Movement Across the Plasma Membrane Chapter 3

PLASMA MEMBRANE

1. The **plasma membrane** is the outermost part of a cell.

2. The main component of the plasma membrane is **phospholipids**.

FIGURE 2.18

   A. The phosphate end of the molecule is polar (charged) and **hydrophilic** (attracted to water).

   B. The lipid end of the molecule is nonpolar and **hydrophobic** (repelled by water).

2. The phospholipids are arranged into a lipid bilayer that functions to separate the watery environment outside of cells from the watery content inside cells.

FIGURE 3.2

3. **Cholesterol** is found between the phospholipid molecules. Cholesterol stabilizes the membrane and increases membrane flexibility.

4. **Proteins** are found within the lipid bilayer. The proteins are responsible for most of the functions of the plasma membrane. They function as marker molecules (allow cells to identify each other), attachment sites (integrins), channel proteins (through which ions and molecules pass through the plasma membrane), receptor molecules (involved in chemical communication between cells), enzymes, and carrier molecules (move ions or molecules across the plasma membrane.

FIGURES 3.3 - 3.12

5. According to the **fluid mosaic model**, the phospholipids form a "sea" upon which the proteins "float". In other words, the membrane is a highly dynamic structure that changes with time.

MOVEMENT THROUGH THE PLASMA MEMBRANE

1. The plasma membrane is **selectively permeable**, allowing some substances to pass through but not others. As a result **intracellular** (inside cells) contents are different from **extracellular** (outside cells) or **intercellular** (between cells) contents. Also, the cell is able to obtain nutrients and get rid of waste products.

2. Movement through the plasma membrane occurs in four ways:
   A. Diffusion through the lipid bilayer. Example: substances that are lipid soluble (can dissolve in lipids) such as oxygen, carbon dioxide, and steroid hormones.

   B. Diffusion through membrane channels. Example: substances that are water soluble and are small enough to pass through the membrane channels, e.g., water and some ions.

   C. Transport by carrier molecules. Example: substances that are water soluble and are too large to pass through the membrane channels, e.g., glucose and amino acids.

   D. Membrane-bound sacs called **vesicles** transport large water soluble molecules such as proteins and particulate matter.

Diffusion

1. Definitions.
   A. A **solvent** is a liquid or a gas, e.g., water.

   B. A **solute** is a substance that dissolves in the solvent, e.g., sugar dissolves in water.

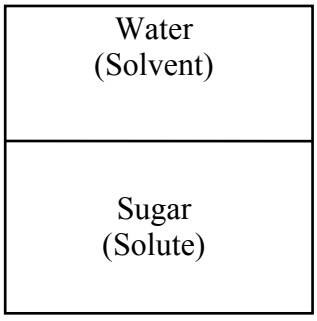
   C. A **solution** consists of a solvent and solutes, e.g., a sugar solution.

   D. **Diffusion** is the tendency for molecules to move from an area of higher concentration to an area of lower concentration.

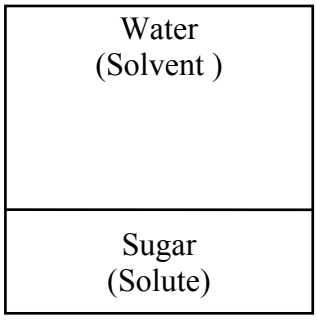
FIGURE 3.13

2. It is possible to predict the direction of diffusion (i.e., which way molecules will move) between two locations if the concentrations at each location is known.
   A. Concentrations are usually expressed as the concentration of a solution. Concentrations can be calculated many different ways.

   B. The important thing to remember about concentration measurements of solutions is that the larger the measurement value, the greater is the amount of solute present. Solution A is twice as concentrated as solution B, i.e., it has twice as much solute.



Sugar Solution A



Sugar Solution B

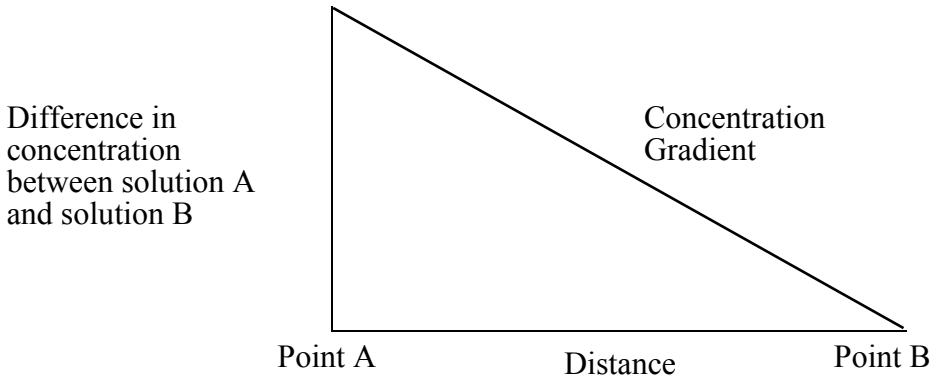
C. Also note that the greater the concentration of a solution, the smaller is the amount of solvent present.

- ☞ Sugar would diffuse from solution _____ to solution _____.
- ☞ Water would diffuse from solution _____ to solution _____.

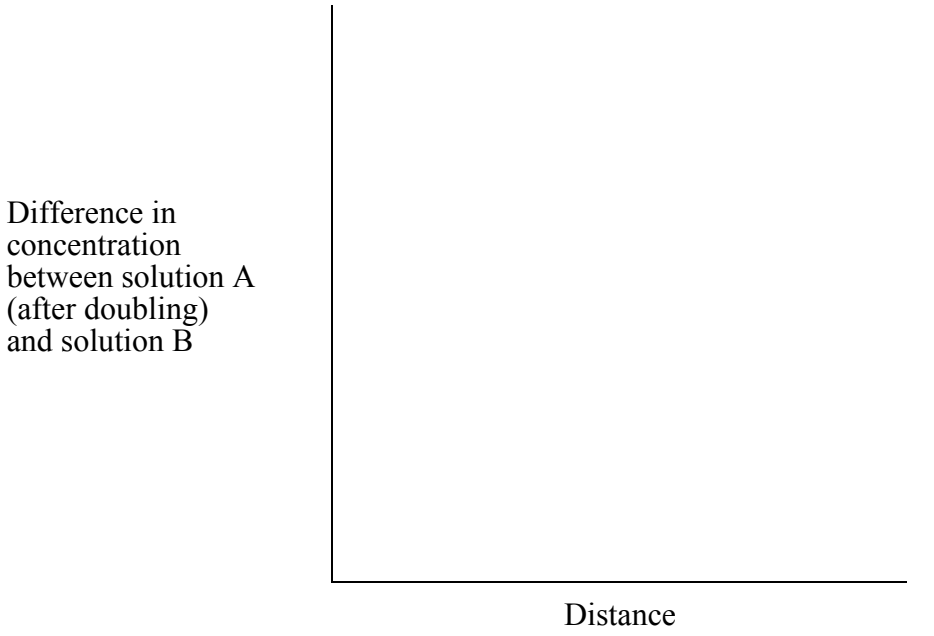
3. The concentration gradient is the concentration difference between two points divided by the distance between those two points.

$$\text{Concentration Gradient} = \frac{\text{Concentration Difference}}{\text{Distance}}$$

4. The greater (steeper) the concentration gradient, the greater the rate of diffusion. Rate is the amount moved per unit time. The greater the rate of diffusion, the greater the amount moved. Molecules diffuse down their concentration gradients.



- ☞ If the concentration of solution A was increased (doubled) would the concentration gradient between solutions A and B increase or decrease?



5. Diffusion of molecules is important because it is a major means by which molecules move about in the human body.
   A. Oxygen and carbon dioxide diffuse through air and through body fluids. Many nutrients and waste products move by diffusion through body fluids.

   B. Many substances diffuse through the lipid bilayer or through membrane channels.

Osmosis

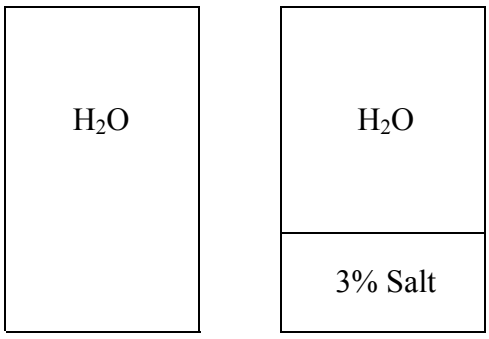
1. Definitions.
   A. **Osmosis** is diffusion of water (solvent) across a selectively permeable membrane.

   B. A **selectively permeable membrane** (e.g., a plasma membrane) allows water to pass through it, but not all solutes to pass through it.

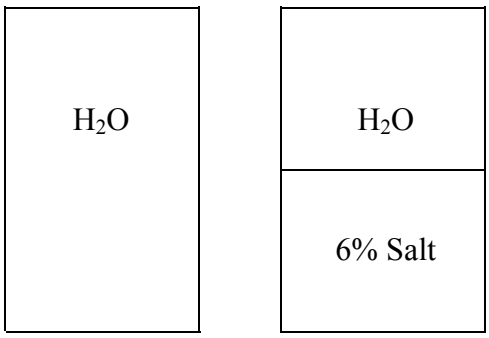
   C. **Osmotic pressure** is the force required to <u>prevent</u> the movement of water across a selectively permeable membrane.

FIGURE 3.16

☞ Why does water move from the beaker into the tube?



☞ If the concentration of salt inside the tube increased, would the osmotic pressure of the solution in the tube increase or decrease? Explain.



2. Osmotic pressure is a function of the concentration of the solution. Three terms are used to describe osmotic concentrations of particles. These terms are useful for comparing solutions because you don't have to remember the exact concentrations. The term particle is use to described the solute. What the particle is (e.g., ion, molecule) doesn't matter, only the number of the particles is important.
   A. An **isosmotic** solution has the same number of solute particles as a reference solution.

   B. A **hyperosmotic** solution has a greater number of solute particles than a reference solution.

   C. A **hyposmotic** solution has a smaller number of solute particles than a reference solution.

   D. Note that the "osmotic" terms refer to concentration of a solution.

   ☞ Complete the following statement:

   Sugar solution A is _____ to sugar solution B.

   Does water move into or out of a hyperosmotic solution?

3. Three additional terms are used to describe the tendency of cells to swell or shrink when placed in a solution.

FIGURE 3.17

   A. In an **isotonic** solution a cell neither swells nor shrinks. Solutions administer to patients are often isotonic because such solution maintain homeostasis.

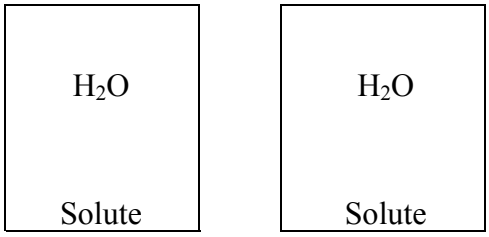
   B. In a **hypertonic** solution a cell shrinks, a process called **crenation**.

   C. In a **hypotonic** solution a cell swells. A cell that swells can rupture, a process called **lysis**.

   D. Note that the "tonic" terms refer to the tendency of cells to swell or shrink. The "osmotic" and "tonic" terms are not interchangeable.

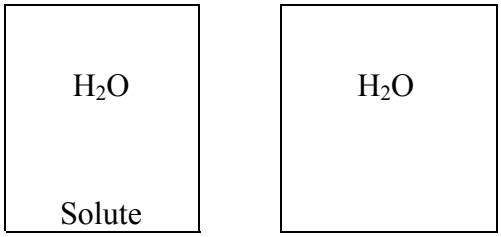
☞ **Practice Problems**

1. Suppose you are on an ocean cruise and the ship sinks. After a few days in your life raft you desperately drink sea water (which is hyperosmotic to the cells in your body). Would you expect your cells to stay the same size, swell, or shrink? Explain.



Body's cells Sea water

2. Suppose you are mowing your lawn on a hot, summer, Phoenix day. After a few hours work you come inside and drink a large amount of distilled water. You would expect your cells to stay the same size, swell, or shrink? Explain.



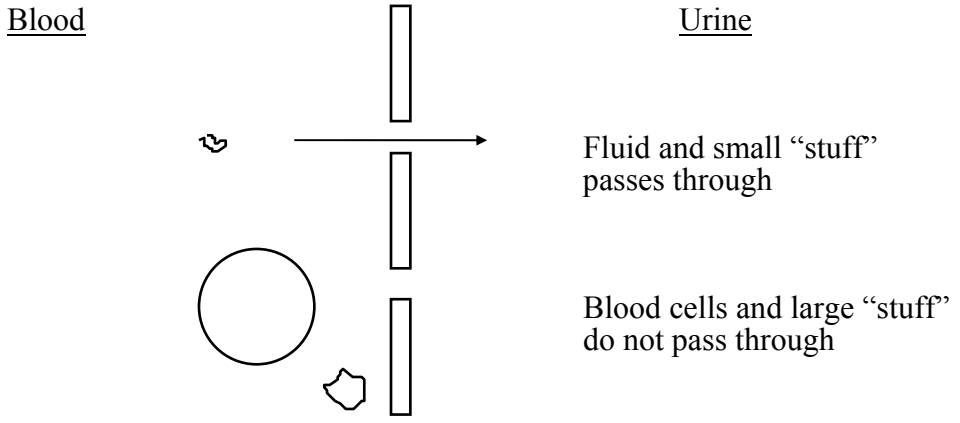
Body's cells Distilled water

Filtration

1. **Filtration** is the movement of fluid through a partition containing small holes.
   A. Fluid movement results from the force or weight of the fluid pushing against the partition.

   B. The fluid and substances small enough to pass through the holes moves through the partition, but substances larger than the holes do not pass through.

2. Filtration occurs in the kidneys. Blood pressure moves fluid through a partition to form urine, but blood cells and large molecules remain in the blood.



Mediated Transport Mechanisms

FIGURE 3.7

1. **Mediated transport** involves carrier proteins in the plasma membrane. The **carrier proteins** have the ability to combine with the ion or molecule to be transported and move it across the cell membrane.

2. Mediated transport is necessary for large, water-soluble molecules because they are too large to pass through membrane channels and the they do not dissolve in the phospholipid bilayer.

3. Mediated transport exhibits three characteristics.

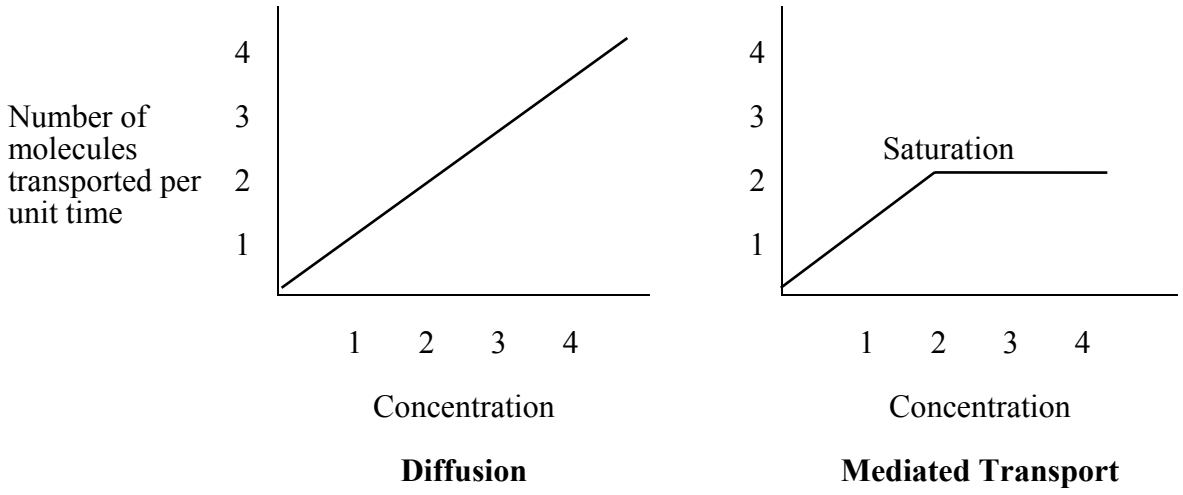
FIGURE 3.18 and 3.19

A. **Specificity**. The carrier molecule combines with only one specific molecule or one class of molecules (very similar molecules).

B. **Competition**. Within a class of molecules, the similar molecules compete for the carrier molecule. The molecule that "fits" the carrier best will be transported the most.

C. **Saturation**. The rate of transport of molecules across the cell membrane is limited by the number of carrier molecules available.

D. Comparing graphs of diffusion and mediated transport.



Facilitated Diffusion

FIGURE 3.20

1. **Facilitated diffusion** is a carrier-mediated process that moves molecules across cell membranes from areas of higher concentration to areas of lower concentration.

2. Facilitated diffusion does not require the expenditure of energy (ATP, adenosine triphosphate - the energy "currency" of the cell).

Active Transport

FIGURE 3.21

1. **Active transport** is a carrier-mediated process that moves molecules across cell membranes from areas of lower concentration to areas of higher concentration.

2. Active transport does require the expenditure of energy (ATP)

3. Although active transport's claim to fame is the ability to move substances against their concentration gradient, active transport can also move substances from higher to lower concentrations.

4. An **exchange pump** is a carrier molecule that uses active transport to exchange one substance for another. For example, the sodium-potassium exchange pump moves sodium out of cells and potassium into cells.

Secondary Active Transport

FIGURE 3.22

1. The sodium-potassium exchange pump establishes a concentration gradient for sodium ions by pumping sodium ions out of the cell. Thus, there is a greater concentration of sodium ions outside the cell than inside.

2. The sodium ions diffuse back into the cell by binding to a carrier molecule.

3. At the same time, another ion or molecule, such as glucose, binds to the carrier molecule. The movement of sodium ions down their concentration gradient provides the energy to move the glucose into the cell.

4. Because energy is involved, glucose can move against its concentration gradient and accumulate inside the cell.

5. The movement of sodium ions and the transported ion or molecule in the same direction is called **cotransport**. If the sodium ions and the transported ion or molecule move in opposite directions it is called **countertransport**. For example, as sodium ions move into cells, hydrogen ions are pumped out.

6. This process is called secondary active transport because the movement of the transported substance is secondary to (after, derived from) the active transport process. That is, active transport establishes the sodium ion concentration gradient that makes the transport of other substances possible.

☞ **Practice Problem**
Given that a transport process exhibits saturation; poisons that block metabolism (i.e., ATP production) do not affect the transport process; and movement is always from a higher to a lower concentration. Is the transport process diffusion, facilitated diffusion, active transport, or secondary active transport? Explain.

Endocytosis and Exocytosis

FIGURE 3.23 – 3.25

1. **Endocytosis** is bulk transport of materials across the cell membrane by the formation of a vesicle.
   A. **Phagocytosis** is the transport of solid particles, e.g., cell debris and foreign particles such as bacteria.

   B. **Pinocytosis** is the transport of liquid and materials dissolved in the liquid. Molecules can be transported by pinocytosis and, in some cases, the molecules bind to specific receptors on the cell membrane before the vesicle is formed. This is called **receptor-mediated endocytosis**.

2. **Exocytosis** is the movement of materials out of the cell. Vesicles containing materials produced inside the cell move to the cell surface and are released.

FIGURE 3.26