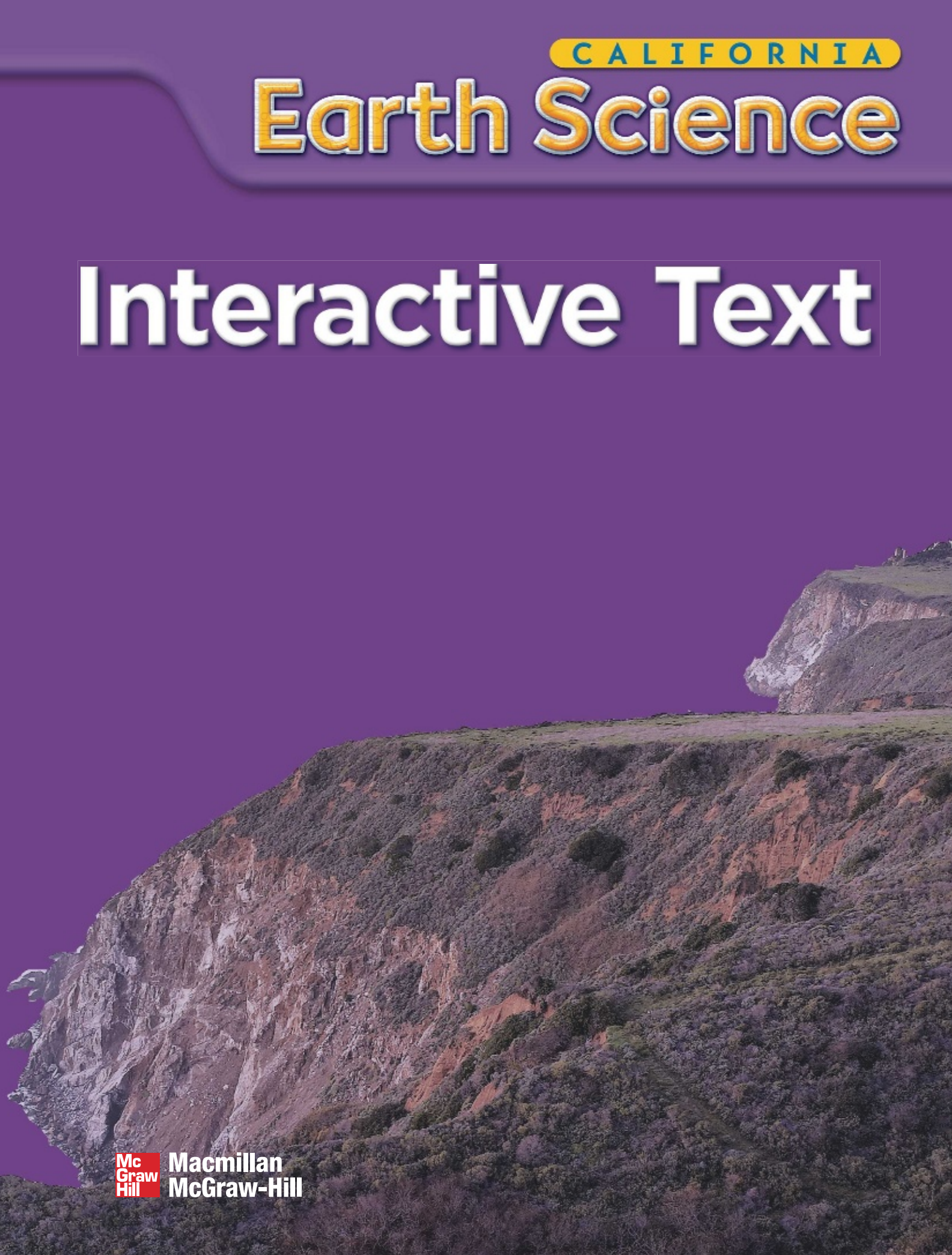
CALIFORNIA

Earth Science

Interactive Text



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Contents

CHAPTER 1

Earth's Ecosystems

Vocabulary

ecosystem a place where living and nonliving things interact

population members of one kind of living thing in an ecosystem

community all the populations in an area

photosynthesis the way that plants and some other living things make food by using sunlight

respiration the release of energy from food

producer a living thing that makes its own food

consumer a living thing that eats plants or animals

decomposer a living thing that feeds on dead plants or animals

food chain the path of the Sun's energy from one living thing to another

food web all the food chains in an ecosystem

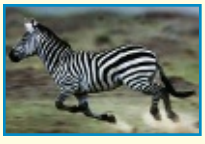
The Big Idea: How do organisms exchange energy and nutrients in an ecosystem?

herbivore an animal that eats plants

carnivore an animal that eats other animals

omnivore an animal that eats plants and animals

predator an animal that hunts, kills, and eats other animals



prey an animal that a predator hunts

scavenger an animal that eats dead animals without hunting or killing them

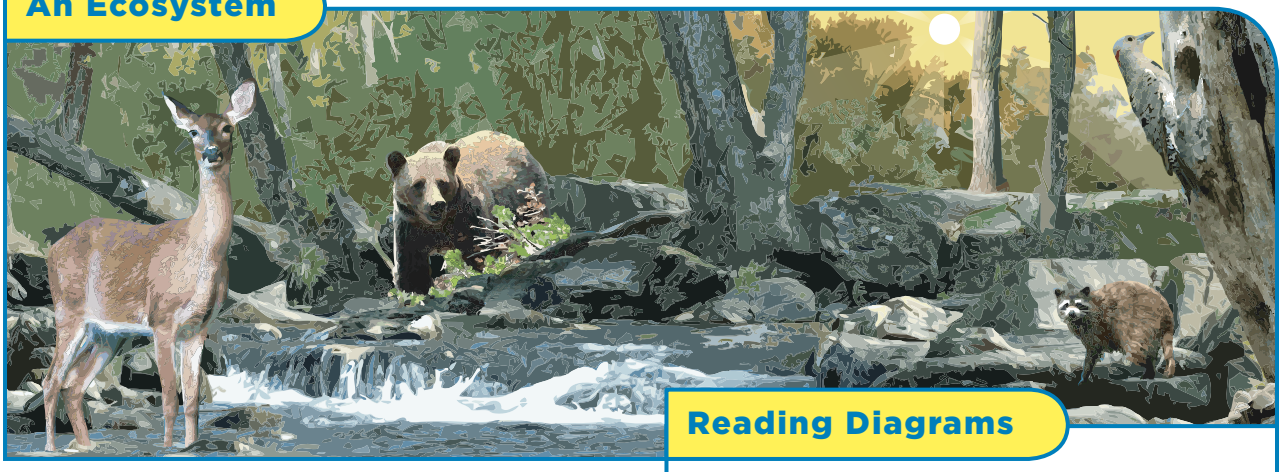
energy pyramid a model that shows how energy moves through an ecosystem

evaporation the changing of a liquid into a gas

condensation the changing of a gas into a liquid

precipitation water that falls to Earth

An Ecosystem



Reading Diagrams

This diagram shows living and nonliving parts of a pond ecosystem.

What is an ecosystem?

A *system* is a group of things that work closely with each other. There are systems all around you. The planets are part of the solar system. Many organs in your body belong to various systems.

Living things are also part of a system. They belong to an ecosystem (EK•.oh•sis•tuhm). In an **ecosystem**, living things and nonliving things in an area interact together. The living things depend on the same conditions. They can all be affected by changes that happen around them. A major change such as a forest fire can affect the whole ecosystem.

Quick Check

1. What kind of system is an ecosystem?

_____

_____

2. What do living things in an ecosystem depend on?

_____

_____

Parts of an Ecosystem?

All ecosystems have a nonliving part and a living part. The nonliving parts help make life possible. The table shows some nonliving and living parts of an ecosystem.

Living and Nonliving Parts of an Ecosystem

Nonliving Parts	Living Parts
• Sunlight	• Bacteria
• Temperature	• Plants
• Water	• Animals
• Soil	• Mushrooms
• Air	
• Weather patterns	
• Altitude	

Quick Check

3. Name five living parts of the ecosystem shown in the picture on page 2. _____, _____, _____, _____, _____.

4. Name five nonliving parts of an ecosystem. _____, _____, _____, _____, _____.

Why are sunlight and temperature important?

The amount of sunlight an area receives affects the temperature of that area.

Areas near the Equator

Areas near the equator get a lot of direct sunlight. Temperatures there are high. They may be around 27°C (80°F) almost all the time. In these areas, many different kinds of plants and animals can live.

Parrots thrive in warm areas, such as the Amazon rain forest in Brazil. ▶

Quick Check

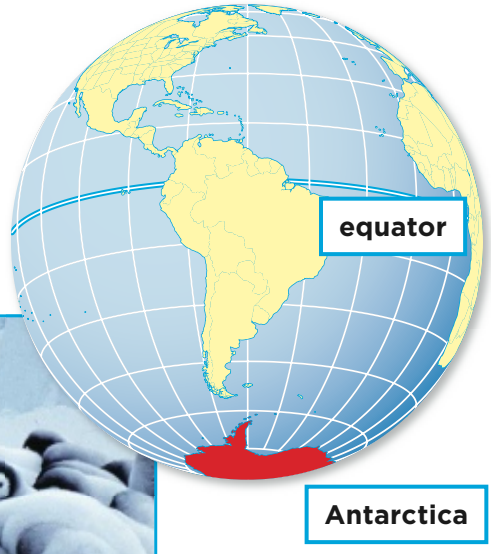
5. What are temperatures like near the equator? Explain your answer.

Areas Away from the Equator

Areas near Earth's poles get very little direct sunlight. Temperatures here are in general much cooler. These areas have fewer kinds of plants and animals.

What are temperatures like between the poles and the equator? In these areas, the amount of sunlight is more than at the poles—but less than at the equator. So temperatures vary throughout the year.

In areas with cold winters, some animals travel to a warmer place. Others become less active or sleep. Some, like penguins, have changed over time to fit the conditions where they live.



▲ **Penguins learned to huddle to keep warm. They have a layer of fur-like feathers.**

Quick Check

6. Areas near the North and South Poles get _____ amounts of direct sunlight than areas near the equator.

7. Two things that some kinds of living things do to survive cold winters are _____

and _____.

Why is water important?

Living things need water. Your body is 60–70% water. Water carries nutrients to parts of your body. It helps to cool your skin.

The amount of water in an ecosystem affects its living things. Areas with little water, such as deserts, have fewer kinds of living things living there. These living things have features that help them survive with less water. For example, when it rains, the barrel cactus swells and stores water.

People have also developed ways to live in dry areas. They use irrigation to water their fields. For example, water taken from the Colorado River helps irrigate almost 1 million acres of land in Southern California.

Barrel cactus, California desert

Central Valley irrigation

Quick Check

8. Some kinds of living things can live in places where there is little water because _____.

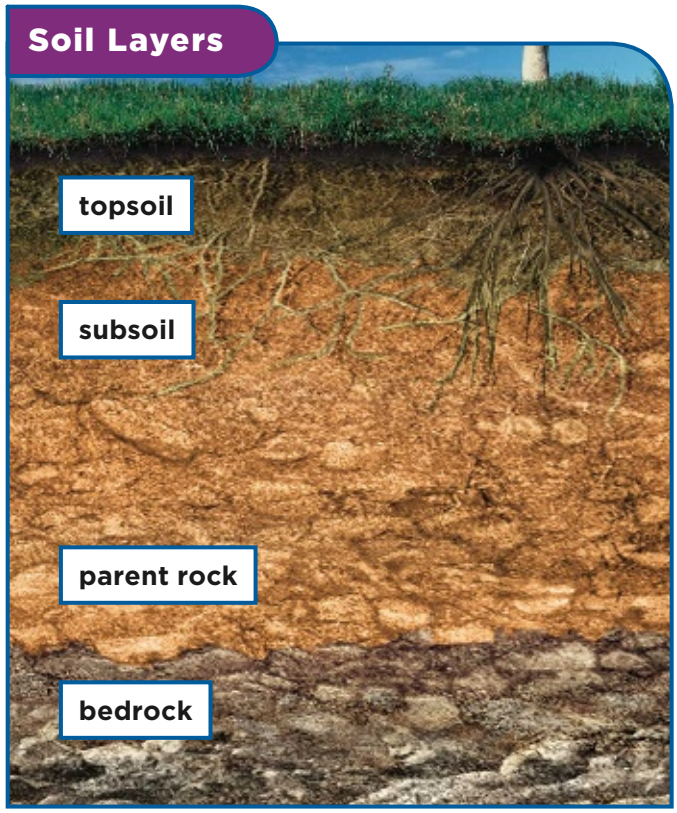
Why is soil important?

Soil supplies water, air, and food that plants need to grow. By helping plants grow, soil helps living things survive. It is important to conserve (or save) soil. For example, we put plants on hillsides so that wind and water will not carry soil away.

Soil is broken-down rock and humus (HYEW•muhs). *Humus* is the material in soil formed by the decay of dead plants and animals. Humus adds food to the soil.

Soil usually has four layers:

- *Topsoil*, the upper layer of soil, contains humus, water, air, and other things organisms need.
- Subsoil is the layer below the topsoil. It has some humus and minerals.
- Parent rock is the rock that made the soil. It has no humus.
- Bedrock is the lowest layer, of solid rock.



Quick Check

9. Three things that soil supplies to plants are _____,

_____, and _____.

10. Unscramble the following soil layers. List them from the top to bottom: subsoil, topsoil, bedrock, parent rock.

_____, _____, _____, _____

the top **the bottom**

What lives in an ecosystem?

The nonliving parts in an area influence what living things are found there. In an ecosystem, all the members of one kind of living things make up a **population**. For example, sea lions that live along the coast of California are a population.

The place where a population lives is a *habitat*. The California coast is the sea lions' habitat. A habitat supplies a population with everything it needs. These needs include food and shelter. What other needs would a habitat supply?

California sea lions

Quick Check

11. All the members of one kind of living thing in an area make up a _____.

12. What needs would have to be met for an aquarium to be a habitat for tropical fish? _____, _____, _____, _____, and _____.

Communities

All the populations living in an area make up a **community**. Each community includes populations that can survive in that area. For example, tide-pool communities live along the shore of an ocean. Populations there must be able to survive the changing tides and the motion of waves.

To survive, populations in a community must interact in a balanced way. For this to happen, each kind of living thing in a community has a role to play, a *niche* (nitch). A beaver's niche includes building dams. The dams flood the surrounding area. The flooded area is a habitat for many living things.

Beavers help provide habitats for other members of a community.

Tide-Pool Community

Reading Photos

This photo shows some populations in a tide-pool community.

Quick Check

13. What must populations do to survive in a community?

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Why is photosynthesis important?

All living things need energy to live and grow. They get this energy from food. Some living things, like animals, get their food by eating plants or other animals. Plants get their food from the Sun. **Photosynthesis** (foh•toh•SIN•thuh•sis) is a way that plants and some other living things make food by using sunlight.

Poppies use sunlight to make food.

Quick Check

14. A way that plants and some other living things make food by using sunlight is _____.

15. Which of the following organisms would be most likely to use photosynthesis for its food? Circle your answer(s).

a. lion **c.** grass

b. tree **d.** snake

Raw Materials for Photosynthesis?

To bake a cake, basic ingredients, or raw materials, are needed. These raw materials are heated (given energy) and eventually become a cake. Raw materials are also needed for photosynthesis. These raw materials are carbon dioxide, water, and chlorophyll.

Chlorophyll (KLOR•uh•fil) is a green substance in plants that absorbs energy from sunlight. Plants have structures that help them get the raw materials they need and turn them into food.

▲ **This leaf is green bcause it contains chlorophyll. The shape allows the leaf to be exposed to as much sunlight as possible.**

	Cake	Plant
Raw Materials	flour, water, sugar, yeast	carbon dioxide, water, chlorophyll
Source of Energy	heat from oven	sunlight
Where It Happens	oven	leaves

Quick Check

16. For photosynthesis to occur, there must be

_____,

_____,

_____, and

_____.

What are roots and stems?

Roots and stems move water and food inside a plant.

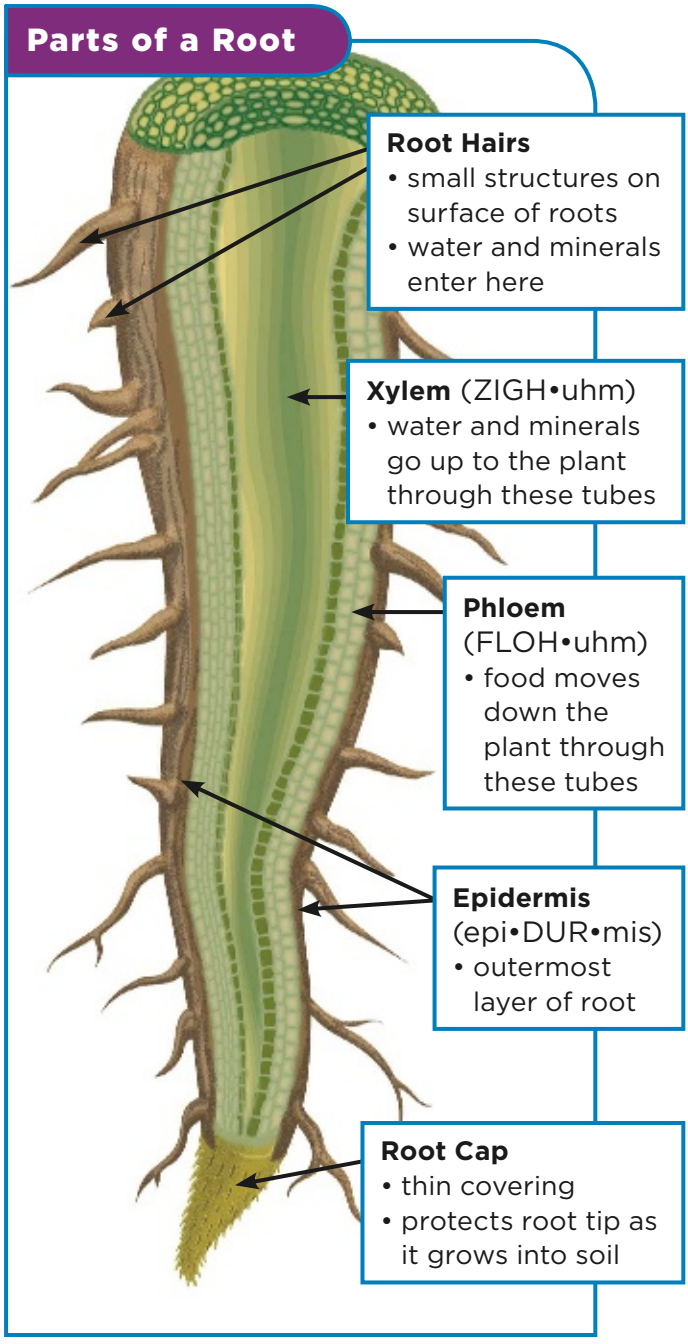
Roots

Roots hold plants in the soil. They also take in water and other substances that the plant needs.

Some roots called *taproots* are thick and straight. They grow deep and make it hard to pull the plant from the ground.

Some roots called *fibrous roots* are thin and have lots of root hairs. They grow into a dense network, but are not deep.

Roots also store some of the food the plant produces. This is why edible roots such as carrots and sweet potatoes are so nutritious.



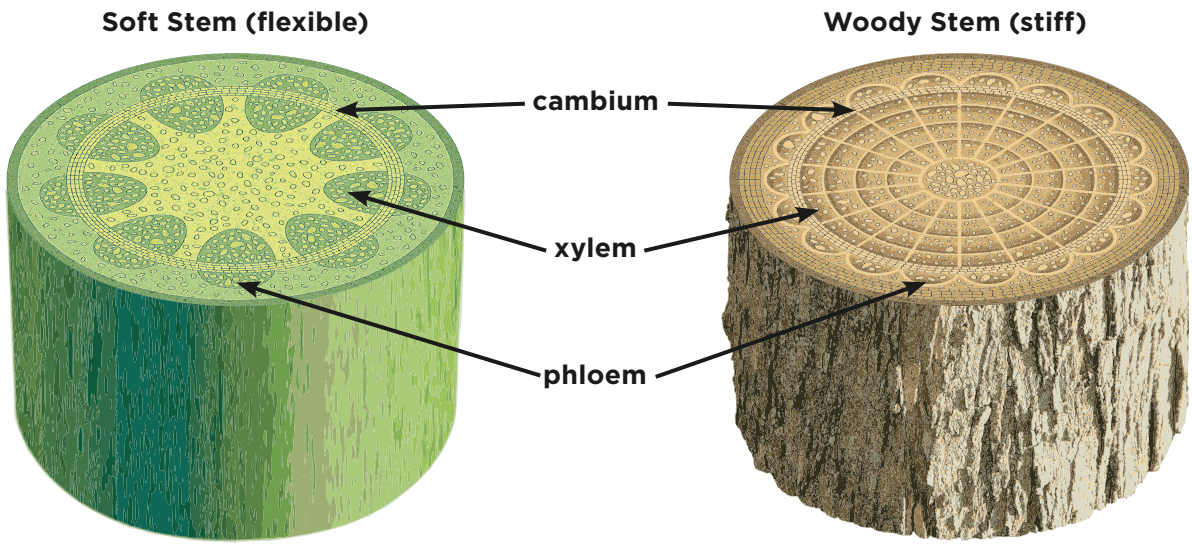
Quick Check

17. Why are roots important? _____

_____

18. I am the part of the root through which water and other substances enter. What am I? _____

Parts of a Stem



Reading Diagrams

The xylem, phloem, and cambium are arranged differently in a woody stem and in a soft stem.

Stems

Stems have two very important roles:

- support leaves and flowers
- transport water and other substances between root and leaves

Inside a stem are xylem and phloem. The xylem carries water and minerals from the roots up the plant to the leaves. Phloem carries food from the leaves to other parts of the plant. Between the xylem and the phloem is a layer of cells called the *cambium* (KAM•bee•uhm). New cells grow from this layer.

Like roots, some stems store food. Sugarcane and asparagus are examples of edible stems.

Quick Check

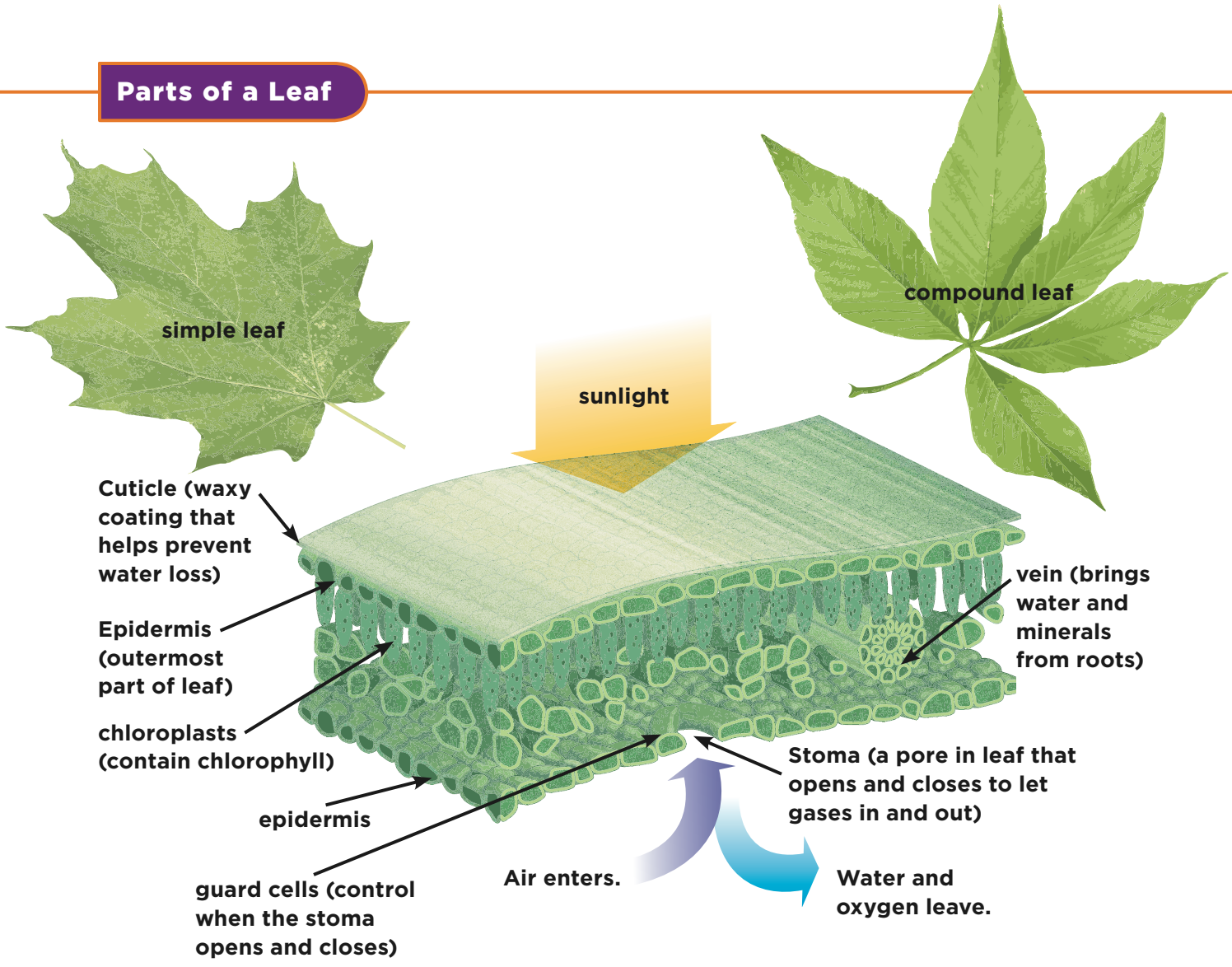
19. Two important roles that stems perform are _____

_____ and _____.

What are leaves?

When you look at a tree or shrub, the first thing you may notice are its leaves. Leaves come in many sizes. They also have many shapes. But they all have the same basic parts and jobs. Leaves help keep the plant alive. Also, leaves supply living things with food and oxygen.

Parts of a Leaf



Quick Check

20. Leaves get water from the roots through their _____.

21. Chlorophyll is found in the _____.

How Leaves Work

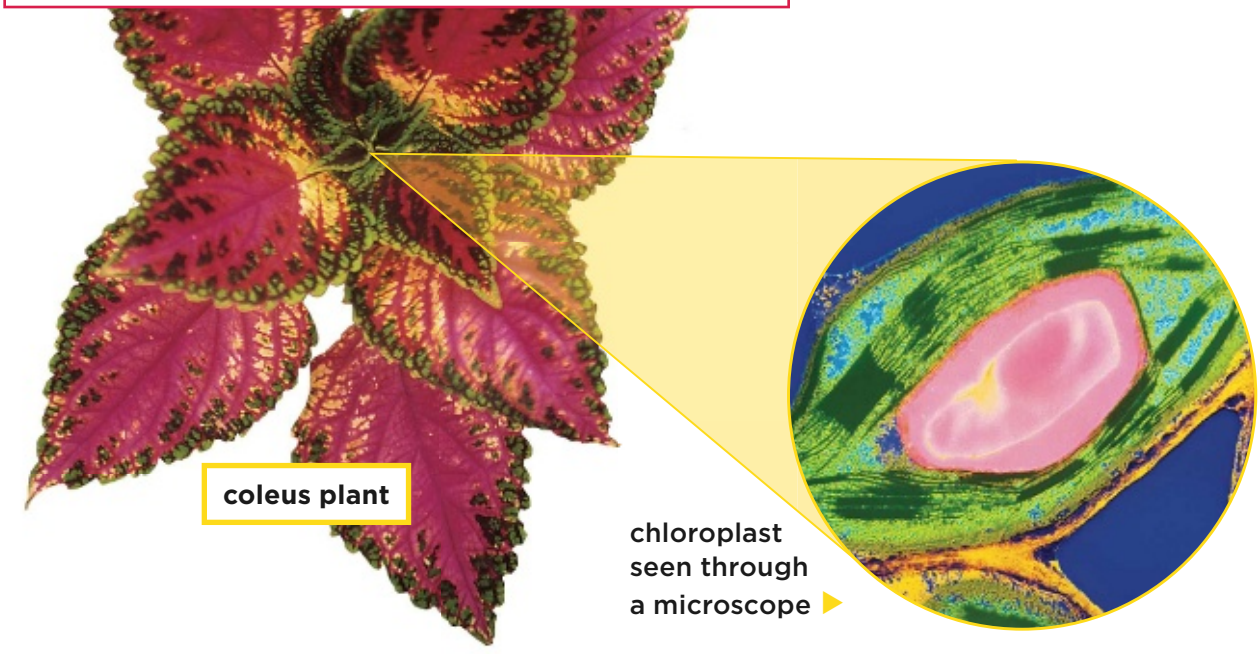
Recall that photosynthesis is the way plants make food. It occurs in the leaves. Water travels through the stem to the leaves. Carbon dioxide enters through the *stoma* (STOH•muh). Sunlight is absorbed by the *chlorophyll*. Chlorophyll is found in a part of a cell called the *chloroplast* (KLOR•uh•plast).

When all these ingredients are in place, the leaf can produce food. In the presence of sunlight, carbon dioxide and water produce sugar (food) and oxygen. You can show this as a formula.

The food is then carried to other parts of the leaf, the stem, or the roots.

Photosynthesis

Light
Water + Carbon dioxide ⟶ Sugar + Oxygen



Quick Check

22. During photosynthesis, _____ and water combine and produce food and oxygen.

23. Photosynthesis mostly occurs in the _____.

How does a plant get energy?

A plant takes in energy from the Sun. It stores that energy in the food it makes. To make food, the leaves need to take in carbon dioxide Also, water has to get to the leaves. See the diagram on page 17. With water and carbon dioxide, the leaves make food (sugar). The food has the Sun's energy stored inside.

Respiration

Plants then get energy from the food they make—much the way animals get energy from the food they eat. The energy is released from the food. The release of energy from food is called **respiration** (res•puh•RAY•shuhn). In respiration, sugars and oxygen combine. The process releases water, carbon dioxide, and energy.

So in photosynthesis, energy is stored in food. In respiration, energy is released from food.

Apples contain energy stored when leaves of apple trees made food during photosynthesis.

Quick Check

24. Put the steps of how water moves through a plant in the correct order. Number the steps from 1 to 4.

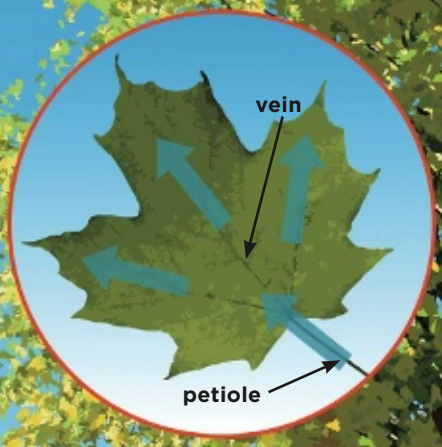
____ Transpiration helps pull the water toward the top of the plant.

____ Water travels from the roots to the stem.

____ Water moves into the leaves from the stem, replacing lost water.

____ Water in the soil enters the root hairs.

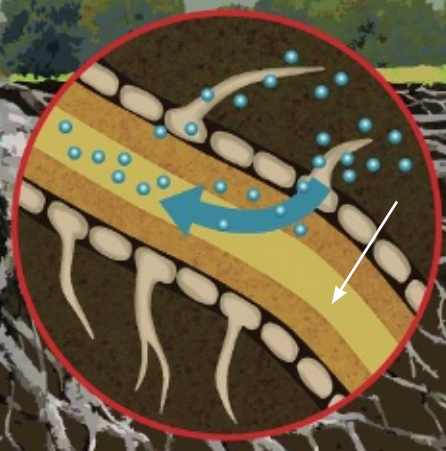
How Water Moves Through a Plant



5. Almost 99% of the water that enters the roots is given off into the air by transpiration through the leaves' stomata (plural of stoma).

4. Water moves up the stem into the leaves, replacing the water lost.

3. Loss of water from plant leaves, or transpiration (trans•puh•RAY•shuhn), helps pull the water upward toward the top of the plant.



2. Water and other substances travel from the roots to the stem.

1. Water and other substances in the soil enter root hairs.

Reading Diagrams

What causes water to travel from a plant's roots to its stem?

LOG ON *Science in Motion* Watch how plants transport water @ www.macmillanmh.com

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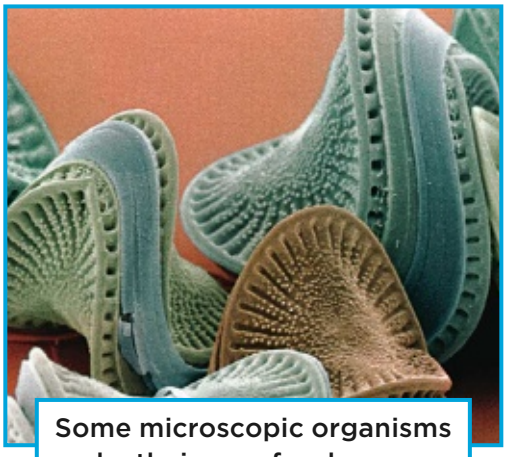
What are microscopic organisms?

Beyond the world you see is another one you cannot see. It is the world of microscopic organisms. These living things are too small for you to see. However, they are part of every ecosystem, and they have a niche, which they occupy. Their niche is the role they play in an ecosystem.

Some microscopic organisms break down dead organisms.



Some microscopic organisms make their own food.

Some microscopic organisms eat food.

Quick Check

25. Microscopic organisms can make their food, eat food, or _____

_____.

Studying Microscopic Organisms

To study microscopic organisms, scientists use a microscope. The object to be studied is placed on the stage. Two lenses are used to produce a magnified image of the object.

Compound Microscope

Reading Diagrams

The labels point out the parts of a microscope.

Quick Check

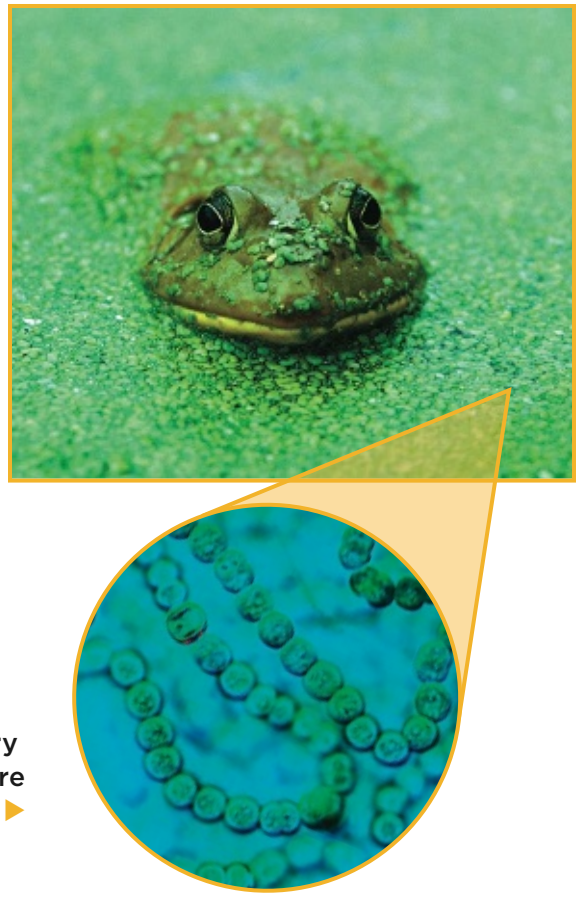
26. The _____ controls the amount of light entering the microscope.

Which microorganisms make their own food?

Scientists group microscopic organisms by how simple they are and by how they get food. For example, some microscopic organisms are simple cells without a nucleus. Some are cells with a nucleus.

Some microscopic organisms eat other organisms. Others make their own food. Remember, plants make their own food. They use sunlight to carry on photosynthesis. As a result oxygen is released into the air.

Many microscopic organisms also make their own food by photosynthesis. They also give off oxygen as a result. In fact, microscopic organisms may produce about half of Earth's oxygen supply!



The chain of blue-green dots are very simple organisms. Most organisms are much more complicated than these. ▶

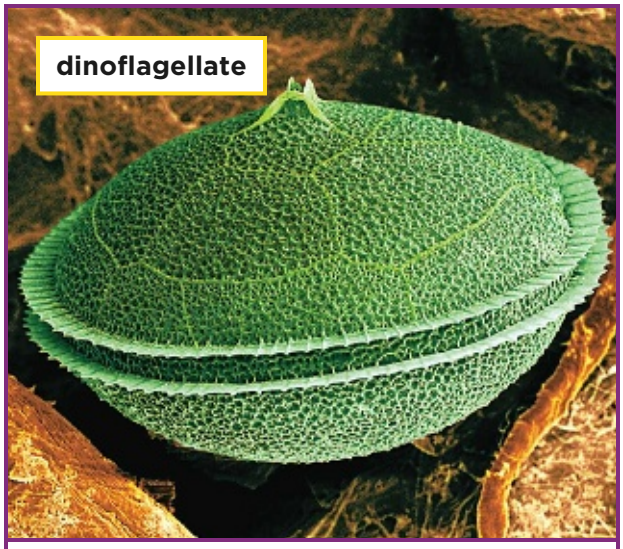
Quick Check

27. How are plants and microscopic organisms that make their own food alike? _____

_____

28. Microscopic organisms produce about _____ of Earth's oxygen supply.

Some protists make their own food by photosynthesis. They live in salt or fresh water and can have many shapes.



Some protists have properties of both plants and animals. Some of these protists can light up like fireflies.

Protists

Another kind of microscopic organism is a *protist*. Protists are hard to classify. Some protists produce their own food, as do plants. Others eat microscopic organisms, like animals.

However, they are all single-celled organisms and each cell has a nucleus. Most live in water. Some live in ocean water. Others live in fresh water (lakes, ponds, and rivers).

For example, one kind of protist that makes its own food is a diatom. Diatoms are an important source of oxygen for living things. They are also a source of food.

Dinoflagellates (dighn•uh•FLAJ•uh•luhtz) are another kind of protist that produces oxygen. They are an important source of food for other living things.

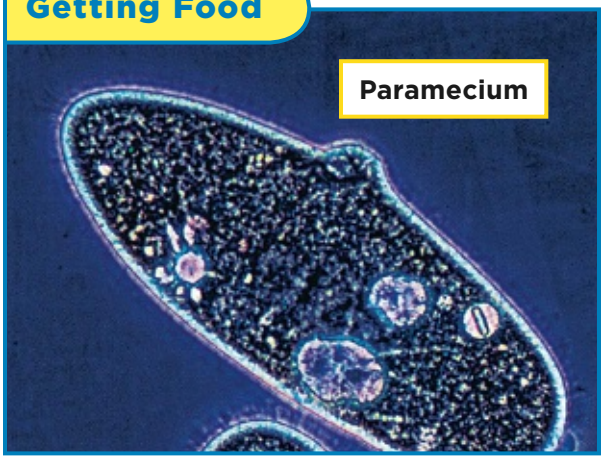
Quick Check

29. Why are protists important for life on Earth?_____

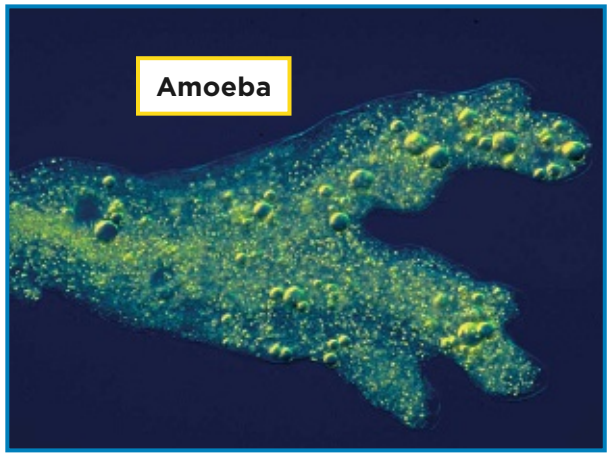
Which microscopic organisms eat food?

Some microscopic organisms cannot make their own food. They must get food from the place they live. To help them get their food, some have developed special structures.

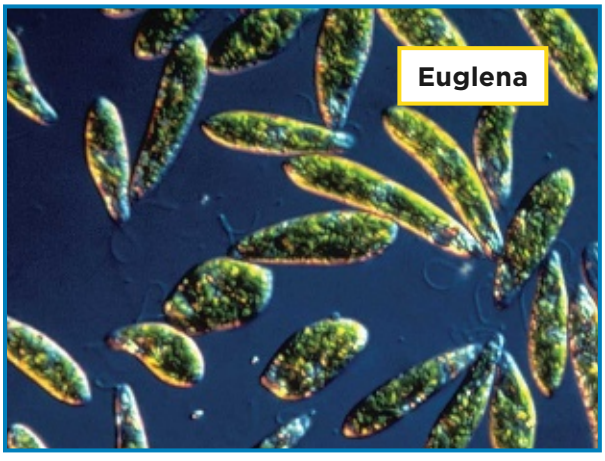
Getting Food



▲ This paramecium has tiny surface hairs. It uses them to move. Moving enables it to find food.



▲ An amoeba moves by pushing out part of its body like a foot. The rest of the amoeba flows with it. The amoeba also uses this "foot" to wrap around its food.



▲ The euglena can make its own food or eat other organisms.

Reading Photos

These photos show three different kinds of microscopic organisms that eat food.

Quick Check

30. Name three microscopic organisms that eat food.

_____, _____, and _____.

Roles for Microscopic Organisms

Some microscopic organisms have three basic roles when it comes to food:

- some make their own food.
- some eat other microscopic organisms.
- some microscopic organisms feed on dead organisms.

Microscopic organisms that make their own food or eat other organisms are the main food source for larger animals.

Those that feed on dead organisms feed on the remains of all both large and small organisms. They help to return to the community the raw materials its members need to live.

lake ecosystem

Quick Check

31. What is the value of having microscopic organisms that feed on dead organisms? _____

_____

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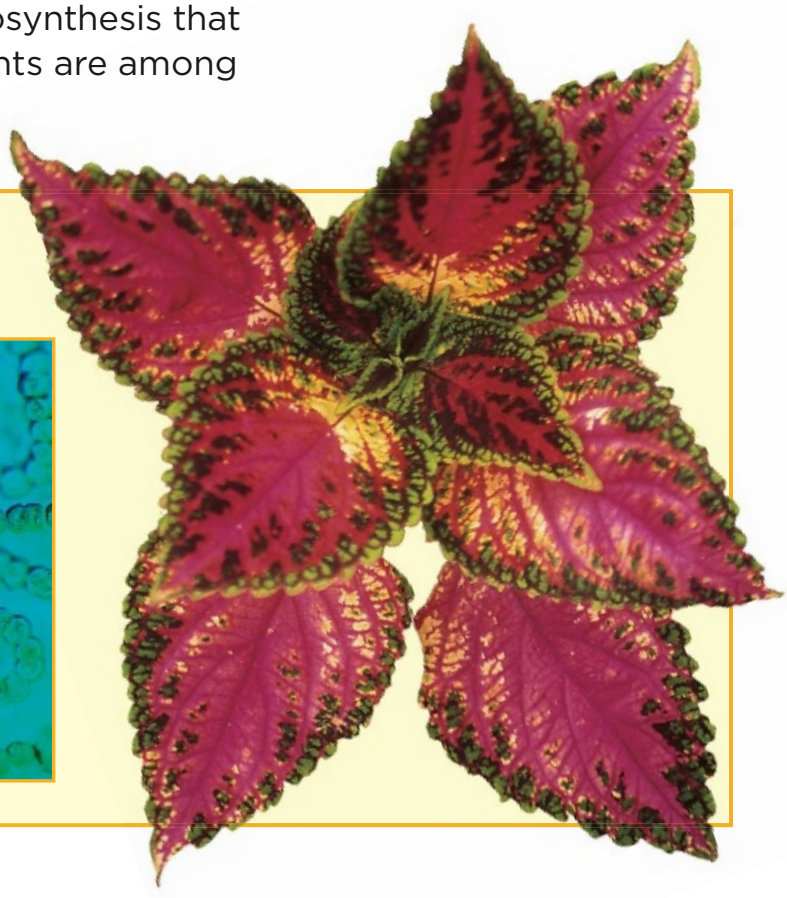
What are producers, consumers, and decomposers?

Some living things are producers. **Producers** make their own food. Plants are producers. So are many microscopic organisms. Any living thing that uses the energy of the Sun to make its own food is a producer.

Most producers on Earth live near the surface of the oceans. Here microscopic producers carry out more than 70% of the photosynthesis that takes place on Earth. Green plants are among Earth's land producers.

These living things make their own food. They are producers.



Quick Check

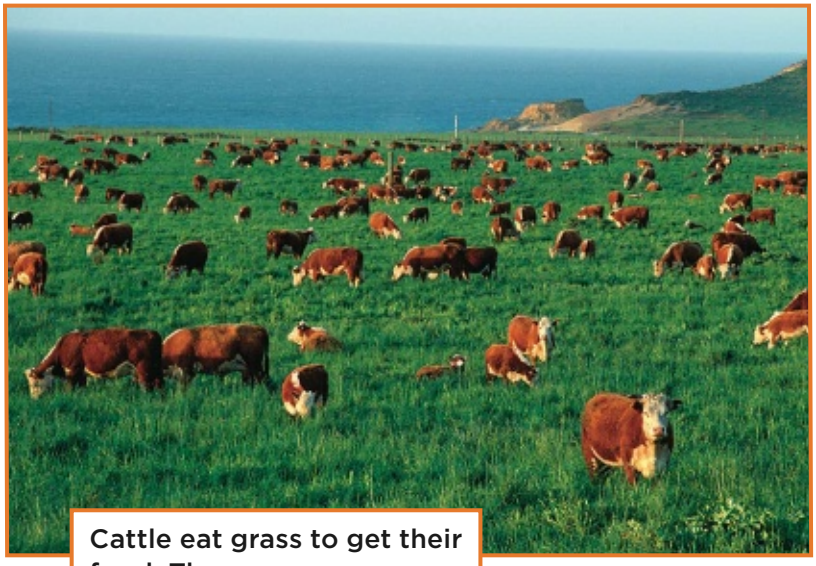
32. Circle the producers in this list of living things:

coleus, frog, cow, euglena, grass, fish, paramecium

A **consumer** is a organism that eats living plants or animals. All animals are consumers because they do not make their own food. Many microscopic organism are consumers too.

An organism that feeds on dead organisms is a **decomposer**. Decomposers break down dead organisms into simpler substances. Most of these substances are returned to the ecosystem. Decomposers include worms, bacteria, fungi (such as mushrooms), and many insects.

Yellow decomposers breaking down dead tree.



Cattle eat grass to get their food. They are consumers.

Mushrooms break down the maple tree stump into simpler substances. They are decomposers.

Producers	Consumers	Decomposers
maple tree	sea lion	worms
rose bush	condor	bacteria
California poppy	humans	mushrooms

Quick Check

33. What is the difference between a consumer and a decomposer?

What is a food chain?

In an ecosystem, producers absorb the Sun's energy when they make food by using photosynthesis. This energy is then passed on to consumers and decomposers when they feed on the producers. This path from producer to consumer to decomposer can get complicated. A **food chain** is the path of the Sun's energy from one living thing to another

Overall, here is the path in which energy from the Sun travels.

The Sun ⟶ producers ⟶ consumers ⟶ decomposers

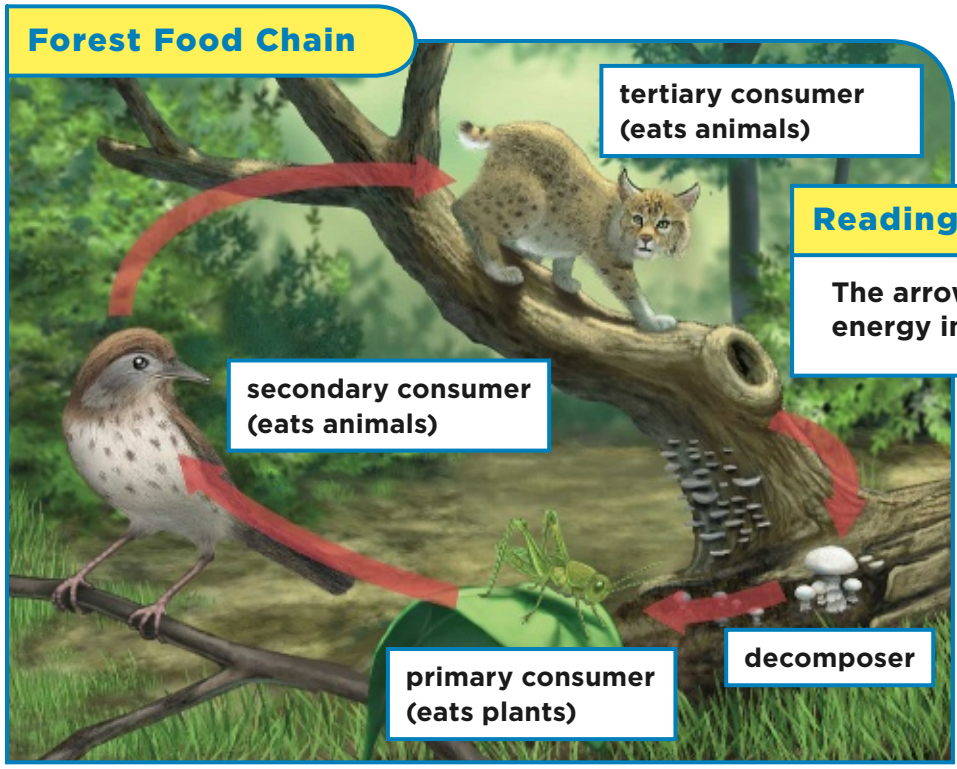
▲ **The zebra and the lion are part of a food chain.**

Quick Check

34. With what do all food chains start? With what do they end?

start _____

end _____



Reading Diagrams

The arrows show the path of energy in this forest food chain.

Consumers and Decomposers

Consumers are classified by what they eat.

Primary Consumers

- eat producers
- include some insects, rabbits, horses

Secondary Consumers

- eat primary consumers
- include many birds, foxes, some whales

Tertiary Consumers

- eat secondary consumers
- usually top hunter in food chain
- include snakes, lions, orcas

Last in the food chain are the decomposers. They break down remains of dead organisms into substances producers use. And the food chain continues.

Quick Check

35. At a Scout campfire, Balek said a *T-rex* was a secondary consumer. Do you agree or disagree with Balek's statement? Why?

What is a food web?

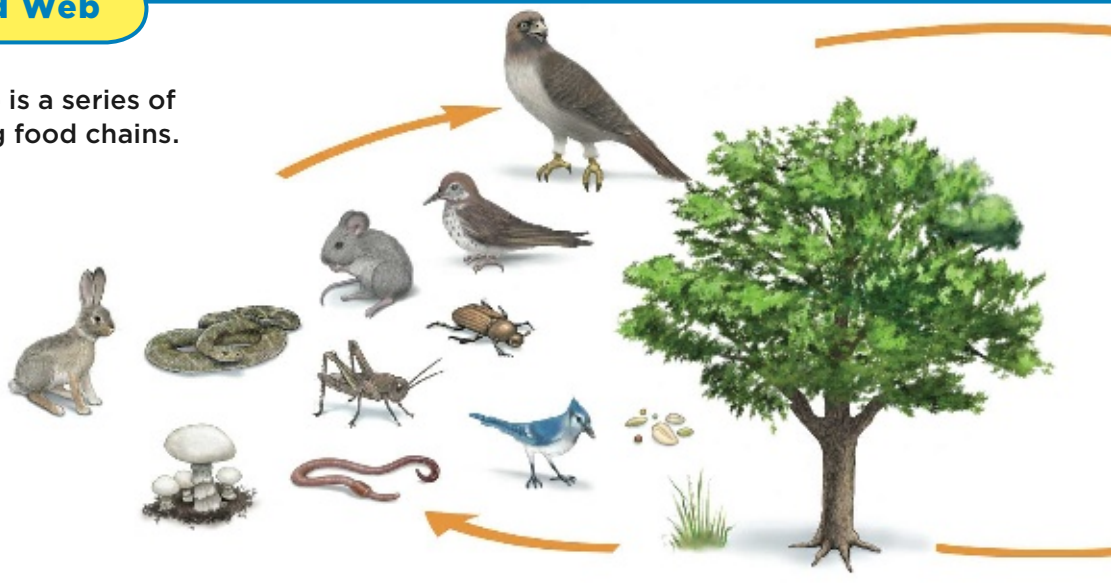
Most consumers eat more than just one kind of food. A **food web** shows all the food chains in an ecosystem. Food webs also show the roles each of its members play.

Food webs have three main kinds of members:

Type of Consumer	Examples
Herbivores plant eaters (primary consumers)	deer, zebra, cows
Carnivores animal eaters (secondary and tertiary consumers)	coyotes, cats, snakes
Omnivores eat plants and animals (highest level of consumer)	raccoons, bears, humans

Land Food Web

A food web is a series of overlapping food chains.



Quick Check

36. List two possible paths in the food web starting with the grass and ending with the large bird. _____

_____

_____

_____

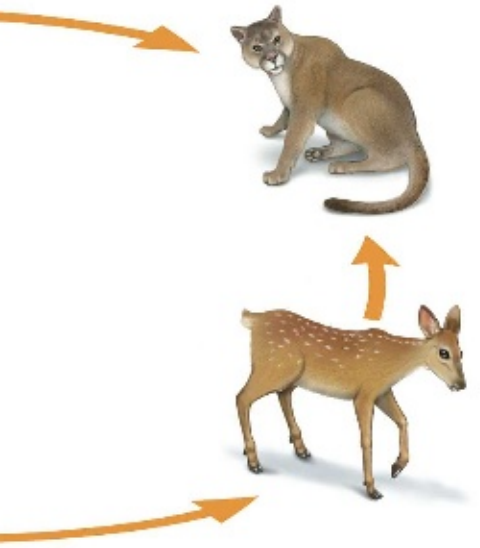
Other Roles in a Food Web

In addition to whether animals eat plants or other animals, animals in a food web have different ways of getting food.

Predators hunt, kill and eat other animals. Lions, polar bears, and preying mantises are predators. **Prey** are the animals predators hunt. A rabbit may be the prey of a hawk.

Scavengers eat dead animals without hunting or killing them. Jackals and vultures are scavengers. Fungi, such as mushrooms, are also scavengers. They get their food from decaying plants and animals.

▲ The California condor is a large scavenger.



Reading Diagrams

The arrows show the levels of a food web.

Quick Check

37. Use the diagram to give an example of an animal that can be both a predator and a prey. Explain your answer. _____

_____

_____

_____

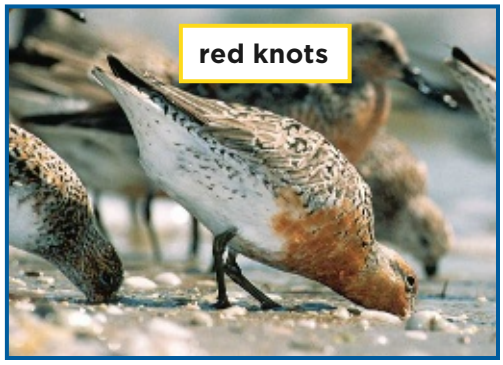
What is a marine food web?

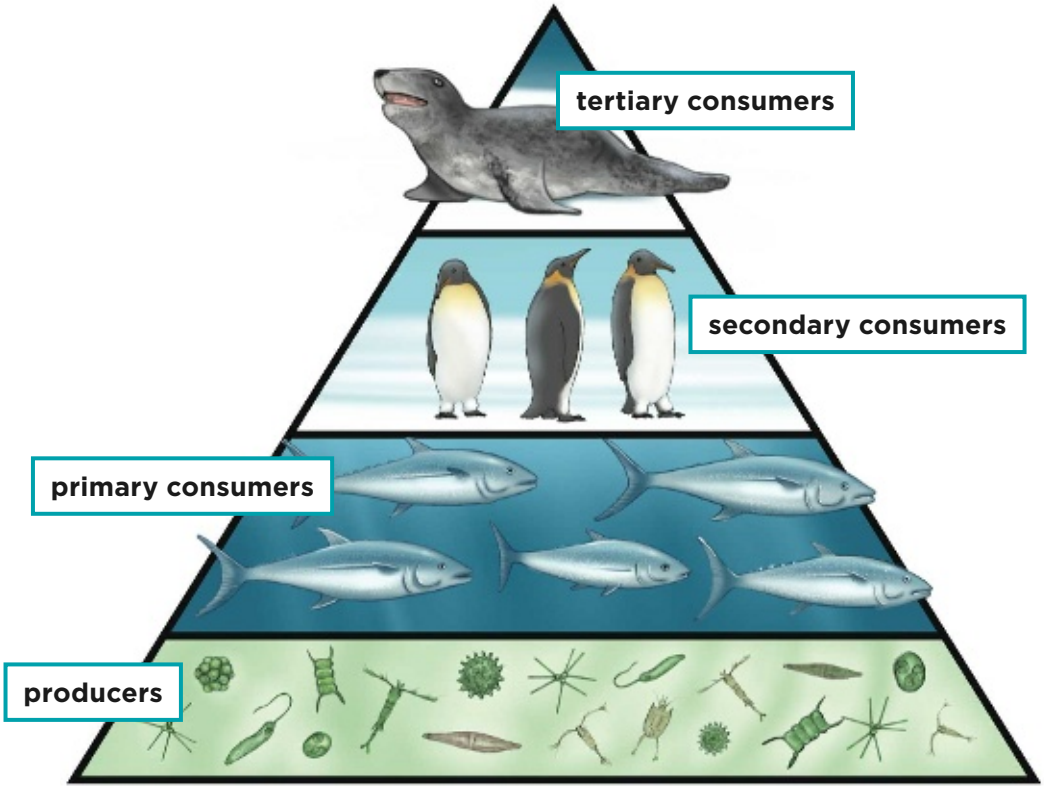
The oceans have food webs, too. Here, the webs depend on how deep into the water the sunlight reaches. Each food web has its own set of organisms. There are food webs at the shore where the tides come in or go out.

Other food webs exist in the shallow waters near the ocean's edge away from the shore. Here the waters are calmer. The underwater kelp forests off the coast of California provide food and shelter for hundreds of kinds of living things.

Finally, in the open ocean are webs that occur near the surface. Sunlight reaches down to about 200 meters (656 feet). Also, food webs can be found between 200 meters (656 feet) and 1,000 meters (3,280 feet), where there is little light. They are in a dark zone with no light.

Sea otters find shelter and food in a kelp forest.





▲ ocean energy pyramid

How are populations connected?

Populations are connected by an energy pyramid. **Energy pyramids** are models that show how energy moves through a food chain.

The base of the pyramid is the producers. Each level is a higher level of consumer. At each level, less energy is available. So, fewer animals live at each higher level. Very few animals are at the top of a food chain.

Small changes in an ecosystem can upset the energy balance. As long as populations get food, they survive. If they do not, competition may occur. In that case, a population may decrease or die out.

Quick Check

38. In the ocean energy pyramid shown, which organism would have the fewest number of members? Why? _____

_____

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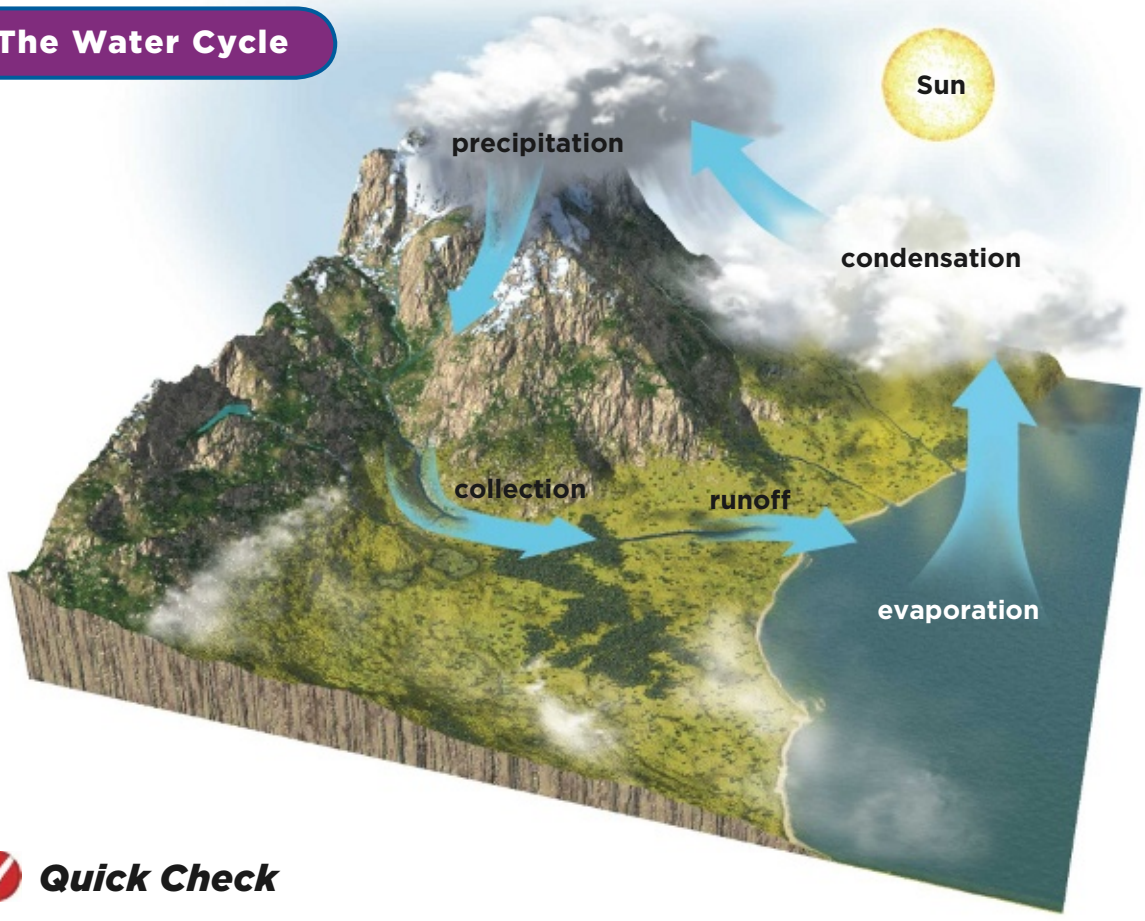
What is the water cycle?

Have you ever heard someone talk about the "cycle of the seasons?" A cycle is a set of events that follow each other over and over: spring, summer, autumn, winter, spring, summer, autumn, and so on.

The *water cycle* is the nonstop movement of water between Earth's surface and the air. The water cycle happens because water can exist in solid, liquid, or gas forms. The Sun's energy makes the water cycle happen.

The Water Cycle



Quick Check

39. Where does water move in the water cycle? _____

_____

_____

Parts of the Cycle

There are four main parts in the water cycle.

1. **Evaporation** Liquid changes to a gas.

   Cause: Sun heats up bodies of water.

   Effect: Liquid water becomes water vapor (gas).

2. **Condensation** Gas becomes a liquid.

   Cause: Vapor rises into air, and cools.

   Effect: Water vapor (gas) changes into liquid water (clouds).

3. **Precipitation** Water falling to Earth.

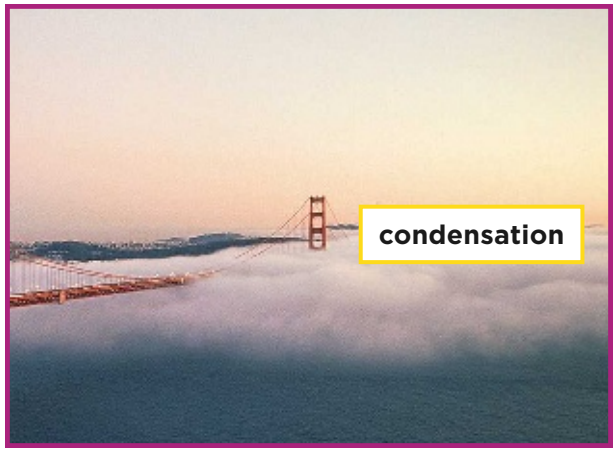
   Cause: Cloud droplets become too heavy. They fall.

   Effect: Precipitation (rain, snow, sleet, hail)

4. **Collection and Runoff:** Water soaks into the ground.

   Cause: Water collects on Earth's surface. Sometimes it runs off before collecting.

   Effect: Lakes, ponds, oceans, rivers, streams

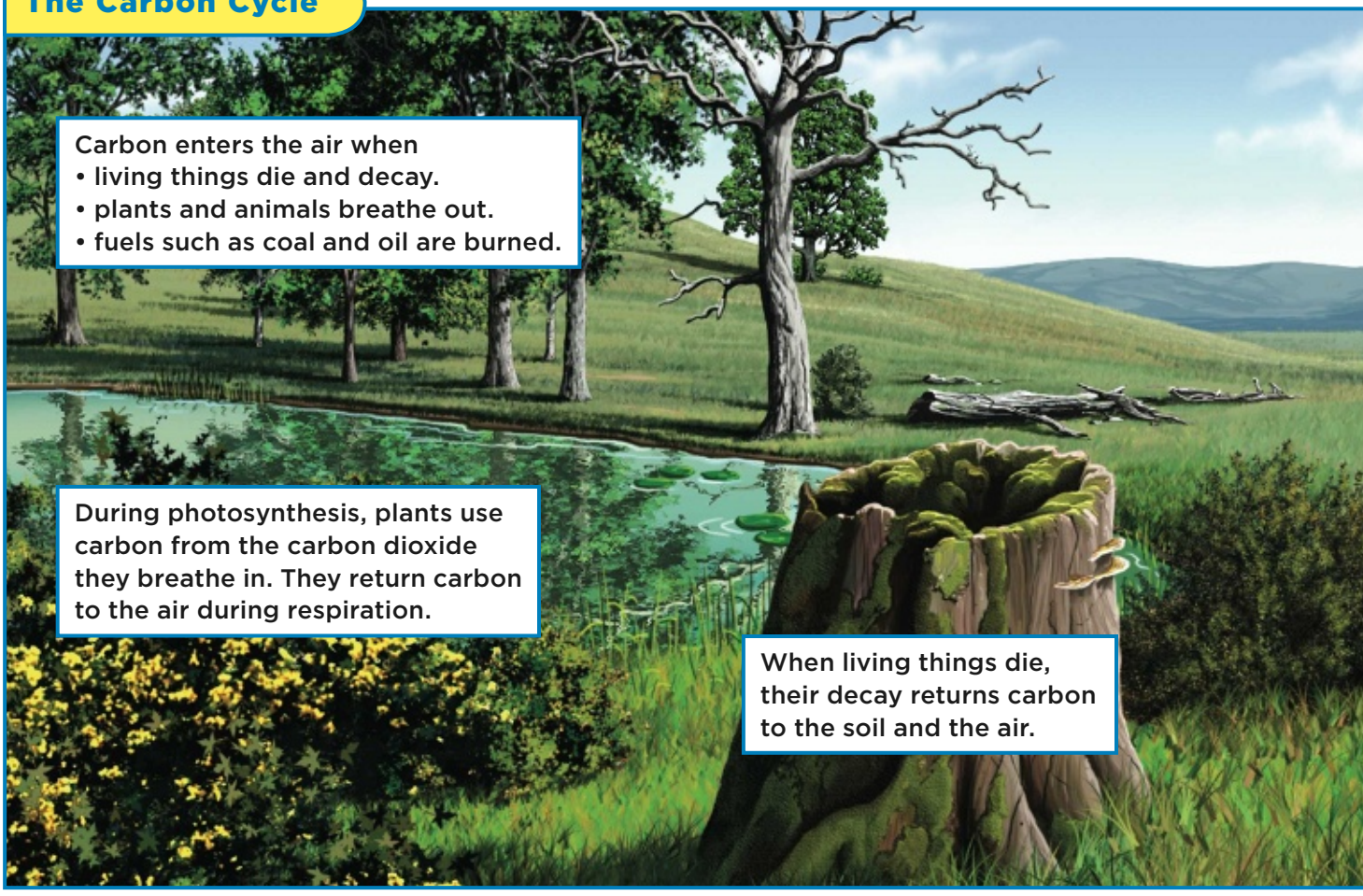


Quick Check

40. What part of the water cycle is occurring in each of the following?

- A puddle disappears in the sunlight _____.
- Snow falls in the Cascade Mountains _____.
- Thunderclouds build off the island of Catalina _____.

The Carbon Cycle



What is the carbon cycle?

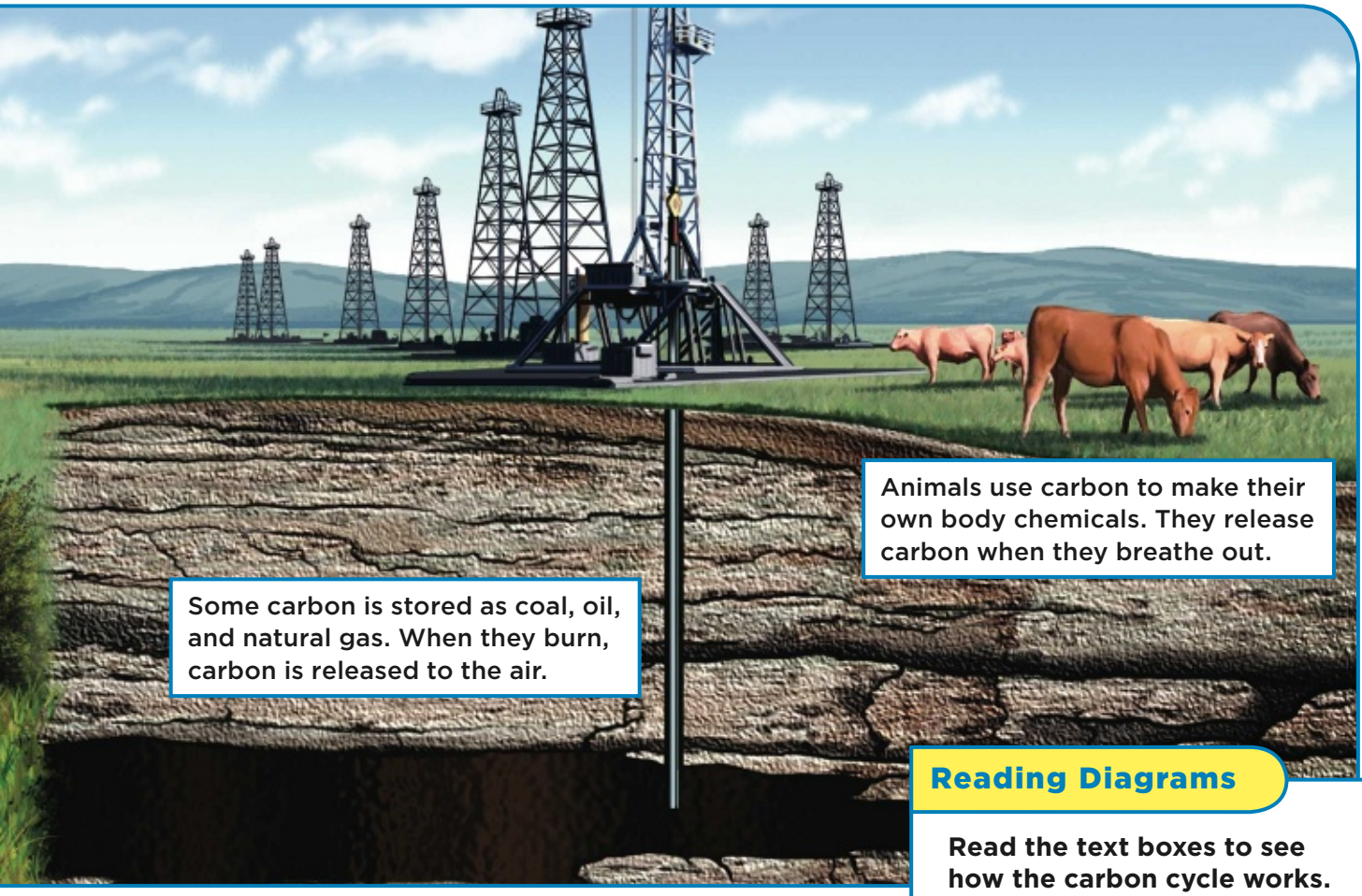
Carbon is one of the elements that living things are made of. Living things need carbon to live and grow. They get it from the air. However, air does not have much carbon. So, the carbon that living things take from the air has to be replaced, or recycled. Carbon is recycled between the air and living things by the *carbon cycle*.

Quick Check

41. Carbon enters the air when _____,

_____,

and _____.



Reading Diagrams

Read the text boxes to see how the carbon cycle works.

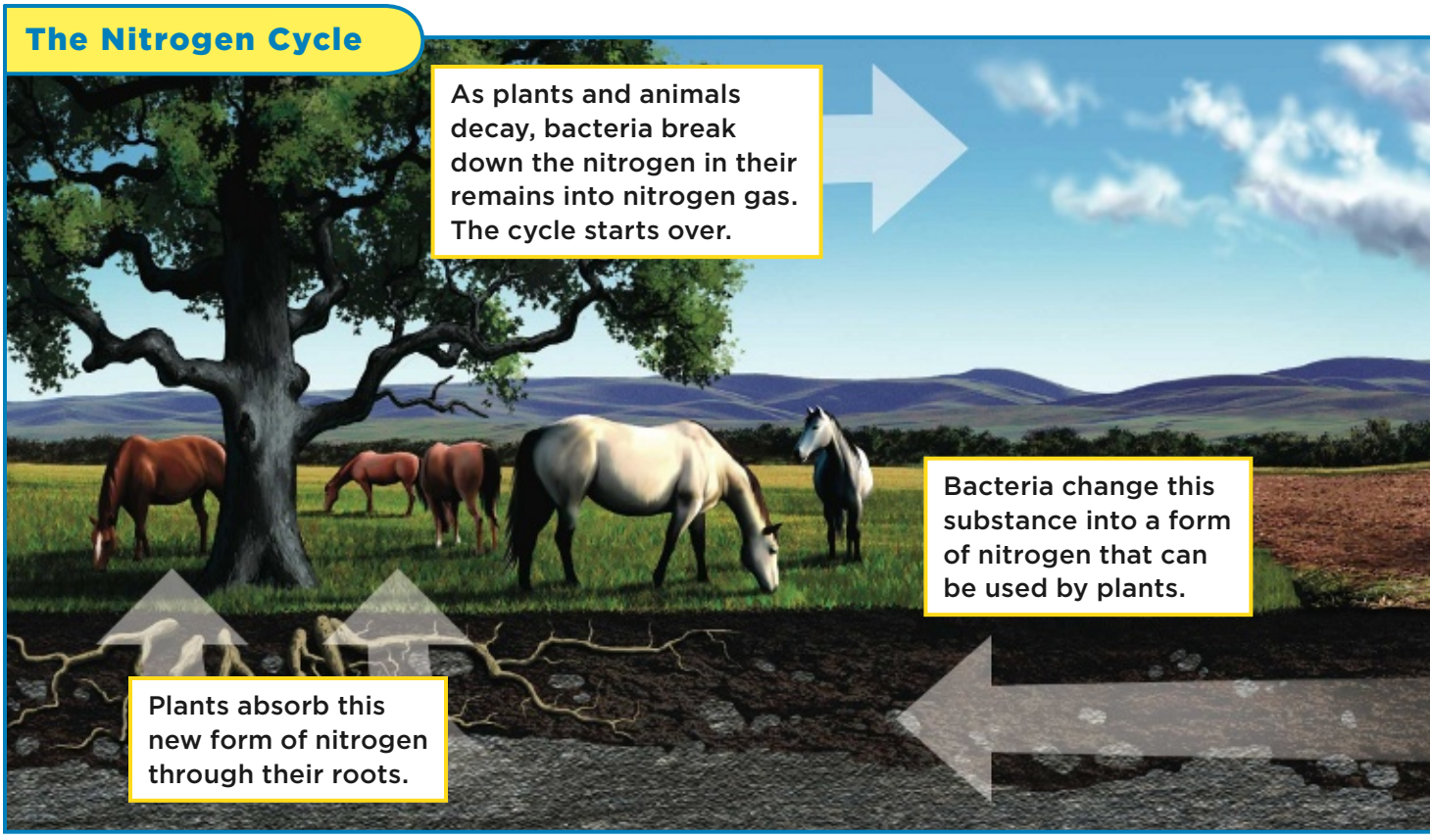
Carbon and Life

Carbon and living things are connected. Carbon is stored in living things. It is also found in soil, in the air, and in some fuels.

Producers use carbon when they make food. But, they give off oxygen in the process. Animals use oxygen to get energy from food. They release carbon to the air as a result. Thus the carbon is recycled by living things. When they die, decomposers return carbon to the ecosystem.

Quick Check

42. What members in the food chain help recycle carbon when living things die? _____



What is the nitrogen cycle?

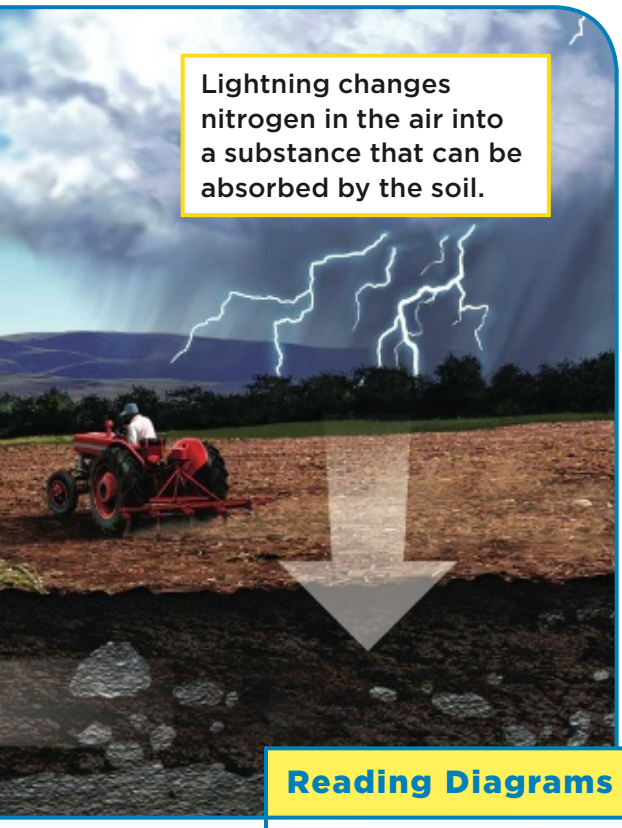
All living things need nitrogen to develop and grow. Like carbon, nitrogen is cycled through the environment. And also like carbon, nitrogen can not be used in its pure form. It has to be changed into a form that living things can use. The *nitrogen cycle* is the way that nitrogen gas is made into compounds and put into the soil. It is also the way nitrogen gas is put back into the air.

Quick Check

43. How do decomposers contribute to the nitrogen cycle? _____

_____

_____



Recycling Plants

When plants die, their remains may become a home for other living things. After a while decomposers break down dead organisms into useful substances. Thus, each member of an ecosystem has a job that helps the community survive.

People can help an ecosystem, too. They can mix vegetable food scraps with dry leaves and grass clippings. This mixture is then broken down by decomposers. The mix can then be used as a natural fertilizer for gardens and farms.

Reading Diagrams

Follow the arrows to see how the nitrogen cycle works.

Adding vegetable scraps to garden material to make natural fertilizer. ▶

Quick Check

44. What might happen first when a large tree in a forest dies and falls?

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Earth's Ecosystems

Match the description in the second column with the word in the first column.

1. ____ ecosystem

2. ____ population

3. ____ herbivores

4. ____ energy pyramid

5. ____ photosynthesis

6. ____ omnivores

7. ____ predators

8. ____ producer

9. ____ condensation

10. ____ precipitation

a. the changing of a gas into a liquid

b. a living thing that makes its own food

c. the food-making process in plants

d. where living and nonliving things interact

e. animals that hunt, kill, and eat other animals

f. water that falls to Earth

g. members of one kind of living thing

h. animals that eat plants and other animals

i. how energy moves through an ecosystem

j. animals that eat plants

Use the words from 1 to 10 above in your answer to 11.

11. Give an example of one word that contains another word.

For example, a food chain contains a producer. _____

_____

Fill in one letter for each blank. Some blanks are boxed.

1. All the populations in an area make up a(n)
__□__ __ __ __ __ __□__.

2. All the food chains in an ecosystem are the __□__ __ __□__.

3. An animal that a predator hunts is its□__ __ __ __ .

4. An animal that eats dead animals without hunting and killing them is
a□__ __ __ __ __ __ __ __.

5. The release of energy from food is called
__ __□__ __ __ __ __ __ __ __ __.

6. Any living thing that eats other living things is a(n)
__ __□__ __ __ __ __ __.

7. A living thing that feeds on dead plants and animals is a(n)
__ __ __ __ __ __ __□__ __.

8. The path of energy from the Sun from one living thing to another is
a __ __ __ __ __□__ __ __ __.

9. An animal that eats other animals is a(n) __ __ __ __□__ __ __ __ __.

10. The changing of a liquid to a gas is __ __ __ __ __ __ __□__ __ __ __.

Use the boxed letters above to complete the answer to this riddle.

This process makes life possible on Earth.

__ h __ __ __ __ __ __ t __ __ __ __ __

CHAPTER 2

Earth's Land and Water

Vocabulary

biome a large area of land that has certain kinds of plants and animals

climate the weather conditions of an area

deciduous trees that change colors during autumn

taiga a forest of evergreen trees

tundra a very cold, dry biome

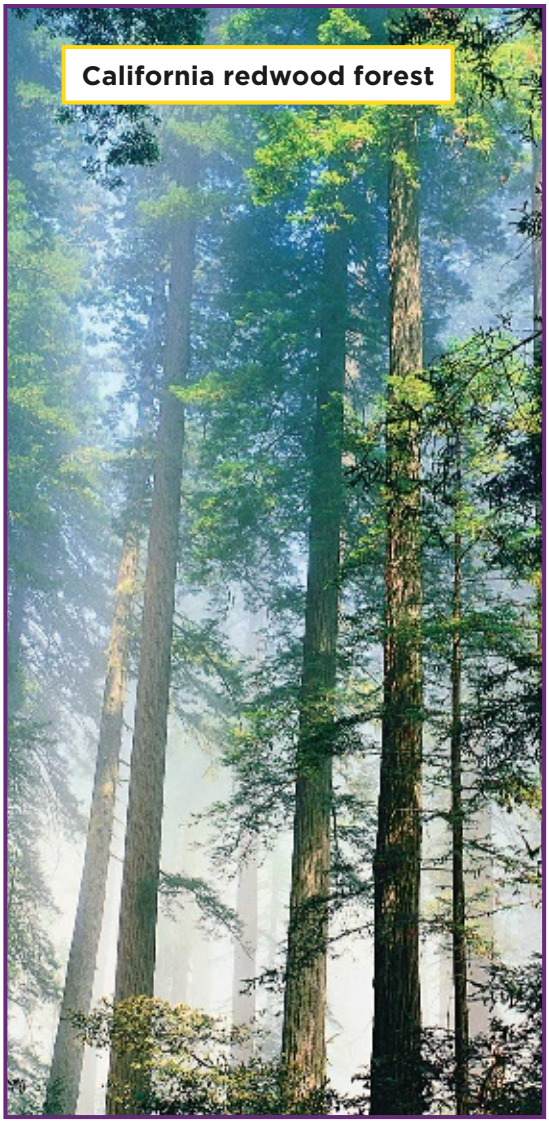
The Big Idea: How do organisms survive in land and water ecosystems?

intertidal zone an area affected by tides

estuary an area where fresh water meets the sea

wetlands areas where water is almost always near the surface

chaparral a dry region with thick brush and small trees



This is one of the six kinds of biomes.

Biomes

A **biome** is a large area of land that has certain kinds of plants and animals. Earth is grouped into six biomes. Each biome has a type of climate. **Climate** describes the weather conditions of an area, such as tropical.

Many things affect the climate of an area. One is the amount of direct sunlight. Areas that are closer to the equator receive more direct sunlight. Areas far from the equator receive less.

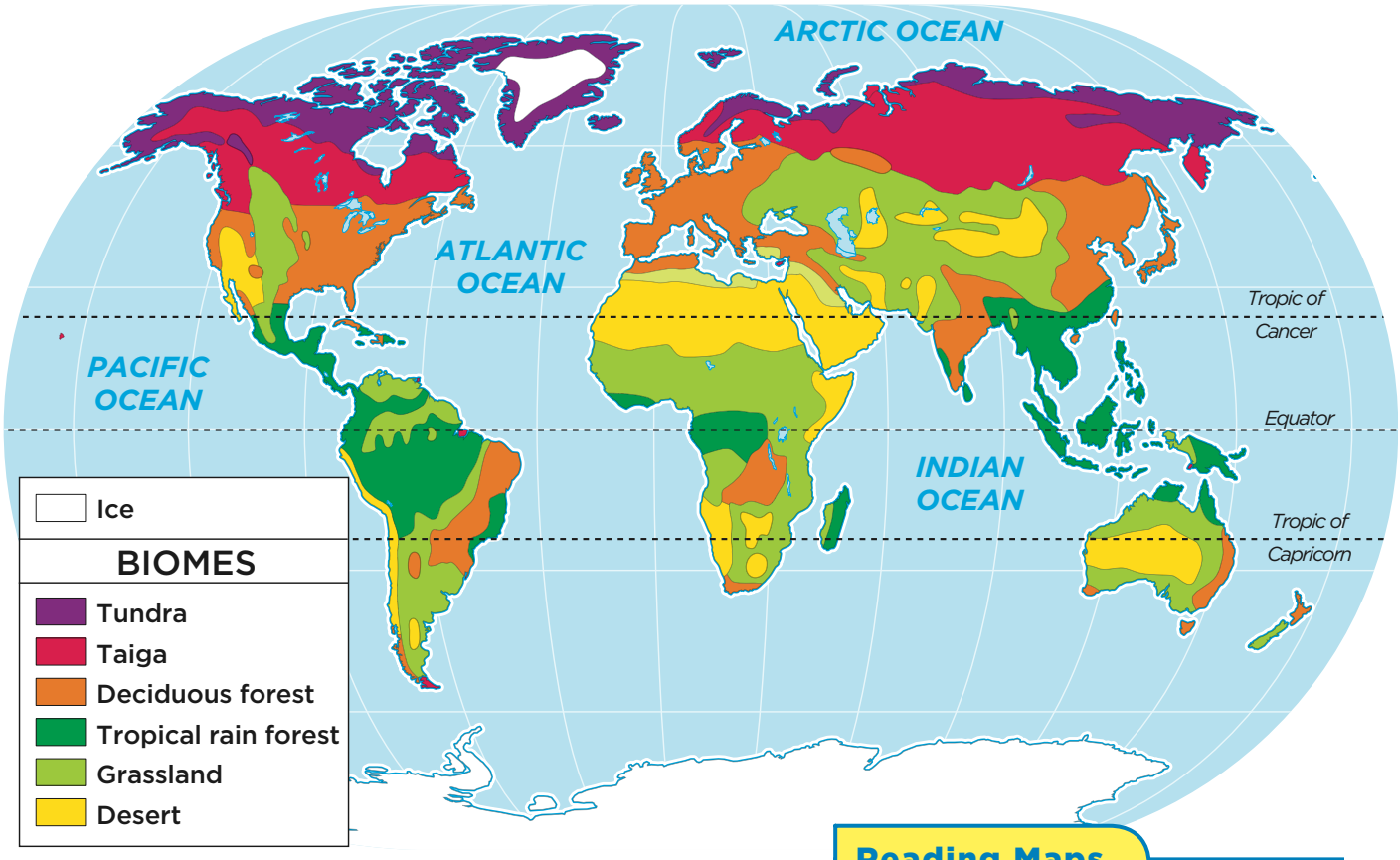
Sea level also affects climate. Places that are high above sea level have cooler climates. Places near sea level generally have warmer climates. Wind patterns, ocean currents, and mountains also affect climate.

Quick Check

Fill in the blanks.

1. Three things that affect the climate in an area are _____, _____, and _____.

Earth's Biomes



Reading Maps

This map shows Earth's six biomes and the polar regions.

Quick Check

Use the map to answer the questions.

2. Name the six biomes. _____

_____

_____

_____

3. What biome is found near the Arctic Ocean?

_____

Tropical Rain Forests

Tropical rain forests are biomes near the equator. The Sun's rays shine more directly here. The climate in tropical rain forests is hot and humid. There is a lot of rain, 80–180 inches per year. More kinds of plants and animals live in tropical rain forests than in all the other biomes combined.

Rain forests are found in Central America, South America, India, Africa, Southeast Asia, Australia and tropical islands.

Quick Check

4. What kind of climate do you find in a tropical rain forest? _____

_____

_____

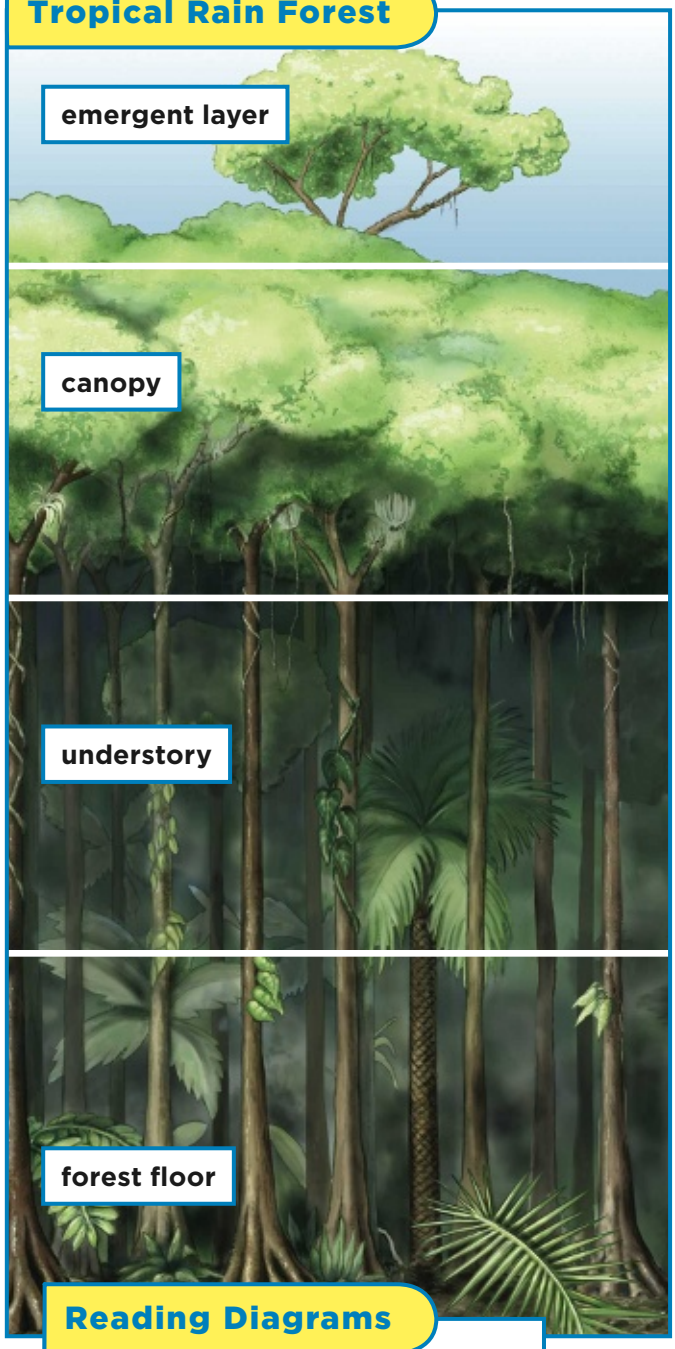
Plant life in the rain forest grows in four levels. The top level is the *emergent layer*. This layer includes the tops of the tallest trees. Many birds make their homes here.

The next level is the *canopy*. Its thick layer of leaves prevents much sunlight from passing through. Birds, monkeys, snakes, owls, and many insects live in the canopy.

Beneath the canopy is the *understory*. This level is made up of the trunks of the canopy trees. Shrubs, vines, and small plants also grow here. Very little sunlight reaches the understory. It is home to frogs, insects, snakes, and jaguars.

The bottom layer of the rainforest is the *forest floor*. Most plants that grow here have very large leaves. This helps them to take in the limited amount of sunlight. Insects, snakes, and frogs live here.

Tropical Rain Forest



Reading Diagrams

This diagram shows the four levels of the rain forest.

Quick Check

5. Why does only a small amount of light reach the understory and forest floor? _____

_____

_____

deciduous forest

Deciduous Forests

The trees of **deciduous** (di•SIHJ•uh•wuhs) forests change colors during autumn. They turn from green to red, orange, yellow, and brown. Deciduous trees lose their leaves as the temperature gets cooler. When the leaves fall to the ground, they decay, or break apart. This helps make the soil very rich so many things can grow. Deciduous forests are found in parts of North America, Asia, and Europe.

Evergreen trees also live in deciduous forests. Instead of losing their leaves, evergreens keep most of their leaves all year.

Animals in a Deciduous Forest

Birds such as cardinals, robins, crows, and hawks live in deciduous forests. Chipmunks, squirrels, mice, and deer are herbivores, or plant eating animals, that move through the forest looking for nuts, berries, and leaves. Carnivorous, or meat eating animals, such as cougars, coyotes, bears, owls are found there too.

Deer often live in forests. These animals will eat almost any plant.

Quick Check

6. What happens to trees in the deciduous forest in cool weather? _____

_____

_____

7. How does this affect the forest's soil?

_____

_____

_____

Deserts

A desert is a biome that receives less than 25 cm (about 10 in.) of rainfall per year. There are four types of deserts: hot and dry deserts, semideserts, coastal deserts, and cold deserts.

Arches National Park, Utah

Hot and Dry Deserts

The weather in these deserts is hot and dry year-round. At night, the air becomes very cool.

Hot and dry deserts receive little rain. When rain falls, the water often evaporates before it reaches the ground.

The Mojave Desert in California has plants and animals that live in dry conditions. Plants like the yucca store water to help it survive. Some animals rest during the hot day and come out at night when it is cooler. These include insects, spiders, reptiles, and birds.

California's other desert is the Colorado Desert, the warmest desert in the United States. A common plant here is the creosote bush. The waxy leaves of this bush help prevent water loss, even in driest seasons.

Quick Check

8. What do some plants and animals do to help them survive in a desert climate? _____

_____

_____

_____


collared lizard

Semideserts

Semideserts are often located between hot, dry deserts and grasslands or woodlands. Like other deserts, temperatures in semideserts are hot during the day and cooler at night. Insects stay in shaded areas during the day. Many animals go underground to stay cool.

Coastal Deserts and Cold Deserts

Coastal deserts are usually on the western edges of continents. They have cool winters and warm summers. The Atacama Desert in Chile is a coastal desert. It is Earth's driest desert. Several years may go by before any rain falls there.

Cold deserts are found near the North and South Poles. Antarctica, central Asia, and Greenland have cold deserts. These deserts have long, cold winters and short summers.

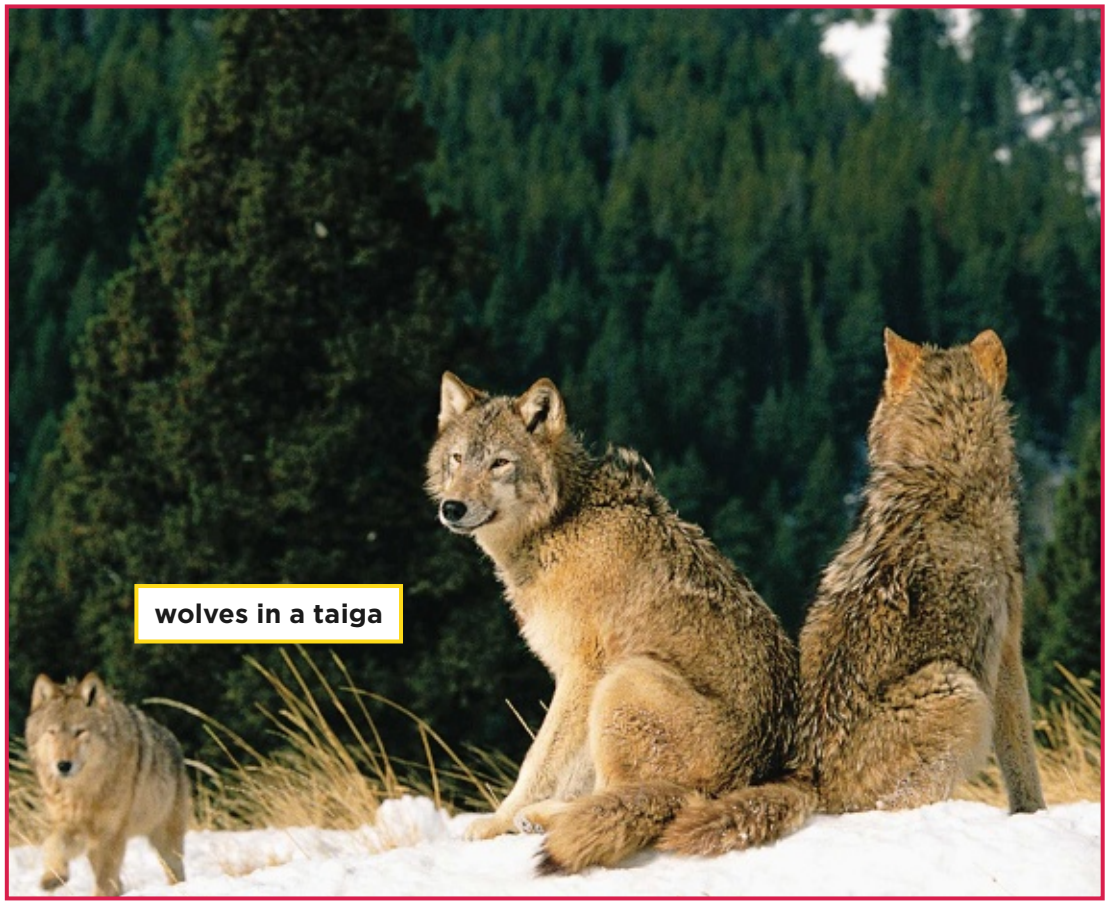
Quick Check

9. Compare the daytime and nightime temperatures in the desert. _____

_____

_____

_____



wolves in a taiga

Taigas

Taigas (TIGH•guhs) are biomes found in far northern regions. They have very cold winters. Taigas have fewer kinds of plants and animals than other biomes.

Taiga is the Russian word for "forest." A taiga is a forest of evergreen trees. The taiga of the Northern Hemisphere stretches across Eurasia and North America. It is the world's largest biome.

Taiga winters are very cold. Its summers are warm, rainy, and humid. Taiga plant life includes trees such as pine, spruce, and hemlock. Lynxes, wolverines, and bobcats are predators that live in taigas.


caribou in a tundra

Tundras

Tundras are also biomes found in the far north. A **tundra** is a very cold, dry biome. The ground has a layer of soil that is always frozen. This layer is called permafrost. Tundras cover about 20% of Earth's surface. They are located near the North Pole and spread south to the taigas.

The cold, dry tundra climate makes it hard for plants and animals to live there. The permafrost prevents trees and large plants from growing deep roots. But mosses, grasses, lichens, flowers, and low shrubs are able to survive the cold.

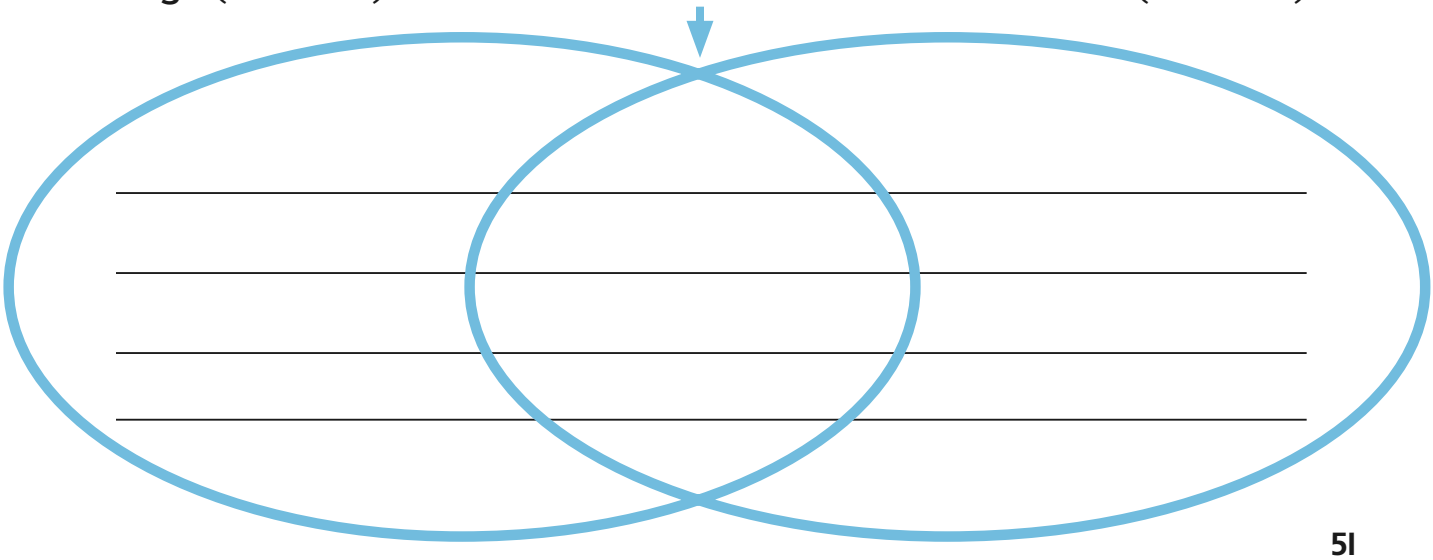
Snowshoe hares, caribou, musk oxen, hawks, wolves, arctic foxes, and polar bears make their homes in the tundra.

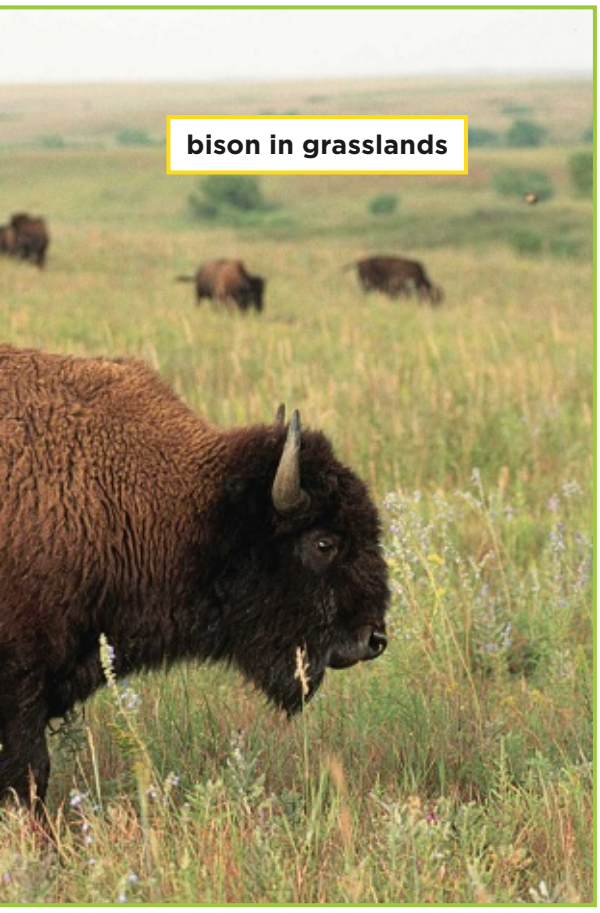
Quick Check

10. How are the tundra and taiga alike? How are the different?

Use the diagram below to help you.

taiga (different) **alike** **tundra** (different)





▲ A bison grazes in a grassland biome.

Grasslands

Grasslands are biomes in which grasses are the main plant life. Winters are cool and summers are warm. Rainfall is not plentiful, that is why there are no tall plants. The soil is often fertile and used for farming. The roots of grass and plants hold the soil in place, and keep it from blowing away. Gophers, prairie dogs, and coyotes are some of the animals that live in North America's grasslands.

Savannas

Savannas are a type of grassland that is warm all year round. The soil is not as fertile as other grasslands. Summers are long and dry, but winters are wet. Africa's savannas are the homes of lions, giraffes, zebras, and antelopes.

Quick Check

11. In grasslands, why are the roots of grass and plants important?

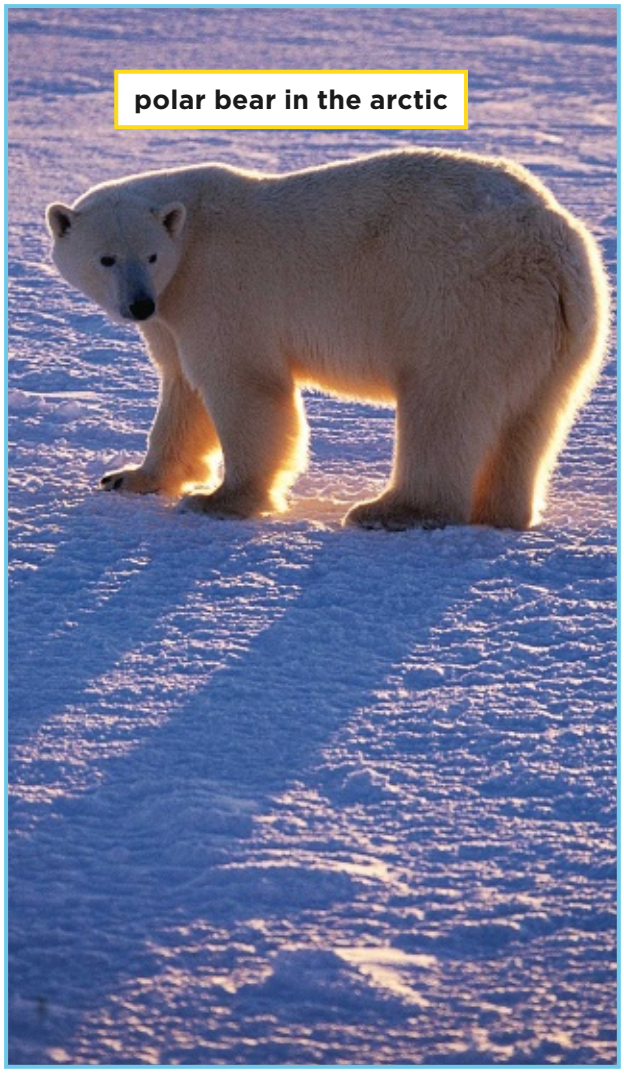
Earth's Coldest Places

Freezing temperatures and cold winds mark Earth's North and South Poles. Snow or ice lasts all year long.

In arctic regions near the North Pole, what looks like land is actually water covered with snow and ice. In summers the ice can break into pieces and float as icebergs. The North Pole is the home of Earth's largest carnivore, polar bears. They eat seals, walruses, and fish. In winter they move south to land areas.

The snow and ice near the South Pole cover the continent of Antarctica, even in the summer. It is the home of penguins. These birds feed in the ocean, far from their inland nests. Penguins are hunted by sharks and leopard seals.

Plants cannot grow on land in the polar regions. All life in these regions depends upon the sea.



polar bear in the arctic

Quick Check

12. Why is the sea important to animals that live in the polar regions? _____

_____

_____

_____

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These fish live in a shallow-water ecosystem.

What are ocean ecosystems?

Oceans cover about 75% $\left(\frac{3}{4}\right)$ of Earth's surface. They are an important part of the water cycle. The oceans are a major source of evaporation.

The oceans are divided into regions similar to biomes. Each region has factors that affect the life in them. These factors include:

- temperature
- amount of salt in the water
- amount of sunlight
- depth of water
- nearness to shore

Quick Check

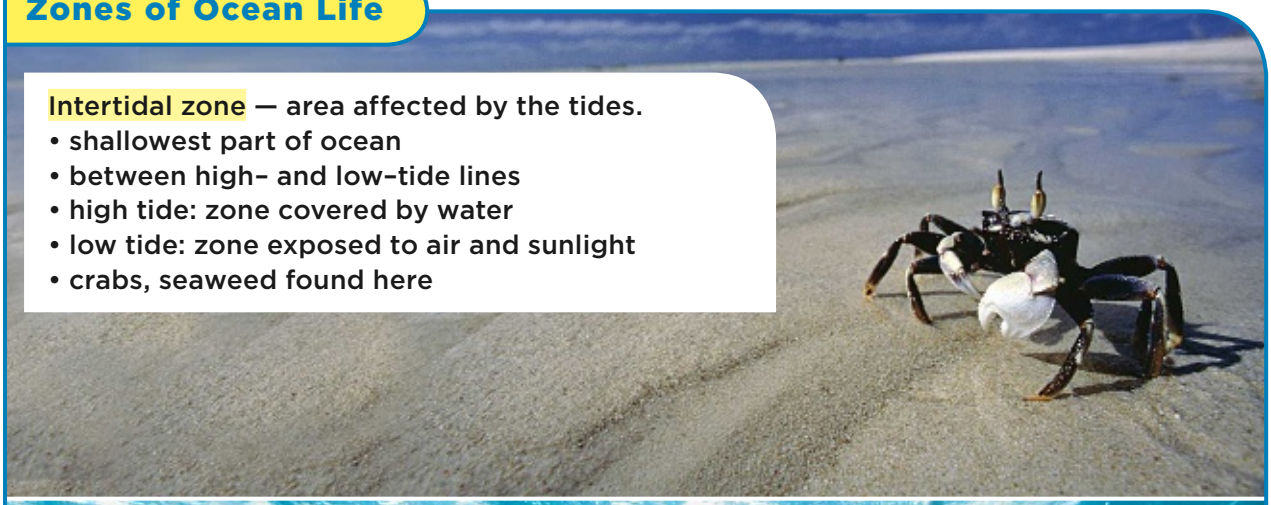
13. Some of the conditions that affect ocean organisms are

_____, _____,

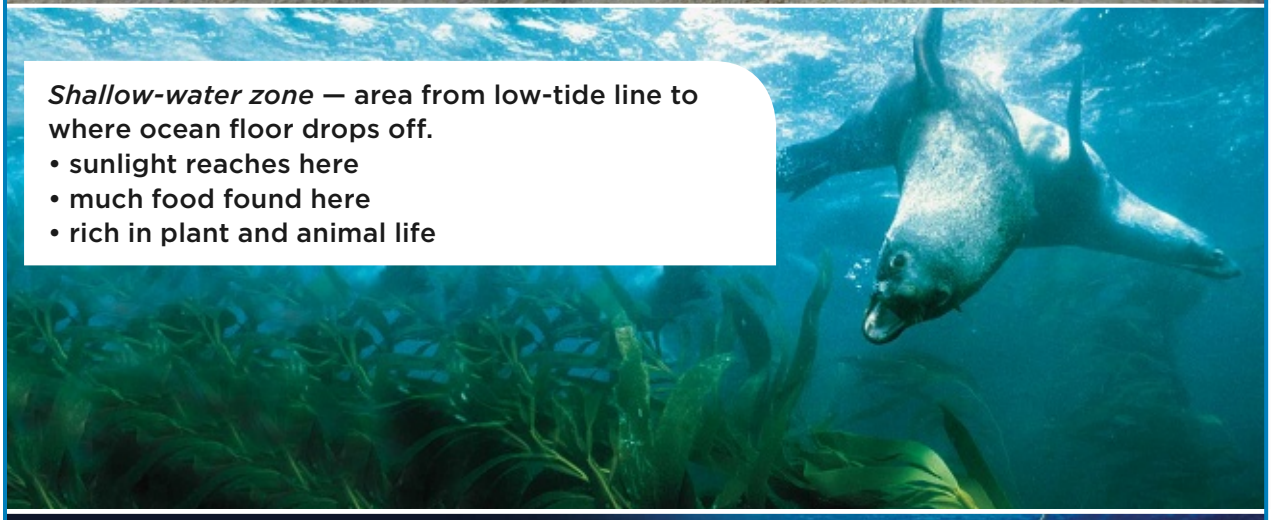
_____, _____, and

_____.

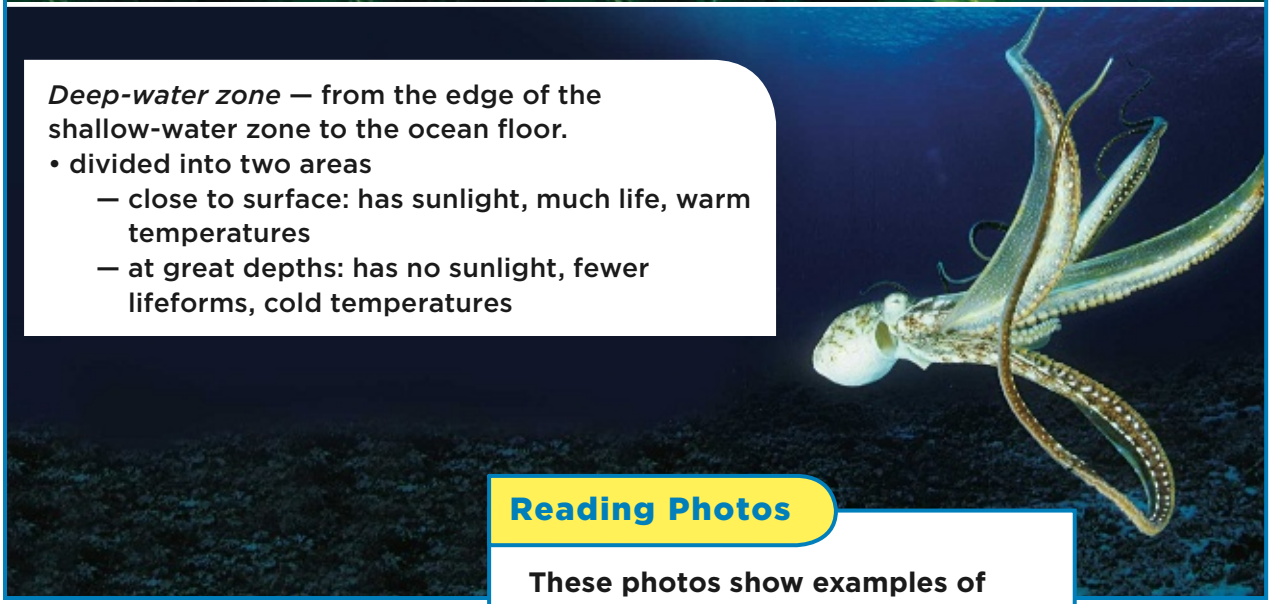
Zones of Ocean Life



Intertidal zone — area affected by the tides.
- shallowest part of ocean
- between high– and low–tide lines
- high tide: zone covered by water
- low tide: zone exposed to air and sunlight
- crabs, seaweed found here



Shallow-water zone — area from low-tide line to where ocean floor drops off.
- sunlight reaches here
- much food found here
- rich in plant and animal life



Deep-water zone — from the edge of the shallow-water zone to the ocean floor.
- divided into two areas
  - — close to surface: has sunlight, much life, warm temperatures
  - — at great depths: has no sunlight, fewer lifeforms, cold temperatures

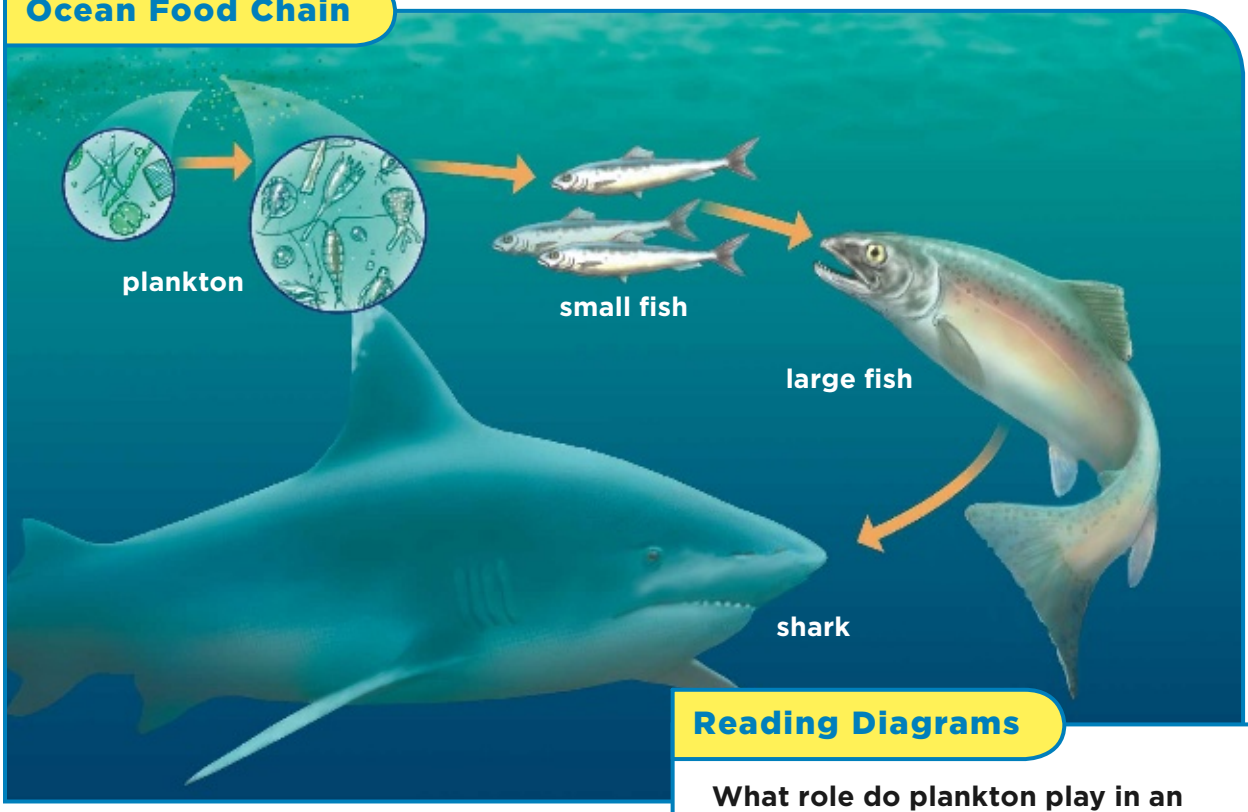
Reading Photos

These photos show examples of organisms that live in the zones of ocean life.

What are ocean food chains like?

The oceans have many food chains. They have producers, consumers, and decomposers. The producers are the plantlike plankton. They use the Sun to make food. The consumers eat the plankton and other animals. Ocean food chains may be short or long.

Ocean Food Chain



Reading Diagrams

What role do plankton play in an ocean food chain?

LOG ON *Science in Motion* Watch an ocean food chain@ **www.macmillanmh.com**

Quick Check

14. In the Ocean Food Chain diagram, identify the producers and consumers, including the level of consumer. _____

_____

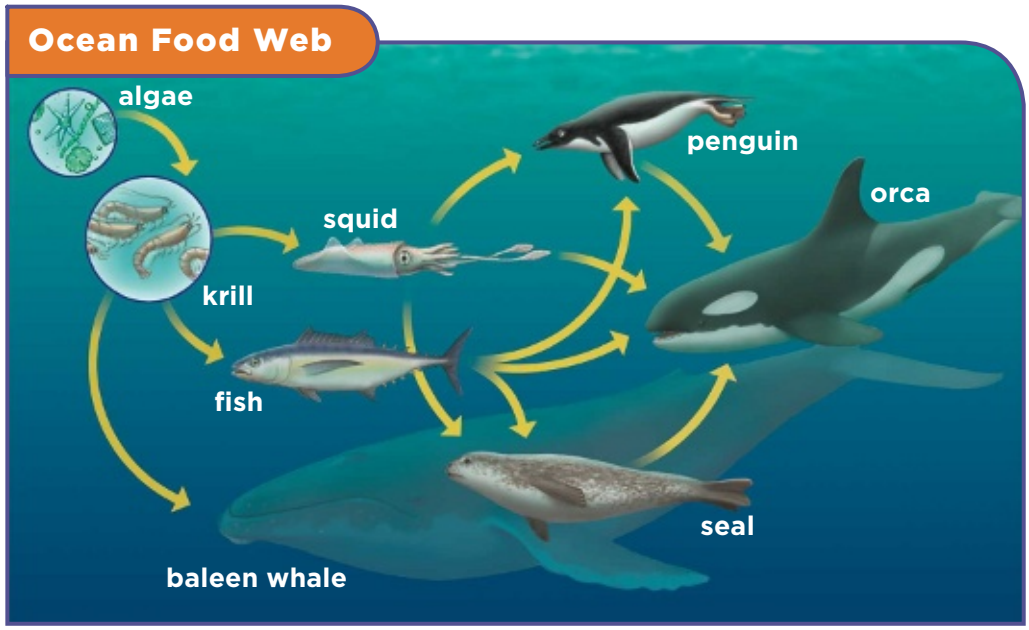
_____

_____

Ocean Organisms

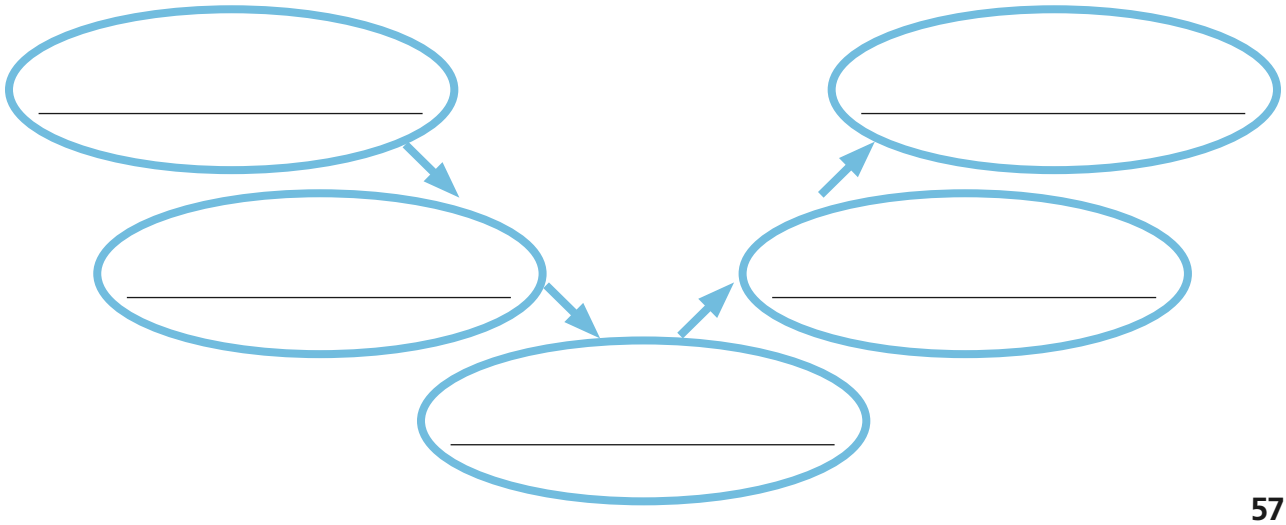
Ocean organisms are grouped according to where they live.

- **Plankton**
  - float near surface of ocean
- **Swimmers**
  - swim through the water
  - most fish
  - can be predators or prey
- **Bottom dwellers**
  - live on or near ocean floor
  - some seaweed and kelp
  - some, such as tube worms, use a chemical process to get energy from their surroundings



Quick Check

15. Give one example of a food chain within the food web shown.



What are freshwater ecosystems?

Freshwater ecosystems occur in or near bodies of water with little salt. These bodies of water include:

- **Still waters:** lakes, ponds
  - may be covered by algae
  - contains water plants (cattails, reeds) and many insects
- **Running water:** streams, rivers
  - no algae on surface
  - plants and animals have structures to avoid being swept away (roots, streamlined bodies)
- **Wetlands**: areas where water is almost always near the surface.
  - rest stop for traveling birds
  - nursery for many birds and fish

young river otter in a freshwater ecosystem

Quick Check

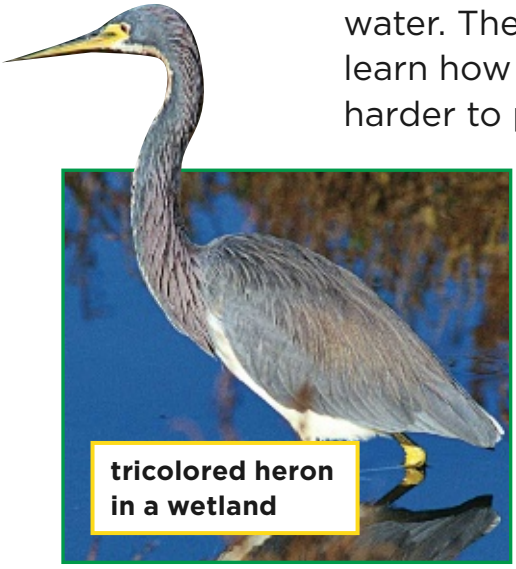
16. The three basic types of freshwater ecosystems are

_____, _____, and

_____.

Wetlands and Estuaries

In California, most wetlands are salt marshes. They help keep the shore from washing away. Wetlands help remove harmful substances from the water. They also protect against floods. As people learn how important wetlands are, they are trying harder to protect them.



tricolored heron in a wetland

An **estuary** is found where the fresh water of a river or a bay meets the sea. An estuary is affected by the tides. The water is not as salty as the ocean, but saltier than fresh water of a river. Many plants and animals live there due to the food carried in by rivers.

estuary, Russian River, California

Quick Check

17. How is an estuary like a wetland? _____

_____

_____

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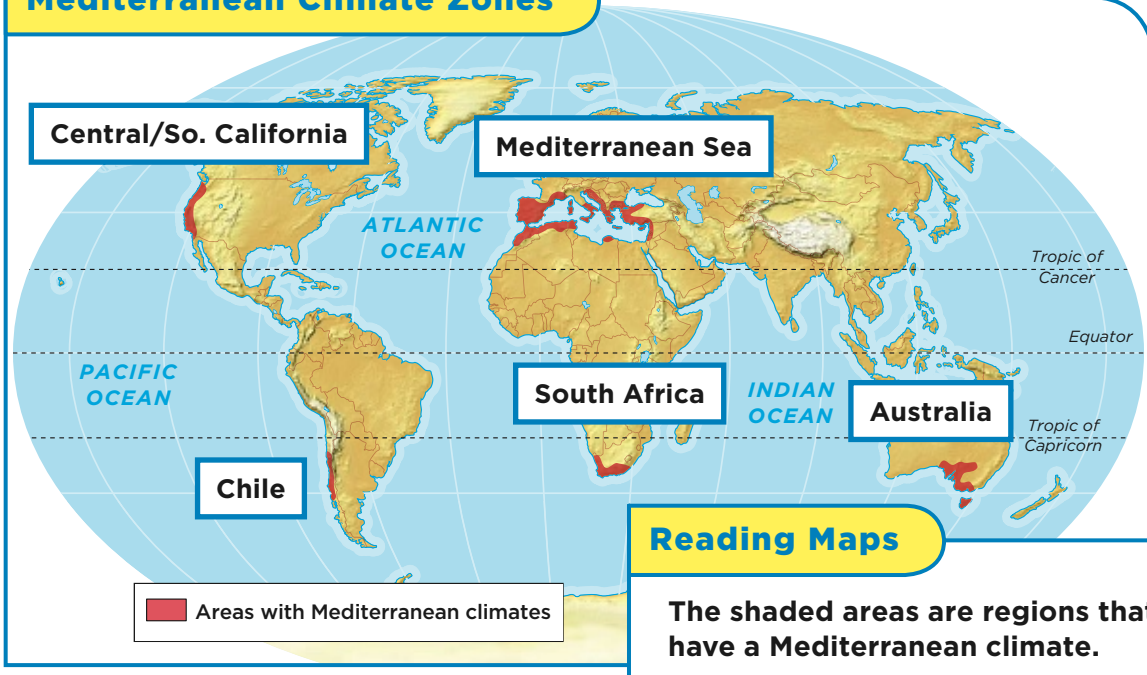
What Is a Mediterranean climate?

California has many different ecosystems. They are home to many native plants and animals.

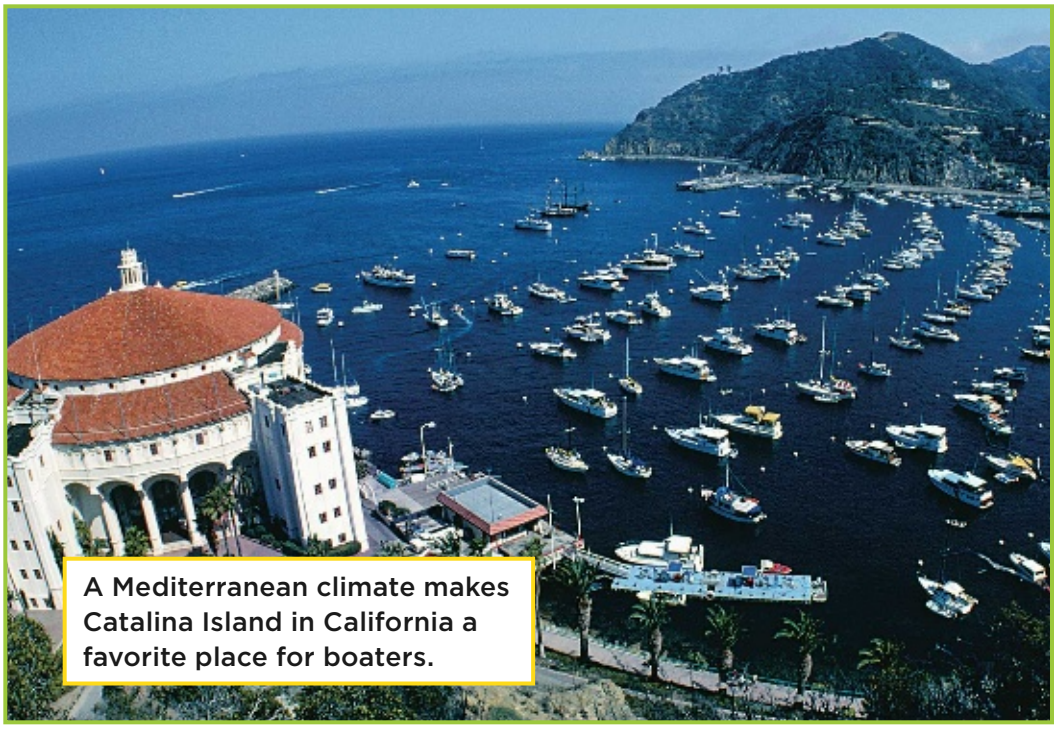
The climate along the coast of North America around Central and South California has a special name. It is a Mediterranean climate. It is named after the area around the Mediterranean Sea between Europe and Africa. Mediterranean climates are found about halfway between the equator and the poles.

Mediterranean Climate Zones



Reading Maps

The shaded areas are regions that have a Mediterranean climate.



A Mediterranean climate makes Catalina Island in California a favorite place for boaters.

Features of Mediterranean Climates

Mediterranean climates are often found along the west coasts of continents. Land near a coast heats up. The air above it warms and rises. Cool ocean air flows in, replacing the warm air. As a result, the temperature does not change much.

Areas with Mediterranean climates grow crops such as grapes and citrus fruits. California is famous for these crops.

To live in these areas, plants have changed, or adapted. Plants have thick bark to protect from fire, deep roots, or rest during summer.

Wildfires often occur. But the fires remove old growth and help new plants to grow.

Quick Check

18. What are the characteristics of a Mediterranean climate? _____

_____

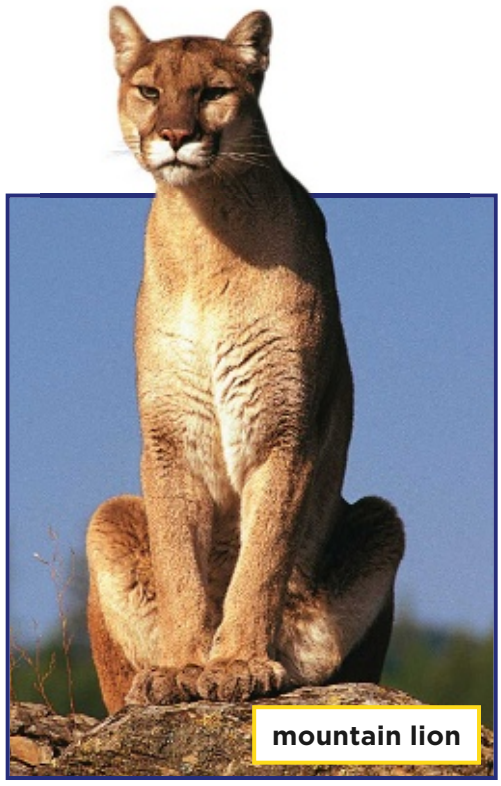
_____

What is a chaparral?

Along California's southern mountains and the California coast is the **chaparral** (shap•uh•RAL), a dry region with thick brush and small trees.

The plants in a chaparral have large thick or needlelike leaves. Roots spread out just below the soil surface. Animals such as jackrabbits and quail live here. Mountain lions and hawks are predators.

At summer's end, hot Santa Ana winds blow across the chaparral. The dry conditions can result in wildfires. Wildfires can burn large areas in a short time.



mountain lion

A food chain in a chaparral may begin with native grasses and end with a mountain lion.

Quick Check

19. Plants have adapted to the chaparral by having _____

_____, and _____.

Where are California's forests found?

Along the northern California coast are redwoods, giant evergreens that tower overhead. Away from the sea live giant sequoias. They are not as tall as the coast redwoods. But their trunks are much larger.

Some forests have grown undisturbed for centuries. These are *old-growth* forests. Here, trees can get wider than a person's reach. In these forests live the northern spotted owl. It has adapted to these forests and cannot live elsewhere.

Redwood National Park, California

Quick Check

20. List two types of California evergreens and indicate where they grow.

What are California's deserts like?

California has two deserts. The Mojave Desert is in the southeastern part of the state. The Colorado Desert is south of the Mojave Desert.

The Mojave Desert has very hot dry days and cool nights during the summer. In winter, temperatures can be freezing and rain or snow can fall. Death Valley, the lowest point in the U.S., is in the Mojave.

The Colorado Desert is the warmest desert in the U.S. Summers are hot and dry. Winters are cool and moist. Much of the Colorado Desert is used in farming, especially cotton.

Anza-Borrego Desert State Park, part of the Colorado Desert, in California

Quick Check

21. Indicate which California desert is being referred to in each case:

a. warmest desert in U.S. _____

b. Death Valley _____

c. used in farming _____

How Lifeforms Adapt

The dry conditions of each desert has made desert plants adapt in special ways. The creosote bush in the Colorado Desert has small, waxy leaves. They reduce water loss to transpiration. In the Mojave Desert, the Joshua tree lives. This tree has raised branches and bunches of needlelike leaves.

When it rains in the spring, both deserts bloom with thousands of beautiful flowers.

Animals also thrive in both deserts. Bighorn sheep, coyotes, hawks, roadrunners, and tortoises are just a few of the many animals that live there.

A black-throated sparrow perches on a cardon cactus.

▲ When desert tortoises leave their burrows, other animals use them. Desert tortoises are keystone animals because other animals depend on them.

Quick Check

22. Why do you think the desert tortoise lives in a burrow? _____

_____

_____

Deer eat the leaves of poison oak, and birds spread its seeds, but you should not touch it.

What are California's producers?

California has more than 5000 different kinds of plants. They have adapted to the various climates that California has. California's producers include:

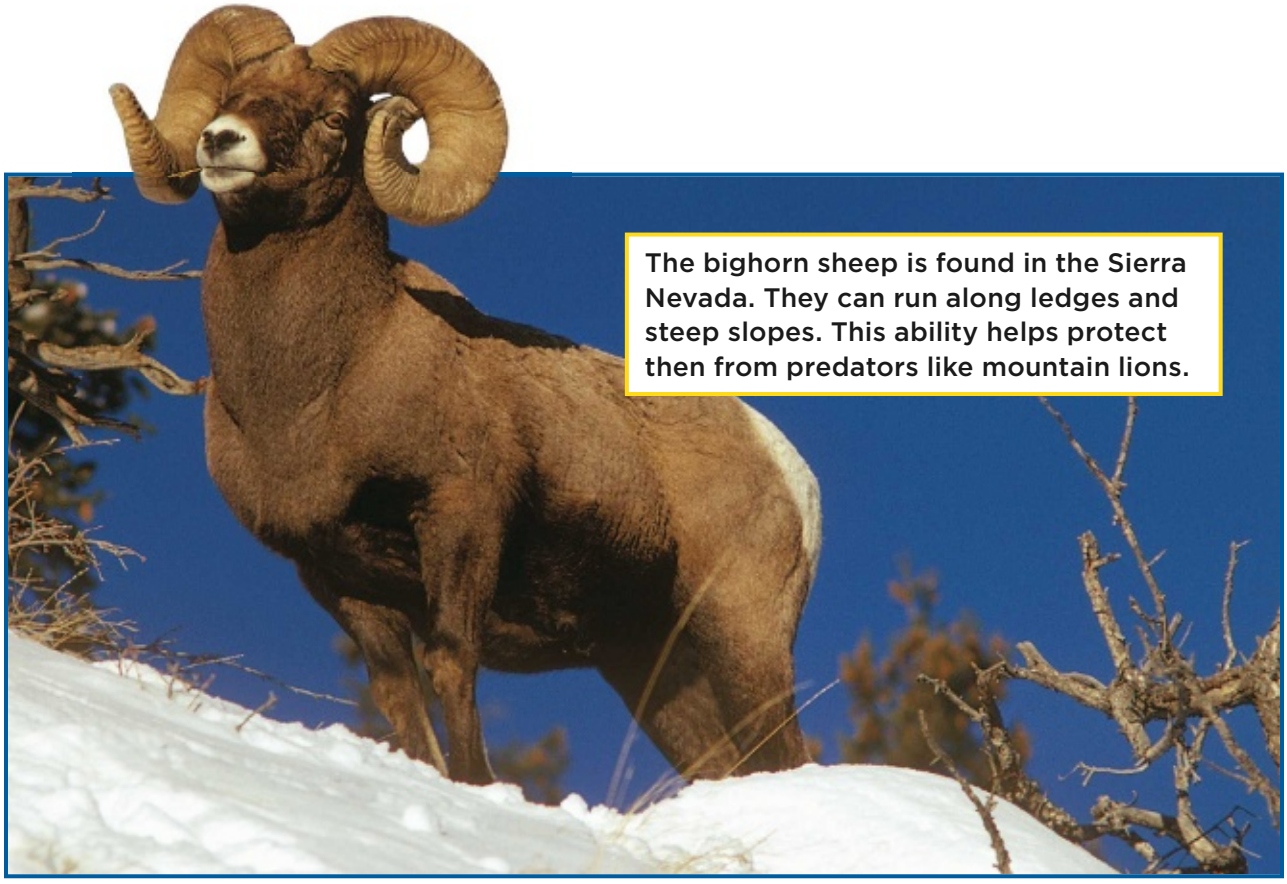
- redwoods
- sequoias
- Joshua trees
- reed grass
- California poppy

Some areas of California have the rock known as *serpentine* in the soil. When this rock breaks down, it releases substances harmful to many plants. Only plants that can tolerate serpentine can live here.

What are California's consumers?

California has a great number of animals. Kangaroo rats, foxes, and snakes are just a few.

California also has over 9000 types of insects. Some are found only in California, such as the Kelso Dunes Jerusalem cricket. The Thorne's hairstreak butterfly and the Hermes copper butterfly are found only in San Diego County and in Baja California.



The bighorn sheep is found in the Sierra Nevada. They can run along ledges and steep slopes. This ability helps protect then from predators like mountain lions.

Quick Check

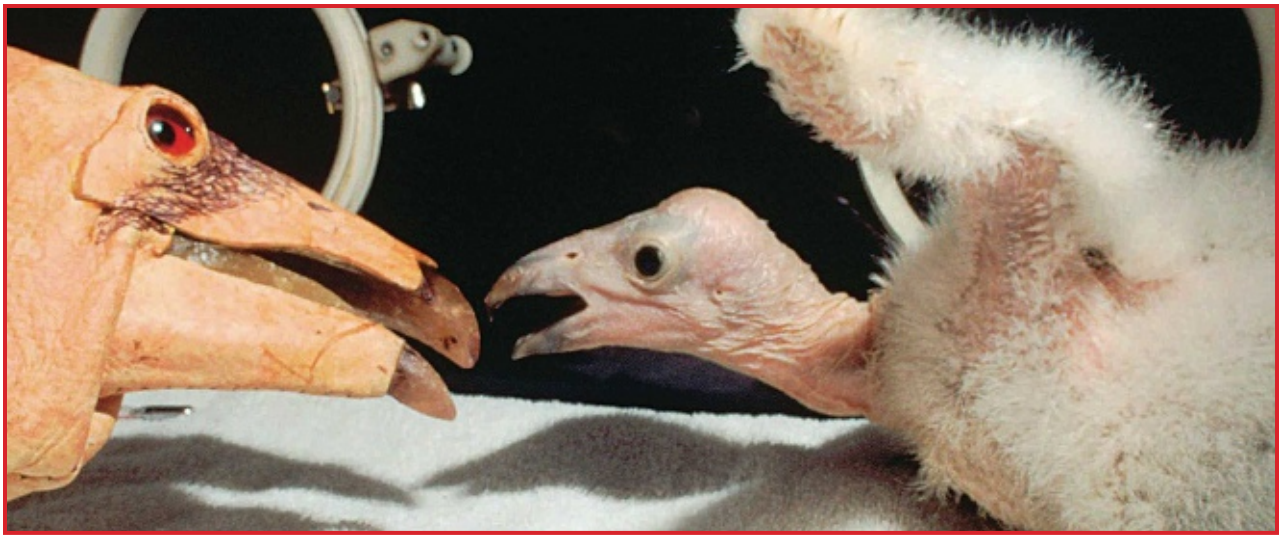
23. How is the bighorn sheep able to protect itself against predators?

What are California's most endangered animals?

The California condor is one of California's endangered animals. It is a scavenger. At one time it was on the brink of extinction. However, humans have been able to increase the number of condors born.

The San Joaquin's Kit Fox is found only in California. However, people moving into its habitat have reduced the number of these foxes.

▲ The San Joaquin kit fox hunts mostly at night. Its large ears enable it to listen for its prey.



▲ The eggs of the California condor are collected and placed in incubators. Then the condor chicks are fed by people who use a condor "puppet." Scientists never let the chicks see the people who feed them. In time the young condors will find their own food.

Quick Check

24. How have humans been able to increase the number of California condors? _____

_____

Why are nonnative plants and animals a problem?

Nonnative plants and animals are a major concern. Most of these organisms were brought here by accident. As a result, many of these organisms have nothing to stop their spread. They have no predators. They can also outcompete native plants and animals for food. Scientists need to study how these nonnative plants and animals can affect the native population.

▲ The yellow starthistle covers about 12 million acres in California. The plant is poisonous to horses. Most grazing animals, however, will not eat it because of its spines.

▲ These wild pigs were released into the wild in California. Because these animals will eat almost anything, they outcompete animals that eat a more limited diet.

Quick Check

25. Two reasons why nonnative plants and animals are dangerous are

_____, and _____.

Vocabulary Review

Earth's Land and Water

Choose the letter of the best answer.

1. A large area of land with certain kinds of living things is a(n)

a. biome
b. intertidal zone
c. wetland
d. estuary

2. Fresh water meets the sea in a(n)

a. taiga
b. chaparral
c. intertidal zone
d. estuary

3. Areas where water is almost always near the surface are

a. deciduous
b. wetlands
c. tundras
d. estuaries

4. A very cold, dry biome is a(n)

a. taiga
b. tundra
c. estuary
d. chaparral

5. Intertidal zones are affected by

a. deciduous trees
b. deep ocean water
c. the tides
d. fresh water

6. Evergreen trees are found in the

a. tundra
b. taiga
c. intertidal zone
d. chaparral

7. The weather conditions of an area are called its

a. biome
b. climate
c. temperature
d. food chain

8. Trees that change colors during autumn are called

a. taigas
b. tundras
c. deciduous
d. chaparral

Fill in each blank with a letter.

1. A forest of evergreen trees is a(n) __ __ __ __ __
4 7

2. One of the two deserts in California is the __ __ __ __ __ __ __ __
6 3 5

3. A dry region with thick brush and small trees is a(n)

__ __ __ __ __ __ __ __ __
2 1

Now answer the riddle by putting the corresponding letter on the line above each number.

Riddle: What do you call a St. Bernard in the middle of August?

Answer:

__ __ __ __ __ __ __
1 2 3 4 5 6 7

CHAPTER 3

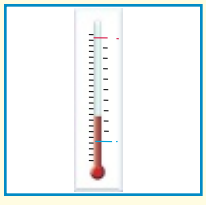
Heat Energy

Vocabulary

energy the ability to cause changes

kinetic energy the energy of a moving object

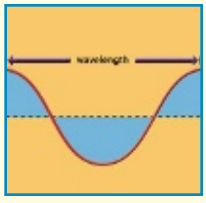
potential energy the energy in an object because of its height above the ground



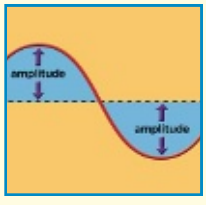
temperature the average kinetic energy of the molecules of an object

insulation material used to prevent heat from flowing between two substances

wave a way to carry energy from place to place

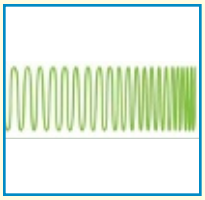


wavelength the distance from one crest to the next



amplitude the height of a wave above its rest level

The Big Idea: How does heat move from one object to another?



frequency the number of waves that pass any point in a second

sound wave a wave made when an object vibrates

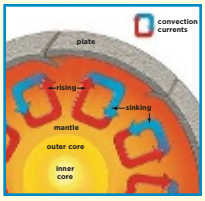
fossil fuel fuel that comes from the remains of plants and animals

work pushing or pulling to move an object through a distance

friction a force that acts when two surfaces rub against each other.

conduction the flow of energy by direct contact

convection the flow of energy through a fluid, a liquid, or a gas.

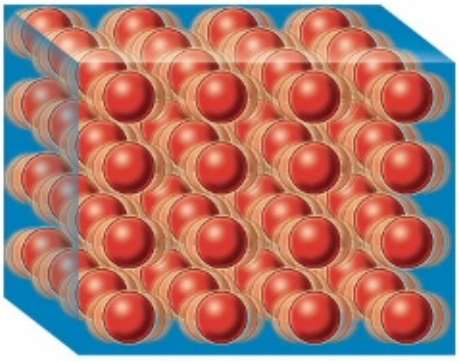


convection current circular movement of fluids

How is energy related to motion?

If you place an ice cube in the Sun, the ice soon melts. The ice molecules got something from the Sun. This something made the ice change from a solid to liquid water. The ice received energy. **Energy** is the ability to cause changes.

For example, the molecules that make up a solid are in back-and-forth motion because the object has energy. When you heat the solid, the molecules move faster because the solid is taking in energy. If enough energy is added, the solid will melt when the molecules begin to move past one another.



▲ Molecules in a solid have limited motion.

▲ This blacksmith uses the energy of the fire to change the shape of the iron.

Quick Check

1. Circle the examples that would need energy to do the action.

- melt chocolate
- sing a song
- wash dishes
- play baseball

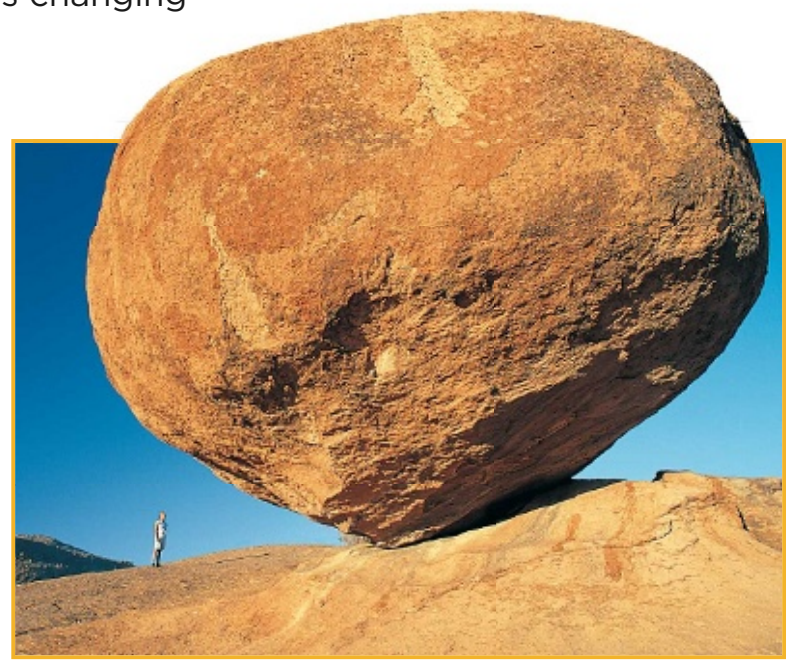
Two Kinds of Energy

Energy is classified according to motion. **Kinetic energy** (ki•NET•ik EN•uhr•jee) is the energy a moving object has. A skateboarder moving down a ramp has kinetic energy.

When the skater is at the top of the ramp, she has a different kind of energy. The energy in an object because of its height above the ground is called **potential energy**. Potential energy is stored energy.

Energy can change from one form to another. A rock at the top of a hill has potential energy as long as it is still. If it begins to tumble downhill—faster and faster—the potential energy is changing into kinetic energy.

The higher off the ground the girl is, the more potential energy she has.



Quick Check

2. What would happen to the boulder if its potential energy was changed into kinetic energy? _____

_____

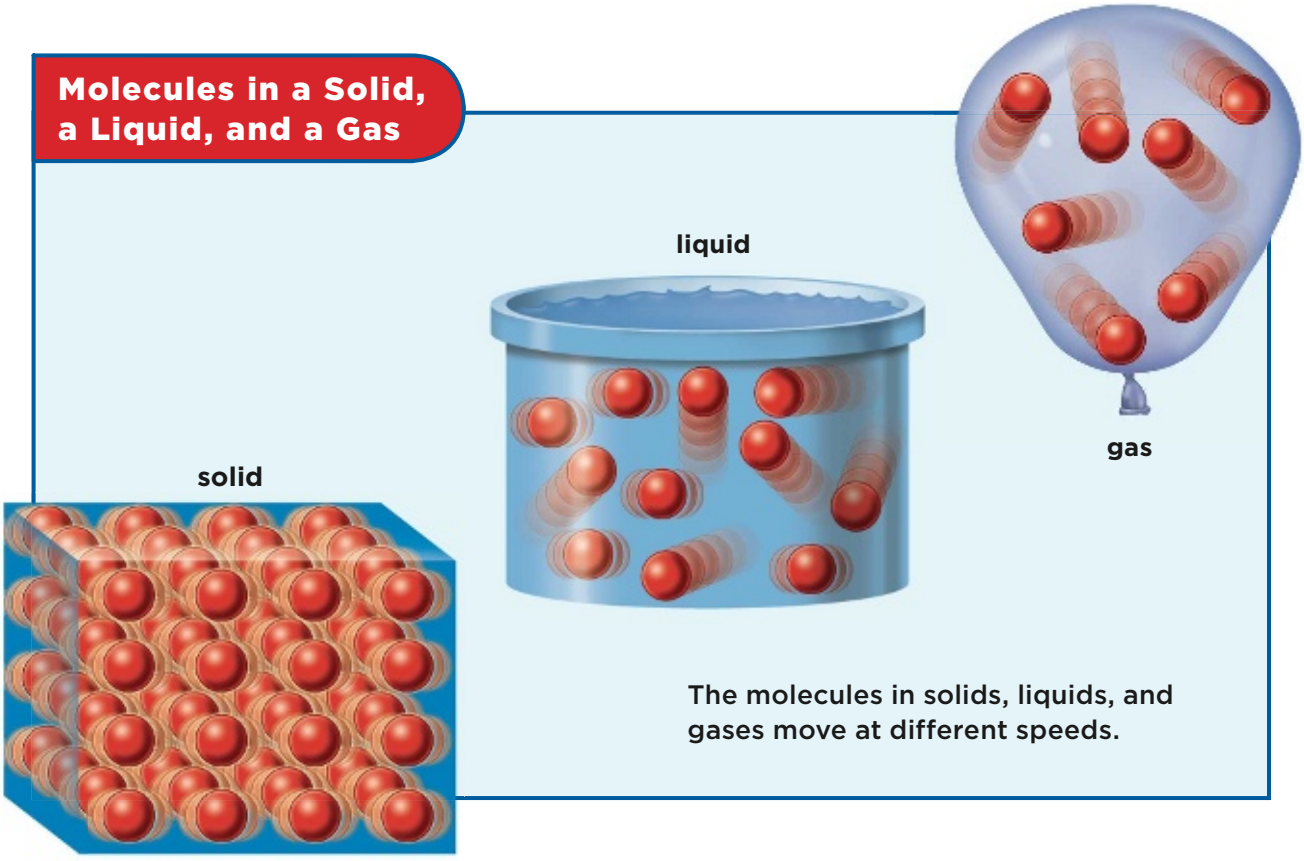
_____

How is temperature different from heat?

The **temperature** of an object is the average kinetic energy of its molecules.

Molecules in all things are always moving. Some molecules move faster than others. You cannot find the kinetic energy of millions of molecules one by one. So, scientists find an average kinetic energy, or temperature.

Molecules in a Solid, a Liquid, and a Gas



The molecules in solids, liquids, and gases move at different speeds.

Quick Check

3. Look at the art of the molecules. Which kind of molecules seems to be moving slowest? Which kind seems to be moving the fastest?

Heat Flow

Water is heated on the stove. Then the hot water is mixed with cocoa. Energy is transferred from the hot cocoa to the girl's hands—that is from a warmer object to a cooler one.

Heat Flow

If you hold a mug of hot cocoa, your hand becomes warm. Energy has moved from the cup to your hand. Energy is transferred from a warmer object to a cooler one. **Heat flow** is the transfer of energy from a warmer object to a cooler object.

When something is heated, its molecules move faster. Because they move faster, they have more kinetic energy. The temperature of the object goes up. As energy is transferred out of the warm object, its molecules gradually slow down. The temperature of the object goes down.

Quick Check

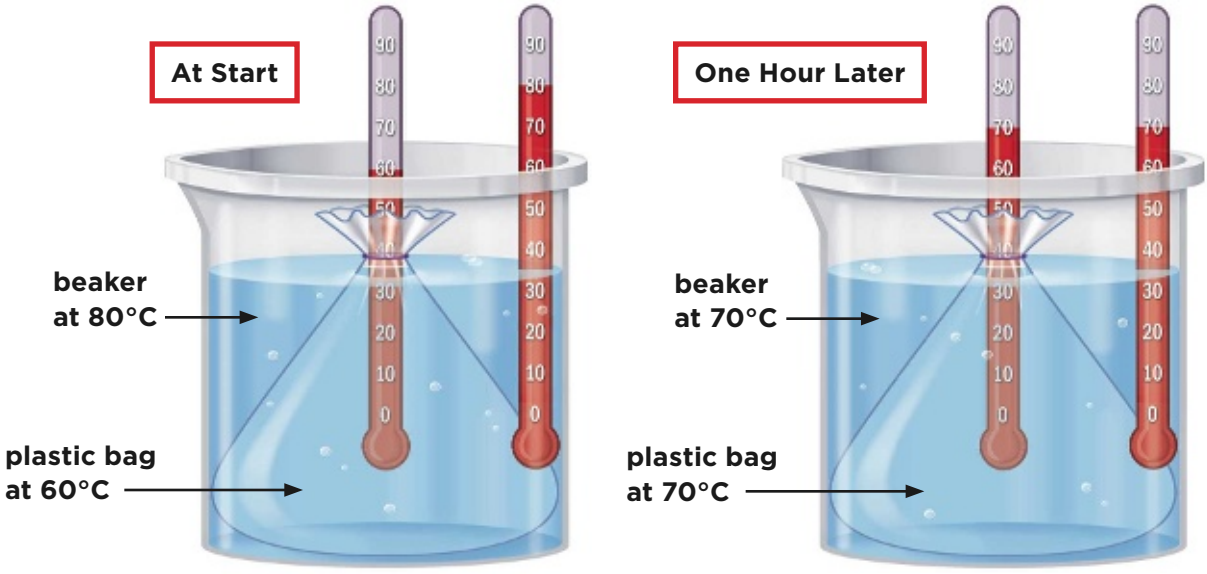
4. _____ is the average kinetic energy of a substance.

5. Energy is transferred from _____ objects to _____ objects.

Why does heat flow from one object to another?

Remember, heat flow is the movement of energy from a warmer object to a cooler object. Energy moves between objects because of differences in temperature. Suppose an ice cube is placed in a glass of warm water. The molecules in the warm water collide with the molecules in the ice cube. They give energy to the molecules in the ice cube. The molecules in the ice cube now move faster. Their temperature rises. The process continues until all the molecules are at the same temperature. That is why the plastic bag became warm when it was put into the beaker of warm water below.

Measuring Heat Flow



Reading Diagrams

The diagram shows heat flow between warm water and cooler water in the plastic bag (left).

Quick Check

6. What is a clue that energy is moving between two objects? _____

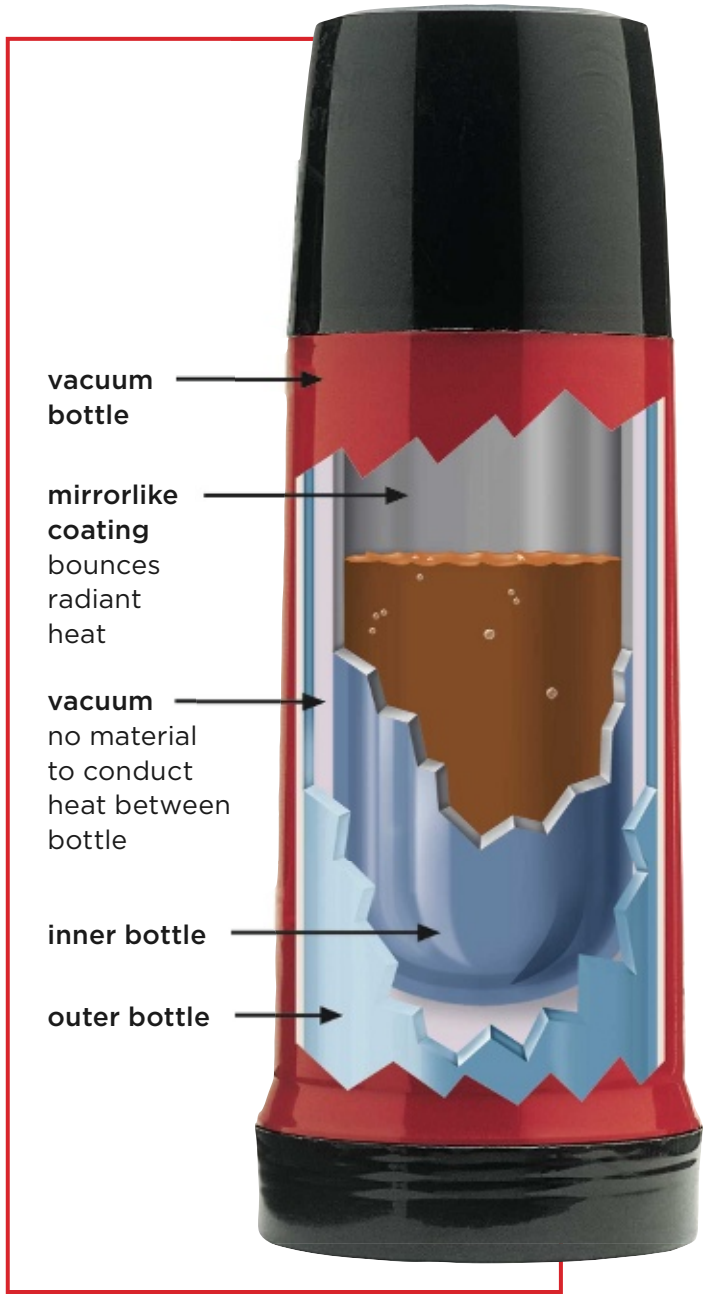
_____

What is insulation?

Conductors, such as metals, absorb heat and transfer it. They make a path for heat to flow. If you hold a metal spoon, it will be warm where you held it. The warmth will spread out through the spoon.

Insulators, like wood, absorb heat but do not transfer it. They do not allow heat to flow. If you hold a piece of wood, it will be warm where you held it. However, the warmth will not spread through the wood.

Insulation (IN•suh•lay•shuhn) is a material used to prevent heat flow between two materials. You *insulate* something by wrapping it or stuffing it with a material that is not a good conductor. For example, walls may be insulated. An insulated wall contains material that helps keep heat inside on a cold day.



▲ A vacuum bottle has no material to conduct heat between the inner and outer bottle. The vacuum insulates the inner bottle.

Quick Check

7. How do insulators differ from conductors?

_____

_____

_____

_____

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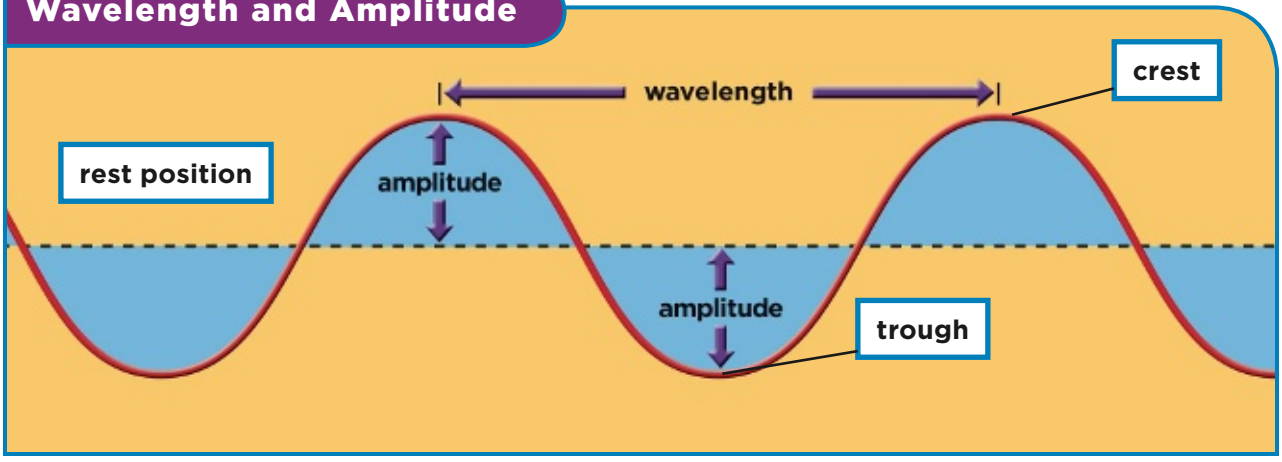
What is a wave?

A **wave** is a way that energy is carried from place to place. As a wave moves through water, the water moves up and down. However, the water itself does not move in the direction of the wave.

A wave can be described by its parts.

- *crest*—the highest point on a wave
- *trough*—the lowest point on a wave
- **wavelength**—the distance from one crest to the next crest
- **amplitude**—the distance from the crest to the rest position of the water

Wavelength and Amplitude



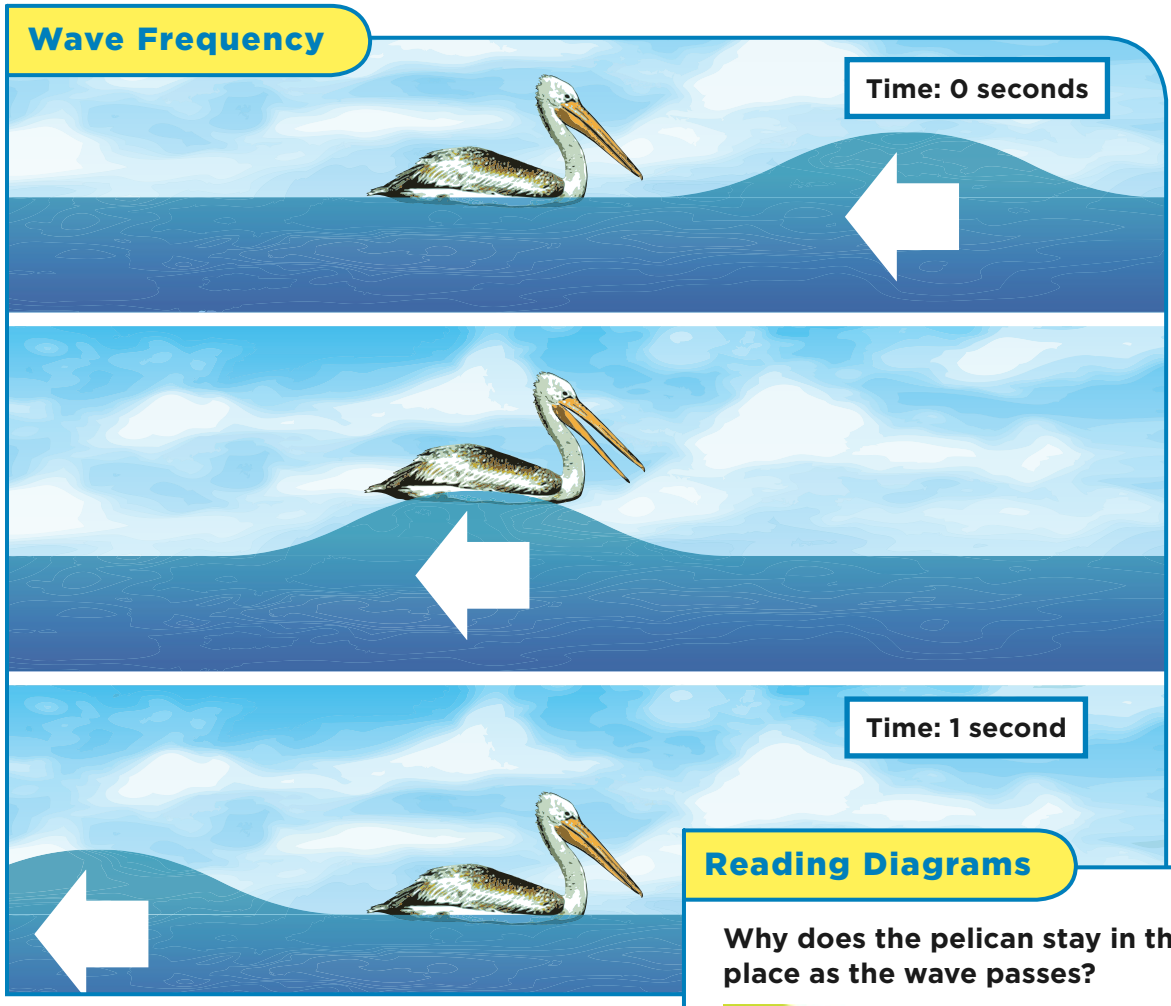
Quick Check

Match the description with the word in the first column.

8. ____ wavelength	**a.** how energy is carried from place to place
9. ____ crest	**b.** the highest point on a wave
10. ____ trough	**c.** the distance from crest to crest
11. ____ wave	**d.** the lowest point on a wave

Frequency

A wave can also be described by its frequency. **Frequency** is the number of waves that pass any point in a second. In the picture, one wave has passed the pelican in 1 second. The frequency of the wave is 1 wave per second.



Reading Diagrams

Why does the pelican stay in the same place as the wave passes?

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Quick Check

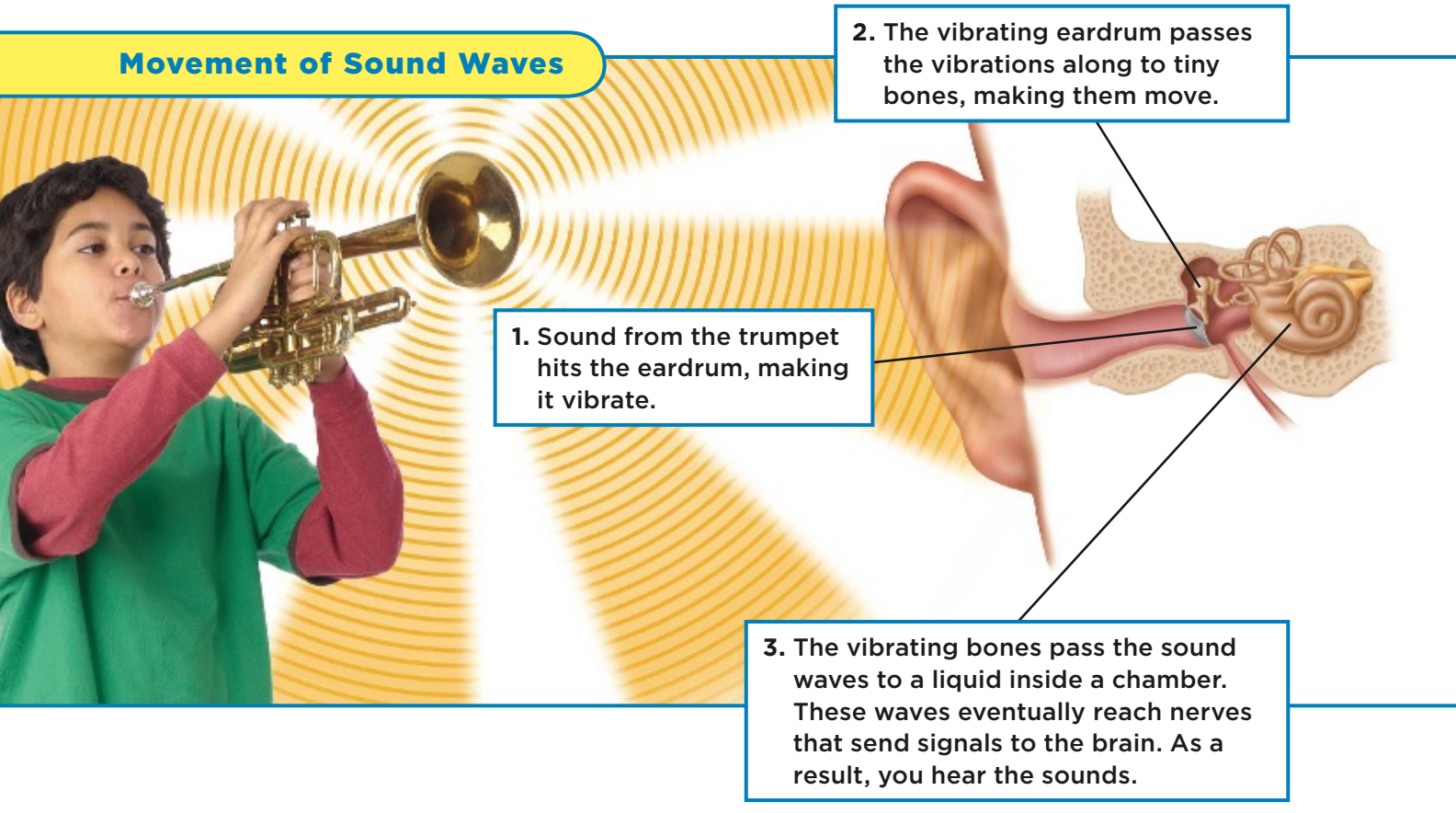
12. Suppose 4 waves pass the pelican in 1 second. What is the frequency of the waves? _____

13. If 6 waves pass the pelican in 2 seconds, what is the frequency of the waves? _____

What is sound?

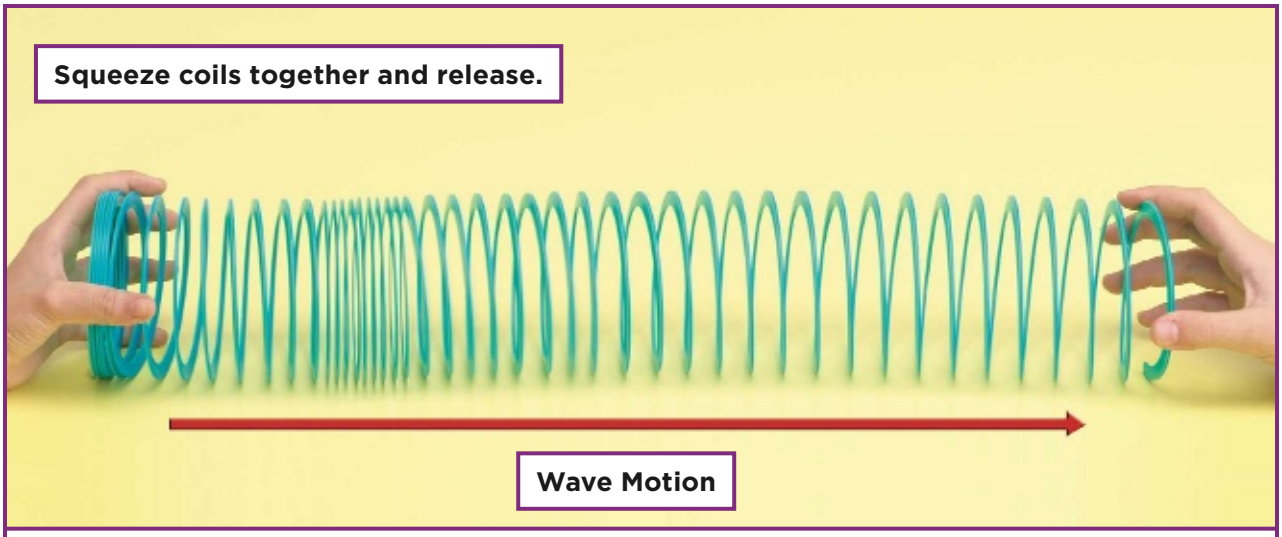
Water waves are one kind of wave. Sound is another kind of wave. A **sound wave** is made when an object vibrates, or moves back and forth. A drum makes sound when the drum head vibrates. Your voice is made when your vocal chords vibrate. Sounds are detected by your ears.

Pitch, the highness or lowness of a sound, is an important property. Pitch depends on frequency. The higher the frequency is, the higher the pitch. A high-pitched sound, like a tea-kettle whistle, has a higher frequency than a low-pitched sound, like a foghorn.



Quick Check

14. Sound is made when _____.



Sound waves travel through the air like the ripples of a coiled spring toy.

How do sound waves travel?

Sound waves travel through a series of compressions. A *compression* is a squeezing together of something.

To understand this, think of a coiled spring toy. Squeeze one end of the spring and then release it. A wave moves through the coils toward the other end. As it passes through each part of the toy, the wave pushes, or compresses, the coils. As the wave moves on, the coils pull apart.

Sound waves need molecules in order to travel. Without matter, nothing would compress and pull apart. The molecules conduct the sound away from the vibrating object that made the sound. In a sound wave, the wave and the molecules of matter in the wave move back and forth in the same direction as the wave.

Quick Check

15. What happens when you squeeze one end of a spring and then release it? _____

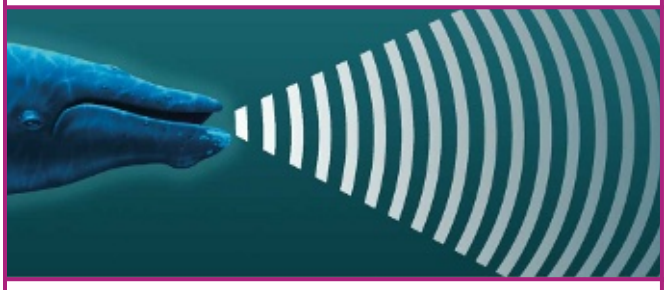
_____

What can sound waves move through?

Place a wind-up clock at one end of a table. Walk to the other end of the table. The ticking sound gets quieter. Now put your ear to the table. The sound is louder. Sound travels better through the table than through the air.

Sound travels through different materials. In fact, without a material, sound cannot travel. Sounds can move through solids, liquids, and gases. It moves fastest in solids, and slowest in gases.

Sound moves through air, but it does not travel very far. It also does not travel very fast.



Sound travels about 4 times faster through water than through air. Whales can communicate over long distances because of this fact.

In space there is nothing for sound to travel through. So sound cannot be heard in space.

Quick Check

16. Why does sound travel faster through a solid than a gas? _____

_____

_____

What are electromagnetic waves?

Are there waves other than waves made by water and sound? In fact, there is a whole range, or spectrum, of waves. Each kind of wave has its own special range of wavelengths and its own special uses. These waves are *electromagnetic* (ee•LEK•troh•mag•NET•ik). People often call them "light" or "rays."

Unlike sound, electromagnetic waves do not need matter to carry them. They can travel through empty space.

Other Kinds of Waves

Infrared light cannot be seen by humans. But photographic film that is sensitive to infrared can be used to take night pictures.

Visible light can be seen by humans. Visible light is actually made up of many colors. A prism separates visible light into its colors.

X rays cannot be seen by humans. X rays are used to show a person's bones.

Quick Check

17. Circle the kind of wave that does not belong with the others.

visible light ultraviolet light sound X rays

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What are fuels?

A fuel is a material that releases heat when it is burned. A fuel is a source of energy.

There are many kinds of fuels. One of the most important kinds is fossil fuels. A **fossil fuel** is a fuel that comes from the remains of plants and animals. Coal, oil, and natural gas are fossil fuels. The organisms that became these fuels lived millions of years ago. When they died, their remains were covered by layers of sand or mud. Over time, heat and pressure changed them into fuels.

▲ Fossil fuels contain energy from ancient plants and animals.

What are other sources of energy?

Fuels are an energy resource. Fuels are said to be *renewable* or *nonrenewable*.

Renewable resources can be replaced in a relatively short time. Nonrenewable resources cannot be replaced in a short time or at all.

Fuel	Type	How Obtained
Coal	Nonrenewable	Fossil fuel
Oil	Nonrenewable	Fossil fuel
Natural Gas	Nonrenewable	Fossil fuel and biomass
Biomass	Renewable	Corn, manure, animal fats, etc.
Wood	Renewable, if used carefully	Trees
Water	Renewable	Running rivers
Wind	Renewable	Moving air
Solar	Renewable	Sun

Quick Check

18. How are renewable and nonrenewable resources different?

_____

_____

_____

19. Circle the renewable resources in this list:

coal, oil, water, wind, natural gas

What happens when fuel burns?

Oxygen must be present for a fuel to burn. When it is heated, fuel combines with oxygen in the air. This combination, or reaction, of fuel and oxygen releases energy. You see the energy as heat and light.

Methane is one of the ingredients in natural gas. When methane burns, it produces a lot of energy.

Burning Methane Gas

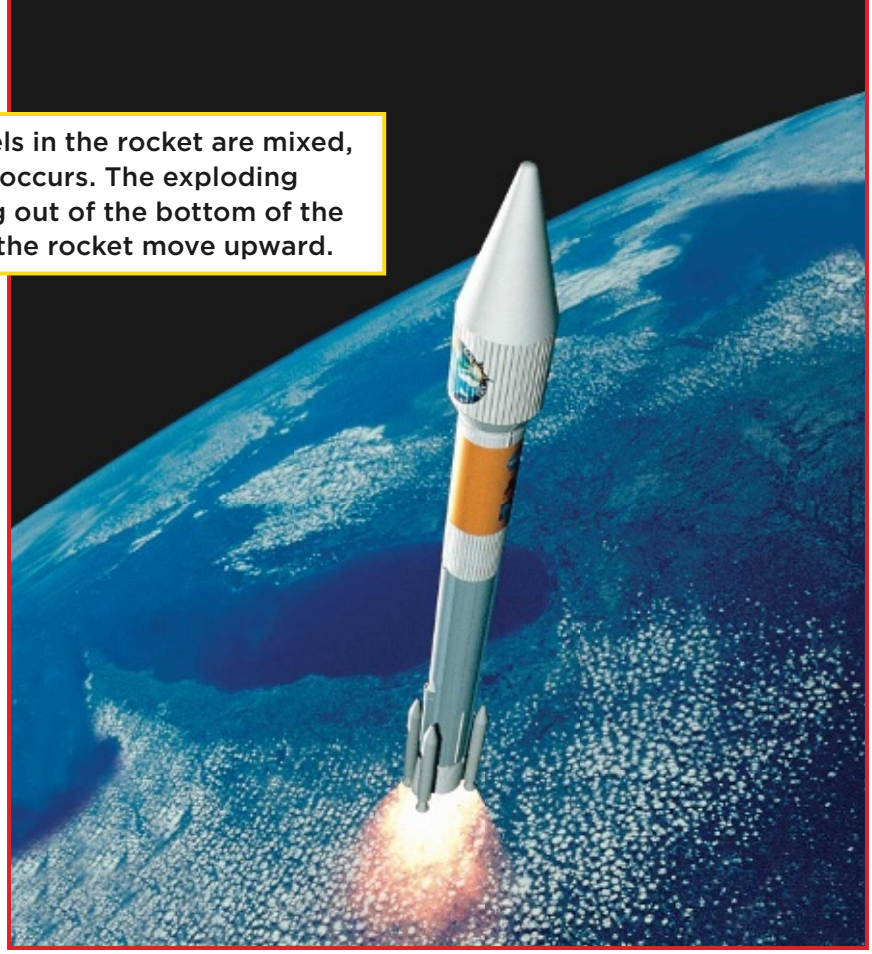
1. Methane is a gas made up of carbon and hydrogen.
2. Oxygen is needed for methane to burn. It comes from the air.
3. As the methane burns, the carbon in it combines with the oxygen. Carbon dioxide is made as a result.
4. The burning methane gives off a lot of heat and light. The heat is what cooks the meal.
5. The hydrogen in the methane combines with the oxygen. Water vapor is made as a result.

Reading Diagrams

The diagram describes the steps involved when methane is burned.

Quick Check

20. When methane is burned, _____ and _____ combine together. As a result, _____ and _____ are made. _____ and _____ are given off.



When the fuels in the rocket are mixed, an explosion occurs. The exploding gases moving out of the bottom of the rocket make the rocket move upward.

Fuel and Energy

Burning fuel is a way to change potential energy (in the fuel) into kinetic energy. Here are some examples. When fuel is burned, many different kinds of energy can be released:

- *heat* Coal and petroleum are especially good at this.
- *light* Candles and kerosene lamps can give off enough light to brighten a room.
- *sound* Exploding fireworks produce sound as well as brilliantly colored light.
- *kinetic energy* Burning fuels change potential energy in the fuel into kinetic energy of motion.

Quick Check

21. Four kinds of energy produced when fuels are burned are

_____, _____,

_____, and _____.

When a car's engine burns gasoline, gases are produced. The gases push down the pistons that turn the crankshaft. The wheels spin, and the car races around the track.

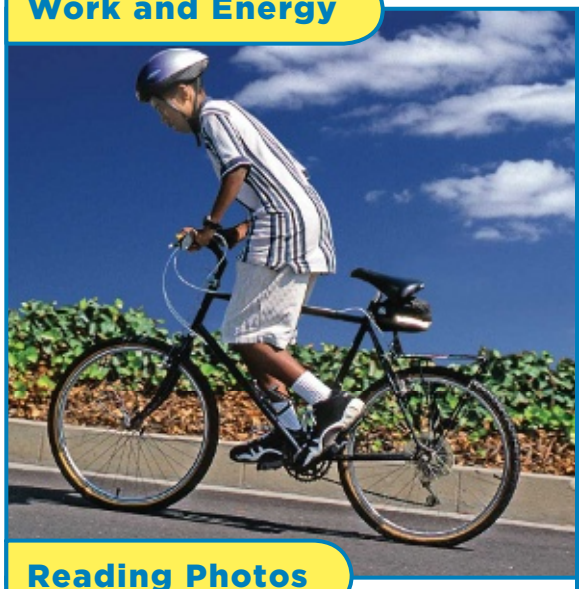
How can energy be used to do work?

People use energy to do work. **Work** is pushing or pulling to move an object through a distance. People do work when they move objects from one place to another. You do work when you:

- lift up a book
- use a screwdriver
- ride a bicycle

Burning fuel also can do work. For example, the burning fuel in a jet plane makes it move forward.

Work and Energy



Reading Photos

The photo shows how a boy can use the pedals and hand brakes to control the bicycle.

Quick Check

22. Is reading a book doing work? Explain your answer. _____

_____

_____

Friction: Nature's Brakes

To slow a car, you use **friction**, a force that acts when two surfaces rub against each other. When you step on the brake, you press the brakes against the wheel. The resulting friction slows the car.

Friction makes heat. Rub your hands together. What do you feel? The heat you feel is caused by friction.

Quick Check

23. An ice skater has to turn the skates in order to stop. Why can't the skater just press harder on the skates? _____

_____

_____

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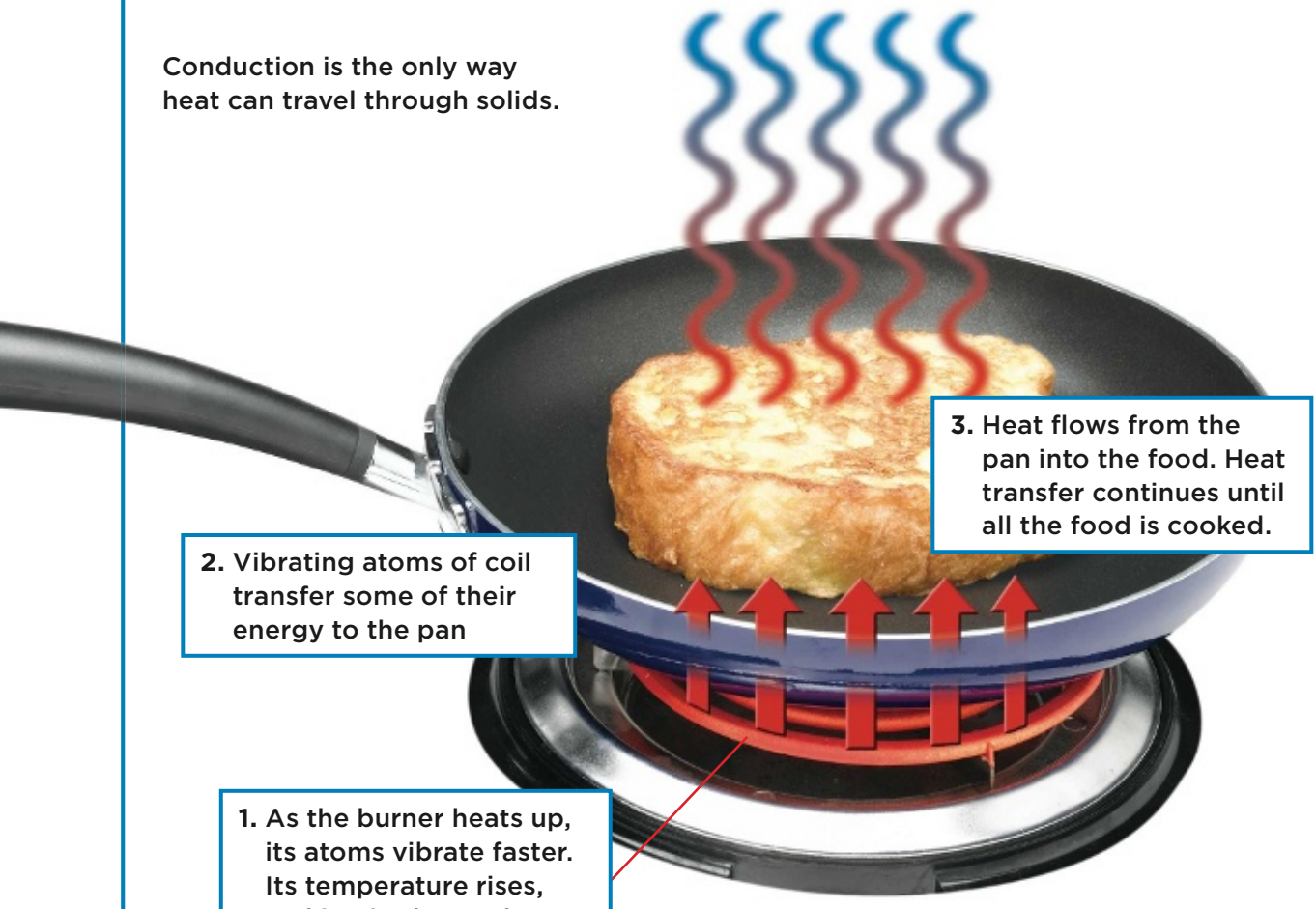
How is heat transferred?

Heat can be transferred in three ways. One way is by **conduction**, the flow of energy by direct contact. For conduction to occur, the objects must be touching.

Heating by Conduction

Conduction is the only way heat can travel through solids.



4. Heat from the top of the food is transferred to the air above the food.

3. Heat flows from the pan into the food. Heat transfer continues until all the food is cooked.

2. Vibrating atoms of coil transfer some of their energy to the pan

1. As the burner heats up, its atoms vibrate faster. Its temperature rises, making it glow red.

Reading Photos

This photo describes how food is cooked on an electric stove.

What is convection?

If you put your hand over the food in the pan, you would feel heat. But the hot pan is not touching the air. Can heat travel in other ways? Heat moves through fluids—liquids and gases—by **convection**.

Convection happens because fluids become less dense when heated. For example, as air heats up, its molecules spread out. The air gets less dense. The heated air rises. As the air rises, it cools. The water vapor condenses. It turns into a liquid—a cloud.

▲ **Heated air is less dense than cooled air. As a result, the heated air rises until molecules of water condense, making clouds.**

Quick Check

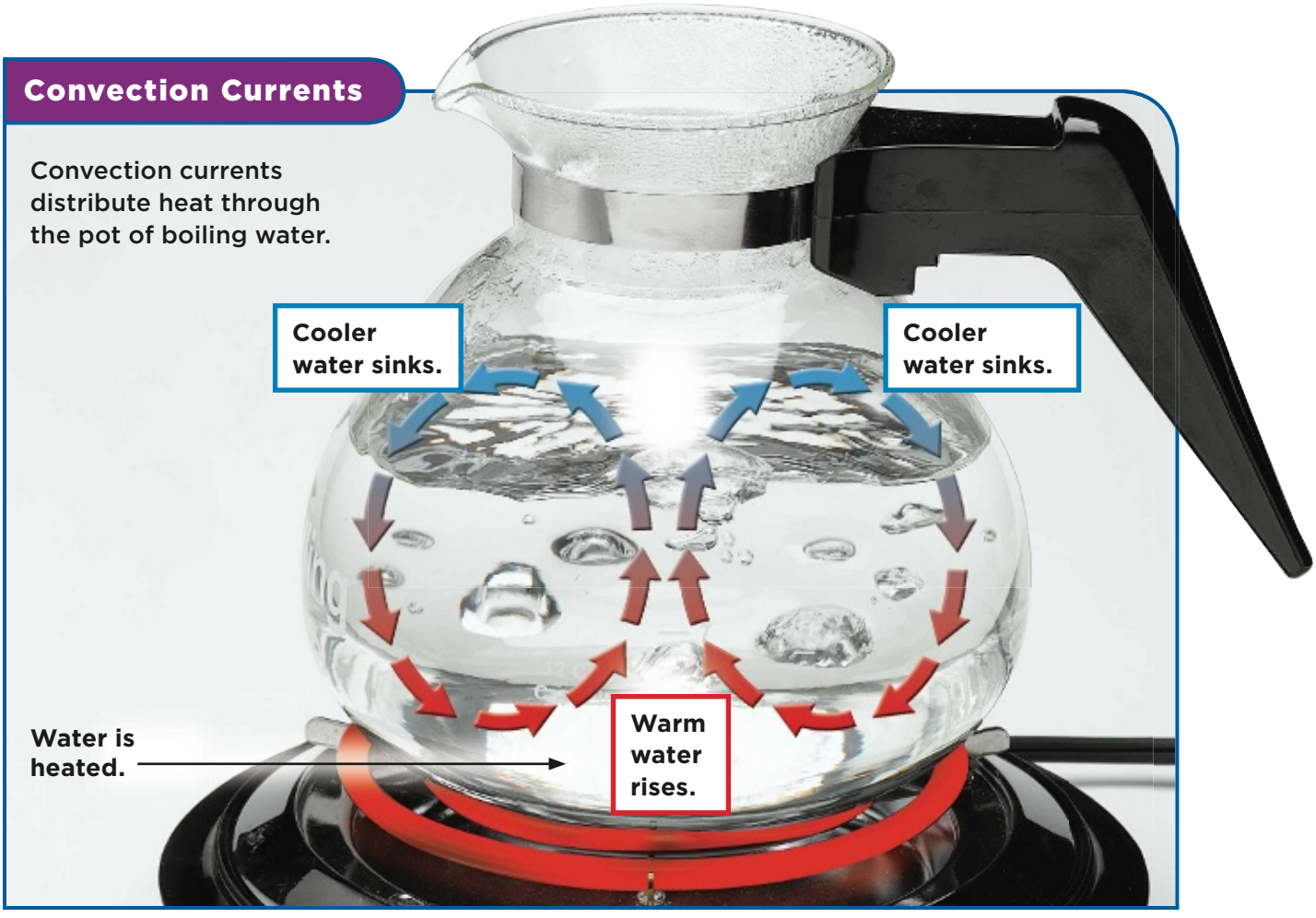
24. Compare conduction and convection. _____

_____

_____

What are convection currents?

As a hot fluid rises away from its heat source, it may cool. It will get denser and sink. When it reaches the heat source, it will be warmed again. The circular movement of fluids is called a **convection current**. This current helps warm the entire pot of water.



Quick Check

25. Why is it hotter near the ceiling than near the floor of a room? _____

_____

_____

Do some materials warm faster than others?

Sand on a beach warms up faster than the water. Some things warm up faster than others. They do because it takes less energy to warm them up.

The table below shows how much energy it takes to raise the temperature of different things one degree. It takes more energy to warm up liquid water one degree than anything else in the table. So water warms up slower than anything else in the table.

Material	Amount of energy (joules) to raise 1 gram by 1 degree
Air	1.004
Aluminum	0.897
Copper	0.385
Water (liquid)	4.181
Ice	2.114
Sand	0.835
Wood	0.42
Brick	0.84
Concrete	0.88

Quick Check

26. Which material in the table warms up the fastest? How can you tell? _____

_____

Heat Energy

Choose the letter of the best answer.

1. The energy in an object because of its height

a. kinetic **c.** heat

b. potential **d.** wave

2. The distance from one crest of a wave to the next is the wave's

a. amplitude

b. frequency

c. kinetic energy

d. wavelength

3. A thermos bottle is an example of

a. conduction **c.** fuel

b. insulation **d.** fossil

4. An athlete swinging a bat is

a. using kinetic energy

b. doing work

c. producing heat

d. all of the above

5. The ability to cause changes is called

a. matter **c.** heat flow

b. convection **d.** energy

6. Fossil fuels are sometimes called

a. renewable resources

b. stored sunlight

c. plants

d. released sunlight

7. Amplitude is a measure of a wave's

a. height **c.** frequency

b. length **d.** pitch

8. To keep heat inside, you might use

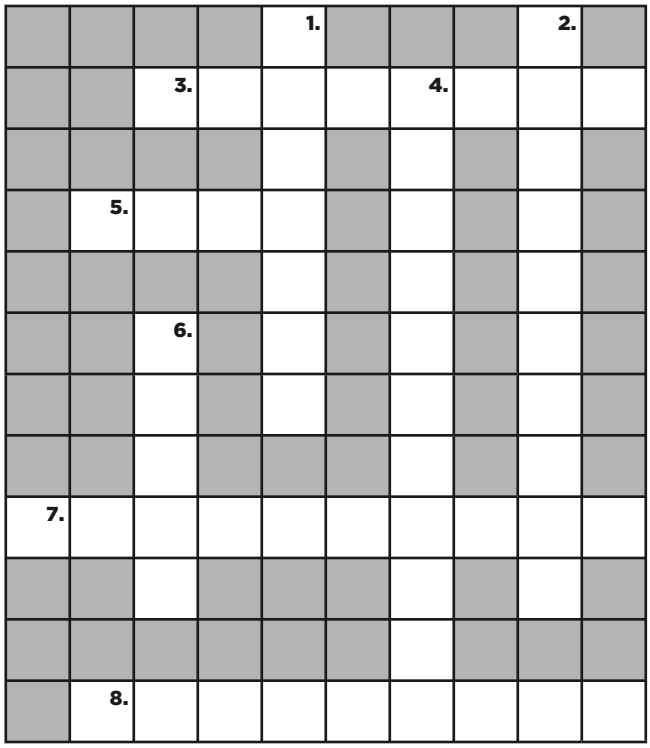
a. a conductor

b. a metal

c. insulation

d. heat flow

Read each clue. Write the answers in the blanks and then fill in the crossword puzzle.



Across

3. A force that acts when two surfaces rub against each other _____

5. A way to carry energy from place to place _____

7. The flow of energy through a fluid _____

8. The number of waves per second _____

Down

1. The energy of a moving object _____

2. The flow of energy by direct contact _____

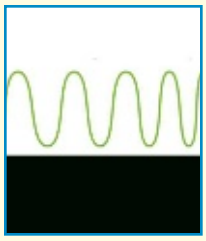
4. The average kinetic energy of an object _____

6. A wave made by a vibrating object _____

CHAPTER 4

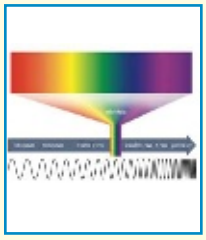
Energy in the Earth System

Vocabulary

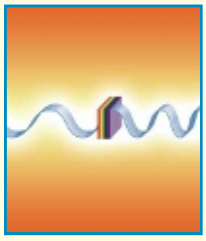


electromagnetic wave vibrating electric charges

light wave an electromagnetic wave you can see

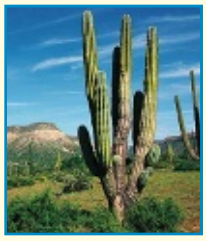


electromagnetic spectrum grouping of electromagnetic waves in order of wavelength



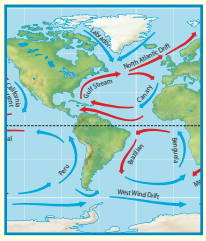
radiation the transfer of energy by electromagnetic waves

solar radiation light from the Sun that shines on Earth's surface



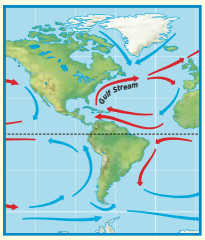
absorption taking in radiant energy

emission giving off radiant energy



ocean current a river of water in the ocean

How do radiation and convection currents affect phenomena on Earth?



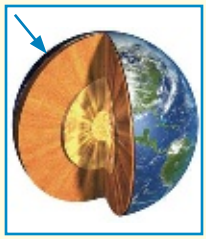
Gulf Stream a warm surface current flowing along the East Coast

California Current a cold surface current flowing along the West Coast

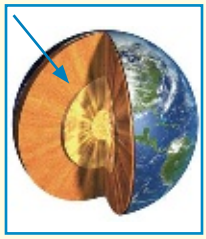
wind the horizontal flow of air

Santa Ana wind the warm, dry wind that blows out of the desert in Southern California

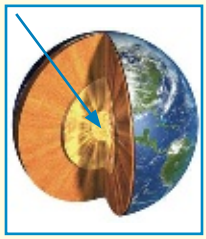
ENSO the way the Pacific Ocean and the air interact



crust the thin, solid, outermost layer of Earth



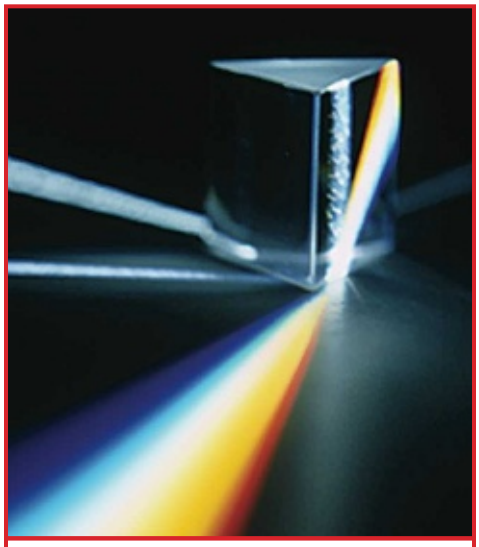
mantle the thick layer of rock below the crust



core the central part of Earth

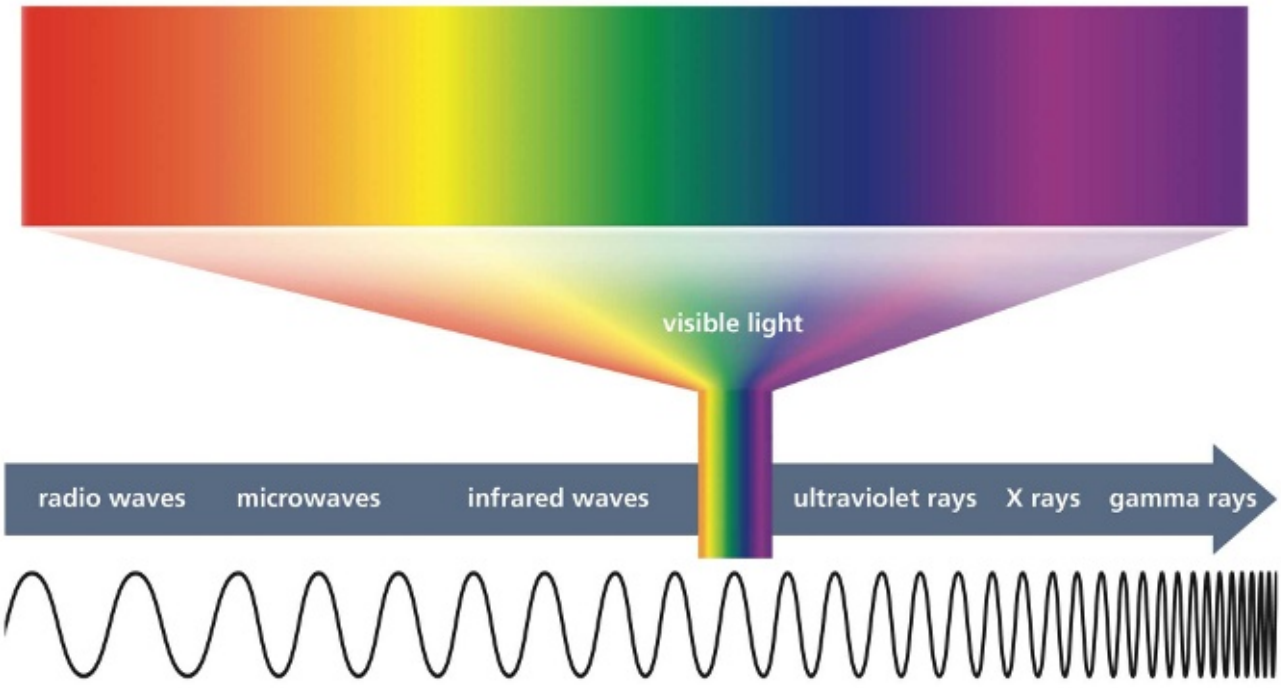
What is the electromagnetic spectrum?

The Sun's energy is carried to Earth by vibrating electric charges, or **electromagnetic waves**. These waves can have many wavelengths. **Light waves** for example, have wavelengths that you can see. The **electromagnetic spectrum** is the grouping of electromagnetic waves in order of wavelength.



Each wavelength of visible light is a color. When all the colors mix, white light results.

The Electromagnetic Spectrum



Reading Diagrams

This picture shows the waves that make up the electromagnetic spectrum.

Comparing Electromagnetic Waves

You can compare electromagnetic waves in many ways. The table shows some of these ways.

Kind of Wave	Wavelength	Amount of Energy	Examples
radio	longest	lowest	AM/FM radio TV
microwave			microwave ovens
infrared			heat infrared lamps at restaurants
visible			colors from red to violet
ultraviolet			tanning (UV) lamps
X rays			medicine dentistry
gamma rays	shortest	highest	gamma ray telescopes

Quick Check

1. Arrange electromagnetic waves from shortest wavelength to longest wavelength. Use the diagram below to help you.

First _____

Next _____

Last _____

▲ The International Space Station collects radiation from the Sun to make electricity.

How does electromagnetic radiation reach Earth?

Energy given off by the Sun is called *radiant energy.* Radiant energy travels about 150 million kilometers (93 million miles) from the Sun to reach Earth! There is no air or other matter between Earth's atmosphere and the Sun. What transfers the Sun's energy to Earth?

Radiant energy travels in the form of electromagnetic waves. Electromagnetic waves do not need matter to travel. They can travel through empty space. The transfer of energy by electromagnetic waves is called **radiation**.

Not just the Sun, but all objects give off electromagnetic waves of different wavelengths. The wavelengths depend on the object's temperature. The Sun's surface temperature is about 6,000°C (11,000°F). At this temperature, most **solar radiation**, energy from the Sun that shines on the Earth's surface, is made of visible and infrared wavelengths.

Absorption and Emission of Radiant Energy

An object will take in or give off radiant energy. Taking in of radiant energy is called **absorption**. Giving off of radiant energy is **emission**. A good absorber is also a good emitter. Once away from the source of radiation, the absorber will become an emitter.

Absorption	Emission
• dark objects absorb better than light objects.	• dark objects emit better than light objects
• dark objects heat up faster than light objects.	• dark objects cool off faster than light objects.

Absorption and Emission

Reading Photos

The photos show how an absorber of radiation (the desert floor) during the day can be an emitter at night.

Quick Check

2. Would you wear a yellow or a dark brown sweater on a chilly autumn day? Why? _____

_____

_____

What forms of radiation are useful?

Many kinds of electromagnetic radiation are useful. They are also safe if used properly.

Uses of Radiation

In a microwave oven, microwaves shake water molecules in food, causing friction, which heats the food.

Infrared light from the tuner activates a sensor in the TV, turning it on or off, or changing channels.

The DJ's voice is changed into radio waves, which travel to your receiver (radio) and are changed back into sound.

The film in the camera reacts to visible light, making an image.

Harmful Radiation

The more energy that radiation has, the greater the danger. Short-wavelength radiation, such as gamma rays, has the most energy. However, all radiation is harmful in large amounts. For example, an infrared heat lamp can burn you if used too long.

A special film in an X-ray machine reacts to the X rays, making an image of the teeth. The dentist studies the pictures to detect cavities.

▲ Scientists take care when working with gamma rays.

Quick Check

3. Why does the doctor taking a chest X ray of you leave the room?

Why don't you need to wear protection? _____

_____

_____

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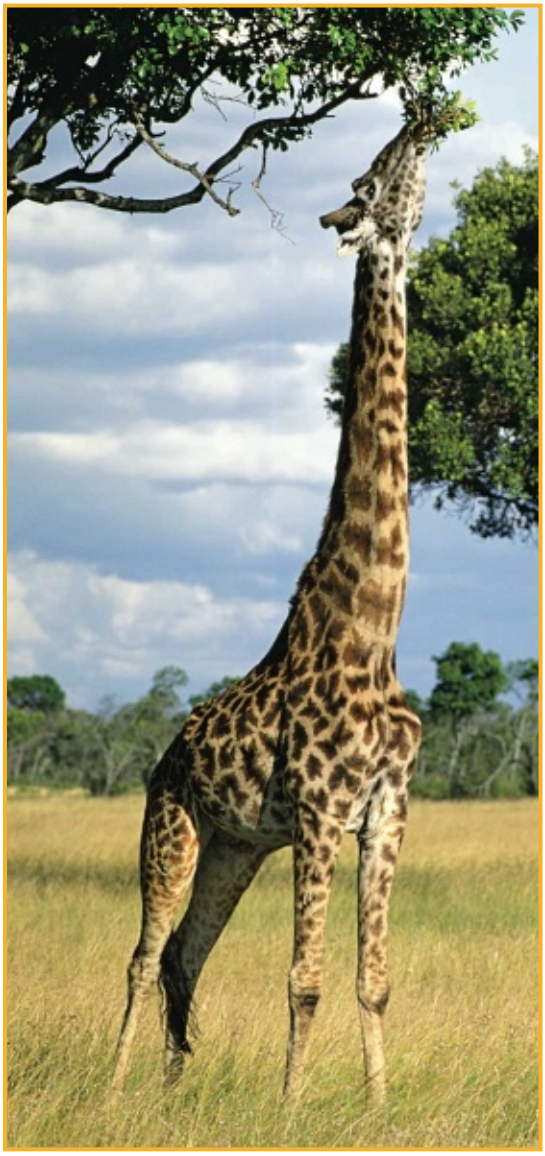


How is the Sun an important energy source?

Solar radiation is a very important energy source.

- Plants use it to make food.
- Fossil fuels were formed from lifeforms that contained stored energy from the sun.
- It helps cause winds and ocean currents.
- It influences weather.
- It drives the water cycle.

The Sun is the start of most typical food chains of Earth. Energy from the Sun is trapped by plants. Plants use the energy to make food by photosynthesis. The energy is stored in the food in the plant. Animals get the energy by eating plants or by eating animals that eat plants.

When animals, such as this giraffe, eat, they take in the Sun's energy trapped by plants.

Quick Check

4. How do animals get solar radiation by eating plants? _____

_____

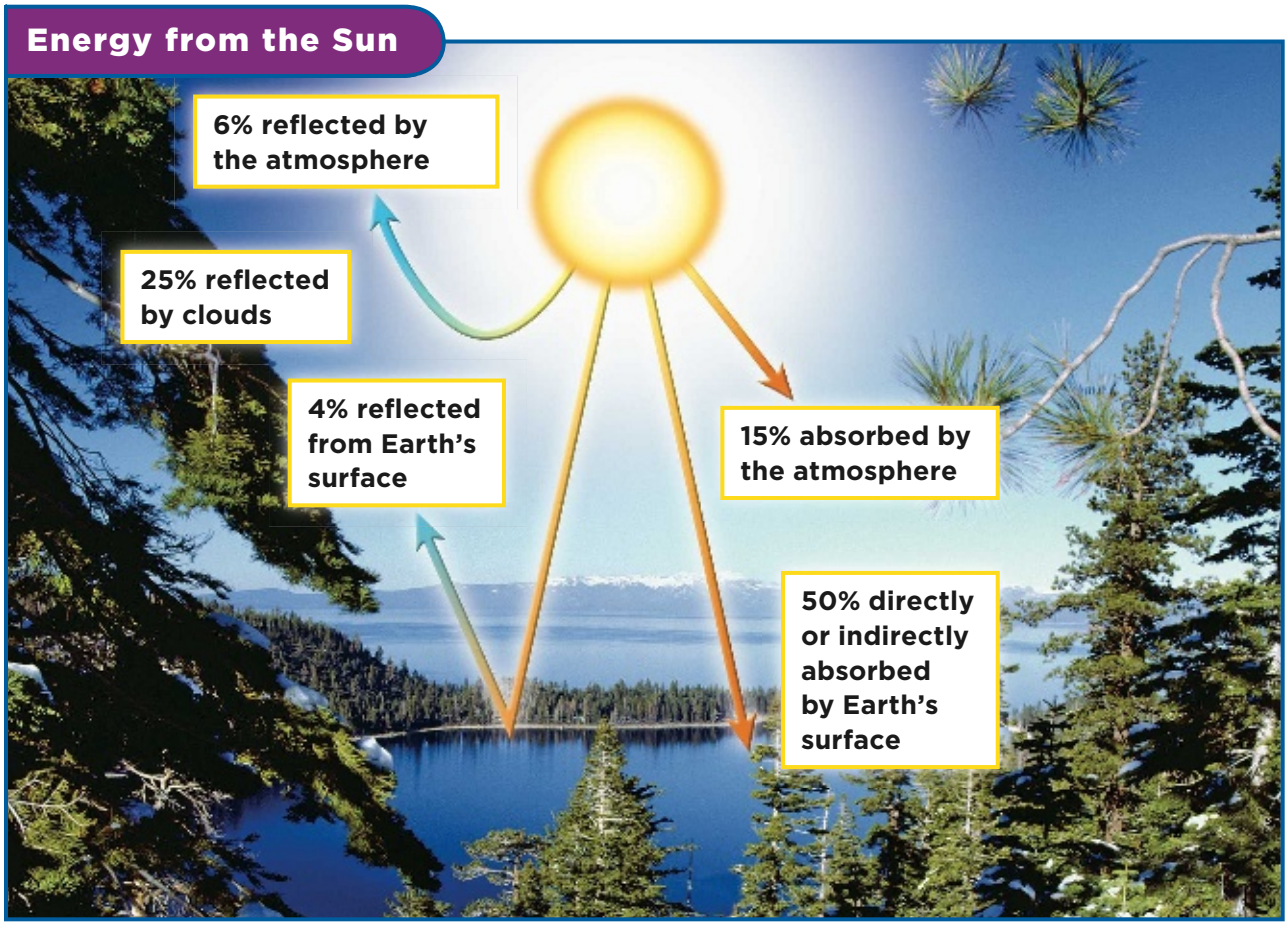
_____

_____

How does Earth gain and lose energy?

Most of the heat on Earth comes from the Sun. But Earth also gives off, or radiates, heat into space. Because this happens, Earth's average surface temperature stays about the same. It is about 140°C (59°F).

The picture shows how energy from the Sun is gained or lost.



Quick Check

5. Describe what happens to the Sun's energy after it reaches Earth.

How does the Sun affect the water cycle?

Solar energy helps recycle Earth's water supply. It plays a role in each of the main parts of the water cycle: evaporation, condensation, and precipitation.

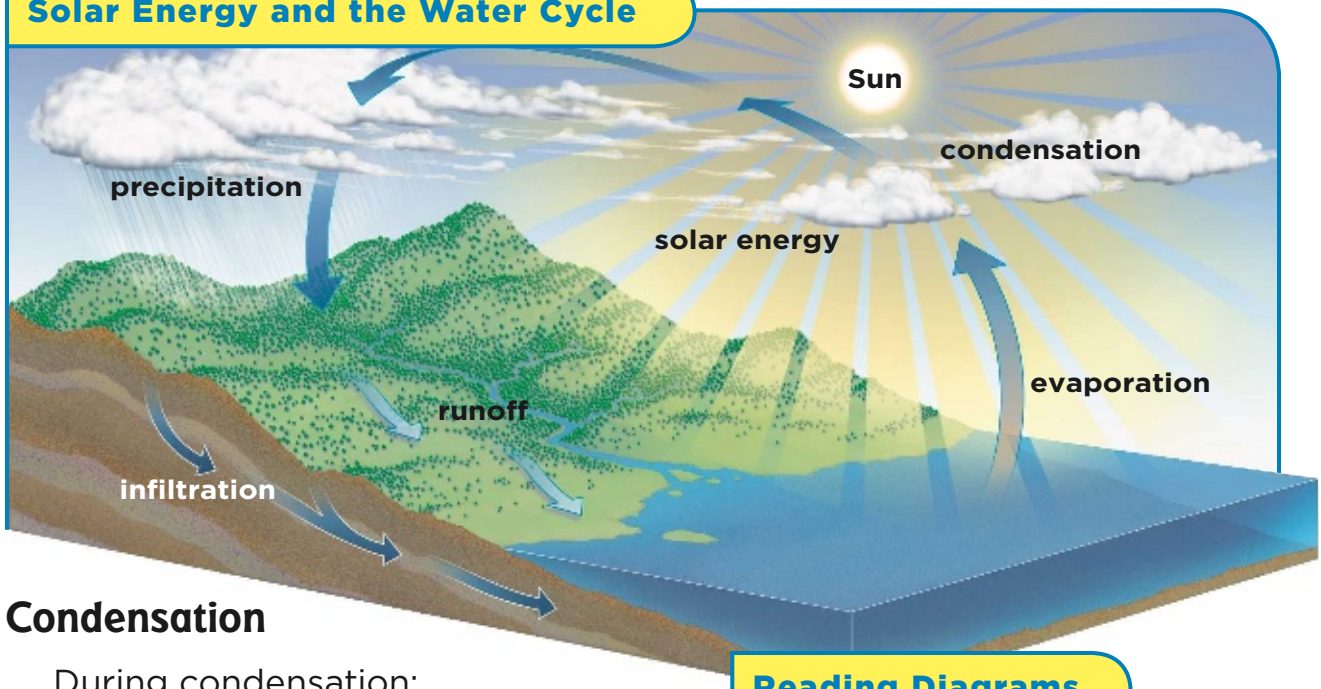
Evaporation

During evaporation:

- Solar radiation warms Earth's surface water.
- The water molecules move faster as a result.
- Water molecules near water's surface escape into the air as water vapor (evaporation).

▲ Solar energy evaporates the water in the seawater. It leaves behind the salt.

Solar Energy and the Water Cycle



Condensation

During condensation:

- Earth's air absorbs less solar energy than Earth's surface.
- As a result, water molecules in the air slow down.
- The water vapor changes into water droplets (condensation).

Reading Diagrams

What is the path of water in the water cycle?

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Precipitation

During precipitation:

- Water droplets in air join together and form a cloud.
- When enough water droplets collect in the cloud, they fall to Earth's surface (precipitation).
- Depending on how much Sun's energy air absorbs, precipitation falls as rain, sleet, snow, or hail.

Quick Check

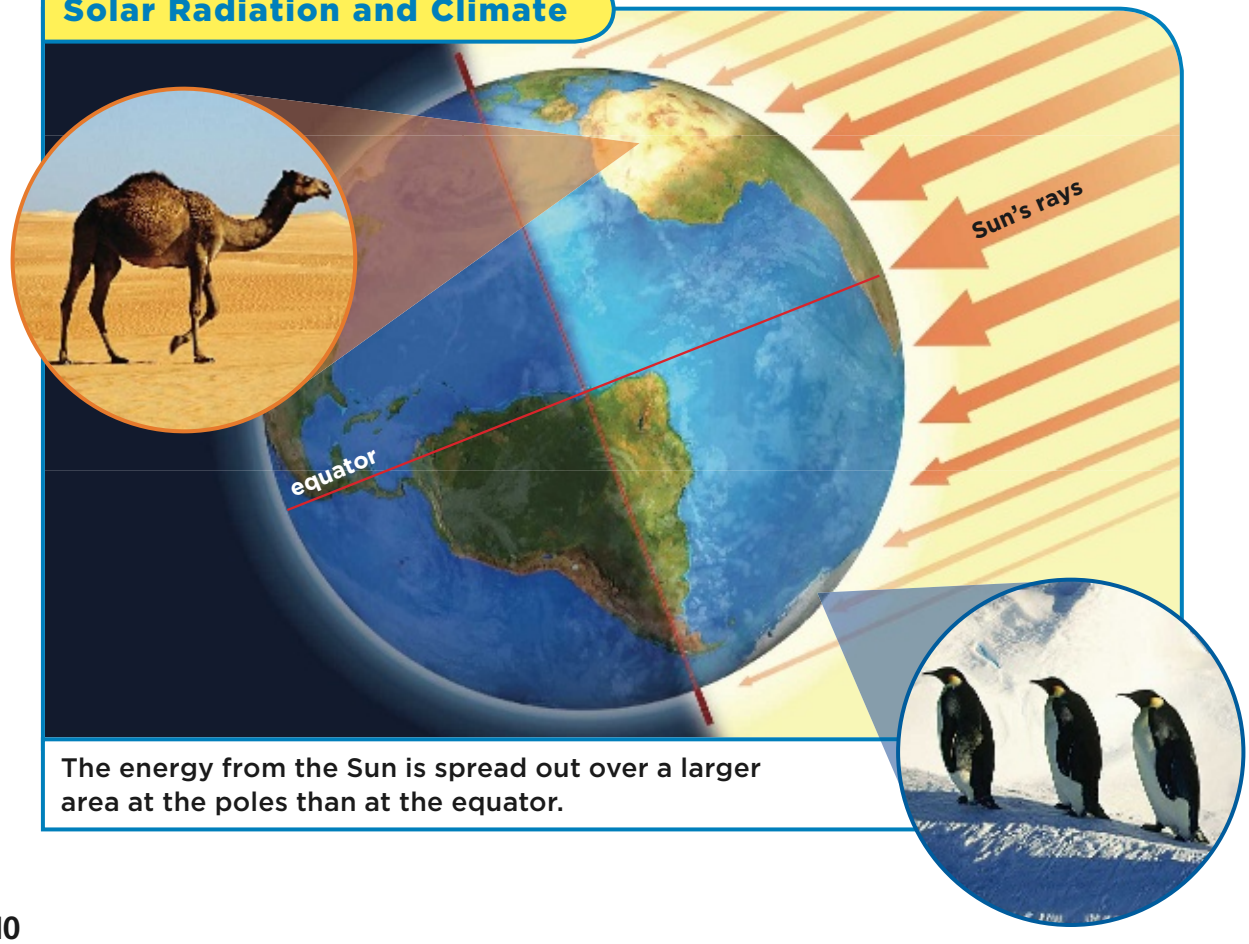
6. Francie says the part of the water cycle most affected by solar energy is condensation. Do you agree with her? Why or why not?

How does the Sun affect climate and weather?

Climate and weather depend on how much solar energy reaches the Earth. Climate is the average weather for a region.

Factors that affect climate	What the Sun does
• temperature • precipitation • wind • ocean currents	Solar energy heats air, land, and water. It helps create patterns of precipitation, wind, and ocean currents.
• latitude	Sunlight hits surface at a high angle near equator and at a low angle near poles. Less energy available near poles, so climate is cooler.
• altitude (mountains)	The higher up you go, the less air there is, and the less solar energy absorbed. Climate is colder.

Solar Radiation and Climate



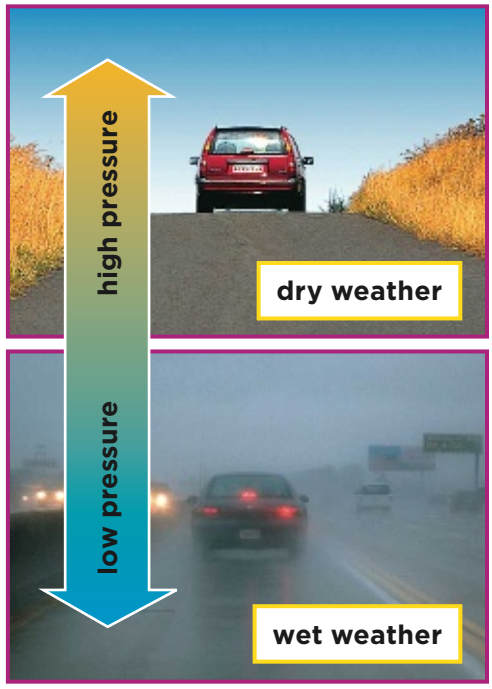
The energy from the Sun is spread out over a larger area at the poles than at the equator.

Weather

Weather is the state of the atmosphere at a given place and time. Like climate, weather is influenced by many variables. The Sun also plays an important role.

Factors that affect weather	The Sun's role
• air moisture • clouds • precipitation	result from evaporation caused by solar energy
• air temperature	heats up air
• air pressure*	heated air exerts less pressure than cool air
• wind	wind moves from area of high pressure to an area of low pressure

* Remember, air pressure is how hard the air above a region pushes down on it.



Quick Check

7. As the air temperature increases, the air pressure

_____.

8. The Sun affects a region's climate and weather by providing

_____.

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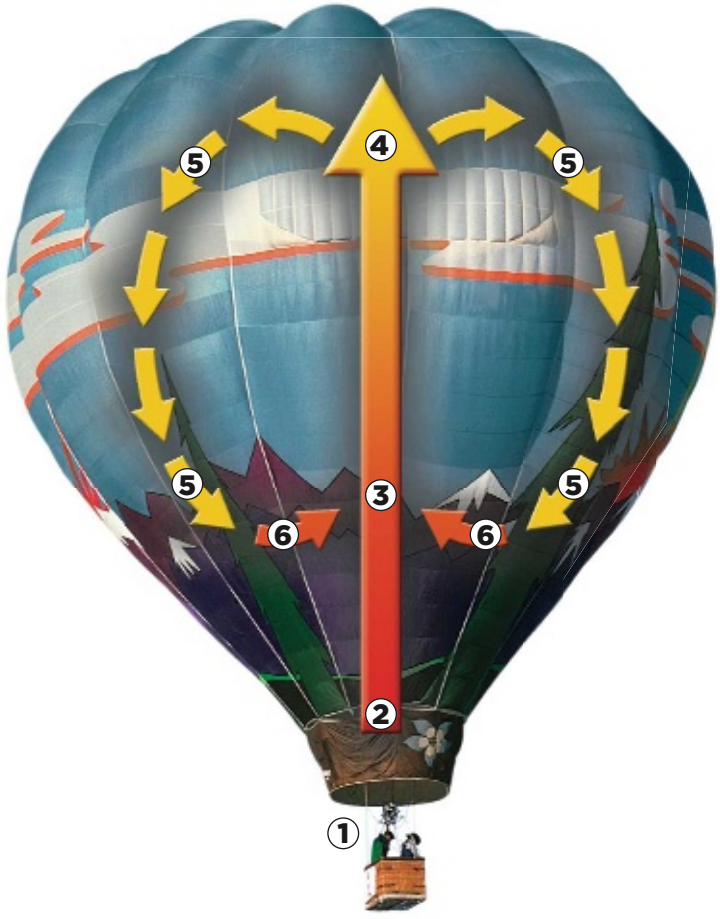
What are convection currents?

A convection current is a pattern of rising and sinking air or other fluid.

A hot-air balloon shows a convection current at work.



1. A burner heats the air.
2. The heated air molecules move apart. They become less dense.
3. The less dense air rises above the surrounding unheated air.
4. The air at the top begins to cool. It becomes denser.
5. The cooling air sinks toward the bottom.
6. When the air reaches the bottom, it is once again heated up. It rises and the pattern starts over—a convection current!

Quick Check

9. What would happen to the convection current if the burner under the balloon was turned off? Explain. _____

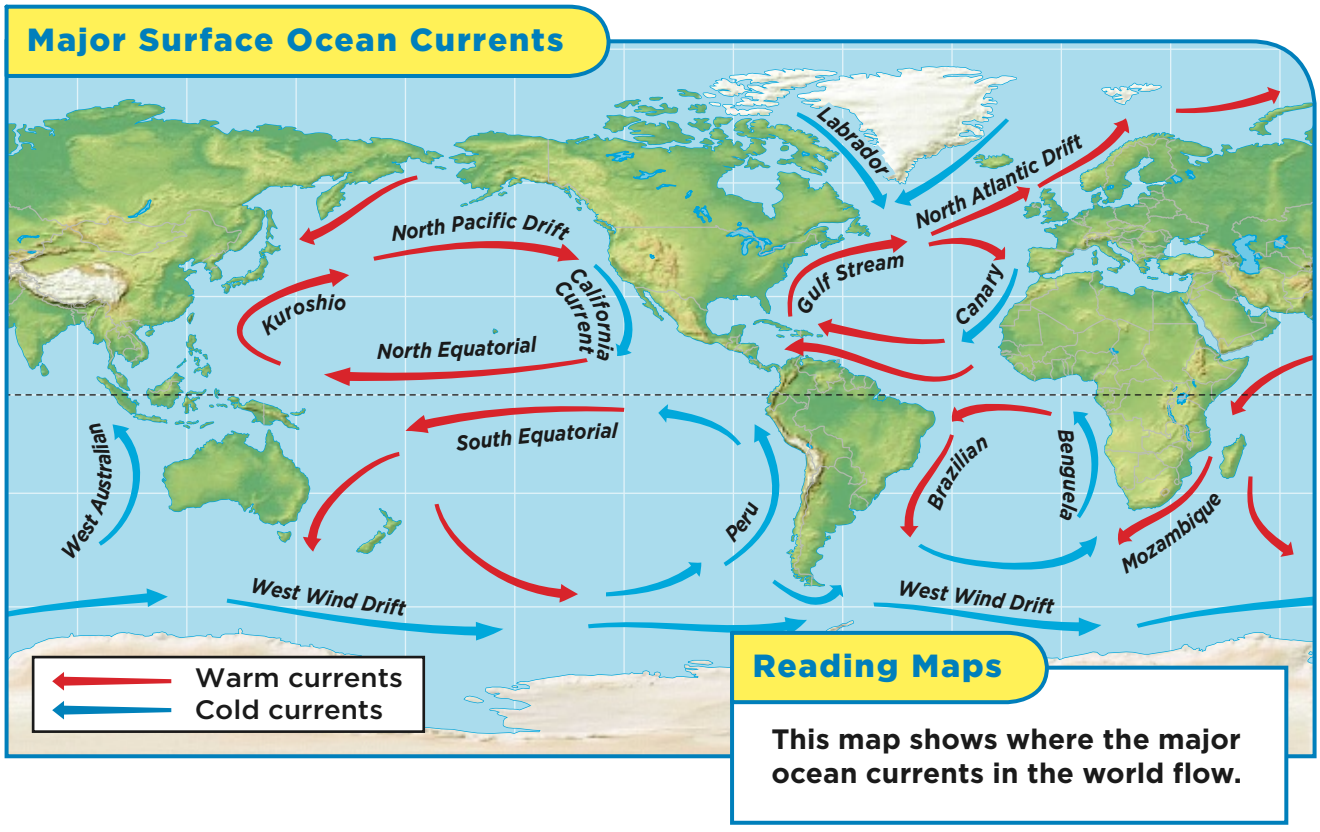
_____

_____

What causes ocean currents?

An **ocean current** is a river of water in the ocean. Ocean currents follow definite paths. Here are some facts about them.

- Warm currents carry warm water toward the poles.
- Cold currents move cold water toward the equator.
- Some currents flow near the surface. They are moved by Earth's global winds. The **Gulf Stream** is a warm surface current. It flows along the East Coast. The **California Current** is a cold surface current. It flows along the West Coast.
- Some currents flow far below the ocean's surface.
- Currents flow in huge circles, just like convection currents.



Reading Maps

This map shows where the major ocean currents in the world flow.

Quick Check

10. What pattern do you see in the currents in the map? _____

_____

What makes the wind blow?

Wind is the horizontal flow of air. It is caused by differences in air pressure. Winds move from high-pressure areas to low-pressure areas.

Global Winds	Local Winds
• blow from a specific direction	• blow from any direction
• cover long distances	• cover short distances
• are caused by convection currents: warm air moving from equator to poles, cool air moving from poles to equator	• often are given special names. For example, **Santa Ana winds** are warm, dry winds that blow out of desert in Southern California.

The hot Santa Ana winds dry out plant life, making it fuel for wildfires.

Quick Check

11. Compare and contrast global and local winds. _____

_____

_____

_____

Sea breezes and land breezes are convection currents.

Factors That Affect Winds
Earth's Rotation (curves paths of winds)
• Northern Hemisphere: winds flow clockwise • Southern Hemisphere: winds flow counterclockwise
Geography (mountains and valleys)
• Valley breeze: in the morning, warm air rises off mountain slopes. Cool air from the valley takes its place. • Mountain breeze: in the evening, mountain air cools, sinks, and replaces warm air in the valley.
Type of Material (land and water)
• Sea breeze: in the morning, air over land warms and rises. Cool air from the sea flows toward the land. • Land breeze: in the evening, air over land cools faster than over the sea. Cool air flows from the land toward the sea.

Quick Check

Fill in the blanks with *sea* or *land*.

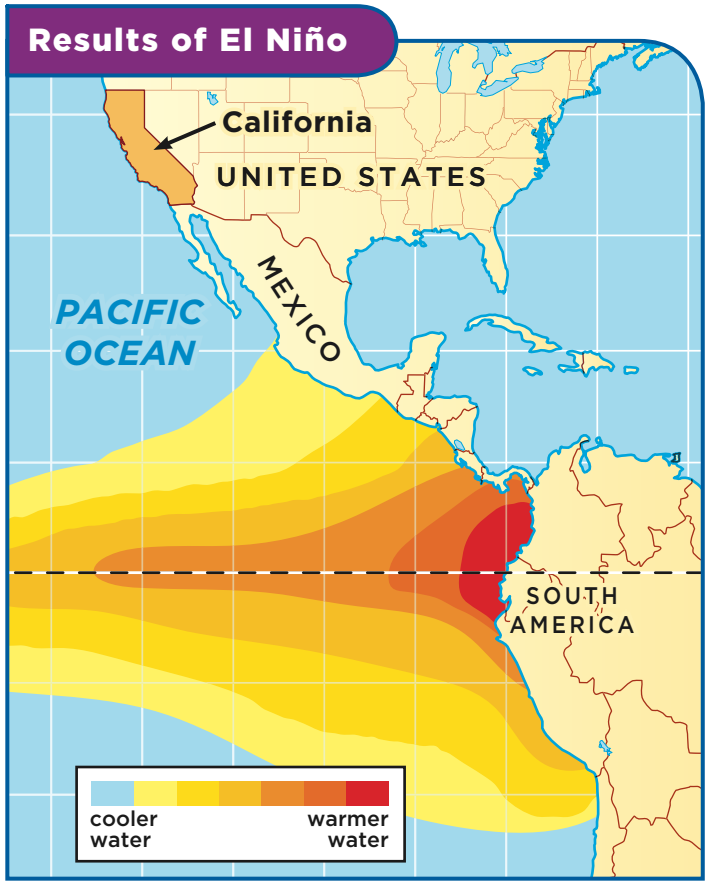
12. A valley breeze is like a _____ breeze.

13. A mountain breeze is like a _____ breeze.

What is El Niño/ Southern Oscillation?

The oceans and the atmosphere are always interacting. In the Pacific Ocean, strong winds near the equator usually blow toward the west. Warm surface water is pushed toward Japan and Australia. Deep, cold water along western South America rises to the surface to replace it. This cold water is rich in nutrients. It supports a large number of fish.

Every 3 to 7 years, the winds are weak. Little water is pushed across the Pacific. As a result, no deep, cold water rises. With no cold water rising, the ocean stays warm. This pattern is called *El Niño* (el NEEN•yoh).



El Niño is part of the ENSO or **El Niño/Southern Oscillation** (ah•si•LAY•shuhn), the way the Pacific Ocean and the air interact. The Southern Oscillation is back-and forth reversing of winds.

- In normal conditions, winds blow from North America and South America across the Pacific Ocean toward Australia and Japan.
- In El Niño conditions, winds blow in the opposite direction.

Quick Check

14. During an _____, deep-level cold water does not rise toward the surface.

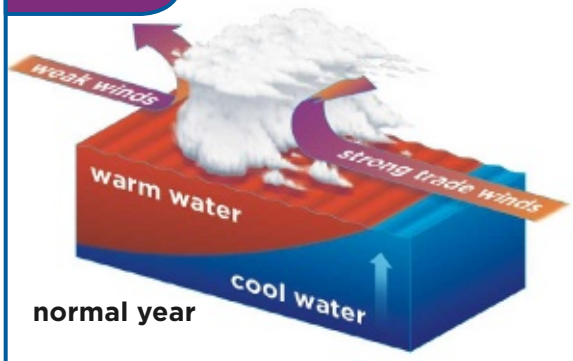
Effects of ENSO

In normal years, cold water from deep in the oceans brings food that supports many fish. During ENSO, many changes occur.

- Without food from the cold waters, many fish die. The food chain is affected.
- Dry areas may receive a lot of rain.
- Wet areas may experience drought.
- Heavy storms often affect the Gulf of Mexico and western South America.
- Eastern Asia is hit by drought.
- Changes in the path of the *jet stream* occur.

The jet stream is a current of fast-moving air in the upper atmosphere. It is one factor that has a major influence on weather in North America.

ENSO

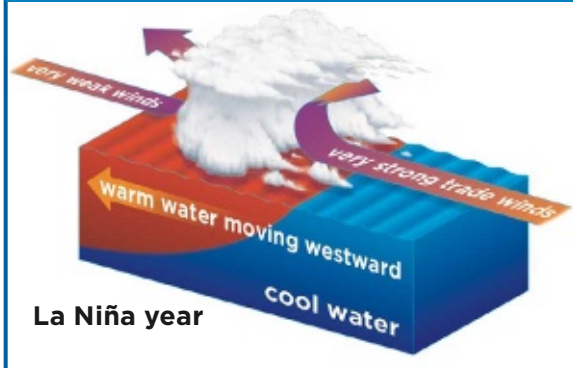


normal year

Strong winds keep warm surface water in the western Pacific Ocean. Cooler water rises to the surface of the eastern Pacific Ocean.

El Niño year

Warm waters in the western Pacific Ocean move east and prevent cool water from rising to the surface.



La Niña year

Very strong winds push warm water to the western Pacific Ocean. Cool water surfaces near California, bringing drier weather to much of the United States.

Quick Check

15. How can El Niño cause the weather to change in parts of the world?

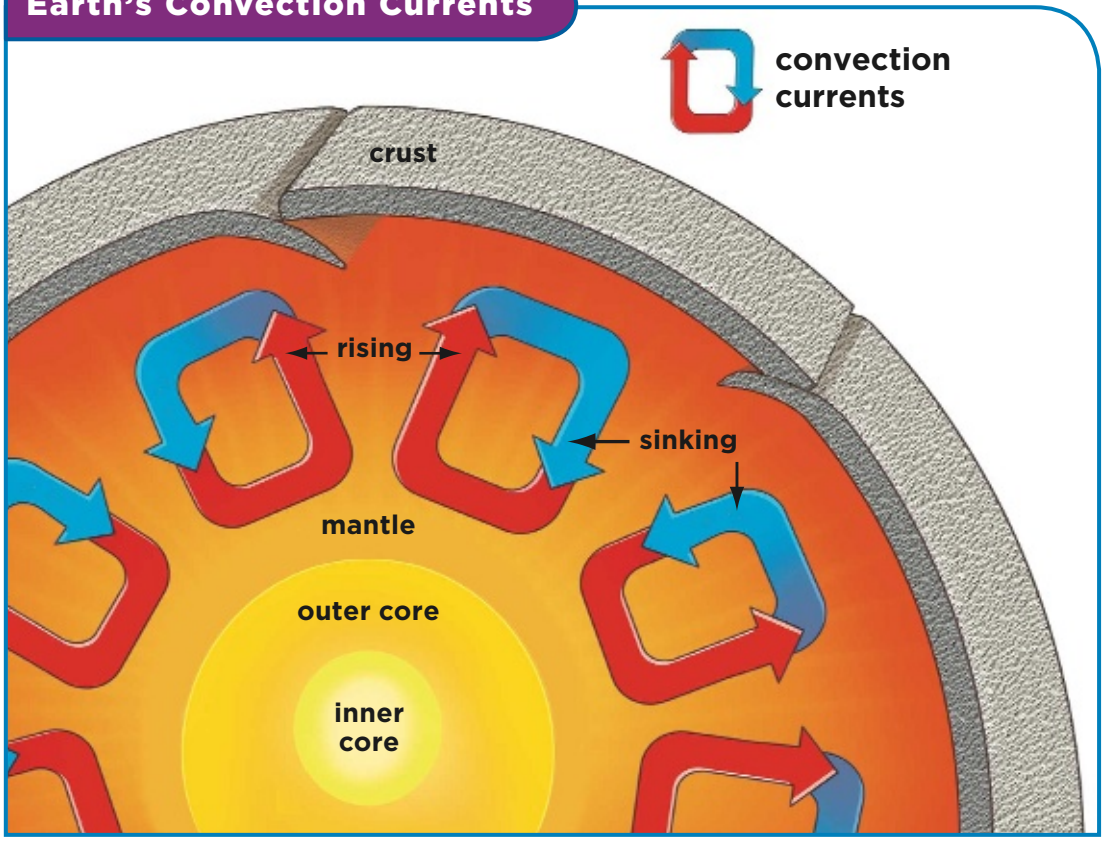
How do convection currents work underground?

Earth is divided into three parts:

- **crust** thin, solid, outermost layer
- **mantle** thick layer of rock below crust
- **core** central part of the Earth

Temperatures in the Earth slowly rise until they reach about 5,500°C (9,932°F) at the center of the core. Temperatures in the mantle are high enough to make the rock there flow very slowly, like honey. Rock is a poor conductor of heat. So, heat is transferred away from the core by convection currents. The hot mantle rock rises toward the crust. The cooler mantle rock sinks toward the core.

Earth's Convection Currents



a thermal spring in Iceland

Effects of Convection on Earth's Surface

Convection in the Earth makes the mantle rock move slowly in a circle. As this happens, the mantle rock pulls on the bottom of the crust. Some of the crust moves, too.

Sometimes, convection rises as a column of melted rock. If this melted rock reaches the surface, a volcano can occur. Or sometimes a geyser or a hot spring, such as those found in Yellowstone National Park or in Iceland.

Quick Check

16. The Hawaiian Islands are the tops of volcanoes. How might these islands have formed? _____

_____

_____

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Vocabulary Review

Energy in the Earth System

Choose the letter of the best answer.

1. Electromagnetic waves you can see are

a. infrared waves

b. light waves

c. ultraviolet waves

d. X rays

2. Taking in radiant energy is called

a. radiation

b. emission

c. absorption

d. vibration

3. A river of water in the ocean is a(n)

a. ocean current

b. ENSO

c. convection current

d. El Niño

4. The California Current is a(n)

a. cold surface current

b. warm surface current

c. cold deep water current

d. warm deep water current

5. The way the Pacific Ocean and the air interact is called the

a. Santa Ana wind

b. Gulf Stream

c. ENSO

d. electromagnetic spectrum

6. What name is given to the grouping of electromagnetic waves in order of wavelength?

a. electromagnetic spectrum

b. solar radiation

c. emission

d. absorption

radiation	absorption	Santa Ana
mantle	crust	Gulf Stream
wind	core	emission
electromagnetic waves	solar radiation	

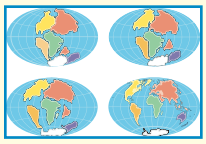
Fill in the blanks with words in the box.

1. _____ Giving off radiant energy
2. _____ A warm surface current
3. _____ A warm, dry wind
4. _____ Earth's thin, solid, outermost layer
5. _____ The thick layer below Earth's surface
6. _____ The transfer of energy by electromagnetic waves
7. _____ A horizontal flow of air
8. _____ The central part of Earth
9. _____ Vibrating electric charges
10. _____ Light from the Sun

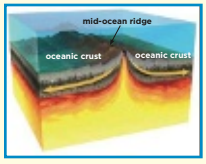
CHAPTER 5

Plate Tectonics and Earth's Structure

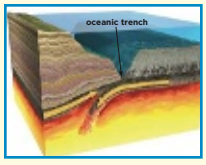
Vocabulary



continental drift Wegener's theory that a supercontinent split apart and the pieces drifted to their present locations



mid-ocean ridge a line of underwater mountains in the middle of an ocean

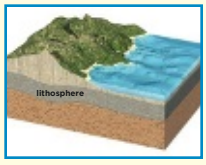


ocean trench a long, deep undersea valley

earthquake a shaking of the ground

volcano a crack in the crust through which magma flows

seismic wave a vibration that travels through Earth



lithosphere rocks in the crust attached to the upper mantle

magma molten rock in the mantle

lava magma on the Earth's surface

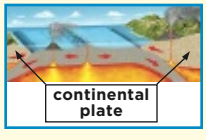
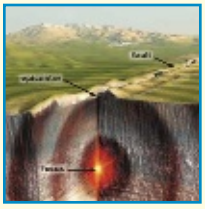


plate tectonics Earth's surface is made of plates that move slowly across the mantle

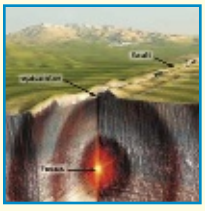
subduction one plate sinking beneath another

The Big Idea: What geologic forces have shaped Earth's landscape?

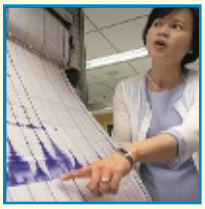
fault a crack in the lithosphere



focus the point below Earth's surface where an earthquake occurred



epicenter the point on Earth's surface just above the focus



magnitude the amount of energy released in an earthquake

Summary of the Richter Scale

Magnitude	Description
1–2+	Recorded on local seismographs but not generally felt
3–4+	Often felt, no damage
5+	Widely felt, slight damage near epicenter
6+	Damage to poorly constructed buildings and other structures within tens of miles or kilometers from epicenter
7+	"Major" earthquake causing serious damage within up to 100 km (60 mi) of epicenter
8+	"Great" earthquake causing great destruction and loss of life in areas more than 100 km (60 mi) from epicenter
9+	"Rare great" earthquake causing major damage over a large region more than 1,000 km (600 mi) from epicenter

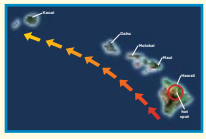
Richter scale a way to measure the magnitude of an earthquake

intensity the measure of an earthquake's strength

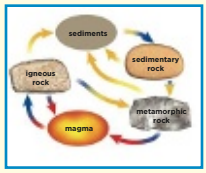
Summary of the Mercalli Scale

Intensity	Descripton
II	Felt by persons at rest or in places more favorable to sensing tremors
IV	Felt indoors and outdoors; like vibrations of passing heavy trucks; windows, doors, and dishes rattle
VI	Felt by almost everyone, walking is unsteady, pictures fall off walls, furniture may move or fall over
VIII	Walls may collapse, monuments may fall
X	Most buildings are destroyed, large landslides occur, train tracks are bent slightly
XII	Damage nearly total, objects thrown into the air, some landforms moved

Mercalli scale a way to measure the intensity of an earthquake



hot spot a region of volcanic activity in the middle of a plate



rock cycle the process by which one kind of rock is changed into another

San Andreas Fault the boundary between the North American and Pacific plates.

What forces shape Earth?

Look at the outlines of North and South America. Now do the same for Africa. Do you see a pattern? The bulge of Africa seems to fit into the area between the two Americas, right at the Gulf of Mexico and the Caribbean Sea. Is there a reason for this match? In 1912 the German scientist Alfred Wegener made a hypothesis. He said the continents were once part of a supercontinent. This supercontinent split apart into pieces. Over time the pieces drifted to their present locations. Wegener's hypothesis is known as **continental drift**.

Quick Check

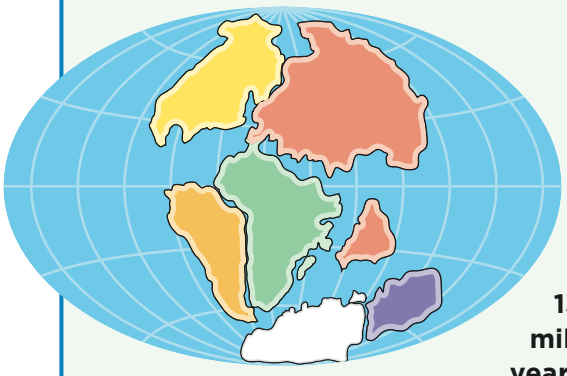
1. How did Wegener explain the fit of the continents? _____

_____

_____

Motion of Continents

225 million years ago



135 million years ago

65 million years ago

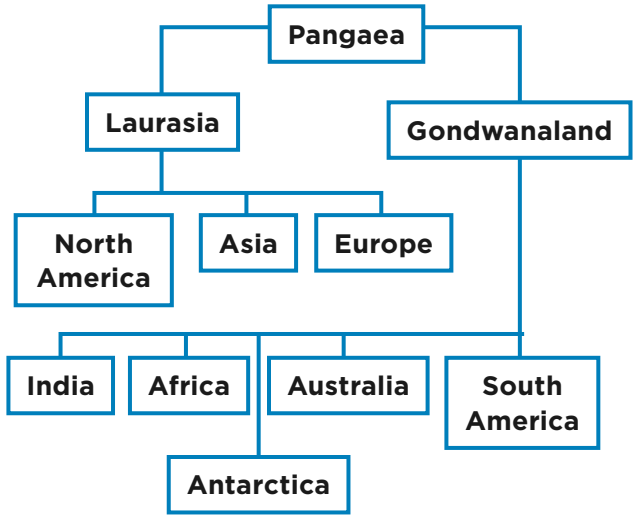
present day

Reading Maps

The map shows how the positions of the continents have changed over time.

Continental Drift

Wegener called his supercontinent *Pangaea* (pan•Jee•uh). About 200 million years ago Pangaea split into two parts. Over millions of years, these parts split and drifted to their present locations.



Quick Check

2. About 200 million years ago, *Pangaea* split apart into

_____ and

_____.

What evidence supports continental drift?

Continental drift is supported by evidence from rocks and from fossils.

Evidence from Rocks

Rocks provide the following clues:

- Parts of Africa and South America have rocks of the same type and age.
- Mountain ranges line up across the two continents as if these two continents were once joined.
- Coal formed from tropical plants is found in North America and Antarctica. This implies they were both much closer to the equator at one time.

Fossil Evidence

Fossils of *Glossopteris*, a fern, have been found in South America, Africa, India, Antarctica, and Australia.

Fossils of *Cynognathus*, a Triassic land reptile about 3 m (10 ft) long, have been found in South America and Africa.

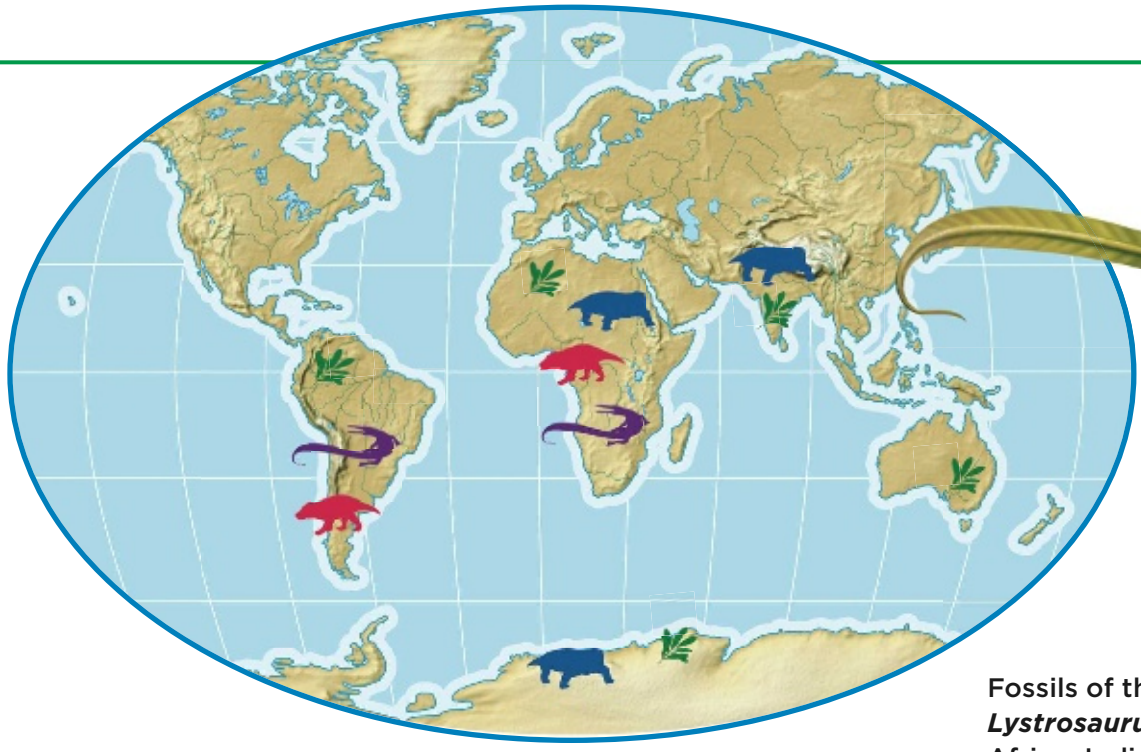
Evidence from Rocks' Ages

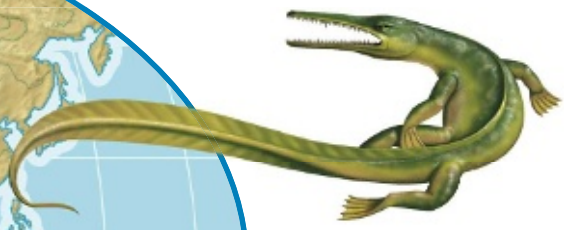
- When two rock layers are found in the same area or landform, usually the lower layer is older.

Evidence from Fossils

Fossils also give clues that the continents have moved in the past.

- *Index fossils,* which lived only during a short time, are found only in certain areas. This can only happen if continents were once joined.
- Fossil plants and animals of the same kind are found on continents separated by oceans.
- Tropical fern fossils have been found in Antarctica.





Fossils of ***Mesosaurus***, a freshwater reptile, have been found in South America and Africa.

Fossils of the Triassic land reptile ***Lystrosaurus*** have been found in Africa, India, and Antarctica.

The map shows where fossils of ancient organisms have been found in the southern continents. It also shows how these continents would once have fit together in a way that explains the distribution of the fossils.

Quick Check

3. What fossil evidence supports continental drift?

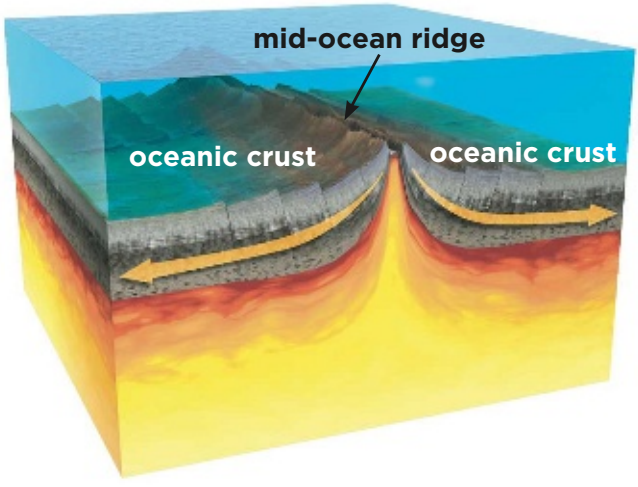
4. Dinosaur fossils were found in Alaska that were previously found only in tropical Asia. What might this evidence suggest about Alaska?

What clues are found on the ocean floor?

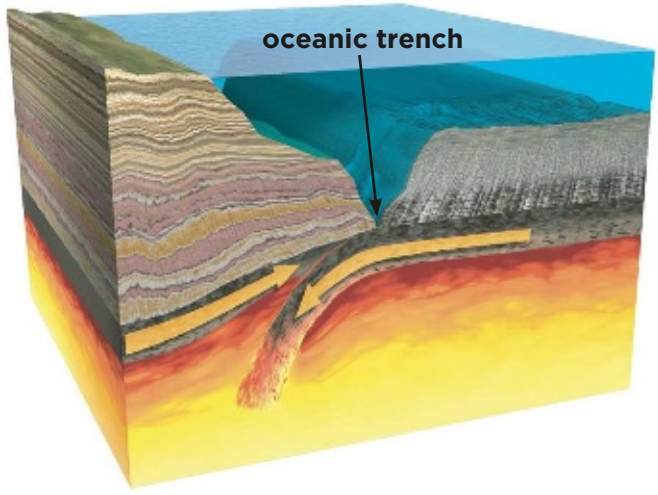
Support for continental drift also came from the ocean floor. Scientists discovered in the 1960s that Earth's crust was made up of large pieces called *plates*. They found out that:

- plates carry both continents and ocean floors with them.
- when plates move apart under the oceans, new rock from below may move up. It may form mountains in the space between the plates. These underwater mountains are called a **mid-ocean ridge**.
- when plates move together, one may sink under the other. A long, deep valley, an **ocean trench**, may form.

Mid-Ocean Ridge



Ocean Trench



Quick Check

5. Challenger Deep is an ocean trench. How might it have formed?

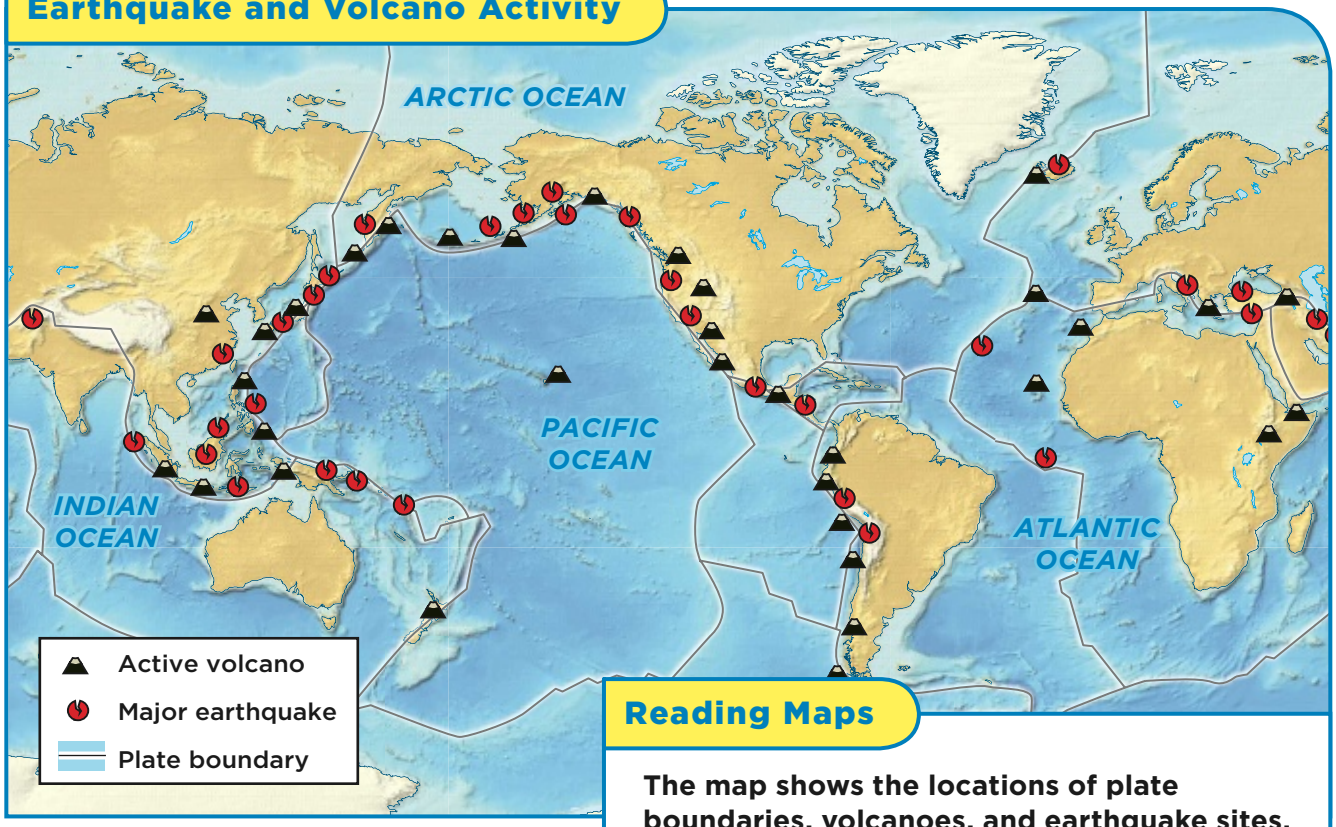
What other events occur at plate boundaries?

If you push two stacks of paper together, they might bunch up, forming a mountain. When two plates meet, if they don't form a trench, they may form a mountain. The Appalachian Mountains were made this way.

Sometimes plates slide past each other. When this happens, a shaking of the ground, or an **earthquake** may occur.

When melted rock and hot gases erupt through a crack in the crust, a **volcano** may occur.

Earthquake and Volcano Activity



Reading Maps

The map shows the locations of plate boundaries, volcanoes, and earthquake sites.

Quick Check

6. What conclusion can you draw if you study the locations of volcanoes and earthquakes? _____

_____

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San Andreas Fault

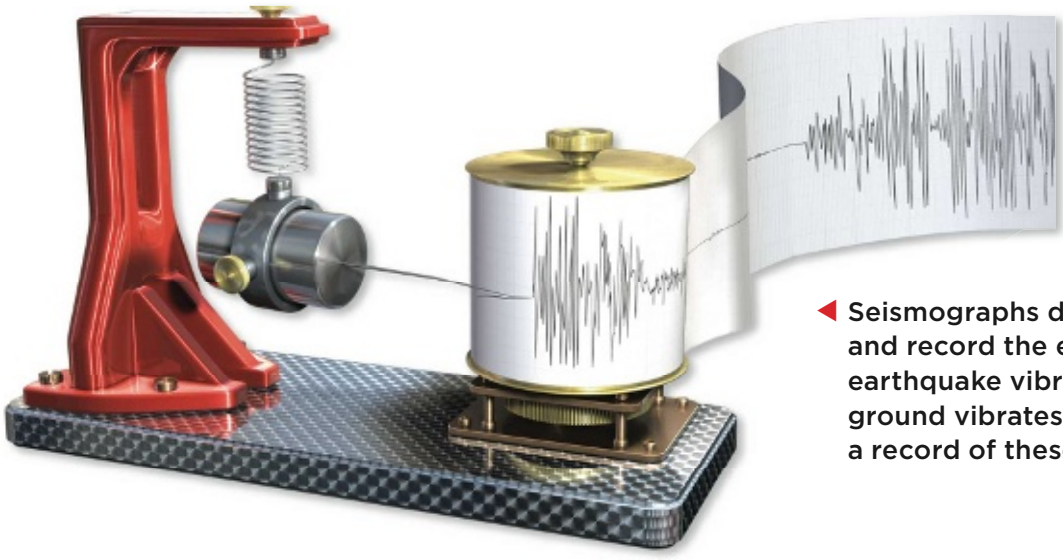
How do scientists study Earth's structure?

Scientists cannot see far enough into Earth to see its structure. Instead, they use seismic waves. A **seismic wave** is a vibration that travels through Earth.

There are two kinds of seismic waves: *surface waves* and *body waves*. Each kind of wave has its own properties. There are even two kinds of body waves. By studying seismic waves, scientists learn a lot about Earth's interior.

Instruments on Earth's surface record these movements or vibrations. These instruments are called seismographs (SIZE•muh•grafs).

Based on studying these waves, scientists conclude that Earth's interior is made up of layers with different properties.



Seismographs detect, measure, and record the energy of earthquake vibrations. As the ground vibrates, the pen traces a record of these seismic waves.

Seismic Waves	
Kind of Wave	**Properties**
Surface wave	• is trapped near Earth's surface • moves slower than body waves • travels like water waves
Primary body wave (*P* wave)	• goes through interior of Earth • moves fastest of seismic waves • moves through solids, liquids, or gases • travels like a sound wave
Secondary body wave (*S* wave)	• moves only through solids • vibrates up and down and side to side as it moves forward

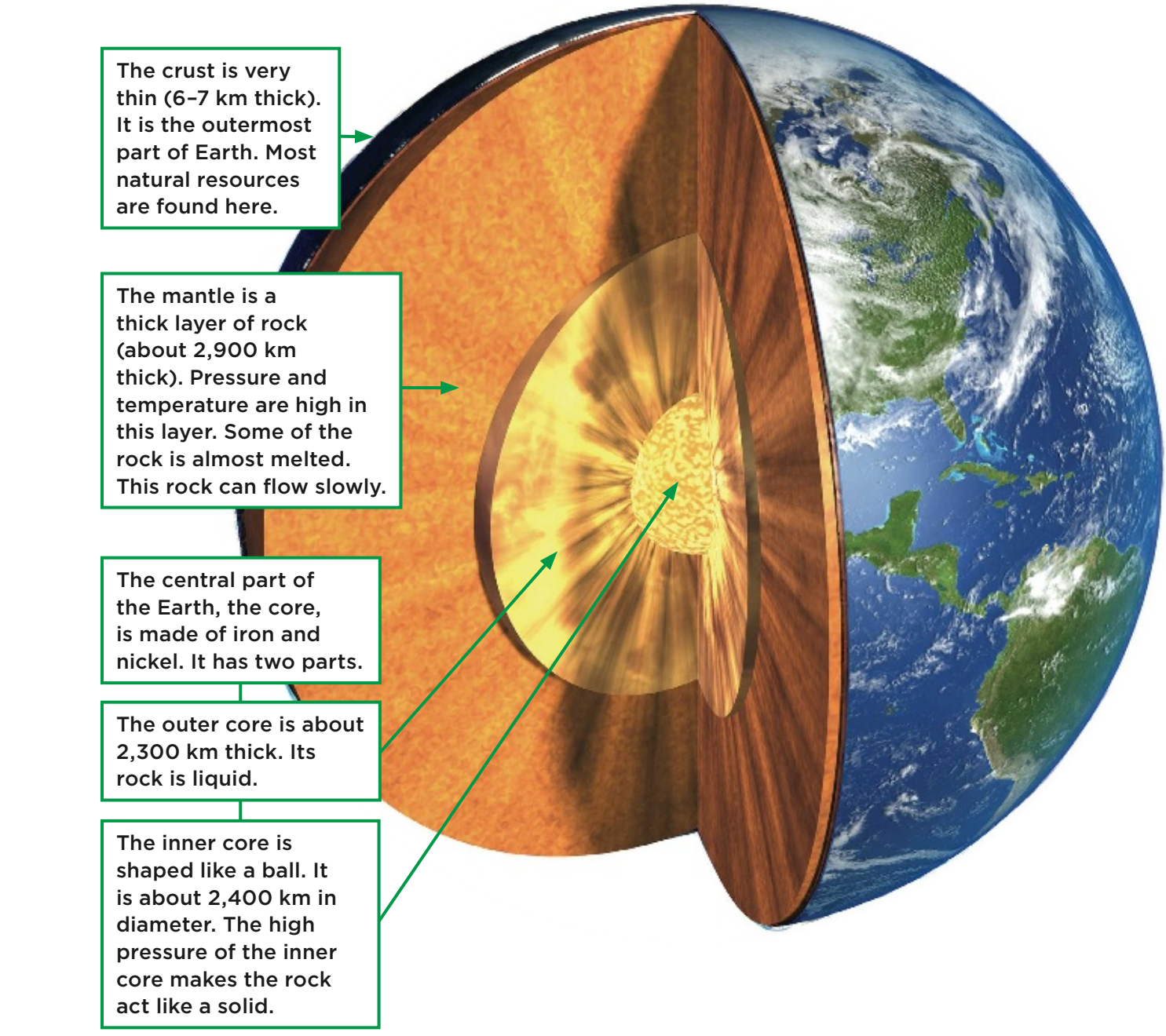
Quick Check

7. _____ waves and _____ waves are kinds of body waves. The _____ waves travel with the greatest speed.

What are the main layers of Earth?

The Earth has three main layers—the crust, the mantle, and the core. The core, in turn, has an outer part and inner part. Each layer has its own properties. These properties depend on the pressure exerted by the layers above. It also depends on the temperature, which goes up as you go deeper into Earth.

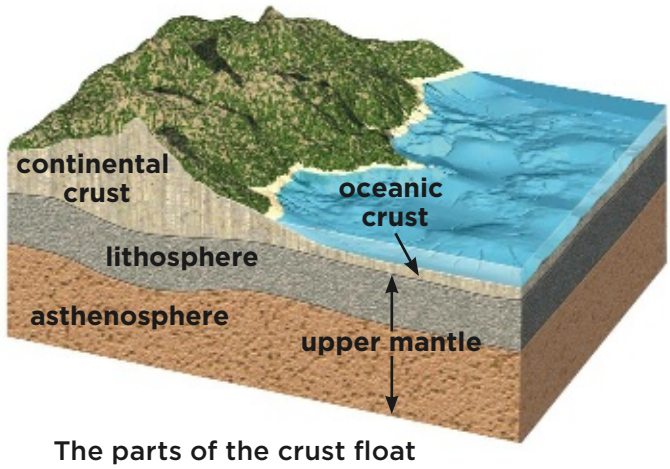
Earth's Layers



How the Main Layers of Earth Are Subdivided

The crust has two parts.

Continental crust
• made of light rock called granite • average thickness about 32 km • makes up Earth's land
Oceanic crust
• made of denser rock called basalt • average thickness about 6 km • makes up ocean floor



The parts of the crust float on the asthenosphere.

The mantle also has two parts: the upper mantle and the lower mantle. The rocks in the crust attached to the upper part of the mantle make up the **lithosphere** (LITH•uh•sfeer). The almost melted mantle rocks below the lithosphere make up the *asthenosphere*.

The melted, or molten, rock in the mantle is called **magma**. Magma on Earth's surface is called **lava**.

Quick Check

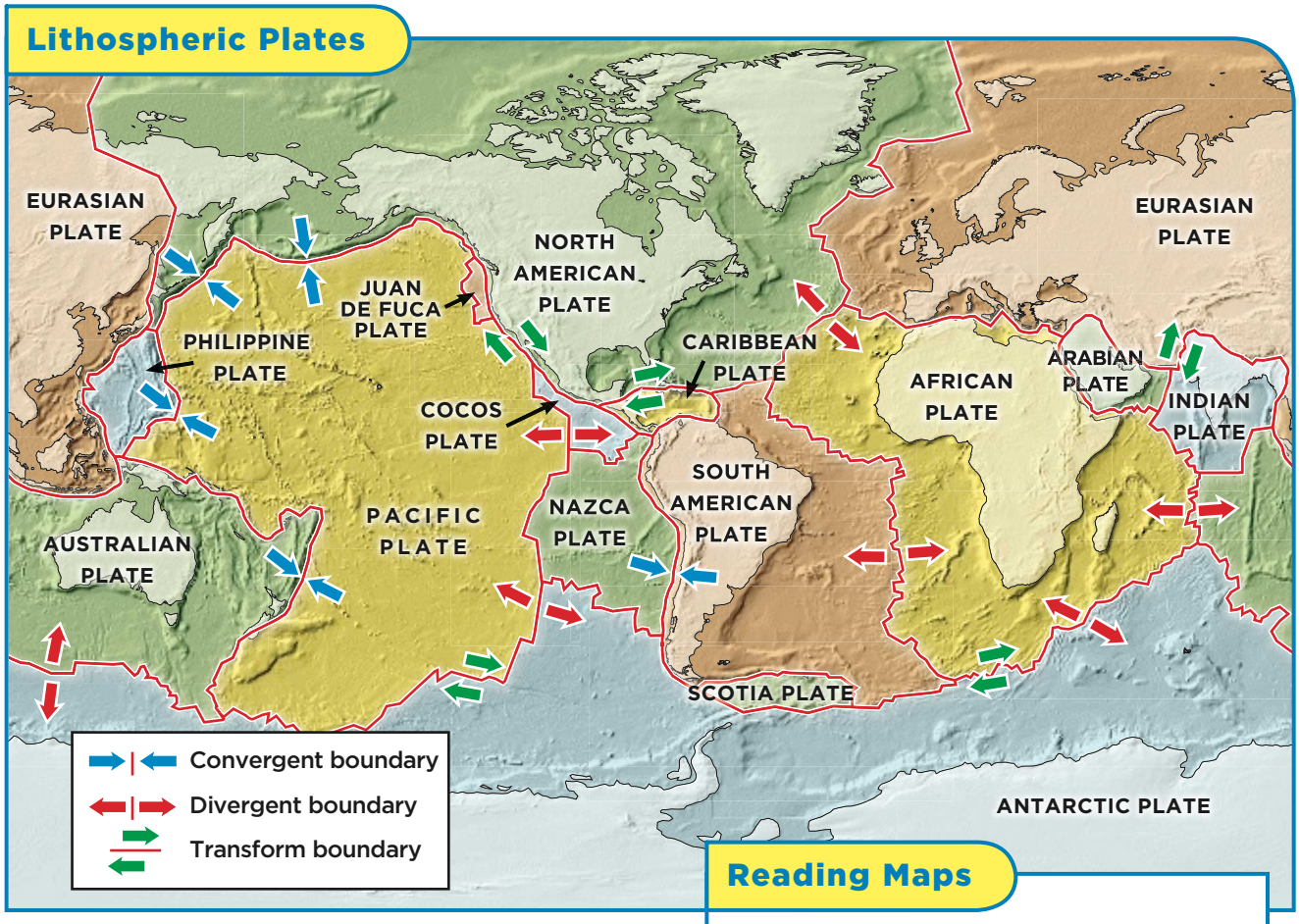
8. Name and describe two properties of each of Earth's three layers. Use the diagrams on these two pages as your guide.

Layer	Properties
a. _____	
b. _____	
c. _____	

What moves the plates?

The lithosphere is broken into plates. The plates contain the continents as well as the ocean floor. The plates are moving slowly. How can the plates move?

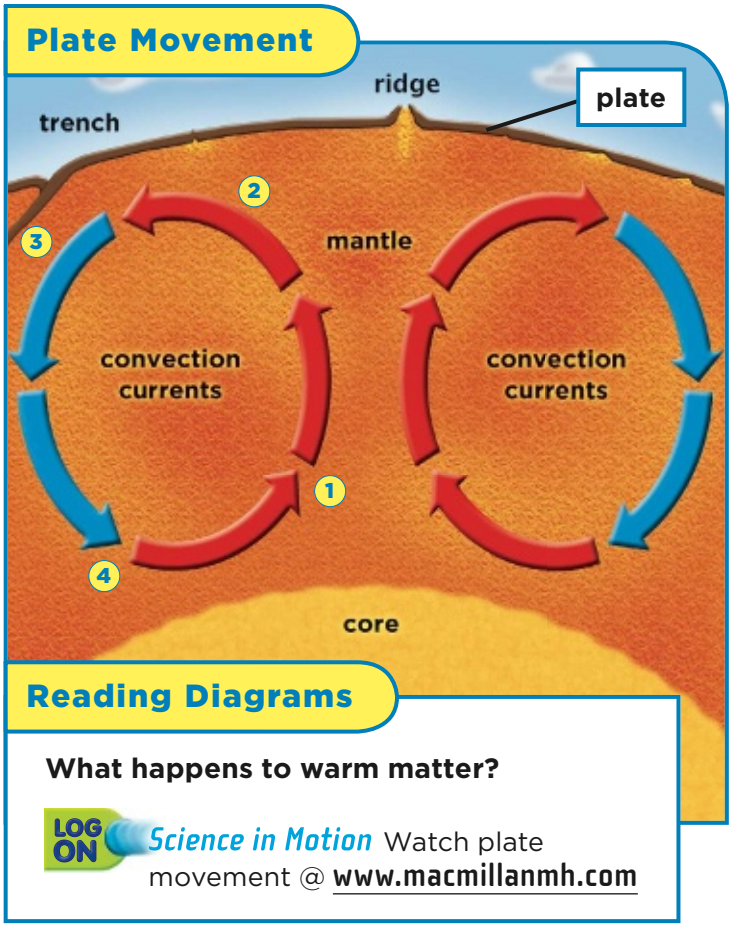
They are moving because of movement in the part of the mantle just below the plates. The rocks of this part of the mantle rise and flow because of *convection*. Convection is the transfer of energy through a liquid or gas. For example, convection is how heat moves through a pot of water that is heated from below.

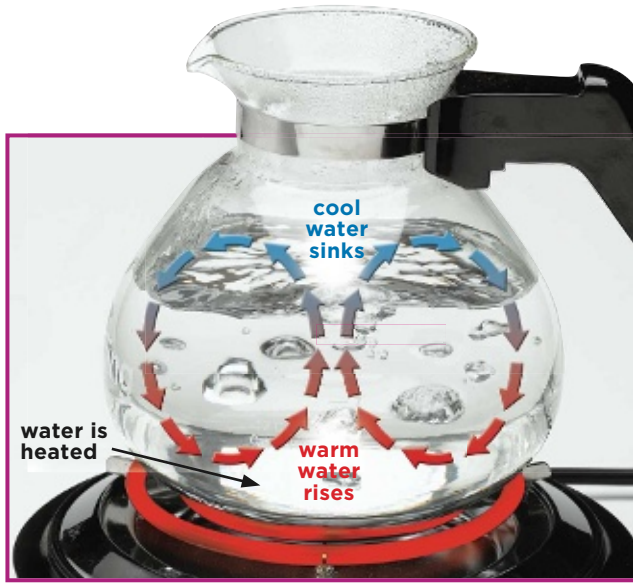


▲ Each plate is constantly in motion in a set direction. This causes pressure to build in locations between plates.

Reading Maps

The arrows show the directions in which different plates are moving.





▲ Convection currents distribute heat through the pot of boiling water.

Convection in the Mantle

Convection in the mantle occurs in almost the same way that it does in water. The main difference is that convection in the mantle occurs very slowly.

1. Hot, less dense rock in the mantle rises toward the bottom of the plates.
2. As it rises, it cools and gets denser. It moves sideways.
3. In time it cools enough to sink.
4. As the rock sinks, it heats up and rises, repeating the cycle.

Quick Check

9. Earth's plates move as a result of _____

_____.

What is plate tectonics?

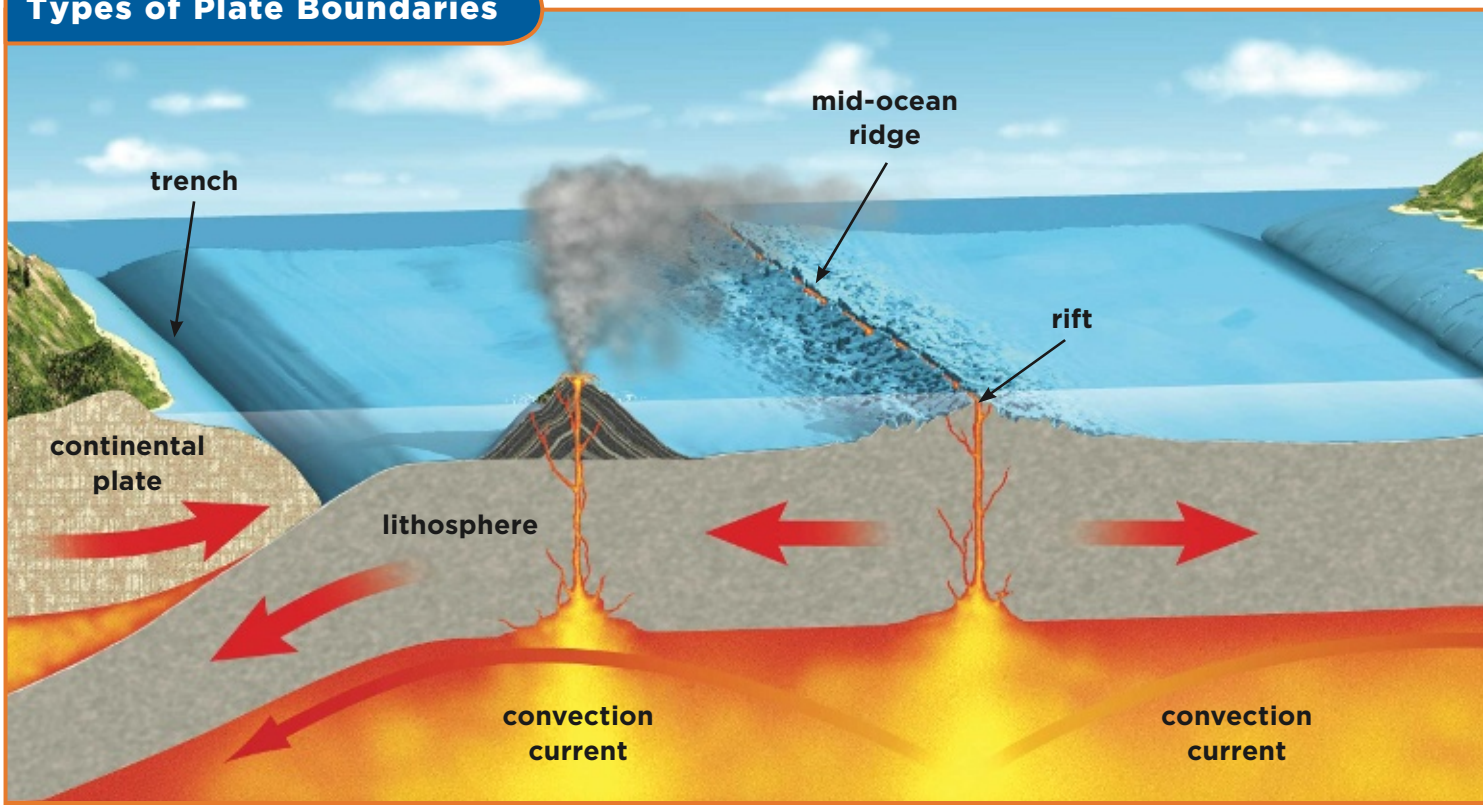
Scientists do not fully understand what makes the Earth's plates move. But they continue to try to explain all the data they have collected.

A Unifying Theory

A *unifying theory* gives a complete picture of natural occurrences. It ties together other related theories. Plate tectonics is such a theory. **Plate tectonics** (playt•tek•TAHN•iks) states that Earth's surface is made up of many plates that move slowly across the mantle. Plate tectonics combines Wegener's theory of continental drift, seafloor spreading, and other supporting data.

Earth's plates move in different ways and speeds. Although some move faster, most plates move only a few centimeters (or inches) a year—about as much as your fingernails grow in a year.

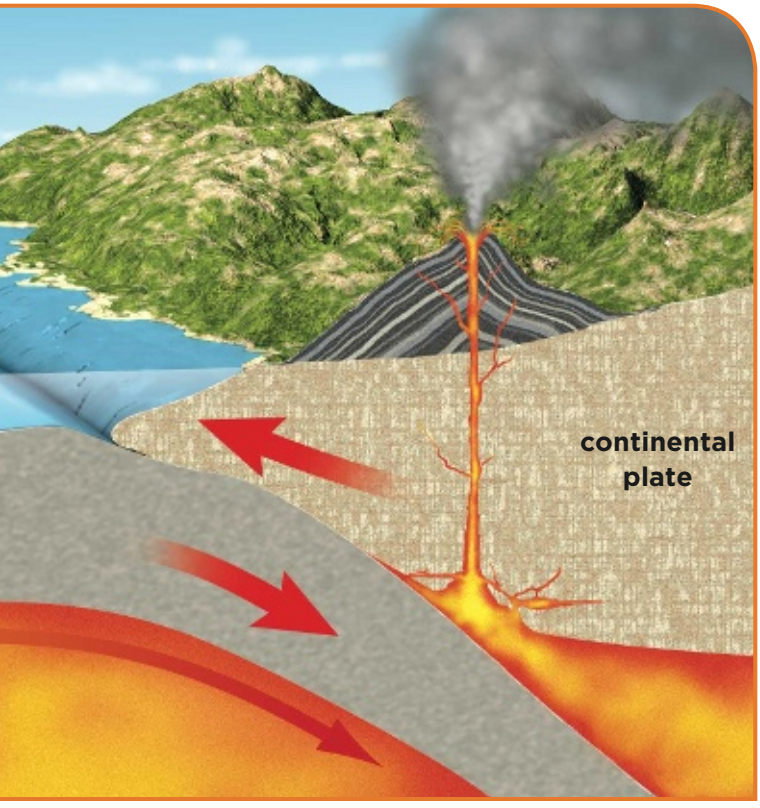
Types of Plate Boundaries



How Plates Move

There are seven large plates and about a dozen smaller ones. Each plate can move in a different direction or speed. At the boundaries where plates meet, dramatic events can occur.

Divergent boundaries **(Mid-Atlantic Ridge)**
• plates move away from each other • new crust forms (seafloor spreading) • occur at mid-ocean ridges
Convergent boundaries **(Himalaya Mountains)**
• plates move toward each other (collide) • one plate usually sinks under the other, or **subduction** • an ocean plate meets a continental plate (trench) • two continental plates meet (mountain range) • two ocean plates meet (trench or volcanic islands)
Transform boundaries **(San Andreas Fault)**
• plates slide past each other (earthquake)



Quick Check

10. Explain the three kinds of boundaries that can form when plates meet.

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Can earthquakes happen anywhere?

In mid-April 1906 San Francisco was hit by an earthquake, a shaking of the ground. The shaking destroyed most of the buildings in the city.

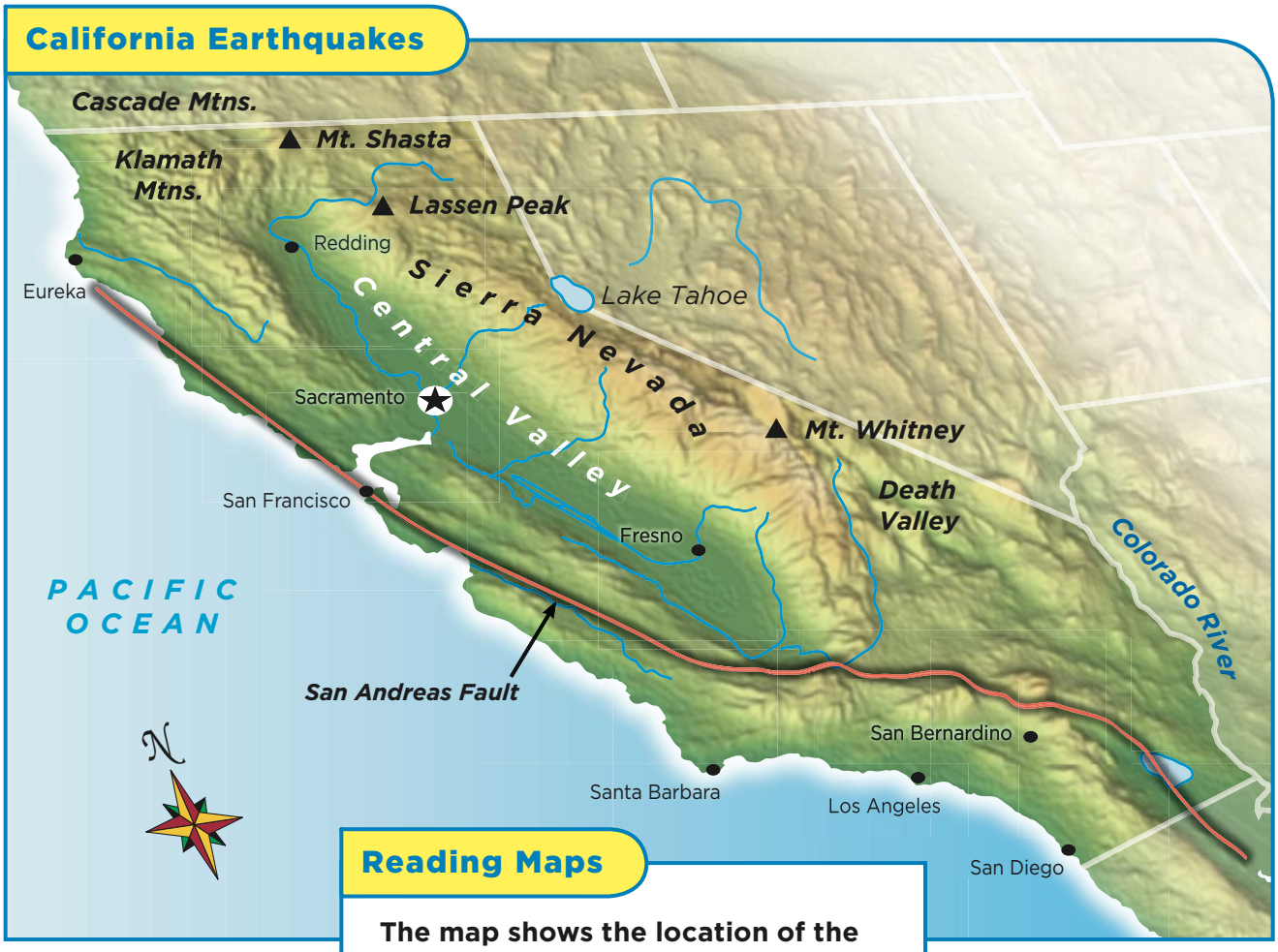
What causes an earthquake? Convection does. Because of convection, Earth's mantle is always moving. As the mantle drags on the plates, stresses build. When these stresses grow big enough, they overcome the strength of the rocks. The rocks move. Energy is released. An earthquake occurs.

San Francisco earthquake of 1906

Fault Zones

A **fault** is a crack in the lithosphere. Movements along faults cause earthquakes. Most faults are found along plate boundaries.

Many faults are connected to each other in some way. Areas that contain these kinds of faults are called fault zones. Earthquakes that occur along one of these faults often affect other faults in a fault zone.



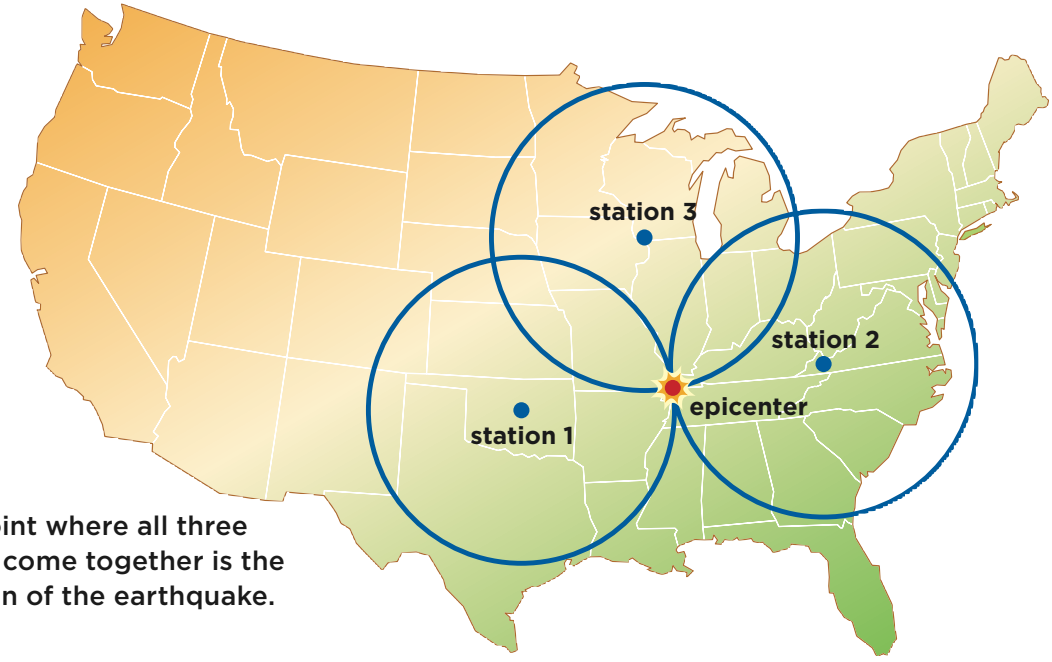
Reading Maps

The map shows the location of the San Andreas Fault. Many California earthquakes occur along the fault zone that includes the San Andreas.

Quick Check

11. Earthquakes occur along _____, which are

_____.

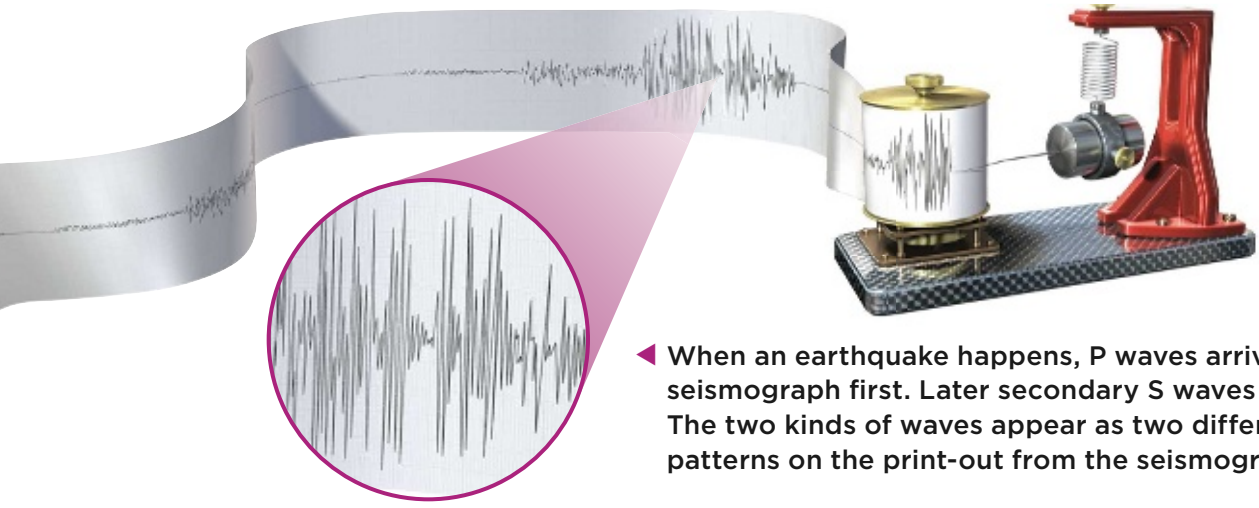


The point where all three circles come together is the location of the earthquake.

How do scientists learn about earthquakes?

To learn about earthquakes, remember that scientists use seismographs. These instruments measure the energy of an earthquake at the location of the seismograph. Seismograph stations are set up in many places throughout the world.

When an earthquake occurs, each seismograph records the vibrations from it. A circle is drawn on a map around each of these seismograph stations. The size of the circle shows how far the earthquake is from the station. The earthquake is located where all the circles meet.



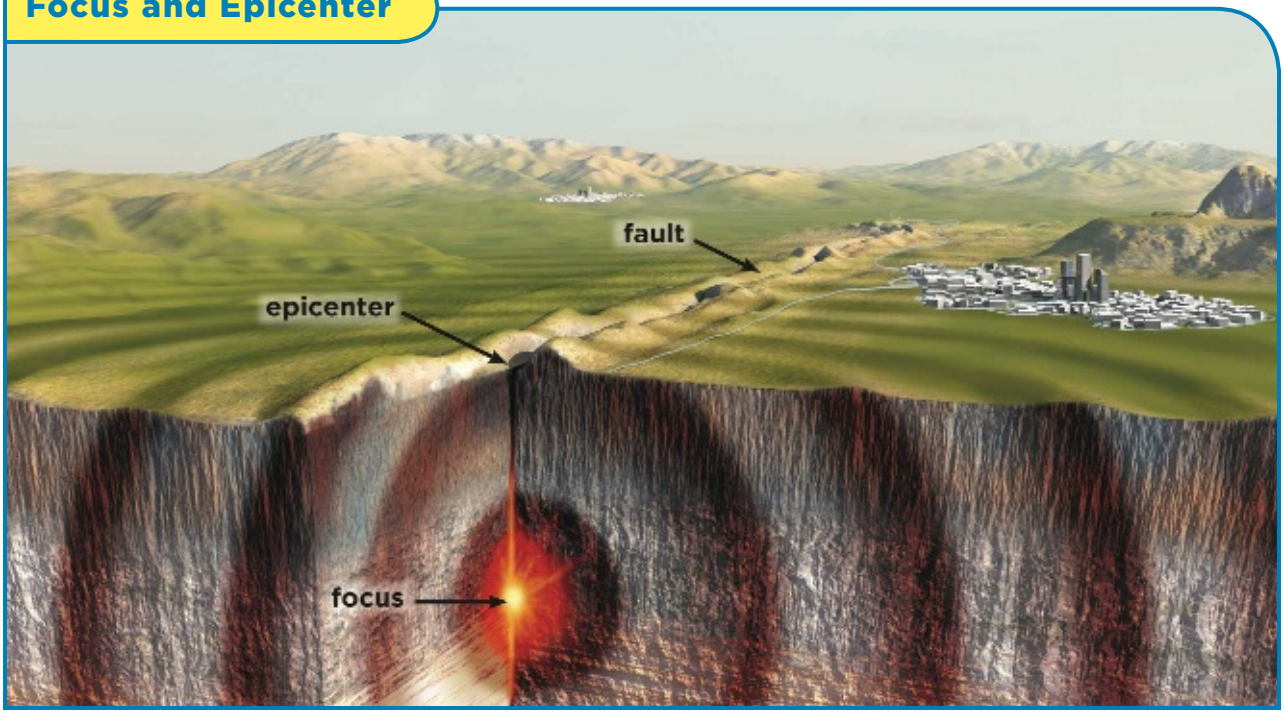
When an earthquake happens, P waves arrive at a seismograph first. Later secondary S waves arrive. The two kinds of waves appear as two different patterns on the print-out from the seismograph.

Using a Seismograph

Scientists use a seismograph to find two very important pieces of information about an earthquake. The **focus** is the point below the surface of the Earth where an earthquake occurs. The **epicenter** is the point on the surface directly above the focus.

To find these places, scientists study the wavy lines of the P waves and S waves that are recorded by the seismograph. Since P waves travel faster than S waves, they arrive at the seismograph station at different times. This time difference helps them find the epicenter and focus.

Focus and Epicenter



Quick Check

12. What is the difference between the focus and the epicenter of an earthquake? _____

_____

_____

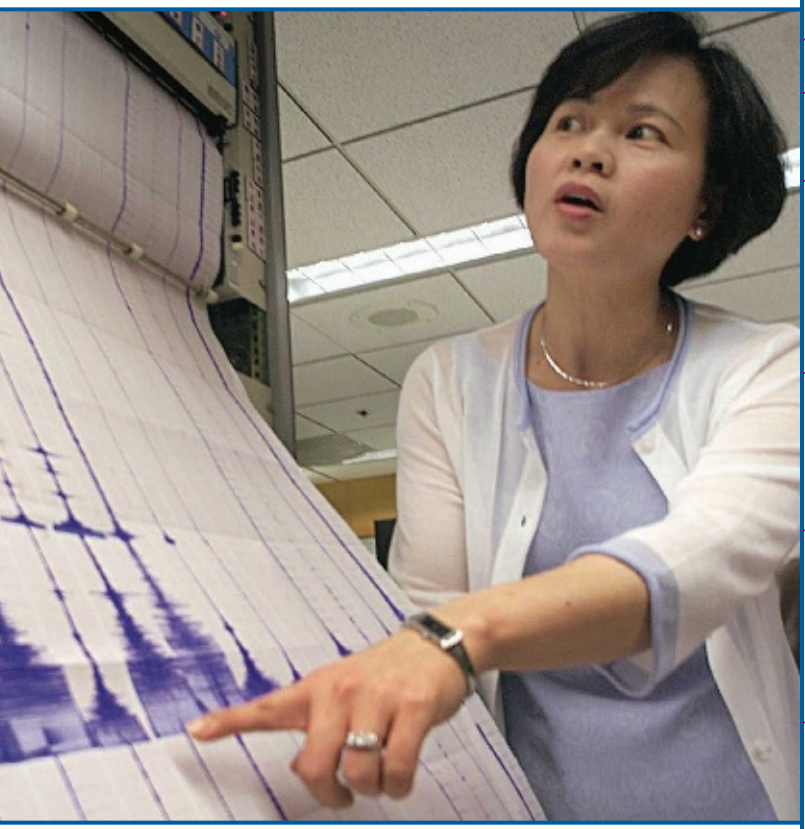
How is the strength of an earthquake measured?

The strength of an earthquake is measured in two ways. One way is by indicating its magnitude. **Magnitude** tells how much energy was released during an earthquake. It is based on the amplitude, or height, of the waves recorded on the seismograph.

Magnitude is measured on the **Richter scale**. Magnitude is expressed in whole numbers and decimals. An increase of 1 on the Richter scale means an increase of about 30 times in the energy released.

Quick Check

13. What magnitude on the Richter scale would indicate a major earthquake? _____



▲ A seismologist monitors the strength of an earthquake.

Summary of the Richter Scale

Magnitude	Descripton
1–2+	Recorded on local seismographs but not generally felt
3–4+	Often felt, no damage
5+	Widely felt, slight damage near epicenter
6+	Damage to poorly constructed buildings and other structures within tens of miles or kilometers from epicenter
7+	"Major" earthquake causing serious damage within up to 100 km (60 mi) of epicenter
8+	"Great" earthquake causing great destruction and loss of life in areas more than 100 km (60 mi) from epicenter
9+	"Rare great" earthquake causing major damage over a large region more than 1,000 km (600 mi) from epicenter

How is the intensity of an earthquake measured?

Another way to measure an earthquake's strength is by its intensity. **Intensity** is how strong the earthquake feels at the surface. Intensity is measured using the **Mercalli scale**. It tells what people feel and observe when an earthquake occurs. The Mercalli scale is based on observed effects, not on math. This scale is not as scientific as the Richter scale.

▲ **An earthquake measured at intensity VI on the Mercalli scale can cause damage inside a building.**

Summary of the Mercalli Scale

Intensity	Descripton
II	Felt by persons at rest or in places more favorable to sensing tremors
IV	Felt indoors and outdoors; like vibrations of passing heavy trucks; windows, doors, and dishes rattle
VI	Felt by almost everyone, walking is unsteady, pictures fall off walls, furniture may move or fall over
VIII	Walls may collapse, monuments may fall
X	Most buildings are destroyed, large landslides occur, train tracks are bent slightly
XII	Damage nearly total, objects thrown into the air, some landforms moved

Quick Check

14. Why is the Richter scale a more useful scale than the Mercalli scale when measuring the strength of an earthquake?

How can we prepare for earthquakes?

In 1906 and 1989 San Francisco was hit by huge earthquakes. In 1857 the largest California earthquake, the Fort Tejon quake, struck. These quakes and others have caused tremendous damage and loss of life.

During an earthquake, the ground may open. Some parts of the ground may rise or sink. The wave motion of an earthquake may cause bridges, highways, and buildings to collapse. The motion of an earthquake may also trigger landslides.

Scientists still cannot predict when an earthquake will occur. Nor can they prevent them. However, people can take steps to lessen the effects of an earthquake.

Seismic Safety

Many California cities and towns are taking steps to limit the damage caused by earthquakes. New buildings have shock absorbers built into them. Highways have special structures built into them to support them during an earthquake. Topographic maps are made to help scientists learn which areas are likely to suffer most during an earthquake. You can also take steps to be seismically safe.

Earthquake Safety

Before an Earthquake

- Make an emergency escape plan with your family.
- Put together an earthquake kit that includes drinking water, a flashlight, extra batteries, a portable radio, and a first-aid kit.
- Take a course in first aid and CPR.

During an Earthquake

- If you are outside, move into the open, away from buildings, streetlights, and utility wires.
- If you are in your house, go to the corner of the room, away from windows, shelves, or mirrors.
- If you are in school, get under your desk, and follow the school emergency plan.

After an Earthquake

- Check yourself for injuries.
- Remind your parents to turn off sources of natural gas, electricity, and water.
- Know how and when to dial 9-1-1 or your local emergency number and which radio station to tune to for emergency information.
- Stay away from damaged buildings.

Quick Check

15. Three steps you can take to prepare for an earthquake are

_____, _____, and

_____.

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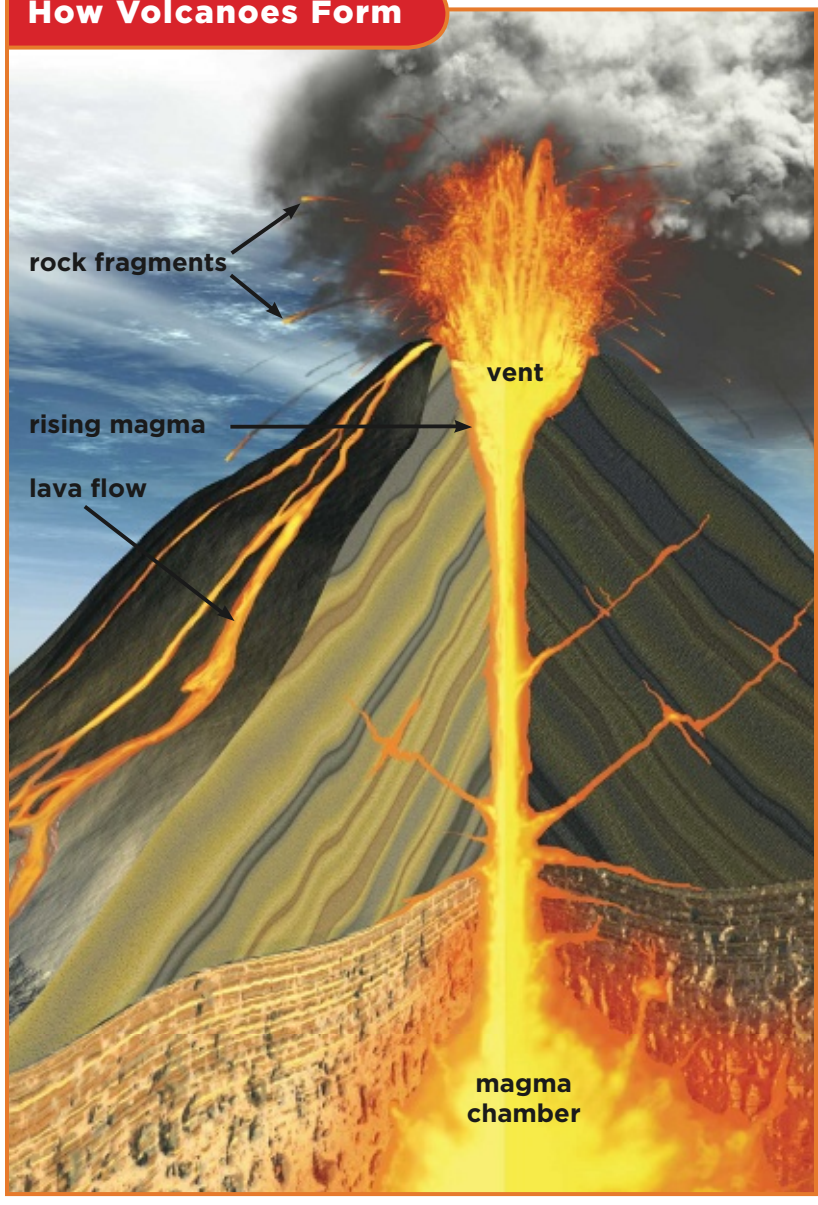
What are volcanoes?

Volcanoes are vents in the crust through which magma, gases, and other materials erupt. Most volcanoes are found along plate boundaries.

Volcanoes are produced by powerful forces inside the Earth.

- One plate is subducted below another.
- Mantle rocks melt and become magma.
- Gases mix with the magma.
- The magma rises toward the surface.
- Magma collects, forming a *magma chamber*.
- In time, magma escapes through an opening in the crust, a *vent*. An eruption occurs.
- The magma, now called lava, hardens into rocks. A volcanic mountain forms.
- The top of a volcano often has a bowl-like feature called a *crater*.

How Volcanoes Form



Quick Check

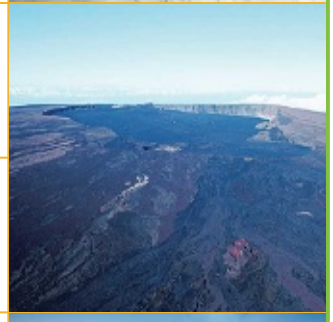
16 The magma in a volcano collects in a _____ _____ and erupts through a _____.

What kinds of volcanic landforms are there?

No two volcanoes are the same. Volcanoes differ in

- the kinds of materials they give off
- the intensity of eruptions (how strong eruptions are)
- how often eruptions occur
- the types of landforms that result.

With all these differences, there are basically three main types of volcanoes.

Type of Volcano	Examples	Features	Photo
Cinder cone volcano 	Paricutìn (Mexico)	• made up of small rock particles, or cinders • usually a small cone (top) with steep sides	
Shield volcano 	Mauna Loa (Hawaii)	• made up of layers of lava rocks. • usually has broad, gently sloping sides	
Composite volcano 	Mount Pelée (Martinique), Mount Vesuvius (Italy)	• made up of alternating layers of lava and ash • usually symmetric cones with steep sides that curve inward	

Quick Check

17. Why do volcanoes have such different shapes? _____

_____

How do eruptions differ?

There are four basic types of eruptions. They are named after volcanoes that show that kind of volcanic activity.

Hawaiian eruptions

- named after volcanoes in Hawaiian Islands
- least violent eruptions
- very liquid lava flows out slowly
- builds up shield volcanoes

Vulcanian eruptions

- named after volcano off island of Sicily
- violent eruptions
- huge, loud explosions
- lots of ash, dust thrown into air

Strombolian eruptions

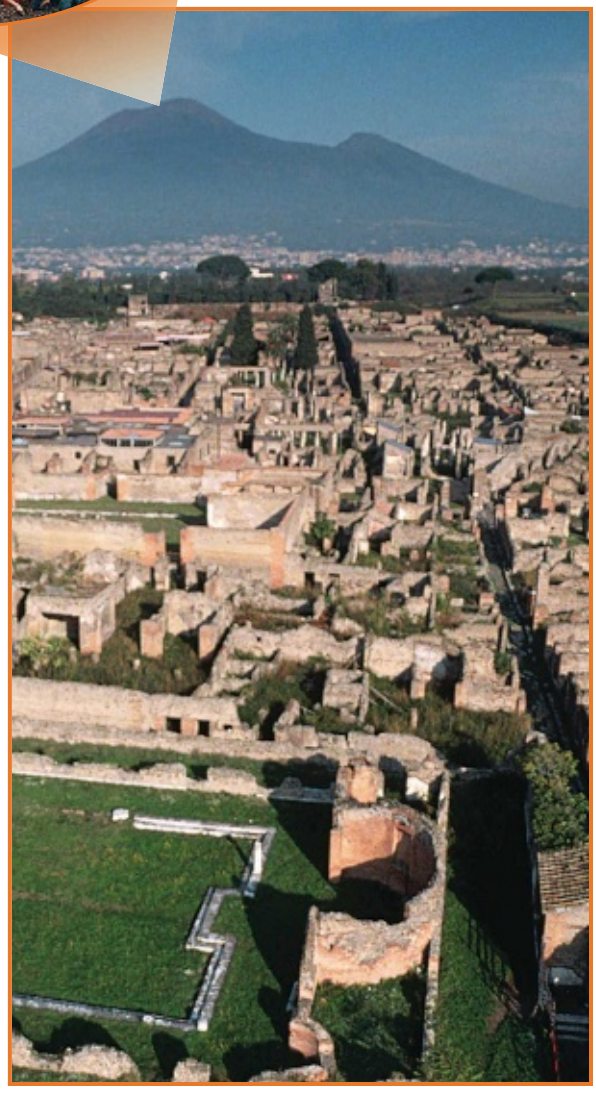
- named for volcano off Italian coast
- fairly gentle eruptions
- thick magma
- builds up cinder cones

Peléean eruptions

- named after Mount Pelée in Martinique
- most violent eruptions
- sticky magma contains gas under much pressure
- parts of the mountains may be blown away

▲ devastation from the 1980 eruption of Mount Saint Helens

Tourists view the crater of Mount Vesuvius. Mount Vesuvius, below, overlooks the ruins of Pompeii.



Volcanic Activity

To summarize kinds of eruptions, eruptions are often classified by how violent they are. Eruptions can:

- be violent explosions
- have lava flowing out slowly and quietly
- can have lava flowing more quickly, like a car on a highway

Scientists also classify volcanoes according to how often they erupt. A volcano may be active, intermittent, dormant, or extinct:

- Active volcanoes erupt constantly.
- Intermittent volcanoes erupt fairly often.
- Dormant volcanoes have become inactive for a long period of time. However, scientists are not sure that they will not erupt again. (*Dormant* is from the French word *dormir*, which means "to sleep.")
- Extinct volcanoes have not erupted within recorded history.

Quick Check

18. How do scientists distinguish between volcanoes?

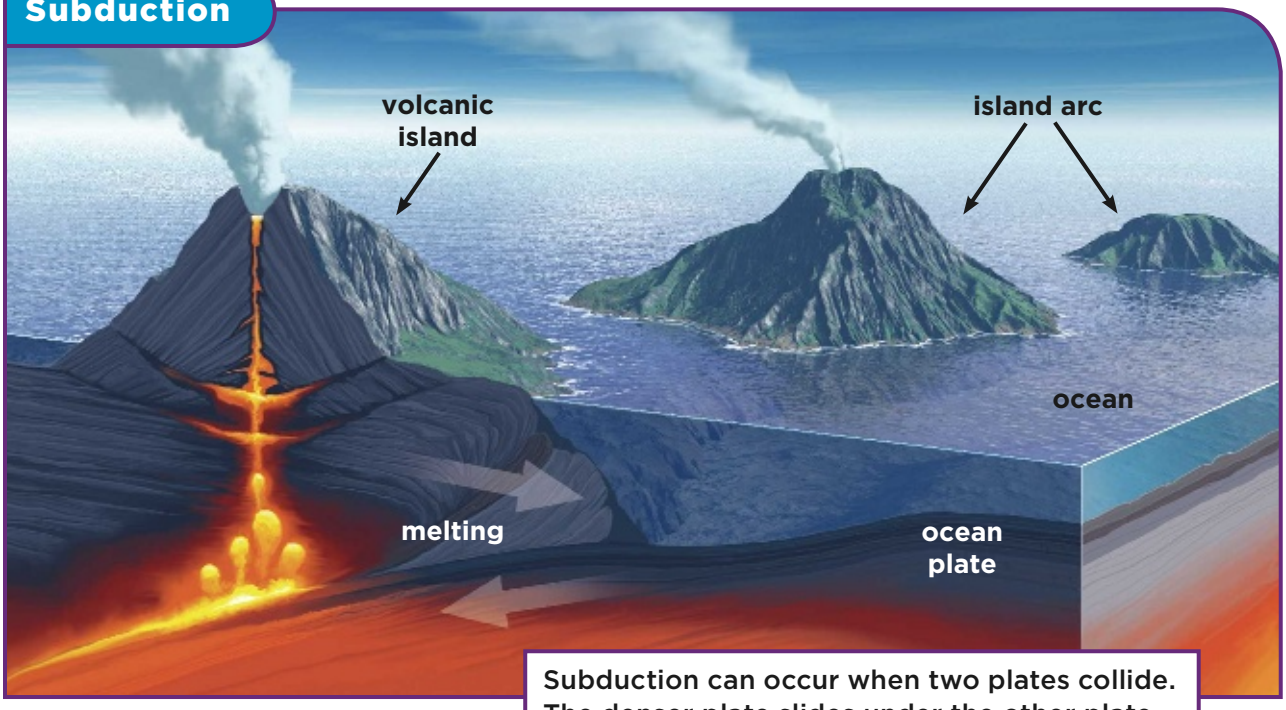
What are subduction zones, island arcs, and hot spots?

When an oceanic and a continental plate collide, the oceanic plate slides under the other. Rocks in the continental plate are pushed up to form mountains and mountain ranges. Many parallel mountain ranges make up a mountain belt.

When oceanic plates collide, one may be subducted. The melting plate forms undersea volcanoes, which in time reach the surface. A volcanic island arc forms. Island arcs and volcanoes around the Pacific Ocean rim form the Ring of Fire.

Most volcanoes occur along plate boundaries. The Hawaiian Islands are far from boundaries. They formed over a **hot spot**, a region of volcanic activity in the middle of a plate.

Subduction



Subduction can occur when two plates collide. The denser plate slides under the other plate and becomes part of the mantle.

hot spring, Yellowstone National Park

What are hot springs, geysers, and fumaroles?

New volcanic activity is still occurring. One place is Yellowstone National Park in Wyoming. Magma below Yellowstone is a source of heat for many volcanic features:

hot spring — a stream of hot, bubbling water flowing out of the ground.
geyser — a fountain of hot water and steam that shoots into the air. Eruptions may occur at regular or irregular intervals.
fumarole — a "geyser" in which only steam escapes.

Old Faithful geyser

Quick Check

19. What is the difference between a fumarole and a geyser?

20. Yellowstone is located over a hot spot. What can you conclude about Yellowstone's location on its plate?

What are the three main types of rocks?

Earth has many kinds of rocks. However, all rocks can be classified as one of three types. One of these types, igneous rocks, comes from magma or lava.

Igneous Rocks

Igneous rocks form in two ways:

- Lava from a volcano cools and hardens quickly. Basalt is a type of igneous rock.
- Magma below Earth's surface cools very slowly. Granite is an example of this kind of igneous rock.


granite

Sedimentary Rocks

Sedimentary rocks form over long periods of time:

- Wind and water break rocks into smaller rocks.
- Over time, these smaller pieces settle into layers. The layers build up.
- Pressure builds up on the bottom layers.
- The layers harden into rock.

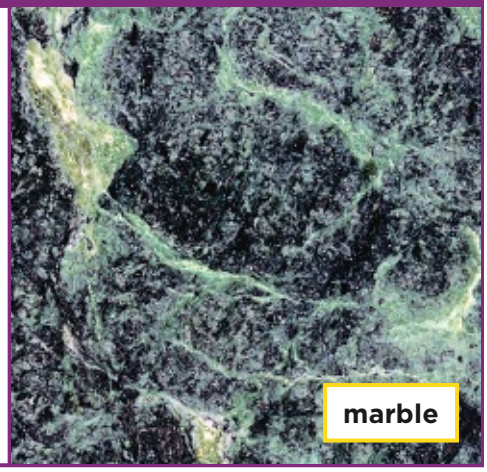
Sedimentary rocks can sometimes contain pieces of shell or fossils. They may also contain minerals.

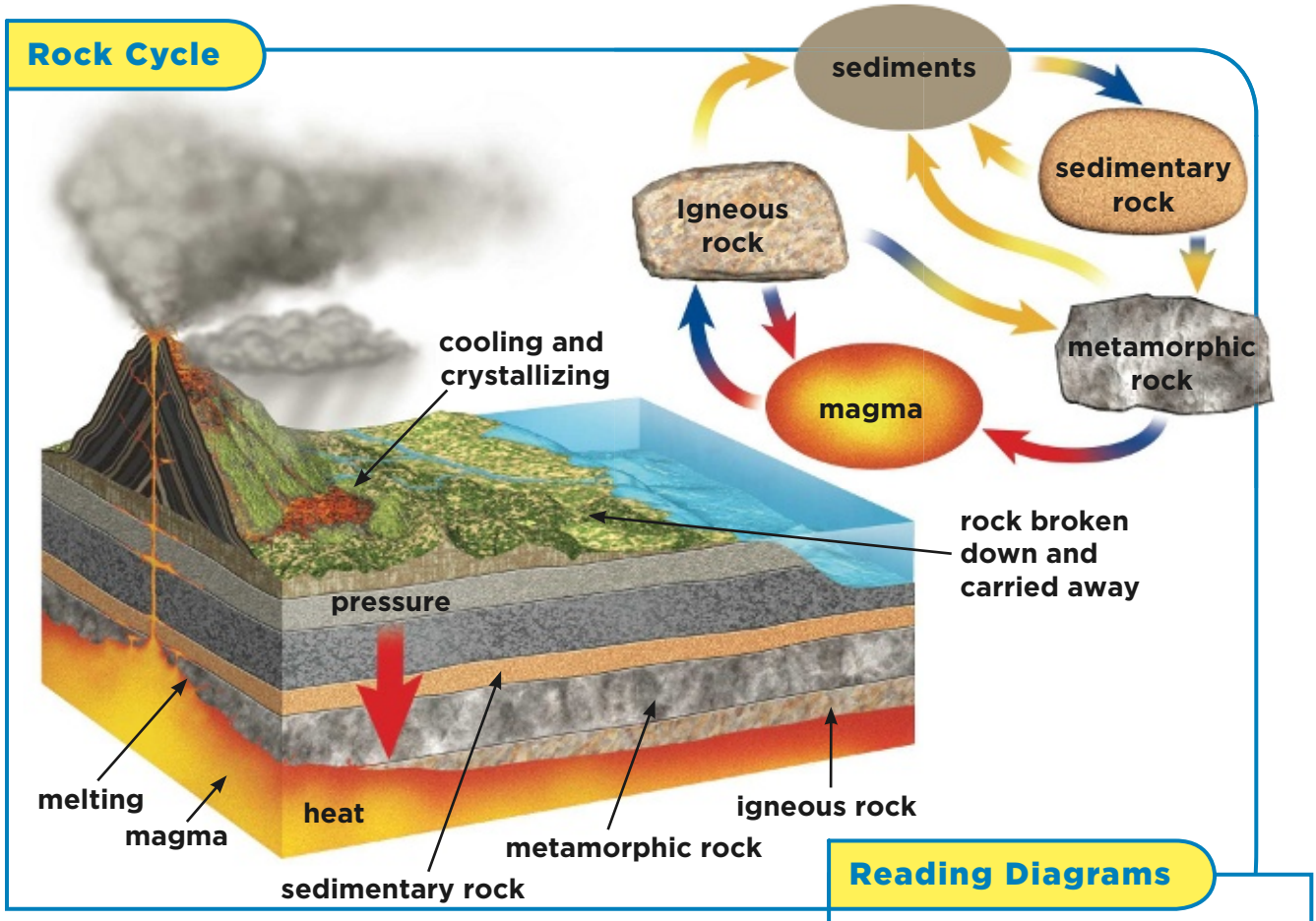

sandstone

Metamorphic Rocks

Metamorphic rocks are changed rocks:

- They were once igneous, sedimentary, or even other metamorphic rocks.
- Very high temperatures and pressures changed the form of the original rocks.
- They often form deep underground.


marble



The Rock Cycle

Where do rocks come from? Igneous rocks break down and eventually become sedimentary rocks. Under high pressure sedimentary rocks may become metamorphic. So, where do rocks come from?

Rocks come from other rocks. Rocks are changed from one type into another in a process called the **rock cycle**. Like the water cycle, the rock cycle never ends.

Quick Check

21. Evidence exists that suggests Earth started out totally molten. If this is so, what type of rock was the first type of rock? Why?

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What parts of California lie on different plates?

California lies on two lithospheric plates. Most of the state rests on the North American Plate, which includes all of North America and part of the Atlantic Ocean. A small part of California lies on the Pacific Plate. This plate includes a narrow piece of California west of the North American Plate and the Pacific Ocean.

Reading Maps

The map indicates the tectonic plates on which California lies.

San Andreas fault line is where the Pacific Plate and the North American Plate meet.

The San Andreas Fault

In California, the boundary between the North American Plate and the Pacific Plate is called the **San Andreas Fault**. It begins just north of San Francisco and extends south into Mexico and the Gulf of California.

The two plates slide past each other along the San Andreas Fault. The Pacific Plate is slowly moving northwest along the fault. Sometimes the Pacific Plate does not move for years. Then, suddenly, the rocks may jump forward as much as several meters. The result is often large earthquakes.

Quick Check

22. The Pacific Plate is moving northwest at about 5 cm (2 in.) per year. Where might Los Angeles be located in about 2 million years?

What features of California are the result of plate tectonics?

Millions of years ago, much of Central and Southern California was under water. The major features of California's landscape are the result of plate tectonics.

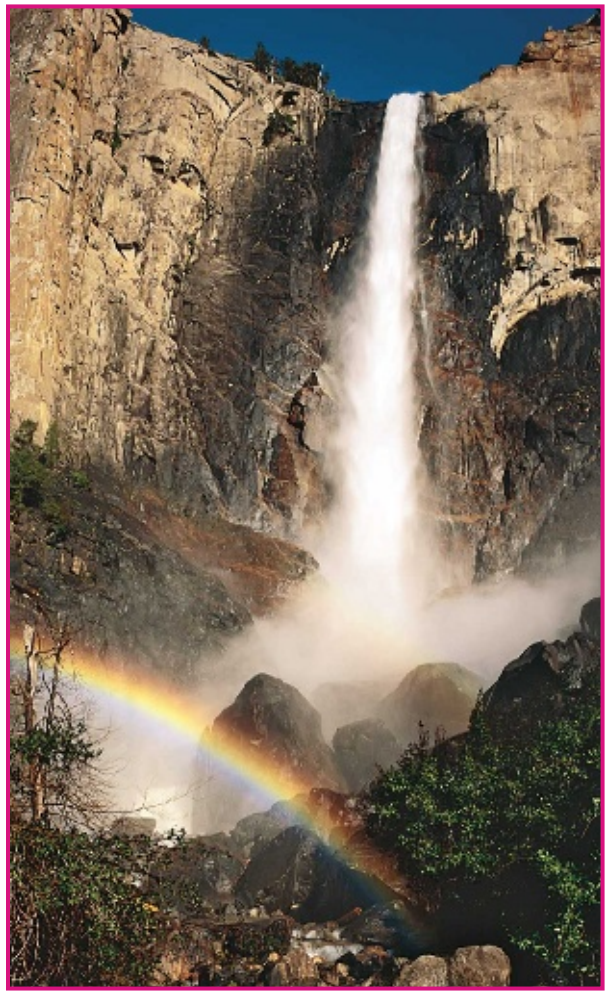
Feature	Facts
Central Valley	• largest valley in California • 800 km long, 64 km wide • bordered by Sierra Nevada and Coast Ranges
Los Angeles Basin and Ventura Basin	• valleys between Transverse and Peninsular Ranges • unstable (frequent earthquakes)
Coast Ranges	• low narrow ridges rising from the sea
Klamath Mountains	• were an island long ago
Cascade Range	• many volcanoes are located here
Sierra Nevada	• highest mountain range in California

Land, long ago pushed upward and northward, helped form Big Sur's rugged coastline.

What are some of California's notable features?

In many ways California is the result of tectonic forces, which are still at work today. Here are some of California's tectonic landforms that help make it one of the most beautiful states in the United States.

- The Sierra Nevada range has deep canyons and high waterfalls. Three national parks — Yosemite, Kings Canyon, and Sequoia — are located here.
- Mount Whitney, at 4,419 m, is the highest point in the state.
- Death Valley contains the lowest point in North America (–82 m).
- Mount Shasta and Lassen Peak are two volcanoes that erupted within the last 300 years.



▲ **Bridal Veil Falls, Yosemite National Park, California**

Quick Check

23. Why might Yosemite Park have so many high waterfalls?

24. Why are there so many mountain ranges and valleys in our state?

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Vocabulary Review

Plate Tectonics and Earth's Structure

Write the letter of the description in the second column to match the word(s) in the first column.

1. ____ continental drift
2. ____ fault
3. ____ focus
4. ____ lava
5. ____ lithosphere
6. ____ magnitude
7. ____ Mercalli Scale
8. ____ mid-ocean ridge
9. ____ ocean trench
10. ____ plate tectonics
11. ____ Richter scale
12. ____ intensity
13. ____ seismic wave
14. ____ subduction

a. the strength of an earthquake

b. one plate sinking under another

c. rocks in the crust attached to the upper mantle

d. a way to measure the intensity of an earthquake

e. a long, deep undersea valley

f. Wegener's theory that a supercontinent split apart

g. the idea that Earth's surface is made up of moving plates

h. a vibration that travels through Earth

i. a way to measure the magnitude of an earthquake

j. magma at Earth's surface

k. a line of underwater mountains in the middle of an ocean

l. a crack in the lithosphere

m. the point below the surface where an earthquake occurred

n. the amount of energy released in an earthquake

Fill in the missing words in the blanks below. Then find and circle those words in the Word Search at the bottom.

1. A shaking of the ground is a(n) _____.

2. A crack in the crust through which magma flows is a(n) _____.

3. Molten rock in the mantle is called _____.

4. The point on Earth's surface just above the focus is the _____.

5. A region of volcanic activity in the middle of a plate is a(n) _____.

6. The boundary between the North American and Pacific plates is the San _____ Fault.

7. The process by which one kind of rock is changed into another is the _____.

E	A	R	T	H	Q	U	A	K	E
P	V	O	L	C	A	N	S	P	L
I	E	C	V	O	L	C	A	N	I
C	R	K	H	O	T	S	P	O	T
E	Y	C	O	S	L	R	M	N	H
N	H	Y	L	E	R	C	E	T	O
T	T	C	M	A	G	M	A	N	S
E	P	L	S	A	E	R	D	N	A
R	L	E	Q	U	A	L	E	T	O

CHAPTER 6

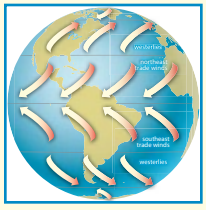
Shaping Earth's Surface

Vocabulary

weather the day-to-day conditions of the atmosphere in an area

humidity the amount of water vapor in the air

dew point the temperature at which condensation occurs



Coriolis effect the shift in wind direction caused by Earth's rotation

weathering the slow breakdown of rock into smaller pieces by natural events

abrasion the slow scraping away of land by tiny rock pieces carried by wind

erosion the wearing away of the land and carrying away of pieces the land

deposition the dropping off of soil and rock pieces in new places

sediment the rock particles that are dropped off on land or in water

glacier a slow-moving river of ice

What effects do weathering, erosion, and deposition have on Earth's landforms?

landslide the rapid, downward movement of rock, soil, and objects

flood plain the flat area of land on both sides of a river

delta a triangle-shaped deposit at the mouth of a river

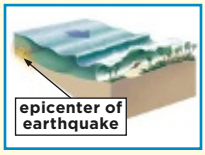
watershed the area from which water is drained

arroyo a small channel with steep banks located in a dry area

oxbow lake a portion of a stream channel cut off from the rest of the stream by erosion

beach erosion the way that waves pick up sand particles and move them along the shore

breaker a wave that breaks into foam as it moves against the shore



tsunami a series of waves caused by an earthquake or volcanic eruption beneath or near the ocean

levee a wall or large mound of earth built along a river

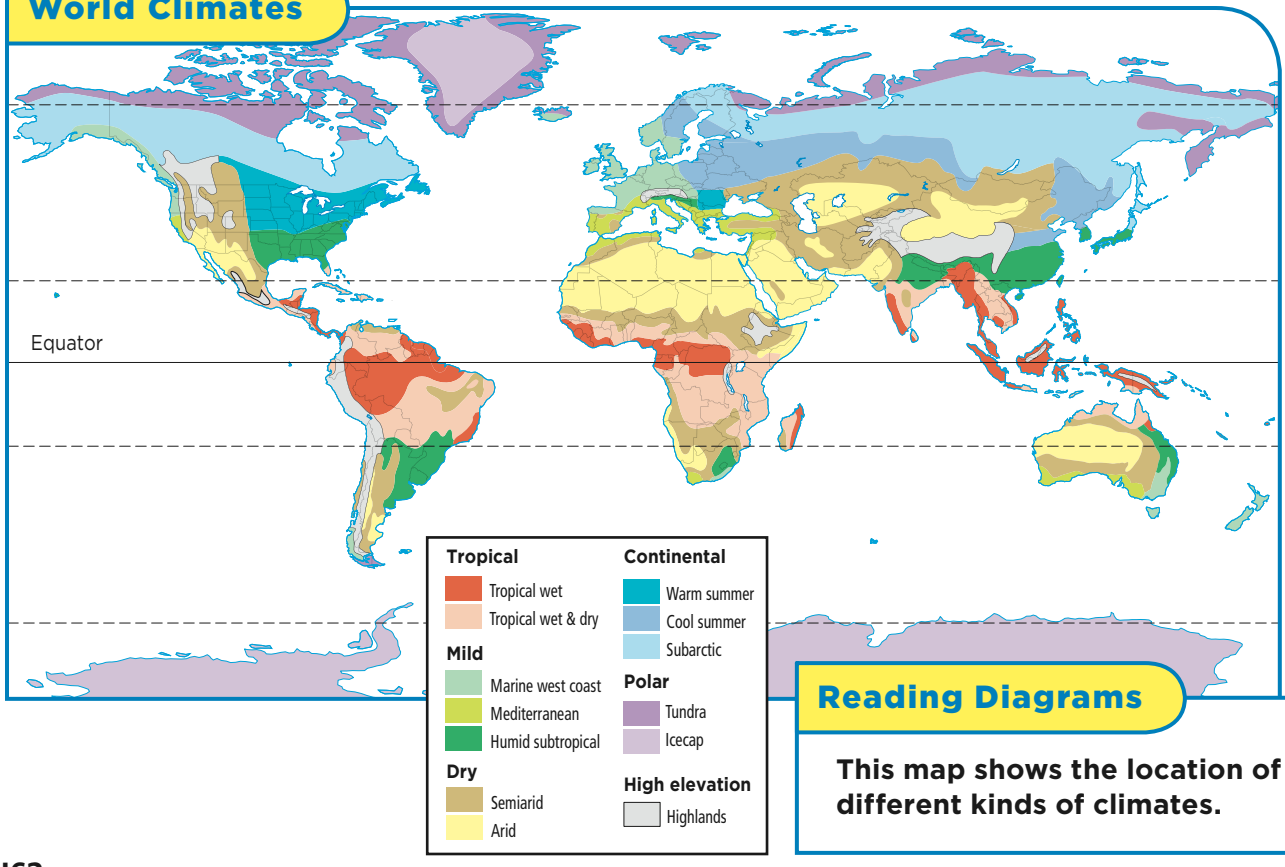
What is the difference between climate and weather?

Weather is the day-to-day conditions of the atmosphere in an area. *Climate* is the average weather conditions of a region. To talk about an area having cold winters, you are talking about climate. When you talk about yesterday being a cold day, you are talking about weather.

Climate is affected by

- latitude (distance from the equator) Areas near the equator will usually have a warm climate. Those nearer the poles will tend to have a cold climate.
- altitude (height above sea level) The higher up you go on a mountain, the cooler it gets.

World Climates



Reading Diagrams

This map shows the location of different kinds of climates.

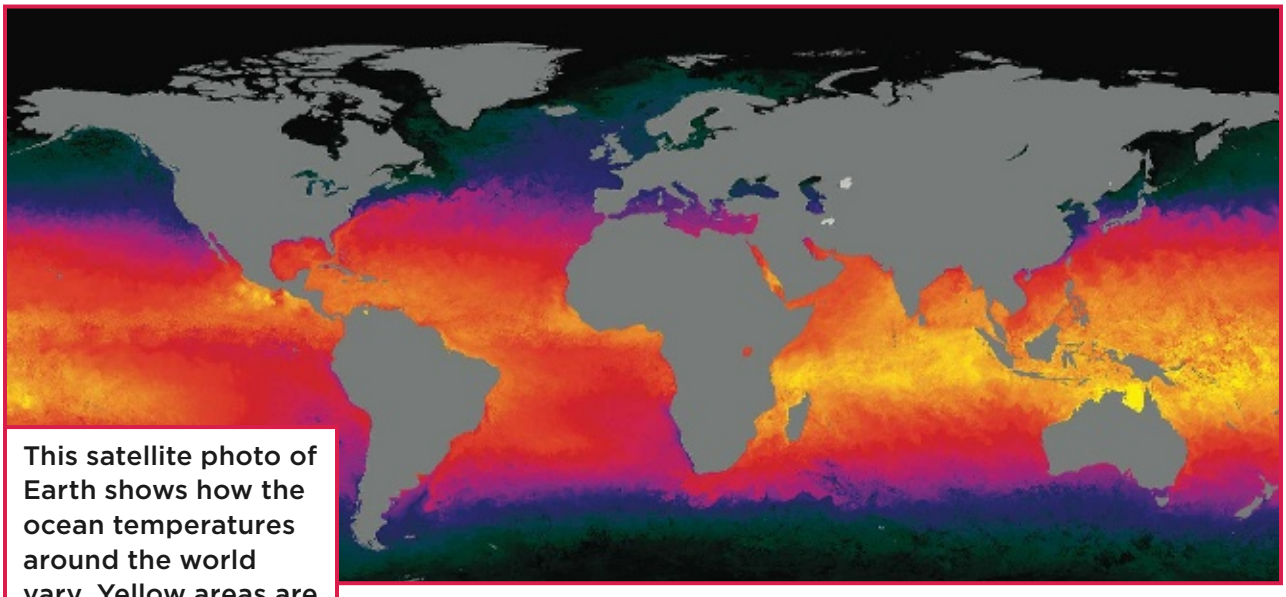
Changes in Weather

Many factors make up or contribute to the weather of an area. They include:

- air temperature
- air pressure
- moisture in the air
- cloud cover
- ocean temperature
- wind patterns

A change in any of these factors can change the weather. Weather conditions averaged over a long period of time determine an area's climate. For example:

- Tropical climates have high temperatures and rain all year.
- Polar climates are cold all year.



This satellite photo of Earth shows how the ocean temperatures around the world vary. Yellow areas are the warmest.

Quick Check

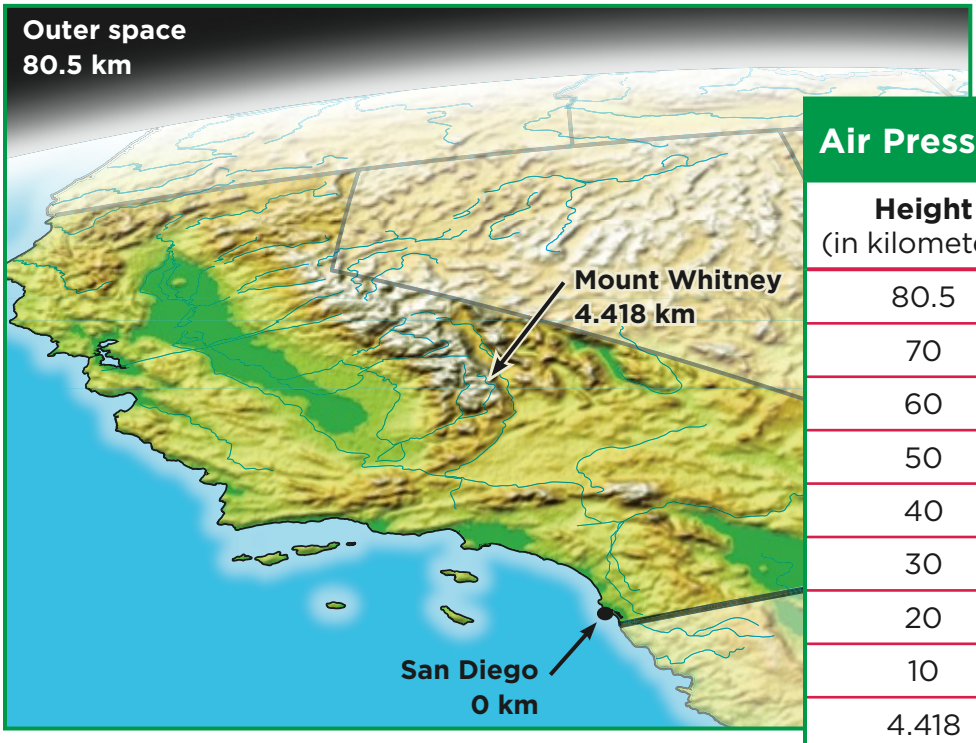
1. Juneau, Alaska, has a cold climate. San Diego, California, has a warm climate. How can you explain the difference in climate?

What is air pressure?

If you take a trip to the top of a mountain, you may feel your ears pop. This popping is a result of air pressure. *Air pressure* is the force on a region caused by the weight of air above. Air pressure is measured in Pascals.

Air pressure depends on temperature and gravity.

- *Air temperature* As the temperature rises, air molecules move apart. The air pressure goes down. As the temperature goes down, pressure goes up.
- *Gravity* Gravity pulls air molecules toward Earth, causing air pressure. At higher altitudes, there are fewer air molecules for gravity to attract. Air pressure decreases.

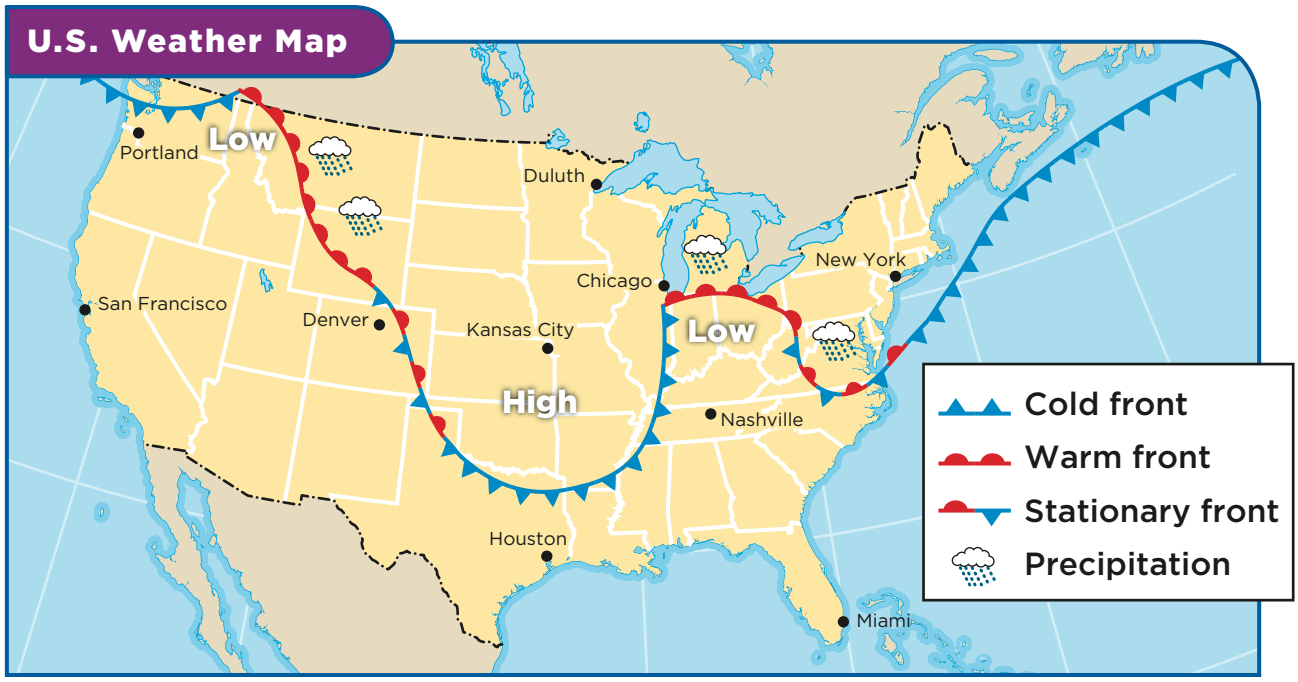


Air Pressure and Altitude

Height (in kilometers)	Air Pressure (in Pascals)
80.5	0.64
70	3
60	13
50	59
40	263
30	1,160
20	5,125
10	22,638
4.418	51,876
0	100,000

Quick Check

2. Using the table and diagram, the air pressure at the top of Mount Whitney is about _____ Pascals.



High- and Low-Pressure Systems

The Sun does not heat up all areas of Earth equally. As a result, some areas are warmer than others. A general rule is that as temperature goes up, pressure goes down. A warm area may cause a low-pressure system (a Low). A cool area may cause a high-pressure system (a High).

Warm air in the center of a Low rises and cools. Water vapor condenses, forming clouds. A Low often brings rainy or stormy weather. By contrast, a High usually brings fair weather with few clouds.

As Earth rotates, warm and cold air masses move as a result. The line where air masses meet is called a *front*. Fronts can be cold, warm, or stationary.

Quick Check

Write the letter of the description that fits each word.

3. ____ Low **a.** a line where air masses meet

4. ____ High **b.** usually brings storms

5. ____ front **c.** usually brings fair weather

What causes rain?

Precipitation is one of the steps in the water cycle. As solar energy causes evaporation, water vapor collects in the air. The amount of water vapor in the air is **humidity** (hew•MID•i•tee).

Warm air is less dense than cool air. So, it rises. As it rises, the temperature falls. As the temperature falls, less water vapor can stay in the air. When the air cannot hold any more water, the relative humidity is 100%. *Relative humidity* is the amount of water vapor in the air compared with how much it could hold at that temperature.

At 100% relative humidity, the vapor condenses. The temperature at which condensation occurs is called the **dew point**.

▲ These low clouds formed from water droplets. The arrows show the path water on the surface takes as it evaporates and forms clouds.

Types of Precipitation

There are four main types of precipitation. They are rain, sleet, snow, and hail. Each type begins as either water droplets or ice crystals in clouds. The temperature of the lower atmosphere determines which form the precipitation will take as it falls.

Precipitation	
	**Rain** falls when the air temperatures are above freezing.
	**Sleet** occurs when raindrops fall through freezing air near Earth's surface. The drops turn into pellets of ice.
	**Snow** falls when water vapor passes through air that is very cold. As a result, the water vapor crystallizes and builds into snowflakes.
	**Hail** forms when thunderstorm winds push water back up into the atmosphere. The water turns into ice, is coated with more water, and pushed up to freeze again. This process repeats until the hailstone is heavy enough to fall.

Quick Check

6. The dew point occurs when the relative humidity is

_____.

7. The four types of precipitation are _____,

_____, _____,

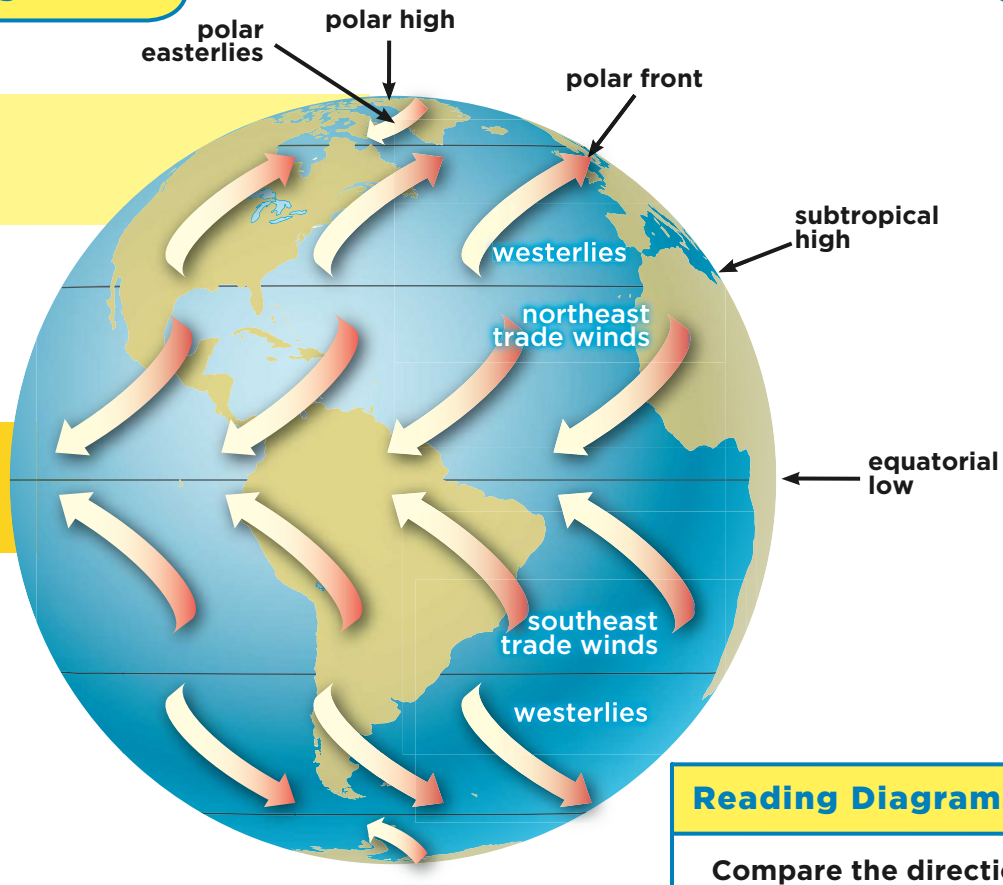
and _____.

How does wind change weather?

Wind travels from areas of high-pressure to areas of low-pressure. However, Earth is rotating. As a result, winds are shifted in a curve. This shift in wind direction is called the **Coriolis effect** (kaw•ree•OH•luhs).

The Coriolis effect makes winds blowing from the North Pole to curve to the right in northern latitudes. (South of the equator, winds curve to the left.) As a result, in the Northern Hemisphere, weather usually travels from west to east.

Prevailing Winds



Reading Diagrams

Compare the directions of wind zones in the Northern and Southern Hemisphere.

Quick Check

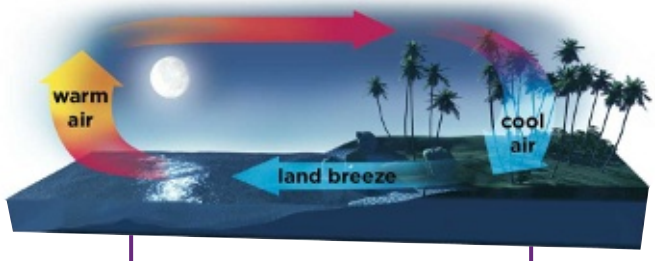
8. The curving of winds due to Earth's rotation is the

_____.

Sea and Land Breezes

Winds can affect how it feels near the seashore. During the day, the Sun heats the land faster than the water. Air pressure is higher over the water than the land. Wind flows toward the shore, making a *sea breeze*. At night, the land cools off faster, resulting in a flow of wind toward the sea — a *land breeze*.

During the day, winds usually blow rom the water toward the land.



At night, the wind changes direction and blows from the land toward the water.

Cyclones

Winds affect large areas. A *cyclone* is a huge mass of spinning air surrounded by high pressure. Winds in a cyclone blow inward counterclockwise. Because cyclones are Lows, they bring storms. They can turn into *hurricanes*.

Hurricanes are very large storms with powerful winds and heavy rains, which can cause great destruction.

Quick Check

Write the letter of the description that fits each word.

9. ____ sea breeze	**a.** huge mass of spinning air
10. ____ land breeze	**b.** huge storm with wind and rain
11. ____ cyclone	**c.** winds blowing from shore to sea
12. ____ hurricane	**d.** winds blowing from sea to shore

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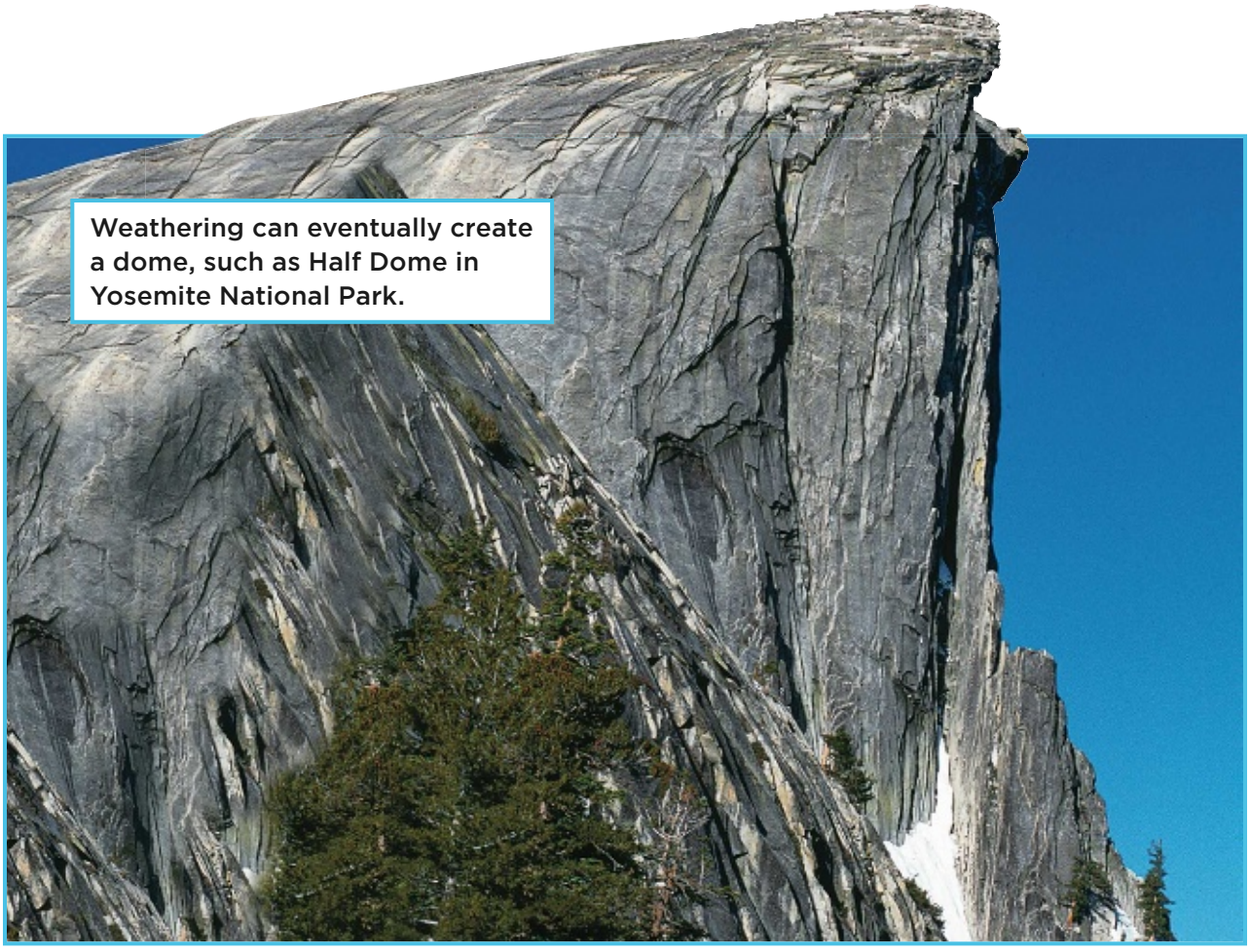
What is weathering?

Weathering is the slow breakdown of rock into smaller pieces by natural events. These events include precipitation, wind, plant growth, and temperature changes.

Chemical Weathering

There are two types of weathering. One type is *chemical weathering*. This kind occurs when minerals in rock interact with chemicals in water and the air. For example, acid rain may eat away limestone. Chemical weathering changes the composition of the rock.

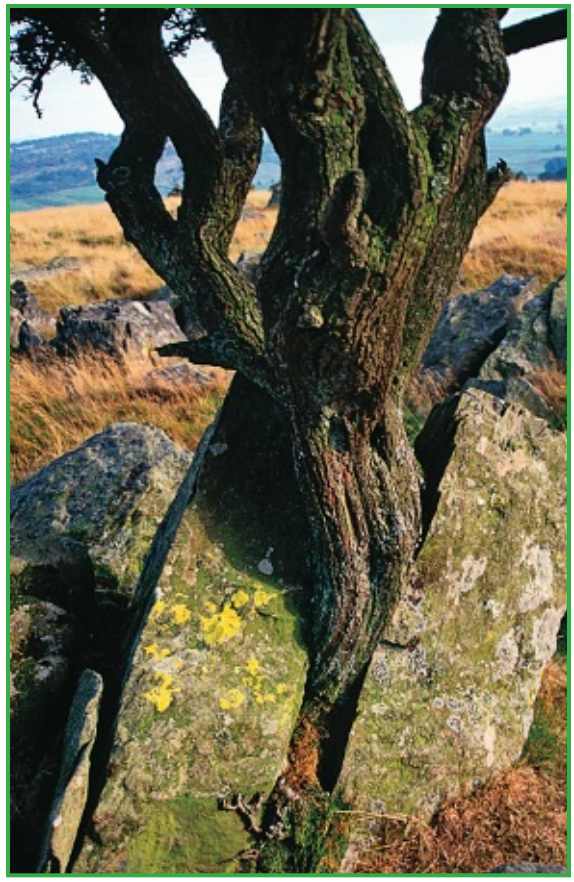


Weathering can eventually create a dome, such as Half Dome in Yosemite National Park.

Physical Weathering

Another kind of weathering is *physical weathering*. Physical weathering breaks rock into smaller pieces but the rock pieces keep the properties of the original rock. There are three main causes of physical weathering.

- *Water* — When water freezes, it expands. Water in cracks in rock push outward when it freezes, slowly breaking the rock.
- *Roots* — As roots push their way into rocks, the pressure they exert slowly pushes the rock apart.
- *Wind* — Tiny rock pieces carried by wind slowly drill and grind away landforms. This process is called **abrasion**. Abrasion acts like sandpaper, pitting and polishing the surface.

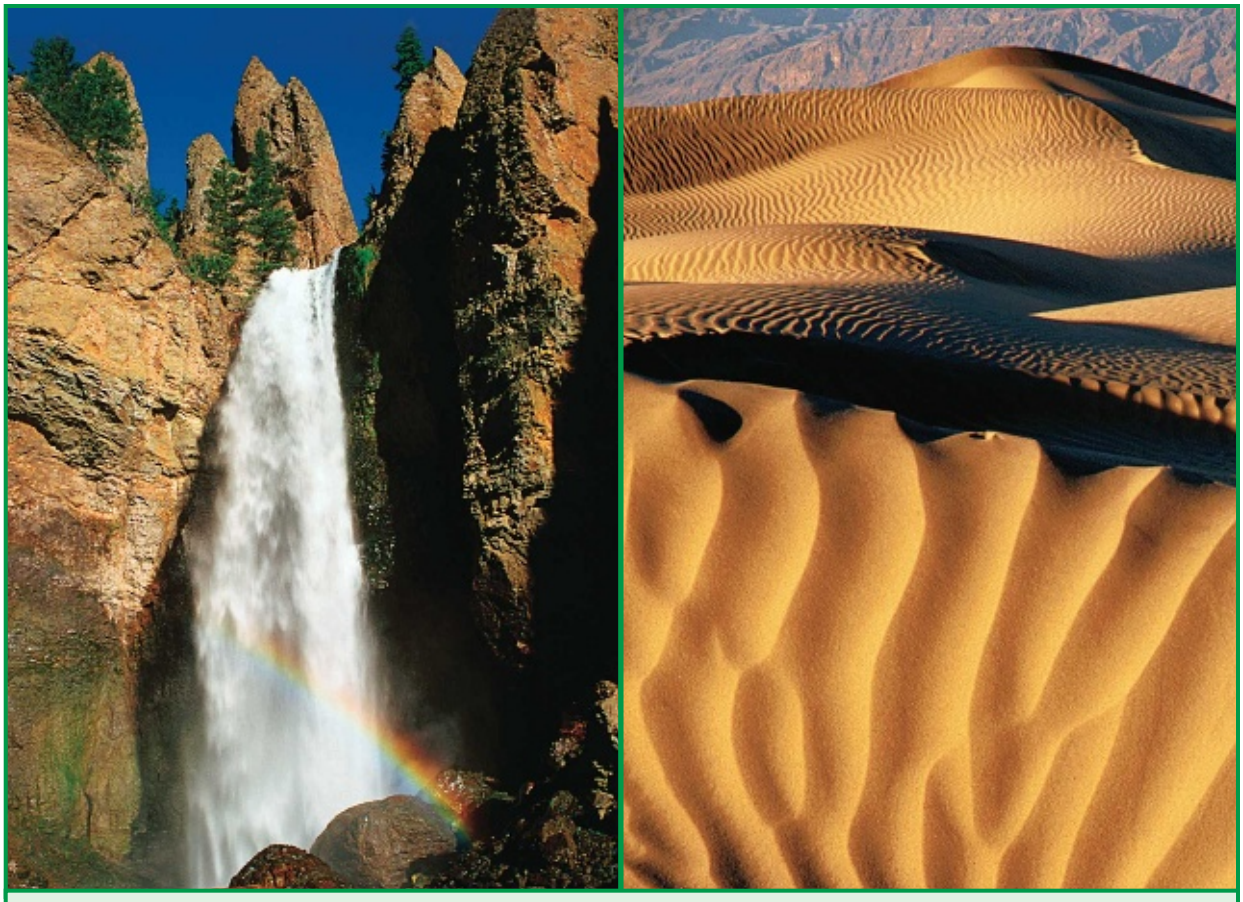


▲ **Tree roots can penetrate cracks in rock. In time the rock may break apart.**

Quick Check

Use the diagram below to show how physical weathering can change rock.

Cause	→	Effect
13.	→	
14.	→	
15.	→	



Water and wind are both very powerful agents of erosion.

How is Earth's surface reshaped?

Earth's surface is reshaped by

- **erosion** (i•ROH•shuhn), the wearing away and movement of Earth's surface, and
- **deposition** (DEP•uh•zi•shuhn), the way the eroded soil and rock are put down in new places. Most of the rock particles, called **sediment**, (SED•i•muhnt) are deposited in deserts, rivers, flood plains, and oceans.

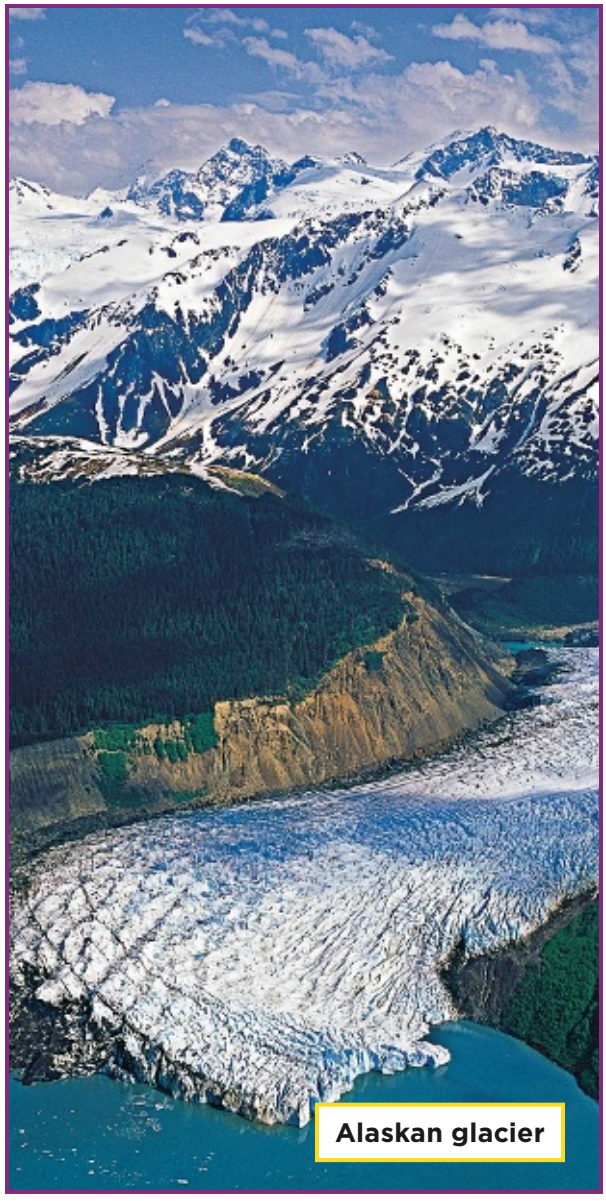
Water plays the main role in erosion and deposition. However, wind also plays an important role in these processes. This is especially true in dry areas. Blowing wind picks up and drops off particles of sand into wavy mounds called *sand dunes*.

Glaciers

A **glacier** is a slow moving river of ice. Although glaciers move slowly, they can erode the land the similar ways as water and wind do. As a glacier moves along the ground, it scrapes the land underneath it. It drags rocks along with it. A glacier also pushes material in front of it as it moves.

Some glaciers form in high mountainous areas. These glaciers often carve out U-shaped valleys as they move. Alaska has many examples of this type of glacier. Other glaciers are huge sheets of ice. These glaciers flow outward in all directions from a central place. Such glaciers may cover large areas. The island of Greenland is covered by this type of glacier.

Glaciers move and deposit amounts of sediment. Large parts of North America were once covered by glaciers. These glaciers deposited layers of soil and rock tens or hundreds of meters thick.



Alaskan glacier

Quick Check

16. Erosion and deposition are caused by _____,

_____, and _____.

17. How do glaciers change the land? _____

_____

What are landslides?

How fast materials are eroded depends on the speed and amount of wind or water. However, soil and rock can move downhill without wind or water. They move downhill because of the slope of the land.

The movement can be so slow that it is barely noticeable. On the other hand it can be a **landslide**—a rapid, downward movement of rock, soil, and other objects. In mountains that have a thick cover of snow, landslides are called *avalanches*.

Landslide

Reading Photos

This photo shows how dangerous a landslide can be.

Factors in Landslides

Several factors can cause a landslide to occur. They include

- **gravity** Earth pulls everything toward its center. If rock weakens, it eventually falls. The Old Man in the Mountain in New Hampshire fell due to gravity.
- **slope of the land** The steeper a hillside is, the easier it is for rock and soil to slip.
- **water** Water seeps into the spaces between rocks. This makes it easier for the rocks to slide.
- **loud noises** Loud noises make the rock and soil vibrate. The vibrations make it easier for the rock to move.

Gravity and a steep slope caused this landslide near La Conchita, California.

Quick Check

18. Which four factors can cause a landslide?

_____, _____,

_____, _____

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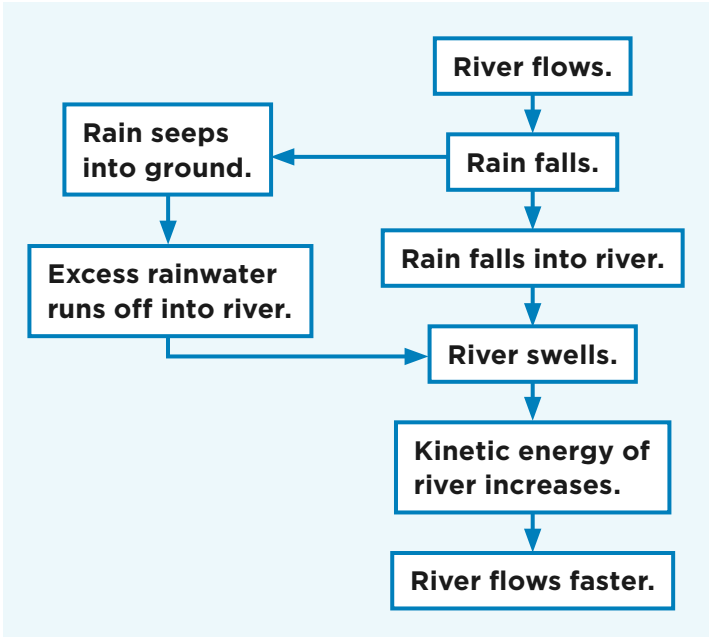
What affects how a river or stream flows?

If you live near a river or stream, you may notice that the water flows fast and high on some days. On other days, the water is slow and may be just a trickle. Why is there a difference?

Rainfall can affect how fast or slow a river or stream flows. As more water enters a river or stream, the speed of the flow increases. The following diagram summarizes this river flow.



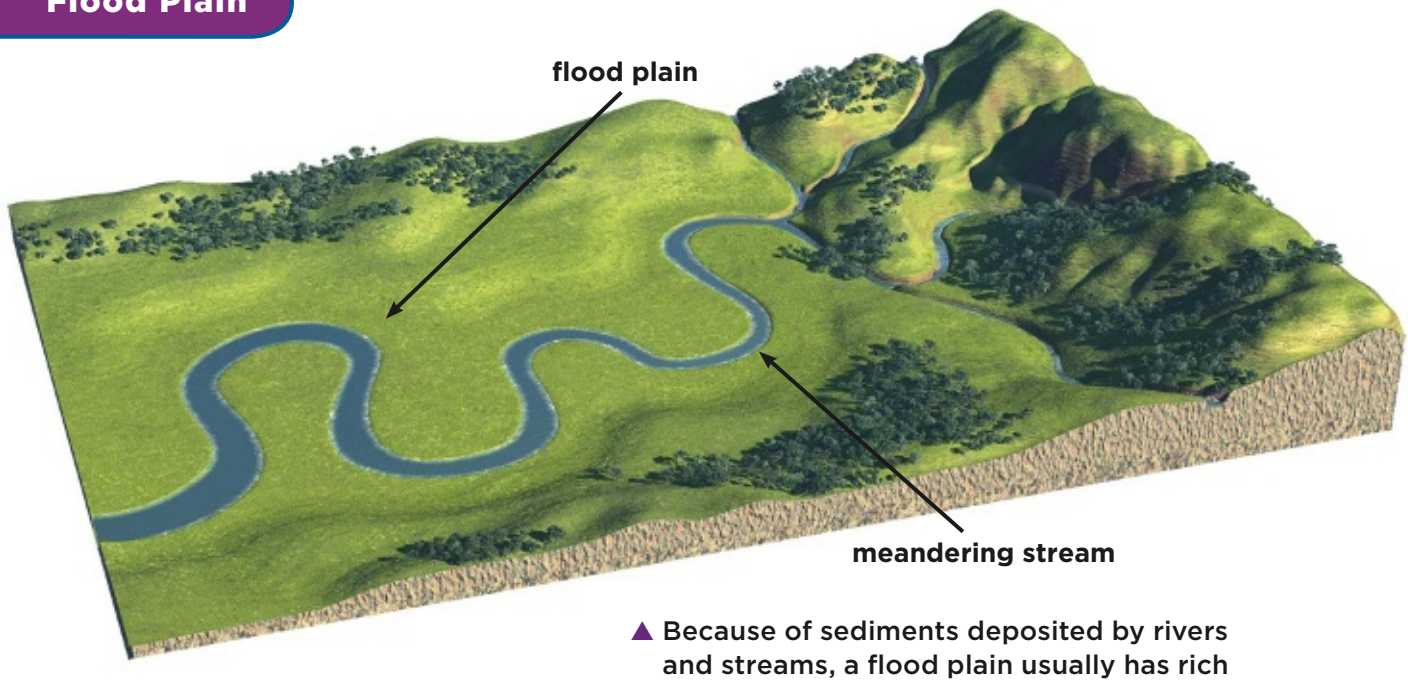
▲ After a heavy rain, the amount of water in a river increases, so the river flows at a greater speed.

Flowing Water

Flowing water is a powerful force. It can change the look of a river. Any river has a *bank*, the rising ground at its edges. When a river overflows its banks, the water covers its flood plain. A **flood plain** is the flat area of land on both sides of a river.

As a river flows, small pieces of it are carried along with it. These particles act like tiny drills. They slowly erode the banks. Eventually the path of the river develops curves, or *meanders* (mee•AN•durz), as the river flows to the sea.

Flood Plain



▲ Because of sediments deposited by rivers and streams, a flood plain usually has rich soil that can produce good crops.

Quick Check

19. How does rainfall increase the speed of a river? _____

_____

_____

What are the stages of stream development?

No two streams are exactly alike. However, streams go through three similar stages.

- A *young stream* moves swiftly down steep slopes. It may have rapids and waterfalls.
- A *mature stream* has most of the rocks in its bed eroded. At this stage, streams often develop meanders, as well as a flood plain.
- An *old river* flows slowly through a broad, flat flood plain. A delta often forms. A **delta** is a triangular-shaped deposit that forms at the mouth of a river.

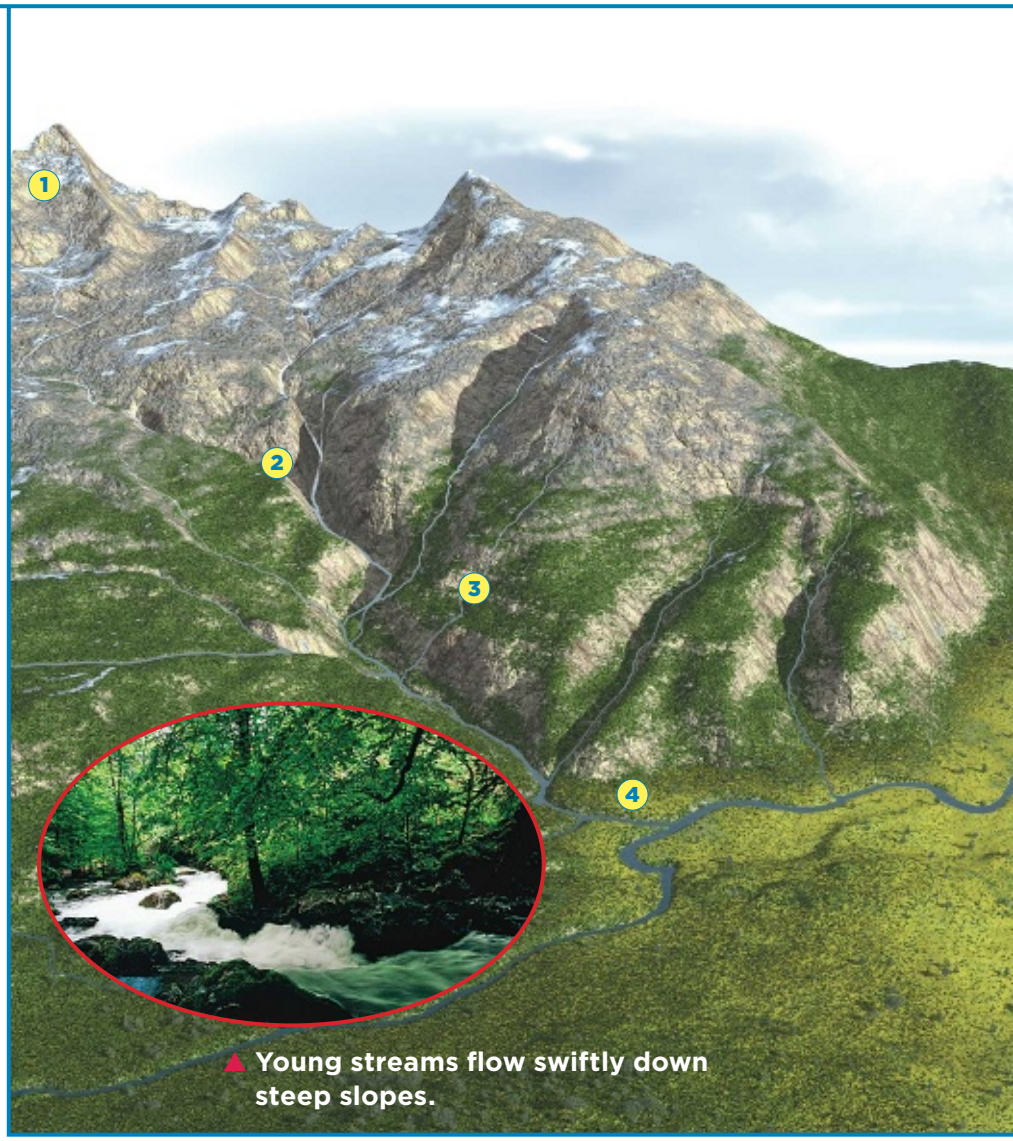
The Life of a Stream

A river usually has more water than a stream. However, scientists consider all rivers to be streams, and they believe that all streams go through similar stages of development.

1. The *source* of a river or a stream often occurs in a mountainous area. Here the force of gravity causes water to flow quickly. Some streams flow from springs, lakes, or the ends of glaciers.

2. The fast-flowing stream can carry many sediments and often carves out V-shaped valleys. Fast-moving streams are often used for rafting.

3. Smaller streams add water, increasing the size of the stream and often forming a young river.



▲ Young streams flow swiftly down steep slopes.

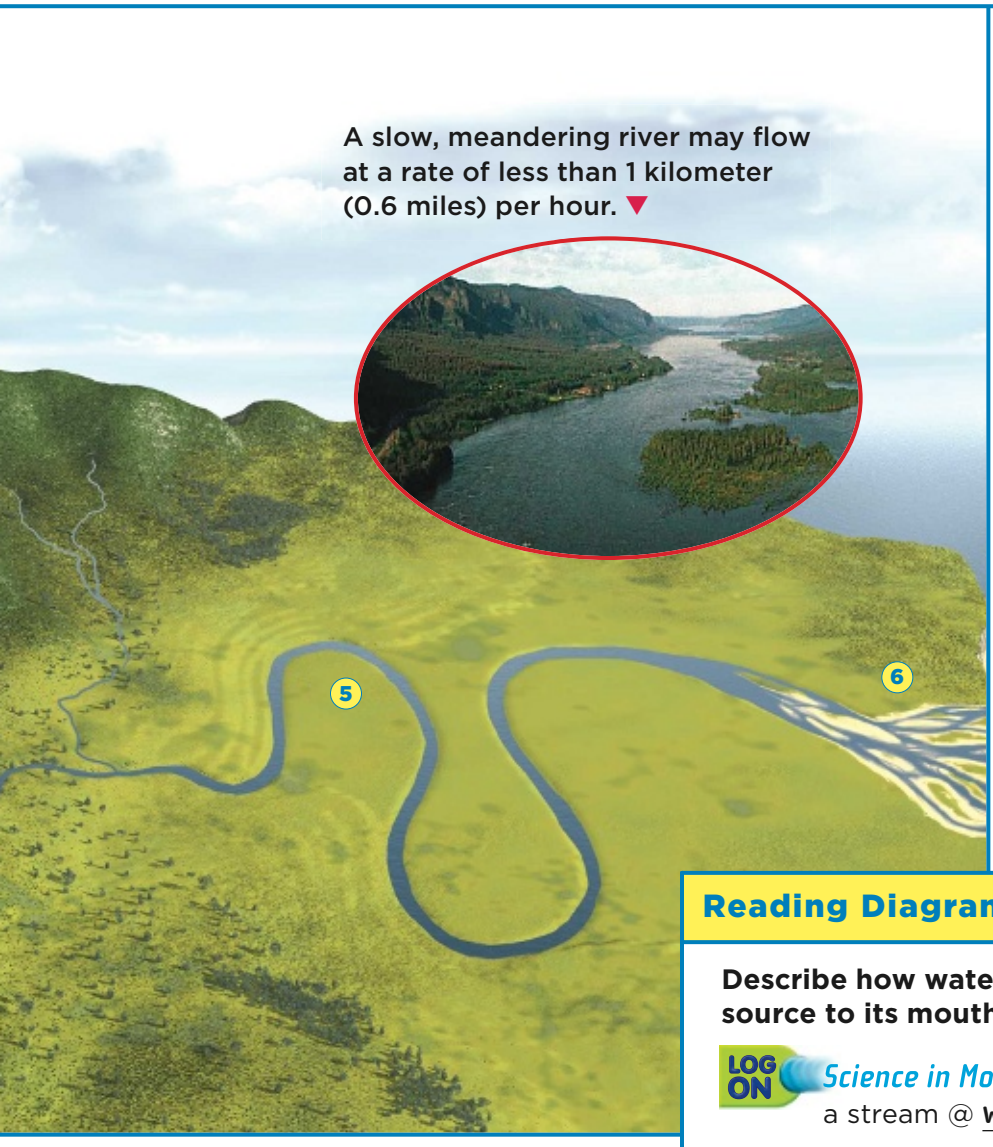
Quick Check

Match the stage with its description.

20. ____ young **a.** smoothly flowing with meanders

21. ____ mature **b.** slowly moving over broad, flat flood plain

22. ____ old **c.** swiftly flowing, steep slopes



A slow, meandering river may flow at a rate of less than 1 kilometer (0.6 miles) per hour. ▼

4 As the river reaches flatter land, it slows down. As it slows it deposits some of the sediments it carried.

5 The slow-moving river flows across flat land, forming large curves called *meanders*. Water flows faster along the outside of a meander, eroding or wearing away the bank.

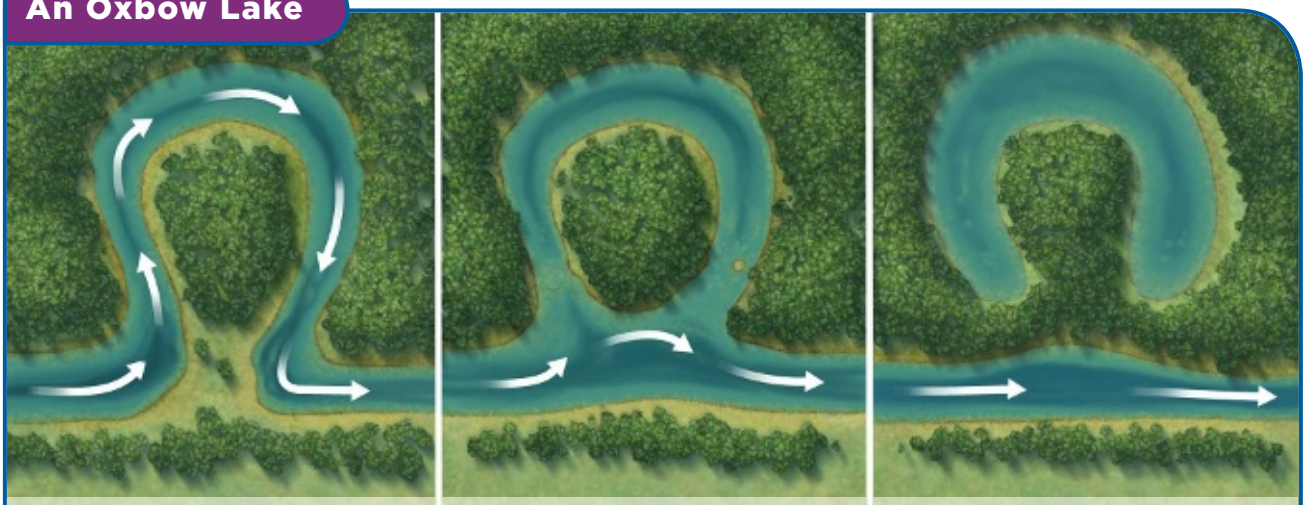
6 When a river empties into a larger body of water such as an ocean or a bay, it deposits the remaining sediments it has carried. These deposits can form a delta that extends from the river's mouth.

Reading Diagrams

Describe how water flows from a river's source to its mouth.

LOG ON *Science in Motion* Watch the life of a stream @ **www.macmillanmh.com**

An Oxbow Lake



The meanders change position over time by eroding sideways and slightly downstream, slowly moving down the river valley.

Sometimes a meander hits a part of the valley where the soil is heavier or where there are large rocks that resist erosion.

An **oxbow lake** is a portion of a stream channel that is cut off from the rest of the stream by erosion.

How does flowing water affect a watershed?

Rivers get water from the land. A **watershed** is the area from which water is drained. Watersheds may be small or large. In a watershed the flow of water and the resulting erosion and deposition may vary. Seasonal changes are common.

For example, in the spring, rain and melting snows can carry large amounts of water and sediment to streams and rivers. Flooding may bring sediment onto the flood plains. In the summer, with much less rain, rivers can be slow and shallow.

River erosion sometimes carve an arroyo (uh•ROY•oh). An **arroyo** is a small channel with steep banks located in a dry area. Arroyos are dry most of the time, but fill with water quickly after a heavy rainstorm.

Erosion can also cause other features to form. One such feature is an oxbow lake. See the diagram above.

A River's Mouth

All rivers in time flow into a larger body of water. When a river enters a lake or ocean, its speed drops quickly. The river drops the rest of its sediment at its mouth. This deposit eventually builds up a triangular-shaped delta at the mouth of the river.

Sometimes a stream enters a plain or flat valley. The sediment it drops looks like a delta. This fan-shaped deposit is called an alluvial deposit.

Formation of a Delta

Reading Photos

This photo shows how sediment can form a delta.

Quick Check

23. How might a delta be useful to wildlife? _____

_____

_____

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How do waves change the shoreline?

Waves have a lot of power. They roll in to shore and back out to sea, often pounding against the shore. They can change the shape of the coast. **Beach erosion** occurs when waves pick up sand particles and move them along the shore. This process helps smooth out the shoreline. Chemicals in the seawater help break up the rocks.

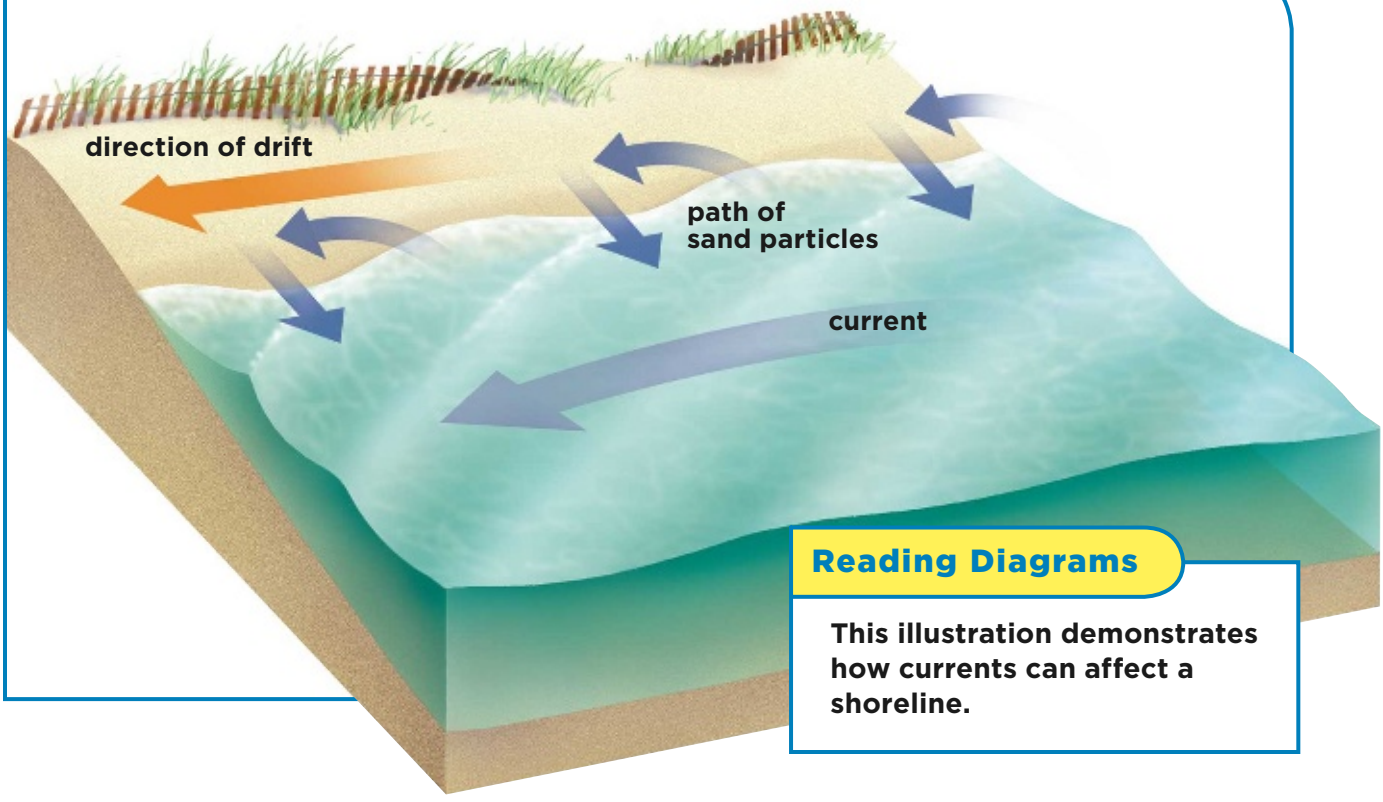
beach erosion

Shorelines

Beach erosion can produce many effects. Sometimes waves pound hard against the shore. Over time, they carve out a cliff. They smooth out the seafloor and form a flat step. Eventually the step is exposed to air and becomes a marine terrace.

Waves hitting the shore hit at an angle. As they move, breakers form. **Breakers** are waves that break into foam against the shore. When the waves wash back into the ocean, they also leave at an angle. The waves pull sand particles down the beach.

Beach Drift



Reading Diagrams

This illustration demonstrates how currents can affect a shoreline.

Quick Check

24. How do breakers affect a beach? _____

_____

_____

What is sand?

Most sand is weathered rock. Sand has certain properties.

- It has the same composition as the rock it came from.
- River sediments are a major source.
- Sand can be beige or brown, black, green, pink, or white.
- Some sand is made of the remains of tiny red-shelled organisms.

Sometimes waves deposit sand and cause shallow water to be collected. This formation is called a **sandbar**. Sandbars more than 100 m (328 ft) wide are called *barrier islands*.

Types of Sand

Reading Photos

These photos show the range of colors that sand can have.

Quick Check

25. Sand that contains the remains of tiny red-shelled organisms would be the color _____.

How can you identify the weathered parts of sand?

The sand on beaches can be divided into two types: silicate sand and carbonate sand. Some beaches contain a mixture of both types.

Type of Sand	Comes from	Made of	Also contains
Silicate	land	silicon and oxygen	minerals such as quartz, feldspar, and magnetite
Carbonate	shells of marine organisms	calcium, carbon, and oxygen	limestone

Calcium in underwater springs and carbonates in lakewater mixed, forming these tufa towers. They appeared above water when Mono Lake's water level fell.

Quick Check

26. The two types of sand are _____ and _____.

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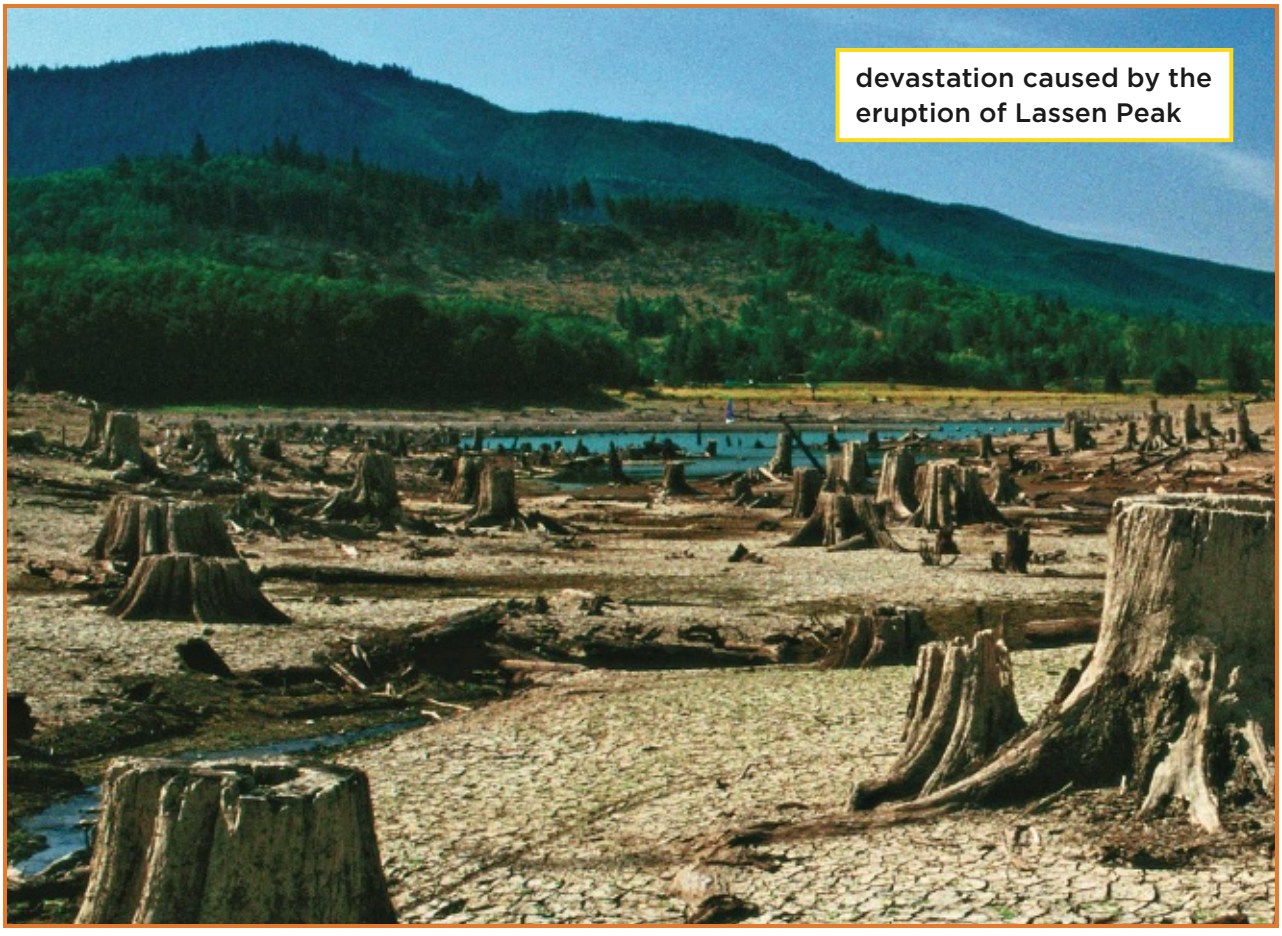
How do natural disasters affect habitats?

Natural disasters can cause sudden and violent changes to Earth's surface. Natural disasters include earthquakes, landslides, floods, erupting volcanoes.

Plants, animals, and people are often severely affected by any natural disaster. For example, Lassen Peak in California erupted in 1915. When it erupted, heat from the lava melted most of the snow on the mountain. A *lahar* (LAH•hahr), a mudflow containing volcanic ash and rock, flooded the surrounding valley. Ranchers had to leave their homes to survive.

▲ Lassen Peak erupted early in the twentieth century. It is still an active volcano.



devastation caused by the eruption of Lassen Peak

Impact on Wildlife

Natural disasters also affect wildlife.

- Volcanoes can shatter and burn trees and other forms of life.
- Landslides can carry away plants and animals.
- Floods can cover a region with water, killing plants and animals. They can also wash away soil.
- Earthquakes can start fires, trigger landslide, and cause huge ocean waves.

Quick Check

27. How might an earthquake affect wildlife? _____

_____

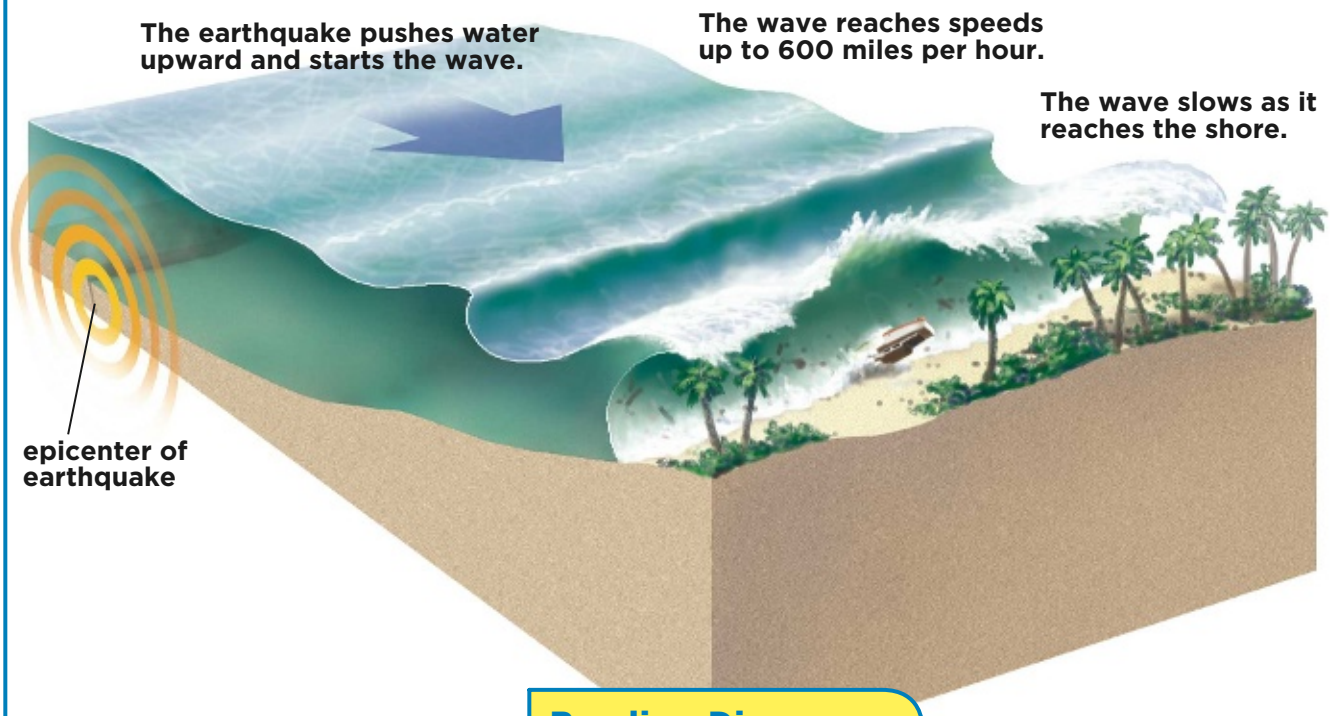
_____

How do tsunamies affect habitats?

A **tsunami** (tsoo•NAH•mee) is a series of waves caused by an earthquake or volcanic eruption beneath or near the ocean. Tsunamis are usually started by an earthquake. The speed of a tsunami depends on the depth of the ocean.

In the open ocean, tsunamis are not very high, but travel very fast. As a tsunami nears the shore, it slows down. The energy that is still in the wave makes the height of the wave increase dramatically. Finally, the tsunami crashes onto the shore as a giant wall of water.

How a Tsunami Moves Across the Ocean



Reading Diagrams

The arrow and the labels explain how a tsunami develops as it approaches the coast.

Effects of a Tsunami

Reading Photos

These photos show how a tsunami can affect a shore community.

Effects on Habitat

On December 26, 2004, an earthquake with a magnitude between 9.0 and 9.3 on the Richter Scale occurred. The epicenter was in the Indian Ocean about 160 km (100 mi) off Sumatra. A tsunami was triggered. The waves hit Thailand and other countries along the rim of the Indian Ocean.

Hundreds of thousands of people died. Whole villages were wiped out. Many plants and animals were killed. Habitats were destroyed. Many parts of the region are still trying to recover.

Tsunamis often take hours to travel across the ocean. So there may be time to warn people. Scientists are working to set up a tsunami warning system in the Indian Ocean.

Quick Check

28. What habitats of a region are most likely to be affected by a tsunami?

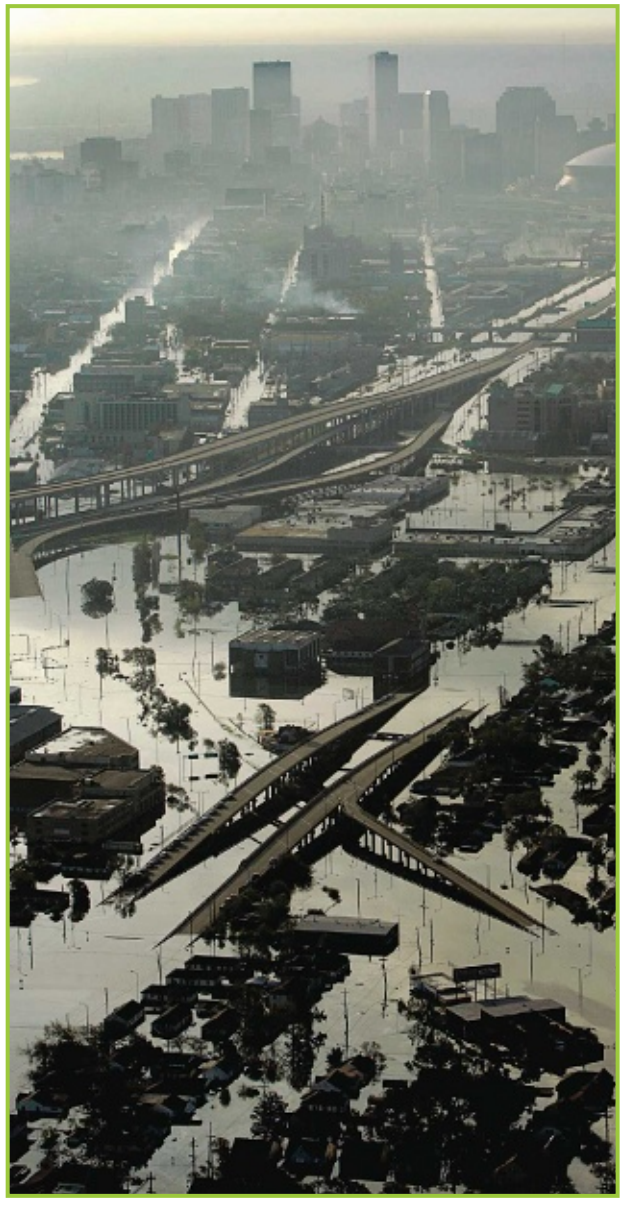
How do floods affect habitats?

Floods are often caused by sudden, heavy downpours, melting snow in the spring, and failure of dams.

Floods can affect habitats in many ways.

- Moving floodwater can knock down trees.
- A flood can carry away tons of soil.
- Mud from a flood can cover plants and animals, killing them.
- Floods renew the soil, making it more fertile. This helps future crops.

To prevent flooding, people may make a **levee**, a wall or large mound of earth built along a river. A levee raises a river's bank, but they can fail, or break. The failure of levees during Hurricane Katrina in 2005 resulted in much damage.



Flooding in New Orleans caused by Hurricane Katrina in 2005 ▶

Quick Check

29. How might floods affect habitats? _____

_____

_____

How do earthquakes and landslides affect habitats?

Earthquakes and landslides can have a major effect on a habitat.

Earthquakes can:

- rupture power and gas lines
- cause fires
- damage buildings
- open cracks in ground
- change a river's course
- drain lakes
- cause landslides

An earthquke in Alaska caused the ground to sink, flooding these trees.

Landslides can:

- carry buildings down hillsides
- bury highways under debris
- uproot plants
- change the slope of a cliff
- create a natural dam

A landslide can also benefit some fish, such as salmon, by changing the river's flow and leaving behind small pools where these fish can lay their eggs.

Quick Check

30. How might earthquakes affect habitats? _____

_____

_____

How can people plan for natural disasters?

Natural disasters cannot be prevented. However, they can sometimes be predicted. What's more, people can prepare for them.

▲ **This skyscraper in San Francisco is twice as strong as building codes in the area require.**

▲ **a seismic test with lasers near Parkfield, California**

Natural Disaster	Predictable	Ways to Prepare
Flood	Sometimes: melting snow in spring	• Don't build on flood plain.
		• Build levees to hold water back.
Earthquake	Some areas prone to them can be predicted. Computers being used to help.	• Don't live close to an earthquake fault.
		• Use laser technology to detect movement along fault.
		• Build structures to withstand tremors.
Volcanic eruption	Some eruptions preceded by earthquakes	• Get out of harm's way.
		• Don't live close to active volcano.

Long-term Effects

Natural disasters can have long term effects on Earth and its habitats. Some of the effects can be harmful. But some effects are helpful.

Harmful Effects	Helpful Effects
• Volcanic ash in air dims solar radiation. Global temperatures fall.	• Landslides, floods, eruptions can cause new growth and enrich soil.
	• Floods and landslides leave nutrient-rich mud behind.
• Earthquakes, floods, tsunamis destroy habitats.	• New habitats are created.

An eruption of Mount Pinatubo in the Philippines produced volumes of ash that caused temperatures worldwide to drop by about 1°F.

Ash from the eruption enriched the soil, enabling new plant life to grow.

Quick Check

31. How can a volcanic eruption help create new habitats?

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Shaping Earth's Surface

Write the letter of each description in the second column to match the word(s) in the first column.

1. ____ humidity
2. ____ dew point
3. ____ weather
4. ____ erosion
5. ____ glacier
6. ____ arroyo
7. ____ flood plain
8. ____ Coriolis effect
9. ____ weathering
10. ____ abrasion
11. ____ deposition
12. ____ oxbow lake
13. ____ beach erosion
14. ____ tsunami

a. a slow-moving river of ice

b. the day-to-day atmosphere conditions

c. the amount of water vapor in the air

d. the wearing away of Earth's surface

e. the flat area of land on both sides of a river

f. the temperature at which condensation occurs

g. a small channel with steep banks in a dry area

h. a wave caused by an earthquake or volcanic eruption

i. a cut off portion of a stream

j. the carrying and dropping of sand along a shore

k. the shift in wind direction caused by Earth's rotation

l. the slow breakdown of rock into smaller pieces

m. dropping off soil and rock in new places

n. scraping away of land by wind-carried bits of rock

Use the clues to fill in the crossword puzzle.

Across

3. The area from which water is drained.

5. A wall or large mound of earth built along a river.

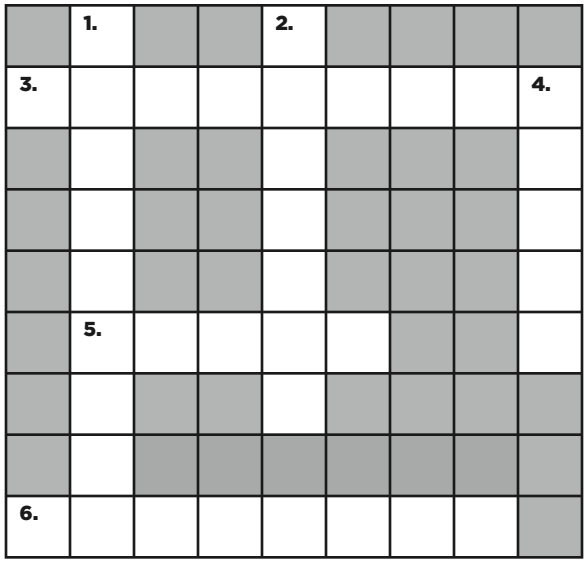
6. Rock particles deposited in deserts, rivers, and oceans.

Down

1. Rapid, downward movement of rock, soil, and objects.

2. A wave that breaks into foam as it moves against the shore.

4. Triangular deposit at the mouth of a river.



CHAPTER 7

Earth's Resources

Vocabulary

energy source where the light, heat, and electricity people use come from

coal a hard, black substance formed from plants that lived about 300 million years ago

oil a thick, black liquid that forms from decaying plants and animals

natural gas a mixture of gases formed from marine organisms

geothermal energy heat energy from inside Earth

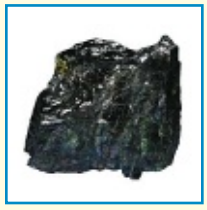
solar energy any form of energy radiated by the Sun

efficiency the amount of usable energy compared with the total amount of energy used to produce the usable energy

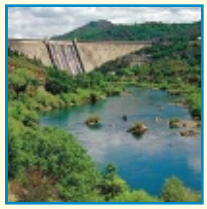
pollution a harmful addition to the natural environment

natural resource any material people take from Earth

Where do the energy and the materials people use come from?



nonrenewable resource any material taken from Earth that takes a long time to replace or cannot be replaced



renewable resource any material taken from Earth that can be replaced in a relatively short time

nuclear fuel a source of energy in a nuclear power plant

fusion the joining of two nuclei to make a nucleus with a larger mass

hydroelectric power collecting energy that is produced by falling or running water and changing it into electricity

conservation the wise use of natural resources

recycling making new products by reusing materials that would be thrown away

synthetic a material made artificially

Why is energy important?

Almost all the things you do use energy, from using a computer to riding the bus. The light, heat, and electricity we use come from an **energy source**.

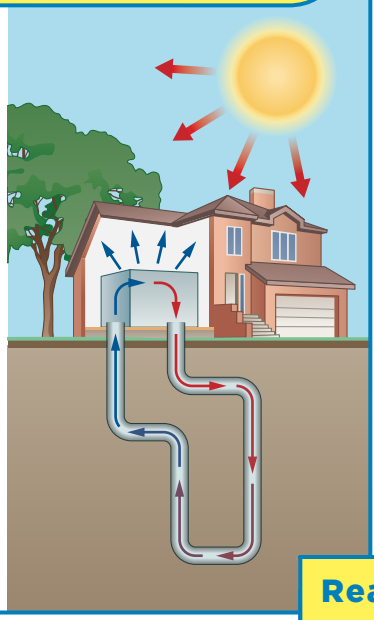
Most forms of energy come from the Sun. Most of the energy people use can be traced to fossil fuels. Fossil fuels come from life forms that originally used the Sun's energy to survive. Fossil fuels have stored Sun's energy inside.

Los Angeles, California

How Geothermal Systems Work

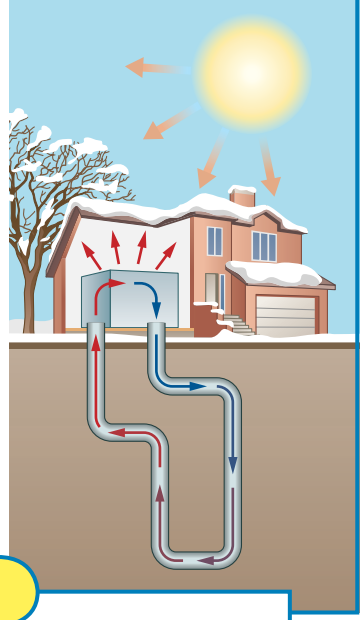
Summer

1. Liquid from geothermal system in house is piped below ground. Ground absorbs heat and cools liquid.
2. Cooled liquid returns to house.
3. Inside house liquid absorbs heat from rooms and cools the air.



Winter

1. Liquid from house is piped below ground, which is warmer than air. Liquid becomes warmer.
2. Warmed liquid returns to house.
3. Inside house warm liquid gives off heat and warms the air in rooms.



Reading Diagrams

The red arrows stand for warmed liquid. The blue arrows stand for cooled liquid.

Types of Energy

People have many ways to get energy. Fossil fuels such as coal, oil, and natural gas, are just one way. **Coal** is a hard, black substance formed from plants that lived about 300 million years ago. **Oil**, or petroleum, is a thick, black liquid that forms underground, over millions of years, from decaying plants and animals. **Natural gas** is a mixture of gases formed from marine organisms.

People use **geothermal energy**, heat energy from inside Earth. They also use **solar energy**, which is any form of energy radiated by the Sun.

Quick Check

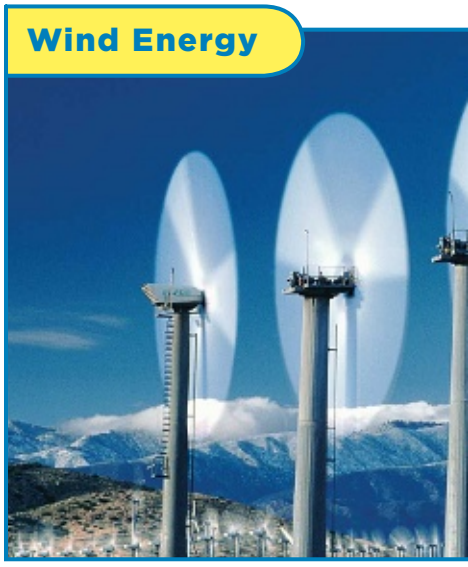
1. List the different types of energy that people use today.

How is energy converted into usable forms?

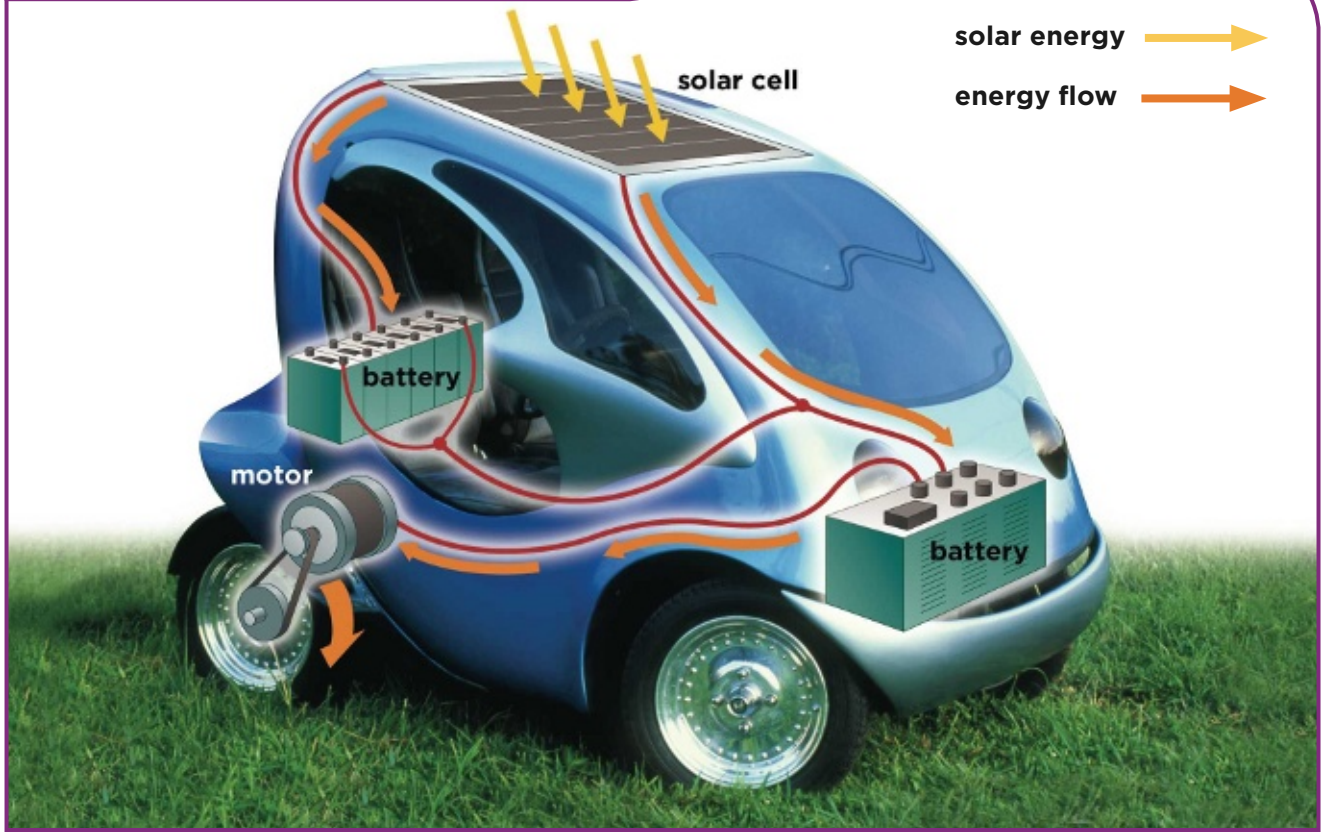
Energy is neither created nor destroyed. It changes from one form into another through a process called *energy conversion*. Some kinds of energy conversion are familiar ones used in your home and school.

Energy Conversion	Example
chemical → light and heat	battery
electric → mechanical	electric fan
sunlight → electricity	solar cell

Wind Energy



How a Solar-Powered Car Works



Reading Photos

These photos compare and contrast modern windmills with older-type windmills.

Complex Energy Conversions

Other energy conversions are more complicated.

Machine	Steps in Energy Conversion
Steam engine	Chemical → heat → mechanical
Hydroelectric power plant	Mechanical → electric
Coal	Heat → electricity

All energy sources have advantages and disadvantages. The disadvantages that must be considered include:

- the financial cost of energy conversion and
- possible harm to the environment due to the use of the energy source.

Quick Check

2. What kind of energy conversion is involved when people use a microwave oven? _____

_____

Geothermal steam pours from a power plant in Iceland.

How does cost affect energy use?

When government officials decide which energy source to recommend, they look at the costs and benefits of the energy. They consider how *cost effective* the source is. To tell how cost effective something is, they compare the cost of an energy source with the consequences of using it.

Many alternative-energy sources are not cost effective right now. They are not because the technology to make the energy sources cost effective is not yet in use. However, newer technologies may make such energy sources more attractive.

Energy Efficiency

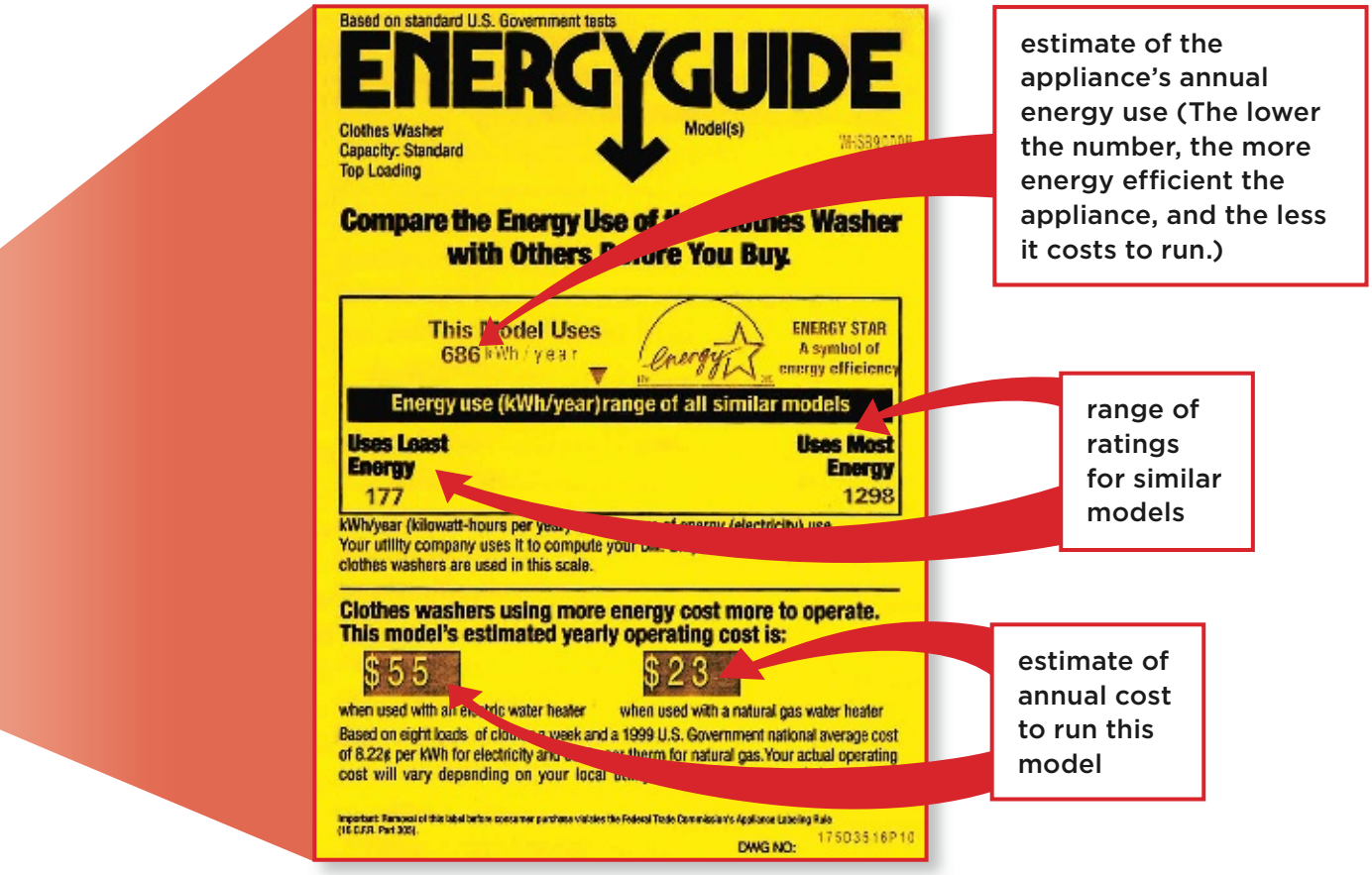
Efficiency is an important factor to consider when you buy a new appliance. **Efficiency** compares the amount of usable energy made with the total amount of energy used up to make the usable energy. No appliance is 100% energy efficient. Some energy is always lost as heat given off to the air.

Before you buy an appliance, look at the Energy Guide tag. The lower the annual energy use, the more energy efficient the appliance is. And the less money you will spend when you use the appliance.

Quick Check

3. What are things that must be compared when selecting a source of energy or an appliance? _____

_____



What are the consequences of energy use?

Energy use has its consequences, including pollution and damage to land and waterways. **Pollution** is a harmful addition to the natural environment.

Pollution may be the release of harmful substances into the air or the release of energy that disrupts an ecosystem.

Energy Source	Pollution Problems
Fossil fuels	• Strip mining peels away topsoil. • Burning releases pollution. • Released gases cause acid rain. • Smog in cities hurts lungs.
Hydroelectric power	• Dams can alter flow of rivers, flood habitats, interfere with natural cycles.
Nuclear power	• Radioactive waste produced. • Hot water released into rivers can kill wildlife and destroy habitats.

At this power plant in Florida, manatees are attracted to the warm water. This behavior alters manatees' migration patterns.

Nonmonetary Costs of Energy Use

Damage to the environment, due to pollution, affects everyone. This damage is known as *nonmonetary* costs, or environmental consequences, of energy use. Examples of nonmonetary costs are:

- pollution caused by fossil fuels
- health problems due to pollution
- smog
- acid rain
- thermal pollution of rivers

Nonmonetary costs can lead to monetary costs. Monetary costs include the cost of repairing or cleaning up damage to the environment. So, people need to be wise in their choice of energy sources.

Quick Check

4. List some nonmonetary costs of nuclear power. _____

_____

_____

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farm near the Russian River, California

What are natural resources?

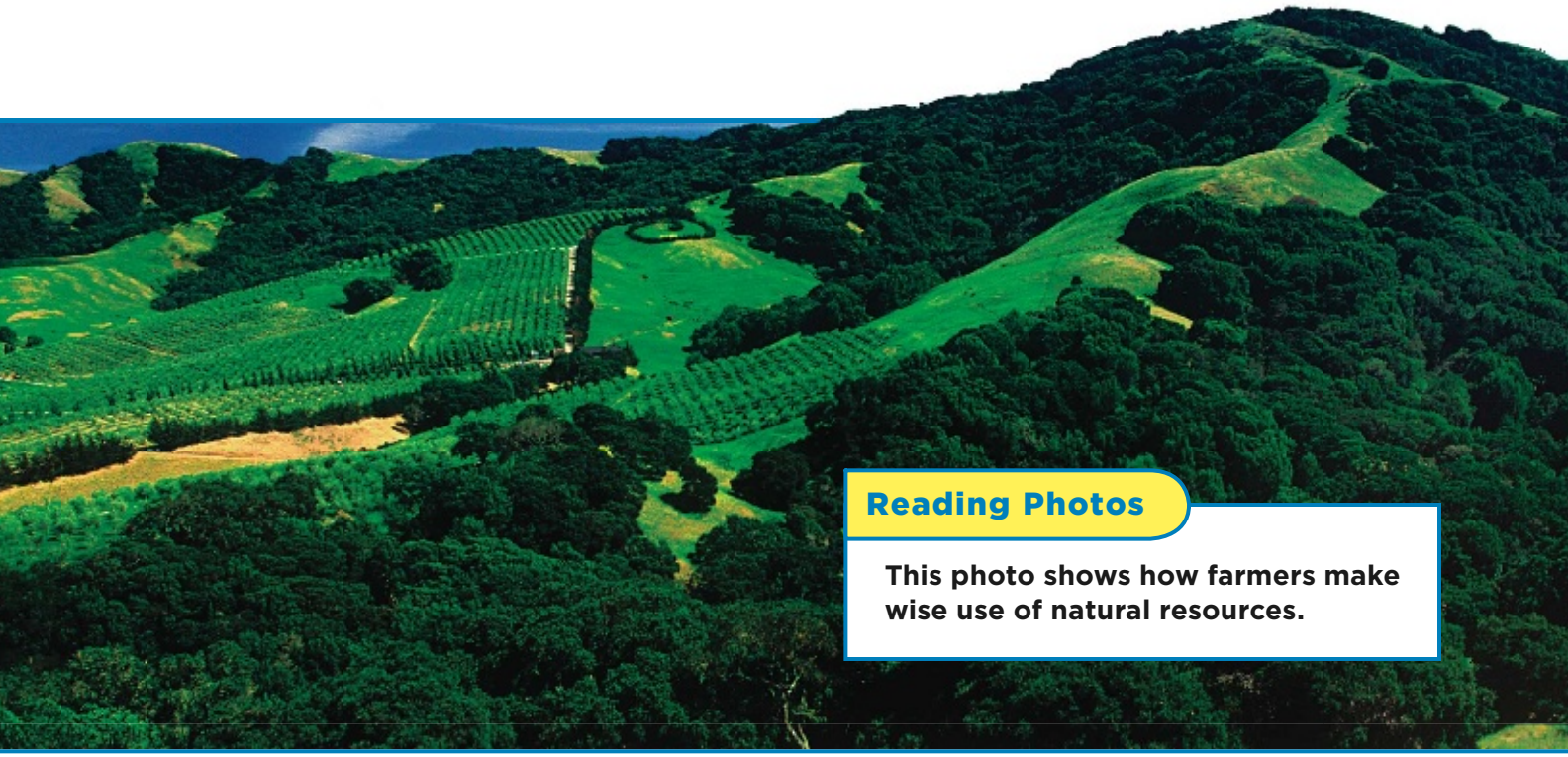
What do we get from Earth that we need to live? We get air to breathe and water to drink. We get food for energy. We get soil to grow food. Forests give us oxygen as well as wood for building and fuel. **Natural resources** are materials people take from Earth. Almost everything people use comes in some way from a natural resource.

Earth's natural resources can be grouped by the time it takes to replace them. A **nonrenewable resource** takes a long time to replace or cannot be replaced at all. A **renewable resource** can be replaced in a relatively short time.

Quick Check

5. Why are natural resources important? _____

_____



Reading Photos

This photo shows how farmers make wise use of natural resources.

Types of Resources

Although some resources are considered renewable, it may take time to replace them. Soil is an example. To replace just a few centimeters of soil can take from 500 to 2,000 years!

Water is renewed naturally by the processes of Earth's water cycle. However, only a small amount of fresh water is available for people to use. Wasting or polluting water can result in severe shortages.

Nonrenewable	Renewable
• fossil fuels	• trees
• minerals such as gold and copper	• water
• nuclear fuels	• soil
	• solar energy

Quick Check

6. Why is water considered a renewable resource? _____

_____

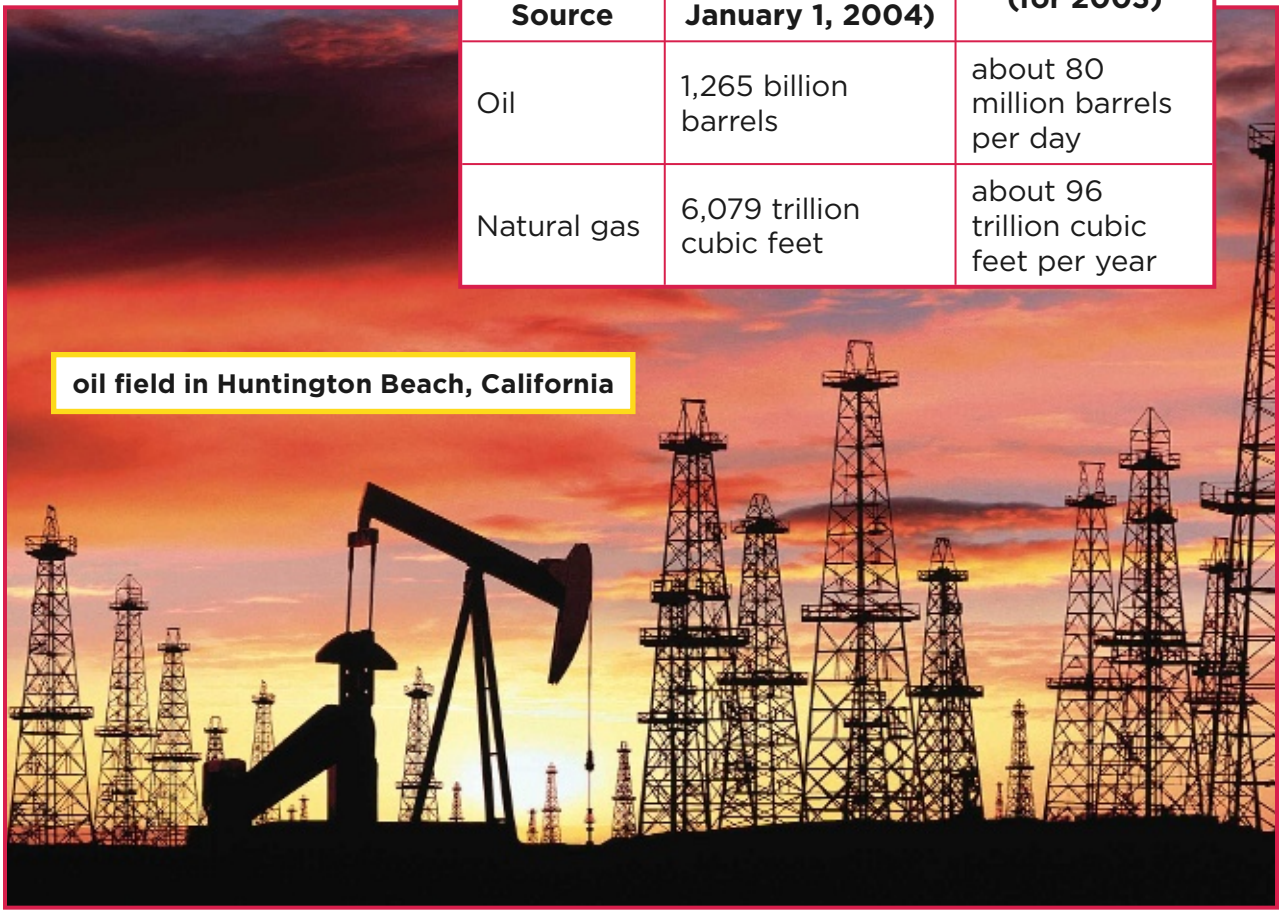
What are nonrenewable resources?

Much of our current technology depends on nonrenewable resources. Two main types of nonrenewable resources are fossil fuels and nuclear fuels.

Fossil Fuels	
Produced	• formed from remains of organisms that lived millions of years ago
Example	• coal, oil, natural gas
Uses	• more than 90% for fuel • about 10% to make plastics
Problems	• air pollution

Fuel Use

Type of Energy Source	Proved Reserves (as of January 1, 2004)	Amount Used (for 2003)
Oil	1,265 billion barrels	about 80 million barrels per day
Natural gas	6,079 trillion cubic feet	about 96 trillion cubic feet per year



oil field in Huntington Beach, California

Nuclear fuels are often produced by *fission*, the splitting of atoms into pieces.

Nuclear Fuels

Nuclear fuels are the energy source for nuclear power plants.

Nuclear Fuels	
Produced	• atoms are split apart
Example	• uranium 235
Uses	• tremendous energy released • good electricity producer
Problems	• getting rid of radioactive waste

Quick Check

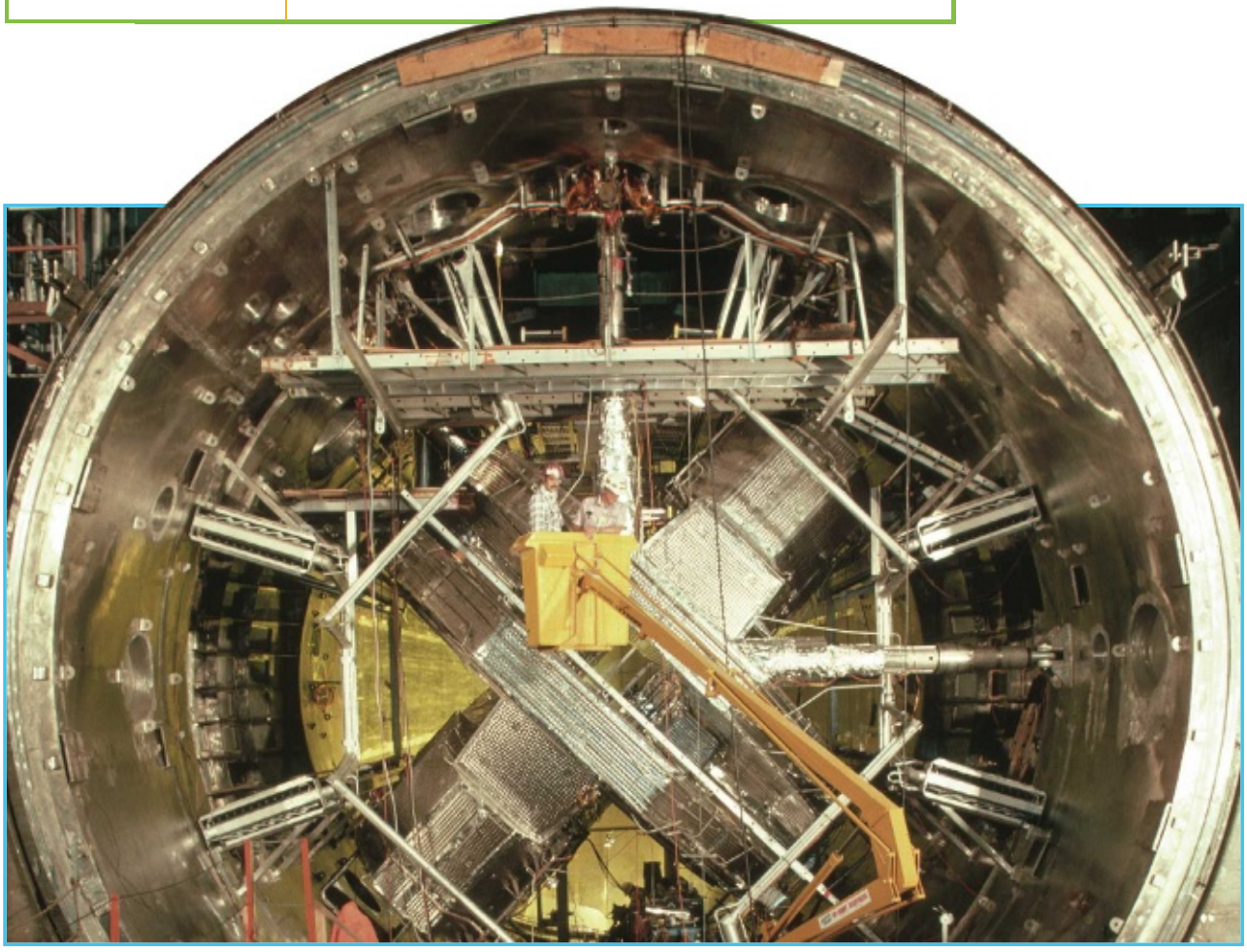
7. From the fuel use table, about how much time will pass until natural gas reserves are used up? (You may round the data.) _____

_____

What are renewable resources?

Renewable resources are those that can be replaced. Some renewable resources, however, are not truly renewable because it takes so long to replenish them. Completely renewable resources include:

geothermal energy	• almost endless due to enormous reserves of heat below Earth's surface.
	• problem: not many places were it can be used.
fusion	• the joining of two nuclei with smaller masses to make a nucleus with a larger mass
	• problem: fusion reactors are not yet cost efficient



▲ Fusion reactors have the potential to provide a cheap, clean source of energy.

Other Renewable Resources

Other completely renewable resources include:

solar power	• solar panels collect Sun's energy and turn it into electricity
wind energy	• windmills send energy from turning blades into a turbine, which makes electricity
hydroelectric power	• collecting energy that is produced by falling or running water and changing it into electricity.

Some resources, such as *biomass*, are renewable, but may take a long time to replace.

Biomass is matter that comes from living things—such as plants and animal wastes. New trees, for example may be planted after trees are cut down. However, the replaced trees take time to grow.

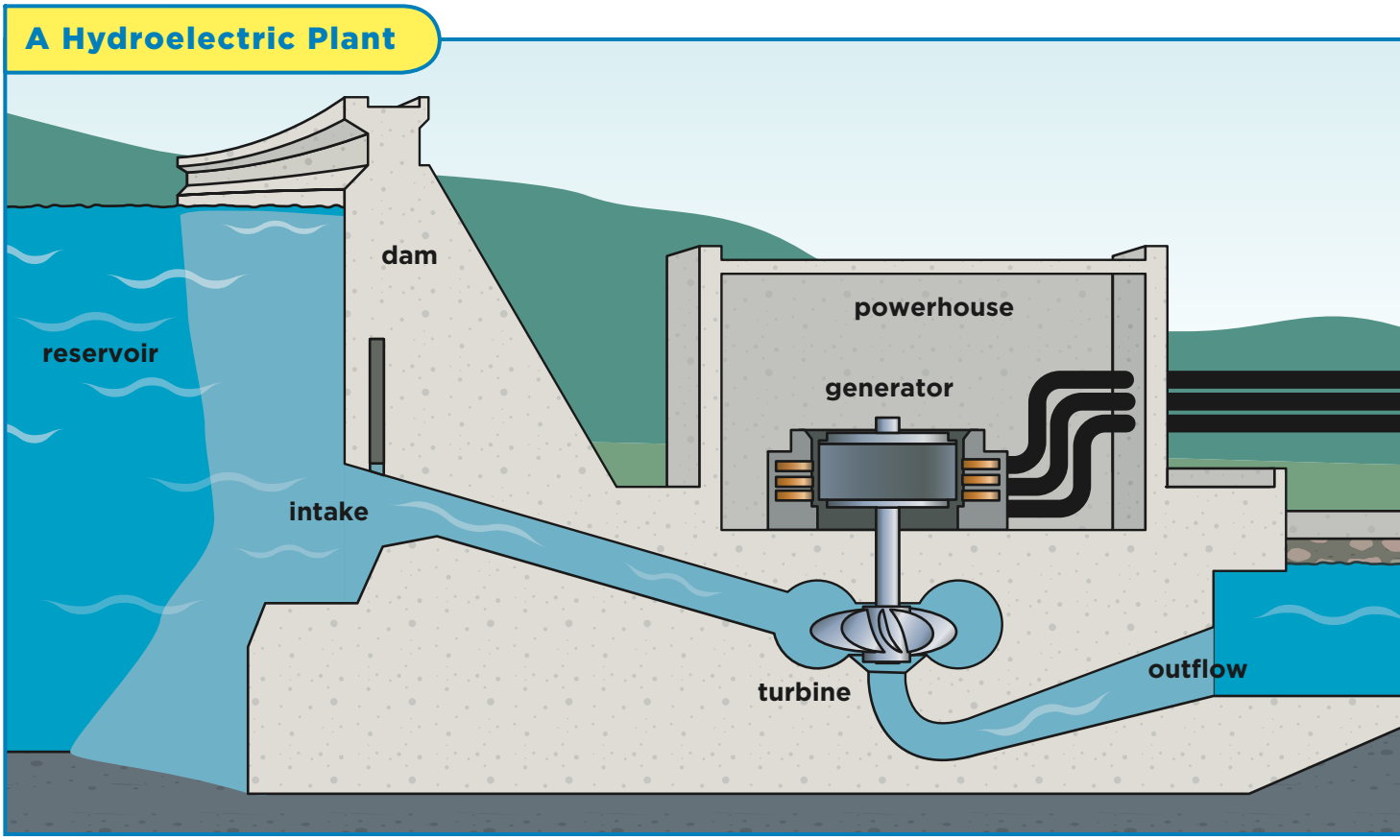
▲ **Trees are a renewable resource. However, replacing a forest can take decades.**

Quick Check

8. Emil says that soil should really be considered a nonrenewable resource. Do you agree or disagree? Why? _____

_____

_____

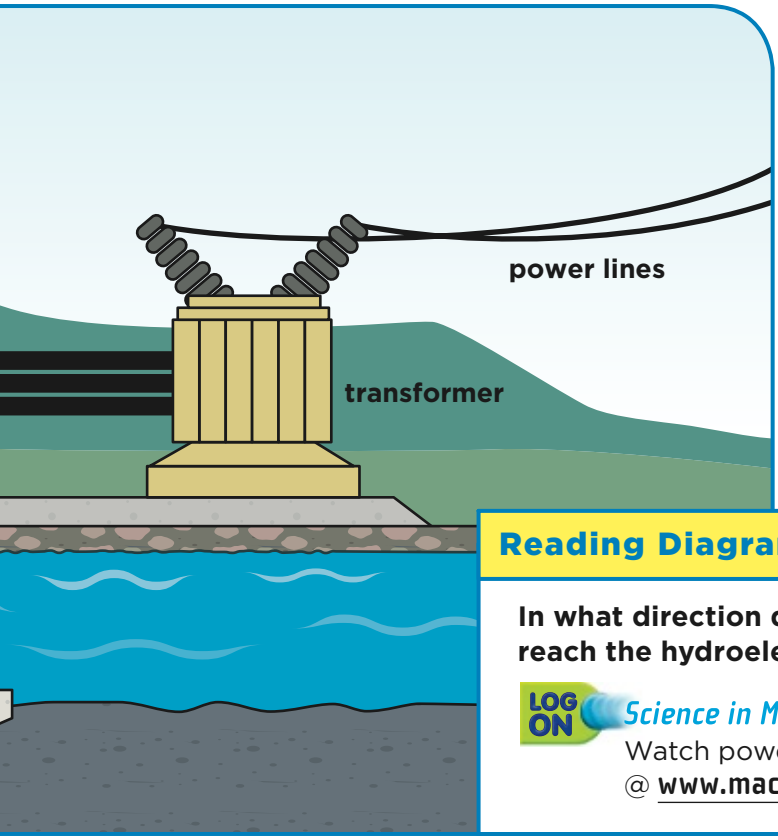


How is hydroelectric power dependent on solar energy?

Hydroelectric power is a renewable-energy resource. It is produced by the force of falling or running water. Hydroelectric power depends on the water cycle. The water cycle, in turn, depends on the Sun.

- The Sun warms water on Earth's surface and causes it to evaporate—that is, turn into water vapor.
- Water vapor rises into the air, cools, and condenses—that is, turns back into liquid water.
- In time, the water falls back to Earth as some form of precipitation,

The precipitation adds to Earth's rivers, lakes, and streams. Flowing water, such as in a river, enters a hydroelectric plant. The water spins the blades of turbines. The spinning turbines produce electricity in generators.



▲ A dam collects and stores the water that will be used to run a hydroelectric power plant's turbines.

Reading Diagrams

In what direction does water move to reach the hydroelectric plant?

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Advantages and Disadvantages of Water Power

Hydroelectric power has both advantages and disadvantages.

Advantages	Disadvantages
• cheap	• not all locations are suitable
• renewable	• flooding behind a dam can destroy or change habitats
• no air pollution	

Quick Check

9. An electric power company wants to build a hydroelectric power plant and dam on the flood plain of a slow-moving river. What would you say about this at a town meeting to discuss the proposal?

How can energy resources be conserved?

Conservation is using natural resources wisely. Conservation is especially important for nonrenewable resources. Conservation can involve something as simple as choosing to walk or riding a bicycle. It may be turning out the lights when you leave a room. It may be putting solar panels in your house to make some of your own electricity.

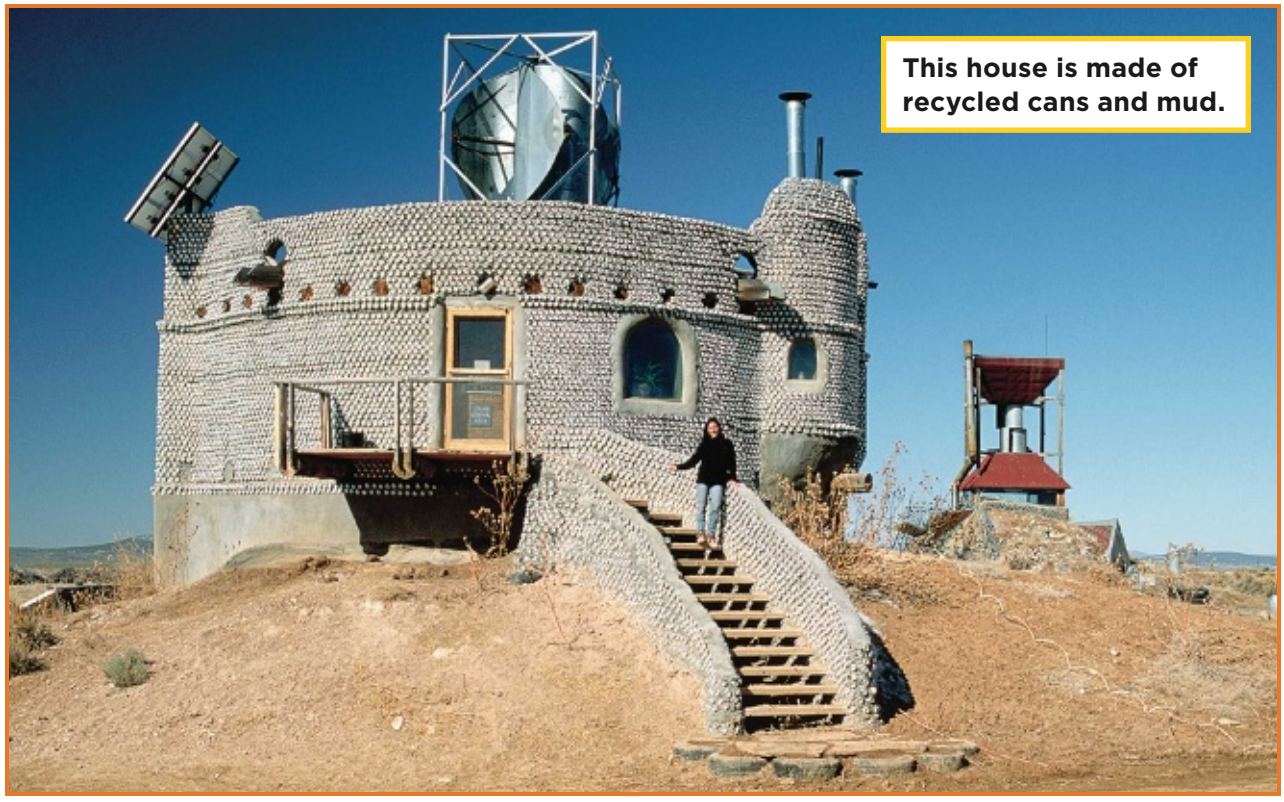
Quick Check

10. Why is it important to practice conservation? _____

_____

_____

_____



This house is made of recycled cans and mud.

Recycling

Recycling is making new products by reusing materials that would otherwise be thrown away. Recycling usually uses less energy than making a product from raw materials.

Also, by recycling, people can reduce the number of things they throw away. Reusing items, instead of throwing them away, also helps to conserve resources. Conservation and recycling are just two ways to save natural resources.

Quick Check

11. List three ways that people can recycle._____

_____

_____

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Where do everyday materials come from?

Raw materials are the building blocks of products. Many products are made from natural resources. Some natural resources can be used immediately. Other natural resources have to be processed using chemicals before they can be used.

▲ **Timber comes from trees, which are a renewable resource.**

Raw material	Products made with raw material
lumber	houses, musical instruments, paper
cotton	clothing
rocks	bricks, concrete, glass
minerals	gems, ceramics
copper metal	electric wires
iron metal	tools, building materials

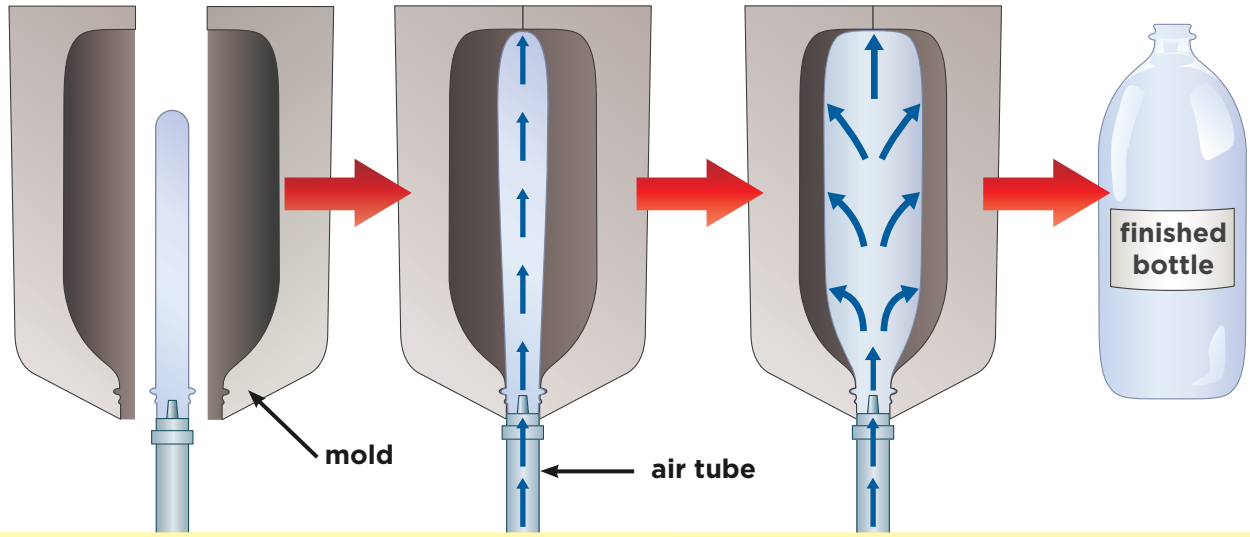
Quick Check

12. What might be a disadvantage of processing raw materials to make products? _____

_____

_____

Extrusion Blow-Molding Process



A hot plastic tube is enclosed in a mold.

Air is blown into the tube inside the mold.

The tube expands and takes the shape of the inside of the mold.

When the mold is opened, the plastic bottle can be removed.

What is plastic?

Materials made artificially—that is, human-made—are called **synthetic**. Plastic is a synthetic material. It is made from petroleum.

Plastic is an example of a *polymer* (PAH•li•muhr). A polymer is made by chemically linking many smaller molecules into a larger molecule. Plastics can be made into fibers and sheets. They can be made flexible or hardened.

Plastics are good insulators. That is, they do not conduct heat well and, thus, are useful as pot handles, cooking utensils, toaster controls, and cookware. Also, many food wraps and containers are made of plastic.

Most plastics can be reheated and remolded. They can be made into bottles. See the diagram. Because they can be reheated and remolded, plastics can be recycled.

Quick Check

13. Four objects in your home made from plastic are

_____, _____,

_____, and _____.

How are textiles produced?

A textile is a fabric made by weaving or knitting fibers together. Their uses include clothing, sails, and furniture upholstery. Fibers as old as 17,000 years have been found in caves in France.

Textiles can be made from animal and plant products or artificially. For example, wool is from sheep's coats. Cashmere comes from goat hair. Angora is from the fur of angora rabbits. Silk is made by silkworms. Cotton is used to make many kinds of clothes. Synthetic textiles are made from fossils fuels. These include nylon, acrylic, and polyester.

As with plastic, textiles can also be recycled. Some clothing can be made from recycled plastic. For example, fleece pullovers are made from old plastic bottles. Plastics can be used for fibers for carpets.

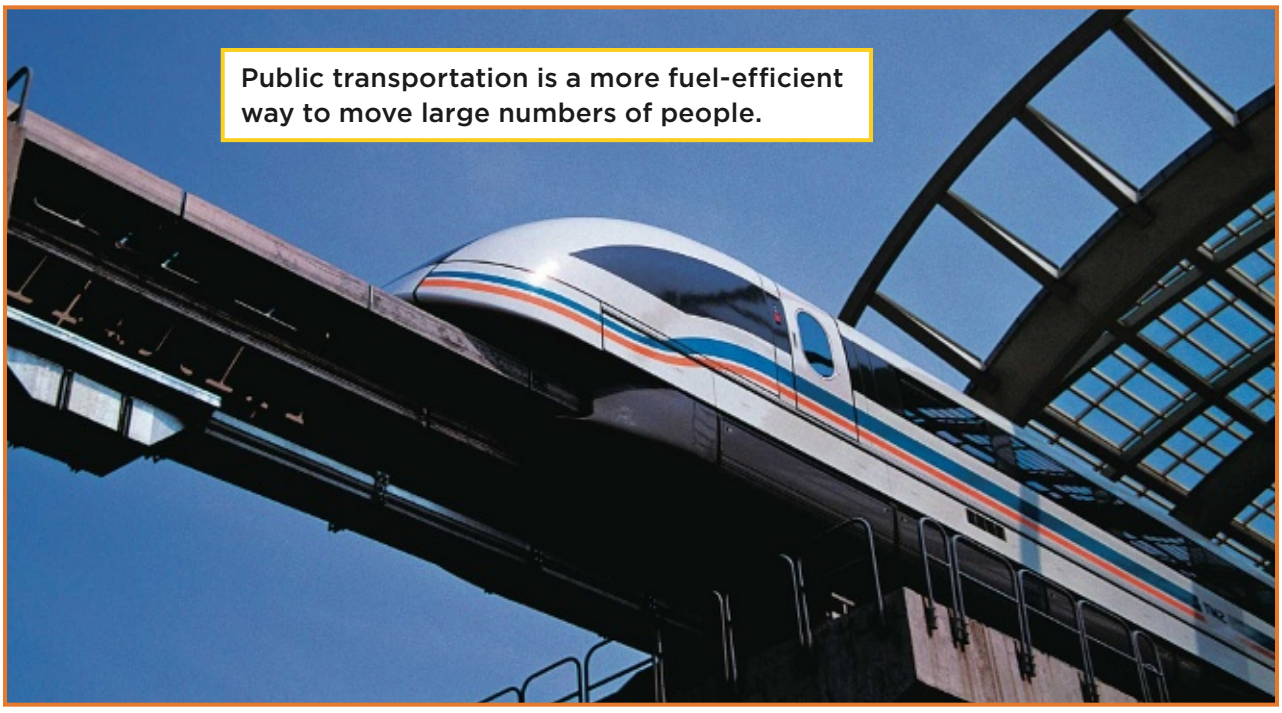
Quick Check

14. Textiles are made by

_____ and are made from

_____.

A cotton plant goes through many processing stages before it becomes a useful fabric.



Public transportation is a more fuel-efficient way to move large numbers of people.

How are fuel resources used for transportation?

Most oil is made into gasoline. However, burning fossil fuels creates pollution, which harms the environment and causes health problems. Scientists are trying to find solutions to these problems.

One option is developing alternative fuels. These fuels are not made from oil, so they burn more cleanly than oil does. But they are not efficient enough to be cost effective.

One very interesting alternative is a hybrid car. Hybrids combine two or more sources of power, usually gasoline and electricity. Hybrids use less fuel and emit less pollution. Some hybrid cars can get 55 miles to the gallon.

Quick Check

15. Why is it important to search for alternative types of transportation?

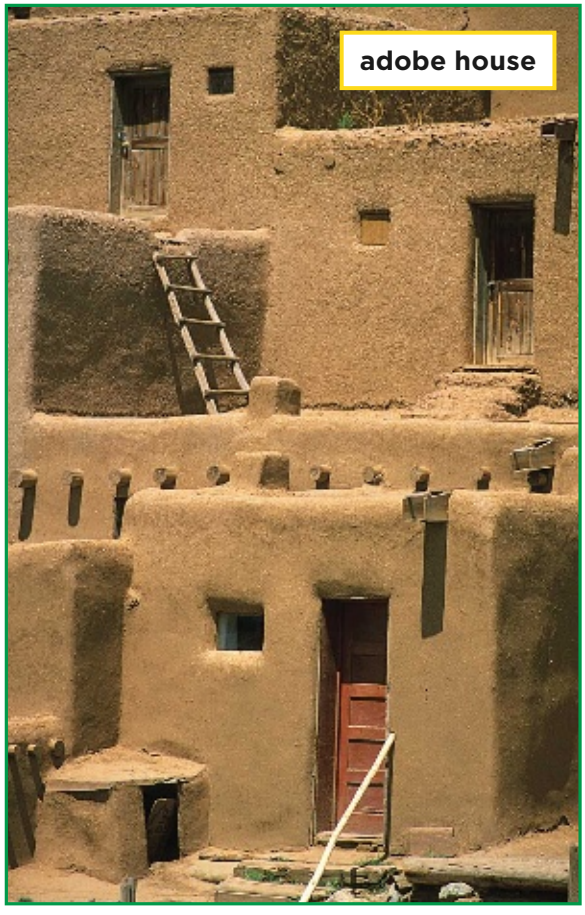
How are natural resources used for shelter?

Every living thing, including people, needs shelter. People use many natural resources to build homes. They include.

- sod
- wood
- adobe
- bricks
- stone
- animal skins

Most houses built today use many types of natural resources. To build a home, you need:

- a strong foundation to support the building
- a frame for the house
- a waterproof roof

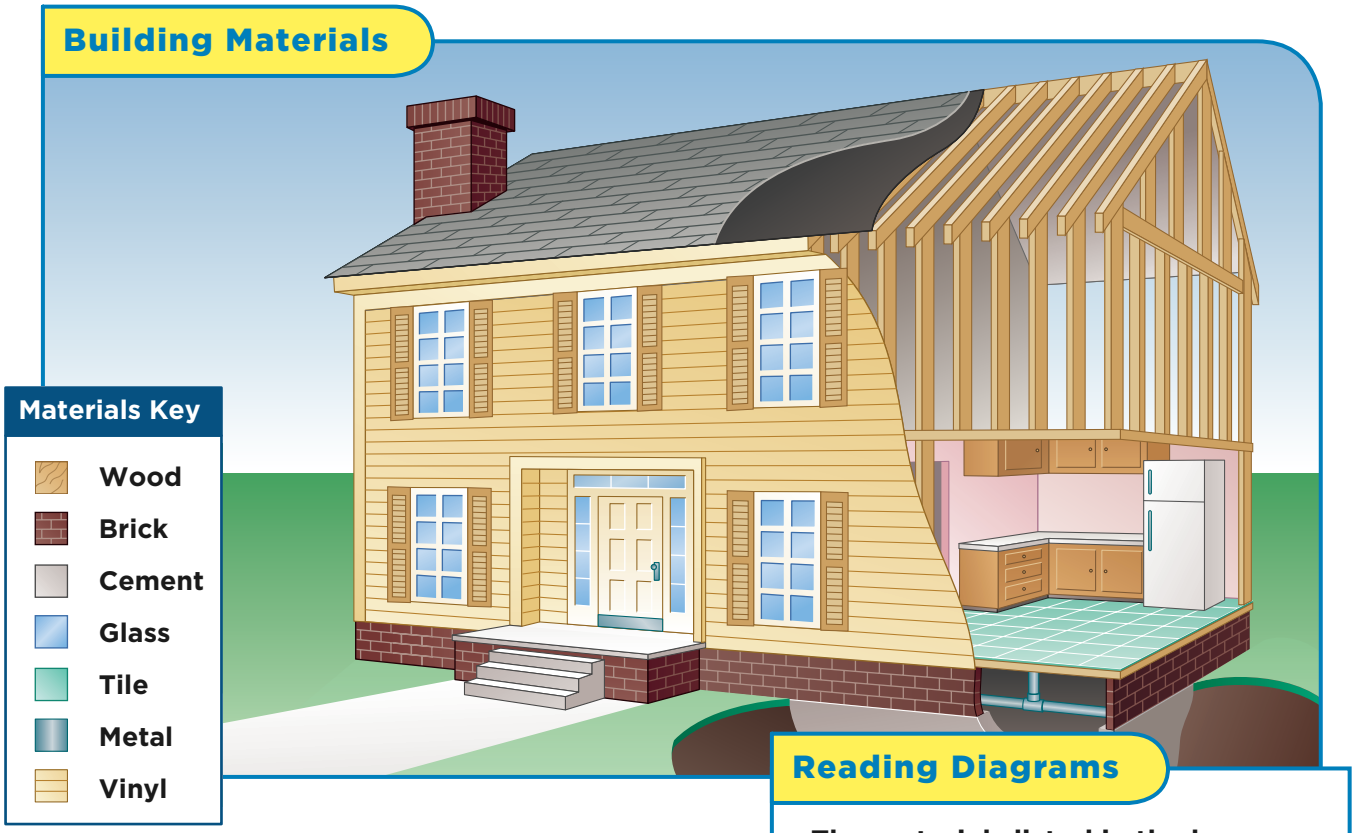


Covering the Exterior

After the house is framed, exterior windows and doors are added. Windows are made of glass, a kind of silicate sand.

Then the house is usually wrapped in a moisture-resistant material. After this the exterior of the home is covered in roofing and wall materials. The walls are usually covered on the sides. Wood, stone, and brush are often options. Electrical wiring and plumbing are put in next. Finally, the house is painted.

Building Materials



Reading Diagrams

The materials listed in the key are used in making the house.

Quick Check

16. Tall buildings are framed with steel. Why do you think this is so?

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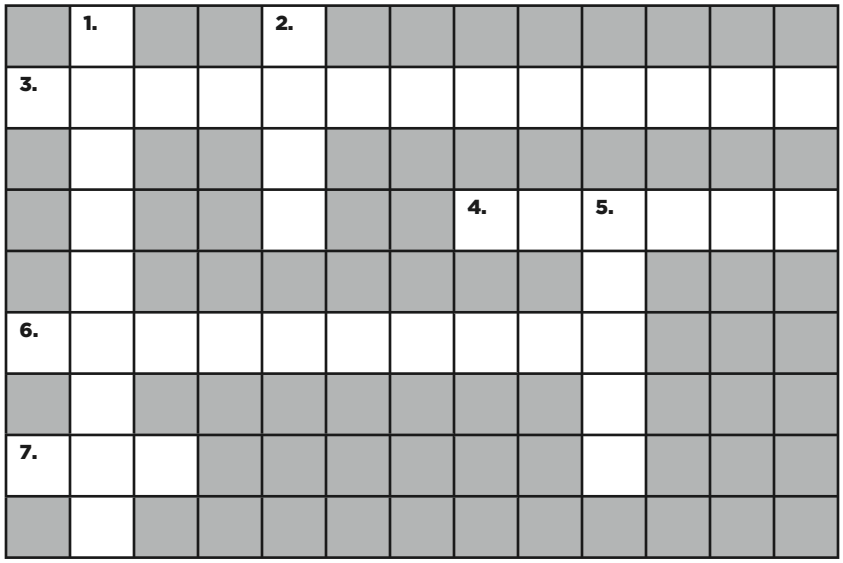
Earth's Resources

Fill in the blanks with words from the vocabulary box.

conservation
efficiency
energy source
natural gas
natural resource
renewable resource
nonrenewable resource
nuclear fuel
pollution
recycling

1. _____ a mixture of gases formed from marine life forms
2. _____ making new products by reusing things that might have been thrown away
3. _____ any source of energy in a nuclear power plant
4. _____ any material taken from Earth that can be replaced in a relatively short time
5. _____ any material taken from Earth that cannot be replaced in a relatively short time or at all
6. _____ the wise use of Earth's materials
7. _____ any material that people take from Earth to use
8. _____ comparing the amount of usable energy produced with the total amount of energy used in the process
9. _____ any harmful addition to the natural environment
10. _____ where the light, heat, or electricity that we use comes from

Use the clues below to fill in the crossword puzzle.



Across

3. Energy collected from falling water and used to make electricity

4. The joining of two nuclei with small masses to form a nucleus with a larger mass

6. Heat energy from within Earth.

7. A thick, black fluid that forms from decaying plants and animals.

Down

1. A material made artificially by treating natural resources with chemicals.

2. A hard, black substance formed from plants that lived about 300 million years ago.

5. Energy radiated by the Sun.

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