

B.Sc. Part 1 Zoology (Subsidiary & General Course)

# ULTRASTRUCTURE OF PLASMA MEMBRANE

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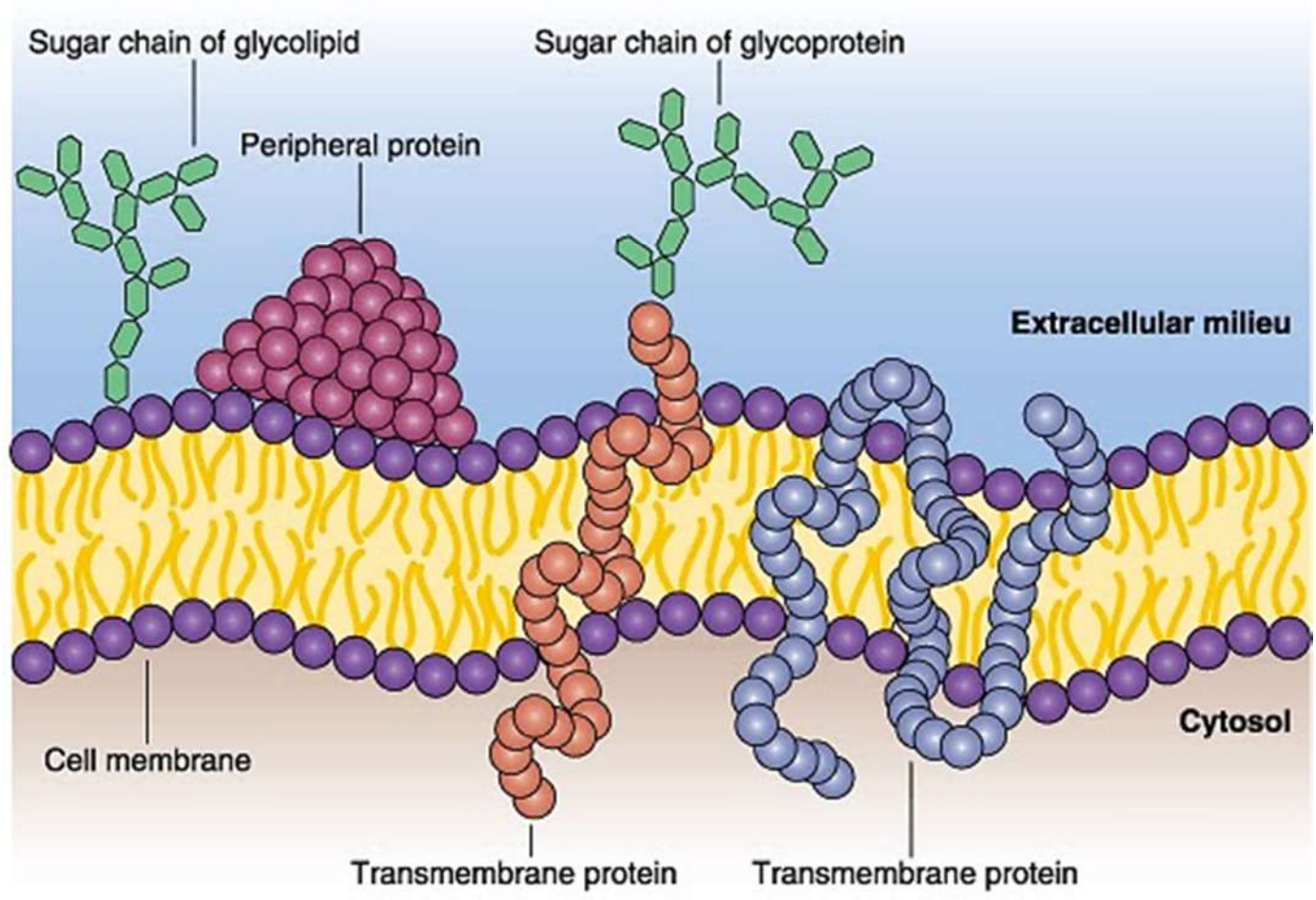


# Plasma membrane

- Plasma membrane is membranous outer layer of the any living cell, thus it separates the interior of cell from external environment.
- It is composed of phospholipid bilayer and different extrinsic and intrinsic protein molecules.
- Phospholipid bilayer forms a stable barrier between two aqueous compartments.
- While proteins embedded in the phospholipid bilayer performs various functions, such as selective molecular transport and cell-cell interaction.
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# Plasma membrane



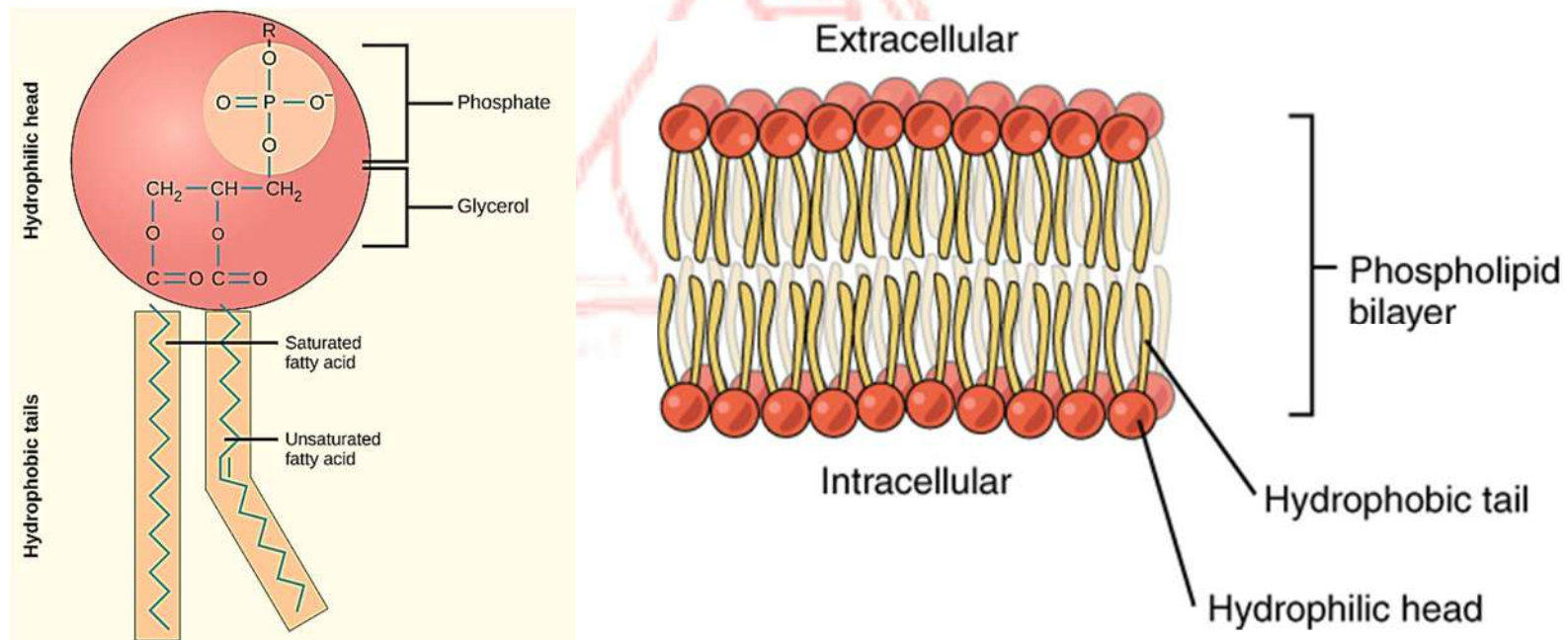
A rail-road appearance

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# Lipid bilayer

- **Phospholipids** consist of a glycerol **molecule**, two fatty acids, and a phosphate group that is modified by an alcohol. The phosphate group is the negatively-charged polar head, which is hydrophilic and the fatty acid chains are the uncharged, nonpolar tails, which are hydrophobic.



# Types of membrane phospholipids

**Saturated fatty acid**

**Unsaturated fatty acid**

Main lipids of cell membrane

**GLYCEROPHOSPHOLIPIDS**

Phosphatidyl ethanolamine    Phosphatidyl choline    Phosphatidyl serine    Phosphatidyl inositol    Phosphatidyl serine

**SPHINGOLIPIDS**

Sphingosine    Ceramide    Sphingomyelin    Cerebroside Glycolipid    Ganglioside Glycolipid

**Cholesterol**

**Glycerophospholipids**  
 Phosphatidylethanolamine  
 Phosphatidylcholine  
 phosphatidylserine  
 phosphatidylinositol  
 Cardiolipin

**Sphingolipids**  
 Sphingomyelin  
 Cerebrosides  
 Gangliosides

**Sterols**  
 Cholesterol

Lipids, In Cell membrane, Atlas of Plant and Animals Histology

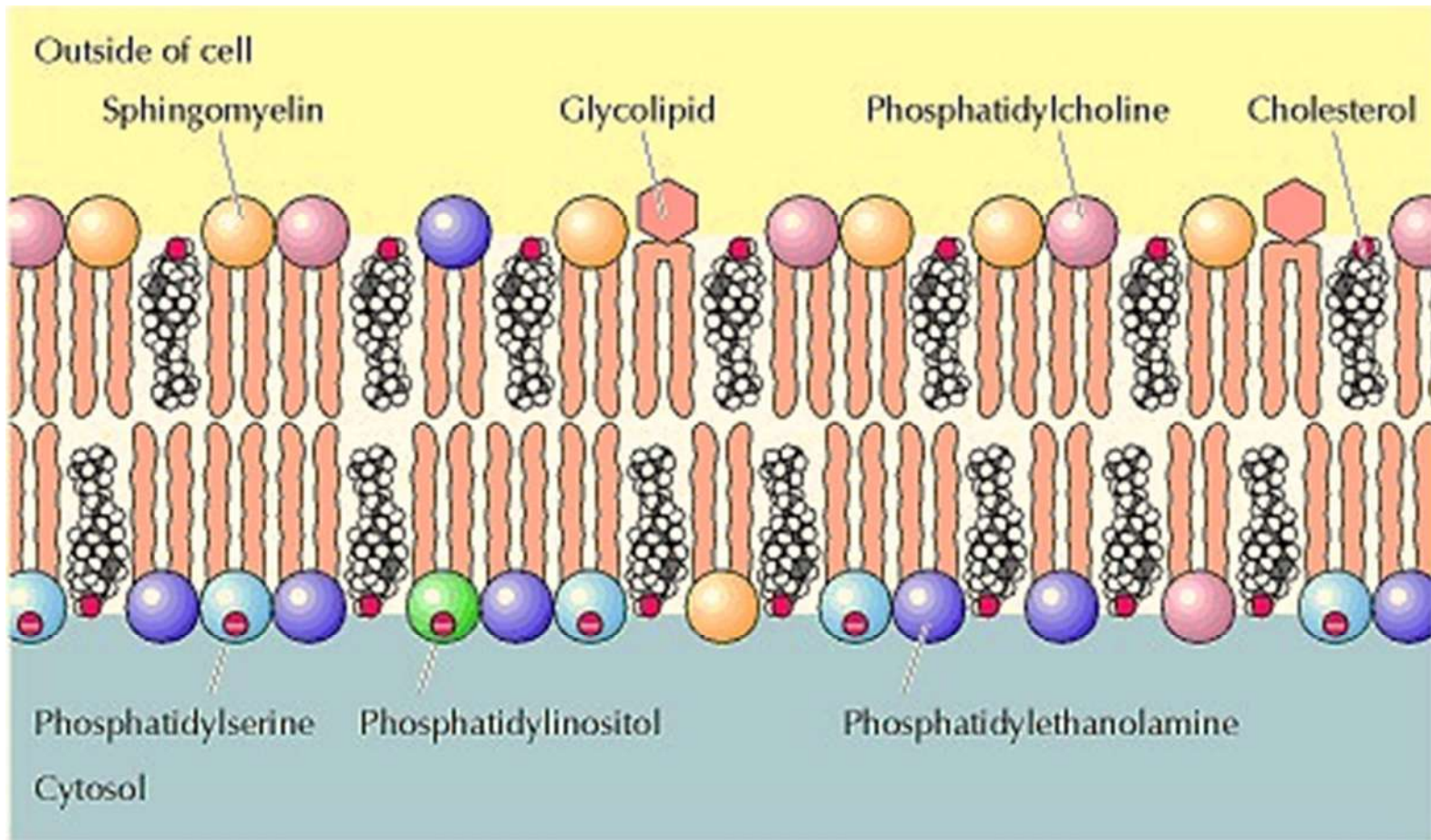


# Phospholipid

- The plasma membrane of animal cells contain four major phospholipids; phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, and sphingomyelin accounting for more than 50% of total lipid.
- The outer layer consists mainly of phosphatidylcholine and sphingomyelin,
- Whereas inner layer consists mainly of phosphatidylethanolamine and phosphatidylserine.
- A fifth phospholipid, phosphatidylinositol, is also localized to the inner layer of the lipid bilayer.



# Lipid components of plasma membrane



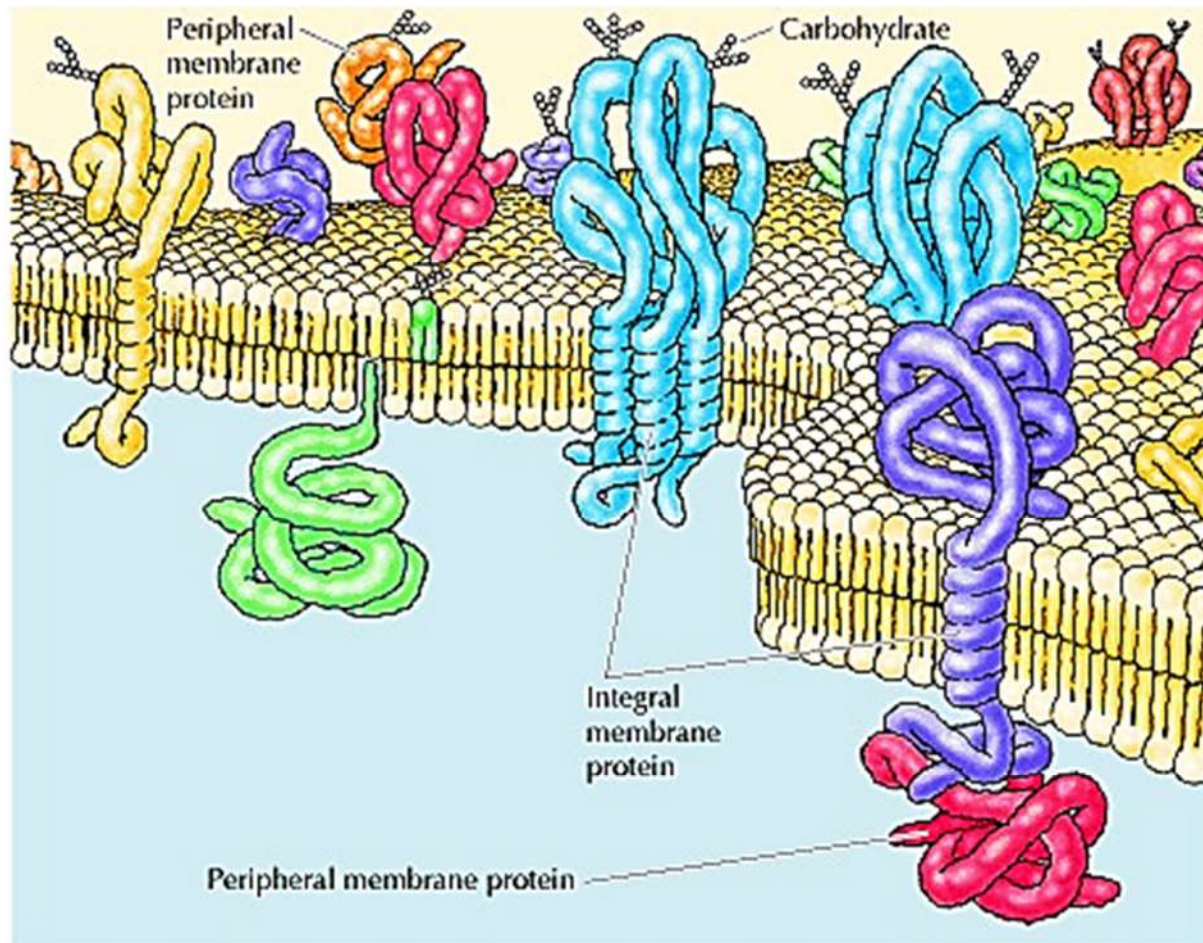
# Lipid components of plasma membrane

- Hydrophobicity of interior of the bilayer makes any water, ionic and most biological molecules impermeable.
- Membrane phospholipid may have one or more double bonds which results in kinks into hydrocarbon chain.
- In addition to the phospholipid, plasma membrane of animals cells contain glycolipids and cholesterol.
- The glycolipids are found exclusively in the outer layer and constitute only 2% of total lipid. Its carbohydrate portions flanks to extracellular space.
- Dutch scientists (E. Gorter and R. Grendel) extracted the membrane lipids from a known number of red blood cells.





# Protein components of plasma membrane



Singer & Nicolson  
fluid mosaic model



Universally  
accepted



Membrane is 2-  
dimensional fluids  
in which proteins  
are inserted into  
lipid bilayers.

The Cell: A Molecular Approach. 2nd edition. Cooper GM.

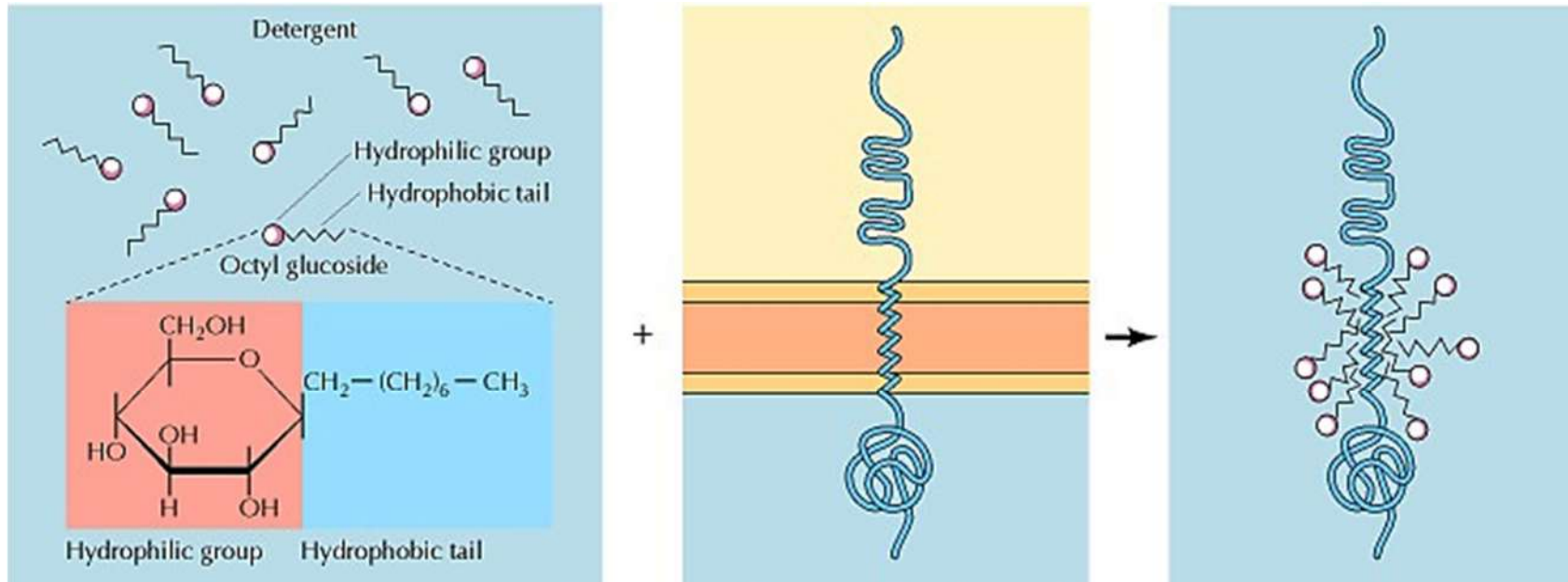


# Protein components of plasma membrane

- It is 50% of total plasma membrane by weight which.
- It is larger molecules compared with that of lipids and estimated to be one protein molecules per every 50 to 100 lipid molecules.
- Membrane proteins are classified into two; peripheral proteins & integral proteins.
- Those proteins which are indirectly associated with membranes through protein-protein interactions, and therefore can be dissociated without disruption of bilayer.
- Integral proteins are inserted into the lipid bilayer so it can not be dissociated without disrupting lipid bilayer.



# Protein components of plasma membrane



**Solubilization of integral membrane proteins.** Detergents, such as octyl glucoside, are amphipathic molecules containing hydrophilic head groups and hydrophobic tails. The hydrophobic tails bind to the hydrophobic regions of integral membrane proteins, forming detergent-protein complexes that are soluble in aqueous solution.

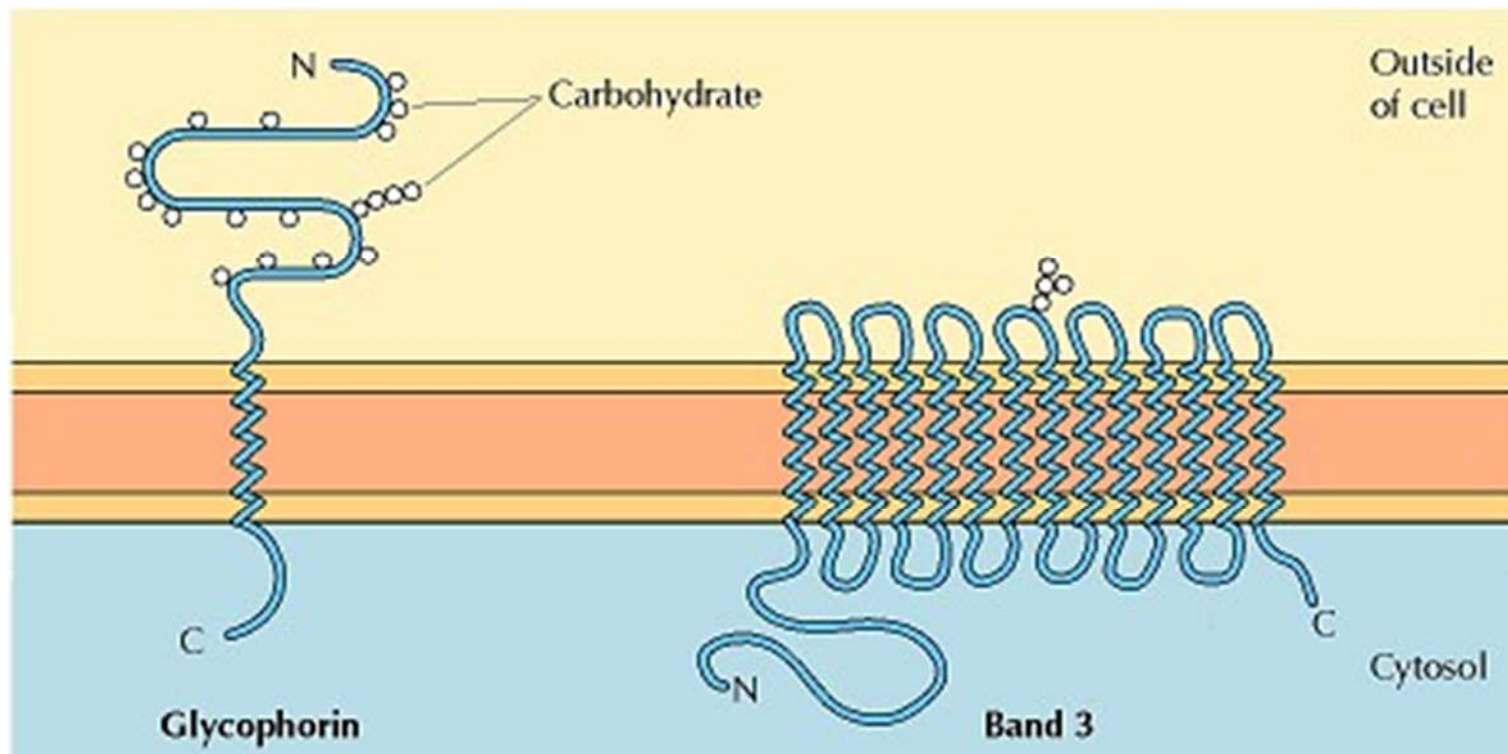


# Protein components of plasma membrane

- Many integral proteins are transmembrane proteins, i.e. the proteins which are exposed on both sides of the membrane.
- Membrane-spanning portion are usually a helix of 20 to 25 hydrophobic amino acids (Generally tryptophan & tyrosine).
- Most abundant peripheral protein of RBCs is spectrin, which is a major cytoskeletal protein. Other proteins are actin, ankyrin and band 4.1.
- Integral proteins are two major types; glycophorin which is a small 131 aa and 30kDa protein (Half carbohydrate) and band 3 which is larger, 929 aa long thought to have 14 membrane spanning alpha helices (anion transporter).



# Protein components of plasma membrane

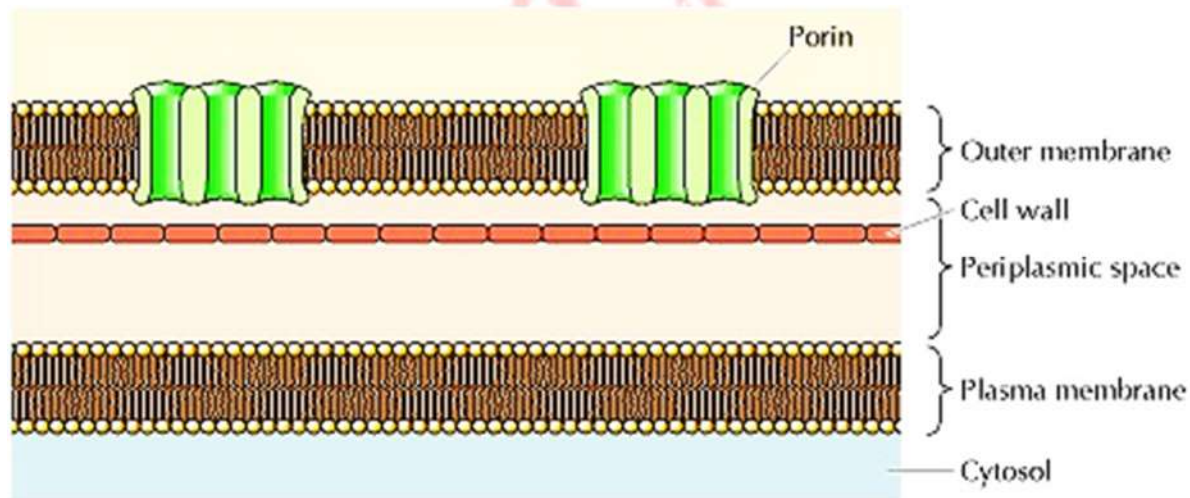


Integral membrane proteins of red blood cells.



# Protein components of plasma membrane

- Some integral proteins known to have transmembrane region of beta-sheets, such as Porins (forms an open aqueous channel in outer membrane of bacteria) found in bacteria, mitochondria, and chloroplast.

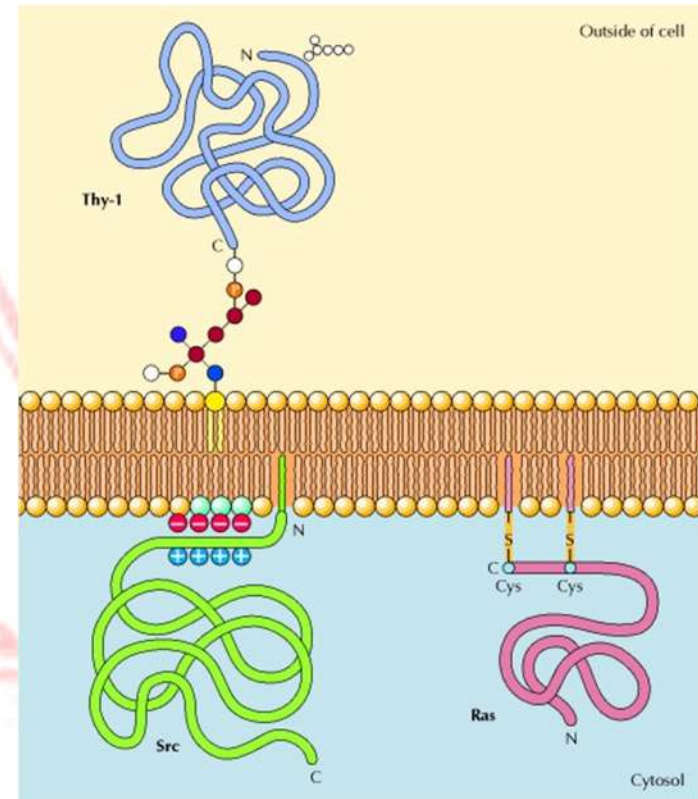


**Porin in bacterial outer membrane.** It crosses the membrane as  $\beta$  barrels, in which 16  $\beta$  sheets fold up into a barrel-like structure enclosing an aqueous pore



# Protein components of plasma membrane

- A variety of proteins are also anchored in the plasma membrane by covalently attached lipids or glycolipids.
- Such proteins are inserted into the outer leaflet of the plasma membrane by glycosylphosphatidylinositol (GPI) anchors.
- GPI-anchored proteins have mainly role in signal transduction.

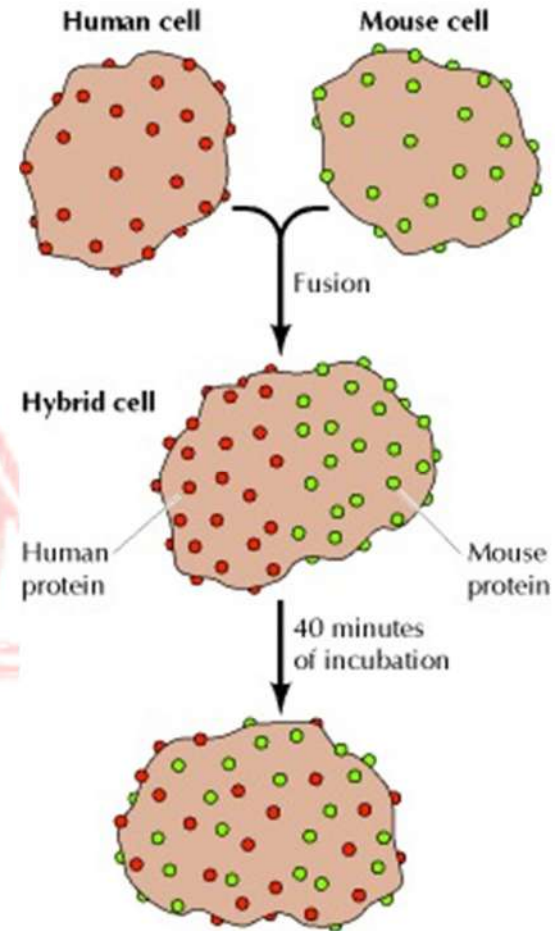


Some proteins, such as Thy-1, are anchored in the outer leaflet of the plasma membrane by GPI anchor added to their C-terminus.



# Protein components of plasma membrane

- Larry Frye and Michael Edidin in 1970 (shown in figure).
- Both proteins and lipids are able to diffuse through the membrane (signifies its fluidic nature).
- However, those proteins which are associated with cytoskeleton, can not diffuse.



Mobility of membrane proteins





# Carbohydrate components of plasma membrane

- They are relatively minor component of plasma membrane, which is only 2% of membrane mass.
- Carbohydrate is found in the form of glycolipids or glycoproteins.
- Glycolipids are exposed on the outer face of the plasma membrane forming a carbohydrate coat, known as glycocalyx.
- Its main role is to protect the cells and play a role in cell-to-cell interaction.
- Example of cell-cell interaction is interaction of selectin (a transmembrane glycoprotein; E, endothelial or P, platelet) binds to specific oligosaccharides (E-selectin ligand-1, ESL-1; or P-selectin glycoprotein-1, PSGL-1 ) expressed on leukocytes.



# Functions of plasma membrane

- It forms an outermost boundary of the cell, i.e. it has protective role.
- It takes in food and excretes waste products.
- It helps in transport across the membrane.
- It contains cell surface receptors which are important in signal transduction.
- It contains cell adhesion molecules, i.e. cadherins, that play an important role in inflammation.
- It contains proteins that are important for cell to cell interaction and helps in formation of various types of junctions with cytoskeletal proteins.



# Further readings

- Cooper G.M., Hausman R.E. The Cell – A molecular Approach. ASM Press, Washington, DC, USA.
- Iwasa J., Marshall W. Karp's Cell and Molecular Biology – Concepts and Experiments, Eighth Edition. John Willey & Sons, Inc., MA, USA.

