

## 3.5 Active Transport, Endocytosis, and Exocytosis

### VOCABULARY

active transport  
endocytosis  
phagocytosis  
exocytosis

**KEY CONCEPT** Cells use energy to transport materials that cannot diffuse across a membrane.

### MAIN IDEAS

- ▶ Proteins can transport materials against a concentration gradient.
- ▶ Endocytosis and exocytosis transport materials across the membrane in vesicles.

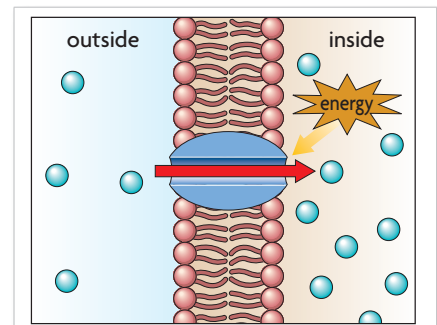
### ☀️ Connect to Your World

If you want to go up to the second floor of the mall, you're going to need help beating gravity. You could take an escalator, which uses energy to move you against gravity, much like transport proteins involved in active transport use energy to move molecules against a gradient. Alternatively, you might take the elevator, entering on the first floor and hopping out when the doors open on the second. In endocytosis and exocytosis, vesicles act like that elevator, surrounding molecules on one side of a membrane and releasing them into the other.

### ▶ MAIN IDEA

## Proteins can transport materials against a concentration gradient.

You just learned that some transport proteins let materials diffuse into and out of a cell down a concentration gradient. Many other transport proteins, often called pumps, move materials against a concentration gradient. **Active transport** drives molecules across a membrane from a region of lower concentration to a region of higher concentration. This process, shown in **FIGURE 5.1**, uses transport proteins powered by chemical energy. Cells use active transport to get needed molecules regardless of the concentration gradient and to maintain homeostasis.



**FIGURE 5.1** During active transport, a cell uses energy to move substances against a concentration gradient—that is, from a lower to a higher concentration.

### ☀️ CONNECT TO

#### HUMAN BIOLOGY

As you will learn in **Digestive and Excretory Systems**, active transport is a necessary part of nutrient absorption.

Before we discuss active transport proteins, let's look at transport proteins in general. All transport proteins span the membrane, and most change shape when they bind to a target molecule or molecules. Some transport proteins bind to only one type of molecule. Others bind to two different types. Some proteins that bind to two types of molecules move both types in the same direction. Others move the molecules in opposite directions.



**FIGURE 5.2** Just as a cell uses energy in the process of active transport, this boy uses energy to pump air against a concentration gradient.

The key feature of active transport proteins is that they can use chemical energy to move a substance against its concentration gradient. Most use energy from a molecule called ATP, either directly or indirectly. For example, nerve cells, or neurons, need to have a higher concentration of potassium ions and a lower concentration of sodium ions than the fluid outside the cell. The sodium-potassium pump uses energy directly from the breakdown of ATP. It pumps three sodium ions out of the cell for every two potassium ions it pumps in. The proton pump, another transport protein, uses energy from the breakdown of ATP to move hydrogen ions (or protons) out of the cell. This action forms a concentration gradient of hydrogen ions ( $H^+$ ), which makes the fluid outside the cell more positively charged than the fluid inside. In fact, this gradient is a form of stored energy that is used to power other active transport proteins. In plant cells, this gradient causes yet another protein to transport sucrose into the cell—an example of indirect active transport.

**Synthesize** In what ways are active transport proteins similar to enzymes?

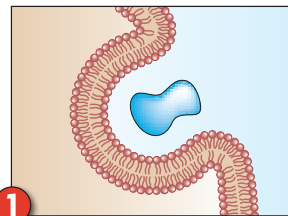
**▶ MAIN IDEA**

## Endocytosis and exocytosis transport materials across the membrane in vesicles.

A cell may also use energy to move a large substance or a large amount of a substance in vesicles. Transport in vesicles lets substances enter or exit a cell without crossing through the membrane.

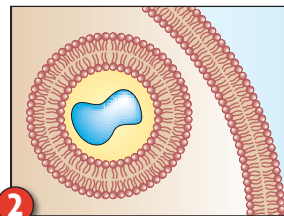
### Endocytosis

**Endocytosis** (EN-doh-sy-TOH-sihs) is the process of taking liquids or fairly large molecules into a cell by engulfing them in a membrane. In this process, the cell membrane makes a pocket around a substance. The pocket breaks off inside the cell and forms a vesicle, which then fuses with a lysosome or a similar type of vesicle. Lysosomal enzymes break down the vesicle membrane and its contents (if necessary), which are then released into the cell.



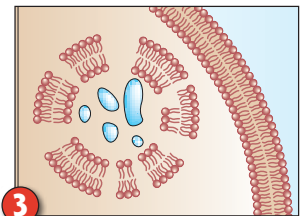
**1**

During endocytosis, the cell membrane folds inward and fuses together, surrounding the substance in a pocket.



**2**

The pocket pinches off inside the cell, forming a vesicle.



**3**

The vesicle fuses with a lysosome or a similar vesicle, where enzymes break down the membrane and its contents.

**Phagocytosis** (FAG-uh-sy-TOH-sihs) is a type of endocytosis in which the cell membrane engulfs large particles. The word literally means “cell eating.” Phagocytosis plays a key role in your immune system. Some white blood cells called macrophages help your body fight infection. They find foreign materials, such as bacteria, and engulf and destroy them.

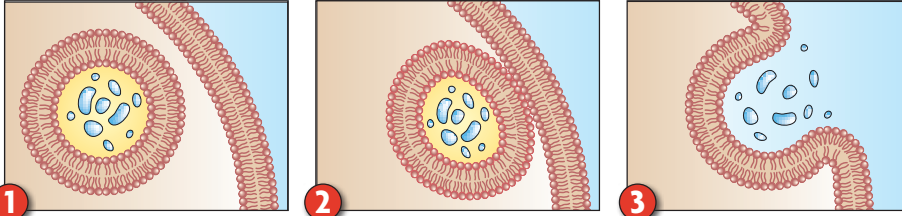
**READING TOOLBOX**

**VOCABULARY**

The words *endocytosis*, *exocytosis*, and *phagocytosis* share the word part *cyto-*, which means “cell.” The prefixes *endo-* and *exo-* indicate location or direction. *Endo-* means “within,” and *exo-* means “out of.” The prefix *phago-* means “eating.”

## Exocytosis

**Exocytosis** (EHK-soh-sy-TOH-sihs), the opposite of endocytosis, is the release of substances out of a cell by the fusion of a vesicle with the membrane. During this process, a vesicle forms around materials to be sent out of the cell. The vesicle then moves toward the cell's surface, where it fuses with the membrane and lets go of its contents.



**1** The cell forms a vesicle around material that needs to be removed or secreted.

**2** The vesicle is transported to the cell membrane.

**3** The vesicle membrane fuses with the cell membrane and releases the contents.

Exocytosis happens all the time in your body. In fact, you couldn't think or move a muscle without it. When you want to move your big toe, for example, your brain sends a message that travels through a series of nerve cells to reach your toe. This message, or nerve impulse, travels along each nerve cell as an electrical signal, but it must be converted to a chemical signal to cross the tiny gap that separates one nerve cell from the next. These chemicals are stored in vesicles within the nerve cells. When a nerve impulse reaches the end of a cell, it causes the vesicles to fuse with the cell membrane and release the chemicals outside the cell. There they attach to the next nerve cell, which triggers a new electrical impulse in that cell.

**Hypothesize** What might happen if vesicles in your neurons were suddenly unable to fuse with the cell membrane?

### CONNECT TO

#### ENDOCRINE SYSTEM

As you will learn in **Nervous and Endocrine Systems**, thyroid hormones play an important role in controlling your growth and development. These hormones are released into the blood by exocytosis.

### Virtual INVESTIGATION



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#### PREMIUM CONTENT

Transport Across Cell Membrane

## 3.5 Formative Assessment

### REVIEWING ► MAIN IDEAS

1. How do transport proteins that are pumps differ from those that are channels?
2. How do **endocytosis** and **exocytosis** differ from diffusion?

### CRITICAL THINKING

3. **Apply** Small lipid molecules are in high concentration outside a cell. They slowly cross the membrane into the cell. What term describes this action? Does it require energy?
4. **Apply** Ions are in low concentration outside a cell. They move rapidly into the cell via protein molecules. What term describes this action? Does it require energy?



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#### PREMIUM CONTENT

### CONNECT TO

#### DIFFUSION

5. Suppose molecules were unable to diffuse into and out of cells. How might life be different if cells had to use **active transport** to move every substance? Explain your reasoning.