

# LESSON 3

## Earth's Spheres

**Guiding Question:** What are the characteristics of Earth's geosphere, biosphere, atmosphere, and hydrosphere?

### Knowledge and Skills

- Describe the parts of Earth's geosphere.
- Describe Earth's biosphere and atmosphere.
- Discuss the water cycle.

### Reading Strategy and Vocabulary

**Reading Strategy** As you read, draw a concept map that relates Earth's geosphere, lithosphere, mantle, and core.

**Vocabulary** crust, mantle, core, tectonic plate, landform, deposition, evaporation, transpiration, precipitation, condensation, aquifer, groundwater



### 3.3 LESSON PLAN PREVIEW

**Inquiry** Students explore convection and its relationship to plate tectonics through a teacher demonstration.

**Differentiated Instruction** Less proficient readers learn about the atmosphere and biosphere by making a cluster diagram.

**Real World** Students research typical local precipitation.

### 3.3 RESOURCES

Paper and Pencil Activity, *Age the Islands* • Bellringer Video, *Volcano to Earthquake* • Map It Online • Lesson 3.3 Worksheets • Lesson 3.3 Assessment • Chapter 3 Overview Presentation

**FOCUS** Watch the ABC News video **Volcano to Earthquake**, which describes the devastation caused by an earthquake in Indonesia and points out the connection between the earthquake and volcanic activity nearby. Use this video to introduce the idea that changes in the geosphere are related to earthquakes and volcanoes.

**YOU MAY BE THINKING** of Earth's geosphere, biosphere, atmosphere, and hydrosphere as a set of concentric spheres or Russian dolls, fitting neatly together but separate. As you will learn in the next two lessons, however, Earth's spheres interact with each other. You could think of each sphere as a different highway in the same area. Cars on the highways can travel independently of one another. But at interchanges, there is an intricate dance between cars traveling on a highway and those entering or exiting it.

## The Geosphere

**Earth's geosphere consists of the crust, the mantle, and the core.**

Earth's geosphere consists of the rock and minerals (including soil) on Earth's surface and below it. It includes the crust, the mantle, and the core. Tectonic plates that carry the continents move with the mantle, whose movement is fueled by heat from Earth's core.

**Earth's Crust and Mantle** Earth's **crust** is a thin layer of relatively cool rock that forms Earth's outer skin both on dry land and in the ocean. Below the crust is the **mantle**, a layer of very hot but mostly solid rock. The crust and the uppermost part of the mantle make up the lithosphere. The lithosphere is carried on a softer, hot layer of rock called the *asthenosphere*. The lower part of the lithosphere and the asthenosphere are included in the upper mantle. Below the upper mantle is the solid rock of the lower mantle.

**The Core** Beneath the lower mantle is Earth's **core**. Earth's outer core is made of molten metals such as iron and nickel that are almost as hot as the surface of the sun. Earth's inner core is a dense ball of solid metal. The heat from the outer core pushes the asthenosphere's soft rock upward (as it warms). The rock then sinks downward as it cools, like a gigantic conveyor belt. This process is called *convection*.

# Map it

**Plate Tectonics** As the asthenosphere moves, it drags along large plates of lithosphere called **tectonic plates**. Earth's surface consists of about 15 major tectonic plates, most of which include some combination of ocean floor and continent (**Figure 15a**). Imagine peeling an orange and putting the pieces of peel back onto the fruit; the ragged pieces of peel are like the plates of Earth's crust. These plates move about 2 to 15 centimeters (1 to 6 inches) per year. This movement has influenced Earth's climate and life's evolution as the continents have combined, separated, and recombined. By studying ancient rock formations throughout the world, geologists have determined that, at least twice, all the world's continents were combined as a supercontinent. Scientists call the most recent supercontinent *Pangaea* (**Figure 15b**).

These collisions and separations of plates result in **landforms**—features such as mountains (above and beneath the ocean's surface), islands, and continents. Landforms created by tectonic processes influence climate by altering patterns of rainfall, wind, ocean currents, heating, and cooling. These climate characteristics, in turn, affect the rates of soil formation, erosion, and **deposition** (the depositing of eroded soil at a new location). And climate, soil formation, erosion, and deposition affect the ability of a given plant or animal to inhabit a region. Thus, plate tectonics affects the types of animals that can live in an area.

## Pangaea

Trace Pangaea and the boundaries drawn on it in **Figure 15b**. Then refer to **Figure 15a** as you respond to the items below.

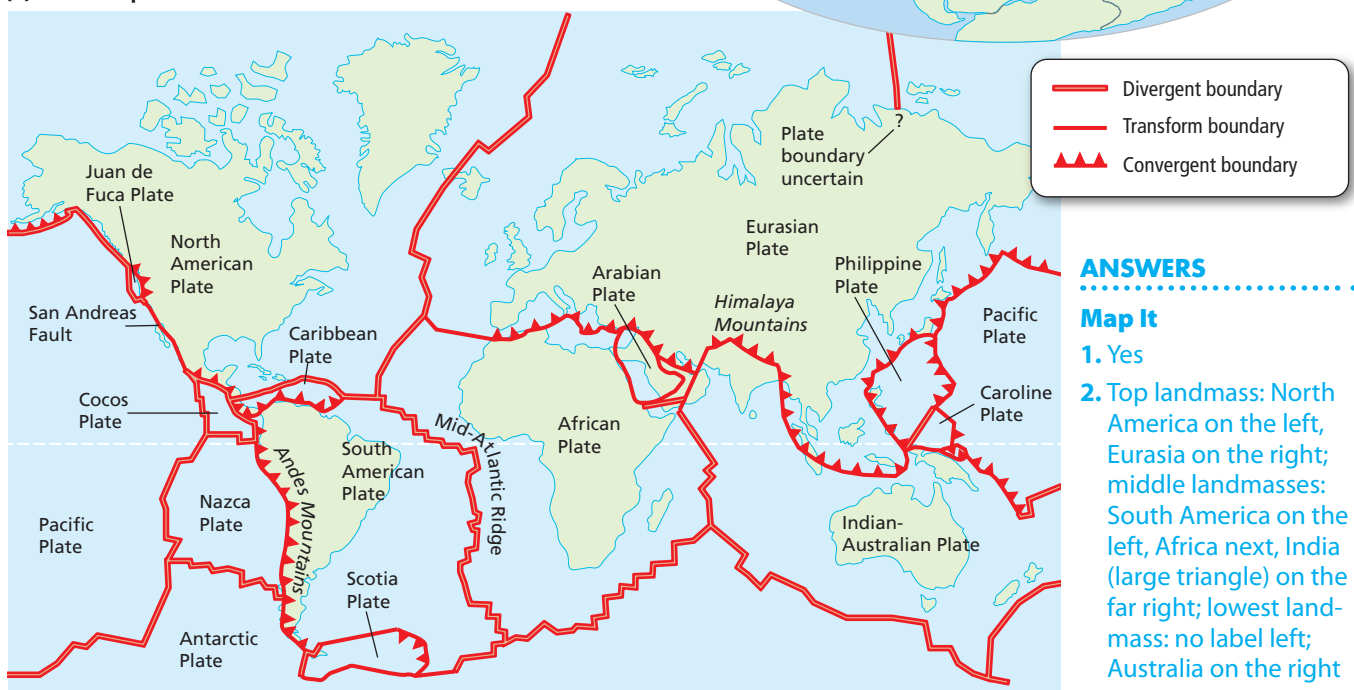
### 1. Compare and Contrast

Compare the shapes drawn on Pangaea to the shapes of today's continents. Aside from Antarctica, can you match each of those shapes, to one of today's continents?

**2. Interpret Maps** On your tracing, label the shapes that correspond to modern North America, South America, Eurasia, Africa, India, and Australia.

**FIGURE 15 Tectonic Plates** Earth's crust consists of about 15 major plates (**a**) that move very slowly by the process of plate tectonics. Today's continents were joined in the supercontinent Pangaea (**b**) about 225 million years ago.

(a) Tectonic plates

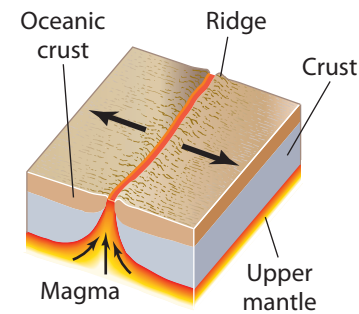


## ANSWERS

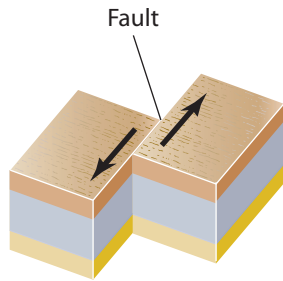
### Map It

1. Yes

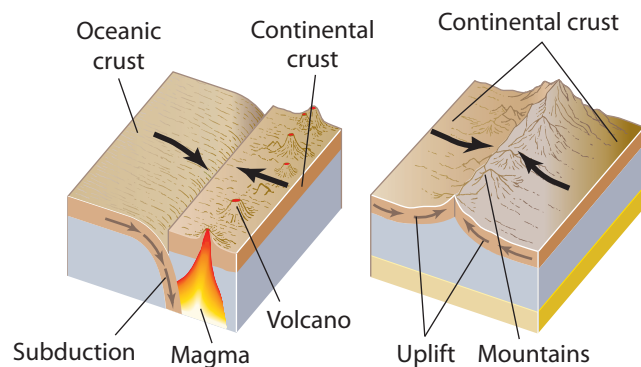
2. Top landmass: North America on the left, Eurasia on the right; middle landmasses: South America on the left, Africa next, India (large triangle) on the far right; lowest landmass: no label left; Australia on the right



(a) Divergent plate boundary



(b) Transform plate boundary



(c) Convergent plate boundaries

**FIGURE 16 Plate Boundaries** Different types of boundaries between tectonic plates result in different geologic processes (above). At a divergent plate boundary (a), magma surges up through the crust, and the two plates move gradually away like conveyor belts. At a transform plate boundary (b), two plates slide alongside each other, producing friction that leads to earthquakes. At a convergent plate boundary (c), one plate may be subducted beneath another, leading to volcanoes, or both plates may be uplifted, resulting in mountain ranges, such as the Himalayas (right).

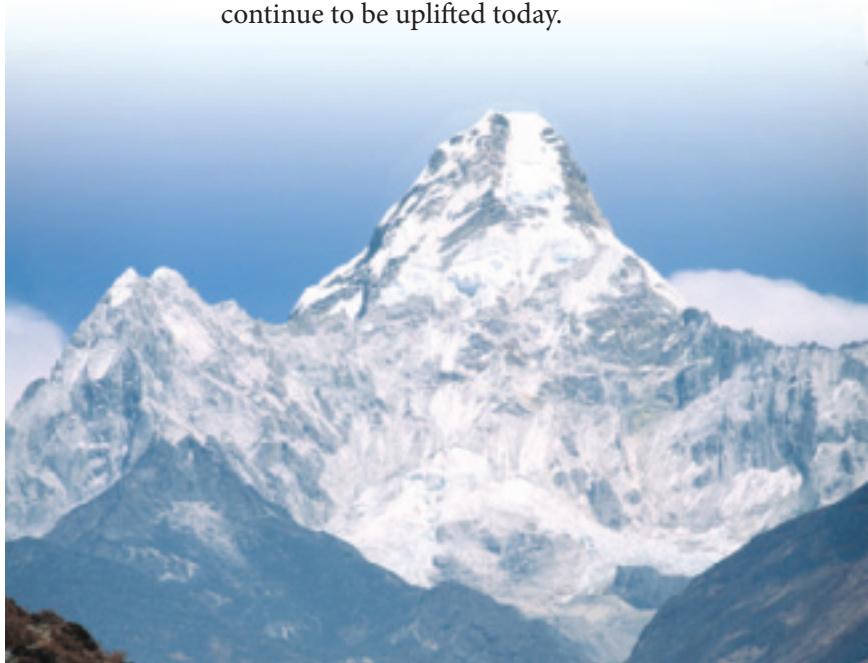
**Types of Plate Boundaries** Plates interact in different ways based on the type of boundary between them. The type of plate boundary also determines the type of landform that results from a collision. Plate boundaries are either divergent, transform, or convergent.

► **Divergent Plate Boundaries** At divergent plate boundaries, magma, or molten rock, surges upward to the surface and pushes plates apart, creating new crust as it cools (Figure 16a). A prime example is the Mid-Atlantic Ridge, part of a 74,000-kilometer (46,000-mile) system that cuts across the ocean floor. Plates expanding outward from divergent plate boundaries at mid-ocean ridges bump against other plates, forming transform or convergent plate boundaries.

► **Transform Plate Boundaries** When two plates meet, they may slip and grind alongside one another, forming a transform plate boundary (Figure 16b). The friction between plates at transform plate boundaries often spawns earthquakes. The Pacific Plate and the North American Plate, for example, rub against each other along California's San Andreas Fault, the origin of many of North America's most severe earthquakes.


► **Convergent Plate Boundaries** When plates collide at convergent plate boundaries, one of two events happens (Figure 16c). One plate of crust may slide beneath another in a process called *subduction*. The subducted crust is heated as it dives into the mantle, and it may send up magma that erupts through the surface in volcanoes. Mount Saint Helens in Washington, which erupted violently in 1980 and became active again in 2004, is fueled by magma from this process of subduction.

Alternately, the two plates may collide, slowly lifting material from both plates in a process called *mountain-building*. The Himalayas, the world's highest mountains, formed through mountain-building. They are the result of the Indian-Australian Plate's collision with the Eurasian Plate 40–50 million years ago. The Himalayas continue to be uplifted today.





# The Biosphere and Atmosphere

 Earth's biosphere and atmosphere are the living Earth and the ocean of gases that supports and protects it.

Like all of Earth's systems, Earth's biosphere and atmosphere interact. The gases used and expelled by organisms in the biosphere affect the composition of gases in the atmosphere. In turn, the gases in the atmosphere protect and support the organisms in the biosphere.

**The Biosphere** The part of Earth in which living things interact with nonliving things is Earth's biosphere, which you could call “the living Earth.” You may think that all of Earth has living things, but remember that Earth is not an empty shell. It is filled with hot rock and metal—and scientists know of no organisms living in Earth's mantle or core.

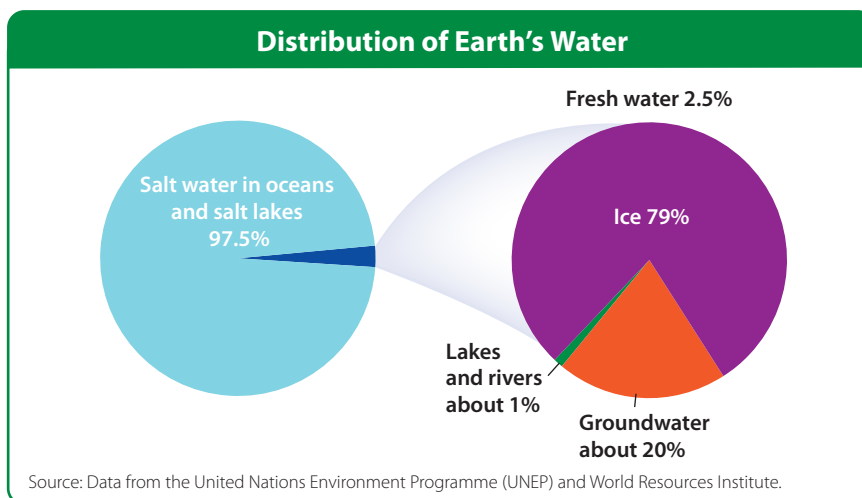
**The Atmosphere** When you look at a photo of Earth from space, the atmosphere looks like a very thin blue line (**Figure 17**). But that thin blue line is an ocean of gases that support and protect the entire biosphere. The atmosphere contains the gases, such as oxygen, that organisms use for their life processes. It also contains *ozone*, a gas made up of oxygen molecules that each have three oxygen atoms. A layer of ozone protects the biosphere from the sun's radiation—it is a sort of global sunscreen.

The atmosphere also includes gases that keep Earth warm enough to support life, protecting the biosphere from the bitter cold of space. These gases, which include carbon dioxide and methane, are called greenhouse gases because the way they keep Earth warm is analogous to the way the sun's energy, enhanced by the windows of a greenhouse, keeps plants warm. The process is called the greenhouse effect. As you may already know, human activities can affect it. You will read more about the greenhouse effect in a later chapter.

**FIGURE 17 Atmosphere** From space, Earth's atmosphere looks like a thin blue line hovering over the surface.



**FIGURE 18 Distribution of Earth's Water** Most of Earth's water is salt water, which cannot be used for drinking or for watering crops. Only 2.5 percent of Earth's water is fresh water, and 79 percent of that is frozen. A tiny percentage of Earth's water is vapor.



## The Hydrosphere

Water cycles through the lithosphere, biosphere, and atmosphere endlessly.

Water is essential to life, but we frequently take it for granted. As a means of transport and as a solvent, water plays key roles in nearly every environmental system, including all the other cycles of matter and the life processes of every organism in the biosphere.

### ANSWERS

#### Quick Lab

1. *Groundwater, Lakes and Rivers*
2. About 0.5%
3. Oceans contain salt water, which is not usable for drinking or for watering crops. If a coastal region has little groundwater and few lakes or rivers, it could have water shortages.

**Earth's Water** Most of Earth's water is salt water (**Figure 18**). The salt water in oceans and salt lakes makes up about 97.5 percent of Earth's water. So only 2.5 percent of Earth's water is fresh water. And more than three quarters of that fresh water is ice. (The ice-covered parts of Earth are sometimes called the *cryosphere*.) Only about 0.5 percent of Earth's water is unfrozen fresh water that might be used for drinking or watering crops. Most of that water is underground, in groundwater, and must be brought to the surface via pumps and/or wells. The rest is in lakes and rivers and must be transported to the areas that need it. Given water's importance and its limited accessibility, it is easy to see how shortages and conflicts over its use occur.

## Quick Lab

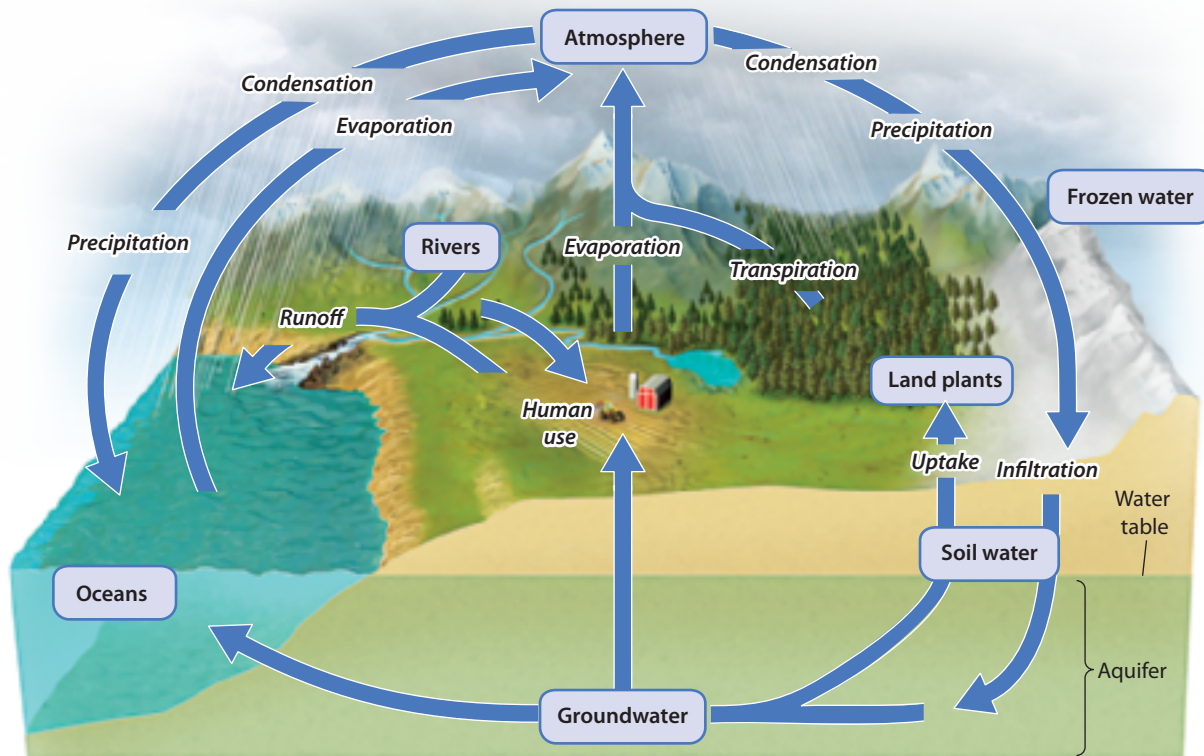
### Distribution of Earth's Water

- 1 Fill a 1-liter plastic bottle with water. This amount represents all of Earth's water.
- 2 Pour 97.5 percent, or 975 milliliters, of the water into a large bowl. This amount represents Earth's salt water.
- 3 Label cups *Ice*, *Groundwater*, and *Lakes and Rivers*.
- 4 Using **Figure 18**, calculate how much of the remaining 25 milliliters should be poured into each cup.
- 5 Use a graduated cylinder to measure and pour the correct amount of water into each cup.

### Analyze and Conclude

1. **Infer** Which cup(s) represent water that humans can easily use for drinking or watering crops?
2. **Calculate** Calculate the percentage of Earth's water that those cups represent, combined.
3. **Draw Conclusions** Some regions have water shortages even though they are located on ocean coasts. How could that be the case?

**FIGURE 19 The Water Cycle** The water cycle summarizes the many routes that water molecules take through Earth's spheres. In this diagram, labels in boxes refer to sources of water, and italic labels refer to processes of the water cycle.



Adapted from Schlesinger, W.H. 1997. *Biogeochemistry: An analysis of global change*, 2nd ed. London: Academic Press

**The Water Cycle** The *water cycle*, or *hydrologic cycle* (Figure 19), summarizes the roles that water—liquid, gaseous, and solid—plays in our environment. Evaporation, transpiration, precipitation, and condensation are the major processes of the water cycle.

► **Evaporation and Transpiration** Water moves from bodies of water and moist soil into the atmosphere by **evaporation**, the conversion of a substance from a liquid to a gas. Warm temperatures and strong winds speed evaporation. Exposed soil loses moisture very quickly—a logged area or an area converted to farms or buildings will lose moisture faster than a similar-sized area covered with natural vegetation. Water also enters the atmosphere by **transpiration**, the release of water vapor by plants through their leaves. Evaporation and transpiration distill water naturally, creating pure water by filtering out minerals and pollutants. Small amounts of water also enter the atmosphere as byproducts of cellular respiration and combustion.

► **Precipitation and Condensation** Water returns from the atmosphere to Earth's surface as **precipitation** such as rain or snow. Precipitation occurs when water vapor undergoes **condensation**, a change in state from a gas to a liquid. Precipitation may be taken up by plants and used by animals, but much of it flows as *runoff* into bodies of surface water such as rivers, lakes, and oceans.

#### GUIDING QUESTION

**How do the nonliving parts of Earth's systems provide the basic materials to support life?**

*Self-Knowledge* Pose the following question to students: Do modern conveniences, such as running water in homes and bottled drinking water, cause people to forget or ignore their reliance on the natural processes of the water cycle? Have students form small groups to discuss the problems that can arise when people do not understand the importance of the water cycle to their own survival.





## FIND OUT MORE

Are there any conflicts over water use in your area? What pollution threats does the water supply in your town face? Given your knowledge of the water cycle, what solution would you propose for one of the water problems in your area?

**FIGURE 20 Human Impacts on the Water Cycle** People draw groundwater out of aquifers to water crops, such as those planted on these circular fields near Dimmitt, Texas. Crops are planted on circular fields so that they can be efficiently watered by a sprayer pipe that extends across the radius of the circle.

### ANSWERS

**Find Out More** Answers will vary but should show knowledge of water conflicts in the local area or threats to the area's water supply.

**Lesson 3 Assessment** For answers to the Lesson 3 Assessment, see page A-4 at the back of the book.

► **Groundwater** Some precipitation and surface water soaks down through soil and rock to recharge underground reservoirs, or storage areas, known as **aquifers**. Aquifers are layers of rock and soil that hold **groundwater**, fresh water found underground. The upper limit of groundwater held in an aquifer is called the *water table*. Groundwater can take hundreds or even thousands of years to recharge fully after being depleted, if it *ever* recharges, so it is an extremely precious resource.

► **Human Impacts** Human activity can affect every aspect of the water cycle. By clearing plants from Earth's surface, we increase runoff and erosion, increase evaporation, and reduce transpiration. By spreading water on farm fields, we can deplete surface water and groundwater and increase evaporation (**Figure 20**). And by releasing certain pollutants into the atmosphere, we cause precipitation to become more acidic. Perhaps most threatening to our future, we are depleting groundwater with unrestrained use by irrigation and industry. The depletion is so severe in some areas, such as South Asia, the Middle East, and the American West, that water shortages have given rise to political, or even armed, conflicts.

## LESSON 3 Assessment

1. **Apply Concepts** What parts of the geosphere are involved in plate tectonics? What are their functions in that process?
2. **Use Analogies** Use an analogy to describe one way that gases in Earth's atmosphere protect the biosphere.
3. **Relate Cause and Effect** Describe the two processes by which most water moves into the atmosphere.
4. **Explore the BIG QUESTION** How are the processes of the water cycle essential to an unpolluted biosphere?