Various models of Plasma membrane

In eukaryotic cells, the **plasma membrane** surrounds a cytoplasm filled with ribosomes and organelles. Organelles are structures that are themselves encased in membranes. Some organelles (nuclei, mitochondria, chloroplasts) are even surrounded by double membranes. All cellular membranes are composed of two layers of phospholipids embedded with proteins. All are selectively permeable (semi-permeable), allowing only certain substances to cross the membrane. The unique functions of cellular membranes are due to their different phospholipid and protein compositions. Decades of research have revealed these functions.

Various models of Plasma membrane:

The four historical models of Plasma Membrane are:

1. Lipid and Lipid Bilayer Model (1925-26)

2. Dannelli Model. (1935

3. Unit Membrane Model (Protein-Lipid Bilayer-Protein) (1953)

4. Fluid Mosaic Model (1972)

1. Lipid and Lipid Bilayer Model:

In 1902, Overton observed that substances soluble in lipid could selectively pass through the membranes. On this basis he stated that plasma membrane is composed of a thin layer of lipid.

Gorter and Grendel (1925)' were the first to suggest a possible structure of the cell membrane. On the basis of studies of cell membranes of erythrocytes they showed that the lipid extracted from the red cell ghost spread in area twice that of a simple molecular film. So it was thought that the membrane consisted of double layers of lipid molecules, the polar hydrophilic groups of the molecules being situated on the outside and hydrophobic ends standing at right angles to the surface are oriented inwardly. These models of Gorter and Grendel could not explain the proper structure of plasma membrane but they put the foundation of future models of membrane structure.

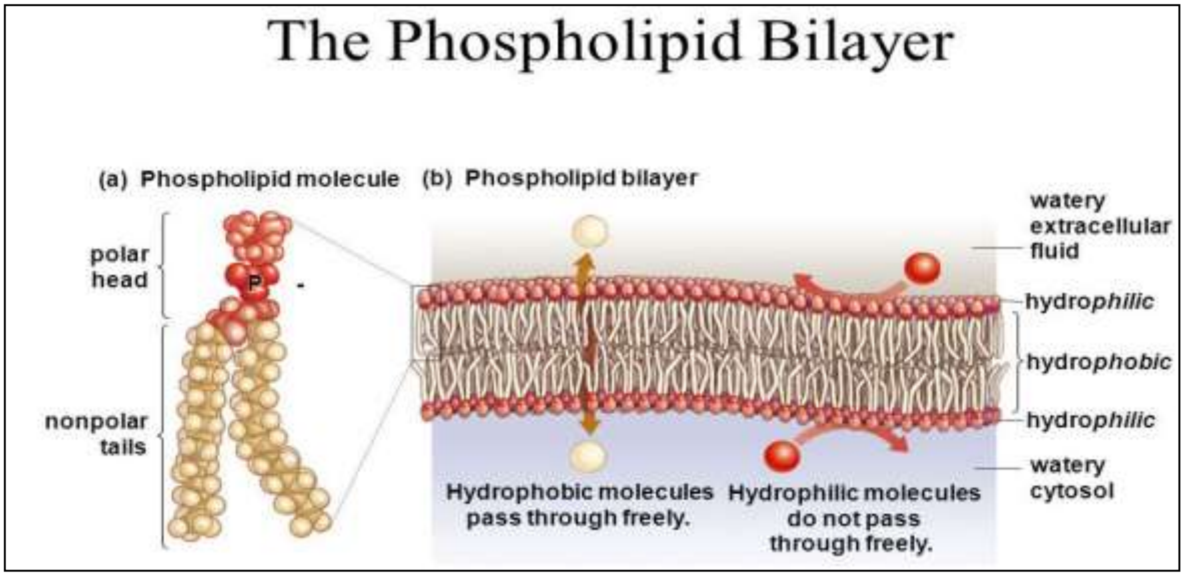


Fig: Lipid and Lipid Bilayer Model

2. Dannelli Model (Sandwich Models):

James Danielli and Hugh Davson in 1935 have suggested bimolecular leaflet model of cell membrane. Danielli and Davson model was the first attempt to describe membrane structure in terms of molecules and to relate the structure to biological and chemical properties.

According to bimolecular model of Danielli and Davson, plasma membrane consists of two layers of phospholipid molecules (a bimolecular leaflet) in which phospholipid molecules are arranged in such a way that hydrophilic heads of the phospholipid molecules face outside and hydrophobic non-polar lipid chains are associated in the inner region of leaflet. The hypothesis also suggested that the polar ends of lipid molecules are associated with monomolecular layer of globular proteins. The plasma membrane would thus consist of a double layer of phospholipid molecules sandwiched between two essentially continuous layers of protein.

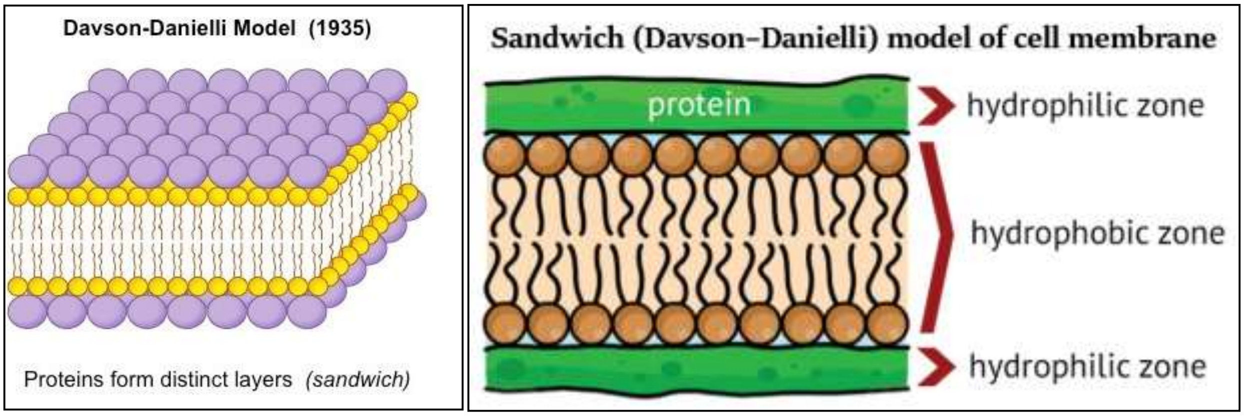


Fig: Sandwich (Davson–Danielli) model of plasma membrane

The model was also described as a 'lipo-protein sandwich', as the lipid layer was sandwiched between two protein layers. The Davson–Danielli model predominated until Singer and Nicolson advanced the fluid mosaic model in 1972. The fluid mosaic model expanded on the Davson–Danielli model by including transmembrane proteins and eliminated the previously-proposed flanking protein layers that were not well-supported by experimental evidence.

3. Unit Membrane Model:

In late 1950s Robertson summarized a large number of ultra-structural data obtained by him and some other workers and concluded that the plasma membrane and the membranes of all cell organelles were similar in structure. Although the similarity is not resolved by light microscopy, it is clearly seen in electron micrographs.

This conclusion led Robertson in 1953 to propose unit membrane hypothesis according to which all biological membranes show generalized unit membrane construction. The unit membrane model visualizes cell membrane as a trilaminar and indicates structure consisting of two dark osmiophilic layers separated by a light osmiophilic layer.

The physical appearance of this trilaminar model has led to the term unit membrane. The unit membrane concept implies a trilaminar appearance with a bimolecular lipid layer between two protein layers. Each dense osmiophilic band is made up of protein (20 Å) and the polar groups of phospholipids (5 A) and is thus 25 Å thick.

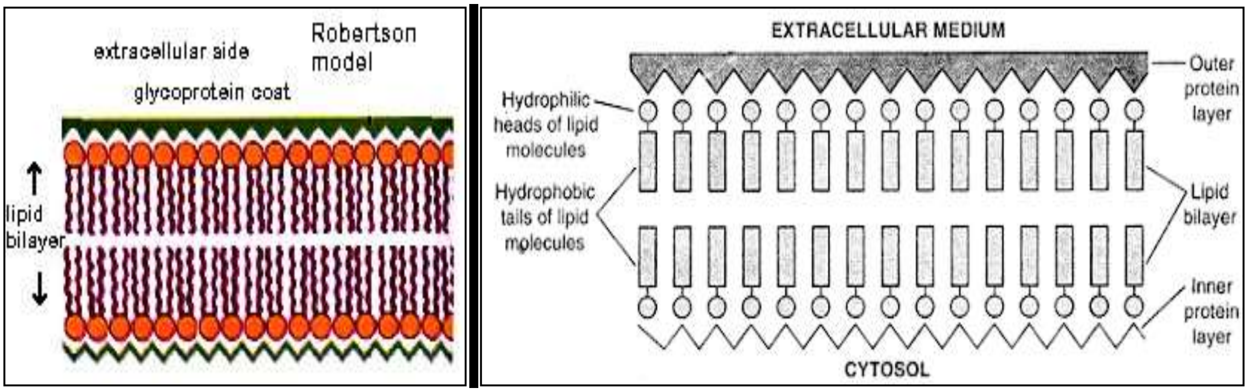


Fig: Unit Membrane Model

The clear Osmiophilic zone 35 A in thickness is a bimolecular layer of lipids without the polar groups. In other words, the unit membrane is 75 Å thick with a 35 Å thick phospholipid layer between two 20 Å thick protein layers. The plasma membrane surrounding the cell is thicker at the free surfaces of the cell than where it is in contact with other cells.

In unit membrane model the protein layers are asymmetrical. On the outer surface it is mucoprotein while on the inner surface it is non-mucoid protein

3. Fluid Mosaic Model

The fluid mosaic model was first proposed by S.J. Singer and Garth L. Nicolson in 1972 to explain the structure of the plasma membrane. The fluid mosaic model describes the structure of the plasma membrane as a mosaic of components —including phospholipids, cholesterol, proteins, and carbohydrates—that gives the membrane a fluid character. Plasma membranes range from 5 to 10 nm in thickness. The proportions of proteins, lipids, and carbohydrates in the plasma membrane vary with cell type. For example, myelin contains 18% protein and 76% lipid. The mitochondrial inner membrane contains 76% protein and 24% lipid.

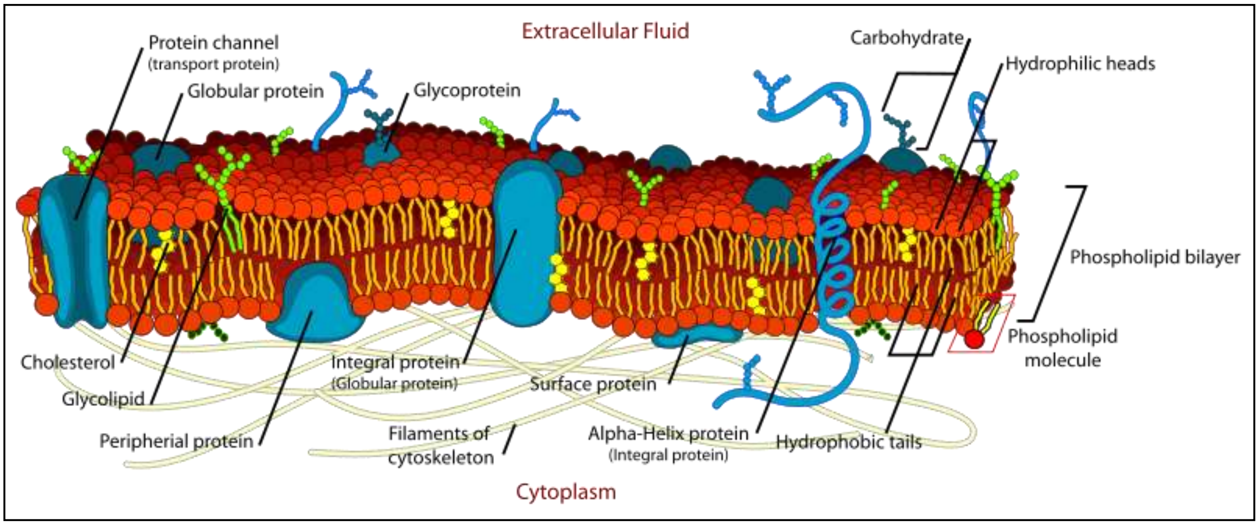
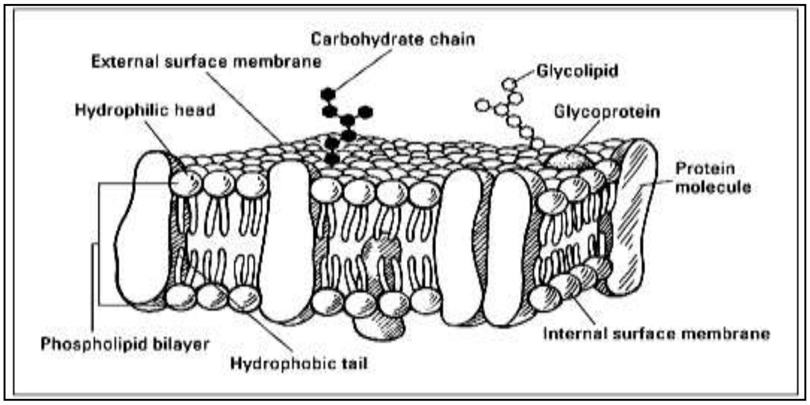


Fig: Fluid Mosaic Model

Each phospholipid molecule has a head that is attracted to water (*hydrophilic: hydro* = water; *philic* = loving) and a tail that repels water (*hydrophobic: hydro* = water; *phobic* = fearing). Both layers of the plasma membrane have the hydrophilic heads pointing toward the outside; the hydrophobic tails form the inside of the bilayer. Because cells reside in a watery solution (extracellular fluid), and they contain a watery solution inside of them (cytoplasm), the plasma membrane forms a circle around each cell so that the water-loving heads are in contact with the fluid, and the water-fearing tails are protected on the inside.



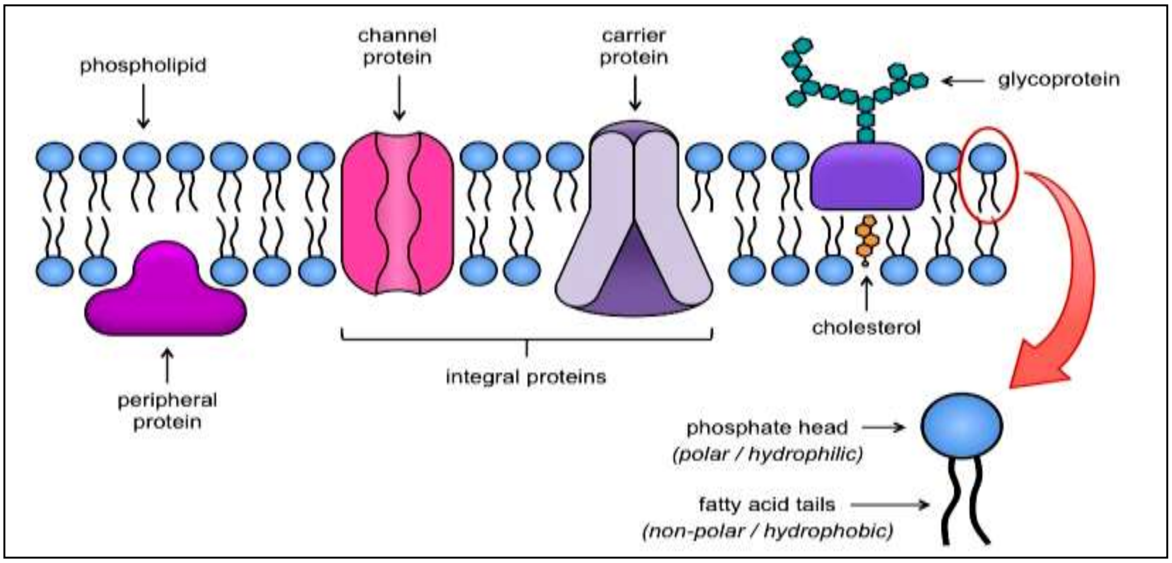


Fig: Fluid Mosaic Model

Proteins and substances such as cholesterol become embedded in the bilayer, giving the membrane the look of a mosaic. Because the plasma membrane has the consistency of vegetable oil at body temperature, the proteins and other substances are able to move across it. That's why the plasma membrane is described using the *fluid*-mosaic model.

By: Dr. Bibha Kumari, Department of Zoology, Magadh Mahila College, Patna University Patna. Email: bibhak136@gmail.com