PLASMA MEMBRANE (= CELL MEMBRANE)

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Unit - I

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Introduction:

Plasma membrane is an ultrathin selectively permeable structure surrounding the cytoplasm of all living organisms which maintains a definite physicochemical environment for the cells and protects the latter from the variable external environment. It also allows selective influx or efflux of materials into and out of the cells. It may possess certain signalling molecules as well. Thus they are an absolute requirement for all living organisms.

General Structural Characteristics:

(i) It encloses the cytoplasm of both prokaryotic and eukaryotic cells.

(ii) Membranes contain both lipids and proteins, although their exact proportions vary widely.

(iii) Prokaryotic plasma membranes usually have a higher proportion of proteins than do eukaryotic membranes. This is presumably because prokaryotic membranes have to perform so many different functions that are carried out by organelle membranes in eukaryotes.

(iv) Plasma membranes of prokaryotes are less rigid than those of eukaryotes due to absence of typical sterols (e.g., cholesterol). However, mycoplasmal plasma membranes have sterols.

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Detailed Structural Features:

Electron microscopy and freeze-etching technique have been used to study the ultrastructure of plasma membranes. The following structural features are known through these studies:

(i) It is a two-layered structure made up of phospholipids and proteins.

(ii) Lipids are organized as a two-layered component (bilayer).

(iii) Most membrane bound lipids are amphipathic with polar and non-polar ends.

(iv) Their polar ends or heads made up of glycerol and phosphate group are hydrophilic whereas the non-polar tails are made up of fatty acids and are hydrophobic. Many of the lipids in the membrane are phospholipids.

(v) Prokaryotic membranes usually differ from eukaryotic membranes in lacking sterols such as cholesterol.

— However, many bacterial membranes do contain pentacyclic sterol-like molecules called hapnoids.

— Hapnoids are synthesized from the same precursors as steroids.

— Like steroids in eukaryotes, hapnoids stabilize bacterial membranes.

(vi) Distribution of lipids in eukaryotic membranes is asymmetric.

— Lipids in the outer monolayer differ from those of the inner monolayer.

— Archaeal membranes may have lipids arranged in bilayers (as in bacteria) or they may have a monolayer with lipid molecules spanning the whole membrane.

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(vii) Thickness of the cell membranes: 5–10nm; visible only under the electron microscope.

(viii) Proteins found in the membranes may be extrinsic/peripheral and intrinsic/integral proteins based on their distribution in the lipid bilayer.

(ix) Peripheral proteins are loosely connected to the lipid bilayer surface and can be easily removed.

— They are soluble in aqueous solutions and make up about 20–30% of the total membrane proteins.

(x) About 70–80% of the membrane proteins are integral proteins which traverse along the whole thickness of the lipid bilayer and cannot be easily removed from membranes.

— Like lipids, integral proteins are amphipathic, with hydrophobic region buried in the lipid bilayer and hydrophilic portion projecting from the membrane surface.

(xi) Phospholipid and protein molecules in the membranes are not static, rather move quite freely within the membrane surface without destroying the membrane structure.

(xii) The most widely accepted current model of plasma membrane structure is the fluid mosaic model proposed by Singer and Nicholson (1972).

— This accommodates dynamic arrangement of phospholipid and protein in the membrane.

(xiii) Phospholipids in the presence of water form a self-sealing bilayer, with the result that breaks and tears in the membrane are healed themselves.

Functions of the Plasma Membrane:

(1) Selectively Permeable Layer

(i) Plasma membranes are always

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selectively (differentially) permeable and thus act as a selective barrier between the internal cell millieu and the external environment.

— Differential permeability property of the membrane is on account of specific protein molecules called permeases built into the membrane structure. A large number of permeases may occur in a cell.

— Smaller molecules such as H_2O, O_2, CO_2, simple sugars, etc. usually pass through the membranes easily.

— Large molecules, eg., proteins cannot pass through the plasma membrane as these molecules are larger than the pores in the integral proteins that function as channels of transport across the membrane.

(2) Energy Production

—Respiratory electron transport leading to ATP formation occurs in the prokaryotic plasma membrane.

— Thylakoids containing chromatophores are formed in prokaryotes due to infoldings of the plasma membrane in the cytoplasm.

— Enzymes and carrier molecules of energy production processes are found in the plasma membrane in the prokaryotes.

③ Extracellular Polymer Production

Final stages in the synthesis of some of the polymers in the cell wall, capsule and extracellular fluids are catalyzed by membrane enzymes in prokaryotes.

④ Site of Chromosome attachment

In prokaryotes, single chromosome (Double stranded DNA) and the plasma membrane

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are attached at a specific point at which replication starts.

– The first stage in nuclear division involves duplication of this attachment site, followed by a progressive bidirectional replication of the DNA by two replication forks.

(5) Besides acting as a selective transport barrier, plasma membrane in prokaryotes is also the site of a variety of metabolic processes such as respiration, photosynthesis, lipid synthesis for the cell wall components and probably chromosome segregation.

– It also contains special receptor molecules that help prokaryotes detect and respond to chemicals in their surroundings.

Fig.: Fluid Mosaic Model

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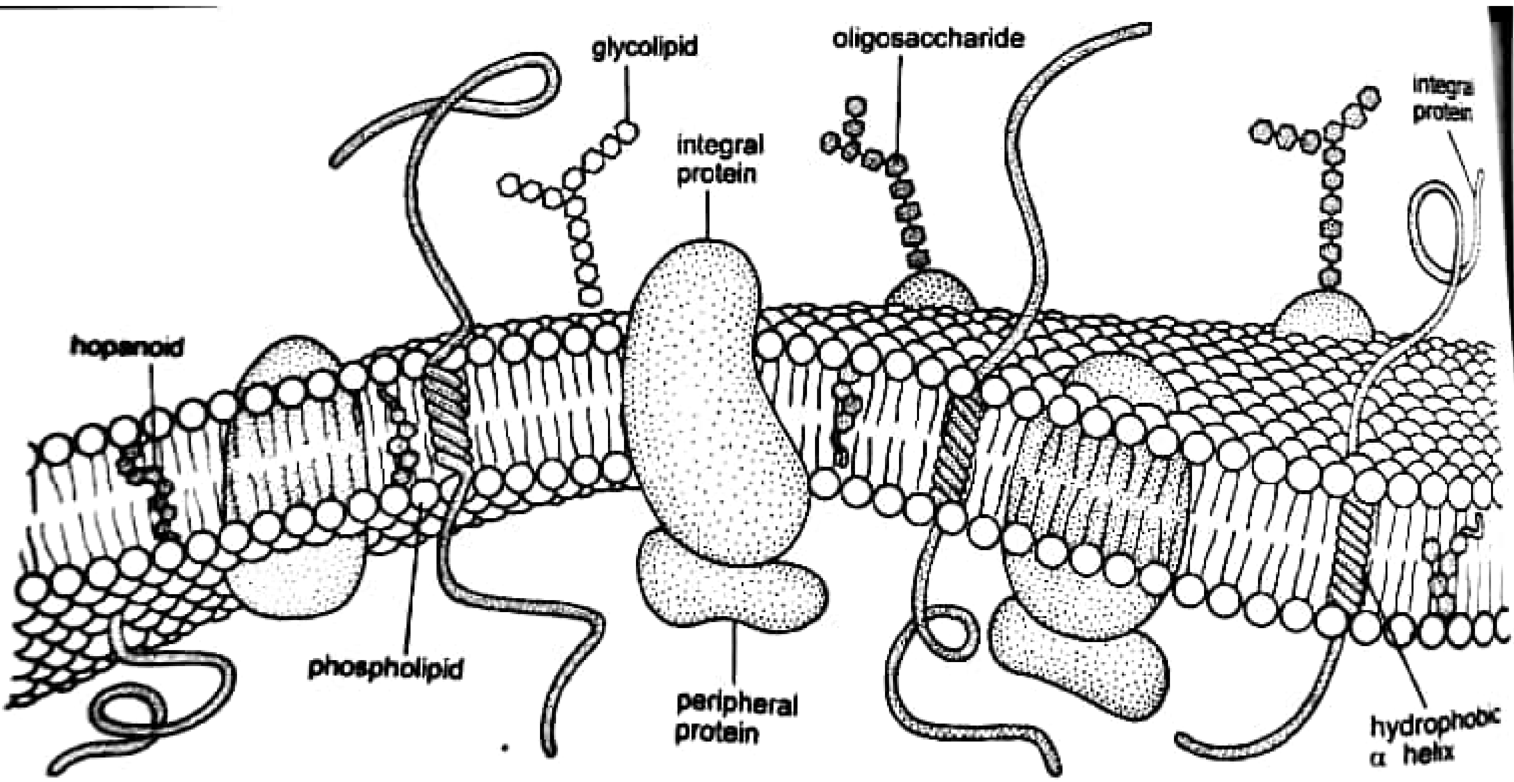

Fig. 3.15. The diagram of the fluid mosaic model of bacterial membrane structure.