EYE ON THE ENVIRONMENT

Alien Invasion
A group of tiny aliens left their ship in Mobile, Alabama. Their bodies were red and shiny, and they walked on six legs. The aliens looked around and then quietly crawled off to make homes in the new land.

Westward Ho!
In 1918, fire ants were accidentally imported into the United States by a freighter ship from South America. In the United States, fire ants have no natural predators or competitors. In addition, these ants are extremely aggressive, and their colonies can harbor many queens, instead of just one queen, like many other ant species. With all these advantages, it is not surprising that the ants have spread like wildfire. By 1965, fire-ant mounds were popping up on the southeastern coast and as far west as Texas. Today they are found in at least 10 southern states and may soon reach as far west as California.

Jaws of Destruction
Imported fire ants have done a lot of damage as they have spread across the United States. Because they are attracted to electrical currents, they chew through wire insulation, causing shorts in electrical circuits. The invaders have also managed to disturb the natural balance of native ecosystems. In some areas, they have killed off 70 percent of the native ant species and 40 percent of other native insect species. Each year, about 25,000 people seek medical attention for painful fire-ant bites.

Fighting Fire
Eighty years after the fire ants’ introduction into the United States, the destructive ants continue to multiply. About 157 chemical products, including ammonia, gasoline, extracts from manure, and harsh pesticides, are registered for use against fire ants, but most have little or no success. Unfortunately, many of these remedies also harm the environment. By 1995, the government had approved only one fire-ant bait for large-scale use.

An Ant-Farm Census
How many total offspring does a single fire-ant queen produce if she lives for 5 years and produces 1,000 eggs a day? If a mound contains 300,000 ants, how many mounds will her offspring fill?
1. What is meant by recycling?
2. What happens to rainwater after it falls to Earth?
A CLASSROOM AQUARIUM

Did you know an aquarium is a small environment? In this activity, you will put an aquarium together. As you plan the aquarium, think about how all the parts are connected with each other.

Procedure

1. Get a tank from your teacher. Check the Internet, your library, or a pet store to find directions on the proper way to clean and prepare an aquarium.

2. Find out about the kinds of plants and animals that you can put in your aquarium.

3. Choose a place to put the tank, and tell your teacher your plans. Then set up the aquarium.

Analysis

4. How is the aquarium similar to and different from a natural body of water? Identify the limitations of your model.

5. After you read Section 1, take another look at the aquarium. See if you can name all the parts of this small ecosystem.
The Cycles of Matter

The matter in your body has been on Earth since the planet was formed billions of years ago! Matter, which is anything that occupies space and has mass, is used over and over again. Each kind of matter has its own cycle. In these cycles, matter moves among the environment and living things.

The Water Cycle

The movement of water among the oceans, atmosphere, land, and living things is known as the water cycle. Locate each part of the water cycle in Figure 1 as it is discussed.

Precipitation Water moves from the atmosphere to the land and oceans as precipitation, which includes rain, snow, sleet, and hail. About 91 percent of precipitation falls into the ocean. The rest falls on land, renewing the supply of fresh water.

Figure 1 Water from the environment moves through plants and animals and back to the environment.
**Evaporation** Water cycles back to the atmosphere through evaporation. During evaporation, the sun's heat causes water to change from liquid to vapor. When the water vapor cools during the process of condensation, it forms a liquid that can fall to the Earth as precipitation.

**Ground Water** Some precipitation seeps into the ground, where it is stored in underground caverns or in porous rock. This water, known as ground water, may stay in the ground for hundreds or even thousands of years. Ground water provides water to the soil, streams, rivers, and oceans.

**Water and Life** All organisms, from tiny bacteria to animals and plants, contain a lot of water. Your body is composed of about 70 percent water. Water carries waste products away from body tissues. Water also helps regulate body temperature through perspiration and evaporation, returning water to the environment in a process called transpiration. Without water, there would be no life on Earth.

**The Carbon Cycle**
Carbon is essential to living things because it is part of all biological molecules. The movement of carbon from the environment into living things and back into the environment is known as the carbon cycle, shown in Figure 2.

![Carbon Cycle Diagram](image)
QuickLab

Combustion
Place a candle on a jar lid and secure it with modeling clay. Light the candle. Hold the jar very close to the candle flame. What is deposited on the jar? Where did the substance come from? Now place the jar over the candle. What is deposited inside the jar? Where did this substance come from?

Photosynthesis Photosynthesis is the process by which carbon cycles from the environment into living things. During photosynthesis, plants use carbon dioxide from the air to make sugars. Most animals get the carbon they need by eating plants.

Respiration How does carbon return to the environment? Animals and plants both respire. During respiration, sugar molecules are broken down to release energy. Carbon dioxide and water are released as byproducts.

Decomposition The breakdown of dead materials into carbon dioxide and water is called decomposition. When fungi and bacteria decompose organic matter, they return carbon to the environment.

Combustion The carbon in coal, oil, and natural gas returns to the atmosphere as carbon dioxide when these fuels are burned. The process of burning fuel is known as combustion. Combustion provides much of the fuel people need to drive cars, heat homes, and make electricity.

The Nitrogen Cycle
The movement of nitrogen from the environment to living things and back again is called the nitrogen cycle, shown in Figure 3.
A Sea of Nitrogen  About 78 percent of the Earth’s atmosphere is nitrogen gas. However, most organisms cannot use nitrogen gas to obtain the nitrogen they need to build proteins and DNA. But bacteria in the soil are able to change nitrogen gas into forms that can be used by plants. This is called nitrogen fixation. Most animals get the nitrogen they need by eating plants.

Back to Gas  The final step of the nitrogen cycle is also performed by bacteria in the soil. These bacteria are different species than the bacteria that fix nitrogen. The bacteria break down dead organisms and animal wastes. This process produces nitrogen gas, which is returned to the atmosphere.

The Pollution Cycle
Isabel read an article about how power plants near her home emit sulfur dioxide into the atmosphere. When sulfur dioxide mixes with water, it forms sulfuric acid, which is extremely toxic to living things. Isabel also learned that sulfur dioxide from these power plants has killed all the fish in a lake hundreds of kilometers away. Trees growing near the lake were also killed. Using what you know about the water cycle, write a letter to Isabel explaining how this could happen.

SECTION REVIEW

1. How are precipitation, evaporation, and ground water involved in the water cycle?

2. Draw a simple diagram of the nitrogen cycle. Make sure you include how animals get nitrogen.

3. Analyzing Relationships  How is decomposition related to the carbon cycle?
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 found large areas of the park 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, as shown in Figure 4.

![Figure 4](image1)

**Figure 4** Parts of Yellowstone National Park burned in 1988.

**Regrowth of a Forest**

The following spring, the appearance of the "dead" forest began to change. In Figure 5, you can see that some of the dead trees are beginning to fall over, and small, green plants have begun to grow in large numbers. National Park foresters report that the number and kinds of plants growing in the recovering area have increased each year since the fire.

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. Succession occurs through predictable stages over time, as described on the following pages.

![Figure 5](image2)

**Figure 5** In the spring of 1989, regrowth was evident in the burned parts of Yellowstone National Park.
Primary Succession

Sometimes a small community of living things starts to live in an area that did not previously contain any plants or other organisms. There is no soil in this area, usually just bare rock. Over a very long time, a series of organisms live and die on the rock, and the rock is slowly transformed into soil. This process is called 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. Because lichens are the first organisms to live on the rock, they are called pioneer species.

3. After many years, the soil is deep enough for mosses to grow. The mosses eventually replace the lichens. Other tiny organisms, such as insects, also make their home among the lichens and mosses. When they die, their remains add to the soil.

4. Over time, the soil layer thickens, and the moss community is replaced by ferns. The ferns in turn may be replaced by grasses and wildflowers. Once there is sufficient soil, shrubs and small trees come into the area.

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

Sometimes an existing community is destroyed by a natural disaster, such as fire or flood. Or, a farmer might stop growing crops in an area that had been cleared. In either case, if soil is left intact, the original plant community may regrow through a series of stages called secondary succession.

1 The first year after a farmer stops growing crops, or after some other major disturbance, many weeds grow. Crabgrass is usually the most common weed during the first year.

2 By the second year, new weedy plants appear. Their seeds may have blown into the field by the wind, or insects may have carried them. One of the most common weeds during the second year is horseweed.

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

4 As older pines die, they may be replaced by hardwoods if the climate can support them.

Self-Check

Describe the differences between primary succession and secondary succession. (See page 168 to check your answer.)
Where Does It All End? In the early stages of succession only a few species grow in an area. These species grow fast and make many seeds that scatter easily. Because there are only a few species, they are open to invasion by other, longer-lasting species, disease, and other disturbances. In later stages of succession there are usually many more species present. Because of this, there are more pathways available to absorb disturbances. For example, in a mature forest, many species will survive an invasion by insects if these insects prefer to eat only one species of plant.

Eventually, if an area experiences no fires or other disturbances, it will reach a more or less stable stage. Communities change over time even though they are considered to be stable. A stable community may not always be a hardwood forest. Look at Figure 6. Why might a stable hardwood forest not develop there? The answer is that the area does not have the kind of climate that will support a stable hardwood forest. The climate in this area supports a desert community.

Figure 6 This is how a stable community in the Sonoran Desert in Arizona looks in spring.

SECTION REVIEW

1. Define succession.

2. Describe succession in an abandoned field.

3. Applying Concepts Explain why soil formation is always the first stage of primary succession. Does soil formation stop when trees begin to grow? Why or why not?
Succession is the progressive replacement of one type of community by another in a single area. The area could be one that has never seen life before and has no soil, such as a cooled lava flow or a rock uncovered by a retreating glacier. In an area where there is no soil, the process is called primary succession. In an area where soil is already there, such as a forest after a fire, the process is called secondary succession. In this exercise, you will build a model of secondary succession using natural soil.

**Procedure**

1. Using a balance, measure 500 g of the soil you brought from home or the schoolyard. Place the soil into the fishbowl. Wet the soil with 250 mL of water. Cover the top of the fishbowl with plastic wrap, and place the fishbowl in a sunny window. **Caution:** Do not touch your face, eyes, or mouth during this exercise. Wash your hands when you are finished.

2. For two weeks, watch the soil for any new growth. Describe and draw any new plants you see. Record these and all other observations in your ScienceLog.

3. Name and record as many of these new plants as you can.

**MATERIALS**

- large fishbowl
- 500 g of soil from home or schoolyard
- balance
- 250 mL graduated cylinder
- plastic wrap
- water
- protective gloves
Analysis

4. What kinds of plants grew in your model of secondary succession? Were they tree seedlings, grass, or weeds?

5. Were the plants that sprouted in the fishbowl strange or ordinary for your area?

6. Explain how the plants that grew in your model of secondary succession can be called pioneer species.

7. Using your observations, explain how ecological succession worked to maintain equilibrium in your model.

Going Further

Look at each picture on this page. Analyze whether each area, if left alone, would go through primary or secondary succession. You may decide that an area will not go through succession at all. Explain your reasoning.

A pond choked with vegetation

Bulldozed land

Mount St. Helens volcano

Cycles in Nature 39
Chapter Highlights

SECTION 1

Vocabulary
- precipitation (p. 30)
- evaporation (p. 31)
- ground water (p. 31)
- decomposition (p. 32)
- combustion (p. 32)

Section Notes
- Water that falls is held in soil or porous rocks as ground water.
- Photosynthesis, respiration, decomposition, and combustion are important steps in the carbon cycle.
- Carbon enters plants from the nonliving environment as carbon dioxide.
- The process of changing nitrogen gas into forms that plants can use is called nitrogen fixation.

Labs
- Nitrogen Needs (p. 130)

Skills Check

Math Concepts

SAVING WATER 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 using a more-efficient toilet if you flush five times a day?

\[
\begin{align*}
6 \text{ gal} - 1.5 \text{ gal} &= 4.5 \text{ gal} \\
4.5 \text{ gal} \times 5 \text{ flushes} &= 22.5 \text{ gal} \\
1 \text{ gal} &\text{ is equal to } 3.79 \text{ L} \\
3.79 \text{ L} \times 22.5 \text{ gal} &= 85.275 \text{ L of water saved}
\end{align*}
\]

Visual Understanding

SOIL FORMATION

The formation of soil is part of every stage of primary succession. Look at page 35 to review how soil forms.
Vocabulary
succession (p. 34)
pioneer species (p. 35)

Section Notes

• 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 occurs in an area where an earlier community was disturbed by fire, landslides, floods, or plowing for crops; soil is present.
Chapter Review

USING VOCABULARY

To complete the following sentences, choose the correct term from each pair of terms listed below:

1. During ___, water moves from the atmosphere to the land and ocean. (evaporation or precipitation)

2. All biological molecules contain ___. (carbon or carbon dioxide)

3. The combustion of coal, oil, and natural gas is part of the ___. (nitrogen cycle or carbon cycle)

4. The development of a community on bare, exposed rock is an example of ___. (primary succession or secondary succession)

5. The recovery of Yellowstone National Park following the fires of 1988 is an example of ___. (primary succession or secondary succession)

UNDERSTANDING CONCEPTS

Multiple Choice

6. Water changes from a liquid to a vapor during
   a. precipitation. c. evaporation.
   b. respiration. d. decomposition.

7. The process of burning fuel, such as oil and coal, is
   a. combustion. c. decomposition.
   b. respiration. d. photosynthesis.

8. One of the most common plants in a recently abandoned farm field is
   a. horseweed.
   b. young pine trees.
   c. young oak and hickory trees.
   d. crabgrass.

9. Which of the following statements about ground water 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.

10. Which of the following processes produces carbon dioxide?
    a. decomposition c. combustion
    b. respiration d. all of the above

11. During nitrogen fixation, nitrogen gas is converted into a form that can use.
    a. plants c. fungi
    b. animals d. all of the above

12. Bacteria are essential to
    a. combustion. c. nitrogen fixation.
    b. photosynthesis. d. evaporation.

13. The pioneer species on bare rock are usually
    a. ferns. c. mosses.
    b. pine trees. d. lichens.

Short Answer

14. Is snow a part of the water cycle? Why or why not?

15. Can a single scientist observe all of the stages of secondary succession on an abandoned field? Explain your answer.
Concept Mapping

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

CRITICAL THINKING AND PROBLEM SOLVING

Write one or two sentences to answer the following questions:

17. Explain how living things would be affected if the water on our planet suddenly stopped evaporating.

18. How would living things be affected if there were no decomposers to cycle carbon back to the atmosphere?

19. Explain how living things would be affected if the bacteria responsible for nitrogen fixation were to die.

20. Describe why a lawn doesn’t go through succession.

INTERPRETING GRAPHICS

The following graph illustrates the concentration of carbon dioxide in the atmosphere from 1958 to 1994:

24. What was the concentration of carbon dioxide in parts per million in 1960? in 1994?

25. Is the concentration of carbon dioxide increasing or decreasing? Explain.

26. If the level of carbon dioxide continues to change at the same steady rate, what might be the concentration in 2010?

MATH IN SCIENCE

In 1996, 129 million metric tons of fertilizer were used world-wide. Use the following information to answer items 21, 22, and 23: 1996 world population = 5.7 billion; 1 metric ton = 1,000 kg; 1 kg = 2.2 lb.

21. Write out the number corresponding to 5.7 billion. How many zeros are in the number?

22. How many kilograms of fertilizer were used per person in 1996?

23. How many pounds of fertilizer were used per person?

Reading Check-up
Take a minute to review your answers to the Pre-Reading Questions found at the bottom of page 28. Have your answers changed? If necessary, revise your answers based on what you have learned since you began this chapter.
WEATHER FROM FIRE

As a wildfire burned near Santa Barbara, California, in 1993, huge storm clouds formed overhead. Fiery whirlwinds danced over the ground. The fire not only was destroying everything in its path—it was also creating its own weather!

Fire-Made Clouds
Hot air rising from a forest fire can create tremendous updrafts. Surrounding air rushes in underneath the rising air, stirring up columns of ash, smoke, hot air, and noxious gases. Cool, dry air normally sinks down and stops these columns from developing any further. But if the conditions are just right, a surprising thing happens.

If the upper atmosphere contains warm, moist air, the moisture begins to condense on the ash and smoke. These droplets can develop into clouds. As the clouds grow, the droplets begin to collide and combine until they are heavy enough to fall as rain. The result is an isolated rainstorm, complete with thunder and lightning.

Whirlwinds of Fire
Forest fires can also create whirlwinds. These small, tornado-like funnels can be extremely dangerous. Whirlwinds are similar to dust devils that dance across desert sands. Their circular motion is created by an updraft that is forced to turn after striking an obstacle, such as a cliff or hill. Whirlwinds move across the ground at 8–11 km/h, sometimes growing up to 120 m high and 15 m wide.

Most whirlwinds last less than a minute, but they can cause some big problems. Firefighters caught in the path of whirlwinds have been severely injured and even killed. Also, if a whirlwind is hot enough, it can suck up tremendous amounts of air. The resulting updraft can pull burning debris up through the whirlwind. In some cases, burning trees have been uprooted and shot into the air. When the debris lands, it often starts new fires hundreds of meters away.

Think About It
Fires are a natural part of the growth of a forest. For example, some tree seeds are released only under the extreme temperatures of a fire. Some scientists believe that forest fires should be allowed to run their natural course. Others argue that forest fires cause too much damage and should be extinguished as soon as possible. Do some additional research and then decide what you think.