

Plasma membrane

Plasma membrane is the biological membrane which is present both in prokaryotic and eukaryotic cells. It acts as a barrier between outer and inner surface of a cell. Plasma membrane is present as outer most layer or envelope in animal cell but is present beneath the cell wall in plant cell as well as most of prokaryotic cells. The plasma membrane, which is also referred to as the cytoplasmic membrane, is a biological membrane that encloses the contents of the cell (protoplasm) and separates it from the outer environment.

The cell or bio membrane has extracellular face(facing outer environment) and intracellular face (facing cytoplasm). Plasma membranes appears trilaminar (Protein-phospholipid bilayer- protein) when viewed under electron microscope.

Protoplasm of all type of cells is surrounded by plasma membrane, which in eukaryotic cells extends into the interior of the cell to divide the protoplasm into a number of compartments to form cell organelles as Endoplasmic reticulum, mitochondria, plastids, golgi apparatus etc. for various cellular functions.

Plasma membrane is thin (4-10nm) ,delicate ,permeable , semi-porous barrier to outside environment. The membrane acts as a boundary, holding the cell constituents together and keeping other substances from entering. Membranes are impermeable to most polar or charged solutes but permeable to non polar compounds. Permeability of cell membrane depends on physiological state of cell and size and nature of molecules.

CHEMICAL COMPOSITION OF PLASMA MEMBRANE

The basic structural framework is the lipid bilayer. Made up of 3 macromolecules: (Lipids, Proteins, Carbohydrate).

1.Membrane lipids:-

It constitute about 75% - phospholipids , 20% - cholesterol, 5% - glycolipids. Mostly lipids are Amphipathic having both polar & nonpolar parts. Acts as permeability barriers. Essential for the maintenance of fluidity of membranes.

Phospholipids

It consist of “Head” – Polar part – phosphate group and “Tail” – Non polar part – long chain fatty acids. These includes phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, plasmalogens & sphingomyelin.

Cholesterol

Cholesterol molecules are weakly amphipathic & are interspersed among the other lipids in both layers of the membrane.

Glycolipids

Glycolipids present only in the membrane layer that faces the extracellular fluid.

2.Membrane Proteins

Two types of proteins are present in membrane 1. Integral proteins 2. peripheral proteins.

1. Integral proteins

Integral proteins extend through the lipid bilayer are firmly embedded in it. Most integral proteins are transmembrane proteins.

2. peripheral proteins

Peripheral proteins are not embedded in the membrane. They associate more loosely with the polar heads of membrane lipids at the inner or outer surface of the membrane. Many membrane proteins are glycoproteins

Membrane Proteins functions

Ion channels, Carriers (transporters) ,Receptors, Enzymes, Cell identity markers (glycoproteins & glycolipids)

3. Membrane Carbohydrate

Carbohydrate are covalently bound to lipids to form glycolipids and to the protein to form glycoproteins. These are mostly Glucose , Galactose, Mannose , N-acetyl glucosamine , N-acetylgalactosamine

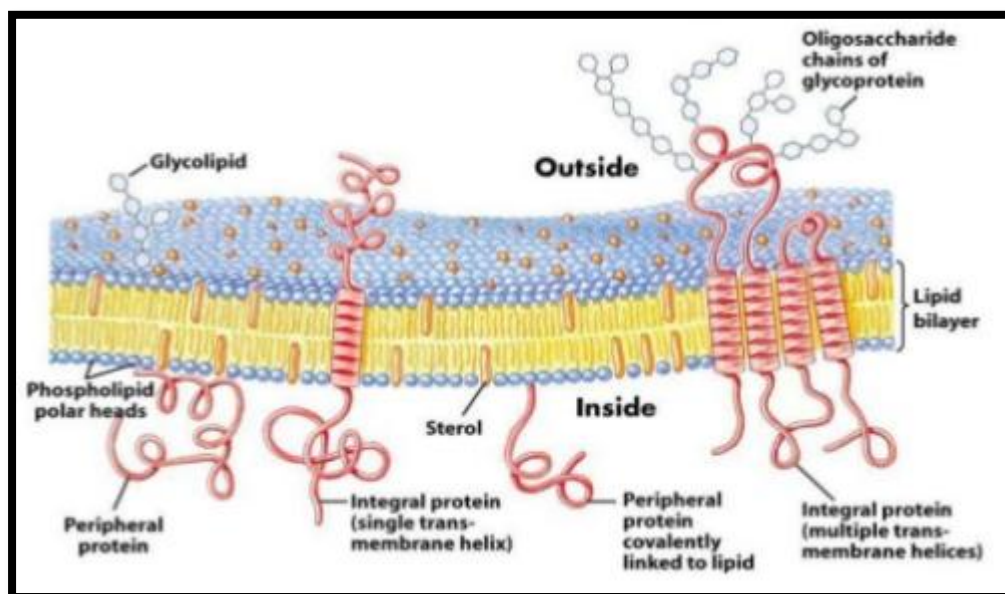


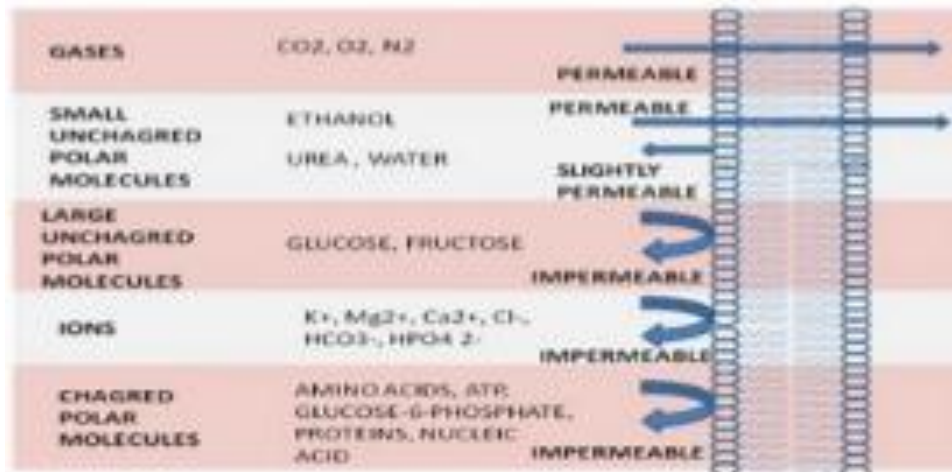
Figure illustrated Fluid Mosaic Model for structure of cell membrane

Cell membrane architecture in transport across cell membrane:

The cell membrane plays an important role in transport of molecules. Because it acts as a semi-permeable barrier, allowing specific molecules to cross while fencing the majority of organically produced chemicals inside the cell. Electron microscopic examinations of cell membranes reveal the development of the lipid bilayer model (fluid-mosaic model). The model consists of phospholipid, which has a polar (hydrophilic) head and two non- polar (hydrophobic) tails. These phospholipids are aligned tail to tail so the non-polar areas form a hydrophobic region between the hydrophilic heads on the inner and outer surfaces of the membrane.

Permeability of molecules across phospholipid bilayer:

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 O₂ and CO₂, 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 bilayers 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⁺



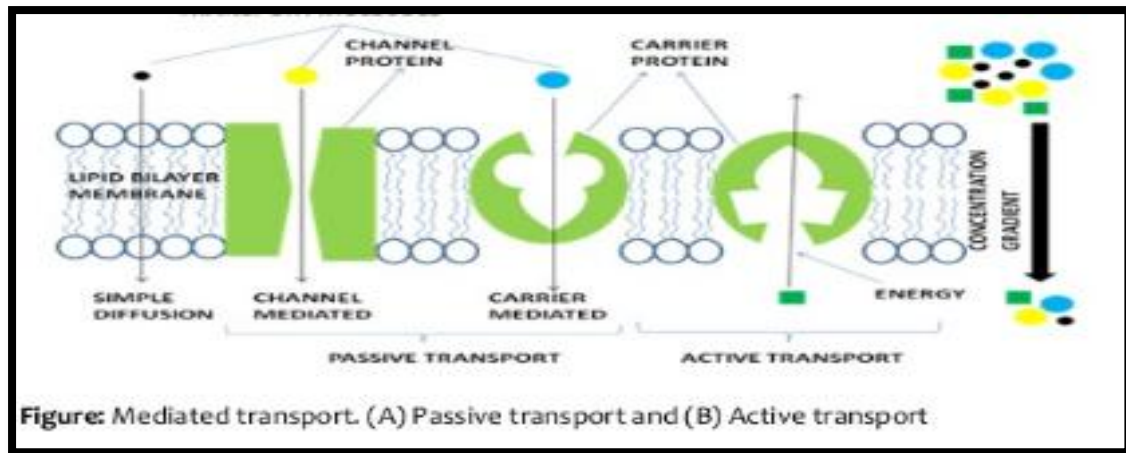
Types of transport process:

Two types of transport process occur across the membrane.

1. Non-mediated transport
2. Mediated transport

Non-mediated transport occurs through the simple diffusion process and the driving force for the transport of a substance through a medium depends on its chemical potential gradient. Whereas mediated transport requires specific carrier proteins.

1. Passive-mediated transport, or facilitated diffusion: In this type of process a specific molecule flows from high concentration to low concentration.
2. Active transport: In this type of process a specific molecule is transported from low concentration to high concentration, that is, against its concentration gradient.



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.

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.

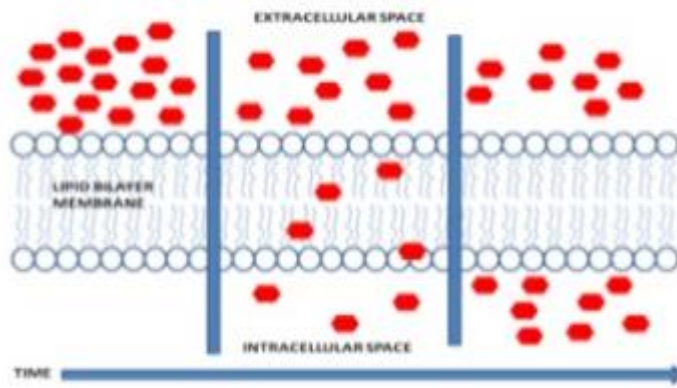
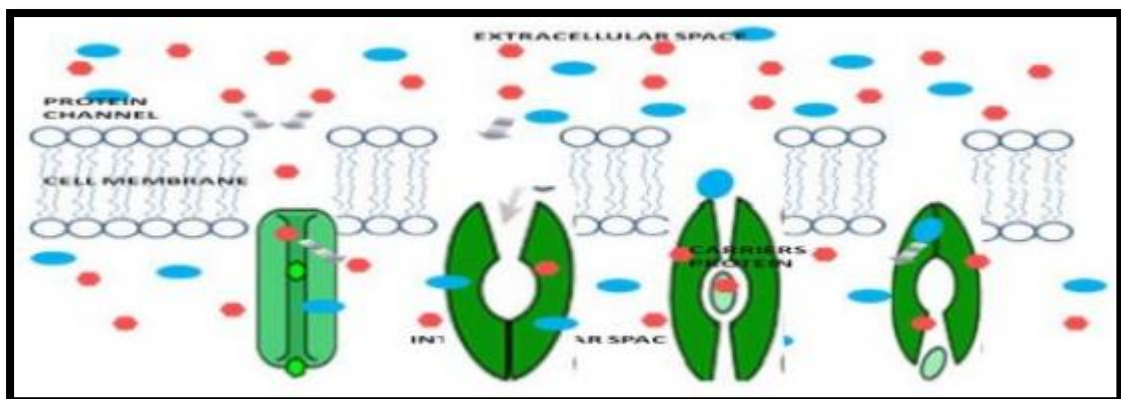


Figure: Diffusion. Extracellular space contains high concentration of solutes than intracellular space and hence the solutes move from extracellular space to intracellular space till there is no concentration gradient between the spaces.

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.



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

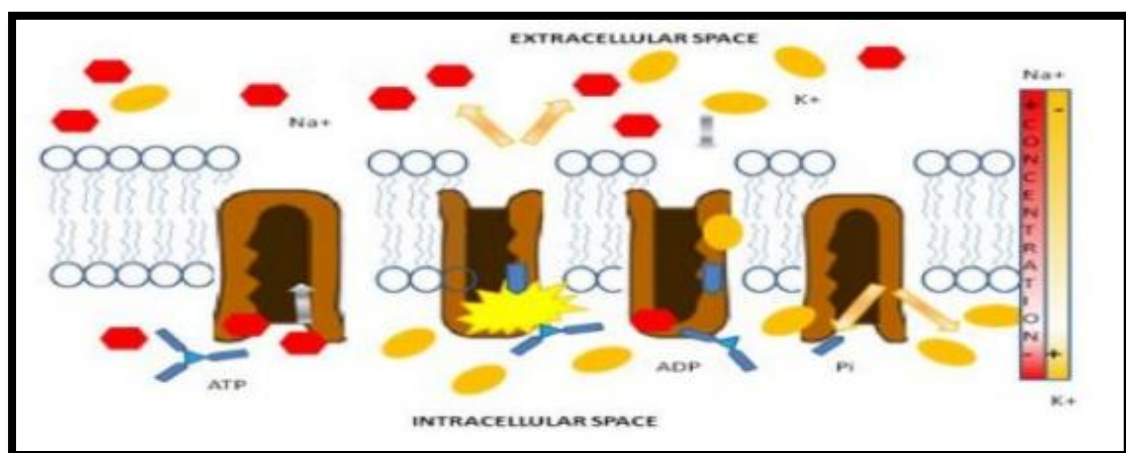
Bowman's capsule in the kidneys are very small, and only albumins (smallest of the proteins) can filter through. On the other hand, the membrane pores of liver cells are extremely large, to allow a variety of solutes to pass through and be metabolized.

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.

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

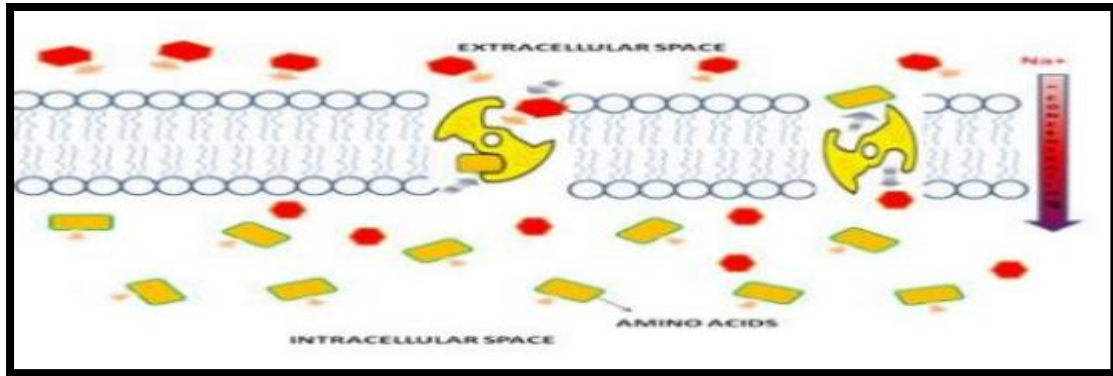
Types of active transport:

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.



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.



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

1.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.

2.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-transportes one glucose (or galactose) molecule into the cell for every two sodium ions it imports into the cell.