Membrane Structure and Function

Chapter 5
Plasma Membrane

- So far we’ve discussed the phospholipid bilayer of the plasma membrane and the presence of glycolipids and glycoproteins.
- There are multiple types of glycoproteins, which allow for messages and molecules to pass through the membrane.
- There are also multiple methods for which molecules can move through the membrane.
Diffusion

- Diffusion is the movement of molecules from high concentrations to low concentrations
  - This is called a concentration gradient
- It is a natural phenomenon that molecules will spread as evenly as they can in a given area
- If there are more hydrogen atoms on the outside of a membrane than on the inside, the hydrogen will want to move inside the membrane to even out the concentration
Passive transport

Diffusion

Facilitated diffusion

Active transport

ATP
Types of Passage Systems

- Depending on the type of molecule and the concentration of substances in and out of the cell, there are four methods of molecule transport.

1. Simple Diffusion
   - Molecules flow between the phospholipid bilayer with the concentration gradient (gasses, and lipid-soluble molecules).

2. Facilitated transport
   - Molecules flow through the membrane with the aid of membrane proteins. They rely on the concentration gradient (sugars and amino acids).

3. Active transport
   - Molecules flow through the membrane with the aid of membrane proteins. Proteins require energy because the flow is against the concentration gradient (sugars and amino acids).

4. Bulk transport
   - Movement of large macromolecules through the plasma membrane using miniature phospholipid vesicles.
Protein #1: Channel Proteins

- Channel proteins are proteins involved in facilitated diffusion.
- They contain small tubes that allow molecules to pass through from one side of the membrane to the other.
- Each tube is the specific shape of the atom/molecule that it allows to pass in or out:
  - Sodium atom, water molecule, etc
- Because they rely on the concentration gradient in facilitated diffusion, channel proteins require no energy but also have little control.
Diffusion

Facilitated diffusion
Protein #2: Carrier Protein

- Sometimes a cell needs to transport a molecule against the concentration gradient
  - Moving from low to high concentration
- Carrier proteins use active transport to take the necessary molecule and force it in or out of the cell
  - The cell has more control over the process
  - The cell has to use energy to make the protein work
Protein #3: Cell Recognition

- Cell recognition proteins contain glycolipids copied from foreign substances.
- Their job is to alert the cell anytime this particular glycoprotein appears again.
- The cells communicate with other cells in the organism to destroy the invading pathogen before it can infect another unsuspecting cell.
1. Receptor-ligand binding
2. Signal transduction (via second messengers)
3. Cellular responses
4. Changes in gene expression
Protein #4: Receptor Protein

- Receptor proteins bond with specific molecules that come in contact with the cell.
- The molecules do not enter the cell. Instead, the bonding triggers the protein to send a message within the cell.
- Nerve cells, liver cells, and other hormonal organs use receptor proteins to know when to activate and when to shut off.
(a) Channel closed → Channel open

Neurotransmitter (ligand) released from axon terminal of presynaptic neuron

(b) Receptor

G protein → GTP → GDP

Adenylate cyclase

GTP → ATP → cAMP → Changes in membrane permeability and potential

Enzyme activation → Protein synthesis → Activation of specific genes

Nucleus
Protein #5: Enzymatic Protein

- Enzymatic proteins are enzymes embedded in the membrane which cause a specific reaction
  - Intestine cell membranes have enzymes for digesting molecules
  - Nervous system cells have enzymes for turning on or shutting off signals throughout the rest of the membrane
Water also undergoes diffusion, but in a different way.

A solution is a substance that contains both a solid and a liquid (salt and water).
- The solid is called the solute.
- The liquid is called the solvent.

Concentration is the percentage of a solution that is the solute, or the amount of solute that is in the solvent.
Concentration = \frac{\text{Amount of Solute}}{\text{Amount of Water}}
Osmosis

- Instead of maintaining an equal number of water molecules on each side of a membrane, water maintains an equal concentration on either side of the membrane.
- Thus, water will flow toward high solute concentrations.
- Even if there is more water molecules on one side of a membrane, water will still flow to that side to maintain an equal concentration.
- Water will attempt to form an isotonic solution (same concentration on both sides).
- By bringing in extra solutes or removing solutes, cells can force water in or out of the membrane.
Osmosis

- **Hypertonic solution**
  - A hypertonic solution is when the solute concentration is higher OUTSIDE the cell.
  - Water will flow out of the cell.
  - This is dangerous for a cell.
  - The cell can become dehydrated, or collapse.

- Meat is preserved with salts using this method.

- **Plasmolysis**: shrinking of plant cells due to a hypertonic environment.

- **Crenation**: shrinking of animal cells due to a hypertonic environment.
Hypotonic solution

Lysed

Isotonic solution

Normal

Hypertonic solution

Animal cell

Shriveled

Plant cell

Turgid (normal)

Flaccid

Plasmolyzed
Osmosis

**Hypotonic Solution**
- A hypotonic solution is when the solute concentration is higher **INSIDE** the cell.
- If a plant needs to take in water, it can take in extra solutes.
- Water will then flow into the cell.
- The cell walls of plants are rigid, however, and the extra water does not cause the cell to burst.
- The ability for plants to remain erect and upright by bringing in water is called turgor pressure.
Hypotonic solution

Lysed

H_2O

Isotonic solution

Normal

H_2O

H_2O

H_2O

Hypertonic solution

Shriveled

H_2O

Plant cell

Turgid (normal)

Flaccid

Plasmolyzed

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Hypotonic
Bulk Transport: Exocytosis

- Some molecules are too large to be transported in or out of the cell through a protein.
- The golgi apparatus builds a miniature bubble of phospholipids called a vesicle.
- The molecule is then placed inside the vesicle.
- The vesicle then attaches to the outer membrane of the cell and fuses.
- As the vesicle “bursts” the particle is expelled out of the cell.
EXOCYTOSIS

Plasma membrane

Extracellular fluid

Cytoplasm

Material for secretion

Secretory vesicle (from Golgi apparatus)
Endocytosis

- Endocytosis is the process of a large macromolecule entering the cell.

- Phagocytosis
  - When large macromolecules or foreign bacteria enter the cell it is surrounded by a small vesicle.
  - The vesicle then carries this particle to a lysosome.
  - The lysosome hydrolyzes the particle into its basic elements or molecules, a process called digestion.
Endocytosis

- **Pinocytosis**
  - Pinocytosis occurs when vesicles form around a liquid, or extremely simple molecules
  - Pinocytosis occurs much more often than phagocytosis and requires smaller vesicles

- **Receptor-Mediated Endocytosis**
  - Some smaller molecules, such as vitamins, are needed so often that cells have built specific receptor proteins for binding with these molecules
  - The receptor protein then becomes part of the vesicle carrying the molecule
  - This allows for much more rapid and specific transport of molecules within the cell.
Cell Modification

- Cells need to attach and transport between other cells too.

- Some structures in cell membranes are designed to hold multiple cells in place or communicate between cells
  - Adhesion junctions: sections of the cytoskeleton that bind two cells together
  - Tight junctions: proteins in the membranes of two cells are attached to each other
  - Gap junctions: channel proteins that allow substances to pass between cells
  - Plasmodesmata: membrane-lined channels in plant cells that are able to pass through thick, rigid cell walls between cells
Model of the Evolution of Cell Adhesion Junctions

1. Adhesion via Single Cell Adhesion Molecules
2. Association of Groups of Cell Adhesion Molecules
3. Recruitment of Cytosolic Proteins; Extracellular Matrix Develops
4. Adaptor Proteins Allow Association with Cytoskeleton
Gap junctions create gaps that connect animal cells.

Membrane proteins from adjacent cells line up to form a channel.
Extra Credit Question

- This question is worth an extra 5% on your essay exam
- You may check your answers with me ahead of time for a yes or no response as many times as you like.

- The molecule humans must inhale during respiration is oxygen. The molecule humans must exhale during respiration is carbon dioxide. So why does mouth-to-mouth resuscitation work?