2 Cycles in Nature

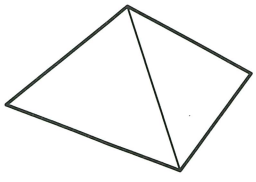
About the PHOTO

These penguins have a unique playground on this iceberg off the coast of Antarctica. Icebergs break off from glaciers and float out to sea. A glacier is a giant "river" of ice that slides slowly downhill. Glaciers are formed from snow piling up in mountains. Eventually, glaciers and icebergs melt and become liquid water. Water in oceans and lakes rises into the air and then falls down again as rain or snow. There is a lot of water on Earth, and most of it is constantly moving and changing form.

PRE-READING ACTIVITY

FOLDNOTES

Pyramid Before you read the chapter, create the FoldNote entitled "Pyramid" described in the **Study Skills** section of the Appendix. Label the sides of the pyramid with "Water cycle," "Carbon cycle," and "Nitrogen cycle." As you read the chapter, define each cycle, and write the steps of each cycle on the appropriate pyramid side.



START-UP ACTIVITY

Making Rain

Do you have the power to make rain? Yes!—on a small scale. In this activity, you will cause water to change state in the same way that rain is formed. This process is one way that water is reused on Earth.

Procedure

1. Start with a **large, sealable, plastic freezer bag.** Be sure that the bag is clean and dry and has no leaks. Place a **small, dark-colored bowl** inside the bag. Position the bag with the opening at the top.
2. Fill the bowl halfway with water. Place a few drops of **red food coloring** in the water. Seal the bag.
3. Place the bowl and bag under a strong, warm **light source,** such as a lamp or direct sunlight.
4. Leave the bag in the light for as long as possible. Observe the bag at regular time intervals.

Analysis

1. Each time you observe the bag, describe what you see. Explain what you think is happening.
2. After observing the bag several times, carefully remove the bowl from the bag. Observe and describe any water that is now in the bag. Where did this water come from? How does it differ from the water in the bowl?

SECTION 1

The Cycles of Matter

The matter in your body has been on Earth since the planet formed billions of years ago!

Matter on Earth is limited, so the matter is used over and over again. Each kind of matter has its own cycle. In these cycles, matter moves between the environment and living things.

READING WARM-UP

Objectives

- Diagram the water cycle, and explain its importance to living things.
- Diagram the carbon cycle, and explain its importance to living things.
- Diagram the nitrogen cycle, and explain its importance to living things.

Terms to Learn

evaporation
condensation
precipitation
decomposition
combustion

READING STRATEGY

Mnemonics As you read this section, create a mnemonic device to help you remember the parts of the water cycle.

evaporation the change of a substance from a liquid to a gas

condensation the change of state from a gas to a liquid

precipitation any form of water that falls to the Earth's surface from the clouds

The Water Cycle

The movement of water between the oceans, atmosphere, land, and living things is known as the *water cycle*. The parts of the water cycle are shown in **Figure 1.**

How Water Moves

During **evaporation,** the sun's heat causes water to change from liquid to vapor. In the process of **condensation,** the water vapor cools and returns to a liquid state. The water that falls from the atmosphere to the land and oceans is **precipitation.** Rain, snow, sleet, and hail are forms of precipitation. Most precipitation falls into the ocean. Some of the precipitation that falls on land flows into streams, rivers, and lakes and is called *runoff*. Some precipitation seeps into the ground and is stored in spaces between or within rocks. This water, known as *groundwater,* will slowly flow back into the soil, streams, rivers, and oceans.

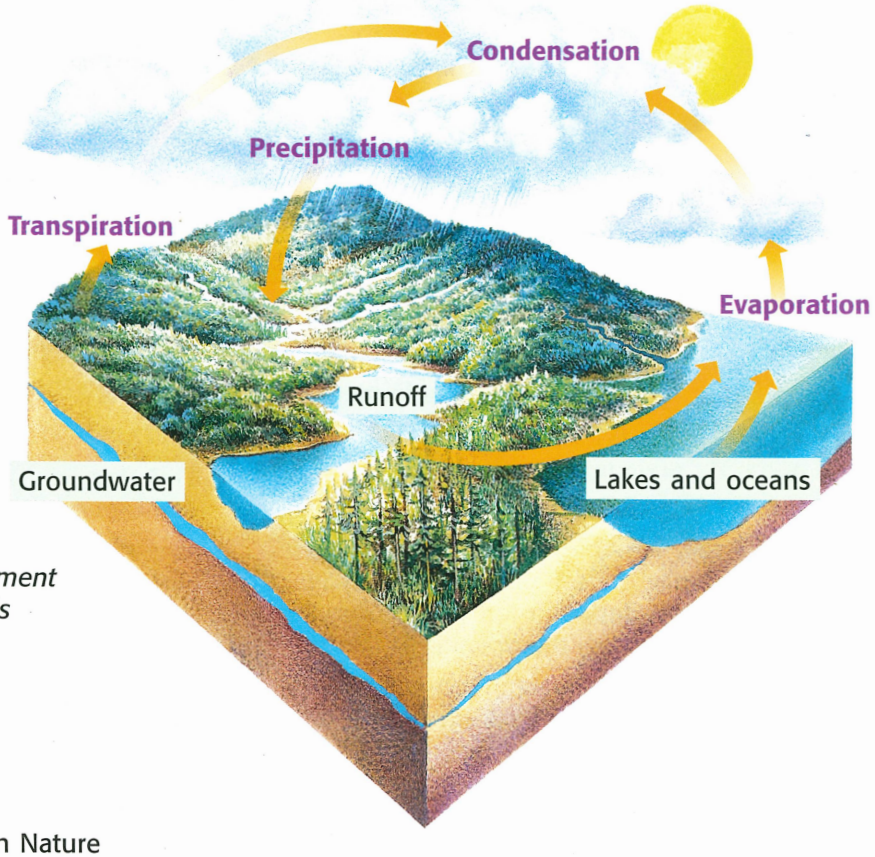


Figure 1 *Water from the environment moves through plants and animals and back to the environment.*

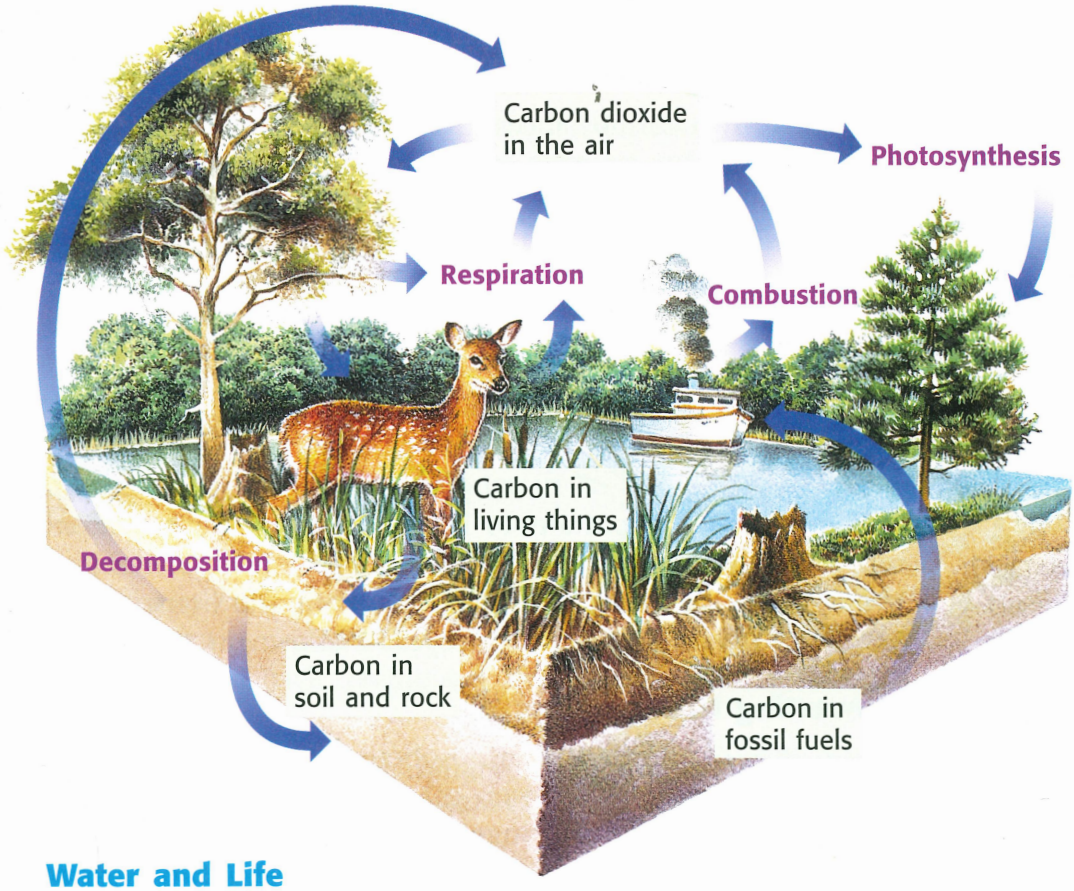


Figure 2 *Carbon may remain in the environment for millions of years before becoming available to living things.*

Water and Life

Without water, there would be no life on Earth. All organisms, from bacteria to animals and plants, are composed mostly of water. Water helps transport nutrients and wastes within an organism. Water also helps regulate temperature. For example, when you sweat, water evaporates from your skin and cools your body. Eventually, all the water taken in by organisms is returned to the environment. For example, plants release a large amount of water vapor in a process called *transpiration*.

Reading Check **Why is water important?** (*See the Appendix for answers to Reading Checks.*)

MATH PRACTICE

Where's the Water?

There are about 37.5 million cubic kilometers of fresh water on Earth. Of this fresh water, about 8.3 million cubic kilometers is groundwater. What percentage of Earth's fresh water is groundwater?

The Carbon Cycle

Besides water, the most common molecules in living things are *organic* molecules, or molecules that contain carbon. The exchange of carbon between the environment and living things is known as the *carbon cycle*, as shown in **Figure 2.**

Photosynthesis and Respiration

Photosynthesis is the basis of the carbon cycle. During photosynthesis, plants use carbon dioxide from air to make sugars. Most animals get the carbon and energy they need by eating plants. How does carbon return to the environment? It returns when sugar molecules are broken down to release energy. This process, called *respiration*, uses oxygen. Carbon dioxide and water are released as byproducts of respiration.

decomposition the breakdown of substances into simpler molecular substances

combustion the burning of a substance

Decomposition and Combustion

The breakdown of substances into simpler molecules is called **decomposition.** For example, when fungi and bacteria decompose organic matter, carbon dioxide and water are returned to the environment. You may have witnessed another way to break down organic matter—using fire. **Combustion** is the process of burning a substance, such as wood or fossil fuels. Like decomposition, combustion of organic matter releases carbon dioxide into the atmosphere.

QUICK LAB

Combustion

1. Place a **candle** on a **jar lid,** and secure the candle with **modeling clay.** Have your teacher light the candle.
2. Hold the jar near the candle flame. Do not cover the flame with the jar. Describe the jar. Where did the substance on the jar come from?
3. Now, place the jar over the candle. What is deposited inside the jar? Where did this substance come from?

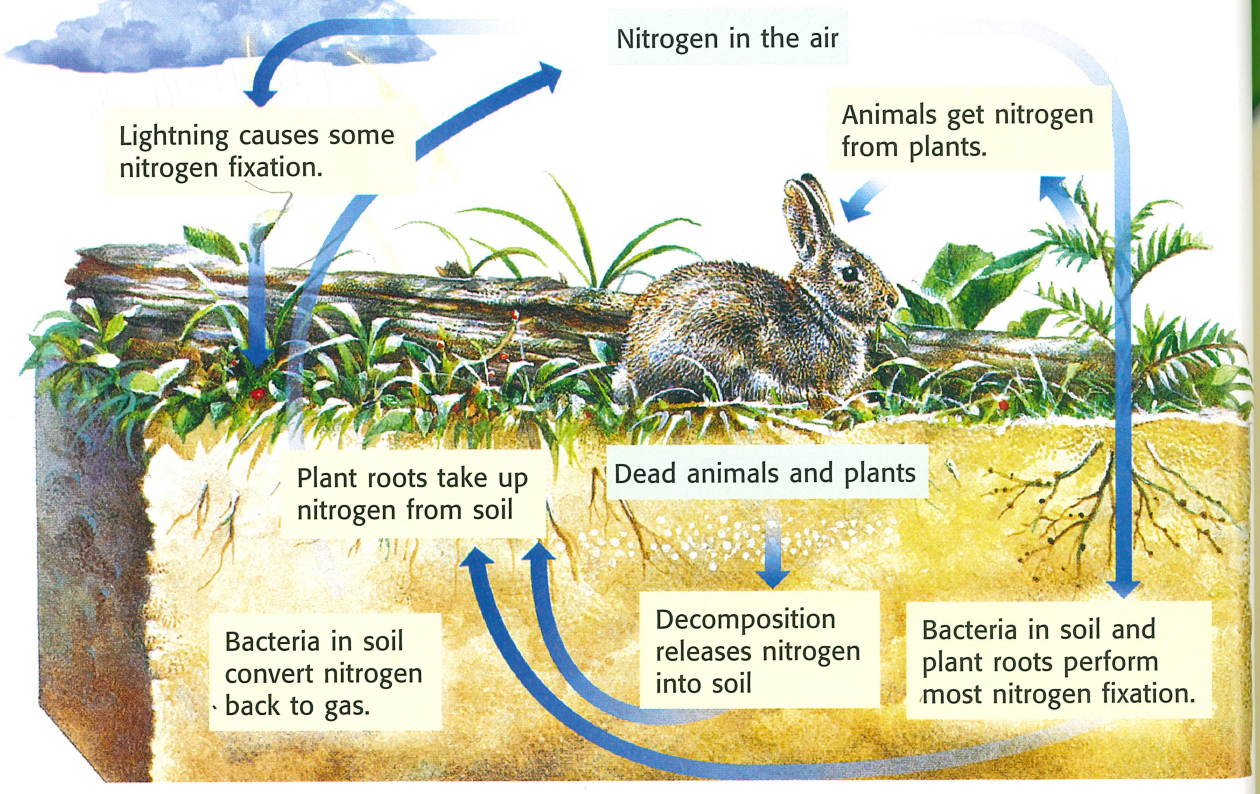
The Nitrogen Cycle

Nitrogen is also important to living things. Organisms need nitrogen to build proteins and DNA for new cells. The movement of nitrogen between the environment and living things is called the *nitrogen cycle*. This cycle is shown in **Figure 3.**

Converting Nitrogen Gas

About 78% of the Earth's atmosphere is nitrogen gas. Most organisms cannot use nitrogen gas directly. However, bacteria in the soil are able to change nitrogen gas into forms that plants can use. This process is called *nitrogen fixation*. Other organisms may then get the nitrogen they need by eating plants or eating organisms that eat plants.

Figure 3 *Without bacteria, nitrogen could not enter living things or be returned to the atmosphere.*



Passing It On

When organisms die, decomposers break down the remains. Decomposition releases a form of nitrogen into the soil that plants can use. Finally, certain types of bacteria in the soil convert nitrogen to a gas, which is returned to the atmosphere.

Many Cycles

Other forms of matter on Earth also pass through cycles. Many of the minerals that living cells need, such as calcium and phosphorous, are cycled through the environment. When an organism dies, every substance in its body is likely to be recycled or reused.

Each of the cycles is connected in many ways. For example, some forms of nitrogen and carbon are carried through the environment by water. Many nutrients pass from soil to plants to animals and back. Living organisms play a part in each of the cycles.

Reading Check **Give an example of a form of matter—other than carbon, water, or nitrogen—that is cycled through the environment.**

CONNECTION TO Environmental Science

Global Warming The quantity of carbon dioxide being released into the atmosphere is increasing. Carbon dioxide can cause the atmosphere to hold heat. A warmer atmosphere would cause the temperatures of the land and ocean to increase. Scientists think that this situation, known as *global warming,* may be happening. Research data on changes in average global temperature and carbon dioxide levels for the past 50 years, and summarize your findings.

SECTION Review

Summary

- Precipitation, evaporation, transpiration, and condensation are parts of the water cycle.
- Photosynthesis, respiration, decomposition, and combustion are parts of the carbon cycle.
- In the nitrogen cycle, nitrogen gas is converted into other forms and back to gas again.
- Many forms of matter on Earth pass through cycles. These cycles may be connected in many ways.

Using Key Terms

For each pair of terms, explain how the meanings of the terms differ.

1. *evaporation* and *condensation*
2. *decomposition* and *combustion*

Understanding Key Ideas

3. Nitrogen fixation
   - **a.** is done only by plants.
   - **b.** is done mostly by bacteria.
   - **c.** is how animals make proteins.
   - **d.** is a form of decomposition.
4. Describe the water cycle.
5. Describe the carbon cycle.

Math Skills

6. The average person in the United States uses about 78 gal of water each day. How many liters of water does this equal? How many liters of water will the average person use in a year?

Critical Thinking

7. **Analyzing Processes** Draw a simple diagram of each of the cycles discussed in this section. Draw lines between the cycles to show how parts of each cycle are related.
8. **Applying Concepts** Give an example of how the calcium in an animal's bones might be cycled back into the environment.

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For a variety of links related to this chapter, go to www.scilinks.org

Topic: Cycles of Matter
SciLinks code: HSM0373

SECTION 2

Ecological Succession

Imagine you have a time machine that can take you back to the summer of 1988. If you had visited Yellowstone National Park during that year, you would have seen fires raging throughout the area.

By the end of that summer, large areas of the park were burned to the ground. When the fires were put out, a layer of gray ash blanketed the forest floor. Most of the trees were dead, although many of them were still standing.

READING WARM-UP

Objectives

- Describe the process of succession.
- Contrast primary and secondary succession.
- Explain how mature communities develop.

Terms to Learn

succession
pioneer species

READING STRATEGY

Reading Organizer As you read this section, make a table comparing primary succession and secondary succession.

Regrowth of a Forest

The following spring, the appearance of the "dead" forest began to change. **Figure 1** shows the changes after just one year. Some of the dead trees fell over, and small, green plants grew in large numbers. Within 10 years, scientists reported that many trees were growing and the forest community was coming back.

A gradual development of a community over time, such as the regrowth of the burned areas of Yellowstone National Park, is called **succession.** Succession takes place in all communities, not just those affected by disturbances such as forest fires.

Reading Check **What happened after the Yellowstone fires?** (*See the Appendix for answers to Reading Checks.*)

succession the replacement of one type of community by another at a single place over a period of time

Figure 1 *Huge areas of Yellowstone National Park were burned in 1988* (left). *By the spring of 1989, regrowth was evident in the burned parts of the park* (right).

Primary Succession

Sometimes, a small community starts to grow in an area where other organisms had not previously lived. There is no soil in this area. And usually, there is just bare rock. Over a very long time, a series of organisms live and die on the rock. The rock is slowly transformed into soil. This process is called *primary succession,* as shown in **Figure 2.** The first organisms to live in an area are called **pioneer species.**

pioneer species a species that colonizes an uninhabited area and that starts a process of succession

Figure 2 **An Example of Primary Succession**

1 A slowly retreating glacier exposes bare rock where nothing lives, and primary succession begins.

2 Most primary succession begins with lichens. Acids from the lichens begin breaking the rocks into small particles. These particles mix with the remains of dead lichens to start forming soil. Lichens are an example of a pioneer species.

3 After many years, there is enough soil for mosses to grow. The mosses eventually replace the lichens. Insects and other tiny organisms begin to live there. When they die, their remains add to the soil.

4 Over time, the soil deepens, and the mosses are replaced by ferns. The ferns may slowly be replaced by grasses and wildflowers. If there is enough soil, shrubs and small trees may grow.

5 After hundreds or even thousands of years, the soil may be deep and stable enough to support a forest.

Secondary Succession

INTERNET ACTIVITY

For another activity related to this chapter, go to **go.hrw.com** and type in the keyword **HL5CYCW.**

Sometimes, an existing community is destroyed by a natural disaster, such as a fire or a flood. Sometimes, a community is affected by another type of disturbance. For example, a farmer might stop growing crops in an area that had been cleared. In either case, if soil is left intact, the original community may regrow through a series of stages called *secondary succession*. **Figure 3** shows an example of secondary succession.

Reading Check How does secondary succession differ from primary succession?

Figure 3 An Example of Secondary Succession

1 The first year after a farmer stops growing crops or the first year after some other major disturbance, weeds start to grow. In farming areas, crab grass is the weed that often grows first.

2 By the second year, new weeds appear. Their seeds may have been blown into the field by the wind, or insects may have carried them. Horseweed is common during the second year.

3 In 5 to 15 years, small conifer trees may start growing among the weeds. The trees continue to grow, and after about 100 years, a forest may form.

4 As older conifers die, they may be replaced by hardwoods, such as oak or maple trees, if the climate can support them.

Mature Communities and Biodiversity

In the early stages of succession, only a few species grow in an area. These species grow quickly and make many seeds that scatter easily. But all species are vulnerable to disease, disturbances, and competition. As a community matures, it may be dominated by well-adapted, slow-growing *climax species*.

Furthermore, as succession proceeds, more species may become established. The variety of species that are present in an area is referred to as *biodiversity*. Biodiversity is important to communities of organisms. For example, a forest that has a high degree of biodiversity is less likely to be destroyed by an invasion of insects. Most plant-damaging insects prefer to attack only one species of plants. The presence of a variety of plants will lessen the impact and spread of invading insects.

Keep in mind that a mature community may not always be a forest. A mature community simply has organisms that are well adapted to live together in the same area over time. For example, the plants of the Sonoran Desert, shown in **Figure 4,** are well-adapted to the desert's conditions.

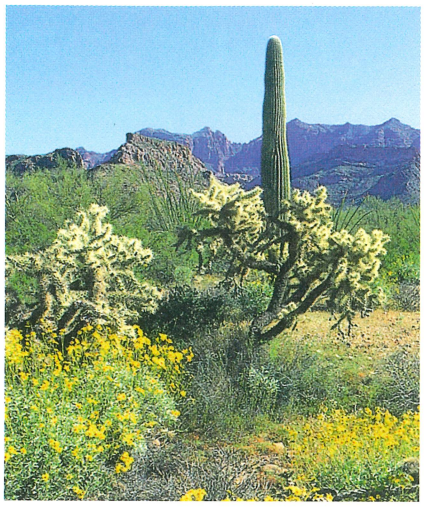


Figure 4 *This area of the Sonoran Desert in Arizona is a mature community.*

SECTION Review

Summary

- Ecological succession is the gradual development of communities over time. Often a series of stages is observed during succession.
- Primary succession occurs in an area that was not previously inhabited by living things; no soil is present.
- Secondary succession takes place in an area where an earlier community was disturbed by fire, landslides, floods, or plowing for crops and where soil is present.

Using Key Terms

1. In your own words, write a definition for the term *succession*.

Understanding Key Ideas

2. An area where a glacier has just melted away will begin the process of
   - **a.** primary succession.
   - **b.** secondary succession.
   - **c.** stability.
   - **d.** regrowth.
3. Describe succession that takes place in an abandoned field.
4. Describe a mature community. How does a mature community develop?

Math Skills

5. The fires in 1988 burned 739,000 of the 2.2 million acres that make up Yellowstone National Park. What percentage of the park was burned?

Critical Thinking

6. **Applying Concepts** Give an example of a community that has a high degree of biodiversity, and an example of one that has a low degree of biodiversity.
7. **Analyzing Ideas** Explain why soil formation is always the first stage of primary succession. Does soil formation ever stop? Explain your answer.

Skills Practice Lab

Nitrogen Needs

The nitrogen cycle is one of several cycles that are vital to living organisms. Without nitrogen, living organisms cannot make amino acids, the building blocks of proteins. Animals obtain nitrogen by eating plants that contain nitrogen and by eating animals that eat those plants. When animals die, decomposers return the nitrogen to the soil in the form of a nitrogen-containing chemical called *ammonia*.

In this activity, you will investigate the nitrogen cycle inside a closed system to discover how decomposers return nitrogen to the soil.

OBJECTIVES

Investigate the nitrogen cycle inside a closed system.

Discover how decomposers return nitrogen to the soil.

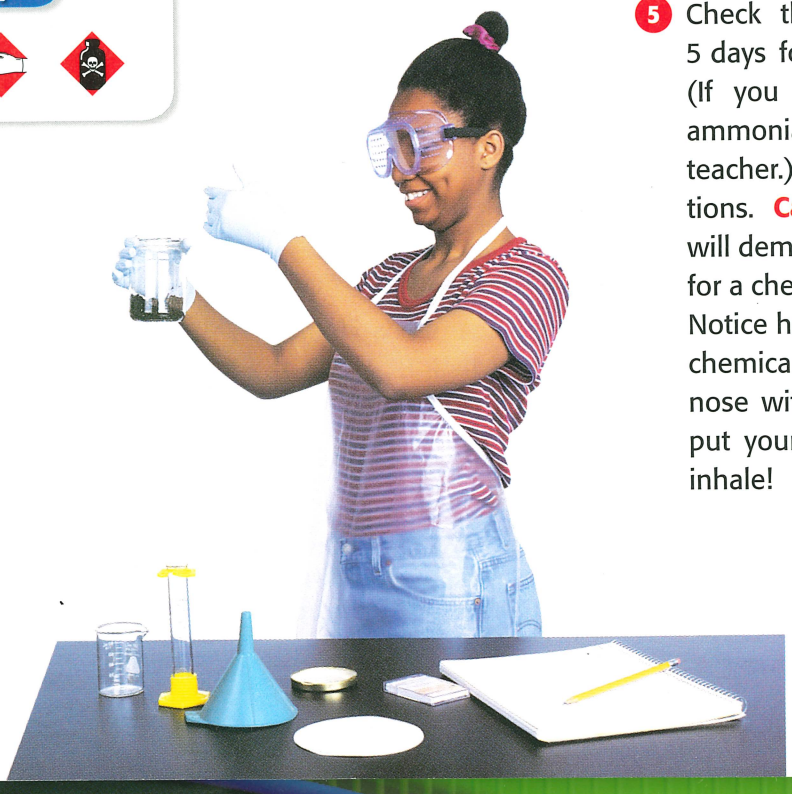
MATERIALS

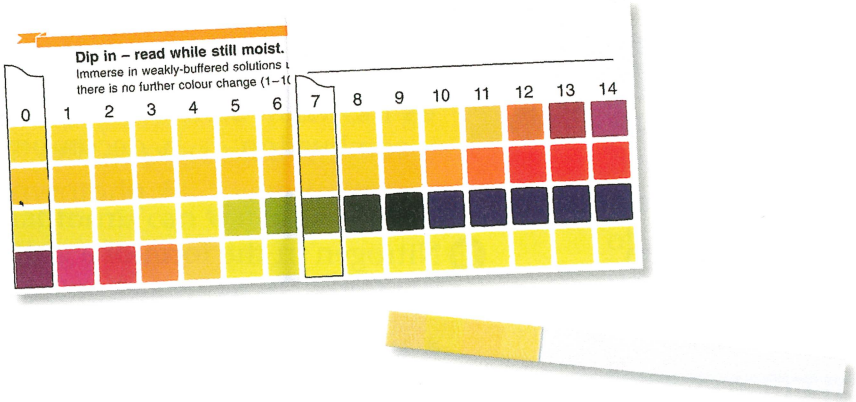
- balance or scale
- beaker, 50 mL
- funnel
- gloves, protective
- graduated cylinder, 25 mL
- insects from home or schoolyard, large, dead (5)
- jar with lid, 1 pt (or 500 mL)
- paper, filter (2 pieces)
- pH paper
- soil, potting, commercially prepared without fertilizer
- water, distilled, 60 mL

SAFETY

Procedure

1. Fit a piece of filter paper into a funnel. Place the funnel inside a 50 mL beaker, and pour 5 g of soil into the funnel. Add 25 mL of distilled water to the soil.
2. Test the filtered water with pH paper, and record your observations.
3. Place some soil in a jar to cover the bottom with about 5 cm of soil. Add 10 mL of distilled water to the soil.
4. Place the dead insects in the jar, and seal the jar with the lid.
5. Check the jar each day for 5 days for an ammonia odor. (If you do not know what ammonia smells like, ask your teacher.) Record your observations. **Caution:** Your teacher will demonstrate how to check for a chemical odor by wafting. Notice how to gently wave the chemical fumes toward your nose with your hand. Do not put your nose in the jar and inhale!





6. On the fifth day, place a second piece of filter paper into the funnel, and place the funnel inside a 50 mL beaker. Remove about 5 g of soil from the jar, and place it in the funnel. Add 25 mL of distilled water to the soil.

7. Once again, test the filtered water with pH paper, and record your observations.

Analyze the Results

1. **Examining Data** What was the pH of the water in the beaker in the first trial? A pH of 7 indicates that the water is neutral. A pH below 7 indicates that the water is acidic, and a pH above 7 indicates that the water is basic. Was the water in the beaker neutral, acidic, or basic?

2. **Analyzing Data** What was the pH of the water in the beaker in the second trial? Explain the difference, if any, between the results of the first trial and the results of the second trial.

Draw Conclusions

3. **Drawing Conclusions** Based on the results of your pH tests, do you think ammonia is acidic or basic?

4. **Evaluating Results** On which days in your investigation were you able to detect an ammonia odor? Explain what caused the odor.

5. **Applying Conclusions** Describe the importance of decomposers in the nitrogen cycle.

Applying Your Data

Test the importance of nitrogen to plants. Fill two 12 cm flowerpots with commercially prepared potting soil and water. Be sure to use soil that has had no fertilizer added. Obtain a dozen tomato or radish seeds. Plant six seeds in each pot. Water your seeds so that the soil is constantly damp but not soaked. Keep your pots in a sunny window. Use a nitrogen-rich liquid plant fertilizer to fertilize one of the pots once a week. Dilute or mix the fertilizer with water according to the directions on the container. Water the other pot once a week with plain tap water.

1. After the seedlings appear, use a metric ruler to measure the growth of the plants in both pots. Measure the plants once a week, and record your results.
2. You may plant other seeds of your choice, but do not use legume (bean) seeds. Research to find out why!

Chapter Review

USING KEY TERMS

Complete each of the following sentences by choosing the correct term from the word bank.

evaporation	condensation
precipitation	decomposition
combustion	succession

1. The breakdown of dead materials into carbon dioxide and water is called ___.
2. The gradual development of a community over time is called ___.
3. During ___, the heat causes water to change from liquid to vapor.
4. ___ is the process of burning a substance.
5. Water that falls from the atmosphere to the land and oceans is ___.
6. In the process of ___, water vapor cools and returns to a liquid state.

UNDERSTANDING KEY IDEAS

Multiple Choice

7. Clouds form in the atmosphere through the process of
   - **a.** precipitation.
   - **b.** respiration.
   - **c.** condensation.
   - **d.** decomposition.
8. Which of the following statements about groundwater is true?
   - **a.** It stays underground for a few days.
   - **b.** It is stored in underground caverns or porous rock.
   - **c.** It is salty like ocean water.
   - **d.** It never reenters the water cycle.
9. Burning gas in an automobile is a type of
   - **a.** combustion.
   - **b.** respiration.
   - **c.** decomposition.
   - **d.** photosynthesis.
10. Nitrogen in the form of a gas can be used directly by some kinds of
    - **a.** plants.
    - **b.** animals.
    - **c.** bacteria.
    - **d.** fungi.
11. Bacteria are most important in the process of
    - **a.** combustion.
    - **b.** condensation.
    - **c.** nitrogen fixation.
    - **d.** evaporation.
12. The pioneer species on bare rock are usually
    - **a.** ferns.
    - **b.** pine trees.
    - **c.** mosses.
    - **d.** lichens.
13. Which of the following is an example of primary succession?
    - **a.** the recovery of Yellowstone National Park following the fires of 1988
    - **b.** the appearance of lichens and mosses in an area where a glacier has recently melted away
    - **c.** the growth of weeds in a field after a farmer stops using the field
    - **d.** the growth of weeds in an empty lot that is no longer being mowed
14. One of the most common plants in a recently abandoned farm field is
    - **a.** oak or maple trees.
    - **b.** pine trees.
    - **c.** mosses.
    - **d.** crabgrass.

Short Answer

15 List four places where water can go after it falls as precipitation.

16 In what forms can water on Earth be found?

17 What role do animals have in the carbon cycle?

18 What roles do humans have in the carbon cycle?

19 Earth's atmosphere is mostly made up of what substance?

20 Compare and contrast the two forms of succession.

CRITICAL THINKING

21 **Concept Mapping** Use the following terms to create a concept map: *abandoned farmland, lichens, bare rock, soil formation, horseweed, succession, forest fire, primary succession, secondary succession,* and *pioneer species*.

22 **Identifying Relationships** Is snow a part of the water cycle? Why or why not?

23 **Analyzing Processes** Make a list of several places where water might be found on Earth. For each item on your list, state how it is part of the water cycle.

24 **Forming Hypotheses** Predict what would happen if the water on Earth suddenly stopped evaporating.

25 **Forming Hypotheses** Predict what would happen if all of the bacteria on Earth suddenly disappeared.

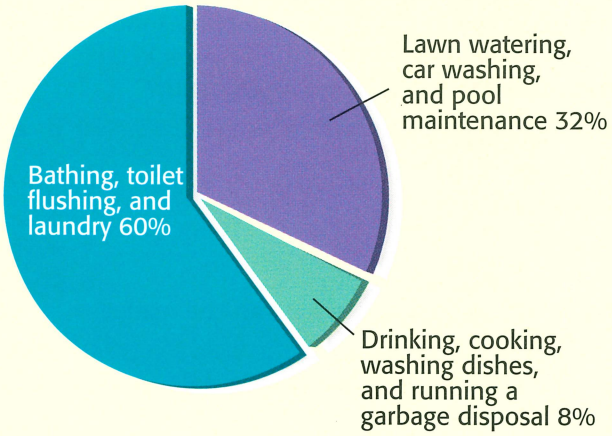
26 **Making Inferences** Describe why a lawn usually doesn't go through succession.

27 **Making Inferences** Can one scientist observe all of the stages of secondary succession on an abandoned field? Explain your answer.

INTERPRETING GRAPHICS

The graph below shows how water is used each day by an average household in the United States. Use the graph to answer the questions that follow.

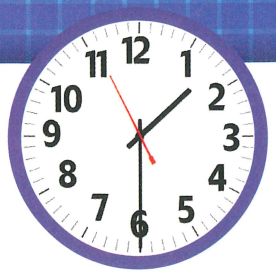
Average Household Daily Water Use



28 According to this graph, which of the following activities uses the greatest amount of water?

a. bathing
b. toilet flushing
c. washing laundry
d. There is not enough information to determine the answer.

29 An average family used 380 L of water per day, until they stopped washing their car, stopped watering their lawn, and stopped using their pool. Now, how much water per day do they use?



Standardized Test Preparation

READING

Read each of the passages below. Then, answer the questions that follow each passage.

Passage 1 The scientist woke up and jogged over to the rain forest. There she observed the water-recycling experiment. She took a swim in the ocean, and she walked through the aspen forest on her way home. At home, she ate lunch and then went to the computer lab. From the lab, she could monitor the sensors that would alert her if any part of the ecosystem failed to cycle properly. This monitoring was very important to the scientist and her research team because their lives depended on the health of their sealed environment. Several weeks ago, the sensors began to detect trouble.

1. In the passage, what does *aspen* mean?

- **A** a type of experiment
- **B** a type of tree
- **C** beautiful
- **D** ugly

2. Based on the passage, what can the reader conclude?

- **F** The scientist lives in an artificial environment.
- **G** The scientist lives by herself.
- **H** The scientist and her research team are studying a newly discovered island.
- **I** The scientist does not rely on the sensors to detect trouble.

3. Based on the passage, which of the following statements is a fact?

- **A** The scientist is scared that her environment is being destroyed.
- **B** The scientists depend on the sensors to alert them of trouble.
- **C** The scientists live on an island.
- **D** The scientist eats lunch at home every day.

Passage 2 Every summer, millions of fish are killed in an area in the Gulf of Mexico called a *hypoxia region*. Hypoxia is a condition that occurs when there is an unusually low level of oxygen in the water. The area is often referred to as the *dead zone* because almost every fish and crustacean in the area dies. In 1995, this zone covered more than 18,000 km^2, and almost 1 million fish were killed in a single week. Why does this happen? Can it be stopped?

1. Based on the passage, what is the **best** definition of a hypoxia region?

- **A** a region where millions of fish are killed
- **B** a region where there is a low level of oxygen
- **C** a region that creates a "dead zone"
- **D** a region that is 18,000 km^2

2. Why is the hypoxia region called a *dead zone*?

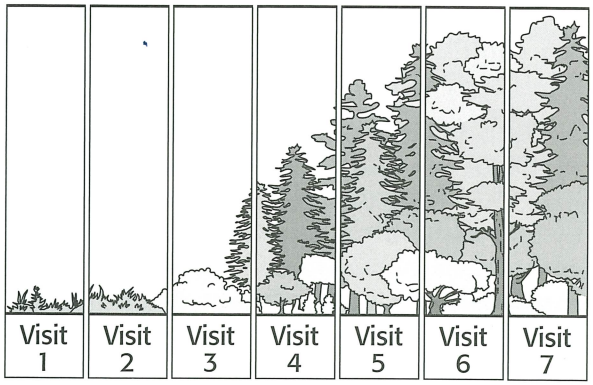
- **F** because the oxygen in the region is dead
- **G** because the region covers more area than fish can live in
- **H** because the Gulf of Mexico is not a popular fishing zone anymore
- **I** because almost every fish and crustacean in the area dies

3. What information would the paragraph following the passage provide?

- **A** an explanation of the definition of hypoxia
- **B** a description of how hypoxia occurs in other parts of the world
- **C** a list all of the animals that died in the Gulf of Mexico in 1995
- **D** an explanation of how the hypoxia region is formed in the Gulf of Mexico

INTERPRETING GRAPHICS

The illustration below shows what an area looked like when visited on several successive occasions. Use the illustration to answer the questions that follow.



1. In the area illustrated, what process is evident over time?
   - **A** ecological succession
   - **B** combustion of fossil fuels
   - **C** pioneer speciation
   - **D** ecological organization

2. During which of the following visits would you see the **most** mature community?
   - **F** visit 1
   - **G** visit 3
   - **H** visit 5
   - **I** visit 7

3. Assume that a forest fire happened after the seventh visit. If the scientist were to visit again within 1 year after the fire, the area would most likely look like it did during which visit?
   - **A** visit 1
   - **B** visit 3
   - **C** visit 5
   - **D** visit 7

MATH

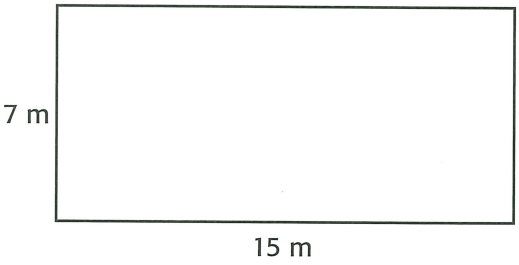
Read each question below, and choose the best answer.

1. Flushing the toilet accounts for almost half the water a person uses in a day. Some toilets use up to 6 gal per flush. More-efficient toilets use about 1.5 gal per flush. How many liters of water can you save each day by using a more-efficient toilet if you flush five times a day?
   - **A** 4.5 gal
   - **B** 20 gal
   - **C** 80 L
   - **D** 85 L

2. About 15 m of topsoil covers the eastern plains of the United States. If topsoil forms at the rate of 2.5 cm per 500 years, how long did it take for the 15 m of topsoil to form?
   - **F** 3,000 years
   - **G** 18,750 years
   - **H** 30,000 years
   - **I** 300,000 years

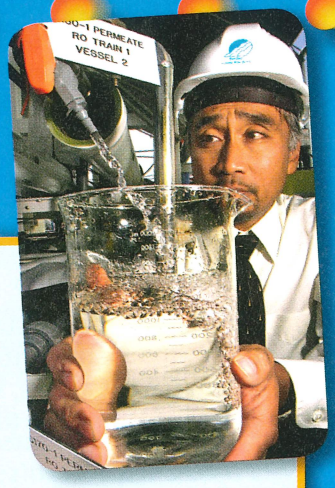
3. If $16 = 2x + 10$, what is x?
   - **A** 2
   - **B** 3
   - **C** 4
   - **D** 8

4. What is the area of the rectangle below?



   - **F** 22 m
   - **G** 22 m^2
   - **H** 105 m
   - **I** 105 m^2

Science in Action



Science, Technology, and Society

Desalination

By the year 2025, it is estimated that almost a billion people on Earth will face water shortages. Only about 3% of the water on Earth is *fresh water*—the kind of water that we use for drinking and farming. And the human population is using and polluting Earth's fresh water too quickly. The other 97% of Earth's water is mostly in oceans and is much too salty for drinking or farming.

Until recently, it was very expensive and time-consuming to filter salt out of water, a process known as *desalination*. But new technologies are making desalination an affordable option for some areas.

Math ACTIVITY

You need to drink about 2 quarts of water each day. Imagine that you have a simple device that evaporates sea water and collects fresh, drinkable water at the rate of 6 mL/min. How long will it take your device to collect enough water each day?

Scientific Discoveries

The Dead Zone

Every summer, millions of fish are killed in an area in the Gulf of Mexico called a hypoxia region. *Hypoxia* (hy PAWK see UH) is a condition of water with unusually low levels of oxygen. The Gulf's hypoxia region is called a "dead zone" because a large number of organisms in the area die. Why does this happen? Scientists think that the region may be polluted with large amounts of nitrogen and phosphorus. These nutrients promote the growth of algae, which "bloom" and then die in huge numbers. When the algae is decomposed by bacteria, the bacteria use up oxygen in the water and hypoxia results. Scientists think that the polluting chemicals are washed into the Gulf by the Mississippi River. This river receives runoff from a large area that includes farms, housing, and cities. The scientists propose that adding wetlands to the Mississippi River watershed could reduce the chemicals reaching the Gulf.

Language Arts ACTIVITY

WRITING SKILL

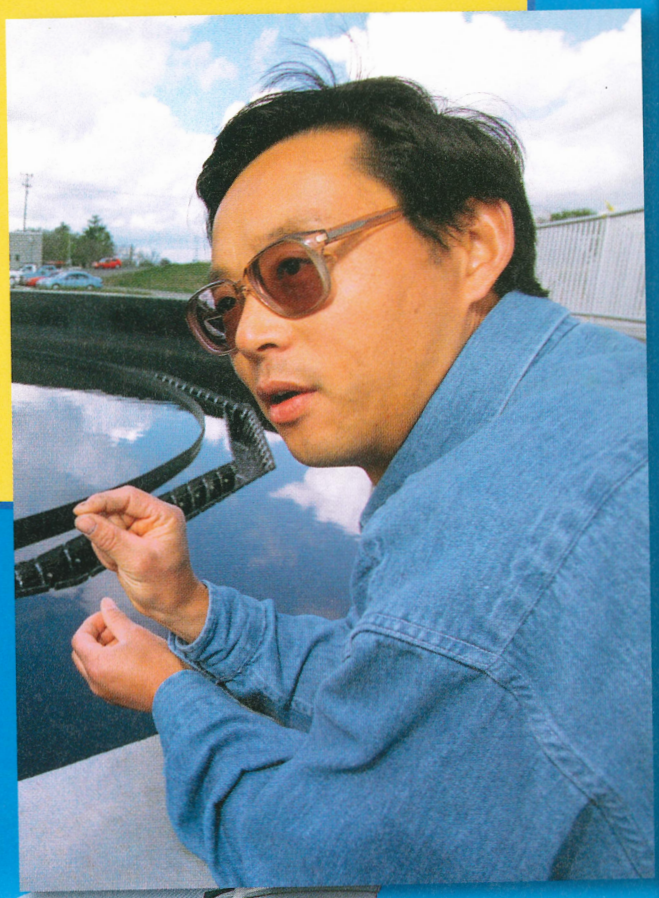
The Gulf of Mexico is not the only place where a hypoxia region exists. Research other bodies of water to find out how widespread the problem is. Write a short report telling what scientists are doing to reduce hypoxia in other places.

For several years after it was first noticed, the Gulf of Mexico hypoxia region became larger.

Michael Fan

Wastewater Manager If you are concerned about clean water and you like to work both in a laboratory and outdoors, you might like a career in wastewater management. The water cycle helps to keep water in nature pure enough for most organisms. But when humans use water in houses, factories, and farms, we create *wastewater*, often faster than natural processes can clean it up. To make the water safe again, we can imitate the ways water gets cleaned up in nature—and speed up the process.

Michael M. Fan is the Assistant Superintendent of wastewater operations at the Wastewater Treatment Plant at the University of California in Davis, California. This plant has one of the most advanced wastewater management systems in the country. Mr. Fan finds his job exciting. The plant operates 24 hours a day, and there are many tasks to manage. Running the plant requires skills in chemistry, physics, microbiology, and engineering. Many organisms in the Davis area are counting on Mr. Fan to make sure that the water used by the University campus is safely returned to nature.



Social Studies ACTIVITY

Research the ways that the ancient Romans managed their wastewater. Make a poster that illustrates some of their methods and technologies.

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Current Science

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