Cell membrane transport

Cell membrane is selectively permeable membrane also regarded as semi permeable membrane, because is allow some molecules pass through it while prevent other molecule from passing.

Permeable molecules to the cell membrane include: small hydrophobic molecule like O2, CO2, N2 and benzene. And small uncharged polar molecules like water, glycerol and ethanol.

Non permeable molecules to the cell membrane include: large uncharged polar molecules like sugar, amino acids. And Ions like H+, Na+, K+, Cl^-, Ca++, Mg++, $HCO3^-$.

Molecules cross the plasma membrane in 2 ways:

1. **Passive ways**: no energy used. Include: simple diffusion and facilitated diffusion.
2. **Active ways**: use energy. Include: active transport and vesicular transport.

❖ Passive ways

1. **Simple diffusion** is the movement of molecules from higher concentration gradient to lower concentration gradient until they are distributed equally without using energy for examples
   - Respiratory gases diffuse through the lipid bilayer, this is the mechanism by which oxygen enters cells and carbon dioxide exits cells.
   - Glycerol and ethanol diffuse simply through the plasma membrane.
   - Also lipid soluble molecules pass though the cell membrane without any energy or transport protein or carrier include steroid hormones like{ estrogen, testosterone…..ect}, vitamin D and lipid soluble drug

     All above molecules are non charged and non polar

     ❖ Water molecules, for instance, cannot cross the membrane rapidly (although to their small size and lack of a full charge, they can cross at a slow rate). The phenomena of water movement though semi permeable membrane called **osmosis**.

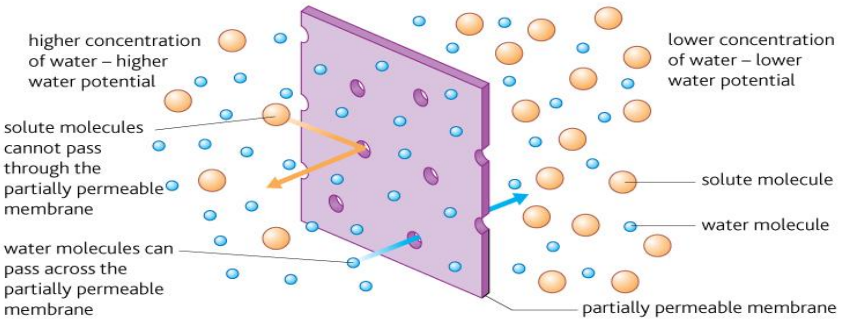


Figure: cell membrane permeability, simple diffusion (osmosis)

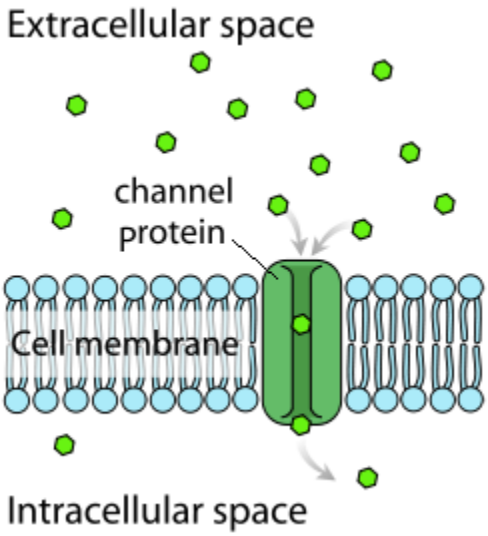
Osmosis is the movement of water molecules through semi-permeable membrane from a solution with a low solute concentration to a solution with a higher solute concentration until there is an equal solute concentration on both sides of the membrane. So that the movement of water though cell membrane depend on solute concentration inside and outside the cell.

2. **Facilitated diffusion:** this type of passive transport system also doesn't use energy, molecules diffuse across the plasma membrane with assistance from membrane proteins (transmembrane protiens), such as channels and carriers. Because these molecules are charged or polar, they can't cross the phospholipid part of the membrane without help. Facilitated transport proteins shield these molecules from the hydrophobic core of the membrane, providing a route by which they can cross. Two major classes of facilitated transport proteins are channels and carrier proteins.

a) Channel proteins: used for movement of polar or charged molecules like water and Ions. There are particular channel proteins for each particular molecule for example the water diffuse through the plasma membrane by using specific protein channels called ***aquaporins***. Aquaporins allow water to cross the membrane very quickly, and they play important roles in red blood cells, and certain parts of the kidney (where they minimize the amount of water lost as urine).

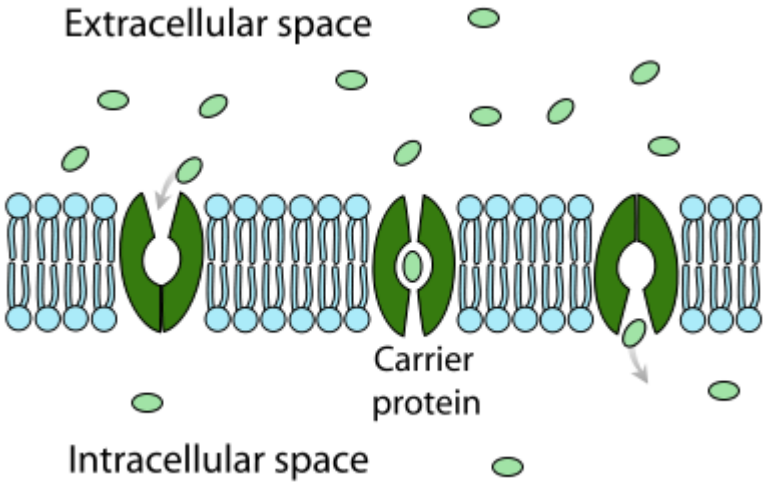
There are two types of protein channels:

i. Leak channels are continuously opened
ii. Gated channels are stimulus to open



b) Carrier proteins: Another class of transmembrane proteins involved in facilitated transport consists of the carrier proteins assist in the movement of large molecules like sugar, carbohydrate

and amino acids from high concentration gradient to low concentration gradient. Each protein carrier which actually changes shape during process, sometimes called a **transporter,** binds only to a particular molecule, such as glucose transporter or amino acids transporter. *Type 2 diabetes mellitus results when cells lack a sufficient number of glucose transporters.*



❖ **Active ways:** Active transport mechanisms can be divided into two categories.

i. **Active transport:** directly uses a source of chemical energy (e.g., ATP) to move molecules across a membrane against their gradient.

- ✓ Molecules and ions can be transported across cell membrane against their concentration gradient if the appropriate transport proteins and a source of energy (ATP) are available.
- ✓ **ATP** Adenosine Triphosphate -Nucleotide with three phosphate groups.
  The breakdown of ATP into ADP and one inorganic phosphate molecules by ATPase makes energy available for energy-requiring processes in cells.
- ✓ Proteins transporter involved in active transport mechanism often are called **pumps; pump** is used energy to move substances against their concentration gradients.
- ✓ Just as water **pump** uses energy to move water against the force of gravity.
- ✓ **Sodium-Potassium Pump** or called Na/K ATPase – is transport protein (pump) in the plasma membrane that moves sodium ions (Na^+) out of and potassium ions (K^+) into cells; important in nerve and muscle cells. The sodium potassium pump cause an electrical concentration gradient (difference of charge) across the membrane and this is known as a membrane potential. Nerve cells use this membrane potential to send electrical signals along nerves.

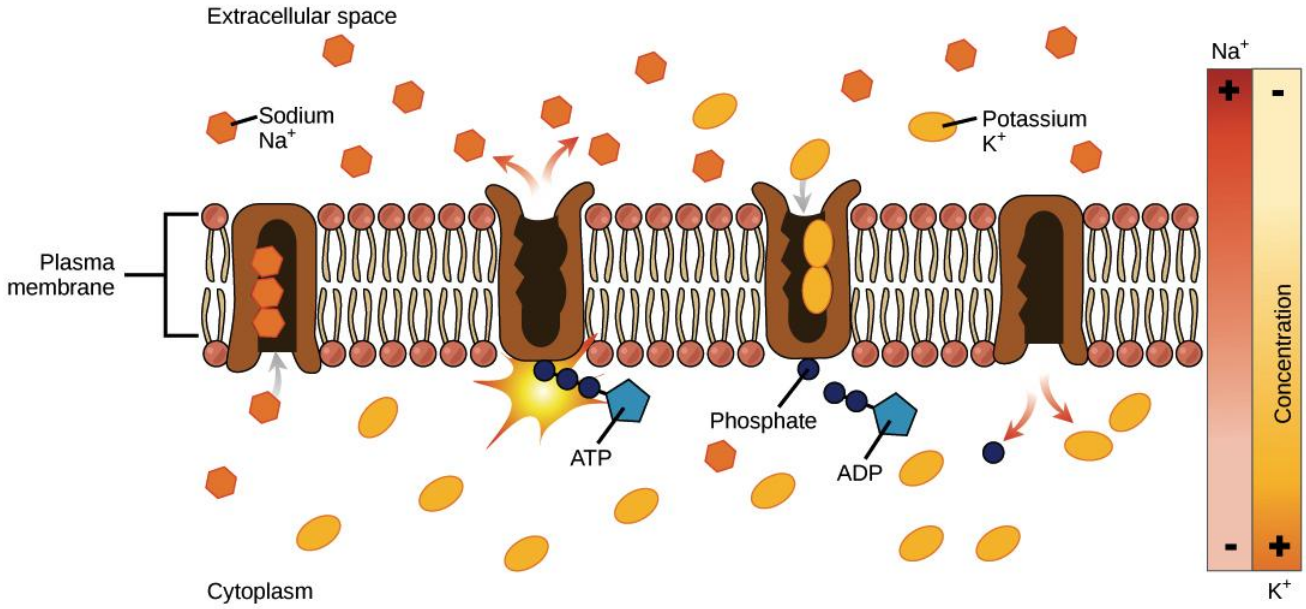


Figure shows the sodium-potassium pump cycle

One of important clinical application on active transport is a cystic fibrosis (CF).

CF is a genetic disorder occurs when there is a defects in a gene on chromosome 7 .This gene, called CFTR (cystic fibrosis Transmembrane conductance regulator), codes for the CFTR protein is a channel protein that controls the flow of H2O and Cl- ions in and out of cells inside the lungs. When the CFTR protein is working correctly, ions freely flow in and out of the cells. However, when the CFTR protein is malfunctioning, these ions cannot flow out of the cell due to a blocked channel. This causes cystic fibrosis, characterized by the buildup of thick mucus in the lungs.

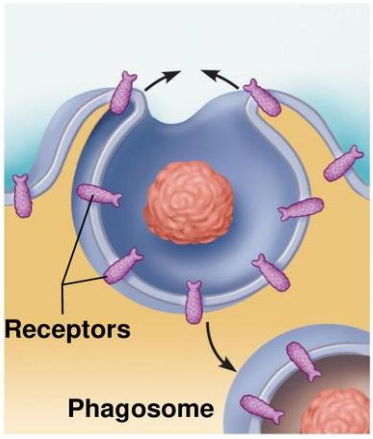
ii. **Vesicular transport**: is the transport of large substance across the plasma membrane by vesicle , which is a membrane bounded sac filled with materials

Endocytosis: is uptake process of molecules and transport it across cell membrane into the cell interior by vesicle formation, a portion of the plasma membrane invaginates to envelop the substance, and then the membrane pinches off to form an intracellular vesicle. **There are three methods of endocytosis**:

A. **Phagocytosis**: means "**cell eating**", occurs when large **solid** materials taken inside the cell, such as food particles, dead cell, cell debris or another cell such as bacteria . *Best example on phagocytic cell*

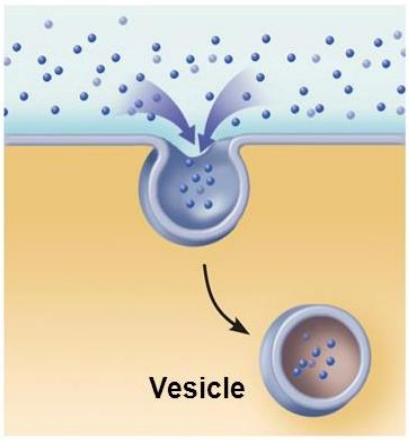
is white blood cells (WBC) can engulf bacteria and worn- out red blood cells by phagocytosis.

Digestion occurs when the resulting vacuole (phagocytic vacuole) fuses with a lysosome.



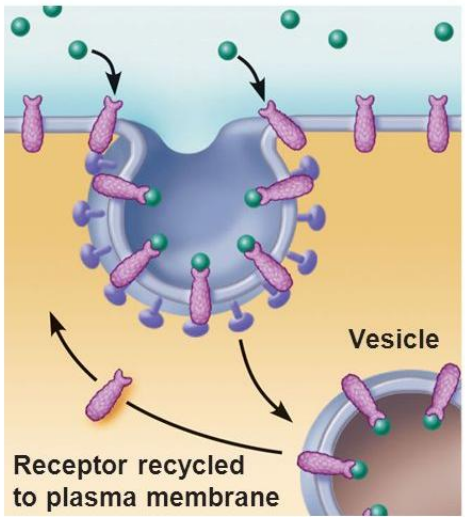
(a) Phagocytosis
The cell engulfs a large particle by forming projecting pseudopods ("false feet") around it and enclosing it within a membrane sac called a phagosome. The phagosome is combined with a lysosome. Undigested contents remain in the vesicle (now called a residual body) or are ejected by exocytosis. Vesicle may or may not be protein coated but has receptors capable of binding to microorganisms or solid particles.

B. **Pinocytosis**: means "**cell drinking**" occurs when vesicles form around fluid droplets. *Pinocytosis takes place in almost all cells, including the secretory cells and epithelial cells of the blood vessels also cells that line the kidney tubules or intestinal wall*



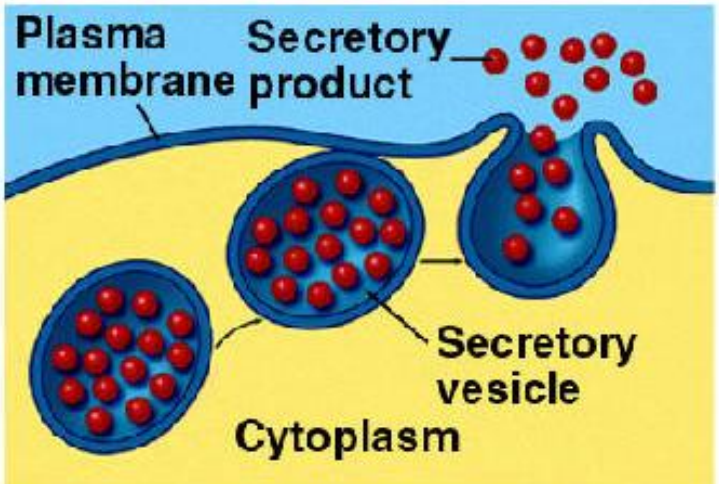
(b) Pinocytosis
The cell "gulps" a drop of extracellular fluid containing solutes into tiny vesicles. No receptors are used, so the process is nonspecific. Most vesicles are protein-coated.

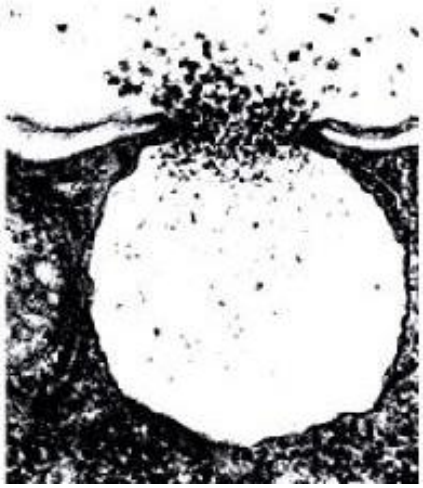
C. **Receptor- mediated endocytosis**: A special form of endocytosis uses a **receptor**, a special form of membrane protein on the surface of the cell to concentrate specific molecules of interest for endocytosis. *one type of dwarfism are caused by nonfunctioning growth hormone receptors, In this condition the gland produce the hormone, but the target cells cannot respond because they lack normal receptors. Also an inherited form of cardiovascular disease (familial hypercholesterolemia) occurs when cells fail to take up a combined lipoprotein and cholesterol molecule from the blood .*



(c) Receptor-mediated endocytosis
Extracellular substances bind to specific receptor proteins in regions of coated pits, enabling the cell to ingest and concentrate specific substances (ligands) in protein-coated vesicles. Ligands may simply be released inside the cell, or combined with a lysosome to digest contents. Receptors are recycled to the plasma membrane in vesicles.

Exocytosis: is release process of material from the cell. During exocytosis vesicles often formed by Golgi apparatus and carrying a specific molecule fused with plasma membrane and secretion occurs. **e.g**. release of insulin molecules from beta **c**ells or releasing of neurotransmitter molecules into the synaptic cleft by the process of exocytosis.





Functions of plasma membrane

1. Protect a cell by acting as a barrier between cell contents and surrounding environment.
2. Regulate the movement of substances in and out of a cell. It allows the passage of substance selectively in order to maintain a constant cell environment a phenomenon called homeostasis.
3. Connect cells together in specific way by cell junctions and pass on information to neighboring cell, so that the activities of tissue and organs are coordinated.
4. Serve as the attachment surface for many extracellular structures.