Lectures of Histology

(1st Stage)
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Anatomy and Histology Department

By

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Plasma Membrane

Also called the **cell membrane**, forms the boundary of cell that separates the intracellular from extracellular space (environment). It is selectively/semi-permeable barrier around cell regulates/limits what gets in and out of the cell (by controlling the entrance and exit of the molecules and ions to ensure the maintenance of dynamic equilibrium between cell and environment). It's so difficult to distinguish easily using a light microscope because it's very thin (average thickness is 7.5-10 nm).

Isolation of Plasma Membrane

Plasma membranes were isolated to study their composition from various types of cells such as RBCs, liver cells and some types of amoebae. Red blood cells were the most suitable because the nucleus and other organelles are missing, therefore it was easier to isolate their membranes by exposure them to hemolysis by using hypotonic solution as they swell and explode/rupture then lose hemoglobin leaving plasma membrane.

Chemical Structure

Plasma membrane discovery is closely related to the upgrading of microscopic techniques, especially with electron microscopy, by which was observed typical structure, appears as pair of dark parallel lines (Fig.1). Further observations showed that plasma membrane of cells is similar in structure and slight differences in chemical composition are due to cell differentiation and specialization.

Plasma membrane carries out several important functions because it possesses many features:

1. modifications (communication between cells).
2. ion pumps for controlling internal environment of the cell.
3. receptors.
4. transporters.
5. antigens.

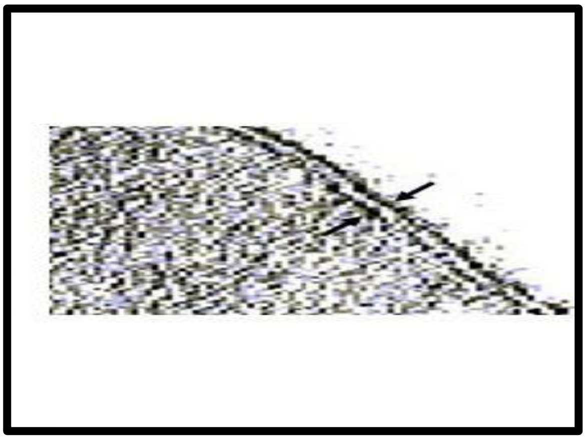


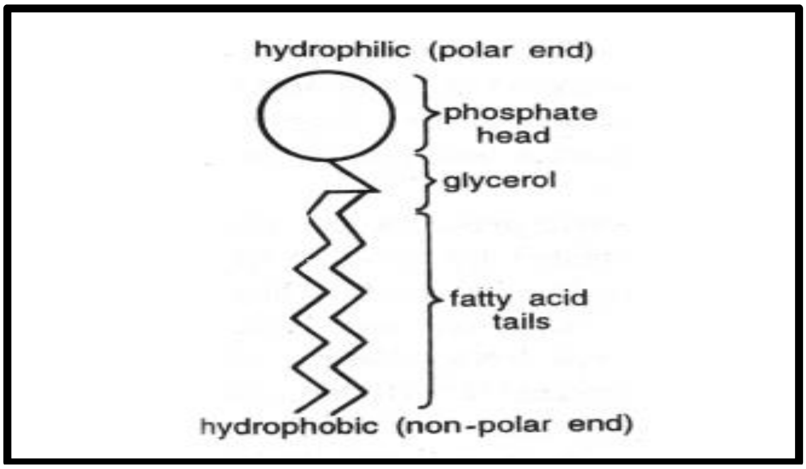
Fig. 1: Structure of cell membrane.

Plasma membrane is a discrete structure and is remarkably complex in its molecular organization. It consists of proteins and lipids that are arranged together in a thin layer by non-covalent bonds, in addition to short chains of carbohydrates (attached to the outer peripheral proteins or to the outer polar ends of the lipid molecules).

Lipids

The ratio of lipid to protein depends on the type of cell membrane (plasma membrane and other organelles membranes) and the type of organism (eukaryotic or prokaryotic) affects also at this percentage.

Lipid molecule consists of two parts: polar portion (hydrophilic/ phosphate head) and nonpolar portion (hydrophobic/fatty acid tails). Results of studies indicate that the lipid molecules arranged where the nonpolar parts meet each other while the polar parts face the inner and outer surface of the cell creating so-called phospholipid bilayer (Fig.2).



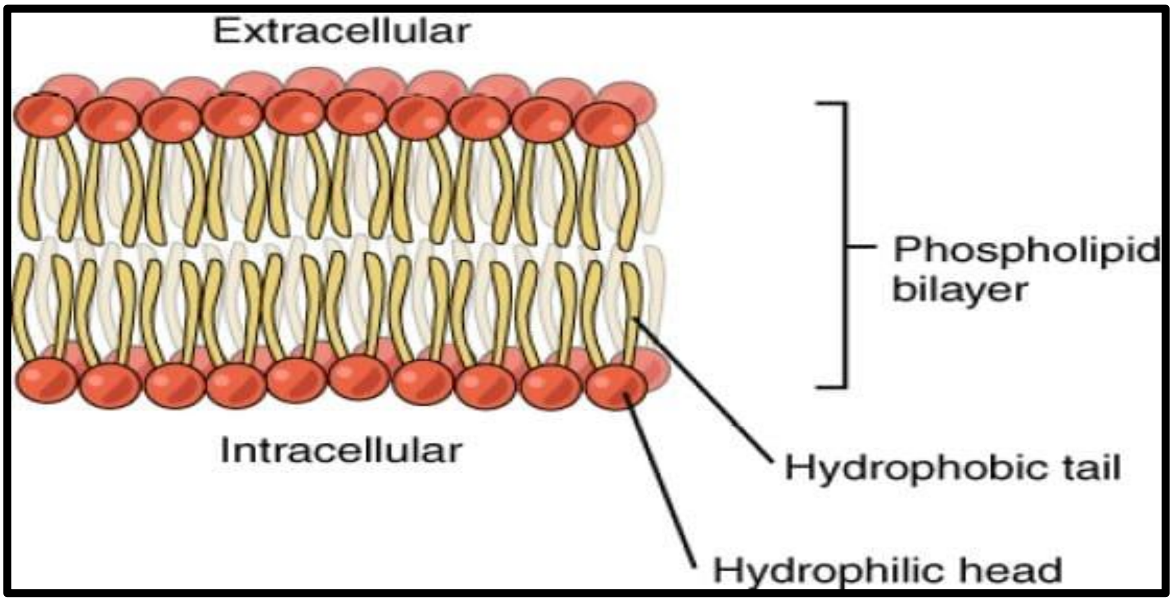


Fig. 2: **Schematic representation of phospholipid bilayer.**

The main components of cell membranes are lipid (phospholipids), most abundant are lecithin, sphingomyelin and amino phospholipids. Membranous lipids have a high degree of mobility, their lateral movement is much more than their oscillation movement/shaking.

Single lipid molecule may move several lateral microns through the membrane at a second or two (Fig.3). Mobility of lipid molecules adjacent to each other is higher than the mobility of lipid molecules that are in direct contact with proteins, so these lipid (which are unable or limited movement) are called boundary lipid.

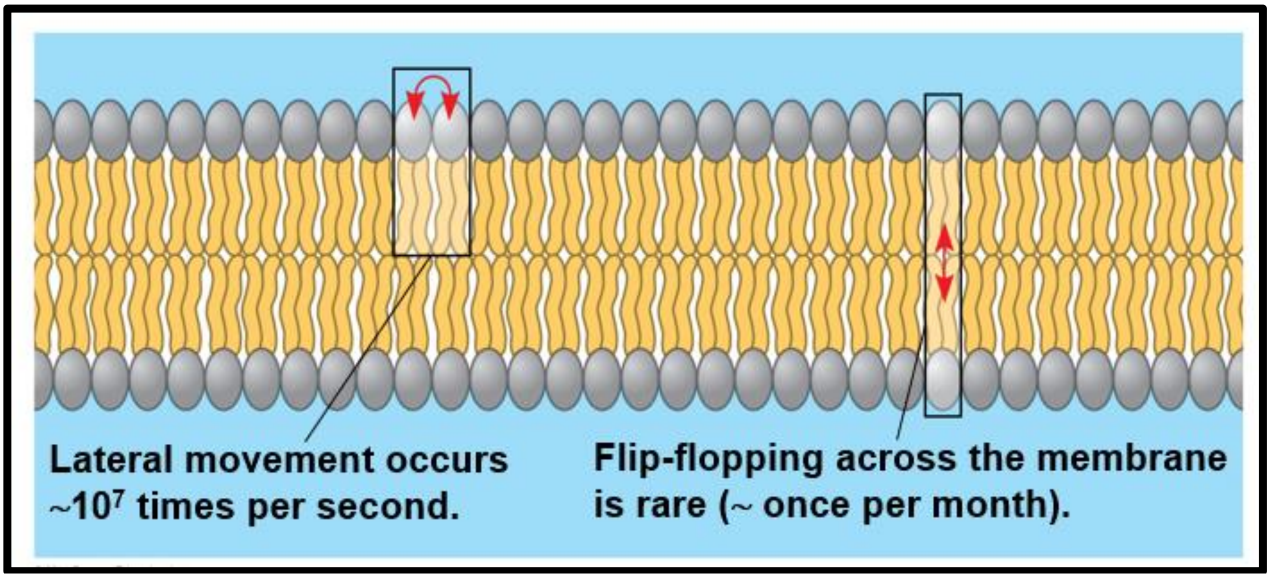


Fig. 3: **Mobility/movement of lipid molecules.**

Movement of lipid and protein molecules in plasma membrane is evidence to the fluidity of the membrane. In layers of phospholipids composed of **saturated fatty acids**, their side chains are linked to each other in form of a regular crystalline ray and therefore they form a relatively tough/solid structure, while in the layers of phospholipids consisting of side chains of **saturated and unsaturated fatty acids**, the arrangement of adjacent molecules is less regular and therefore more liquid (greater the number of double bonds in bilayer of lipid, the less arrangement with much fluidity) (Fig.4).

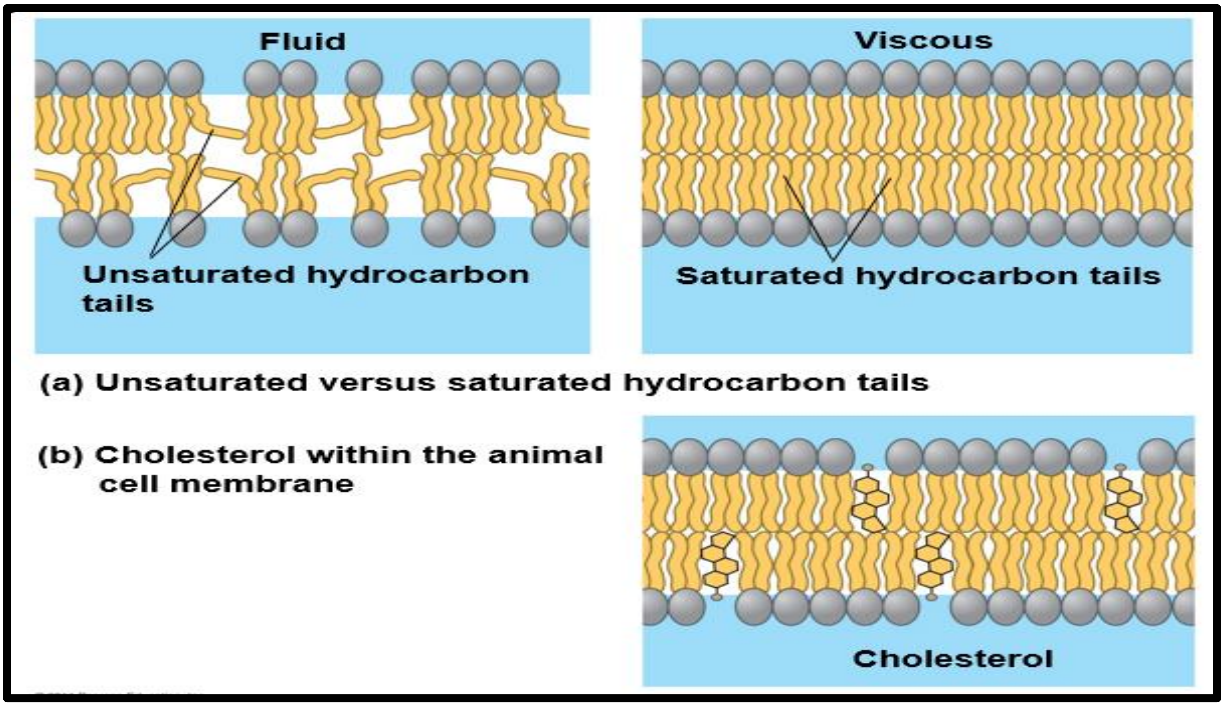


Fig. 4: Saturated and unsaturated fatty acids.

Carbohydrates

Carbohydrate chains are found only on the outer surface of plasma membrane in a very small proportion, as short or branched chains attached to the outer proteins forming glycoproteins or branching from the polar ends of the phospholipid molecules in the outer lipid layer to form glycolipids, so membranous carbohydrates are not found on the inner surface of plasma membrane (facing the cytoplasm) (Fig. 5).

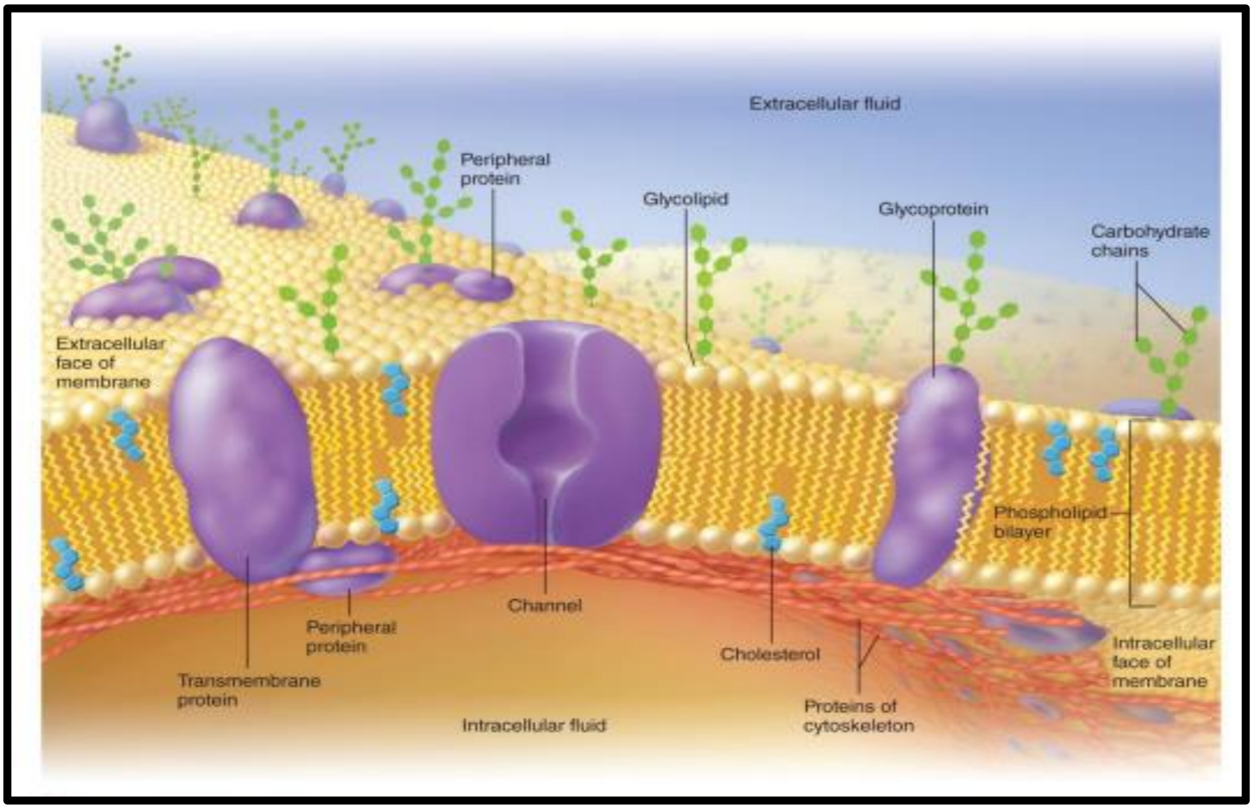


Fig. 5: **Structural components of plasma membrane.**

Proteins

One of the main components of plasma membrane. Proteins are not only provided mechanical support but also as carriers or channels serving for transport. In addition to numerous enzymes, antigens and various kinds of receptor molecules are present in plasma membranes. Membrane proteins are classified according to their association with the membrane into:

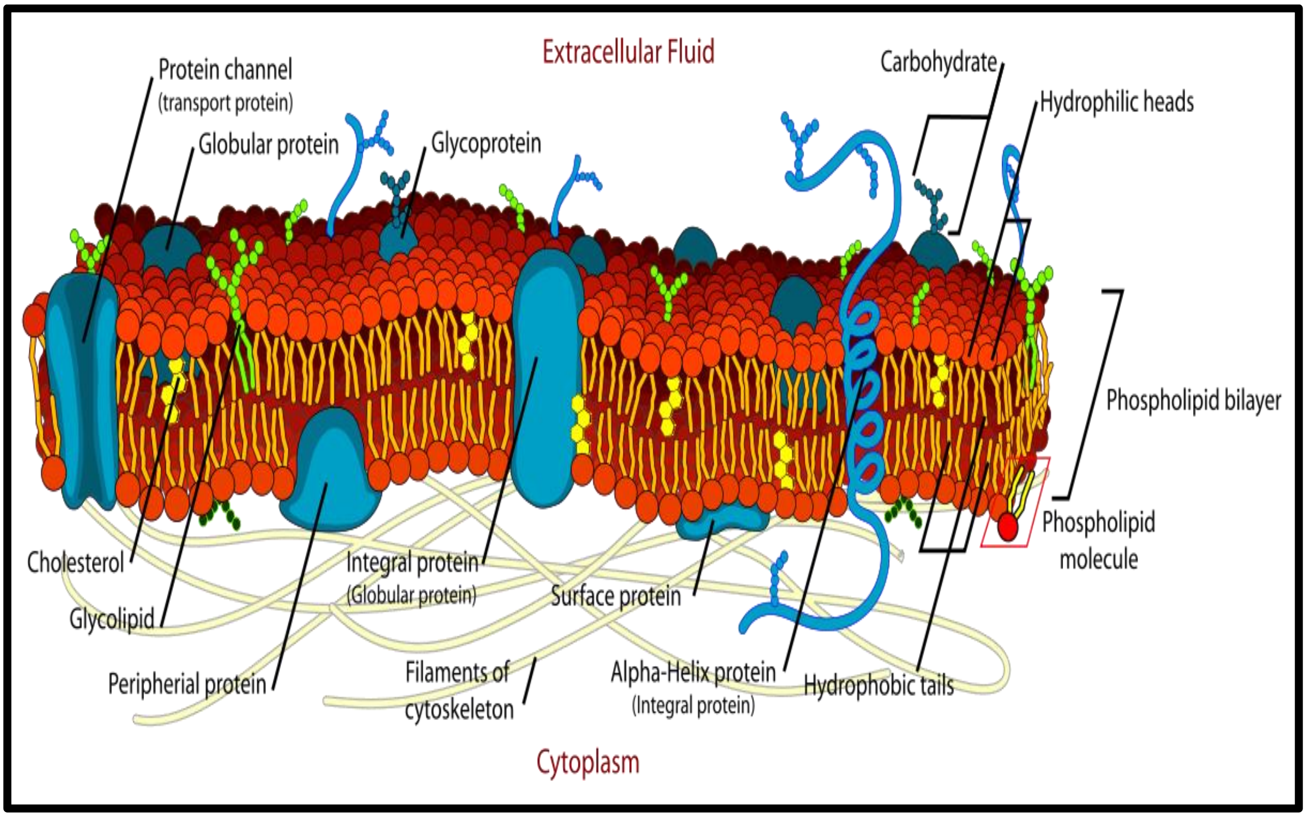
1. peripheral or extrinsic proteins: are associated with membrane surface and can be easily separated, soluble in aqueous solutions and usually free of lipids. They are bound to the surface by electrostatic and hydrogen bond interactions. They form outer and inner layers of the lipid bilayer of plasma membrane.

2. integral or intrinsic proteins: penetrate lipid bilayer wholly or partially and represent more than (70%) of the two protein types. Their polar ends protrude/emerge from the membrane surface while non-polar regions are embedded in the interior of the membrane. Usually are insoluble in water solutions and hardly separable.

Movement of Membrane Proteins

Cells that grown in a culture tend to unite/merge with each other to form a larger cell, this phenomenon (cell union) increases greatly when sendai virus is added (presence of this virus stimulate to a union of different strains of cells and production the hybrid cells/ heterokaryon), Frye and Edidin exploited this phenomenon to prove that membranous proteins move through the lipid bilayer.

They merged human and mouse cells to form heterokaryon cells, using parameters labeled of antibodies, at the beginning, the membranous proteins of human and mouse cells were confined to their halves in the hybrid cell, but in less than one hour both types of membranous proteins became uniformly distributed throughout the entire membrane. The distribution of membrane proteins was not dependent on the provision/supply of ATP, so this indicates that the movement of protein in the membrane occurs by diffusion (not all membranous proteins are capable of diffusion) the integral proteins are bound within the membrane by network of protein that extends under the inner face of the membrane, this network associates with a system of filaments and cytoplasmic microtubules in many cells forming the cytoskeleton (Fig.6).



<u>Fig. 6:</u> Structure of cell membrane (Singer and Nicolson model/ fluid mosaic).