Reading Preview

Objectives

- **Describe** how nutrients move through the biotic and abiotic parts of an ecosystem.
- **Explain** the importance of nutrients to living organisms.
- **Compare** the biogeochemical cycles of nutrients.

Review Vocabulary

cycle: a series of events that occur in a regular repeating pattern

New Vocabulary

matter
nutrient
biogeochemical cycle
nitrogen fixation
denitrification

Cycling of Matter

MAIN Idea **Essential nutrients are cycled through biogeochemical processes.**

Real-World Reading Link Do you recycle your empty soda cans? If so, then you know that materials such as glass, aluminum, and paper can be reused. Natural processes in the environment cycle nutrients to make them available for use by other organisms.

Cycles in the Biosphere

Energy is transformed into usable forms to support the functions of an ecosystem. A constant supply of usable energy for the biosphere is needed, but this is not true of matter. The law of conservation of mass states that matter is not created or destroyed. Therefore, natural processes cycle matter through the biosphere. **Matter**—anything that takes up space and has mass—provides the nutrients needed for organisms to function. A **nutrient** is a chemical substance that an organism must obtain from its environment to sustain life and to undergo life processes. The bodies of all organisms are built from water and nutrients such as carbon, nitrogen, and phosphorus.

Connection to Chemistry In most ecosystems, plants obtain nutrients, in the form of elements and compounds, from the air, soil, or water. Plants convert some elements and compounds into organic molecules that they use. The nutrients flow through organisms in an ecosystem, such as the ecosystem shown in **Figure 2.16.** The green grass captures substances from the air, soil, and water, and then converts them into usable nutrients. The grass provides nutrients for the cow. If an organism eats the cow, the nutrients found in the cow are passed on to the next consumer. The nutrients are passed from producer—the green grass—to consumers. Decomposers return the nutrients to the cycle at every level.

The cycling of nutrients in the biosphere involves both matter in living organisms and physical processes found in the environment such as weathering. Weathering breaks down large rocks into particles that become part of the soil used by plants and other organisms. The exchange of matter through the biosphere is called the **biogeochemical cycle.** As the name suggests, these cycles involve living organisms (*bio*), geological processes (*geo*), and chemical processes (*chemical*).

Reading Check **Explain** why it is important to living organisms that nutrients cycle.

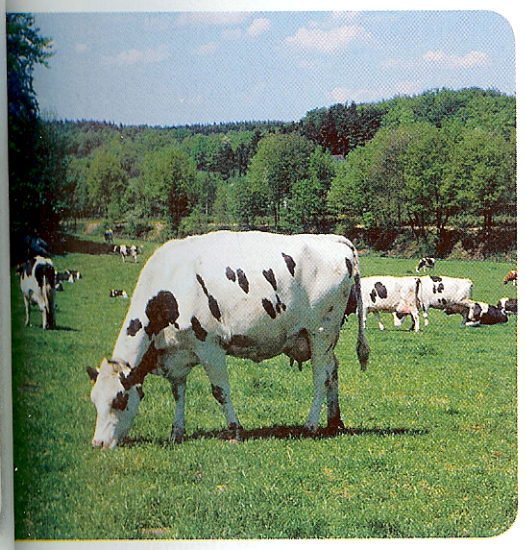


Figure 2.16 Nutrients are cycled through the biosphere through organisms. In this example, the grasses are the producers and begin the cycle by capturing energy from the Sun. **Explain** *how nutrients continue to be cycled through the biosphere in this photo.*

CAREERS IN BIOLOGY

Hydrologist A hydrologist studies water processes, such as the distribution in nature, the water flow in a dam or river, or the water flow in a sewer or a city drinking-water system. For more information on biology careers, visit biologygmh.com.

Personal Tutor

To learn about biogeochemical cycles, visit biologygmh.com.

The water cycle Organisms cannot live without water. Hydrologists study water found underground, in the atmosphere, and on Earth's surface in the form of lakes, streams, rivers, glaciers, ice caps, and oceans. Follow along with **Figure 2.17** to trace processes that cycle water through the biosphere.

Connection to Earth Science Water is constantly evaporating into the atmosphere from bodies of water, soil, and organisms. Water in the atmosphere is called water vapor. Water vapor rises and begins to cool in the atmosphere. Clouds form when the cooling water vapor condenses into droplets around dust particles in the atmosphere. Water falls from clouds as precipitation in the form of rain, sleet, or hail, transferring water to the Earth's surface. As shown in **Figure 2.17,** groundwater and runoff from land surfaces flow into streams, rivers, lakes, and oceans, where they evaporate into the atmosphere to continue through the water cycle. Approximately 90 percent of water vapor evaporates from oceans, lakes, and rivers; about 10 percent evaporates from the surface of plants through a process called transpiration. You will learn more about transpiration in Chapter 22.

All living organisms rely on freshwater. Even ocean-dwelling organisms rely on freshwater flowing to oceans to prevent high saline content and maintain ocean volume. Freshwater constitutes only about 3 percent of all water on Earth. Water available for living organisms is about 31 percent of all freshwater. About 69 percent of all freshwater is found in ice caps and glaciers, which then is unavailable for use by living organisms.

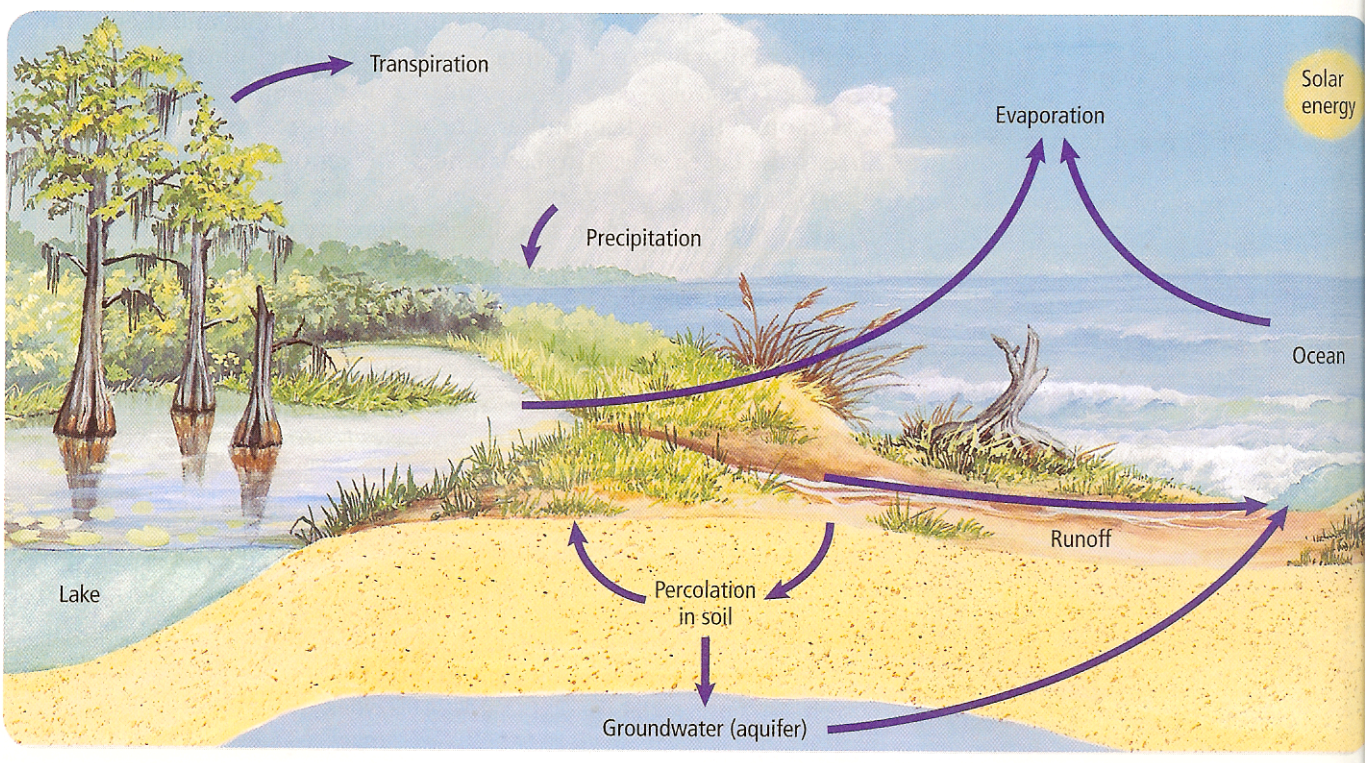
Reading Check **Identify** three processes in the water cycle.

Concepts In Motion

Interactive Figure To see an animation of the water cycle, visit biologygmh.com.

Figure 2.17 The water cycle is the natural process by which water is continuously cycled through the biosphere.

Infer *What are the largest reservoirs of water on Earth?*



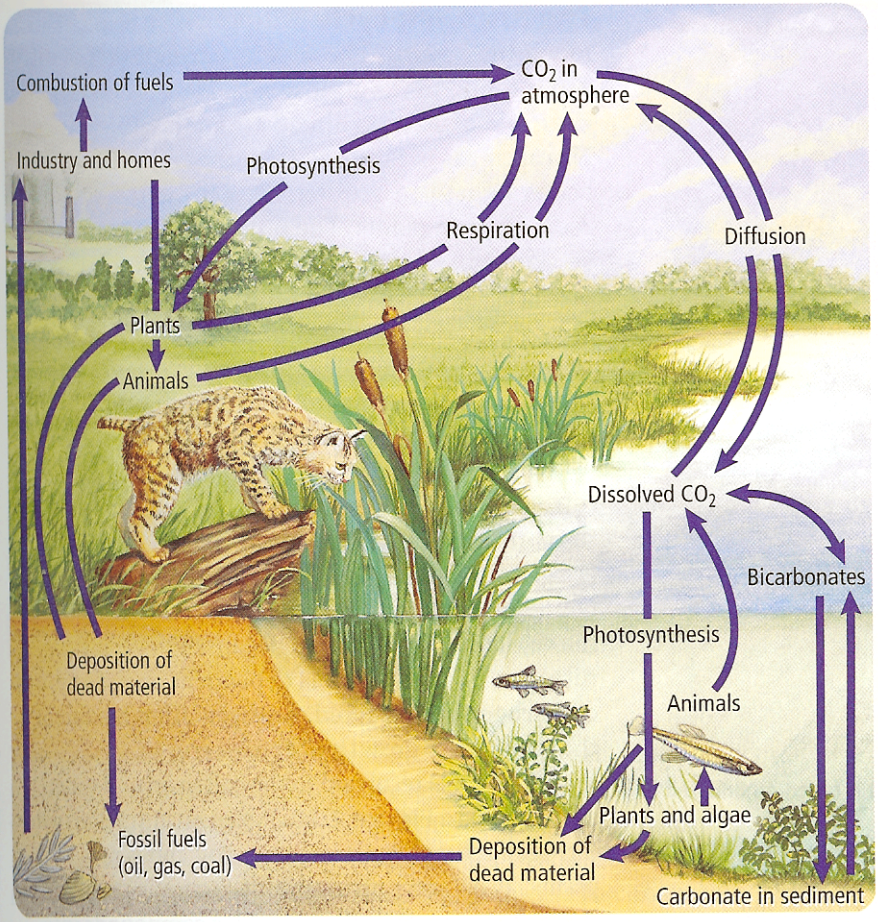


Figure 2.18 The diagram shows how carbon and oxygen cycle through the environment.

Describe ***How does carbon move from the abiotic to the biotic parts of the ecosystem?***

Concepts In Motion

Interactive Figure To see an animation of the carbon cycle, visit biologygmh.com.

The carbon and oxygen cycles As you will learn in Chapter 6, all living things are composed of molecules that contain carbon. Atoms of carbon form the framework for important molecules such as proteins, carbohydrates, and fats. Oxygen is another element that is important to many life processes. Carbon and oxygen often make up molecules essential for life, including carbon dioxide and simple sugar.

Look at the cycles illustrated in **Figure 2.18.** During a process called photosynthesis, discussed in Chapter 8, green plants and algae convert carbon dioxide and water into carbohydrates and release oxygen back into the air. These carbohydrates are used as a source of energy for all organisms in the food web. Carbon dioxide is recycled when autotrophs and heterotrophs release it back into the air during cellular respiration. Carbon and oxygen recycle relatively quickly through living organisms.

Carbon enters a long-term cycle when organic matter is buried underground and converted to peat, coal, oil, or gas deposits. The carbon might remain as fossil fuel for millions of years. Carbon is released from fossil fuels when they are burned, which adds carbon dioxide to the atmosphere.

In addition to the removal of carbon from the short-term cycle by fossil fuels, carbon and oxygen can enter a long-term cycle in the form of calcium carbonate, as shown in **Figure 2.19.** Calcium carbonate is found in the shells of plankton and animals such as coral, clams, and oysters. These organisms, such as algae, fall to the bottom of the ocean floor, creating vast deposits of limestone rock. Carbon and oxygen remain trapped in these deposits until weathering and erosion release these elements to become part of the short-term cycle.

FOLDABLES
Incorporate information from this section into your Foldable.

Figure 2.19 The white cliffs in Dover, England are composed almost entirely of calcium carbonate, or chalk. The calcium and oxygen found in these cliffs are in the long-term part of the cycle for calcium and oxygen.

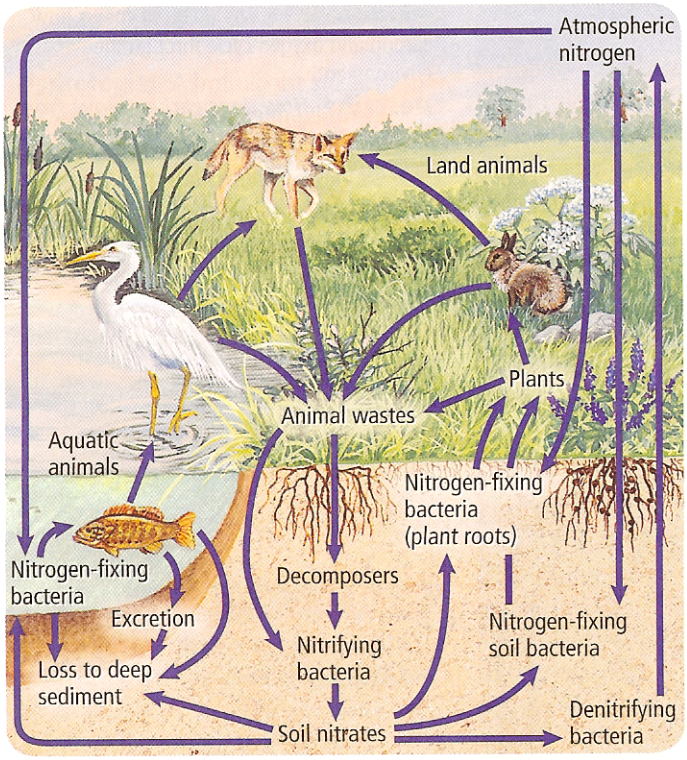


Figure 2.20 Nitrogen is used and reused as it is cycled continuously through the biosphere.

Concepts In Motion

Interactive Figure To see an animation of the nitrogen cycle, visit biologygmh.com.

The nitrogen cycle Nitrogen is an element found in proteins. The largest concentration of nitrogen is found in the atmosphere. Plants and animals cannot use nitrogen directly from the atmosphere. Nitrogen gas is captured from the air by species of bacteria that live in water, the soil, or grow on the roots of some plants. The process of capture and conversion of nitrogen into a form that is useable by plants is called **nitrogen fixation.** Some nitrogen also is fixed during electrical storms when the energy from lightning bolts changes nitrogen gas to nitrates. Nitrogen also is added to soil when chemical fertilizers are applied to lawns, crops, or other areas.

Nitrogen enters the food web when plants absorb nitrogen compounds from the soil and convert them into proteins, as illustrated in **Figure 2.20.** Consumers get nitrogen by eating plants or animals that contain nitrogen. They reuse the nitrogen and make their own proteins. Because the supply of nitrogen in a food web is dependent on the amount of nitrogen that is fixed, nitrogen often is a factor that limits the growth of producers.

Nitrogen is returned to the soil in several ways, also shown in **Figure 2.20.** When an animal urinates, nitrogen returns to the water or soil and is reused by plants. When organisms die, decomposers transform the nitrogen in proteins and other compounds into ammonia. Organisms in the soil convert ammonia into nitrogen compounds that can be used by plants. Finally, in a process called **denitrification,** some soil bacteria convert fixed nitrogen compounds back into nitrogen gas, which returns it to the atmosphere.

MiniLab 2.2

Test for Nitrates

How much nitrate is found in various water sources? One ion containing nitrogen found in water can be easily tested—nitrate. Nitrate is a common form of inorganic nitrogen that is used easily by plants.

Procedure

1. Read and complete the lab safety form.
2. Prepare a data table to record your observations.
3. Obtain the **water samples** from different sources that are provided by your teacher.
4. Using a **nitrate test kit,** test the amount of nitrate in each water sample.
5. Dispose of your samples as directed by your teacher.

Analysis

1. **Determine** Did the samples contain differing amounts of nitrate? Explain.
2. **Identify** What types of human activities might increase the amount of nitrate in the water?
3. **Infer** What problems could a high nitrate level cause considering that nitrates also increase the growth rate of algae in waterways?

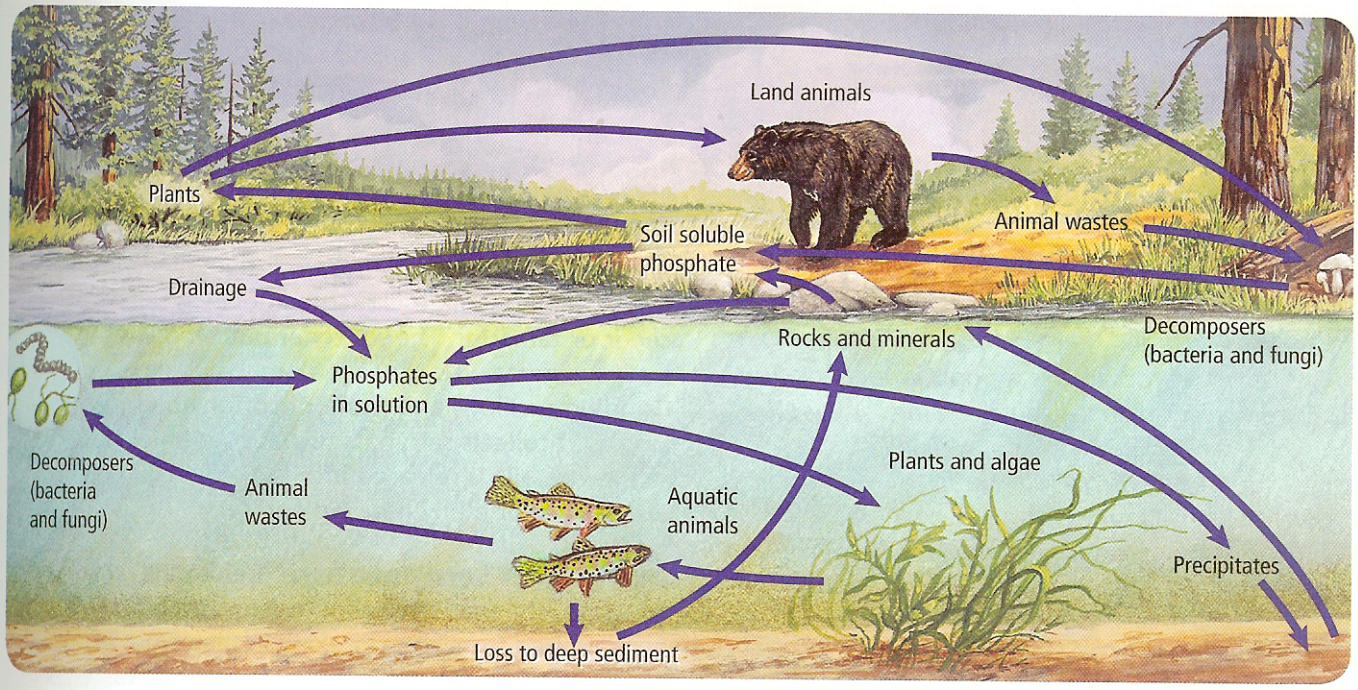


Figure 2.21 The phosphorus cycle has a short-term cycle and a long-term cycle.

Concepts In MOtion

Interactive Figure To see an animation of the phosphorus cycle, visit biologygmh.com.

The phosphorus cycle Phosphorus is an element that is essential for the growth and development of organisms. **Figure 2.21** illustrates the two cycles of phosphorus—a short-term and long-term cycle. In the short-term cycle, phosphorus in phosphates in solution, is cycled from the soil to producers and then from the producers to consumers. When organisms die or produce waste products, decomposers return the phosphorus to the soil where it can be used again. Phosphorus moves from the short-term cycle to the long-term cycle through precipitation and sedimentation to form rocks. In the long-term cycle, weathering or erosion of rocks that contain phosphorus slowly adds phosphorus to the cycle. Phosphorus, in the form of phosphates, might be present only in small amounts in soil and water. Therefore, phosphorus often is a factor that limits the growth of producers.

Section 2.3 Assessment

Section Summary

- Biogeochemical cycles include the exchange of important elements between the abiotic and biotic parts of an ecosystem.
- The carbon and oxygen cycles are closely intertwined.
- Nitrogen gas is limited in its ability to enter biotic portions of the environment.
- Phosphorus and carbon have short-term and long-term cycles.

Understand Main Ideas

1. MAIN Idea **List** four important biogeochemical processes that cycle nutrients.
2. **Compare and contrast** two of the cycles of matter.
3. **Explain** the importance of nutrients to an organism of your choice.
4. **Describe** how phosphorus moves through the biotic and abiotic parts of an ecosystem.

Think Critically

5. **Design an Experiment** Suppose a particular fertilizer contains nitrogen, phosphorus, and potassium. The numbers on the fertilizer's label represent the amounts of each element in the fertilizer. Design an experiment to test how much fertilizer should be added to a lawn to obtain the best results.