

4

The Cell in Action

The Big Idea

Cells carry out important life functions including taking in nutrients and releasing materials, obtaining energy, and growing.

SECTION

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About the PHOTO

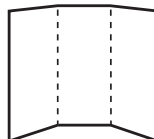
This adult katydid is emerging from its last immature, or nymph, stage. As the katydid changed from a nymph to an adult, every structure of its body changed. To grow and change, an organism must produce new cells. When a cell divides, it makes a copy of its genetic material.

PRE-READING ACTIVITY



Tri-Fold Before you read the chapter, create the FoldNote entitled “Tri-Fold”

described in the **Study Skills** section of the Appendix. Write what you know about the actions of cells in the column labeled “Know.” Then, write what you want to know in the column labeled “Want.” As you read the chapter, write what you learn about the actions of cells in the column labeled “Learn.”





START-UP ACTIVITY

Cells in Action

Yeast are single-celled fungi that are an important ingredient in bread. Yeast cells break down sugar molecules to release energy. In the process, carbon dioxide gas is produced, which causes bread dough to rise.

Procedure

1. Add **4 mL of a sugar solution** to **10 mL of a yeast-and-water mixture**. Use a **stirring rod** to thoroughly mix the two liquids.
2. Pour the stirred mixture into a small test tube.
3. Place a slightly **larger test tube** over the **small test tube**. The top of the small test tube should touch the bottom of the larger test tube.
4. Hold the test tubes together, and quickly turn both test tubes over. Place the test tubes in a test-tube rack.
5. Use a **ruler** to measure the height of the fluid in the large test tube. Wait 20 min, and then measure the height of the liquid again.

Analysis

1. What is the difference between the first height measurement and the second height measurement?
2. What do you think caused the change in the fluid's height?

Exchange with the Environment

What You Will Learn

- Explain the process of diffusion.
- Describe how osmosis occurs.
- Compare passive transport with active transport.
- Explain how large particles get into and out of cells.

Vocabulary

diffusion
osmosis
passive transport
active transport
endocytosis
exocytosis

READING STRATEGY

Reading Organizer As you read this section, make a table comparing active transport and passive transport.

diffusion the movement of particles from regions of higher density to regions of lower density

What would happen to a factory if its power were shut off or its supply of raw materials never arrived? What would happen if the factory couldn't get rid of its garbage?

Like a factory, an organism must be able to obtain energy and raw materials and get rid of wastes. An organism's cells perform all of these functions. These functions keep cells healthy so that they can divide. Cell division allows organisms to grow and repair injuries.

The exchange of materials between a cell and its environment takes place at the cell's membrane. To understand how materials move into and out of the cell, you need to know about diffusion.

What Is Diffusion?

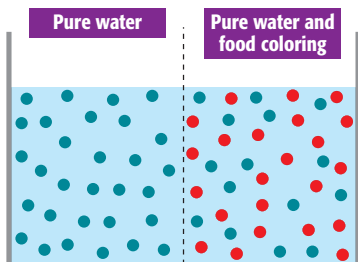
What happens if you pour dye on top of a layer of gelatin? At first, it is easy to see where the dye ends and the gelatin begins. But over time, the line between the two layers will blur, as shown in **Figure 1**. Why? Everything, including the gelatin and the dye, is made up of tiny moving particles. Particles travel from where they are crowded to where they are less crowded. This movement from areas of high concentration (crowded) to areas of low concentration (less crowded) is called **diffusion** (di FYOO zhuhn). Dye particles diffuse from where they are crowded (near the top of the glass) to where they are less crowded (in the gelatin). Diffusion also happens within and between living cells. Cells do not need to use energy for diffusion.



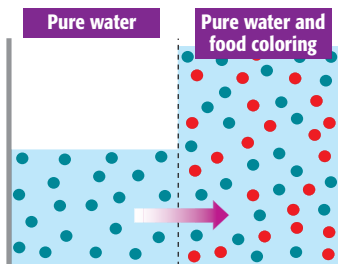
Figure 1 The particles of the dye and the gelatin slowly mix by diffusion.

Figure 2 Osmosis

- 1** The side that holds only pure water has the higher concentration of water particles.



- 2** During osmosis, water particles move to where they are less concentrated.



Diffusion of Water

The cells of organisms are surrounded by and filled with fluids that are made mostly of water. The diffusion of water through cell membranes is so important to life processes that it has been given a special name—**osmosis** (ahs MOH sis).

Water is made up of particles, called *molecules*. Pure water has the highest concentration of water molecules. When you mix something, such as food coloring, sugar, or salt, with water, you lower the concentration of water molecules. **Figure 2** shows how water molecules move through a membrane that is semipermeable (SEM i PUHR mee uh buhl). *Semipermeable* means that only certain substances can pass through. The picture on the left in **Figure 2** shows liquids that have different concentrations of water. Over time, the water molecules move from the liquid with the high concentration of water molecules to the liquid with the lower concentration of water molecules.

The Cell and Osmosis

Osmosis is important to cell functions. For example, red blood cells are surrounded by plasma. Plasma is made up of water, salts, sugars, and other particles. The concentration of these particles is kept in balance by osmosis. If red blood cells were in pure water, water molecules would flood into the cells and cause them to burst. When red blood cells are put into a salty solution, the concentration of water molecules inside the cell is higher than the concentration of water outside. This difference makes water move out of the cells, and the cells shrivel up. Osmosis also occurs in plant cells. When a wilted plant is watered, osmosis makes the plant firm again.

✓ Reading Check Why would red blood cells burst if you placed them in pure water? (See the Appendix for answers to Reading Checks.)

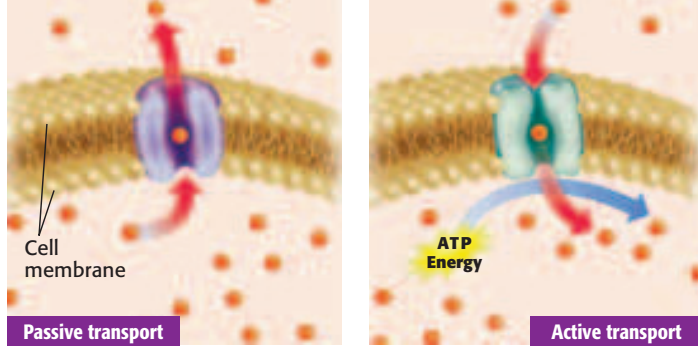
osmosis the diffusion of water through a semipermeable membrane



Bead Diffusion

1. Put three groups of **colored beads** on the bottom of a **plastic bowl**. Each group should be made up of five beads of the same color.
2. Stretch some **clear plastic wrap** tightly over the top of the bowl. Gently shake the bowl for 10 seconds while watching the beads.
3. How is the scattering of the beads like the diffusion of particles? How is it different from the diffusion of particles?

Figure 3 In passive transport, particles travel through proteins to areas of lower concentration. In active transport, cells use energy to move particles, usually to areas of higher concentration.



passive transport the movement of substances across a cell membrane without the use of energy by the cell

active transport the movement of substances across the cell membrane that requires the cell to use energy

endocytosis the process by which a cell membrane surrounds a particle and encloses the particle in a vesicle to bring the particle into the cell

Moving Small Particles

Small particles, such as sugars, cross the cell membrane through passageways called *channels*. These channels are made up of proteins in the cell membrane. Particles travel through these channels by either passive or active transport. The movement of particles across a cell membrane without the use of energy by the cell is called **passive transport**, and is shown in **Figure 3**. During passive transport, particles move from an area of high concentration to an area of low concentration. Diffusion and osmosis are examples of passive transport.

A process of transporting particles that requires the cell to use energy is called **active transport**. Active transport usually involves the movement of particles from an area of low concentration to an area of high concentration.

Moving Large Particles

Small particles cross the cell membrane by diffusion, passive transport, and active transport. Large particles move into and out of the cell by processes called *endocytosis* and *exocytosis*.

Endocytosis

The active-transport process by which a cell surrounds a large particle, such as a large protein, and encloses the particle in a vesicle to bring the particle into the cell is called **endocytosis** (EN doh sie TOH sis). *Vesicles* are sacs formed from pieces of cell membrane. **Figure 4** shows endocytosis.

Figure 4 Endocytosis

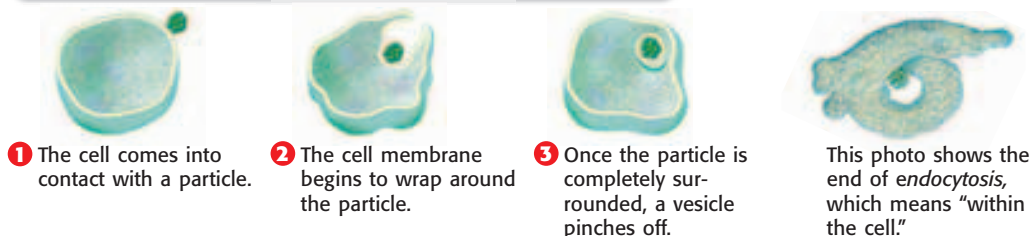
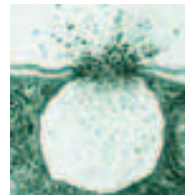


Figure 5 Exocytosis

- 1 Large particles that must leave the cell are packaged in vesicles.
- 2 The vesicle travels to the cell membrane and fuses with it.
- 3 The cell releases the particle to the outside of the cell.



Exocytosis means "outside the cell."



Exocytosis

When large particles, such as wastes, leave the cell, the cell uses an active-transport process called **exocytosis** (EK soh sie TOH sis). During exocytosis, a vesicle forms around a large particle within the cell. The vesicle carries the particle to the cell membrane. The vesicle fuses with the cell membrane and releases the particle to the outside of the cell. **Figure 5** shows exocytosis.

Reading Check What is exocytosis?

exocytosis the process in which a cell releases a particle by enclosing the particle in a vesicle that then moves to the cell surface and fuses with the cell membrane

SECTION Review

Summary

- Diffusion is the movement of particles from an area of high concentration to an area of low concentration.
- Osmosis is the diffusion of water through a semi-permeable membrane.
- Cells move small particles by diffusion, which is an example of passive transport, and by active transport.
- Large particles enter the cell by endocytosis, and exit the cell by exocytosis.

Using Key Terms

For each pair of terms, explain how the meanings of the terms differ.

1. *diffusion* and *osmosis*
2. *active transport* and *passive transport*
3. *endocytosis* and *exocytosis*

Understanding Key Ideas

4. The movement of particles from a less crowded area to a more crowded area requires
 - a. sunlight.
 - b. energy.
 - c. a membrane.
 - d. osmosis.
5. What structures allow small particles to cross cell membranes?

Math Skills

6. The area of particle 1 is 2.5 mm^2 . The area of particle 2 is 0.5 mm^2 . The area of particle 1 is how many times as big as the area of particle 2?

Critical Thinking

7. **Predicting Consequences** What would happen to a cell if its channel proteins were damaged and unable to transport particles? What would happen to the organism if many of its cells were damaged in this way? Explain your answer.
8. **Analyzing Ideas** Why does active transport require energy?

SCILINKS

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For a variety of links related to this chapter, go to www.scilinks.org

Topics: *Diffusion; Osmosis*
SciLinks code: *HSM0406; HSM1090*

Cell Energy

Why do you get hungry? Feeling hungry is your body's way of telling you that your cells need energy.

All cells need energy to live, grow, and reproduce. Plant cells get their energy from the sun. Many animal cells get the energy they need from food.

What You Will Learn

- Describe photosynthesis and cellular respiration.
- Compare cellular respiration with fermentation.

Vocabulary

photosynthesis
cellular respiration
fermentation

READING STRATEGY

Discussion Read this section silently. Write down questions that you have about this section. Discuss your questions in a small group.

photosynthesis the process by which plants, algae, and some bacteria use sunlight, carbon dioxide, and water to make food

From Sun to Cell

Nearly all of the energy that fuels life comes from the sun. Plants capture energy from the sun and change it into food through a process called **photosynthesis**. The food that plants make supplies them with energy. This food also becomes a source of energy for the organisms that eat the plants.

Photosynthesis

Plant cells have molecules that absorb light energy. These molecules are called *pigments*. Chlorophyll (KLAWR uh FIL), the main pigment used in photosynthesis, gives plants their green color. Chlorophyll is found in chloroplasts.

Plants use the energy captured by chlorophyll to change carbon dioxide and water into food. The food is in the form of the simple sugar glucose. Glucose is a carbohydrate. When plants make glucose, they convert the sun's energy into a form of energy that can be stored. The energy in glucose is used by the plant's cells. Photosynthesis also produces oxygen. Photosynthesis is summarized in **Figure 1**.

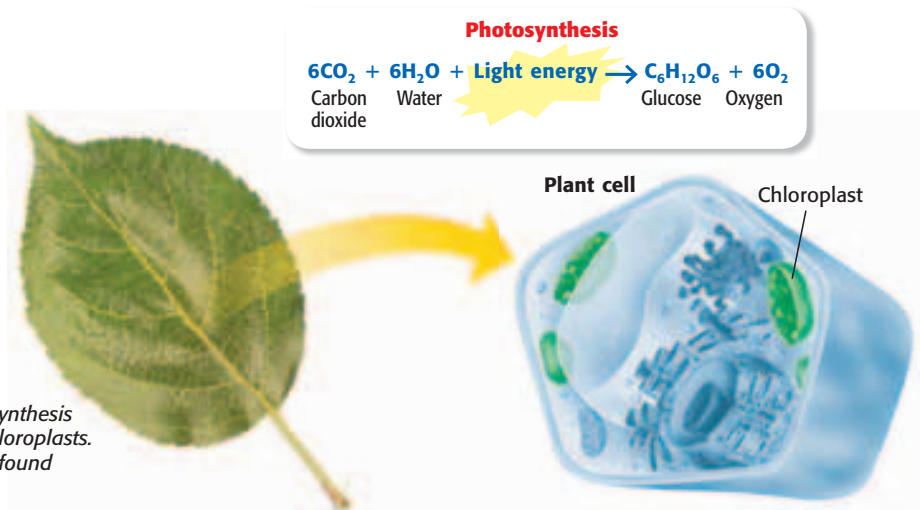


Figure 1 Photosynthesis takes place in chloroplasts. Chloroplasts are found inside plant cells.

Getting Energy from Food


Animal cells have different ways of getting energy from food. One way, called **cellular respiration**, uses oxygen to break down food. Many cells can get energy without using oxygen through a process called **fermentation**. Cellular respiration will release more energy from a given food than fermentation will.

Cellular Respiration

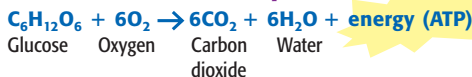
The word *respiration* means “breathing,” but cellular respiration is different from breathing. Breathing supplies the oxygen needed for cellular respiration. Breathing also removes carbon dioxide, which is a waste product of cellular respiration. But cellular respiration is a chemical process that occurs in cells.

Most complex organisms, such as plants and animals, obtain energy through cellular respiration. During cellular respiration, food (such as glucose) is broken down into CO_2 and H_2O , and energy is released. In animals, most of the energy released maintains body temperature. Some of the energy is used to form adenosine triphosphate (ATP). ATP supplies energy that fuels cell activities.

Most of the process of cellular respiration takes place in the cell membrane of prokaryotic cells. But in the cells of eukaryotes, cellular respiration takes place mostly in the mitochondria. The process of cellular respiration is summarized in **Figure 2**. Does the equation in the figure remind you of the equation for photosynthesis? **Figure 3** on the next page shows how photosynthesis and respiration are related.

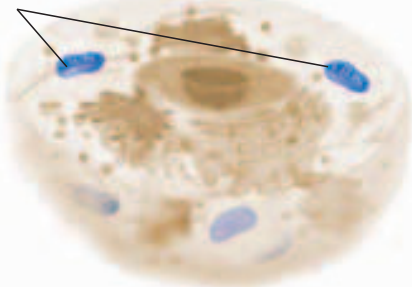
 **Reading Check** What is the difference between cellular respiration and breathing? (See the Appendix for answers to Reading Checks.)

Cellular Respiration



Mitochondria

Animal cell



CONNECTION TO Chemistry

Earth's Early Atmosphere

Scientists think that Earth's early atmosphere lacked oxygen. Because of this lack of oxygen, early organisms used fermentation to get energy from food. When organisms began to photosynthesize, the oxygen they produced entered the atmosphere. How do you think this oxygen changed how other organisms got energy?

cellular respiration the process by which cells use oxygen to produce energy from food

fermentation the breakdown of food without the use of oxygen

Figure 2 The mitochondria in the cells of this cow will use cellular respiration to release the energy stored in the grass.



Figure 3 The Connection Between Photosynthesis and Respiration

Cellular Respiration

Cellular respiration releases carbon dioxide and water, which are used by plant cells to make glucose. During photosynthesis, oxygen is released.

ATP



Mitochondrion

Chloroplast

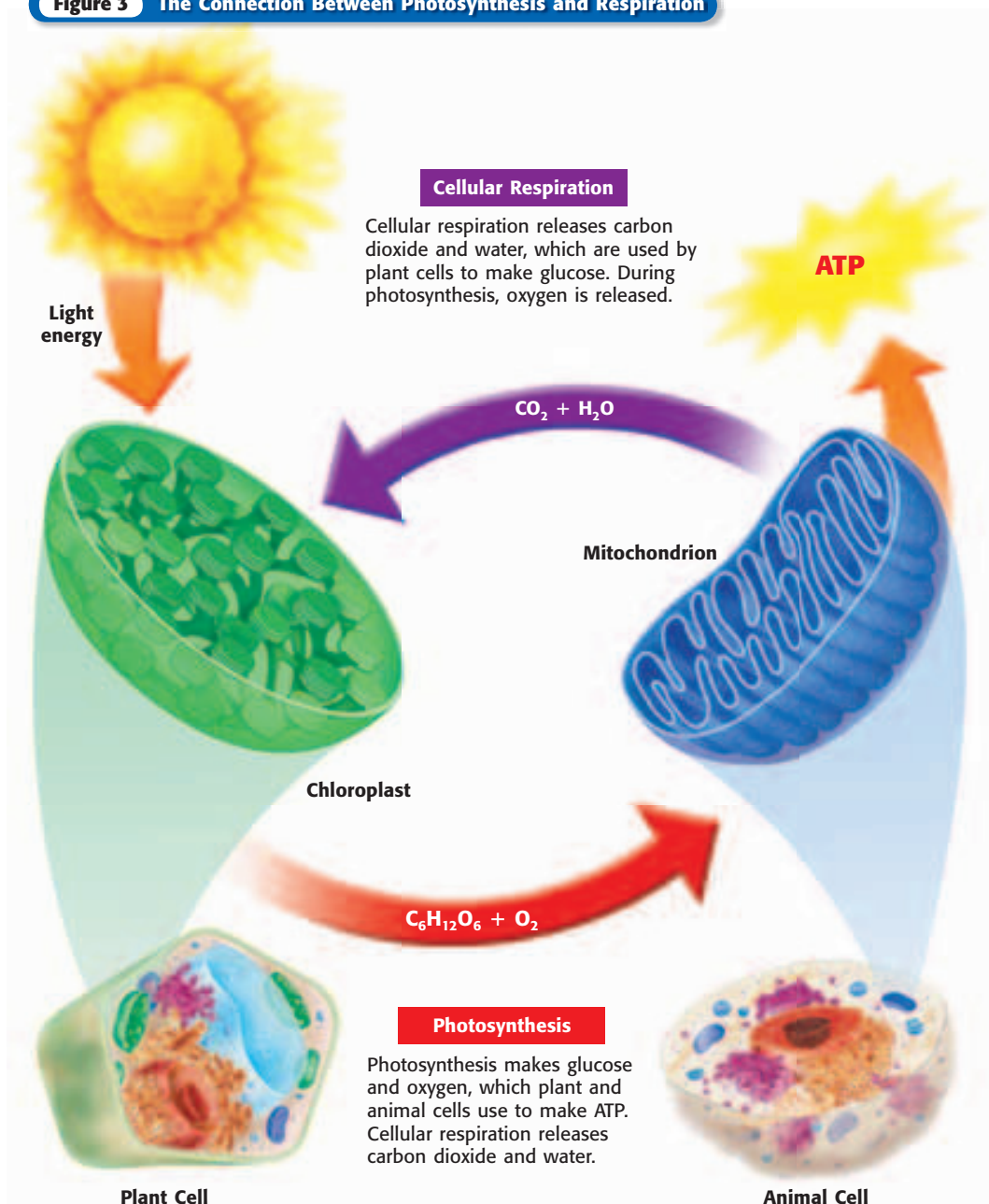


Photosynthesis

Photosynthesis makes glucose and oxygen, which plant and animal cells use to make ATP. Cellular respiration releases carbon dioxide and water.

Plant Cell

Animal Cell



Connection Between Photosynthesis and Respiration

As shown in **Figure 3**, photosynthesis transforms energy from the sun into glucose. During photosynthesis, cells use CO_2 to make glucose, and the cells release O_2 . During cellular respiration, cells use O_2 to break down glucose and release energy and CO_2 . Each process makes the materials that are needed for the other process to occur elsewhere.

Fermentation

Have you ever felt a burning sensation in your leg muscles while you were running? When muscle cells can't get the oxygen needed for cellular respiration, they use the process of fermentation to get energy. One kind of fermentation happens in your muscles and produces lactic acid. The buildup of lactic acid contributes to muscle fatigue and causes a burning sensation. This kind of fermentation also happens in the muscle cells of other animals and in some fungi and bacteria. Another type of fermentation occurs in some types of bacteria and in yeast as described in **Figure 4**.

 **Reading Check** What are two kinds of fermentation?



Figure 4 Yeast forms carbon dioxide during fermentation. The bubbles of CO_2 gas cause the dough to rise and leave small holes in bread after it is baked.

SECTION Review

Summary

- Most of the energy that fuels life processes comes from the sun.
- The sun's energy is converted into food by the process of photosynthesis.
- Cellular respiration breaks down glucose into water, carbon dioxide, and energy.
- Fermentation is a way that cells get energy from their food without using oxygen.

Using Key Terms

1. In your own words, write a definition for the term *fermentation*.

Understanding Key Ideas

2. O_2 is released during
 - a. cellular respiration.
 - b. photosynthesis.
 - c. breathing.
 - d. fermentation.
3. How are photosynthesis and cellular respiration related?
4. How are respiration and fermentation similar? How are they different?

Math Skills

5. Cells of plant A make 120 molecules of glucose an hour. Cells of plant B make half as much glucose as plant A does. How much glucose does plant B make every minute?

Critical Thinking

6. **Analyzing Relationships** Why are plants important to the survival of all other organisms?
7. **Applying Concepts** You have been given the job of restoring life to a barren island. What types of organisms would you put on the island? If you want to have animals on the island, what other organisms must you bring? Explain your answer.

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Topic: Cell Energy; Photosynthesis
SciLinks code: HSM0237; HSM1140