SECTION 2

Cycles in Nature

As You Read

What You'll Learn

- **Explain** the importance of Earth's water cycle.
- **Diagram** the carbon cycle.
- **Recognize** the role of nitrogen in life on Earth.

Vocabulary

evaporation
condensation
water cycle
nitrogen fixation
nitrogen cycle
carbon cycle

Why It's Important

The recycling of matter on Earth demonstrates natural processes.

The Cycles of Matter

Imagine an aquarium tank containing water, fish, snails, plants, algae, and bacteria. The tank is sealed so that only light can enter. Food, water, and air cannot be added. Will the organisms in this environment survive? Through photosynthesis, plants and algae produce their own food. They also supply oxygen to the tank. Fish and snails take in oxygen and eat plants and algae. Wastes from fish and snails fertilize plants and algae. Organisms that die are decomposed by the bacteria. The organisms in this closed environment can survive because the materials are recycled. A constant supply of light energy is the only requirement. Earth's biosphere also contains a fixed amount of water, carbon, nitrogen, oxygen, and other materials required for life. These materials cycle through the environment and are reused by different organisms.

Water Cycle

If you leave a glass of water on a sunny windowsill, the water will disappear. It evaporates. **Evaporation** takes place when liquid water changes into water vapor, which is a gas, and enters the atmosphere, as shown in **Figure 9.** Water evaporates from the surfaces of lakes, streams, puddles, and oceans. Water vapor enters the atmosphere from plant leaves in a process known as transpiration (trans puh RAY shun). Animals release water vapor into the air when they exhale. Water also returns to the environment from animal wastes.

Figure 9
Water vapor is a gas that is present in the atmosphere.

A Water evaporates after a summer rain.

B Water also evaporates from the ocean.

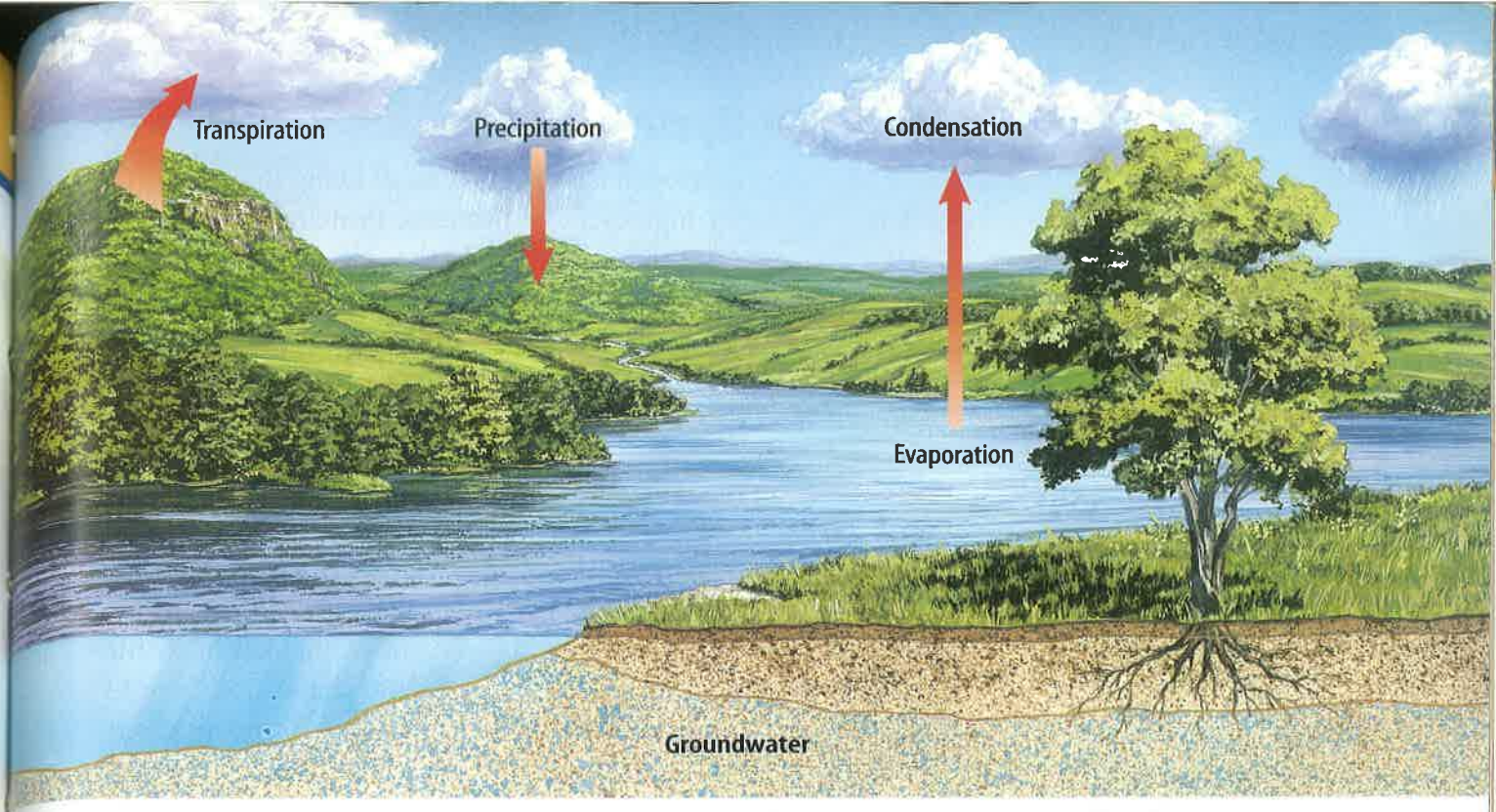


Figure 10
The water cycle involves evaporation, condensation, and precipitation. Water molecules can follow several pathways through the water cycle. *How many water cycle pathways can you identify from this diagram?*

Condensation Water vapor that has been released into the atmosphere eventually comes into contact with colder air. The temperature of the water vapor drops. Over time, the water vapor cools enough to change back into liquid water. The process of changing from a gas to a liquid is called **condensation.** Water vapor condenses on particles of dust in the air, forming tiny droplets. At first, the droplets clump together to form clouds. When they become large and heavy enough, they fall to the ground as rain or other precipitation. As the diagram in **Figure 10** shows, the **water cycle** is a model that describes how water moves from the surface of Earth to the atmosphere and back to the surface again.

Water Use **Table 1** gives data on the amount of water people take from reservoirs, rivers, and lakes for use in households, businesses, agriculture, and power production. These actions can reduce the amount of water that evaporates into the atmosphere. They also can influence how much water returns to the atmosphere by limiting the amount of water available to plants and animals.

Table 1 U.S. Estimated Water Use in 1990

Water Use	Millions of Gallons per Day	Percent of Total
Homes and Businesses	39,100	11.5
Industry and Mining	27,800	8.2
Farms and Ranches	141,000	41.5
Electricity Production	131,800	38.6

Nitrogen Cycle

The element nitrogen is important to all living things. Nitrogen is a necessary ingredient of proteins. Proteins are required for the life processes that take place in the cells of all organisms. Nitrogen is also an essential part of the DNA of all organisms. Although nitrogen is the most plentiful gas in the atmosphere, most organisms cannot use nitrogen directly from the air. Plants need nitrogen that has been combined with other elements to form nitrogen compounds. Through a process called **nitrogen fixation,** some types of soil bacteria can form the nitrogen compounds that plants need. Plants absorb these nitrogen compounds through their roots. Animals obtain the nitrogen they need by eating plants or other animals. When dead organisms decay, the nitrogen in their bodies returns to the soil or to the atmosphere. This transfer of nitrogen from the atmosphere to the soil, to living organisms, and back to the atmosphere is called the **nitrogen cycle,** shown in **Figure 11.**

Reading Check *What is nitrogen fixation?*

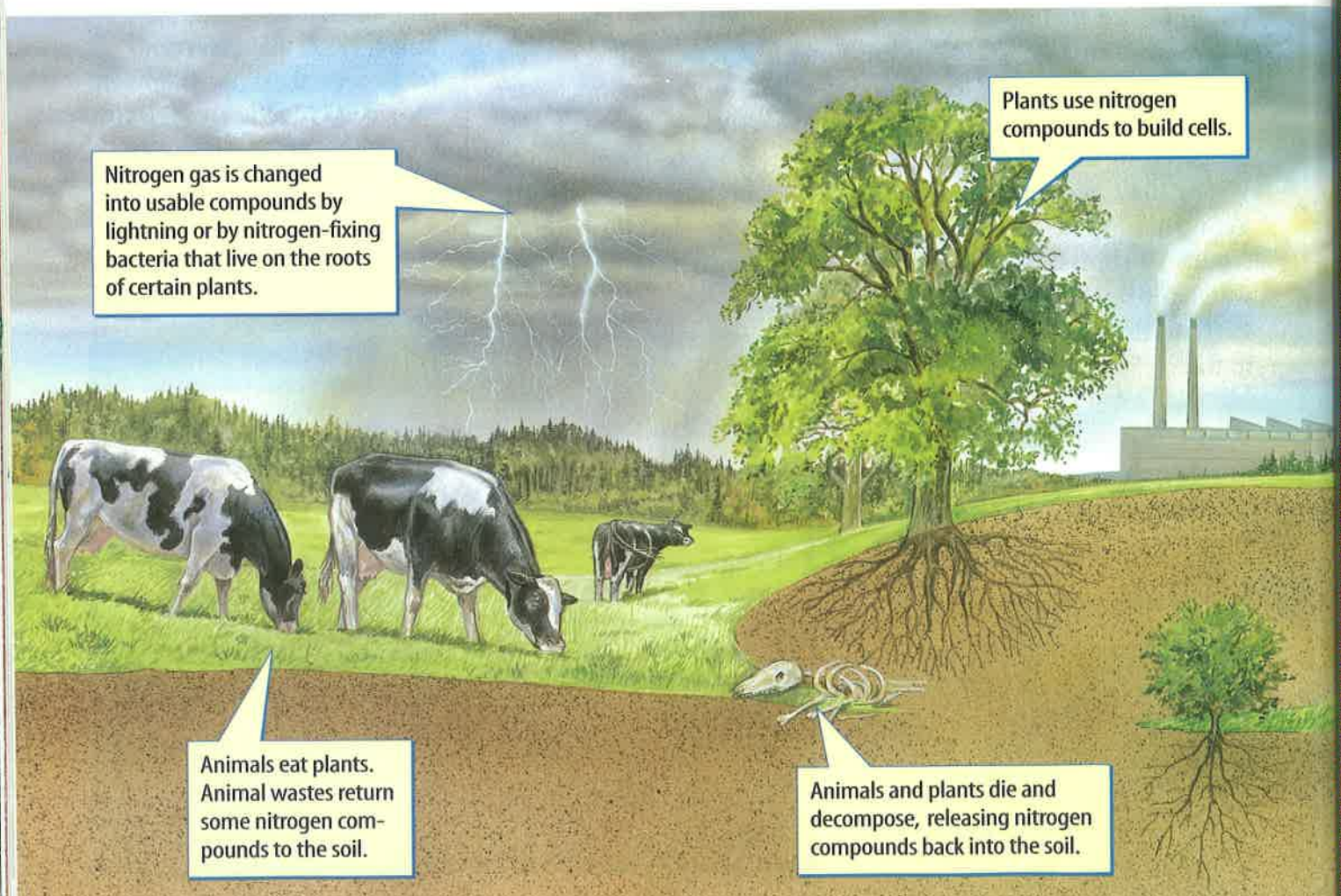


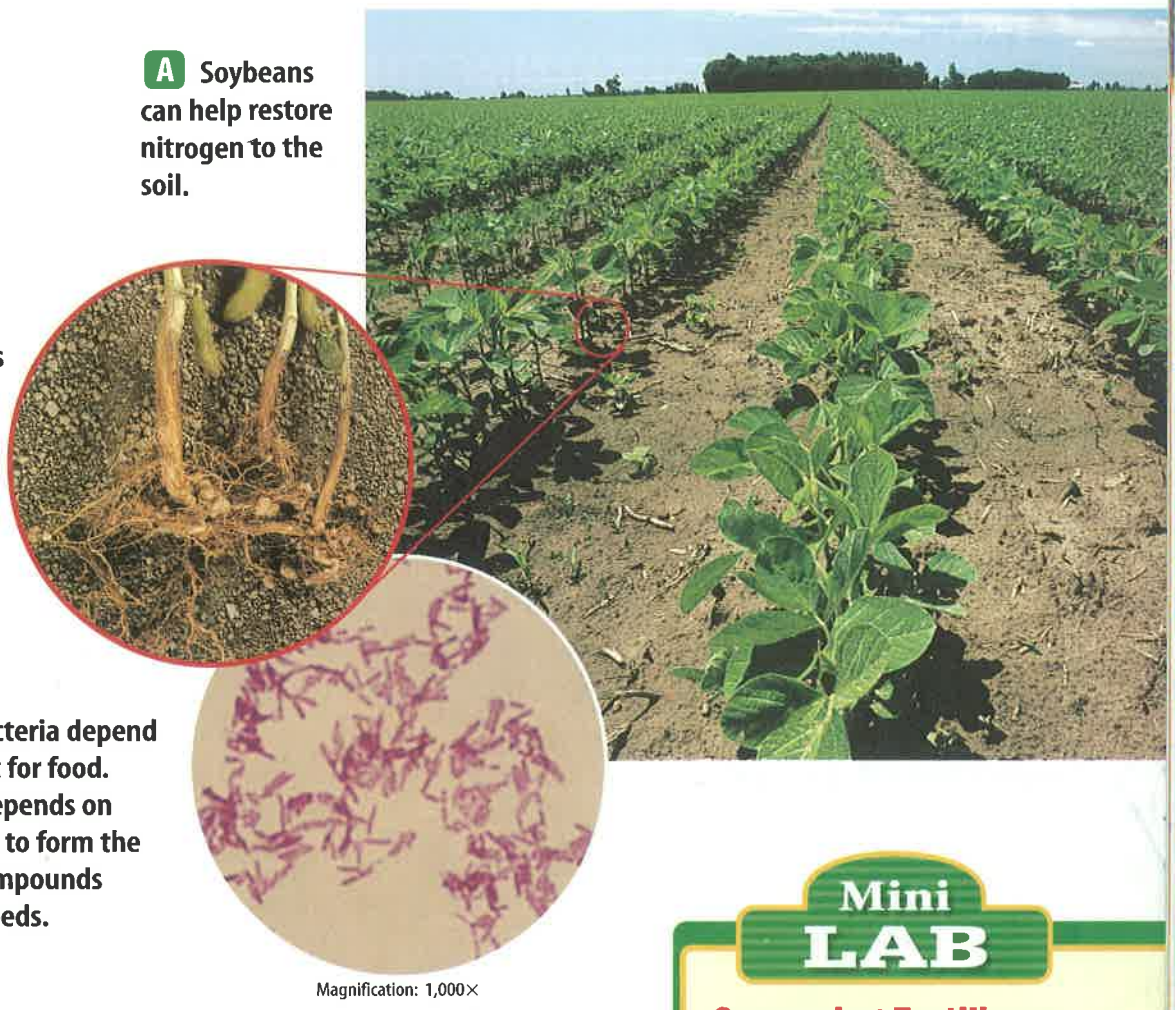
Figure 11
During the nitrogen cycle, nitrogen gas from the atmosphere is converted to a soil compound that plants can use.

Figure 12
Nitrogen fixation is important to plant growth.

A Soybeans can help restore nitrogen to the soil.

B The swollen nodules on the roots of the soybean plants contain colonies of nitrogen-fixing bacteria.

C The bacteria depend on the plant for food. The plant depends on the bacteria to form the nitrogen compounds the plant needs.



Magnification: 1,000×

Soil Nitrogen Human activities can affect the part of the nitrogen cycle that takes place in the soil. If a farmer grows a crop, such as corn or wheat, most of the plant material is taken away when the crop is harvested. The plants are not left in the field to decay and return their nitrogen compounds to the soil. If these nitrogen compounds are not replaced, the soil could become infertile. You might have noticed that adding fertilizer to soil can make plants grow greener, bushier, or taller. Most fertilizers contain the kinds of nitrogen compounds that plants need for growth. Fertilizers can be used to replace soil nitrogen in crop fields, lawns, and gardens. Compost and animal manure also contain nitrogen compounds that plants can use. They also can be added to soil to improve fertility.

Another method farmers use to replace soil nitrogen is to grow nitrogen-fixing crops. Most nitrogen-fixing bacteria live on or in the roots of certain plants. Some plants, such as peas, clover, and beans including the soybeans shown in **Figure 12,** have roots with swollen nodules that contain nitrogen-fixing bacteria. These bacteria supply nitrogen compounds to the soybean plants and add nitrogen compounds to the soil.

Mini LAB

Comparing Fertilizers

Procedure

1. Examine the three numbers (e.g., 5-10-5) on the **labels of three brands of houseplant fertilizer.** The numbers indicate the percentages of nitrogen, phosphorus, and potassium, respectively, that the product contains.
2. Compare the prices of the three brands of fertilizer.
3. Compare the amount of each brand needed to fertilize a typical houseplant.

Analysis

1. Which brand has the highest percentage of nitrogen?
2. Which brand is the most expensive source of nitrogen? The least expensive?

The Carbon Cycle

Carbon atoms are found in the molecules that make up living organisms. Carbon is an important part of soil humus, which is formed when dead organisms decay, and it is found in the atmosphere as carbon dioxide gas (CO_2). The **carbon cycle** describes how carbon molecules move between the living and nonliving world, as shown in **Figure 13.**

The carbon cycle begins when producers remove CO_2 from the air during photosynthesis. They use CO_2, water, and sunlight to produce energy-rich sugar molecules. Energy is released from these molecules during respiration—the chemical process that provides energy for cells. Respiration uses oxygen and releases CO_2. Photosynthesis uses CO_2 and releases oxygen. These two processes help recycle carbon on Earth.

Reading Check ***How does carbon dioxide enter the atmosphere?***

Human activities also release CO_2 into the atmosphere. Fossil fuels such as gasoline, coal, and heating oil are the remains of organisms that lived millions of years ago. These fuels are made of energy-rich, carbon-based molecules. When people burn these fuels, CO_2 is released into the atmosphere as a waste product. People also use wood for building and for fuel. Trees that are harvested for these purposes no longer remove CO_2 from the atmosphere during photosynthesis. The amount of CO_2 in the atmosphere is increasing. Extra CO_2 could trap more heat from the Sun and cause average temperatures on Earth to rise.

SCIENCE Online

Research Visit the Glencoe Science Web site at **science.glencoe.com** for the chemical equations that describe photosynthesis and respiration. In your Science Journal, write these equations and use them to explain how respiration is the reverse of photosynthesis.

Section 2 Assessment

1. Describe the water cycle.
2. Explain how respiration can be considered the reverse of photosynthesis.
3. How might burning fossil fuels affect the composition of gases in the atmosphere?
4. Why do plants, animals, and other organisms need nitrogen?
5. **Think Critically** Most chemical fertilizers contain nitrogen, phosphorus, and potassium. Why don't they contain carbon? How do plants obtain carbon?

Skill Builder Activities

6. **Identifying and Manipulating Variables and Controls** Describe an experiment that would determine whether extra carbon dioxide enhances the growth of tomato plants. **For more help, refer to the Science Skill Handbook.**
7. **Communicating** Pretend you are a carbon molecule. Write a fictional account of your travels from the atmosphere, through at least two organisms, and back to the atmosphere. **For more help, refer to the Science Skill Handbook.**