Transport mechanisms across bio membranes and osmosis

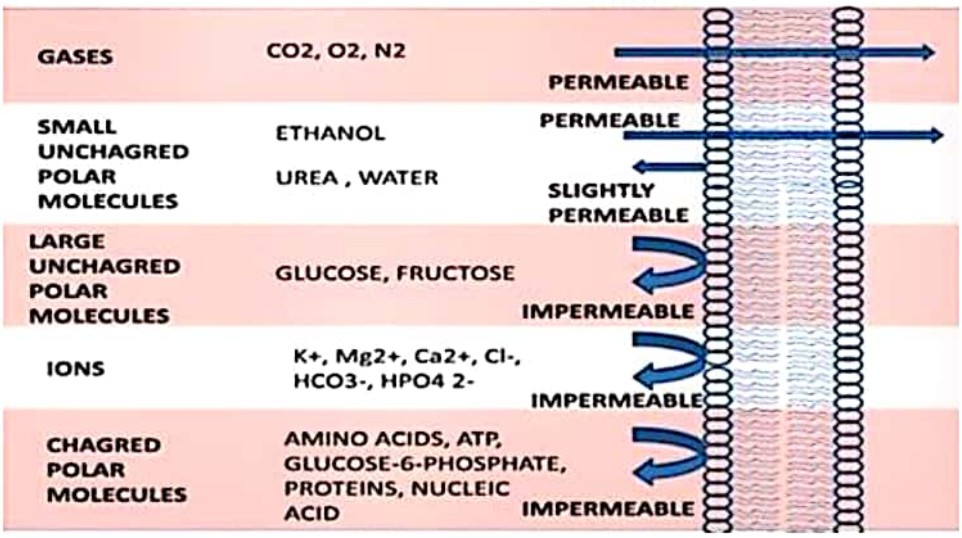
Transport across a Cell Membrane

The cell membrane is one of the great multi-taskers of biology. It provides structure for the cell, protects cytosolic contents from the environment, and allows cells to act as specialized units. A membrane is the cell's interface with the rest of the world - its gatekeeper, if you will. This phospholipid bilayer determines what molecules can move into or out of the cell, and so is in large part responsible for maintaining the delicate homeostasis of each cell.

To perform these roles, the plasma membrane needs lipids, which make a semi-permeable barrier between the cell and its environment. It also needs proteins, which are involved in cross-membrane transport and cell communication, and carbohydrates (sugars and sugar chains), which decorate both the proteins and lipids and help cells recognize each other.

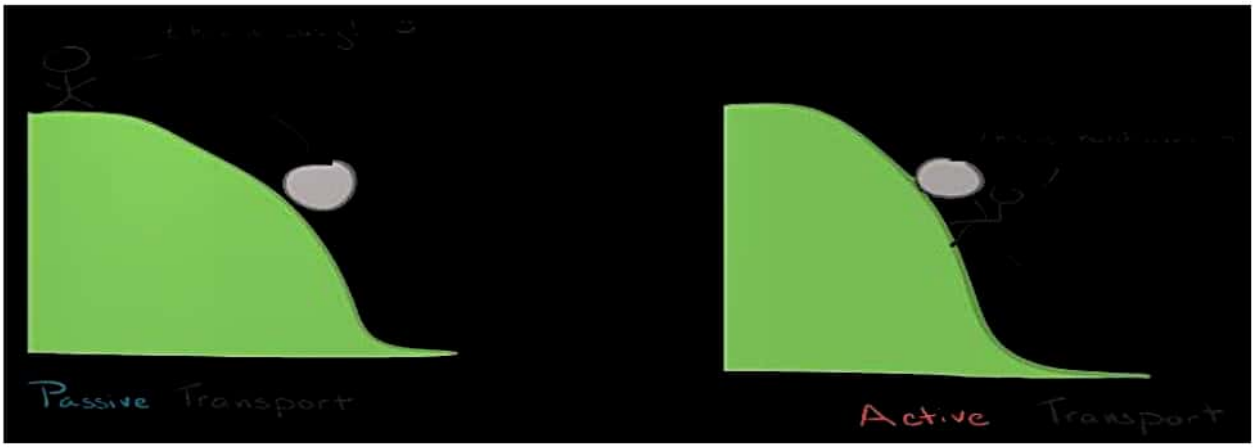
Semi-Permeability

Most of the molecule will diffuse across a protein-free lipid bilayer down its concentration gradient, if provided enough time. The diffusion rate is the function of the size of the molecule and its relative solubility in oil. In general, the smaller the molecule and the more soluble in oil (the more hydrophobic or non-polar), the more rapidly it will diffuse across a cell membrane. Small non-polar molecules, such as O_2 and CO_2, readily dissolve in cell membrane and therefore diffuse rapidly across them whereas small uncharged polar molecules, such as water or urea, also diffuse across a bilayer, but much more slowly but ethanol diffuses readily. Conclusively it can be said that lipid bilayer are highly impermeable to charged molecules (ions) by considering its size also because the charge and high degree of hydration of such molecules prevents them from entering the hydrocarbon phase of the bilayer. Thus, these bilayers are 109 times more permeable to water than to even such small ions as Na+ or K.



Movement across a Membrane and Energy

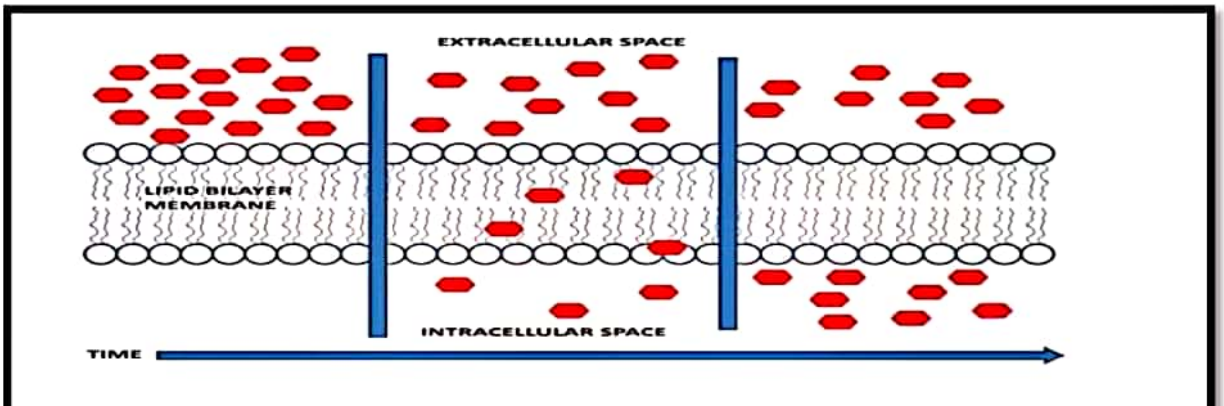
There are two major ways that molecules can be moved across a membrane, and the distinction has to do with whether or not cell energy is used. Passive mechanisms like diffusion use no energy, while active transport requires energy to get done.



Passive mediated transport: Substances that are too large or polar diffuse across the lipid bilayer on their own through membrane proteins called carriers, permeases, channels and transporters. Unlike active transport, this process does not involve chemical energy. So the passive mediated transport is totally dependent upon the permeability nature of cell membrane, which in turn, is function of organization and characteristics of membrane lipids and proteins.

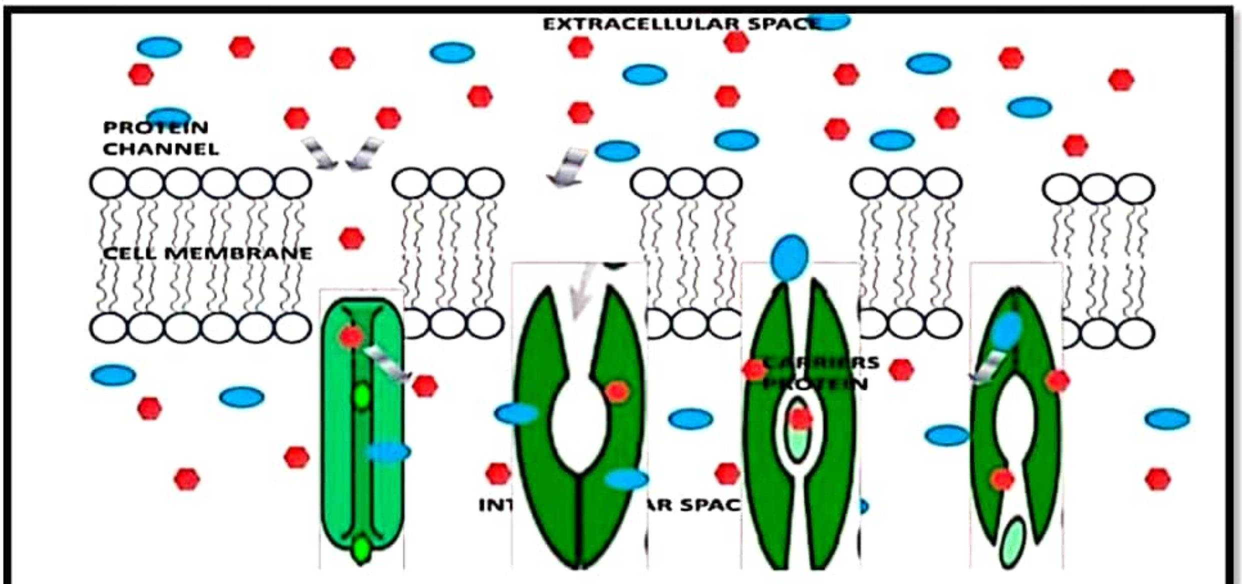
Types of passive transport:

1. Diffusion: The process of the net movement of solutes from a region of high concentration to a region of low concentration is known as diffusion. The differences of concentration between the two regions are termed as concentration gradient and the diffusion continues till the gradient has been vanished. Diffusion occurs down the concentration gradient.



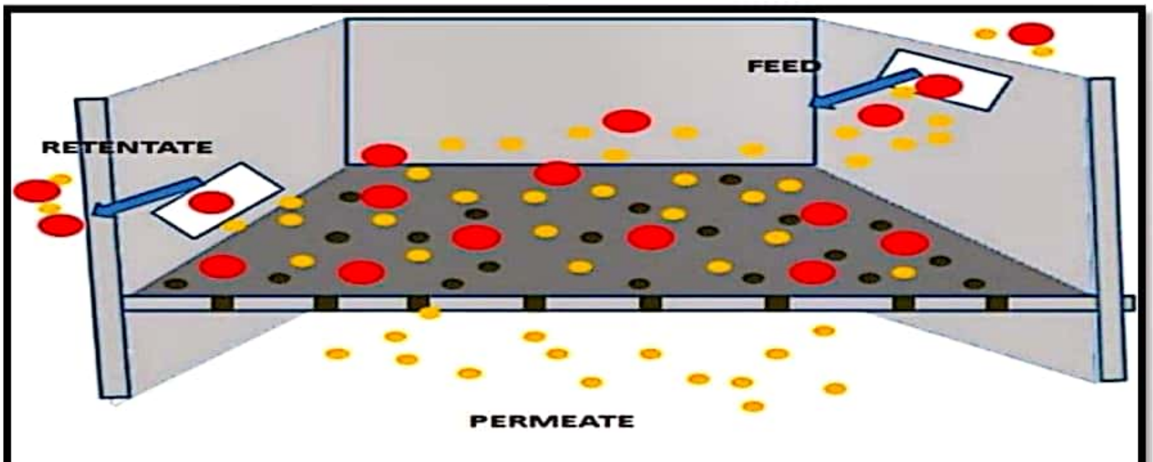
: Diffusion.Extracellular space contains high concentration of solutes than intracellular space and hence the solutes move from extracellular space to intracellular space till there is no concentration gradient between the spaces.

2. Facilitated diffusion: The process of the movement of molecules across the cell membrane via special transport proteins that are embedded within the cellular membrane is known as facilitated diffusion or called carrier-mediated diffusion. Many large molecules, such as glucose, are insoluble in lipids and too large to fit into the porins, therefore, it will bind with its specific carrier proteins, and the complex will then be bonded to a receptor site and moved through the cellular membrane.



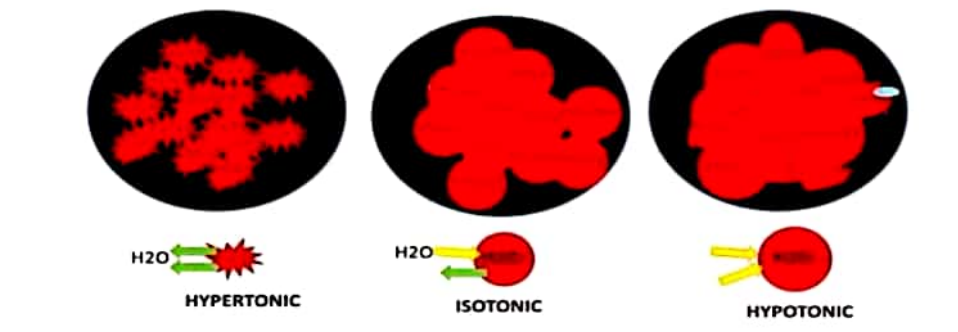
Facilitated transport.Movement of the solutes from extracellular space to intracellular space via carrier proteins and down its concentration gradient.

3. Filtration: Filtration is the process of the movement of water and solute molecules across the cell membrane due to hydrostatic pressure generated by the system. Depending on the size of the membrane pores, only solutes of a certain size may pass through it. The membrane pores of the Bowman's capsule in the kidneys are very small, and only albumins (smallest of the proteins)can filter through. On the other hand, the membrane pores of liver cells are extremely large, to allow a variety of solutes to pass through and be metabolized.



Filtration

4. Osmosis: Osmosis is the type of diffusion of water molecules across a semi- permeable membrane, from a solution of high water potential to a region of low water potential. A cell with a less negative water potential will draw in water but this depends on other factors as well such as solute potential (pressure in the cell e.g. solute molecules) and pressure potential (external pressure e.g. cell wall).

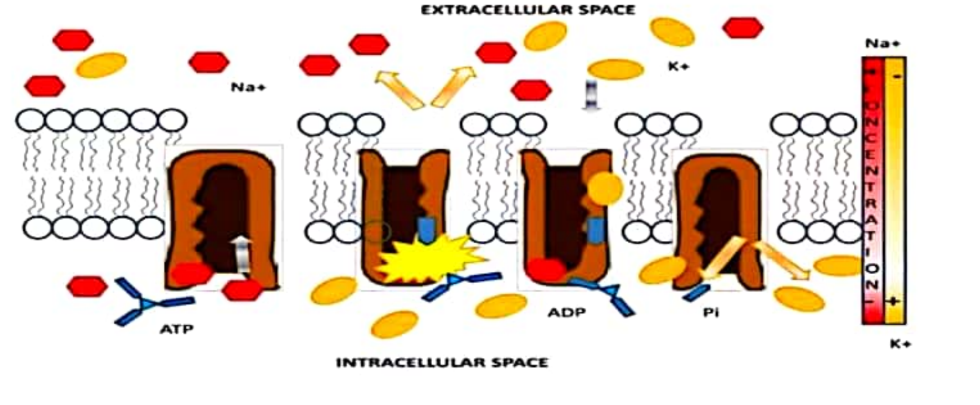


Osmosis.(A) In hypertonic solution, there are more solute molecules outside the cell, which causes the water to be sucked in that direction which leads to the shrinkage of cells. (B) In isotonic solution, there is equal concentration of solute on both sides, henceforth the water with move back in forth. (C) In hypotonic solution, there are less solute molecules outside the cell, since salt sucks and water will move inside the cell. The cell will gain water and grow larger, and finally burst.

Active transport: Active transport is the movement of a substance against its concentration gradient (i.e. from low to high concentration). It is an endergonic process that, in most cases, is coupled to the hydrolysis of ATP.

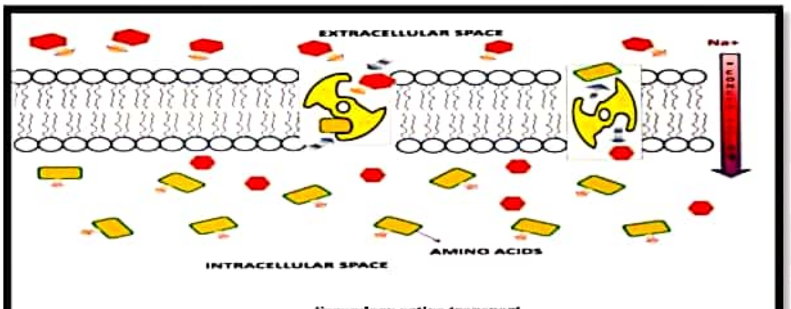
Types of active transport:

1. Primary active transport: Primary active transport, also called direct active transport, directly uses energy to transport molecules across a membrane. Example: Sodium-potassium pump, which helps to maintain the cell potential.



Primary active transport.The action of the sodium-potassium pump is an example of primary active transport.

2. Secondary active transport: Secondary active transport or co-transport also uses energy to transport molecules across a membrane; however, in contrast to primary active transport, there is no direct coupling of ATP; instead, the electrochemical potential difference created by pumping ions out of the cell is instrumental.

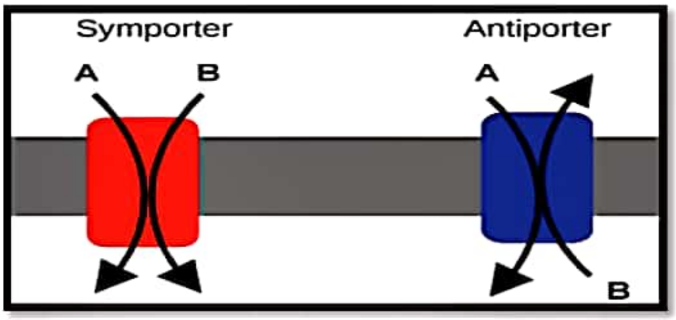


Secondary active transport

The two main forms of active transport are antiport and symport.

(a) Antiport: In antiport two species of ion or solutes are pumped in opposite directions across a membrane. One of these species is allowed to flow from high to low concentration which yields the entropic energy to drive the transport of the other solute from a low concentration region to a high one. Example: the sodium-calcium exchanger or antiporter, which allows three sodium ions into the cell to transport one calcium out.

(b) Symport: Symport uses the downhill movement of one solute species from high to low concentration to move another molecule uphill from low concentration to high concentration (against its electrochemical gradient). Example: glucose symporter SGLT1, which co-transports one glucose (or galactose) molecule into the cell for every two sodium ions it imports into the cell.



- ✓ When they move in the same direction, the protein that transports them is called a **symporter**, while if they move in opposite directions; the protein is called an **antiporter**.

Recommendation:

- https://youtu.be/QpcACa39YtA
- https://youtu.be/LXaPt9i9hqk
- https://youtu.be/TsoAA7zOyj8
- https://youtu.be/jQN07Hvq6WI
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