Building Blocks of Science®

Earth and Space Systems

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by Nicholas Moore

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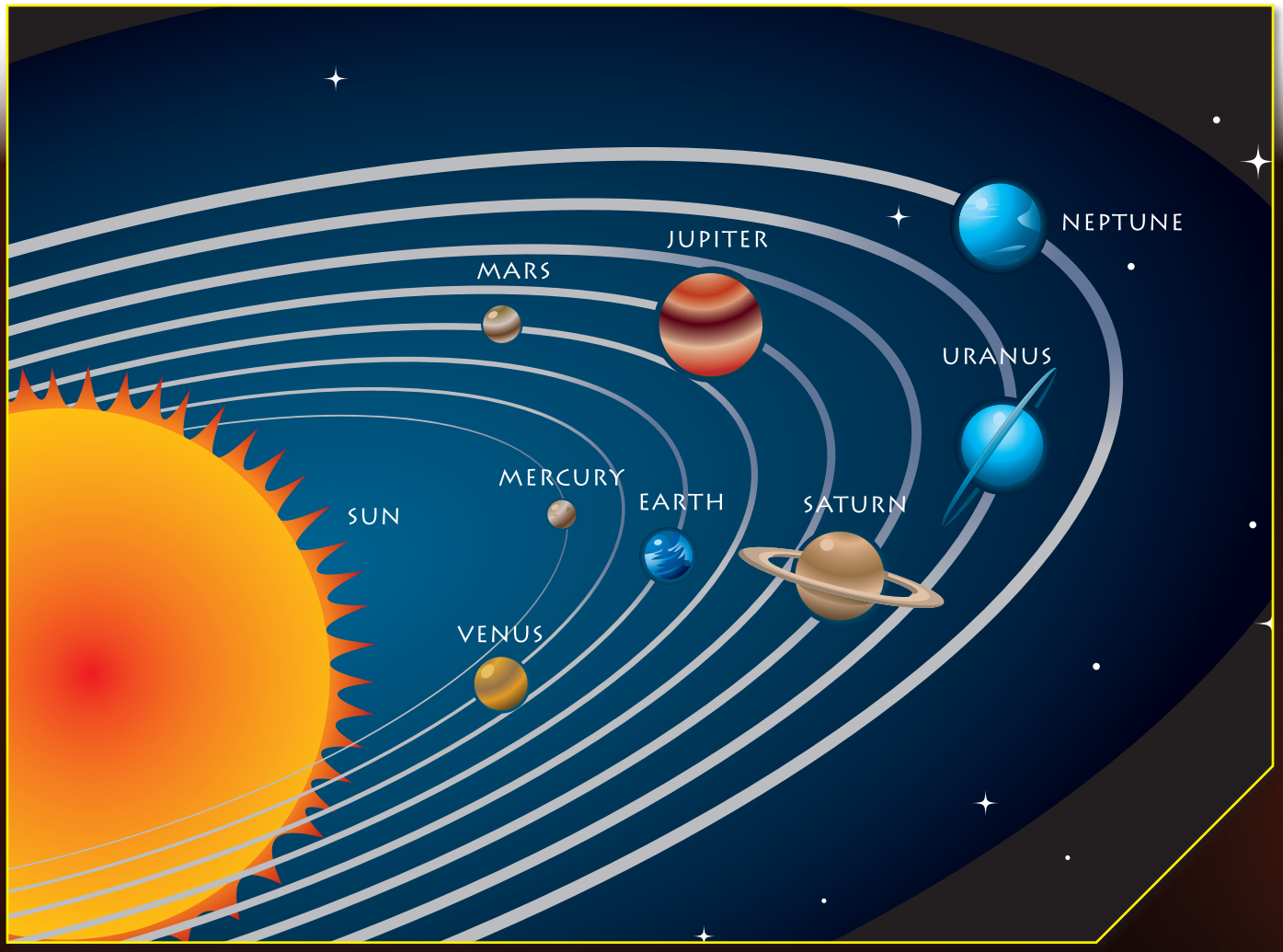
Earth's Place in Space

The Solar System

Long ago astronomers looked at the night sky and saw "wanderers." These were bright objects that followed a path different from the other stars. We now know that these wanderers are planets. Like Earth, these planets **revolve**, or travel, around the Sun. Their paths are called **orbits**.

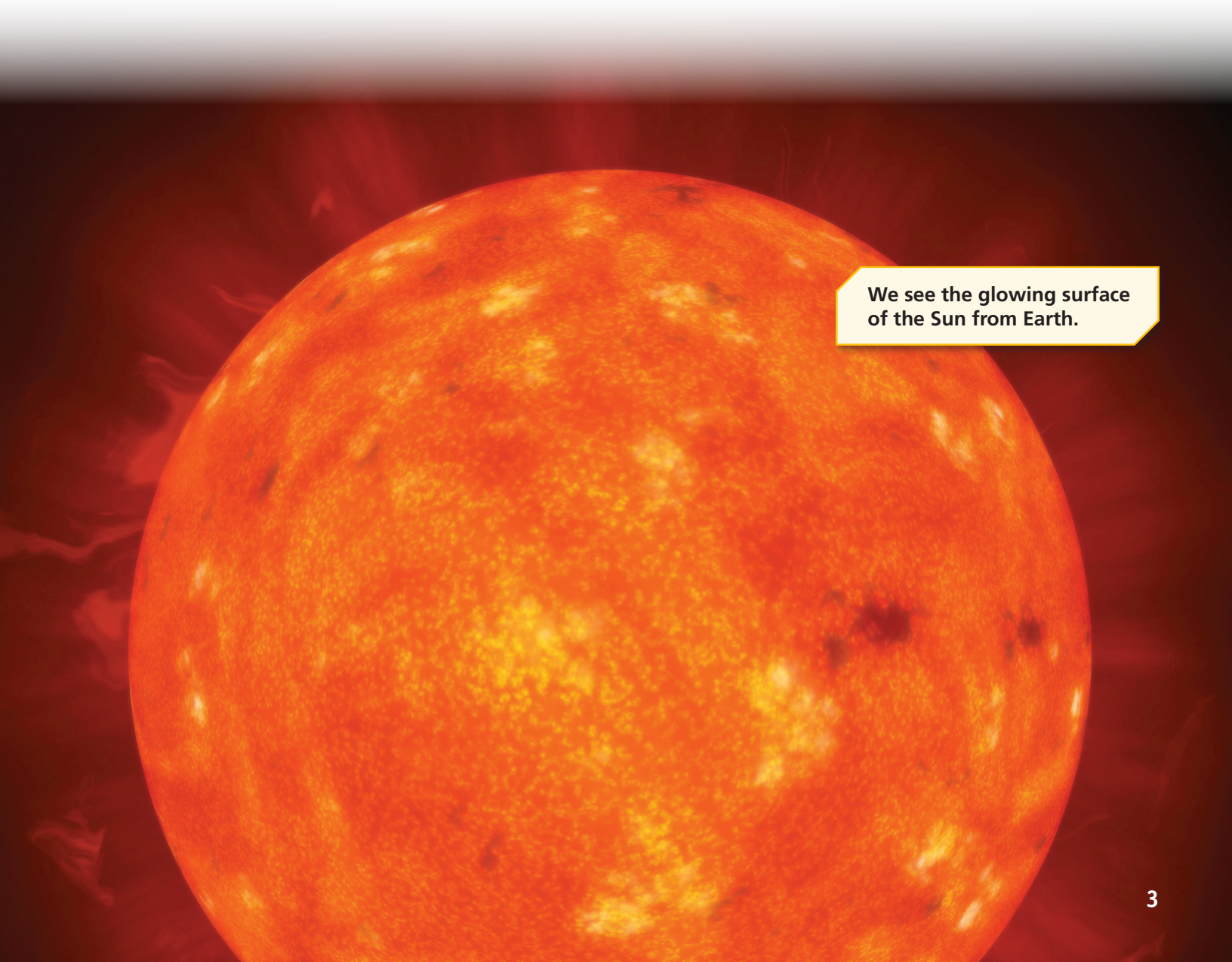
The Sun is a **star**, a huge ball of very hot gases in space. The Sun is at the center of our solar system. It is the star closest to Earth. A **solar system** is made up of a star and all the planets and other objects that revolve around that star. There are eight planets in our solar system. They revolve around the Sun in oval paths. The planets in order from the Sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.



The planets are held in their orbits by gravity. **Gravity** is a force that pulls objects toward each other. You are held on Earth's surface by the pull of Earth's gravity. Two things affect the force of gravity: how massive each object is and how far apart the objects are.

More than 98 percent of all the mass of the solar system is in the Sun. It is this mass that keeps the planets in orbit. The Sun is much bigger than Earth. Astronomers estimate that it would take more than one million Earths to fill the Sun!

The Sun is the most massive object in the solar system. But the Sun is just average in size and brightness compared to other stars. The Sun looks huge and very bright because it is the star closest to Earth.

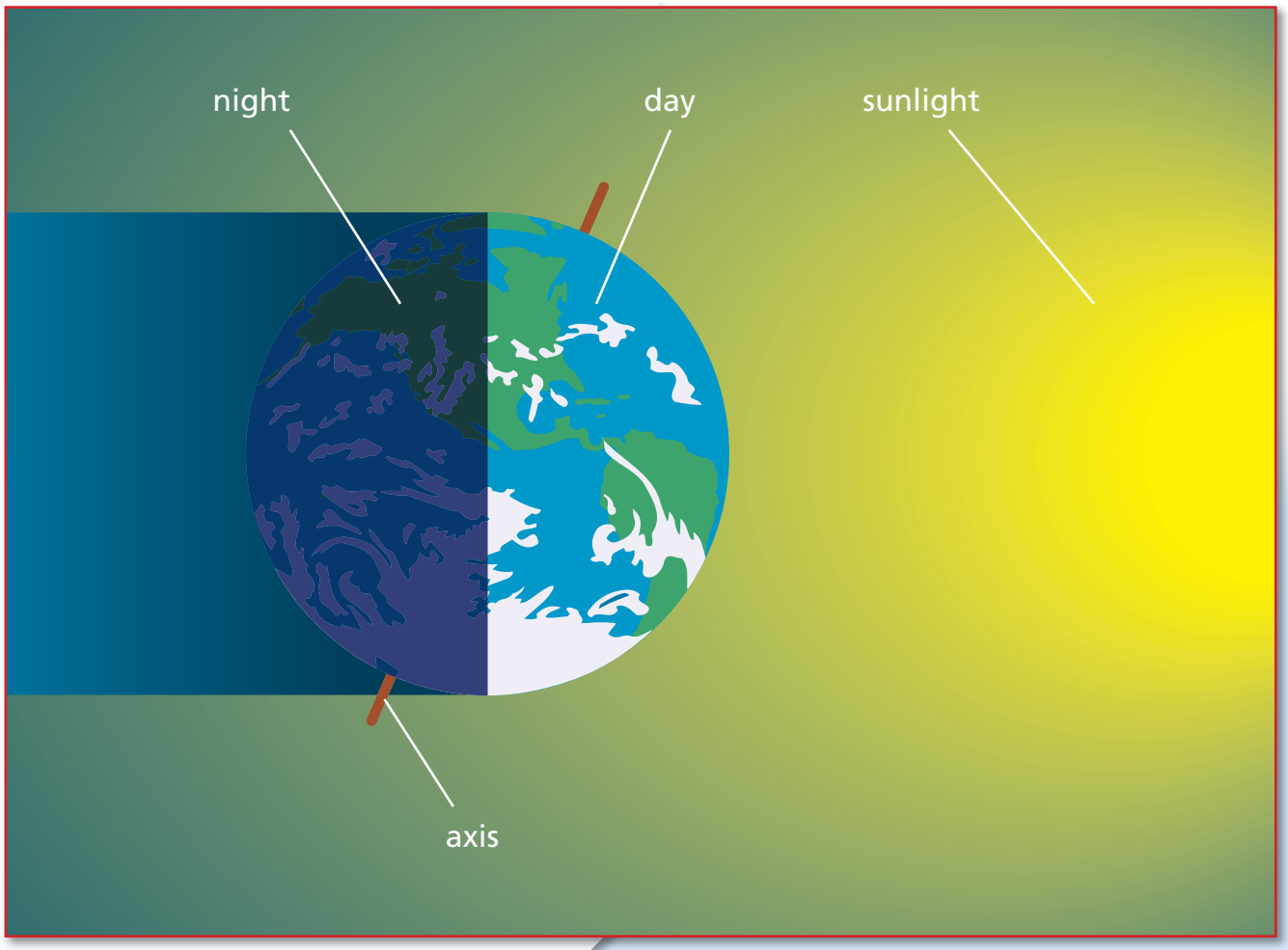


We see the glowing surface of the Sun from Earth.

Earth Rotates

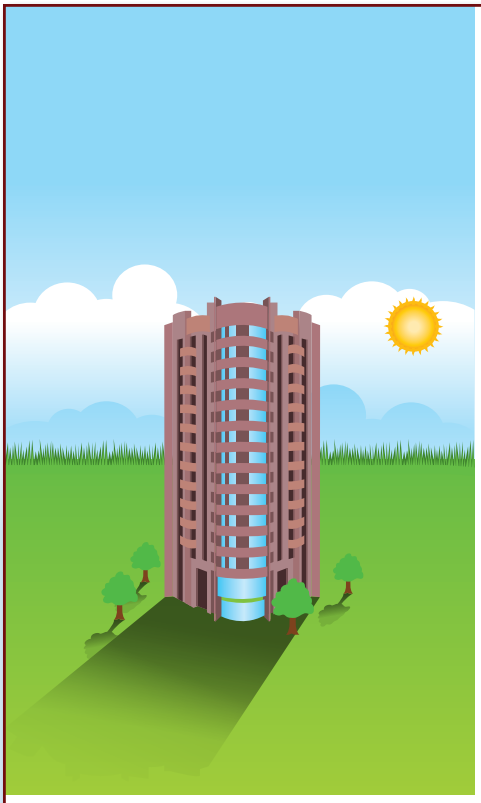
Every day the Sun appears to rise in the east. Around noon the Sun is high in the sky. In the evening the Sun appears to set in the west. After a period of darkness, this cycle, or pattern, repeats.

The cycle of day and night occurs because Earth **rotates**, or spins, on its **axis**. Earth's axis is an imaginary line running through the center of the planet from North Pole to South Pole. When a place on Earth faces the Sun, it is day in that place. When that place faces away from the Sun, it is night. One day/night cycle takes 24 hours.

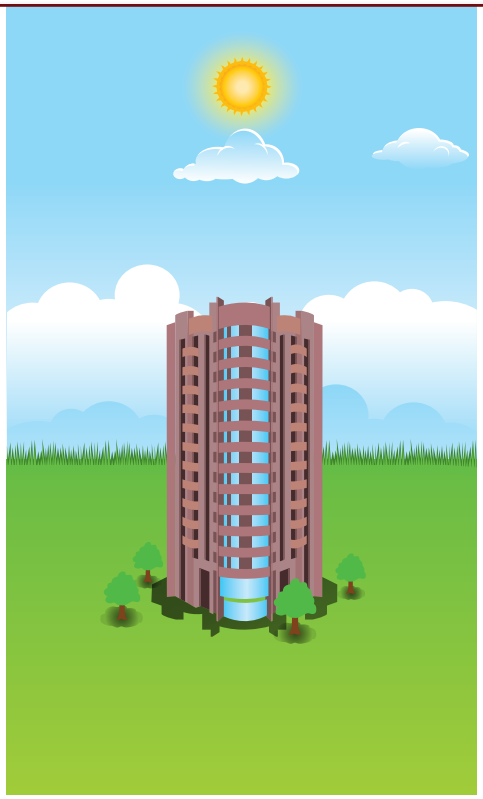


The Sun appears to rise and set. But it is Earth's rotation that causes the Sun to appear to move across the sky.

The position of the Sun in the sky is not the only thing that changes as Earth rotates. Shadows change, too. A **shadow** forms when an object blocks the light. Shadows change because Earth is rotating.



In the morning the Sun appears in the eastern sky. Shadows are long. They stretch toward the west.



At noon the Sun appears high overhead. Shadows are short.

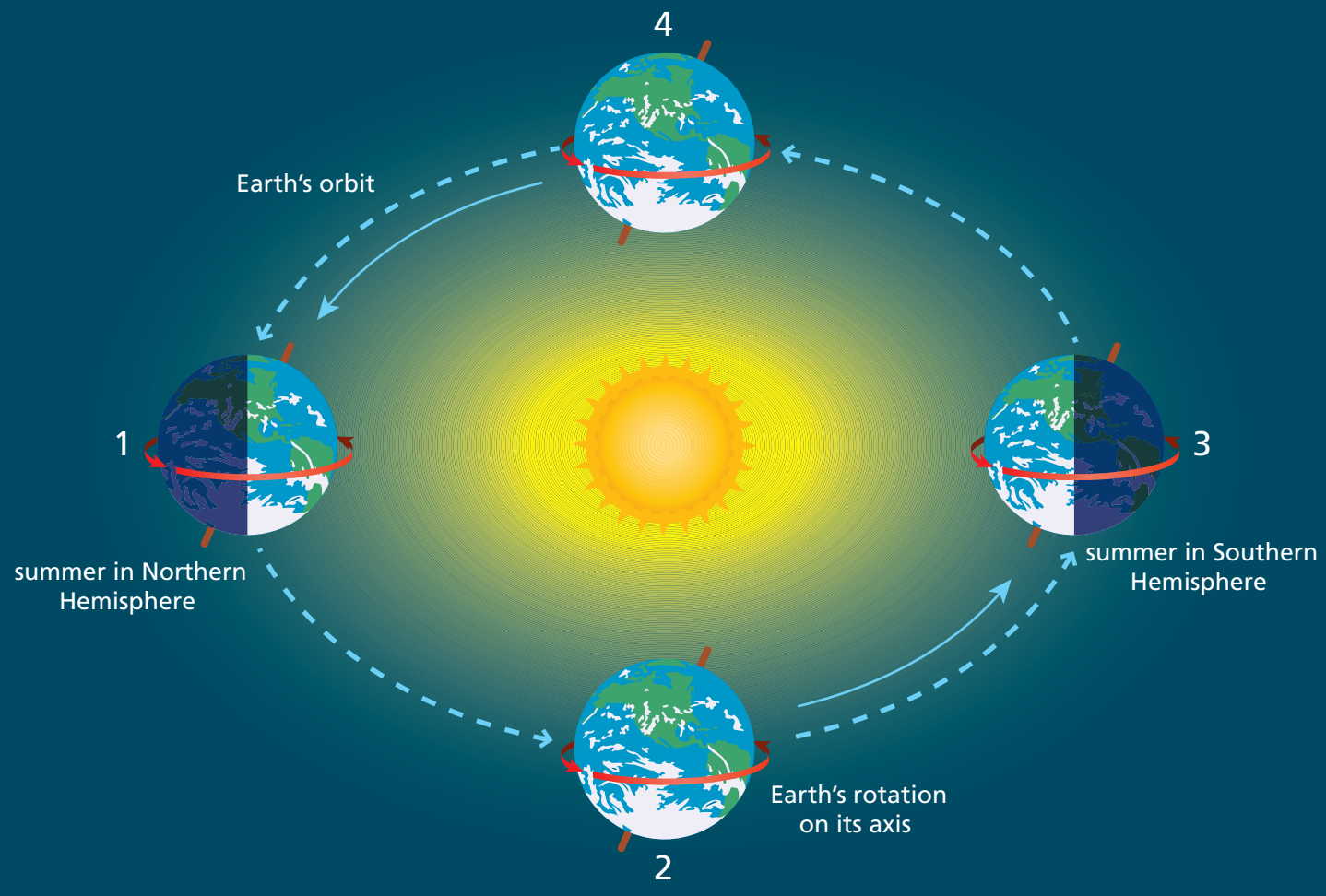
In the evening the Sun appears in the western sky. Shadows are long. They stretch toward the east.

Seasons

Like the other planets, Earth revolves around the Sun. Earth's orbit takes about 365 days, or one year.

You probably know that most places on Earth have seasons. During the summer there are more hours of daylight than hours of darkness. Temperatures are usually higher, too. The opposite happens in winter. These seasonal changes are a result of the tilt of Earth's axis as Earth revolves around the Sun.

What Causes Seasons. Earth's axis is always tilted at an angle of 23.5°. Near the equator, sunlight strikes Earth's surface straight on. Near the poles, sunlight strikes Earth at an angle, so the sunlight is spread out over a greater area. This makes the areas near the equator warmer than areas near the poles.



But Earth's tilt isn't the only factor. Earth's revolution plays a part, too. As Earth revolves around the Sun, the North Pole always points in the same direction. In December the North Pole is tilted away from the Sun, and the Northern Hemisphere has winter. In June the North Pole is tilted toward the Sun, so the Northern Hemisphere has summer.

Crosscutting Concept

When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere. Use the diagram on page 6 to figure out why.

Seasons in the Northern Hemisphere

1 **Summer** Summer is the warmest season. Summer days have the most hours of sunlight. The Sun's energy strikes parts of the Northern Hemisphere almost straight on.

2 **Fall** Because of Earth's tilt, the Sun's energy strikes less directly in the fall than in summer. The weather cools and hours of daylight decrease.

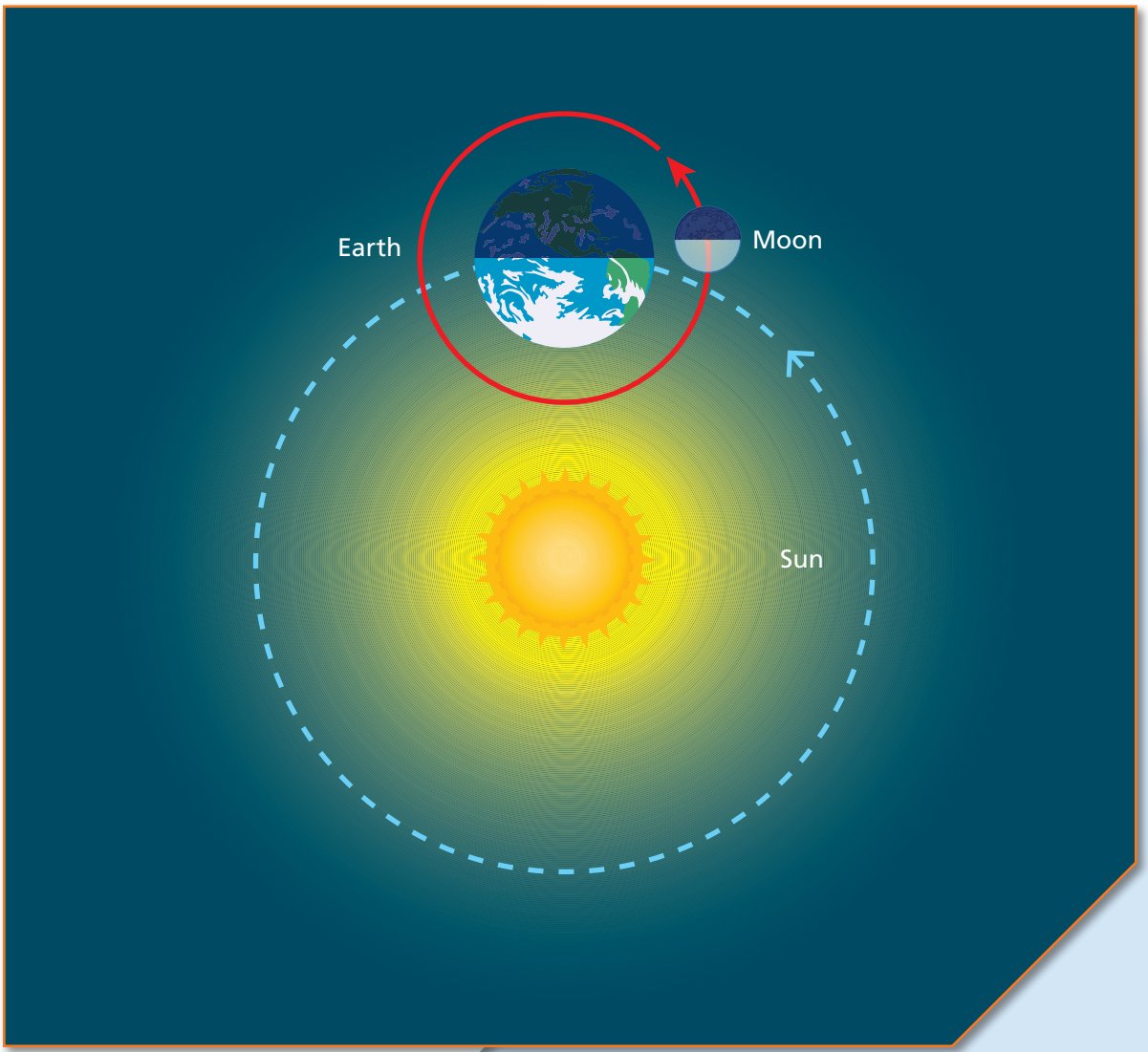
3 **Winter** During winter the Sun's energy strikes the Northern Hemisphere least directly. This causes fewer daylight hours and colder weather.

4 **Spring** In spring the Sun's energy strikes Earth more directly than it did in winter. The weather warms and daylight hours increase.

Earth and the Moon

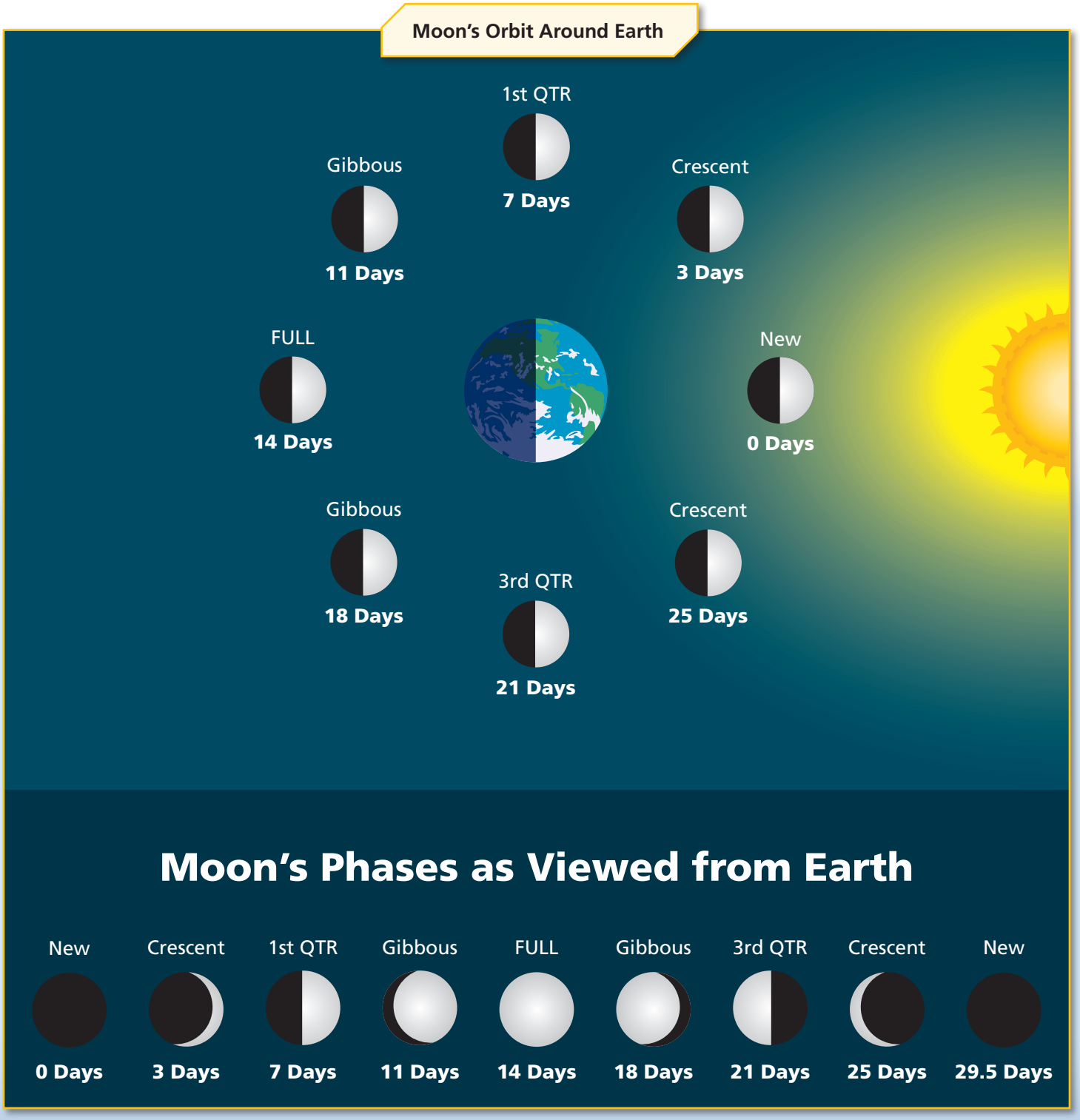
The Moon is Earth's natural satellite. A **satellite** is an object in space that orbits around a bigger object. The Moon orbits Earth in the same way that Earth orbits the Sun. Earth's greater gravitational force keeps the Moon in orbit. Like Earth, the Moon rotates as it travels in its orbit. It takes just over 29 days for the Moon to travel once around Earth.

The Moon does not make its own light. Instead, it reflects light from the Sun. The side of the Moon facing the Sun is always lit. As the Moon revolves around Earth, we can see different amounts of the moon's lighted side. The changes in shape we see happen in a predictable pattern called *phases*. The Moon's **phases** are the different shapes that the Moon seems to have when viewed from Earth.



The Moon revolves around Earth. Together, Earth and the Moon revolve around the Sun.

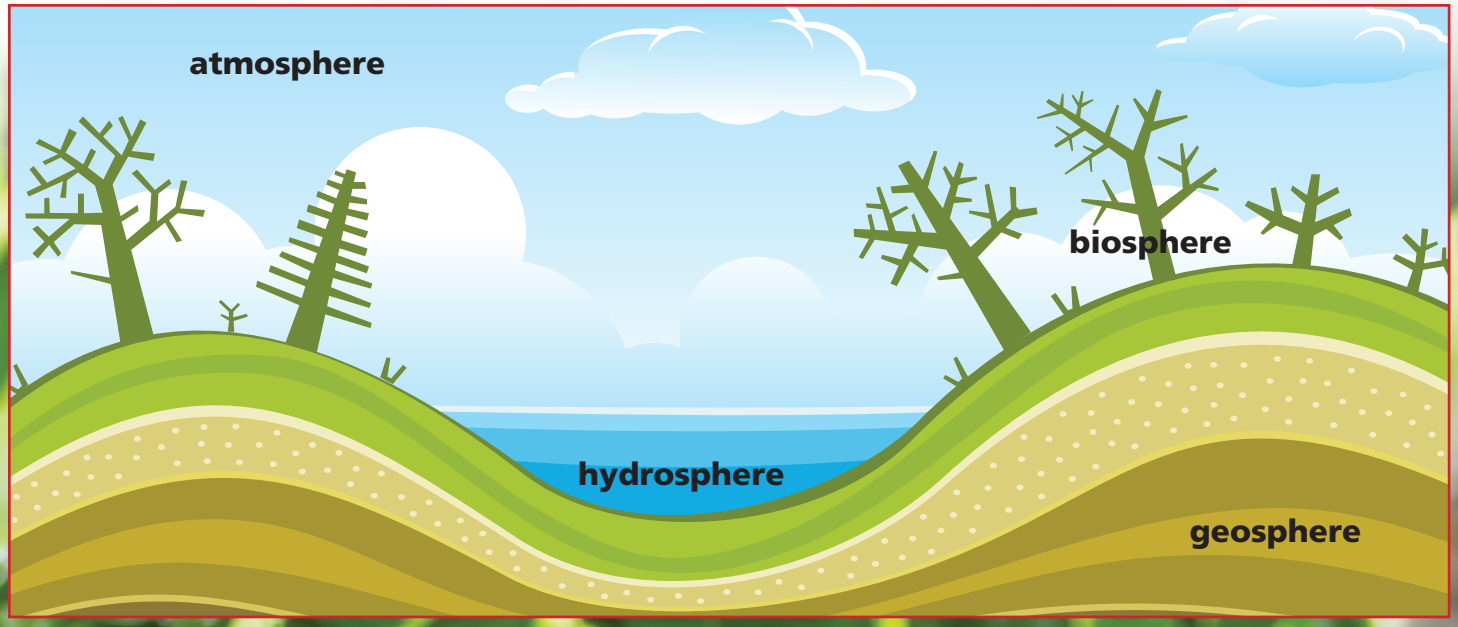
During its orbit, the Moon is sometimes directly between Earth and the Sun. At this time, we can see only a dim outline of the Moon's shape, or the new moon. As the Moon continues through its orbit, we can see more and more of its lighted side. When the Moon reaches the side of Earth opposite the Sun, we can see the bright, round phase known as the full moon. As the Moon moves through the last half of its orbit, we see less and less of the lighted side. Finally the Moon is again new.



Earth's Major Systems

Rock, water, air, and life all act together in Earth's major systems, or spheres. Each of these spheres is made up of many parts that work together.

- The **atmosphere** is the mixture of gases surrounding Earth. The air you breathe is part of the atmosphere.
- The **hydrosphere** includes all of Earth's liquid water and ice, water in soil and rock, and water vapor in the air. About three-fourths of Earth's surface is covered by water.
- The **geosphere** is made up of solid and liquid rock. Soil and sediment are also part of the geosphere.
- The **biosphere** is made up of all living things. The biosphere includes life in the atmosphere, the hydrosphere, and the geosphere. Humans are part of the biosphere.



The Biosphere

The biosphere is made up of all of the living things on Earth. It includes all of the plants, animals, fungi, and microbes. It also includes humans.

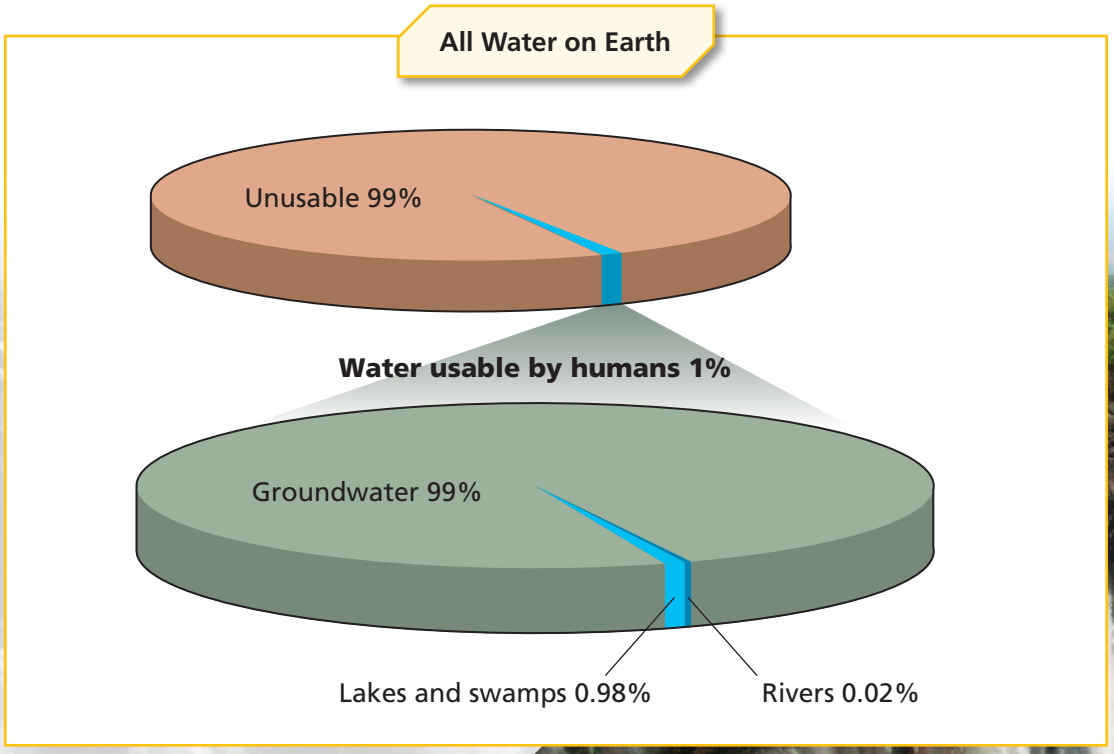
The organisms of the biosphere interact with the other systems. They get their water from the hydrosphere. Many get the air they need from the atmosphere. Plants get nutrients from the soil of the geosphere. People grow food in that same soil.

The living things in the biosphere interact with each other and with parts of the other spheres.

The Hydrosphere and Atmosphere

The hydrosphere is made up of all the liquid water on Earth. It also includes water frozen in ice and snow. The water droplets that make up the clouds and the invisible water vapor in the air are part of the hydrosphere. Water is also found in soil and in cracks in rock underground.

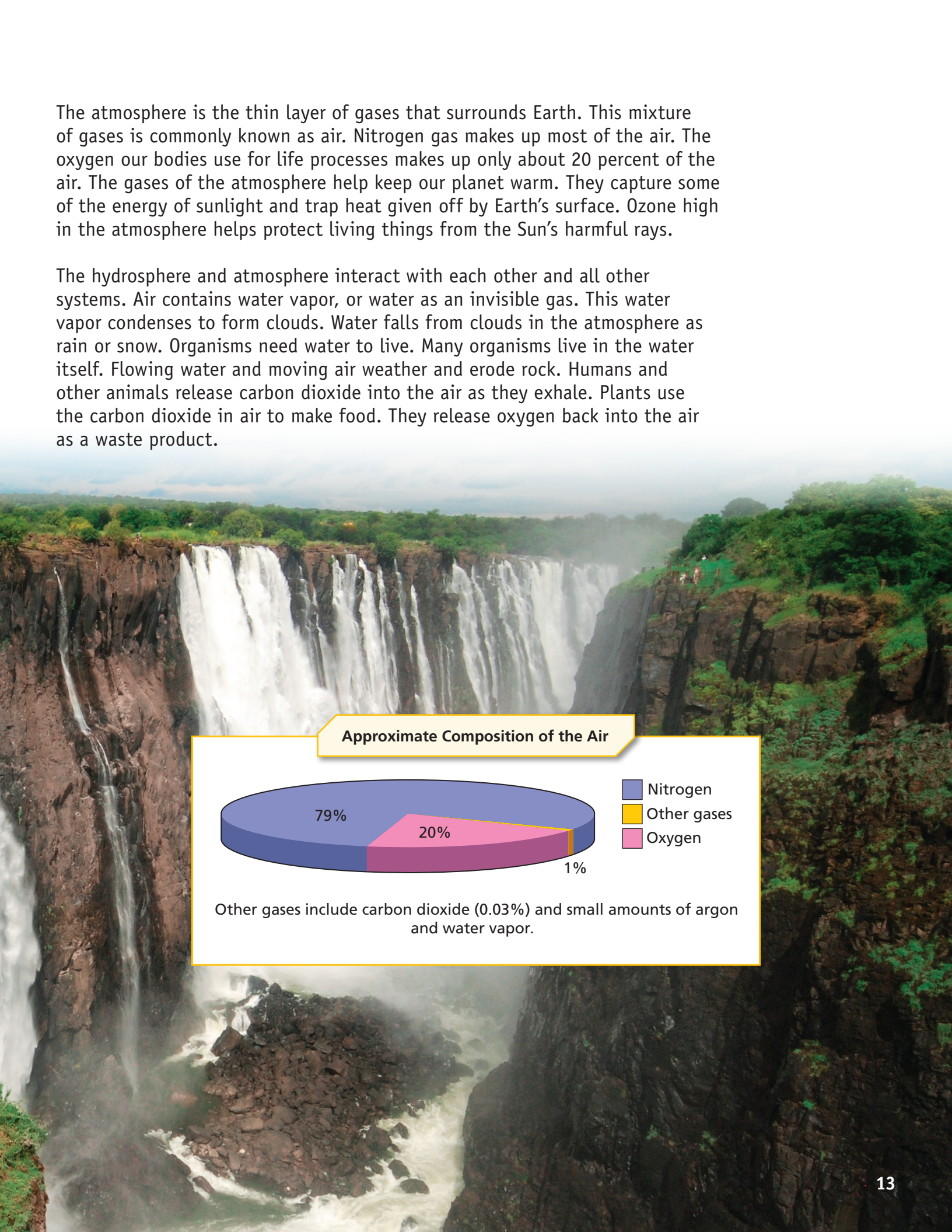
Most of Earth's water is not drinkable by humans. This water includes all the water in the ocean, water frozen as ice, and water in the atmosphere. Usable water is found in rivers and lakes, ponds, and underground.



Most of the water humans can use is stored in the ground.

The atmosphere is the thin layer of gases that surrounds Earth. This mixture of gases is commonly known as air. Nitrogen gas makes up most of the air. The oxygen our bodies use for life processes makes up only about 20 percent of the air. The gases of the atmosphere help keep our planet warm. They capture some of the energy of sunlight and trap heat given off by Earth's surface. Ozone high in the atmosphere helps protect living things from the Sun's harmful rays.

The hydrosphere and atmosphere interact with each other and all other systems. Air contains water vapor, or water as an invisible gas. This water vapor condenses to form clouds. Water falls from clouds in the atmosphere as rain or snow. Organisms need water to live. Many organisms live in the water itself. Flowing water and moving air weather and erode rock. Humans and other animals release carbon dioxide into the air as they exhale. Plants use the carbon dioxide in air to make food. They release oxygen back into the air as a waste product.



Approximate Composition of the Air

Other gases include carbon dioxide (0.03%) and small amounts of argon and water vapor.

The Geosphere

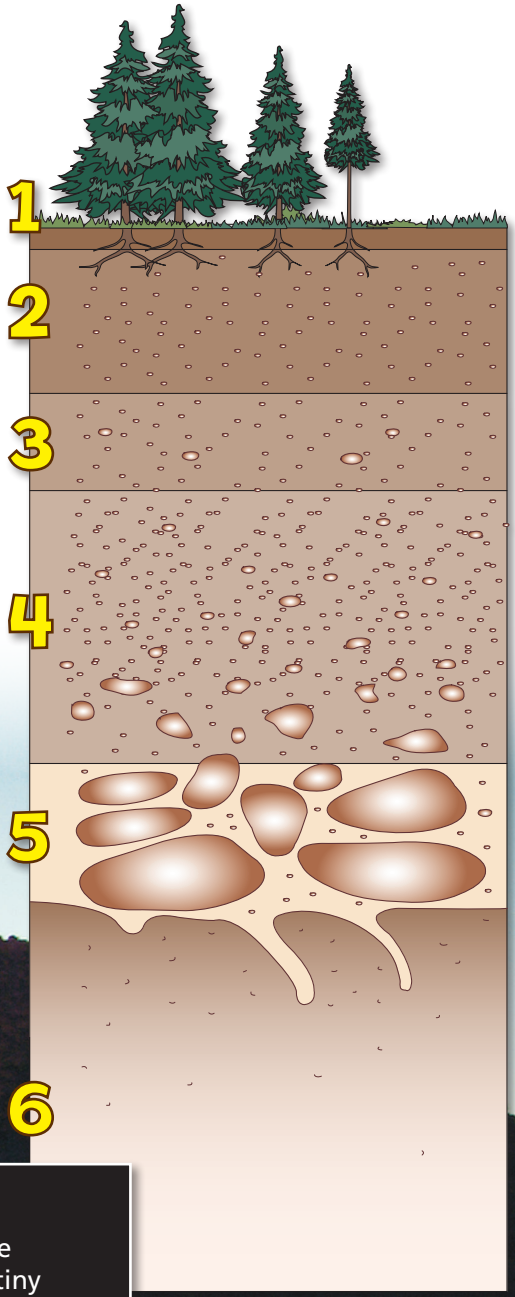
The geosphere is made up of all the rocks on Earth. It includes the soil and rocks in mountain ranges, canyons, and beaches. The solid rocks and **molten**, or liquid, materials under the surface are also part of the geosphere.

The geosphere is constantly changing. Forces within Earth crack and move the land. Ice freezes in cracks and causes rock to break. Water flowing over rock wears it away from one area and deposits it in another. Trees growing in cracks in rock also break it apart.

Molten rock flowing over the surface is called *lava*. Lava hardens to form the rock of the geosphere.

Living things of the biosphere also depend on the geosphere. Plants grow in soil, which is made up of broken rock. Other organisms live in soil. These organisms include worms, grubs, and insects. Also included are billions of microorganisms. These tiny living things are too small to see with the unaided eye.

Soil forms in layers called *horizons*. The top layers usually include living and once-living things. The middle and bottom layers have more minerals and rock pieces. The development of soil is an example of how all of Earth's systems work together.



Soil Layers

1. The top layer of soil is mostly leaf litter and humus. Humus is made up of dead plants and animals and decayed animal wastes. Many tiny organisms live in this layer and the one below it.
2. The next layer is known as topsoil. It is a mix of humus and weathered rock particles.
3. The layer below topsoil does not have a lot of nutrients. Water trickling down through this layer washes the nutrients deeper into the soil.
4. Subsoil collects dissolved minerals and clay from the layers above it.
5. As you move deeper in soil, rock particles get larger. This layer is mostly broken-up rock.
6. The lowest layer has no soil particles at all. It is made of bedrock. Bedrock is solid rock that is not broken or weathered.

Earth's Oceans

The ocean covers more that 70 percent of Earth's surface. The water in the ocean is salty. The salt in the water comes from minerals that have washed from the land over time.

The ocean has many environments. Most of these environments change with depth. Three factors change as you move deeper in the ocean.

- **Temperature** At the surface, ocean water is warmed by the Sun. But most of an ocean is deep, and deep water is cold with a temperature just above the freezing point of water.

- **Light** Water absorbs and scatters light, so the ocean gets darker with depth. Generally, there is no light 200 meters (about 650 feet) below the ocean's surface.

- **Pressure** Imagine diving into a deep pool. The deeper you go, the more water there is above you. The water presses down on your body. Ocean water is very deep—almost 11 kilometers (about 7 miles) at the deepest point. Water pressure at this depth can crush most objects.

Some organisms that live in the dark areas of the ocean make their own light. The light helps them attract prey.

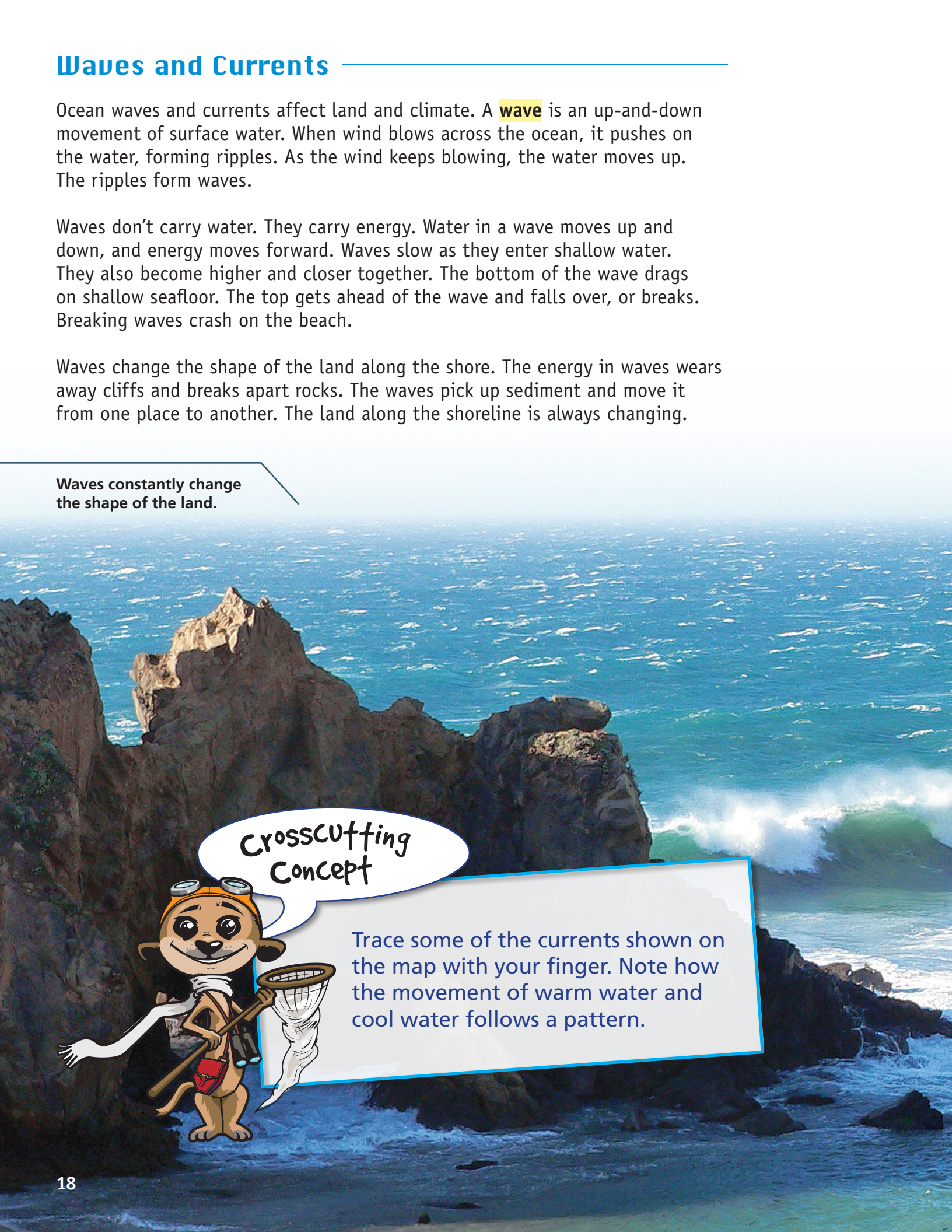
Waves and Currents

Ocean waves and currents affect land and climate. A **wave** is an up-and-down movement of surface water. When wind blows across the ocean, it pushes on the water, forming ripples. As the wind keeps blowing, the water moves up. The ripples form waves.

Waves don't carry water. They carry energy. Water in a wave moves up and down, and energy moves forward. Waves slow as they enter shallow water. They also become higher and closer together. The bottom of the wave drags on shallow seafloor. The top gets ahead of the wave and falls over, or breaks. Breaking waves crash on the beach.

Waves change the shape of the land along the shore. The energy in waves wears away cliffs and breaks apart rocks. The waves pick up sediment and move it from one place to another. The land along the shoreline is always changing.

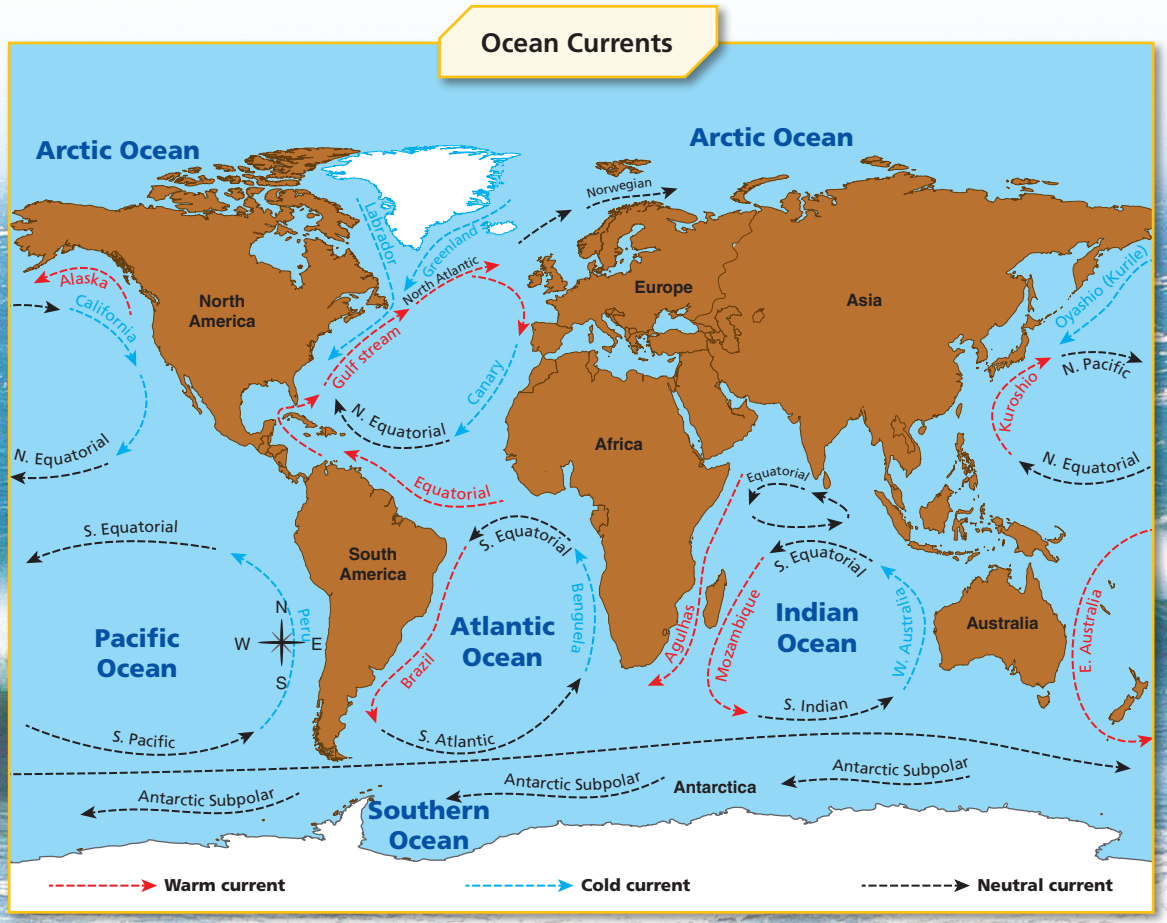
Waves constantly change the shape of the land.



A **current** is like a river moving through an ocean. Currents are caused by many factors, including wind, gravity, heating from the Sun, and Earth's rotation.

Surface currents are currents near the surface of the ocean. They are caused by winds that blow in a constant pattern. Because the winds follow a pattern, the currents do, too.

Currents have a strong influence on climate. Warm-water currents begin near the equator. They carry warm water toward the poles, warming areas near the ocean as they move. Currents that form near the poles and that flow toward the equator carry cooler water. These currents cause warmer areas to cool.



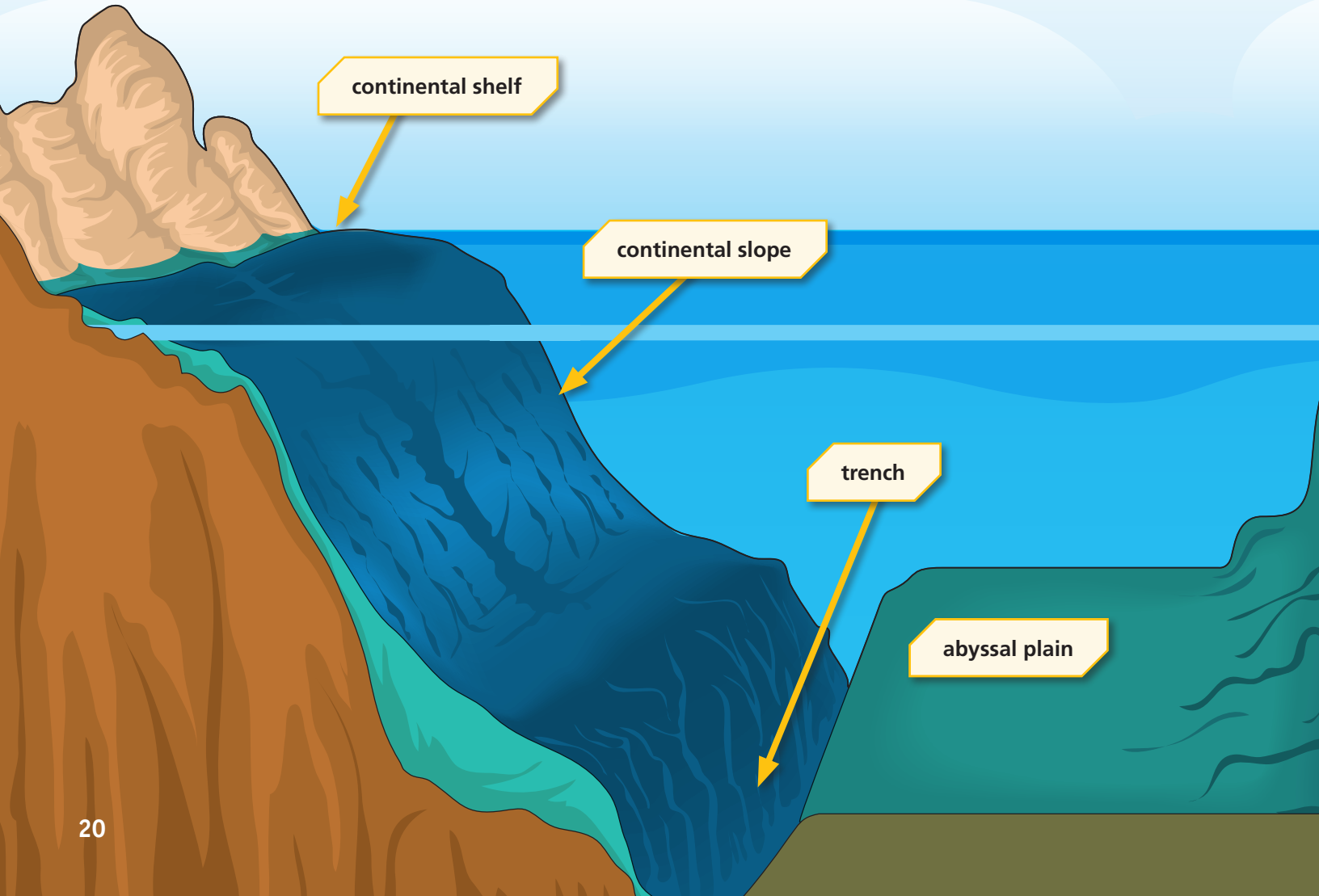
The Ocean Floor

The ocean looks flat when you view it from the surface. But the ocean floor has mountains, valleys, and plains, just like the surface of the land. Find each feature on the diagram as you read about the features of the ocean floor.

- **Continental Shelf** The part of the ocean floor that slopes gently near the land is the continental shelf. The depth of the shelf increases gradually. The average depth of the shelf is about 140 m (460 ft). Its width ranges from about 1.6 km to 1,200 km (1 mi to 750 mi).

- **Continental Slope** The continental slope drops steeply to about 3,000 m (10,000 ft) below the surface of the ocean. Both the continental shelf and slope have deep canyons that form as sediments from large rivers rush down these surfaces.

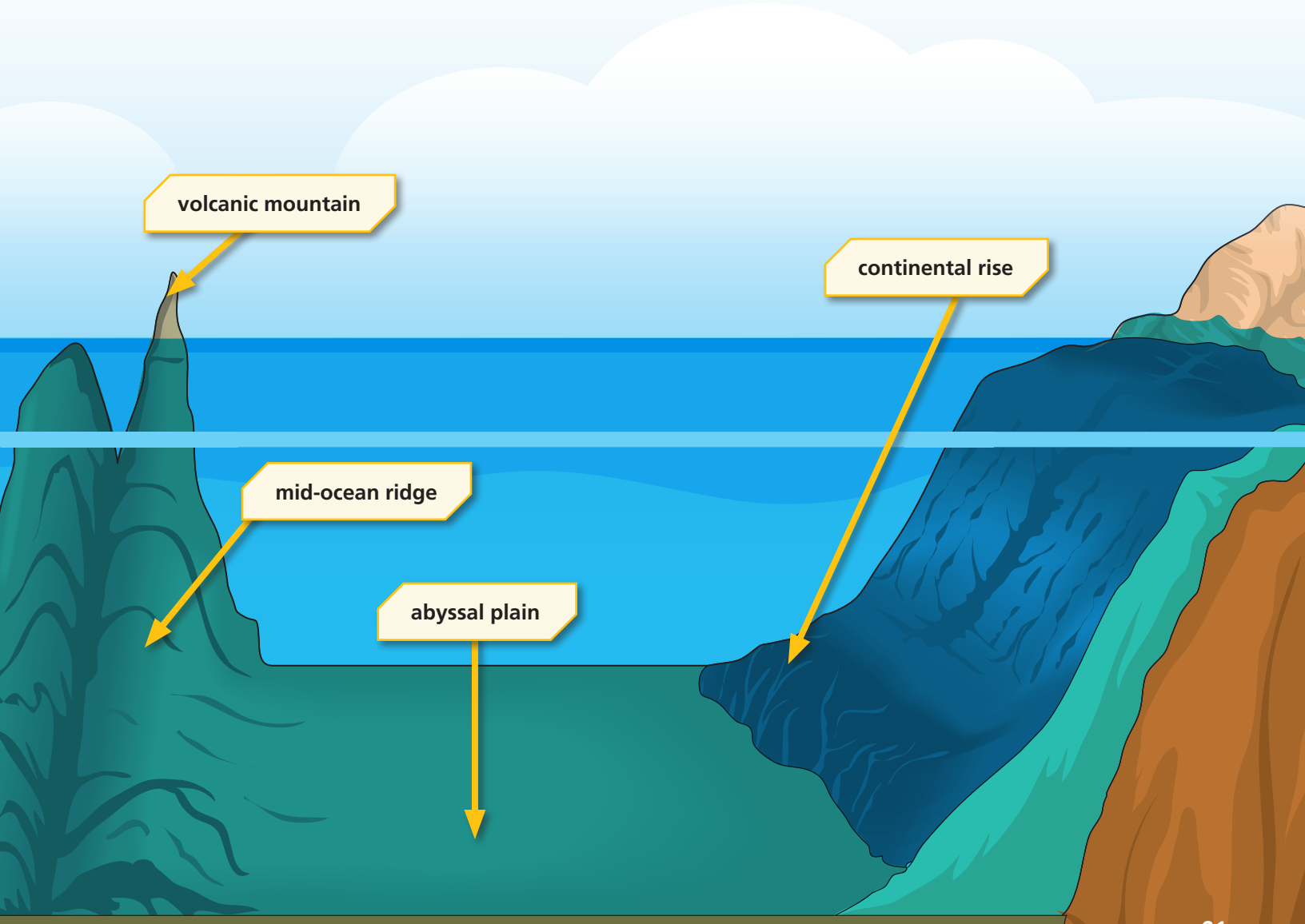
- **Continental Rise** The sediments that carve canyons into the shelf and slope, along with other materials, are carried out to sea. The sediments settle along the base of the continental slope. This pile of sediment forms the continental rise. The rise drops down to about 4,000 m (13,000 ft) below the surface of the ocean.



- **Abyssal Plains** The largest, flattest areas of the ocean floor are the abyssal plains. A thick layer of sediment covers these plains.

- **Trenches** Trenches cut across the abyssal plains in some areas. These trenches include the deepest parts of the ocean floor. The Mariana Trench in the Pacific Ocean is about 11,000 m (36,000 ft) below the surface.

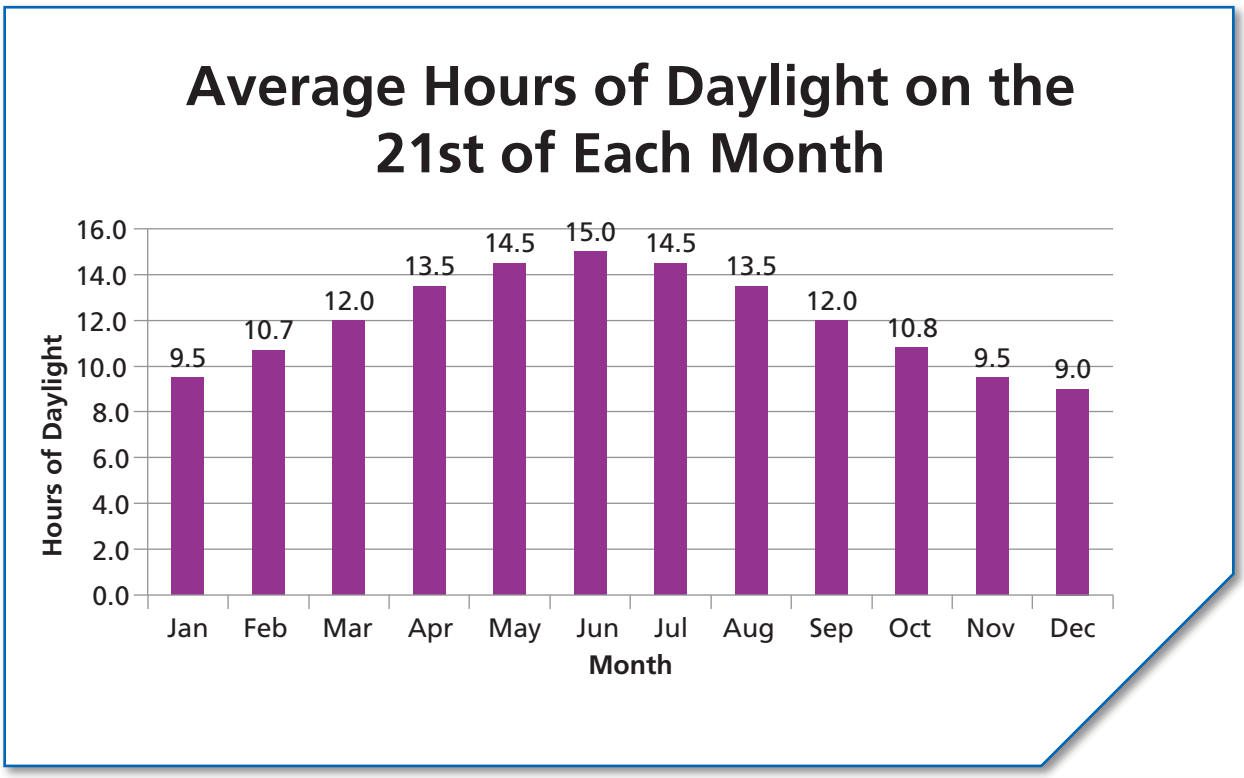
- **Volcanic Mountains** The abyssal plains also contain mountains. Many are formed by volcanic eruptions. Sometimes these mountains build up until they extend above the ocean surface. The Hawaiian Islands formed in this way. In the middle of the ocean are mid-ocean ridges. These are long chains of underwater mountains formed by magma coming up through cracks in the sea floor.



Science and Engineering Practices

Read the Graph!

You read on pages 6 and 7 that the number of hours of daylight changes with the seasons. Look at the graph below. Describe how the average number of daylight hours changes as the seasons change. Then explain why these changes occur.

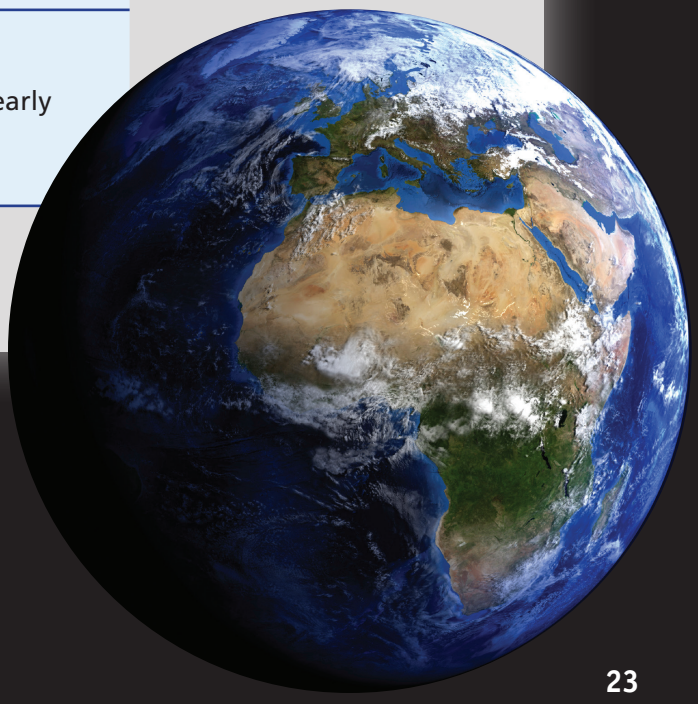


Careers

Hydrologist

Hydrology is the study of water. You know that most of Earth's surface is covered with water. But the water is not always in the right place at the right time or of the right quality. Hydrologists solve water-related problems. They may help farmers find sources of water for irrigating crops. They may help cities plan for future water needs. Some help clean up polluted water. Still others study how water moves through the ground in order to site landfills.

Would I like this career?	You might like this career if • you like to work with a team of people. • you enjoy working in the field. • you enjoy interpreting your findings for others
What would I do?	• You would study how water moves across and through Earth's crust. • You would use what you learn to solve problems of water quality or availability. • You would communicate solutions with planners and people in government.
How can I prepare for this career?	• Study science and math. • Learn to communicate clearly both when speaking and writing.



Glossary

atmosphere the blanket of air that surrounds Earth

axis the imaginary line that passes through Earth's center and its North and South Poles

biosphere all the living things on Earth

current a steady, stream-like movement of water though the ocean

geosphere the outer part of Earth composed of solid and liquid rock

gravity the force that pulls objects toward each other

hydrosphere all the water on Earth, including liquid bodies of water, frozen water as ice and snow, groundwater, and water vapor in the air

molten melted

orbit the path a body follows as it revolves around another body

phase how the Moon appears from Earth

revolve to travel around, or orbit, another object

rotate to spin around

satellite an object in space that orbits a larger object

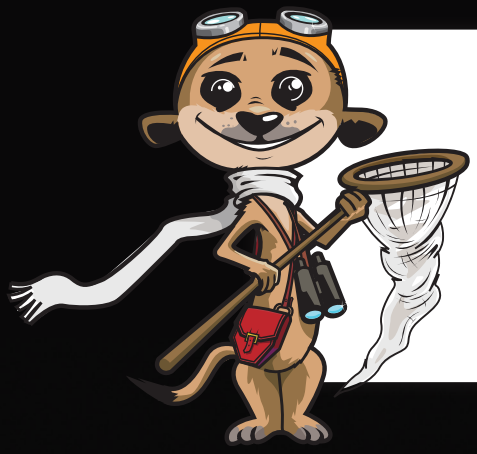
shadow the dark area formed when an object blocks the light

solar system a star and all the planets and other objects that revolve around it

star a ball of hot gases that gives off light and other types of energy

wave an up-and-down movement of surface water

p. 3: bikerboy82/istockphoto; **pp. 10-11:** tiverylucky/istockphoto; **pp. 12-13:** GeeeJay/istockphoto; **pp. 14-15:** Beboy_ltd/istockphoto; **pp. 16-17:** vilainecrevette/istockphoto; **pp. 17:** sculder19/istockphoto; **pp. 18-19:** keewizane/istockphoto; **p. 22:** ep_stock/istockphoto; **p. 23:** Tenedos/istockphoto; MarcelC/istockphoto



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