Chapter 4

How Cells Work

4.1 How things get in and out of cells

Cells need to take in a variety of resources, including water, oxygen, and organic molecules. Cells also generate wastes they must dispose. Now that we know the structure of the cell membrane, we can discuss how it performs the important task of controlling how materials move into and out of cells. Transport across the cell membrane occurs in a number of ways—through simple diffusion, facilitated diffusion, active transport, endocytosis, and exocytosis.

Simple Diffusion

Some molecules are able to cross the phospholipid bilayer of the cell membrane directly. Hydrophobic molecules, such as the gases oxygen and carbon dioxide, can pass directly through the double layer of hydrophobic tails. Certain small hydrophilic molecules—such as water—can also cross the cell membrane this way. What governs the way these substances move into and out of cells? Answer: a process known as **diffusion**, which is the movement of molecules from an area of high concentration to an area of low concentration—that is, down a concentration gradient. A familiar example of diffusion is the way a drop of food coloring spreads in a beaker of water (Figure 4.1).

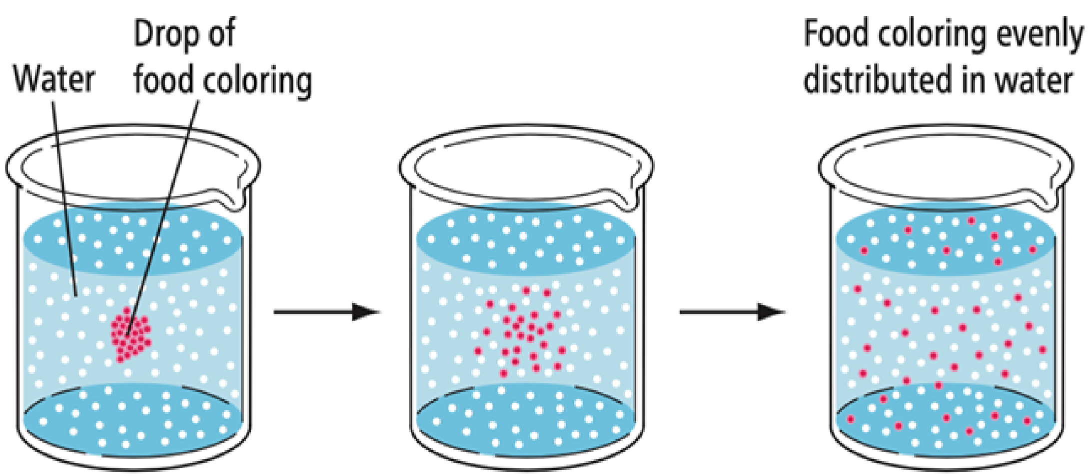

FIGURE 4.1

A drop of food coloring diffuses in a beaker of still water. Over time, and without any stirring, molecules diffuse from where they are more concentrated to where they are less concentrated. Eventually, the water becomes uniformly colored.

The diffusion of molecules directly across the phospholipid bilayer of the cell membrane is known as simple diffusion. For example, consider how oxygen diffuses from the fluid surrounding our cells into the cells themselves (Figure 4.2). Oxygen molecules are found both inside and outside the cell, and they move around randomly. Sometimes an oxygen molecule drifts from outside the cell to inside, and sometimes an oxygen molecule drifts from inside the cell to outside. However, because there is a higher concentration of oxygen molecules outside the cell than inside, the net effect of diffusion is to move oxygen molecules into the cell. (Note that there are fewer oxygen molecules inside cells because cells use oxygen in cellular respiration, a process we will discuss later in this chapter.)

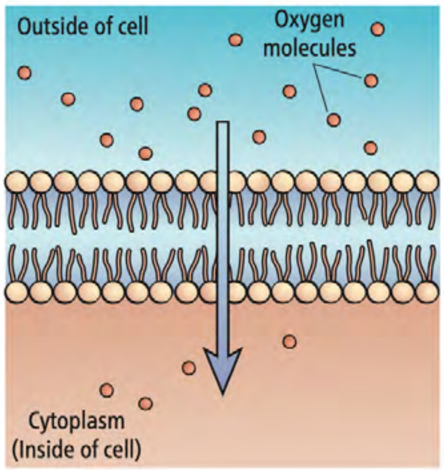

FIGURE 4.2

Molecules that diffuse freely across the cell membrane show a net overall movement from an area of higher concentration to an area of lower concentration.

FIGURE 4.3

The Chinese giant salamander is the largest amphibian in the world. These salamanders live in streams and obtain oxygen from diffusion across their wrinkly skin.

Diffusion works best over small distances. Because of this, bodily processes that depend on diffusion require very thin structures. The walls of our capillaries are very thin so oxygen can diffuse efficiently from our blood to our tissues. Processes that depend on diffusion also require large surface areas. The intricate branching of our lungs creates a greater amount of surface area so that more oxygen can diffuse into the blood. If you know that amphibians receive much of their oxygen from simple diffusion across the skin, can you develop a hypothesis for why the giant salamander in Figure 4.3 has such wrinkly skin?

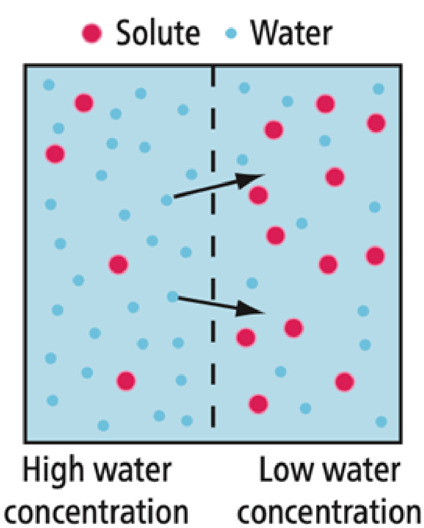

FIGURE 4.4

In osmosis, water molecules move from an area of lower solute concentration to an area of higher solute concentration. Note that the solute molecules cannot cross the barrier, but the water molecules can.

The diffusion of water has a special name—*osmosis*. Like other substances, water diffuses from an area with a high concentration of water molecules to an area with a low concentration of water molecules. Because a higher concentration of water molecules means a lower concentration of solutes, and vice versa, another way to say this is that diffusion moves water from an area of lower solute concentration to an area of higher solute concentration (Figure 4.4). This is important because controlling water flow is important to all cells—with too much water, they could burst; with too little, they shrivel.

Facilitated Diffusion

Many of the molecules that cells need, including ions and large hydrophilic molecules such as proteins and carbohydrates, cannot pass freely across the phospholipid bilayer of the cell membrane. How do these molecules get into and out of cells? They use special "gates" in the cell membrane. These gates are membrane proteins called *transport proteins*.

Transport proteins are very specific about the molecules they let across the cell membrane. A molecule fits into its transport protein the same way that a key fits into a lock—only the right key will work in a given lock (Figure 4.5).

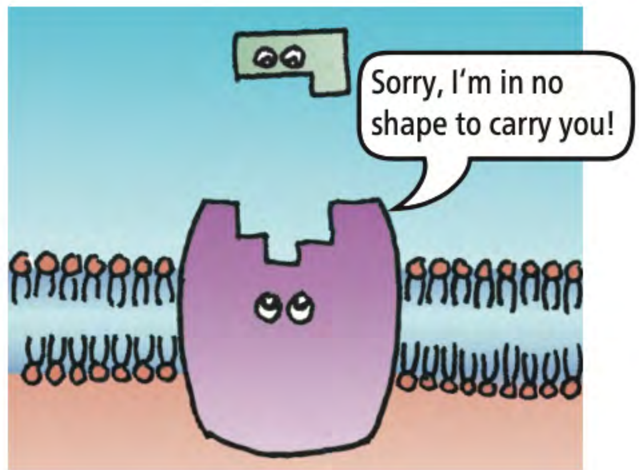

FIGURE 4.5

Transport proteins and the molecules they transport fit together like a lock and key.

In *facilitated diffusion*, a transport protein moves molecules down a concentration gradient, from an area of high concentration to an area of low concentration (Figure 4.6). One example of facilitated diffusion is the movement of the sugar glucose (the basic fuel that cells burn for energy) into red blood cells. Water, in addition to diffusing directly across the phospholipid bilayer, can also use facilitated diffusion to cross the cell membrane. The transport proteins used by water are called aquaporins. Aquaporins allow water to move more quickly across the cell membrane than it can through diffusion alone. Like diffusion, facilitated diffusion requires no energy from the cell. For this reason, simple diffusion and facilitated diffusion are both examples of **passive transport**.

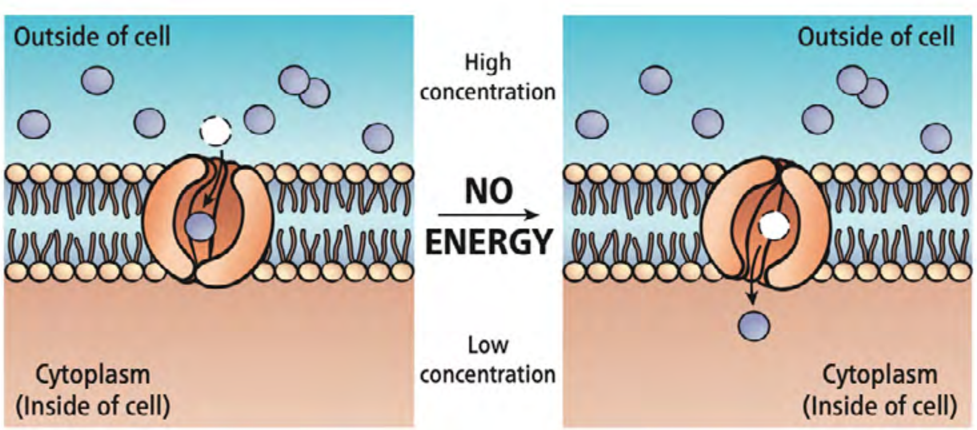

FIGURE 4.6

In facilitated diffusion, molecules move from an area of high concentration to an area of low concentration using a "gate" provided by a transport protein.

Active Transport

In **active transport**, a transport protein moves molecules *against* a concentration gradient, from an area of low concentration to an area of high concentration (Figure 4.7). In this case, energy from the cell is required. Active transport is used to move many organic molecules, including most proteins, into cells. Active transport is also used to control the concentration of many ions inside and outside cells. An example of active transport, the movement of sodium and potassium ions by the sodium-potassium pump, is described later in this chapter.

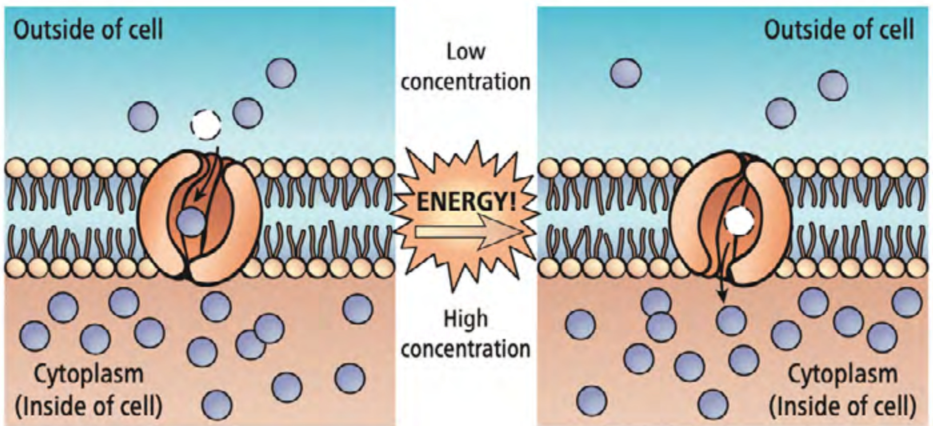

FIGURE 4.7

In active transport, molecules move from an area of low concentration to an area of high concentration—that is, against a concentration gradient. During active transport, a transport protein embedded within the membrane uses energy supplied by the cell.

Endocytosis and Exocytosis

Larger amounts of material can be moved into and out of cells through endocytosis and exocytosis (Figure 4.8). Both these processes require the input of energy from the cell. In endocytosis, a portion of the cell membrane folds inward and pinches off, enclosing material within a vesicle inside the cell. Endocytosis is used by certain white blood cells of the human immune system to engulf invading bacteria. In exocytosis, the opposite process occurs—a vesicle fuses its membrane with the cell membrane and dumps its contents outside the cell. Many endocrine cells use exocytosis to release hormones into the bloodstream. Neurotransmitters—the chemicals that neurons use to signal one another—are also released through exocytosis.

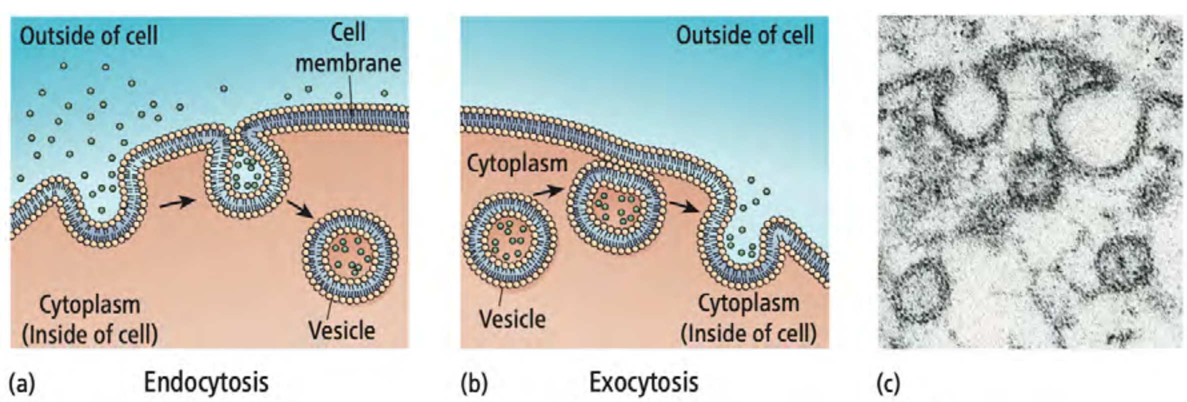

FIGURE 4.8

(a) In endocytosis, a portion of the cell membrane pinches off to form a vesicle that brings materials into the cell. (b) In exocytosis, a vesicle inside the cell fuses with the cell membrane, dumping its contents outside the cell. (c) This photo shows vesicles dumping their contents through exocytosis.

READING CHECK

Insects don't have lungs. Instead, they get oxygen from a series of small branching tubules in their bodies that are connected to the outside air. Oxygen diffuses through the tubules to reach their tissues. Use this information to explain why a mosquito could never grow to be 12 feet tall.

CHECK YOUR ANSWER

Because diffusion works well only at small distances, the insect respiratory system constrains insects to small body sizes. A 12-foot mosquito would not be able to get enough oxygen to the tissues deep inside its body.

You can read more about active and passive transport at this website:

https://microbenotes.com/difference-between-active-transport-and-passive-transport/