TRANSPORT ACROSS MEMBRANE

The plasma membrane functions to isolate the inside of the cell from its environment, but isolation is not complete. A large number of molecules constantly transit between the inside and outside of the cell, most frequently one-at-a-time, but also in large packages. The plasma membrane functions as a selectively permeable membrane with exquisite selectivity regarding which molecules cross and which direction they are allowed to travel. In the simplest case, nutrients must be allowed to enter the cell and waste products to exit. Another critical task is to maintain an ionic composition inside the cell that is very different from that outside the cell.

All transport across cell membranes takes place by one of two fundamental processes:

a. Passive: Transport from higher concentration to lower concentration without expenditure of energy
b. Active: Transport from lower concentration to higher concentration by utilizing ATP.

PASSIVE TRANSPORT

Transport by Simple Diffusion

Water, oxygen, carbon dioxide, ethanol and urea are examples of molecules that readily cross cell membranes by simple diffusion. They pass either directly through the lipid bilayer or through pores created by certain integral membrane proteins. The relative rate of diffusion is roughly proportional to the concentration gradient across the membrane. For example, oxygen concentrations are always higher outside than inside the cell and oxygen therefore diffuses down its concentration gradient into the cell; the opposite is true for carbon dioxide.

The rate limiting step for simple diffusion across a cell membrane is movement of the molecule from the aqueous environment outside or inside the cell into the lipid bilayer of the membrane. Rate of transport for a particular molecule is therefore proportional to the lipid solubility or hydrophobicity of that molecule. Oxygen, carbon dioxide and ethanol are highly lipid soluble and therefore diffuse across the bilayer almost as if it were not there.

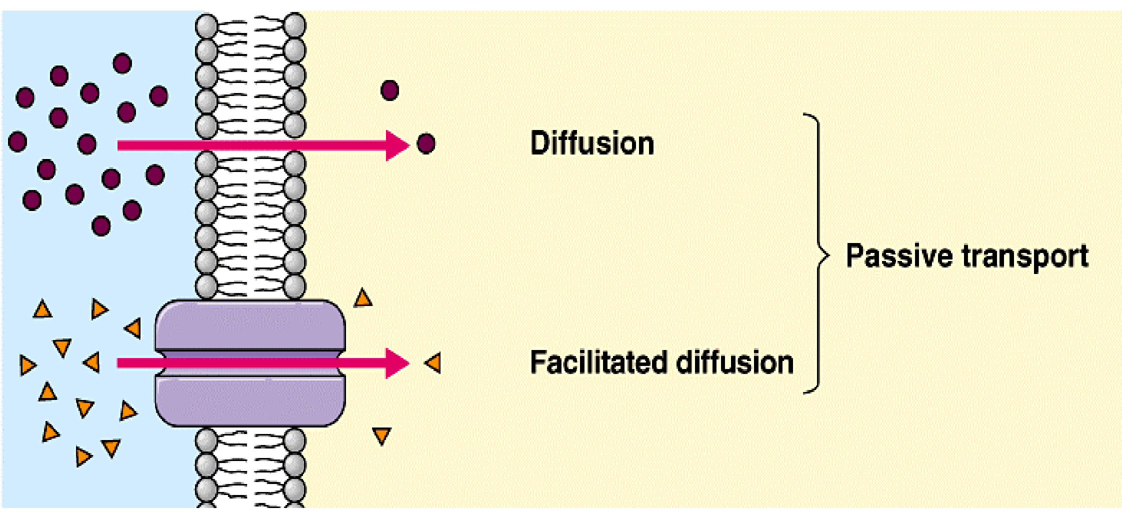
Ions and charged molecules diffuse cross the lipid bilayer of cell membranes very, very poorly. Their charge, either positive or negative, causes them to be repelled from like charges in the cell membrane. Additionally, their charge causes them to electrically bind water molecules, causing them to be hydrated and effectively quite large.

Facilitated Diffusion

Glucose, sodium ions and choride ions are just a few examples of molecules and ions that must efficently get across the plasma membrane but to which the lipid bilayer of the membrane is virtually impermiable. Their transport must therefore be "facilitated" by proteins that span the membrane and provide an alternative route or bypass. Facilitated diffusion is the name given this process. It is similar to simple diffusion in the sense that it does not require expenditure of metabolic energy and transport is again down an electrochemical gradient.

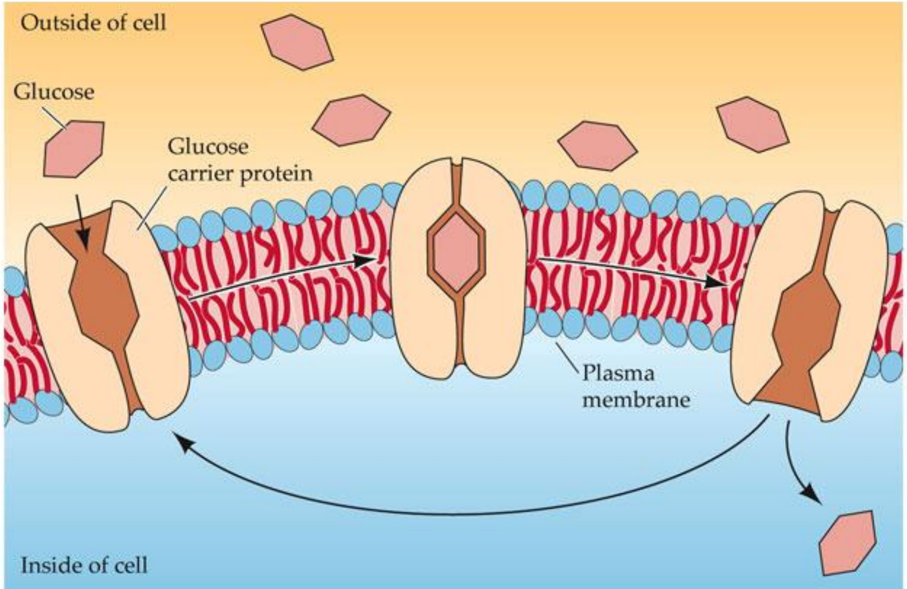
Two major groups of integral membrane proteins are involved in facilitated diffusion:

1. **Carrier proteins**(also known as permeases or transporters) bind a specific type of solute and are thereby induced to undergo a series of conformational changes which has the effect of carrying the solute to the other side of the membrane. The carrier then discharges the solute and, through another conformational change, reorients in the membrane to its original state.
2. **Ion Channels** do not really bind the solute, but are like hydrophilic pores through the membrane that open and allow certain types of solutes, usually inorganic ions, to pass through. In general, channels are quite specific for the type of solute they will transport and transport through channels is quite a bit faster than by carrier proteins. Additionally, many channels contain a "gate" which is functions to control the channel's permiability. When the gate is open, the channel transports, and when the gate is closed, the channel is closed. Such gates can be controlled either by voltage across the membrane (voltage-gated channels) or have a binding site for a ligand which, when bound, causes the channels to open (ligand-gated channels).



Osmosis

Water flows from the solution with the lower solute concentration into the solution with higher solute concentration. This means that water flows in response to differences in molarity across a membrane. *The size of the solute particles does not influence osmosis*. Equilibrium is reached once sufficient water has moved to equalize the solute concentration on both sides of the membrane, and at that point, net flow of water ceases.



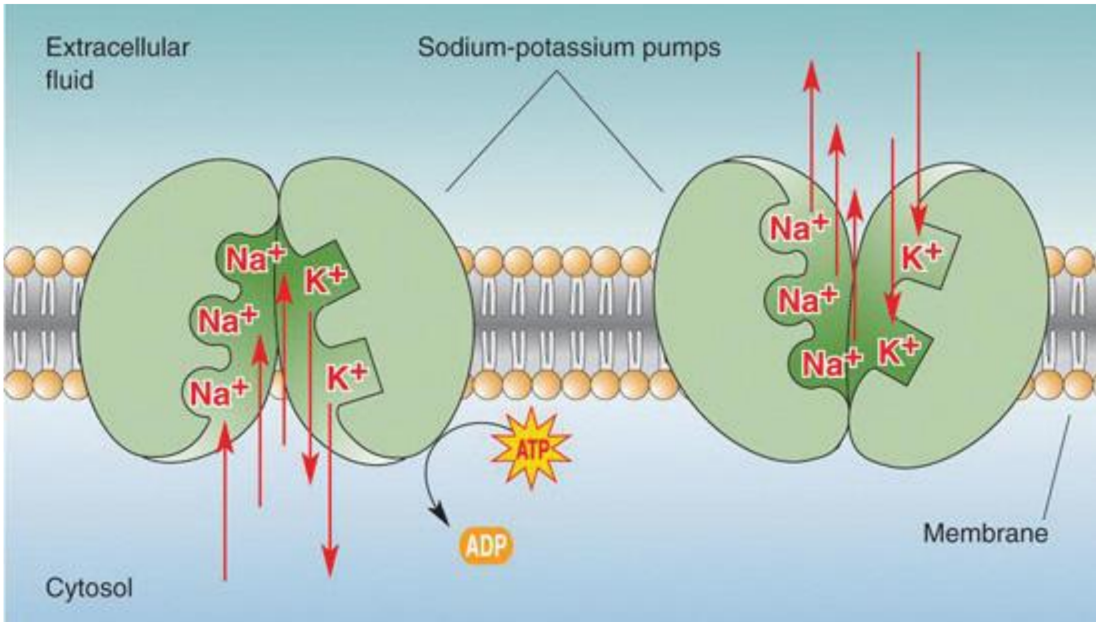
Facilitated diffusion of Glucose

Active Transport

Althought a lot of molecules are transported across the plasma membrane by passive transport, in many case, the cell must transport molecules against the concentration gradient. This requires energy which is generally provided by the hydrolysis of the molecules such as ATP.

Example of Active transport:

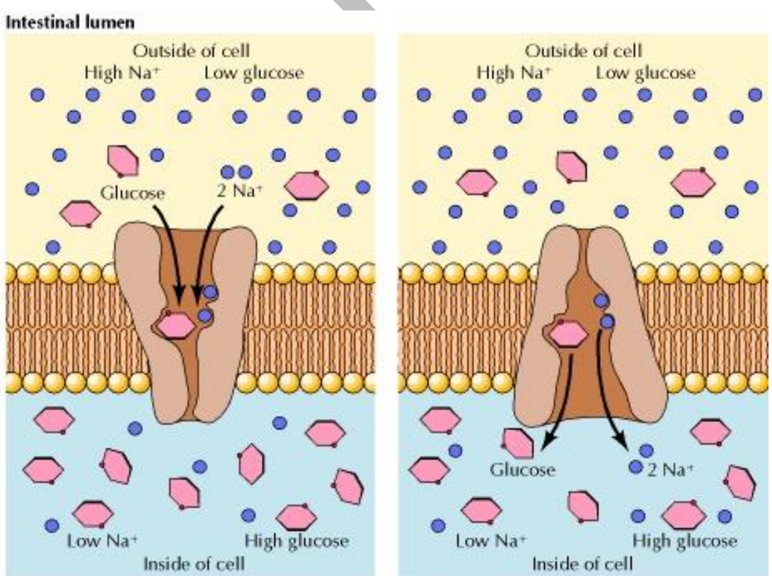
1. The ion pumps responsible for maintaining gradients of ions across the plasma membrane are an example of active transport.The concentration of Na+ is approximately 10 times higher outside than inside of the cell, whereas the concentration of K+ is higher inside than outside. These ion gradients are maintained by Na+-K+ pumps, which use energy derived from ATP hydrolysis to transport Na+ and K+ against the concentration gradient. First, Na+ ions bind to high affinity sites **inside** the cell. This stimulates the hydrolysis of ATP and phosphorylation of the pump. A conformational change exposes the Na+ binding sites to the outside of the cell and reduces their affinity for Na+. As a result, Na+ is released into the extracellular fluid. At the same time, high affinity K+ binding sites are exposed on the outer surface of the cell. The binding of extracellular K+ to these sites causes a conformational change exposing the K+ binding sites to the inside of the cell. The pump has 3 binding sites for Na+ and 2 for K+.



Na+- K+ pump

2. Other molecules are transported against their concentration gradient using energy **not** from ATP hydrolysis but from coupled transport of second molecule in energetically favourable direction.

The Na+ gradient established by Na+-K+ pump provides energy for the active transport of sugars, amino acids and ioins in mammalian cells.



Active transport of Glucose

Symport, Uniport and Antiport

The transport of two molecules in the same direction is called as **Symport**.

Example: uptake of Na+ and glucose.

The transport of a single molecule is called as **uniport.**

Example: Facilitated diffusion of glucose.

Transport of two molecules in opposite directions is known as **antiport.**