

## Membrane Structure & Function

1. Membrane structure
  - a. Our current model of the cell membrane is called the **fluid mosaic model**. It is called this because the membrane is fluid and contains several different components embedded in it.
  - b. It is a lipid bilayer, meaning it is made of two layers of fatty molecules (called **phospholipids**) sandwiched together.
    - i. Phospholipids have a hydrophilic (or polar) head and two long, hydrophobic (or nonpolar) tails. This means the heads like to be near (or interact with) water while the tails prefer to be away from (or not interact with) water. Molecules that have both polar and nonpolar portions are called **amphipathic**.
    - ii. In general, nonpolar molecules do not interact with polar molecules. This can be seen when oil (nonpolar) is mixed with water (polar). Polar molecules interact with other polar molecules and ions while nonpolar molecules interact with other nonpolar molecules. *E.g.*, table salt (ionic) dissolves in water (polar).
    - iii. The easiest way to satisfy both heads and tails is for the phospholipids to form two layers with the tails between them and the heads facing water on both sides. Phospholipids do this spontaneously.
  - c. The fluid nature of the membrane means that
    - i. components of the membrane can move sideways like buoys floating in water.
    - ii. small tears in a membrane will repair themselves spontaneously so that the tails avoid contact with water.
    - iii. two membranes can fuse together very easily.
  - d. The membrane contains **proteins** that have a variety of functions:
    - i. channels for allowing substances to move into and out of the cell
    - ii. pumps for transporting substances across the cell membrane
    - iii. receptors for hormones
    - iv. binding adjacent cells together
    - v. markers used for cell recognition
      - (1) Glycoproteins are proteins with sugars attached. They function in cell recognition, allowing cells to identify other cells. This is particularly important in the immune system where cells need to be able to identify and destroy foreign invaders such as bacteria or viruses.
2. Selective permeability
  - a. The cell membrane forms a barrier between the cell and the external environment. It separates the contents of the cell from its environment and regulates the passage of molecules into and out of the cell. The membrane allows the cell to
    - i. retain the molecules it requires.
    - ii. exclude unwanted molecules.
    - iii. recognize one another by molecules attached to their membranes.
  - b. Membranes are **selectively permeable** barriers. This means that some molecules are able to pass through while others cannot.
    - i. Substances able to pass through a membrane are
      - (1) nonpolar molecules like fats (or lipids);
      - (2) very small polar molecules like water.

- ii. Substances that are unable to pass through a membrane are:
  - (1) ions and charged molecules like salts dissolved in water;
  - (2) polar molecules like glucose;
  - (3) macromolecules.

### **Transport Across Membranes**

1. The cell membrane prevents the free movement of water and dissolved substances from inside to outside the cell. Many substances cannot pass through biological membranes. The transport of materials across a cell membrane falls into two general categories: passive and active.
2. **Passive transport** does not require energy use by the cell. There are three types of passive transport: simple diffusion, facilitated diffusion, and osmosis.
  - a. Simple diffusion
    - i. Heat energy causes molecules to move randomly. This motion is called **Brownian motion**.
    - ii. Brownian motion causes all molecules to move continuously by random, **simple diffusion**. This movement is spontaneous and does not require energy. Diffusion is the movement of particles from an area of higher concentration to an area of lower concentration.
    - iii. If the concentration of molecules in 2 areas is different, diffusion will cause molecules to move from the area with the higher concentration to the area with the lower concentration.
    - iv. The greater the concentration difference, the more rapid the net diffusion.
    - v. Diffusion evens out the concentrations so they are equal everywhere. This condition of uniform concentration is called **equilibrium**.
  - b. **Facilitated Diffusion**
    - i. Some important molecules, like glucose, cannot easily cross the membrane so their movement must be helped (or facilitated).
    - ii. Special protein channels help move these substances across the membrane. Each protein channel is specific for the molecule it is transporting.
    - iii. Like simple diffusion, this process is spontaneous and does not require energy.
  - c. Osmosis
    - i. Remember that, in a solution, the substance present in the greatest amount is called the **solvent**. In biology the solvent is almost always water. **Solutes** are the substances dissolved in the solvent.
    - ii. When water diffuses across a selectively permeable membrane, it is called **osmosis**. It occurs when a solute cannot pass through a membrane but the solvent (water) can.
    - iii. Because it is a special kind of diffusion, osmosis occurs spontaneously and requires no energy.
    - iv. Water moves from an area where there is more water to an area where there is less water. In general, water moves toward the area with a higher solute concentration because it has a lower water concentration.

- v. The amount of water in a solution is indirectly proportional to the amount of solute in the solution.
  - (1) Think of a dilute solution (call it A) as having a high water concentration (because it has few solutes) and a concentrated solution (call it B) as having a lower water concentration (because it has lots of solutes). If these two solutions were separated by a selectively permeable membrane, water would flow from high water to low water concentration. *I.e.*, from A to B.
- vi. We can categorize solutions into one of three types based on the amount of solute they contain compared to their surroundings. There are three types of solutions:
  - (1) **Hypotonic** - a solution which is more dilute (*i.e.*, less solute) than the cytosol. A cell in a hypotonic solution would gain water and swell. This is a problem for many freshwater organisms.
  - (2) **Hypertonic** - a solution which is more concentrated (*i.e.*, more solutes) than the cytosol. A cell in a hypertonic solution would lose water and shrink. This is a problem for many marine organisms.
  - (3) **Isotonic** - a solution which has the same concentration of solutes as the cytosol. A cell in an isotonic solution neither gains nor loses water but remains unchanged.
- vii. Osmotic swelling dilutes the cytosol and can eventually cause the cell to burst (**lyse**). The opposite problem, the cell shrinking, would occur in a hypertonic solution. Cells have different ways of dealing with these differences in concentration
  - (1) Cell walls of plant, fungal and bacterial cells are rigid and prevent swelling. The walls are strong enough to withstand a fairly high pressure. When a plant cell absorbs water, it swells and the cell membrane pushes against the cell wall. This is called **turgor pressure** and allows the plant to stay upright. Without the cell wall, the uptake of water could cause the cell to burst. Plant cells placed in a hypertonic solution will undergo **plasmolysis**, a condition where the plasma membrane pulls away from the cell wall as the cell shrinks. The cell wall is rigid and does not shrink.
  - (2) Some simple, single-celled organisms have contractile vacuoles which store excess water and then squirt it out.
  - (3) In complex organisms such as humans, the blood is isotonic to cytosol so cells do not have to face these problems.
- d. Whether we are talking about simple diffusion, facilitated diffusion, or osmosis, the movement of particles is due to collisions between particles. Three factors affect the rate of movement.
  - (1) Temperature - rate of diffusion increases as temperature increases.
  - (2) Concentration - rate of diffusion increases as concentration increases.
  - (3) Size - rate of diffusion decreases as molecule size increases.

3. Active transport requires that the cell use energy.
- a. Often, a cell requires substances that are at a lower concentration outside the cell than inside the cell. These substances will not move by diffusion.
  - b. **Active transport** allows a cell to concentrate materials inside itself that are at a low concentration in the environment.
  - c. In humans, active transport can account for 30% of your resting energy use.
  - d. There are two types of active transport
    - i. Special proteins in the membrane use energy to transport these substances into the cell. Note this is much like facilitated diffusion in that it is specific but different in that it requires energy.
    - ii. Endocytosis and exocytosis
      - (1) These processes are used for macromolecules that are too big to pass through the cell membrane normally (*e.g.*, proteins).
      - (2) The cell membrane bends inward, forming a vesicle containing extracellular fluid and other substances dissolved in it. This is called **endocytosis**.
        - (a) The vesicle is then fused with a lysosome to be digested macromolecules.
        - (b) **Phagocytosis** is bringing particles into the cell while **pinocytosis** is bringing in fluid.
      - (3) Exocytosis is the opposite of endocytosis. Materials are excreted from a cell but the mechanism is the same.
4. Comparison of simple diffusion, facilitated diffusion and active transport.

Property	Simple Diffusion	Facilitated Transport	Active Transport
Requires special membrane proteins			
Highly selective			
Has a maximum rate			
Can be inhibited			
Goes against concentration			
Requires energy			