Structure of the Plasma Membrane Lecture-1

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Structure of plasma membrane

What is a cell ? Is it a unit of Life??

- Cell is defined as **structural** and **functional** unit of Life.

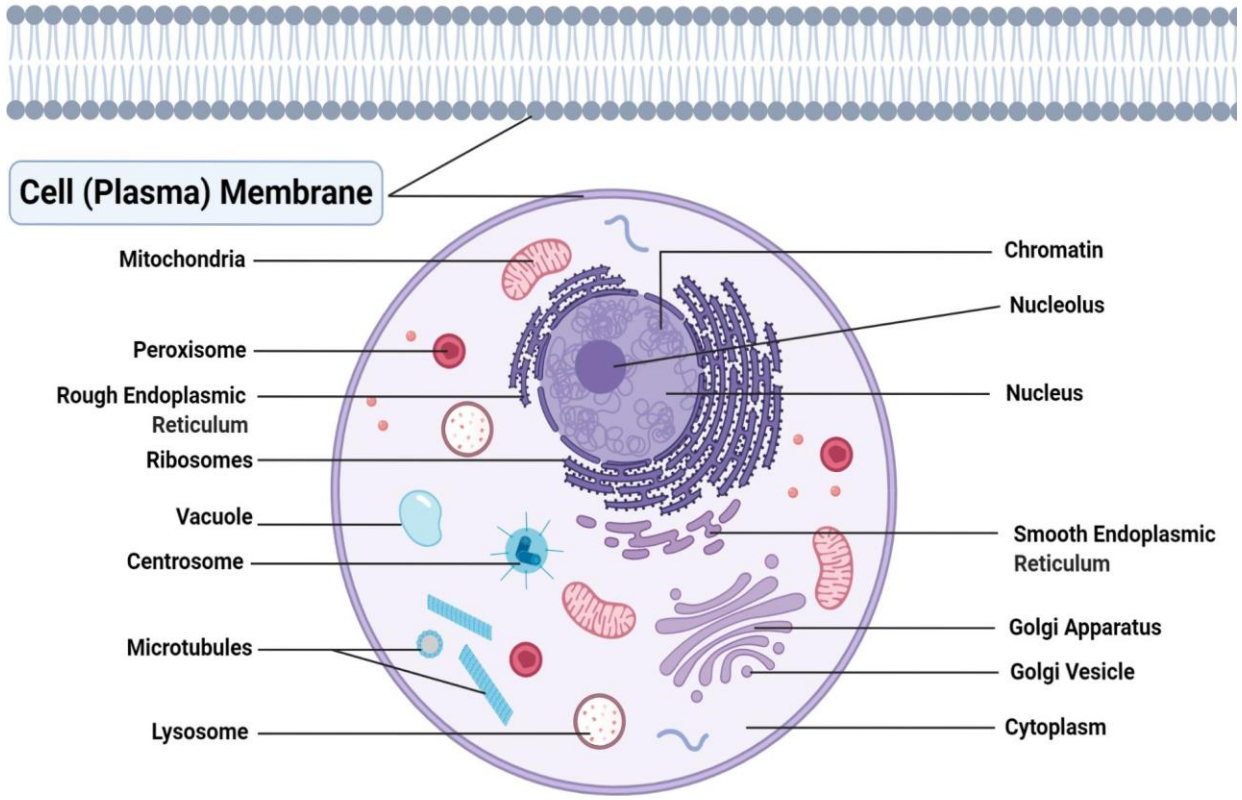
- **Structural unit :** Because without a cell we can not define the grades of organization in biology which are unicellular, tissue grade, organ grade and organ system grade.

- **Functional unit:** Because a cell should be able to perform all the functions that a macro organism is able to perform. E.g. *Amoeba,* a single celled organism is capable of performing all the basic functions that a macro sized animal will perform.

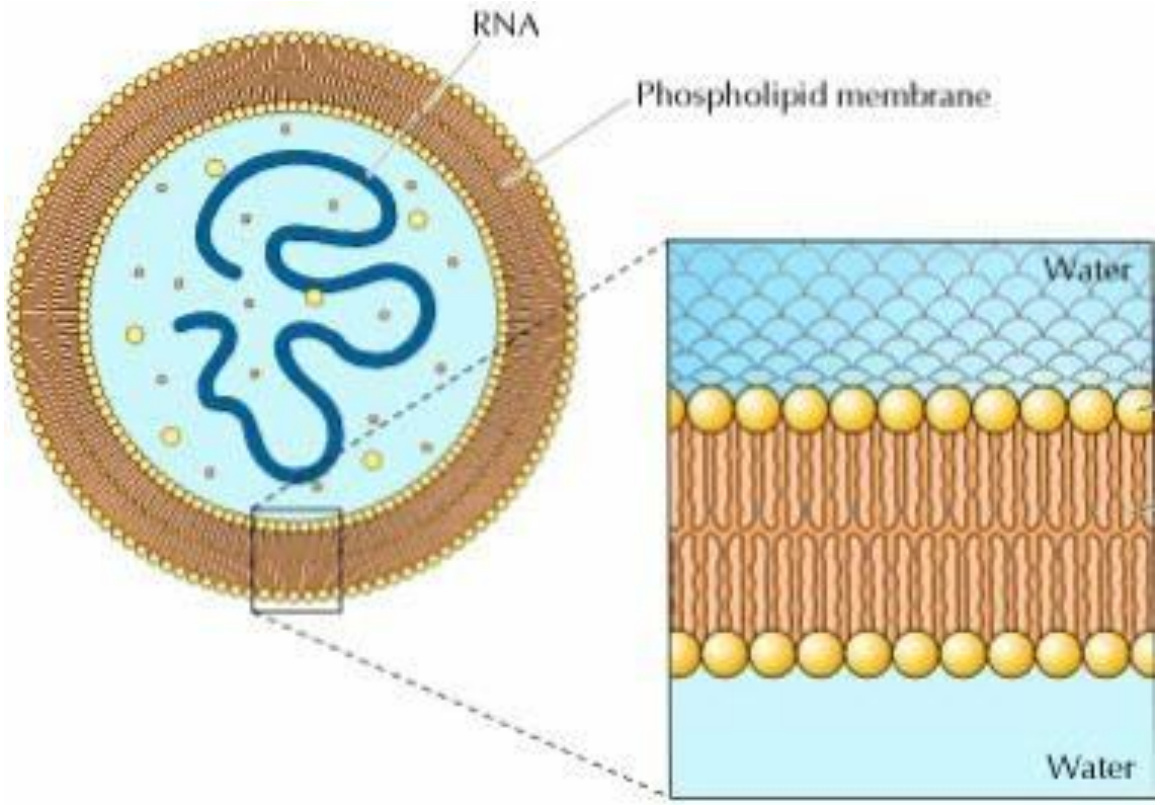
- Since life can not exist without these two elements being there, cell is the most basic unit of Life.

Membrane locations in cell

Animal cell.



Earliest cell



Structure of plasma membrane

- Following models were proposed for study of plasma membrane

1. Gorter and Grendel's membrane theory in 1920.

2. Davson and Danielle model in 1935 and also called as Sandwich model.

3. Unit membrane model in 1950s by Robertson and was first model based on Electron Microscopic studies.

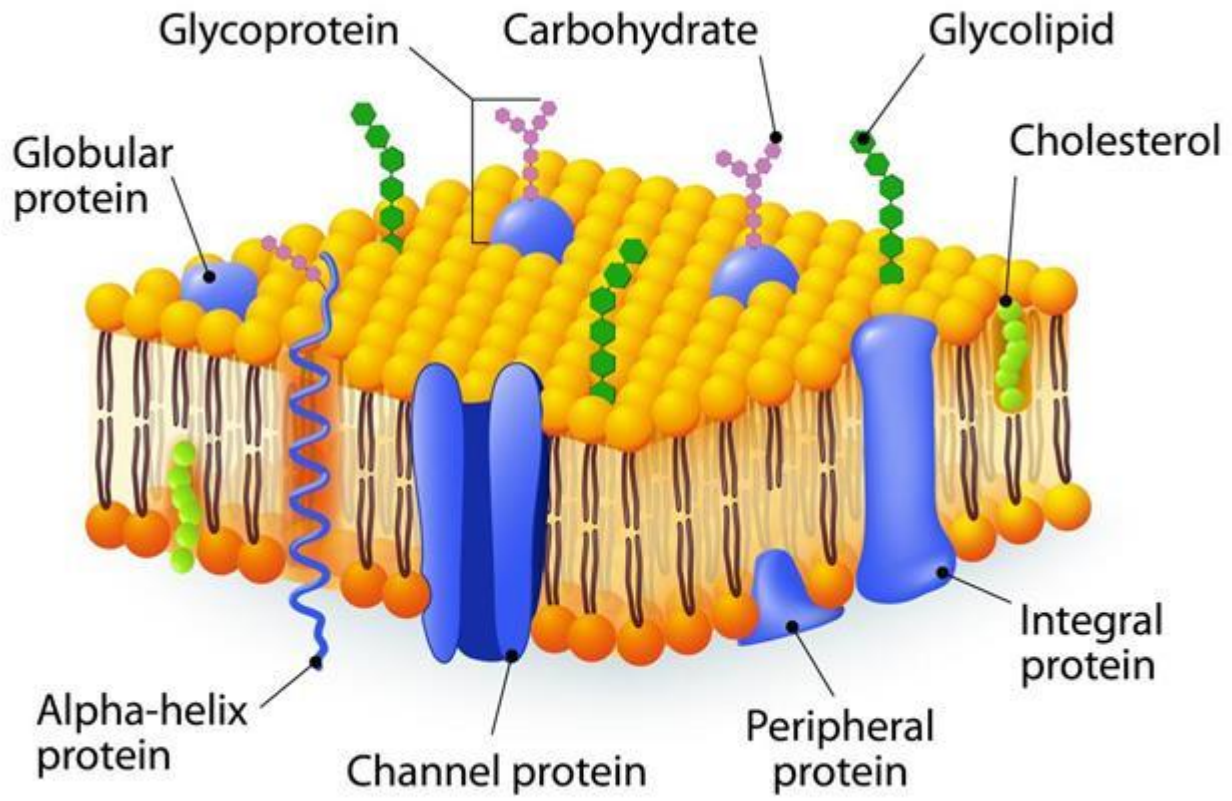
4. Fluid mosaic model by Singer and Nicholson in 1972. It is currently most accepted model of plasma membrane.

5. Henderson and Unwin's membrane theory. This is the most modern theory and is currently under development. It talks about the structural arrangements and their functional effects based on 3D modelling of membrane components.

Fluid mosaic model: Basic tenets

- The main fabric of the membrane is composed of amphiphilic or dual-loving, phospholipid molecules.
- Integral proteins, the second major component of plasma membranes, are integrated completely into the membrane structure with their hydrophobic membrane-spanning regions interacting with the hydrophobic region of the phospholipid bilayer.
- Peripheral proteins are found attached to one side of the lipid bilayer.
- Carbohydrates, the third major component of plasma membranes, are always found on the exterior surface of cells where they are bound either to proteins (forming glycoproteins) or to lipids (forming glycolipids).

Location of molecules in the plasma membrane



Lipids in plasma membrane

- Plasma membrane has different types of lipids in them

Phospholipids:

- They are most abundant of the lipids in PM and form the bulk of the membrane.
- They are also most amphipathic group of lipids.
- They are called as phospholipids because they contain a phosphate group in their structure.
- E.g. Phosphatidylserine, phosphatidylethanolamine, Phosphatidylcholine, phosphotidylinositol etc.

Types of phospholipids found in plasma membrane

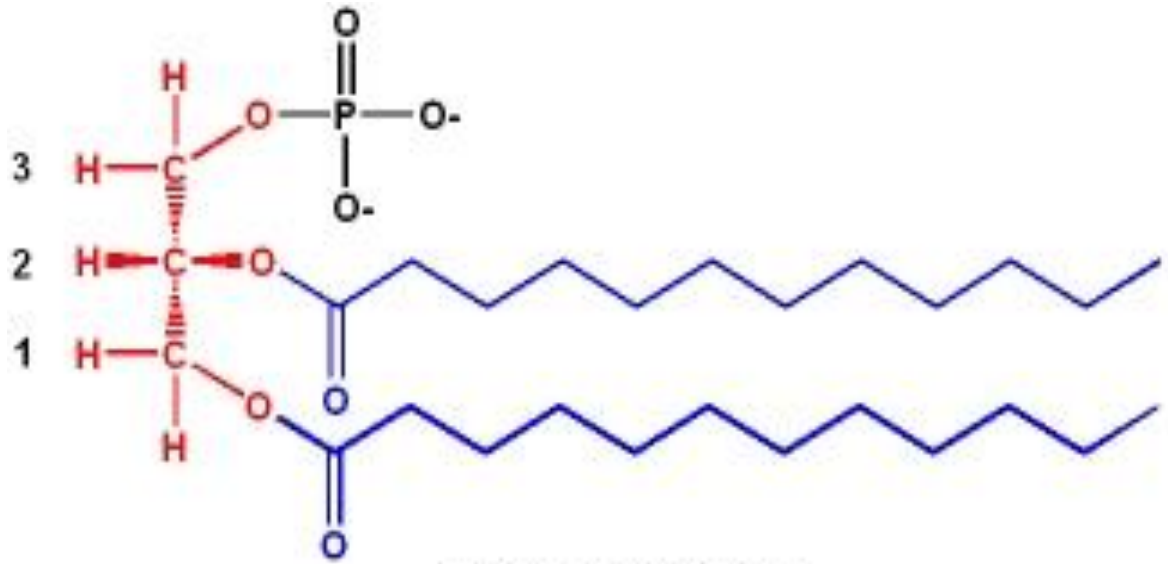
- There are two basic types

1. **Phosphoglycerides:** It is the type that we are more familiar with and most of the examples of phospholipids belong to it. E.g. **Phosphatidylcholine, phosphatidylethanolamine etc.**

2. **Sphingolipids:** They are less common type and less known example because as a class of lipids they have phospholipids as well as non phospholipids. E.g. **Sphingomyelin, ganglioside etc.**

Phosphoglycerides in plasma membrane

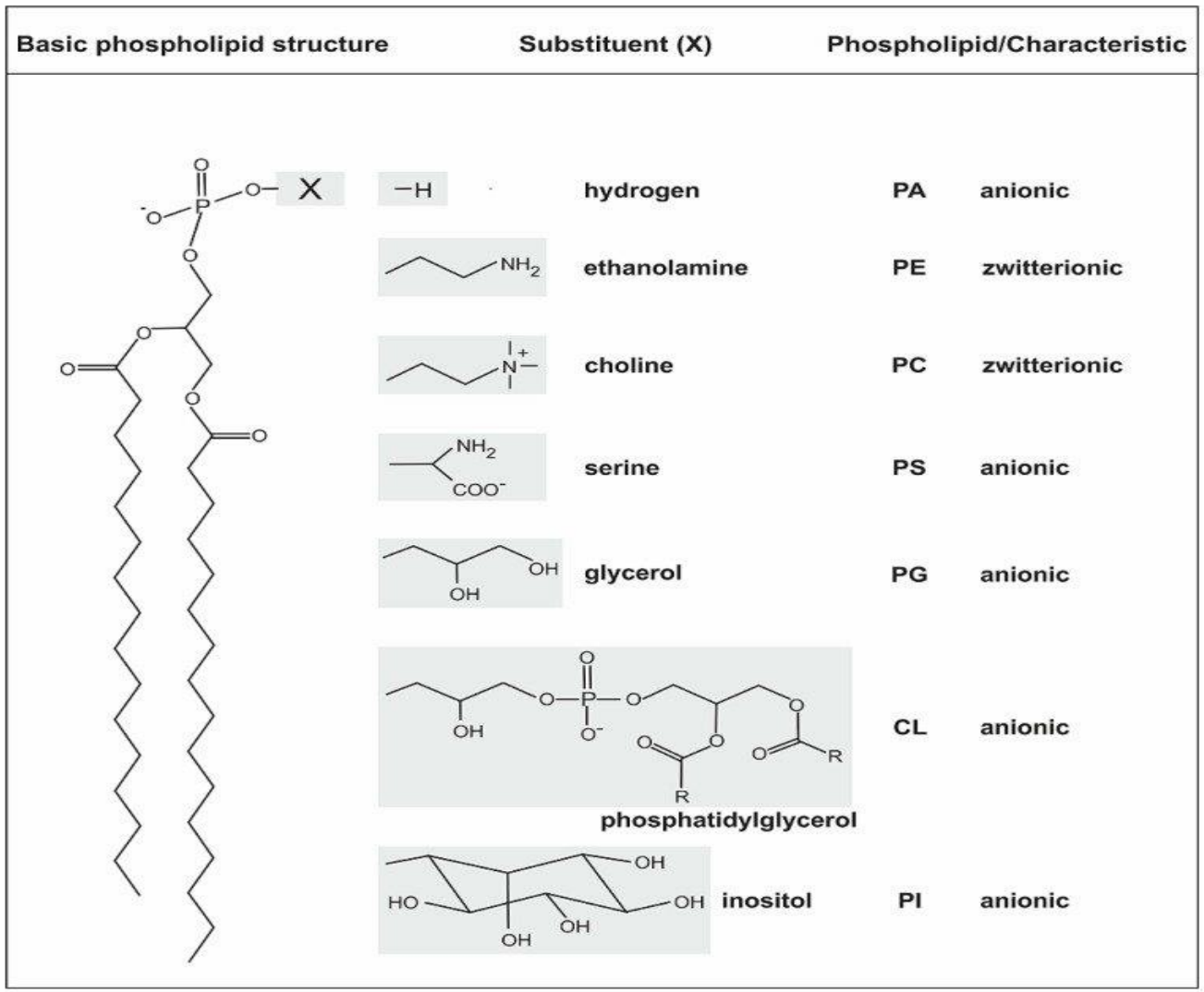
- They are most abundant phosholipid in PM. They are called so because of their glycerol backbone.



A Phosphoglyceride

- They have long chain fatty acids on C1& C2 of glycerol backbone linked with ester bond. They provide apolar part.
- They have a phosphate group on the C3 of glycerol backbone linked with ester bond.
- It is on this phosphate group that polar head groups are attached.

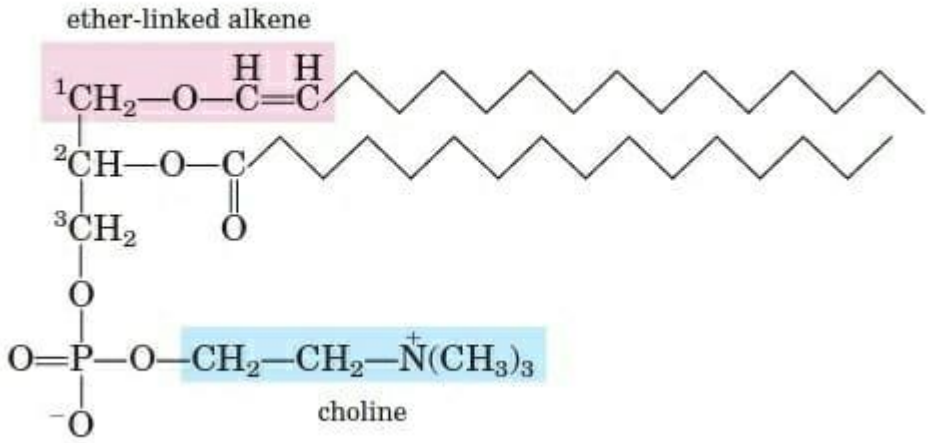
Structure of some of the phosphoglycerides



- They are also called as glycerophospholipids.
- Most abundant phosphoglyceride in PM is Phosphatidylcholine (PC).
- They are also called as lecithins. These are found in all living organisms.
- Egg yolks are especially rich in lecithins.Commercial grade lecithins are isolated from soyabean and widely used in foods as emulsifying agent.
- Phosphatidylethanolamine is another common phosphoglyceride.
- It is also called as cephalin.
- They are relatively common in brain tissue and nerves.

Plasmalogens : Ether linked phosphoglyceride

- They are special because unlike other phosphoglycerides they have ether linkage between fatty acyl chain and glycerol at C1 or C2.

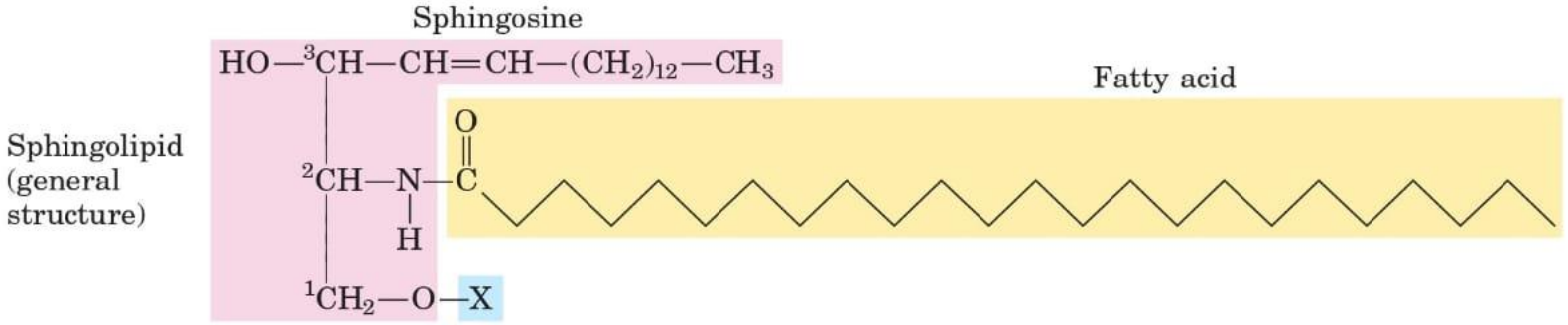


Plasmalogen

They are highly abundant in Vertebrate heart tissue.

Sphingolipids: The sphingosine derivatives

- They are derivatives of a long chain amino alcohol, sphingosine. They have following general structure.

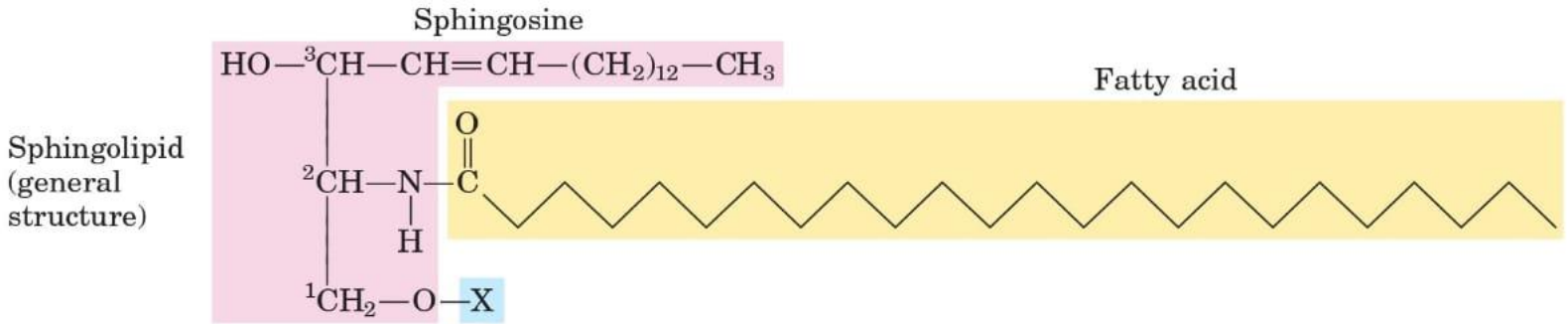


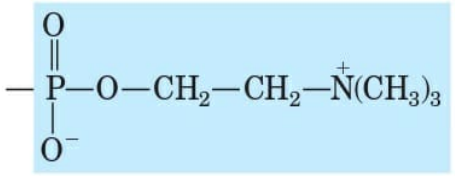
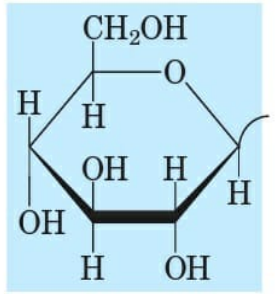
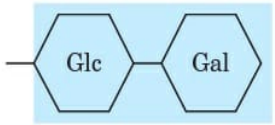
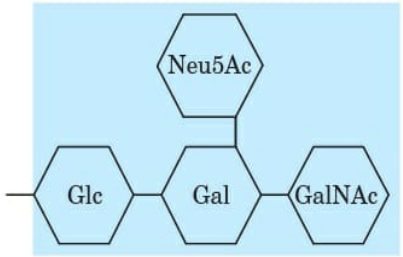
The polar head group is attached at C1 of the sphingosine and fatty acyl is attached to amino group at C2 via amide linkage.

If polar head group has phosphate in it's structure then corresponding sphingolipid is called a phospholipid.

E.g. Sphingomyelins because they contain phosphocholine or phosphoethanolamine as polar head group.

Basic structure of sphingolipids

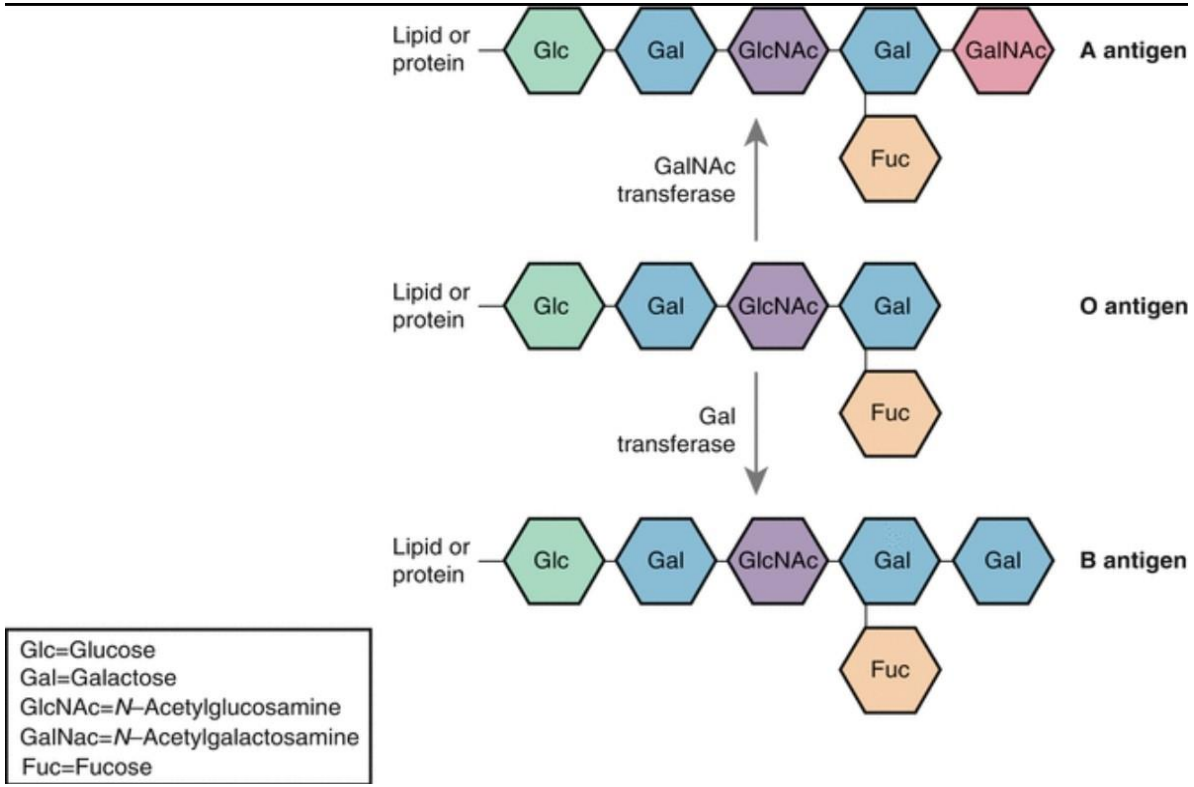


Name of sphingolipid	Name of X	Formula of X
Ceramide	—	—H
Sphingomyelin	Phosphocholine	
Neutral glycolipids Glucosylcerebroside	Glucose	
Lactosylceramide (a globoside)	Di-, tri-, or tetrasaccharide	
Ganglioside GM2	Complex oligosaccharide	

- Those that lack phosphate containing polar head group and contain carbohydrates as polar head group are called as glycosphingolipids.
- They are found on the outer leaflet of plasma membrane.
- If a single sugar is the polar group then it's called as cerebroside. E.g. Galactose containing cerebroside is abundant in PM of cells in neural tissue and glucose containing cerebroside is abundant in PM of nonneural cells.
- If di, tri or tetrasaccharide is the polar head group then it's called as globoside.
- If oligosaccharide is the polar head group then it's called as ganglioside.

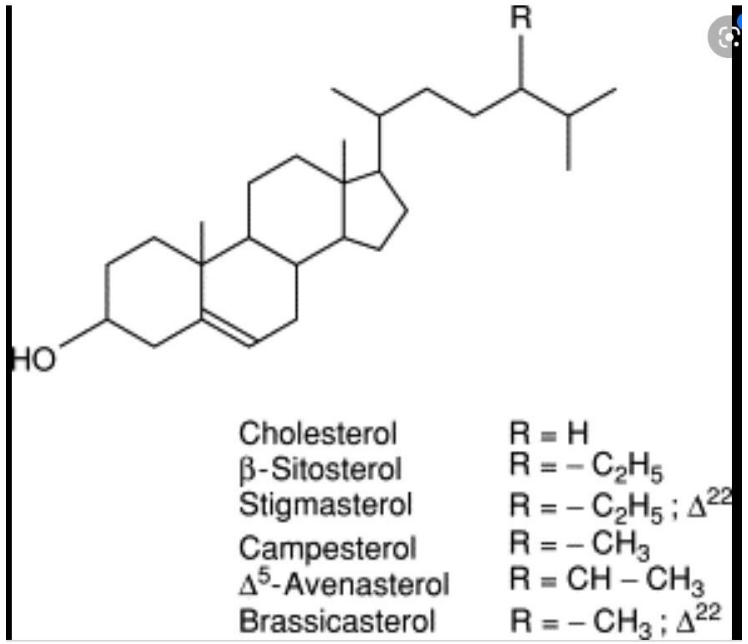
Blood group antigens are Glycosphingolipid.

- They are found on RBC and project on the outer side as shown.



Sterols as membrane lipids

- They are most hydrophobic component of PM. They have typical 4 ringed sterol nucleus.



The substitutions in 5 membered ring decide the nature of sterol.

Cholesterol is the major sterol found in PM of animal cells.

It's major function is to provide rigidity to the PM and stabilize it's fluid nature.

Fluidity of membrane

- Plasma membrane is semi fluid in nature.

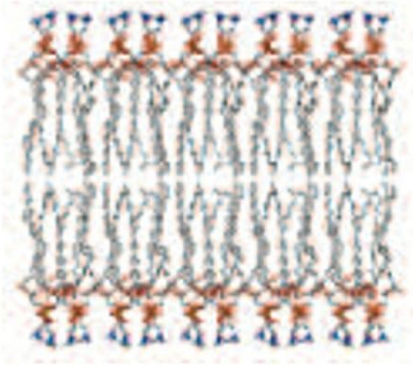
- It’s fluidity is function of temperature. Because temperature affects the fatty acyl composition and saturation states of lipids found in PM.

- At 25°C, there is balance between saturated and unsaturated fatty acids.
- At 37°C, there is greater proportion of saturated and long chain fatty acids in PM.
- At 10°C, there is greater proportion of unsaturated and short chain fatty acids.

- It is because melting point of fatty acids is directly proportional to saturation and chain length.

- This can be seen in gel to fluid transition in membrane and in PM composition of animals living in cold areas, especially in parts directly in contact with ice.

(a) Paracrystalline state (gel)



Heat produces thermal motion of side chains (gel → fluid transition)

(b) Fluid state

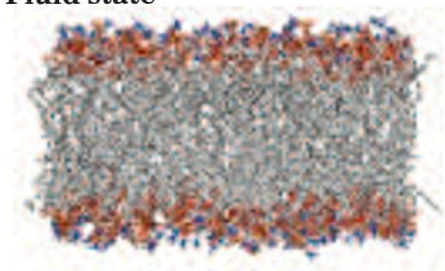


TABLE 11–2 Fatty Acid Composition of *E. coli* Cells Cultured at Different Temperatures

	Percentage of total fatty acids[*]			
	10 °C	*20 °C*	*30 °C*	*40 °C*
Myristic acid (14:0)	4	4	4	8
Palmitic acid (16:0)	18	25	29	48
Palmitoleic acid (16:1)	26	24	23	9
Oleic acid (18:1)	38	34	30	12
Hydroxymyristic acid	13	10	10	8
Ratio of unsaturated to saturated[†]	2.9	2.0	1.6	0.38

Thank you