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LIPIDS

Classification, functions and structure

Lipids are non-polar
(hydrophobic) compounds,
insoluble in water,
but soluble in organic solvents

Lipids have a very heterogeneous

chemical structure and play

very different functions

LIPID FUNCTIONS

The biological functions of the lipids are very diverse:

Energy storage

- Fats stored in adipose tissue.

▣ Fats and oils - are the principal stored forms of energy in many organisms,

Cell membrane structure

- Creates a barrier for the cell.
- Controls flow of materials.

▣ Phospholipids and sterols - make up about half the mass of biological membranes.

Hormones and Vitamins

- Hormones - communication between cells.
- Vitamins - assist in the regulation of biological processes.

▣ Steroid hormones – sex hormones, glucocorticoides and mineralocorticoides

▣ Liposoluble vitamins – vitamins A, D, E and K

Lipids are classified into 2 general groups:

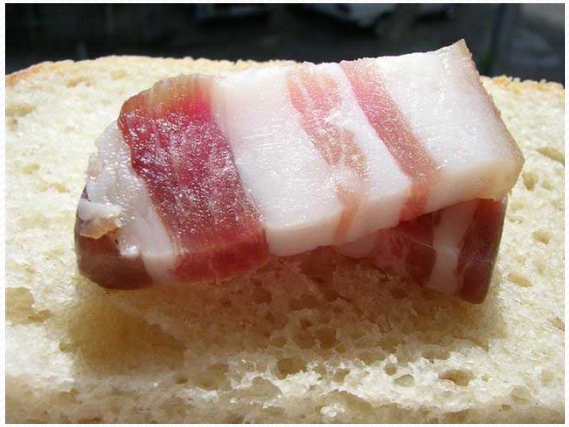
I. Non- hydrolysable (non-saponifiable) lipids:

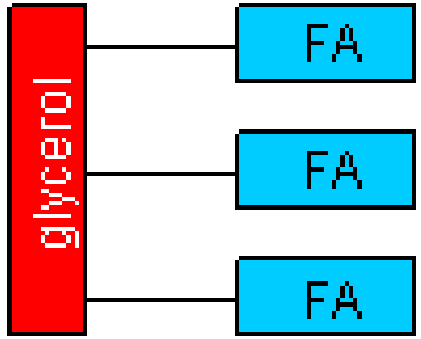
- **Derived lipids:**
  - **Fatty acids**
  - **Fatty alcohols**
  - **Fatty aldehydes**
  - **Hydrocarbons**
- **Terpenes:** **fat soluble Vitamin A, E and K**
  (made up of repeating isoprene units).
- **Sterols and steroids:**
  Cholesterol
  Vitamin D
  Androgens and estrogens (Sex hormones)
  Adrenal corticosteroids
  Bile acids

II. Hydrolysable (saponifiable) lipids

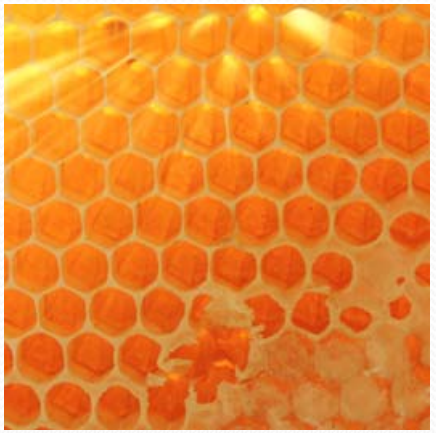
- **Simple Lipids** –consist from only two components:

a) Triglycerides (neutral fats and oils – storage lipids): Esters of three molecules of fatty acids plus one molecule of glycerol;





b) Waxes: Composed of esters of fatty acids with alcohol other than glycerol;



• Complex Lipids (membrane lipids)-

– consist from more than two components

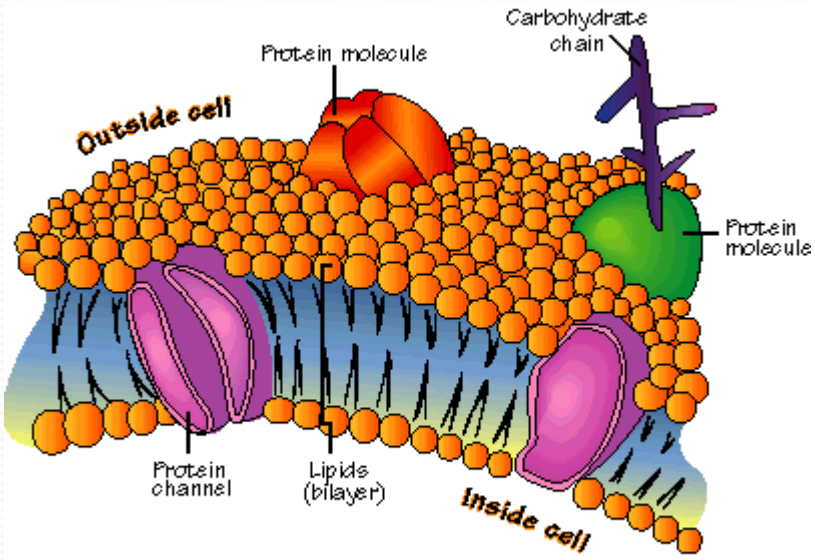
a) Phospholipids:

- **glycerophospholipids -** composed of glycerol, fatty acids, and phosphoric acid bound to a nitrogenous base.
- **sphingophospholipids (sphingomyelins):** containing sphingosine, fatty acids, phosphoric acid, choline, and no glycerol;

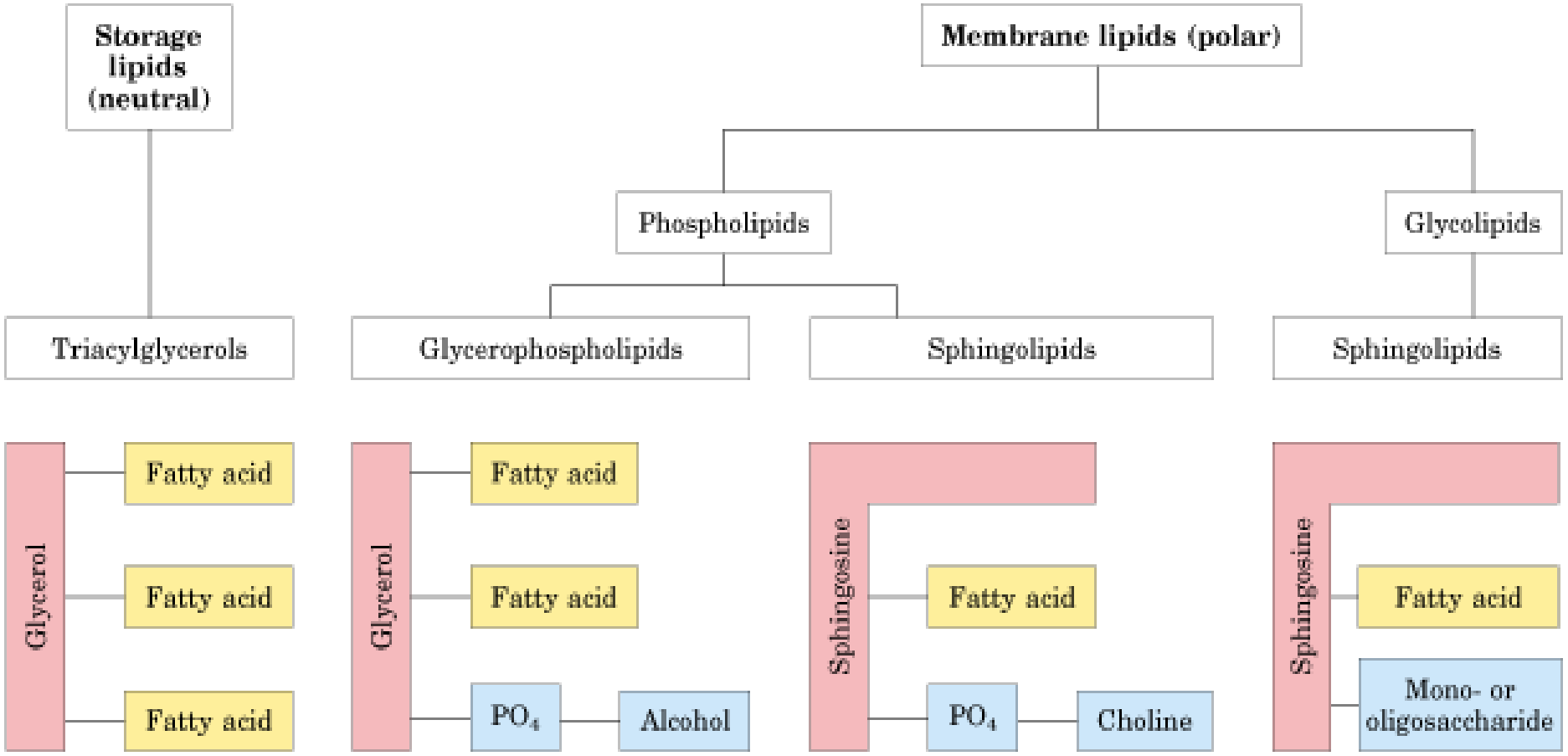
b) Glycolipids (Sphingoglycolipids):

- **Cerebrosides:** contains sphingosine, fatty acid and galactose (or glucose).
- **Gangliosides:** contains sphingosine, fatty acid and an oligosaccharide
- **Sulpholipids:**

Sulphur-containing glycolipids.



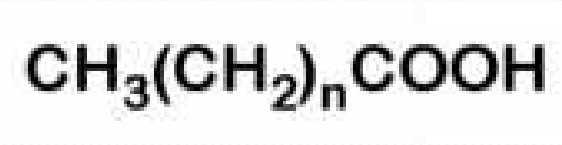
The principal classes of storage and membrane lipids



Fatty acids

Fatty acids are present in all organisms as components of storage and membrane lipids.

The naturally occurring **fatty acids** are carboxylic acids with unbranched hydrocarbon chains of 12–24 carbon atoms.



Most naturally occurring fatty acids have an **even number** of carbon atoms.

Some fatty acids contain one or more *double bonds*, and are therefore ***"unsaturated."*** Double bonds in fatty acids usually have the **cis** configuration.

Some naturally occurring fatty acids.

1. **<u>Saturated fatty acids:</u>** general formula $C_nH_{2n+1}COOH$; have no double bonds in the chain.

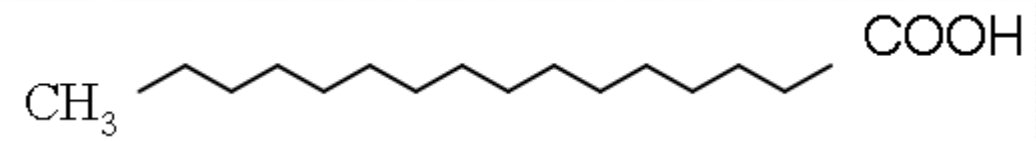
$C_{11}H_{23}COOH$ (**CH_3-$(CH_2)_{10}$-COOH**) - **lauric acid** (C_{12})

$C_{13}H_{27}COOH$ (**CH_3-$(CH_2)_{12}$-COOH**) - **myristic acid** (C_{14})

$C_{15}H_{31}COOH$ (**CH_3-$(CH_2)_{14}$-COOH**) - **palmitic acid** (C_{16})

$C_{17}H_{35}COOH$ (**CH_3-$(CH_2)_{16}$-COOH**) - **stearic acid** (C_{18})

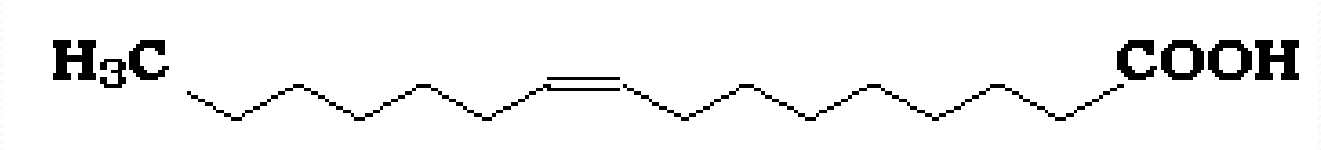
The conformation of carbon chain is a zigzag. For example- palmitic acid:



2. The unsaturated acids with one double bond (monounsaturated acids) - C_nH_{2n-1}-COOH:

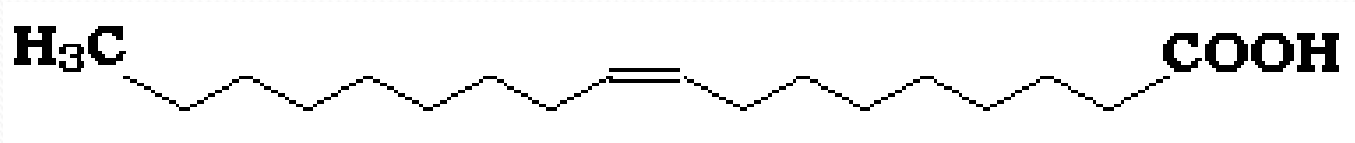
palmitoleic acid $C_{16}:\Delta^9$

$C_{15}H_{29}COOH$ **CH_3-$(CH_2)_5$-CH=CH-$(CH_2)_7$-COOH**

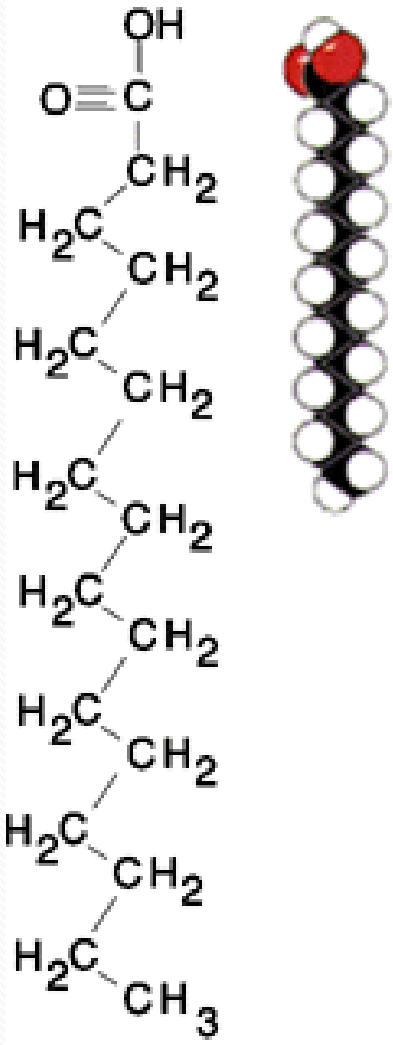


oleic acid $C_{18}:\Delta^9$

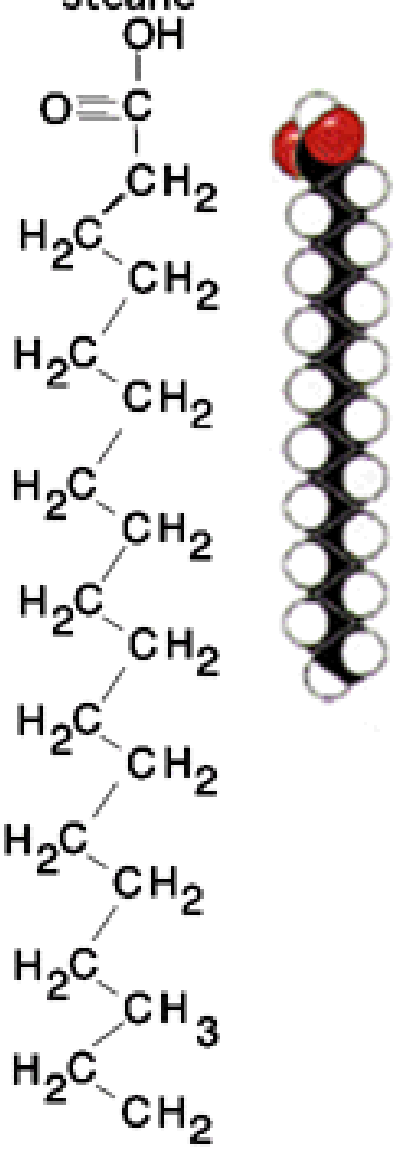
$C_{17}H_{33}COOH$ **CH_3-$(CH_2)_7$-CH=CH-$(CH_2)_7$-COOH**



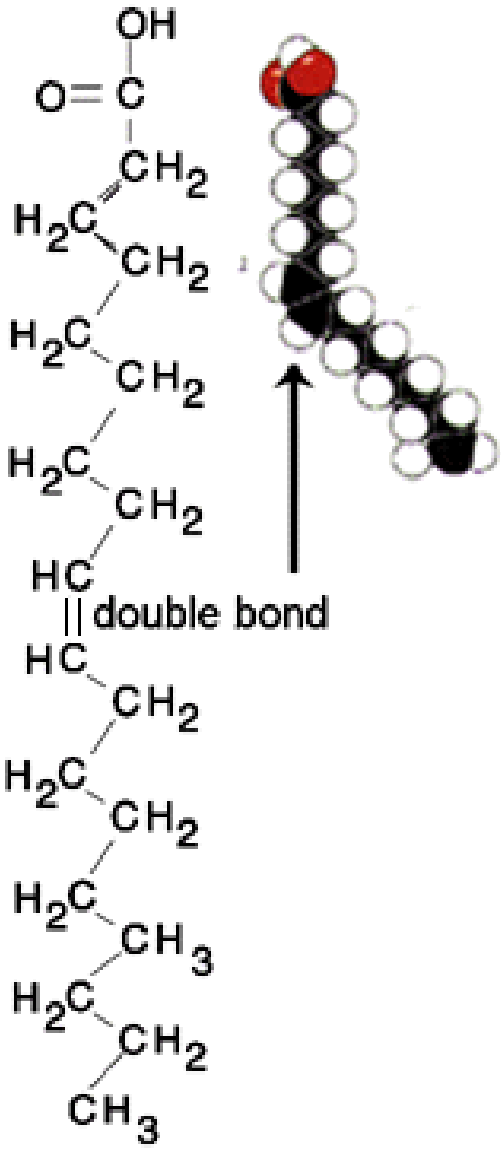
Palmitic



stearic



oleic

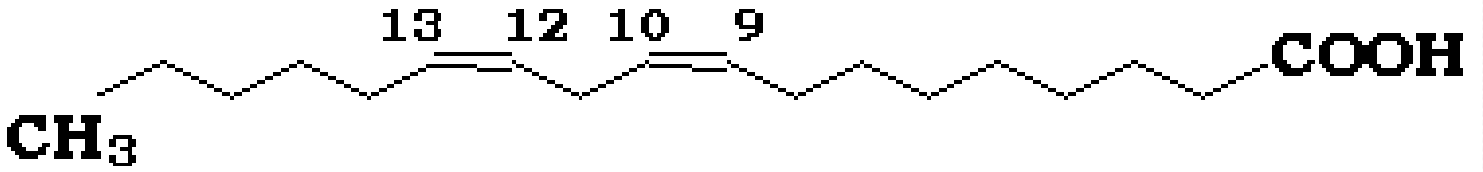


double bond

3. The unsaturated acid with two double bounds – C_nH_{2n-3}-COOH:

linoleic acid $C_{18}:\Delta^{9,12}$ $C_{17}H_{31}COOH$

CH_3-$(CH_2)_4$-CH=CH-CH_2-CH=CH-$(CH_2)_7$-COOH



4. The unsaturated acids with three double bounds – C_nH_{2n-5}-COOH:

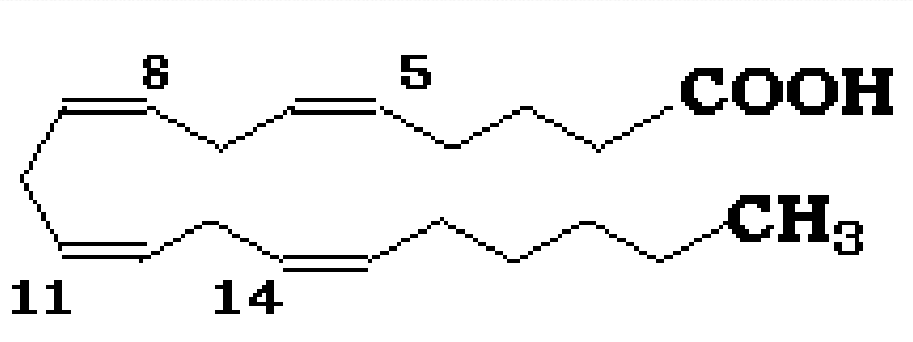
linolenic acid $C_{18}:\Delta^{9,12,15}$ $C_{17}H_{29}COOH$

CH_3-CH_2CH=CH=CH_2-CH=CH-CH_2-CH=CH-$(CH_2)_7$-COOH

5. The unsaturated acids with four double bounds

C_nH_{2n-7}-COOH:

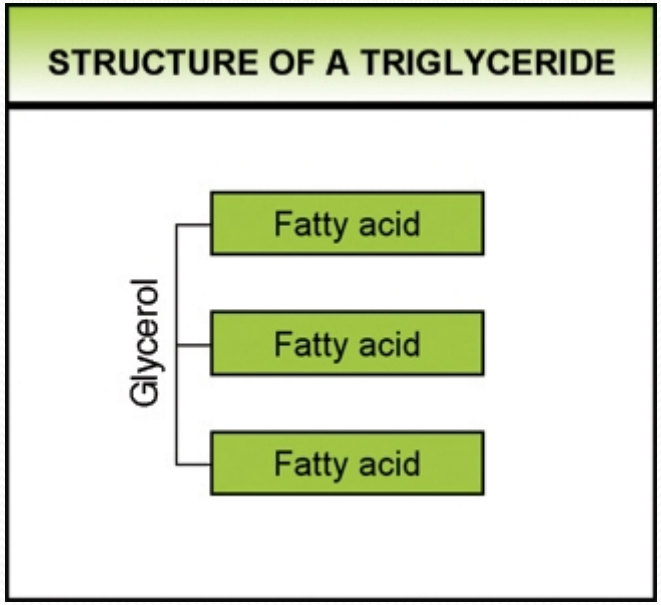
arahidonic acid $C_{20}:\Delta^{5,8,11,14}$ $C_{19}H_{31}COOH$

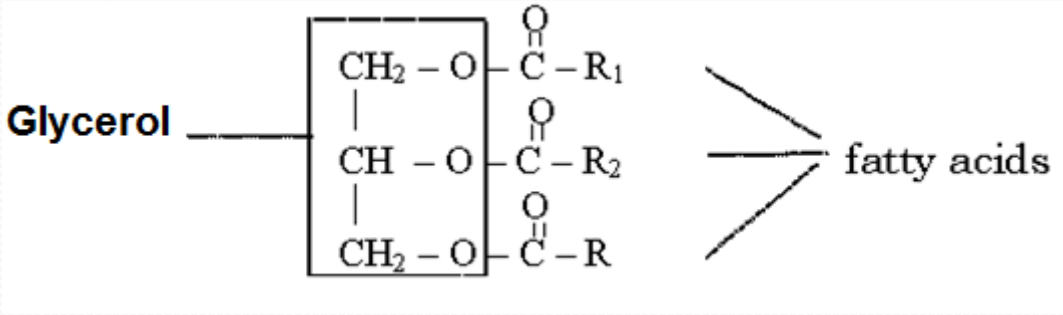


All polyunsaturated fatty acids: *arachidonic, linoleic* and *linolenic acid* **are essential fatty acids** - they are not produced in human organism and have to be supplied in the diet. They are indispensable components of nutrition.

Storage Lipids

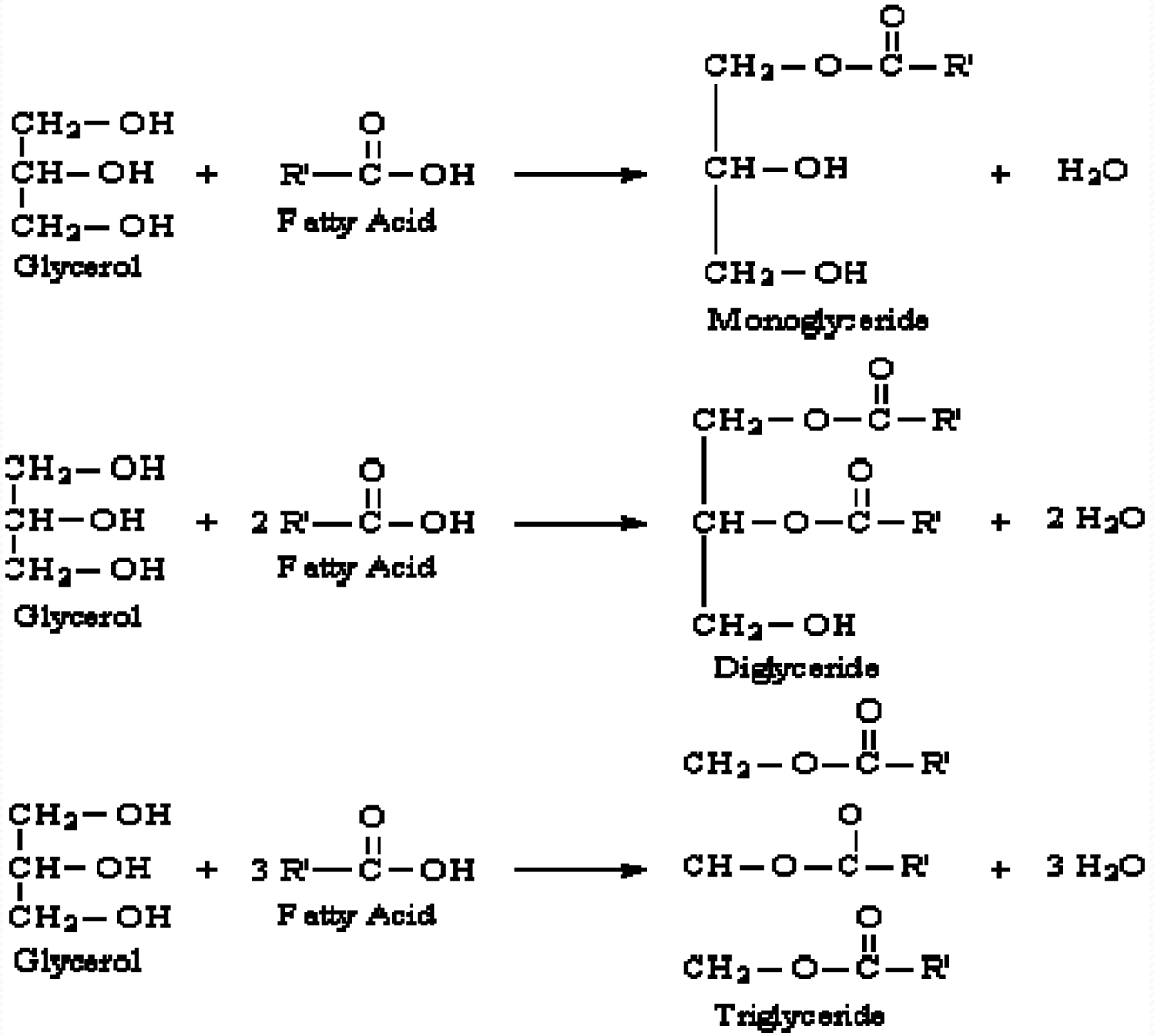
Animal fats and vegetable oils are the most widely occurring lipids. Although they look different – animal fats such as butter and lard (fat) are solids, and vegetable oils are liquids – their structures are closely related. Chemically, fats and oil are triacylglycerols (also called triglycerides), esters of glycerol with three long-chain carboxylic acids.





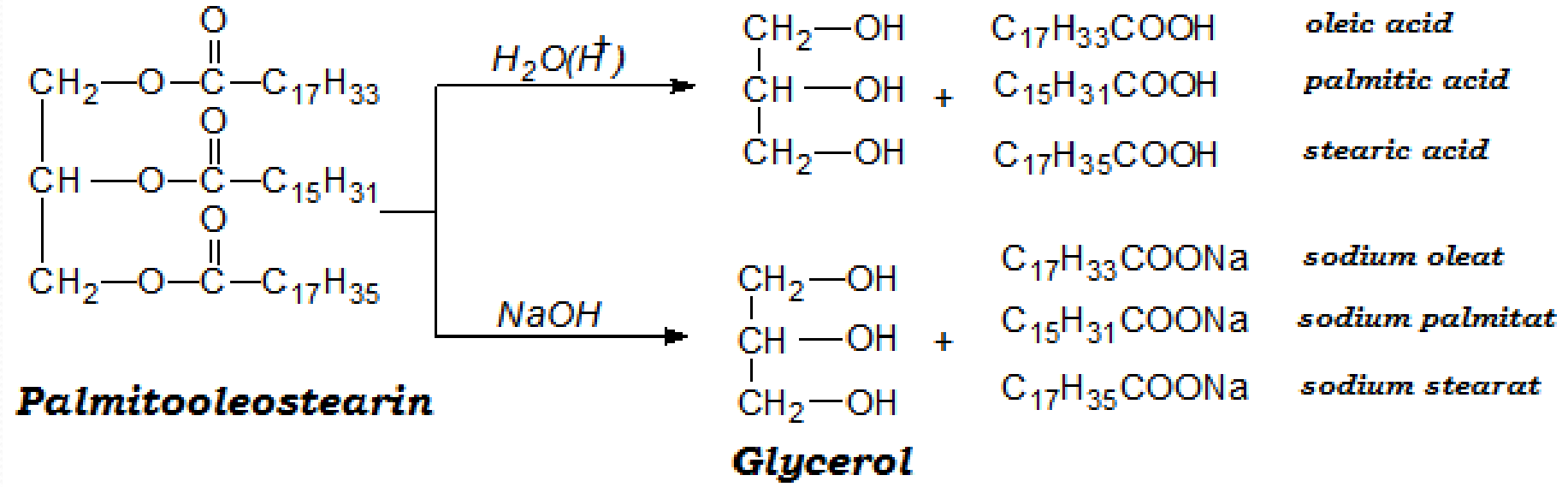
Triglycerides are completely unpolar, hydrophobic compounds, called neutral lipids.

Triacylglycerols Are Fatty Acid Esters of Glycerol

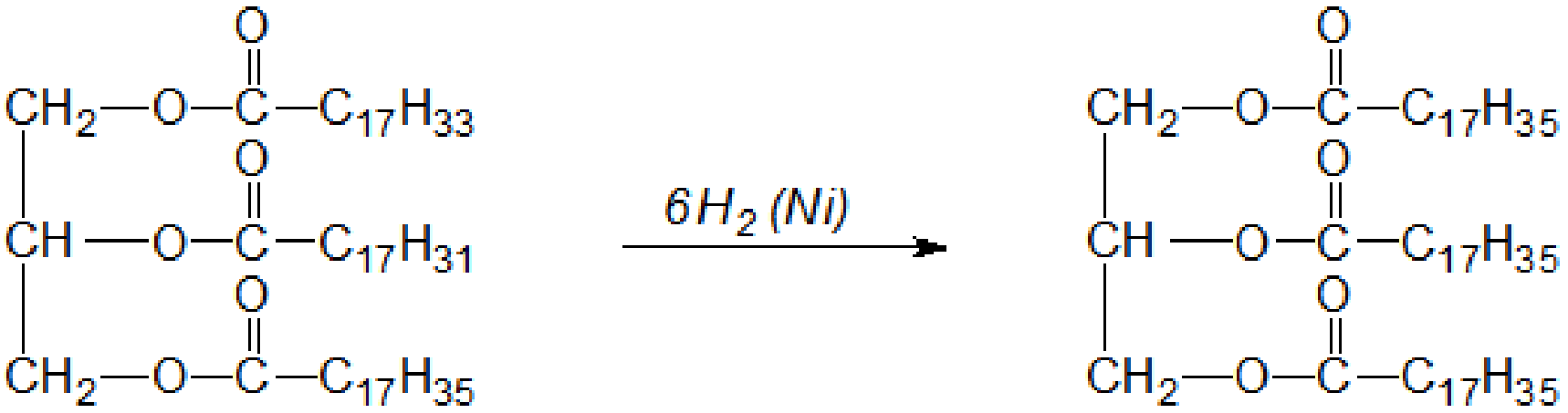


The chemical properties of triglyceride

1. One of the most important properties of triacylglycerols is their chemical hydrolysis in the both acid and basic medium. For example:



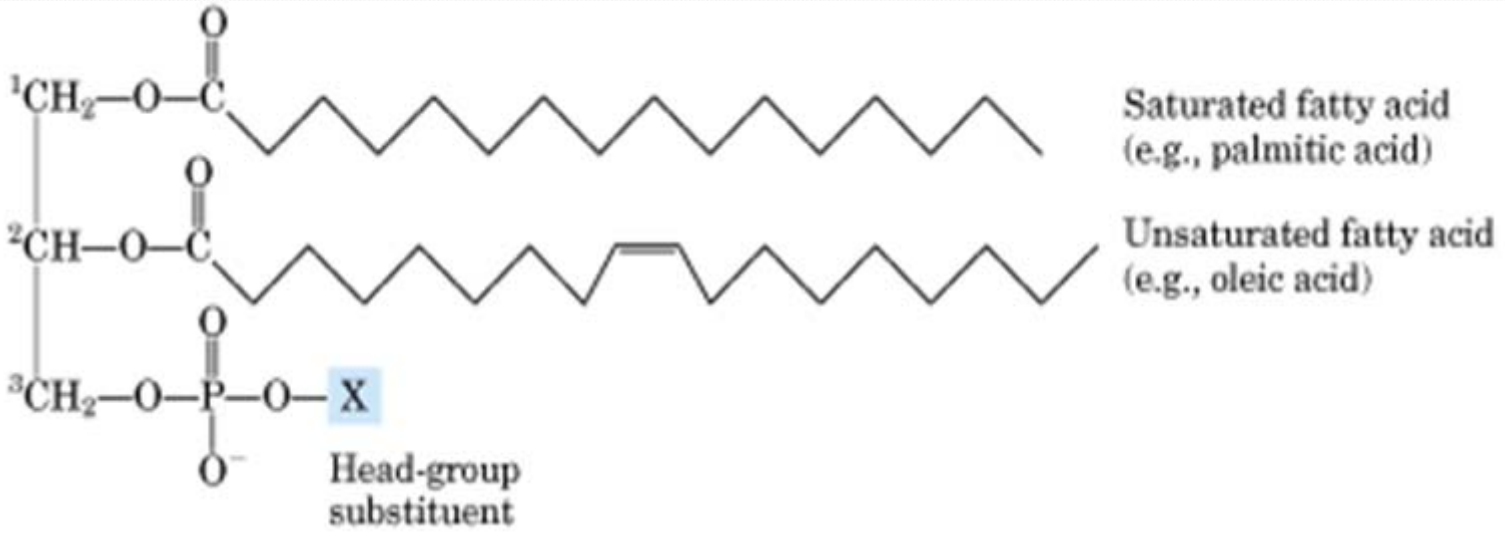
2. The second major reaction is the reaction of hydrogenation of fats, which are used in the conversion of liquid oils into solid fat:

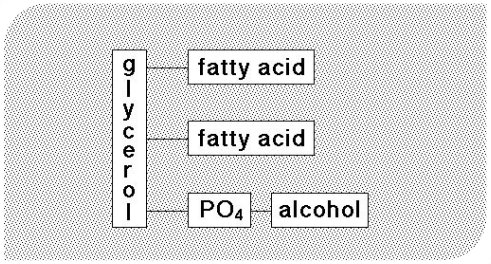


Oleolinostearin ***Tristearin***

Glycerophospholipids

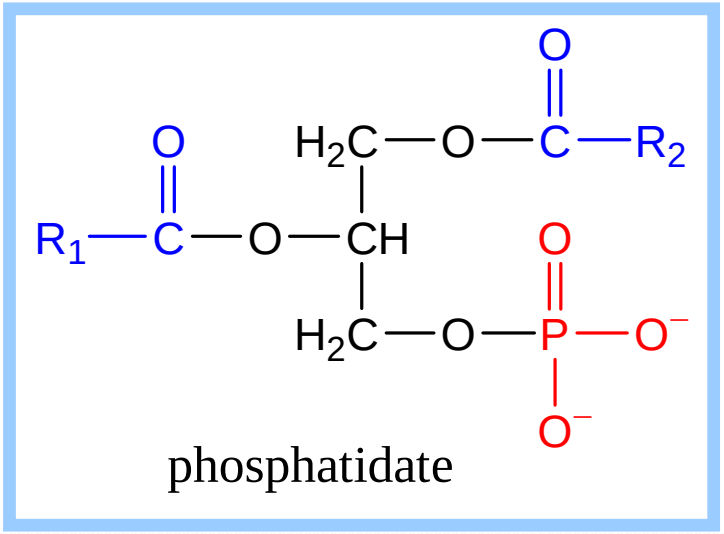
- are common constituents of cellular membranes. They are composed of glycerol, fatty acids and phosphoric acid bound to a **polar head group – an alcohol** (**X**):





Glycerophospholipids Are Derivatives of Phosphatidic Acid

Glycerol + 2 fatty acids + phosphoric acid = **phosphatidic acid** or *phosphatidat:*

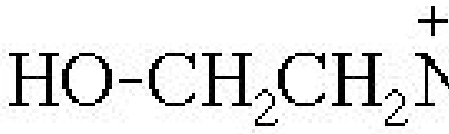


phosphatidate

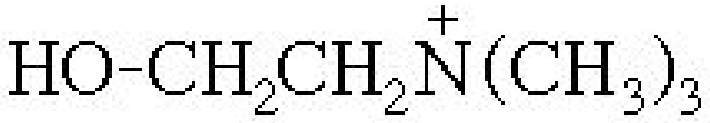
In phosphatidic acid the hydroxyls at **C1** & **C2** of glycerol are esterified to **fatty acids and** the **C3** hydroxyl is esterified to **Pi**.

Pi is in turn esterified to **OH** of a **polar head group** (**X**):

serine, choline, ethanolamine or inositol.

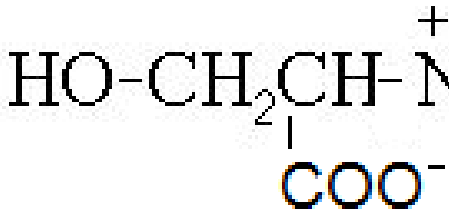


Ethanolamine

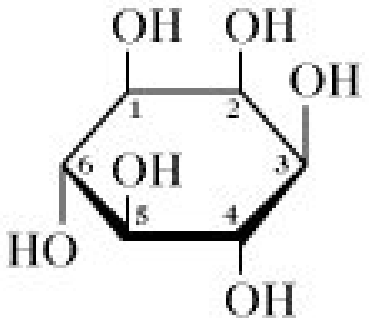


Choline

Aminoalcohols

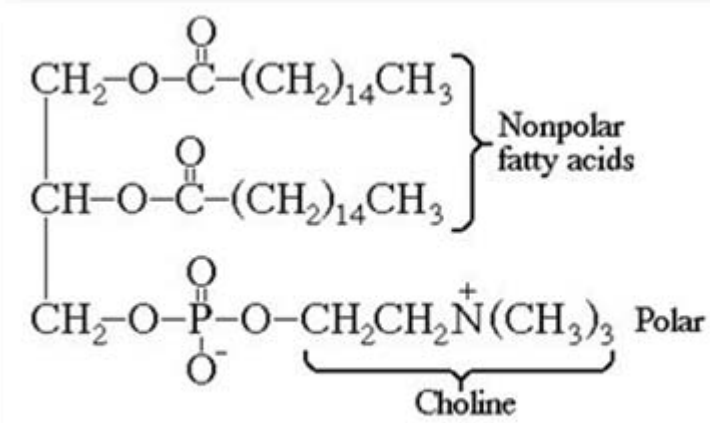


Serine **Hydroxyamino acid**

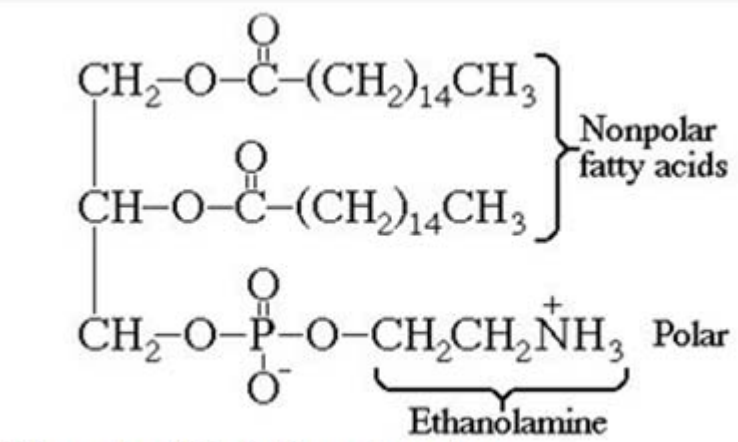


Inositol **Cyclic poly alcohol**

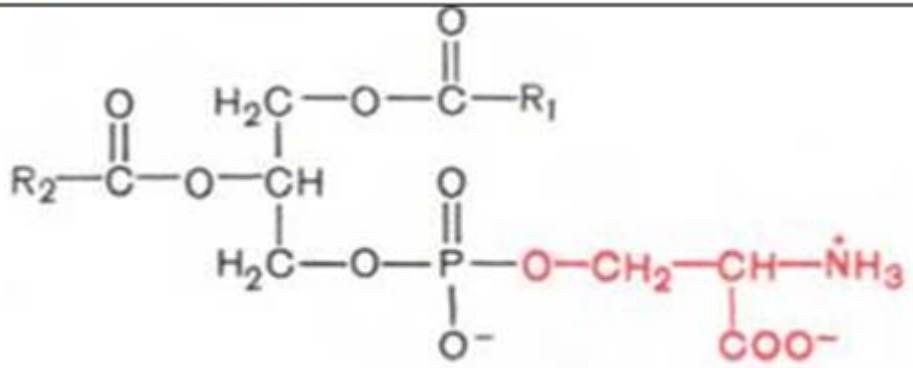
Glycerophospholipids are named for their polar head groups:



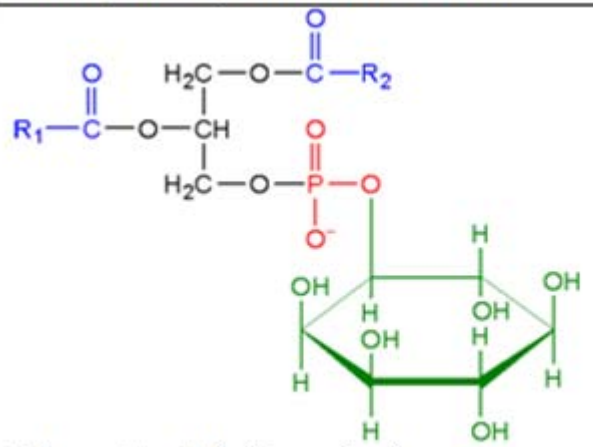
Phosphatidylcholine



Phosphatidylethanolamine



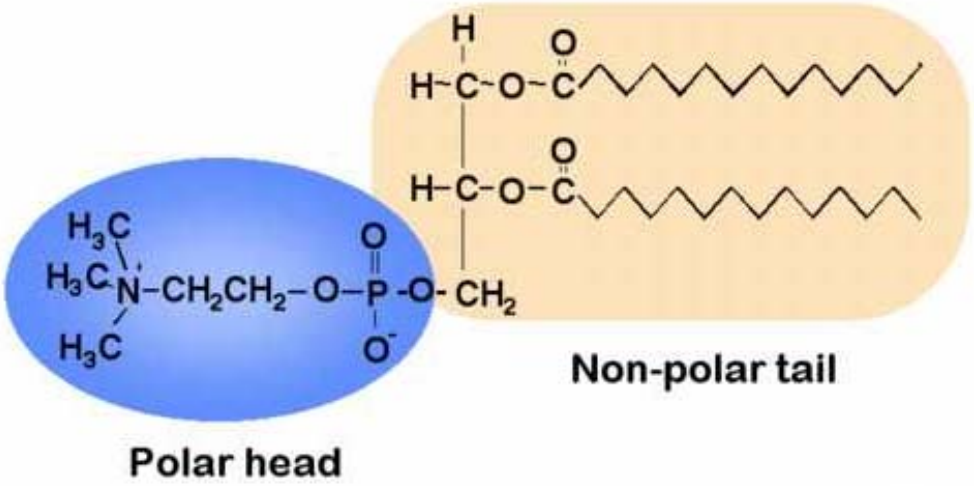
Phosphatidylserine



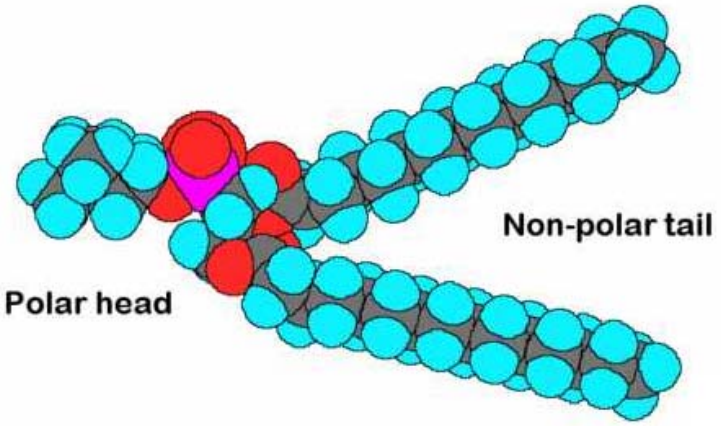
Phosphatidylinositol

Each glycerophospholipid includes:

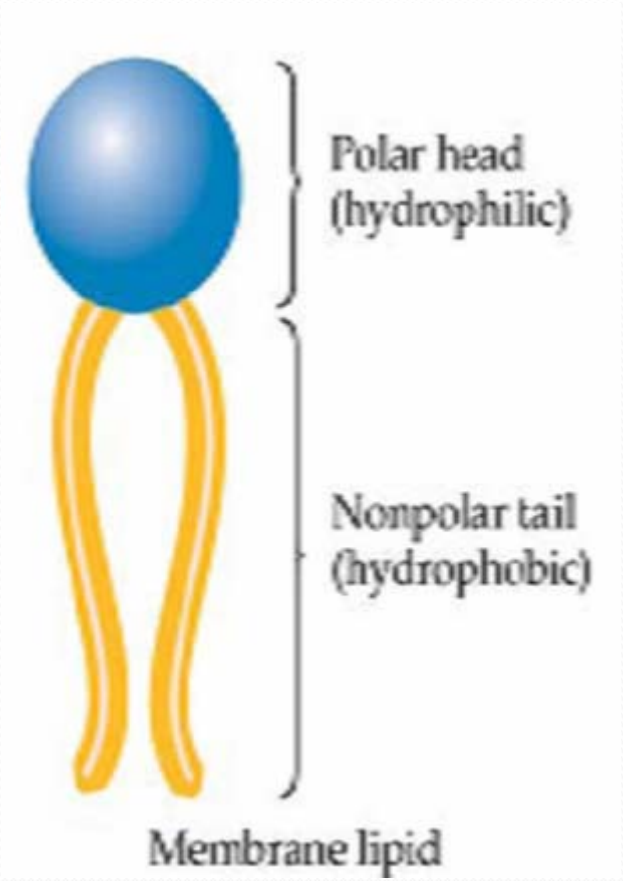
- a **polar** region: P_i, and the polar head group (**X**)
- **non-polar** hydrocarbon tails of fatty acids (R_1, R_2).

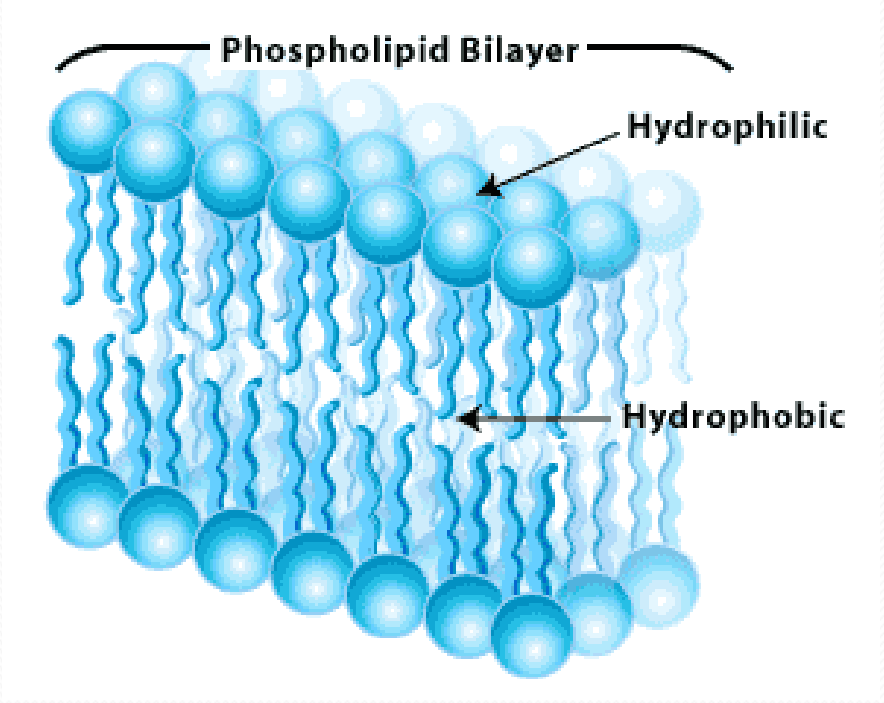


phosphatidylcholine

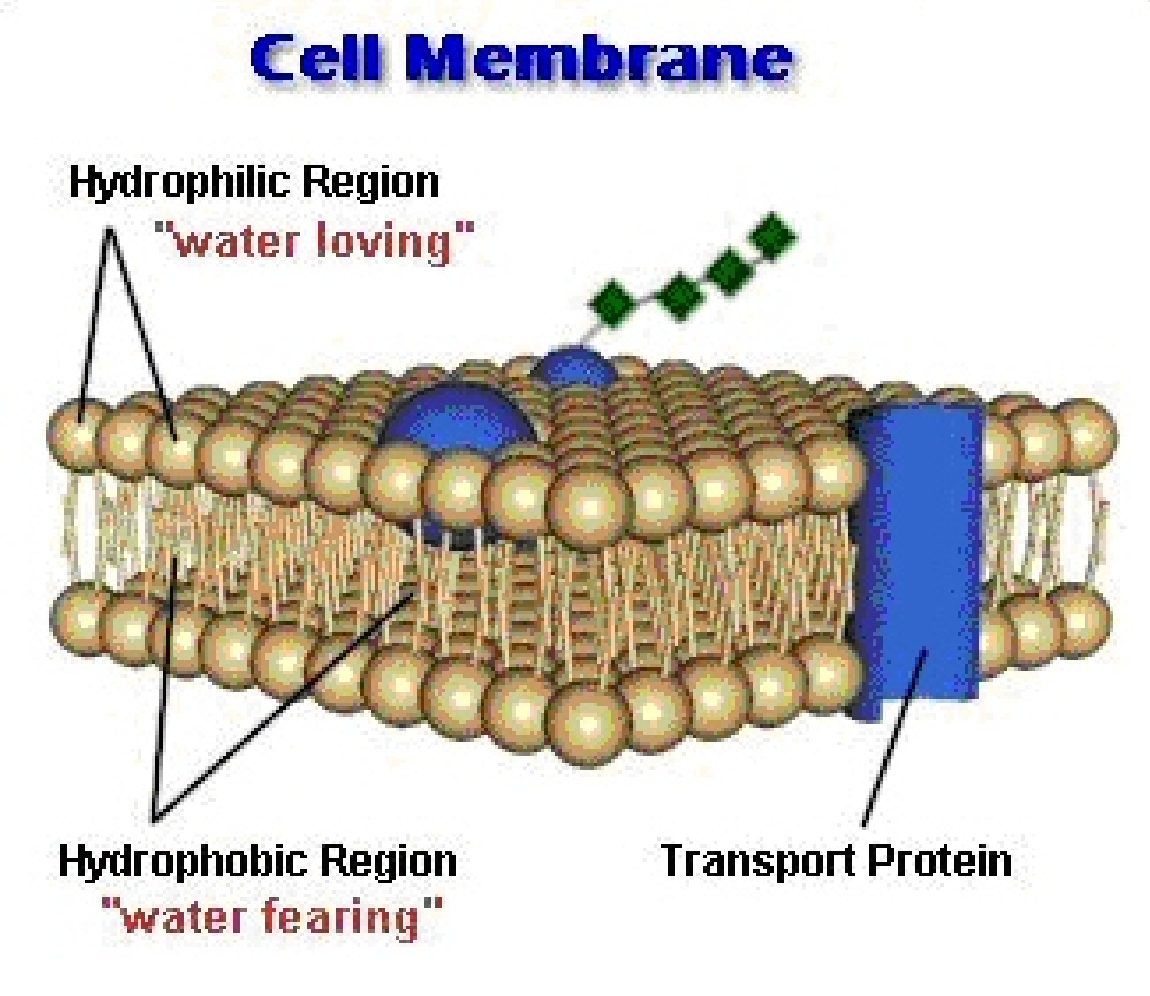


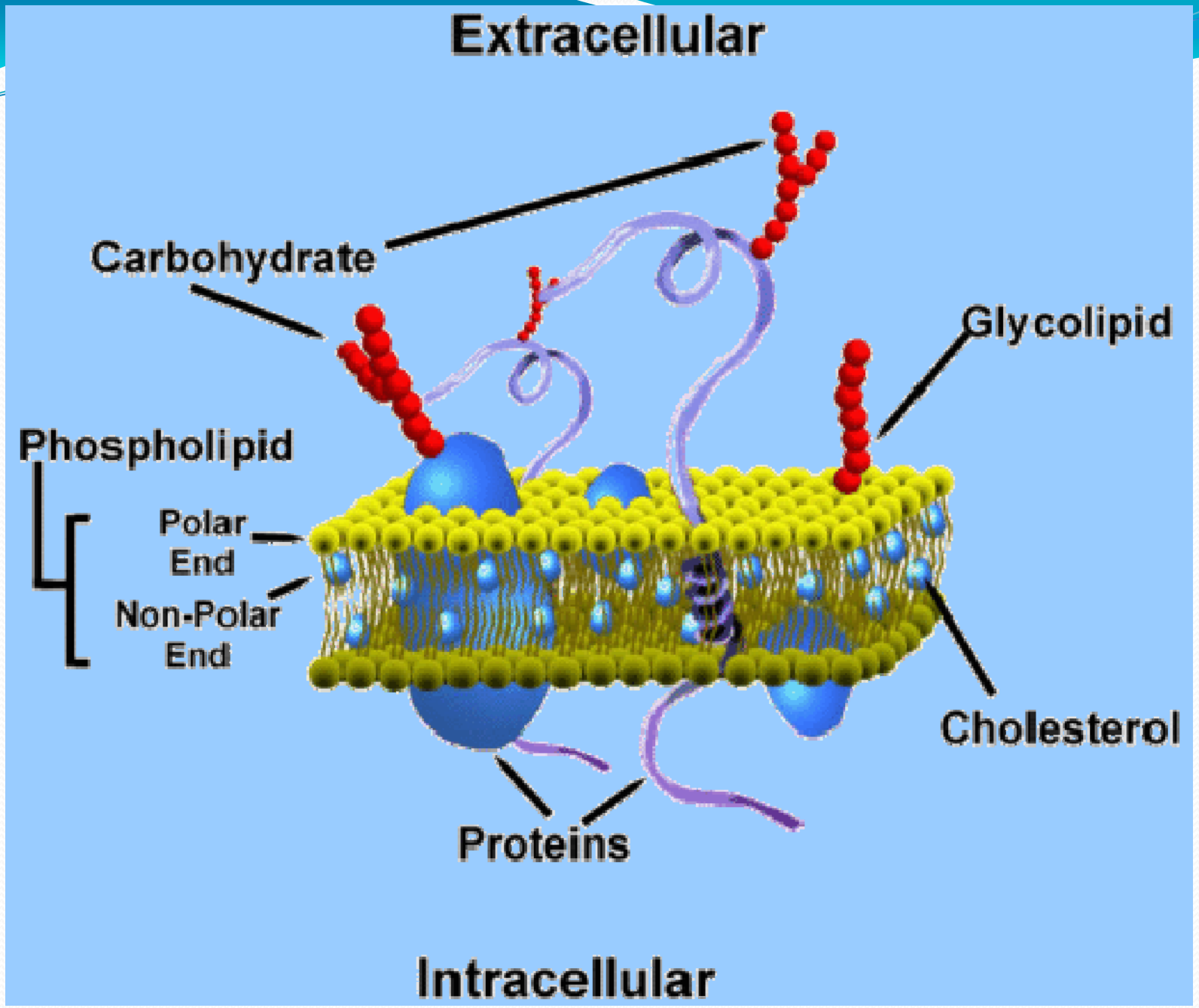
Glycerophospholipids are amphipathic - they have **hydrophilic (polar)** and **hydrophobic (nonpolar)** portions located at separate parts of each molecule. As a result, the lipid components are arranged in a continuous **bimolecular bilayer**. The polar portions of the constituent molecules lie in the two bilayer faces, while the nonpolar portions constitute the interior of the bilayer.





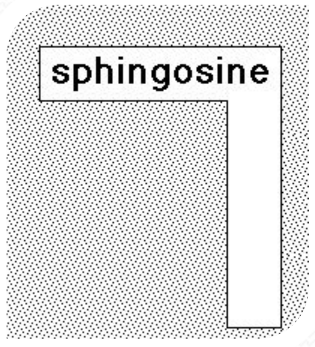
The lipidic bilayer forms the cell membranes:

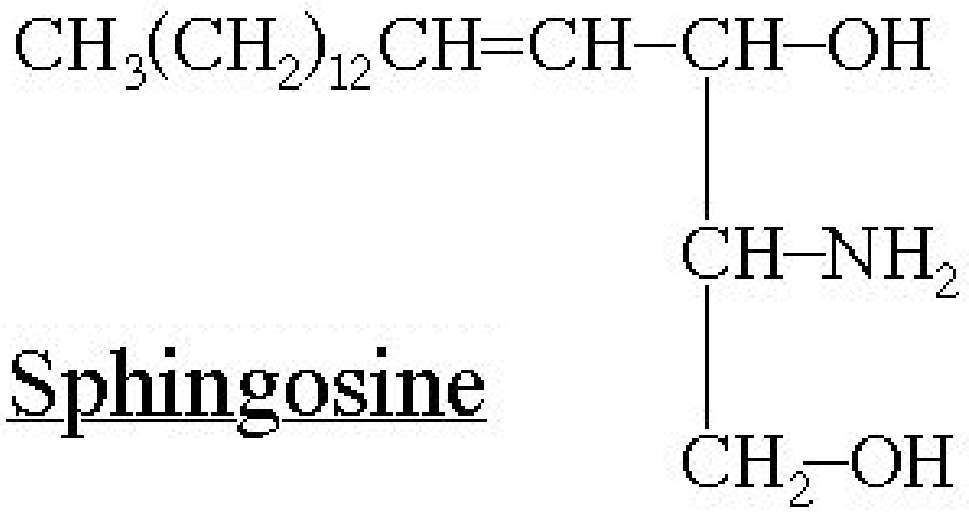



Extracellular
Carbohydrate
Glycolipid
Phospholipid
Polar End
Non-Polar End
Cholesterol
Proteins
Intracellular

Sphingolipids

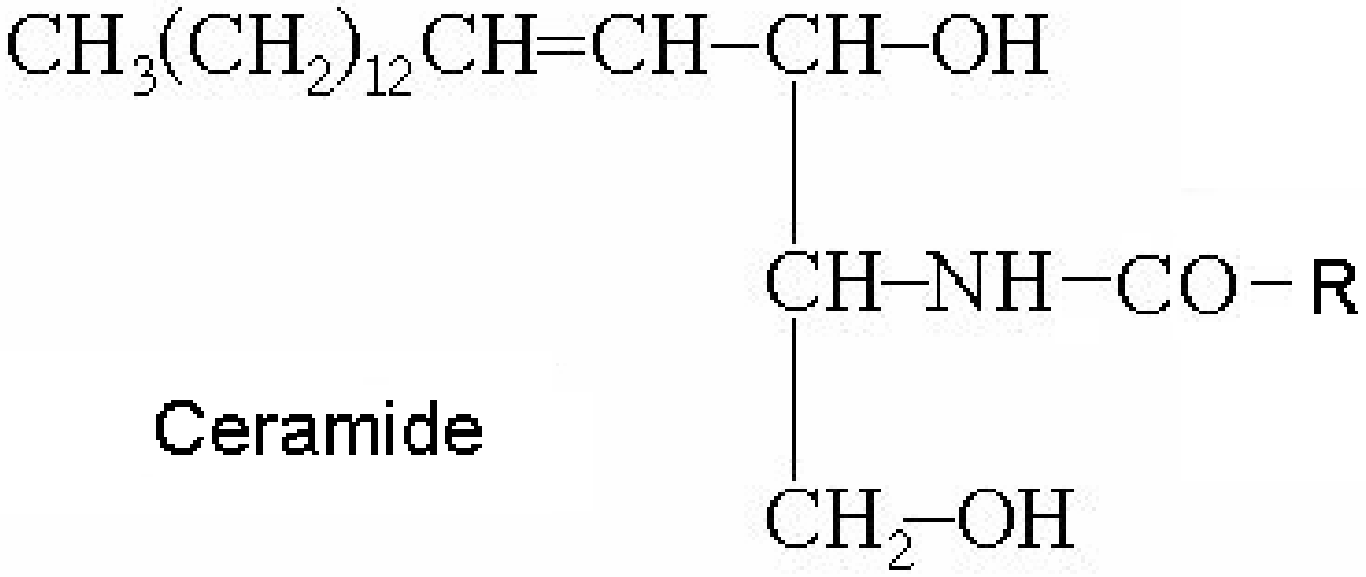
- **- sphingophospholipids (sphingomyelins) and glycolipids -** are the second large class of membrane lipids, also have a polar head and two nonpolar tails, but unlike glycerophospholipids they contain no glycerol.
- **All sphingolipids** contain one molecule of the long-chain unsaturated amino alcohol **sphingosine**.



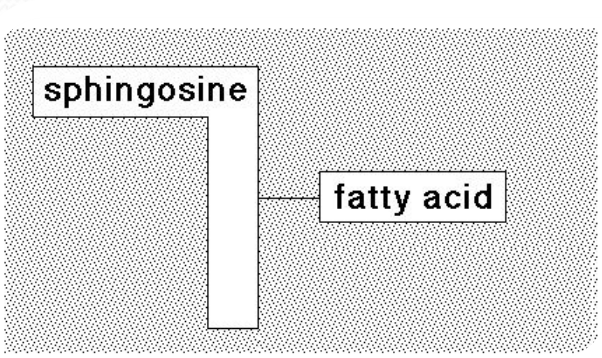


Sphingosine

In all sphingolipids sphingosine is bound by a amide bond to a fatty acid and forms a **ceramide**:

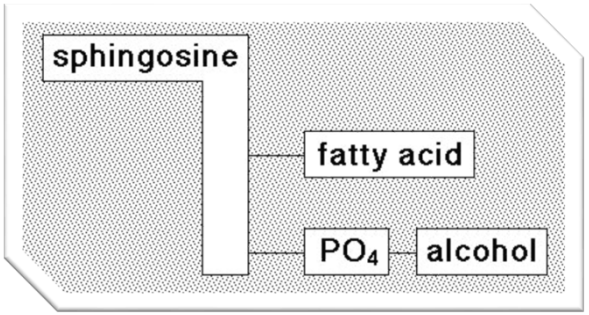


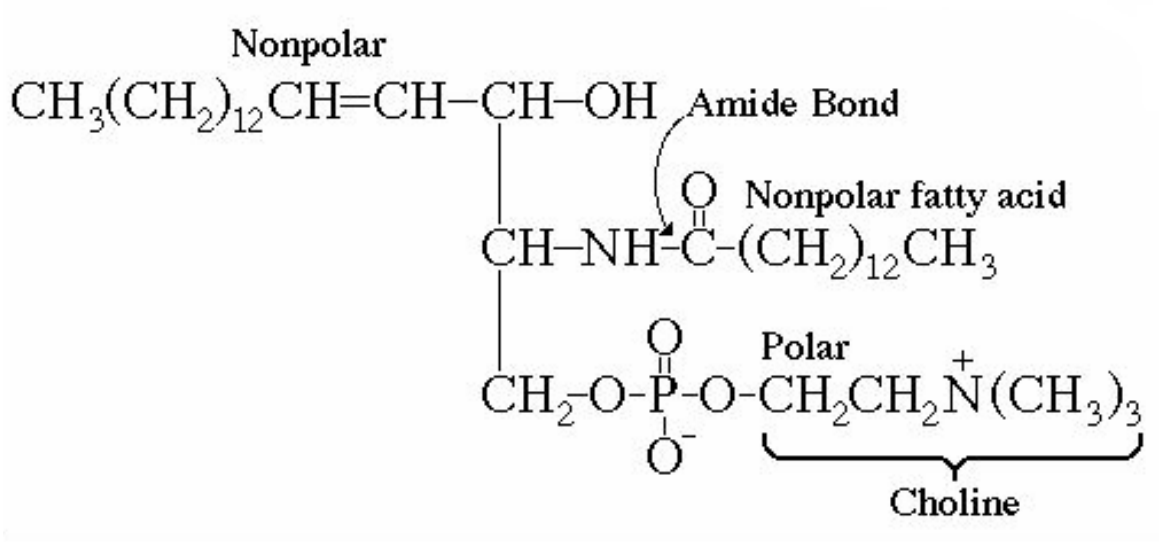
Ceramide



Sphingolipids Are Derivatives of Sphingosine

- **Sphingophospholipids (**Sphingomyelins) contain phosphocholine or phosphoethanolamine as their polar head group, and are therefore classified as phospholipids.



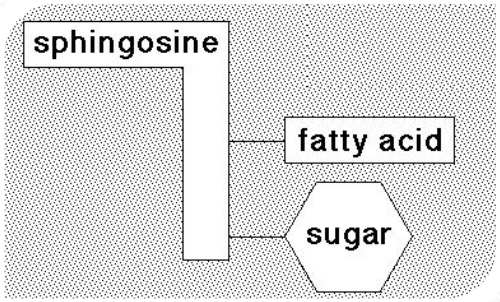


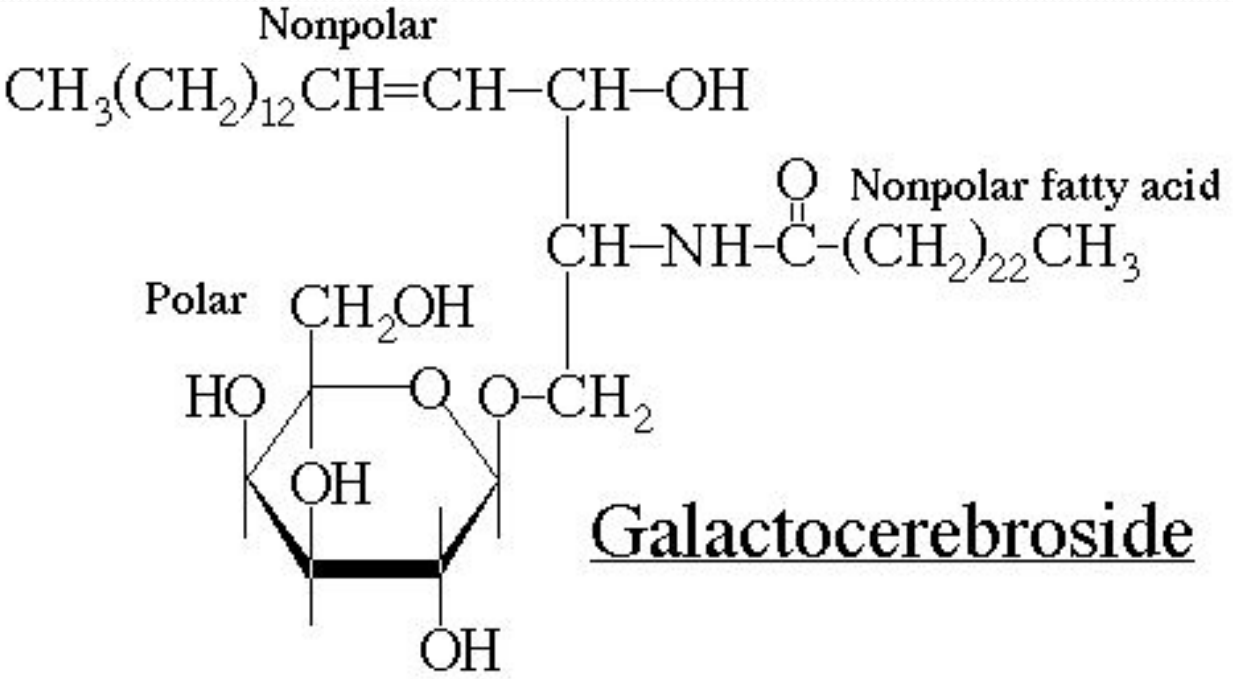
- Sphingomyelins are present in plasma membranes of animal cells; the myelin sheath which surrounds and insulates the axons of myelinated neurons is a good source of sphingomyelins, and gives them their name.

Glycolipids

Glicolipids (sphingoglycolipids) occur largely in the outer surface of the plasma membrane.

- **Cerebrosides** have a single sugar (glucose or galactose) linked to ceramide:





▣ **Gangliosides**, the most complex sphingolipids, contain a ceramide and an **olygosaccharide frag**ment. Gangliosides make up about 6% of the membrane lipids in the gray matter of the human brain and play an important role in molecular recognition.

Glycosphingolipids are the determinants of blood types