Cell Membrane

Dr Surendra kr Prasad

Associate Professor in Botany

Bsc part II, Paper IV

Subject – Botany

email-surendra_kumar010@yahoo.com

Cell membrane is the outer boundary of animal cell. It is a sub complex ,sub assembled molecular composite which is responsible for protection and transport and others. The cell membrane is a thin semi-permeable membrane that surrounds the cytoplasm of a cell. It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others. In prokaryotes it is responsible for respiration.

Chemical Composition

The cell membrane is primarily composed of a mix of proteins and lipids. Depending on the membrane's location and role in the body, lipids can make up anywhere from 20 to 80 percent of the membrane, with the remainder being proteins. While lipids help to give membranes their flexibility, proteins monitor and maintain the cell's chemical climate and assist in the transfer of molecules across the membrane.

Cell MembraneLipid

Phospholipids are a major component of cell membranes. Phospholipids form a lipid bilayer in which their hydrophilic (attracted to water) head areas spontaneously arrange to face the aqueous cytosol and the extracellular fluid, while their hydrophobic (repelled by water) tail areas face away from the cytosol and extracellular fluid. The lipid bilayer is semi-permeable, allowing only certain molecules to diffuse across the membrane.

Cholesterol is another lipid component of animal cell membranes. Cholesterol molecules are selectively dispersed between membrane phospholipids. This helps to keep cell membranes from becoming stiff by preventing phospholipids from being too closely packed together. Cholesterol is not found in the membranes of plant cells.

Glycolipids are located on cell membrane surfaces and have a carbohydrate sugar chain attached to them. They help the cell to recognize other cells of the body.

Cell Membrane Proteins

The cell membrane contains two types of associated proteins. **Peripheral membrane proteins** are exterior to and connected to the membrane by interactions with other proteins. **Integral membrane proteins** are inserted into the membrane and most pass through the membrane. Portions of these transmembrane proteins are exposed on both sides of the membrane. Cell membrane proteins have a number of different functions.

Structural proteins help to give the cell support and shape.

Cell membrane **receptor proteins** help cells communicate with their external environment through the use of hormones, neurotransmitters, and other signaling molecules.

Transport proteins, such as globular proteins, transport molecules across cell membranes through facilitated diffusion.

Glycoproteins have a carbohydrate chain attached to them. They are embedded in the cell membrane and help in cell to cell communications and molecule transport across the membrane.

Structure

The first model for biological membrane called Sandwitch model was proposed by H.Davidson and j.danieli(1935).This model depicts membrane as a bimolecular lipid layer ,where the polar ends of the lipid face outward and hydrophilic part of the proteins coat these polar ends. Hoever this theory was not accepted due to the differences in chemical composition of membrane surface as seen by electron microscop. In 1957JD Robertson proposed "Unit Membrane Model"of the cell stated that lipid bilayers were sandwiched between proteins on the outer and inner surfaces

Fluid mosaic model

According to the fluid mosaic model of S. J. Singer and G. L. Nicolson (1972), which replaced the earlier model of Davson and Danielli, biological membranes can be considered as a two-dimensional liquid in which lipid and protein molecules diffuse more or less easily.[36] Although the lipid bilayers that form the basis of the membranes do indeed form two-dimensional liquids by themselves, the plasma membrane also contains a large quantity of proteins, which provide more structure. Examples of such structures are protein-protein complexes, pickets and fences formed by the actin-based cytoskeleton, and potentially lipid rafts.

Lipid bilayer

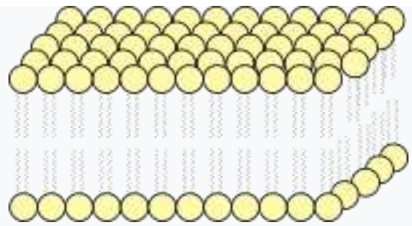


Diagram of the arrangement of amphipathic lipid molecules to form a lipid bilayer. The yellow polar head groups separate the grey hydrophobic tails from the aqueous cytosolic and extracellular environments.

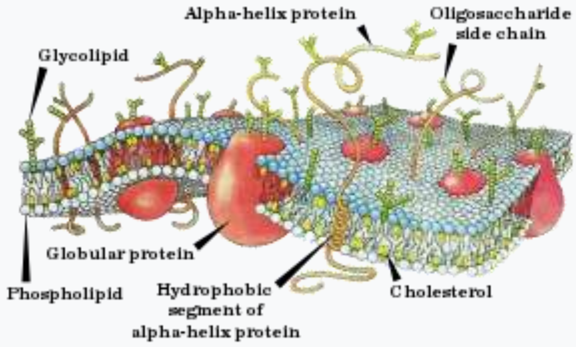
Lipid bilayers form through the process of self-assembly. The cell membrane consists primarily of a thin layer of amphipathic phospholipids that spontaneously arrange so that the hydrophobic "tail" regions are isolated from the surrounding water while the hydrophilic "head" regions interact with the intracellular (cytosolic) and extracellular faces of the resulting bilayer. This forms a continuous, spherical lipid bilayer. Hydrophobic interactions (also known as the hydrophobic effect) are the major driving forces in the formation of lipid bilayers. An increase in interactions between hydrophobic molecules (causing clustering of hydrophobic regions) allows water molecules to bond more freely with each other, increasing the entropy of the system. This complex interaction can include noncovalent interactions such as van der Waals, electrostatic and hydrogen bonds.

Lipid bilayers are generally impermeable to ions and polar molecules. The arrangement of hydrophilic heads and hydrophobic tails of the lipid bilayer prevent polar solutes (ex. amino acids, nucleic acids, carbohydrates, proteins, and ions) from diffusing across the membrane, but generally allows for the passive diffusion of hydrophobic molecules. This affords the cell the ability to control the movement of these substances via transmembrane protein complexes such as pores, channels and gates. Flippases and scramblases concentrate phosphatidyl serine, which carries a negative charge, on the inner membrane.

Fluid mosaic model

According to the fluid mosaic model of S. J. Singer and G. L. Nicolson (1972), which replaced the earlier model of Davson and Danielli, biological membranes can be considered as a two-dimensional liquid in which lipid and protein molecules diffuse more or less easily.[36] Although the lipid bilayers that form the basis of the membranes do indeed form two-dimensional liquids by themselves, the plasma membrane also contains a large quantity of proteins, which provide more structure. Examples of such structures are protein-protein complexes, pickets and fences formed by the actin-based cytoskeleton, and potentially lipid rafts.

. **Membrane structures**



The fluid mosaic model clearly describe the structure of cell membrane.The term fluid is used because of dynamic nature of phospholipid and the term Mosaic represents many different parts like proteins etc. fluid nature of the membrane as based on the images observed in Scanning electron Microscope, hich shows following characters-

i. It has three major constituents I carbohydrate ,lipid and proteins,apart from water and other small molecules. The protein to lipid ration is 1:1 in plasma membrane while in mitochondria it 1:3.

ii. Two dimensional structure of fluids ,lipids maintain the fluidity of the membrane

iii. cholesterol molecule in the bilayer cause rigidity and there by assist in controlling fluidity of the membrane

iv. Lipid bilayer is generally 6-10nm thickness depending on the type of the cell.

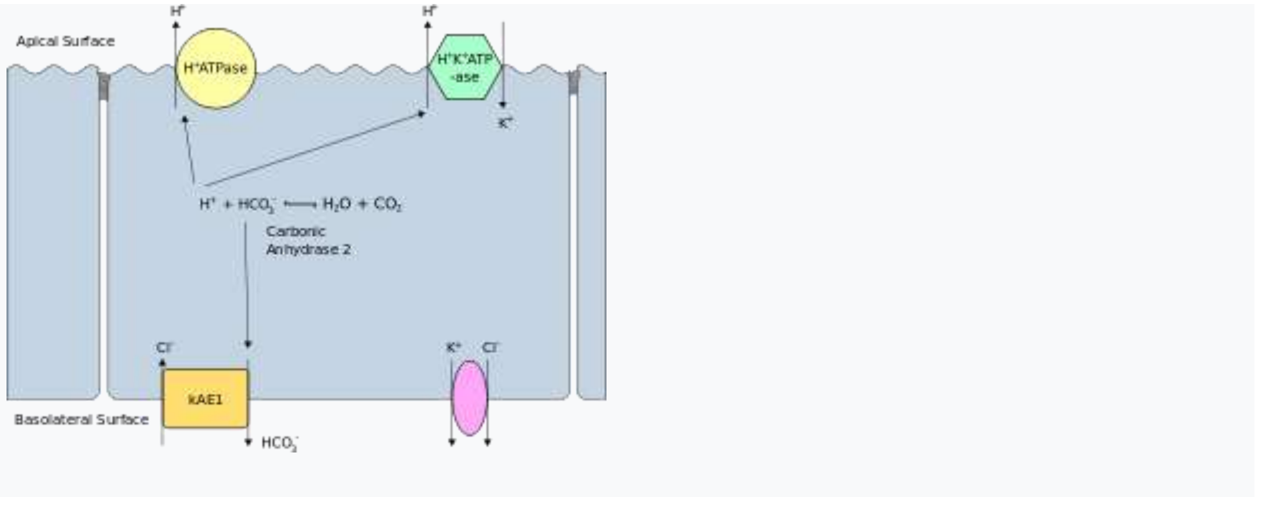
v. Two types of proteins present in the membrane are –

   I, Peripheral or surface protein-They are not embedded in lipid bilayer .Each cell has particular glucoprotein structure based on its need to attract ot repelvarious molecule in the membrane traffic.eg-membrane bound antibody involved in the interaction with antigen to induce immune response.
   ii.Integeral membrane proteins hich is about thickness of 5nm aross the lipid bilayer.

vi. Individual lipid and protein molecule an move freely along the plane of the membrane but is unable to move freely in transverse section. In the lipid bilayer the polar heads of the phospholipids are exposed to the solvent. The hydrophobic core impedes the transport of hydrophilic structures , such as ions mad polar molecules but enable hydrophobic molecules.

Functions

Membranes serve diverse functions in eukaryotic and prokaryotic cells. One important role is to regulate the movement of materials into and out of cells. The phospholipid bilayer structure (fluid mosaic model) with specific membrane proteins accounts for the selective permeability of the membrane and passive and active transport mechanisms. In addition, membranes in prokaryotes and in the mitochondria and chloroplasts of eukaryotes facilitate the synthesis of ATP through chemiosmosis.



Transport

i. active transport
   i. primary
   ii. Secondary transport

ii . Vesicle mediated transport (Exocytosis and Endocytosis)

active transport

Primary transport

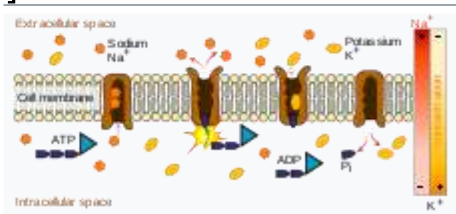
Primary transport involves ATP hydrolysis,hich cause a conformational change and result in transport of molecules. The Nernst potential of ions in the cells are – Na^+(+67mV0,K^+(-98mV),Ca^{++}(129mV) and cl^-(-90)

i. The cytosol of animal cells contain 20 times higher concentration of K^+ than that in extra cellular fluid .on contrary ,the extracellular fluid contains a concentration of Na^+~10 times greater than that within the cell. these concentrations gradients are responsible for transport of ions by Na^{+} /K^{+} ATPase it uses the energy from the hydrolysis of ATP to actively transport of 3 Na^{+} out of cell for 2 k $^{+}$pumped into the cell. Thus Na^{+} -K^{+}pump as antiport symport. Almost one third of all the energy generated by mitochondria in animal cells is used to run Na^{+}/K^{+} ATPase pump.

ii. Some of the important functions of Na-K are-

a.the accumulation of Na ions out side of the cell draws water out of the cell and thus enables osmotic balance

]



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

Secondary active transport

Secondary active transport

In secondary active transport, also known as *coupled transport* or *cotransport*, energy is used to transport molecules across a membrane; however, in contrast to primary active transport, there is no direct coupling of ATP; instead it relies upon the electrochemical potential difference created by pumping ions in/out of the cell.[17] Permitting one ion or molecule to move down an electrochemical gradient, but possibly against the concentration gradient where it is more concentrated to that where it is less concentrated increases entropy and can serve as a source of energy for metabolism (e.g. in ATP synthetase). The energy derived from the pumping of protons across a cell membrane is frequently used as the energy source in secondary active transport. In humans, sodium (Na^+) is a commonly co-transported ion across the plasma membrane, whose electrochemical gradient is then used to power the active transport of a second ion or molecule against its gradient.[18] In bacteria and small yeast cells, a commonly cotransported ion is hydrogen.[18] Hydrogen pumps are also used to create an electrochemical gradient to carry out processes within cells such as in the electron transport chain, an important function of cellular respiration that happens in the mitochondrion of the cell.[19]

In August 1960, in Prague, Robert K. Crane presented for the first time his discovery of the sodium-glucose cotransport as the mechanism for intestinal glucose absorption.[20] Crane's discovery of cotransport was the first ever proposal of flux coupling in biology.[21][22]

Cotransporters can be classified as symporters and antiporters depending on whether the substances move in the same or opposite directions.

Exocytosis-some cells need to transport large amount of material across their plasma membranes. This amount is too large and cannot be carried out by diffusion or active transport. for this specialized transport cells make micro containers from the plasma membrane itself. These sac like structures are called vesicles. Vesicles can be used to transport solids or liquids across the plasma membrane either into or out of the cell. the former is called exocytosis and later is called endocytosis.Phagocytosis is type endocytosis here entire cell is engulfed where as pinocytosis is hen the external liquid is taken.