Some very key processes…
Diffusion, Osmosis, Exocytosis, Endocytosis

Diffusion and Osmosis

- Diffusion refers to the process by which molecules intermingle as a result of their kinetic energy of random motion.
- Molecules diffuse down a concentration gradient from higher to lower concentrations
  - diffusion ends when **equilibrium** is reached

How diffusion works

- Only certain substances undergo diffusion across the plasma membrane
  - molecules like oxygen, carbon dioxide, and non-polar lipids
  - ions and polar molecules cannot cross the interior of the membrane

- Water, although polar, is able to diffuse freely across the plasma membrane
  - **aquaporins** are selective channels that permit water to cross

- Water moves down its concentration gradient in moving into or out of a cell through a process called **osmosis**

or

- Osmosis is the diffusion of water from a hypotonic solution into a hypertonic solution across and selectively permeable membrane.
  - the movement of water is dependent on the concentration of other substances in a solution
  - the greater the amount of solutes that are dissolved in a solution, then the lesser the amount of water molecules that are free to move

- The concentration of all molecules dissolved in a solution is called the osmotic concentration of the solution
- Osmotic concentrations of different solutions can be compared relative to each other
- Consider two solutions with unequal osmotic concentrations
- the solution with the higher concentration is called **hypertonic**
- The solution with the lower concentration is called **hypotonic**
- Consider two solutions with equal osmotic concentrations
- The solutions are each called **isotonic**

- Movement of water by osmosis into a cell causes pressure called **osmotic pressure**
  - enough pressure may cause a cell to swell and burst
  - osmotic pressure may explain why so many cell types are reinforced by cell walls

Endocytosis

- Endocytosis is a process in which a substance gains entry into a cell without passing through the cell membrane. This process is subdivided into three different types: pinocytosis, phagocytosis, and receptor mediated endocytosis.

Pinocytosis

- In the process of pinocytosis, the plasma membrane forms an invagination.What ever substance is found within the area of invagination is brought into the cell.
- In general, this material will be dissolved in water and thus this process is also referred to as "cellular drinking" to indicate that liquids and material dissolved in liquids are ingested by the cell.
- This is opposed to the ingestion of large particulate material like bacteria or other cells or cell debris.

Phagocytosis

- Phagocytosis is a form of endocytosis.
- In the process of phagocytosis the cell changes shape by sending out projections which are called pseudopodia (false feet).
- The phagocytic cell such as a macrophage may be attracted to a particle like a bacterium or virus by chemical attractants.

- This process is called chemotaxis (movement toward a source of chemical attractant).
- The phagocytic cell sends out membrane projections that make contact with some particle. Some sort of receptor ligand interaction occurs between the phagocytic cell surface and the particle that will be ingested.

- The pseudopodia then surround the particle and when the plasma membrane of the projection meet, membrane fusion occurs. This results in the formation of an intracellular vesicle.

Receptor mediated endocytosis

- Receptor mediated endocytosis is an endocytotic mechanism in which specific molecules are ingested into the cell.
  - molecules to be transported must first bind to specific receptors in the plasma membrane
  - a portion of the receptor extends into the membrane in an indented pit coated with the protein **clathrin**
  - when a molecule binds to its specific receptor, the cell reacts immediately by initiating endocytosis of a now clathrin-coated vesicle

Receptor-mediated endocytosis

Exocytosis

- Exocytosis is the opposite of endocytosis.
- Active cells can endocytose large amounts of plasma membrane that can almost equal the total amount of the cell's plasma membrane.
- So, the cell must have some way to restore the normal amount of plasma membrane that it originally has.
- Membrane-bound vesicles move to the cell surface where they fuse with the plasma membrane. This action results in three things.
- First, it restores the normal amount of plasma membrane.

- Secondly, any molecules dissolved in the fluid contents of these vesicles are discharged into the extracellular fluid. This is the process of secretion.

- Any integral membrane proteins (proteins associated with the plasma membrane) exposed to the interior surface of the vesicles will now be displayed at the cell surface because the vesicles turn inside out as they fuse with the plasma membrane.
- Therefore, exocytosis does not simply replenish the plasma membrane, but it also ensures that the plasma membrane will display its characteristic cell-surface proteins.

Exocytosis

Kiss-and-Run

- In some cells, like at synapses, something different happens.
- The vesicles make brief contact at the plasma membrane.
- They then release their contents to the exterior, and then retreat back to the cytosol.
- In this form of exocytosis, plasma membrane is not restored to the cell.

Selective Permeability

- **Selective permeability** allows cells to control specifically what enters and leaves
  - involves using proteins in the membrane for transporting substances across
  - transport can be down a concentration gradient (i.e., diffusion) or against a concentration gradient (i.e., **active transport**)

  - **Selective diffusion**
    - proteins act as open channels for whatever is small enough to fit inside the channel
    - this form of diffusion is common in ion transport

  - **Facilitated diffusion**
    - proteins act as carriers that can bind only to specific molecules to transport
    - transport is limited by the availability of carriers
    - if there are not enough carriers, then the transport is **saturated**

- **Active transport**
  - utilizes protein channels that open only when energy is supplied
  - energy is used to pump substances against or up their concentration gradients
  - allows cells to maintain high or low concentration of certain molecules
    - recall that diffusion always ends in equilibrium

- There are two kinds of channels that perform active transport in cells
  - sodium-potassium pump
  - proton pump

Sodium-potassium Pump

- Sodium-potassium (Na^+-K^+) pump
  - uses energy, in the form of ATP, to pump three Na^+ **out of** the cell and to pump

two K^+ **into** the cell
  - nearly 1/3 of the energy expended by the body's cells is given over to driving these pumps

How the sodium-potassium pump works

- The result of the Na^+-K^+ pump is to generate a concentration gradient with more Na^+ outside of the cell than inside

- Cells exploit this gradient in key ways
  - for the conduction of signals along nerve cells
  - for the transportation of important molecules into the cell against their concentration gradient
- the cell membrane has many facilitated diffusion channels for Na^+ but it is only transported if partnered with another substance
  - this is called **coupled transport**
- The concentration gradient favoring the entry of Na+ into the cell is so strong that a coupled substance will be transported even if it is against the concentration gradient
  - coupled transport is a common way for cells to accumulate sugars and amino acids

A coupled channel

Proton Pump

- **Proton pump**
  - expends energy to pump protons across membranes
  - the result is a concentration gradient favoring the re-entry of protons back into the cell
  - the only way that protons can cross back into the cell is through channels that generate ATP
    - this process, known as **chemiosmosis**, is essential to energy metabolism

How the proton pump works