Lipids

-Ms. Rupal Mishra

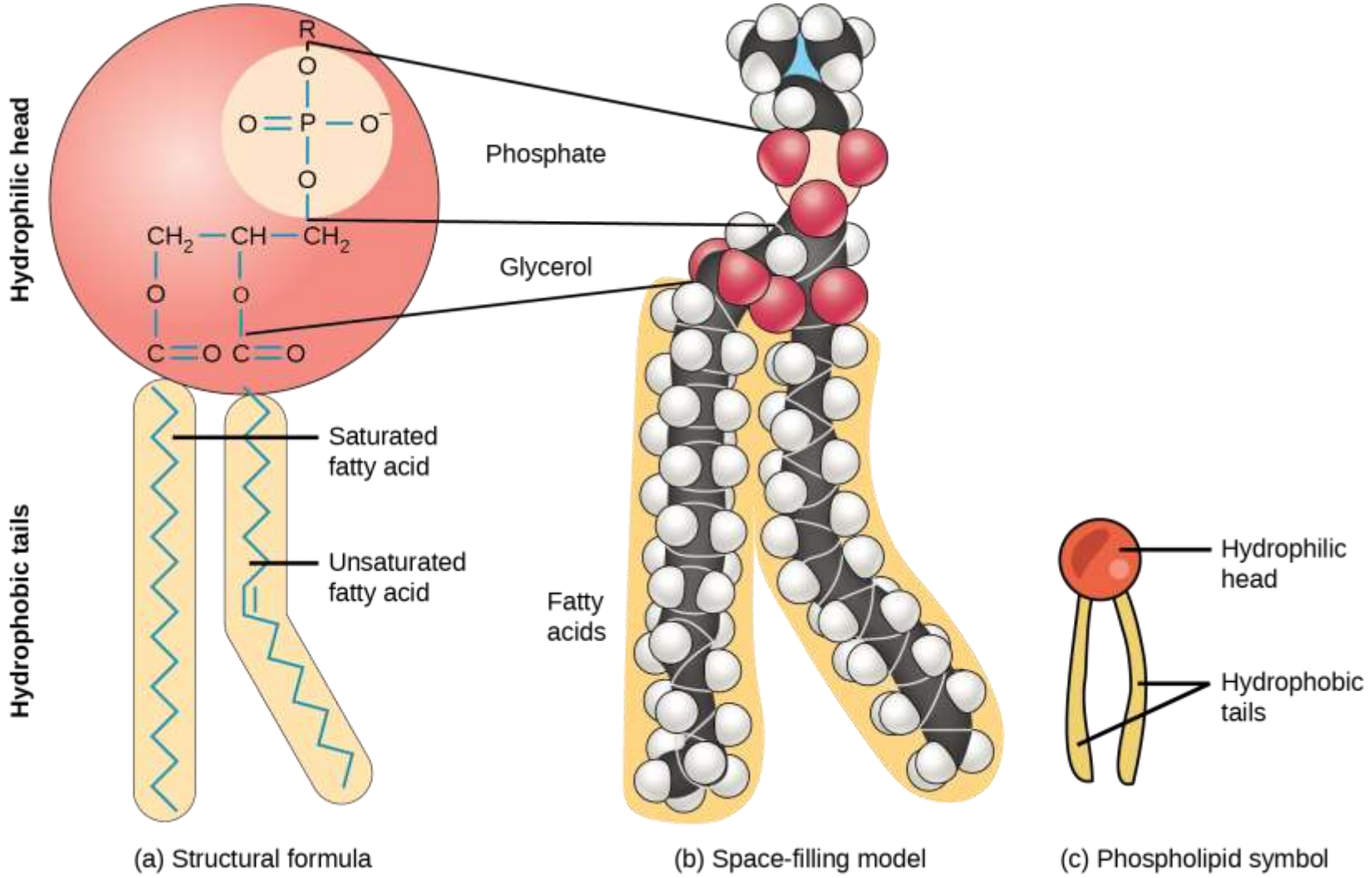
Why are Lipids Imp?

- Lipids occur in plants and animals as **storage and structural components**.
- Fats supply over **twice as much energy** per unit weight as proteins or carbohydrates.
- Lipids also **supply the essential fatty acids** which are not synthesized in human beings but are essential for growth.
- Lipids are essential for the effective **absorption of fat-soluble vitamins** A, D, E and K from intestine.
- Lipids are a class of compounds **distinguished by** their insolubility in water and solubility in non-polar solvents.

Lipids

- Lipids can be divided in **two major classes-** nonsaponifiable lipids and saponifiable lipids.
- **Non-saponifiable lipid** cannot be broken up into smaller molecules by hydrolysis, which includes triglycerides, waxes, phospholipids, and sphingolipids.
- **Eg:** Cholesterol, steroids, eicosanoids and terpenes.
- **Saponifiable lipid** contains one or more ester groups allowing it to undergo hydrolysis in the presence of an acid, base, or enzyme.
- **Eg:** Glycerophospholipids, SphingoPhospholipids, Sphingoglycolipids and triacylglycerols.

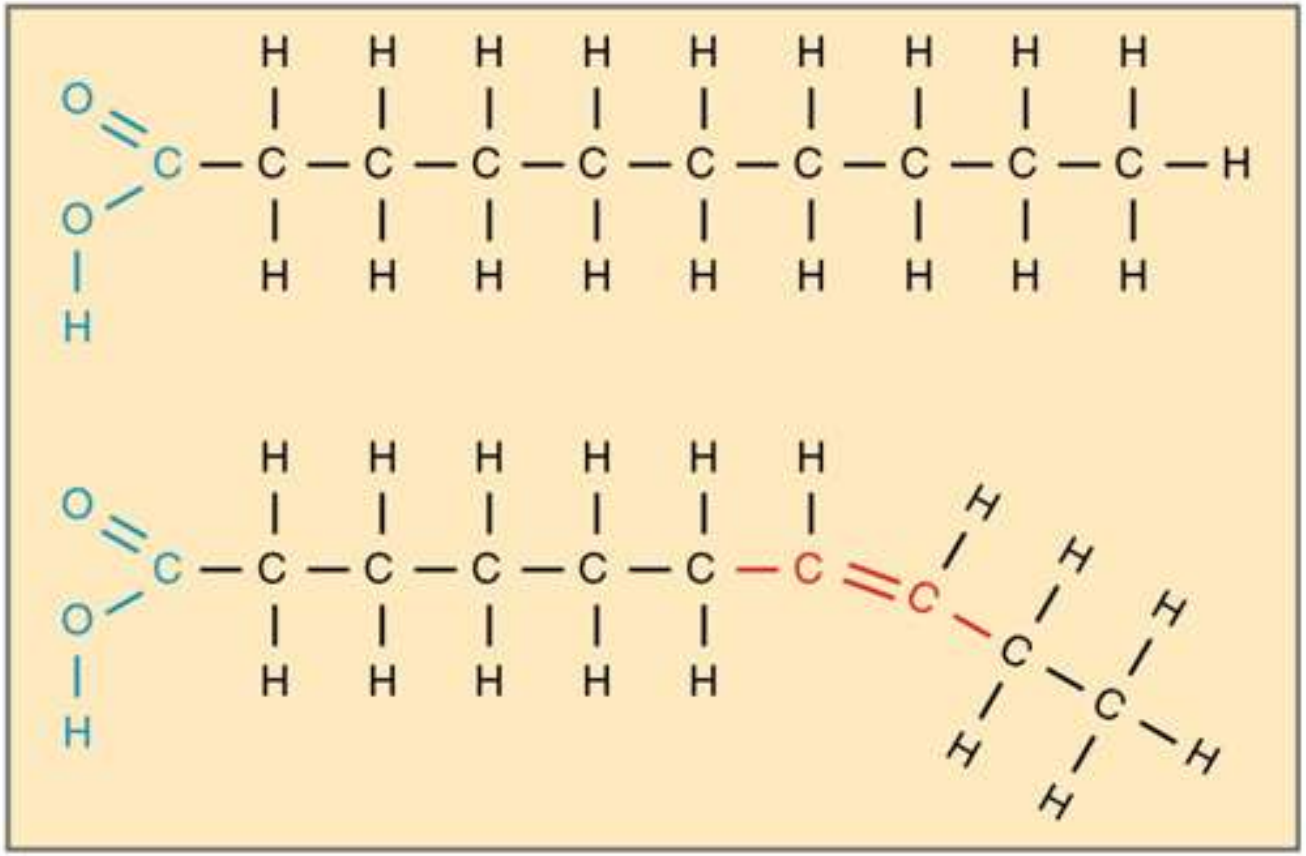
Lipid Basic Structure



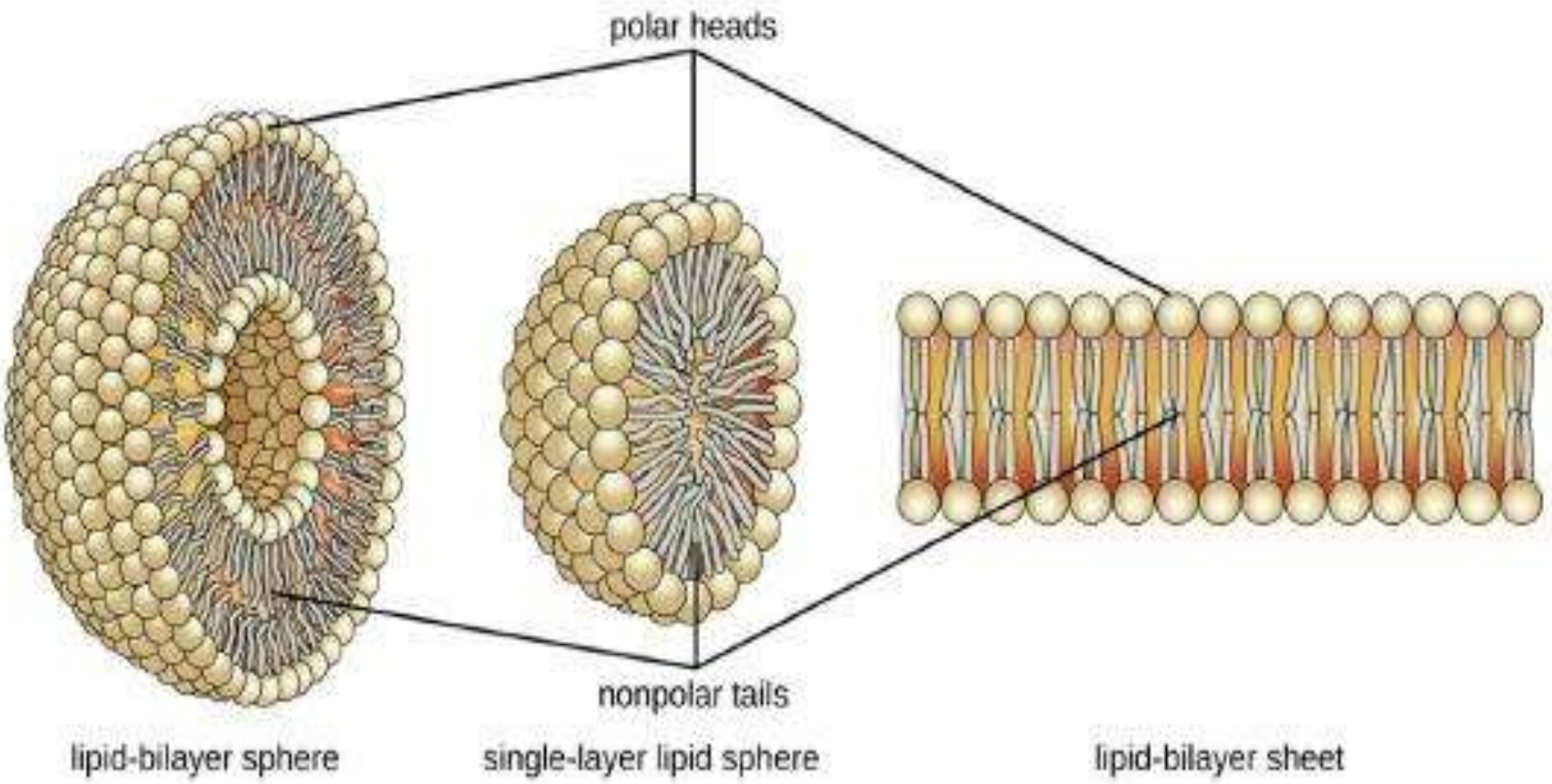
Lipid Basic Structure

(a) Saturated

(b) Unsaturated



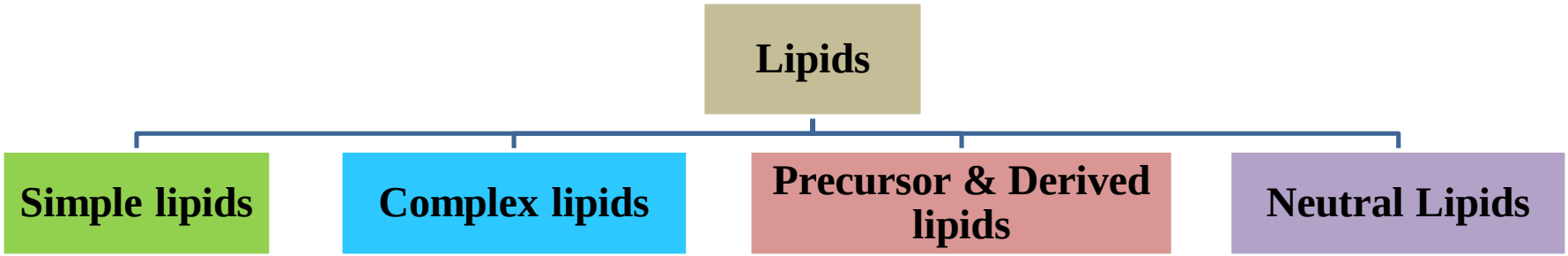
Lipid Basic Structure



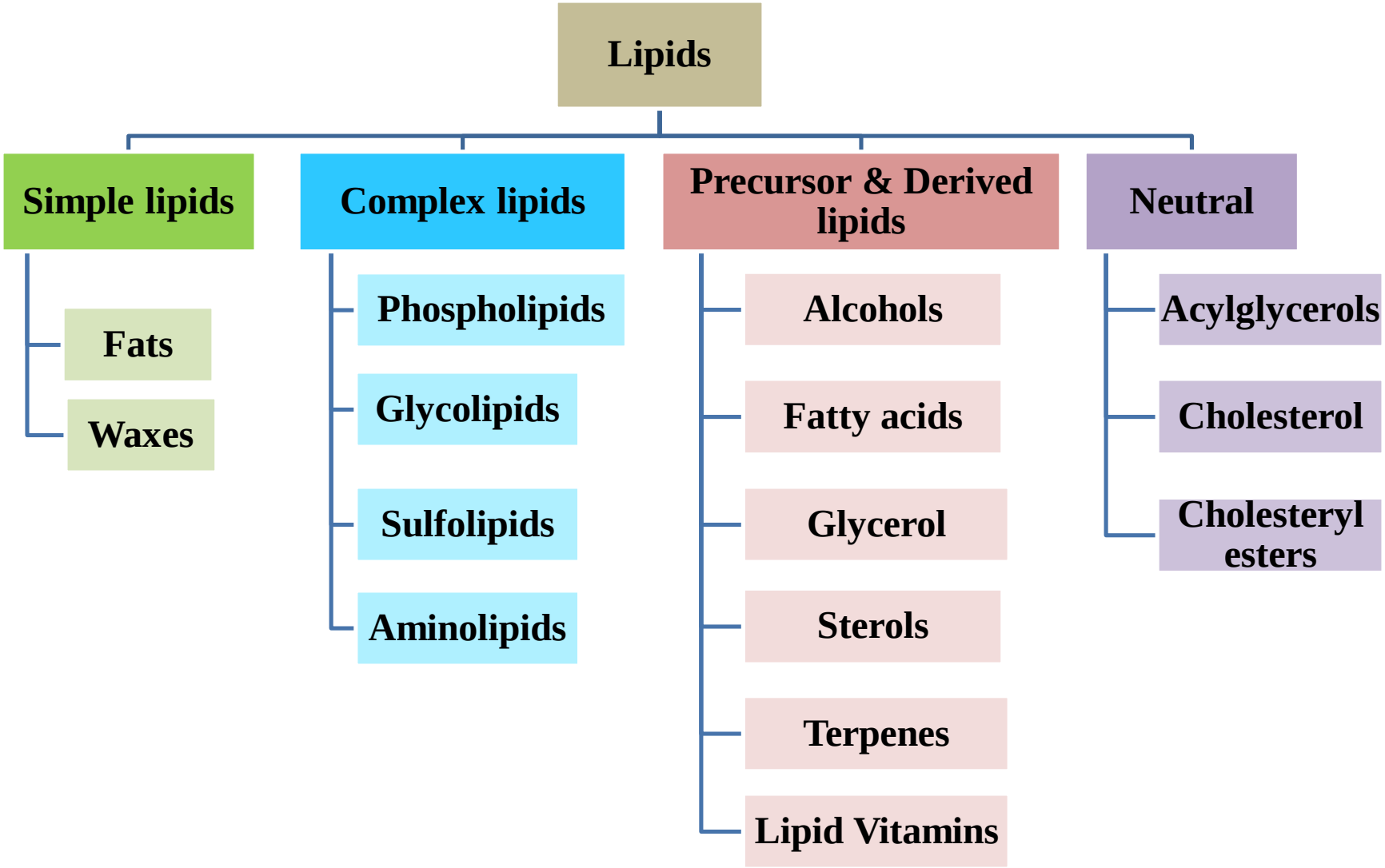
Classification

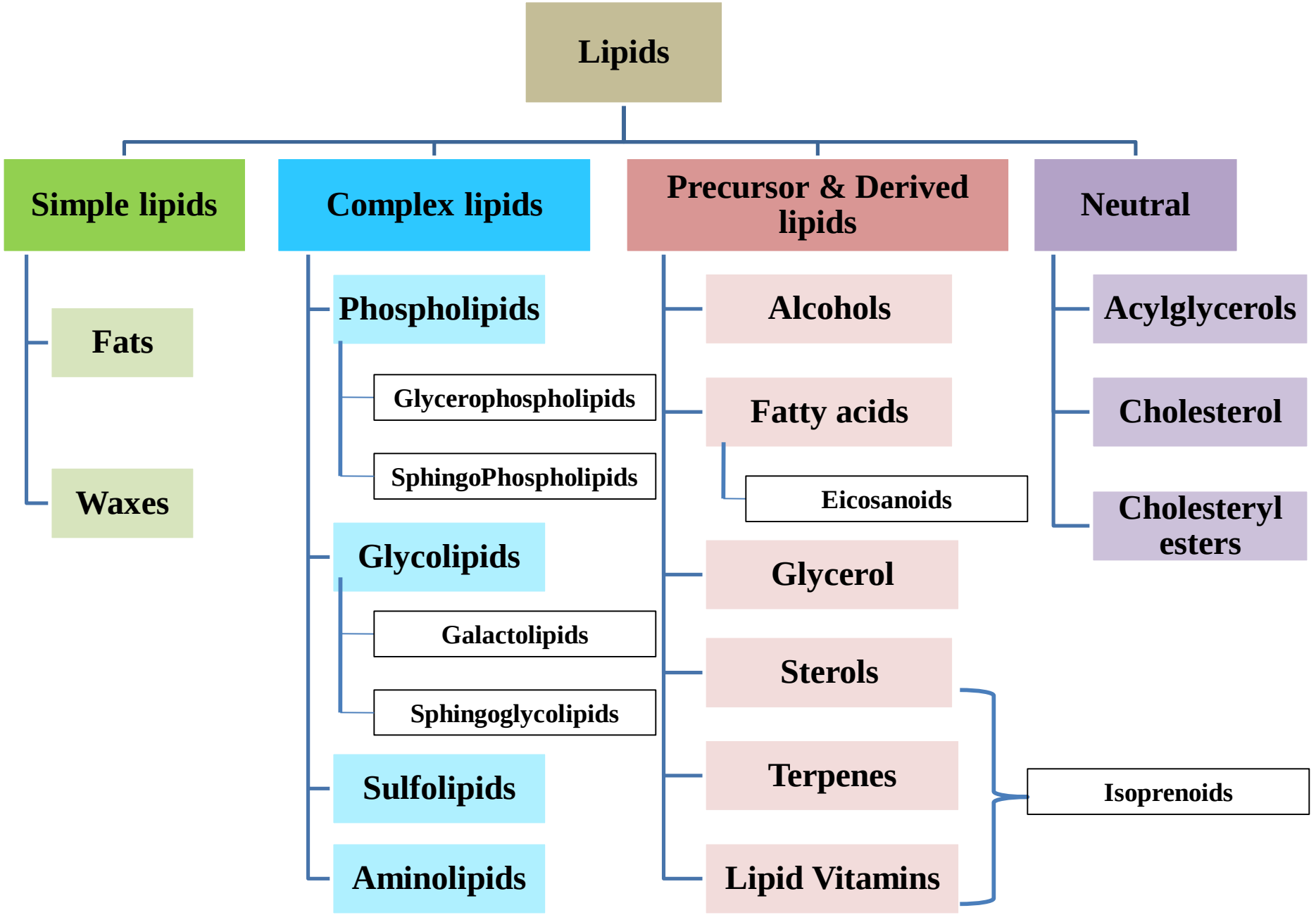
Lipids are classified as:

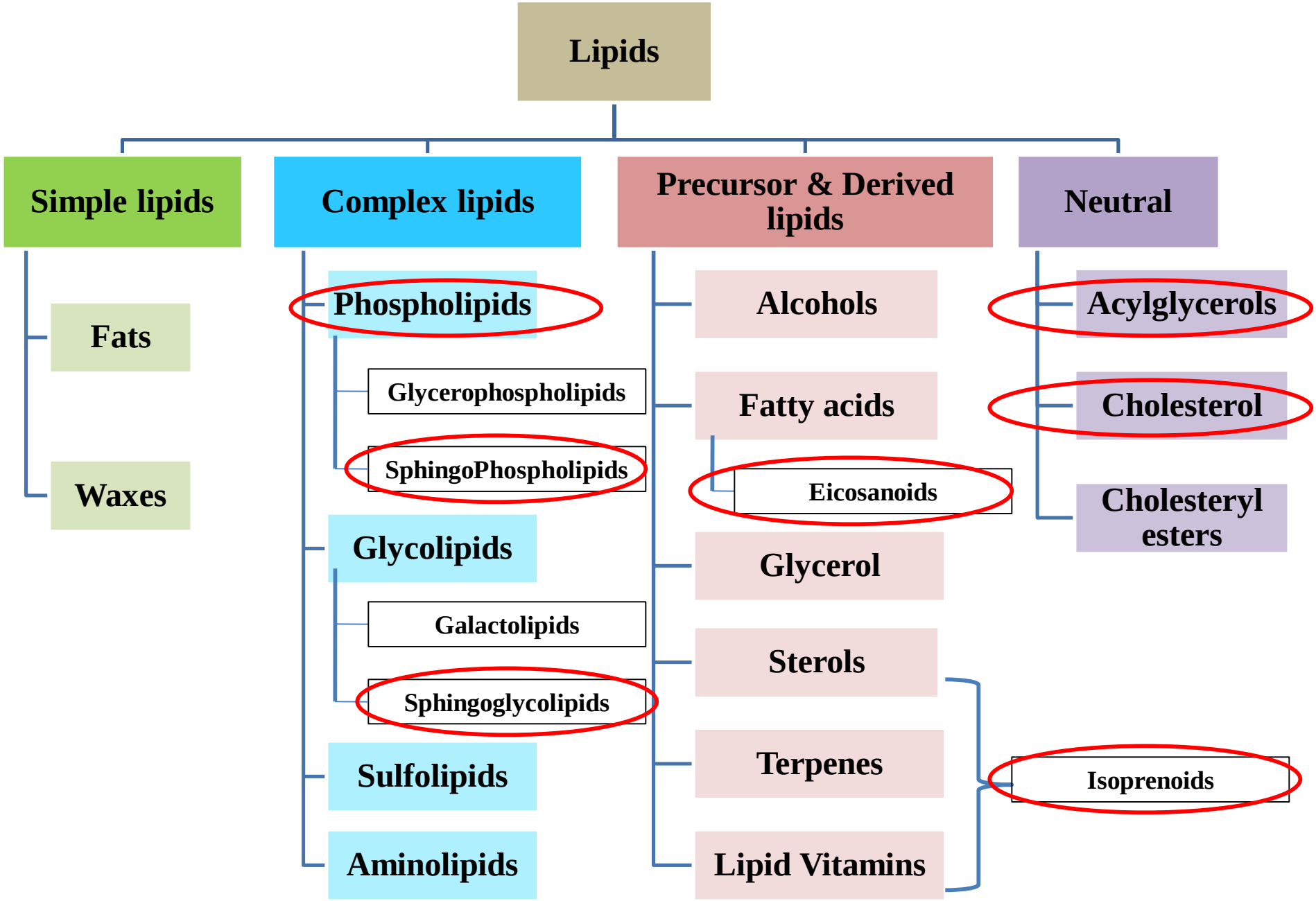
1. **Simple lipids**: fatty acid ester of different alcohols and carries no other substance.
2. **Complex lipids**: Esters of fatty acids containing groups in addition to an alcohol and a fatty acid.
3. **Precursor and derived lipids**: compounds produced when simple and complex lipids undergo hydrolysis.
4. **Neutral Lipids**: Hydrophobic molecules lacking charged groups.



Classification




Lipids
Simple lipids
Fats
Waxes
Complex lipids
Phospholipids
Glycerophospholipids
SphingoPhospholipids
Glycolipids
Galactolipids
Sphingoglycolipids
Sulfolipids
Aminolipids
Precursor & Derived lipids
Alcohols
Fatty acids
Eicosanoids
Glycerol
Sterols
Terpenes
Lipid Vitamins
Isoprenoids
Neutral
Acylglycerols
Cholesterol
Cholesteryl esters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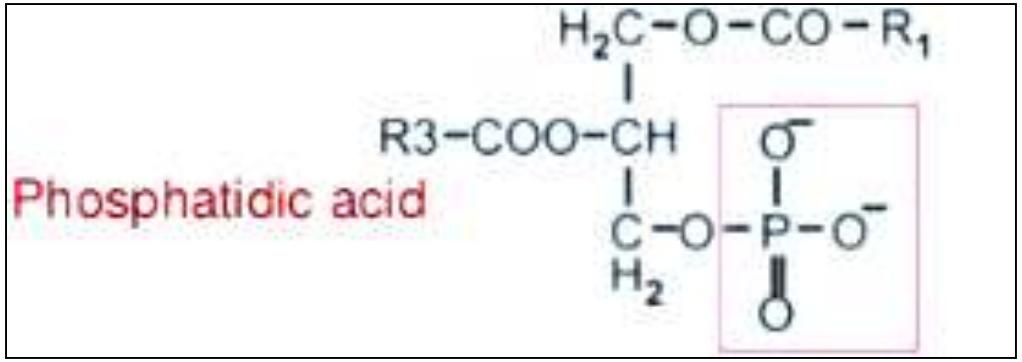
Lipid Vitamins
Isoprenoids
Acylglycerols
Cholesterol
Cholesteryl esters

Phospholipids

- Phospholipids are a specialized group of lipids performing a **variety of functions**.
- These include the membrane structure & functions, involvement in blood clotting & supply of arachidonic acid for the synthesis of prostaglandins.
- Phospholipids are **synthesized from** phosphatidic acid & 1,2-diacylglycerol, intermediates in the production of triacylglycerols.
- Phospholipids **synthesis occurs in** the smooth endoplasmic reticulum and inner mitochondrial membrane.
- These lipids **contain phosphoric acid**, in addition to fatty acids, nitrogenous base and alcohol.

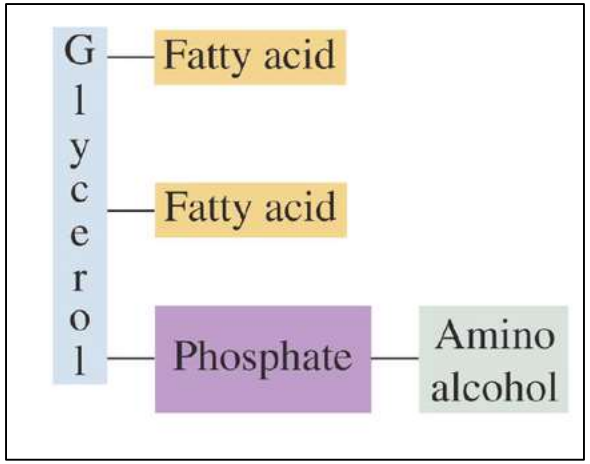
Phospholipids

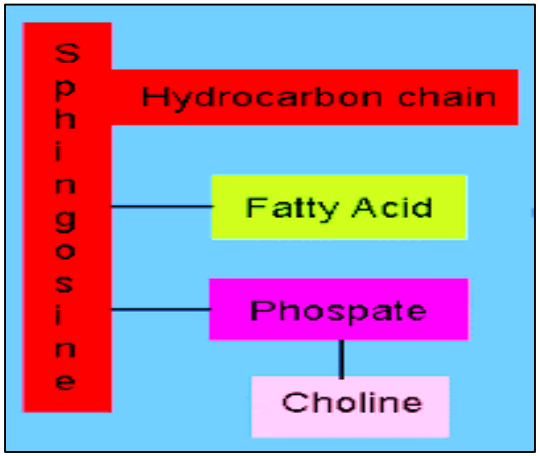
- **Phosphatidates**- These are derivatives of phosphatidic acid, which is the simplest phospholipid.
- **Phosphatidic acid is made up** of one glycerol to which two fatty acid residues are esterified to carbon atoms 1 and 2. The 3rd hydroxyl group is esterified to a phosphoric acid.



Phospholipids

- There are two classes of phospholipids - **Glycerophospholipids** (containing glycerol as the alcohol) and **Sphingophospholipids** (containing sphingosine as the alcohol).
- The glycerophospholipids examples are lecithin and cephalin.
- The Sphingophospholipids examples are ceremide and sphingomyelin.





Sphingolipids

- Sphingolipids are the fourth large class of membrane lipids
- They have a polar head group and two non-polar tails, but unlike glycerophospholipids and galactolipids they contain no glycerol.
- Sphingolipids are **composed of** :
  - one molecule of the long-chain amino alcohol (sphingosine)
  - one molecule of a long-chain fatty acid
  - a polar head group that is joined by a glycosidic linkage in some cases and by a phosphodiester in others.
- **Ceramide** is the structural parent of all sphingolipids.

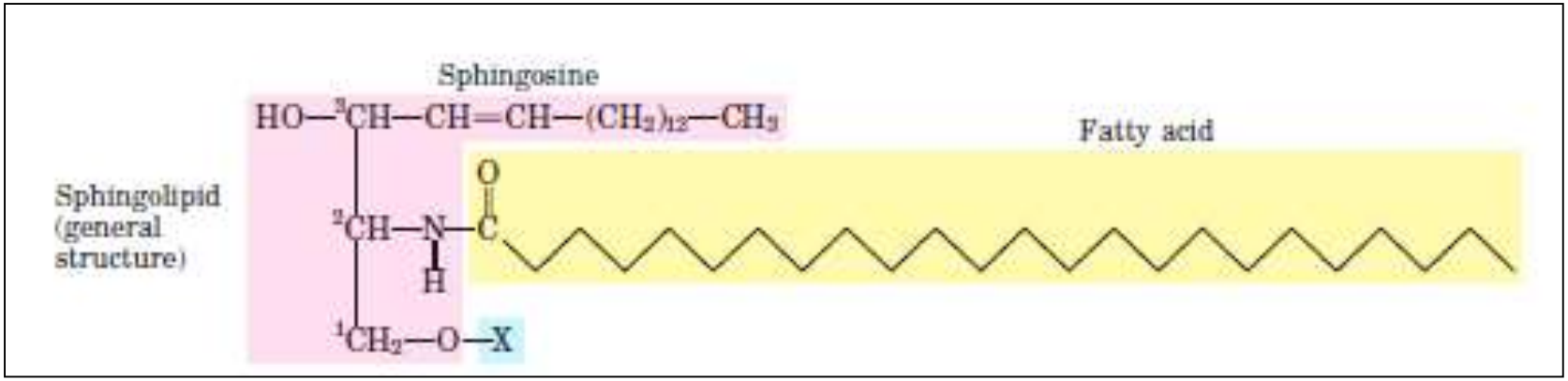
Sphingolipids

- There are **three subclasses of sphingolipids**, all derivatives of ceramide but differing in their head groups:

  1) Sphingomyelins (Sphingophospholipids)

  2) Neutral glycolipids (glycosphingolipids)

  3) Gangliosides (glycosphingolipids)



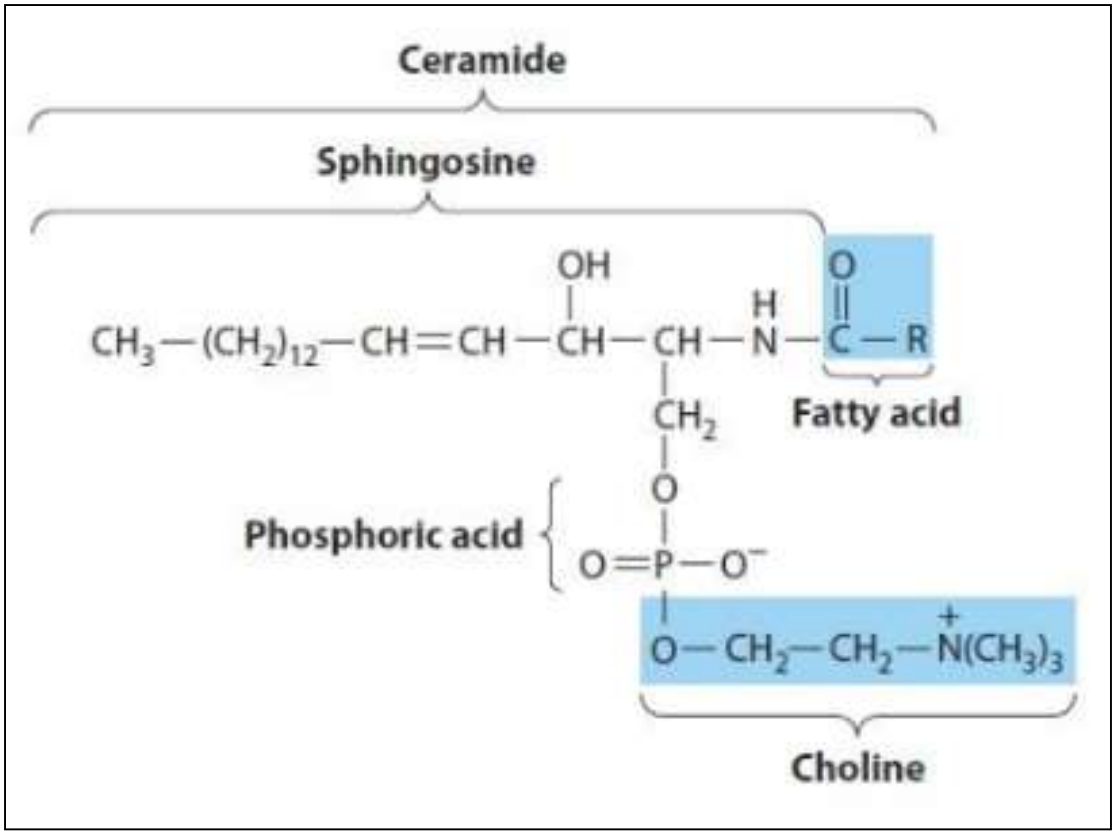
Sphingophospholipids

- They were **discovered in brain extracts** in the 1870s and were **named after** the mythological sphinx because of their enigmatic nature.
- These compounds **play important roles in** signal transduction and cell recognition.
- **Sphingolipidoses**, or disorders of sphingolipid metabolism, have particular impact on neural tissue.
- **Sphingosine** is an 18-carbon amino alcohol with an unsaturated hydrocarbon chain, which forms a primary part of sphingolipids.

Sphingophospholipids

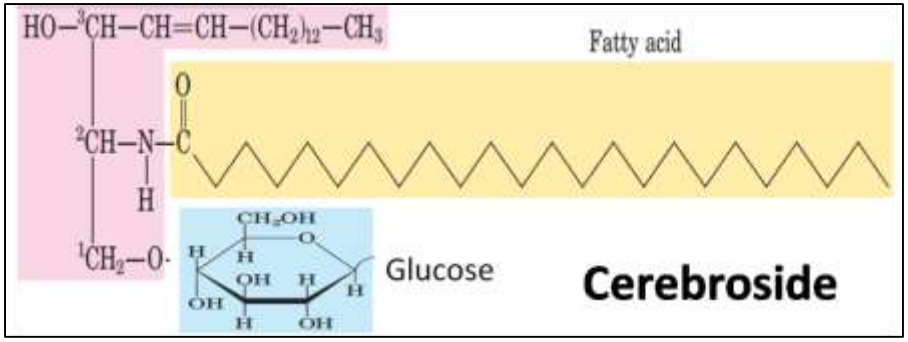
- The **backbone** of sphingomyelin is the amino alcohol sphingosine, rather than glycerol.
- A long-chain fatty acid is attached to the amino group of sphingosine through an amide linkage, producing a ceramide, which serve as a precursor of glycolipids.
- The alcohol group at carbon 1 of sphingosine is esterified to phosphorylcholine, producing sphingomyelin, the only significant sphingophospholipid in humans.
- **Sphingomyelin** is an important component of the myelin of nerve fibers (myelin sheath) that insulates & protects neuronal fibers of the central

Sphingophospholipids



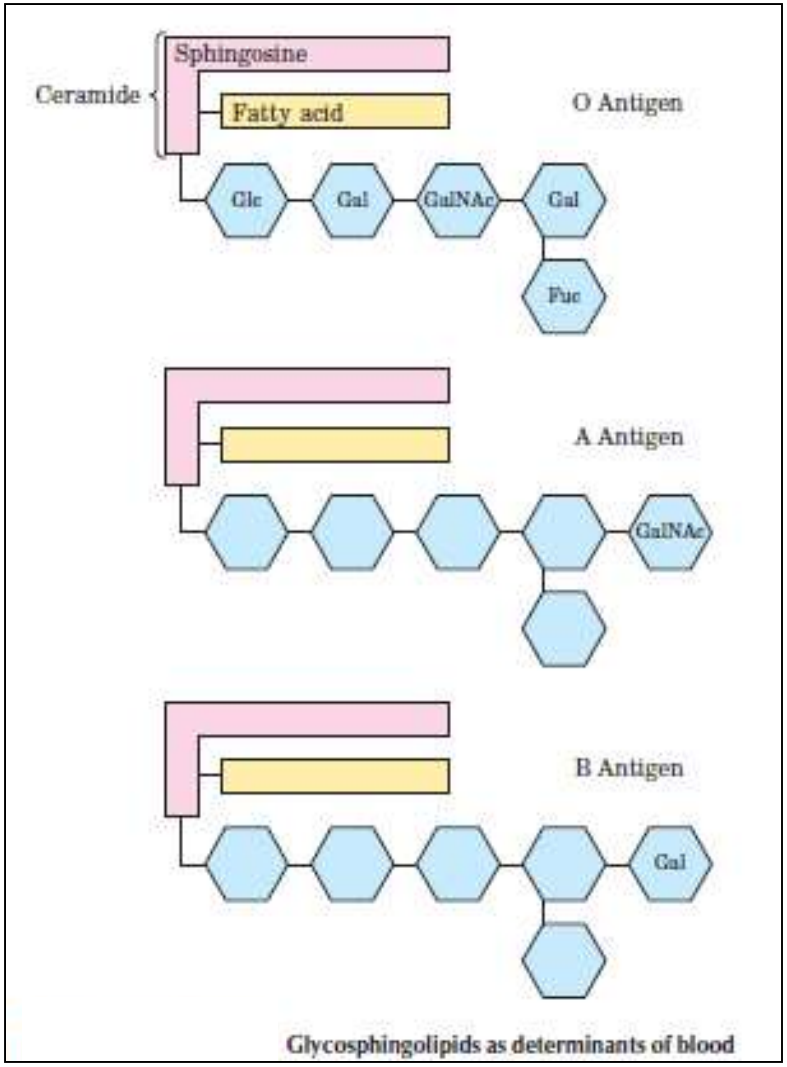
Neutral Glycolipids

- **Glycosphingolipids** occur largely in the outer face of plasma membranes
- They have head groups with one or more sugars connected directly to the C-1 of the ceramide moiety
- They **do not contain phosphate**.
- **Eg**: Cerebrosides and globosides
- They are sometimes called neutral glycolipids, as they have no charge at pH 7.



Neutral Glycolipids

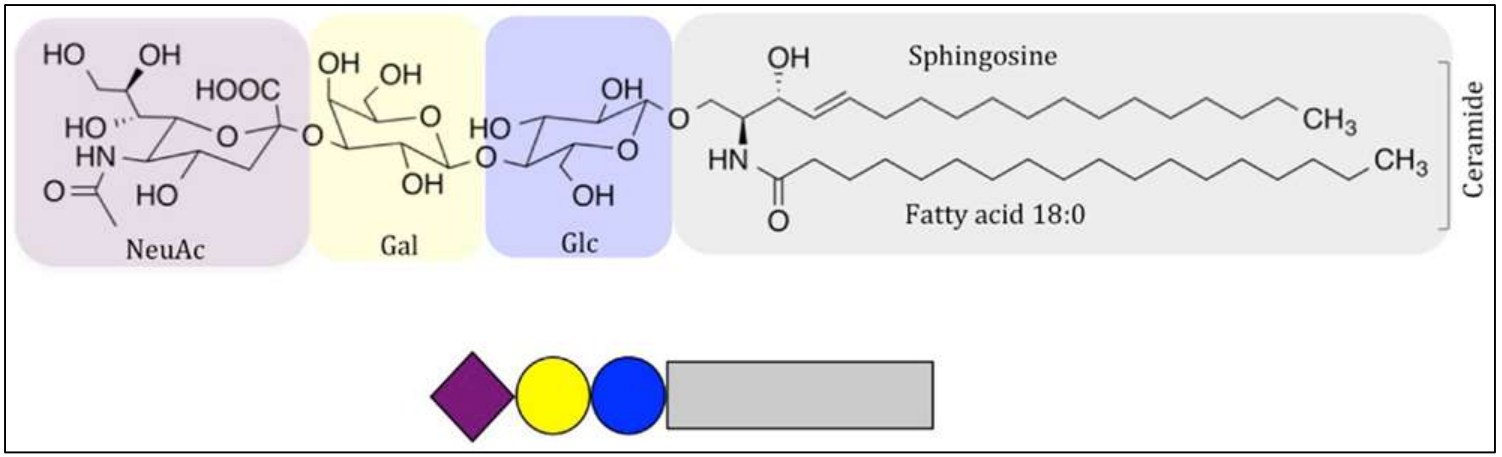
- **Cerebrosides have a single sugar linked to ceramide;** those with galactose are characteristically found in the plasma membranes of cells in neural tissue, and those with glucose in the plasma membranes of cells in non-neural tissues.
- **Globosides are neutral (uncharged)** glycosphingolipids with two or more sugars, usually D-glucose, D-galactose, or *N-acetyl-D-galactosamine.*

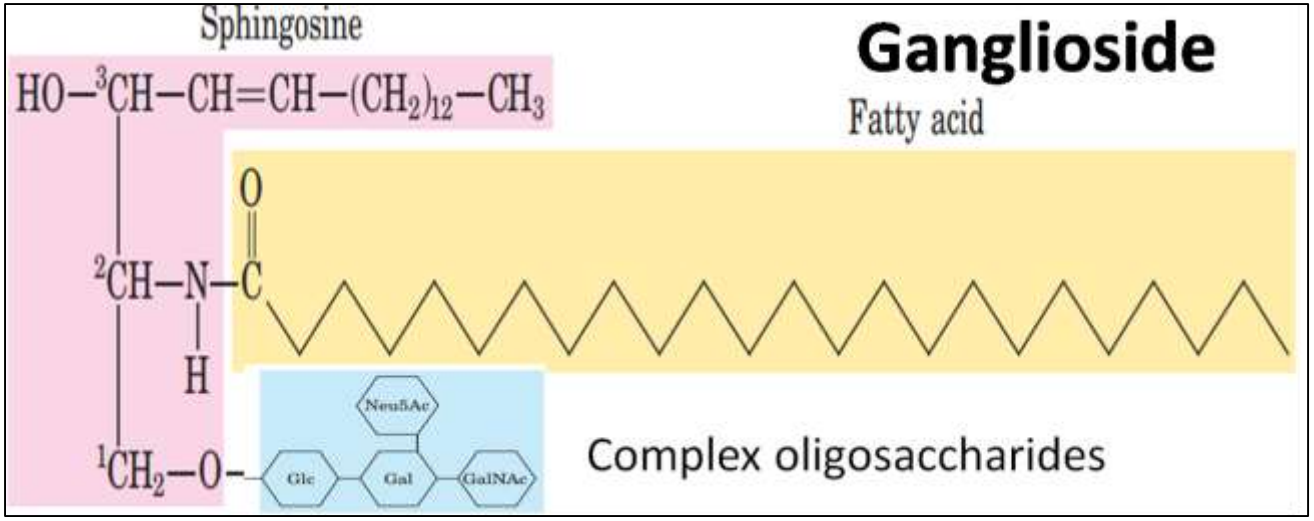


Gangliosides

- **Gangliosides the most complex sphingolipids**
- They are composed of **a ceramide lipid tail** attached through **glycosidic linkage** to a **glycan head group** containing one or more sialic acid residues.
- Sialic acids are a class of alpha-keto acid sugars with a nine-carbon backbone
- Sialic acid gives gangliosides the negative charge at pH 7 that distinguishes them from globosides.
- Gangliosides with one sialic acid residue are in the GM (M for mono-) series, those with two are in the GD (D for di-) series, and so on (GT, three sialic acid residues; GQ, four).

Gangliosides



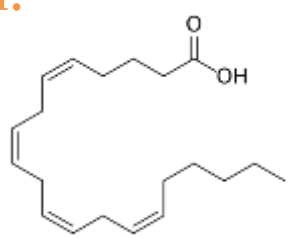


Eicosanoids

- Eicosanoids are a class of compounds derived from polyunsaturated fatty acids and involved in cellular activity.
- Eicosanoids include **leukotrienes, eoxins and three types of prostanoids** – prostaglandins, prostacyclins and thromboxanes.
- Eicosanoids are often thought of as local hormones.
- They rapidly break down, so they are not able to travel very far.
- Eicosanoids go by the nickname 'local hormones' because they act on cells close to their site of production.

Eicosanoids

- Most eicosanoids are produced from arachidonic acid.
- **Arachidonic acid** is a polyunsaturated fatty acid and specifically a type of omega-6 fatty acid.



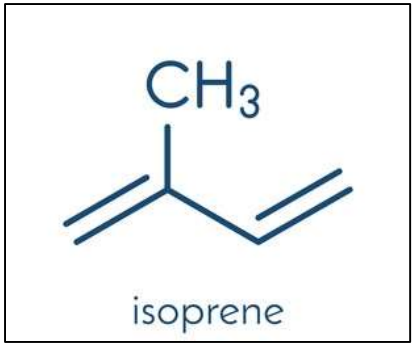
- This fatty acid is obtained through your diet, mainly from animal fats.
- So, chicken, eggs, hamburgers, and hot dogs are examples of foods you might eat that provide arachidonic acid.
- Eg: They play a role in inflammation, fever promotion, blood pressure regulation, and blood clotting. They also influence the immune response and certain respiratory and reproductive processes.

Eicosanoids Examples

- **Prostaglandins** can dilate or constrict blood vessels (which brings about a change in blood pressure), can regulate inflammation (cause pain and induce fever), can also dilate or constrict the bronchi of the lungs, contract smooth muscles (including those of the uterus during labor).
- **Thromboxane** constrict blood vessels and cause platelet to aggregate and help out with thrombosis.
- **Leukotrienes** are important mediators of inflammatory response, they increases permeability of blood vessels, stimulate platelet aggregation and attract white blood cells to that area.

Isoprenoids

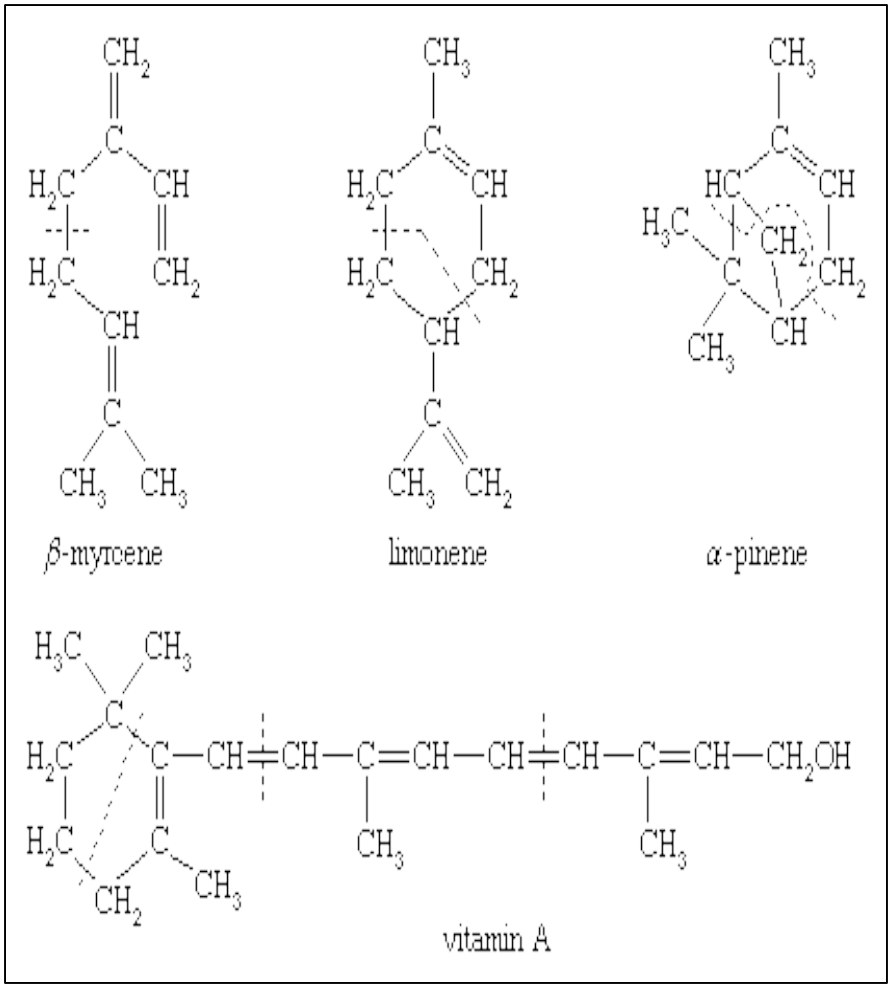
- **Isoprene** (2-methyl-1,3-butadiene) is a branched-chain unsaturated hydrocarbon(two c-c double bonds).
- **Isoprenoids** contain from two to many thousands of isoprene units.
- Isoprenoids play wide variety of roles in the physiological processes of plants and animals and also have a number of commercial uses.



Isoprene Smallest unit of Isoprenoid

Isoprenoids

- Isoprenoids in living organisms range in function from pigments and fragrances to vitamins and precursors of sex hormones
- Other commercially valuable isoprenoids are those used as flavourings, solvents, and raw materials for chemicals .

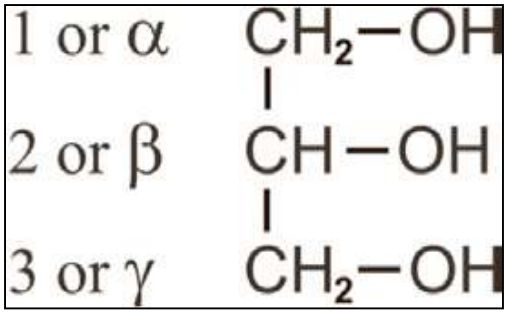


Isoprenoids Examples

- **In plants**, isoprenoids occur in the essential oils, which are found in the gummy exudates (oleoresins and latices) of many trees and shrubs.
- Plant isoprenoids effect growth (e.g., the hormone gibberellic acid) and contribute to red, yellow, and orange pigments (carotenoids).
- **In animals**, isoprenoids comprise various oily or waxy substances such as fish liver oils, wool wax, and the yellow pigments in egg yolk, butterfat, feathers, and fish scales.
- One of the most familiar natural substances, rubber, is a polyisoprene

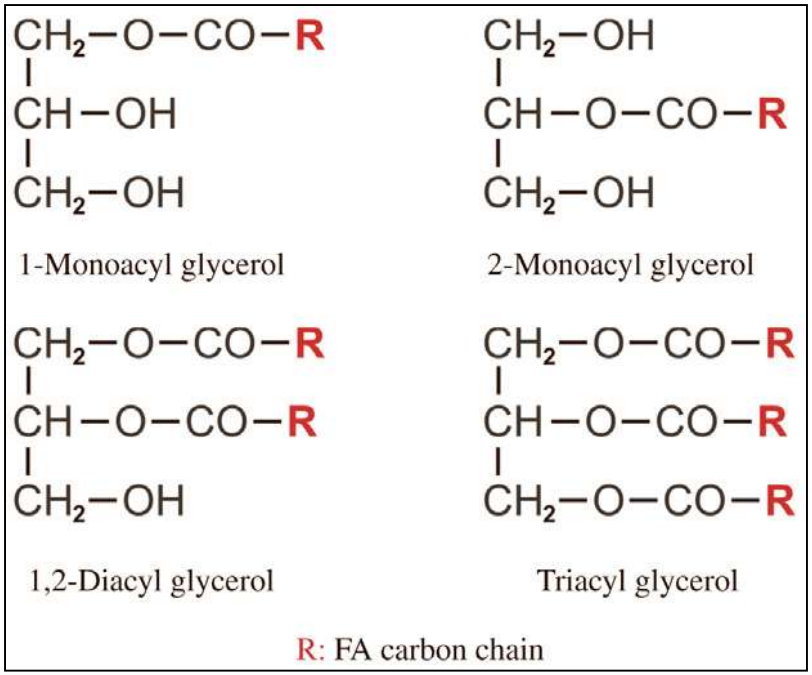
Acylglycerols

- Most of the Fatty acids (FA's) of the body form esters with different alcohols, preferably glycerol, **generating acylglycerols** or acylglycerides.
- **Glycerol** has 3 alcohol groups bound to each of its carbons.
- Glycerol carbons are designated by numerals or Greek letters. The primary carbons C1 and C3 are also named α and γ, while C2 is named β.



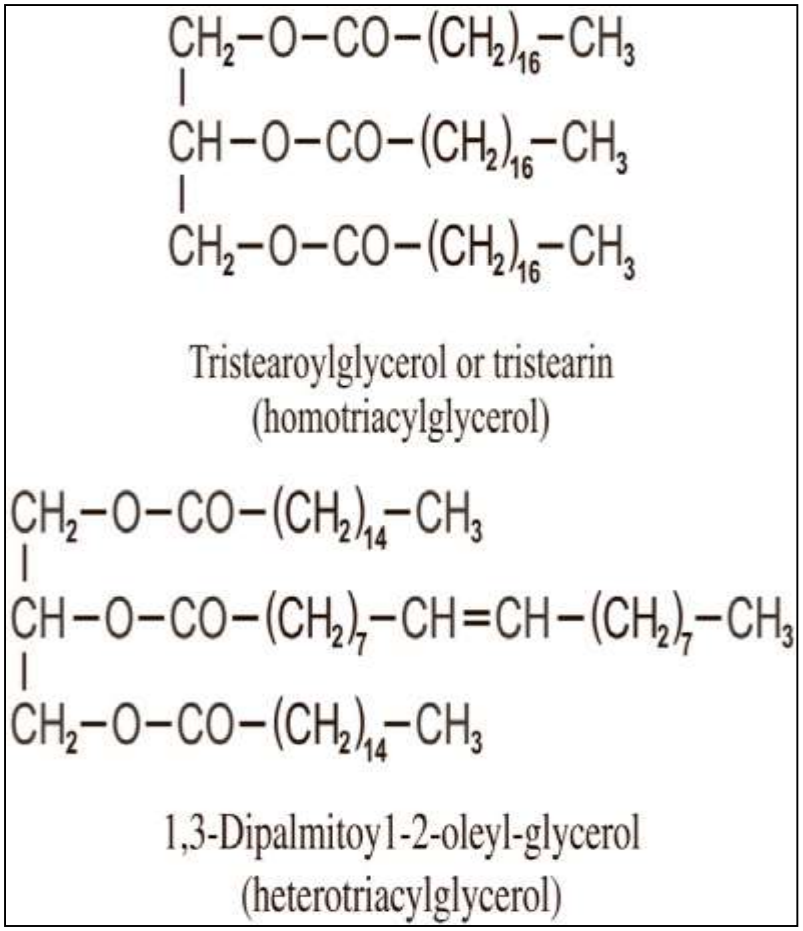
Acylglycerols

- Depending on the number of alcohol groups esterified by FA's, acylglycerols are designated monoacylglycerols, diacylglycerols, or triacylglycerols.



Acylglycerols

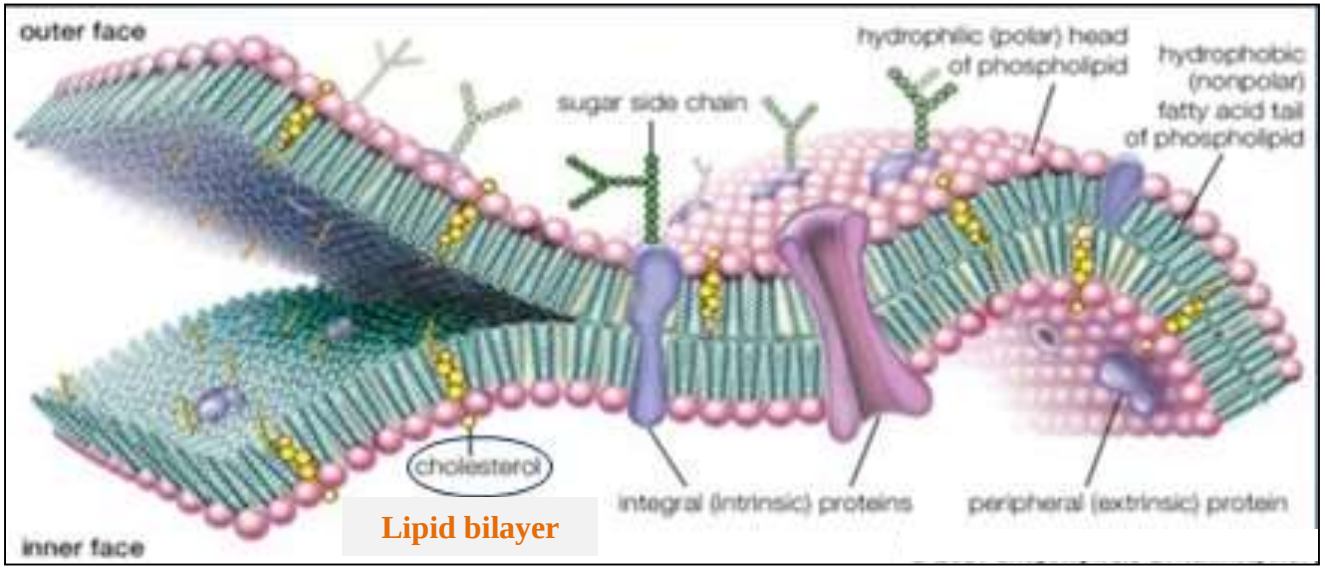
- If the FAs are all the same, the di- and triacylglycerols are called **homoacylglycerols**.
- If they are different, the acylglycerols are named **heteroacylglycerols**.



Acylglycerols Examples

- All animals store neutral fats as energy reserve (Triacylglycerols are efficient molecules for energy storage).
- It has been observed that the consumption of diets rich in **polyethylenic cis FAs** contributes to the reduction of cholesterol concentration in people with elevated blood cholesterol.
- linoleic acid, linolenic, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) exert a protective action against coronary heart disease.
- EPA and DHA help to maintain normal vascular endothelium, blood pressure, levels of plasma triacylglycerides, and prevent platelet aggregation.

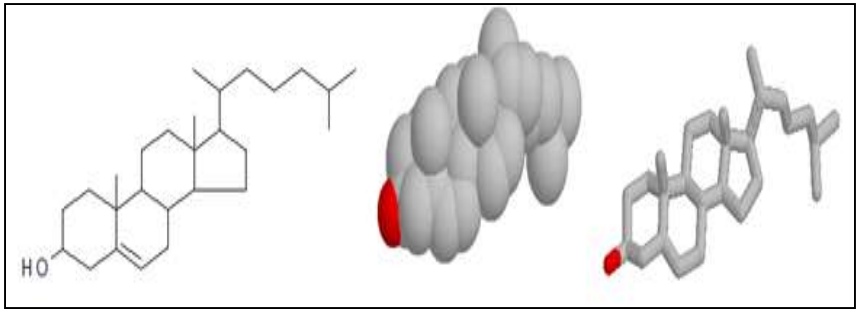
Cholesterol & Membrane



- Cholesterol is a compound of the **sterol** type found in most body tissues
- Cholesterol and its derivatives are important constituents of cell membranes and precursors of other steroid compounds, but high concentrations in the blood are thought to promote atherosclerosis.

Cholesterol & Membrane

- **Cholesterol**, an important constituent of cell membranes, has a **rigid** ring system and a short branched hydrocarbon tail.
- Cholesterol is largely **hydrophobic** substance but it has one **polar** group and a **hydroxyl**, making it **amphipathic**.
- **Cholesterol** inserts into bilayer membranes with its hydroxyl group oriented toward the aqueous phase & its hydrophobic ring system adjacent to fatty acid chains of phospholipids.
- The **OH** group of cholesterol forms hydrogen bonds with polar phospholipid head groups.



Structure of Cholesterol Molecule

Cholesterol & Membrane

- Cholesterol slightly immobilize the outer surface of the membrane and make it less soluble to very small water-soluble molecules that could otherwise pass through more easily.
- Without **cholesterol**, cell membranes would be too fluid, not firm enough, and too permeable to some molecules.
- Phospholipid membranes with a high concentration of cholesterol have a fluidity intermediate between the liquid and crystal states.

THANK YOU