



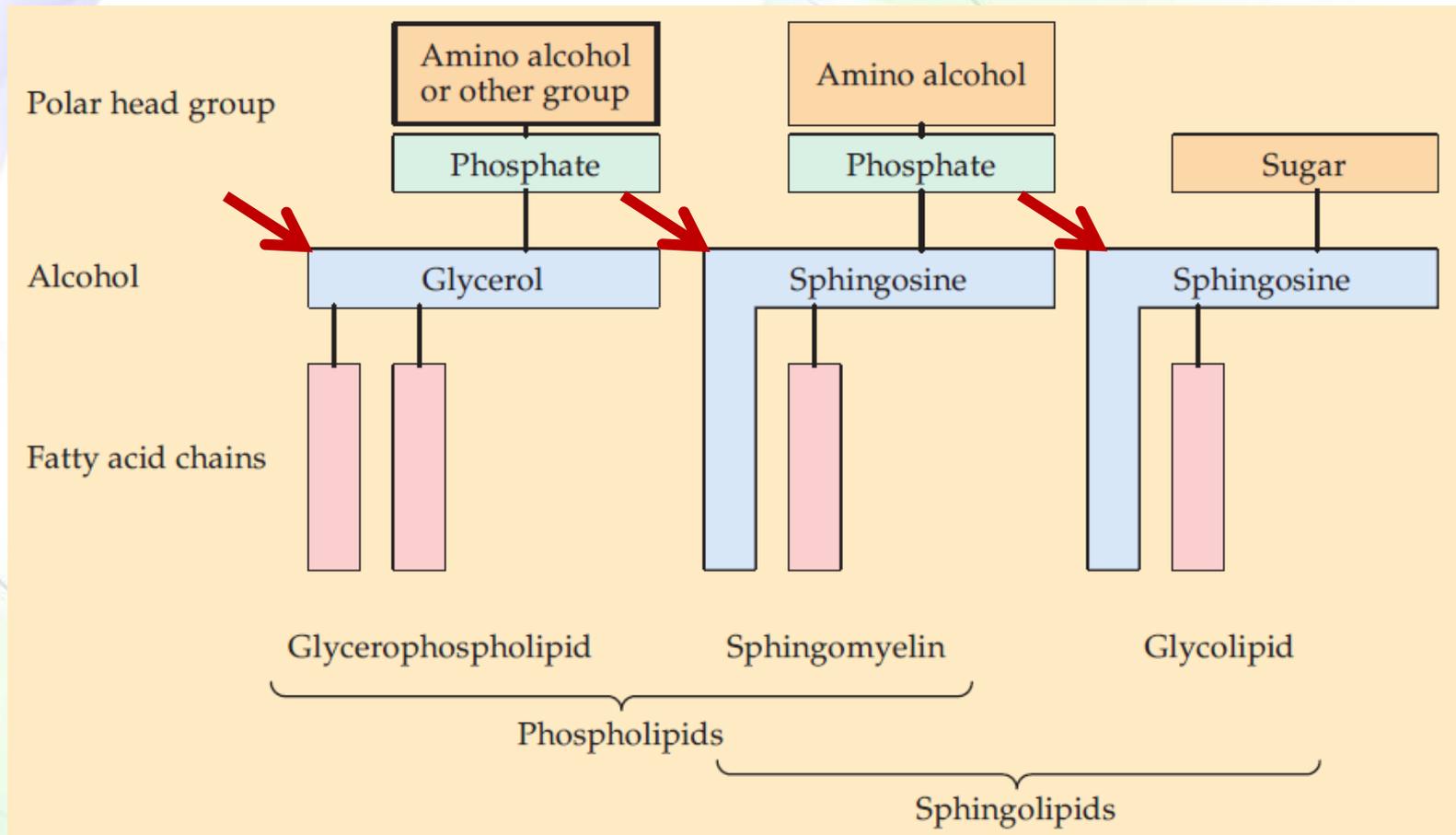
# Lipids- Part 2

Dr. Diala Abu Hassan

## **Resources**

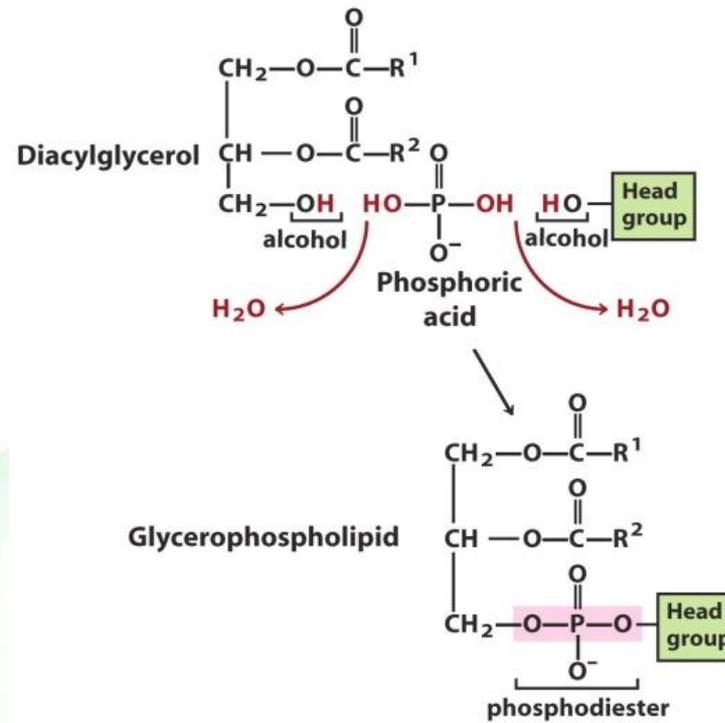
Campbell and Farrell's Biochemistry, Chapter 8

# Membrane lipids



**The most prevalent class of lipids in membranes is the glycerophospholipids**

# Phospholipids (phosphoacylglycerols)



Phosphatidic acid	—	— H
Phosphatidylethanolamine	Ethanolamine	— CH <sub>2</sub> —CH <sub>2</sub> —NH <sub>3</sub> <sup>+</sup>
Phosphatidylcholine	Choline	— CH <sub>2</sub> —CH <sub>2</sub> —N <sup>+</sup> (CH <sub>3</sub> ) <sub>3</sub>
Phosphatidylserine	Serine	— CH <sub>2</sub> —CH—NH <sub>3</sub> <sup>+</sup>   COO <sup>-</sup>

# Classification of Glycerophospholipids



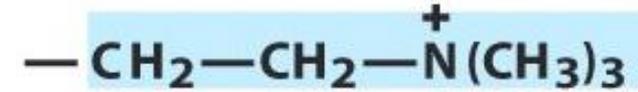
- Phosphatidic acids
- Phosphatidylcholine (lecithins)
  - Most abundant membrane lipid
- Cephalins
  - Phosphatidylethanolamine
  - Phosphatidylserine
    - abundant in brain
- Phosphatidylinositol
  - sends messages across cell membranes
- Cardiolipin
- Plasmalogens

# Glycerophospholipids - Lecithins



Phosphatidylcholine

Choline



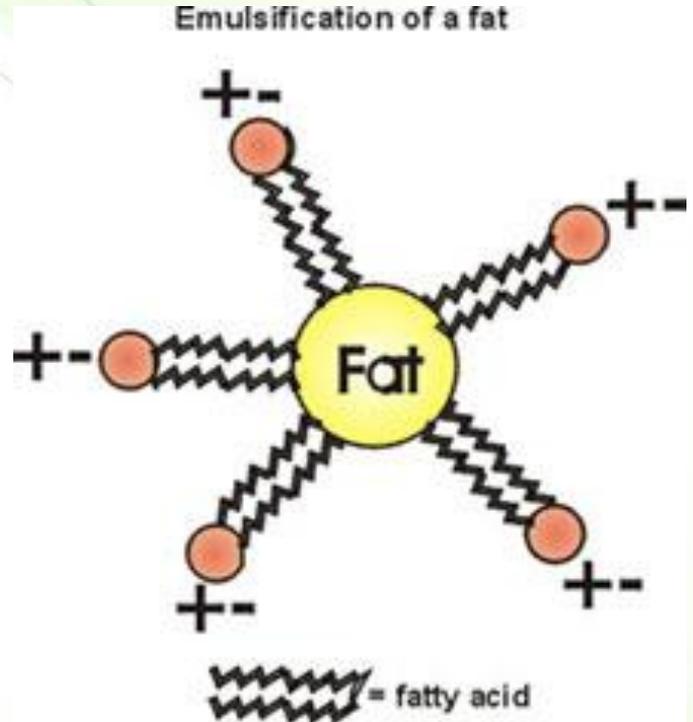
- Snake venom contain lecithinase, which hydrolyzes polyunsaturated fatty acids and converting lecithin into lysolecithin
  - hemolysis of RBCs



# Emulsification



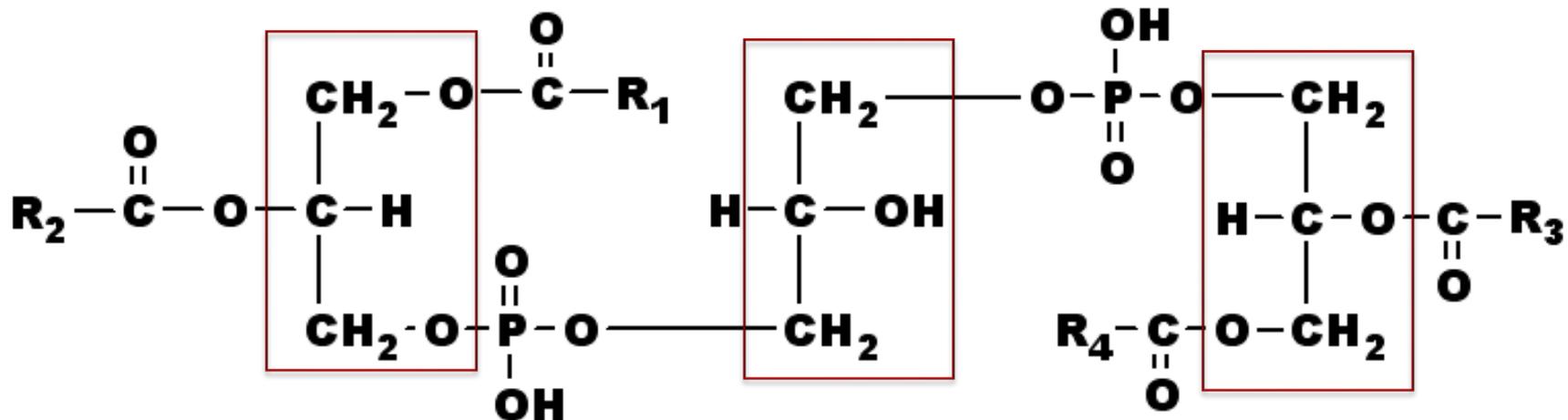
- Because of their amphipathic nature, they act as emulsifying agents, that is substances that can surround nonpolar molecules and keep them in suspension in water.



# Glycerophospholipids - Cardiolipins



- Diphosphatidyl-glycerol
- Found in the inner membrane of mitochondria
- Initially isolated from heart muscle (cardio)
- Structure: 3 molecules of glycerol, 4 fatty acids & 2 phosphate groups

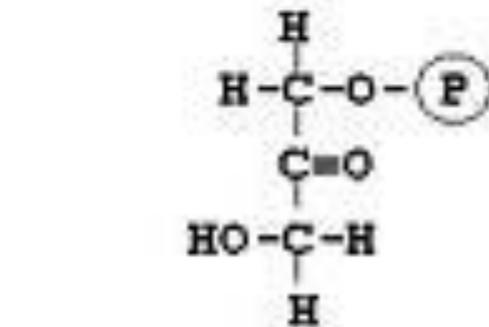
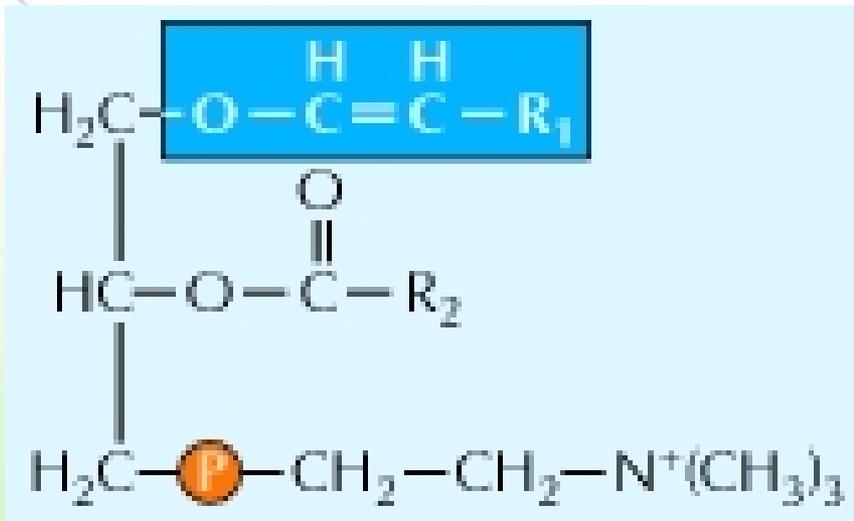


Cardiolipin

# Plasmalogens



- They are found in the cell membrane phospholipids fraction of brain & muscle, liver, and semen.
- They have a protective role against reactive oxygen species
- Structure:
  - Precursor: Dihydroxyacetone phosphate
  - Unsaturated fatty alcohol at C1 connected by ether bond
  - In mammals: at C3; phosphate + ethanolamine or choline

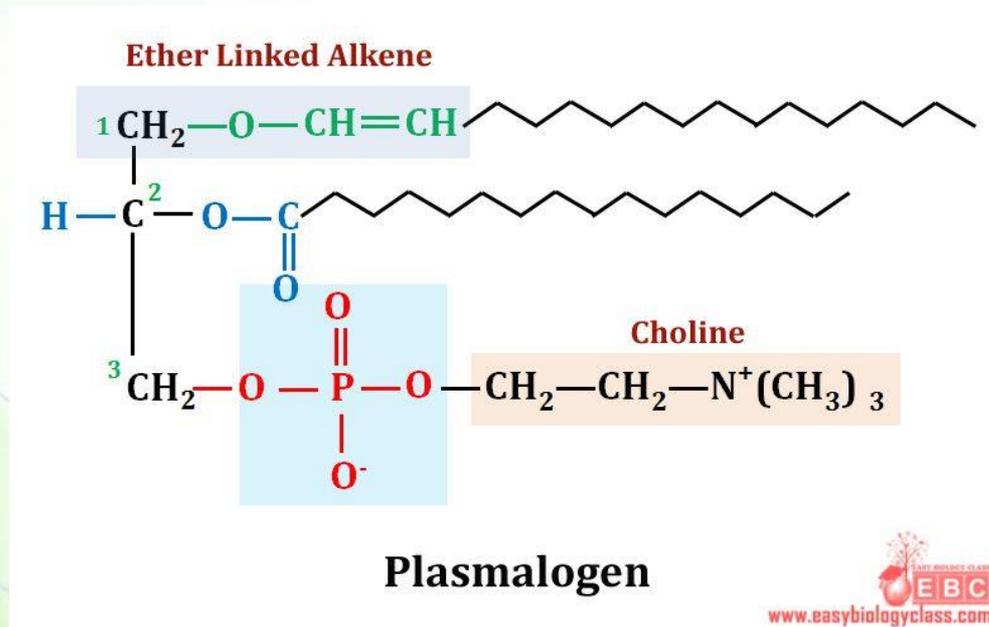


Dihydroxyacetone phosphate

# Major classes of plasmalogens



- Ethanolamine plasmalogen (myelin-nervous tissues)
- Choline plasmalogen (cardiac tissue)
  - Platelet activating factor
- Serine plasmalogens



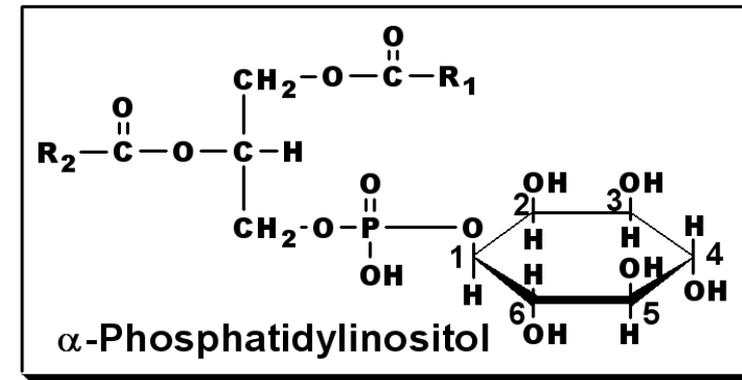
# Glycerophospholipids - Inositides



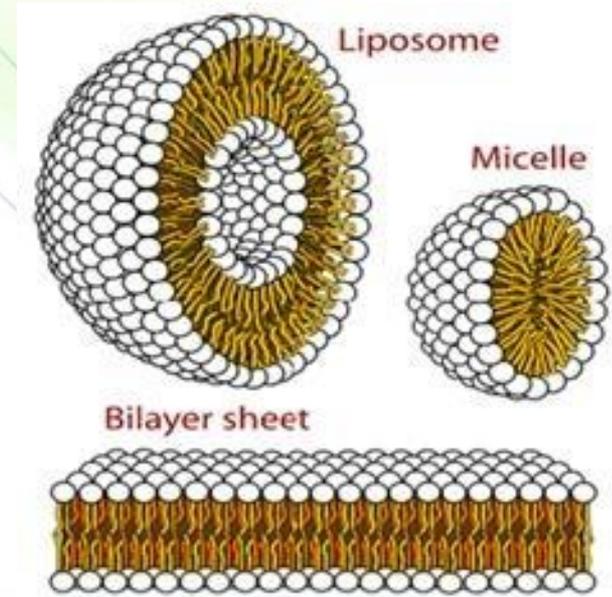
- Phosphatidyl inositol
- Nitrogenous base: cyclic sugar alcohol (inositol)
- Structure: glycerol, saturated FA, unsaturated FA, phosphoric acid, & inositol
- Source: Brain tissues

## ■ Functions:

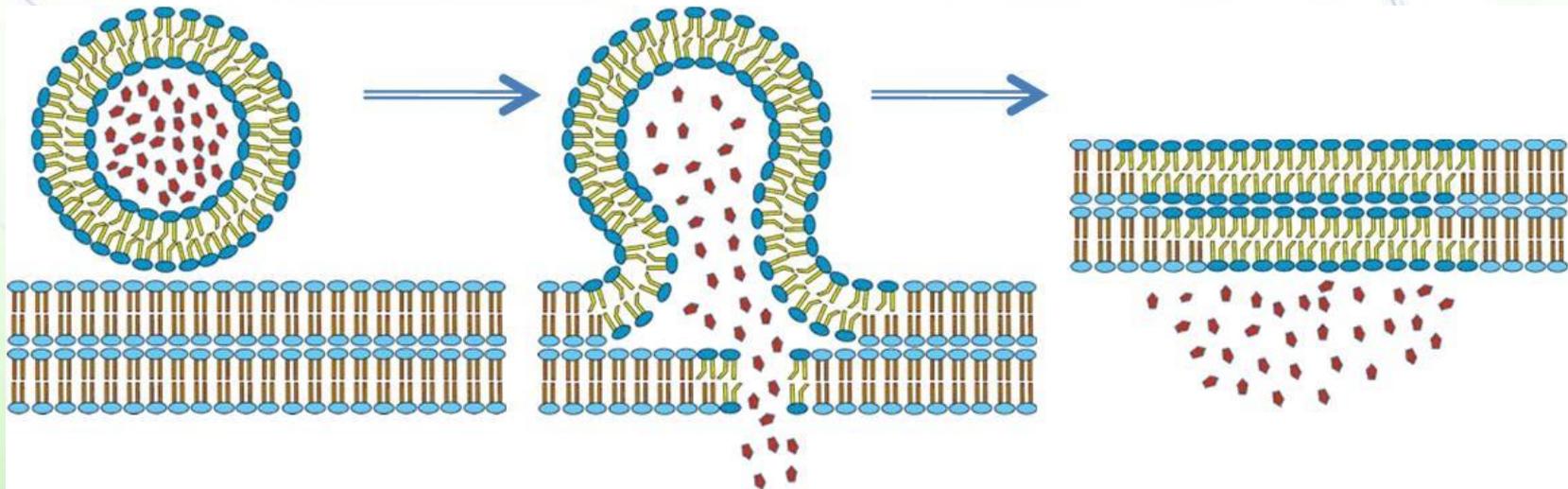
- Major component of cell membrane
- Second messenger during signal transduction
- On hydrolysis by phospholipase C, phosphatidyl-inositol-4,5-diphosphate produces diacyl-glycerol (DAG) & inositol-triphosphate (IP3); which liberates calcium



# The different structures of phospholipids



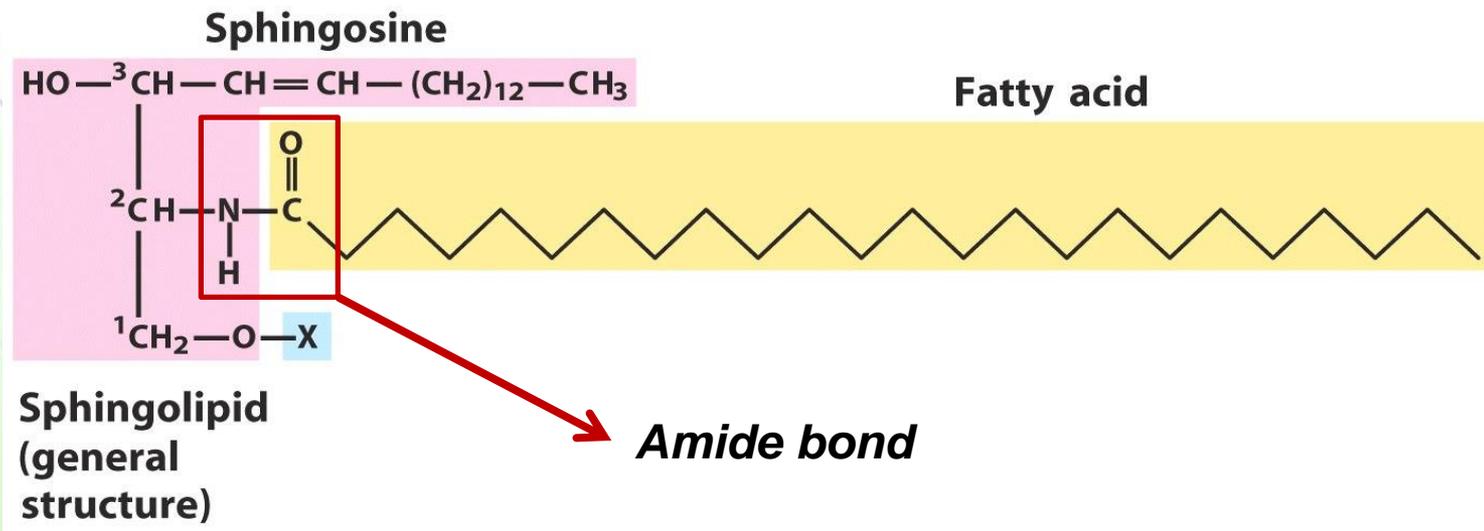
## Uses of liposomes: delivery



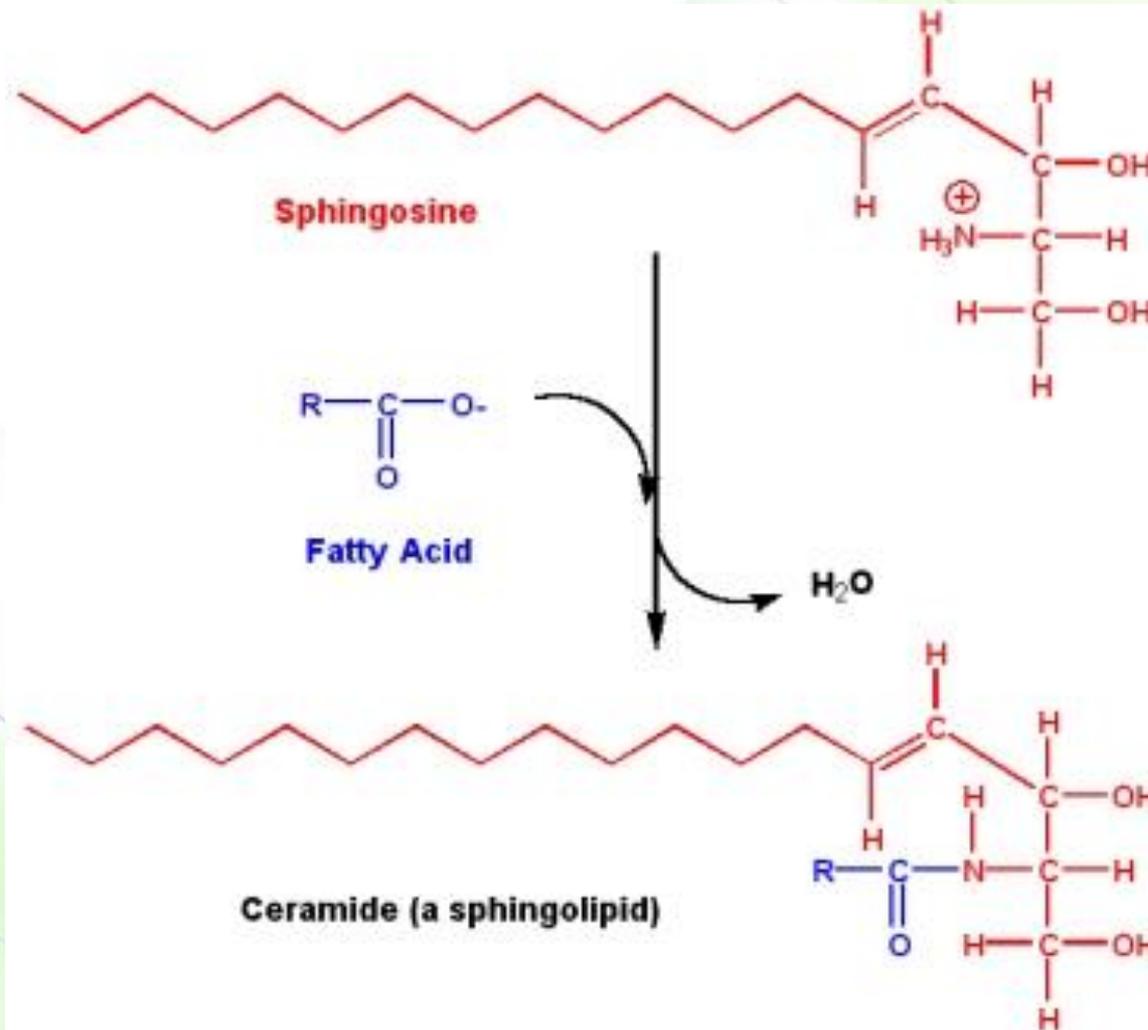
# Sphingolipids



- Sphingolipids are found in the plasma membranes of all eukaryotic cells and is highest in the cells of the central nervous system
- The core of sphingolipids is the long-chain amino alcohol, sphingosine



# Ceramide



# Types of sphingolipids

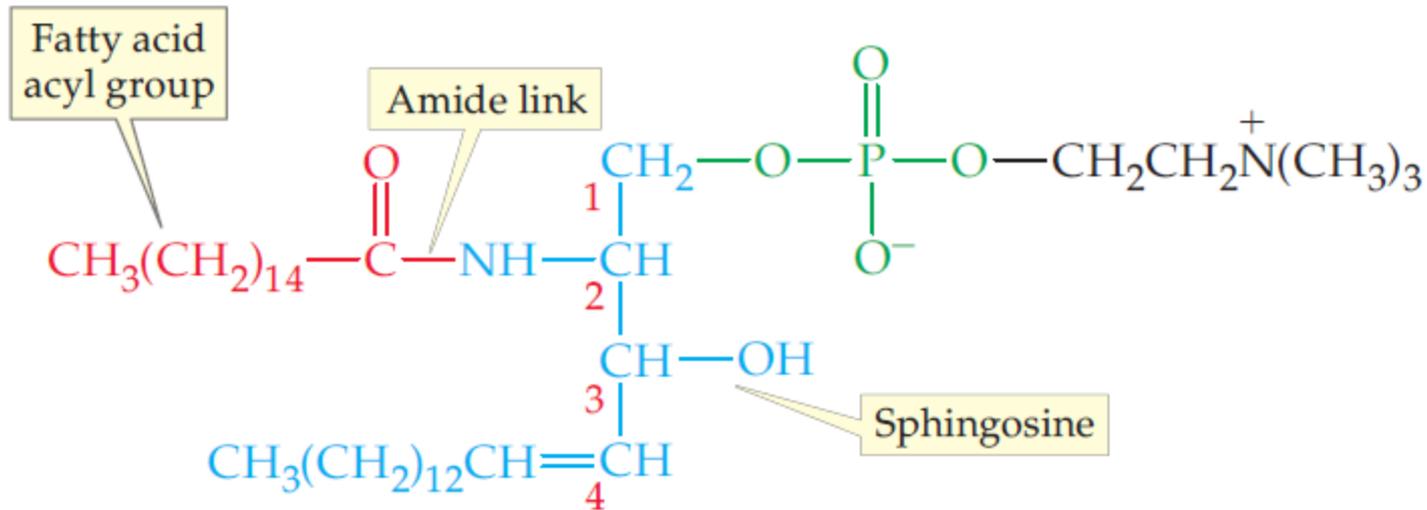


- The sphingolipids are divided into the two subcategories:
  - Sphingomyelins
  - Glycosphingolipid (or glycolipids)

# Sphoingomyelin



- Sphoingomyelin is a sphingolipid that is a major component of the coating around nerve fibers
- The group attached to C1 is a phosphocholine



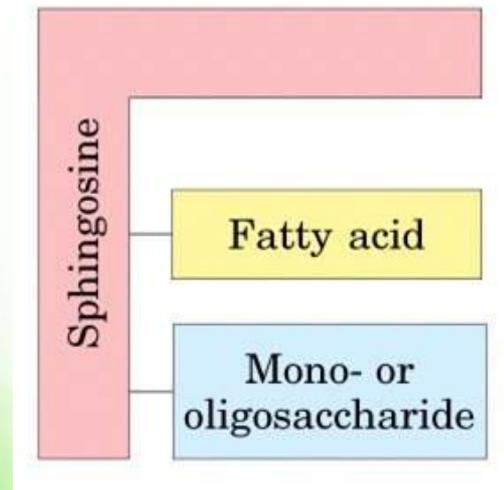
A sphingomyelin (a sphingolipid)



# Glycolipids



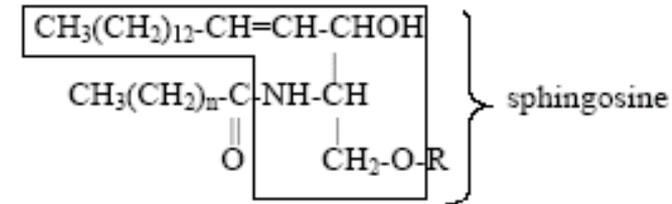
- Sphingolipids can also contain carbohydrates attached at C-1 and these are known as glycolipids
- Glycolipids are present on cell membranes and act as cell surface receptors that can function in cell recognition (e.g., pathogens) and chemical messengers
- There are three types of glycolipids
  - Cerebrosides
  - Globosides
  - Gangliosides



# Glycolipids

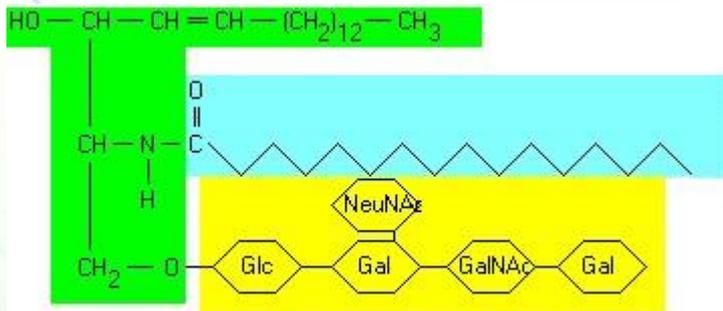


- **Cerebrosides: the simplest glycolipids, contain a single hexose (galactose or glucose).**
- **Globosides and gangliosides are more complex glycolipids.**
- **Both contain glucose, galactose, and N-acetylgalactosamine, but gangliosides must also contain sialic acid.**

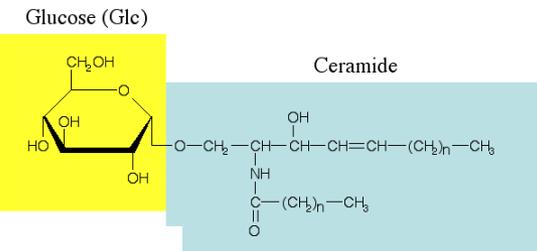


Spingolipid type	R group
Ceramide	H
Sphingomyelin	phosphocholine
Cerebroside	monosaccharide (galactose or glucose)
Globoside	two or more sugars (galactose, glucose, N-acetylglucosamine)
Ganglioside	three or more sugars including at least one sialic acid

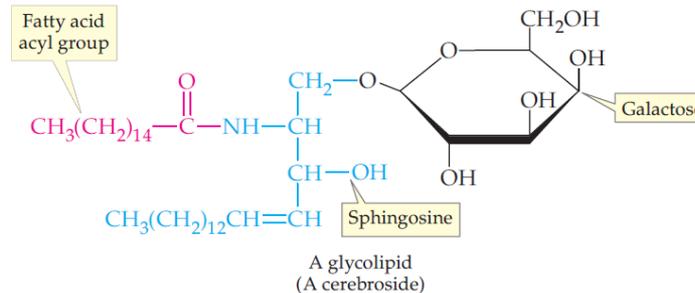
glycolipids



## Glucocerebroside



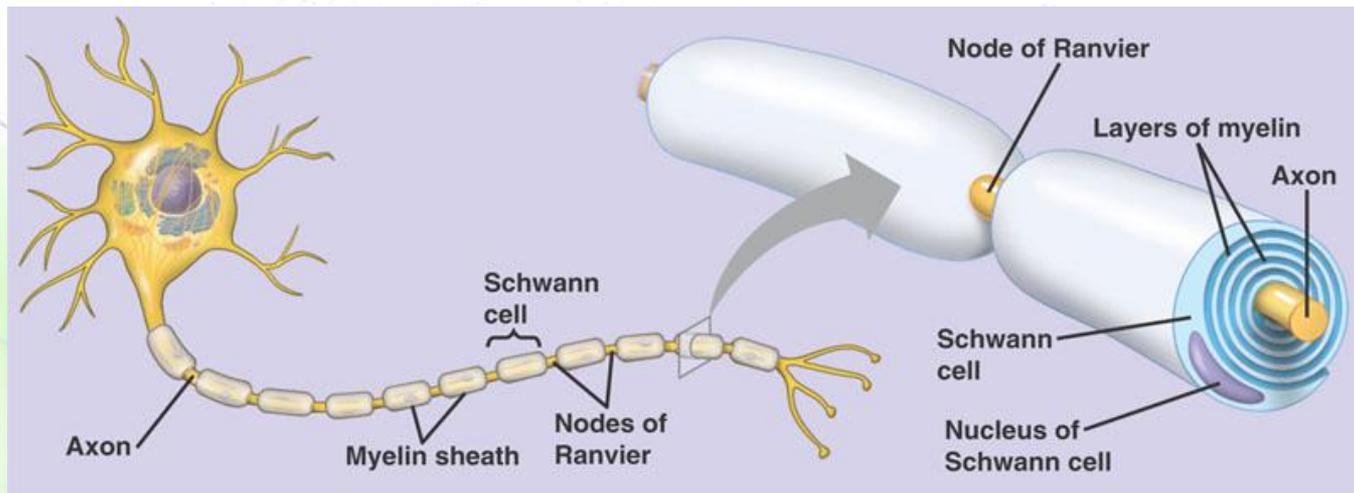
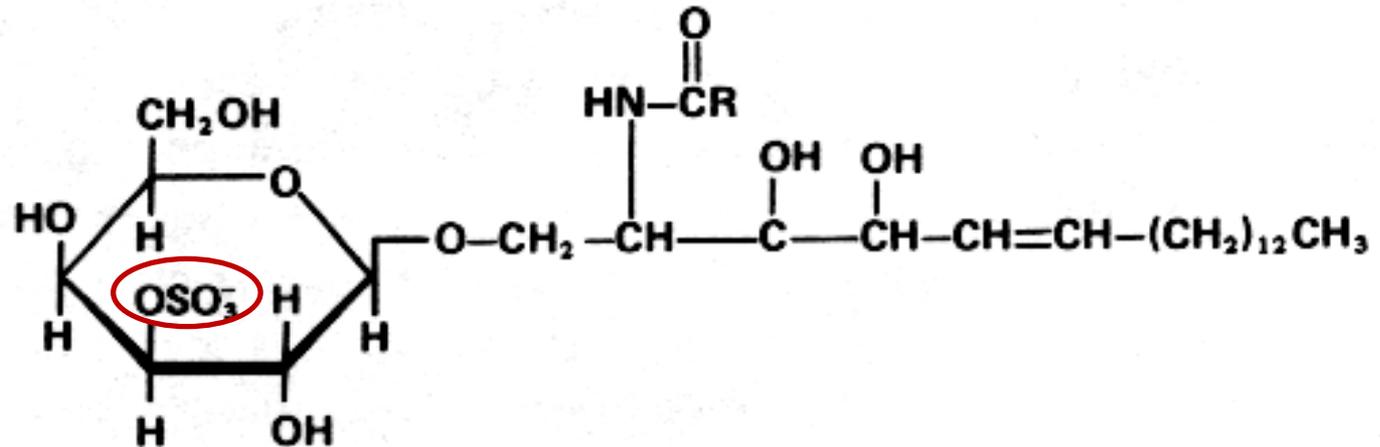
**Gangliosides are targeted by cholera toxin in the human intestine.**



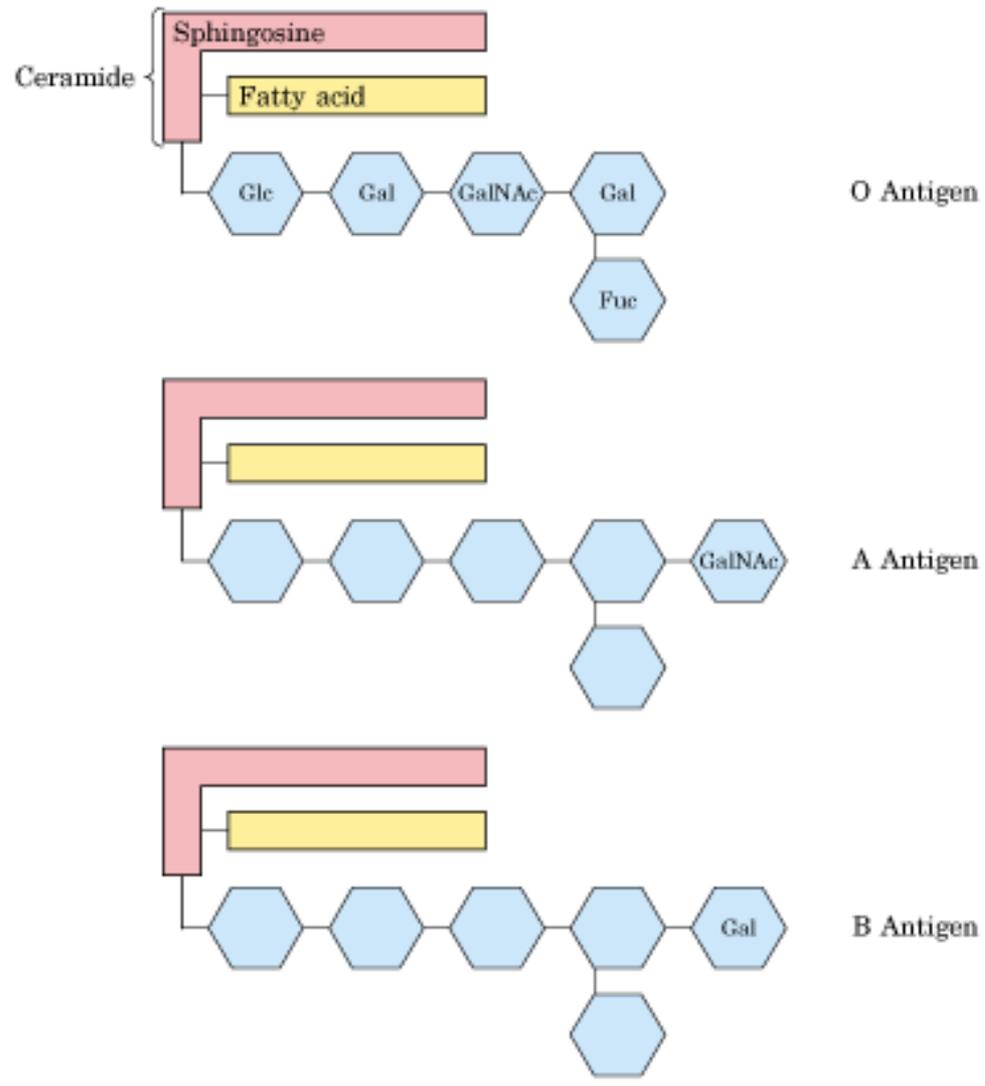
# Sulfatides



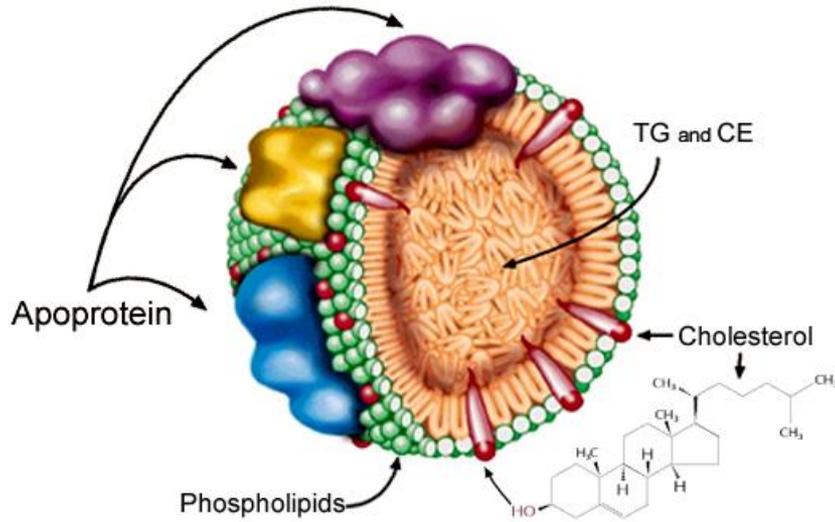
- Synthesized from galactocerebroside
- Abundant in brain myelin



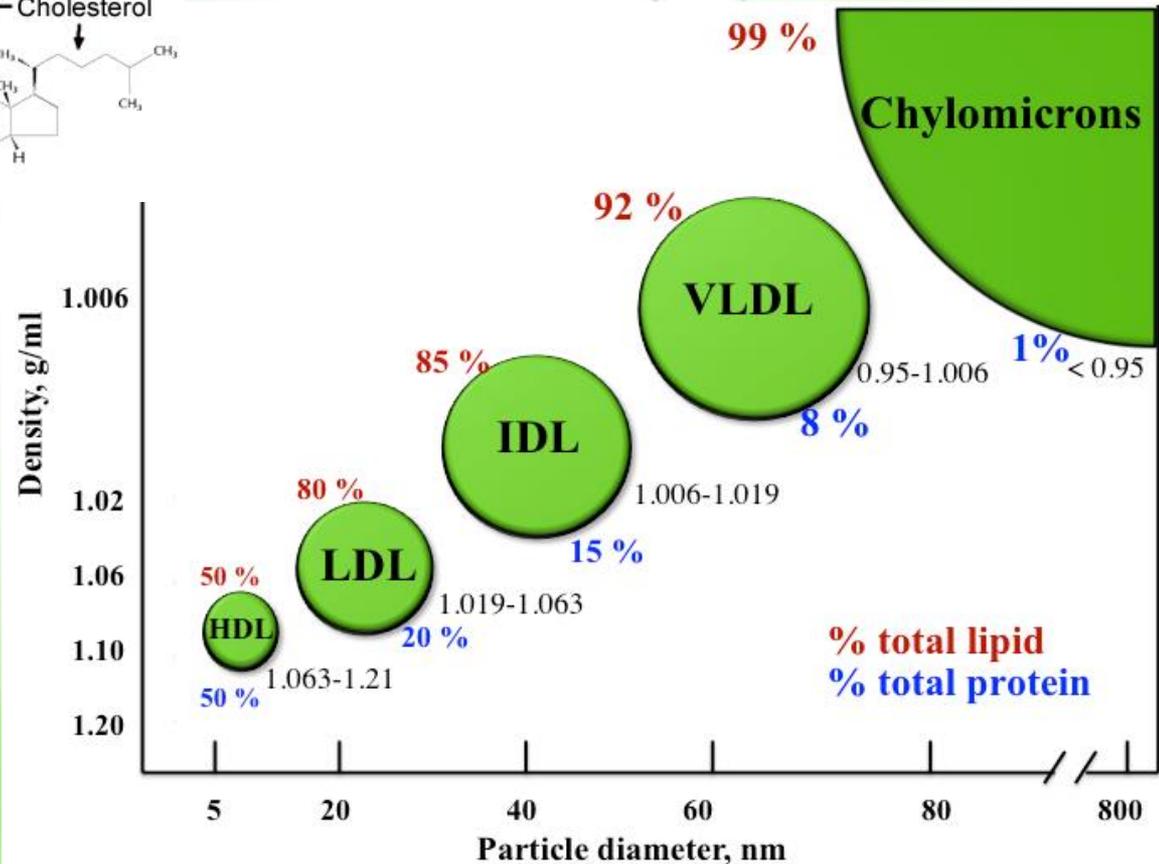
# Sphingolipids and blood groups



# Lipoproteins



**Function: transport of different types of lipids (cholesterol, cholesterol esters, phospholipids & triacylglycerols) in blood plasma.**

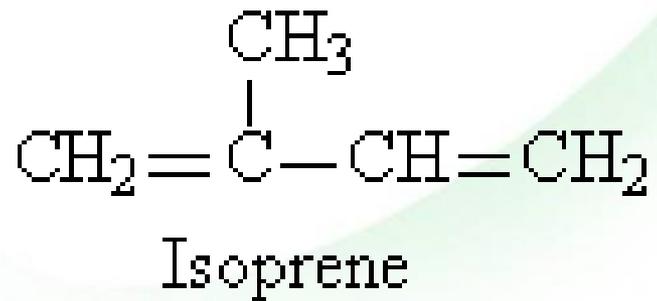


**As lipid content increases, the density decreases**

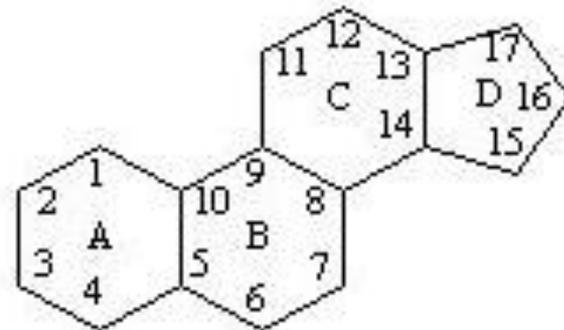
# Steroids



## The precursor

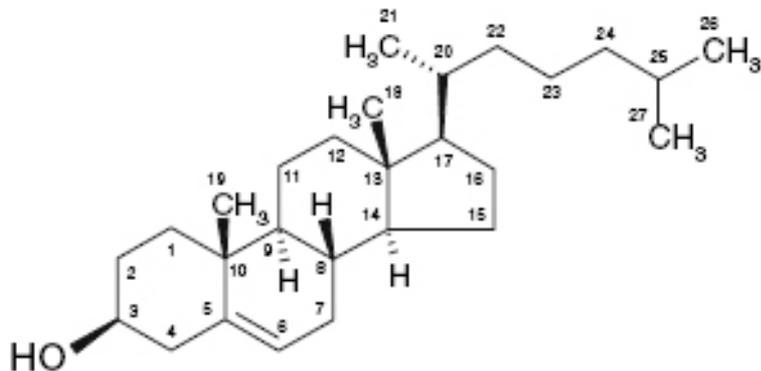


## The nucleus



Steroid nucleus

## The most common steroid



# Products of cholesterol



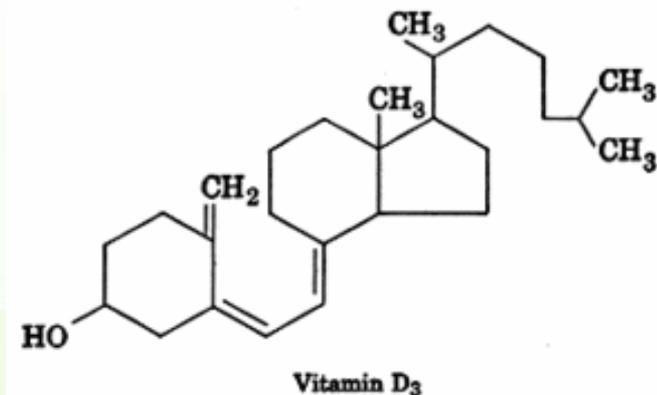
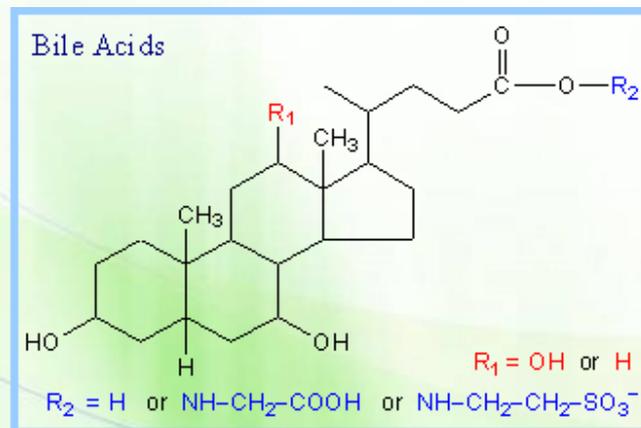
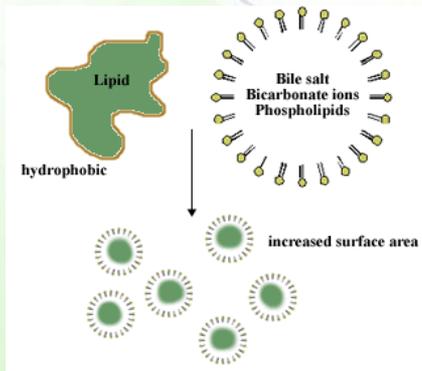
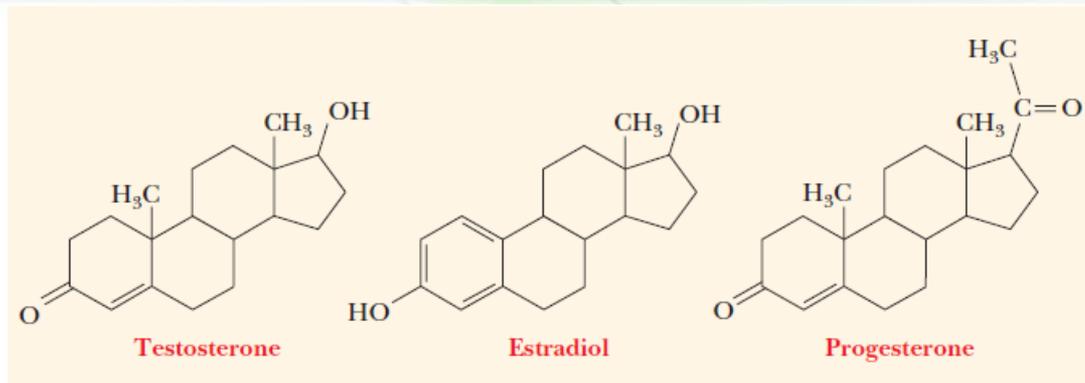
- **Hormones**

- sex hormones (androgens, estrogens, progestins)

- **Some vitamins such as vitamin D**

- Vitamins A, D, E, and K are made from isoprenoids

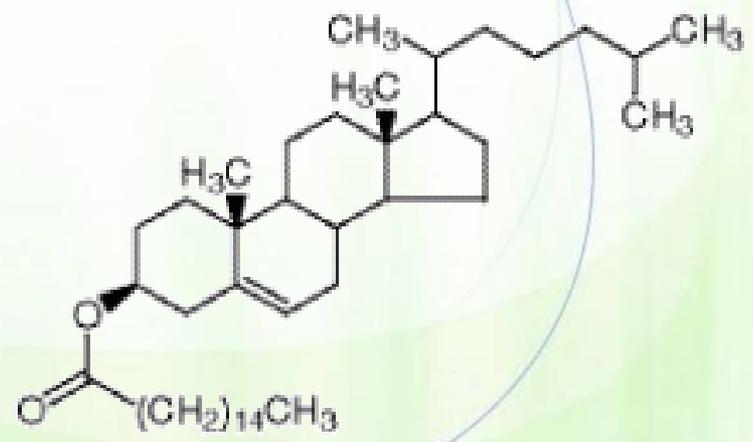
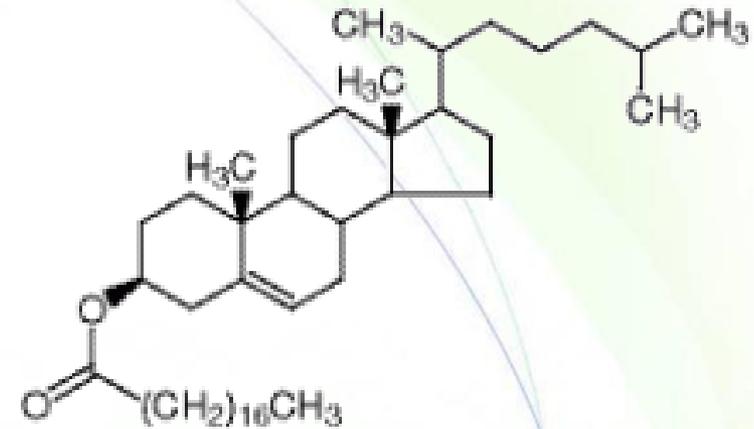
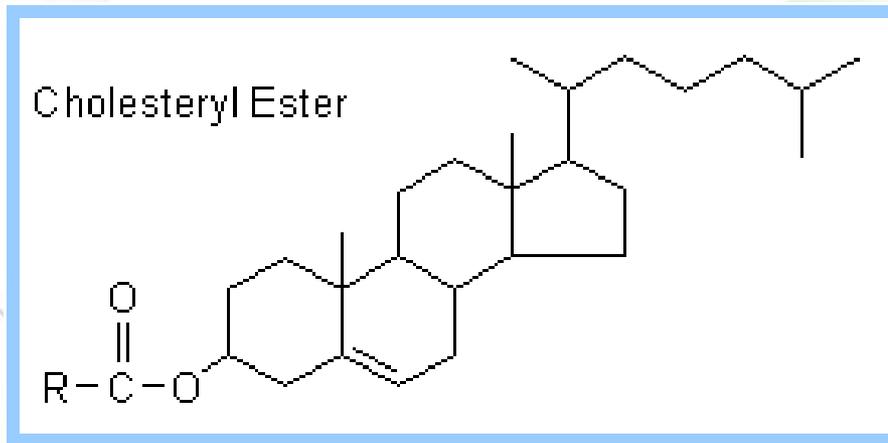
- **Bile acids (intestinal absorption of fat)**



# Cholesterol esters



- A cholesterol with a fatty acid attached at (-OH) of C3

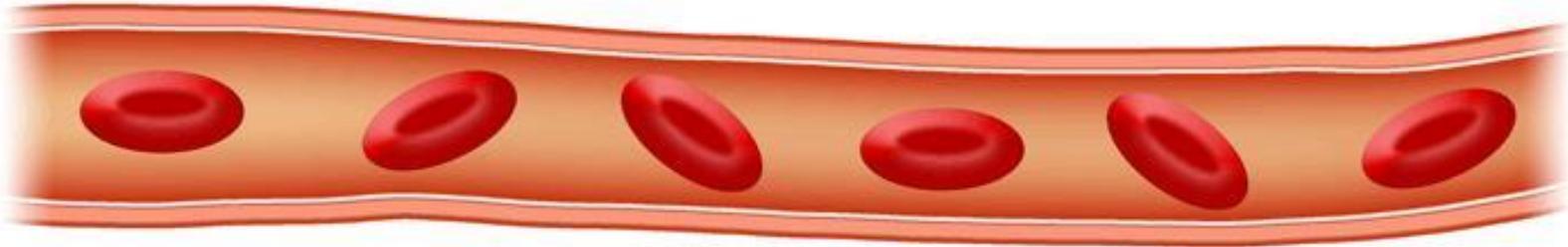


**Name the molecules?**

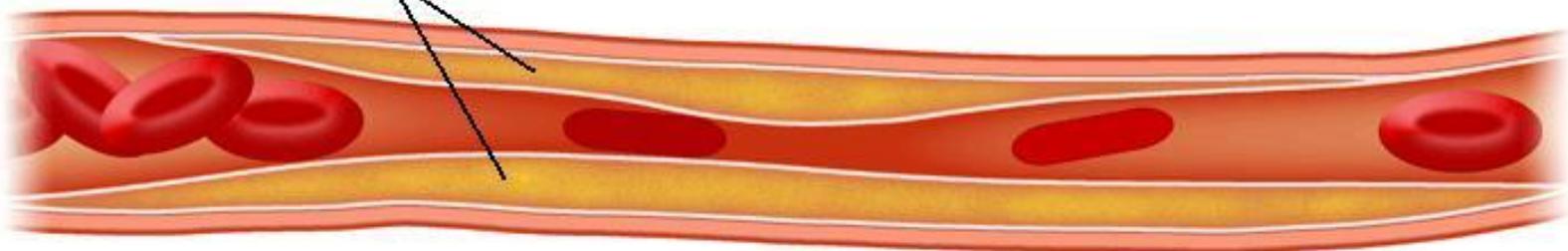
# Atherosclerosis



**Normal Coronary Artery with Normal blood flow**



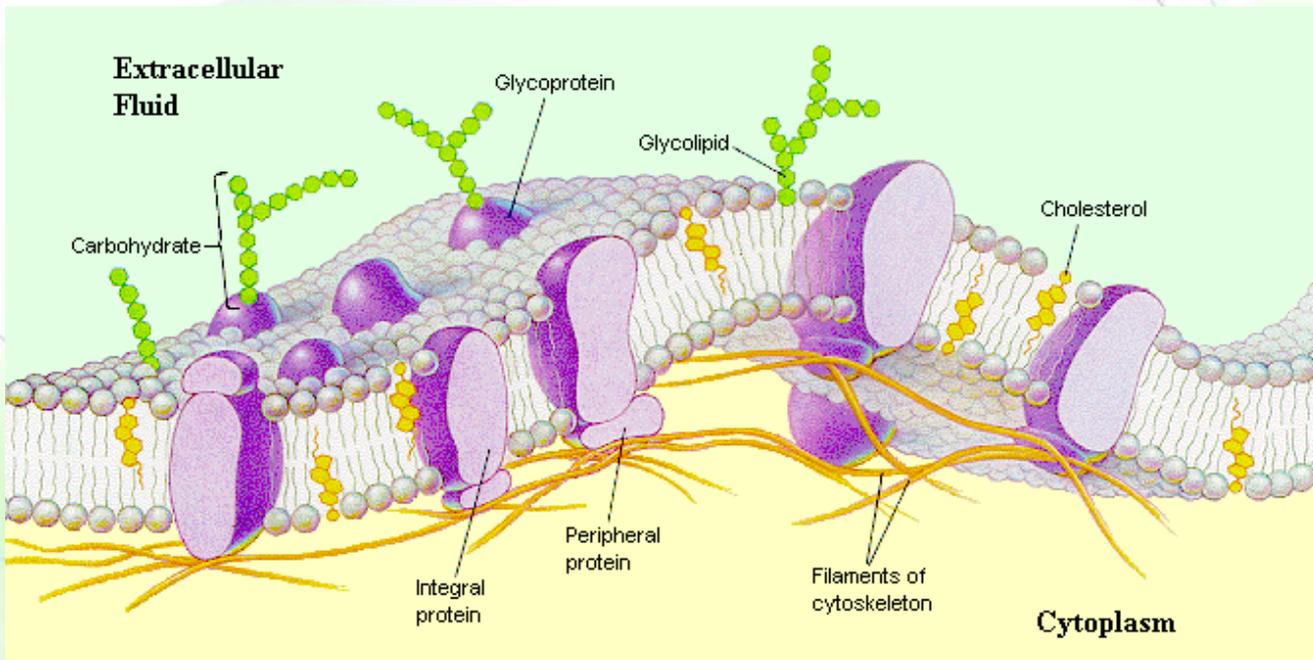
**Cholesterol Deposition in Coronary Artery with Impaired blood flow**



# Cell membranes



- The membrane is hypothesized in a model known as the fluid mosaic model.
- Components: 45% lipid, 45% protein and 10% carbohydrate
- They exist side by side without forming some other substance of intermediate nature.



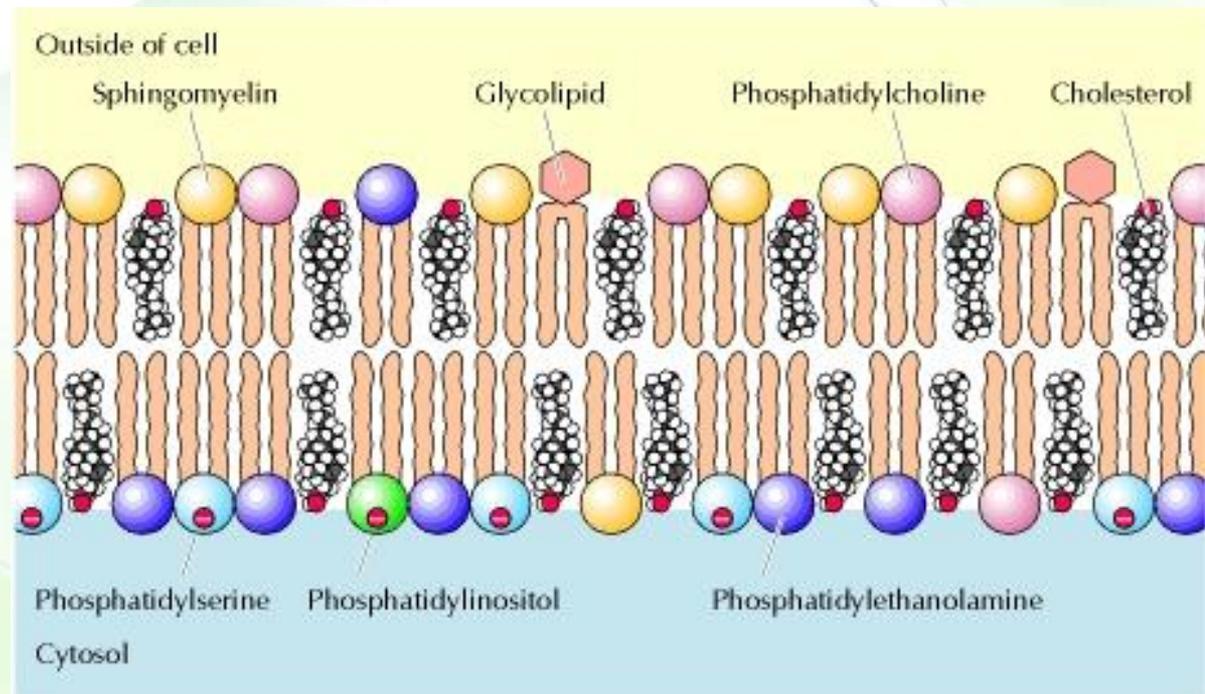
# Phospholipids



- The outer: phosphatidylcholine, sphingomyelin, and glycolipids (cell recognition)
- The inner: phosphatidylethanolamine, phosphatidylserine, and phosphatidylinositol (signaling)

**Cholesterol is distributed in both leaflets**

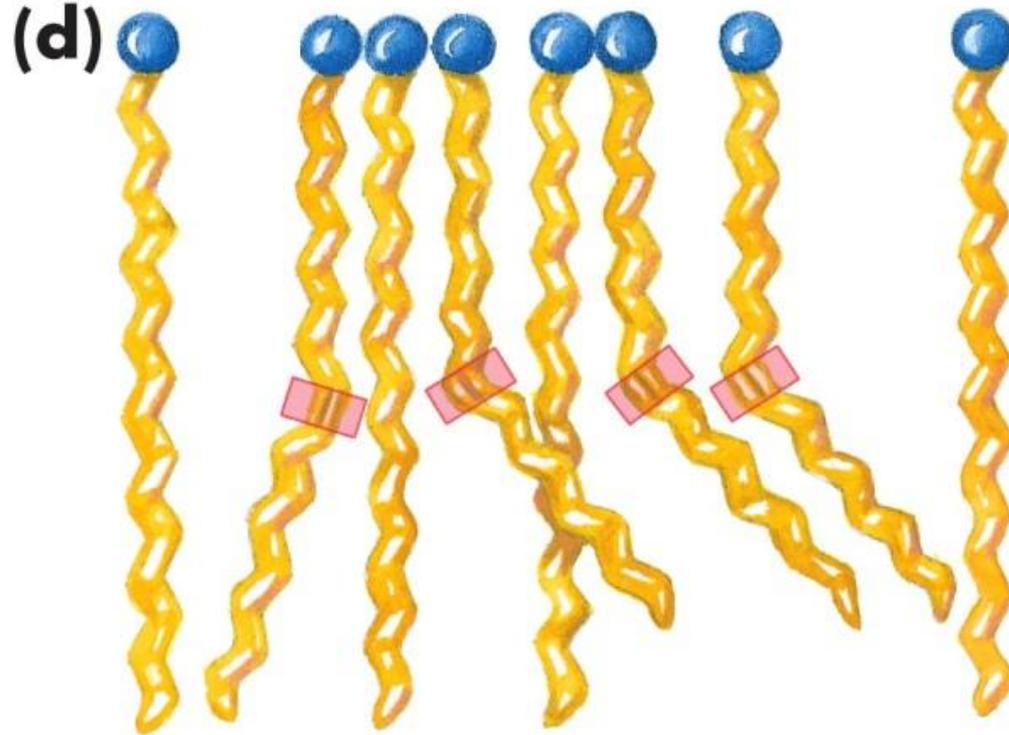
**Animal cells vs. plant cells vs. prokaryotic cells**



# Fatty acids and membrane fluidity

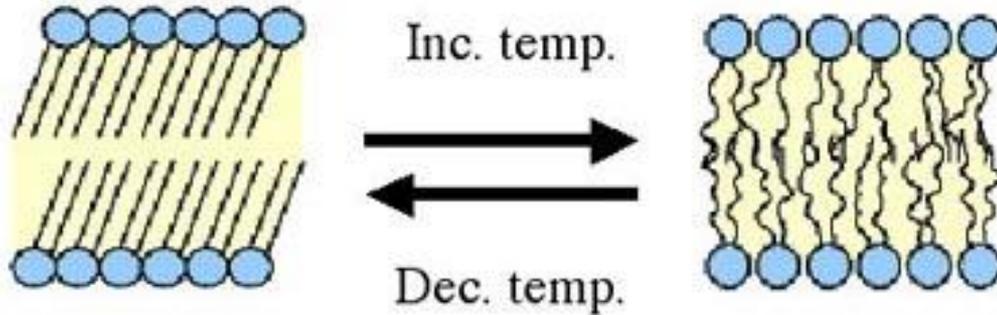


**Saturated  
fatty acids**



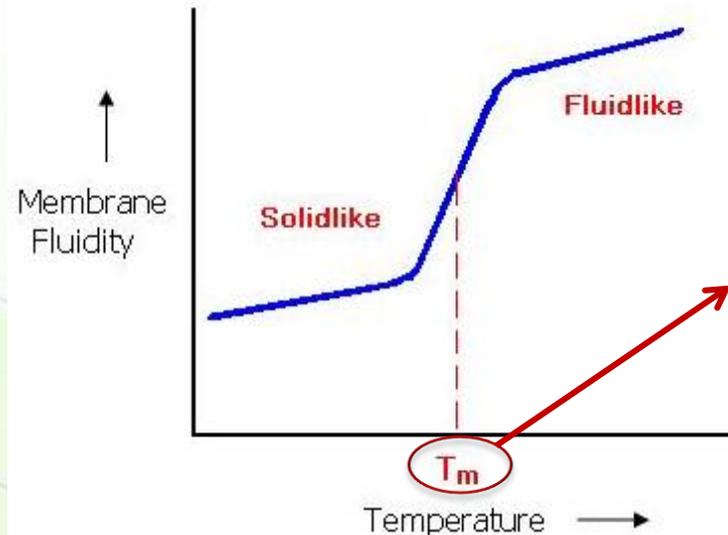
**Mixture of saturated and  
unsaturated fatty acids**

# Membrane fluidity and temperature



Very regular,  
Ordered structure

Less tightly packed,  
Hydrocarbon tails  
Disordered.



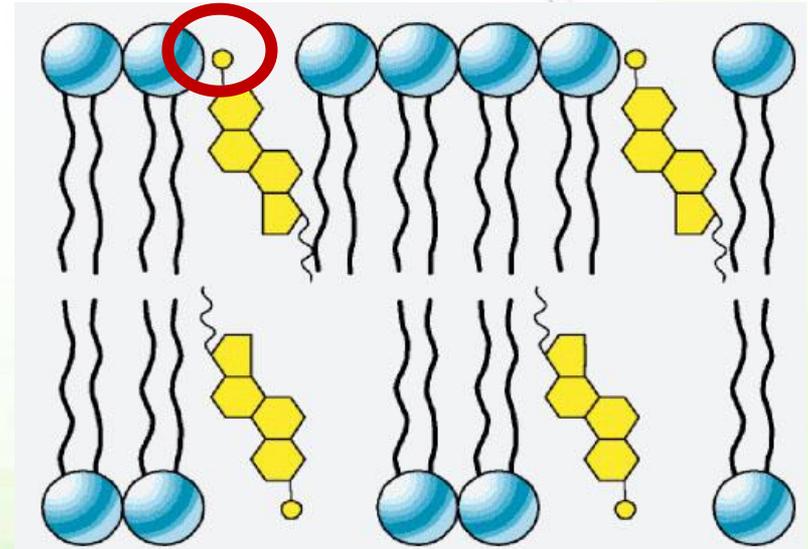
**Melting temperature  
(transition temperature)**

# Cholesterol and membrane fluidity

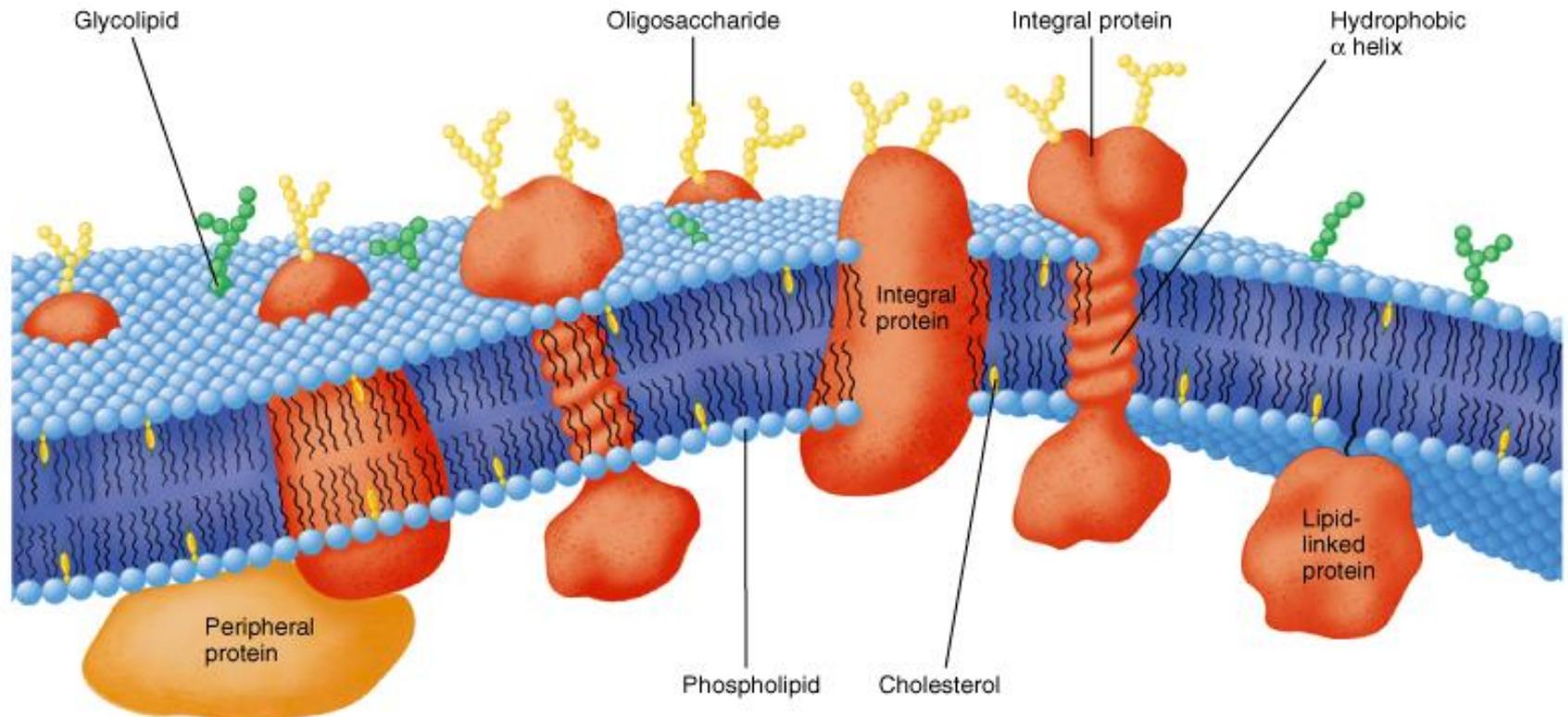


- The presence of cholesterol stabilizes the extended straight-chain arrangement of saturated fatty acids by van der Waals interactions.
- Cholesterol makes a membrane less solid at low temperatures and more solid at high temperatures.

- **It decreases the mobility of hydrocarbon tails of phospholipids.**
- **It interferes with close packing of fatty acid tails in the crystal state.**



# Membrane proteins



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# Types of membrane proteins

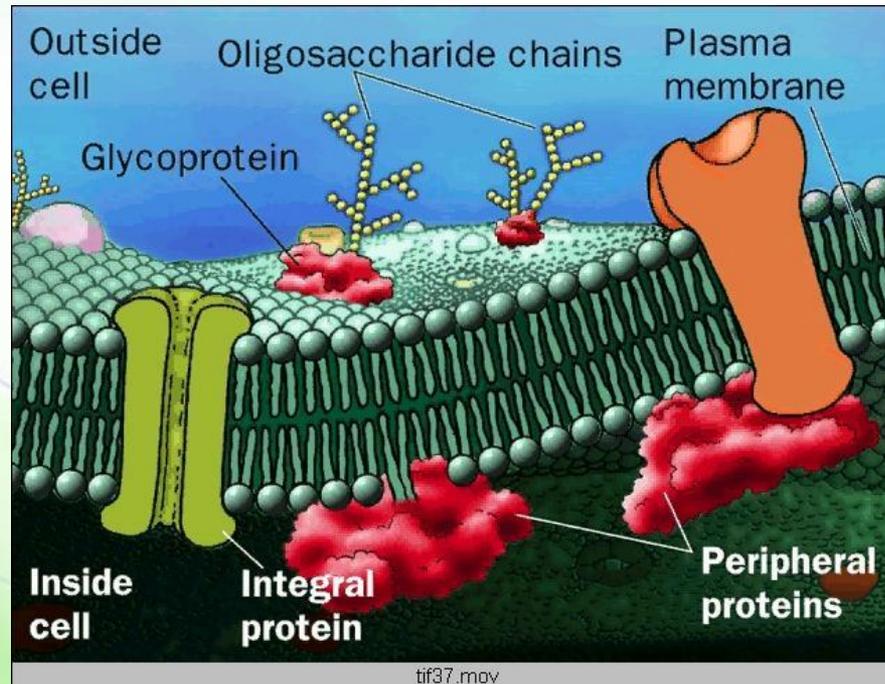


- **Peripheral proteins:**
  - are associated with the exterior of membranes via noncovalent interactions
- **Integral membrane proteins:**
  - anchored into membrane via hydrophobic regions
- **Lipid-anchored:**
  - associated via a lipid group

# Peripheral membrane proteins



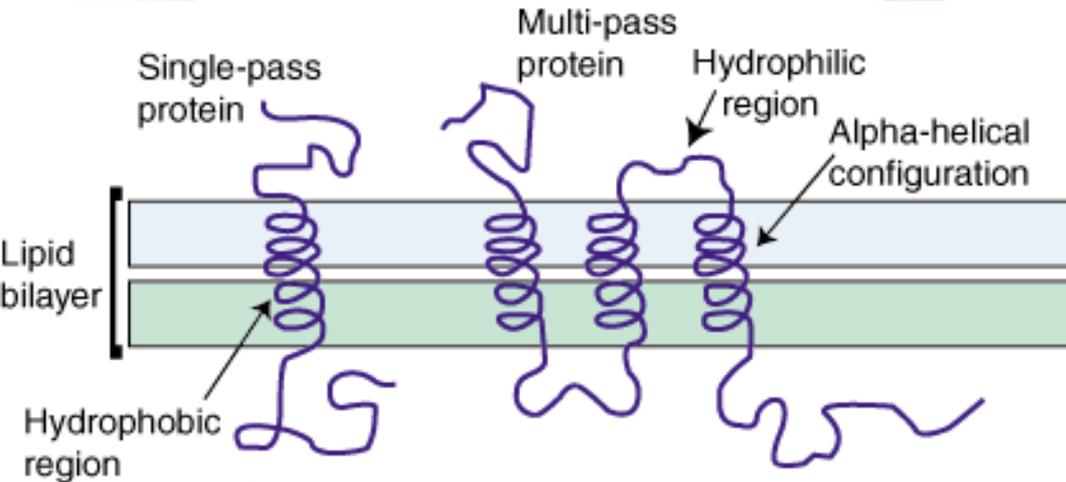
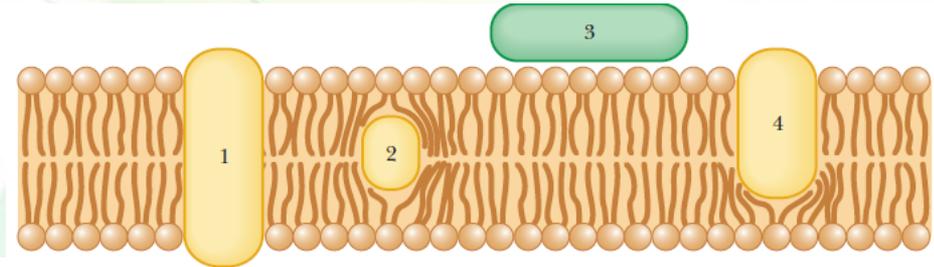
- They are associated with membranes but do not penetrate the hydrophobic core of the membrane
  - often associated with integral membrane proteins
- They are not strongly bound to the membrane and can be removed without disrupting the membrane structure
  - treatment with mild detergent



# Integral membrane proteins



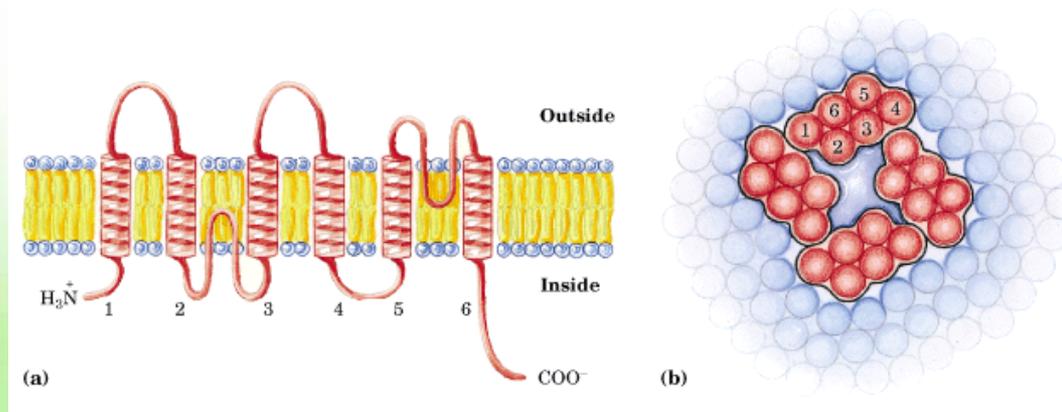
The integral proteins can be associated with the lipid bilayer in several ways.



The membrane integral domains are:

1. Single or multiple
2.  $\alpha$ -helix or  $\beta$ -sheet

Some can form channels.



# Structure-Function of Membranes



- **Transport:**
  - Membranes are impermeable barrier
  - Proteins can be carriers or channels
- **Signaling**
  - Protein receptors and small molecules (some can be lipids themselves)
- **Catalysis**
  - Enzyme-linked receptors