MEMBRANES AND RECEPTORS MODULE

SESSION 1: LIPIDS, PROTEINS AND MEMBRANE STRUCTURE

LECTURE: 1

DURATION: 1hr

THE MEMBRANE BILAYER

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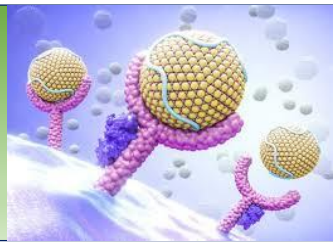
Bruce A, Dennis B, Karen H, Alexander J, Julian L, Martin R, Keith R. ESSENTIAL CELL BIOLOGY, FOURTH EDITION, 2014.
Victor W r, Peter J k, David A B, Anthony W. Harpers Illustrated Biochemistry, thirty- first Edition, 2018.



AIM of the Session

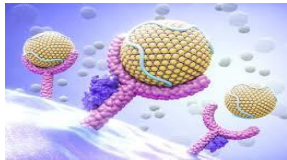
To introduce the structure and dynamics of biological membranes.

LEARNING OUTCOMES:

By this lecture you should be able to:

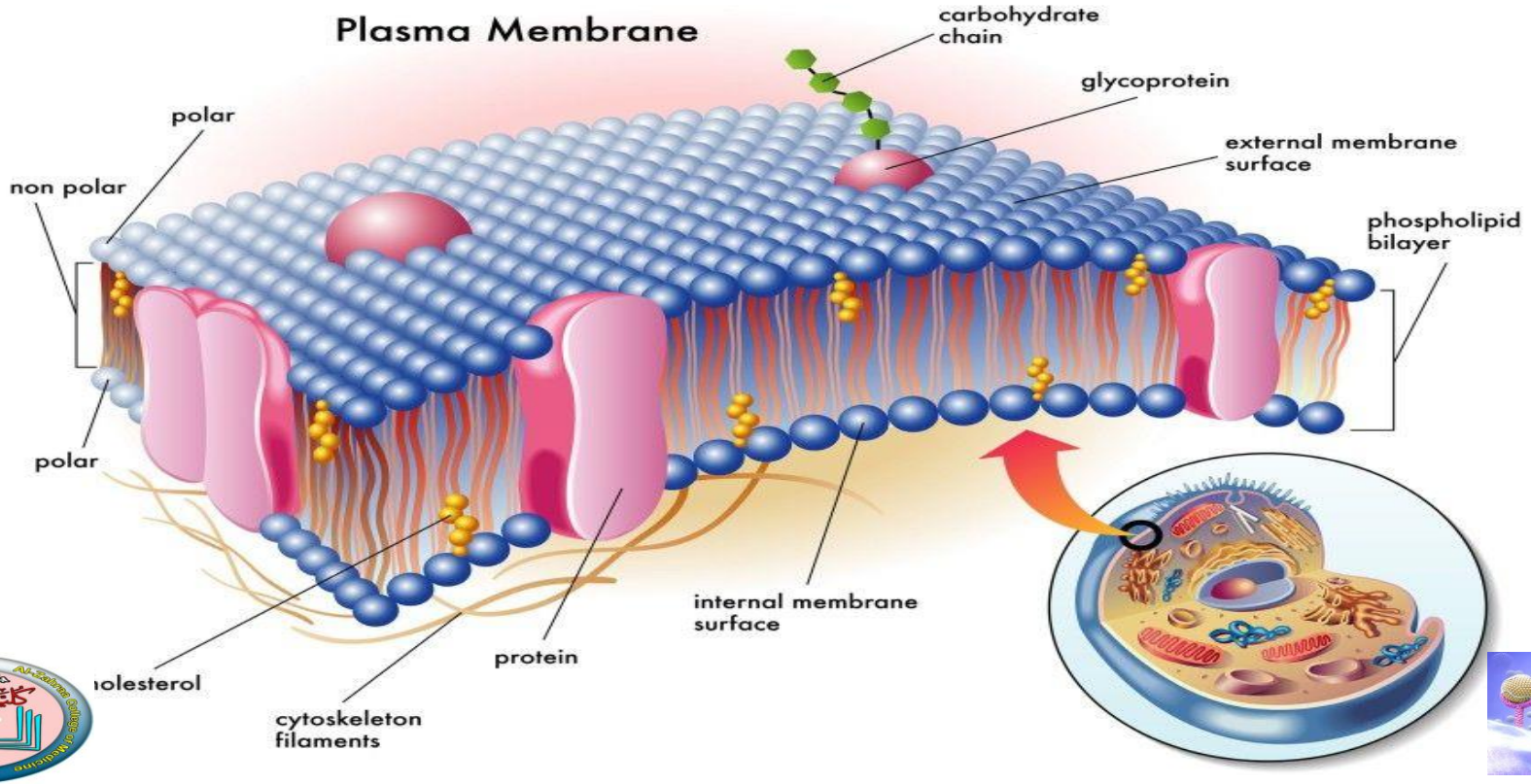
- List the main kinds of lipids and general properties of fatty acids. Describe the properties of amphipathic molecules and explain the process of formation of lipid bilayers. **(LO 1)**
- Distinguish peripheral from integral membrane proteins and explain the forces associating them with the membrane.

  (LO 2)



The cell membrane (plasma membrane): (LO. 1)

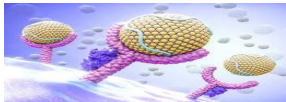
Is a biological membrane separating the interior of a cell from the outside environment.

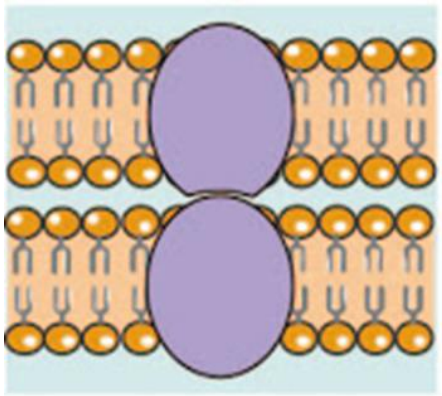


General functions of biological membranes (cells and organelles) (LO.1)

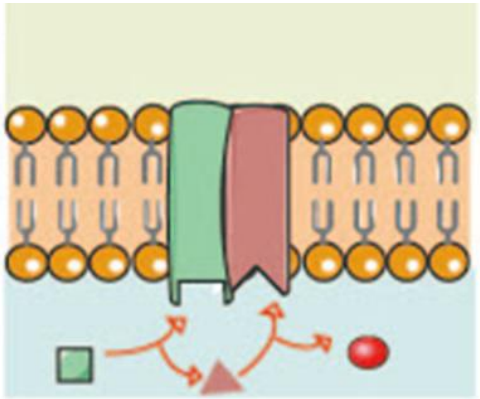
Continuous highly selective permeability barrier.

1. Allows control of the enclosed chemical environment.
2. Communication control the flow of information between cells and their environment.
3. Recognition signaling molecules, adhesion proteins, immune surveillance.
4. Signal generation in response to stimuli (electrical, chemical).

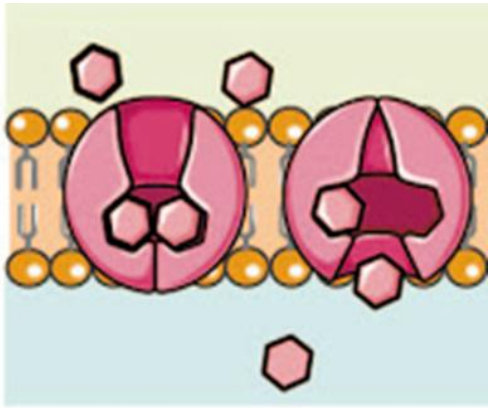




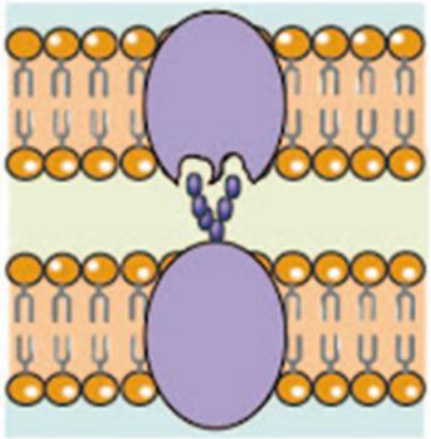
Intercellular Joinings



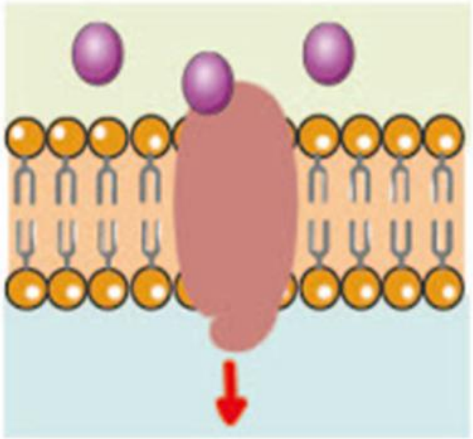
Enzymatic Activity



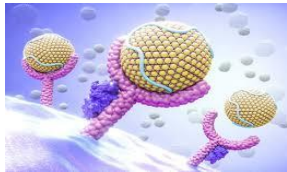
Transport



Cell-cell Recognization



Signal Transduction



Different membranes have specialized functions:

(LO.1)

Plasma membrane

all of the above functions

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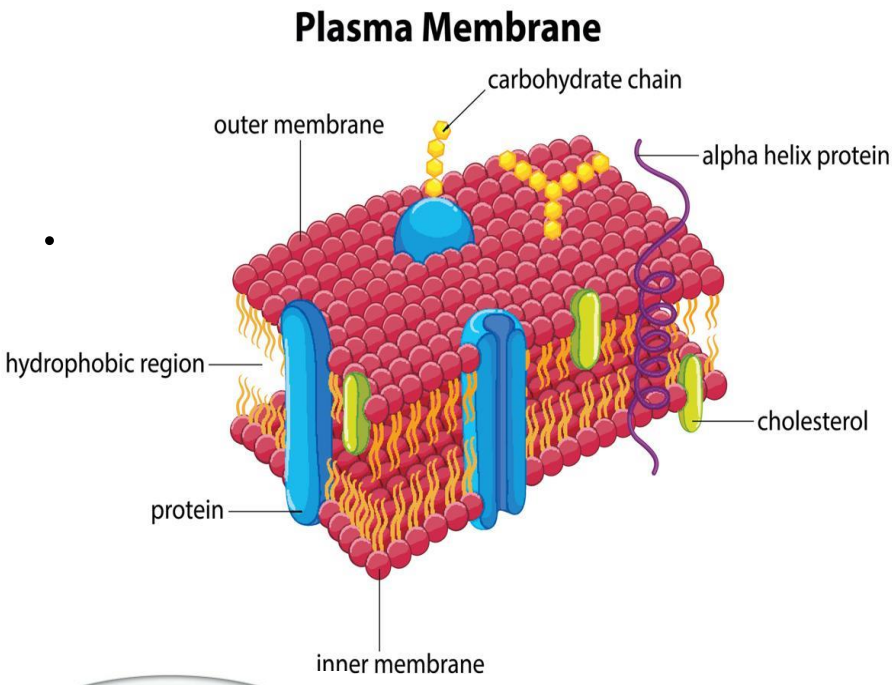
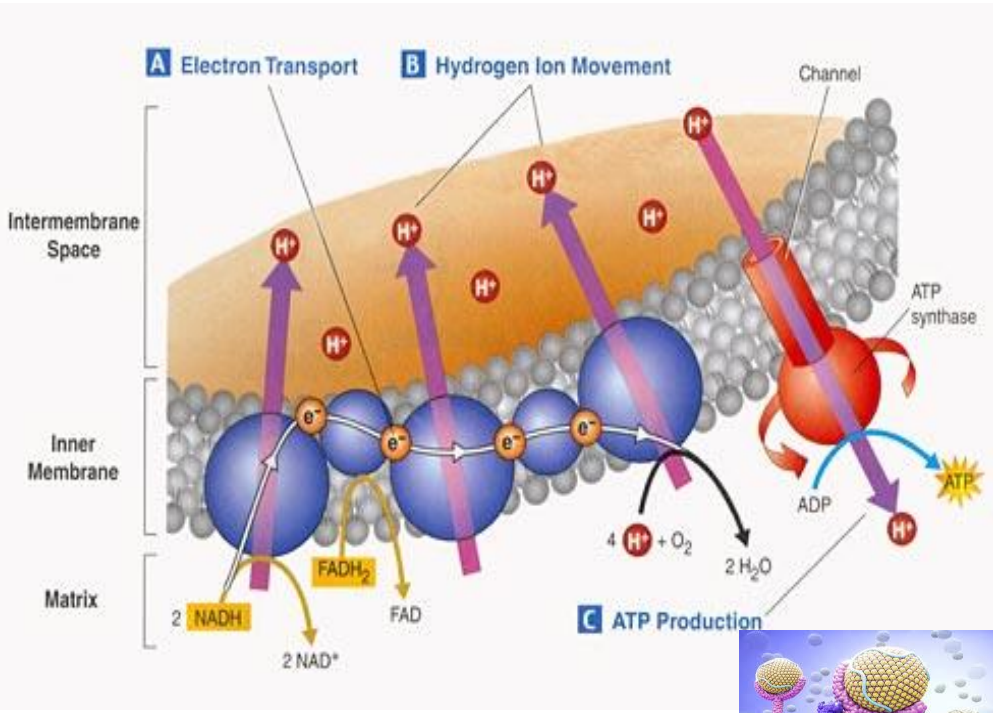


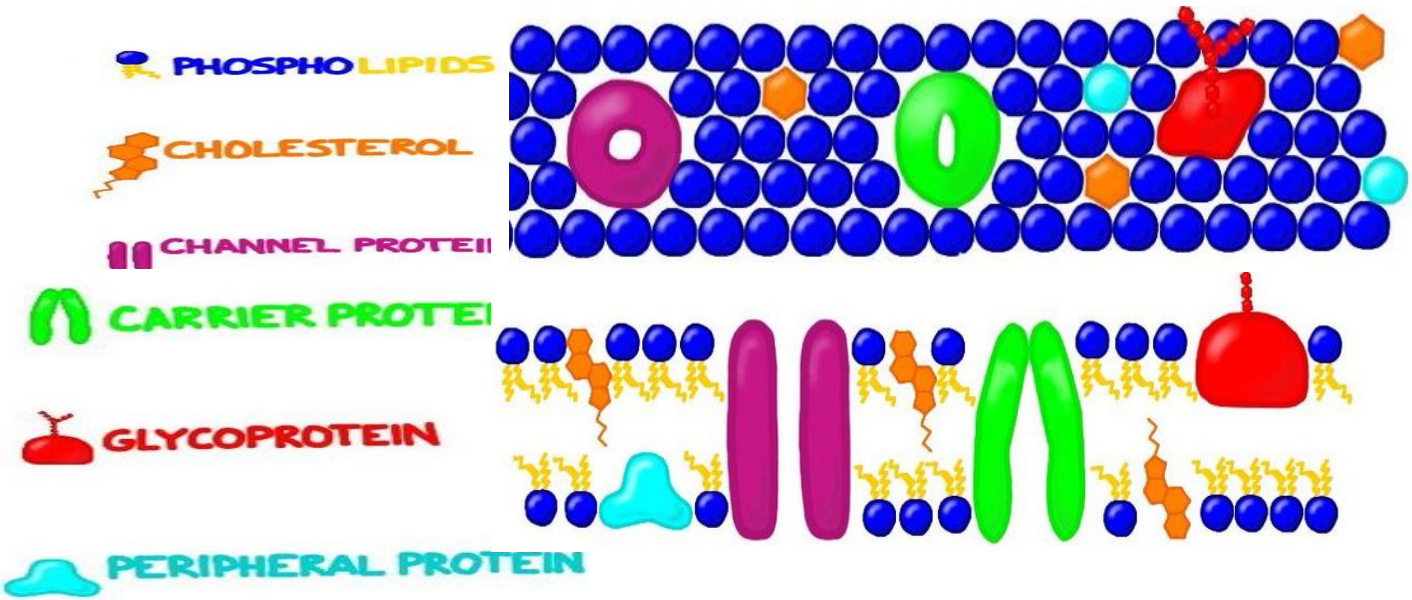
Mitochondrial membrane

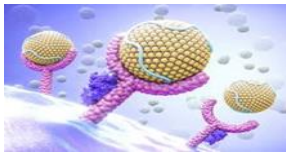
energy conservation by oxidative phosphorylation.



Fluid mosaic model (LO.1)

The fluid mosaic model describes the cell membrane as a tapestry of several molecules (**phospholipids**, **cholesterols**, and **proteins**) that are constantly moving.



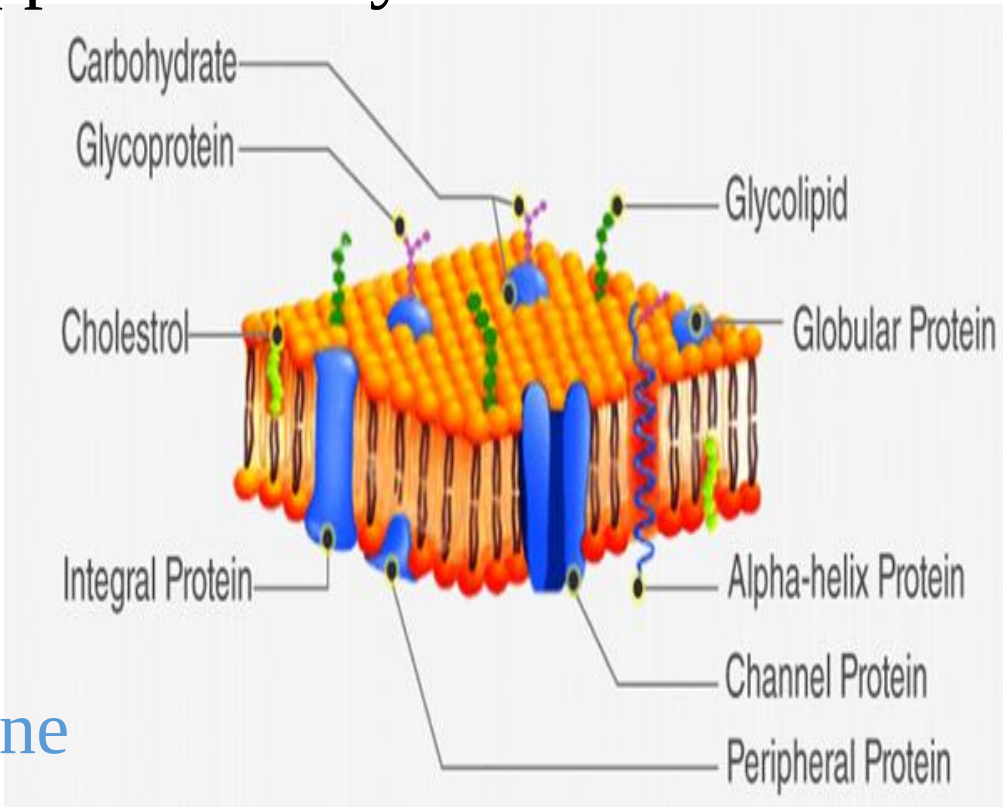


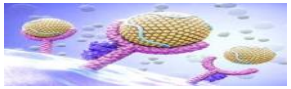
Membrane Composition: (LO .1)

The membranes contain approximately:

1. **40% lipid**
2. **60% protein**
3. **1-10% carbohydrate.**

The membrane bilayer is a hydrated structure and hence 20 % of total membrane weight is water.





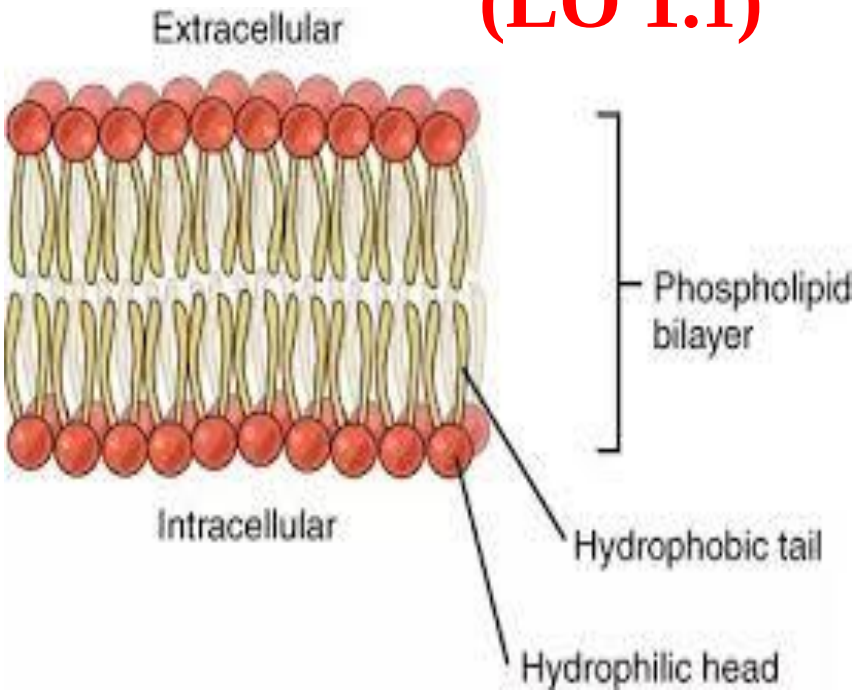
1. Membrane lipids (LO 1.1)

- **Amphipathic molecules:**

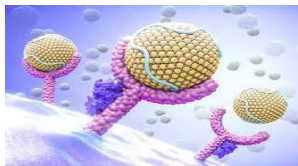
  they contain both

  hydrophilic and **hydrophobic**

  moieties.



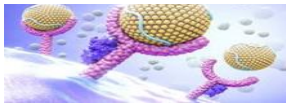
- **Distribution of different lipids is tissue specific and related to function.**



Membrane Lipids

(LO.1)

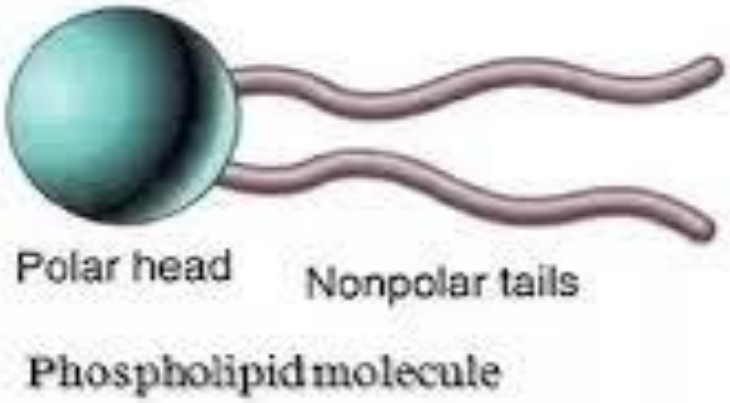
- Phospholipids
  - Phospho-glycerides
    - Phosphatidylcholine (lecithin)
    - Phosphatidyle-thanolamine (cephalin)
    - Phosphatidylserine
    - Phosphatidylthreonine
    - Phosphatidylglycerol
    - Phosphatidylinositol
    - Diphosphatidyl glycerol (cardiolipin)
  - Sphingo-phospholipids
    - Sphingomyelin
- Glycolipids
  - Cerebrosides
  - Sulfatides
  - Gangliosides
- Steroids
  - Cholesterol
  - Stigmasterol

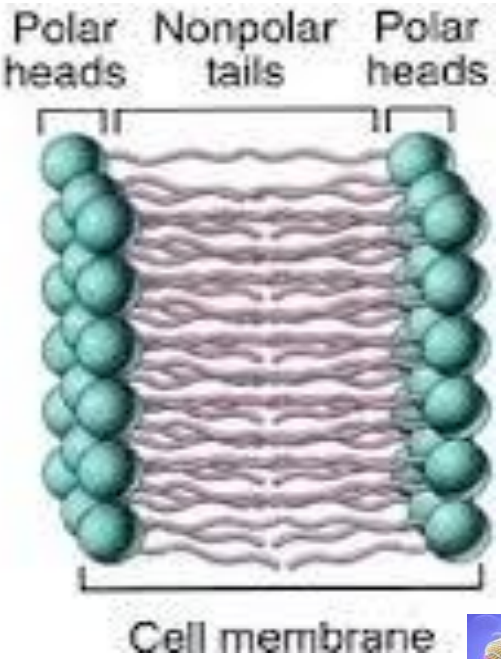


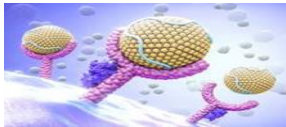
Three kinds of membrane lipids

A. Phospholipids: (LO.1)

A class of lipids whose molecule has a hydrophilic "head" containing a phosphate group, and two hydrophobic "tails" derived from fatty acids, joined by an alcohol residue.







Phospholipids components

(LO.1)

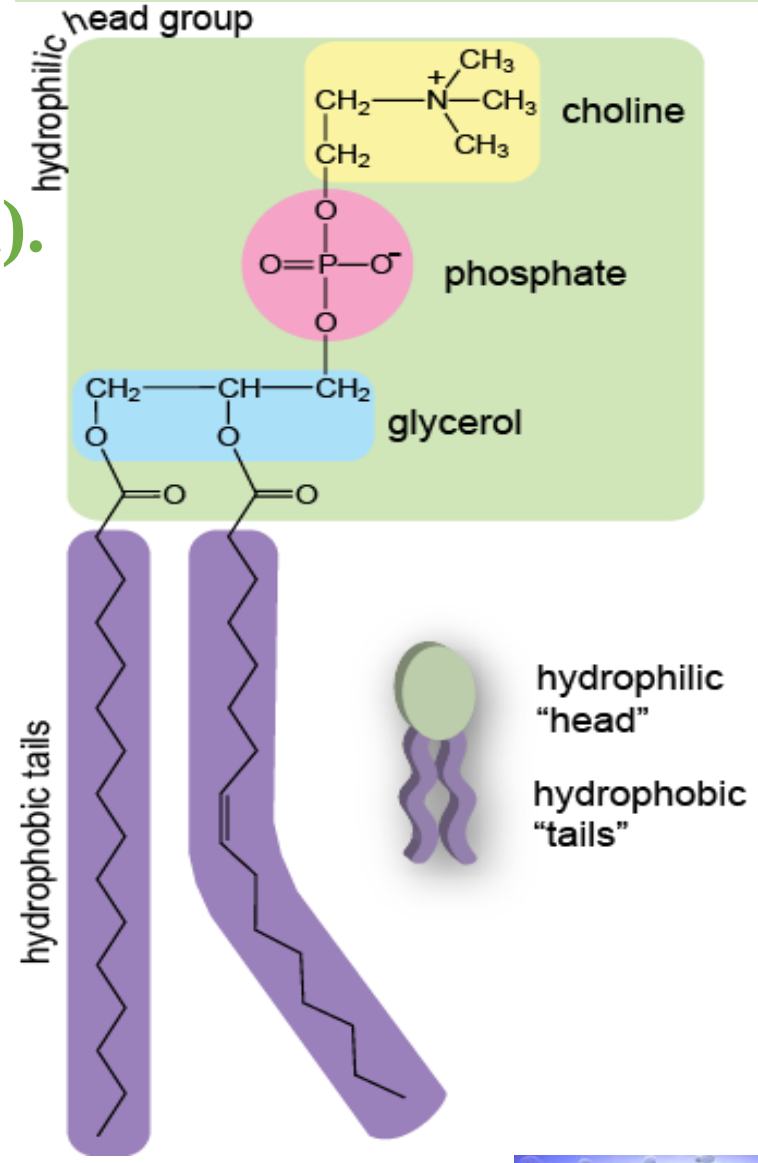
1. Glycerol backbone (C-3 carbon).

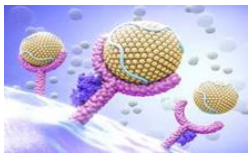
2. Phosphoric acid group.

3. Head groups:

a range of polar (charged) head groups are employed

- **Choline.**
- **Amines.**
- **Amino acids.**
- **Sugars.**



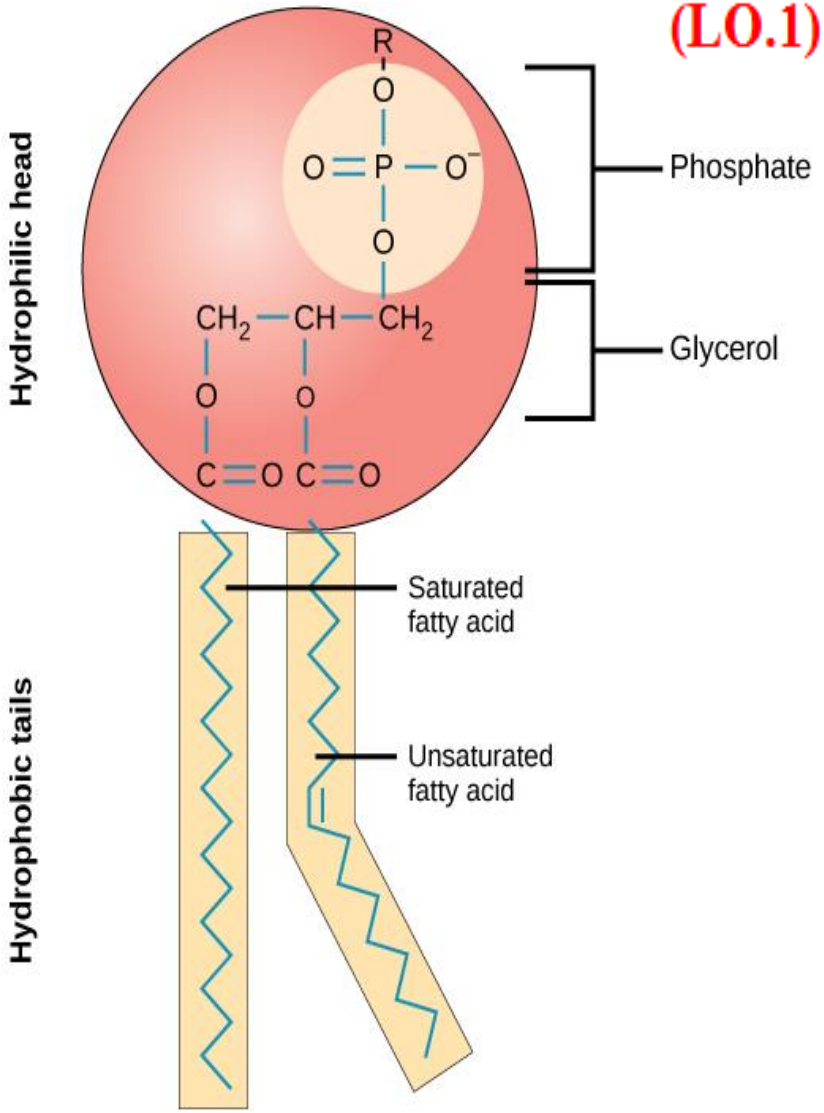


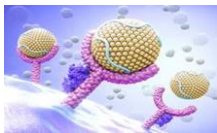
4. Fatty acid chains.

(LO.1)

1. Saturated fatty acid
   - Single bond.
   - Enormous variety, C16 and C18 most prevalent
2. Unsaturated fatty acid
   - double bonds.
   - In cis conformation.
   - Introduce a kink in the chain which reduces phospholipid packing

   (Double bonds increase fluidity).





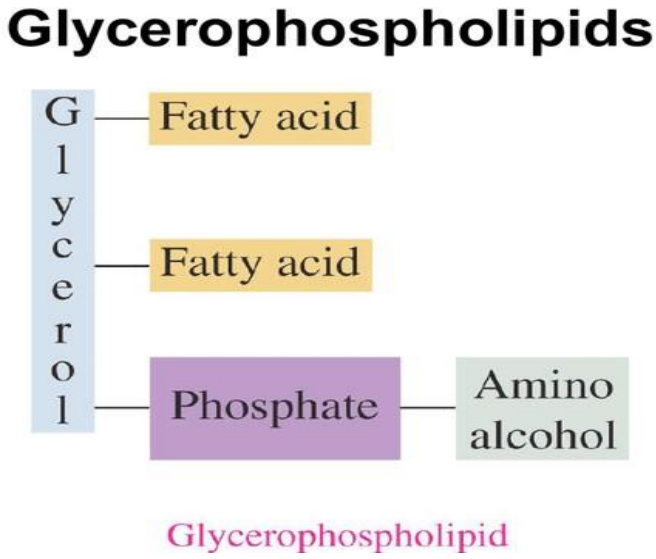
Structural classification of phospholipids: (LO.1)

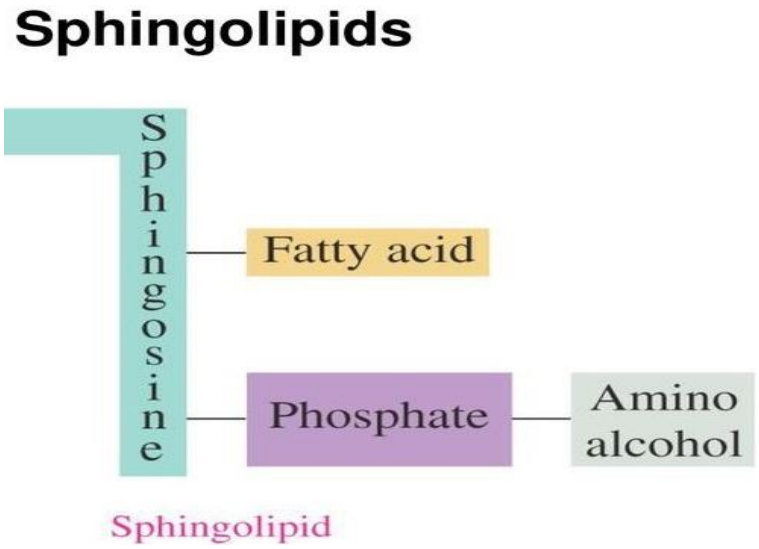
Glycerophospholipids

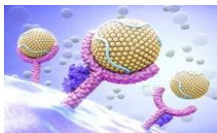
with glycerol backbone

Sphingolipids

with sphingosine backbone

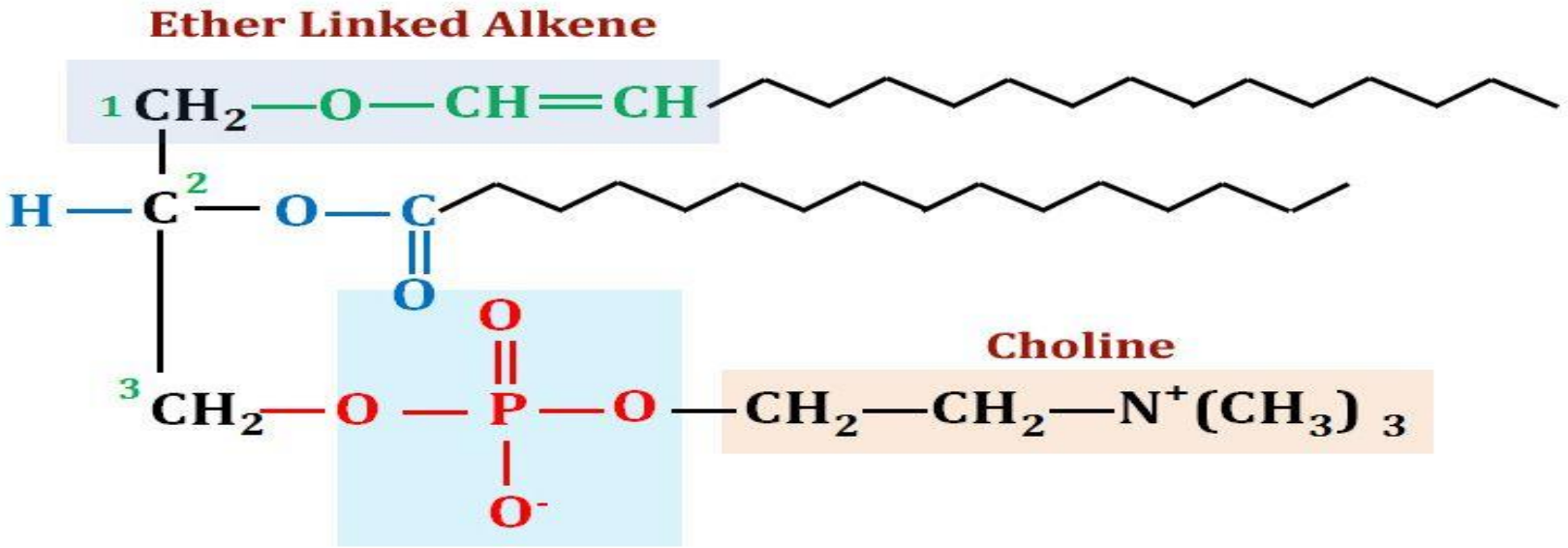




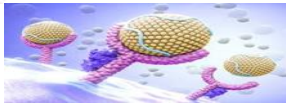


Plasmalogen: (L0.1)

Is a subclass of **Glycerophospholipids** which contain ether phospholipids that are commonly found in cell membranes in the nervous, immune and cardiovascular systems.



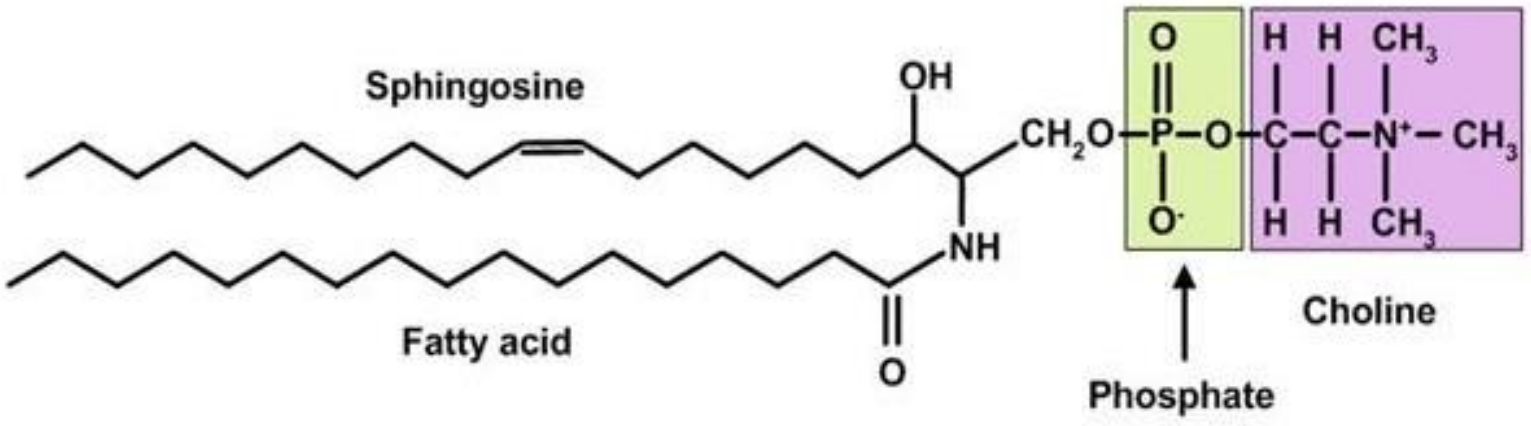
Plasmalogen



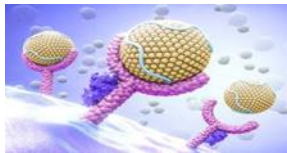
(LO.1)

Sphengomyelin:

- is a type of Sphingolipid.
- the backbone is sphingosine (amino alcohol).
- Its an important component of myelin of nerve fibers.
- Its the only phospholipid not based on glycerol.

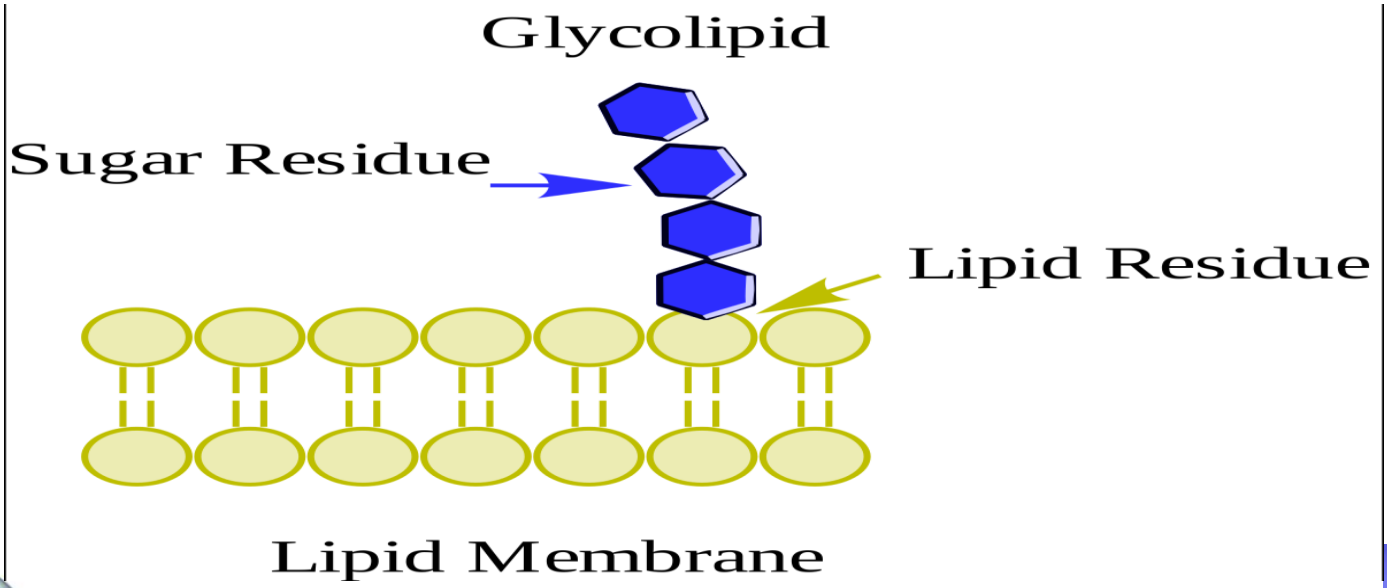


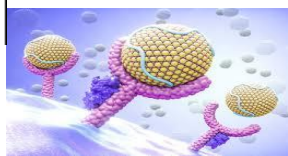
Sphingolipids: Sphingomyelin



B. Glycolipids (LO.1)

are components of cellular membranes comprised of a hydrophobic lipid tail and one or more hydrophilic sugar groups (glucose or galactose) linked by a glycosidic bond.





(LO.1)

Types of glycolipid:

I. Cerebrosides.

Head group sugar monomers

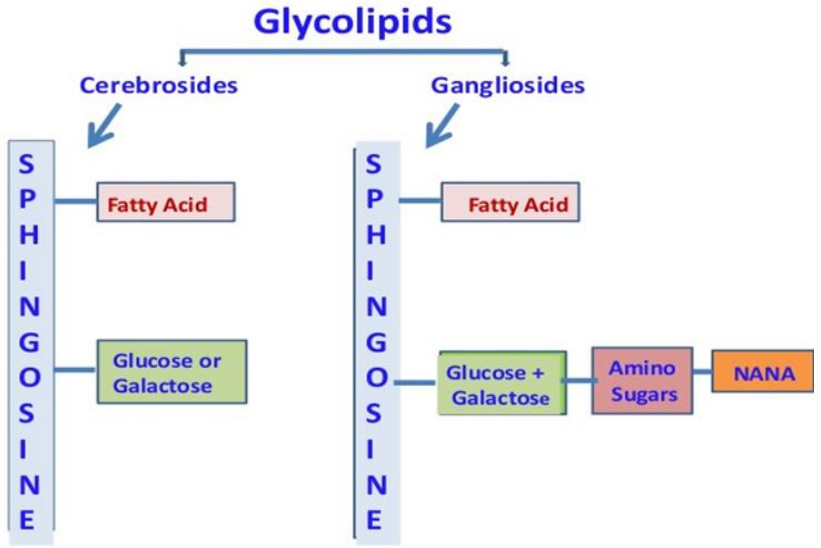
II. Gangliosides.

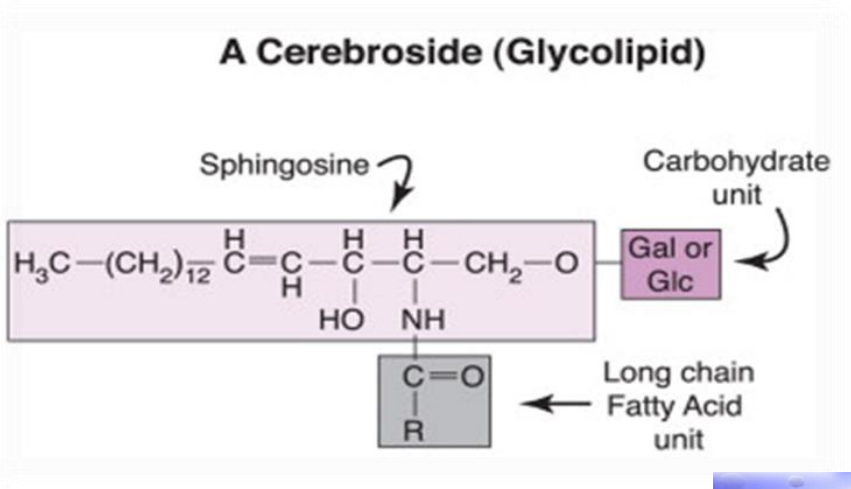
head group oligosaccharides

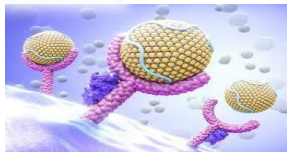
(sugar multimers)

e.g. n-acetylneuraminic acid

(NANA)

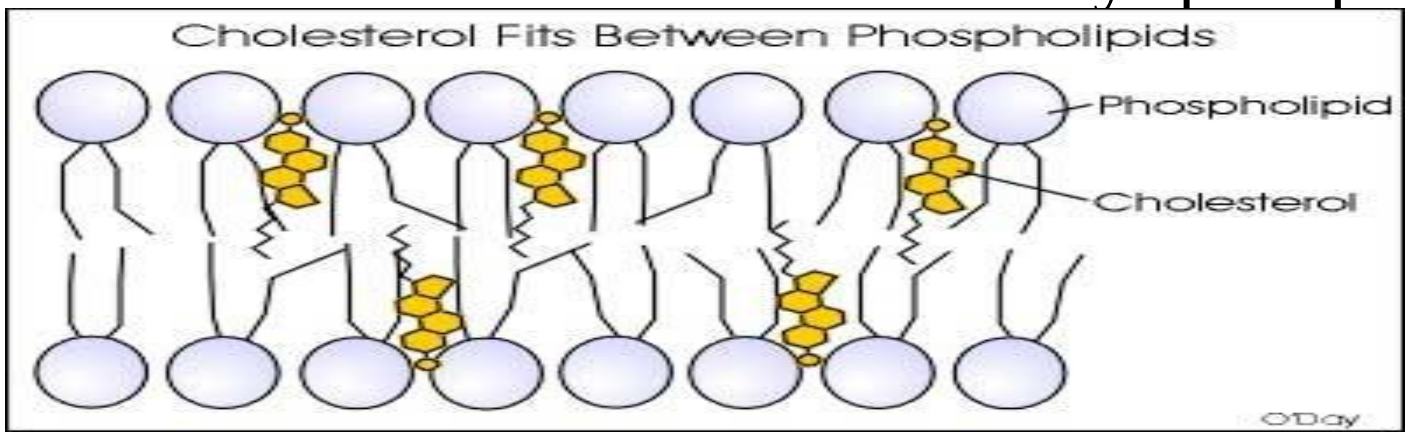


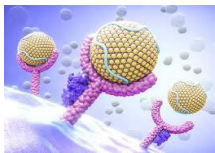




C. Sterol (Cholesterol). (LO.1)

- Represents 45% of the total membrane lipid.
- Cholesterol inserts into bilayers and disrupts the interactions :
  1. Reduce membrane fluidity and permeability.
  2. Increases the stability of the membrane. Without cholesterol the membrane would easy split apart.

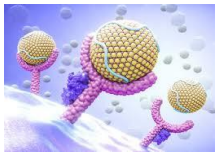




1-What are the importance of Cholesterol in the body other than in cell membrane

2- Is membrane cholesterol included in the estimation of serum cholesterol

?



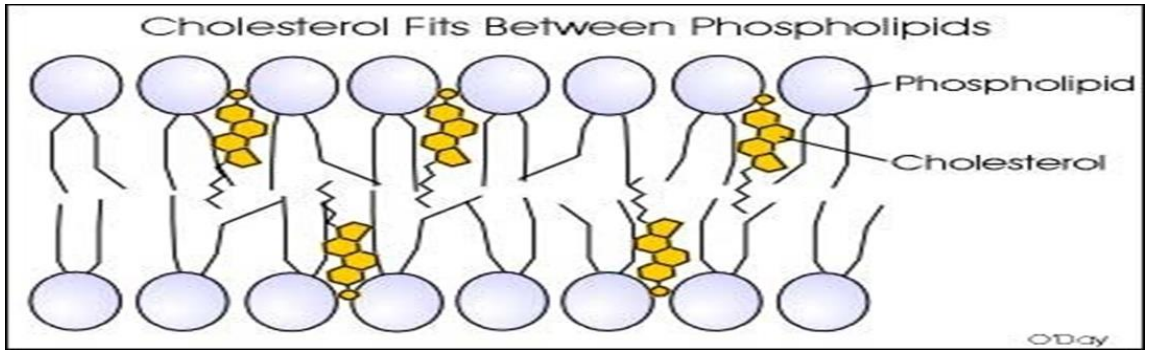
Regulation of Membrane Fluidity: (L0.1)

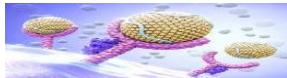
1. Temperature. **At higher temperatures**, lipid bilayers become more fluid and more permeable. **While at lower temperatures,** it becomes rigid.

Mechanism ?

2. Sterols (cholesterol) increases membrane packing to **reduce** membrane fluidity and permeability.

Mechanism ?

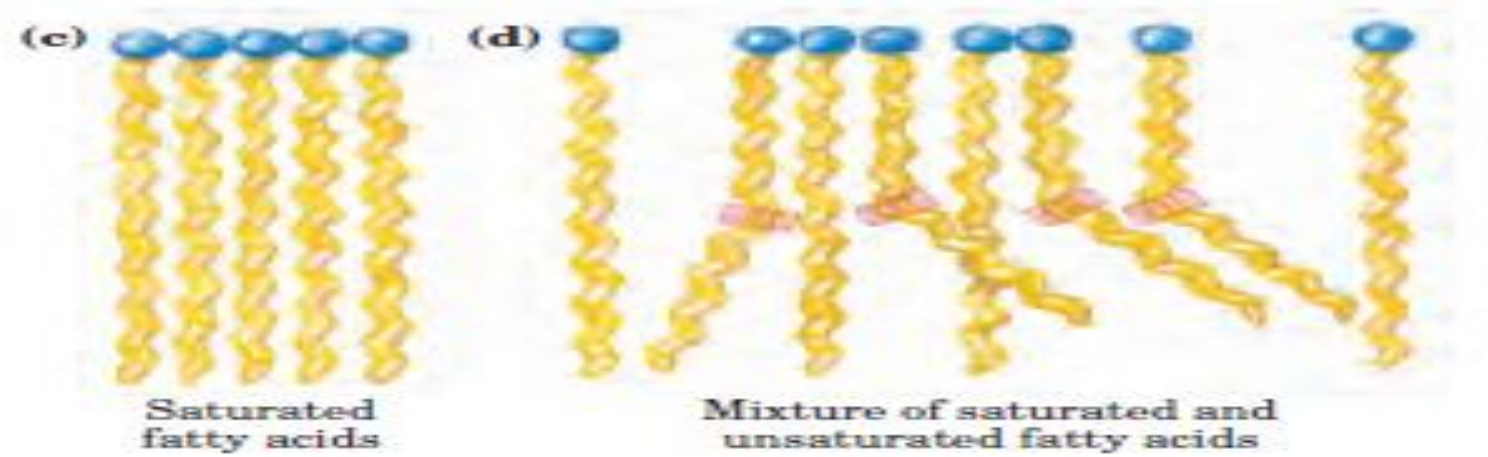




Regulation of Membrane Fluidity: (L0.1)

3. Fatty acids :

- longer fatty acids are more rigid, **reduce** membrane fluidity and permeability.
- *cis*-unsaturated fatty acids **increase** membrane fluidity and permeability by disrupting close packing of fatty acid tails.

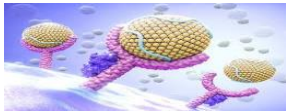


Lipid Bilayer (LO.1)

- Amphipathic molecules form one of two structures in water, **micelles** and **bilayers**.

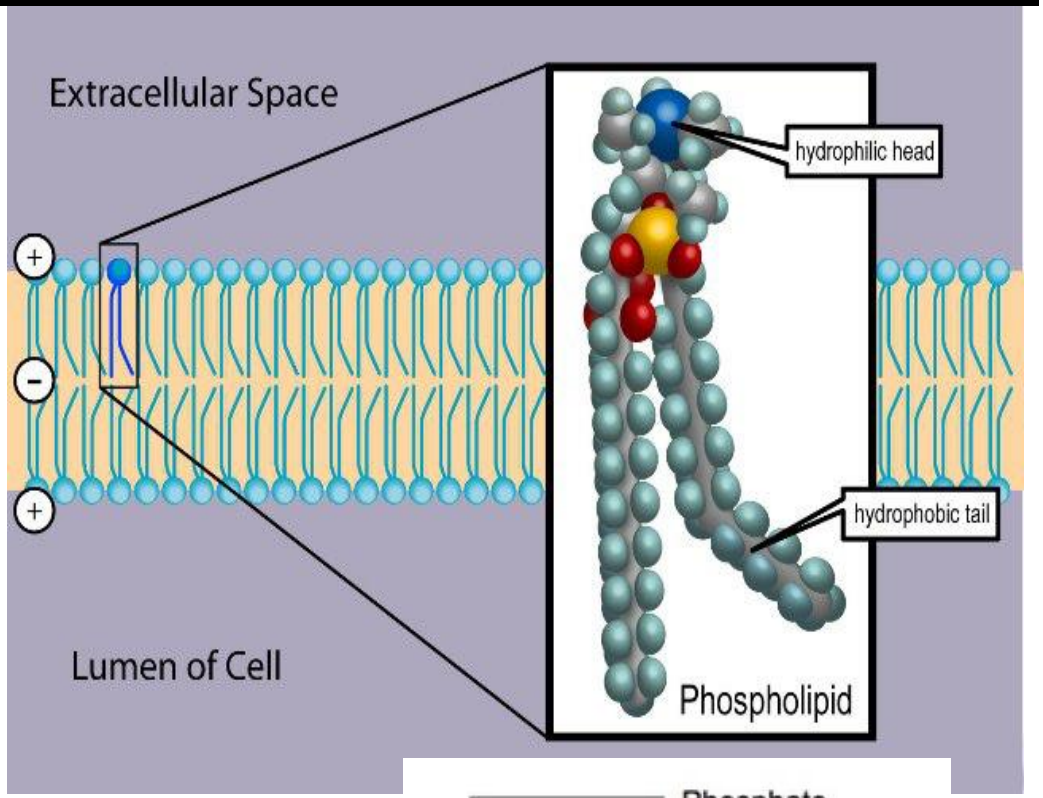
- Bilayer formation is spontaneous in water driven by the **Van der Walls** attractive forces between the hydrophobic tails.

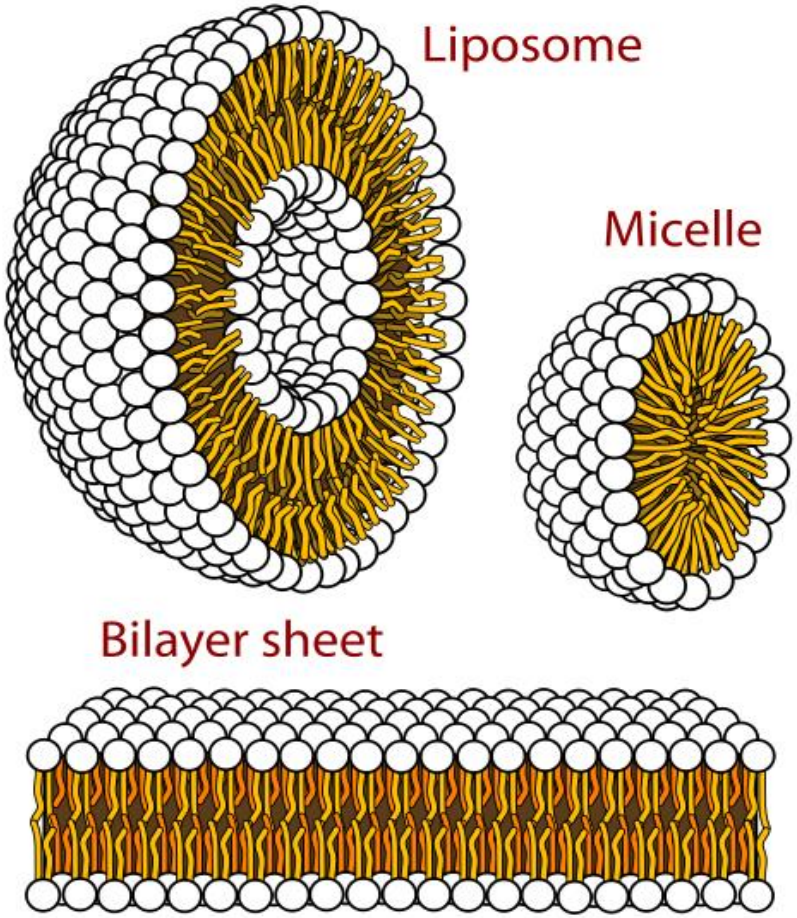
- The co-operative structure is stabilized by **non-covalent forces**; **electrostatic** and **hydrogen bonding** between hydrophilic moieties and interactions between hydrophilic groups and water.

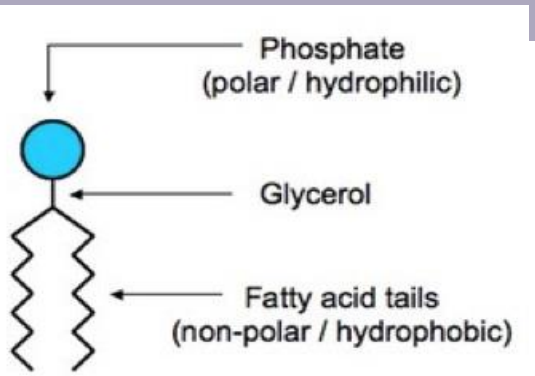


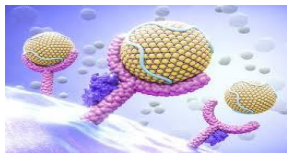
Phospholipids form bilayers in water due to the amphipathic properties of phospholipid molecules.

(L0.1)



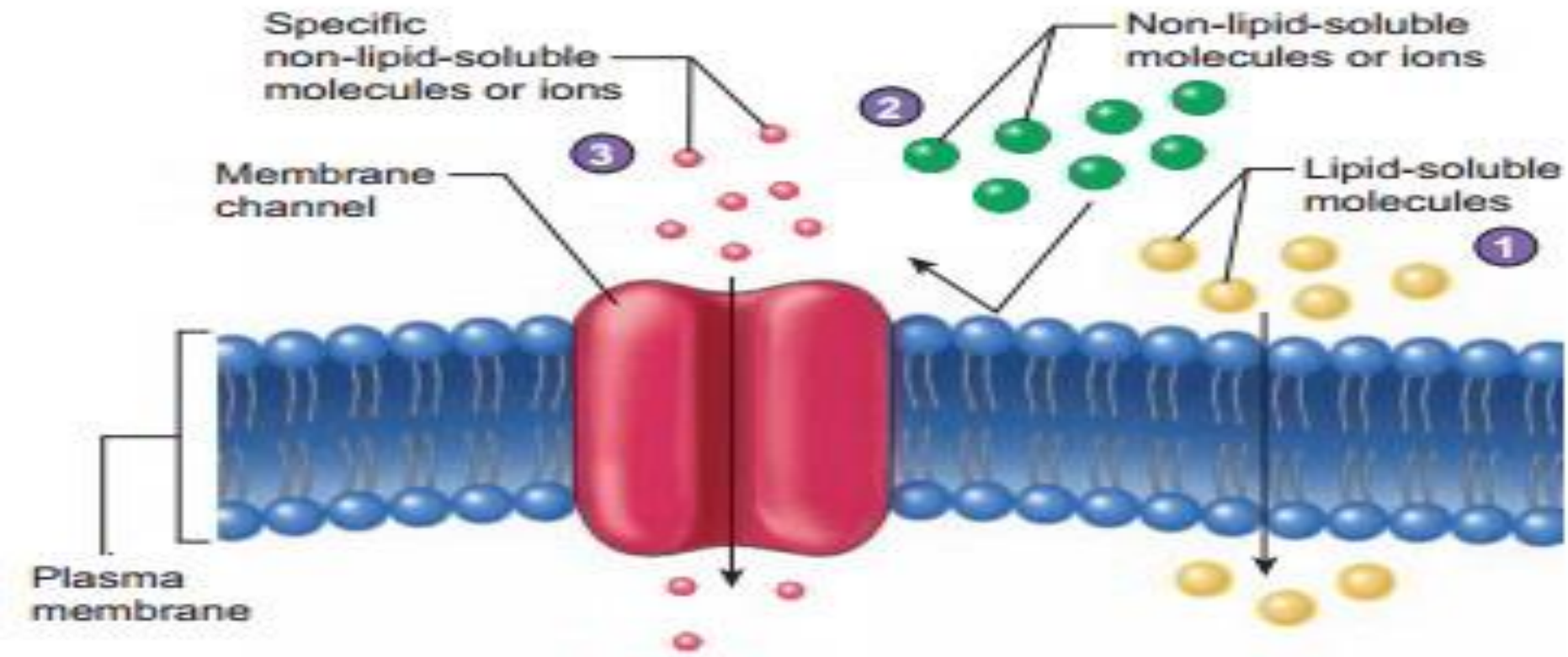


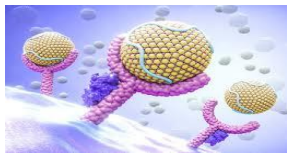




Pure lipid bilayers have a very low permeability to ions and polar molecules.

(LO.1)

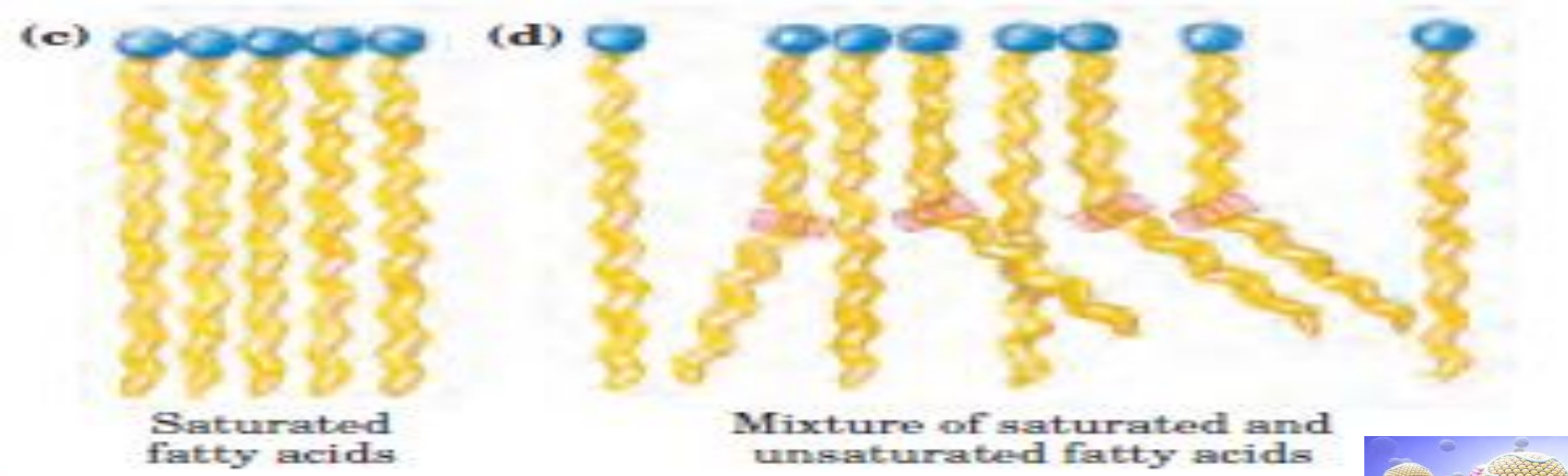


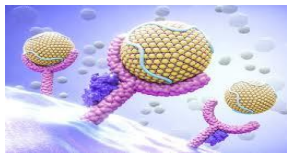


Dynamics in lipid bilayers (LO.1)

Four permitted modes of mobility in the lipid bilayer

1. Intra- chain motion - kink formation in the fatty acyl chains.

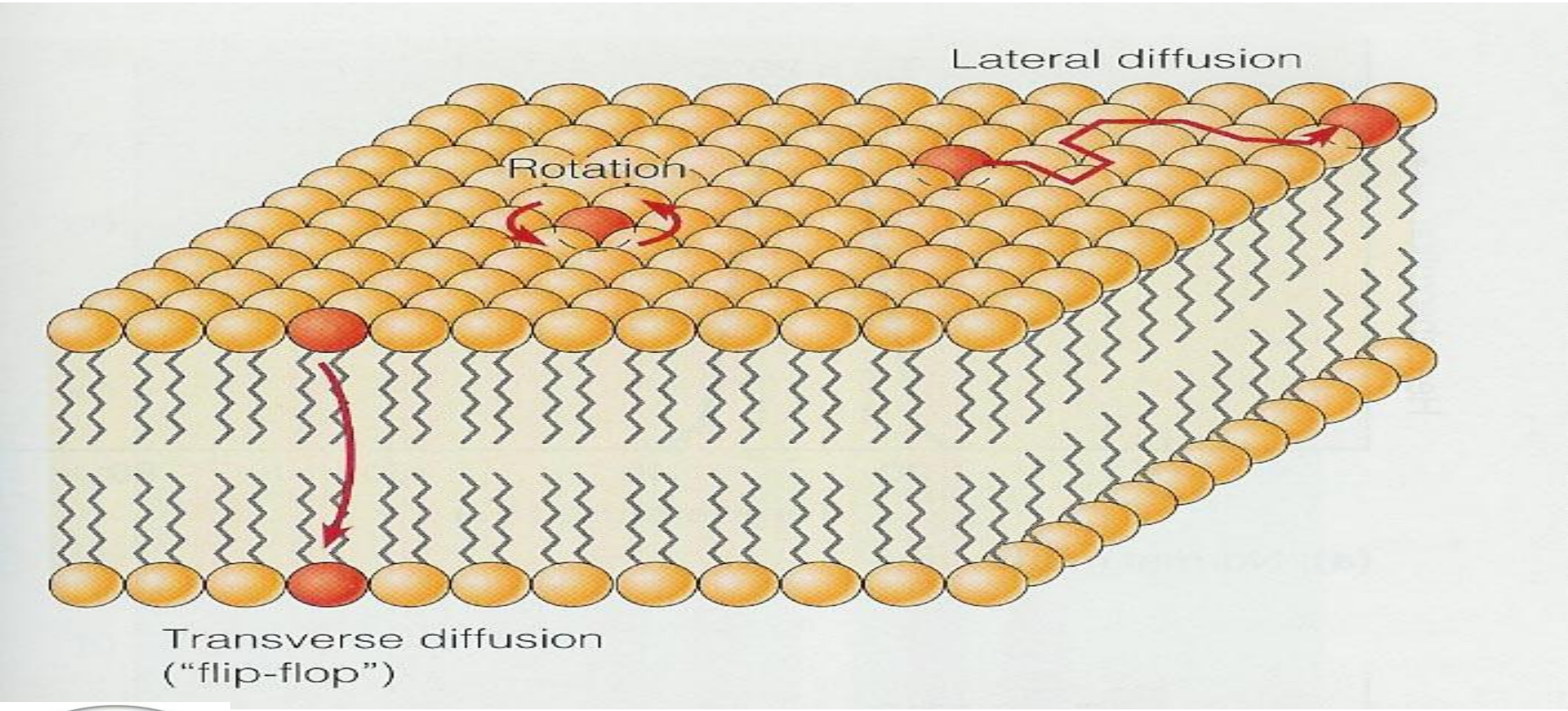


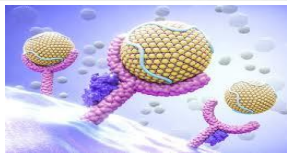


2. Fast axial rotation.

(LO.1)

Axial rotation is a rotary motion of an object around its own axis.

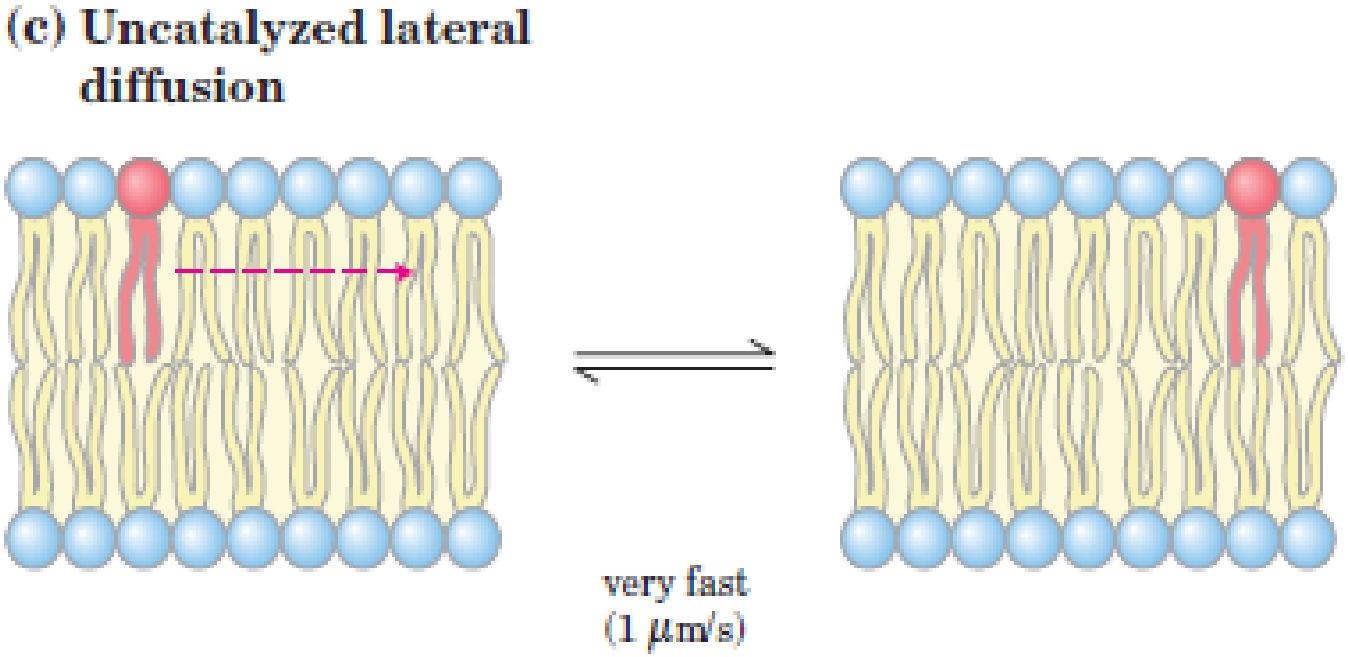


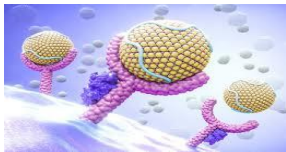


3. Fast lateral diffusion within the plane of the bilayer

(LO.1)

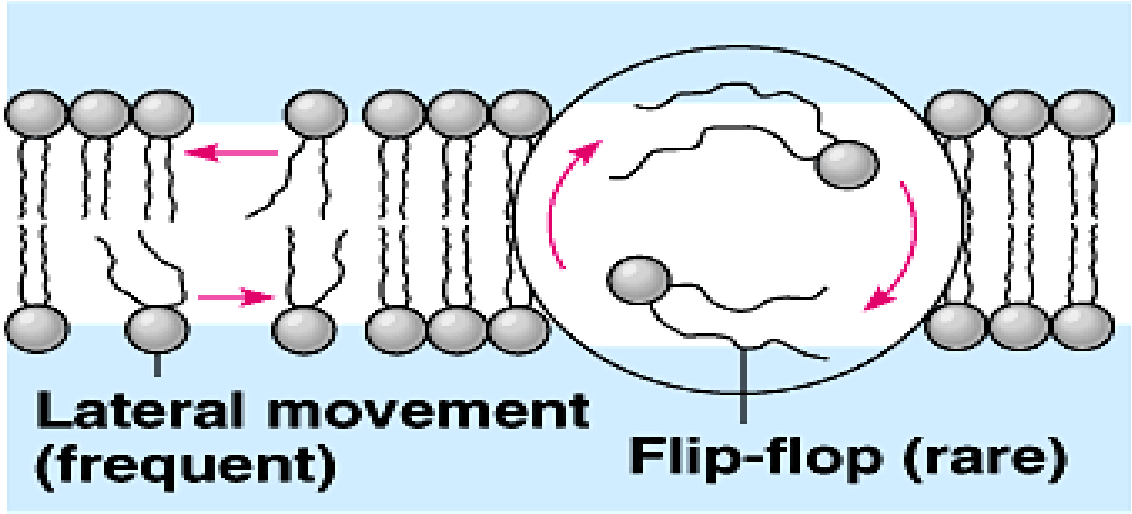
Movement of lipids within each leaflet of the lipid bilayer occurs readily and rapidly due to membrane fluidity

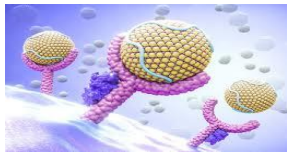




4. Flip-flop - movement (LO.1)

The **movement** of a molecule from one side of the membrane to the other is called transverse diffusion or **flip** flopping. Phospholipids can **flip-flop** but do so at a much lower rate than lateral diffusion.

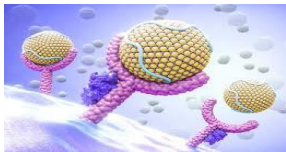




Membrane proteins (LO2)

• **Membrane proteins** carry out the distinctive functions of membranes which include: **enzymes**, **transporters**, **pumps**, **ion channels**, **receptors**, **and energy transducers.**

• Protein content can vary from approximately 18% in myelin (nerve cell) to 75% in the mitochondria.



Mobility of proteins in bilayers (LO2)

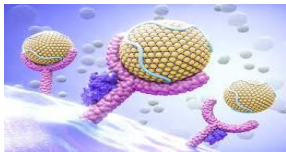
- **Three modes of motion permitted**:

  Conformational change, Rotational and Lateral.

  NO FLIP-FLOP.

- **Restraints on mobility:**

  - **Lipid mediated effects -** proteins tend to separate out into the fluid phase or cholesterol poor regions.
  - **Membrane protein associations.**
  - **Association with extra-membranous proteins** (peripheral proteins) e.g. cytoskeleton..



Thank you