Chapter 3 • Lesson 10

Cells

Key Words • organism • cell • organelle • eukaryote • prokaryote • cytoplasm • nucleus • chromosome • cell membrane • ribosome • mitochondria • vacuole • chloroplast • cell wall

Getting the Idea

All **organisms**, or living things, are made up of cells. Some organisms consist of only one cell. Other organisms, including humans, are made up of trillions of cells. Cells are very small, and individual cells can be seen only under a microscope. In this lesson, you will learn about the parts of a cell and different kinds of cells.

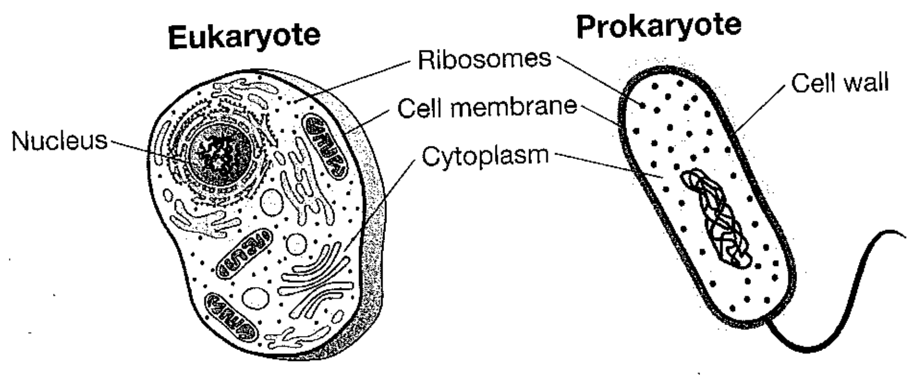
The Unit of Life

The **cell** is the basic unit of structure and function in all organisms. This means that a cell is the smallest structure that can carry out all the functions of life. These functions include growing, taking in and using food, responding to the environment, and reproducing. Cells also regulate the amount of water they contain and release waste products.

Some organisms, such as bacteria, are made up of only one cell. You will learn more about bacteria in Lesson 14. Other organisms consist of many cells working together. These include the plants and animals you see around you.

Prokaryotic and Eukaryotic Cells

There are two basic types of cells: prokaryotic and eukaryotic. These are shown below:



The diagrams above are not drawn to scale. In fact, eukaryotic cells are much larger than prokaryotic cells.

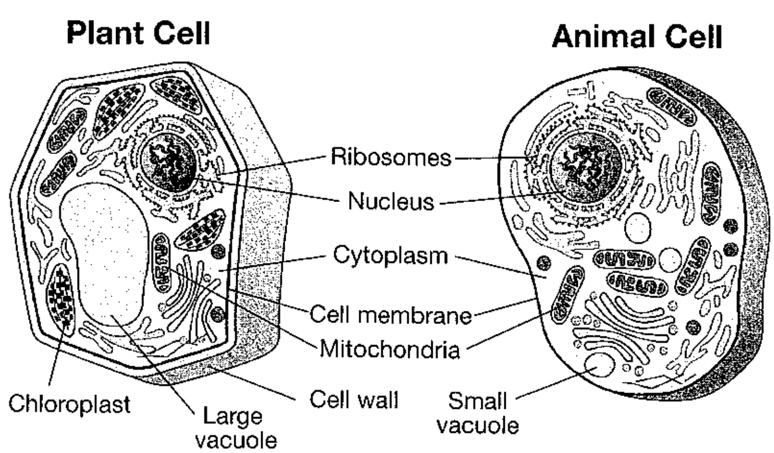
Both kinds of cells perform all the functions of life. For example, they release energy from food and get rid of wastes. But the two kinds of cells have different internal structures. A eukaryotic cell has a large structure called a nucleus, which is enclosed within a membrane. The nucleus is an **organelle**—a structure inside a cell that carries out a certain function. A eukaryotic cell also has other organelles, which you will read about in this lesson. Like the nucleus, these organelles are enclosed in membranes. Organisms whose cells have a distinct nucleus and organelles are called **eukaryotes**.

Plants, animals, protists, and fungi are all eukaryotes. Many eukaryotes consist of large numbers of cells that work together. All plants and animals, and some protists and fungi, are *multicellular*, or made up of many cells. Some protists and fungi are *unicellular*, or made up of a single cell. You will learn more about protists and fungi in Lesson 32.

Notice that the prokaryotic cell is much simpler. It does not have a nucleus. It does not have organelles enclosed in membranes. It does have structures called ribosomes, but they do not have membranes around them. Organisms whose cells lack a nucleus and membrane-bound organelles are **prokaryotes**. In prokaryotes, most of the processes of life occur in the cytoplasm. The **cytoplasm** is the fluid that fills most of the space in a cell. Almost all prokaryotes are one-celled. Bacteria are prokaryotes.

Structure of Eukaryotic Cells

The cells of eukaryotes have many specialized structures in the cytoplasm. As you have learned, this type of cell has a nucleus. The **nucleus** is a large structure inside the cell that controls many functions in the cell. The nucleus contains the cell's genetic material. This material is organized into structures called **chromosomes**. Recall that a prokaryotic cell does not have a nucleus. In these cells, the genetic material is found in the cytoplasm.



The **cell membrane** is a thin, flexible outer layer that holds the cell together and controls which materials can enter and leave the cell. **Ribosomes** are cell structures that make proteins. As shown in the diagram on page 60, prokaryotic cells also have cell membranes and ribosomes. However, prokaryotic cells do not have most of the other structures shown in the diagram above.

All cells need energy, which they get from molecules of glucose, a kind of sugar. In eukaryotes, structures called **mitochondria** (singular: *mitochondrion*) release the chemical energy stored in glucose. Mitochondria are like power plants. They take in fuel—glucose—and change it into a substance that the cell can use for energy. You will learn more about this process in Lesson 11.

Vacuoles store materials inside the cell. These saclike organelles store water, salts, proteins, and carbohydrates. Animal cells have small vacuoles. Plant cells usually have one large vacuole, which helps support the structure of the cell.

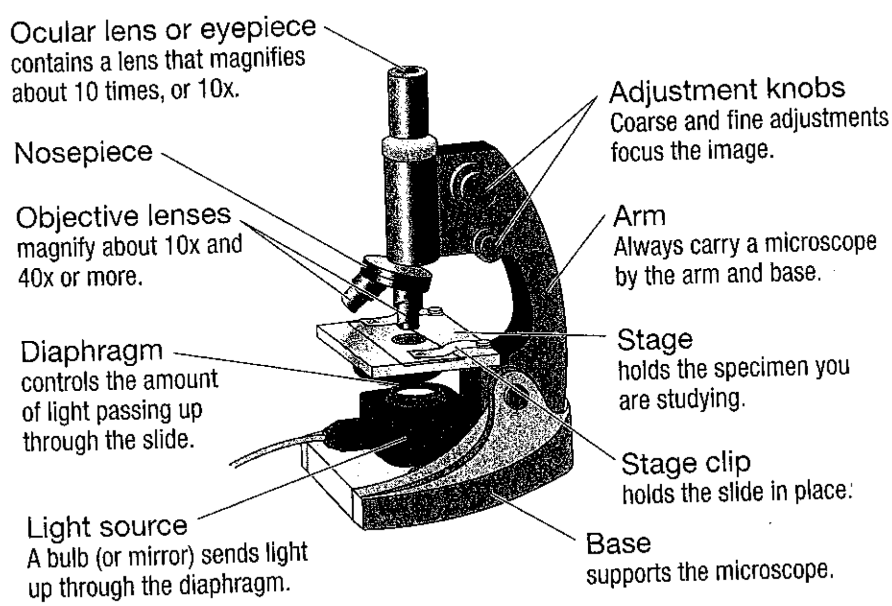
Plant cells have two structures that animal cells do not have: chloroplasts and cell walls. **Chloroplasts** are organelles that make food for the cell. Chloroplasts contain chlorophyll, a pigment that makes plants green. Chlorophyll captures energy from sunlight. In the chloroplasts, this energy is used to convert carbon dioxide and water into glucose and oxygen. In Lesson 11, you will learn more about this process.

The **cell wall** is a protective layer that surrounds the cell membrane of plant cells. The cell wall is made of a tough carbohydrate called cellulose. Because the cell wall is rigid, it supports plant cells. The cell wall allows plants to stand upright and to support heavier structures such as flowers and leaves.

Focus on Inquiry

The compound microscope is an important tool used for observing cells. A compound microscope uses two or more lenses to magnify small objects. The diagram shows and describes the main parts of a compound microscope.

Parts of a Compound Microscope



Lesson Review

1. How does a prokaryotic cell differ from a eukaryotic cell?

   A. A prokaryotic cell does not contain ribosomes.

   B. A prokaryotic cell does not contain genetic information.

   C. A prokaryotic cell does not have a cell wall.

   D. A prokaryotic cell does not have a nucleus.

2. What cell structure controls which materials enter or leave a cell?

   A. nucleus

   B. cytoplasm

   C. cell membrane

   D. vacuole

3. What is the function of mitochondria?

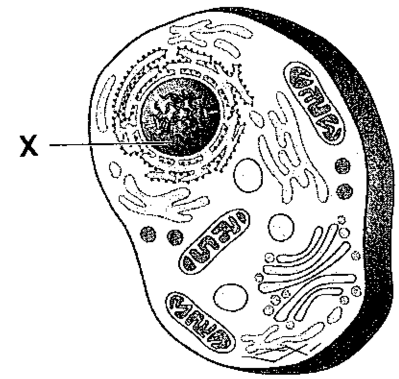
   A. to make food

   B. to make proteins

   C. to release energy

   D. to store proteins

4. A diagram of a cell is shown below.



   Which of the following structures is labeled "X" on the diagram?

   A. nucleus

   B. mitochondrion

   C. ribosome

   D. vacuole

Objective: 8.L.5.1

ıergy and Matter for Cells

Words • photosynthesis • cellular respiration • nutrient

Getting the Idea

All living things need food. Food provides organisms with energy to perform life functions, such as reproducing and responding to the environment. Food also provides organisms with the materials they need to grow and repair damaged tissues. Cells of plants, algae, and some other organisms make their own food. All cells process food to obtain the energy they need.

Photosynthesis

Photosynthesis is the process in which the cells of plants and some other organisms use the energy of sunlight to make food. In this process, light energy is transformed into chemical energy. The sun is the source of almost all energy for living things on Earth. Organisms that carry out photosynthesis use sunlight to make food. These organisms are then eaten by animals. In this way, the energy captured by photosynthesis flows from one organism to another. You will learn more about this transfer of energy in Lesson 18.

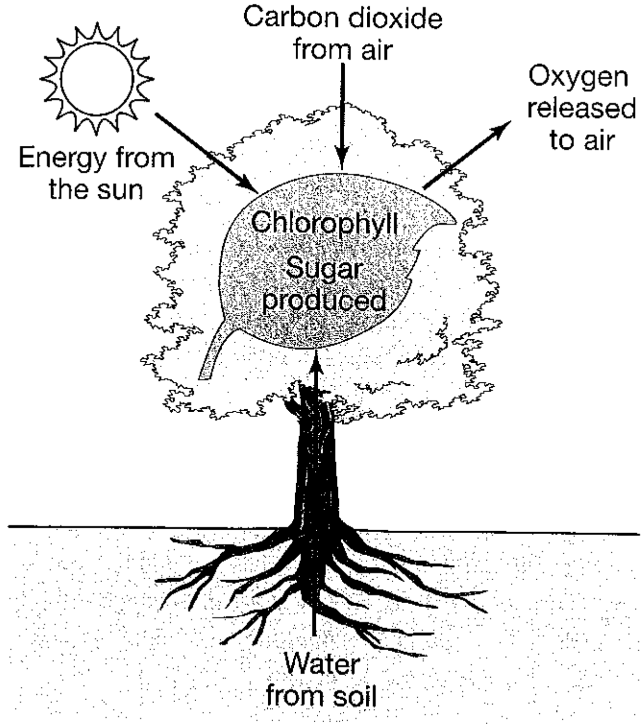
During photosynthesis, sunlight provides the energy to make glucose ($C_6H_{12}O_6$) and oxygen (O_2) from carbon dioxide (CO_2) and water (H_2O). The balanced equation below summarizes photosynthesis.

$$\text{Sunlight} + \underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \rightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

Photosynthesis occurs in two stages, both of which take place in chloroplasts. Chloroplasts are found in the cells of plants and some other organisms. Recall that chloroplasts contain a green pigment called *chlorophyll*. This pigment makes plant leaves and stems green. In the first stage of photosynthesis, chlorophyll traps the energy of sunlight. In the second stage, the chloroplast uses this energy to change carbon dioxide and water into glucose. Organisms that perform photosynthesis use this glucose for food.

Organisms that perform photosynthesis get carbon dioxide and water from their environment. For example, a plant absorbs water from the soil through its roots. Carbon dioxide, a gas in air, enters a plant through small openings in the plant's leaves. These substances move to chloroplasts in the plant's cells. Then a series of chemical reactions produces glucose.

The equation on page 65 shows that in addition to glucose, photosynthesis forms oxygen gas (O_2). Plants release this oxygen into the air through openings in their leaves.



Cellular Respiration

All organisms, including those that carry out photosynthesis, break down simple sugars for energy. Recall that this process takes place in the mitochondria of eukaryotic cells. In prokaryotes, the process takes place in the cytoplasm. The process by which cells break down sugar to release stored energy is called **cellular respiration**. Organisms use this energy to carry out life processes, in the cell and in the whole organism.

Organisms oxidize their food to release energy. Oxygen is combined with the sugar glucose. Cellular respiration produces carbon dioxide and water as waste products. The balanced equation below summarizes cellular respiration.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2} \rightarrow \text{Energy} + \underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O}$$

If you compare the chemical equations for photosynthesis and cellular respiration, you can see that the processes are opposites. Photosynthesis uses energy, carbon dioxide, and water to make sugar and oxygen. Cellular respiration uses sugar and oxygen to release energy, carbon dioxide, and water. Some of this energy is released as heat.

Like most other animals, you get the oxygen needed for cellular respiration from the air you breathe. Your respiratory system takes in oxygen. Your blood carries the oxygen to all the cells of your body. After releasing oxygen to the cells, the blood picks up the carbon dioxide formed by cellular respiration. The carbon dioxide, along with some water vapor, is released into the air when you exhale.

Your body changes the chemical energy released by cellular respiration into other forms of energy. Some is transformed into mechanical energy, allowing your muscles to move. Some is transformed into thermal energy, which keeps your body warm. And some is stored as chemical energy in the bonds of new molecules as you grow.

Building Cells

While much of an organism's food is used as a source of energy, some food is used for growth and repair. To grow or to repair damages, an organism makes new cells. The compounds that provide energy and building materials for living things are called **nutrients**. Three important kinds of nutrients are carbohydrates, lipids, and proteins.

Carbohydrates are made of hydrogen, oxygen, and carbon. They are quickly broken down by living things to release energy. The glucose produced during photosynthesis is a carbohydrate. Plants use some of the glucose they produce for their own energy needs, but they also store large amounts of glucose. Individual glucose molecules link together to form long-chain molecules called starches. Plants use starches to store energy. Glucose molecules also link together to form cellulose. Plants use cellulose for structure, not energy storage. Cellulose makes up part of the cell wall of plant cells and is what gives celery and other vegetables their "crunch" when you eat them.

Fats and oils are examples of *lipids*. Oils are liquid at room temperature and often come from plants. Fats are solid at room temperature and usually come from animals. In animals, lipids are the body's second choice as an energy source. Lipids are also used to produce oils that keep skin, hair, and feathers smooth and waterproof. Lipids are important to cells. They make up part of the cell membrane and other cell structures.

Animals store energy in the form of fat. If more food is eaten than is used, the extra food is converted to fat for storage. Fat is found in deposits under the skin, where it forms a layer of insulation that helps keep animals warm.

Proteins are nutrients that are made up of carbon, hydrogen, oxygen, and nitrogen. Proteins are necessary for growth and repair of the body. They are also involved in regulation of body functions. Proteins are more varied than other nutrients and have a greater variety of functions in living things. Enzymes and other chemicals are proteins. Much of the body's structure is made from proteins. Proteins are found in the cell membrane, and protein fibers make up muscle cells. Proteins are also found in bones and connective tissue.

Discussion Question

Where do you think plants get the oxygen that they need for cellular respiration?

Lesson Review

1. What is the source of energy for photosynthesis?
   - **A.** sunlight
   - **B.** carbon dioxide
   - **C.** glucose
   - **D.** water

2. What are the products of photosynthesis?
   - **A.** water and glucose
   - **B.** glucose and carbon dioxide
   - **C.** carbon dioxide and water
   - **D.** glucose and oxygen

3. Which of the following is needed as a reactant for cellular respiration?
   - **A.** carbon dioxide
   - **B.** oxygen
   - **C.** water
   - **D.** chlorophyll

4. Which form of energy is stored in glucose?
   - **A.** solar energy
   - **B.** chemical energy
   - **C.** mechanical energy
   - **D.** thermal energy

5. Which of the following is a primary way in which proteins are used in the body?
   - **A.** Proteins form a layer of insulation.
   - **B.** Proteins help the body lose weight.
   - **C.** Proteins provide materials for growth and repair.
   - **D.** Proteins provide a quick energy source.

Objective: 8.L.5.1

Cell Division and Reproduction

Key Words • reproduce • chromosome • gene • DNA • mitosis • asexual reproduction • sexual reproduction • gamete • fertilization • zygote • meiosis

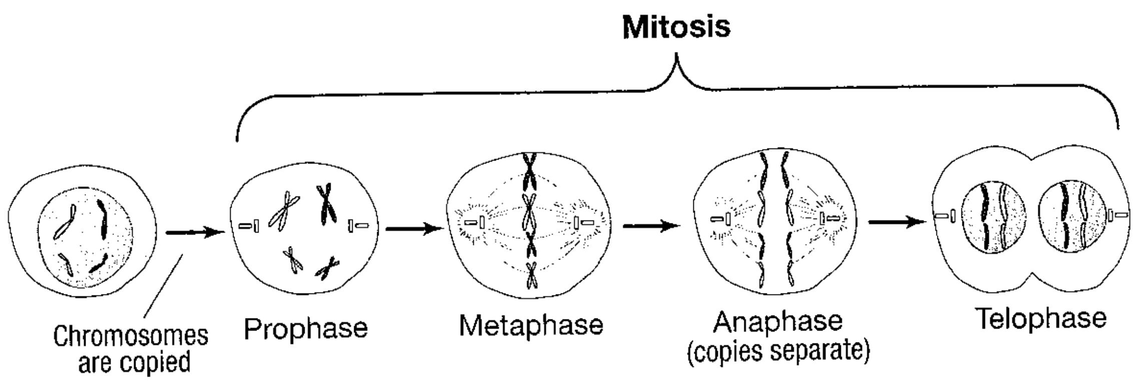
Getting the Idea

Recall that cells carry out all life functions. They obtain and use food, and they produce and release wastes. They respond to changes in their environment. Cells also **reproduce**, or make more cells like themselves. They do this by dividing. In this lesson, you will learn about two types of cell division.

Chromosomes and Cell Division

Chromosomes are structures in a cell's nucleus that contain genes. A **gene** is a tiny part of a chromosome that helps give a living thing a certain trait, or characteristic. Genes tell cells how to grow and develop. Genes are made up of a large molecule called **DNA**, or deoxyribonucleic acid.

At the cell level, reproduction occurs when one cell called the parent cell divides to form two new cells called daughter cells. Each daughter cell is an exact copy of the parent. Before dividing, the cell makes copies of its chromosomes. Then the cell and its nucleus divide by a process called **mitosis**. Each daughter cell produced by mitosis has the same number and kind of chromosomes as the parent cell. The diagram below shows the four stages of mitosis.



Between cell divisions, the chromosomes cannot be seen, even under a microscope. This is because they are extremely long and thin and spread out through the nucleus. In prophase, the chromosomes condense. They become much shorter and thicker, so they can be seen in the nucleus. Then the membrane that holds the nucleus together disappears. Each chromosome looks as if it has four "arms" because it is a pair of strands called *chromatids* joined in the middle.

In the next stage, called metaphase, the chromosomes line up in the center of the cell. Then, in the stage called anaphase, the chromatids are pulled apart. A group of chromosomes, which are now single chromatids, moves to each end of the cell. In the last stage, called telophase, the chromosomes separate from each other, and nuclear membranes form around each group. The cell membrane begins to pinch in between the two nuclei. After telophase, the cell splits to form two daughter cells, each with one nucleus.

Mitosis is the process by which living things grow. For example, your muscles grow by mitosis. One muscle cell divides and produces two identical muscle cells. Each of these cells then divides to produce more muscle cells. A plant root grows farther into the ground as cells at the root's tip divide and grow. Other parts of a plant grow larger in the same way.

Mitosis is also the process by which the bodies of multicelled organisms repair themselves. Your skin cells divide and produce new skin cells to replace the ones you lose. If you cut yourself, new cells form by cell division to heal the cut. Some animals can use mitosis to replace entire lost limbs. This ability is known as *limb regeneration*. For example, if an arm of a sea star breaks off its body, the sea star can grow a new arm to replace the one that was lost. Some amphibians and crustaceans are also capable of limb regeneration.

Asexual Reproduction

In many organisms, cells of a single parent divide to form offspring with the same chromosomes and genes as the parent. The production of a new organism from one parent is called **asexual reproduction**. Offspring produced in this way are identical to the parent.

One-celled organisms such as bacteria and amoebas reproduce asexually. A few animals, such as hydras, also reproduce in this way. Hydras are tube-shaped freshwater animals related to jellyfish. Their offspring grow from outgrowths called buds that form on the body of the parent.

Many plants can reproduce asexually by growing new plants from parts such as roots or stems. For example, strawberry plants can form new strawberry plants from runners. A runner is a stem that grows along the surface of the ground. Buds that can grow into new plants form along the runner. New potato plants can grow from "eyes," or buds, on a potato.

Did You Know?

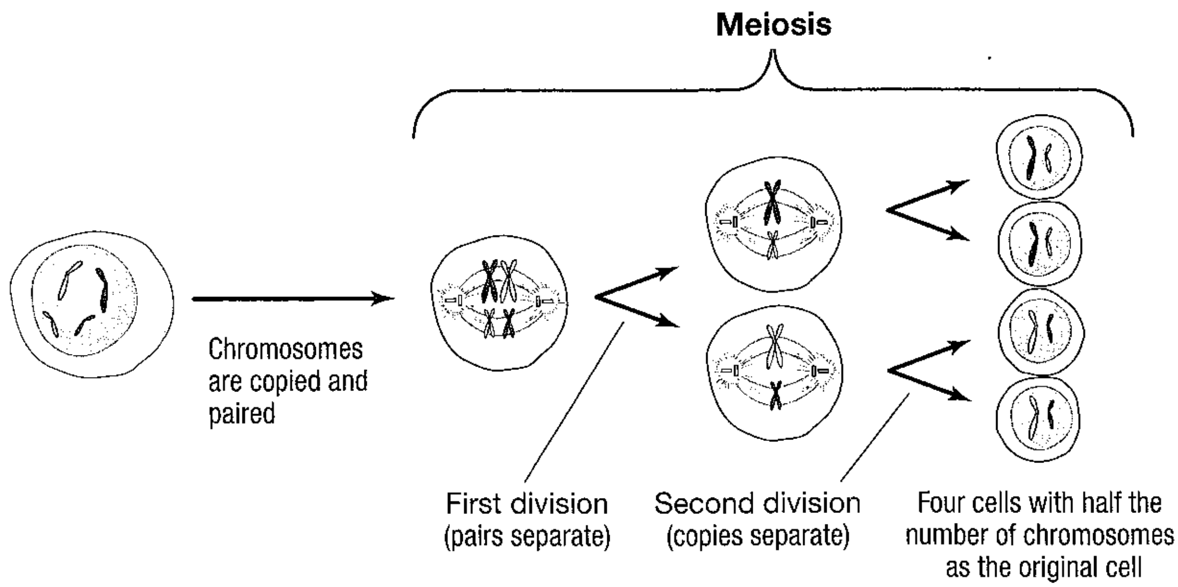
Some plants, such as kalanchoes, can reproduce asexually by growing new plants on their leaves. Special cells along the edges of the leaves carry out mitosis to produce tiny plants. When the tiny plants have a few leaves and some roots, they fall off and grow on their own.

Sexual Reproduction and Meiosis

Many multicelled organisms produce offspring through sexual reproduction. **Sexual reproduction** is the production of a new organism from two parents, a male and a female. Organisms use specialized cells known as **gametes** for sexual reproduction. Gametes differ from ordinary cells by having only half the number of chromosomes found in the organism's body cells. Organisms produce two types of gametes: sperm cells and egg cells. Male organisms produce sperm cells, the male sex cells. Eggs, or ova, are female sex cells. During sexual reproduction, gametes from a male and a female parent combine in the process of **fertilization**. The resulting cell is a **zygote**.

It is important that gametes have only half the number of chromosomes present in body cells. If two ordinary cells joined together, the organism formed from those cells would have twice as many chromosomes as it should. Because gametes each contain only half this number, the new organism has the correct number of chromosomes. It gets half its chromosomes from each gamete. Its traits, or characteristics, come from both parents.

A process called **meiosis** produces the gametes used for sexual reproduction. The diagram below shows a simplified version of this process.



Notice that meiosis involves two sets of divisions. At the end of meiosis, one cell has produced four gametes. Each of the four has half the number of chromosomes present in the original cell.

When meiosis takes place in a male, the four gametes produced are sperm cells. When it happens in a female, the four gametes are egg cells. A single sperm cell can join with a single egg cell to produce a fertilized cell (zygote) that has a complete set of chromosomes. This zygote can then use mitosis to grow and develop into a complete organism.

Discussion Question

While slicing an apple, you accidentally cut your finger. Through which process will your injury heal—mitosis or meiosis? Explain your answer.

Lesson Review

1. Mitosis is **not** a process for

   A. growth.

   B. repair.

   C. sexual reproduction.

   D. asexual reproduction.

2. Mitosis produces

   A. two cells, each with half as many chromosomes as the parent cell.

   B. two cells, each with the same number of chromosomes as the parent cell.

   C. four cells, each with the same number of chromosomes as the parent cell.

   D. four cells, each with half as many chromosomes as the parent cell.

3. Which is the final product of meiosis?

   A. two cells, each with the same number of chromosomes as the parent cell

   B. four cells, each with the same number of chromosomes as the parent cell

   C. two cells, each with half as many chromosomes as the parent cell

   D. four cells, each with half as many chromosomes as the parent cell

4. Which of these is a fertilized cell?

   A. zygote

   B. gamete

   C. bud

   D. runner

Chapter 5 • Lesson 18

The Flow of Energy in Ecosystems

Key Words • producer • autotroph • photosynthesis • consumer • heterotroph • decomposer • trophic level • food chain • food web • model

Getting the Idea

All organisms need energy for their cells to function. Because of their need for energy, organisms are connected by feeding relationships. Plants, algae, and some bacteria convert energy from the sun into food. These organisms serve as food sources for organisms that do not make their own food. In this process, energy is passed from one organism to another.

Producers, Consumers, and Decomposers

An organism that produces its own food is called a **producer**. These organisms are also called **autotrophs**. Producers include plants, many algae, and some bacteria. Many producers, including plants, make their food through photosynthesis. Recall that **photosynthesis** uses light energy to combine carbon dioxide and water to produce glucose and oxygen. Glucose is an energy-rich sugar.

Consumers are organisms that cannot make their own food. They get their food by eating other organisms. Consumers are also called **heterotrophs**. All animals are consumers. Some consumers eat producers, and some consumers eat other consumers. An organism that feeds directly on producers is a *first-order consumer*. An organism that feeds on first-order consumers is a *second-order consumer*. An organism that feeds on second-order consumers is a *third-order consumer*.

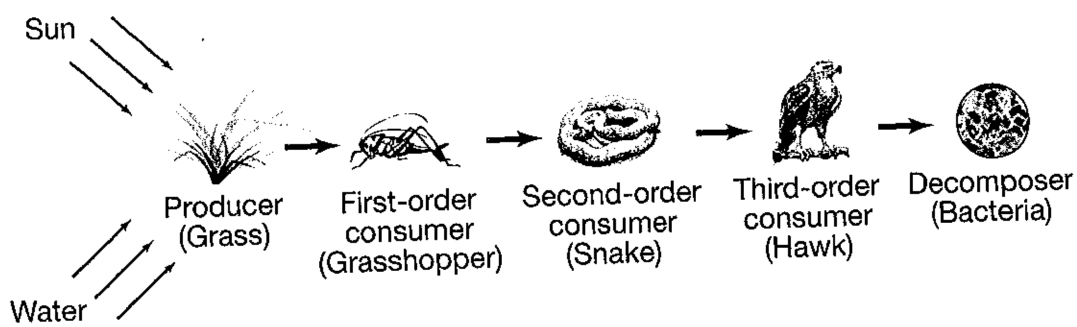
Decomposers are another kind of heterotroph. A decomposer is an organism that gets energy by breaking down the remains of dead organisms and the wastes of living things. Most fungi and many types of bacteria are decomposers. Earthworms and some insects often act as decomposers. Decomposers are important to ecosystems. They are nature's recyclers. Decomposers return materials such as carbon and nitrogen to the air and soil. Then producers can use the materials again for photosynthesis and growth.

Did You Know?

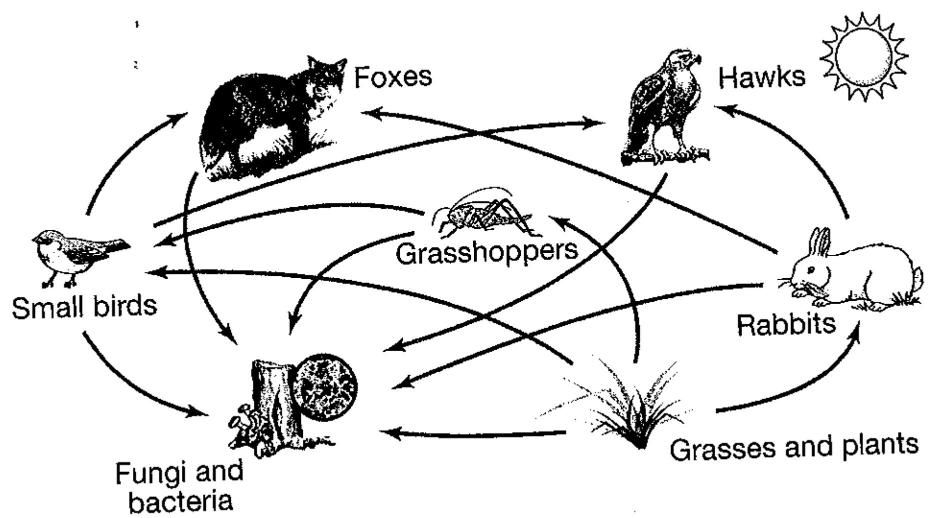
Earthworms are often a sign of healthy soil. As decomposers, earthworms help break down dead plant material so that the nutrients it contains can be used by new and growing plants. Earthworms also loosen the soil as they tunnel through it. Loosening the soil helps air and water circulate.

Food Chains and Food Webs

Each feeding level in an ecosystem is called a **trophic level**. Producers make up the first level. Consumers at each level get energy by feeding on organisms at a lower level. A **food chain** is a series of organisms in which each feeds on the one at the next lower level. The diagram below shows a food chain. The arrows point in the direction of the flow of energy. Note that decomposers break down the remains and wastes of all the organisms in the chain.



A food chain shows only one path for the flow of energy. In most ecosystems, feeding relationships are much more complicated than that. Each organism may be part of several food chains. A **food web** is a network of interconnected food chains in an ecosystem.



The populations of organisms in a food web are all connected. A change to one population affects the other populations in the food web. Suppose a disease suddenly decreases the number of grasshoppers in the food web above. This change may cause a decrease in the populations of small birds that feed on grasshoppers. It may also cause changes in the higher-level consumers, such as foxes and hawks, which feed on the small birds.

Not all the energy at one trophic level is transferred to the next level. Organisms at each level use some of the energy they take in to carry out their life processes. They release some energy into the environment as heat. Some energy is stored in parts of organisms, such as bones and teeth. These parts are not likely to be eaten by other organisms. Only about 10 percent of the energy at one trophic level is passed on to the next trophic level.

Lesson Review

1. Which of these is a first-order consumer?

   A. rabbit

   B. fox

   C. hawk

   D. fern

2. How much of the energy from one trophic level is transferred to the next?

   A. None of the energy is transferred.

   B. About 1% of the energy is transferred.

   C. About 10% of the energy is transferred.

   D. All of the energy is transferred.

3. An organism that performs photosynthesis is called

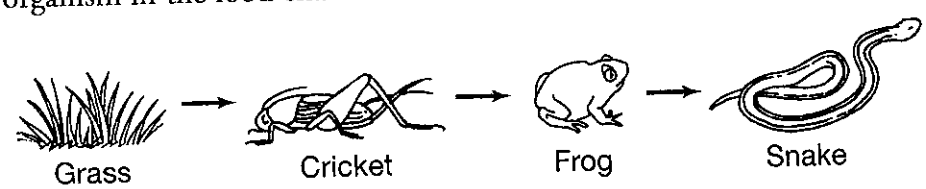
   A. a decomposer.

   B. a consumer.

   C. an autotroph.

   D. a heterotroph.

4. Which organism in the food chain shown is a second-order consumer?



   A. snake

   B. frog

   C. cricket

   D. grass

The Cycling of Matter in Ecosystems

Key Words • decomposition • carbon cycle • nitrogen fixation • nitrogen cycle • denitrification • water cycle • evaporation • transpiration • condensation • precipitation • groundwater • runoff

Getting the Idea

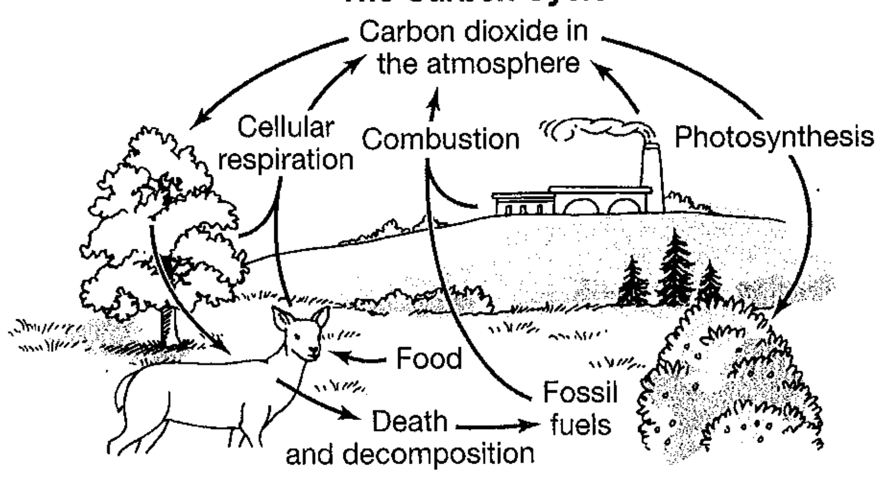
Earth constantly receives energy from the sun. In contrast, the amount of matter on Earth does not change. Matter is recycled from organisms to the environment and back again. Earth's ecosystems cycle carbon, nitrogen, and water. These materials are important to all organisms.

The Carbon Cycle

Carbon is found in every living organism. Carbon is also found in the atmosphere, in gasoline, and in many kinds of rock. One common form of carbon is carbon dioxide. Recall that carbon dioxide is released into the air as a waste product of cellular respiration. In this process, cells break down sugar to get energy. In the opposite process of photosynthesis, producers such as plants use carbon dioxide from the air to make sugar.

The carbon stored in organisms cannot be reused until the organisms are eaten or decomposed. Bacteria and other decomposers break down dead organisms in a process called **decomposition**. Carbon dioxide is released into the atmosphere in this process. Carbon moves among the air, the ground, and plants and animals in the **carbon cycle**. The diagram below shows this cycle.

The Carbon Cycle



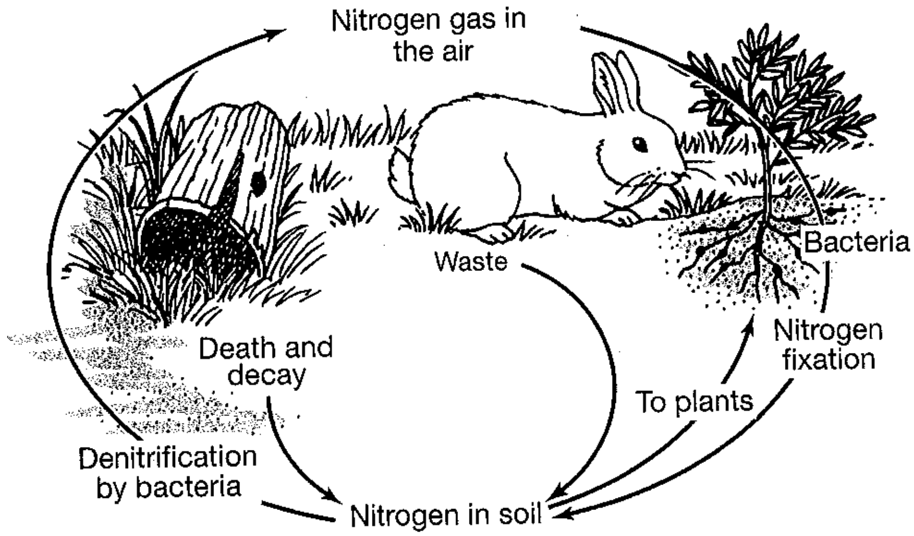
Combustion, or burning, is part of the carbon cycle. When wood or other organic material burns, it releases carbon dioxide. By burning coal and oil, people put large amounts of carbon dioxide into the atmosphere. Recall that coal and oil are fossil fuels. They developed from the remains of plants and animals that died millions of years ago. Carbon from those organisms is stored in the fossil fuel. When fossil fuels are burned, they release most of the carbon as carbon dioxide. Cars, buses, coal-burning power plants, and oil furnaces all affect Earth's carbon cycle. As you learned in Lesson 8, carbon dioxide from burning fossil fuels is also thought to contribute to climate change.

The Nitrogen Cycle

Nitrogen is found in many places on Earth and in many different forms. Most of Earth's nitrogen is in the atmosphere, in the form of nitrogen gas. All living things use nitrogen to make materials such as proteins, but most organisms cannot use nitrogen gas. A natural process converts nitrogen from the atmosphere into forms that are useful to a variety of organisms. This process is called **nitrogen fixation**. It produces compounds such as ammonia and nitrates. Some bacteria perform nitrogen fixation. Lightning can also cause this process to occur. The energy in lighting can cause a chemical reaction between oxygen and nitrogen in the air.

The diagram below shows ways that nitrogen moves through the environment in the **nitrogen cycle**. As you can see, bacteria make nitrogen available to the roots of plants. Animals get nitrogen by eating plants.

The Nitrogen Cycle



Substances containing nitrogen can be found in animal wastes, including urine. In this way, animals return nitrogen to the soil for plants to use. When a plant or animal dies, the remains decay and become part of the soil. The nitrogen in the remains is recycled and can also be used by plants. Human activities also add nitrogen to the soil. Many fertilizers contain nitrates. When fertilizers are spread on soil, the nitrogen content of the soil is increased.

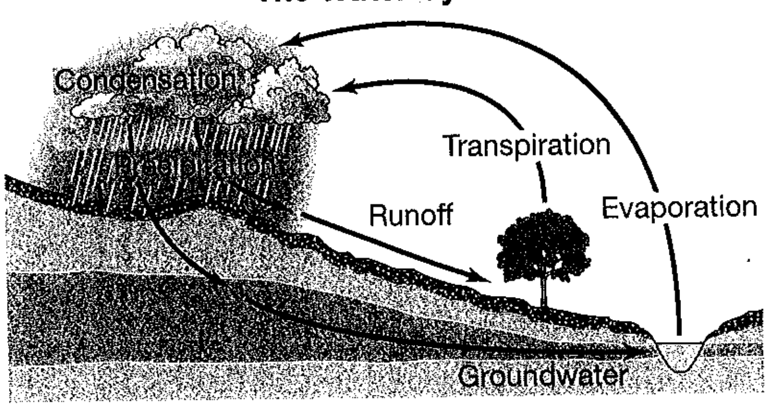
You have seen that several factors increase the amount of nitrogen in soil. Other processes take nitrogen out of the soil. **Denitrification** takes nitrogen from nitrates and other compounds in the soil and releases it as nitrogen gas. Then the nitrogen gas returns to the atmosphere. Denitrifying bacteria live deep in the soil and ocean floor, where there is no free oxygen. They use nitrate compounds to get oxygen for cellular respiration. They produce nitrogen gas as a waste. These bacteria complete the nitrogen cycle.

The Water Cycle

The **water cycle** is the continuous movement of water between Earth's surface and its atmosphere. In this cycle, water changes from one form to another. The sun is the source of energy that drives the water cycle. Heat from the sun causes evaporation of water from Earth's surface. **Evaporation** is a process by which a liquid changes to a gas. The sun warms water on Earth's surface. This includes the water in oceans, lakes, streams, rivers, and puddles. When heated, surface water evaporates and forms water vapor. The water vapor then becomes part of the atmosphere.

Another way water moves into the atmosphere involves plants. During the process of **transpiration**, water vapor is released through tiny openings in plant leaves. That water vapor then joins the water found in the atmosphere. Animals also add water vapor to the atmosphere when they breathe out or when perspiration evaporates. Water also evaporates from urine released by animals onto the ground.

The Water Cycle



Once in the atmosphere, water vapor rises and cools. Then condensation occurs. **Condensation** is the process by which a gas changes to a liquid. Water vapor that has evaporated into the atmosphere condenses to form droplets of water. These water droplets are very tiny—much smaller than raindrops. The droplets condense around tiny solid particles in the atmosphere, such as dust or smoke, and clouds form. Droplets may join together to form much heavier raindrops, which fall from clouds as precipitation. **Precipitation** is water that falls to Earth's surface in the form of rain, snow, sleet, or hail. As precipitation falls, several things can happen. The water can remain on Earth's surface in a solid or liquid form. Water can also sink into soil or cracks in rocks, where it collects and flows underground. Water located below Earth's surface is called **groundwater**.

Did You Know?

The world's rainiest place is Mount Waialeale, Kauai, Hawaii. During an average year, only 15 days are dry.

Precipitation can become surface water by falling directly into bodies of water. It can also become **runoff**, or water that flows over the land without sinking into the ground. Gravity causes runoff and groundwater to flow downhill and eventually into streams, rivers, lakes, and oceans. When this surface water warms up and evaporates, the cycle begins all over again.

Discussion Question

Why are plants important to the carbon, nitrogen, and water cycles?

Lesson Review

1. Which of these is one role of plants in the carbon cycle?

   A. Plants take in oxygen and release carbon dioxide.

   B. Plants take in carbon dioxide and pass it on directly to animals.

   C. Plants take in carbon dioxide released by other organisms.

   D. Plants use carbon dioxide to make nitrates.

2. The process by which bacteria return nitrogen gas to the atmosphere is called

   A. reproduction.

   B. denitrification.

   C. nitrogen fixation.

   D. transpiration.

3. What role does evaporation play in the water cycle?

   A. It heats surface water.

   B. It causes precipitation to form as rain, snow, hail, or sleet.

   C. It moves water from Earth's surface into the atmosphere.

   D. It moves water from Earth's surface into underground areas.

4. Which is the process by which water vapor changes to liquid water?

   A. transpiration

   B. precipitation

   C. runoff

   D. condensation

Chapter 5 • Lesson 20

Objectives: 8.L.3.1; 8.L.3.2

Other Relationships in Ecosystems

Key Words • competition • coexist • cooperation • predation • predator • prey • symbiosis • mutualism • commensalism • parasite • parasitism • host • line graph

Getting the Idea

Recall that an ecosystem includes all the living and nonliving things that interact with each other in a certain environment. The different kinds of organisms in an ecosystem interact with each other as well as with other organisms of their own species.

Competition

Competition occurs when organisms in an ecosystem try to get the same resources. Recall that living things with similar needs compete for food, shelter, water, sunlight, and living space. Competition can take place among members of the same population. For example, all of the hawks in a desert ecosystem compete with each other for food, such as snakes. The snakes in this ecosystem also compete with other snakes for food. Competition can also take place among different populations. In a dense forest, plants compete for living space that allows them to get the sunlight they need for photosynthesis. Animals in the desert compete with each other and with plants for water.

When organisms compete, some living things will get the resources they need to survive. Others will not get resources and will have to move to a different habitat, or they will die. Consider a population of lions. As the population grows, more lions compete for resources such as food and water. If there is too little food or water for the growing population, some lions will die. The number of lions will decrease.

Coexistence and Cooperation

Organisms do not always compete with each other. Organisms may live in the same habitat but rely on different resources. These organisms are said to **coexist.** For example, two bird species may nest in the same kind of tree. One species may prefer the upper branches while the other may prefer the lower branches. As a result, the birds do not compete for living space.

Organisms may even cooperate with each other. **Cooperation** is a helpful interaction among organisms living in a limited area. For example, animals that live in a group may share resources. They may also work together to care for their young or to protect the group. Members of the same population or different populations may show cooperative behavior.

South African meerkats cooperate for protection. The South African meerkat is a small mammal that lives in groups. One or two animals at a time remain on guard. The rest eat and care for the young. If a guard sees a threat, it alerts the other meerkats. All the animals then run into their den.

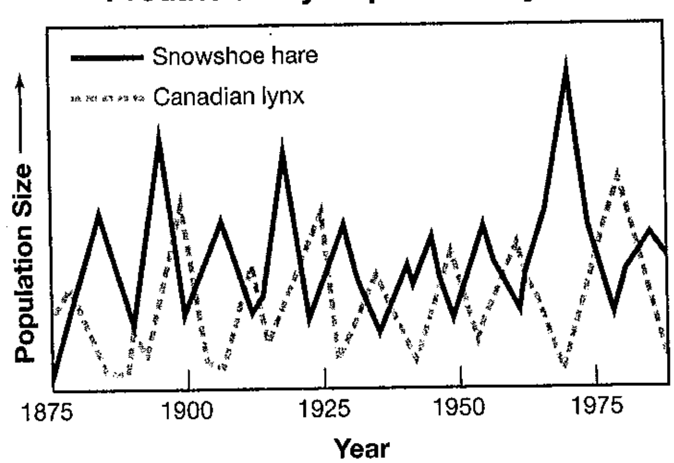
Predation

Many of the interactions in an ecosystem involve food. **Predation**, for example, is a relationship in which one animal hunts, kills, and eats another. Animals that kill and eat other animals are **predators**. The animals that they kill and eat are **prey**. Think of an ecosystem with mice, snakes, and hawks. In this example, the snakes are predators, and the mice are their prey. However, the snakes are not only predators. Snakes are also the prey of hawks.

Suppose that a disease kills most of the mice. Then the snakes will have less food. The number of snakes in the area may drop as snakes die and have fewer offspring. Without snakes, the hawks will have to look elsewhere for food, or they may die, too. In this way, changing the population of one organism can affect populations of other organisms in an ecosystem.

Predator-prey relationships maintain balance in an ecosystem. For example, if an ecosystem has too many predators, the prey population will decline. Less food will be available for the predators. As a result, some predators will either move away or die. A decrease in the number of predators allows a prey population to make a comeback. As fewer prey are killed and eaten, they reproduce more, and their numbers rebound. As the graph below shows, the populations of predators and prey affect each other. When the prey population grows, there is food for more predators. The predator population may increase as a result.

Predator/Prey Population Cycles



Symbiosis

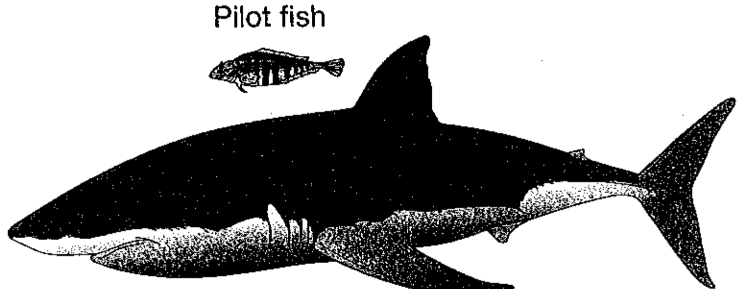
Symbiosis is a close relationship between two different species of organisms living together. The three types of symbiosis are mutualism, commensalism, and parasitism.

Mutualism is a symbiotic relationship in which both species benefit. You may have seen lichens growing on rocks or tree trunks. A lichen is an example of a mutualistic relationship. It involves a fungus and a green alga (plural: *algae*). In this relationship, the fungus anchors the lichen and absorbs water. It also protects the alga from direct sunlight and extreme temperature changes. The alga performs photosynthesis, providing food for both organisms.

An oxpecker is a bird that shares an ecosystem with the rhinoceros. Oxpeckers eat insects that attach themselves to the rhinoceros to feed on its blood. The rhinoceros benefits by being cleaned of these pests. The oxpecker benefits by getting food. This is an example of mutualism.

Another example of mutualism is the relationship between ants and the acacia tree. The tree produces nectar in its stems and has hollow thorns. The ants feed on the nectar and nest in the hollow thorns. When an insect or other herbivore tries to eat the leaves of the acacia, the ants swarm and attack the animal. The ants benefit by getting food and shelter. The acacia tree benefits from the ants' protection.

Commensalism is a symbiotic relationship in which one species benefits without benefiting or harming the other organism. Usually a smaller organism benefits from a relationship with a larger one. The benefit can be food, shelter, transportation, or defense. One example is a pilot fish that swims along with a shark. The shark scares away predators, which helps the pilot fish. The pilot fish also feeds on scraps from the shark's prey. The relationship does not affect the shark.



Recall that a **parasite** is an organism that lives on or in another organism and benefits at the other organism's expense. **Parasitism** is the symbiotic relationship between a parasite and its host. A **host** is the organism that a parasite lives on or in. A parasite often harms its host by taking nutrients away from it. But a parasite generally does not kill its host.

Examples of animal parasites include fleas, ticks, tapeworms, and leeches. Fleas, ticks, and leeches feed on the blood of their hosts, while tapeworms live in their hosts' intestines and take up nutrients there. Mistletoe is an example of a plant parasite. It grows on the branches or trunk of a tree and sends roots into the tree to take up nutrients.

Did You Know?

Mistletoe is an evergreen parasitic plant, so it is easy to see on trees during the winter. The deciduous host tree loses its leaves, while the mistletoe does not. In North Carolina, you can find mistletoe growing on a variety of trees, including the red maple.

Lesson Review

1. Which of the following is a symbiotic relationship in which both organisms benefit?

   A. mutualism

   B. commensalism

   C. competition

   D. parasitism

2. Which of the following pairs of organisms are most likely to have a predator/prey relationship?

   A. dog and tapeworm

   B. rhinoceros and oxpecker bird

   C. spider and fly

   D. fungus and green alga

3. The cattle egret perches on a buffalo's back and is carried from one location to another. The egret eats insects flushed from the grass as the buffalo moves. The buffalo is neither helped nor harmed. This is an example of

   A. mutualism.

   B. commensalism.

   C. parasitism.

   D. predation.

4. Within an ecosystem, grasses are **most likely** to compete with

   A. grasses only.

   B. grasses and other plants.

   C. animals only.

   D. abiotic factors.

Objectives: 8.E.1.1; 8.E.1.2

Earth's Oceans

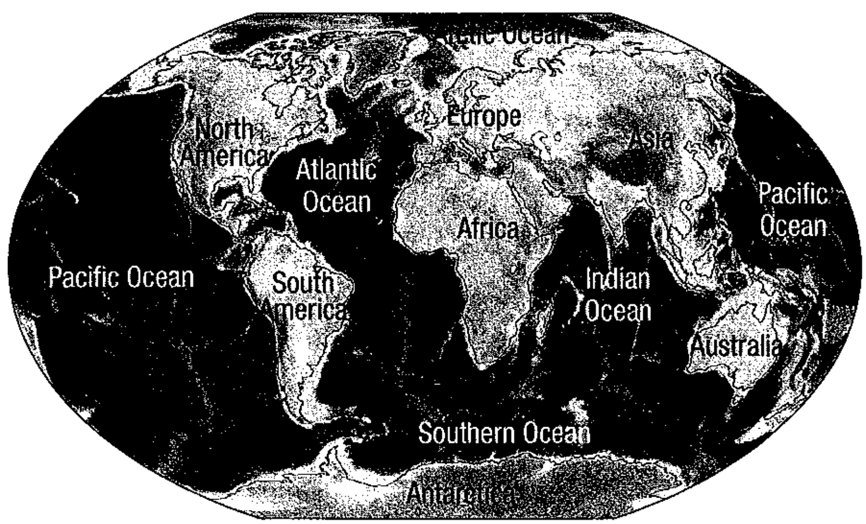
Key Words • ocean basin • salinity • pollution

Getting the Idea

More than 70 percent of Earth's surface is covered by ocean water. The ocean floor is so vast and deep that much of it has yet to be explored. Many of the known features of the ocean floor are similar to those found on land.

One Ocean

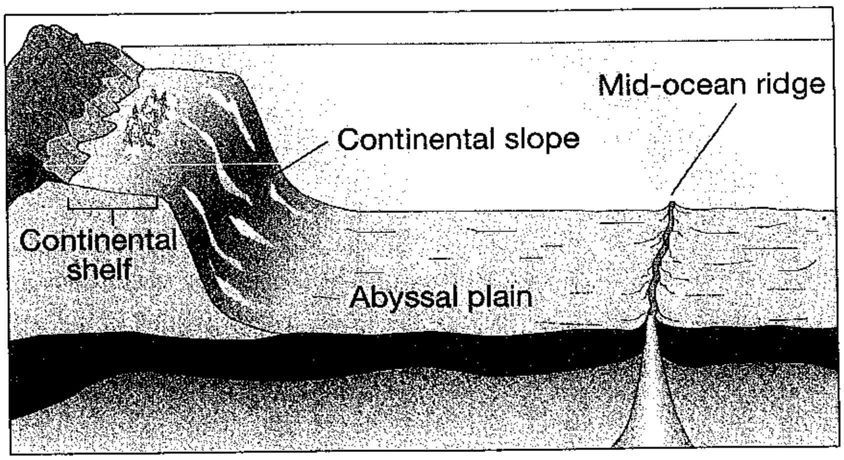
You probably have heard of the Atlantic Ocean and the Pacific Ocean. But Earth's oceans actually make up one continuous ocean. The ocean can be divided into regions called basins. An **ocean basin** is a part of Earth's surface that is covered by ocean water. The main basins are the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, and Arctic. The Atlantic Ocean lies to the east of North America and South America. The eastern border of North Carolina lies along the Atlantic Ocean. The Pacific Ocean lies between the western coasts of the Americas and the eastern coast of Asia. As you can see on the map, the Pacific Ocean is the largest ocean. It is also the deepest ocean.



The Arctic Ocean is the farthest north, lying over the North Pole. Much of the Arctic Ocean is covered with ice, especially when it is winter in the Northern Hemisphere. The Arctic Ocean is the shallowest of the oceans. The region of the ocean around Antarctica is called the Southern Ocean.

Ocean Floor

If you were in a submarine, you would see that the ocean floor contains many different kinds of features. These features include the continental shelf, continental slope, mid-ocean ridge, rift valleys, and trenches. Imagine traveling from the coast out to sea, along the ocean floor. You would first travel down the continental shelf. The continental shelf starts at the shore and slopes gently into the ocean. When the slope starts to get steeper, you have reached the continental slope. The continental slope goes from the edge of the continental shelf to the flatter part of the deep ocean floor.



Most of the ocean floor is a huge, dark, flat region known as the abyssal plain. The abyssal plain is covered with mud and the remains of animals that lived in the ocean. Although much of the ocean floor is flat, the ocean floor has some of the most dramatic features on Earth. One such feature is an ocean trench. An ocean trench is a large, V-shaped valley. Mid-ocean ridges are underwater mountain ranges. The mountains of the mid-ocean ridges can have peaks that rise 2500 meters. Some even reach above the surface of the ocean water, forming islands.

Ocean Composition

Although the ocean contains huge amounts of water, that water is not drinkable because it is salty. The ocean is fed by freshwater sources such as rivers and streams, so why is it salty? The primary reason is that surface water washes over rocks containing salts such as sodium chloride. Sodium chloride is common table salt. As water flows over the rocks, the water picks up some of the salt and carries it into the oceans. When ocean water evaporates, it leaves this salt behind. Over millions of years, this process has made the ocean salty. Underwater volcanoes also add salt to the ocean.

Salinity is the saltiness of a body of water. The salinity of ocean water can vary from place to place, but it is usually about 3.5 percent. In other words, about 3.5 percent of ocean water is made up of dissolved salts. Salinity may be less than 3.5 percent in areas where a large river releases a lot of freshwater into the ocean. Salinity is higher than 3.5 percent in areas where there is more evaporation. When water evaporates from the ocean, it leaves the salt behind. The remaining solution then has a higher salt content.

Ocean Resources

For centuries, people have used the ocean as a source of food. Commercial fishing is an important industry in North Carolina. Ocean waters off the North Carolina shore yield many species of fish, including swordfish, tuna, and flounder. Other species include shrimp, crabs, oysters, and scallops.

Food resources in the ocean are threatened by human activities. Recall that **pollution** is the release of an unwanted substance into the environment. Oil spills and chemicals that wash into the sea from rivers can kill organisms in the sea. Overfishing, the taking of too many fish, also threatens these ocean resources. If too many fish are taken out of the ocean, there will not be enough fish left to reproduce, and the populations will decrease. Fisheries, areas where fish are caught, must be monitored to make sure that too many fish are not taken from the ocean.

The ocean is a source of mineral resources. Two important resources are oil and natural gas. Large deposits of oil and natural gas have been found under the ocean floor. Offshore wells drill through the ocean floor to remove these resources. Magnesium is a metal that can be extracted from seawater.

The Ocean and the Water Cycle

Recall from Lesson 19 that the water cycle is the continuous movement of water between Earth's surface and its atmosphere. The ocean is huge, and large amounts of water evaporate from it every day. This water enters the atmosphere, and winds carry some of the water over land. Eventually, the water condenses and falls to the ground as precipitation.

Did You Know?

More than 80 percent of the water that evaporates from Earth's surface comes from the ocean.

Discussion Question

Manganese is a valuable element used in producing steel. Potato-sized rocks containing large amounts of manganese cover the ocean's abyssal plain. However, this source of manganese is not widely used. Why do you think this is the case?

Lesson Review

1. An ocean basin is

A. a continuous body of water that covers 70% of Earth's surface.

B. a deep trench along the floor of the ocean.

C. a part of Earth's surface covered by ocean water.

D. the layer of the ocean closest to the surface.

2. How is the deep ocean floor different from the shallow parts of the ocean floor near land?

A. The deep ocean floor is flatter than the parts of the ocean floor near land.

B. The deep ocean floor is steeper than the parts of the ocean floor near land.

C. The deep ocean floor receives more light than shallower parts of the ocean.

D. The deep ocean floor is not covered with mud.

3. What is the source of most of the salt in the ocean?

A. human activities

B. rocks on land

C. fish

D. wind

4. Which of these is **not** a threat to living ocean resources?

A. overfishing

B. oil spills

C. evaporation

D. pollution