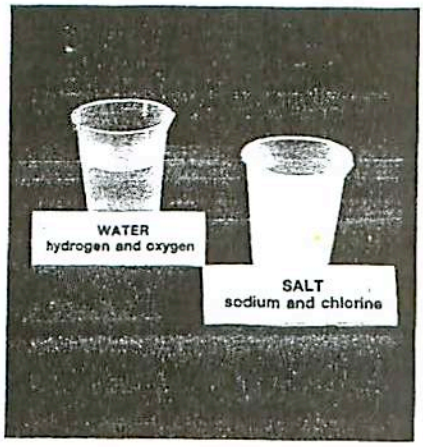
SECTION 1

Chemical Compounds in Cells

DISCOVER

ACTIVITY



What Is a Compound?

1. Your teacher will provide you with containers filled with various substances. All of the substances are chemical compounds.
2. Examine each substance. Read the label on each container to learn what each substance is made of.

Think It Over

Forming Operational Definitions Write a definition of what you think a chemical compound is.

GUIDE FOR READING

- What are the four main kinds of organic molecules in living things?
- How is water important to the function of cells?

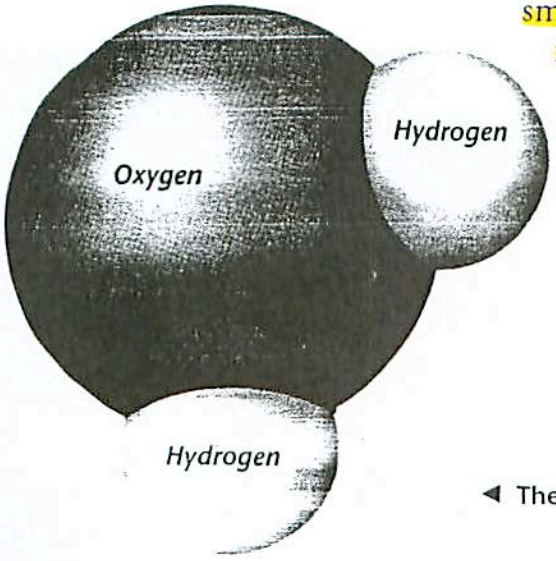
Reading Tip As you read, make a table of the main types of organic molecules and where in the cell each one is found.

If cells are the basic building blocks of living things, then what substances are the basic building blocks of cells? In what ways are the basic building blocks of cells similar to those that make up other things around you? In this section you will explore how the substances that make up living cells differ from those that make up nonliving things.

Elements and Compounds

Think about the air around you. You probably know that air is a mixture of gases, including oxygen and nitrogen. Oxygen and nitrogen are examples of elements. An **element** is any substance that cannot be broken down into simpler substances. The smallest unit of an element is called an **atom.** An element is made up of only one kind of atom. The most common elements in living things, including you, are carbon, oxygen, hydrogen, and nitrogen.

When two or more elements combine chemically they form a **compound.** Water, for example, is a compound made up of the elements hydrogen and oxygen. The smallest unit of most compounds is called a **molecule.** Each water molecule is made up of two hydrogen atoms and one oxygen atom.



◀ The structure of a water molecule

Organic and Inorganic Compounds

Many of the compounds found in living things contain the element carbon, which is usually combined with other elements. Most compounds that contain carbon are called **organic compounds.**

The most important groups of organic compounds found in living things are proteins, carbohydrates, lipids, and nucleic acids. As you may know, many of these compounds are found in the foods you eat. This is not surprising, since the foods you eat come from living things.

Compounds that don't contain the element carbon are called **inorganic compounds.** One exception to this definition is carbon dioxide. Although carbon dioxide contains carbon, it is classified as an inorganic compound. Other inorganic compounds include water and sodium chloride, or table salt.

Proteins

What do a bird's feathers, a spider's web, and your fingernails have in common? All of these substances are made mainly of proteins. **Proteins** are large organic molecules made of carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulfur. Foods that are high in protein include meat, eggs, fish, nuts, and beans.

Cells use proteins for many different things. For instance, proteins form parts of cell membranes. Proteins also make up many of the organelles within the cell. Certain cells in your body use proteins to build body structures such as muscles.

Protein Structure Protein molecules are made up of smaller molecules called **amino acids.** Although there are only 20 common amino acids, cells can combine them in different ways to form thousands of different proteins. The kinds of amino acids and the order in which they link together determine the type of protein that forms.

You can think of the 20 amino acids as being like the 26 letters of the alphabet. Those 26 letters can form thousands of words. The letters you use and their order determine the words you form. Even a change in one letter, for example, from *rice* to *mice*, creates a new word. Similarly, changes in the type or order of amino acids result in a different protein.

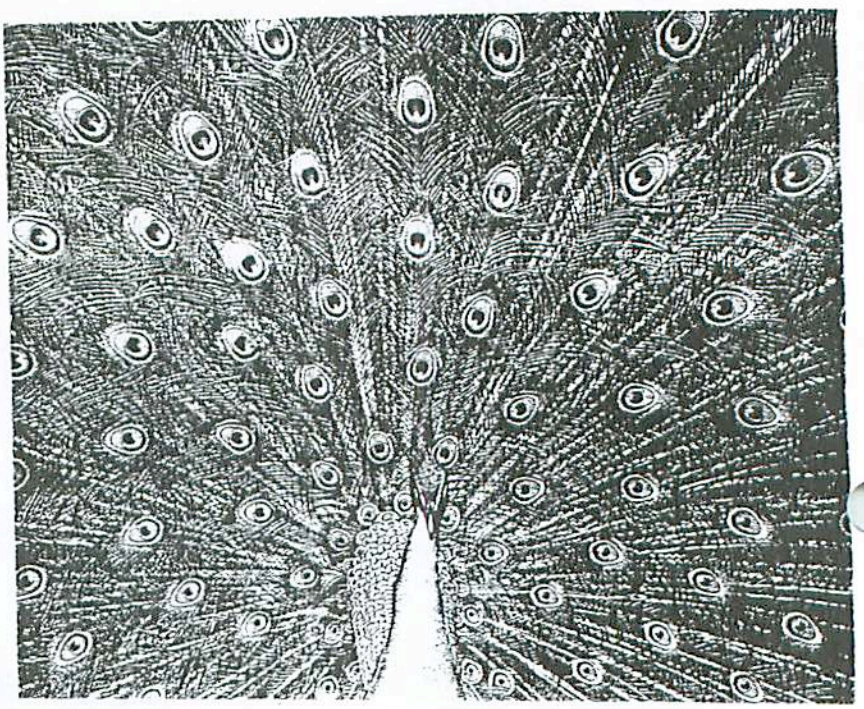


Figure 1 This peacock's feathers are made up mainly of proteins. Proteins are important components of the cell membrane and many of the cell's organelles.

TRY THIS

What's That Taste?

ACTIVITY

Use this activity to discover one role that enzymes play in your body.

1. Put an unsalted soda cracker in your mouth. Chew it up, but do not swallow. Note what the cracker tastes like.
2. Continue to chew the cracker for a few minutes, mixing it well with your saliva. Note how the taste of the cracker changes.

Inferring Soda crackers are made up mainly of starch, with little sugar. How can you account for the change in taste after you chewed the cracker for a few minutes?

Enzymes An enzyme is a type of protein that speeds up a chemical reaction in a living thing. Without enzymes, many chemical reactions that are necessary for life would either take too long or not occur at all. For example, enzymes in your saliva speed up the digestion of food by breaking down starches into sugars in your mouth.

Carbohydrates

A **carbohydrate** is an energy-rich organic compound made of the elements carbon, hydrogen, and oxygen. Sugars and starches are examples of carbohydrates.

Sugars are produced during the food-making process that takes place in plants. Foods such as fruits and some vegetables are high in sugar content. Sugar molecules can combine, forming large molecules called starches. Plant cells store excess energy in molecules of starch.

Carbohydrates are important components of some cell parts. The cellulose found in the cell walls of plants is a type of carbohydrate. Carbohydrates are also found in cell membranes.

Lipids

Have you ever seen a cook trim the fat from a piece of meat before cooking it? The cook is trimming away a lipid. Fats, oils, and waxes are all **lipids.** Like carbohydrates, lipids are energy-rich, organic compounds made of carbon, hydrogen, and oxygen.

Lipids contain even more energy than carbohydrates. Cells store energy in lipids for later use. For example, during winter a dormant bear lives on the energy stored as fat within its cells.

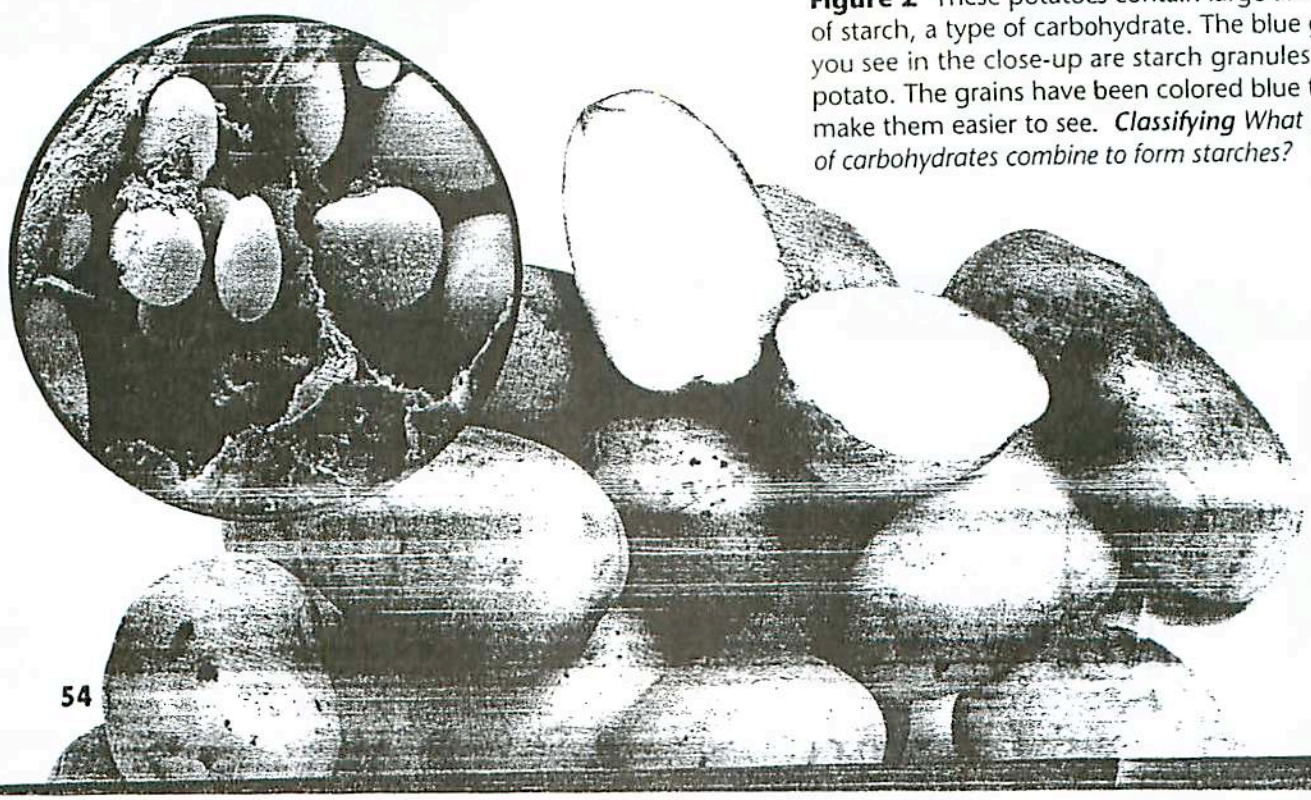


Figure 2 These potatoes contain large amounts of starch, a type of carbohydrate. The blue grains you see in the close-up are starch granules in a potato. The grains have been colored blue to make them easier to see. ***Classifying*** *What types of carbohydrates combine to form starches?*

Nucleic Acids

Nucleic acids are very large organic molecules made of carbon, oxygen, hydrogen, nitrogen, and phosphorus. Nucleic acids contain the instructions that cells need to carry out all the functions of life.

There are two kinds of nucleic acids. Deoxyribonucleic acid (dee ahk see ry boh noo KLEE ik), or **DNA**, is the genetic material that carries information about an organism that is passed from parent to offspring. The information in DNA also directs all of the cell's functions. Most of the DNA in a cell is found in the chromatin in the nucleus. Ribonucleic acid (ry boh noo KLEE ik), or **RNA**, plays an important role in the production of proteins. RNA is found in the cytoplasm, as well as in the nucleus.

Water and Living Things

Did you know that water makes up about two thirds of your body? Water plays many vital roles in cells. For example, most chemical reactions that take place in cells can occur only when substances are dissolved in water. **Without water, most chemical reactions within cells could not take place.** Also, water molecules themselves take part in many chemical reactions in cells.

Water also helps cells keep their size and shape. In fact, a cell without water would be like a balloon without air. In addition, because water changes temperature slowly, it helps keep the temperature of a cell from changing rapidly.

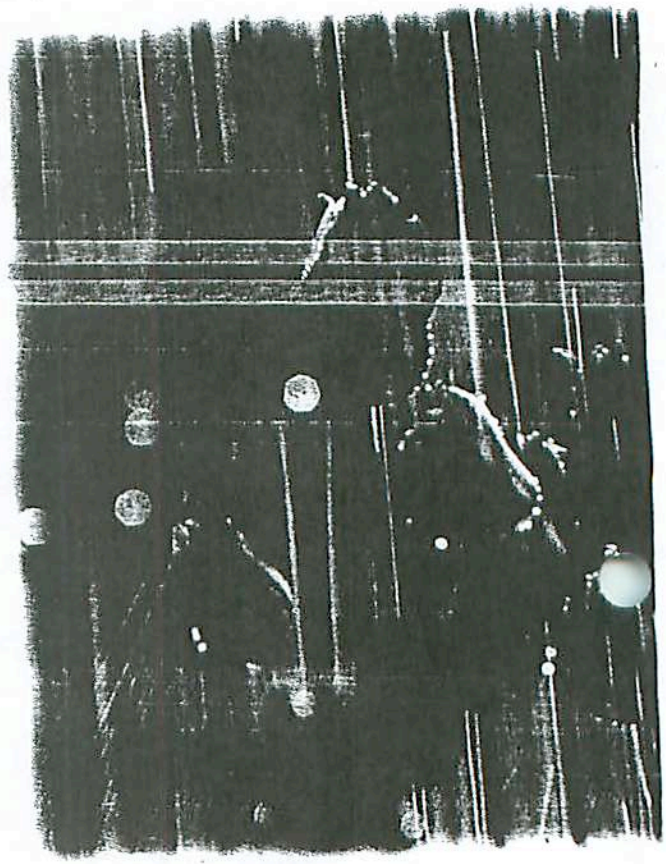


Figure 3 Water is essential for all living things to survive. The cells of these tulips need water to function.

Section 1 Review

1. Name the four main groups of organic molecules in living things. Describe the function of each type of molecule.
2. What roles does water play in cells?
3. How are elements related to compounds?
4. **Thinking Critically Predicting** Suppose a cell did not have a supply of amino acids and could not produce them. What effect might this have on the cell?

Science at Home

Organic Compounds in Food With family members, look at the "Nutrition Facts" labels on a variety of food products. Identify foods that contain large amounts of the following organic compounds: carbohydrates, proteins, and fats. Discuss with your family what elements each of these compounds are made of and what roles they play in cells and in your body.

SECTION 2

The Cell in Its Environment

DISCOVER ..... ACTIVITY

How Do Molecules Move?

1. With your classmates, stand so that you are evenly spaced throughout the classroom.
2. Your teacher will spray an air freshener into the room. When you first begin to smell the air freshener, raise your hand.
3. Note how long it takes for other students in the classroom to smell the scent.

Think It Over

Developing Hypotheses How was each student's distance from the teacher related to when he or she smelled the air freshener? Develop a hypothesis about why this pattern occurred.

GUIDE FOR READING

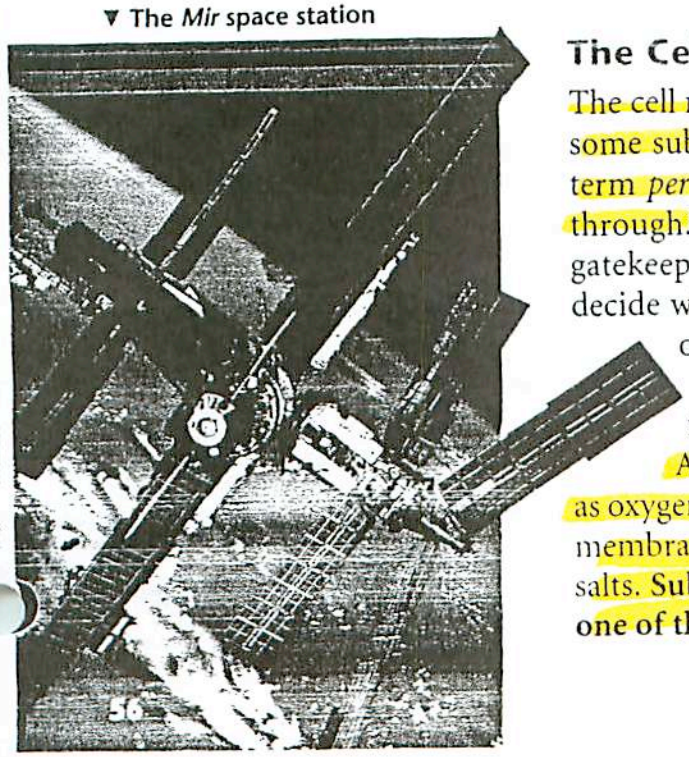
- By what three methods do materials move into and out of cells?
- What is the difference between passive transport and active transport?

Reading Tip Before you read, use the headings to make an outline about how materials move into and out of cells. As you read, make notes about each process.

How is a cell like a space station? The walls of a space station protect the astronauts inside from the airless vacuum of space. Food, water, and other supplies must be brought to the space station by shuttles from Earth. In addition, the space station needs to be able to get rid of wastes. The doors of the space station allow the astronauts to bring materials in and move wastes out into the shuttle to be returned to Earth.

Like space stations, cells also have structures that protect them from the outside environment. As you learned, all cells are surrounded by a cell membrane that separates the cell from the outside environment. Just like the space station, the cell also has to take in needed materials and get rid of wastes. It is the cell membrane that controls what materials move into and out of the cell.

▼ The *Mir* space station



The Cell Membrane as Gatekeeper

The cell membrane is **selectively permeable,** which means that some substances can pass through it while others cannot. The term *permeable* comes from a Latin word that means "to pass through." You can think of the cell membrane as being like a gatekeeper at an ancient castle. It was the gatekeeper's job to decide when to open the gate to allow people to pass into and out of the castle. The gatekeeper made the castle wall "selectively permeable"—it was permeable to friendly folks but not to enemies.

A cell membrane is usually permeable to substances such as oxygen, water, and carbon dioxide. On the other hand, the cell membrane is usually not permeable to some large molecules and salts. **Substances that can move into and out of a cell do so by one of three methods: diffusion, osmosis, or active transport.**

Diffusion—Molecules in Motion

The main method by which small molecules move into and out of cells is diffusion. **Diffusion** (dih FYOO zhun) is the process by which molecules tend to move from an area of higher concentration to an area of lower concentration. The concentration of a substance is the amount of the substance in a given volume.

If you did the Discover activity, you observed diffusion in action. The area where the air freshener was sprayed had many molecules of freshener. The molecules gradually moved from this area of higher concentration to the other parts of the classroom, where there were few molecules of freshener, and thus a lower concentration.

What Causes Diffusion? Molecules are always moving. As they move, the molecules bump into one another. The more molecules there are in an area, the more collisions there will be. Collisions cause molecules to push away from one another. Over time, the molecules of a substance will continue to spread out. Eventually they will be spread evenly throughout the area.

INTEGRATING CHEMISTRY

Diffusion in Cells Have you ever used a microscope to observe one-celled organisms in pond water? These organisms obtain the oxygen they need to survive from the water around them. Luckily for them, there are many more molecules of oxygen in the water outside the cell than there are inside the cell. In other words, there is a higher concentration of oxygen molecules in the water than inside the cell. Remember that the cell membrane is permeable to oxygen molecules. The oxygen molecules diffuse from the area of higher concentration—the pond water—through the cell membrane to the area of lower concentration—the inside of the cell.

MOSH PIT

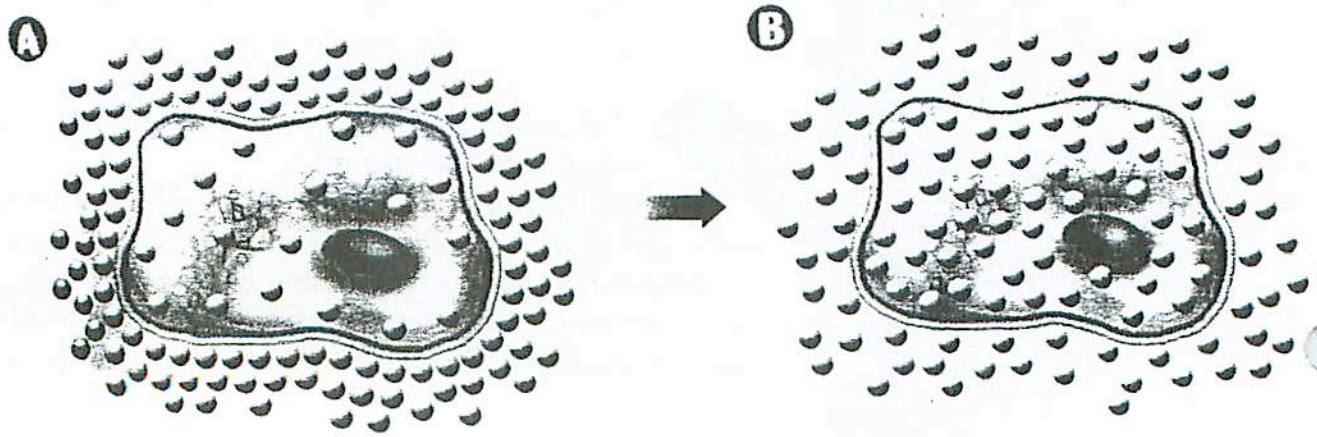


Figure 4 Molecules move by diffusion from an area of higher concentration to an area of lower concentration. A. There is a higher concentration of molecules outside the cell than inside. B. The molecules diffuse into the cell. Eventually, there is an equal concentration of molecules inside and outside the cell.
Predicting *What would happen if the concentration of the molecules outside the cell was lower than the concentration inside?*

TRY THIS

Diffusion in Action

ACTIVITY

Here's how you can observe the effects of diffusion.

1. Fill a small clear plastic cup with cold water. Place the cup on a table and allow it to sit until there is no movement in the water.
2. Use a plastic dropper to add one large drop of food coloring to the water.
3. Observe the water every minute. Note any changes that take place. Continue to observe until you can no longer see any changes.

Inferring What role did diffusion play in the changes you observed?

Osmosis—The Diffusion of Water Molecules

Like oxygen, water passes easily into and out of cells through the cell membrane. The diffusion of water molecules through a selectively permeable membrane is called **osmosis.** Osmosis is important to cells because cells cannot function properly without adequate water.

Remember that molecules tend to move from an area of higher concentration to an area of lower concentration. In osmosis, water molecules move by diffusion from an area where they are highly concentrated through the cell membrane to an area where they are less concentrated. This can have important consequences for the cell.

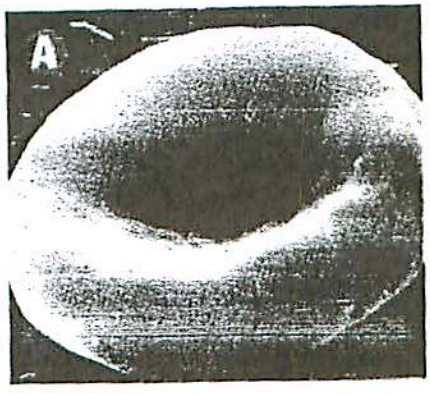
Look at Figure 5 to see the effect of osmosis on cells. In Figure 5A, red blood cells are bathed in a solution in which the concentration of water is the same as it is inside the cells. This is the normal shape of a red blood cell.

Now look at Figure 5B. The red blood cells are floating in water that contains a lot of salt. The concentration of water molecules outside the cells is lower than the concentration of water molecules inside the cells. This is because the salt takes up space in the salt water, so there are fewer water molecules. As a result, water moves out of the cells by osmosis, and the cells shrink.

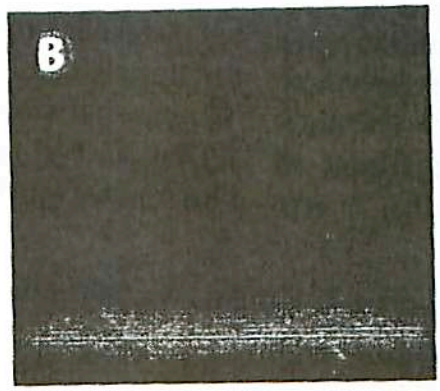
Finally, consider Figure 5C. The red blood cells are floating in water that contains a very small amount of salt. The water inside the cells contains more salt than the solution they are floating in. Thus, the concentration of water outside the cell is greater than it is inside the cell. The water moves into the cell, causing it to swell.

☑ *Checkpoint* *How is osmosis related to diffusion?*

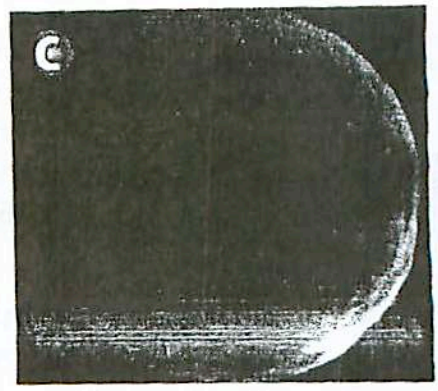
Figure 5 Osmosis is the diffusion of water molecules through a selectively permeable membrane.



A. This is the normal shape of a red blood cell.



B. This cell has shrunk because water moved out of it by osmosis.



C. This cell is swollen with water that has moved into it by osmosis.

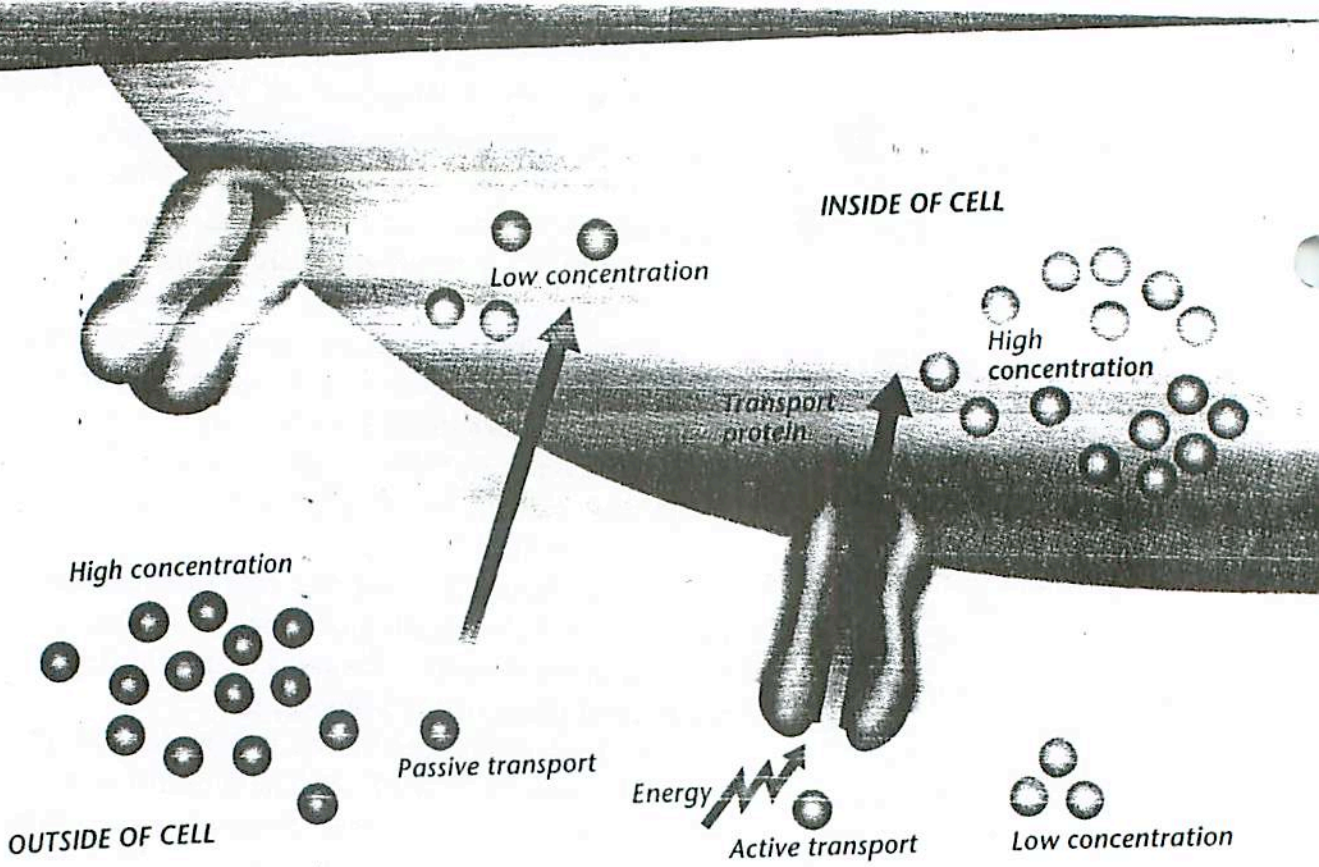


Figure 6 Diffusion and osmosis are forms of passive transport. These processes do not require the cell to use any energy. Active transport, on the other hand, requires the use of energy. ***Interpreting Diagrams*** *How are passive and active transport related to the concentrations of the molecules inside and outside the cell?*

Active Transport

If you have ever ridden a bicycle down a long hill, you know that it doesn't take any of your energy to go fast. But pedaling back up the hill does take energy. For a cell, moving materials through the cell membrane by diffusion and osmosis is like cycling downhill. These processes do not require the cell to use any energy. The movement of materials through a cell membrane without using energy is called **passive transport.**

What if a cell needs to take in a substance that is in higher concentration inside the cell than outside? The cell would have to move the molecules in the opposite direction than they naturally move by diffusion. Cells can do this, but they have to use energy—just as you would use energy to pedal back up the hill. **Active transport** is the movement of materials through a cell membrane using energy. **The main difference between passive transport and active transport is that active transport requires the cell to use energy while passive transport does not.**

Transport Proteins A cell has several ways of moving materials by active transport. In one method, transport proteins in the cell membrane "pick up" molecules outside the cell and carry them in, using energy in the process. Transport proteins also carry molecules out of cells in a similar way. Some substances that are carried into and out of cells in this way include calcium, potassium, and sodium.

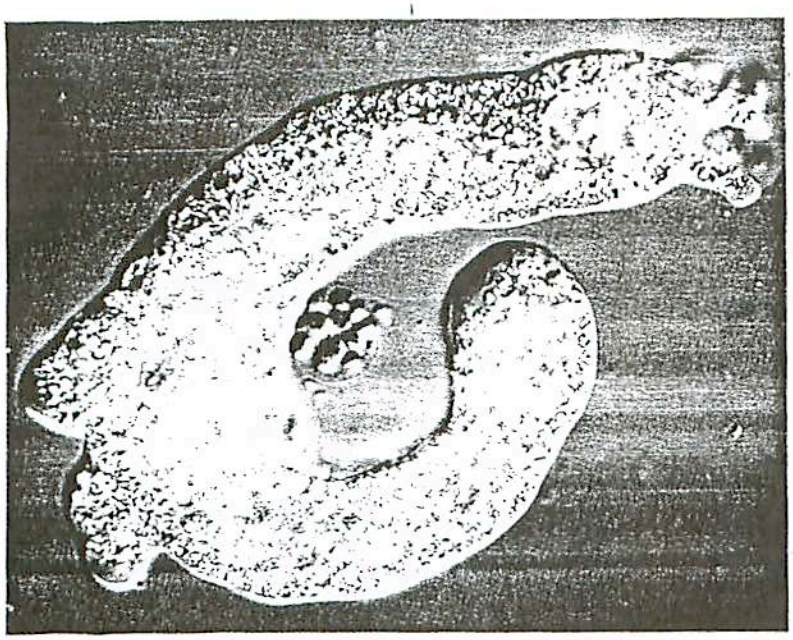


Figure 7 A cell can move some materials into the cell by engulfing them. This single-celled ameba is engulfing a smaller single-celled organism. ***Applying Concepts*** *How does this process differ from passive transport?*

Transport by Engulfing You can see another method of active transport in Figure 7. First the cell membrane surrounds, or engulfs, a particle. Once the particle is engulfed, the cell membrane pinches off and forms a vacuole within the cell. The cell must use energy in this process.

Why Are Cells Small?

As you know, most cells are so small that you cannot see them without a microscope. Have you ever wondered why cells are so small? One reason is related to how materials move into and out of cells.

As a cell's size increases, more of its cytoplasm is located farther from the cell membrane. Once a molecule enters a cell, it is carried to its destination by a stream of moving cytoplasm, somewhat like the way currents of water in the ocean move a raft. But in a very large cell, the streams of cytoplasm must travel farther to bring materials to all parts of the cell. It would take much longer for a molecule to reach the center of a very large cell than it would in a small cell. Likewise, it would take a long time for wastes to be removed. If a cell grew too large, it could not function well enough to survive. When a cell reaches a certain size, it divides into two new cells. You will learn more about cell division later in this chapter.

Section 2 Review

1. Describe three methods by which substances can move into and out of cells.
2. How are passive transport and active transport similar? How do they differ?
3. Why is small size an advantage to a cell?
4. **Thinking Critically Predicting** A single-celled organism is transferred from a tank of fresh water into a tank of salt water. How will the cell change? Explain.

Check Your Progress

By now you should have started your egg-speriment by soaking an uncooked egg in vinegar. Leave your egg in the vinegar for at least two days. Each day, rinse your egg in water and measure its circumference. Record all of your observations. (*Hint:* Handle the egg gently. If your egg breaks, don't give up or throw away your data. Simply start again with another egg and keep investigating.)

SECTION 3 Photosynthesis

DISCOVER ACTIVITY

Where Does the Energy Come From?

1. Obtain a solar-powered calculator that does not use batteries. Place the calculator in direct light.
2. Cover the solar cells with your finger. Note how your action affects the number display.
3. Uncover the solar cells. What happens to the number display?
4. Now cover all but one of the solar cells. How does that affect the number display?

Think It Over

Inferring From your observations, what can you infer about the energy that powers the calculator?

It's a beautiful summer afternoon—a perfect day for a picnic in the park. The aroma of chicken cooking on the grill fills the air. Your dog is busy chasing sticks under a nearby tree. Up above, blue jays swoop down from the tree's branches, hunting for food. "Let's go for a bike ride before lunch," suggests your cousin. "Great idea," you say, and you ride off down the path.

Dogs running, birds flying, people biking—all of these activities require energy. Where do you think this energy comes from? Believe it or not, all the energy used to perform such activities comes from the sun. In fact, the sun provides almost all the energy used by living things on Earth.

GUIDE FOR READING

- **What happens during the process of photosynthesis?**
- **How does the sun supply living things with the energy they need?**

Reading Tip **As you read, create a flowchart that shows the steps involved in the process of photosynthesis.**

What Is Photosynthesis?

Every living thing needs energy. All cells need energy to carry out their functions, such as making proteins and transporting substances into and out of the cell. Your picnic lunch supplies your cells with the energy they need. But plants and other organisms, such as algae and some bacteria, obtain their energy in a different way. These organisms use the energy in sunlight to make their own food.

The process by which a cell captures the energy in sunlight and uses it to make food is called **photosynthesis** (foh toh SIN thuh sis). The term *photosynthesis* comes from the root words *photo*, which means "light," and *synthesis*, which means "putting together." Photosynthesis means using light to make food.

A Two-Stage Process

Photosynthesis is a very complicated process. **During photosynthesis, plants and some other organisms use energy from the sun to convert carbon dioxide and water into oxygen and sugars, including glucose.** You can think of photosynthesis as taking place in two stages: capturing the sun's energy and producing sugars. You're probably familiar with many two-stage processes. To make a cake, for example, the first stage is to combine the ingredients to make the batter. The second stage is to bake the batter in an oven. To get the desired result—the cake—both stages must occur in the correct order.

Capturing the Sun's Energy The first stage of photosynthesis involves capturing the energy in sunlight. In plants, this energy-capturing process occurs in the leaves and other green parts of the plant. Recall from Chapter 1 that chloroplasts are green organelles inside plant cells. In most plants, leaf cells contain more chloroplasts than do cells in other parts of the plant.

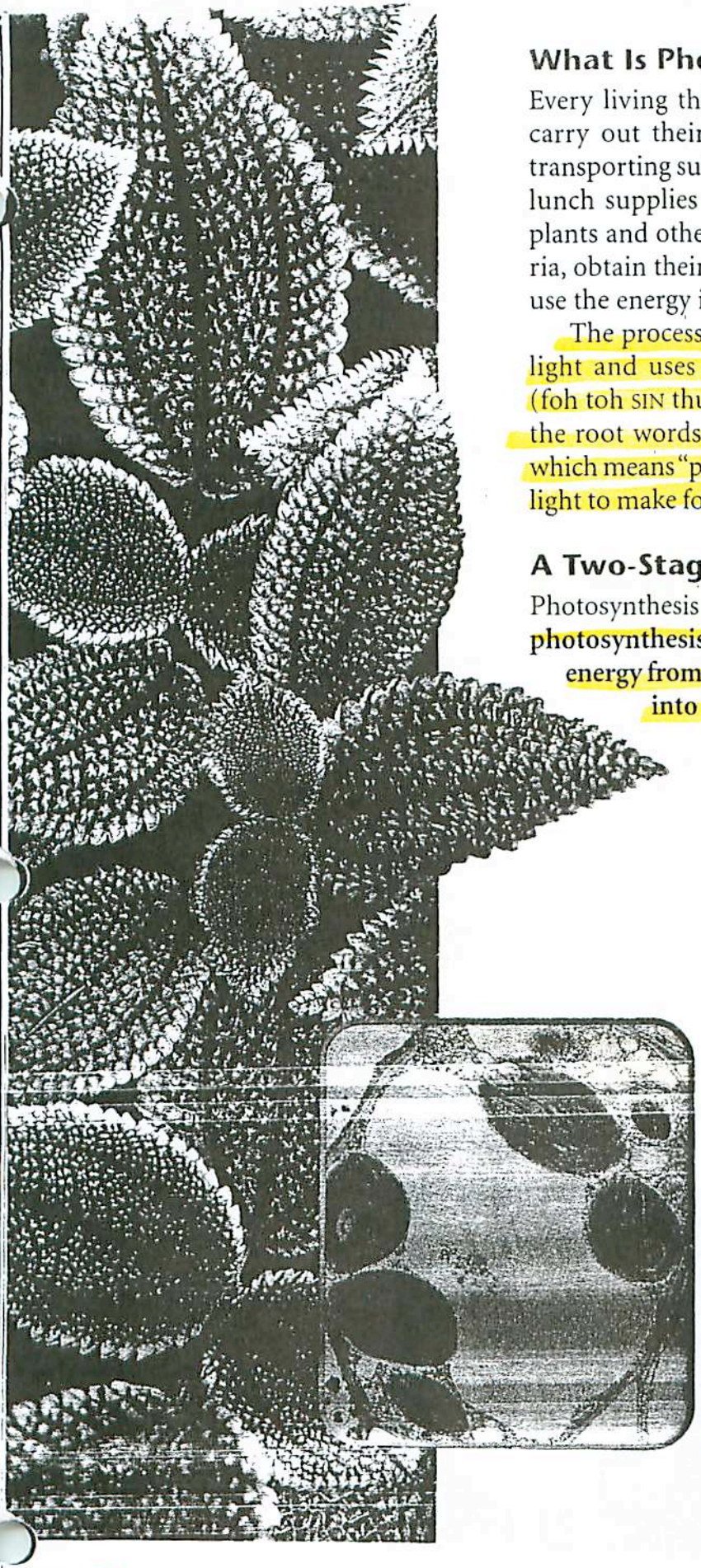


Figure 8 Photosynthesis occurs inside chloroplasts in the cells of plants and some other organisms. The chloroplasts are the green structures in the cell in the inset. ***Applying Concepts*** *Where in a plant are cells with many chloroplasts found?*

The chloroplasts in plant cells give plants their green color. The green color comes from **pigments,** colored chemical compounds that absorb light. The main pigment found in the chloroplasts of plants is **chlorophyll.** Chloroplasts may also contain yellow and orange pigments, but they are usually masked by the green color of chlorophyll.

Chlorophyll and the other pigments function in a manner similar to that of the solar "cells" in a solar-powered calculator. Solar cells capture the energy in light and use it to power the calculator. Similarly, the pigments capture light energy and use it to power the second stage of photosynthesis.

Using Energy to Make Food In the second stage of photosynthesis, the cell uses the captured energy to produce sugars. The cell needs two raw materials for this stage: water (H_2O) and carbon dioxide (CO_2). In plants, the roots absorb water from the soil. The water then moves up through the plant's stem to the leaves. Carbon dioxide is one of the gases in the air. Carbon dioxide enters the plant through small openings on the undersides of the leaves called **stomata** (STOH muh tuh)(singular *stoma*). Once in the leaves, the water and carbon dioxide move into the chloroplasts.

Inside the chloroplasts, the water and carbon dioxide undergo a complex series of chemical reactions. The reactions are powered by the energy captured in the first stage. One of the products of the reactions is oxygen (O_2). The other products are sugars, including glucose ($C_6H_{12}O_6$). Recall from Section 1 that sugars are a type of carbohydrate. Cells can use the energy in the sugars to carry out important cell functions.

Checkpoint *Why are plants green?*

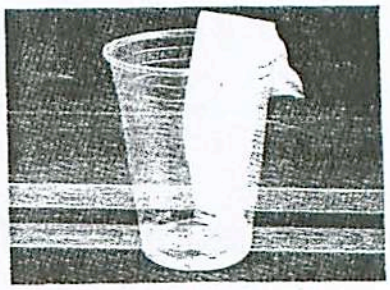
Figure 9 Stomata are small openings on the undersides of leaves. Stomata can open (left) or close (right) to control the movement of carbon dioxide, oxygen, and water vapor.

Sharpen your Skills

Inferring

ACTIVITY

In this activity, you will observe the pigments in a leaf.



1. Cut a strip 5 cm by 20 cm out of a coffee filter.
2. Place a leaf on top of the paper strip, about 2 cm from the bottom.
3. Roll the edge of a dime over a section of the leaf, leaving a narrow band of color on the paper strip.
4. Pour rubbing alcohol into a plastic cup to a depth of 1 cm. Stand the paper strip in the cup so the color band is about 1 cm above the alcohol. Hook the other end of the strip over the top of the cup.
5. After 10 minutes, remove the paper strip and let it dry. Observe the strip.
6. Wash your hands.

What does the appearance of your paper strip reveal about the presence of pigments in the leaf?

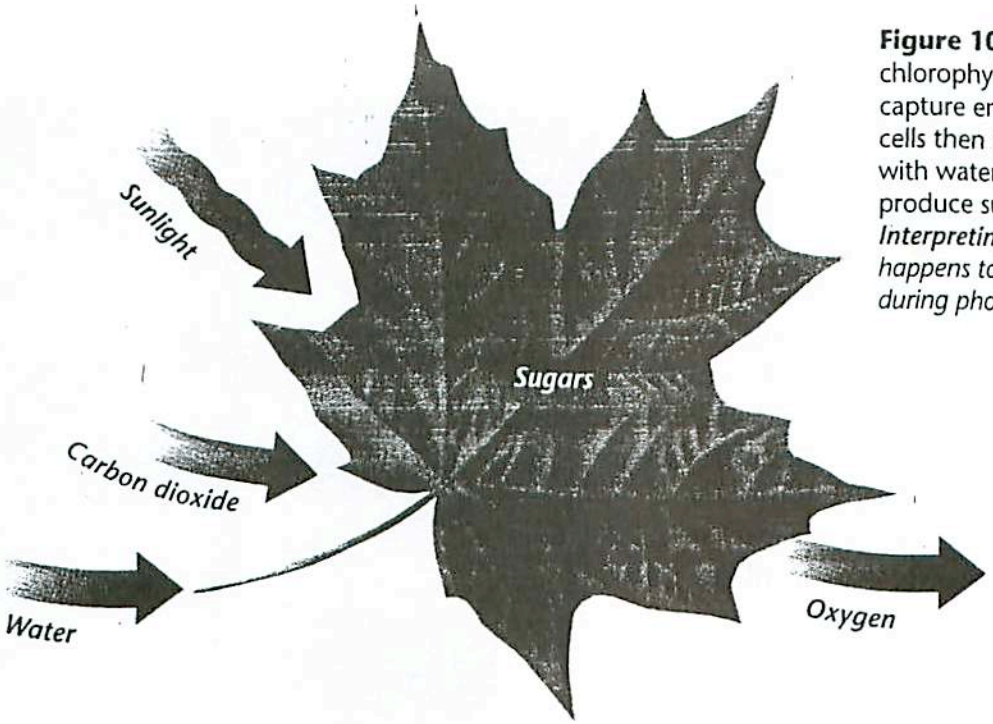


Figure 10 During photosynthesis, chlorophyll and other pigments capture energy from sunlight. The cells then use this energy, along with water and carbon dioxide, to produce sugars and oxygen. *Interpreting Diagrams What happens to the oxygen produced during photosynthesis?*

The Photosynthesis Equation

The events of photosynthesis can be summed up by the following chemical equation:

$$6\,CO_2 + 6\,H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6\,O_2$$

carbon dioxide — water — glucose — oxygen

Integrating Chemistry Notice that the raw materials—six molecules of carbon dioxide and six molecules of water—are on the left side of the equation. The products—one molecule of glucose and six molecules of oxygen—are on the right side of the equation. An arrow, which is read as "yields," connects the raw materials to the products. Light energy, which is necessary for the chemical reaction to occur, is written above the arrow.

What happens to the products of photosynthesis? Plant cells use some of the sugar for food. The cells break down the sugar molecules to release the energy they contain. This energy can then be used to carry out the plant's functions. Some sugar molecules are converted into other compounds, such as cellulose. Other sugar molecules may be stored in the plant's cells for later use. When you eat food from plants, such as potatoes or carrots, you are eating the plant's stored food.

The other product of photosynthesis is oxygen. Most of the oxygen passes out of the plant through the stomata and into the air. All organisms that carry out photosynthesis release oxygen.

Photosynthesis and Life

Integrating Environmental Science

If you were a caterpillar, you might be sitting on a plant chewing on a leaf. The plant is an autotroph, an organism that makes its own food. The plant's leaves contain sugars made during photosynthesis. Leaves also contain starches, cellulose, and other compounds made from sugars. The energy in these compounds originally came from the sun.

The caterpillar is a heterotroph, an organism that cannot make its own food. To live, grow, and perform other caterpillar functions, it needs the energy in the plant's sugars. By eating plants, the caterpillar gets its energy from the sun, although in an indirect way.

Watch out—there's a bird! The bird, a heterotroph, gets its energy by eating caterpillars. Since the energy in caterpillars indirectly comes from the sun, the bird too is living off the sun's energy. **Nearly all living things obtain energy either directly or indirectly from the energy of sunlight captured during photosynthesis.**

Photosynthesis is also essential for the air you breathe. Most living things need oxygen to survive. About 21% of Earth's atmosphere is oxygen—thanks to plants and other organisms that carry out photosynthesis. Almost all the oxygen in Earth's atmosphere was produced by living things through the process of photosynthesis.

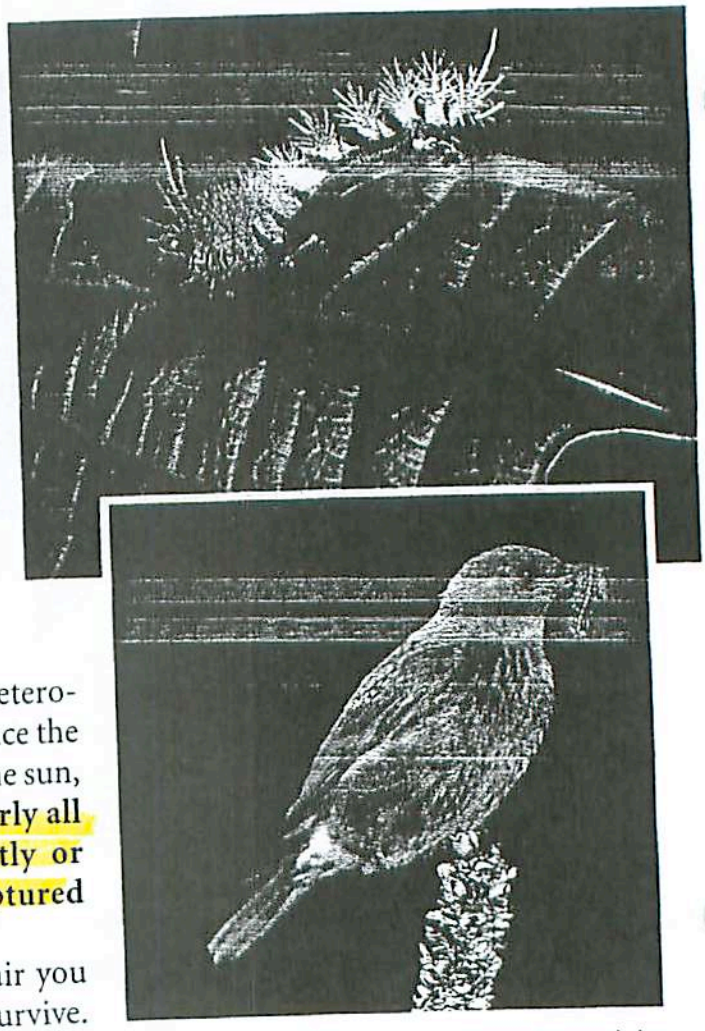


Figure 11 Both the caterpillar and the western bluebird obtain their energy indirectly from the sun.

Section 3 Review

1. What are the raw materials needed for photosynthesis? What are the products?
2. How do plants get energy? How do animals get energy?
3. What role does chlorophyll play in photosynthesis? Where is chlorophyll found?
4. **Thinking Critically Applying Concepts** List three ways that autotrophs were important to you today.

Check Your Progress

At this point, you should soak your egg for one or two days in water, then in water with food coloring, then in salt water, and finally in another liquid of your choice. Continue to rinse your egg and measure and record its circumference every day. Your egg should be going through some amazing changes in appearance.

SECTION 4

Respiration

DISCOVER

Activity

What Is a Product of Respiration?

1. Put on your goggles. Fill two test tubes half full of warm water. Add 5 milliliters of sugar to one of the test tubes. Put the tubes in a test tube rack.
2. Add 0.5 milliliter of dried yeast (a single-celled organism) to each tube. Stir the contents of each tube with a straw. Place a stopper snugly in the top of each tube.
3. Observe any changes that occur in the two test tubes over the next 10 to 15 minutes.

Think It Over

Observing What changes occurred in each test tube? How can you account for any differences that you observed?

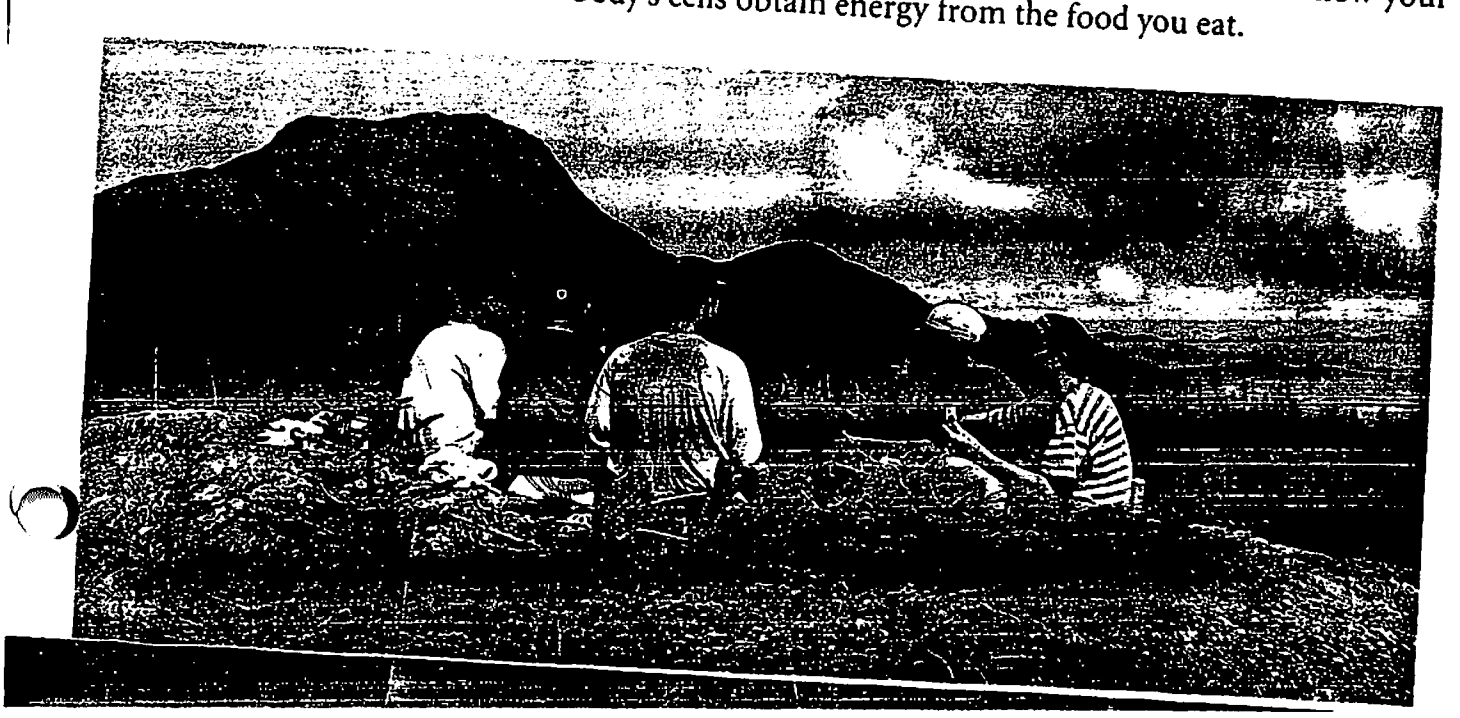
GUIDE FOR READING

- **What events occur during respiration?**
- **How are photosynthesis and respiration related?**
- **What is fermentation?**

Reading Tip **Before you read, write a definition of *respiration*. After reading this section, revise your definition to include what you've learned.**

Your friend stops along the trail ahead of you and calls out, "Let's eat!" He looks around for a flat rock to sit on. You're ready for lunch. You didn't have much breakfast this morning, and you've been hiking for the past hour. As you look around you, you see that the steepest part of the trail is still ahead of you. You'll need a lot of energy to make it to the top.

Everyone knows that food provides energy. But not everyone knows *how* food provides energy. The food you eat does not provide your body with energy immediately after you eat it. First, the food must pass through your digestive system. There, the food is broken down into small molecules. These small molecules can then pass out of the digestive system and into your bloodstream. Next, the molecules travel through the bloodstream to the cells of your body. Inside the cells, the energy in the molecules is released. In this section, you'll learn how your body's cells obtain energy from the food you eat.



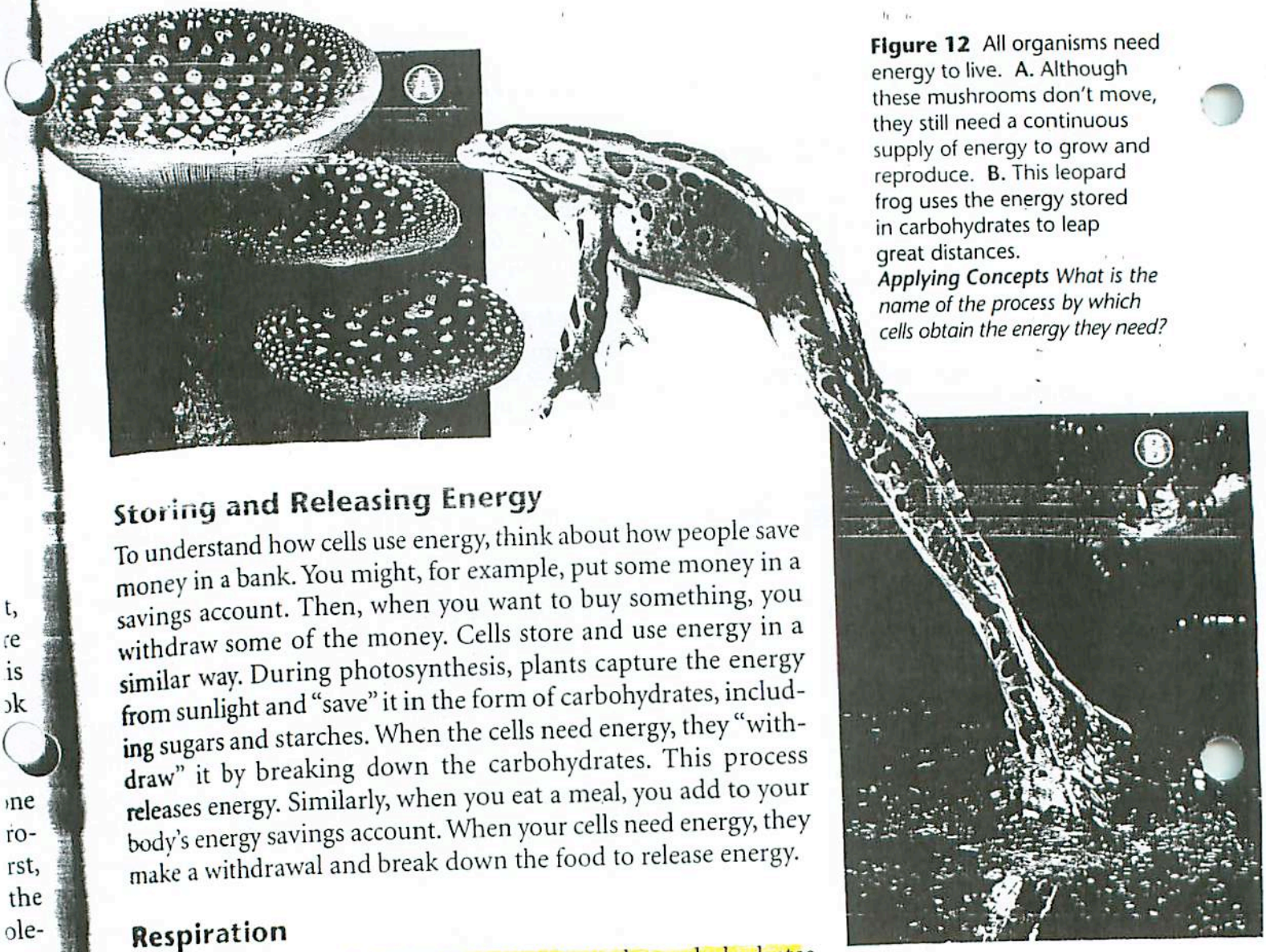


Figure 12 All organisms need energy to live. **A.** Although these mushrooms don't move, they still need a continuous supply of energy to grow and reproduce. **B.** This leopard frog uses the energy stored in carbohydrates to leap great distances.
Applying Concepts *What is the name of the process by which cells obtain the energy they need?*

Storing and Releasing Energy

To understand how cells use energy, think about how people save money in a bank. You might, for example, put some money in a savings account. Then, when you want to buy something, you withdraw some of the money. Cells store and use energy in a similar way. During photosynthesis, plants capture the energy from sunlight and "save" it in the form of carbohydrates, including sugars and starches. When the cells need energy, they "withdraw" it by breaking down the carbohydrates. This process releases energy. Similarly, when you eat a meal, you add to your body's energy savings account. When your cells need energy, they make a withdrawal and break down the food to release energy.

Respiration

After you eat a meal, your body converts the carbohydrates in the food into glucose, a type of sugar. When cells need energy, they "withdraw" energy from glucose in a process called **respiration. During respiration, cells break down simple food molecules such as glucose and release the energy they contain.** Because living things need a continuous supply of energy, the cells of all living things carry out respiration continuously.

The term *respiration* might be confusing. You have probably used it to mean breathing, that is, moving air in and out of your lungs. Because of this confusion, the respiration process that takes place inside cells is sometimes called *cellular respiration*.

The double use of the term *respiration* does point out a connection that you should keep in mind. Breathing brings oxygen into your lungs, and oxygen is necessary for cellular respiration to occur in most cells. The most efficient means of obtaining energy from glucose requires the presence of oxygen. Some cells, however, can obtain energy from glucose without using oxygen.

The Respiration Equation Although respiration occurs in a series of complex steps, the overall process can be summarized in the following equation:

$$\underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6\,O_2} \longrightarrow \underset{\text{carbon dioxide}}{6\,CO_2} + \underset{\text{water}}{6\,H_2O} + \text{energy}$$

Notice that the raw materials for respiration are glucose and oxygen. Plants and other organisms that undergo photosynthesis make their own glucose. The glucose in the cells of animals and other organisms comes from the food they consume. The oxygen comes from the air or water surrounding the organism.

The Two Stages of Respiration Like photosynthesis, respiration is a two-stage process. The first stage takes place in the cytoplasm of the organism's cells. There, glucose molecules are broken down into smaller molecules. Oxygen is not involved in this stage of respiration. Only a small amount of the energy in glucose is released during this stage.

The second stage of respiration takes place in the mitochondria. There, the small molecules are broken down into even smaller molecules. These chemical reactions require oxygen, and a great deal of energy is released. This is why the mitochondria are sometimes called the "powerhouses" of the cell.

Figure 13 summarizes the process of respiration. If you trace the steps in the breakdown of glucose, you'll see that energy is released in both stages. Two other products of respiration are carbon dioxide and water. These products diffuse out of the cell. In animals, the carbon dioxide and some water leave the body when they breathe out. Thus, when you breathe in, you take in oxygen, a raw material for respiration. When you breathe out, you release carbon dioxide and water, products of respiration.

☑ *Checkpoint* *What are the raw materials for respiration?*

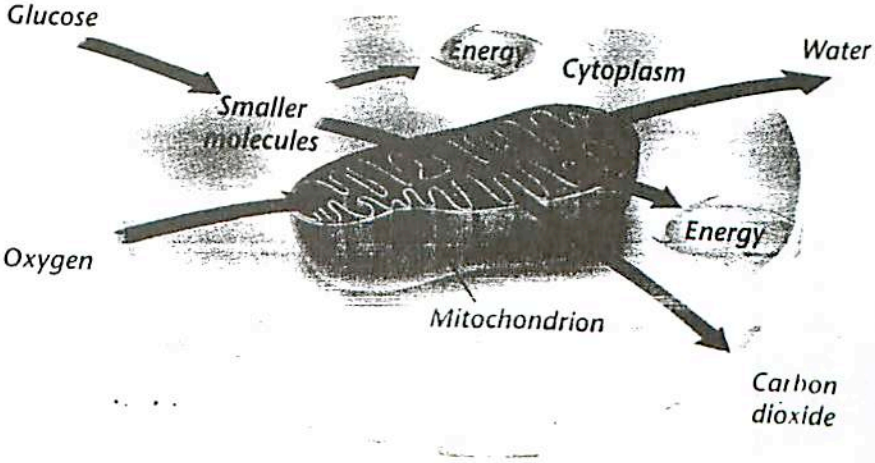


Figure 13 The first stage of respiration, which takes place in the cytoplasm, releases a small amount of energy. The second stage takes place in the mitochondria. A large amount of energy is released at this stage.

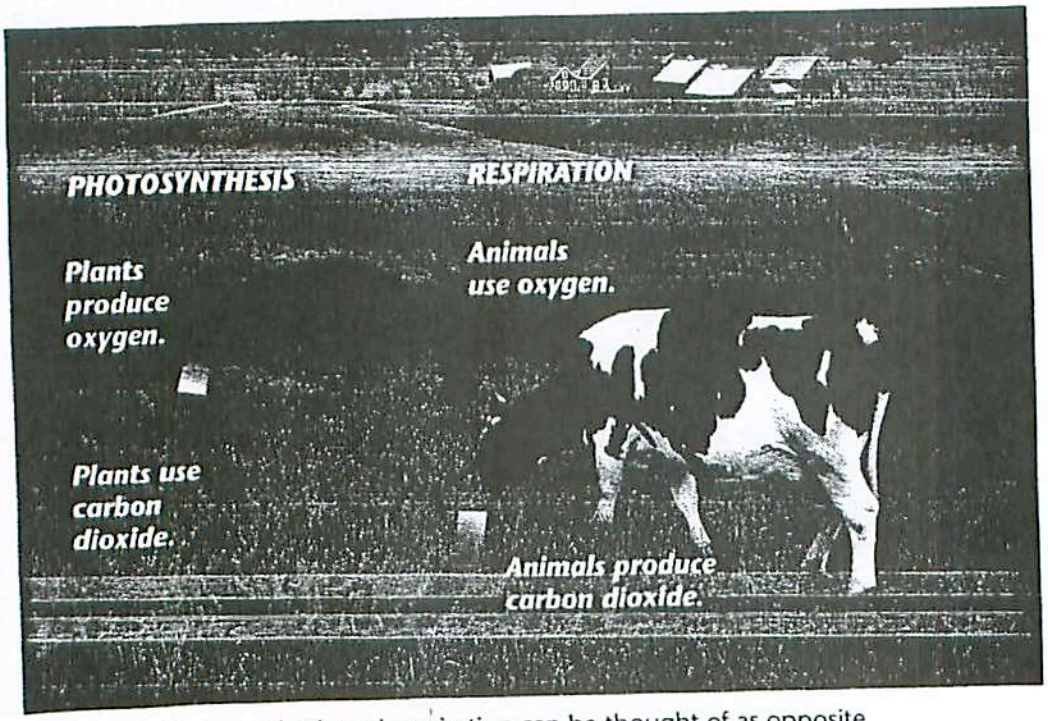


Figure 14 Photosynthesis and respiration can be thought of as opposite processes. *Interpreting Photographs How do these two processes keep the levels of oxygen and carbon dioxide in the atmosphere fairly constant?*

Comparing Photosynthesis and Respiration

Do you notice anything familiar about the equation for respiration? You are quite right if you said it is the opposite of the equation for photosynthesis. This is an important point to remember. During photosynthesis, carbon dioxide and water are used to produce sugars and oxygen. During respiration, glucose (a sugar) and oxygen are used to produce carbon dioxide and water. **Photosynthesis and respiration can be thought of as opposite processes.** Together, these two processes form a cycle that keeps the levels of oxygen and carbon dioxide fairly constant in the atmosphere. As you can see in Figure 14, living things use both gases over and over again.

Fermentation

Some cells are able to obtain energy from food without using oxygen. For example, some single-celled organisms live where there is no oxygen, such as deep in the ocean or in the mud of lakes or swamps. These organisms obtain their energy through **fermentation,** an energy-releasing process that does not require oxygen. **Fermentation provides energy for cells without using oxygen.** The amount of energy released from each sugar molecule during fermentation, however, is much lower than the amount released during respiration.

Social Studies CONNECTION

Many popular Asian foods are produced by fermentation. Kimchee, for example, is a Korean side dish that is similar to sauerkraut. It is made from Asian cabbage, salt, and spices. Naturally occurring bacteria ferment sugars in the cabbage by lactic-acid fermentation. The lactic acid produced during the fermentation process gives the kimchee a tangy flavor. Other Asian foods produced by fermentation include soy sauce and miso.

In Your Journal

Write an ad for kimchee or another fermented food product. Include information about how the food is made and used.

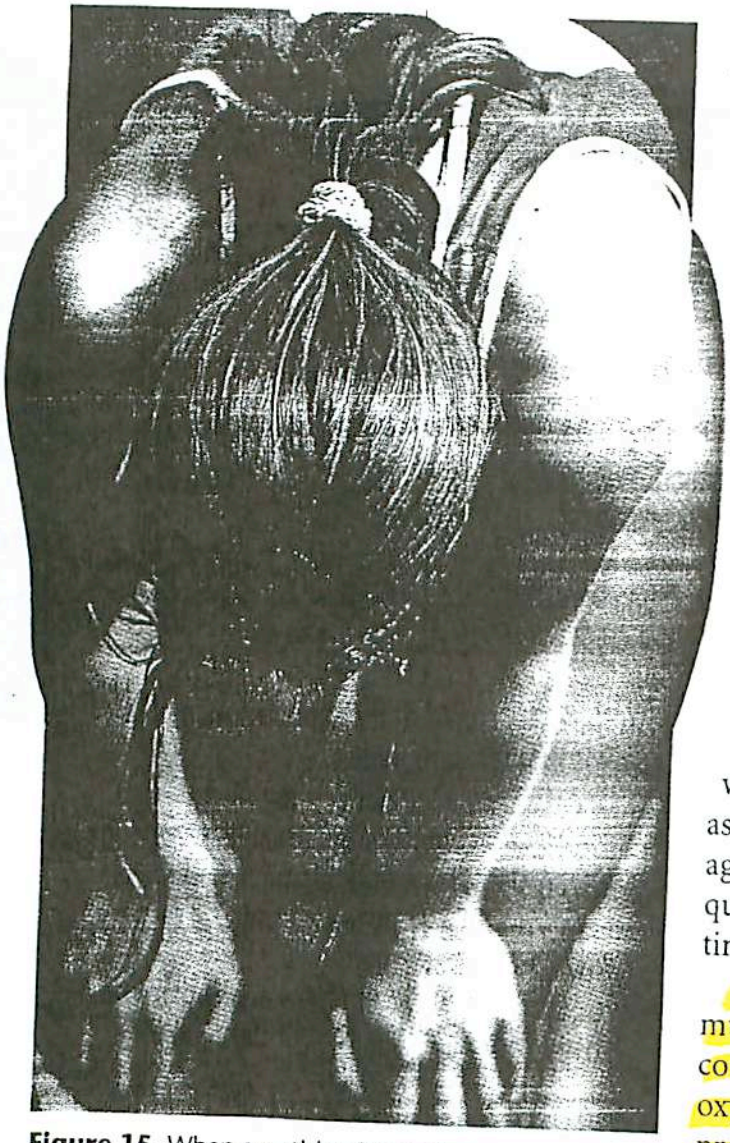


Figure 15 When an athlete's muscles run out of oxygen, lactic-acid fermentation occurs. The athlete's muscles feel tired and sore. *Inferring Which muscles in this runner were producing the most lactic acid?*

Alcoholic Fermentation One type of fermentation occurs in yeast and some other single-celled organisms. This process is sometimes called alcoholic fermentation because alcohol is one of the products made when these organisms break down sugars. The other products are carbon dioxide and a small amount of energy.

The products of alcoholic fermentation are important to bakers and brewers. The carbon dioxide produced by yeast causes dough to rise, and it creates the air pockets you see in bread. Carbon dioxide is also the source of bubbles in alcoholic drinks such as beer and sparkling wine.

Lactic-Acid Fermentation Another type of fermentation takes place at times in your body, and you've probably felt its effects. Think of a time when you've run as fast as you could for as long as you could. Your leg muscles were pushing hard against the pavement, and you were breathing quickly. Eventually, however, your legs became tired and you couldn't run any more.

Integrating Health

No matter how hard you breathed, your muscle cells used up the oxygen faster than it could be replaced. Because your cells lacked oxygen, they used the process of fermentation to produce energy. One by-product of this type of fermentation is a substance known as lactic acid. When lactic acid builds up, your muscles feel weak, tired, and sore.

Section 4 Review

1. Why is respiration important for a cell?
2. Explain the relationship between photosynthesis and respiration.
3. Which raw material is *not* needed for fermentation to occur?
4. How do plants and animals maintain the level of oxygen in the atmosphere?
5. **Thinking Critically Applying Concepts** Do plant cells need to carry out respiration? Explain.

Science at Home

Fermentation in Bread With an adult family member, follow a recipe in a cookbook to make a loaf of bread using yeast. Explain to your family what causes the dough to rise. After you bake the bread, observe a slice and look for evidence that fermentation occurred.

Real-World Lab

Gases in Balance

Problem

How are photosynthesis and respiration related?

Skills Focus

controlling variables, interpreting data

Materials

marking pens
2 *Elodea* plants
plastic graduated cylinder, 100-mL
bromthymol blue solution
3 flasks with stoppers, 250-mL
straws
light source

Procedure

1. Bromthymol blue can be used to test for carbon dioxide. To see how this dye works, pour 100 mL of bromthymol blue solution into a flask. Record its color. **CAUTION:** *Bromthymol blue can stain skin and clothing. Avoid spilling or splashing it on yourself.*
2. Provide a supply of carbon dioxide by gently blowing into the solution through a straw until the dye changes color. Record the new color. **CAUTION:** *Do not inhale any of the solution through the straw.*
3. Copy the data table into your notebook. Add 100 mL of bromthymol blue to the other flasks. Then blow through clean straws into each solution until the color changes.
4. Now you will test to see what gas is used by a plant in the presence of light. Obtain two *Elodea* plants of about the same size.
5. Place one plant into the first flask. Label the flask "L" for light. Place the other plant in the second flask. Label the flask "D" for darkness. Label the third flask "C" for control. Put stoppers in all three flasks.

DATA TABLE

	Color of Solution	
Flask	Day 1	Day 2
L (light)		
D (dark)		
C (control)		

6. Record the colors of the three solutions under Day 1 in your data table.
7. Place the flasks labeled L and C in a lighted location as directed by your teacher. Place the flask labeled D in a dark location as directed by your teacher. Wash your hands thoroughly when you have finished.
8. On Day 2, examine the flasks and record the colors of the solutions in your data table.

Analyze and Conclude

1. Explain why the color of each solution did or did not change from Day 1 to Day 2.
2. Why was it important to include the flask labeled C as part of this experiment?
3. Predict what would happen if you blew into the flask labeled L after you completed Step 8. Explain your prediction.
4. **Apply** How does this lab show that photosynthesis and respiration are opposite processes? Why are both processes necessary to maintain an environment suitable for living things?

More to Explore

Suppose you were to put an *Elodea* plant and a small fish in a stoppered flask. Predict what would happen to the levels of oxygen and carbon dioxide in the flask. Explain your prediction.

SECTION 5 Cell Division

DISCOVER

Activity

What Are the Cells Doing?

1. Use a plastic dropper to transfer some yeast cells from a yeast culture to a microscope slide. Your teacher has prepared the slide by drying methylene blue stain onto it. Add a coverslip and place the slide under a microscope.

2. Examine the cells on the slide. Use low power first, then high power. Look for what appears to be two cells attached to each other. One cell may be larger than the other. Draw what you see.

Think It Over

Developing Hypotheses What process do you think the "double cells" are undergoing? Develop a hypothesis that might explain what you see.

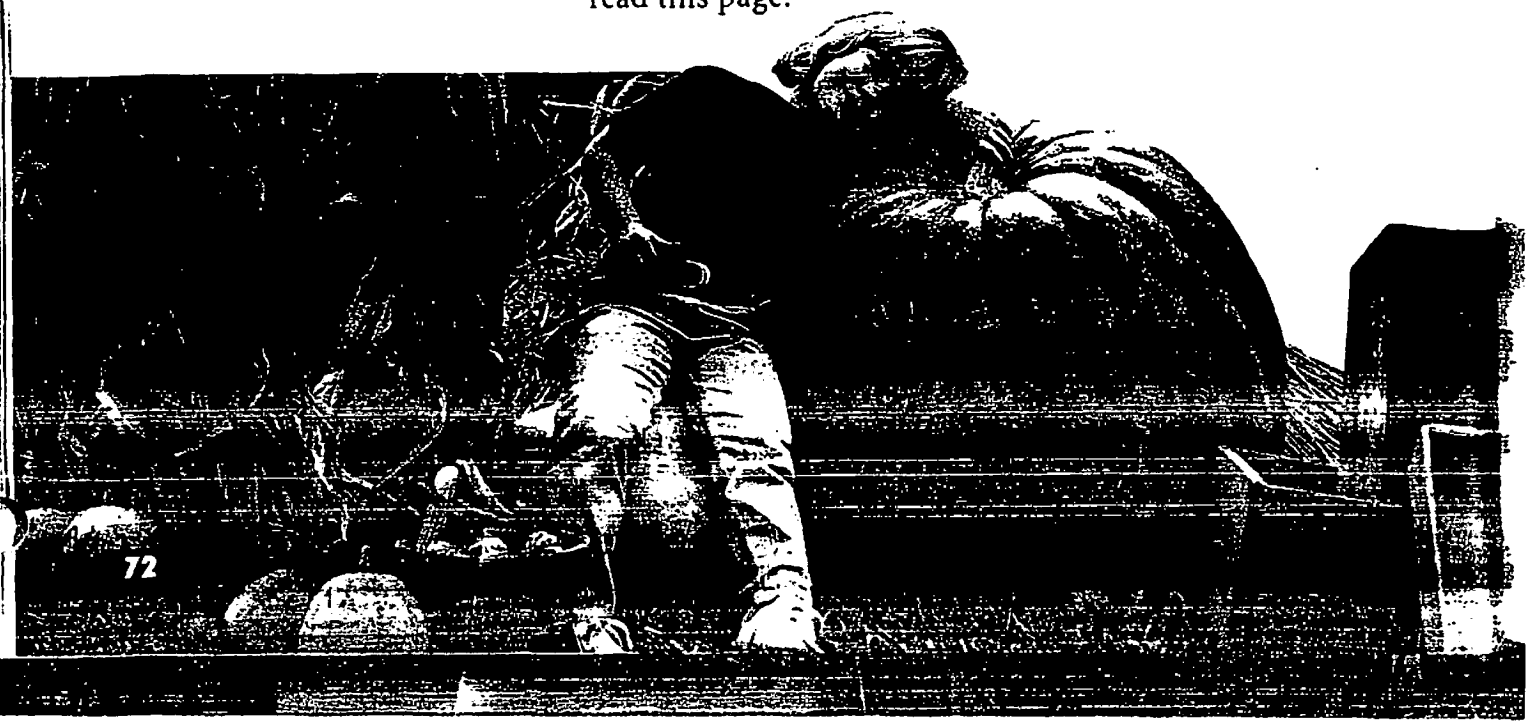
GUIDE FOR READING

- **What events take place during the three stages of the cell cycle?**
- **What is the role of DNA replication?**

Reading Tip **Before you read, use the headings to outline the process of cell division. As you read, draw pictures to help you understand the process.**

In the early autumn, many local fairs run pumpkin contests. Proud growers enter their largest pumpkins, hoping to win a prize. If you've never seen these prize-winning pumpkins, you would be amazed. Some have masses close to 400 kilograms and can be as big as a doghouse. What's even more amazing is that these giant pumpkins began as small flowers on pumpkin plants. How did the pumpkins grow so big?

A pumpkin grows in size by increasing both the size and the number of its cells. A single cell divides, forming two cells. Then two cells divide, forming four, and so on. This process of cell division does not occur only in pumpkins, though. In fact, many cells in your body are undergoing cell division as you read this page.



The Cell Cycle

Think about the cells you learned about in Chapter 1. Each cell contains many different structures, including a cell membrane, a nucleus, mitochondria, and ribosomes. To divide into two equal parts, the cell would need to either duplicate the structures or divide them equally between the two new cells. Both cells would then contain everything they need in order to survive and carry out their life functions.

The regular sequence of growth and division that cells undergo is known as the **cell cycle.** You can see details of the cell cycle in *Exploring the Cell Cycle* on pages 76 and 77. Notice that the cell cycle is divided into three main stages. As you read about each stage, follow the events that occur as one "parent" cell divides to form two identical "daughter" cells.

Figure 16 The cells that make up this young monkey are the same size as those that make up its mother. However, the adult has many more cells in its body. ***Applying Concepts*** *What is the name of the regular sequence of growth and division that a cell undergoes?*

Stage 1: Interphase

The first stage of the cell cycle is called **interphase.** Interphase is the period before cell division occurs. Even though it is not dividing, the cell is quite active during this stage. **During interphase, the cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.**

Growth During the first part of interphase, the cell doubles in size and produces all the structures needed to carry out its functions. For example, the cell enlarges its endoplasmic reticulum, makes new ribosomes, and produces enzymes. Both mitochondria and chloroplasts make copies of themselves during the growth stage. The cell matures to its full size and structure.

DNA Replication After a cell has grown to its mature size, the next part of interphase begins. The cell makes a copy of the DNA in its nucleus in a process called **replication.** Recall that DNA is a nucleic acid found in the chromatin in a cell's nucleus. DNA holds all the information that the cell needs to carry out its functions. The replication of a cell's DNA is very important, since each daughter cell must have a complete set of DNA to survive. At the end of DNA replication, the cell contains two identical sets of DNA. One set will be distributed to each daughter cell. You will learn the details of DNA replication later in this section.

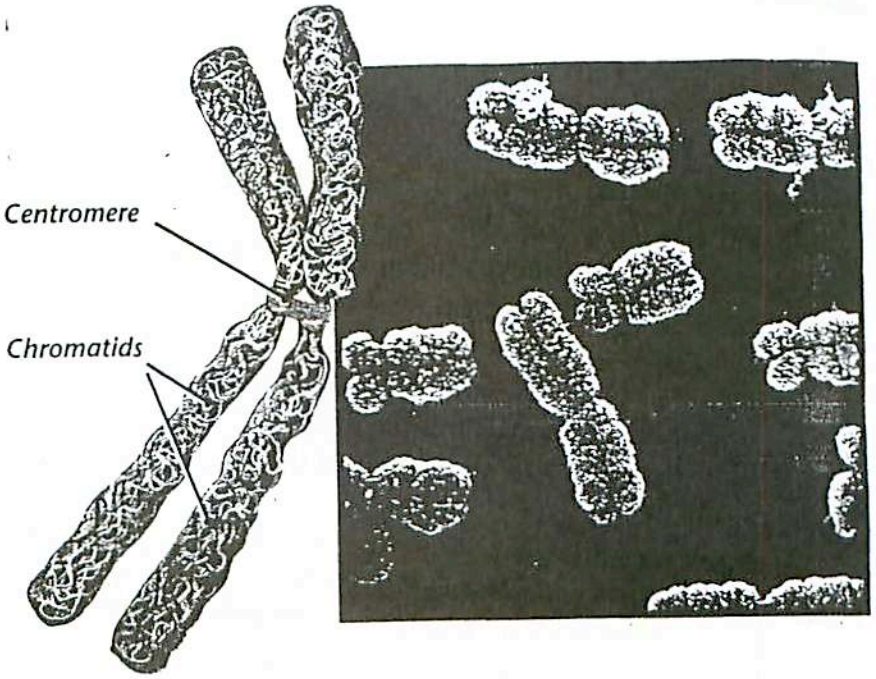


Figure 17 During mitosis, the chromatin condenses to form rodlike chromosomes. Each chromosome consists of two identical strands, or chromatids. ***Interpreting Diagrams*** *What is the name of the structure that holds the chromatids together?*

Preparation for Division Once the cell's DNA has replicated, preparation for cell division begins. The cell produces structures that it will use to divide during the rest of the cell cycle. At the end of interphase, the cell is ready to divide.

Stage 2: Mitosis

Once interphase is complete, the second stage of the cell cycle begins. **Mitosis** (my TOH sis) is the stage during which the cell's nucleus divides into two new nuclei. **During mitosis, one copy of the DNA is distributed into each of the two daughter cells.**

Scientists divide mitosis into four parts, or phases: prophase, metaphase, anaphase, and telophase. During prophase, the threadlike chromatin in the cell's nucleus begins to condense and coil, like fishing line wrapping around a ball. Under a light microscope, the condensed chromatin looks like tiny rods, as you can see in Figure 17. Since the cell's DNA has replicated, each rod has doubled. Each is an exact copy of the other. Scientists call each doubled rod of condensed chromatin a **chromosome.** Each identical rod, or strand, of the chromosome is called a **chromatid.** The two strands are held together by a structure called a centromere.

As the cell progresses through metaphase, anaphase, and telophase, the chromatids separate from each other and move to opposite ends of the cell. Then two nuclei form around the chromatids at the two ends of the cell. You can follow this process in *Exploring the Cell Cycle.*

☑ ***Checkpoint*** *During which stage of mitosis does the chromatin condense to form rodlike structures?*

TRY THIS

Modeling Mitosis

Refer to ACTIVITY *Exploring the Cell Cycle* as you carry out this activity.

1. Construct a model of a cell that has three chromosomes. Use a piece of construction paper to represent the cell. Use different colored pipe cleaners to represent the chromosomes. Make sure that the chromosomes look like double rods.
2. Position the chromosomes in the cell where they would be during prophase.
3. Repeat Step 2 for metaphase, anaphase, and telophase.

Making Models How did the model help you understand the events of mitosis?

Stage 3: Cytokinesis

After mitosis, the final stage of the cell cycle, called cytokinesis (sy toh kih NEE sis), completes the process of cell division. **During cytokinesis, the cytoplasm divides, distributing the organelles into each of the two new cells.** Cytokinesis usually starts at about the same time as telophase.

During cytokinesis in animal cells, the cell membrane squeezes together around the middle of the cell. The cytoplasm pinches into two cells with about half of the organelles in each daughter cell.

Cytokinesis is somewhat different in plant cells. A plant cell's rigid cell wall cannot squeeze together in the same way that a cell membrane can. Instead, a structure called a cell plate forms across the middle of the cell. The cell plate gradually develops into new cell membranes between the two daughter cells. New cell walls then form around the cell membranes.

There are many variations of the basic pattern of cytokinesis. For example, yeast cells divide, though not equally. A small daughter cell, or bud, pinches off of the parent cell. The bud then grows into a full-sized yeast cell.

Cytokinesis marks the end of the cell cycle. Two new cells have formed. Each daughter cell has the same number of chromosomes as the original parent cell. At the end of cytokinesis, each cell enters interphase, and the cycle begins again.

Checkpoint *When in the cell cycle does cytokinesis begin?*

Length of the Cell Cycle

How long does it take for a cell to go through one cell cycle? The answer depends on the type of cell. In a young sea urchin, for example, one cell cycle takes about 2 hours. In contrast, a human liver cell completes one cell cycle in about 22 hours, as shown in Figure 18. The length of each stage in the cell cycle also varies greatly from cell to cell. Some cells, such as human brain cells, never divide—they remain in the first part of interphase for as long as they live.

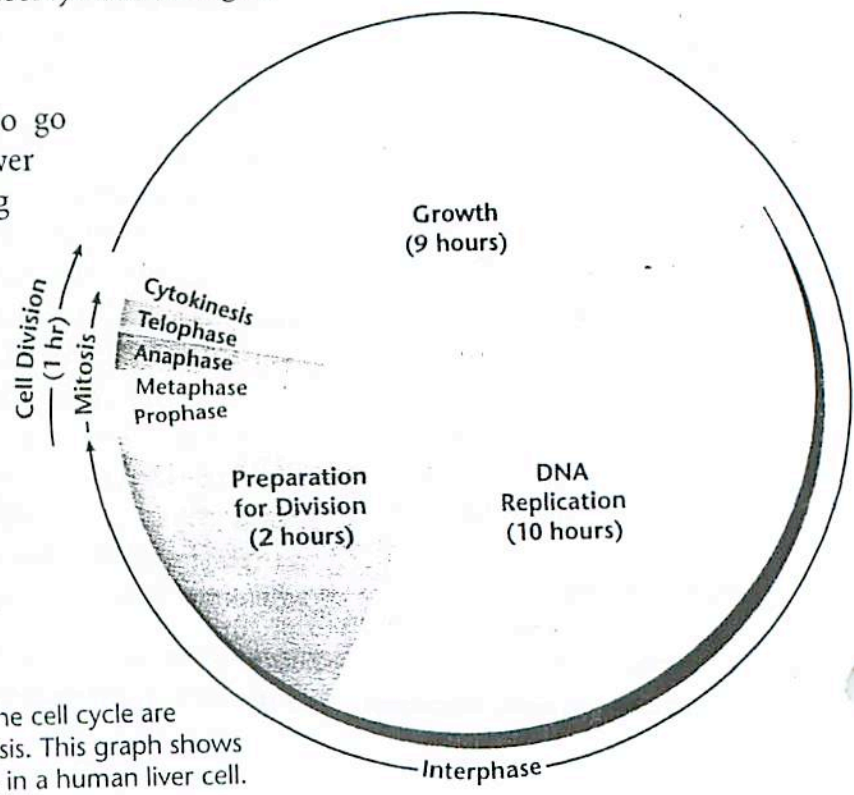


Figure 18 The main stages of the cell cycle are interphase, mitosis, and cytokinesis. This graph shows the average length of each stage in a human liver cell.

Sharpen your Skills

Interpreting Data

ACTIVITY

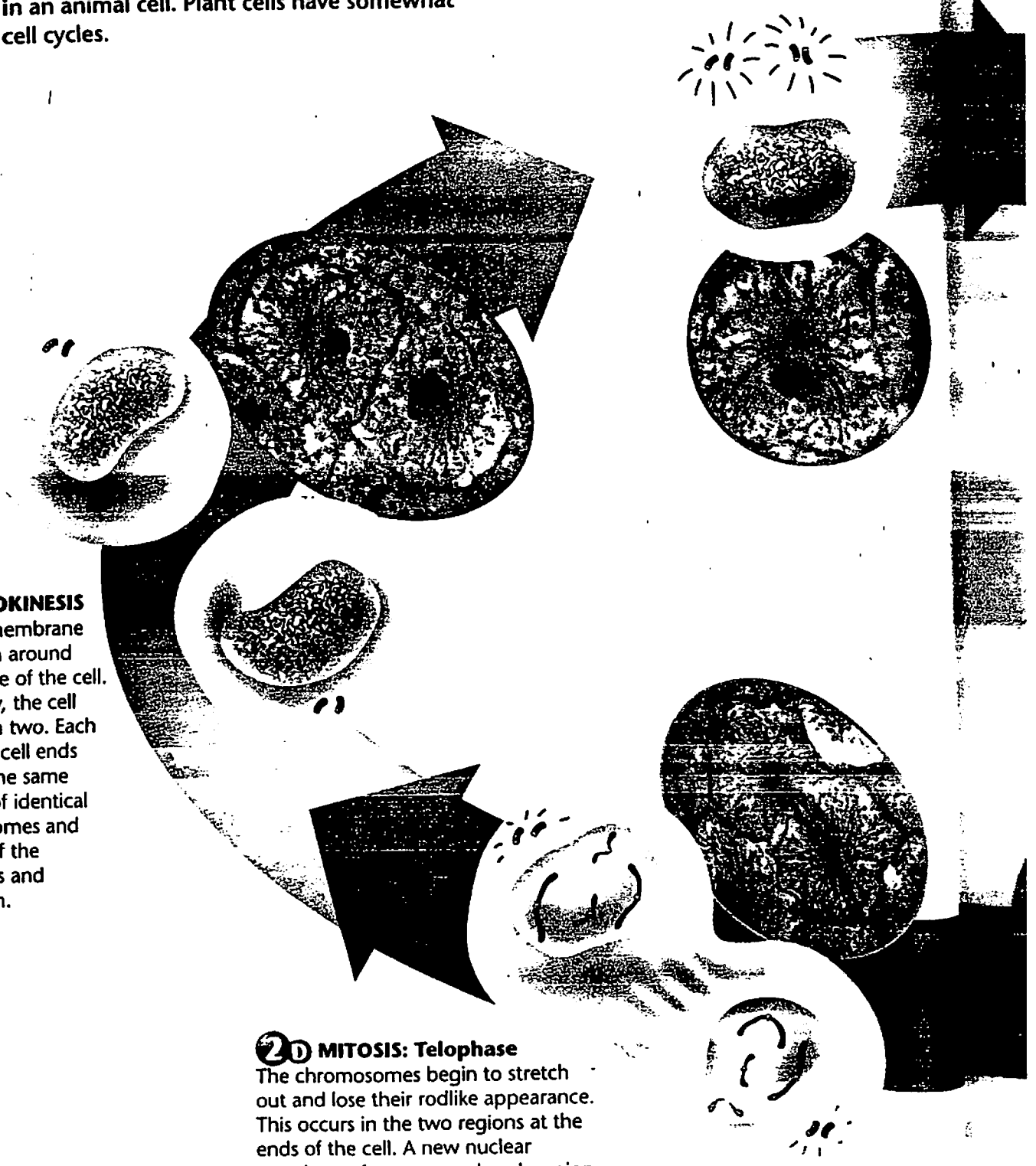
Use the circle graph shown in Figure 18 to answer the following questions.

1. How long is the cell cycle shown in the graph?
2. Which stage of the cell cycle would you expect more of the cells to be in at any given time—interphase, mitosis, or cytokinesis? Explain.

EXPLORING *the Cell Cycle*

Cells undergo an orderly sequence of events as they grow and divide. The sequence shown here is a typical cell cycle in an animal cell. Plant cells have somewhat different cell cycles.

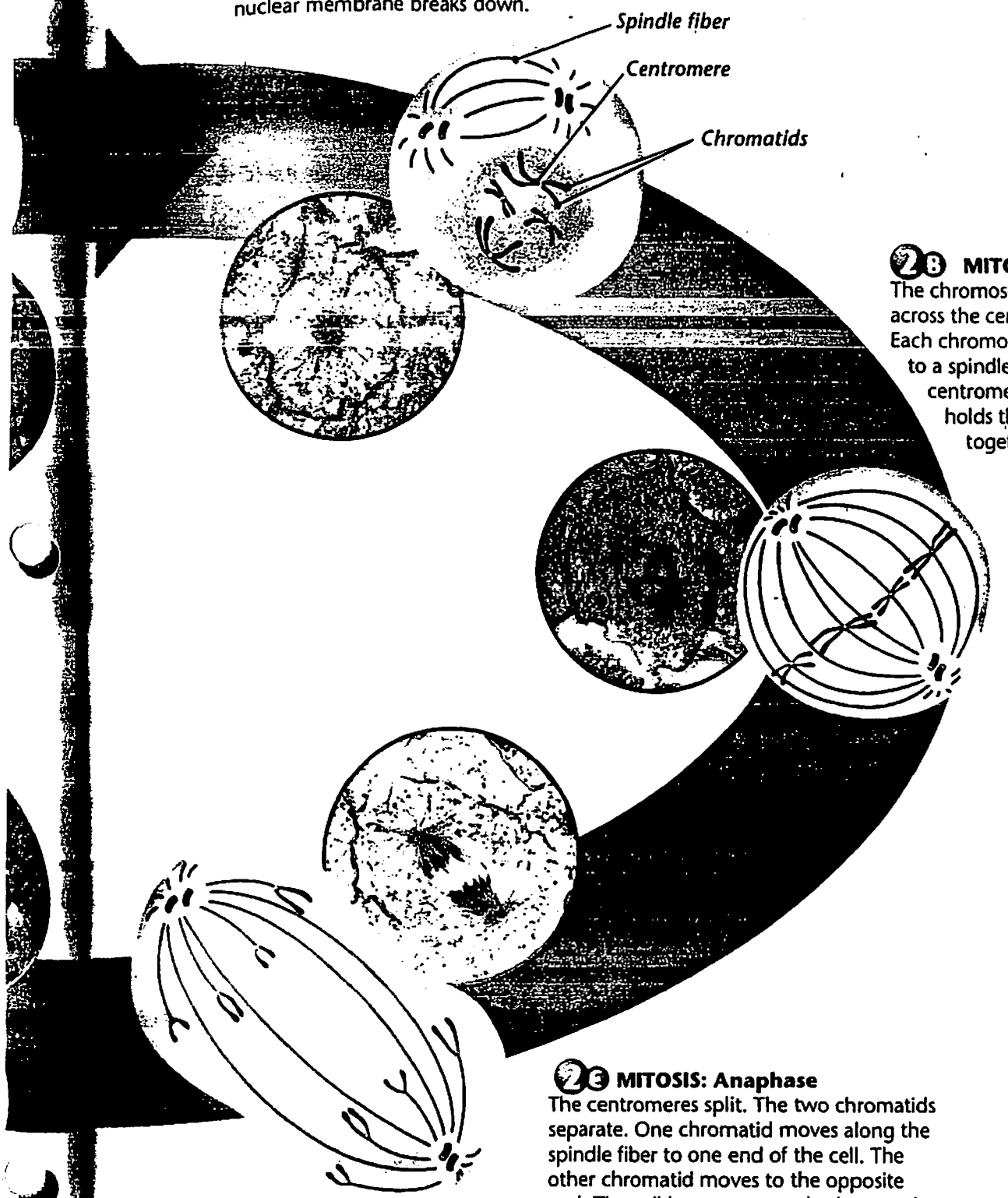
1 INTERPHASE
The cell grows to its mature size, makes a copy of its DNA, and prepares to divide into two cells.



3 CYTOKINESIS
The cell membrane pinches in around the middle of the cell. Eventually, the cell pinches in two. Each daughter cell ends up with the same number of identical chromosomes and about half the organelles and cytoplasm.

2 D MITOSIS: Telophase
The chromosomes begin to stretch out and lose their rodlike appearance. This occurs in the two regions at the ends of the cell. A new nuclear membrane forms around each region of chromosomes.

MITOSIS: Prophase
The chromatin in the nucleus condenses to form chromosomes. Structures called spindle fibers form a bridge between the ends of the cell. The nuclear membrane breaks down.



MITOSIS: Metaphase
The chromosomes line up across the center of the cell. Each chromosome attaches to a spindle fiber at its centromere, which still holds the chromatids together.

MITOSIS: Anaphase
The centromeres split. The two chromatids separate. One chromatid moves along the spindle fiber to one end of the cell. The other chromatid moves to the opposite end. The cell becomes stretched out as the opposite ends pull apart.

Figure 19 A DNA molecule is shaped like a twisted ladder. The sides are made up of sugar and phosphate molecules. The rungs are formed by pairs of nitrogen bases. *Classifying Which base always pairs with adenine?*

DNA Replication

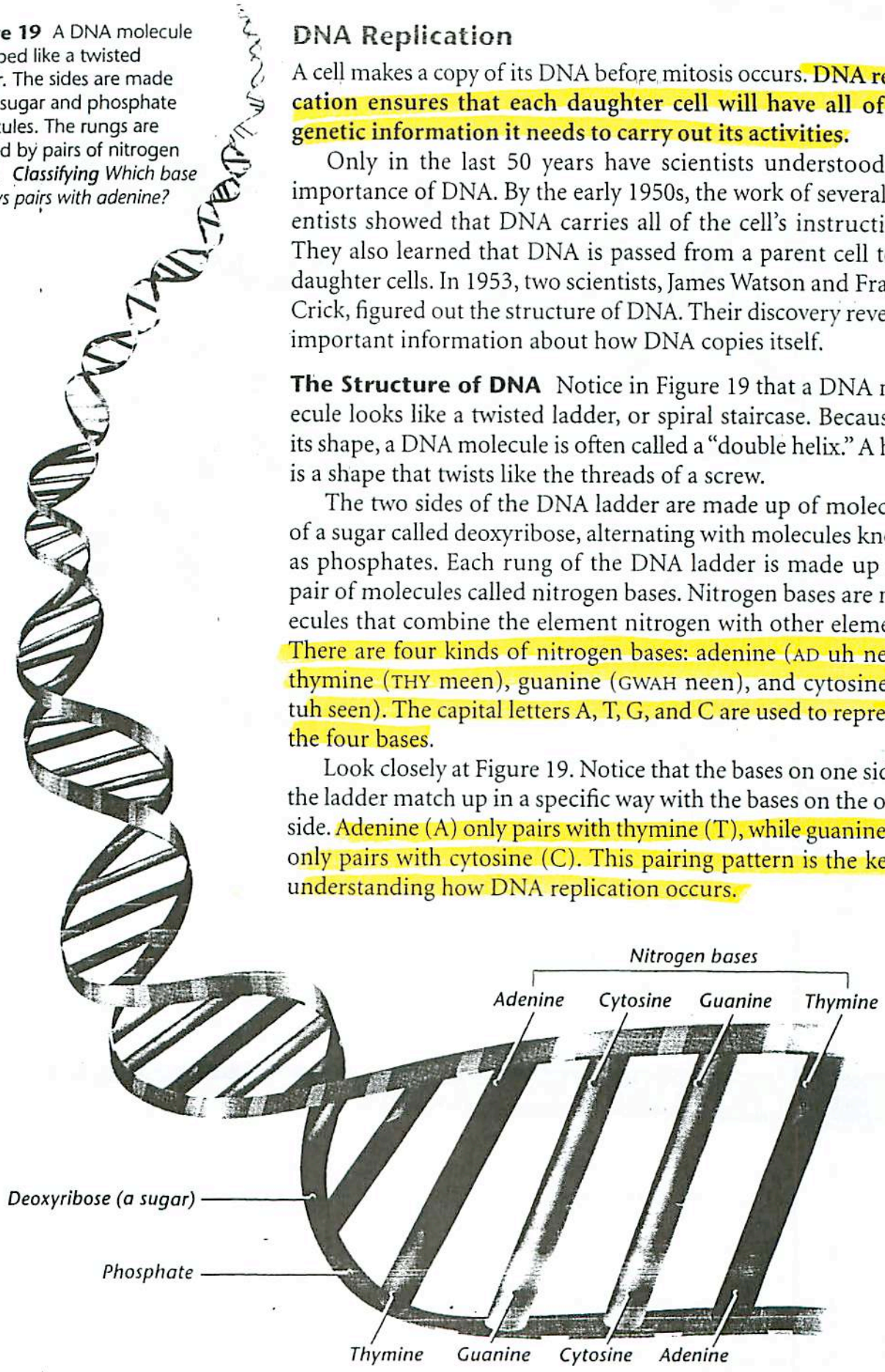
A cell makes a copy of its DNA before mitosis occurs. **DNA replication ensures that each daughter cell will have all of the genetic information it needs to carry out its activities.**

Only in the last 50 years have scientists understood the importance of DNA. By the early 1950s, the work of several scientists showed that DNA carries all of the cell's instructions. They also learned that DNA is passed from a parent cell to its daughter cells. In 1953, two scientists, James Watson and Francis Crick, figured out the structure of DNA. Their discovery revealed important information about how DNA copies itself.

The Structure of DNA Notice in Figure 19 that a DNA molecule looks like a twisted ladder, or spiral staircase. Because of its shape, a DNA molecule is often called a "double helix." A helix is a shape that twists like the threads of a screw.

The two sides of the DNA ladder are made up of molecules of a sugar called deoxyribose, alternating with molecules known as phosphates. Each rung of the DNA ladder is made up of a pair of molecules called nitrogen bases. Nitrogen bases are molecules that combine the element nitrogen with other elements. There are four kinds of nitrogen bases: adenine (AD uh neen), thymine (THY meen), guanine (GWAH neen), and cytosine (SY tuh seen). The capital letters A, T, G, and C are used to represent the four bases.

Look closely at Figure 19. Notice that the bases on one side of the ladder match up in a specific way with the bases on the other side. Adenine (A) only pairs with thymine (T), while guanine (G) only pairs with cytosine (C). This pairing pattern is the key to understanding how DNA replication occurs.



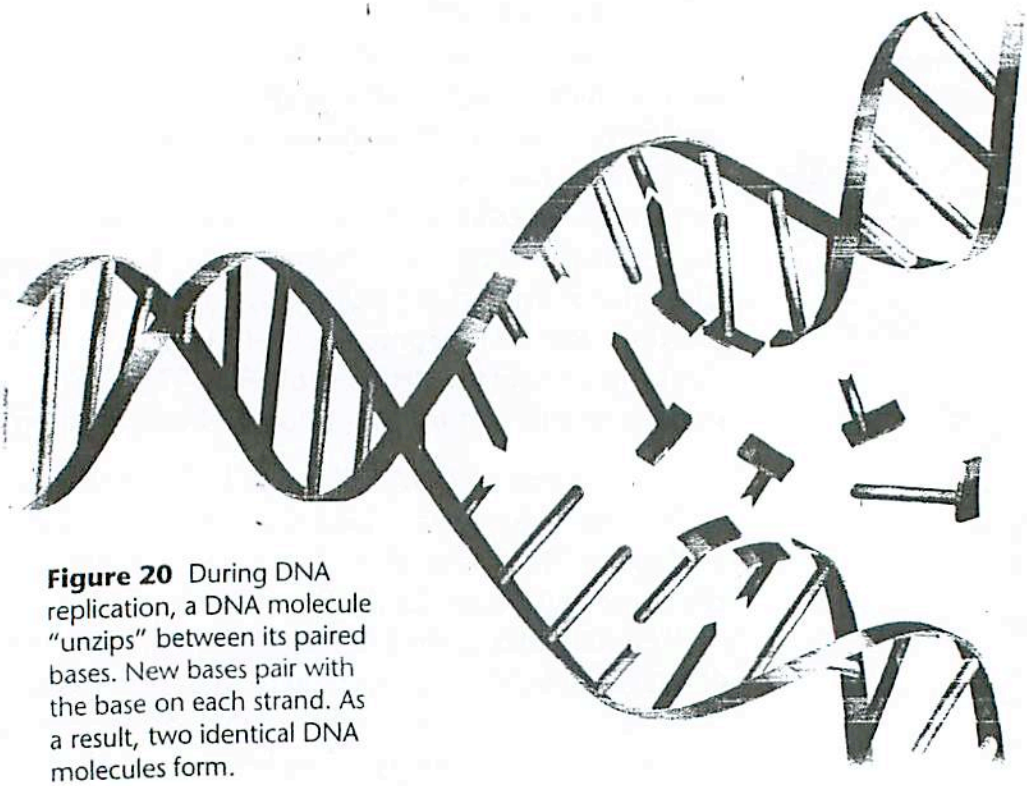


Figure 20 During DNA replication, a DNA molecule "unzips" between its paired bases. New bases pair with the base on each strand. As a result, two identical DNA molecules form.

The Replication Process DNA replication begins when the two sides of the DNA molecule unwind and separate, like a zipper unzipping. As you can see in Figure 20, the molecule separates between the paired nitrogen bases on each rung. Next, nitrogen bases that are floating in the nucleus pair up with the bases on each half of the DNA molecule. Remember that the pairing of bases follows definite rules: A always pairs with T, while G always pairs with C. Once the new bases are attached, two new DNA molecules are formed. The order of the bases in each new DNA molecule will exactly match the order in the original DNA molecule.

Section 5 Review

1. What are the three main stages of the cell cycle? Briefly describe the events that occur at each stage.
2. Why must the DNA in a cell replicate before the cell divides?
3. How does cytokinesis differ in plant and animal cells?
4. **Thinking Critically Predicting** Suppose that during anaphase, the centromeres did not split, and the chromatids did not separate. Predict the results.

CHAPTER PROJECT

Check Your Progress

Begin to think about why the egg changed as it did at each stage of the project. Consider how each of the different substances affected your egg. (*Hint:* Water plays a crucial role in the activities of a cell. How has water been involved in your investigation?) Organize your results into a report and make a graph of your egg's changing circumference. You may want to include diagrams to explain the processes that took place.

Skills Lab

Multiplying by Dividing

Problem

How long do the stages of the cell cycle take?

Materials

microscope
colored pencils
calculator (optional)
prepared slides of onion root tip cells undergoing cell division

Procedure

1. Place the slide on the stage of a microscope. Use low power to locate a cell in interphase. Then switch to high power, and make a labeled drawing of the cell. **CAUTION:** *Slides and coverslips break easily. Do not allow the objective to touch the slide. If the slide breaks, notify your teacher. Do not touch broken glass.*
2. Repeat Step 1 to find cells in prophase, metaphase, anaphase, and telophase. Then copy the data table into your notebook.
3. Return to low power. Find an area of the slide with many cells undergoing cell division. Switch to the magnification that lets you see about 50 cells at once (for example, 100 ×).
4. Examine the cells row by row, and count the cells that are in interphase. Record that number in the data table under *First Sample.*
5. Examine the cells row-by-row four more times to count the cells in prophase, metaphase, anaphase, and telophase. Record the results.
6. Move to a new area on the slide. Repeat Steps 3–5 and record your counts in the column labeled *Second Sample.*
7. Fill in the column labeled *Total Number* by adding the numbers across each row in your data table.
8. Add the totals for the five stages to find the total number of cells counted.

DATA TABLE

Stage of Cell Cycle	First Sample	Second Sample	Total Number
Interphase			
Mitosis: Prophase			
Metaphase			
Anaphase			
Telophase			
Total number of cells counted			

Analyze and Conclude

1. Which stage of the cell cycle did you observe most often?
2. The cell cycle for onion root tips takes about 720 minutes (12 hours). Use your data and the formula below to find the number of minutes each stage takes.

$$\text{Time for each stage} = \frac{\text{Number of cells at each stage}}{\text{Total number of cells counted}} \times 720 \text{ min}$$

3. **Think About It** Use the data to compare the amount of time spent in mitosis with the total time for the whole cell cycle.

More to Explore

Examine prepared slides of animal cells undergoing cell division. Use drawings and descriptions to compare plant and animal mitosis.

CHAPTER 2 STUDY GUIDE

SECTION 1 Chemical Compounds in Cells

INTEGRATING CHEMISTRY

Key Ideas

- When two or more elements combine chemically, they form a compound.
- Organic compounds in living things include proteins, carbohydrates, lipids, and nucleic acids.
- Without water, most chemical reactions within cells could not take place.

Key Terms

element
atom
compound
molecule
organic compound
inorganic compound
protein
amino acid
enzyme
carbohydrate
lipid
nucleic acid
DNA
RNA

SECTION 2 The Cell in Its Environment

Key Ideas

- Substances can move into and out of a cell by diffusion, osmosis, or active transport.
- Active transport requires the cell to use energy while passive transport does not.

Key Terms

selectively permeable
diffusion
osmosis
passive transport
active transport

SECTION 3 Photosynthesis

Key Ideas

- During photosynthesis, plants use energy from the sun to convert carbon dioxide and water into oxygen and sugars.
- Chlorophyll and other plant pigments capture energy from sunlight. Cells use the energy to produce sugars from carbon dioxide and water.
- Most living things obtain the energy they need either directly or indirectly from the sun.

Key Terms

photosynthesis
pigment
chlorophyll
stomata

SECTION 4 Respiration

Key Ideas

- Respiration is a process in which cells break down simple food substances, such as glucose, and release the energy they contain.
- During respiration, glucose and oxygen are converted into carbon dioxide and water.

Key Terms

respiration
fermentation

SECTION 5 Cell Division

Key Ideas

- Cells go through a regular cycle of growth and division called the cell cycle.
- The major phases of the cell cycle are interphase, mitosis, and cytokinesis.

Key Terms

cell cycle
interphase
replication
mitosis
chromosome
chromatid
cytokinesis

Organizing Information

Cycle Diagram Copy the cycle diagram about the cell cycle onto a separate sheet of paper. Then complete it and add a title. (For more on cycle diagrams, see the Skills Handbook.)