Section 2

The Cell in Its Environment

Reading Preview

Key Concepts

- How do most small molecules cross the cell membrane?
- Why is osmosis important to cells?
- What is the difference between passive transport and active transport?

Key Terms

- selectively permeable
- diffusion • osmosis
- passive transport
- active transport

Target Reading Skill

Building Vocabulary

A definition states the meaning of a word or phrase. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

How Do Molecules Move?

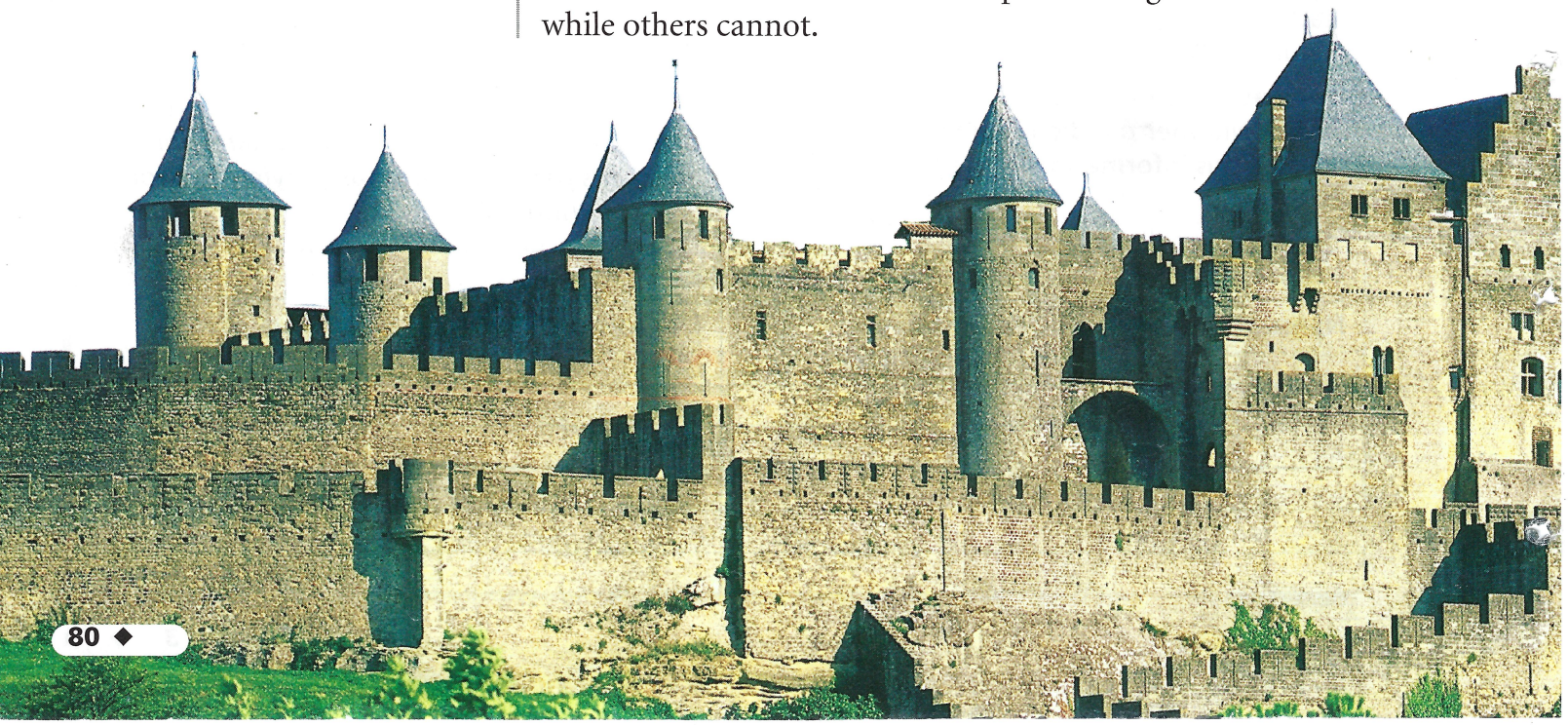
1. Stand with your classmates in locations that are evenly spaced throughout the classroom.
2. Your teacher will spray an air freshener into the room. When you first smell the air freshener, raise your hand.
3. Note how long it takes for other students to smell the scent.

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.

As darkness fell, the knight urged his horse toward the castle. The weary knight longed for the safety of the castle, with its thick walls of stone and strong metal gates. The castle's gatekeeper opened the gates and slowly lowered the drawbridge. The horse clopped across the bridge, and the knight sighed with relief. Home at last!

Like ancient castles, cells have structures that protect their contents from the world outside. All cells are surrounded by a cell membrane that separates the cell from the outside environment. The cell membrane is **selectively permeable,** which means that some substances can pass through the membrane while others cannot.



Cells, like castles, must let things enter and leave. Cells must let in needed materials, such as oxygen and food molecules. In contrast, waste materials must move out of cells. Oxygen, food molecules, and waste products all must pass through the cell membrane.

Diffusion

Substances that can move into and out of a cell do so by one of three methods: diffusion, osmosis, or active transport. **Diffusion is the main method by which small molecules move across the cell membrane. Diffusion** (dih FYOO zhun) is the process by which molecules 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. For example, suppose you dissolve 1 gram of sugar in 1 liter of water. The concentration of the sugar solution is 1 gram per liter.

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 fewer 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.

Math Skills

Ratios

The concentration of a solution can be expressed as a ratio. A ratio compares two numbers. It tells you how much you have of one item in comparison to another. For example, suppose you dissolve 5 g of sugar in 1 L of water. You can express the concentration of the solution in ratio form as 5 g : 1 L, or 5 g/L.

Practice Problem Suppose you dissolve 7 g of salt in 1 L of water. Express the concentration of the solution as a ratio.

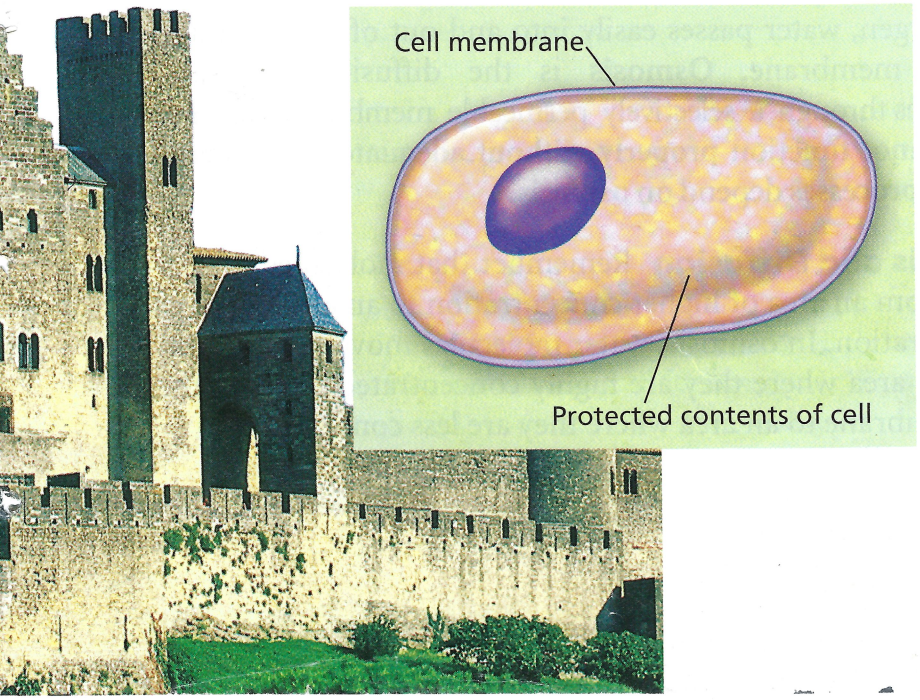
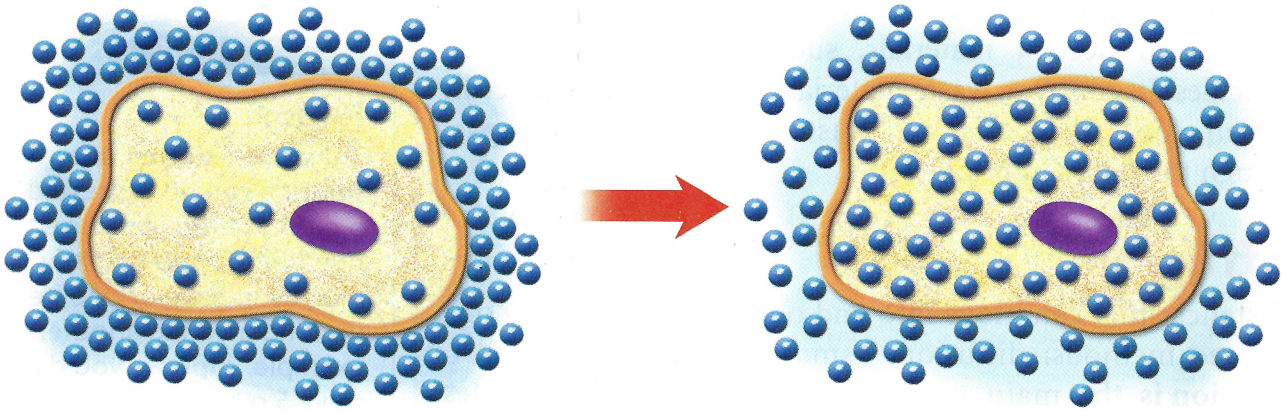


FIGURE 7
A Selective Barrier
The walls of a castle protected the inhabitants within, and the castle gatekeeper allowed only certain people to pass through. Similarly, the cell membrane protects the contents of the cell and helps control the materials that enter and leave.



Before Diffusion
There is a higher concentration of oxygen molecules outside the cell than inside the cell.

After Diffusion
The concentration of oxygen molecules is the same outside and inside the cell.

FIGURE 8
Diffusion in Action
Molecules move by diffusion from an area of higher concentration to an area of lower concentration.
Predicting *What would happen if the concentration of oxygen molecules outside the cell was lower than inside the cell?*

Diffusion of Oxygen 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.

Reading Checkpoint **By what process do small molecules move into cells?**

Osmosis
Like oxygen, water passes easily into and out of cells through the cell membrane. **Osmosis** is the diffusion of water molecules through a selectively permeable membrane. **Because cells cannot function properly without adequate water, many cellular processes depend on osmosis.**

Osmosis and Diffusion 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.

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Effects of Osmosis Osmosis can have important consequences for a cell. Look at Figure 9 to see the effect of osmosis on cells. In Figure 9A, a red blood cell is bathed in a solution in which the concentration of water is the same as it is inside the cell. This is the normal shape of a red blood cell.

Contrast this shape to the cell in Figure 9B. The red blood cell is floating in water that contains a large amount of salt. The concentration of water molecules outside the cell is lower than the concentration of water molecules inside the cell. This difference in concentration occurs because the salt takes up space in the salt water. Therefore, there are fewer water molecules in the salt water outside the cell compared to the water inside the cell. As a result, water moves out of the cell by osmosis. When water moves out, cells shrink.

In Figure 9C, the red blood cell is floating in water that contains a very small amount of salt. The water inside the cell contains more salt than the solution outside the cell. 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.

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

Lab zone Try This Activity

Diffusion in Action

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

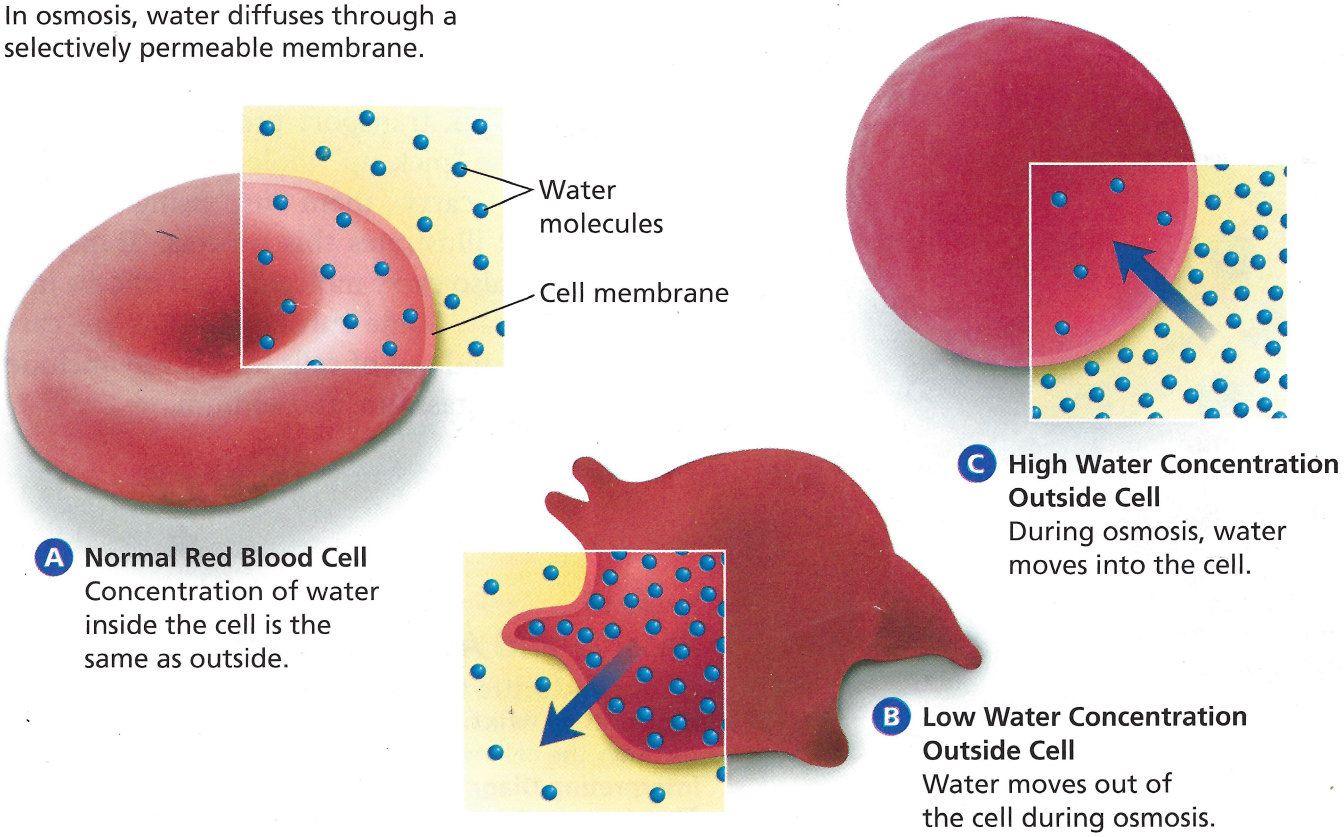
1. Fill a small, clear plastic cup with cold water. Place the cup on the table and allow it to sit until there is no movement in the water.
2. Use a plastic dropper to add one large drop of food coloring to the water.
3. Observe the water every minute. Note any changes that take place. Continue to observe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

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

FIGURE 9

Effects of Osmosis on Cells

In osmosis, water diffuses through a selectively permeable membrane.



A Normal Red Blood Cell
Concentration of water inside the cell is the same as outside.

B Low Water Concentration Outside Cell
Water moves out of the cell during osmosis.

C High Water Concentration Outside Cell
During osmosis, water moves into 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 you do have to use some of your energy to pedal back up the hill. 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 its own energy. The movement of dissolved materials through a cell membrane without using cellular energy is called **passive transport.**

What if a cell needs to take in a substance that is present in a 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 cellular energy. **Active transport requires the cell to use its own energy, while passive transport does not.**

Transport Proteins Cells have 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. Figure 10 illustrates this 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.

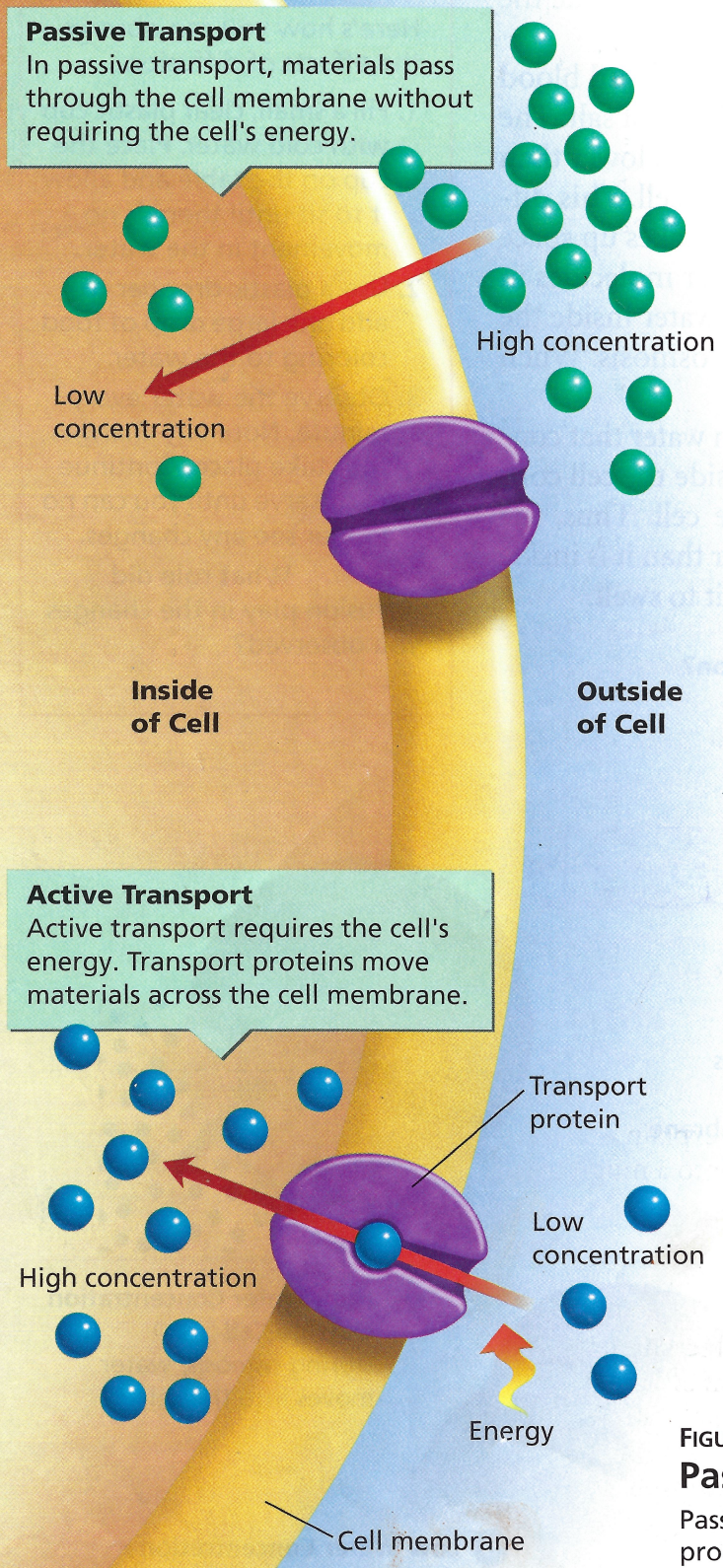


FIGURE 10

Passive and Active Transport

Passive and active transport are two processes by which materials pass through the cell membrane.

Interpreting Diagrams *What is the function of a transport protein?*

Transport by Engulfing Figure 11 shows another method of active transport. First, the cell membrane surrounds and engulfs, or encloses, a particle. Once the particle is engulfed, the cell membrane wraps around the particle and forms a vacuole within the cell. The cell must use energy in this process.

FIGURE 11
Amoeba Engulfing Food
This single-celled amoeba is surrounding a smaller organism. The amoeba will engulf the organism and use it for food. Engulfing is a form of active transport.

Why Cells Are 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 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.

Reading Checkpoint **What prevents cells from growing very large?**

Section 2 Assessment

Target Reading Skill **Building Vocabulary** Use your definitions to help answer the questions below.

Reviewing Key Concepts

1. a. **Defining** What is diffusion?
   b. **Relating Cause and Effect** Use diffusion to explain what happens when you drop a sugar cube into a mug of hot tea.
2. a. **Defining** What is osmosis?
   b. **Describing** Describe how water molecules move through the cell membrane during osmosis.
   c. **Applying Concepts** A selectively permeable membrane separates solutions A and B. The concentration of water molecules in Solution B is higher than that in Solution A. Describe how the water molecules will move.
3. a. **Comparing and Contrasting** How is active transport different from passive transport?
   b. **Reviewing** What are transport proteins?
   c. **Explaining** Explain why transport proteins require energy to function in active transport.

Math Practice

A scientist dissolves 60 g of sugar in 3 L of water.

4. **Calculating a Concentration** Calculate the concentration of the solution in grams per liter.
5. **Ratios** Express the concentration as a ratio.