Glossary

aquaporin: channel protein that allows water through the membrane at a very high rate

cholesterol: a lipid that plays an important role in membrane fluidity

fluid mosaic model: a model of the structure of the plasma membrane as a mosaic of components, including phospholipids, cholesterol, proteins, and glycolipids, resulting in a fluid rather than static character

glycocalyx: a fuzzy-appearing coating around the cell formed from glycoproteins and other carbohydrates attached to the cell membrane.

glycolipid: a combination of carbohydrates and lipids

glycoprotein: a combination of carbohydrates and proteins

hydrophilic: a molecule with the ability to bond with water; “water-loving.”

hydrophobic: a molecule that does not have the ability to bond with water; “water-fearing.”

integral protein: protein integrated into the membrane structure that interacts extensively with the membrane lipids' hydrocarbon chains and often spans the membrane

peripheral protein: protein at the plasma membrane's surface either on its exterior or interior side

phospholipid: a major constituent of the membranes of cells; composed of two fatty acids and a phosphate group attached to the glycerol backbone

5.2 Passive Transport

Learning objectives

By the end of this section, you will be able to:

- *Be prepared to identify what types of molecules can pass directly through the membrane vs. those that need to use a transport protein to enter or exit the cell*
- *Explain why and how passive transport occurs*
- *Understand the processes of simple diffusion and facilitated diffusion*
- *Understand the process of osmosis*
- *Explain the difference between hypertonic, hypotonic, and isotonic environments*
- *Explain how animal and plant cells respond when placed in hypertonic, hypotonic, and isotonic environments*
- *Define tonicity and describe its relevance to passive transport*
- *Be able to define and explain all bolded terms*

One of the great wonders of the cell membrane is its ability to regulate the concentration of substances inside the cell (Figure 4.44). These substances include ions such as Ca^{+2}, Na^{+1}, K^{+1}, and Cl^{-1}; nutrients including sugars, fatty acids, and amino acids; and waste products, particularly carbon dioxide (CO_2), which must leave the cell.

The plasma membrane's lipid bilayer provides the first level of control. The phospholipids are tightly packed together, and the arrangement of the hydrophobic tails causes the membrane to be selectively permeable. A membrane that has **selective permeability** only allows substances meeting specific criteria to pass through it unaided. In the case of the cell membrane, only relatively small, nonpolar materials can move through the phospholipid bilayer. Some examples of these materials are lipids, oxygen and carbon dioxide gases, and alcohol. The chemical makeup or overall size of a molecule can prevent it from easily crossing the membrane. Water-soluble materials such as glucose, amino acids, and electrolytes cannot move directly through the membrane and need some assistance to cross. Later in this section we will discuss how these materials move into or out of the cell.

All substances that move through the membrane do so by one of two general methods, which are categorized based on whether or not energy is required. **Passive transport** is the movement of substances across the membrane without the expenditure of cellular energy. In contrast, **active transport** is the movement of materials across the membrane using energy, usually in the form of ATP.

Passive Transport

The most direct forms of membrane transport are passive. Passive transport occurs naturally and does not require the cell to expend energy to accomplish the movement. To understand *how* substances move passively across a cell membrane, it is necessary to understand concentration gradients. A **concentration gradient** is a difference in the concentration of a substance between two places. Molecules or ions will spread out or diffuse from where they are more concentrated to where they are less concentrated until they are equally distributed in that space. When molecules move in this way, they are said to move *down* their concentration gradient.

When green food coloring is placed in a glass of water, the green food coloring molecules will spread from where they are most concentrated, the initial drop, to where they are less concentrated amongst the water molecules in the glass. The green food coloring molecules will spread out until they are evenly dispersed amongst the water molecules resulting in one homogeneous mixture (Figure 5.6).

Figure 5.6 Diffusion of green food coloring in water. (credit: Robby Remedi)

Diffusion

Diffusion is a type of passive transport where substances move from an area of higher concentration to an area of lower concentration until they reach equilibrium (Figure 5.5). When something reaches equilibrium, it means the molecules are evenly spread out. You may be familiar with the diffusion of substances through the air. For example, think about someone opening a bottle of perfume in a room filled with people. The perfume is at its highest concentration in the bottle and is at its lowest at the edges of the room. The perfume molecules will diffuse or spread away from the bottle, and gradually more and more people will smell the perfume.

For materials that can pass through a membrane, if there is a higher concentration on one side of the membrane that substance will move down its concentration gradient across the membrane (Figure 5.7). Consider materials that can easily diffuse through the lipid bilayer of the cell membrane, such as the gases oxygen (O_2) and CO_2. O_2 generally diffuses into cells because it is more concentrated outside of the cells. CO_2 typically diffuses out of cells because it is more concentrated inside of the cells. Energy does not need to be put in by the cells to move these gases across the membrane. When materials move directly through the lipid bilayer of the cell membrane this process is referred to as **simple diffusion** (Figure 5.7 and 5.8).