

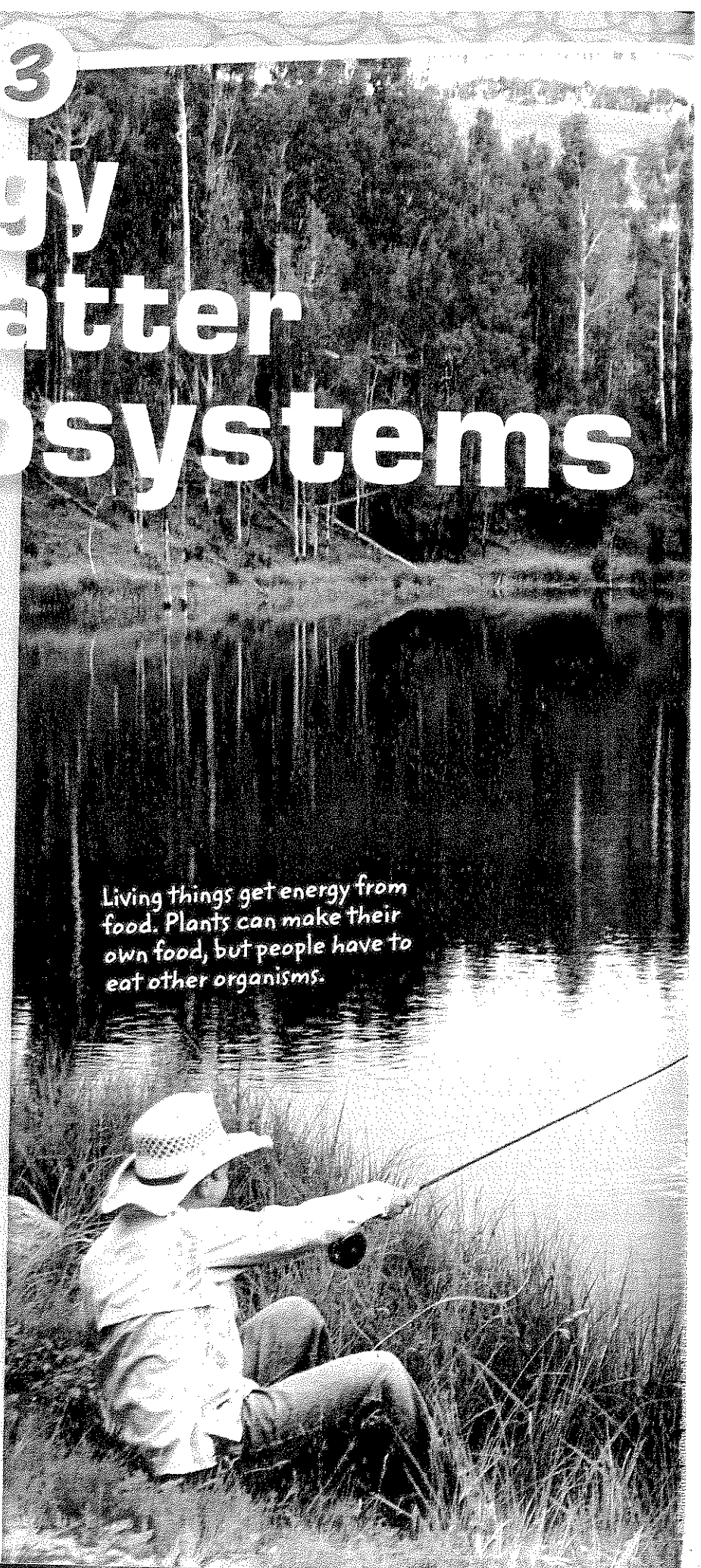
Energy and Matter in Ecosystems

ESSENTIAL QUESTION

*How do energy
and matter
move through
ecosystems?*

By the end of this lesson, you should be able to explain the flow of energy and the cycles of matter in ecosystems.

Living things get energy from food. Plants can make their own food, but people have to eat other organisms.



Soak Up the Sun

How do organisms get energy and matter?

To live, grow, and reproduce, all organisms need matter and energy. **Matter** is anything that has mass and takes up space. Organisms use matter in chemical processes, such as digestion and breathing. For these processes to occur, organisms need energy. **Energy** is the ability to do work and enables organisms to use matter in life processes. Organisms have different ways of getting matter and energy from their environment.

Active Reading

5 Identify As you read, underline the characteristics of producers and consumers.

From the Sun

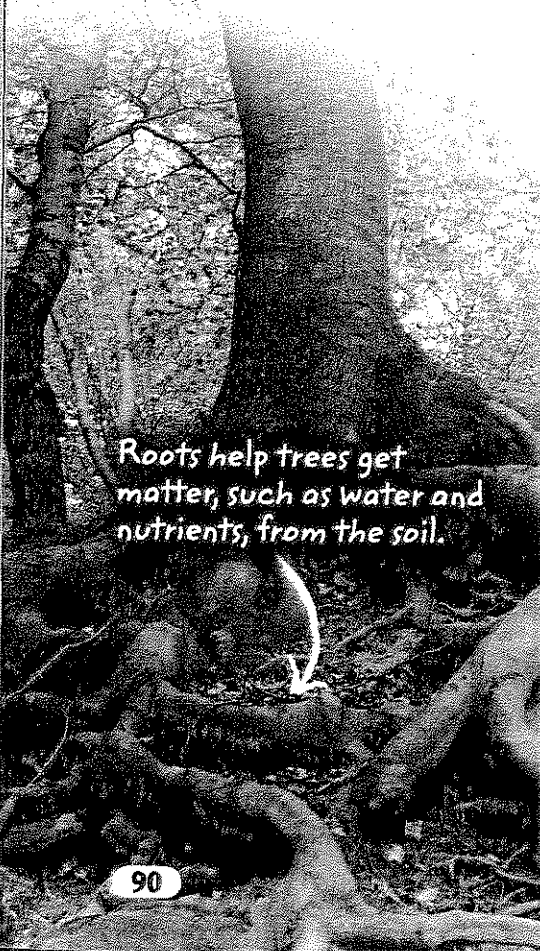
Organisms called *producers* use energy from their surroundings to make their own food. In most ecosystems, the sun is the original source of energy. Producers, like most plants and algae, use sunlight to convert water and carbon dioxide into sugars. In a few ecosystems, producers use chemical energy instead of light energy to make food. Producers take in matter, such as carbon dioxide, nitrogen, and water from air and soil.

From Other Organisms

Consumers are organisms that get energy by eating producers or other consumers. They get materials such as carbon, nitrogen, and phosphorus from the organisms they eat. So, consumers take in both energy and matter when they eat other organisms.

6 Infer Use this table to identify where producers and consumers get energy and matter.

Type of organism	How it gets energy	How it gets matter
Producer		
Consumer		



Roots help trees get matter, such as water and nutrients, from the soil.

What happens to energy and matter in ecosystems?

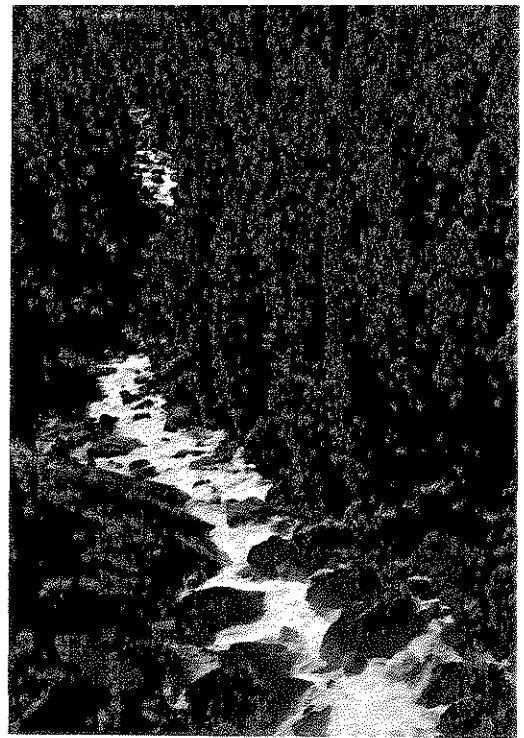
Energy and matter are constantly moving through ecosystems. Organisms need energy and matter for many functions, such as moving, growing, and reproducing. Some producers use carbon dioxide and water to make sugars, from which they get energy. They also collect materials from their environment for their life processes. Consumers get energy and matter for their life processes by eating other organisms. During every process, some energy is lost as heat. And, matter is returned to the physical environment as wastes or when organisms die.

Energy and Matter Are Conserved

The **law of conservation of energy** states that energy cannot be created or destroyed. Energy changes forms. Some producers change light energy from the sun to chemical energy in sugars. When sugars are used, some energy is given off as heat. Much of the energy in sugars is changed to another form of chemical energy that cells can use for life functions. The **law of conservation of mass** states that mass cannot be created or destroyed. Instead, matter moves through the environment in different forms.

Energy and Matter Leave Ecosystems

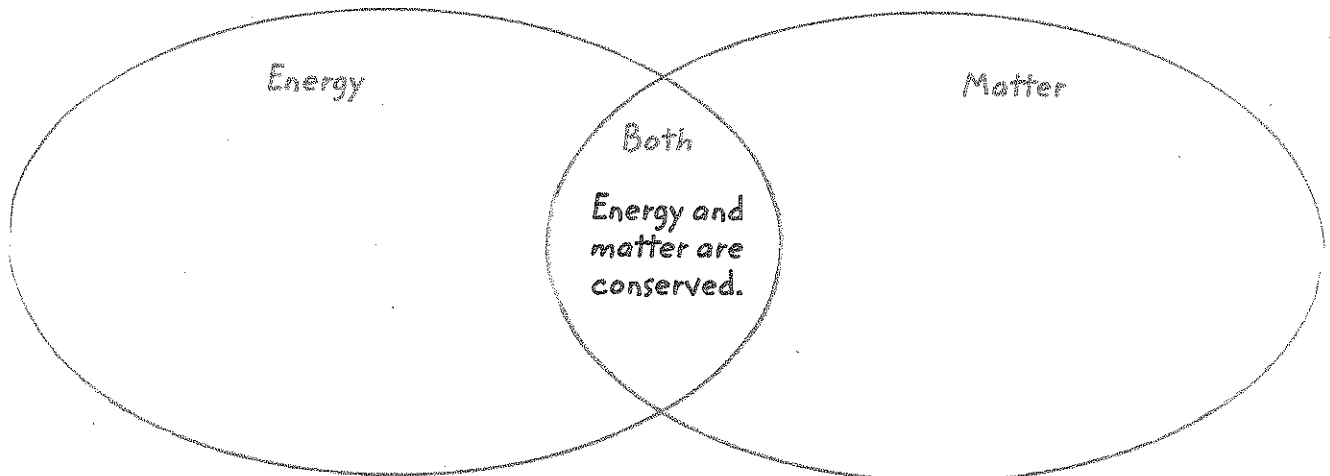
Ecosystems do not have clear boundaries, so energy and matter can leave them. Matter and energy can leave an ecosystem when organisms move. For example, some birds feed on fish in the ocean. When birds fly back to land, they take the matter and energy from the fish out of the ocean. Matter and energy can leave ecosystems in moving water and air. Even though the matter and energy enter and leave an ecosystem, they are never destroyed.



Visualize It!

7 Analyze How might energy and matter leave the ecosystem shown in the picture above?

8 Compare Use the Venn diagram below to relate how energy and matter move through ecosystems.



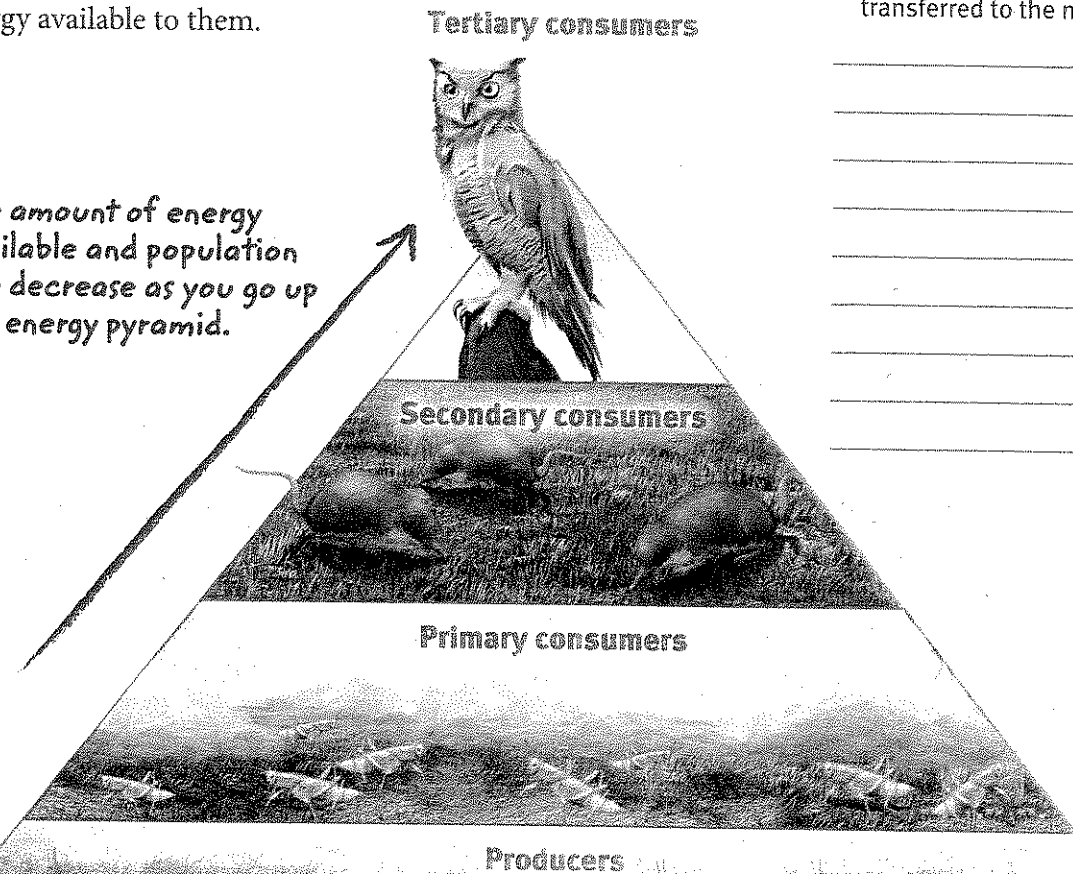
Cycle and Flow

How does energy move through an ecosystem?

Energy enters most ecosystems as sunlight, which some producers use to make food. Primary consumers, such as herbivores, get energy by consuming producers. Secondary consumers, such as carnivores, get energy by eating primary consumers, and so on up the food chain. An organism uses most of the energy it takes in for life processes. However, some energy is lost to the environment as heat. A small amount of energy is stored within an organism. Only this stored energy can be used by a consumer that eats the organism.

An **energy pyramid** is a tool that can be used to trace the flow of energy through an ecosystem. The pyramid's shape shows that there is less energy and fewer organisms at each level. At each step in the food chain, energy is lost to the environment. Because less energy is available, fewer organisms can be supported at higher levels. The bottom level—the producers—has the largest population and the most energy. The other levels are consumers. At the highest level, consumers will have the smallest population because of the limited amount of energy available to them.

The amount of energy available and population size decrease as you go up the energy pyramid.



Visualize It!

9 Analyze Describe how energy flows through each level in this energy pyramid. Is all the matter and energy from one level transferred to the next level?

How does matter move through an ecosystem?

Matter cycles through an ecosystem. For example, water evaporates from Earth's surface into the atmosphere and condenses to form clouds. After forming clouds, water falls back to Earth's surface, completing a cycle.

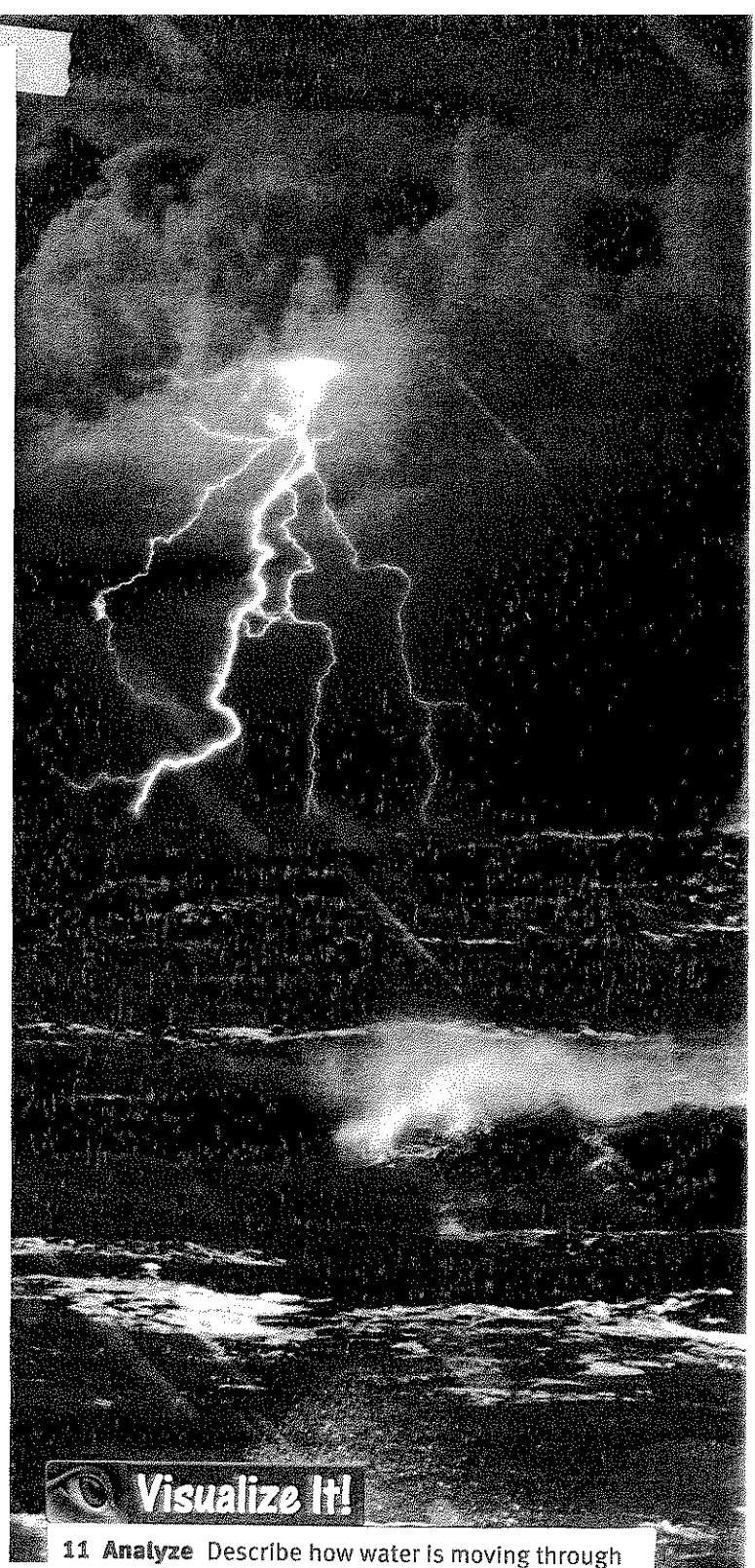
Carbon and nitrogen also cycle through an ecosystem. Producers take in compounds made of carbon and nitrogen from the physical environment. They use these compounds for life processes. Primary consumers get matter by consuming producers.

Secondary consumers eat primary consumers. The matter in primary consumers is used in chemical processes by secondary consumers. In this way, carbon and nitrogen flow from producers through all levels of consumers.

Consumers do not use all of the matter that they take in. Some of the matter is turned into waste products. Decomposers, such as bacteria and fungi, break down solid waste products and dead organisms, returning matter to the physical environment. Producers can then reuse this matter for life processes, starting the cycles of matter again.

All of these cycles can take place over large areas. Matter leaves some ecosystems and enters other ecosystems. For example, water that evaporates from a lake in the middle of a continent can later fall into an ocean. Because matter can enter and leave an ecosystem, it is called an *open system*.

Active Reading 10 Identify What is the role of decomposers in cycling matter?



Visualize It!

11 Analyze Describe how water is moving through the ecosystem on this page.

What is the water cycle?

The movement of water between the oceans, atmosphere, land, and living things is known as the **water cycle**. Three ways water can enter the atmosphere are evaporation, transpiration, and respiration. During *evaporation*, the sun's heat causes water to change from liquid to vapor. Plants release water vapor from their leaves in *transpiration*. Organisms release water as waste during *respiration*.

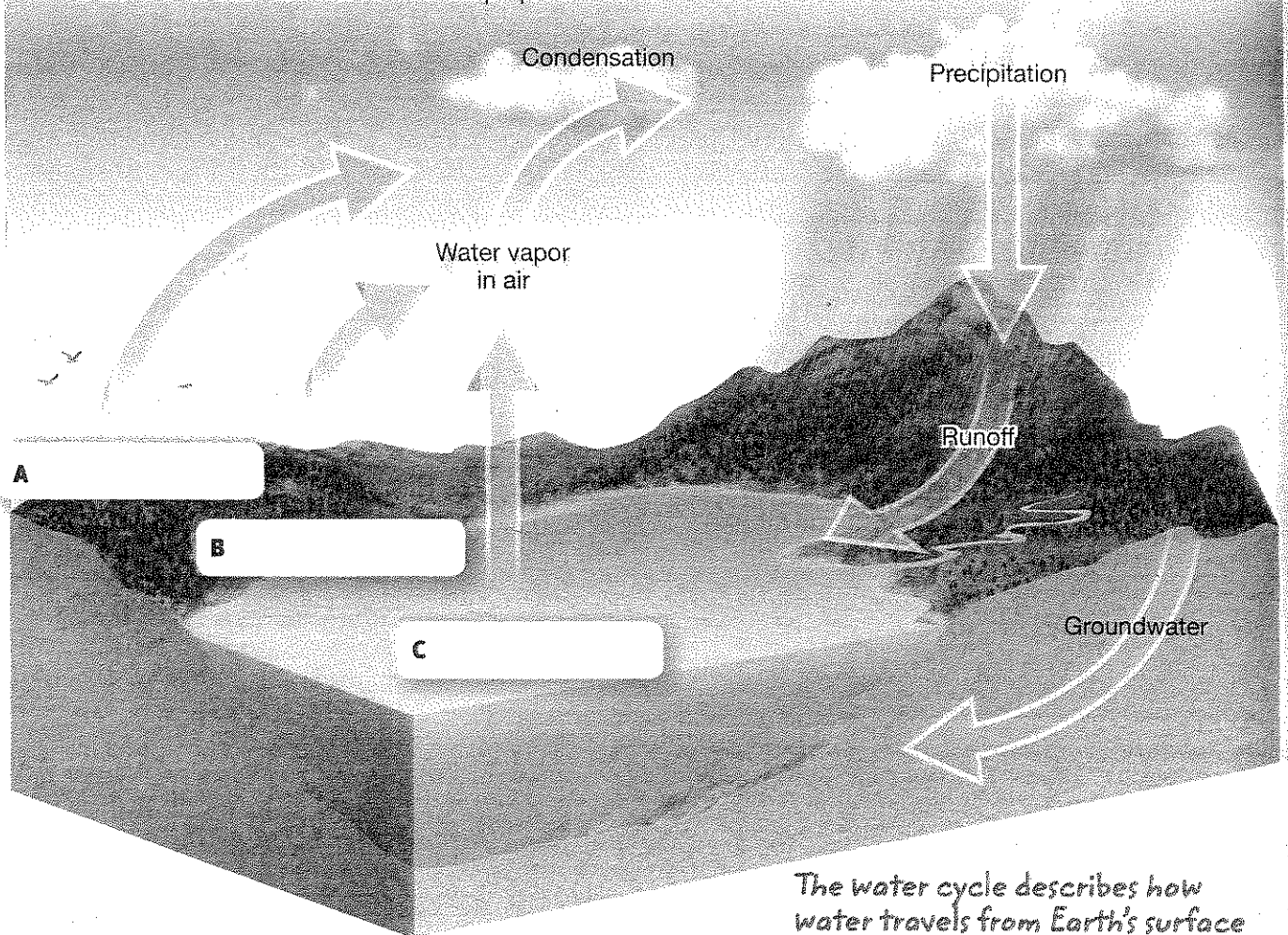
In *condensation*, the water vapor cools and returns to liquid. The water that falls from the atmosphere to the land and oceans is *precipitation*. Rain, snow, sleet, and hail are forms of precipitation. Most precipitation falls into the ocean. The precipitation that falls on land and flows into streams and rivers is called *runoff*. Some precipitation seeps into the ground and is stored underground in spaces between or within rocks. This water, called *groundwater*, will slowly flow back into the soil, streams, rivers, and oceans.

Active Reading

12 Explain How does water from the atmosphere return to Earth's surface?

Visualize It!

13 Label Use the terms *evaporation*, *transpiration*, and *respiration* to correctly complete the diagram. Be sure the arrow for each term leads from the proper source.

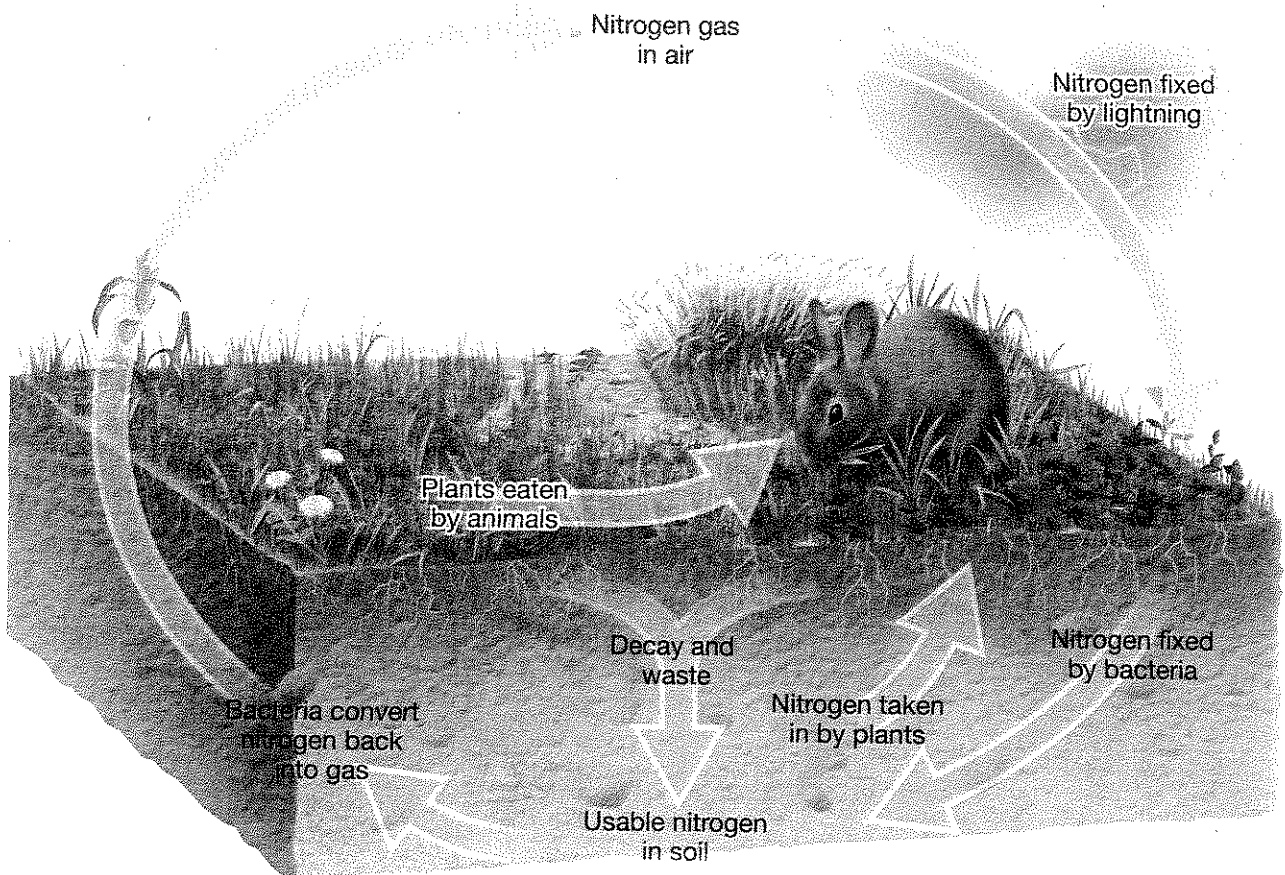


The water cycle describes how water travels from Earth's surface to the atmosphere and back.

What is the nitrogen cycle?

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**. Most of Earth's atmosphere is nitrogen gas. But 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*. Lightning can also fix nitrogen into usable compounds. Plants take in and use fixed nitrogen. Consumers can then get the nitrogen they need by eating plants or other organisms.

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



In the nitrogen cycle, nitrogen gas is converted into usable nitrogen by bacteria and lightning. Plants take in the usable nitrogen. Consumers get the nitrogen they need from the organisms they eat.

Visualize It! *Inquiry*

14 Hypothesize What would happen to the ecosystem if there were no nitrogen-fixing bacteria?

What is the carbon cycle?

Carbon is an important building block of organisms. It is found in sugars, which store the chemical energy that organisms need to live. It also is found in the atmosphere (as carbon dioxide gas), in bodies of water, in rocks and soils, in organisms, and in fossil fuels. Carbon moves through organisms and between organisms and the physical environment in the **carbon cycle**.

Active Reading 15 **List** Identify five places where carbon may be found.

Photosynthesis

During photosynthesis, producers in the water and on land take in light energy from the sun and use carbon dioxide and water to make sugars. These sugars contain carbon and store chemical energy. Oxygen gas is also a product of photosynthesis.

Photosynthesis

Respiration

Respiration

Cellular respiration occurs in producers and consumers on land and in water. During respiration, sugars are broken down to release energy. The process uses oxygen gas. Energy, carbon dioxide, and water are released.

carbon in organisms

carbon dioxide dissolved in water

Visualize It!

16 Relate Briefly describe how carbon enters and exits a consumer, such as the sheep shown in this diagram.

Combustion

Combustion is the burning of materials, including wood and fossil fuels. Burning once-living things releases carbon dioxide, water, heat, and other materials into the environment. It may also produce pollution.

carbon dioxide
in air

Combustion

Photosynthesis

Respiration

carbon in
organisms

Decomposition

Decomposition is the breakdown of dead organisms and wastes. Decomposers get energy from this material by respiration. Decomposition returns carbon dioxide, water, and other nutrients to the environment.

Decomposition

carbon in
fossil fuels

Fossil Fuels

Fossil fuels formed from decomposing organisms that were buried deeply millions of years ago. Fossil fuels are burned during combustion, releasing carbon dioxide into the air.

Think Outside the Book Inquiry

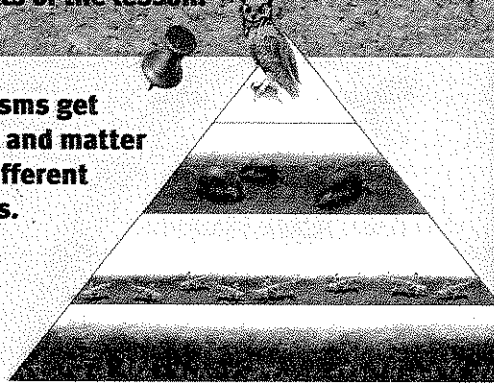
17 Apply With a partner, choose an ecosystem with which you are familiar. Make a diagram of how carbon cycles in the ecosystem and how energy flows through it. Be sure to label your diagram.

Visual Summary

To complete this summary, fill in the blanks with the correct word or phrase. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Energy and Matter in Ecosystems

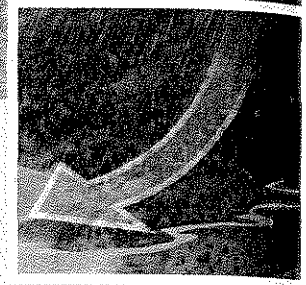
Organisms get energy and matter from different sources.



18 Many _____ get energy from sunlight.

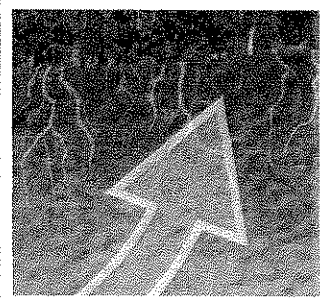
19 _____ get energy by eating other organisms.

Water moves between Earth's surface and the atmosphere in the water cycle.



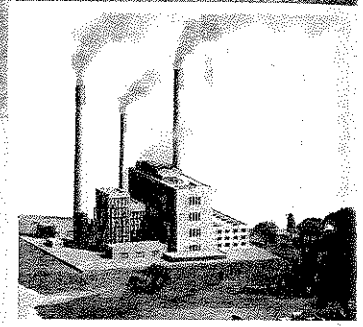
20 Water that flows over the surface of the ground is called _____.

Nitrogen moves from the atmosphere, to organisms, and back to the atmosphere in the nitrogen cycle.



21 _____ is the process by which bacteria turn nitrogen gas into compounds plants can use.

Carbon cycles through organisms, into the physical environment, and back again.



22 Dead organisms that were buried may turn into _____ after millions of years.

23 Carbon from this material reenters the atmosphere by _____.

Answers: 18 producers; 19 consumers; 20 runoff; 21 Nitrogen fixation; 22 fossil fuels; 23 combustion

24 **Explain** If energy and matter cannot be destroyed, what happens to energy and matter when an organism is eaten?

Lesson Review

Vocabulary

Fill in the blanks with the term that best completes the following sentences.

- 1 The ability to do work is called _____.
- 2 _____ is anything that has mass and takes up space.
- 3 A(n) _____ can be used to trace the flow of energy through an ecosystem.

Key Concepts

4 Describe Explain the difference between a producer, a consumer, and a decomposer.

5 Compare How are the law of conservation of energy and the law of conservation of mass similar?

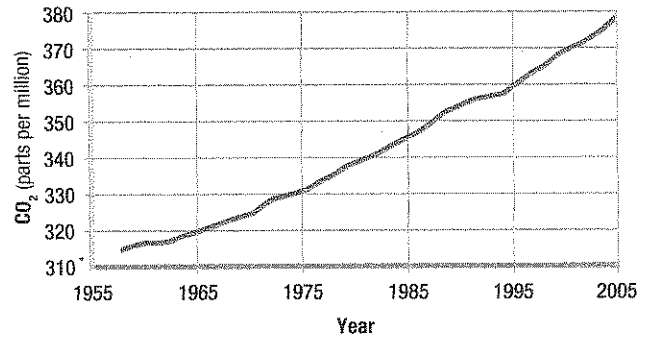
6 Explain Why do organisms need nitrogen?

Critical Thinking

7 Analyze In an ecosystem, which would have a larger population: producers or primary consumers? Explain.

Use the graph to answer the following questions.

Average Carbon Dioxide Levels at Mauna Loa, Hawaii



Source: NOAA 2004

8 Analyze What process of the carbon cycle is likely causing the increase in carbon dioxide levels shown in the graph above?

9 Identify What is the most likely source of the increase in carbon dioxide in the atmosphere shown in the graph above?

10 Evaluate If people planted huge numbers of trees and other plants, how might the carbon dioxide levels in the graph above change? Explain your answer.
