travels as electromagnetic waves.
Conduction	

**3. Explain** How does most of the heat in Earth’s atmosphere move from place to place?

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**4. Identify Relationships** Explain how global warming and the greenhouse effect are related.

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SECTION 3 **Air Movement and Wind**



6.4.a, 6.4.d, 6.4.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What causes wind?
- What is the Coriolis effect?
- What are the major global wind systems on Earth?

**STUDY TIP**

**Underline** Each head in this section is a question. Underline the answer to each question when you find it in the text.

**READING CHECK**

1. **Define** What is wind?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**What Causes Wind?**

**Wind** is moving air. It is caused by differences in air pressure. Air moves from areas of high pressure to areas of low pressure. The greater the pressure difference, the faster the air moves, and the stronger the wind blows. ✓

You can see how air moves if you blow up a balloon and then let it go. The air inside the balloon is at a higher pressure than the air around the balloon. If you open the end of the balloon, air will rush out.



**TAKE A LOOK**

2. **Identify** On the drawing, label the high-pressure area with an **H** and the low-pressure area with an **L**.

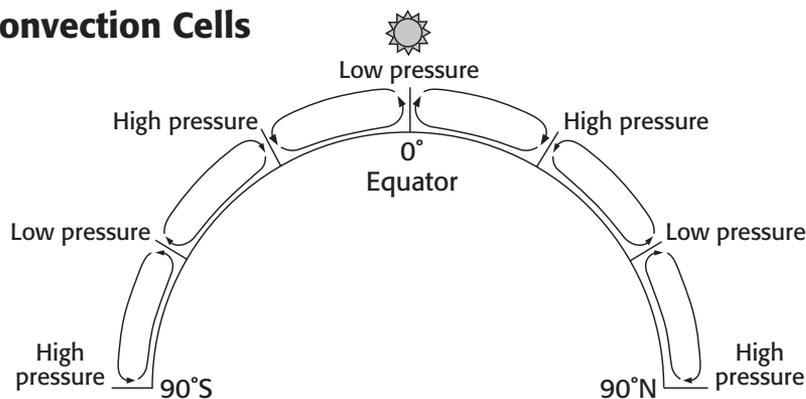
**SECTION 3** Air Movement and Wind *continued*

### What Causes Differences in Air Pressure?

Differences in air pressure on Earth are caused mainly by differences in temperature. The air over some parts of Earth gets more energy from the sun than others. For example, the sun shines more directly on the equator than on the poles. As a result, the air is warmer near the equator.

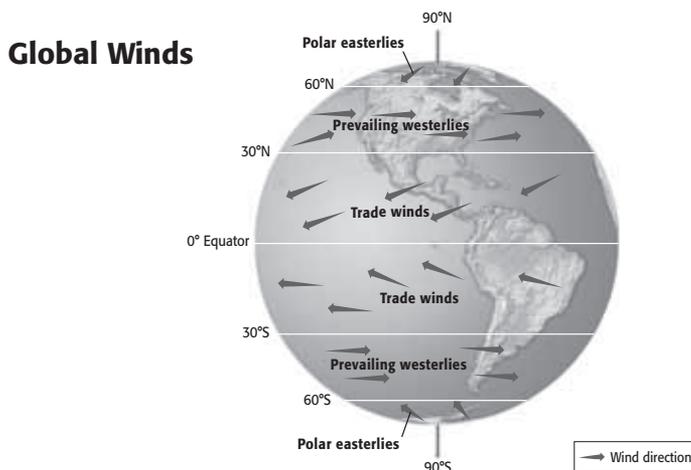
The warm air near the equator is not as dense as the cool air near the poles. Because it is less dense, the air at the equator rises and forms an area of low pressure. The cold air near the poles sinks and forms areas of high pressure. The air moves in large circular patterns called *convection cells*. These convection cells are shown from the side in the drawing below.

#### Convection Cells



### What Are the Major Global Wind Systems?

Global winds are large-scale wind systems. There are three major global wind systems: polar easterlies, prevailing westerlies, and trade winds. The direction the winds blow is controlled by the convection cells and by Earth's rotation.



**CALIFORNIA STANDARDS CHECK**

**6.4.A** Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.

**Word Help: major**  
of great importance or large scale

**Word Help: energy**  
what makes things happen

**Word Help: phenomena**  
any facts or events that can be sensed or described scientifically

**3. Explain** How does the sun cause the wind?

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### TAKE A LOOK

**4. Identify** Which wind system do you live in?

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**5. Identify** In which direction do all of the westerlies blow?

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**SECTION 3** Air Movement and Wind *continued*

## Critical Thinking

**6. Predict** If air is moving south from California, which way will it tend to curve?

\_\_\_\_\_

### Why Do Winds Curve?

Pressure differences cause air to move from the poles toward the equator. However, if you look at the global wind map, you will see that the winds don't actually travel straight north or south. The winds have curved paths.

Winds traveling from the equator to the poles curve to the east. Winds traveling from the poles toward the equator curve to the west. This is known as the **Coriolis effect**. The Coriolis effect happens because Earth is rotating, or turning on its axis.

### What Are Local Winds?

Most of the United States is in the belt of prevailing westerly winds, which move from west to east. Yet, you've probably noticed that the wind can blow from the north, south, east, west, or anywhere in between. These are local winds. Local winds move relatively short distances and can blow from any direction. ✓

Like the other wind systems, local winds are caused by differences in pressure, which are caused by differences in temperature. These temperature differences are caused by geographic features such as mountains and bodies of water.

**READING CHECK**

**7. Compare** Describe one difference between global winds and local winds.

\_\_\_\_\_

\_\_\_\_\_

### TAKE A LOOK

**8. Identify** In the figures, label the high-pressure areas with an **H** and the low-pressure areas with an **L**.

**Say It**

**Share Experiences** Have you ever been in a very strong wind? In groups of two or three, discuss the strongest or worst wind.



# Section 3 Review

6.4.a, 6.4.d, 6.4.e

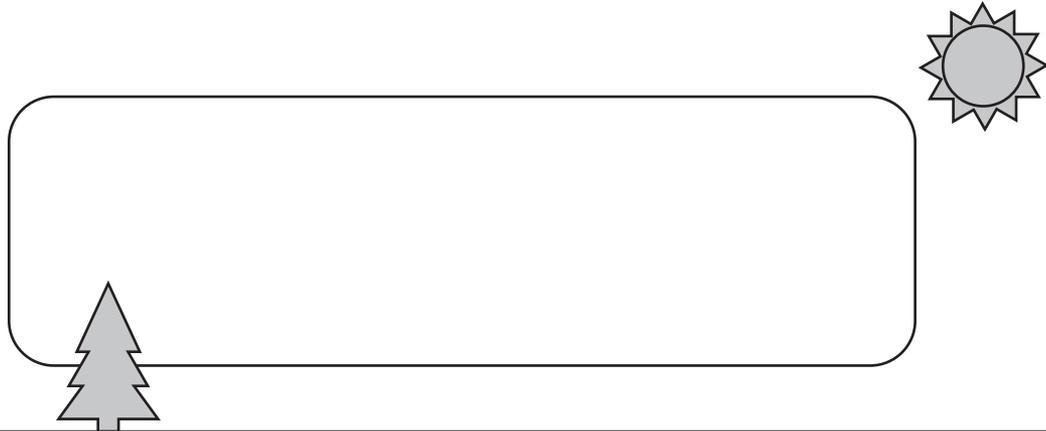


## SECTION VOCABULARY

**Coriolis effect** the apparent curving of the path of a moving object from an otherwise straight path due to the Earth's rotation

**wind** the movement of air caused by differences in air pressure

**1. Identify** The drawing below shows a convection cell. Put arrows on the cell to show which way the air is moving. Label high pressure areas with an **H** and low pressure areas with an **L**. Label cold air with a **C** and warm air with a **W**.



**2. Identify Cause and Effect** Complete the Cause-and-Effect Table below.

Cause	Effect
	differences in air pressure
Differences in air pressure	
	winds that curve to the east as they flow toward the poles

**3. Identify** Name the three global wind systems.

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**4. Apply Concepts** Would there be winds if Earth's surface were the same temperature everywhere? Explain your answer.

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CHAPTER 14 The Atmosphere

SECTION 4 **The Air We Breathe**



6.6.a, 6.6.b

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is air pollution?
- What causes air pollution?
- How does air pollution affect the environment?
- How can people reduce air pollution?

**STUDY TIP**

**Make a List** As you read, make a list of the sources of air pollution discussed in the text.

**What Is Air Pollution?**

**Air pollution** is the addition of harmful substances to the atmosphere. An air pollutant is anything in the air that can hurt the environment or make people sick. Some air pollution comes from natural sources. Other forms of air pollution are caused by things people do. There are two kinds of air pollutants: primary pollutants and secondary pollutants.

*Primary pollutants* are pollutants that are put directly into the air. Dust, sea salt, volcanic ash, and pollen are primary pollutants that come from natural sources. Smoke, chemicals from paint, and vehicle exhaust are primary pollutants that come from human activities.

*Secondary pollutants* form when primary pollutants react with each other or with other substances in the air. Ozone is an example of a secondary pollutant. It forms on sunny days when chemicals from burning gasoline react with each other and with the air. Ozone damages human lungs and can harm other living things, as well. ✓

**READING CHECK**

**1. Explain** Why is ozone called a secondary pollutant?

\_\_\_\_\_

\_\_\_\_\_

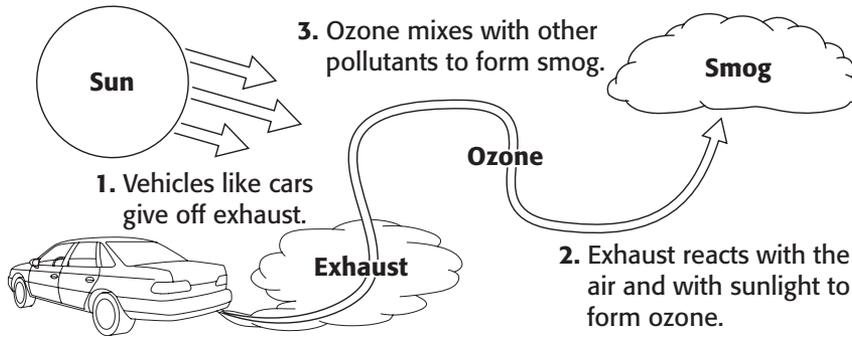
\_\_\_\_\_

\_\_\_\_\_

**TAKE A LOOK**

**2. Fill In** Use the information in the text to fill in the table.

Pollutant	Primary pollutant or secondary pollutant?	Natural or human-caused?
Car exhaust	primary	human-caused
Dust		
Ozone		
Paint chemicals		
Pollen		
Sea salt		
Volcanic ash		

**SECTION 4** The Air We Breathe *continued***TAKE A LOOK**

**3. Identify** What is the primary pollutant in this figure?

\_\_\_\_\_

**What Is Smog?**

On a hot, still, sunny day, yellowish brown air can cover a city. This is called *smog*. Smog forms when ozone mixes with other pollutants. During summer in cities such as Los Angeles, a layer of warm air can trap smog near the ground. In the winter, a storm can clear the air.



This is Los Angeles on a clear day.

Here Los Angeles is covered in smog.

**Say It**

**Discuss** In a small group, discuss how the pollution shown in this photograph formed.

**How Do Humans Cause Air Pollution?**

Many of our daily activities cause air pollution. The main source of human-caused air pollution in the United States is motor vehicles. Cars, motorcycles, trucks, buses, trains, and planes all give off exhaust. Exhaust contains pollutants that create ozone and smog.

Factories and power plants that burn coal, oil, and gas also give off pollutants. Businesses that use chemicals, such as dry cleaners and auto body shops, can add to air pollution. ✓

**READING CHECK**

**4. Identify** What is the main source of human-caused air pollution in the United States?

\_\_\_\_\_

**SECTION 4** The Air We Breathe *continued*

### What Causes Air Pollution Indoors?

Sometimes the air inside a building can be more polluted than the air outside. Because there is no wind to blow pollutants away and no rain to wash them out of the air, they build up inside. It is important to air out buildings by opening the windows or using fans that bring fresh air in from outside. ✓

**READING CHECK**

**5. Explain** Why can air pollution indoors be worse than air pollution outdoors?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

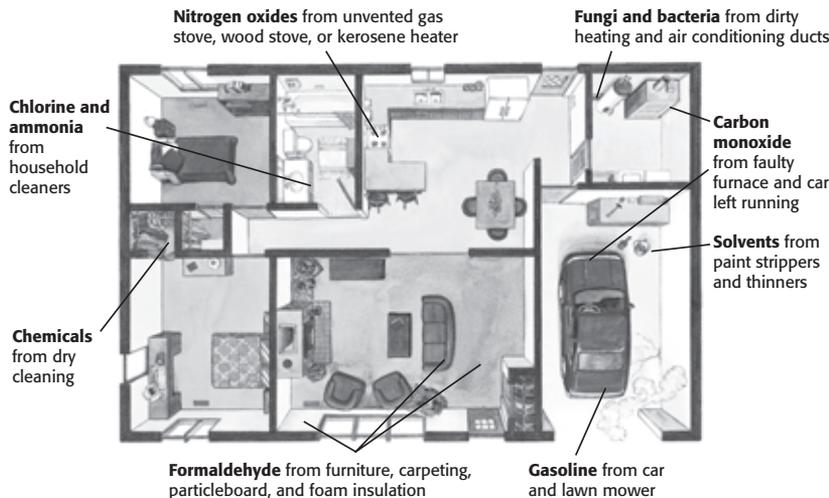
**TAKE A LOOK**

**6. Identify** Name two sources of indoor air pollution shown here that may be in your own home.

\_\_\_\_\_

\_\_\_\_\_

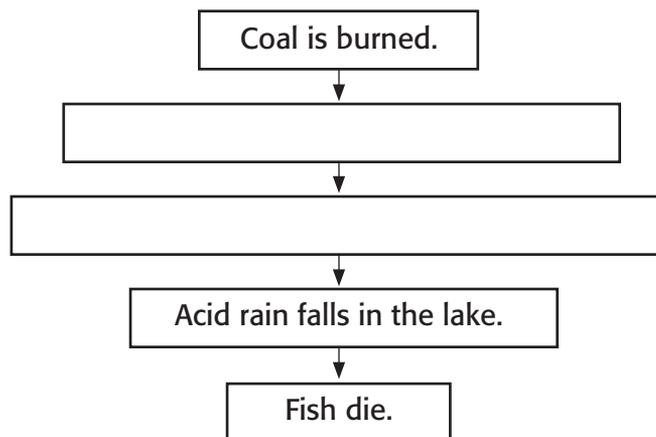
**Sources of Indoor Air Pollution**



### What Is Acid Precipitation?

**Acid precipitation** is rain, sleet, or snow that contains acids from air pollution. When we burn fossil fuels, pollutants such as sulfur dioxide are released into the air. These pollutants combine with water in the atmosphere to form acids.

Acid precipitation can kill or damage plants, change what soil is made of, and poison water. When acid rain flows into lakes, it can kill fish and other aquatic life.



**TAKE A LOOK**

**7. Sequence** Complete the graphic organizer to show how burning coal can cause fish to die.

**SECTION 4** The Air We Breathe *continued*

**What Is the Ozone Hole?**

Close to the ground, ozone is a pollutant formed by human activities. However, high in the stratosphere, ozone is an important gas that forms naturally. The ozone layer absorbs harmful ultraviolet radiation from the sun. Ultraviolet (UV) rays harm living things. UV light can cause skin cancer in humans. ✓

In the 1980s, scientists noticed that the ozone layer over the poles was getting thinner. This hole in the ozone layer was being caused by chemicals called CFCs, which destroy ozone. CFCs were being used in air conditioners and chemical sprays. Many CFCs are now banned. The ozone layer may slowly recover, but it will take a long time. CFCs can remain in the atmosphere for 60 to 120 years.

Ozone in the statosphere	Ozone near the ground
Naturally formed	
Not a pollutant	
	harmful to living things

**How Does Air Pollution Affect Human Health?**

Air pollution can cause many health problems. Some are short-term problems. They happen quickly and go away when the air pollution clears up or the person moves to a cleaner location. Other are long-term health problems. They develop over long periods of time and are not cured easily. The table below lists some of the effects of air pollution on human health. ✓

Short-term effects	Long-term effects
headache	emphysema (a lung disease)
nausea and vomitting	lung cancer
eye, nose, and throat irritation	asthma
coughing	permanent lung damage
difficulty breathing	heart disease
upper respiratory infections	skin cancer
asthma attacks	
worsening of emphysema	

 **READING CHECK**

**8. Explain** How is ozone helpful to humans?

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**TAKE A LOOK**

**9. Compare** Fill in the chart to show the differences between ozone in the atmosphere and ozone near the ground.

 **READING CHECK**

**10. Compare** What is the difference between short-term effects and long-term effects?

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**SECTION 4** The Air We Breathe *continued*

### What Can We Do About Air Pollution?

Believe it or not, air pollution in the United States is not as bad now as it was 30 years ago. People are now much more aware of how they can cause air pollution. Air pollution can be reduced by new laws, by technology, and by people changing their lifestyles.

The United States government and the governments of other countries have passed laws to control air pollution. These laws limit the amount of pollution that sources such as cars and factories are allowed to release. For example, factories and power plants now have scrubbers on smokestacks. A scrubber is a tool that helps remove pollutants from smoke before it leaves the smokestack.

Cars are more efficient now than they used to be, so they run on less fuel. Individuals can do a lot on their own to reduce air pollution, as well. For example, we can walk or bike instead of driving.

**READING CHECK**

**11. Identify** Name two things you can do to limit air pollution.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### Critical Thinking

**12. Analyze Processes**  
Electric cars don't give off any exhaust. They don't cause pollution in the cities where they are driven. However, driving them can cause pollution in other places. How?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



In Copenhagen, Denmark, companies lend bicycles for anyone to use for free. The program helps reduce automobile traffic and reduce air pollution.

# Section 4 Review

## SECTION VOCABULARY

<b>acid precipitation</b> rain, sleet, or snow that contains a high concentration of acids	<b>air pollution</b> the contamination of the atmosphere by the introduction of pollutants from human and natural sources
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**1. Identify Relationships** How are fossil fuels related to air pollution and acid precipitation?

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**2. Compare** Complete the table below to compare different pollutants.

Pollutant	Source	Negative effects	Solutions
CFCs			
Ozone			
Sulfur dioxide			

**3. List** Name three things, other than humans, that could be hurt by air pollution.

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**4. Explain** Why is the ozone hole dangerous?

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CHAPTER 15 Weather and Climate

SECTION 1 **Water in the Air**



6.4.a, 6.4.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What is weather?
- How does water in the air affect the weather?
- What are the forms of water found in the air?

**STUDY TIP**

**Outline** Before you read, make an outline of this section using the question in bold. As you read, fill in the main ideas of the chapter in your outline.

**READING CHECK**

**1. Define** Write your own definition for *weather*.

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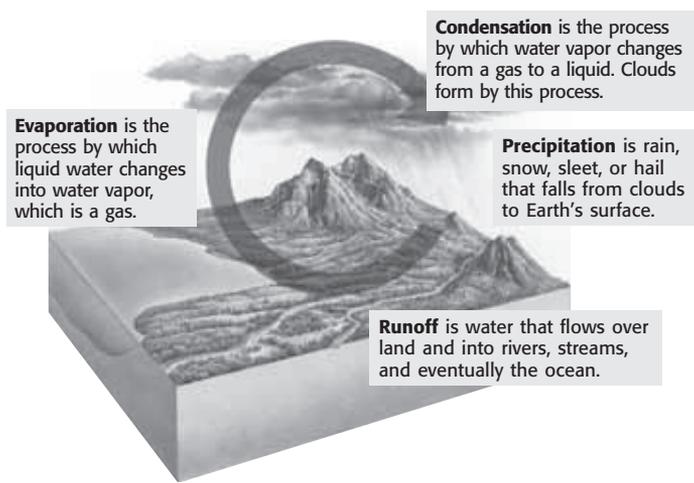
**What Is Weather?**

Knowing about the weather is important in our daily lives. Your plans to play outside can change if it rains. Being prepared for extreme weather conditions, such as hurricanes and tornadoes, can even save lives.

**Weather** is the condition of the atmosphere at a certain time and place. The condition of the atmosphere depends a lot on the amount of water in the air. Therefore, to understand weather, you need to understand how water moves through the atmosphere. ✓

**THE WATER CYCLE**

The movement of water between the atmosphere, the land, and the oceans is called the *water cycle*. The sun is the main source of energy for the water cycle. The sun's energy heats Earth's surface. This causes liquid water to *evaporate*, or change into water vapor (a gas). When the water vapor cools, it may change back into a liquid and form clouds. This is called **condensation**. The liquid water may fall as rain on the land.



**Evaporation** is the process by which liquid water changes into water vapor, which is a gas.

**Condensation** is the process by which water vapor changes from a gas to a liquid. Clouds form by this process.

**Precipitation** is rain, snow, sleet, or hail that falls from clouds to Earth's surface.

**Runoff** is water that flows over land and into rivers, streams, and eventually the ocean.

**TAKE A LOOK**

**2. Describe** How does water move from oceans into the atmosphere?

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**SECTION 1** Water in the Air *continued*

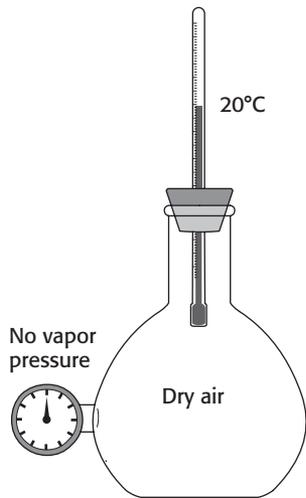
## What Is Humidity?

Water vapor makes up only a few percent of the mass of the atmosphere. However, this small amount of water vapor has an important effect on weather and climate.

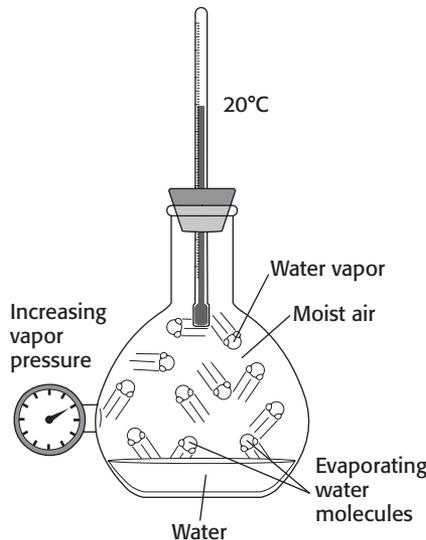
When the sun’s energy heats up Earth’s surface, some of the water in oceans and water bodies changes to a gas, water vapor. The amount of water vapor in the air is called **humidity**. ✓

Humidity depends on the rates of evaporation and condensation. In general, evaporation happens faster when air temperature is higher. The rate of condensation is affected by vapor pressure. Water vapor, like all gases in the atmosphere, adds to the total atmospheric pressure. The portion of air pressure that is caused by water vapor is called *vapor pressure*. ✓

As vapor pressure increases, the rate of condensation increases. When evaporation and condensation happen at the same rate, the air is said to be *saturated* with water. The temperature at which this happens is called the **dew point**. At temperatures below the dew point, liquid water droplets can form from the water vapor in the air.



The dry air in this flask has no water in it. Therefore, it has no water vapor pressure.



When water comes into contact with dry air, some of the water evaporates. The water molecules in the air exert a pressure called vapor pressure.

✓ **READING CHECK**

**3. Identify** What causes water in the oceans to turn into water vapor?

✓ **READING CHECK**

**4. Explain** What two things does humidity depend on?

**TAKE A LOOK**

**5. Describe** How does air pressure change as water vapor pressure increases?

**SECTION 1** Water in the Air *continued*

**RELATIVE HUMIDITY**

Scientists often describe the amount of water in the air using the term relative humidity. **Relative humidity** is the ratio of the amount of water vapor in the air to the greatest amount the air can hold. In other words, relative humidity is a measure of how close air is to its dew point.

To calculate relative humidity, divide the amount of water in the air by the maximum amount of water the air can hold. Then, multiply by 100 to get a percentage. For example, 1 m<sup>3</sup> of air at 25°C can hold up to about 23 g of water vapor. If air at 25°C in a certain place contains only 18 g/m<sup>3</sup> of water vapor, then the relative humidity is:

$$\frac{18 \text{ g/m}^3}{23 \text{ g/m}^3} \times 100 = 78\% \text{ relative humidity}$$

Scientists measure relative humidity using special tools. These tools have sensors that absorb water from the air. When humidity increases, the sensors absorb more water. When humidity decreases, the sensors release water to the air. As the sensors absorb and release water, they send electrical signals to a computer. The computer interprets the signals as a measurement of relative humidity.



Scientists use tools like this to measure relative humidity.

**What Affects the Dew Point?**

Remember that the dew point is the temperature at which air is saturated with water. At the dew point, condensation and evaporation happen at the same rate. When the temperature of the air is below the dew point, liquid water droplets can condense from water vapor.

**Math Focus**

**6. Calculate** What is the relative humidity of 25°C air that contains 10 g/m<sup>3</sup> of water vapor? Show your work.

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**READING CHECK**

**7. Explain** What happens when the temperature of air is below its dew point?

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**SECTION 1** Water in the Air *continued*

**REACHING THE DEW POINT**

Condensation happens when air is saturated with water vapor. Air can become saturated if water evaporates and enters the air as water vapor. Air can also become saturated when it cools below its dew point.

You have probably seen examples of air becoming saturated because of a temperature decrease. For example, when you add ice cubes to a glass of water, the temperatures of the water and of the glass decrease. The glass absorbs heat from the air, so the temperature of the air near the glass decreases. When the air's temperature drops below its dew point, water vapor condenses on the glass. The condensed water forms droplets on the glass.



The glass absorbs heat from the air. The air cools to below its dew point. Water vapor condenses onto the side of the glass.

When air is nearly saturated, only a small temperature drop is needed for condensation to happen. During the night, objects can lose heat and become cooler. Air may cool below its dew point when the air touches the cool objects. The water droplets that form are called *dew*.

**How Do Clouds Form?**

A cloud is made of millions of tiny water droplets or ice crystals. Clouds form as air rises and cools. When air cools below the dew point, water droplets or ice crystals form. Water droplets form when water condenses above 0°C. Ice crystals form when water condenses below 0°C.

Clouds are classified by their shapes and by their altitudes. The three main cloud shapes are stratus clouds, cumulus clouds, and cirrus clouds. The three altitude groups are low clouds, middle clouds, and high clouds. The figure on the top of the next page shows these different cloud types. ✓

*Critical Thinking*

**8. Apply Concepts** People who wear glasses may notice that their glasses fog up when they go indoors on a cold day. Why does this happen?

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**TAKE A LOOK**

**9. Describe** Where did the liquid water on the outside of the glass come from?

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**READING CHECK**

**10. Explain** How are clouds classified?

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**SECTION 1** Water in the Air *continued*

 **Say It**

**Observe and Describe** Look at the clouds every day for a week. Each day, write down the weather and what the clouds looked like. At the end of the week, share your observations with a small group. How was the weather related to the kinds of clouds you saw each day?

**TAKE A LOOK**

**11. Compare** How is a nimbostratus cloud different from a stratus cloud?

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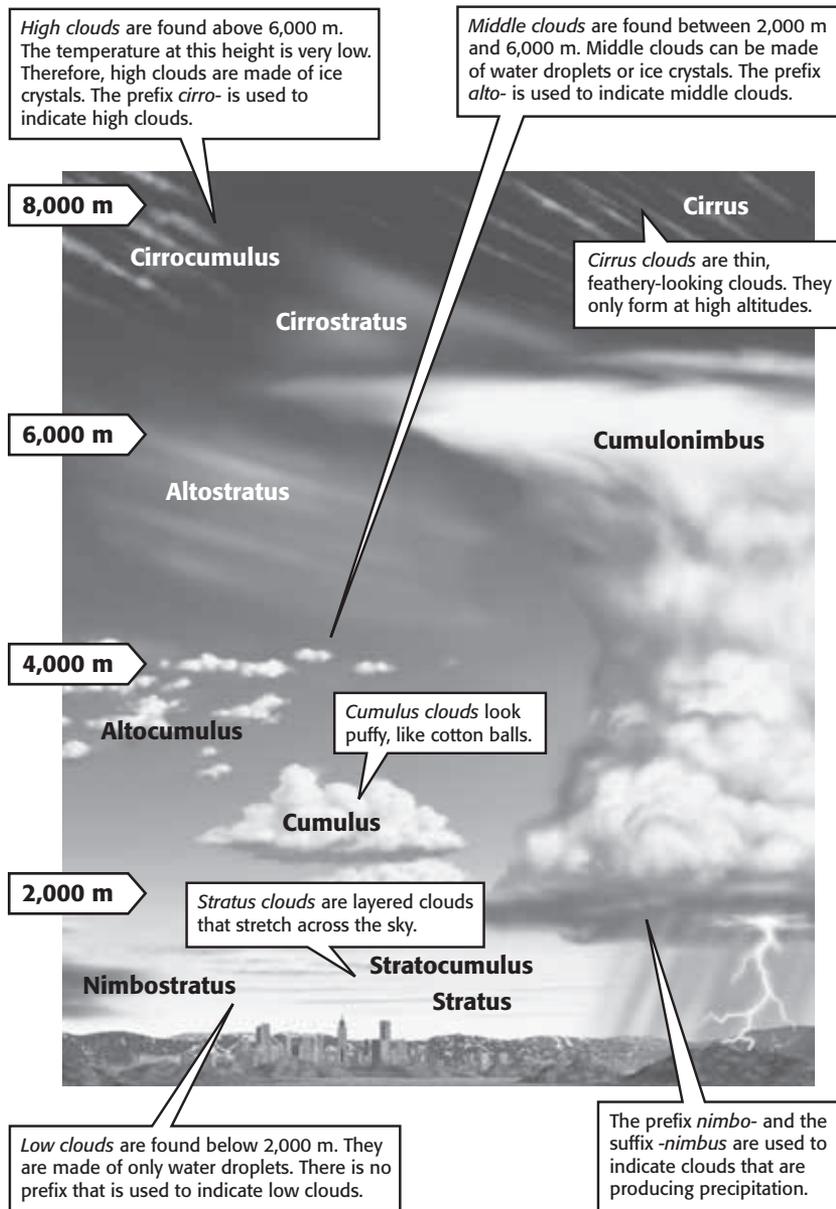
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 **READING CHECK**

**12. Define** What is precipitation?

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**PRECIPITATION**

Water droplets in clouds are very tiny. As droplets combine, they become larger. When a droplet reaches a certain size, it falls to Earth's surface as precipitation.

**Precipitation** is any form of water that falls to Earth's surface from clouds. ✓

There are four main forms of precipitation: rain, snow, sleet, and hail. Rain and snow are the most common kinds of precipitation. Hail and freezing rain are less common.

# Section 1 Review

6.4.a, 6.4.e 

## SECTION VOCABULARY

<p><b>condensation</b> the change of state from a gas to a liquid</p> <p><b>dew point</b> at constant pressure and water vapor content, the temperature at which the rate of condensation equals the rate of evaporation</p> <p><b>humidity</b> the amount of water vapor in the air</p>	<p><b>precipitation</b> any form of water that falls to Earth's surface from the clouds</p> <p><b>relative humidity</b> the ratio of the amount of water vapor in the air to the amount of water vapor needed to reach saturation at a given temperature</p> <p><b>weather</b> the short-term state of the atmosphere, including temperature, humidity, precipitation, wind, and visibility</p>
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**1. Identify Relationships** How is dew point related to condensation?

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**2. Identify** What is the main source of energy for the water cycle?

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**3. Describe** How does vapor pressure affect condensation?

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**4. Explain** How do clouds form?

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**5. Apply Concepts** Fill in the spaces in the table to describe different kinds of clouds.

Name	Altitude	Shape	Precipitation?
Cirrostratus	high		no
Altostratus		puffy	
Nimbostratus			
Cumulonimbus	low to middle		

SECTION 2 **Fronts and Weather**



6.2.d, 6.4.a, 6.4.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What causes weather?
- What is severe weather?

**STUDY TIP**

**Summarize** As you read, make a chart comparing the four kinds of fronts. In your chart, describe how each kind of front forms and what kind of weather it can cause.

**READING CHECK**

1. **Define** What is a front?

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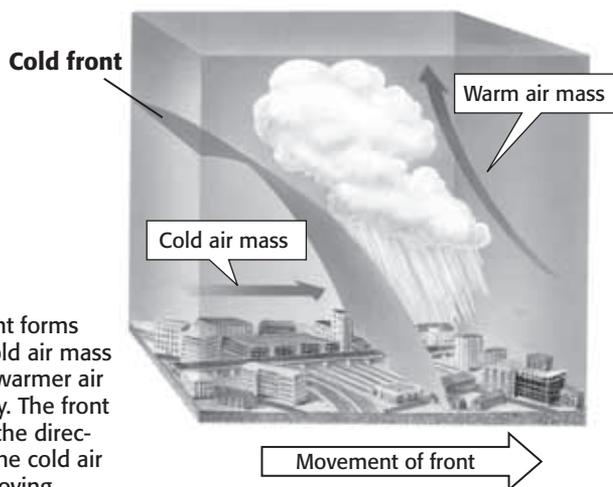
**What Are Fronts?**

Have you ever been caught outside when it suddenly started to rain? What causes such an abrupt change in the weather? Changes in weather are caused by the movement of bodies of air called air masses. An **air mass** is a very large volume of air that has the same temperature and moisture content.

When air masses meet, the less-dense air mass rises over the denser air mass. Warm air is less dense than cold air. Therefore, a warm air mass will generally rise above a cold air mass. The place where two or more air masses meet is called a **front**. There are four main kinds of fronts: cold fronts, warm fronts, occluded fronts, and stationary fronts. ✓

**COLD FRONTS**

A *cold front* forms when a cold air mass moves under a warm air mass. The cold air pushes the warm air mass up. The cold air mass replaces the warm air mass. Cold fronts can move quickly and bring heavy precipitation. When a cold front has passed, the weather is usually cooler. This is because a cold, dry air mass moves in behind the cold front.



A cold front forms when a cold air mass pushes a warmer air mass away. The front moves in the direction that the cold air mass is moving.

**TAKE A LOOK**

2. **Describe** What happens to the warm air mass at a cold front?

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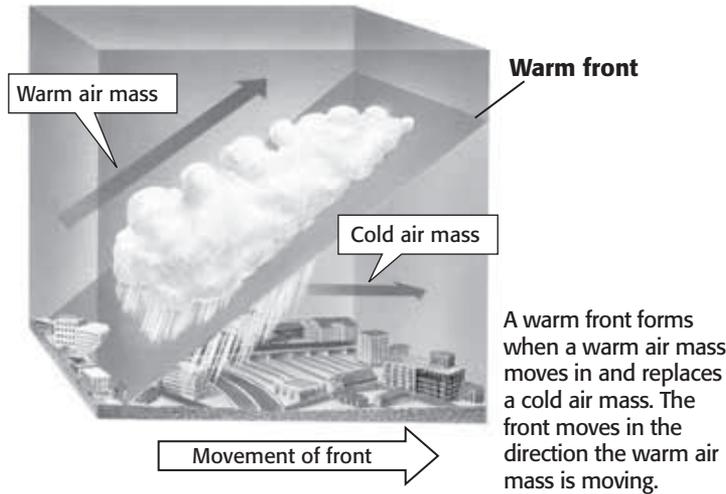
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**SECTION 2** Fronts and Weather *continued*

**WARM FRONTS**

A *warm front* forms when a warm air mass moves over a cold air mass that is leaving an area. The warm air replaces the cold air as the cold air moves away. Warm fronts can bring light rain. They are followed by clear, warm weather. ✓



**READING CHECK**

**3. Define** What is a warm front?

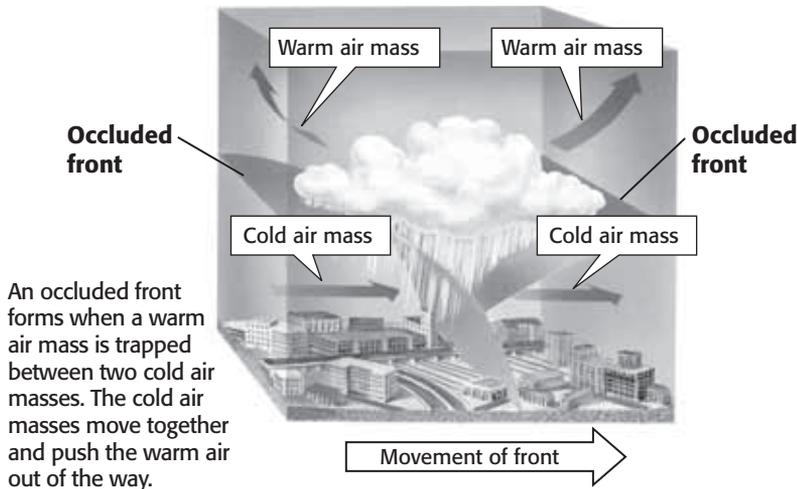
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**OCCLUDED FRONTS**

An *occluded front* forms when a warm air mass is caught between two cold air masses. Occluded fronts bring cool temperatures and large amounts of rain and snow.



**TAKE A LOOK**

**4. Describe** What happens to the warm air mass in an occluded front?

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**STATIONARY FRONTS**

A *stationary front* forms when a cold air mass and a warm air mass move toward each other. Neither air mass has enough energy to push the other out of the way. Therefore, the two air masses remain in the same place. Stationary fronts cause many days of cloudy, wet weather.

**SECTION 2** Fronts and Weather *continued*

**TAKE A LOOK**

**5. Infer** What do you think is the reason that stationary fronts bring many days of the same weather?

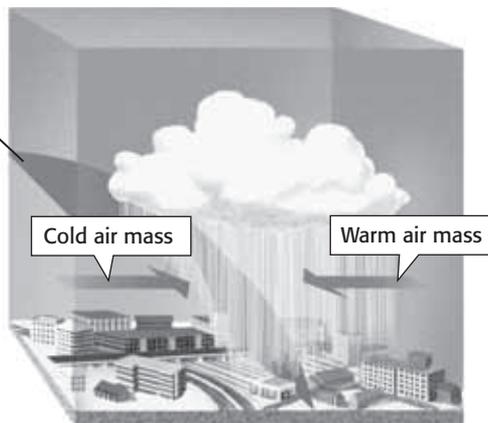
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**Stationary front**



A stationary front forms when air masses stay in one place.

**How Does Air Pressure Affect Weather?**

Remember that air produces pressure. However, air pressure is not always the same everywhere. Areas with different pressures can cause changes in the weather. These areas may have lower or higher air pressure than their surroundings.

A **cyclone** is an area of the atmosphere that has lower pressure than the surrounding air. The air in the cyclone rises. As the air rises, it cools. Clouds can form and may cause rainy or stormy weather.

An **anticyclone** is an area of the atmosphere that has higher pressure than the surrounding air. Air in anticyclones sinks and gets warmer. Its relative humidity decreases. This warm, sinking air can bring dry, clear weather.

**What Causes Thunderstorms?**

A *thunderstorm* is an intense storm with strong winds, heavy rain, lightning, and thunder. Two conditions are necessary for a thunderstorm to form: warm, moist air near Earth's surface and an unstable area of atmosphere.

The atmosphere is unstable when a body of cold air is found above a body of warm air. The warm air rises and cools as it mixes with the cool air. As the warm air reaches its dew point, the water vapor condenses and forms cumulus clouds. If the warm air keeps rising, the cloud may become a dark cumulonimbus cloud.

**CALIFORNIA STANDARDS CHECK**

**6.4.e** Students know differences in pressure, heat, air movement, and humidity result in changes of weather.

**6. Describe** Why do clouds often form in a cyclone?

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**Critical Thinking**

**7. Infer** Why does air near the surface have to be moist in order for a thunderstorm to form?

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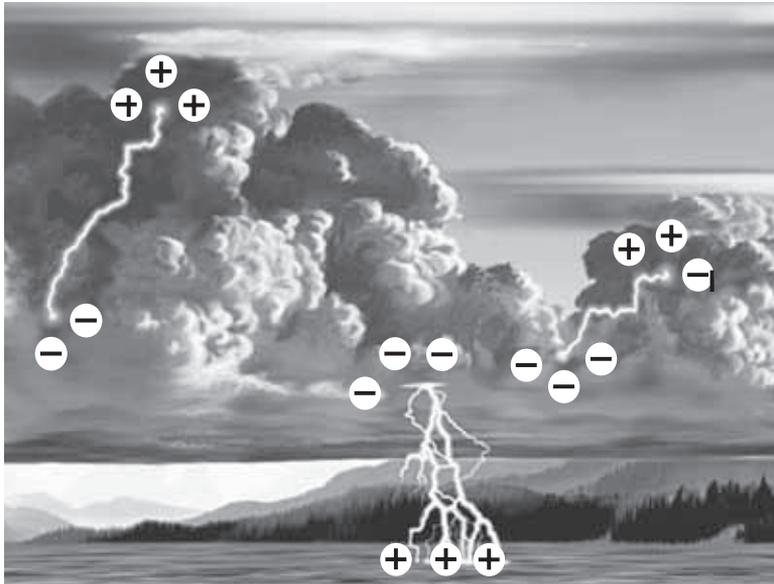
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**SECTION 2** Fronts and Weather *continued*

**LIGHTNING AND THUNDER**

As the cloud grows bigger, parts of it begin to develop electrical charges. The upper parts of the cloud tend to become positively charged. The lower parts tend to become negatively charged. When the charges get big enough, electricity flows from one area to the other. Electricity may also flow between the clouds and the ground. These electrical currents are **lightning**. ✓



Different parts of thunderclouds and the ground can have different electrical charges. When electricity flows between these areas, lightning forms.

You have probably seen large lightning bolts that travel between the clouds and the ground. When the lightning moves through the air, the air gets very hot. The hot air expands rapidly. As it expands, it makes the air vibrate. The vibrations release energy in the form of sound waves. The result is **thunder**. ✓

**How Do Tornadoes Form?**

Fewer than 1% of thunderstorms produce tornadoes. A **tornado** can form when a rapidly spinning column of air, called a *funnel cloud*, touches the ground. The air in the center of a tornado has low pressure. When the area of low pressure touches the ground, material from the ground can be sucked up into the tornado.

A tornado begins as a funnel cloud that pokes through the bottom of a cumulonimbus cloud. The funnel cloud becomes a tornado when the funnel cloud touches the ground. The figures on the top of the next page show how a tornado forms.

✓ **READING CHECK**

**8. Describe** How does lightning form?

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✓ **READING CHECK**

**9. Define** What is thunder?

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**SECTION 2** Fronts and Weather *continued*



**1** Wind moving in opposite directions causes a layer of air in the middle of a cloud to begin to spin.



**2** Strong vertical winds cause the spinning column of air to turn into a vertical position.



**3** The spinning column of air moves to the bottom of the cloud and forms a funnel cloud.



**4** The funnel cloud becomes a tornado when it touches down on the ground.

**TAKE A LOOK**

**10. Describe** When does a funnel cloud become a tornado?

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**How Do Hurricanes Form?**

A *hurricane* is a large, rotating tropical weather system. Hurricanes have wind speeds of over 120 km/h. They can be 160 km to 1,500 km in diameter and can travel for thousands of miles. They are the most powerful storms on Earth.

Most hurricanes form between 5°N and 20°N latitude or between 5°S and 20°S latitude. They form over the warm, tropical oceans found at these latitudes. At higher latitudes, the water is too cold for hurricanes to form. ✓

Hurricanes are powered by solar energy. The sun's energy causes ocean water to evaporate into water vapor. As the water vapor rises in the air, it cools and condenses. A group of thunderstorms form. They produce a large, spinning storm. A hurricane forms as the storm gets stronger.

The hurricane will continue to grow as long as it is over warm ocean water. When the hurricane moves over colder waters or over land, the storm loses energy. This is why hurricanes are not common in California. Hurricanes that move toward California quickly lose their energy over the cold coastal waters.

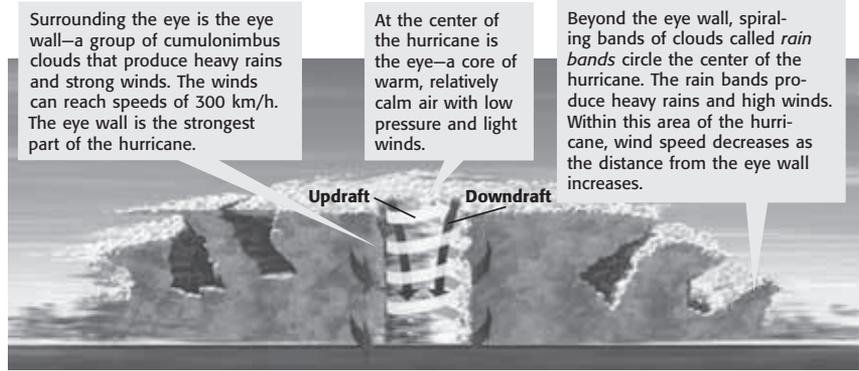
**READING CHECK**

**11. Explain** Why don't hurricanes form at high latitudes?

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**SECTION 2** Fronts and Weather *continued*



Although hurricanes are very destructive storms, the eye at the center of the tropical storm is relatively calm.

**TAKE A LOOK**

**12. Define** What is the eye of a hurricane?

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**What Are the Dangers of Severe Weather?**

Severe weather can cause property damage, injury, and sometimes even death. Hail, lightning, high winds, tornadoes, and flash floods are all part of severe weather. Strong winds can knock down power lines and damage homes. Lightning starts thousands of fires every year.

Heavy rains can cause flooding and major property damage. Flash floods are also responsible for many weather-related deaths. Much of the damage caused by hurricanes comes from the heavy rains and storm surge that these storms produce. A *storm surge* is a rise in sea level that happens during a storm. The storm-surge flooding from Hurricane Katrina in 2005 caused more damage than the high-speed winds from the storm.

**SEVERE-WEATHER SAFETY**

During severe weather, it is important for you to listen to a local TV or radio station. Severe-weather announcements will tell you where a storm is and if it is getting worse. ✓

During most kinds of severe weather, it is safest to stay inside, away from windows. However, there are times when you will need to *evacuate*, or leave your home. For example, if your home is in a low-lying area, you should not stay there during a flash-flood warning. Instead, you should leave and move to higher ground. However, you should never enter floodwaters. Even shallow floodwater can be dangerous.

**READING CHECK**

**13. Explain** Why should you listen to weather reports during severe weather?

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# Section 2 Review

6.2.d, 6.4.a, 6.4.e



## SECTION VOCABULARY

**air mass** a large body of air throughout which temperature and moisture content are similar

**cyclone** an area in the atmosphere that has lower pressure than the surrounding areas and has winds that spiral toward the center

**Wordwise:** The root *cycl* means “circle” or “wheel.” Other examples are *bicycle*, *cyclic*, and *cycle*.

**front** the boundary between air masses of different densities and usually different temperatures

**lightning** an electric discharge that takes place between two oppositely charged surfaces, such as between a cloud and the ground, between two clouds, or between two parts of the same cloud

**thunder** the sound caused by the rapid expansion of air along an electrical strike

**tornado** a destructive, rotating column of air that has very high wind speeds and that may be visible as a funnel-shaped cloud

**1. Identify Relationships** How are fronts and air masses related?

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**2. Compare** Fill in the table to describe cyclones and anticyclones.

Name	The pressure in the middle is . . .	The air inside it . . .	The kind of weather it causes . . .
<b>Cyclone</b>	. . . lower than the surrounding pressure.		
<b>Anticyclone</b>		. . . sinks and warms.	

**3. Explain** Why do thunder and lightning usually happen together?

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**4. Describe** How can flooding affect people?

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**5. Analyze** How does energy from the sun power hurricanes?

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# What Is Climate?

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What is climate?
- What factors affect climate?
- How does climate differ around the world?



California Science Standards

6.4.b, 6.4.d, 6.4.e

## What Is Climate?

How is climate different from weather? *Weather* is the condition of the atmosphere at a certain time. The weather can change from day to day. However, **climate** describes the average weather conditions in a region over a long period of time. The climate of an area includes the area's average temperature and amount of precipitation. Different parts of the world have different climates.



**Ask Questions** As you read this section, write down any questions that you have. When you finish reading, talk about your questions in a small group.

## What Factors Affect Climate?

Climate is mainly determined by temperature and precipitation. Temperature and precipitation can be affected by four factors: latitude, wind patterns, landforms, and ocean currents. ✓



**1. List** What are the two main things that determine climate?

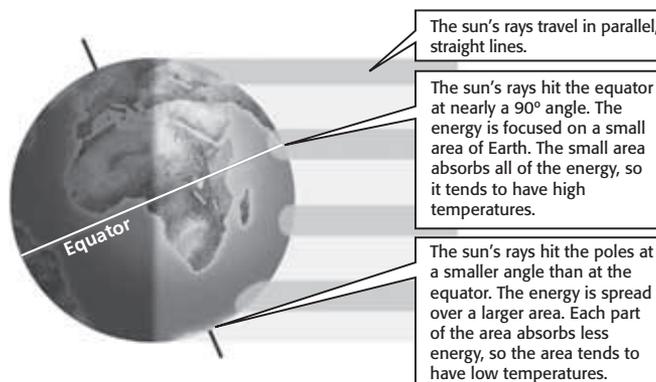
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### SOLAR ENERGY AND LATITUDE

The **latitude** of an area is its distance north or south of the equator. In general, the temperature of an area depends on its latitude: higher latitudes tend to have colder climates. Latitude affects temperature because latitude determines how much direct solar energy an area gets. This is shown in the figure below.



## TAKE A LOOK

**2. Explain** Why do areas near the equator tend to have high temperatures?

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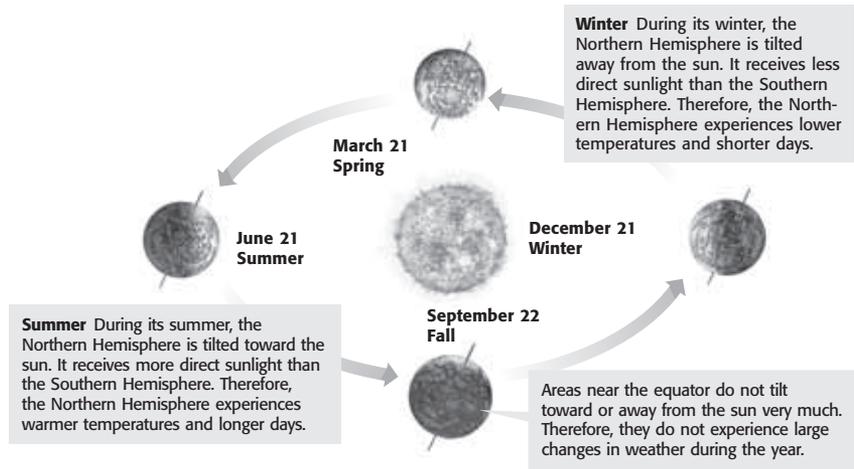
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**SECTION 3** What Is Climate? *continued*

**LATITUDE AND SEASONS**

Most places in the United States have four seasons during the year. However, some places in the world do not have such large seasonal changes. For example, places near the equator have about the same temperatures and amount of daylight all year.

Seasons happen because Earth is tilted on its axis by about 23.5°. The tilt affects how much solar energy an area gets as Earth orbits the sun. The figure below shows how Earth’s tilt affects the seasons.



**TAKE A LOOK**

**3. Explain** Why don't areas near the equator have large seasonal changes in weather?

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**WINDS**

Winds move in predictable patterns over Earth’s surface. The wind patterns on Earth are caused by the uneven heating of Earth’s surface. This uneven heating forms areas with different air pressures. Wind forms when air moves from areas of high pressure to areas of low pressure. ✓

Winds affect climate and weather because they move solar energy from one place to another. This can cause the temperature in one place to decrease and the temperature in another place to increase.

Winds also affect the amount of precipitation an area gets. Winds can carry water vapor away from the oceans. The water vapor can condense and fall to the land somewhere far from the ocean.

The figure on the top of the next page shows the major wind systems, or wind belts, on Earth. Notice that most wind belts blow from west to east or from east to west.

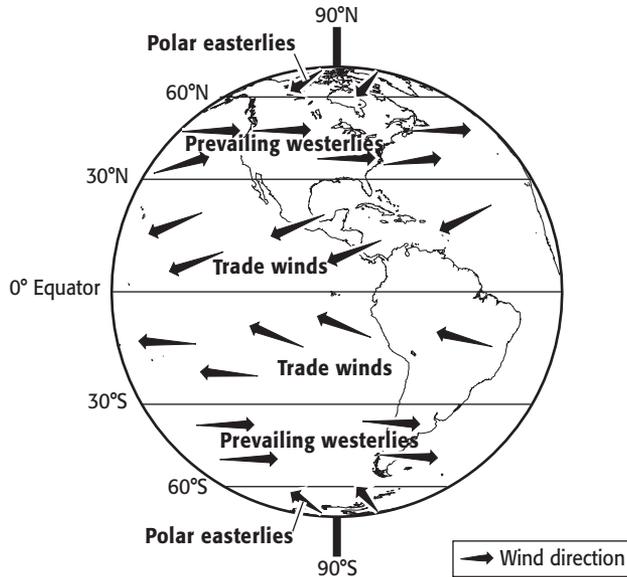
**READING CHECK**

**4. Identify** What causes wind to form?

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**SECTION 3** What Is Climate? *continued*



**TAKE A LOOK**

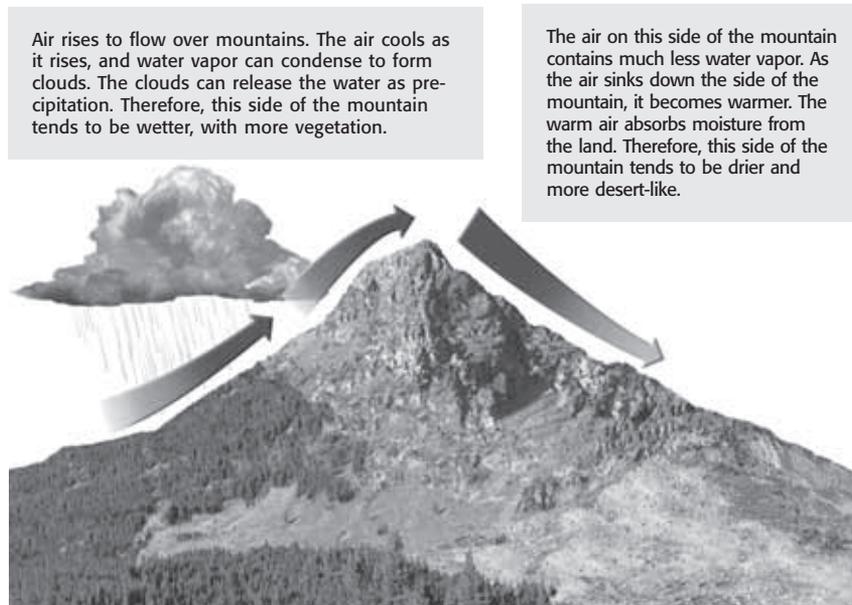
**5. Read a Map** In which direction do the Prevailing Westerlies blow?

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**TOPOGRAPHY**

The topography of an area affects its climate. *Topography* is the sizes and shapes of the land-surface features of a region. Topography can affect the temperature and precipitation of an area. For example, elevation can have a large impact on temperature. **Elevation** is the height of an area above sea level. As elevation increases, temperature tends to decrease. ✓

Mountains can also affect precipitation. As air rises to move over a mountain, the air cools. The cool air condenses, forming clouds. Precipitation may fall. This process causes the *rain-shadow effect*, which is illustrated in the figure below.



**READING CHECK**

**6. Describe** In general, how does elevation affect temperature?

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**TAKE A LOOK**

**7. Explain** Why do clouds form as air moves over a mountain?

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**SECTION 3** What Is Climate? *continued*

**LARGE WATER BODIES**

Large bodies of water can affect an area’s climate. Water absorbs and releases heat more slowly than land. This quality helps regulate the air temperature over the land nearby. This is why sudden temperature changes are not very common in areas near large bodies of water. ✓

An example of this effect is the climate of California. The Pacific Ocean off California’s coast keeps the temperature fairly mild all year round. Other states at the same latitude as California, but far from the oceans, have much less mild climates than California.

**READING CHECK**

**8. Explain** Why aren’t sudden temperature changes common near large bodies of water?

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**Critical Thinking**

**9. Describe Processes** Cool surface currents can cause the air above them to become cooler. Explain how this happens.

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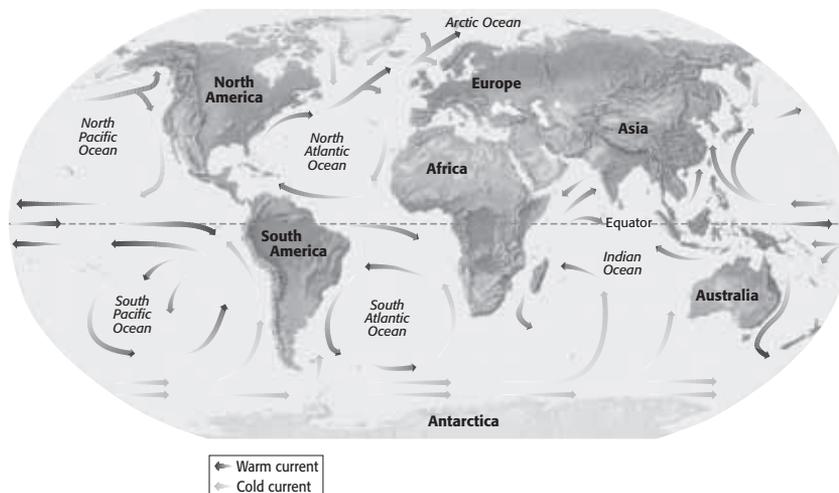
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**OCEAN CURRENTS**

The currents that move along the ocean’s surface can have a big effect on a region’s climate. **Surface currents** are paths of flowing water found near the surface of the ocean. As surface currents move, they carry warm or cool water to different places. The temperature of the water affects the temperature of the air above it. For example, warm currents can heat the surrounding air.

California’s climate is affected by a cool ocean current. Cold water from the northern Pacific Ocean moves south toward Mexico in the California current. You can see other currents in the figure below.



**TAKE A LOOK**

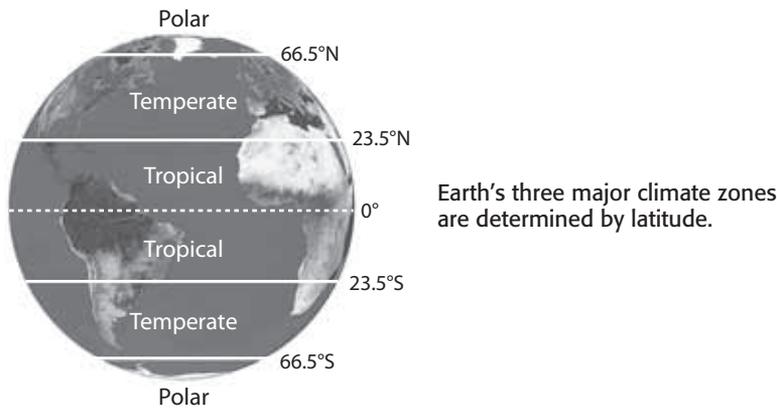
**10. Identify** What kind of surface current is found off the East Coast of the United States?

\_\_\_\_\_

**SECTION 3** What Is Climate? *continued*

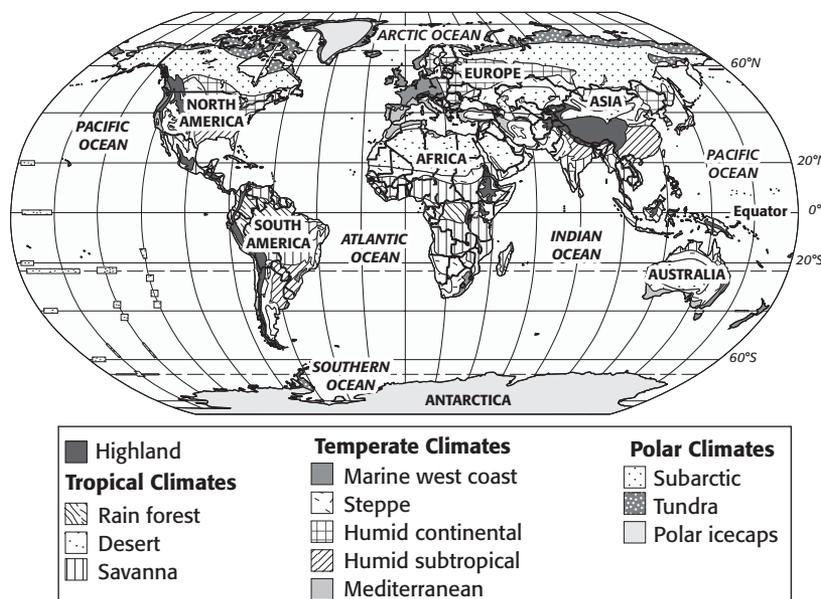
## What Are the Different Climates Around the World?

Earth has three major climate zones: tropical, temperate, and polar. The figure below shows where these zones are found.



Each climate zone has a certain range of temperatures. The tropical zone, near the equator, has the highest temperatures. The polar zones, located at latitudes above 66.5°, have the lowest temperatures. ✓

Each climate zone contains several different kinds of climates. The different climates are the result of topography, winds, and ocean currents. The figure below shows the different kinds of climates on Earth.



### TAKE A LOOK

**11. Identify** What determines Earth's major climate zones?

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### READING CHECK

**12. Describe** Which climate zone has the highest temperatures?

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### TAKE A LOOK

**13. Explain** Why are there different climates in each climate zone, even though the areas are found at similar latitudes?

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# Section 3 Review

6.4.b, 6.4.d, 6.4.e



## SECTION VOCABULARY

**climate** the average weather conditions in an area over a long period of time

**elevation** the height of an object above sea level

**latitude** the distance north or south from the equator; expressed in degrees

**surface current** a horizontal movement of ocean water that is caused by wind and that occurs at or near the ocean's surface

**1. Describe** How is climate different from weather?

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**2. Apply Concepts** Nome, Alaska, lies at  $64^{\circ}\text{N}$  latitude. San Diego, California, lies at  $32^{\circ}\text{N}$  latitude. Which city receives more sunlight? Explain your answer.

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**3. Explain** What causes some places on Earth to have seasons?

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**4. Identify** What are four things that can affect climate?

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**5. Explain** Describe how the rain-shadow effect works.

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# Changes in Climate

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How has Earth's climate changed over time?
- What factors can cause climates to change?



California Science Standards

6.2.d, 6.4.a, 6.4.b, 6.6.a

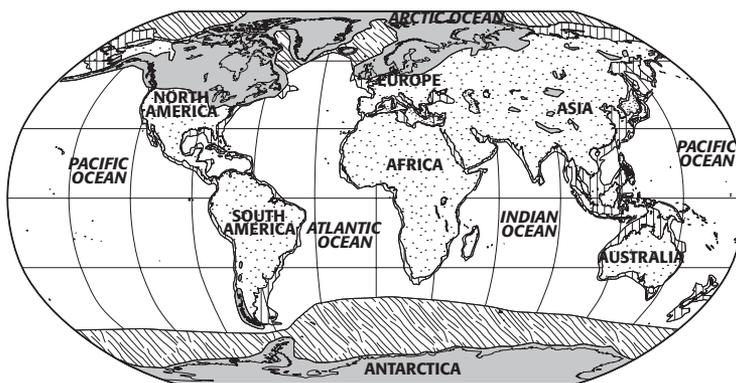
## How Was Earth's Climate Different in the Past?

The geologic record shows that Earth's climate in the past was different from its climate today. During some periods in the past, Earth was much warmer. During other periods, Earth was much colder. In fact, much of Earth was covered by sheets of ice during some times in the past.

An **ice age** happens when ice at high latitudes expands toward lower latitudes. Scientists have found evidence of many major ice ages in Earth's history. The most recent one began about 2 million years ago. ✓

Many people think of an ice age as a time when the temperature is always very cold. However, during an ice age, there can be periods of colder or warmer weather. A period of colder weather is called a *glacial period*. A period of warmer weather is called an *interglacial period*.

During glacial periods, large sheets of ice grow. These ice sheets form when ocean water freezes. Therefore, sea level drops during glacial periods. The figure below shows the coastlines of the continents during the last glacial period. Notice that the continental coastlines extended further into the ocean than they do today.



## STUDY TIP

**Learn New Words** As you read, underline any words that you don't know. When you figure out what they mean, write the words and their definitions in your notebook.

## READING CHECK

**1. Define** Write your own definition for *ice age*.

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## TAKE A LOOK

**2. Explain** Why is more land exposed during glacial periods than at other times?

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**SECTION 4** Changes in Climate *continued*

## What Factors Can Cause Climates to Change?

Scientists have several theories to explain ice ages and other forms of climate change. Factors that can cause climate change are Earth's orbit, plate tectonics, the sun's cycles, asteroid impacts, volcanoes, and human activities.

### CHANGES IN EARTH'S ORBIT

A Serbian scientist, Milutin Milankovitch, found that changes in Earth's orbit and tilt can affect Earth's climate. He modeled the way Earth moves in space and found that Earth's movements change in a regular way. These changes happen over tens of thousands of years. For example, Earth's orbit around the sun is more circular at some times than others.

These variations in Earth's orbit and tilt affect how much sunlight Earth gets. Therefore, they can also affect climate. The figure below shows how these factors can change the amount of sunlight Earth gets.

## Critical Thinking

**3. Infer** Could changes in climate over 100 years be caused by changes in Earth's orbit and tilt? Explain your answer.

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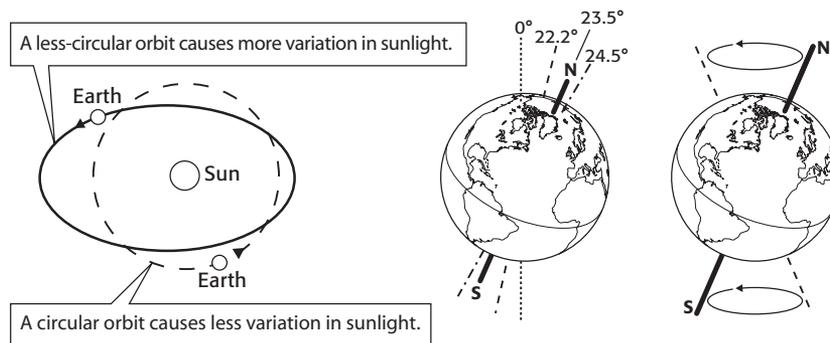
## TAKE A LOOK

**4. Identify** How does the shape of Earth's orbit change?

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Earth's orbit is more circular at some times than at other times. The amount of solar energy that Earth gets from the sun varies more when Earth's orbit is less circular.

Earth's tilt on its axis can vary. When the tilt is greater, the poles get more solar energy.

Earth's axis wobbles slightly. This affects how much sunlight Earth's surface gets at different times of the year.

### PLATE TECTONICS

Plate tectonics and continental drift also affect Earth's climate. When a continent is closer to the equator, its climate is warmer than when it is near the poles. Also, remember that continents can deflect ocean currents and winds. When continents move, the flow of air and water around the globe changes. These changes can strongly affect Earth's climate.

**SECTION 4** Changes in Climate *continued*

**THE SUN**

Some changes in Earth’s climate are caused by changes in the sun. Many people think that the sun is always the same, but this is not true. In fact, the amount of energy that the sun gives off can change over time. The sun follows a regular cycle in how much energy it gives off. Because the sun’s energy drives most cycles on Earth, these changes can affect Earth’s climate. ✓

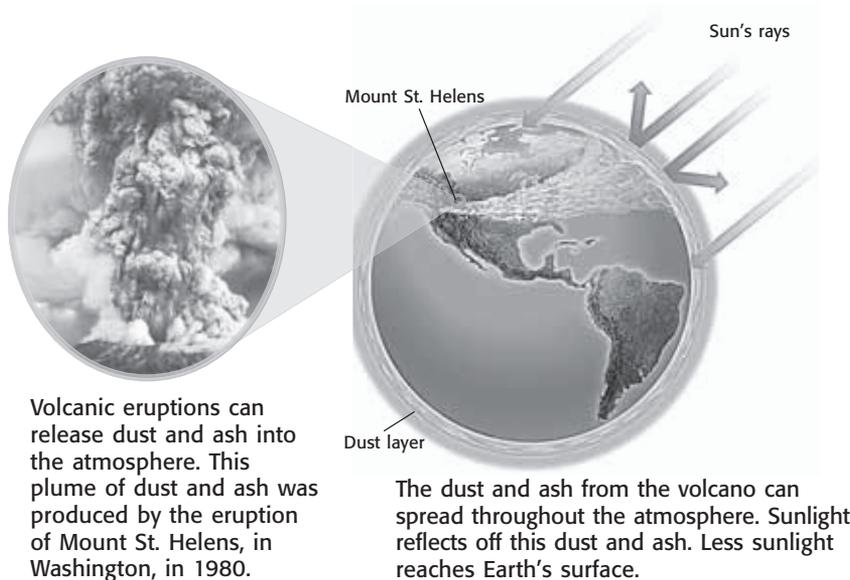
**IMPACTS**

Sometimes, objects from outer space, such as asteroids, crash into Earth. An *asteroid* is a small, rocky object that orbits the sun. If a large asteroid crashed into Earth, the climate of the whole planet could change

When a large object hits Earth, particles of dust and rock fly into the atmosphere. This material can block some sunlight from reaching Earth’s surface. This can cause temperatures on Earth to go down. In addition, plants may not be able to survive with less sunlight. Without plants, many animals would die off. Many scientists believe that an asteroid impact may have caused the dinosaurs to become extinct.

**VOLCANIC ERUPTIONS**

Volcanic eruptions can affect Earth’s climate for a short time. They send large amounts of dust and ash into the air. As with an asteroid impact, the dust and ash block sunlight from reaching Earth’s surface. The figure below shows how volcanic dust can affect sunlight.



Volcanic eruptions can release dust and ash into the atmosphere. This plume of dust and ash was produced by the eruption of Mount St. Helens, in Washington, in 1980.

The dust and ash from the volcano can spread throughout the atmosphere. Sunlight reflects off this dust and ash. Less sunlight reaches Earth’s surface.

**READING CHECK**

**5. Explain** Why do changes in the sun’s energy affect the climate on Earth?

\_\_\_\_\_

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\_\_\_\_\_

**Critical Thinking**

**6. Identify Relationships** Why may animals die off if there are fewer plants around?

\_\_\_\_\_

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**TAKE A LOOK**

**7. Compare** How are the effects on climate of volcanic eruptions and asteroid impacts similar?

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**SECTION 4** Changes in Climate *continued*

**HUMAN ACTIVITIES**

A slow increase in global temperatures is called **global warming**. One thing that can cause global warming is an increase in the greenhouse effect. The **greenhouse effect** is Earth’s natural heating process. During this process, gases in the atmosphere absorb energy in sunlight. This energy is released as heat, which helps to keep Earth warm. Without the greenhouse effect, Earth’s surface would be covered in ice. ✓

 **READING CHECK**

**8. Define** What is global warming?

\_\_\_\_\_

\_\_\_\_\_

One of the gases that absorbs sunlight in the atmosphere is carbon dioxide (CO<sub>2</sub>). If there is more CO<sub>2</sub> in the atmosphere, the greenhouse effect can increase. This can cause global warming.

Much of the CO<sub>2</sub> in the atmosphere comes from natural processes, such as volcanic eruptions and animals breathing. However, human activities can also increase the amount of CO<sub>2</sub> in the atmosphere.

When people burn fossil fuels for energy, CO<sub>2</sub> is released into the atmosphere. When people burn trees to clear land for farming, CO<sub>2</sub> is released. In addition, plants use CO<sub>2</sub> for food. Therefore, when trees are destroyed, we lose a natural way of removing CO<sub>2</sub> from the atmosphere.

Many scientists think that if global warming continues, the ice at Earth’s poles could melt. This could cause sea level to rise. Many low-lying areas could flood. Global warming could also affect areas far from the oceans. ✓

 **READING CHECK**

**9. Explain** Why may sea level rise if global warming continues?

\_\_\_\_\_

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\_\_\_\_\_

**WHAT PEOPLE CAN DO**

Many countries are working together to reduce the effects of global warming. Treaties and laws have helped to reduce pollution and CO<sub>2</sub> production. Most CO<sub>2</sub> is produced when people burn fossil fuels for energy. Therefore, reducing how much energy you use can reduce the amount of CO<sub>2</sub> produced. Here are some ways you can reduce your energy use:

- Turn off electrical equipment, such as lights and computers, when you are not using them.
- Ride a bike, walk, or take public transportation instead of using a car to travel.
- Turn the heat to a lower temperature in the winter.
- Turn the air conditioner to a higher temperature in the summer.

# Section 4 Review

6.2.d, 6.4.a, 6.4.b, 6.6.a 

## SECTION VOCABULARY

<p><b>global warming</b> a gradual increase in average global temperature</p> <p><b>greenhouse effect</b> the warming of the surface and lower atmosphere of Earth that occurs when water vapor, carbon dioxide, and other gases absorb and reradiate thermal energy</p>	<p><b>ice age</b> a long period of climatic cooling during which the continents are glaciated repeatedly</p>
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**1. Identify Relationships** How is global warming related to the greenhouse effect?

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**2. Describe** What did Milutin Milankovitch’s research show can affect Earth’s climate?

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**3. Identify** Give two ways that plate tectonics can affect an area’s climate.

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**4. Predict Consequences** How could global warming affect cities near the oceans? Explain your answer.

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**5. List** Give three ways that human activities can affect the amount of CO<sub>2</sub> in the atmosphere.

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SECTION 1 **Everything Is Connected**



**BEFORE YOU READ**

After you read this section you should be able to answer these questions:

- What do organisms in an ecosystem depend on for survival?
- What are biotic and abiotic factors?
- What are the levels of organization in the environment?

**STUDY TIP**

**Underline** As you read, underline any new science terms. Find their definitions in the section review or a dictionary. Make sure you learn what each term means before you move to the next section.

**What Is the Web of Life?**

All organisms, or living things, are linked together in the web of life. In this web, energy and resources pass between organisms and their surroundings. The study of how different organisms interact with one another and their environment is **ecology**.

A hungry bear may go to a river to catch a fish or look for berries to eat. In both examples, the bear is interacting with the environment, which includes other organisms. The bear depends on the other organisms, and they depend on the bear. For example, after the bear eats berries, it spreads the berry plant's seeds to new areas in its waste.

**TAKE A LOOK**

**1. Identify** List three things the bear in this figure depends on to survive in its environment.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



An environment has both biotic and abiotic factors.

**READING CHECK**

**2. Compare** What is the difference between biotic and abiotic factors?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**What Are the Two Parts of an Environment?**

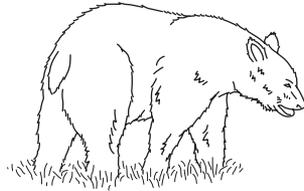
An organism's environment is made up of biotic and abiotic factors. **Biotic** factors are the living parts of the environment, such as fish. **Abiotic** factors are the nonliving parts of the environment, such as rivers. Organisms need both biotic and abiotic factors to live. ✓

**SECTION 1** Everything Is Connected *continued*

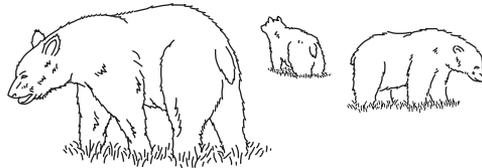
**How Is the Environment Organized?**

The environment can be organized into six levels. Individual organisms are at the first level. The higher levels include more and more parts of the environment. The highest level is the largest. It is the biosphere.

1. An *individual* is a single organism.



2. A **population** is a group of individuals of the same species in the same area. For example, all the black bears in the same forest make a population. The whole population uses the same area for food and shelter.



3. A **community** is made up of all the different populations that live and interact in the same area. The different populations in a community depend on each other. For example, bears eat fish and berries. Berry plants depend on bears to eat their berries, which moves their seeds to other areas. River plants are food for some water animals, and they shelter fish that are hiding from bears.



4. An **ecosystem** is made up of a community and its abiotic environment. The abiotic factors provide resources for all the organisms and energy for some. A river, for example, can provide water for river plants and many animals, and shelter for water insects. It can provide nutrients for plants, as well as food for fish and bears.

*Critical Thinking*

3. **Making Inferences** Could a community be made up of only one population of organisms? Explain.

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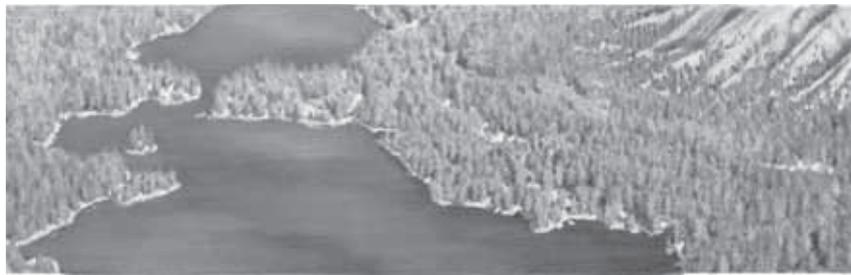


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**TAKE A LOOK**

4. **Identify** Use colored pencils to make circles on the picture.  
 Circle an individual in red.  
 Circle a population in blue.  
 Circle a community in brown.  
 Circle an ecosystem in green.

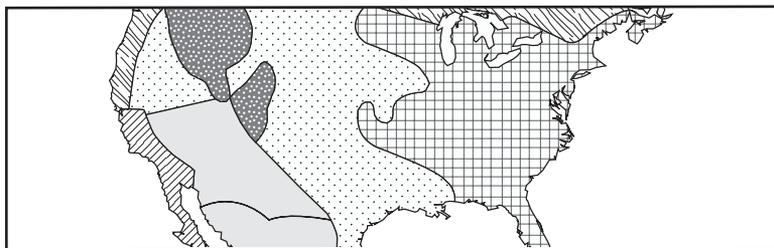
**SECTION 1** Everything Is Connected *continued*



5. A **biome** is a large area made of many similar ecosystems with the same climate. The climate determines the kinds of organisms that live there. The organisms in a biome must be adapted to live in the conditions in that biome. For example, a temperate deciduous forest biome is warm and moist in summer but dry and cold in winter. Only animals and plants that can live through the winter will survive there. Bears and many other animals there sleep for most of the winter, while food is harder to find. Deciduous trees shed their leaves so that they won't dry out.

 **Say It**

**Interpret** Look at the map and read the text above it. With a partner, discuss what the map shows, and what the different patterns on the map mean.



6. The **biosphere** is the part of Earth where life exists. The biosphere is the largest environmental level. It reaches from the bottom of the ocean and the Earth's crust to high in the sky. Scientists study the biosphere and its abiotic factors, such as atmosphere, water, soil, and rock, to learn how life survives.



# Section 1 Review

## SECTION VOCABULARY

<p><b>abiotic</b> describes the nonliving part of the environment, including water, rocks, light, and temperature</p> <p><b>biome</b> a large region characterized by a specific type of climate and certain types of plant and animal communities</p> <p><b>biosphere</b> the part of Earth where life exists</p> <p><b>biotic</b> describes living factors in the environment</p>	<p><b>community</b> all of the populations of species that live in the same habitat and interact with each other</p> <p><b>ecology</b> the study of the interactions of living organisms with one another and with their environment</p> <p><b>ecosystem</b> a community of organisms and their abiotic, or nonliving, environment</p> <p><b>population</b> a group of organisms of the same species that live in a specific geographical area</p>
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**1. Compare** What is the difference between a community and an ecosystem?

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**2. Organize** Complete the chart below to describe the six levels of the environment, from smallest to largest.

Level	Description
	a single organism
Population	
	all of the populations of species that live in the same habitat and interact with one another
Ecosystem	
	a large region with the same climate and same types of organisms
Biosphere	

**3. Identify** What two kinds of factors does an organism depend on for survival?

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SECTION 2 **Living Things Need Energy**



**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do producers, consumers, and decomposers get energy?
- What is a food web?
- How does the amount of resources in an area affect the organisms living there?

**STUDY TIP**

**Circle** Choose different colored pencils for producers, primary consumers, secondary consumers, and decomposers. As you read, circle these terms in the text with the colors you chose. Use the same colors to circle animals in any figures that are examples of each group.

**READING CHECK**

**1. Explain** Why is sunlight important to producers?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Critical Thinking**

**2. Apply Concepts** What types of consumers are the following organisms?

**tigers** \_\_\_\_\_

**deer** \_\_\_\_\_

**humans** \_\_\_\_\_

**How Do Organisms Get Energy?**

Eating gives organisms two things they cannot live without—energy and nutrients. Prairie dogs, for example, eat grasses and seeds to get their energy and nutrients. Like all organisms, prairie dogs need energy to live.

Organisms in any community can be separated into three groups based on how they get energy. These groups are producers, consumers, and decomposers.

**PRODUCERS**

*Producers* are organisms that use the energy from sunlight to make their own food. This process is called *photosynthesis*. Most producers are green plants, such as grasses on the prairie and trees in a forest. Some bacteria and algae also photosynthesize to make food. ✓

**CONSUMERS**

Consumers cannot make their own food as producers can. Consumers need to eat other organisms to obtain energy and nutrients.

Consumers can be put into four groups. A **herbivore** is a consumer that eats only plants. Prairie dogs and bison are herbivores. A **carnivore** is a consumer that eats other animals. Eagles and cougars are carnivores. An **omnivore** is a consumer that eats both plants and animals. Bears and raccoons are omnivores. A *scavenger* is a consumer that eats dead plants and animals. Turkey vultures are scavengers. They will eat animals and plants that have been dead for days. They will also eat what is left over after a carnivore has had a meal.

**SECTION 2** Living Things Need Energy *continued*

**DECOMPOSERS**

Decomposers recycle nature’s resources. Decomposers get energy by breaking down dead organisms into simple materials. These materials, such as carbon dioxide and water, can then be used by other organisms. Many bacteria and fungi are decomposers.

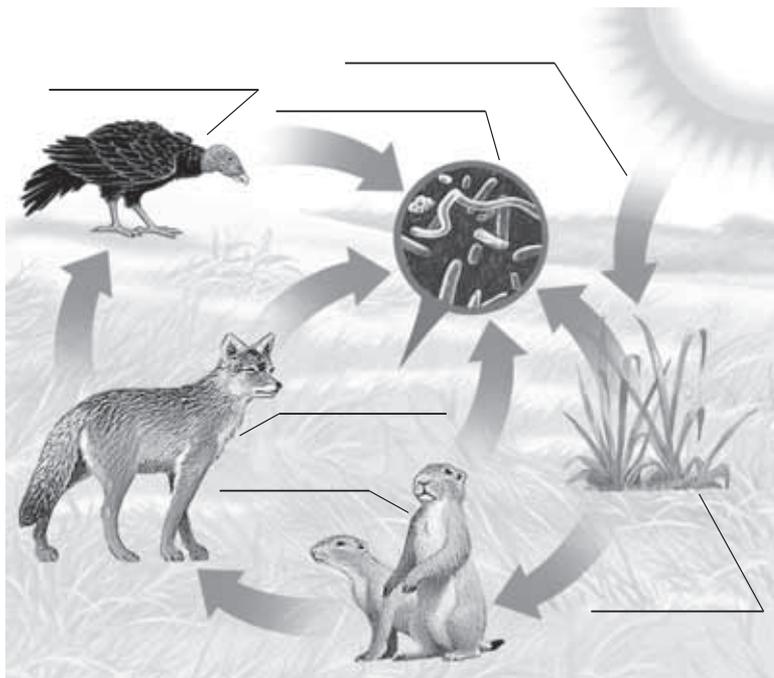
**What Is a Food Chain?**

A **food chain** is the sequence of organisms that pass energy and nutrients from one to the next. Producers form the beginning of the food chain. Energy passes through the rest of the chain as one organism eats another.

- Producers are eaten by primary consumers.
- Primary consumers are eaten by secondary consumers.
- Secondary consumers are eaten by tertiary consumers.

In the food chain below, the grasses are the producers. The grasses are eaten by prairie dogs, which are the primary consumers. The prairie dogs are eaten by coyotes, which are the secondary consumers. When coyotes die, they are eaten by turkey vultures, which are the tertiary consumers. The tertiary consumer is usually the end of the food chain.

**A Prairie Ecosystem Food Chain**



 <p><b>CALIFORNIA STANDARDS CHECK</b></p>
<p><b>6.5.c</b> Students know populations of organisms can be <u>categorized</u> by the <u>functions</u> they serve in an ecosystem.</p> <p><b>Word Help: categorize</b> to put into groups or classes</p> <p><b>Word Help: function</b> use or purpose</p> <p><b>3. Define</b> What is the role of decomposers in an ecosystem?</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p>

**TAKE A LOOK**

**4. Identify** Label the food chain diagram with the following terms: energy, producer, primary consumer, secondary consumer, tertiary consumer, decomposer.

**SECTION 2** Living Things Need Energy *continued*

**What Is a Food Web?**

Simple food chain diagrams do not show how energy really moves through an ecosystem. A **food web** is a system of many connected food chains in an ecosystem. Organisms in the different food chains feed upon one another. A food web is more accurate than a food chain because most animals eat more than one kind of food. ✓

In a food web, energy moves from one organism to the next in one direction. The energy in an organism that is eaten goes into the body of the organism that eats it.

**READING CHECK**

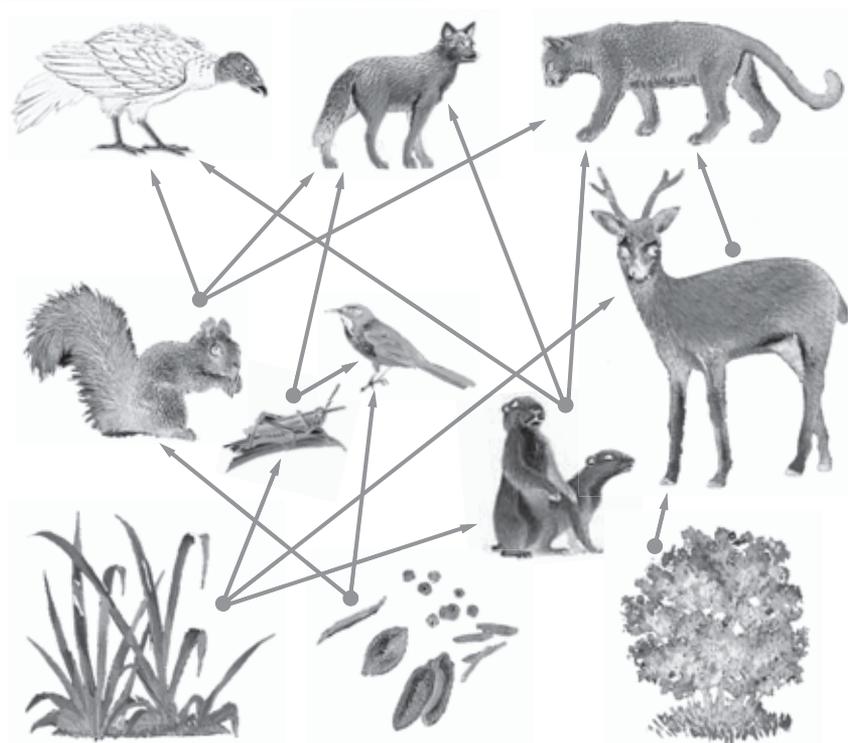
**5. Explain** Why does a food web show feeding relationships better than a food chain?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Simple Food Web**



**CALIFORNIA STANDARDS CHECK**

**6.5.a** Students know energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis and then from organism to organism through food webs.

**Word Help: transfer**  
to carry or cause to pass from one thing to another

**6. Predict Consequences**  
What do you think would happen if all of the plants were taken out of this food web?

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**MANY AT THE BASE**

Only a small part of the energy stored in an organism's body is passed on to the next consumer in a food chain or web. Because of this, many more organisms have to be at the base, or bottom, of the food chain than at the end, or top. For example, in a prairie community, there is more grass than prairie dogs and there are more prairie dogs than coyotes.

**SECTION 2** Living Things Need Energy *continued*

### What Is an Energy Pyramid?

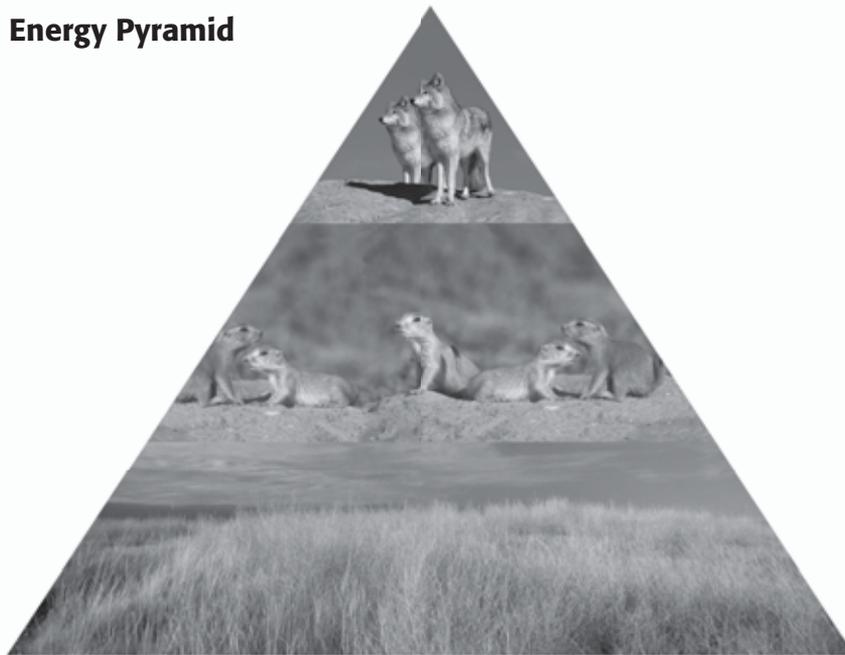
Energy is lost as it passes through a food chain. An **energy pyramid** is a diagram that shows energy loss in an ecosystem. The bottom of the pyramid is larger than the top. There is less energy for use at the top of the pyramid than at the bottom. This is because most of the energy is used up at the lower levels. Only about 10% of the energy at each level of the energy pyramid passes on to the next level.

### Math Focus

**7. Calculate** How much energy is lost at each level of the energy pyramid?

\_\_\_\_\_

**Energy Pyramid**



### TAKE A LOOK

**8. Explain** In which level of this energy pyramid do you think deer would belong? Explain.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### EFFECT OF ONE SPECIES

A single species can change the flow of energy in an ecosystem. For example, gray wolves are at the top of their food chains. They eat a lot of different organisms but are usually not eaten by any other animal. By eating other organisms, wolves help control the size of those populations.

At one point, wolves were found across the United States. As settlers moved west, most wolves moved away or were killed. With few wolves left to feed on the primary consumers, the population of elk began to grow. The elk ate all the grass, and there was none left for the smaller herbivores, such as hares. As these small herbivores died, there was less food for the secondary consumers. When wolves were removed from the food web, the whole ecosystem was affected. ✓

✓ **READING CHECK**

**9. Summarize** Why did a change in the wolf population affect the other organisms in the community?

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

# Section 2 Review

6.5.a, 6.5.b, 6.5.c, 6.5.e



## SECTION VOCABULARY

**carnivore** an organism that eats animals

**energy pyramid** a triangular diagram that shows an ecosystem's loss of energy, which results as energy passes through the ecosystem's food chain

**food chain** the pathway of energy transfer through various stages as a result of the feeding patterns of a series of organisms

**food web** a diagram that shows the feeding relationships between organisms in an ecosystem

**herbivore** an organism that eats only plants

**omnivore** an organism that eats both plants and animals

**1. Explain** Why are producers important in an ecosystem?

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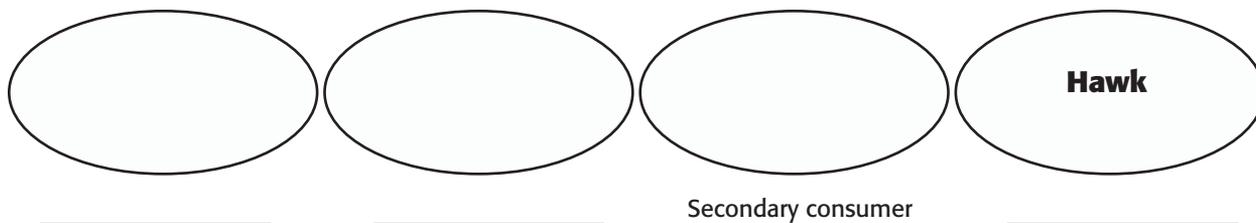


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**2. Connect** Make a food chain using the following organisms: mouse, snake, grass, hawk. Draw arrows showing how energy flows through the chain. Identify each organism as a producer, primary consumer, secondary consumer, or tertiary consumer.



**3. Make Inferences** Do you think you could find a food chain that had 10 organisms? Explain.

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**4. Decide** A food chain off the California coast includes kelp, which is eaten by sea urchins. The urchins are eaten by sea otters, which are eaten by sharks. Can you combine this food chain with the one in question 2 to make a food web? Explain your answer.

## CHAPTER 16 Interactions of Living Things

## SECTION

## 3

## Types of Interactions

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What determines an area's carrying capacity?
- Why does competition occur?
- How do organisms avoid being eaten?
- What are three kinds of symbiotic relationships?



California Science Standards

6.5.a, 6.5.b, 6.5.c, 6.5.e

## How Does the Environment Control Population Sizes?

Most living things have more offspring than will survive. A female frog, for example, may lay hundreds of eggs in a small pond. If all of the eggs became frogs, the pond would soon become very crowded. There would not be enough food for the frogs or other organisms in the pond. But in nature, this usually does not happen. The biotic and abiotic factors in the pond control the frog population so that it does not get too large.

Populations cannot grow without stopping, because the environment has only a certain amount of food, water, space, and other resources. A resource that keeps a population from growing forever is called a *limiting factor*. Food is often a limiting factor in an ecosystem.

## What Is Carrying Capacity?

The largest number of organisms that can live in an environment is called the **carrying capacity**. When a population grows beyond the carrying capacity, limiting factors will cause some individuals to leave the area or to die. As individuals die or leave, the population decreases.

The carrying capacity of an area can change if the amount of the limiting factor changes. For example, the carrying capacity of an area will be higher in seasons when more food is available.



**Make a List** As you read this section, write down any questions you may have. Work with a partner to find the answers to your questions.



### CALIFORNIA STANDARDS CHECK

**6.5.e** Students know the number and types of organisms an ecosystem can support depends on the resources available and on abiotic factors, such as quantities of light and water, a range of temperatures, and soil composition.

**Word Help: resource** anything that can be used to take care of a need

**Word Help: available** that can be used

**Word Help: range** a scale or series between limits

**1. Define** What is a limiting factor?

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**SECTION 3** Types of Interactions *continued*

### How Do Organisms Interact in an Ecosystem?

Populations are made of individuals of the same species. Communities are made of different populations that interact. There are three main ways that individuals and populations affect one another in an ecosystem: in competition, as predator and prey, and through symbiosis. ✓

**READING CHECK**

**2. List** What are three ways that organisms in an ecosystem interact?

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### Critical Thinking

**3. Prediction** In a prairie ecosystem, which two of the following organisms most likely compete for the same food source: elk, coyotes, prairie dogs, vultures?

\_\_\_\_\_

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### Why Do Organisms Compete?

Competition happens when more than one individual or population tries to use the same resource. There may not be enough resources, such as food, water, shelter, or sunlight, for all the organisms in an environment. When one individual or population uses a resource, there is less for others to use.

Competition can happen between organisms in the same population. For example, in Yellowstone National Park, elk compete with one another for the same plants. In the winter, when there are not many plants, competition is much higher. Some elk will die because there is not enough food. In spring, when many plants grow, there is more food for the elk, and competition is lower.

Competition can also happen between populations. In a forest, different types of trees compete to grow in the same area. All of the plant populations must compete for the same resources: sunlight, space, water, and nutrients.

### How Do Predators and Prey Interact?

Another way organisms interact is when one organism eats another to get energy. The organism that is eaten is called the **prey**. The organism that eats the prey is called the **predator**. When a bird eats a worm, for example, the bird is the predator, and the worm is the prey.

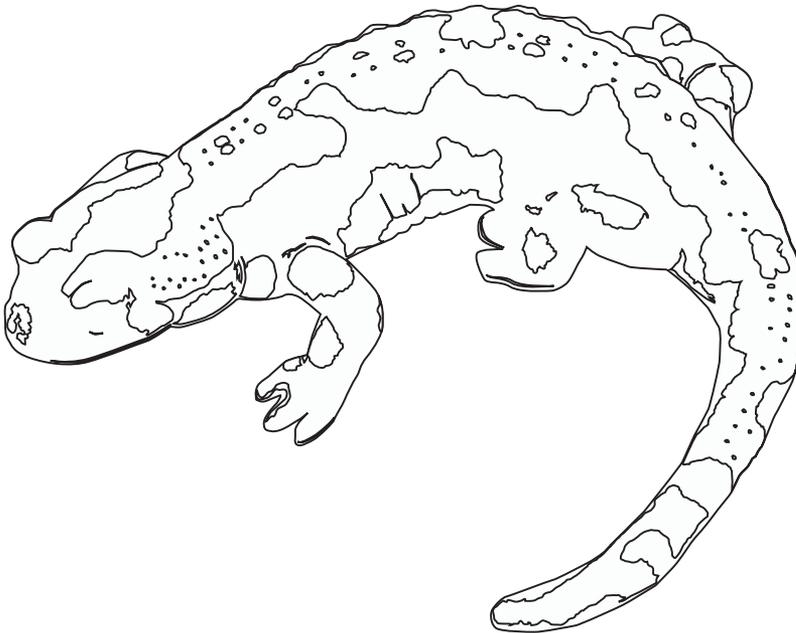
#### PREDATORS

Predators have traits or skills that help them catch and kill their prey. Different types of predators have different skills and traits. For example, a cheetah uses its speed to catch prey. On the other hand, lions have colors that let them blend with the environment so that prey cannot see them easily.

**SECTION 3** Types of Interactions *continued***PREY**

Prey generally have some way to protect themselves from being eaten. Different types of organisms protect themselves in different ways:

- 1. Run Away** When a prairie dog is chased, it runs underground.
- 2. Travel in Groups** Some animals, such as bison, travel in herds, or groups. Many fishes, such as anchovies, travel in schools. All the animals in these groups can help one another by watching for predators.
- 3. Show Warning Colors** Some organisms have bright colors that act as a warning. The colors warn predators that the prey might be poisonous. A brightly colored fire salamander, for example, sprays a poison that burns.



- 4. Use Camouflage** Some organisms can hide from predators by blending in with the background. This is called *camouflage*. A rabbit's natural colors, for example, may help it blend in with dead leaves or shrubs so that it cannot be seen. Some animals may look like twigs, stone, or bark.

**Say It**

**Give examples** In small groups, talk about other animals that escape predators in the four ways described in the text.

**TAKE A LOOK**

**4. Color** A fire salamander has a black body with bright orange or yellow spots. Use colored pencils to give this salamander its warning colors.

**SECTION 3** Types of Interactions *continued*

### What Is Symbiosis?

Some species have very close interactions with other species. A close association between two or more species is called **symbiosis**. Each individual in a symbiotic relationship may be helped, hurt, or not affected by another individual. Often, one species lives on or in another species. Most symbiotic relationships can be divided into three types: mutualism, commensalism, and parasitism. ✓

**READING CHECK**

**5. List** List the three types of symbiotic relationships.

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#### MUTUALISM

When both individuals in a symbiotic relationship are helped, it is called **mutualism**. You can see mutualism in the relationship between a bee and a flower.

Who is hurt?	Who is helped?	Example
No one	both organisms	A bee transfers pollen for a flower; a flower provides nectar to a bee.

#### COMMENSALISM

When one individual in a symbiotic relationship is helped but the other is not affected, this is called **commensalism**.

Who is hurt?	Who is helped?	Example
No one	one of the organisms	A fish called a remora attaches to a shark and eats the shark's leftovers.

#### PARASITISM

A symbiotic relationship in which one individual is hurt and the other is helped is called **parasitism**. The organism that is helped is called the parasite. The organism that is hurt is called the host. ✓

**READING CHECK**

**6. Define** In parasitism, is the host helped or hurt?

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Who is hurt?	Who is helped?	Example
Host	parasite	A flea is a parasite on a dog.

# Section 3 Review

## SECTION VOCABULARY

<p><b>carrying capacity</b> the largest population that an environment can support at any given time</p> <p><b>commensalism</b> a relationship between two organisms in which one organism benefits and the other is unaffected</p> <p><b>mutualism</b> a relationship between two species in which both species benefit</p> <p><b>parasitism</b> a relationship between two species in which one species, the parasite, benefits from the other species, the host, which is harmed</p>	<p><b>predator</b> an organism that kills and eats all or part of another organism</p> <p><b>prey</b> an organism that is killed and eaten by another organism</p> <p><b>symbiosis</b> a relationship in which two different organisms live in close association with each other</p>
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**1. Identify** What are two resources for which organisms are likely to compete?

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**2. Identify Relationships** Complete the chart below to describe the different kinds of symbiotic relationships.

Example organisms	Type of symbiosis	Organism(s) helped	Organism(s) hurt
Flea and dog			host (dog)
Bee and flower	mutualism		
Remora and shark			none

**3. Describe** Give an example of a predator-prey relationship. Be sure to identify which is the predator and which is the prey. Choose a example different from the one in the text.

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SECTION 1 **Studying the Environment**



California Science Standards

6.5.a, 6.5.b, 6.5.c, 6.5.d, 6.5.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are abiotic factors?
- What are the two roles organisms play in an environment?
- Why do similar biomes occur in similar climates?

**STUDY TIP**

**Summarize** After reading each of the subsections, write a short answer to the question asked by the subsection title.

**How Are Environments Different?**

How is a desert different from a forest? Is it that a forest gets more rainfall than a desert? Is it that the kinds of organisms in a desert and a forest are different? Actually, it is both of these, along with other characteristics, that help separate these two types of environment from each other.

You may know that the *biotic factors* of the environment include organisms, or living things. The nonliving parts, such as rainfall, are called *abiotic factors*. Organisms interact with the abiotic parts of their surroundings in different ways. The table below lists some abiotic factors and tells why they are important.

Abiotic factor	Importance to organisms
Sunlight	Plants use sunlight to make food. If sunlight is lacking, plants cannot live. For example, no plants live in the deep ocean, because no sunlight reaches there.
Temperature	Most living things survive better in warm environments. Colder areas have fewer living things than warmer areas. For example, tropical rain forests have more kinds of organisms than colder forests in the north or south.
Rainfall	Areas that get a lot of rain generally have more plants than areas that are dry. Areas with many plants have more animals than areas with few plants.
Soil	Plants rely on chemical nutrients in the soil to grow. If the soil is lacking nutrients, plants do not grow as well.

**Critical Thinking**

**1. Apply Concepts** Explain why adding chemical fertilizers to soil can improve crop growth.

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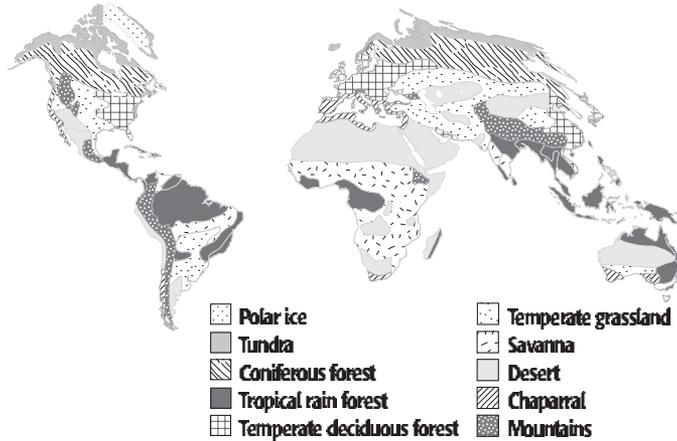
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There are two main kinds of abiotic factors. Some abiotic factors in an area are resources that organisms can use there. For example, organisms can use nutrients in soil as a resource to help them grow. Other abiotic factors are conditions that organisms must adapt to in order to live there. Organisms must adapt to the temperature in an area to live there.

**SECTION 1** Studying the Environment *continued*

## How Are Biomes Different from Ecosystems?

*Ecosystems* are made up of the organisms and abiotic factors in an area. *Biomes* are made up of many connected land and water ecosystems. Therefore, most biomes are much larger than ecosystems. Biomes have certain types of plants that support certain types of animals.



This map shows some of the major land biomes on Earth.

The climate of a biome affects what kinds of organisms can live there. The *climate* of an area is the overall weather conditions in a region over a long time. Climate is caused mainly by a few abiotic factors, such as the amount of rainfall and the temperatures at different times.

## What Are the Roles of Organisms in an Ecosystem?

The biomes and ecosystems on Earth contain many kinds of organisms. However, each organism has one of two main functions, or ecological roles, in an ecosystem. Those roles are producer and consumer.

*Producers* are organisms that make their own food. Plants and many kinds of bacteria are producers. Most producers make their food from sunlight. Other producers, like some bacteria, make their food from chemicals that other organisms cannot use for food-making.

*Consumers* are organisms that cannot make their own food. All animals are consumers. One important kind of consumer is a *decomposer*. Decomposers get their food by breaking down dead organisms. As they eat the dead organisms, decomposers also break them down into simple chemicals that other organisms can use.

### TAKE A LOOK

**2. Infer** Find the tundra biomes on the map. What kind of climate do you think tundra biomes have? Explain your answer.

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 **CALIFORNIA STANDARDS CHECK**

**6.5.c** Students know that populations of organisms can be categorized by the functions they serve in an ecosystem.

**Word Help:** categorize to put into groups or classes

**Word Help:** function use or purpose

**3. Explain** Predators are animals that kill and eat other organisms. Why are both predators and decomposers categorized as consumers?

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**SECTION 1** Studying the Environment *continued*

## Why Do Similar Biomes Occur in Similar Climates?

In places with similar climates, the biomes have similar plant and animal communities. The latitude and height above sea level affect the temperature and rainfall of a location. As you move away from the equator or travel higher up in the mountains, it generally gets colder and drier. ✓

**READING CHECK**

**4. Explain** In general, what happens to temperature as you move away from the equator?

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**READING CHECK**

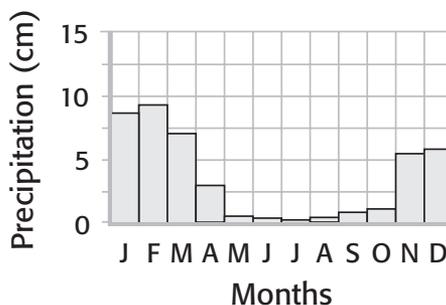
**5. Identify** Why is the climate near the Mediterranean Sea similar to the climate in much of California?

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These changes in climate help explain why biomes found at similar latitudes and similar heights have many things in common. For example, much of California is at the same latitude as the area around the Mediterranean Sea. The two places have similar biomes. The kind of biome found in California and near the Mediterranean Sea is called *chapparral*. ✓



This graph shows the average monthly precipitation in the chaparral biome in Santa Barbara, California.

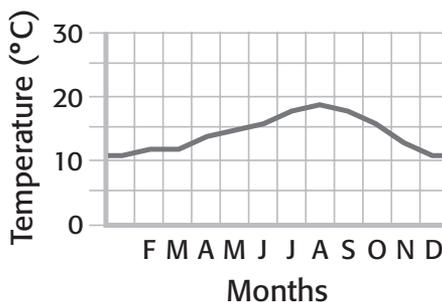
## Math Focus

**6. Read a Graph** In which month does Santa Barbara have the highest average temperature?

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**7. Read a Graph** About how much precipitation does Santa Barbara get in the month of February?

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This graph shows the average monthly temperature in the chaparral biome in Santa Barbara, California.

# Section 1 Review

6.5.a, 6.5.b, 6.5.c, 6.5.d, 6.5.e



**1. Compare** What can producers do that consumers cannot do?

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**2. Identify** How are biomes and ecosystems different?

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**3. Describe** How do abiotic factors affect living things?

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**4. Explain** Why do fewer kinds of organisms live in desert biomes than in forest biomes?

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**5. Apply Concepts** Give two examples of producers. The examples that you give should be from different biomes.

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**6. Infer** What would happen to an ecosystem if all of the decomposers disappeared? Explain your answer.

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**CHAPTER 17** Biomes and Ecosystems  
**SECTION 2** Land Biomes



6.5.c, 6.5.d, 6.5.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What are the eight kinds of land biomes?
- How are organisms adapted to survive in each land biome?
- What organisms fill the ecological roles of producer and consumer in each land biome?

**STUDY TIP**

**Summarize** As you read about each type of land biome, write down its important features. When you finish reading this section, write a summary of the features of each type of land biome into your notebook.

**READING CHECK**

**1. List** What are two ways that burrowing under the ground helps the fringe-toed lizard?

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**Math Focus**

**2. Calculate** About how many inches of rain does a desert get every year? Show your work.

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**What Is a Desert?**

Why are some kinds of organisms common in some areas but not other areas? The reason is that each of Earth’s biomes has different abiotic factors. The organisms that live in a biome are adapted to the biome’s abiotic factors.

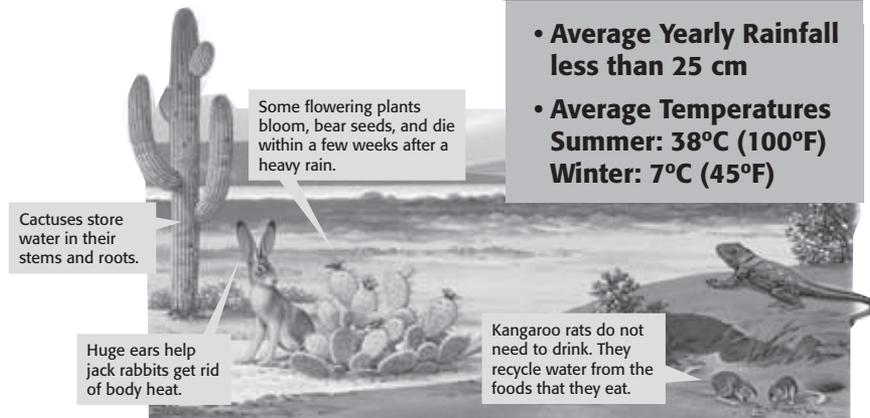
**Deserts** are very dry biomes, and most are very hot. The Mojave Desert in California is an example of a desert. The organisms that can live in a desert have special features that let them survive in the desert.

Many desert plants have roots that spread near the surface. This allows them to take up water quickly after a rain, before it evaporates.

Desert animals also have ways to survive the hot, dry desert conditions. Some live underground, where it is cooler. They come only out at night, when air temperatures are lower. Others, such as the fringe-toed lizard, bury themselves in the loose sand to escape the heat and avoid predators. ✓

**Desert**

- Average Yearly Rainfall less than 25 cm
- Average Temperatures  
**Summer: 38°C (100°F)**  
**Winter: 7°C (45°F)**



**SECTION 2** Land Biomes *continued*

**What Is a Chaparral?**

A biome that has a fairly dry climate but receives more rainfall than a desert is called a **chaparral**. In chaparral biomes, summers are warm and dry, and winters are mild and wet. Chaparral biomes can be found in California and around the Mediterranean Sea. ✓

The plants in a chaparral grow close to the ground. Many are small evergreen trees and shrubs that have wide, flat leaves. *Evergreen* plants are plants that keep their leaves all year round. Many chaparral plants have leaves that help them store water.

During natural fires, chaparral shrubs and trees are destroyed. After a fire, the shrubs grow back more quickly than the trees. Natural fires prevent the trees from competing with the shrubs for resources. Therefore, natural fires are an abiotic factor that helps maintain the chaparral.

The animals of the chaparral also have features to help them survive. Lizards, chipmunks, and mule deer are usually gray and brown, which helps them blend into their surroundings and hide from predators.

Mule deer are herbivores that eat grasses and shrubs. Lizards and chipmunks are omnivores that eat insects and parts of plants. Bobcats are carnivores that eat other animals.

**READING CHECK**

**3. Identify** Where are chaparral biomes found?

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*Critical Thinking*

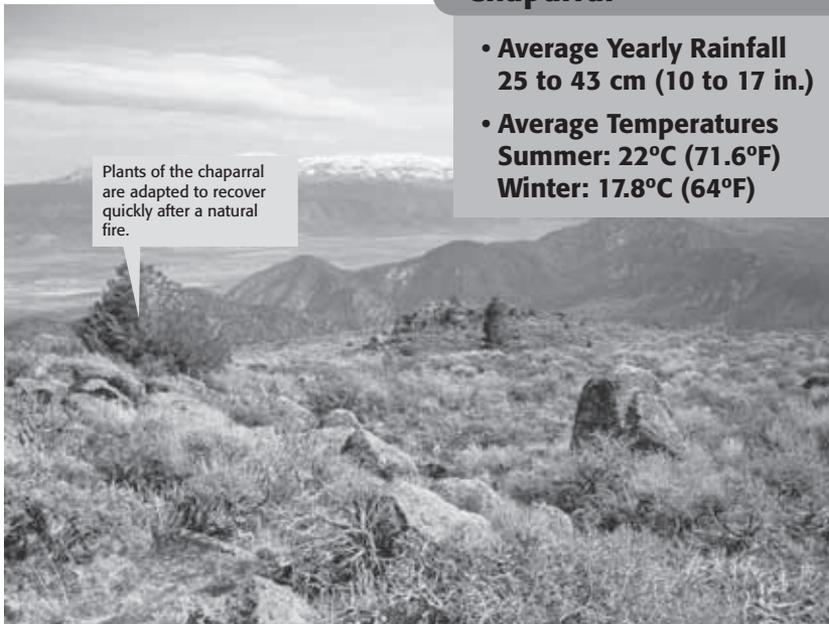
**4. Predict** How would putting out all natural fires affect the types of plants found in a chaparral?

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Plants of the chaparral are adapted to recover quickly after a natural fire.

**Chaparral**

- Average Yearly Rainfall  
25 to 43 cm (10 to 17 in.)
- Average Temperatures  
Summer: 22°C (71.6°F)  
Winter: 17.8°C (64°F)

**TAKE A LOOK**

**5. Identify** What kind of plant is most common in the chaparral?

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**SECTION 2** Land Biomes *continued*

## What Are Two Kinds of Grassland?

A **grassland** is a biome made up mainly of grasses, small flowering plants, and a few trees. The two main kinds of grassland are temperate grasslands and savannas.

### TEMPERATE GRASSLANDS

In temperate grasslands, the summers are warm and the winters are cold. The soils of temperate grasslands are very rich in nutrients. Fires, droughts, and grazing prevent trees and shrubs from growing.

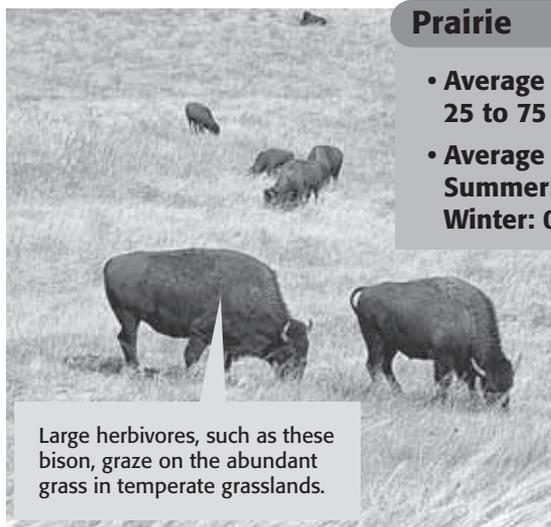
Many seed-eating animals, such as prairie dogs and mice, live in this kind of grassland. They use camouflage and burrows to hide from predators, such as coyotes. ✓

**READING CHECK**

**6. Identify** What are two ways small animals hide from predators?

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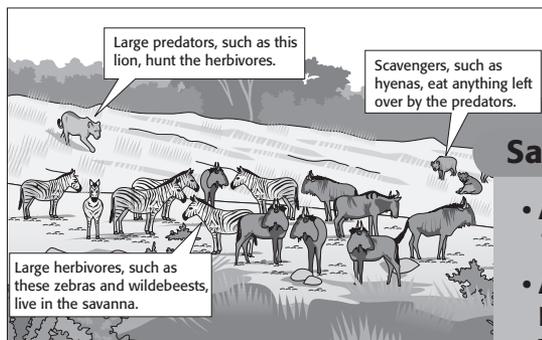
**Prairie**

- Average Yearly Rainfall 25 to 75 cm (10 to 29.5 in.)
- Average Temperatures Summer: 30°C (86°F) Winter: 0°C (32°F)

Large herbivores, such as these bison, graze on the abundant grass in temperate grasslands.

### SAVANNAS

The savanna is a grassland that has a lot of rainfall during some seasons and very little rainfall in other seasons. During the dry season, savanna grasses dry out and turn yellow. However, the roots can live for many months without water.



**Savanna**

- Average Yearly Rainfall 150 cm (59 in.)
- Average Temperatures Dry season: 34°C (93°F) Wet season: 16°C (61°F)

**TAKE A LOOK**

**7. Compare** How does the amount of rainfall in a temperate grassland compare with the amount of rainfall in a savanna?

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**SECTION 2** Land Biomes *continued*

**What Is a Tundra?**

Imagine a place on Earth that is too cold for trees to grow. A **tundra** is a biome that has very cold temperatures and little rainfall. Tundras can be found near the North and South Poles. In a tundra, the layer of soil below the surface stays frozen all year long. This layer is called *permafrost*.

During the short, cool summers, only the water in the soil at the surface melts. This surface soil is too shallow for most plants. Only plants with shallow roots, such as grasses and small shrubs, are common. Mosses and lichens grow beneath these plants. Growing close to the ground helps the plants resist the wind and the cold. ✓

Animals of the tundra also have ways to live in this biome. In the winter, food is hard to find and the weather is very harsh. Some animals, such as bears, sleep through much of the winter. Other animals, like the caribou, travel long distances to find food. Many animals have extra layers of fat to keep them warm.

During the summer, the soil above the permafrost becomes muddy from melting ice and snow. Insects, such as mosquitoes, lay eggs in the mud. Birds that prey on these insects are carnivores. Other carnivores, such as wolves, prey on herbivores, such as caribou and musk oxen.



**Say It**

**Share Experiences** Have you ever been to a very cold place? In a group, discuss what it was like.



**READING CHECK**

**8. Explain** How does growing close to the ground help tundra plants?

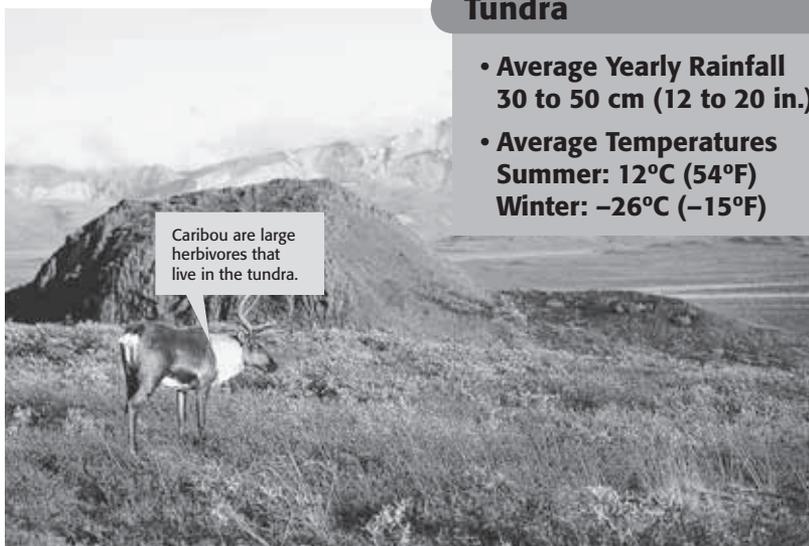
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**Tundra**

- **Average Yearly Rainfall**  
30 to 50 cm (12 to 20 in.)
- **Average Temperatures**  
**Summer:** 12°C (54°F)  
**Winter:** -26°C (-15°F)

Caribou are large herbivores that live in the tundra.

**TAKE A LOOK**

**9. Describe** How are the ecological roles of a caribou in a tundra and a zebra in a savanna similar?

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**SECTION 2** Land Biomes *continued*

### What Are Three Forest Biomes?

Three forest biomes are coniferous forests, temperate deciduous forests, and tropical rain forests. All of these forests receive plenty of rain, and the temperatures are not extreme. The kind of forest that forms in an area depends on the area's climate.

#### CONIFEROUS FORESTS

The coniferous forest gets its name from *conifers*, the main type of tree that grows there. Conifers produce seeds in cones. They have special needle-shaped leaves covered in a thick waxy coating. These features help the tree conserve water during the dry winters. The waxy coating also protects the needles from being damaged by cold weather. Most conifers are evergreens. ✓

In a coniferous forest, decomposition is slow. The ground is often covered by a thick layer of needles. The conifers stop most of the sunlight from reaching the ground. Because there is little light there, not many plants live under the conifer trees.

The animals in a coniferous forest are adapted for cold winters. Like animals in the tundra, they may hibernate or travel to warmer climates in the winter.

**READING CHECK**

**10. Identify** Where do conifers produce their seeds?

\_\_\_\_\_

**TAKE A LOOK**

**11. Explain** Why is it important for trees in a coniferous forest to conserve water?

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 \_\_\_\_\_  
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A coniferous forest is home to many insects and to birds that eat those insects.

These conifer leaves are adapted to conserve water.

Herbivores that live in the coniferous forest include deer, moose, porcupines, and squirrels.

**Coniferous Forest**

- Average Yearly Rainfall 35 to 75 cm (14 to 29.5 in.)
- Average Temperatures  
 Summer: 14°C (57°F)  
 Winter: -10°C (14°F)

**SECTION 2** Land Biomes *continued*

**TEMPERATE DECIDUOUS FORESTS**

Have you seen trees with leaves that change color and then fall off the trees? If so, you have seen deciduous trees. The word *deciduous* comes from a Latin word that means “to fall off.” Deciduous trees shed their leaves to save water during the winter. Temperate deciduous forests contain many deciduous trees.

Since deciduous trees lose their leaves, the ground in deciduous forests gets a lot of sunlight during part of the year. Therefore, small trees and shrubs can grow on the forest floor. ✓

Animals live in different parts of the deciduous forest. Black bears and rabbits live on the forest floor. Bears are omnivores that eat nuts, berries, and small animals. Rabbits are herbivores.

**READING CHECK**

**12. Compare** Why does the floor of a temperate deciduous forest have more small plants than the floor of a coniferous forest?

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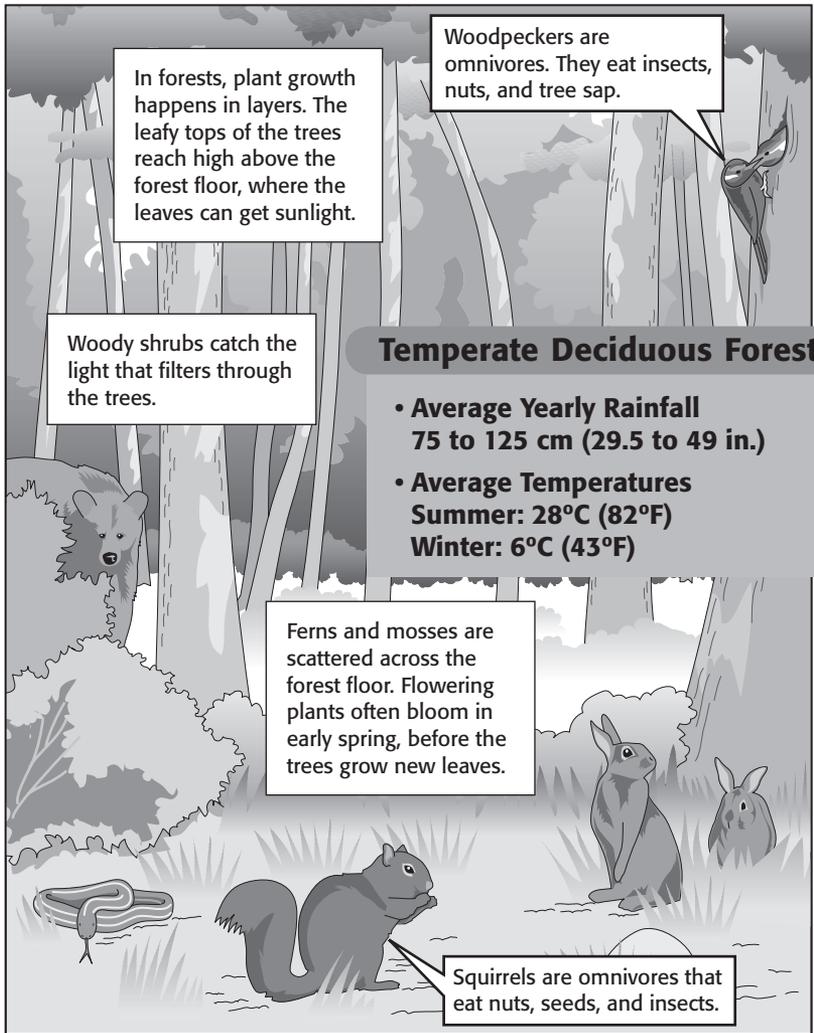
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**TAKE A LOOK**

**13. Identify** What are two producers in a temperate deciduous forest?

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**SECTION 2** Land Biomes *continued*

**TROPICAL RAIN FORESTS**

Tropical rain forest biomes contain the greatest variety of plants and animals on Earth. The warm temperatures and high rainfall allow a lot of plants to grow. Trees grow very tall and dense. Their leaves prevent much light from reaching the forest floor, so not many small plants live on the forest floor. The plants support a large diversity of animals.

Most of the animals in a rain forest live in the trees. Birds such as toucans are omnivores that eat fruits, reptiles, and other birds. Carnivores, such as harpy eagles, eat other animals, such as howler monkeys. Howler monkeys are herbivores that eat fruits, nuts, and leaves. ✓

You may think that the soil in a rain forest is very rich in nutrients because of all the plants that live there. However, most of the nutrients in the tropical rain forest are found in plants, not in soil. The soil is so thin that many trees grow roots above-ground for support.

**READING CHECK**

**14. Describe** Where in a rain forest are most animals found?

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\_\_\_\_\_

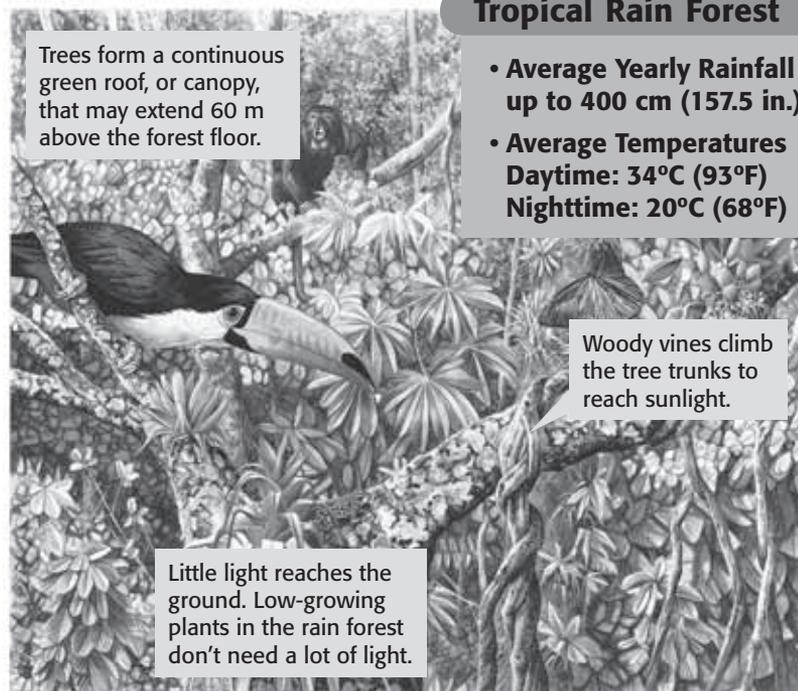
**TAKE A LOOK**

**15. Infer** Why do many vines grow on tree branches instead of on the forest floor?

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**Tropical Rain Forest**

- Average Yearly Rainfall up to 400 cm (157.5 in.)
- Average Temperatures  
Daytime: 34°C (93°F)  
Nighttime: 20°C (68°F)

Trees form a continuous green roof, or canopy, that may extend 60 m above the forest floor.

Woody vines climb the tree trunks to reach sunlight.

Little light reaches the ground. Low-growing plants in the rain forest don't need a lot of light.

# Section 2 Review

6.5.c, 6.5.d, 6.5.e



## SECTION VOCABULARY

<p><b>chaparral</b> a type of vegetation that includes broad-leaved evergreen shrubs and that is located in areas with hot, dry summers and mild, wet winters</p> <p><b>desert</b> a region that has little or no plant life, long periods without rain, and extreme temperatures: usually found in hot climates</p>	<p><b>grassland</b> a region that is dominated by grasses, that has few woody shrubs and trees, that has fertile soils, and that receives moderate amounts of seasonal rainfall</p> <p><b>tundra</b> a treeless plain found in the Arctic, in the Antarctic, or on the tops of mountains that is characterized by very low winter temperatures and short, cool summers</p>
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**1. Explain** The tundra has been called a “frozen desert.” Explain why this is a good name for the tundra.

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**2. Compare** Compare the temperate grassland and the savanna by filling in the blank spaces in the table below.

	Temperate grassland	Savanna
<b>Abiotic factors</b>		constant warmth with seasonal rains
<b>Types of producer</b>	grass with a few trees	
<b>Types of consumer</b>		

**3. List** What are some of the adaptations that allow desert plants to live in such a hot, dry environment?

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SECTION 3 **Marine Ecosystems**



6.5.a, 6.5.c, 6.5.e

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- What abiotic factors affect marine ecosystems?
- What are the major zones found in the ocean?
- What kinds of organisms are found in marine ecosystems?



**Compare** Create a table comparing the locations, abiotic factors, and organisms for each marine ecosystem.

**What Abiotic Factors Affect Marine Ecosystems?**

Oceans cover almost three-fourths of Earth’s surface! Scientists call the ecosystems in the ocean *marine ecosystems*. Marine ecosystems, like all ecosystems, are affected by abiotic factors.

**WATER DEPTH AND SUNLIGHT**

Two abiotic factors that affect marine ecosystems are water depth and sunlight. The average depth of the oceans is 4,000 m, but sunlight does not reach deeper than 200 m. Producers that carry out photosynthesis, such as algae, can live only above 200 m.

**Phytoplankton** are tiny producers that float near the surface of the ocean. Algae and phytoplankton are the producers at the base of most ocean food chains. Large consumers, such as whales, feed on these tiny producers.

**Math Focus**

**1. Calculate** What percentage of the water in the oceans receives sunlight? Show how you got your answer.

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**TAKE A LOOK**

**2. Identify** In the picture, which organism is the producer and which is the consumer?

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**SECTION 3** Marine Ecosystems *continued*

**TEMPERATURE**

A third abiotic factor in marine ecosystems is the temperature of the water. The water near the surface is much warmer than the rest of the ocean because it is heated by the sun. Ocean water becomes colder as it gets deeper.

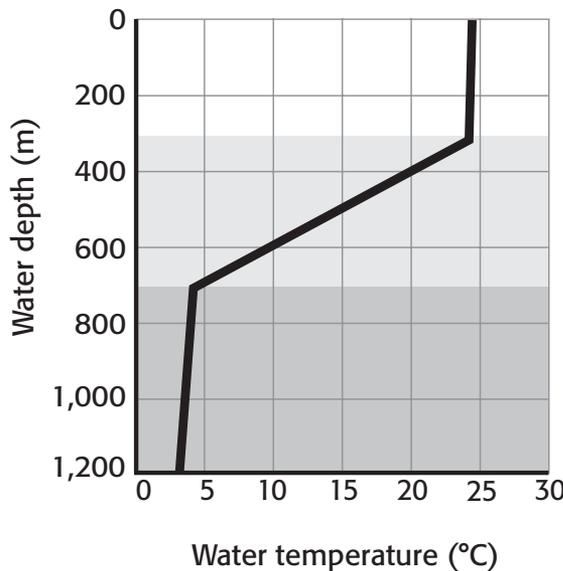
Water temperatures at the surface are also affected by latitude. Water near the equator is generally warmer than water closer to the poles. The water at the surface is also warmer in summer than winter. ✓

Temperature affects the animals that live in marine ecosystems. For example, fish that live near the poles have a special chemical in their blood that keeps them from freezing. Most animals that live in coral reefs need warm water to live.

Most marine organisms live in the warm waters near the surface. Some animals, like whales, migrate from cold areas near the poles to warm areas near the equator to reproduce.

Water temperature also affects whether some animals, such as barnacles, can eat. If the water is too hot or too cold, these animals may not be able to eat. If the temperature changes suddenly, they may die. ✓

**Ocean Temperature and Depth**



**READING CHECK**

**3. List** What are the three main abiotic factors that affect marine ecosystems?

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**READING CHECK**

**4. Identify** Why do most barnacles live in water with a constant temperature?

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**TAKE A LOOK**

**5. Analyze** About how much colder is ocean water at 600 m depth than at 400 m depth?

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**SECTION 3** Marine Ecosystems *continued*

## What Are the Major Zones in the Ocean?

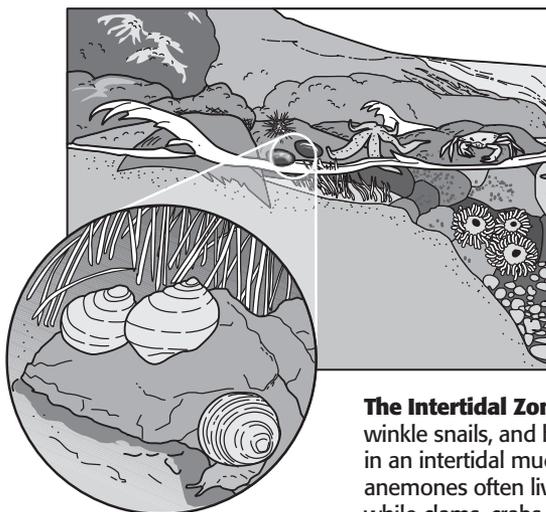
The ocean can be divided into zones based on things such as distance from the shore, water depth, the amount of sunlight, and water temperature.

### Say It

**Share Experiences** In a group, discuss the abiotic factors and the living organisms you have seen or might see at the beach.

### THE INTERTIDAL ZONE

The intertidal zone is where the ocean meets the shore. The organisms of the intertidal zone are covered with water at high tide and exposed to air at low tide.



**The Intertidal Zone** Sea grasses, periwinkle snails, and herons are common in an intertidal mudflat. Sea stars and anemones often live on rocky shores, while clams, crabs, snails, and conchs are common on sandy beaches.

### TAKE A LOOK

**6. Explain** Why is it difficult for many sea creatures to live in the intertidal zone?

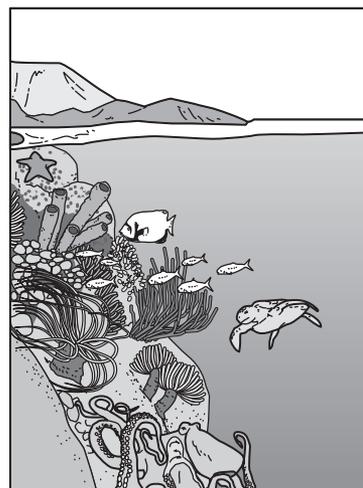
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### THE NERITIC ZONE

The neritic zone is further from shore. In this zone, the water becomes deeper as the ocean floor starts to slope downward. This water is warmer than deep ocean water and receives a lot of sunlight. Corals and producers thrive in this zone. Sea turtles, sea urchins, and fishes are some of the consumers of this zone.

**The Neritic Zone** Although phytoplankton are the major producers in this zone, seaweeds are common, too. Sea turtles and dolphins live in the neritic zone. Other animals, such as corals, sponges, and colorful fishes, contribute to this vivid landscape.



### TAKE A LOOK

**7. Identify** What are the two main kinds of producer in the neritic zone?

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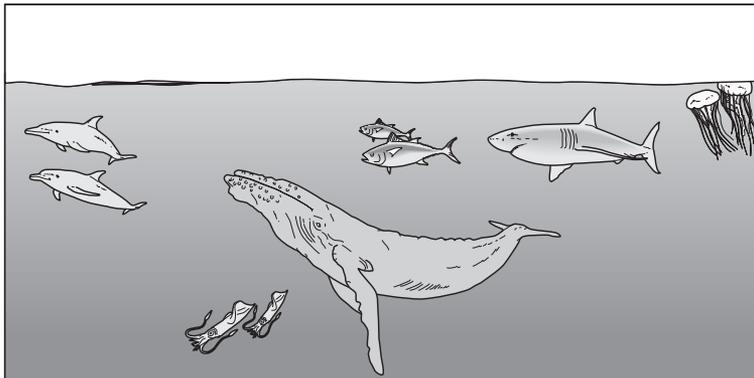
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**SECTION 3** Marine Ecosystems *continued*

**THE OCEANIC ZONE**

In the oceanic zone, the sea floor drops off quickly. The oceanic zone extends from the surface to the deep water of the open ocean. Phytoplankton live near the surface, where there is sunlight. ✓

Consumers such as fishes, whales, and sharks live in the oceanic zone. Some of the animals live in deep waters, where there is no sunlight. These animals feed on each other and on material that sinks from the surface waters.

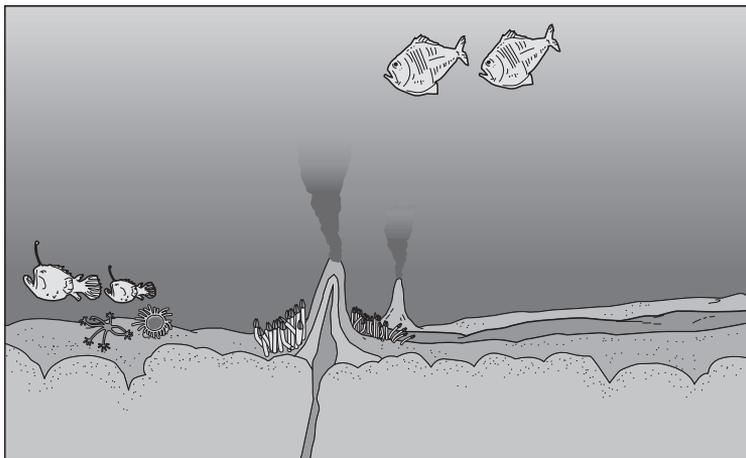


**The Oceanic Zone** Many unusual animals are adapted for the deep ocean. Whales and squids can be found in this zone. Also, fishes that glow can be found in very deep, dark water.

**THE ABYSSAL ZONE**

The abyssal zone is the ocean floor. It does not get any sunlight and is very cold. Fishes, worms, and crabs have special features to live in this zone. Many of them feed on material that sinks from above.

Some organisms, such as angler fish, eat smaller fish. Other organisms, such as bacteria, are decomposers and help break down dead organisms.



**The Abyssal Zone** Organisms such as bacteria, worms, and sea urchins thrive on the sea floor.

**READING CHECK**

**8. Explain** Why do phytoplankton need to live near the surface?

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**TAKE A LOOK**

**9. Explain** How can the consumers that live in deep waters survive if there are no producers present?

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**TAKE A LOOK**

**10. Describe** What abiotic factors do organisms that live in the abyssal zone need to adapt to?

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**SECTION 3** Marine Ecosystems *continued*

**Critical Thinking**

**11. Predict Consequences**

How would humans be affected if there were no oceans?

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**What Kinds of Ecosystems Are in the Marine Biome?**

Life on Earth depends on the ocean. The water that evaporates from the ocean creates most of the rain and snow that falls on land. The ocean affects world climates and wind patterns. Many people depend on the ocean for food.

Many different kinds of organisms live in the ocean. They live in the many ecosystems in the different zones of the ocean.

**INTERTIDAL ECOSYSTEMS**

Organisms in intertidal ecosystems must be able to live both underwater and in the air. Those that live in mudflats and sandy beaches may dig into the ground during low tide.

On rocky shores, organisms have adaptations to keep from being swept away by crashing waves. For example, seaweeds use structures called *holdfasts* to attach themselves to rocks. Other organisms, such as barnacles, attach themselves to rocks with a special cement. Sea stars feed on these organisms. ✓

**READING CHECK**

**12. Describe** How do organisms of intertidal ecosystems protect themselves from being washed away by waves?

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Ecosystem	Location	Abiotic factors	Organisms
Intertidal	intertidal zone: mudflats, sandy beaches, rocky shores	times under water, times above water	worms, clams, crabs, birds, seaweed

**ESTUARIES**

An **estuary** is an area where fresh water from streams and rivers flows into the ocean. The water in an estuary is a mix of fresh water from rivers and salt water from the ocean.

Organisms that live in estuaries must be able to survive the changing amounts of salt in the water. The fresh water that flows into an estuary is rich in nutrients washed from the land. The nutrients in the water support large numbers of producers, such as algae. The algae are able to support many consumers, such as fish, oysters, and crabs.

**TAKE A LOOK**

**13. Compare** What unusual abiotic factor do organisms in an estuary need to adapt to?

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\_\_\_\_\_

Ecosystem	Location	Abiotic factors	Organisms
Estuaries	areas where rivers and streams flow into oceans	changing amounts of salt in the water; nutrient-rich water	large amount of algae, many consumers

**SECTION 3** Marine Ecosystems *continued***CORAL REEFS**

Coral reefs are named for the small animals called *corals* that form the reefs. Many of these tiny animals live together in a colony, or group

Most coral reefs are built on the skeletons of a kind of coral called *stony coral*. The skeleton of a stony coral is made up of a hard chemical called calcium carbonate. When the corals die, their hard skeletons remain. New corals grow on these hard remains.

Over time, layers of skeletons build up and form a rock-like structure called a *reef*. This reef provides a home for many marine animals. These organisms include fishes, sponges, sea stars, and sea urchins. Because so many kinds of organisms live there, coral reefs are some of the most diverse ecosystems on Earth. ✓

Ecosystem	Location	Abiotic factors	Organisms
<b>Coral reefs</b>	shallow areas of the neritic zone	warm water, sunlight	corals, algae, fishes, sponges, sea stars, sea urchins

**KELP FORESTS**

Kelp forests are found in cold, shallow areas of the neritic zone. Kelp are large brown algae that grow well in nutrient-rich waters, such as areas along the coast of California. Some kelp can be as much as 33 m (108 ft) long!

Many consumers, such as sea otters, fishes, crabs, and sea urchins, are found in kelp forests. Sea urchins eat the algae growing on rocks. Sea otters eat many of the organisms in the kelp forest, including sea urchins. ✓

Ecosystem	Location	Abiotic factors	Organisms
<b>Kelp forests</b>	shallow areas of the neritic zone	cold water, sunlight, nutrient-rich water	kelp, sea otters, fishes, crabs, sea urchins

 **READING CHECK**

**14. Explain** How is a coral reef both a living and a nonliving structure?

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 **READING CHECK**

**15. Identify** What are the ecological roles of the sea urchin and sea otter in the kelp forest?

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**SECTION 3** Marine Ecosystems *continued*

**DEEP SEA HYDROTHERMAL VENTS**

In some places on the ocean floor, heat from within the Earth heats the ocean water. The water can get as hot as 350°C! The hot water moves out of cracks in the ocean floor called *hydrothermal vents*.

These vents release chemicals from beneath the surface into the seawater. The chemicals can be made into food by special kinds of bacteria. These bacteria are considered producers. Many unusual consumers, such as tube worms, rely on the bacteria for energy. ✓

**READING CHECK**

**16. Explain** Why are bacteria at hydrothermal vents producers if they do not use sunlight to make food?

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Ecosystem	Location	Abiotic factors	Organisms
Deep sea hydrothermal vents	abyssal zone	hot water with chemicals, high pressure	bacteria, vent worms, clams

**THE SARGASSO SEA**

Floating mats of algae in the middle of the Atlantic Ocean make up the Sargasso Sea ecosystem. Algae called *sargassums* are at the base of this ecosystem. Sargassums float at the surface because parts of the algae are filled with air.

Many animals live in this ecosystem. Most of these are omnivores that can eat many different organisms throughout the year.

**TAKE A LOOK**

**17. Explain** Why is it helpful for the organisms living in sargassums to be omnivores?

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Ecosystem	Location	Abiotic factors	Organisms
Sargasso Sea	Atlantic Ocean near the surface	much sunlight	floating sargassum algae, fishes, mostly omnivores

**POLAR ICE**

The icy waters near the poles are rich in nutrients that support large numbers of phytoplankton. These producers can support many types of consumers. One of these is a small shrimplike organism called krill. Larger consumers eat krill and, in turn, serve as food for other consumers.

Ecosystem	Location	Abiotic factors	Organisms
Polar ice	Arctic Ocean, Antarctica	cold, nutrient-rich water	phytoplankton, krill, fishes, seals, whales, polar bears

# Section 3 Review

6.5.a, 6.5.c, 6.5.e 

## SECTION VOCABULARY

<p><b>estuary</b> an area where fresh water mixes with salt water from the ocean</p>	<p><b>phytoplankton</b> the microscopic, photosynthetic organisms that float near the surface of marine or fresh water</p> <p><b>Wordwise</b> The prefix <i>phyto-</i> means “plant.”</p>
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**1. Describe** What are some of the different kinds of producers found in the marine biome?

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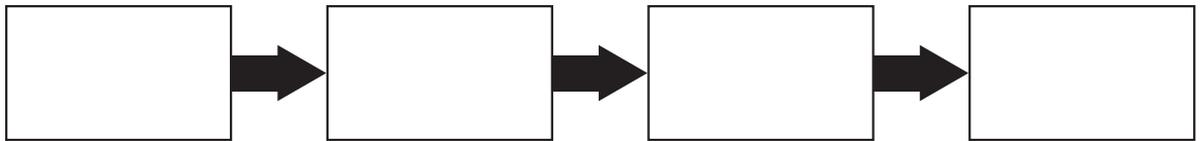


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**2. Apply Concepts** Draw a food chain that shows the flow of energy through a polar ice ecosystem.



**3. Explain** Why are there few producers below 200 m in the ocean?

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**4. Identify** What abiotic factors make the neritic zone a good home for many different organisms?

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**5. List** Give two ecosystems that are found in the neritic zone.

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# Freshwater Ecosystems



California Science  
Standards

6.5.c, 6.5.e

## BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What organisms live in stream and river ecosystems?
- What are the three zones in a pond or lake?
- What are the two kinds of wetlands?



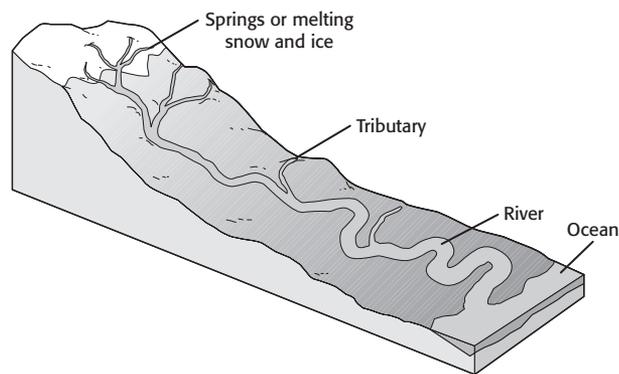
**Answer Questions** Before reading this section, write the three Before You Read questions on a piece of paper. As you read, write down the answers to the questions.

## What Are Stream and River Ecosystems?

One important abiotic factor that affects freshwater ecosystems is how quickly the water is moving. In rivers and streams, the water is moving faster than in other freshwater ecosystems.

The water in streams may come from melted ice or snow. It may also come from a spring. A *spring* is a place where water from under the ground flows to the surface.

Each stream of water that joins a larger stream is called a *tributary*. As more tributaries join a stream, it becomes stronger and wider. A very strong, wide stream is called a *river*.



## TAKE A LOOK

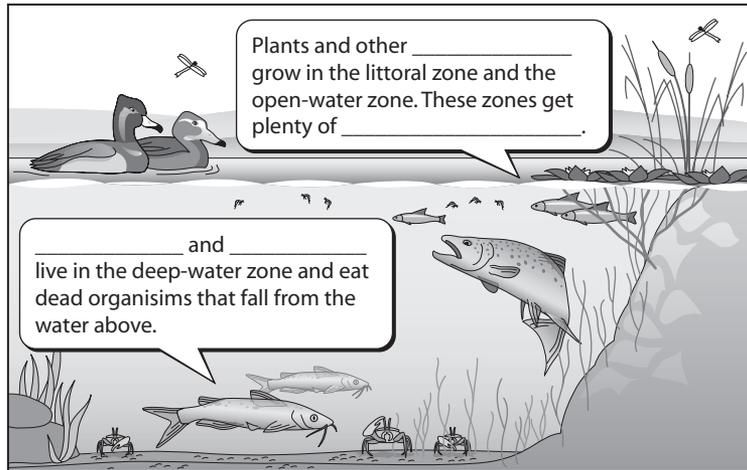
**1. Describe** What happens to the size of a stream when a tributary flows into it?

Stream and river ecosystems are full of life. Plants live along the edges of streams and rivers. Fish live in the open waters. Clams and snails live in the mud at the bottom.

Organisms that live in fast-moving water have to keep themselves from being washed away. Some producers, such as algae and moss, are attached to rocks. Consumers, such as tadpoles, use suction to hold themselves to rocks. Other consumers, such as crayfish, hide under rocks.

**SECTION 4** Freshwater Ecosystems *continued***What Are Pond and Lake Ecosystems?**

The water in ponds and lakes is not moving very much compared with rivers and streams. As a result, they have different types of ecosystems. Like marine ecosystems, pond and lake ecosystems are affected by water depth, sunlight, and temperature.

**TAKE A LOOK**

**2. Identify** Fill in the blank spaces in the figure with the correct words.

**LIFE NEAR THE SHORE**

The area of water near the edge of a pond or lake is called the **littoral zone**. Sunlight reaches the bottom, which allows producers such as algae to grow in this zone. Plants, such as cattails and rushes, grow here too, farther from shore.

Many consumers, such as tadpoles and some insects, eat the algae and plants. Some consumers, such as snails and insects, make their homes in plants. Consumers that live in the mud include clams and worms. Other consumers, such as fishes, also live in this zone. ✓

**LIFE AWAY FROM THE SHORE**

The area of a lake or pond away from the littoral zone near the surface is called the **open-water zone**. This zone is as deep as sunlight can reach. Producers such as phytoplankton grow well here. This zone is home to bass, lake trout, and other consumers.

Beneath the open-water zone is the **deep-water zone**, where no sunlight reaches. Photosynthetic organisms cannot live in this zone. Scavengers, such as catfish and crabs, live here and feed on dead organisms that sink from above. Decomposers, such as fungi and bacteria, also help to break down dead organisms. ✓

**READING CHECK**

**3. Identify** Which consumers of the littoral zone are herbivores?

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**READING CHECK**

**4. Explain** Why can't producers live in the deep-water zone?

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**SECTION 4** Freshwater Ecosystems *continued*

### What Is a Wetland?

A **wetland** is an area of land that is sometimes underwater or whose soil contains a lot of water. Wetlands help control floods. During heavy rains, wetlands soak up large amounts of water. This water sinks into the ground and helps refill underground water supplies. ✓

**READING CHECK**

**5. Define** What is a wetland?

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### TAKE A LOOK

**6. Compare** What is a quick way to tell the difference between a marsh and a swamp?

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Wetlands contain many different plants and animals. There are two main types of wetlands: **marshes** and **swamps**.



### Critical Thinking

**7. Apply Concepts** Why is the amount of oxygen in pond water an abiotic factor?

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### How Can an Ecosystem Change?

Did you know that a pond or lake can disappear? The water flowing into the lake carries sediment. The sediment, along with dead leaves and other materials, sinks to the bottom of the lake.

Bacteria decompose the material at the bottom of the lake. The decay process uses up some of the oxygen in the water. As the amount of oxygen in the water goes down, fewer fish and other organisms can live in it.

Over time, the pond or lake is filled with sediment. New kinds of plants grow in the new soil. Shallow places fill in first, so plants grow closer and closer to the center of the pond or lake. What is left of the pond or lake becomes a wetland. As the soils dry out and the oxygen levels increase, forest plants can grow. In this way, a pond or lake can become a forest.

# Section 4 Review

## SECTION VOCABULARY

<p><b>deep-water zone</b> the zone of a lake or pond below the open-water zone, where no light reaches</p> <p><b>littoral zone</b> the shallow zone of a lake or pond where light reaches the bottom and nurtures plants</p> <p><b>marsh</b> a treeless wetland ecosystem where plants such as grasses grow</p>	<p><b>open-water zone</b> the zone of a pond or lake that extends from the littoral zone and that is only as deep as light can reach</p> <p><b>swamp</b> a wetland ecosystem in which shrubs and trees grow</p> <p><b>wetland</b> an area of land that is periodically underwater or whose soil contains a great deal of moisture</p>
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**1. Compare** Why are the kinds of producers in the littoral zone of a lake different from the producers in the open-water zone?

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**2. Compare** How are the producers in a swamp different from those in a marsh?

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**3. Explain** What ecological role do the fishes in the open-water zone and the fishes in swamps fill?

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**4. Describe** What abiotic factors do organisms living in rivers and streams have to adapt to?

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**5. Describe** How can a pond become a forest?

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