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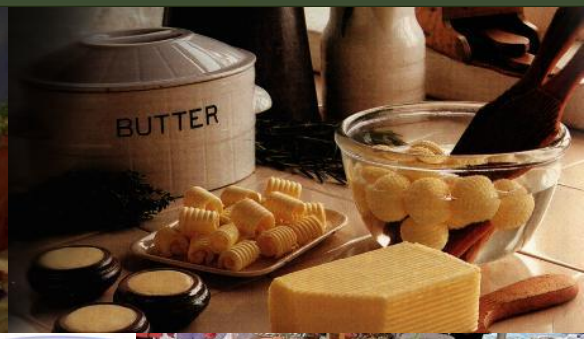
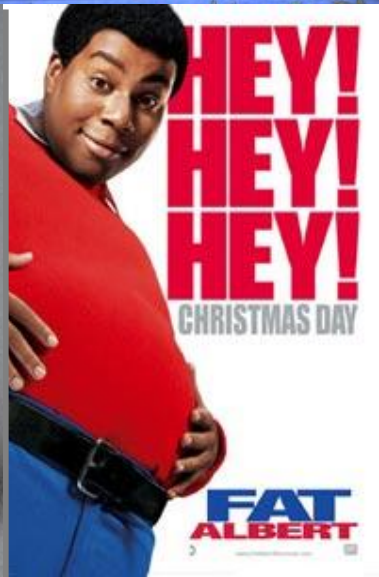
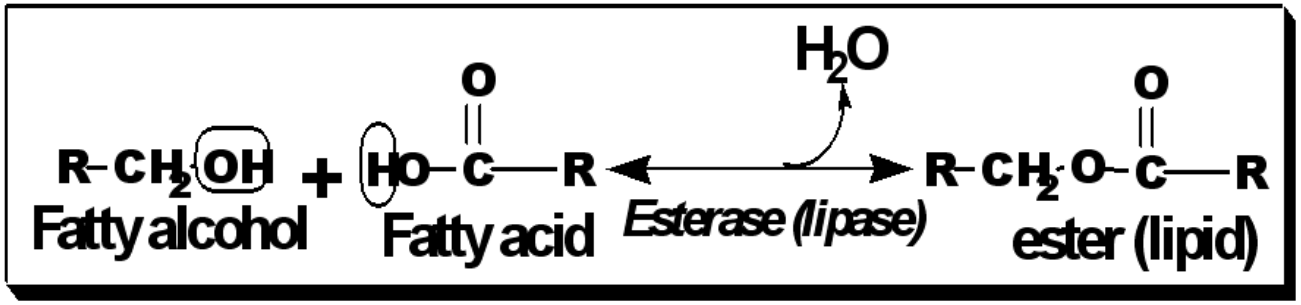
Lipids





Lipids – Definition & General Properties

- A heterogeneous class of naturally occurring organic compounds formed mainly from alcohol & fatty acids combined together by ester linkage



- They are Amphipathic in nature
- Insoluble in water, but soluble in fat or organic solvents (ether, chloroform, benzene, acetone)
- They are not all fats! They include fats, oils, waxes & related compounds
- They are widely distributed in nature both in plants & in animals

Lipids – function & biological importance

1) They are storable to unlimited amount (carbohydrates)
2) They have a high-energy value (25% of body needs) & they provide more energy per gram (carbohydrates & proteins)
3) Supply the essential fatty acids
4) Supply the body with fat-soluble vitamins (A, D, E & K)
5) They are important constituents of the nervous system
6) Tissue fat is an essential constituent of cell membrane (mainly phospholipids in nature that are not affected by starvation)

Lipids – function & biological importance

7) Stored lipids are in all human cells & acts as:
   A. A store of energy
   B. A pad for the internal organs
   C. A subcutaneous thermal insulator against loss of body heat

8) Lipoproteins are important cellular constituents

9) Cholesterol: cell membrane structure & synthesis of adrenal cortical hormones, vitamin D3 & bile acids

10) Lipids provide bases for dealing with diseases such as obesity, atherosclerosis, lipid-storage diseases, essential fatty acid deficiency, respiratory distress syndrome

Classification of Lipids

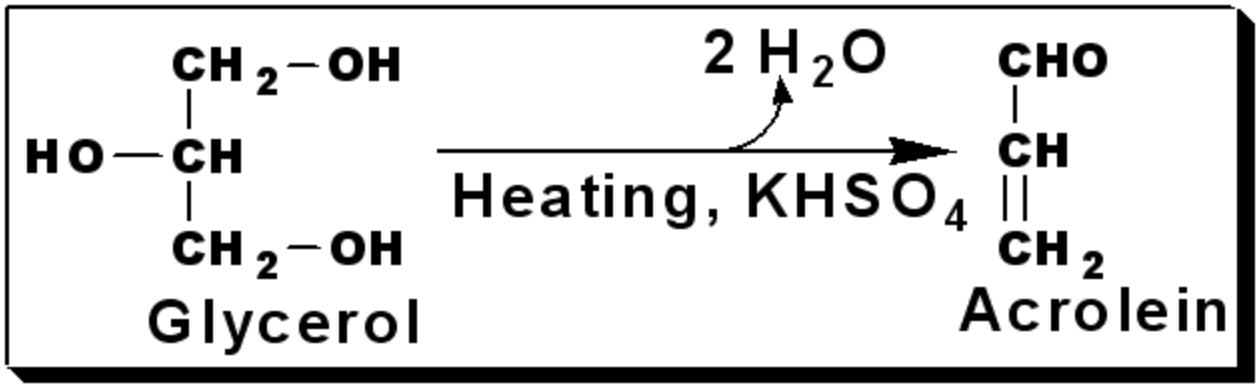
- Lipids include:
  - ✓ Open Chain forms
    - Fatty acids, triacylglycerols, sphingolipids, phosphoacylglycerols, glycolipids,
    - Lipid-soluble vitamins
    - Prostaglandins, leukotrienes, & thromboxanes
  - ✓ Cyclic forms
    - Cholesterol, steroid hormones, & bile acids

- Lipids include:
  - ✓ Simple lipids (Fats & Waxes)
  - ✓ Compound or conjugated lipids
  - ✓ Derived Lipids
  - ✓ Lipid-associating substances

- Lipids include:
  - ✓ Storage Lipids
  - ✓ Structural Lipids in Membranes
  - ✓ Lipids as Signals, Cofactors & Pigments

Fatty alcohols - Glycerol

- It is a trihydroxylic alcohol & has the popular name glycerin
- Synthesized in the body from glucose



- Properties:

1) Colorless viscous oily liquid with sweet taste
2) On heating with sulfuric acid or $KHSO_4$ (dehydration) it gives acrolein that has a bad odor (detection)
3) Combines with three molecules of nitric acid to form trinitroglycerin that is used as a vasodilator

Glycerol

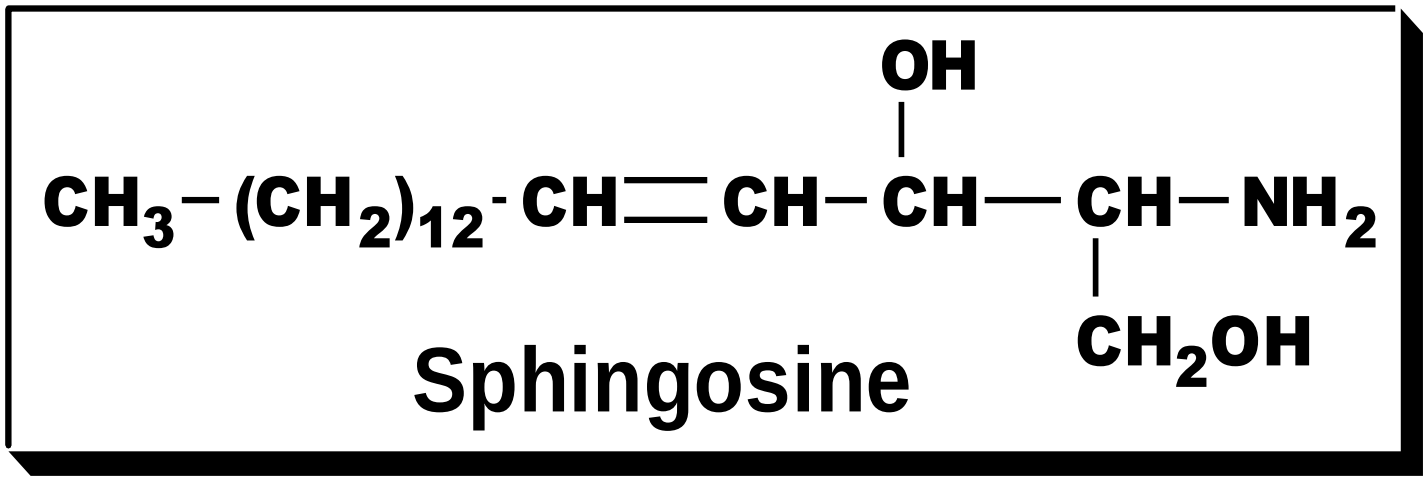
4) It has a nutritive value by conversion into glucose & enters in structure of phospholipids

5) On esterification with fatty acids it gives:

   A. Monoglyceride or monoacyl-glycerol: one fatty acid + glycerol
   B. Diglyceride or diacyl-glycerol: two fatty acids + glycerol
   C. Triglyceride or triacyl-glycerol: three fatty acids + glycerol

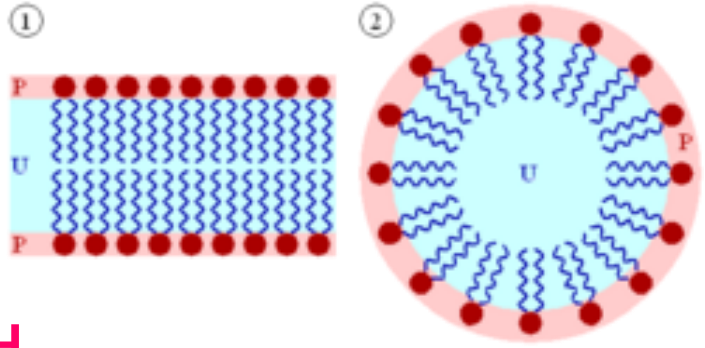
Fatty alcohols - Sphingosine

- It is the alcohol (monohydric) present in sphingolipids
- It is synthesized in the body from serine & palmitic acid
- It is not positive with acrolein test

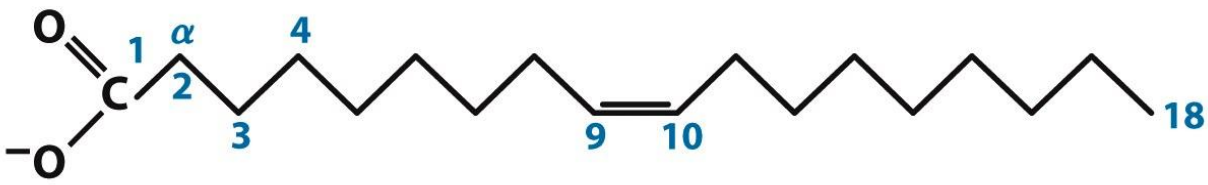


Fatty Acids

- Aliphatic mono-carboxylic acids
- Mostly obtained from hydrolysis of natural fats & oils

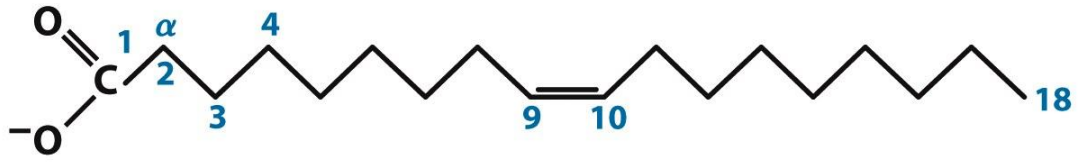


- Have the general formula $R\text{-}(CH_2)_n\text{-}COOH$, where "n" is mostly an even number of carbon atoms (2-34)
- Mostly have straight chain (a few exceptions have branched & heterocyclic chains)
- They are an excellent examples of amphipathic molecules (bilayers & micelles)

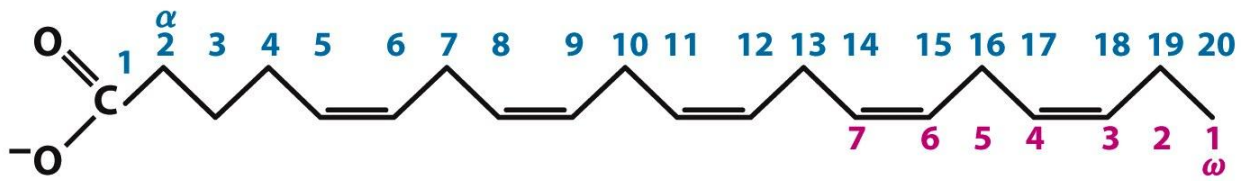


Fatty Acid Structure

- Carboxylic Acids (COOH is C1)
- Hydrocarbon tails (C4 - C36)
- Saturated fatty acids N:0
- Unsaturated Fatty acids. In most unsaturated fatty acids, the cis isomer predominates; the trans isomer is rare
- Double bonds specified by (Δ^n)
- Branches



(a) 18:1(Δ^9) *cis*-9-Octadecenoic acid



(b) 20:5($\Delta^{5,8,11,14,17}$) Eicosapentaenoic acid (EPA), an omega-3 fatty acid

Fatty Acids - Physical Properties

- **Solubility**
  - ✓ **Longer chains**
    - ○ **The more hydrophobic, the less soluble**
  - ✓ **Double bonds increase solubility**

- **Melting points**
  - ✓ **Depend on chain length & saturation**
  - ✓ **Double bonds lead to low melting temps**

Typical Naturally Occurring Saturated Fatty Acids

Acid	Number of Carbon Atoms	Formula	Melting Point (°C)
Lauric	12	$CH_3(CH_2)_{10}CO_2H$	44
Myristic	14	$CH_3(CH_2)_{12}CO_2H$	58
Palmitic	16	$CH_3(CH_2)_{14}CO_2H$	63
Stearic	18	$CH_3(CH_2)_{16}CO_2H$	71
Arachidic	20	$CH_3(CH_2)_{18}CO_2H$	77

Typical Naturally Occurring Unsaturated Fatty Acids

Acid	Number of Carbon Atoms	Degree of Unsaturation*	Formula	Melting Point (°C)
Palmitoleic	16	16:1—Δ^9	$CH_3(CH_2)_5CH{=}CH(CH_2)_7CO_2H$	−0.5
Oleic	18	18:1—Δ^9	$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$	16
Linoleic	18	18:2—$\Delta^{9,12}$	$CH_3(CH_2)_4CH{=}CH(CH_2)CH{=}CH(CH_2)_7CO_2H$	−5
Linolenic	18	18:3—$\Delta^{9,12,15}$	$CH_3(CH_2CH{=}CH)_3(CH_2)_7CO_2H$	−11
Arachidonic	20	20:4—$\Delta^{5,8,11,14}$	$CH_3(CH_2)_4CH{=}CH(CH_2)_4(CH_2)_2CO_2H$	−50

Classification - Double Bonds

1) **Saturated Fatty Acids**
   A. They contain no double bonds with 2-24 or more carbons
   B. They are solid at room temperature except if they are short chained
   C. They may be even or odd numbered
   D. They have the following molecular formula, $C_nH_{2n+1}COOH$
   E. They are either:
      i. Short chain F.A. (1-6 carbons)
      ii. Medium-chain F.A. (7-10 carbons)
      iii. Long chain F.A.(more the 10 carbon)

Short & Medium chain F.A.

SHORT CHAIN F.A.

- They are liquid in nature
- Water-soluble
- Volatile at room temperature
- Examples: acetic, butyric, & caproic acids

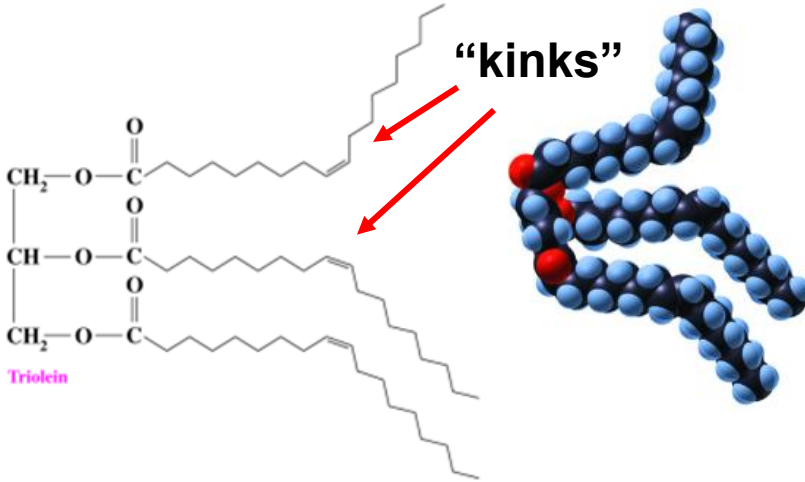
Acetic F.A. (2C) CH_3-COOH
Butyric F.A. (4C) CH_3-$(CH_2)_2$-COOH
Caproic F.A. (6C) CH_3-$(CH_2)_4$-COOH

MEDIUM-CHAIN F.A.

- They are solids at room temperature
- Water-soluble
- Non-volatile at room temperature
- Examples: caprylic & capric F.A.

Caprylic (8 C) CH_3-$(CH_2)_6$-COOH
Capric (10 C) CH_3-$(CH_2)_8$-COOH

Long-chain & Unsaturated F.A.



LONG CHAIN

- They occur in hydrogenated oils, animal fats, butter & coconut & palm oils
- They are non-volatile & water-insoluble
- Examples: palmitic, stearic, & lignoceric F.A.

Palmitic (16C) $CH_3-(CH_2)_{14}-COOH$
Stearic (18 C) $CH_3-(CH_2)_{16}-COOH$
Lignoceric (24C) $CH_3-(CH_2)_{22}-COOH$

2. UNSATURATED

- Monounsaturated: they contain one double bonds with the formula (C_nH_{2n-1} COOH)
- Polyunsaturated: they contain more the one double bond ($C_nH_{2n-\text{more than 1}}$ COOH)
- Do not pack closely

Monounsaturated fatty acids

1) **Palmitoleic acid** :

$CH_3\text{-}(CH_2)_5CH = CH\text{-}(CH_2)_7\text{–}COOH$

- It is found in all fats
- It is C16:1Δ^9, (16 Cs & one double bond at C9-10)

2) **Oleic acid:**

- Is the most common fatty acid in natural fats
- It is C18:1Δ^9

$CH_3\text{-}(CH_2)_7\text{- }CH{=}CH\text{ – }(CH_2)_7\text{-}COOH$

3) **Nervonic acid:** (Unsaturated lignoceric acid)

- It is found in cerebrosides
- It is C24:1Δ^{15}

$CH_3\text{ – }(CH_2)_7\ CH{=}\ CH\text{ – }(CH_2)_{13}\text{- }COOH$

Polyunsaturated fatty acids

- Essential fatty acids:
  - Can not be synthesized
  - They are required for normal growth & metabolism
  - Source: vegetable oils, cod liver oil & animal fats
  - Deficiency: leads to nutrition deficiency disease
  - Its symptoms include: poor growth & health with susceptibility to infections, dermatitis, decreased capacity to reproduce, impaired transport of lipids, fatty liver, & lowered resistance to stress

Function of Essential Fatty Acids

- They are useful in the treatment of atherosclerosis (transporting blood cholesterol & triglycerides & lowering them)
- Synthesis of certain hormones
- Cellular & subcellular membranes
- Skin integrity, normal growth & reproduction
- Blood clotting (intrinsic factor)
- Important role in health of the retina & vision
- They can be oxidized for energy production

Essential fatty acids

1-Linoleic:

- **$C18:2\Delta^{9,12}$** $CH_3\text{-}(CH_2)_4\text{-}CH = CH\text{-}CH_2\text{-}CH{=}CH\text{-}(CH_2)_7\text{-}COOH$
- **It is the most important since other essential fatty acids can be synthesized from it in the body. ω6**

2-Linolenic acid:

- **$C18:3\Delta^{9,12,15}$** $CH_3\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}(CH_2)_7\text{-}COOH$
- **In corn, peanut, olive, cottonseed & soybean oils. ω3**

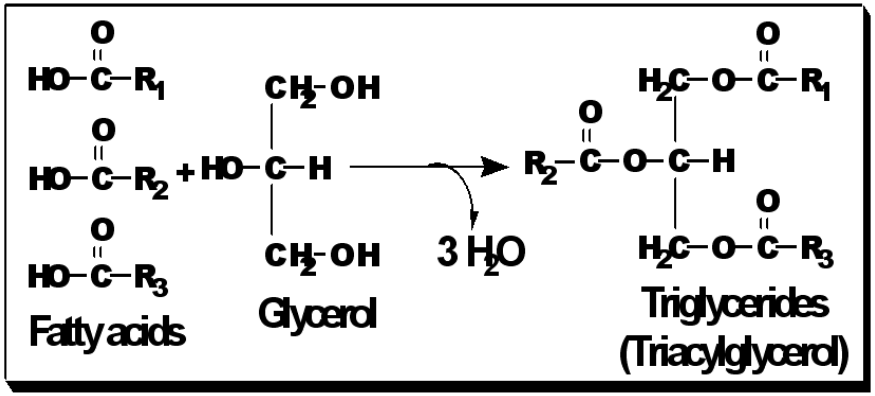
3-Arachidonic acid:

- **$C20:4\Delta^{5,8,11,14}$** $CH_3\text{-}(CH_2)_4\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}CH{=}CH\text{-}(CH_2)_3\text{-}COOH$
- **It is an important component of phospholipids in animal & in peanut oil from which prostaglandins are synthesized**

Simple Lipids

A. Neutral Fats & oils (Triacylglycerols)

1. Esters of glycerol with various F.A(commonest in animal fats are palmitic, stearic & oleic acids)
2. Uncharged due to absence of ionizable groups in it
3. The most abundant lipids in nature

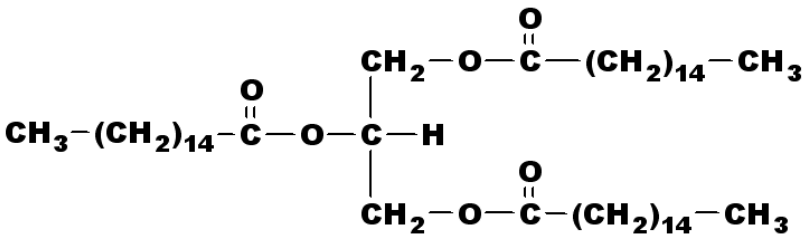


Number of carbons	Number of double bonds	Common name	Systematic name	Formula
16	0	Palmitate	n-Hexadecanoate	$CH_3(CH_2)_{14}COO^-$
18	0	Stearate	n-Octadecanoate	$CH_3(CH_2)_{16}COO^-$
18	1	Oleate	cis-Δ^9-Octadecenoate	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COO^-$

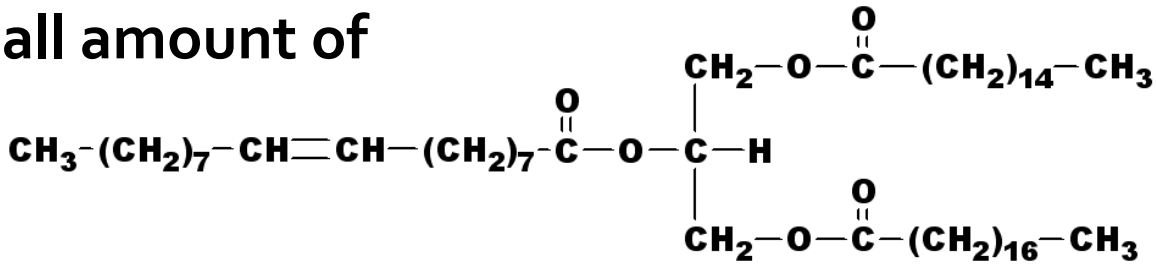
Simple Lipids

A. Neutral Fats & oils (Triacylglycerols)

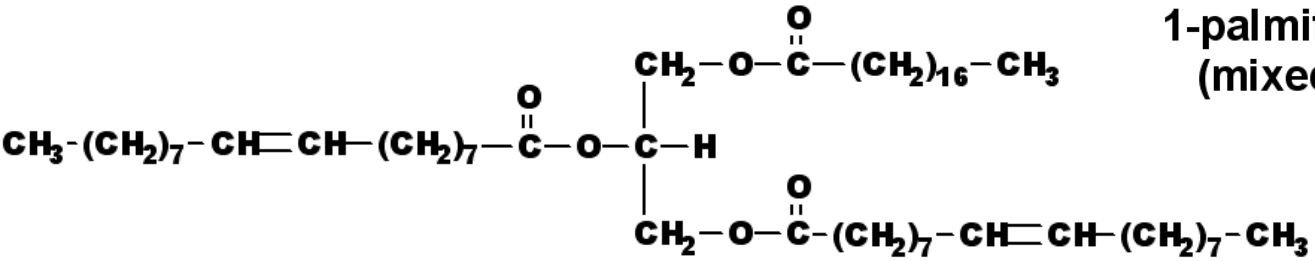
4. Either;
   a) Simple: of the same type, e.g., tripalmitin
   b) Mixed: of different types, e.g., stearo-diolein & palmito-oleo-stearin
5. Natural fats are mixtures of mixed triglycerides with a small amount of simple triglycerides



Tripalmitin
(simple triacylglycerol)



1-palmito-2-oleo-3-stearin
(mixed triacylglycerol)



1-Stearo-2,3-diolein
(mixed triacylglycerol)

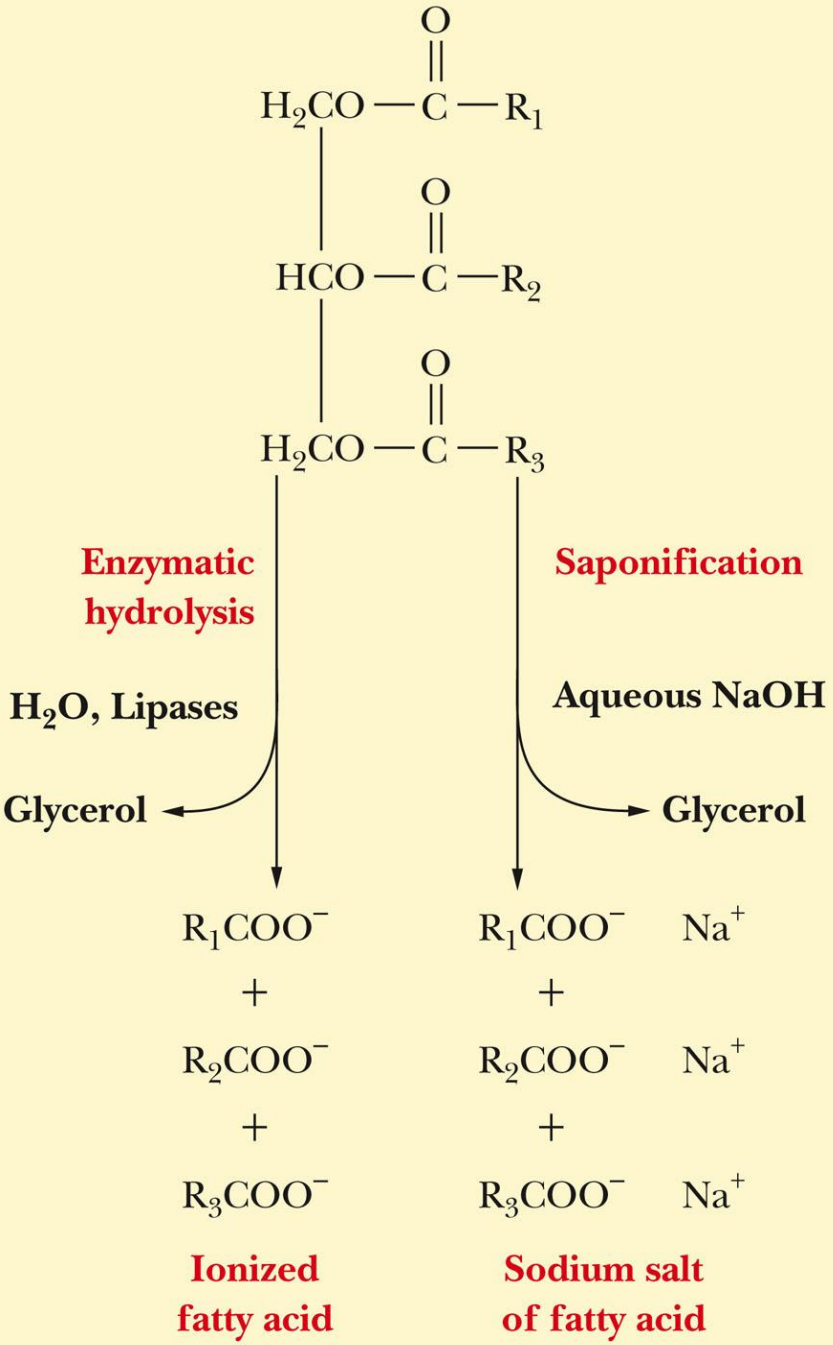
Physical properties of fat & oils

1. Freshly prepared are colorless, odorless & tasteless (the yellow color is due to carotene pigments)
2. Fats have specific gravity less than 1
3. Fats are insoluble in water (organic solvents as ether & benzene)
4. Oils are liquid at room temperature, whereas, fats are solids (unsaturated vs. saturated)

Chemical Properties of fats & oils

A. Hydrolysis : steam, acid, enzyme (e.g., lipase of pancreas)

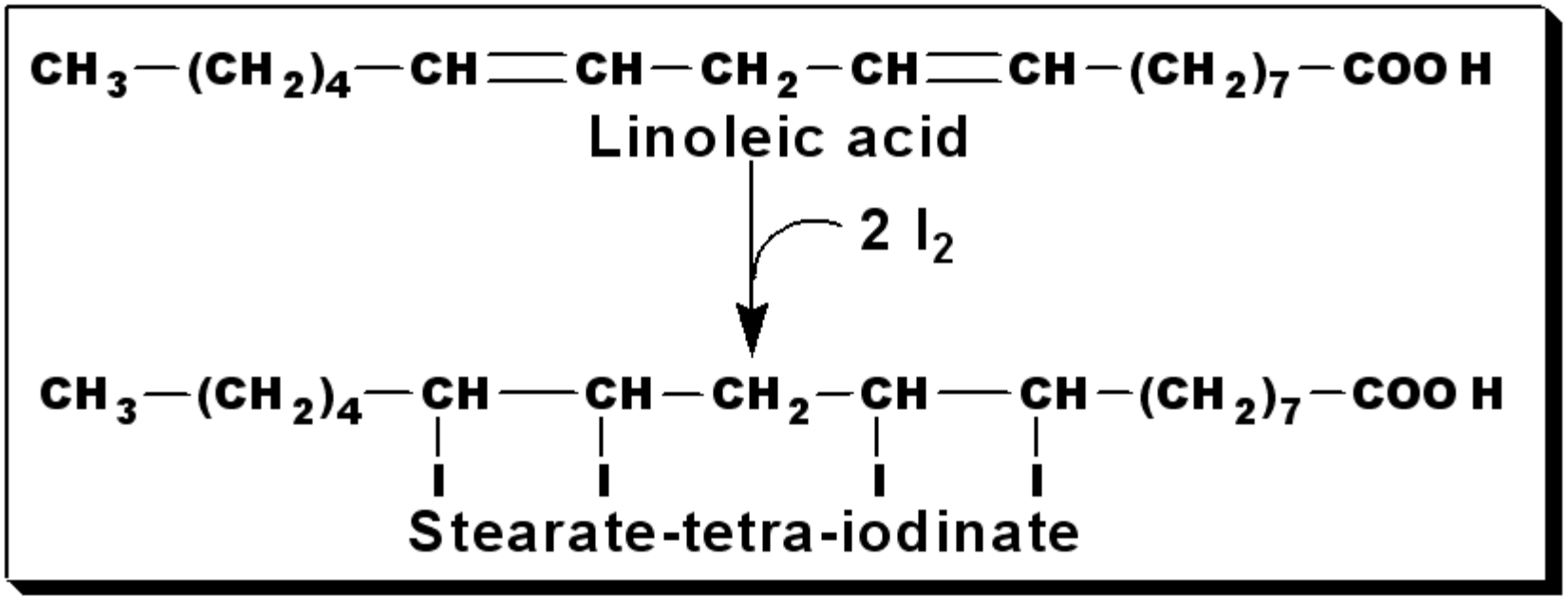
B. Saponification: Alkaline hydrolysis produces salts of fatty acids (soaps). Soaps cause emulsification of oily material



Chemical Properties of fats & oils

C. **Halogenation: halogens added to unsaturated F.A (e.g., iodine or iodination)**

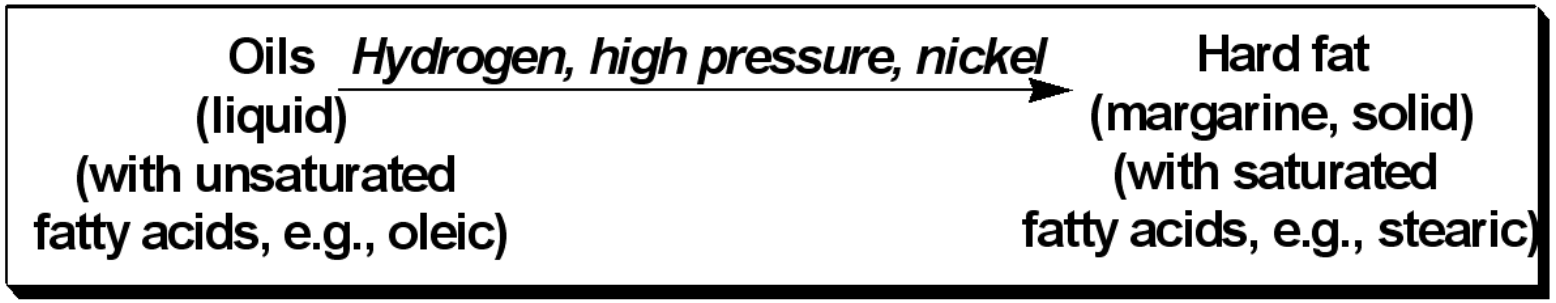
- ✓ **Used to determine the degree of unsaturation of the fat or oil that determines its biological value**



Chemical Properties of fats & oils

D. Hydrogenation or hardening of oils:

- ✓ It is an addition reaction (H at the = of unsaturated F.A)
- ✓ Done under high pressure of hydrogen
- ✓ It is the base of hardening of oils (margarine manufacturing)
- ✓ Hydrogenation of oils converts some cis-double bonds to trans-double bonds
- ✓ Advantages: more pleasant as cooking fat, easily stored & transported, less liable to rancidity
- ✓ Disadvantages: lack of fat-soluble vitamins (A, D, E & K) & essential fatty acids

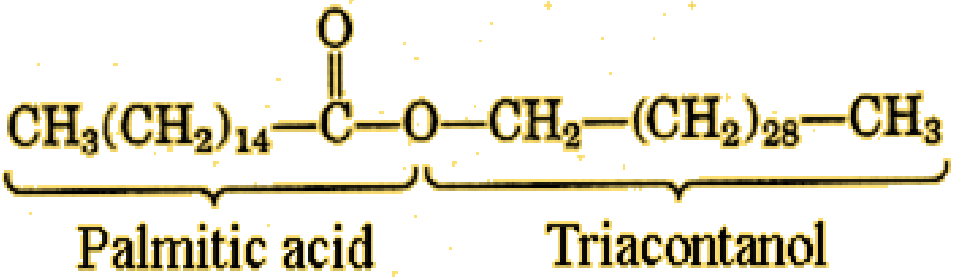


Chemical Properties of fats & oils

E. Oxidation (Rancidty)

- ✓ Oxidation of fatty acids by atmospheric oxygen, light, moisture, bacterial or fungal contamination &/or heat
- ✓ It is a toxic reaction of triglycerides (food poisoning & cancer)
- ✓ Leads to the development of unpleasant odor or taste or abnormal color particularly on aging
- ✓ Saturated fats resist rancidity more than unsaturated fats
- ✓ It is the base for drying oils after exposure to atmospheric oxygen, e.g; paints & varnishes manufacturing
- ✓ Rancidity destroys the fat-soluble vitamins (A, D, K & E)
- ✓ Rancidity destroys the polyunsaturated essential F.A
- ✓ Rancidity causes economical loss because rancid fat is <u>inedible</u>

Simple Lipids
B. Waxes



1. Solid simple lipids containing a monohydric alcohol (C16 ~ C30, higher molecular weight than glycerol) esterified to long-chain fatty acids (C14 ~ C36). Examples: palmitoyl alcohol
2. Insoluble in water & Negative to acrolein test
3. Are not easily hydrolyzed (fats) & are indigestible by lipases
4. Are very resistant to rancidity
5. Are of no nutritional value
6. Coatings that prevent loss of water by leaves of plants

Type	Structural Formula	Source	Uses
Beeswax	$CH_3(CH_2)_{14}-C(=O)-O-(CH_2)_{29}CH_3$	Honeycomb	Candles, shoe polish, wax paper
Carnauba wax	$CH_3(CH_2)_{24}-C(=O)-O-(CH_2)_{29}CH_3$	Brazilian palm tree	Waxes for furniture, cars, floors, shoes
Jojoba wax	$CH_3(CH_2)_{18}-C(=O)-O-(CH_2)_{19}CH_3$	Jojoba	Candles, soaps, cosmetics

Differences between neutral lipids & waxes

Property	Waxes	Neutral lipids
1.Digestibility	Indigestible (not hydrolyzed by lipase)	Digestible (hydrolyzed by lipase)
2-Type of alcohol	Long-chain monohydric alcohol + one fatty acid	Glycerol (trihydric) + 3 F.A
3-Type of F.A	Mainly palmitic or stearic acid	Long & short chain F.A
4-Acrolein test	Negative	Positive
5-Rancidability	Never get rancid	Rancidible
6-Nature at room temperature	Hard solid	Soft solid or liquid
7-Saponification	Nonsaponifiable	Saponifiable
8-Nutritive value	No nutritive value	Nutritive
9-Example:	Bees & carnuba waxes	Butter & vegetable oils

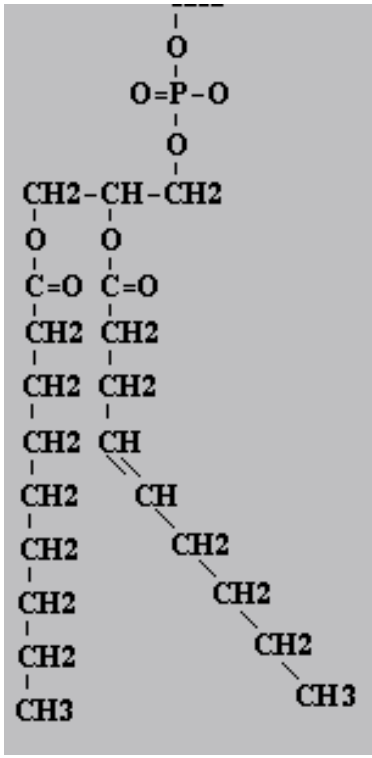
Compound (congugated) Lipids

- They are lipids that contain additional substances, e.g., sulfur, phosphorus, amino group, carbohydrate, or proteins beside fatty acid & alcohol
- Classified into the following types according to the nature of the additional group

1. Phospholipids
2. Glycolipids
3. Lipoproteins
4. Sulfolipids & amino lipids

1. Phospholipids (phosphatides)

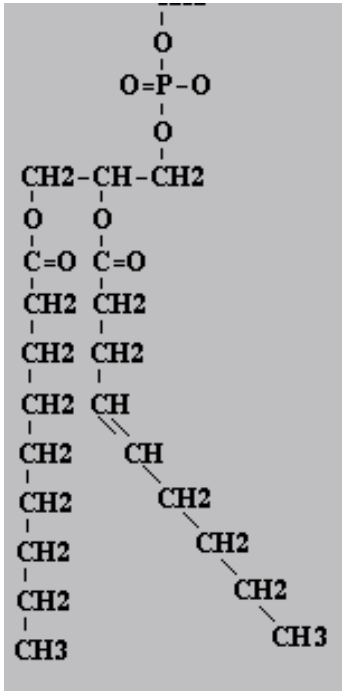
1. Contain phosphoric acid group in their structure
2. Every animal & plant cell contains phospholipids (membranes & subcellular organelles)
3. Present in large amounts in liver & brain as well as blood
4. Myelin sheath of nerves is rich with phospholipids
6. Important in blood clotting & platelet aggregation
7. Provide lung alveoli with surfactants to prevent its irreversible collapse
8. Important role in signal transduction across membranes
9. Snake venom hydrolyses membrane phospholipids
10. A source of polyunsaturated F.A



1. Phospholipids (phosphatides)

- **Sources:** all cells (plants & animals)
- **Structure**:

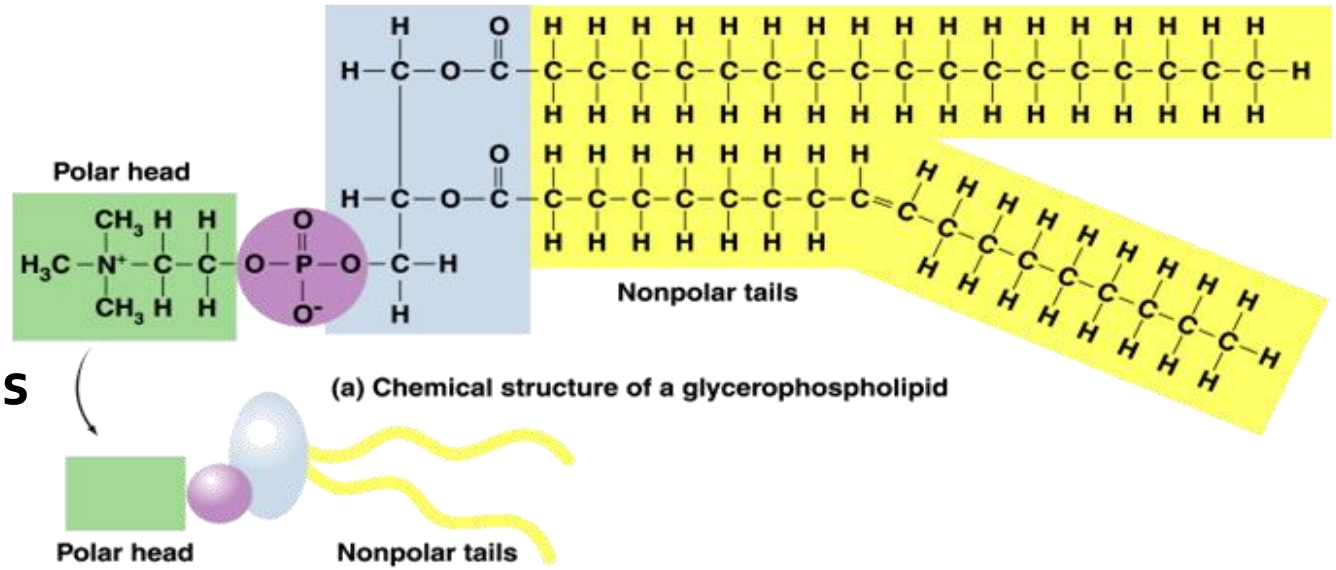
1. Fatty acids (saturated & unsaturated)
2. Nitrogenous base (choline, serine, threonine, or ethanolamine)
3. Phosphoric acid
4. Fatty alcohols (glycerol, inositol or sphingosine)

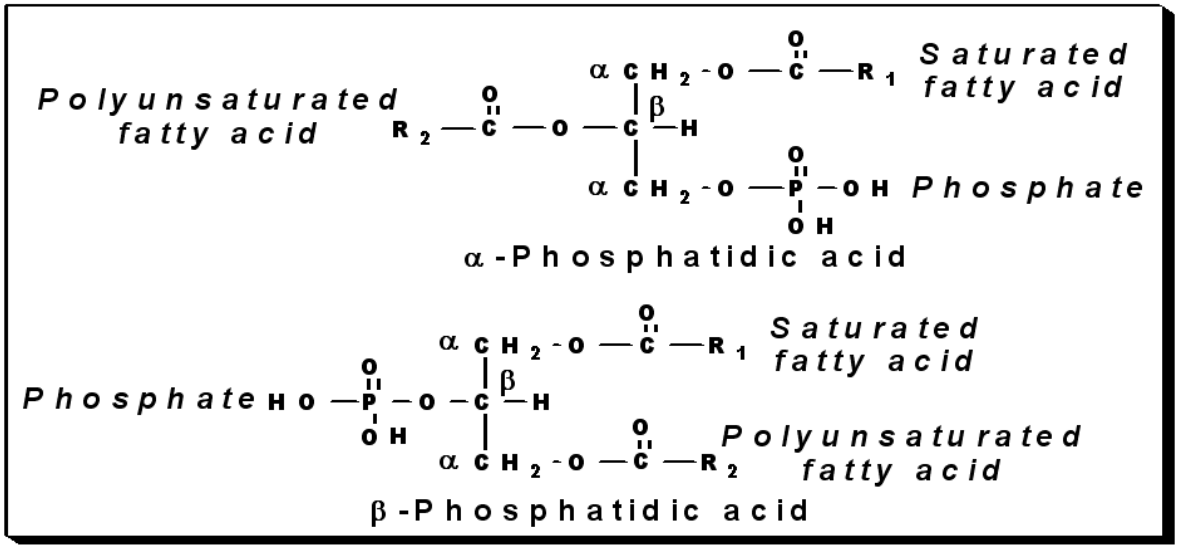


- **Classification: according to the type of the alcohol**
  - **Glycerophospholipids**
    - ✓ Phosphatidic acids
    - ✓ Lecithins
    - ✓ Cephalins
    - ✓ Plasmalogens
    - ✓ Inositides
    - ✓ Cardiolipin
  - **Sphingophospholipids: sphingosine as an alcohol**

Glycerophospholipids - Phosphatidic acids

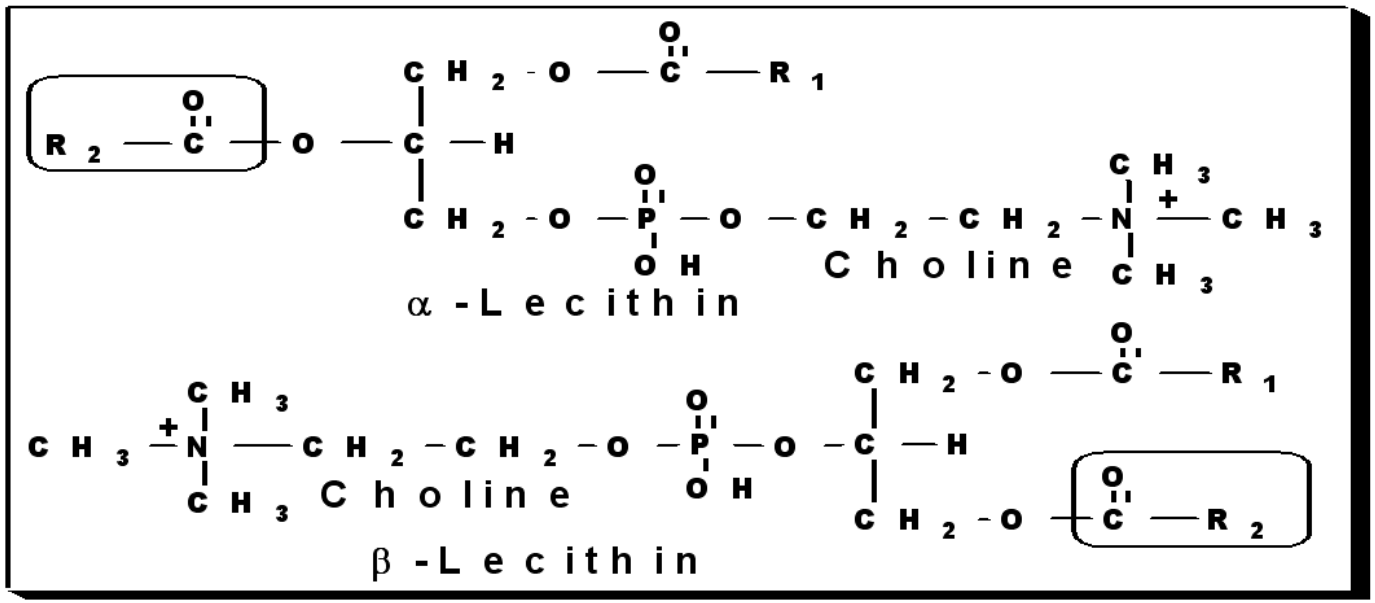
- Exist in two forms according to the position of the phosphate; α & β





Glycerophospholipids - Lecithins

- Contain choline as a nitrogenous base
- Exist in 2 forms α- & β-lecithins
- Common cell constituent: brain (α-type), egg yolk (β-type), or liver (both types)
- Structure: choline connected to phosphate
- Common fatty acids in lecithins are stearic, palmitic, oleic, linoleic, linolenic, & arachidonic acids



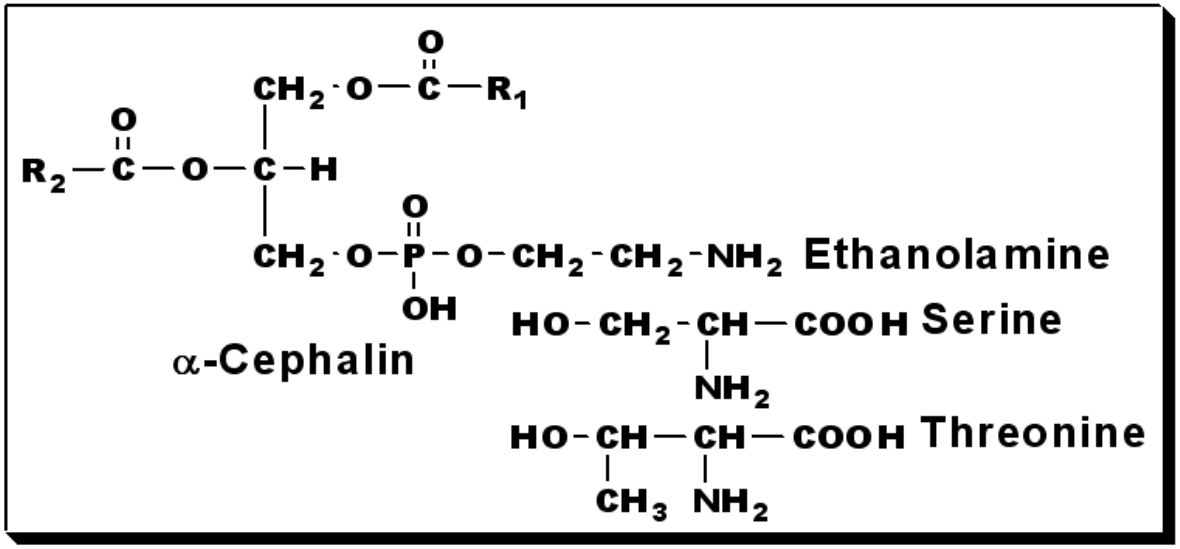
Glycerophospholipids - Lecithins

- Snake venom: lecithinase hydrolyzes PUFAs converting lecithin into lysolecithin (hemolysis of RBCs)

- Lung surfactant: a complex of dipalmitoyl-lecithin, sphingomyelin & a group of proteins
  - Produced by alveolar cells
  - Improves gas exchange
  - Activates macrophages to kill pathogens
  - Premature babies: surfactant is deficient (RDS)
  - Glucocorticoids increase the synthesis of the surfactant complex

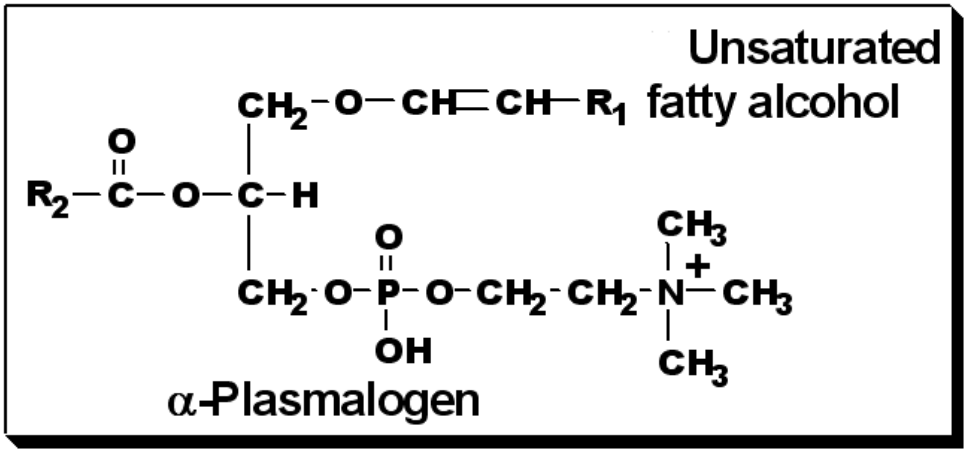
Glycerophospholipids - Cephalins or Kephalins

- Structure: choline is replaced by ethanolamine, serine or threonine amino acids
- Occur in association with lecithins in tissues
- Isolated from the brain (Kephale = head)
- Certain cephalins are constituents of the lipoprotein "thromboplastin" which accelerates the clotting of blood



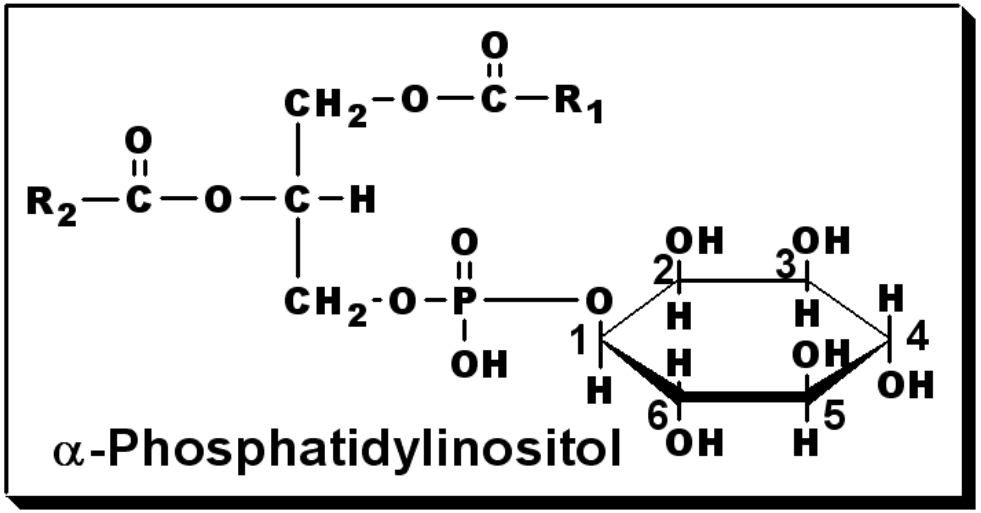
Glycerophospholipids - Plasmalogens

- Found in the cell membrane phospholipids fraction of brain & muscle, liver, semen
- Structure:
  - ✓ Unsaturated fatty alcohol at C1 connected by ether bond
  - ✓ In mammals: at C3; phosphate + ethanolamine or choline
- At C2 there is an unsaturated long-chain fatty acid, however, it may be a very short-chain fatty acid



Glycerophospholipids - Inositides

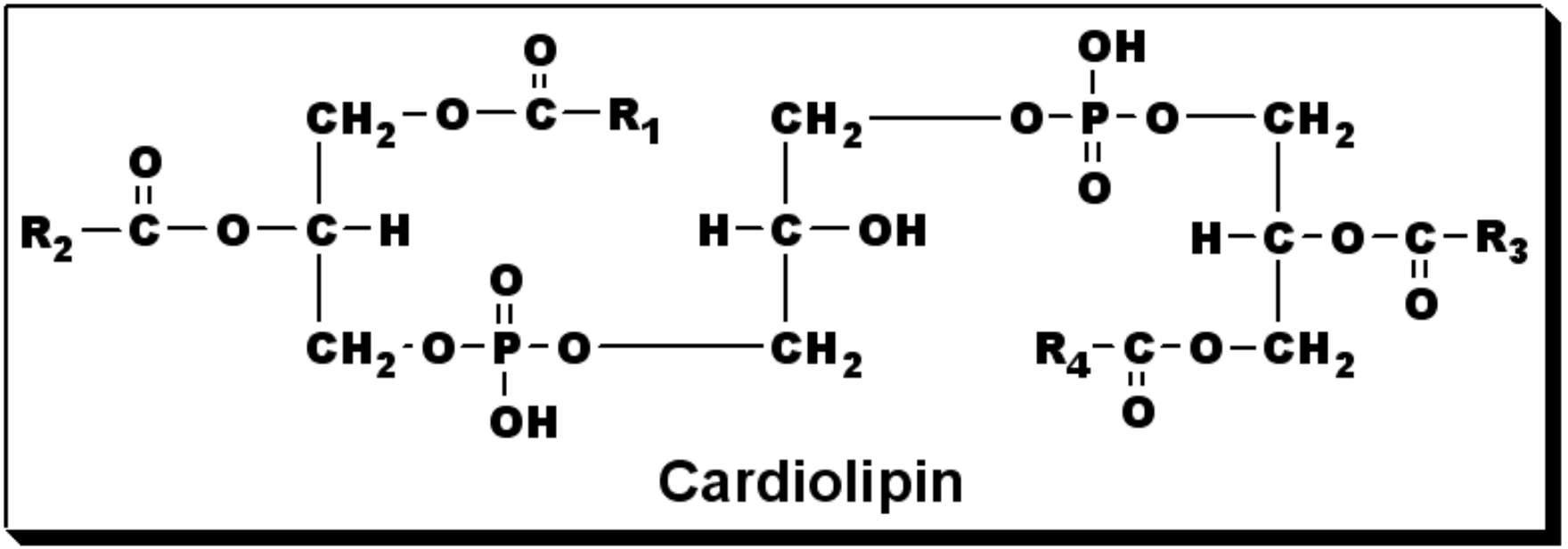
- Phosphatidyl inositol
- They have the cyclic sugar alcohol, inositol as the base
- Structure: glycerol, saturated F.A, unsaturated F.A, phosphoric acid & inositol
- Source: Brain tissues



- Function:
  - 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 (IP_3); which liberates calcium

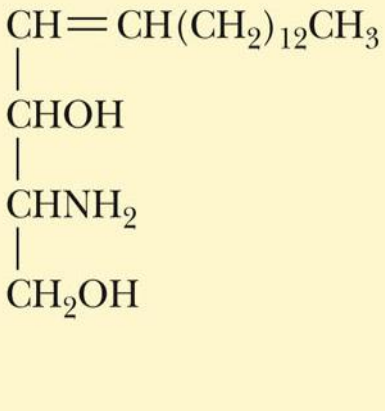
Glycerophospholipids - Cardiolipins

- 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

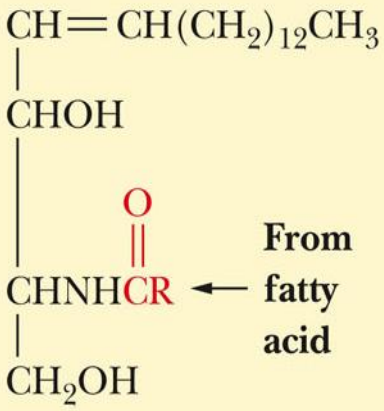


Sphingophospholipids – Sphingomyelins & Ceramides

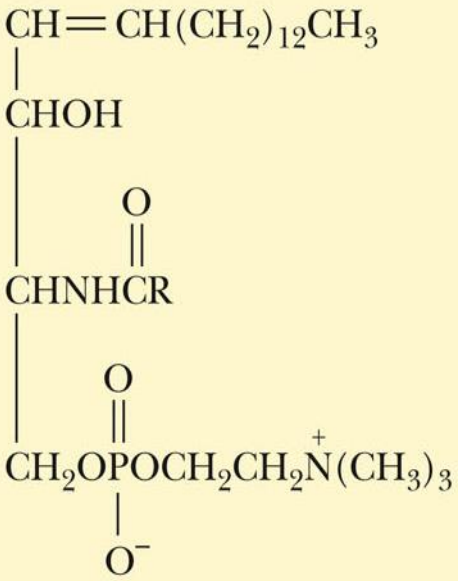
- Sphingomyelins: found in large amounts in brain & nerves
- Structure:
  - Sphingosine as the alcohol
  - Two nitrogenous bases: sphingosine itself & choline
  - One long-chain fatty acid
  - Phosphoric acid
- Ceramides: the amino group of sphingosine is attached to a F.A by an amide linkage
  - Found in spleen, liver & RBCs



Sphingosine



A ceramide (*N*-acylsphingosine)

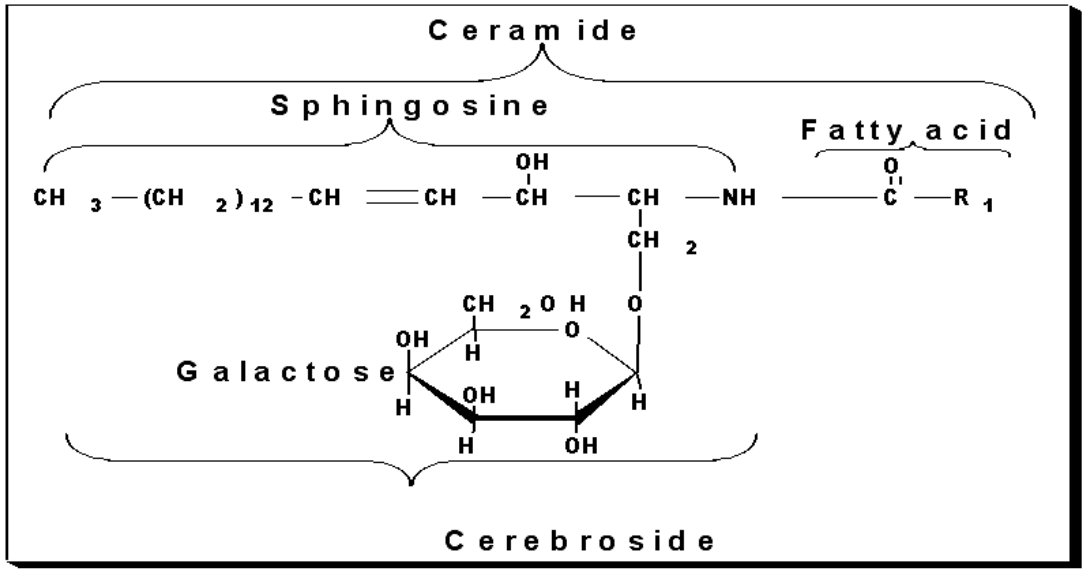


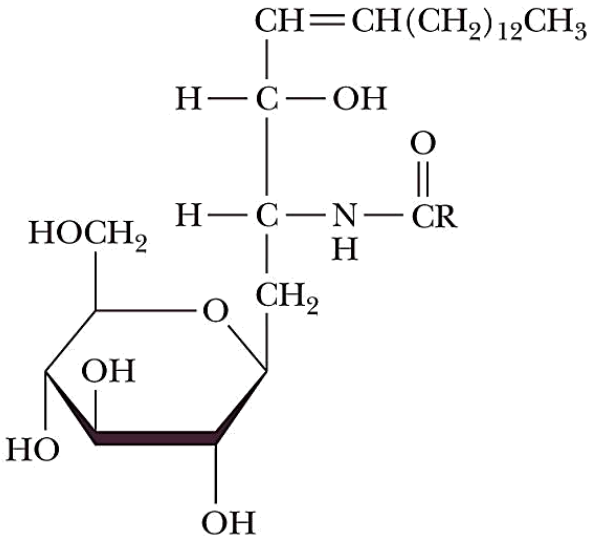
A sphingomyelin

2. Glycolipids

- Lipids that contain carbohydrate residues
- Sphingosine as the alcohol
- Contains a very long-chain fatty acid
- They are present in cerebral tissue (cerebrosides)
- Classification: number & nature of carbohydrate present;

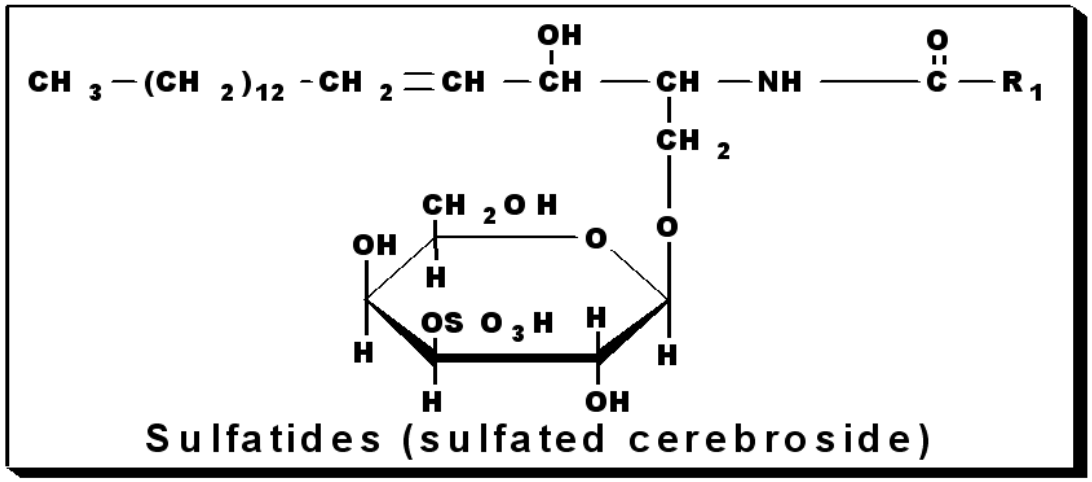
1) Cerebrosides: have one galactose or glucose molecule. Myelin sheath of nerves & white matter of the brain



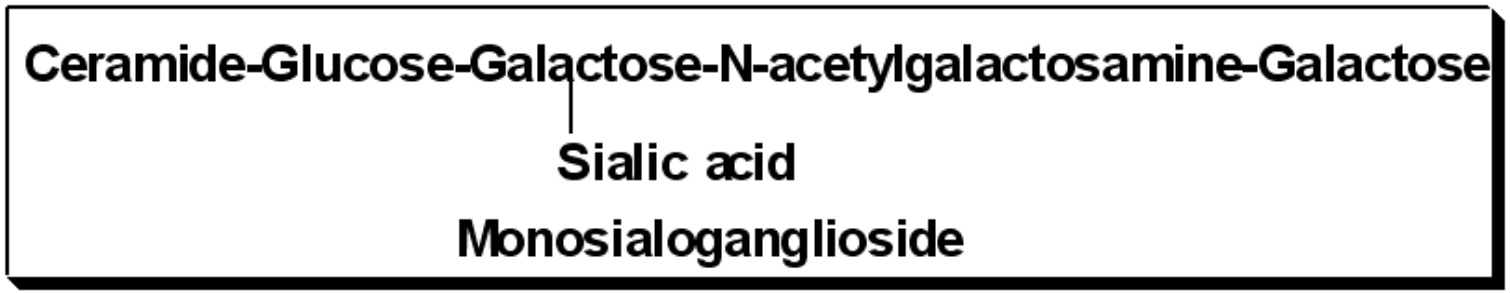


2. Glycolipids

2) Sulfatides: cerebrosides with sulfate on the sugar (sulfated cerebrosides). Brain, liver, muscles & testes



3) Gangliosides: have several sugar & sugaramine residues. Brain, ganglion cells, & RBCs. Receptor for cholera toxin in the human intestine

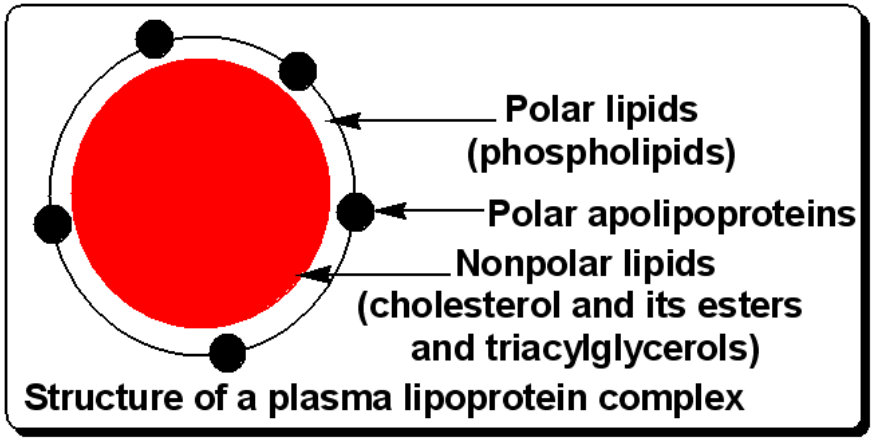


2. Lipoproteins

- Lipids (phospholipid, cholesterol or triacylglycerol) combined with proteins in tissues
- They are either:

1) Structural : cellular & subcellular membranes. In lung tissues (surfactant). In the eye, rhodopsin is a lipoprotein complex

2) Transport: blood plasma. Composed of a protein (apolipoprotein) & different types of lipids (cholesterol, cholesterol esters, phospholipids & triacylglycerols)



Structure of a plasma lipoprotein complex

✓ As lipid content increases, the density decreases

2. Lipoproteins – types (Density)

A. Chylomicrons:
   a) Largest diameter & least density (2% protein)
   b) Main lipid fraction is triacylglycerols (absorbed)

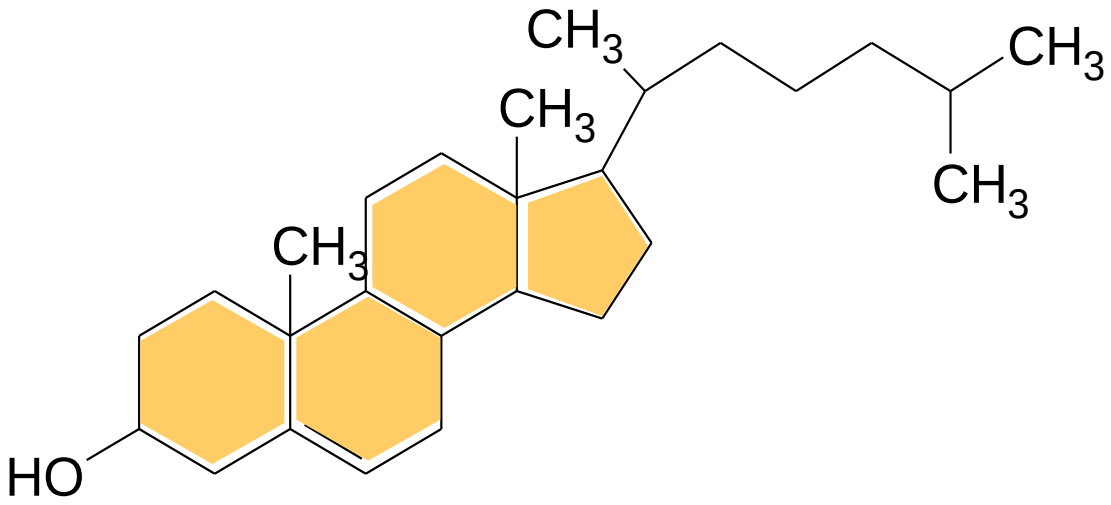
B. Very low-density lipoproteins (VLDL):
   a) Diameter is smaller (chylomicrons)
   b) 7-10% protein
   c) Lipid content is mainly triacylglycerols formed in liver

C. Low-density lipoproteins (LDL):
   a) 10-20% proteins
   b) Contain about 60% of total blood cholesterol & 40% of total blood phospholipids
   c) As their percentage increases, liability to atherosclerosis increases

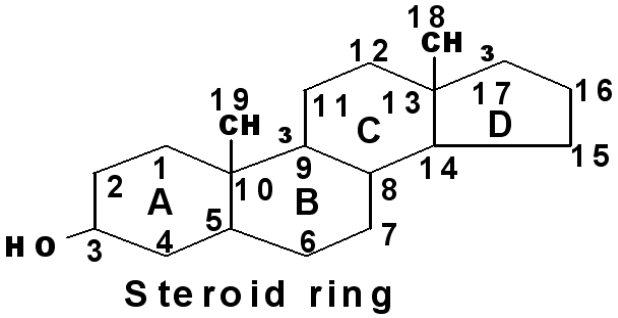
2. Lipoproteins - types

D. High-density lipoproteins (HDL) or α-Lipoproteins:
   a) Highest density (high protein content). 35-55% proteins
   b) Lipids formed of cholesterol (40% of total blood content) & phospholipids (60% of total blood content)
   c) Act as cholesterol scavengers
   d) As their percentage increases, liability to atherosclerosis decreases
   e) Higher in females than in males

Steroids: Cholesterol, Bile Salts, and Steroid Hormones

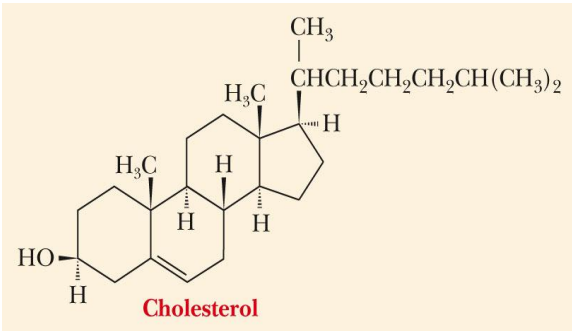


Steroids



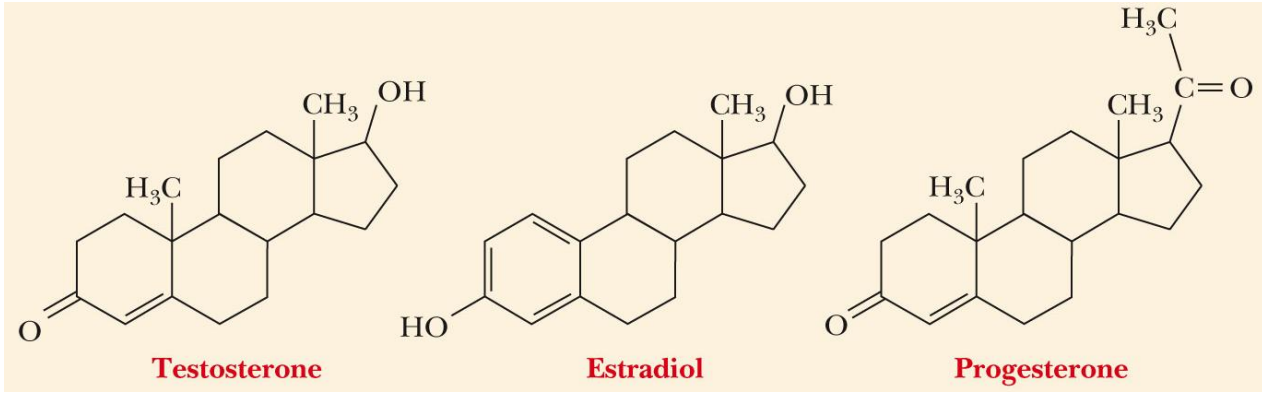
Steroid ring

- A group of lipids that have fused-ring structure of 3 six-membered rings, and 1 five-membered ring
- Usually found in association with fat
- Separated from fats after saponification
- Derivatives of cholesterol
- Biologically important groups of substances:



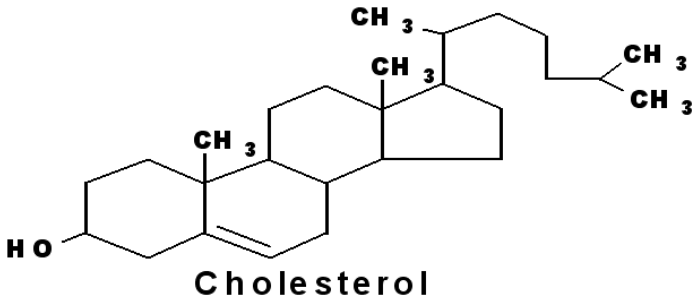
Cholesterol

1. Sterols
2. Adrenal cortical hormones
3. Male and female sex hormones
4. Vitamin D group
5. Bile acids

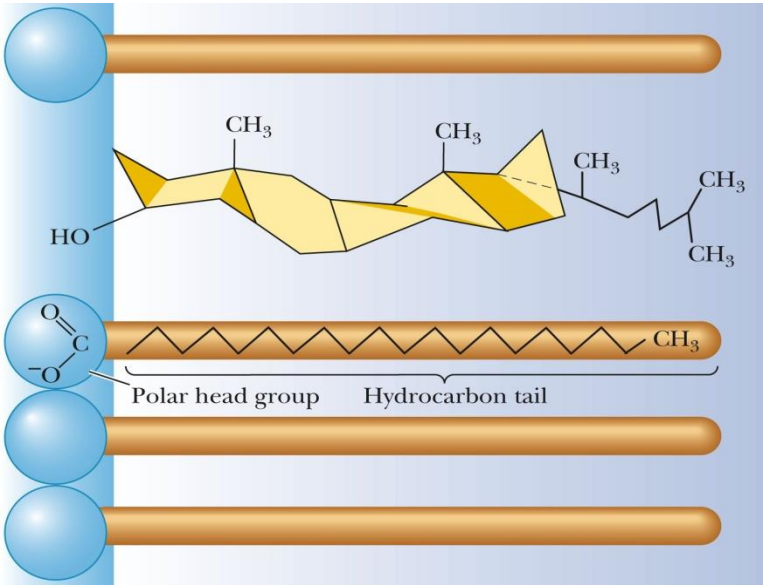


- Androgens: male 2º sex characteristics
- Estrogens: female 2º sex characteristics & control of menstrual cycle

Cholesterol



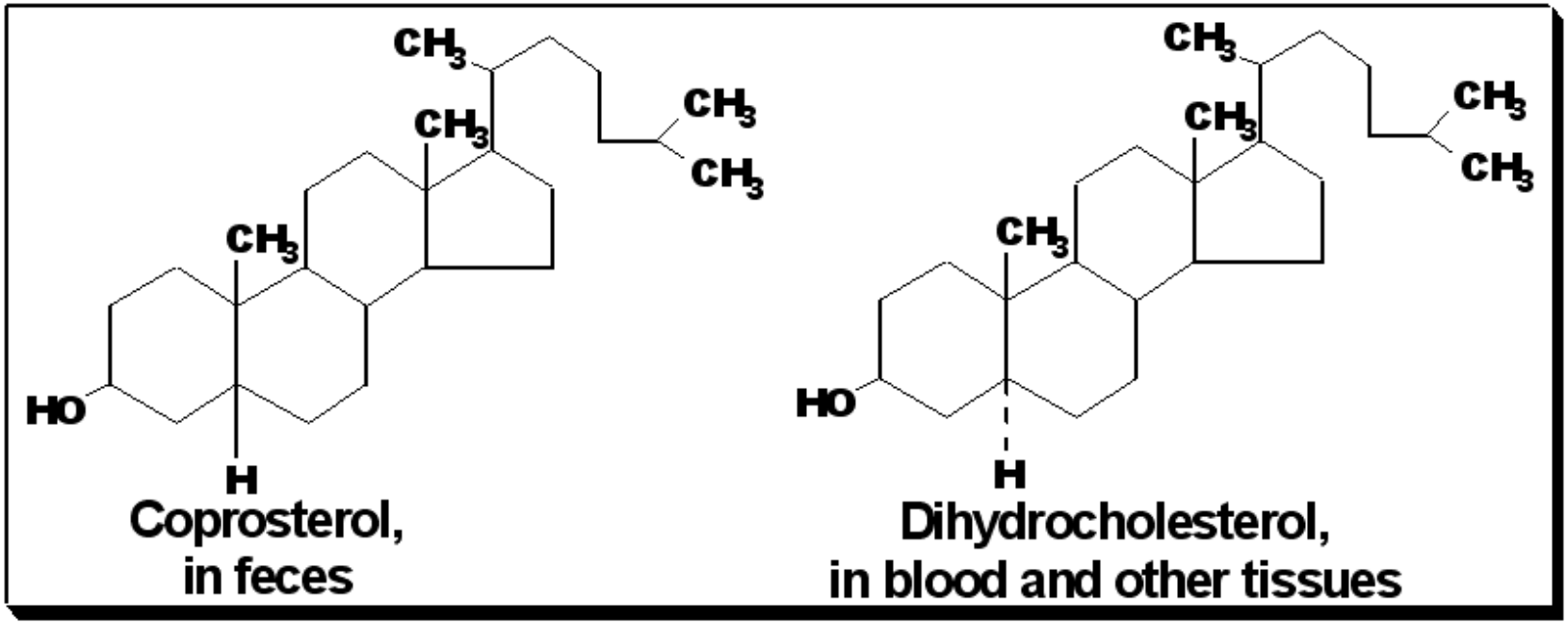
- The most important sterol in animal tissues as free alcohol or in an esterified form (with linoleic, oleic, palmitic acids or other F.A)
- Steroid hormones, bile salts &vitamin D are derivatives
- Tissues contain different amounts of it that serve a structural & metabolic role (adrenal cortex ≈ 10%, whereas, brain is 2%)
- Reduces membrane fluidity
- Source:
  - ✓ Synthesized in the body from acetyl-CoA
  - ✓ Does not exist in plants
  - ✓ In the diet (butter, milk, egg yolk, brain, meat & animal fat)



- stabilizing extended chains of FA due to hydrophobic interactions

Cholesterol - Chemical properties

- Intestinal bacteria reduce cholesterol into coprosterol & dihydrocholesterol
- It is also oxidized into 7-Dehydrocholesterol
- When the skin is irradiated with ultraviolet light 7-dehydrocholesterol is converted to vitamin D3

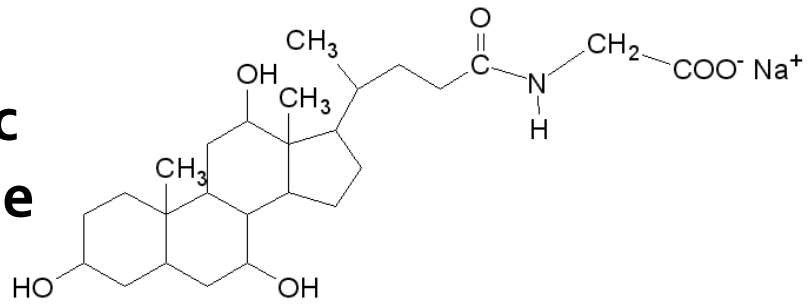


Bile acids

- They are produced from oxidation of cholesterol in the liver
- Produce cholic and chenodeoxycholic acids that are conjugated with glycine (mainly) to produce glycocholic, glycochenodeoxycholic
- They react with sodium or potassium to produce sodium or potassium bile salts

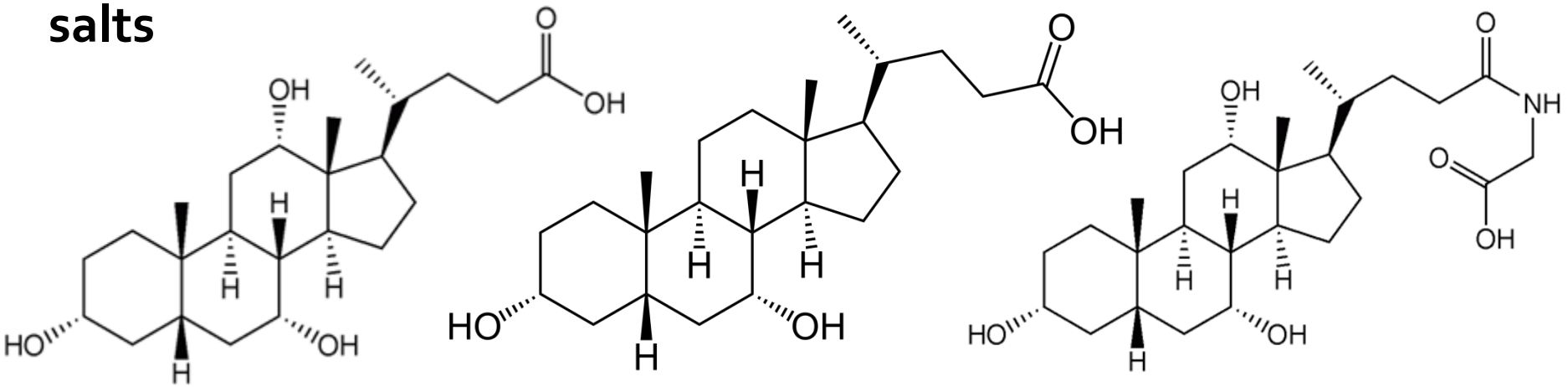
cholic acid, a bile acid

glycine, an amino acid



Nonpolar region

sodium glycocholate, a bile salt

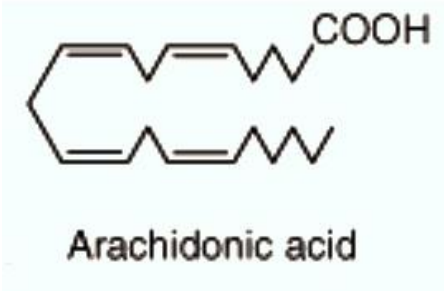


Bile acids - function

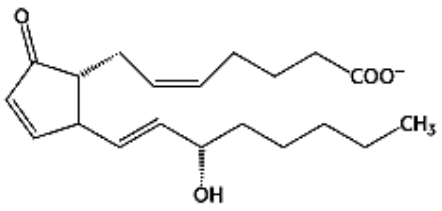
- Their function is as follows:

1) Emulsification of lipids during digestion
2) Activation of pancreatic lipase
3) Help digestion & absorption of fat-soluble vitamins
4) Solubilizing cholesterol in bile & prevent gall stone formation
5) Choleretic action (stimulate their own secretion)

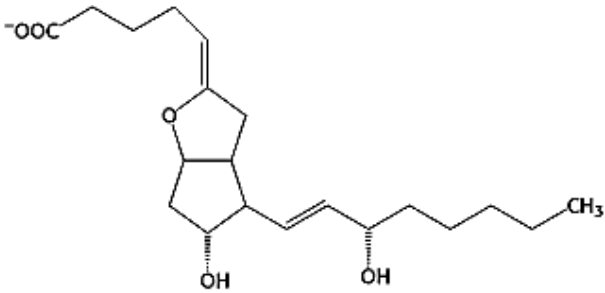
Eicosanoids (icosanoids)



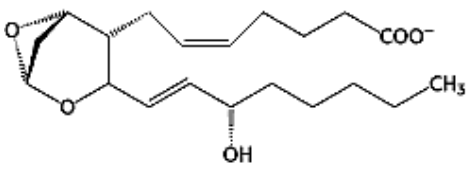
- Signaling molecules made by oxidation of 20-carbon E-PUFA, mainly Arachidonic acid (ω6)
- Source: either ω-3 or ω-6 fatty acids
- Paracrine or autocrine messengers molecules (half-lives 10 secs – 5 mins)
- Various eicosanoids are synthesized throughout the body & synthesis can be very tissue specific
- Most catabolism occurs in the lung
- Families of eicosanoids:
  - ✓ Prostaglandins
  - ✓ Prostacyclins
  - ✓ Thromboxanes
  - ✓ Lipoxins
  - ✓ Leukotrienes



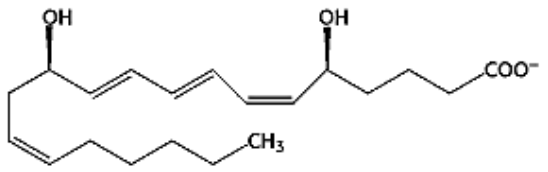
Prostaglandin A_2



Prostacylin (PGI_2)



Thromboxane A_2 (TXA_2)



Leukotriene B_4

Eicosanoids - Functions

- Induction of inflammation
- Mediation of pain signals
- Induction of fever
- Smooth muscle contraction (including uterus)
- Smooth muscle relaxation
- Protection of stomach lining
- Simulation of platelet aggregation
- Inhibition of platelet aggregation
- Sodium and water retention

Anti inflammatory Drugs inhibit Eicosanoid Synthesis

Membrane lipids

Steroids

Phospholipase A2

Arachidonic Acid

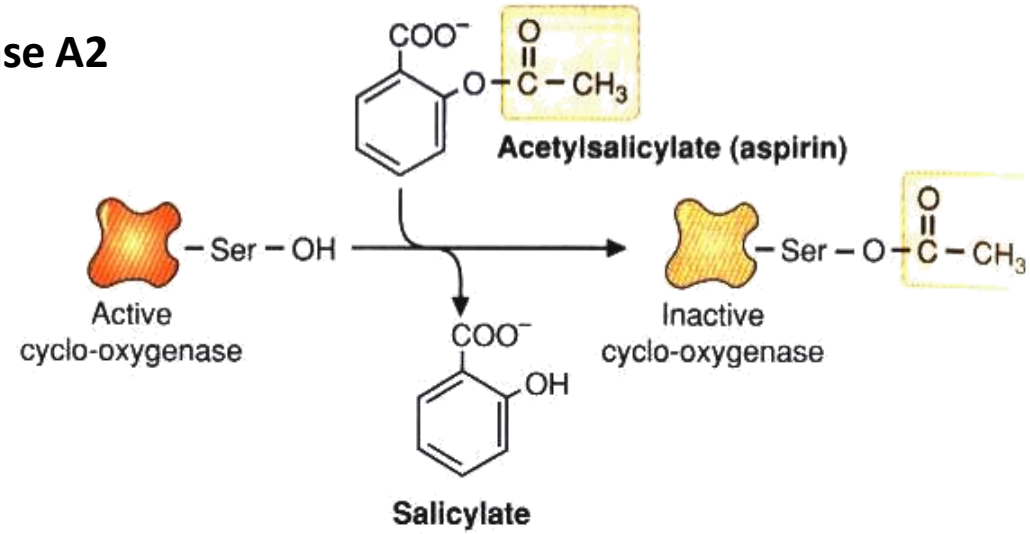
NSAIDs

Cyclo-oxygenase

Lipoxygenase

Prostaglandins, thromboxanes

Leukotrienes



Eicosanoids - Therapeutic uses

- Induction of labor at term
- Therapeutic abortion
- Maintenance of ductus arteriosus
- Treatment of peptic ulcer
- Erectile dysfunction