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Matter & Energy Cycles

UNIT 4

Student Reader

Front Cover:

The front cover shows a photograph of a groundhog eating plants. The groundhog is a consumer because it eats other organisms for energy.

Unit 4: Matter and Energy Cycles

Table of Contents

1 Living Things

Life in a Pond

Ponds have many different kinds of living things.

On its surface, a pond looks quiet and still. Ponds are small bodies of fresh water that are shallow enough for sunlight to reach the bottom and for rooted plants to grow.

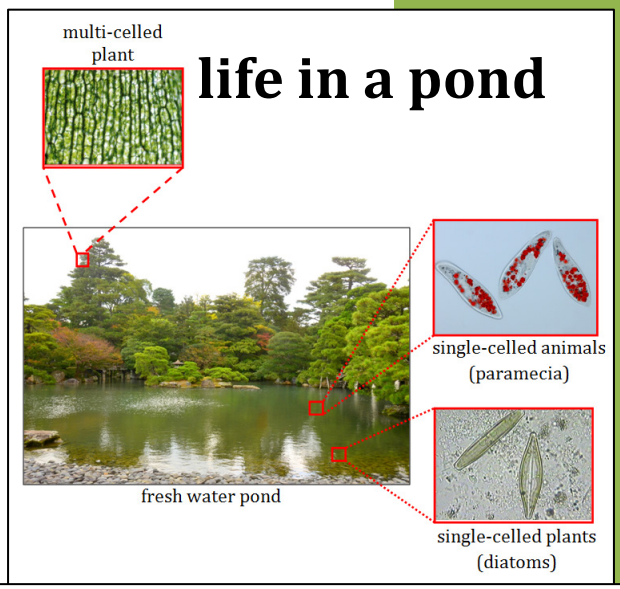
However, ponds are full of activity. They are filled with living things, some so tiny they cannot be seen with the human eye. These tiny living things are called microscopic. For example, a single drop of pond water can hold millions of microscopic bacteria.

Many different kinds of plants and animals also make their home in ponds. **Plants** are living things that capture energy from sunlight for growth and development. Water lilies are common plants found in ponds.

Animals are living things that eat other organisms for energy and undergo growth and reproduction. An **organism** is a complete living thing. Frogs, insects, and fish are common animals that live in ponds.

Living Things Are Made of Cells

All organisms, from the microscopic bacteria to the croaking frog, have something in common. They are all made of cells. A **cell** is the smallest unit of life. Cells are made up of molecules, which are two or more atoms joined together. Living things take in new molecules from air, food, and liquids. These molecules get into the cells and help them function. Some living things, such as bacteria, are made up of just one cell. These organisms are called single-celled organisms.



Both single-celled and multicelled organisms live in ponds.

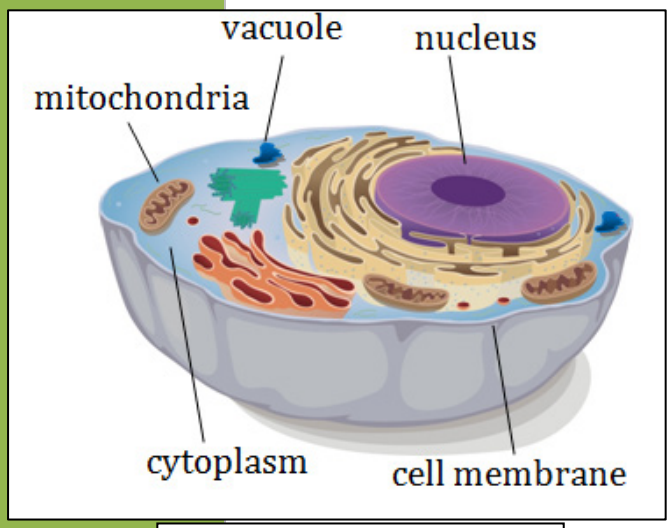
Other organisms are made up of many cells. These organisms are multi-celled organisms. Plants and animals are both kinds of multi-celled organisms.

Cells are alive because they use energy to carry out life functions. Life functions include growing, developing, and getting energy from food. Energy is required because it powers all of these actions. Plant and animal cells have different structures that help them carry out their life functions. A **structure** is the way in which parts are put together to form a whole.

The internal structures of a plant or animal cell are called organelles. Each organelle has a specific function. **Function** is the normal action of something or how something works.

The Parts of a Cell

All cells are filled with a jelly-like liquid. This liquid is called cytoplasm, and it surrounds all of the organelles. The cell membrane surrounds the cell and selects what molecules can enter and exit the cell. The cell membrane is flexible. This is why cells can be many different shapes.



an animal cell

The control center of plant and animal cells is the nucleus. It tells all of the other organelles what to do. This is possible because the nucleus contains the cell's DNA. DNA is an instruction manual for how the cell should look and what it should do.

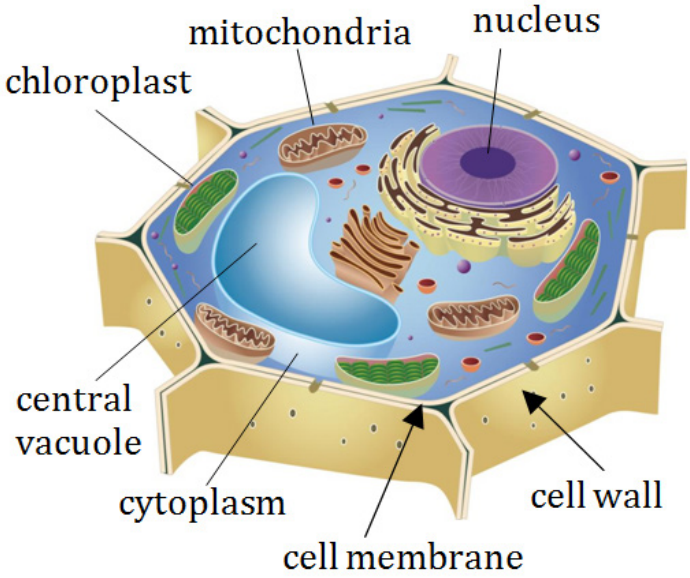
The workers that power the cell are the mitochondria. Mitochondria are organelles that break down food into useable energy.

The storage centers of the cell are the vacuoles. Vacuoles are large sacs that store water and food for the cell. Plant cells contain a larger central vacuole than animal cells. Ninety percent of a plant cell is taken up by the central vacuole. A plant wilts if its cells lose water in their central vacuoles.

Plant Cells

Plant cells have other differences as well. Plant cells have cell walls in addition to a cell membrane. Cell walls are stiff fibers that help plants stay rigid and stand up. Animal cells lack cell walls, so they are less rigid. For this reason, animal cells can take many different shapes.

Plant cells also have organelles called chloroplasts [klawr-*uh*-plasts]. Chloroplasts absorb energy from the sun to make their own food.

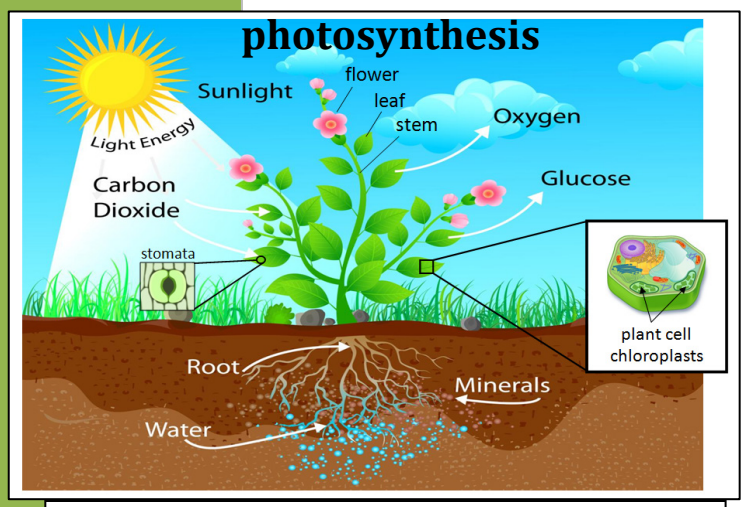


a plant cell

Chloroplasts contain a green pigment called chlorophyll. This pigment absorbs sunlight and gives plant cells their green color. The sunlight absorbed by the chloroplasts begins the process of photosynthesis. **Photosynthesis** uses the sun's energy to convert carbon dioxide and water into a kind of sugar called glucose. Glucose holds stored chemical energy. Plants use glucose for growth and development.

Photosynthesis

Without sunlight, carbon dioxide, and water, plants would not be able to photosynthesize. During photosynthesis, plants transform matter that is not food, including air and water, into matter that is food, specifically glucose. Glucose contains chemical energy that allows the plant to grow and develop.



Plants have different structures to perform photosynthesis.

In addition to chloroplasts, which are found in the cells of a plant's leaves, plants have other structures to perform photosynthesis. For example, leaves also have stomata, which are pores that open and close. They take in carbon dioxide from the environment and release oxygen. This exchange of gases in plants is called respiration. When plants take in carbon dioxide, not all of it is used for photosynthesis. Some of the carbon atoms become part of the plant as they are used for growth.

Plants also have roots to anchor the plant. Roots also gather water and minerals from the soil. Plants need different kinds of minerals, including nitrogen, phosphorous, and potassium. These nutrients help maintain the plants' cells. The stems transport the water and minerals between the roots and the rest of the plant.

Section 1 Review

Reading Comprehension Questions:

1. What is the main idea of Section 1?

2. What key details does the text provide to support the main idea of the text?

3. How are atoms and molecules related to cells?

4. On pages 6 and 7, the text includes a diagram of a plant cell and of an animal cell. What are the most important similarities between these two cells? What are the most important differences between them?

5. How does the text explain why plant cells have chloroplasts, while animal cells do not?

6. Identify a quote from the text that answers the question: "Why do plants need to perform photosynthesis?"

2 Interconnected Organisms

Why Squirrels Store Food

Squirrels are food gathers and hoarders. They spend much of their time gathering and eating acorns and other nuts. This is because they have front teeth that never stop growing. As a result, squirrels have to gnaw on things to keep their teeth from growing too long.

Squirrels have teeth that never stop growing.

Squirrels don't just gather enough food for one or two meals. Instead, they store extra food sources for the winter, when there is less food available. Food provides squirrels with energy and nutrients. **Nutrients** are chemicals that organisms need for growth and the maintenance of cells. Like all living things, squirrels need both energy and nutrients to survive. Energy is different from nutrients because energy is not matter.

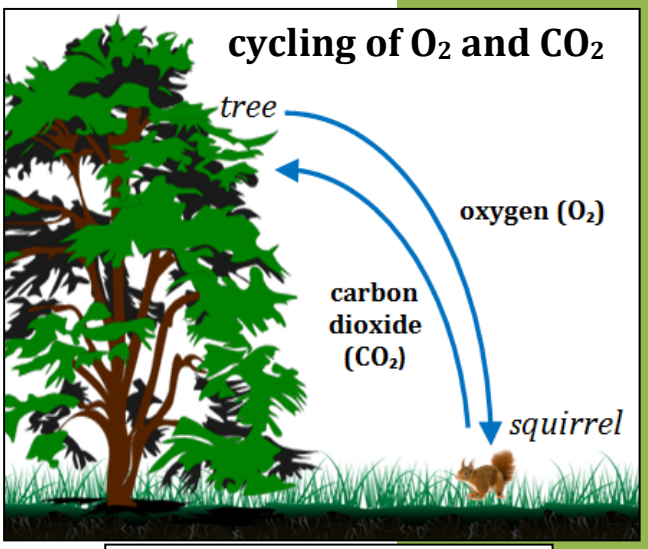
Nutrients are matter because they are made up of atoms and molecules. When squirrels and other animals breathe, eat, and drink, they take in molecules of air, food, and water. These molecules get into cells and help them function.

Parts of an Ecosystem

Squirrels are common in many different ecosystems around the planet. An **ecosystem** is a community of different organisms that depend on interacting with each other and their physical environment for survival. All ecosystems include living things; oxygen and carbon dioxide from the atmosphere; water; and energy from the sun.

All the parts of an ecosystem work together to make a balanced system. For example, squirrels depend on trees that produce acorns and other nuts for food and shelter. At the same time, some squirrels help trees produce new trees. For example, when the gray squirrel buries its acorns all over, it forgets where it has buried some of these acorns. In time, these forgotten acorns grow into trees. This helps trees reproduce.

Squirrels also need trees because like all animals, squirrels breathe in oxygen. Plants release oxygen during photosynthesis. Squirrels and other animals breathe out carbon dioxide, which plants need for photosynthesis. This exchange is called the oxygen cycle.



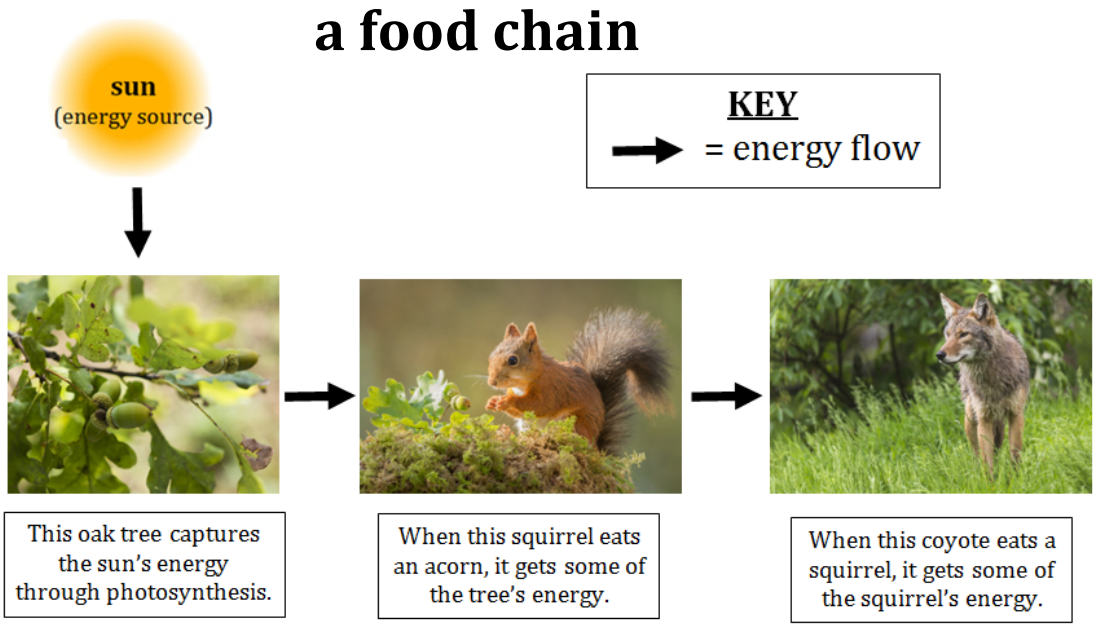
Plants and animals exchange gases.

Energy Moves Through Ecosystems

The need for energy also connects all living things in an ecosystem. When plants capture the sun's energy and turn it into chemical energy stored in glucose through photosynthesis, they are performing an important function. That energy will get passed between organisms as they eat one another. The path that energy travels as one organism eats another is called a **food chain**.

Food chains always begin with energy from the sun and then move to plants and other producers. **Producers** are organisms that capture energy from sunlight through photosynthesis. When organisms eat one another, some of that energy that started with the sun gets passed along.

a food chain



Eating for Energy

When squirrels eat nuts, they get some of the tree's energy. Squirrels are **consumers** because they must eat other organisms for energy and nutrients. All animals are consumers. Food also gives animals the materials they need for body repair and growth. For example, when animals eat plants, they absorb some of the plants' glucose. They also absorb some of the carbon atoms that the plant had stored for its growth and development.

There are different kinds of consumers, depending on what an organism eats. Any animal that eats producers is called a primary consumer. Butterflies are primary consumers that eat the nectar of plants. Primary consumers are also called herbivores.

Butterflies eat nectar.

Carnivores eat only other animals. Coyotes are common carnivores that eat many different kinds of animals. Coyotes eat deer, sheep, rabbits, rodents (like squirrels), snakes, and fish.

Coyotes eat many animals.

Squirrels are omnivores.

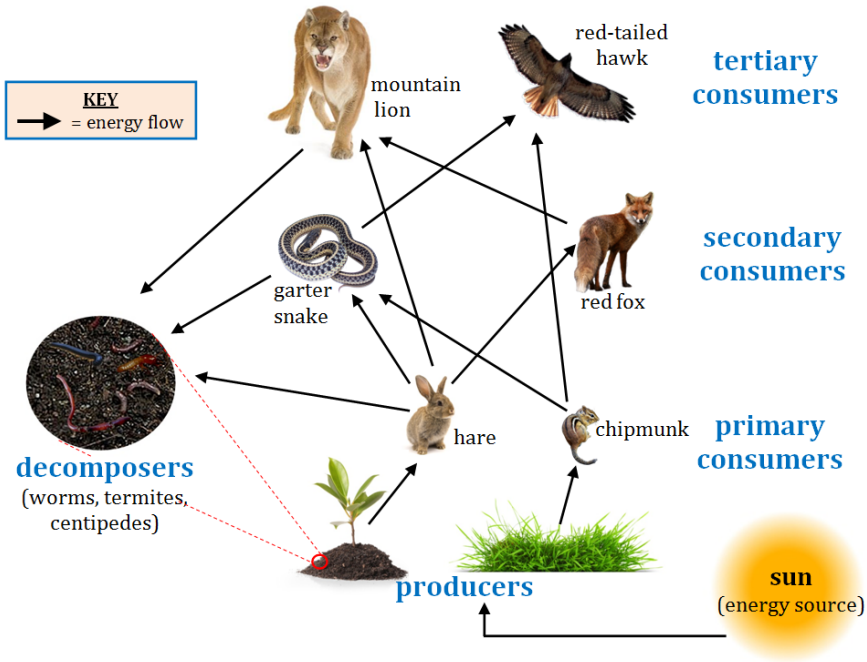
Other animals eat both plants and animals. These are called *omnivores.* Squirrels are omnivores. They eat nuts, fruits, and seeds, which are all plants. They also eat insects and caterpillars, which are other animals.

Any organism that eats primary consumers is called a secondary consumer. Any organism that eats a secondary consumer is called a tertiary consumer. Omnivores and carnivores can be either secondary or tertiary consumers, depending on what they eat.

When animals and plants die, living things called decomposers will eat their remains. **Decomposers** are organisms that break down organic material and feed on the nutrients. They put nutrients (matter) back into the ground. Plants will then use those nutrients to grow. Bacteria, worms, and fungi are common decomposers in a food web.

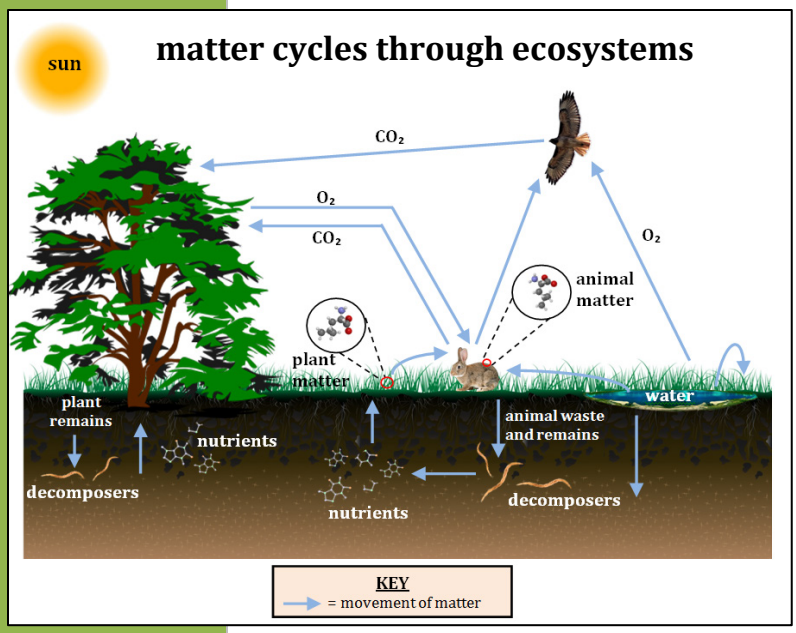
As energy flows from the sun to producers and then to consumers and decomposers, it always moves in one direction. A **food web** is a visual that shows the network of food chains in an ecosystem. It shows the complex set of relationships between organisms that are linked by the flow of energy. Because energy flows in one direction, life requires a constant supply of energy from the sun.

a forest food web



Matter Cycles Through Ecosystems

In contrast to energy, matter is always cycling through ecosystems. Most of the matter that is on Earth today has been around since the planet first formed. Matter is transferred and recycled at every level of a food web. All organisms need to take in new matter to keep their cells healthy and functioning. The nutrients an organism takes in help the organism grow, develop, and reproduce.



For example, the gases oxygen and carbon dioxide are cycled through the atmosphere as plants take in carbon dioxide and release oxygen, while animals take in oxygen and release carbon dioxide. Carbon and oxygen are also cycled through organisms. When plants and animals die, decomposers break down the carbon atoms and return them to the environment.

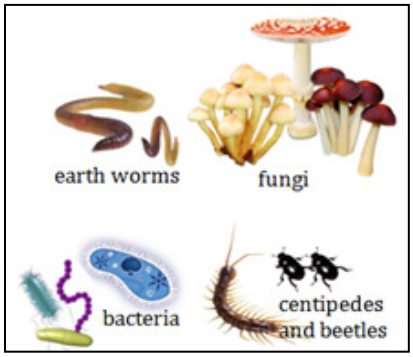
Water is also cycled throughout an ecosystem. Plants absorb water through their roots. They release some of that water back to the environment through transpiration. Animals drink water, and then release some of the water back into the environment as part of their waste.

Temperate Forest Organisms Guide*

grasses – plants that get their energy through photosynthesis 	**tree nuts and seeds** – dry plant fruits in a protective coat 
tree – tall plant that gets its energy through photosynthesis 	**insect** – feeds on grass 
white-footed mouse – feeds on nuts, seeds, grasses, and other plant matter 	**hawk** – feeds on squirrels and small birds 

* Organisms are not to scale.

Temperate Forest Organisms Guide*

groundhog – feeds on grasses 	**coyote** – feeds on squirrels and skunks 
mountain lion – feeds on groundhogs and skunks 	**worms, fungi, bacteria, centipedes, and beetles** – decompose dead animal and plant matter (decomposers) 
bird (chickadee) – feeds on insects, tree nuts, and seeds 	**skunk** – feeds on insects, tree nuts, and seeds 

* Organisms are not to scale.

Name: _____ Date: _____

Energy and Matter Food Web Investigation

How do matter and energy flow through a temperate forest ecosystem? Use the materials listed in the procedure to create two models to investigate the question and then answer the questions that follow.

Section A. Classify the Organisms

1. Use the Temperate Forest Organisms Guide to identify which organisms in the guide are producers, consumers (primary, secondary, and tertiary), and decomposers in a temperate forest ecosystem. Record this information in Table 1 below.

Table 1: Classifying Temperate Forest Plants and Animals				
Producers	**Consumers**			**Decomposers**
	Primary	**Secondary**	**Tertiary**	

Section B: Modeling Energy Flow in the Ecosystem

Use the materials and information from Table 1 to create a food web model on <u>one</u> poster board that shows how energy from the sun moves through a temperate forest ecosystem.

Procedure

1. Position the poster paper in a landscape orientation.

2. Use the green paper, brown paper, yellow paper, blue paper, colored markers, scissors, and glue sticks to create grasses, soil, the sun, and a water source (river or pond) for the temperate forest ecosystem on the poster board. Label the non-living parts of the ecosystem (air, water, soil, and sun).
3. Cut out the temperate forest organisms from the templates.
4. Arrange the cut-outs into general groups on the poster paper according to their classification: producers, primary consumers, secondary consumers, tertiary consumers, and decomposers. Glue the cut-out organisms to the poster paper.
5. Use a colored marker to draw arrows from the sun in the direction that energy travels through the temperate forest ecosystem as one organism eats another. (Use the Temperate Forest Organisms Guide in your student reader to help identify which organisms are eaten by other organisms).
6. Label the producers, primary consumers, secondary consumers, tertiary consumers, and decomposers on the poster.
7. Create a title and key/legend for the poster.

Section C: Modeling the Movement of Matter in the Ecosystem

Use the materials and information from Table 1 to create a model on the second poster board that shows how matter is cycled among the living and nonliving parts of the temperature forest ecosystem.

Procedure

1. Repeat Section B, steps 1-4, with new materials.
2. Use a new colored marker to draw arrows that show how matter moves among the plants, animals, and decomposers (living things) in the ecosystem. (Use the Temperate Forest Organisms Guide in your student reader to help identify which organisms are eaten by other organisms.)
3. Use a second colored marker to draw arrows that show how matter is exchanged between the non-living parts of the environment and living things in the ecosystem.
4. Label the producers, primary consumers, secondary consumers, tertiary consumers, and decomposers on the poster.
5. Create a title and key/legend for the poster.

Section D: Analyze and Compare the Models

1. How is the movement of energy different from the movement of matter in a food web?

_____

_____

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2. How is the movement of energy similar to the movement of matter in a food web?

_____

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Section 2 Review

Reading Comprehension Questions:

1. What are two main ideas of Section 2, and how are these ideas supported by key details?

2. How are the three kinds of consumers—primary, secondary, and tertiary—similar? How are they different?

3. Why do consumers need to eat other organisms?

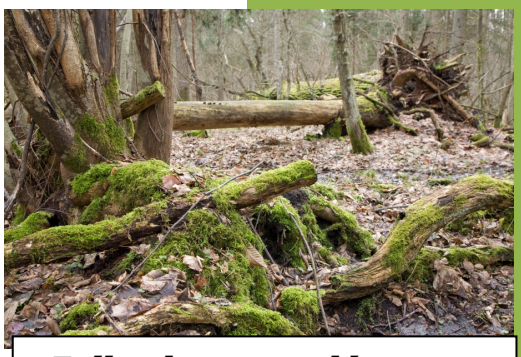
4. How are consumers linked to producers? How are they linked to decomposers?

Decomposition

3

Soil Matters

One tablespoon of soil has more organisms in it than there are people on Earth. **Soil** is a mixture of broken-down rocks, decaying organic matter, and other materials that plants use to grow. It is home to thousands of kinds of bacteria, as well as different kinds of earthworms and fungi.



Fallen leaves and logs are both organic matter.

Soil is made up of 50 percent air and water, 45 percent minerals, and 5 percent organic matter. **Organic** is anything that is living or was once living. This includes fallen leaves and animal remains. **Inorganic** is anything that is not living and never was living. Air, water, rocks, and minerals are all kinds of inorganic matter.

Soil helps the environment in many ways. It connects to the water cycle because it absorbs some precipitation and affects where rain, snow melt, and surface runoff go. It also filters pollutants because minerals and microbes in soil remove toxins from the environment. Finally, soil cycles nutrients such as carbon, nitrogen, and phosphorus through it. Plants use those nutrients to grow.

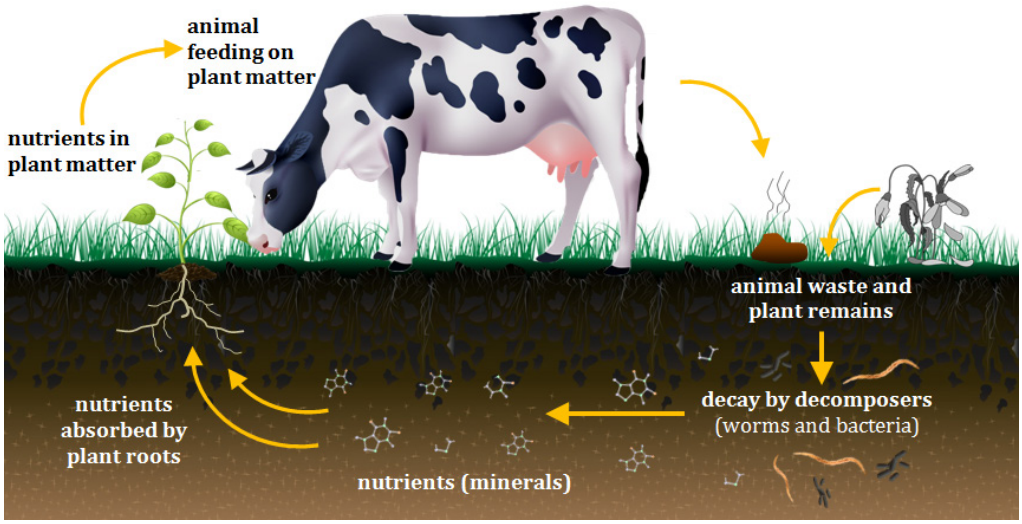
Decomposers Cycle Nutrients

Nutrients are part of the soil because of decomposition. **Decomposition** is the breakdown of organic waste materials into usable nutrients.

The nutrients released by decomposers are essential for plant growth. Because of this, earthworms have been called "nature's gardeners" because of their role in producing healthy soil.

As decomposers feed on organic matter, they break down the once-living matter. This causes the nutrients within the decomposing matter to be recycled back into the environment. The water stored in the once-living matter is also released back into the environment.

Decomposition cycles matter



Composting

Decomposition is essential for plant growth because it returns nutrients to the soil. Because of this, many people use their scientific knowledge about decomposers to design containers that compost organic matter. These containers are called composters. Compost is organic matter that has decomposed and is used as a soil fertilizer. Fertilizer is any kind of matter that is applied to soils or plant structures (often leaves) to supply one or more kind of plant nutrient.

Composting is done by decomposers, primarily microbes. They need four ingredients to work effectively: carbon, nitrogen, oxygen, and water.

Almost all plants and animals contain both carbon and nitrogen. However, different organisms have different amounts of each. For example, matter that has a lot of carbon is often brown and dry. Matter that has a lot of nitrogen tends to be colorful and wet. Fruits and vegetables have a lot of nitrogen in them.

Decomposition is essential for plant growth.

There are many factors that influence how soil forms and how rich in nutrients it is. For example, a dry environment may have a lot of inorganic matter, such as gravel or sand. In contrast, an environment with many trees, like a forest, will have more decaying organic matter.

Weather and climate also affect how many nutrients a particular soil holds. In climates that are wet and warm, decomposition occurs more quickly. This causes more nutrients to be available to growing plants. Dry and cool climates have soils with fewer nutrients, and therefore less plant life. This is because microbes do best in warm temperatures, between 21 and 38 degrees Celsius (70 and 100 degrees Fahrenheit). Populations of microbes double in the soil with every increase of 12 degrees.

The amount of oxygen also influences soil quality. Like all organisms, decomposers need oxygen to survive. That oxygen comes from the air. Because of this, soil that is looser allows oxygen to reach deep into it. This results in decomposition that occurs more quickly. Soils that are tightly packed together, such as soils with clay, have less decomposition because there is less oxygen.

The amount of water also influences how much decomposition happens. All living things, including microbes, need water to survive. However, too much water fills the spaces in the soil, blocking oxygen. Because of this, decomposition happens most quickly in soils that are sometimes wet and sometimes dry.

Section 3 Review

Reading Comprehension Questions:

1. What is the main idea of Section 3? What details are used to support this idea?

2. How does climate affect decomposition?

3. How do soil properties affect decomposition?

4. What can you infer from this section about why people are interested in composting?

Science Words to Know

animal – a living thing that eats other organisms for energy, breathes oxygen, and undergoes growth and reproduction

cell – the smallest unit of life

consumer – an organism that eats other organisms

decomposer – an organism that breaks down organic material and feeds on the nutrients

decomposition – the breakdown of organic waste materials into usable nutrients

ecosystem – a community of different organisms that depend on interacting with each other and their physical environment for survival

food chain – the path that energy travels as one organism eats another

food web – a visual that shows the network of food chains in an ecosystem

function – the normal action of something or how something works

inorganic – anything that is not living and never was living (e.g., water and rocks)

nutrients – chemicals that organisms need for the growth and maintenance of cells

organic – anything that is living or was once living (e.g., fallen leaves and animal remains)

organism – a complete living thing

photosynthesis – the process of turning sunlight, carbon dioxide, and water into glucose and oxygen

plant – a living thing that captures energy from sunlight for growth and development

producer – an organism that captures energy from sunlight through a process called photosynthesis

soil – a mixture of broken-down rocks, decaying organic matter, and other materials that plants use to grow

structure – the way in which parts are put together to form a whole

