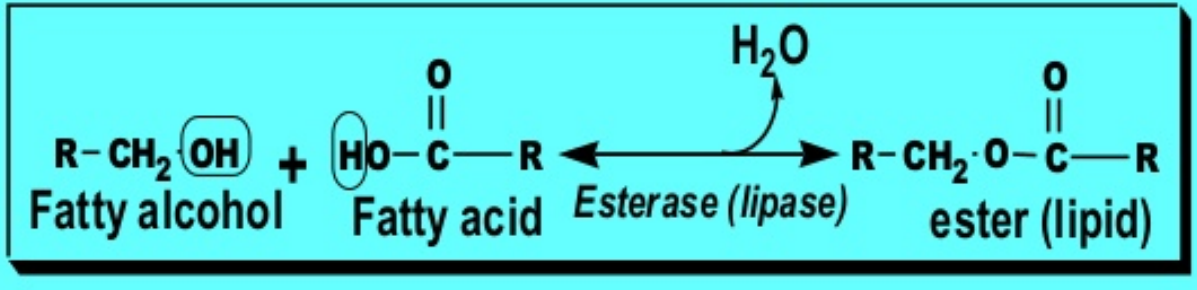
Chemistry of Lipids

Definition:

Lipids are organic compounds.

formed from alcohol and fatty acids combined together by ester linkage.



- **Lipids** (Greek: *lipos*, means fat or lard)
- - are a heterogeneous class of naturally occurring organic substances
- - have a distinguished functional group or structural features
- - are insoluble in water and highly soluble in one or more of the following solvents: ether, chloroform, benzene and acetone. This property sets them apart from proteins, carbohydrates,, nucleic acids and other biomolecules
- - are widely distributed in the biological world
- - play a wide variety of roles in plant and animal tissues

- Lipids are concentrated source of energy. One gram fat gives 9 K calories.
- It serves as a cushion for the vital organs and protects them from external shocks or injuries.
- Lipids are the structural materials of cells and membranes
- Lipids serves as insulator for our body
- Lipids are the carrier / reservoir of fat soluble vitamins
- In food preparations lipids serves as a binding agent. It also enhances the palatability of foods

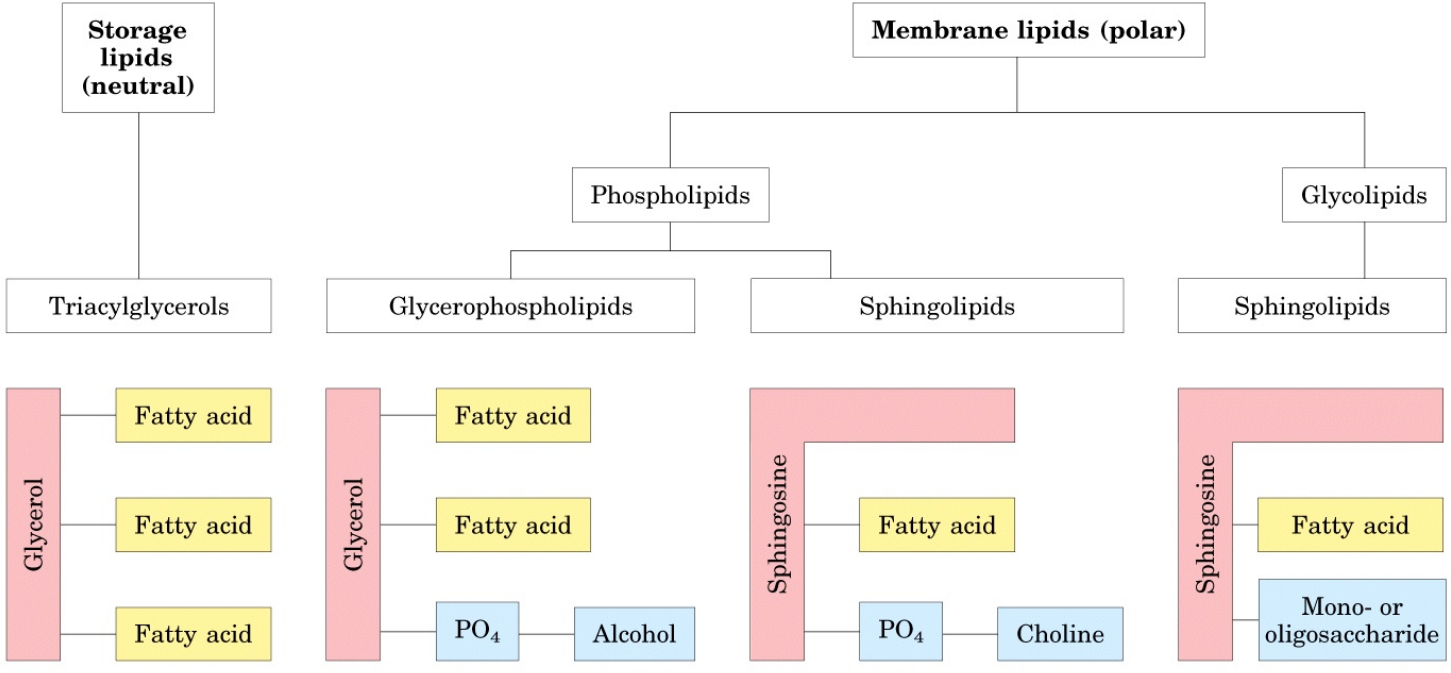
- Lipids are heterogeneous group of water insoluble compounds which are oily or greasy in consistency but soluble in non-polar solvents like ether, chloroform, benzene etc.

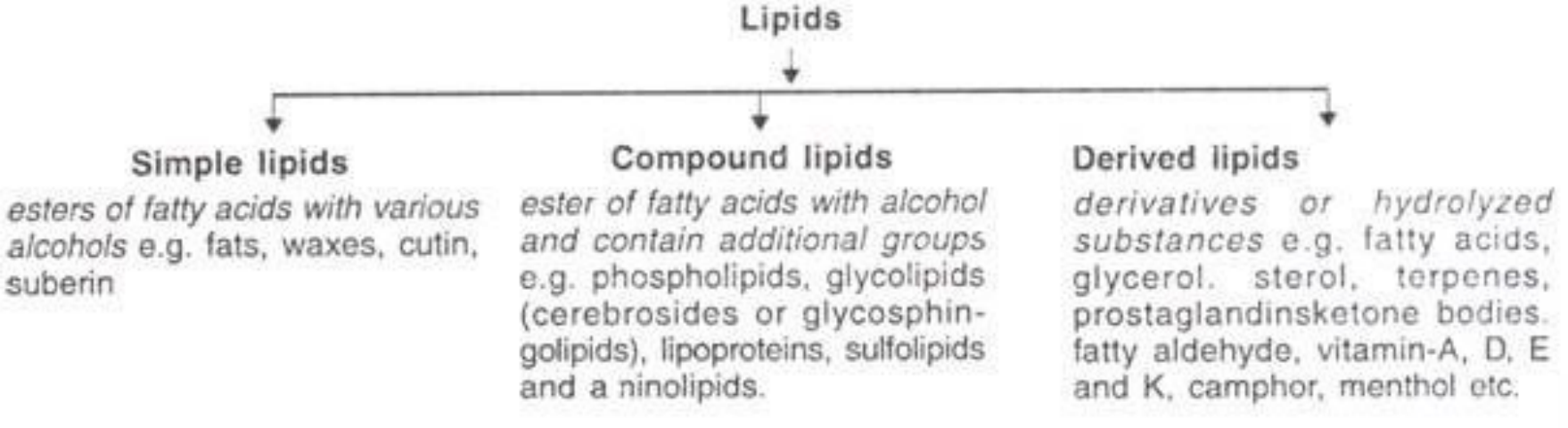
- For examples, fatty acids, fats, oils, waxes, certain vitamins and hormones are considered as lipids. Lipids are composed of C, H, O, like carbohydrates but poor in oxygen and therefore require more oxygen for oxidation to release energy

LIPID

Definition

Lipids are heterogeneous group of water insoluble compounds which are oily or greasy in consistency but soluble in non-polar solvents like ether, chloroform, benzene etc.


Storage lipids (neutral)
Membrane lipids (polar)
Phospholipids
Glycolipids
Triacylglycerols
Glycerophospholipids
Sphingolipids
Sphingolipids
Glycerol
Fatty acid
Fatty acid
Fatty acid
Glycerol
Fatty acid
Fatty acid
PO4
Alcohol
Sphingosine
Fatty acid
PO4
Choline
Sphingosine
Fatty acid
Mono- or oligosaccharide

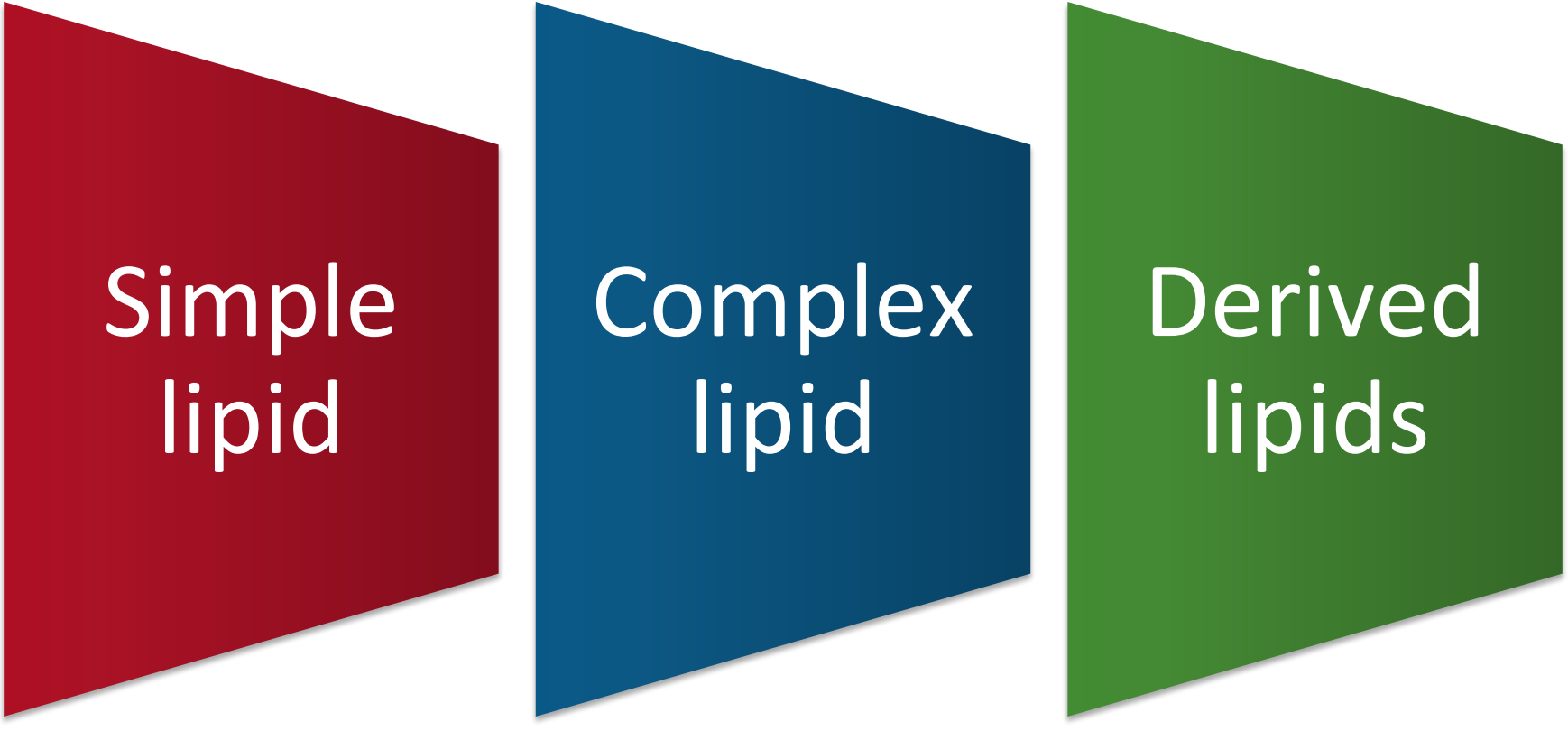

Lipids
Simple lipids
esters of fatty acids with various alcohols e.g. fats, waxes, cutin, suberin
Compound lipids
ester of fatty acids with alcohol and contain additional groups e.g. phospholipids, glycolipids (cerebrosides or glycosphingolipids), lipoproteins, sulfolipids and a ninolipids.
Derived lipids
derivatives or hydrolyzed substances e.g. fatty acids, glycerol, sterol, terpenes, prostaglandinsketone bodies, fatty aldehyde, vitamin-A, D, E and K, camphor, menthol etc.

LIPID CHEMISTRY

Classification

Biological importance

CLASSIFICATION OF LIPIDS



SIMPLE LIPIDS

They are esters of FA with various alcohols

D/U the type of alcohols these are subclassified as

Neutral fats or oils

Alcohol is GLYCEROL

Waxes

Alcohol is other than glycerol

A) Fatty acids:

Fatty acids are monocarboxylic acids (R-COOH) with long hydrocarbon chains. Fatty acids don't occur free in nature; rather occur as esters in natural fats and oils. The fatty acid is called an acyl group when it is a part of ester. In biological systems, fatty acids usually contain an even number of carbon atoms, typically between 14 and 24. The most common fatty acids have 16-18 carbon and 0-3 double bonds. For example, plamitic (C16), stearic (C18), oleic (C18), linoleic (C18)

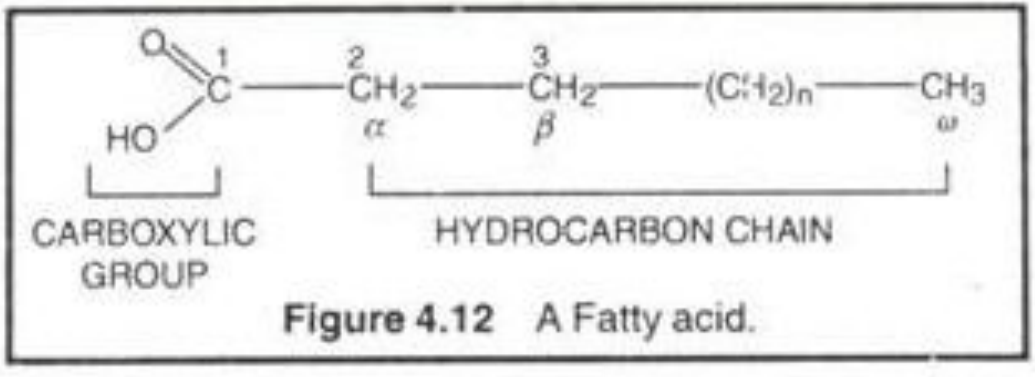
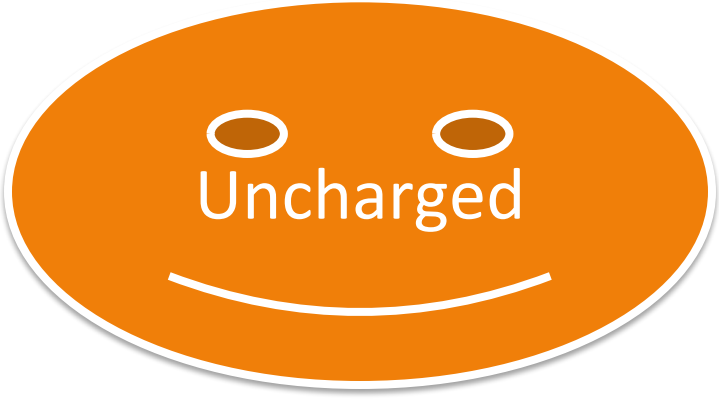
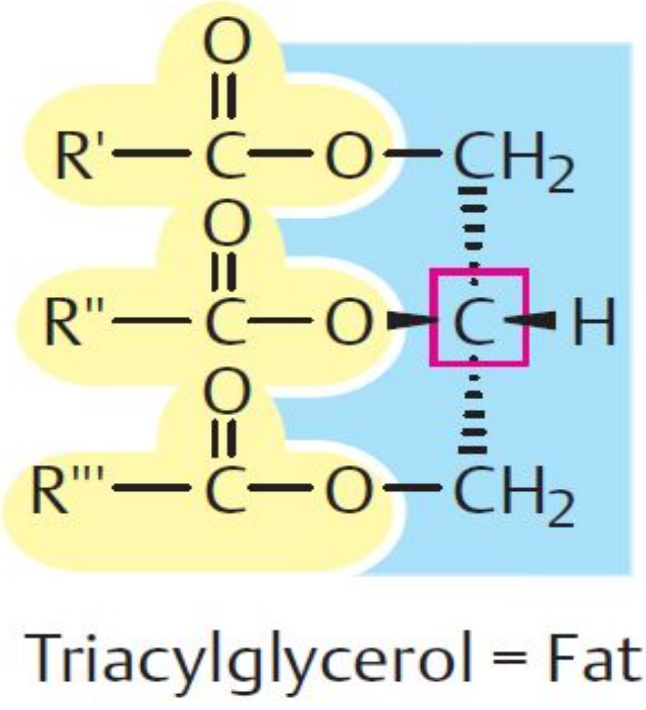


Figure 4.12 A Fatty acid.

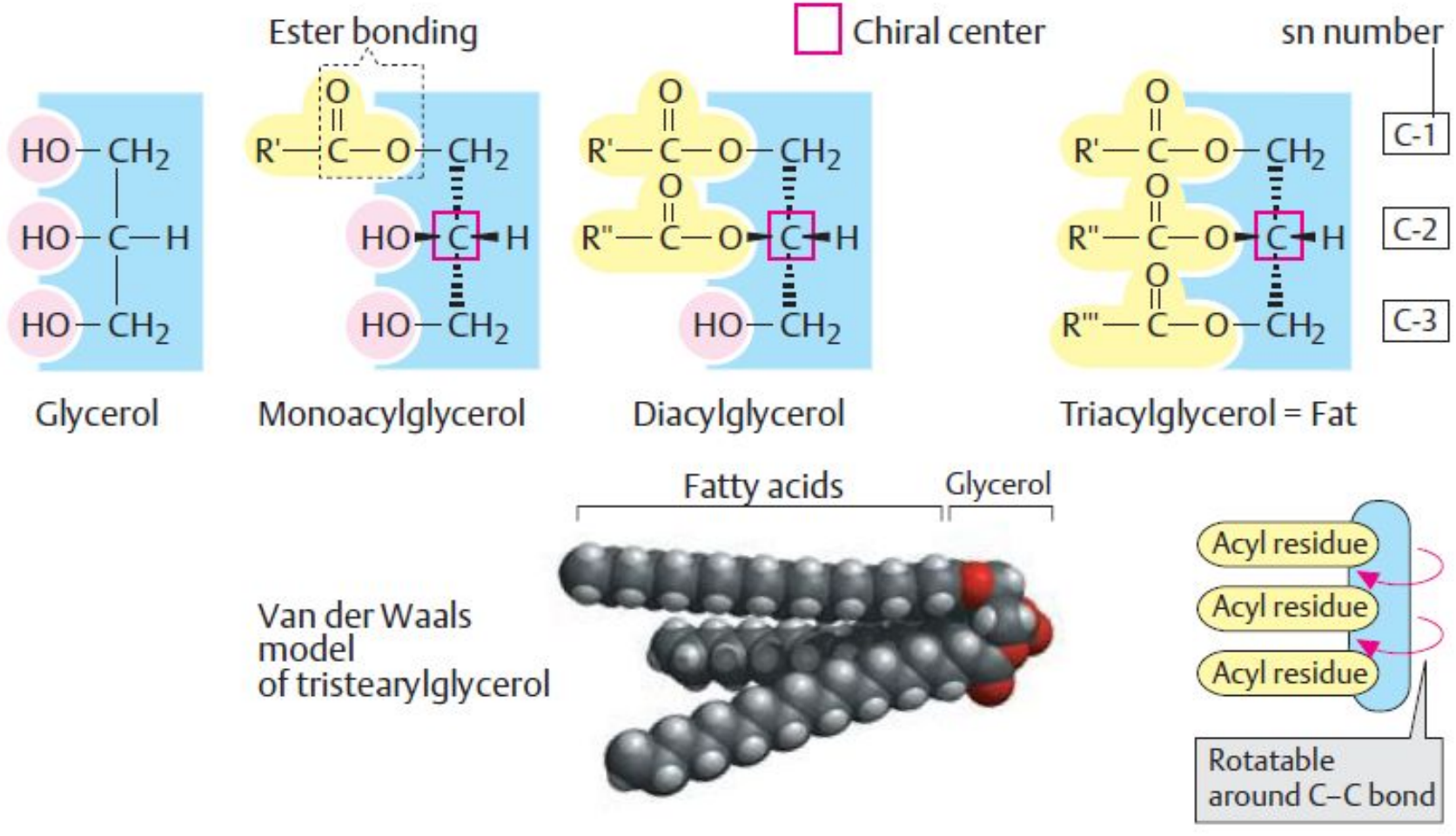
NEUTRAL FATS OR OILS

Esters of FA with alcohol
GLYCEROL





B. Structure of fats



A **triglyceride** (**TG**, **triacylglycerol**, **TAG**, or **triacylglyceride**) is an ester derived from glycerol and three fatty acids (from *tri-* and *glyceride*).

saturated and unsaturated.

Saturated fats are "saturated" with hydrogen – all available places where hydrogen atoms could be bonded to carbon atoms are occupied. These have a higher melting point and are more likely to be solid at room temperature. saturated fat include animal fat as cream, cheese, butter, other whole milk dairy products and fatty meats which also contain dietary cholesterol.Certain vegetable products have high saturated fat content, such as coconut oil and palm kernel oil

Butyric acid with 4 carbon atoms (contained in butter)

Lauric acid with 12 carbon atoms (contained in coconut oil, palm kernel oil, and breast milk)

Myristic acid with 14 carbon atoms (contained in cow's milk and dairy products)

Palmitic acid with 16 carbon atoms (contained in palm oil and meat)

Stearic acid with 18 carbon atoms (also contained in meat and cocoa butter)

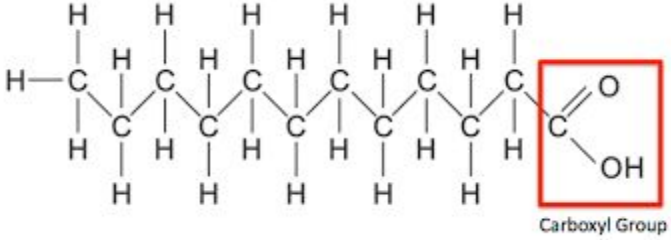
Fatty acids are of 2 types, saturated and unsaturated.

Saturated fatty acids contain **no double bonds (saturated** in hydrocarbon chain, e.g., CH3 (CH2)14COOH (palmitic acid), CH3 (CH2)16COOH (stearic acid), CH3 (CH2)18 carboxylic COOH (arachidonic acid) etc.

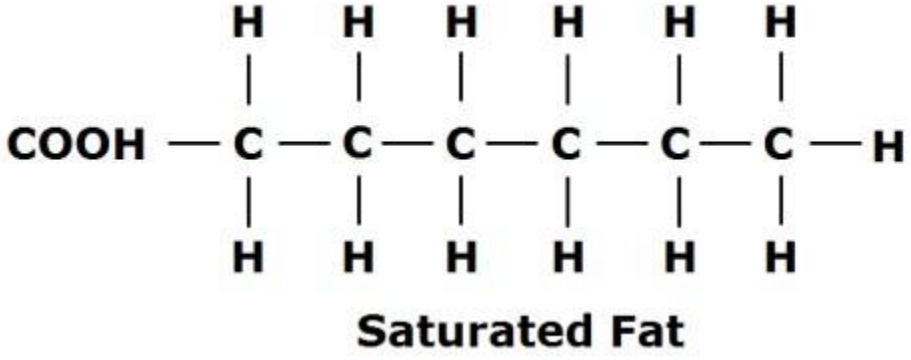
They have higher group melting points and are solid at room temp.

Unsaturated fatty acids contain one or more double bonds (unsaturated) in hydrocarbon chain. A double bond in an unsaturated fatty acid has two possible configurations, cis or Trans.

The double bonds in most unsaturated fatty acids have the cis orientation that introduces a bend or kink in the hydrocarbon side chain.

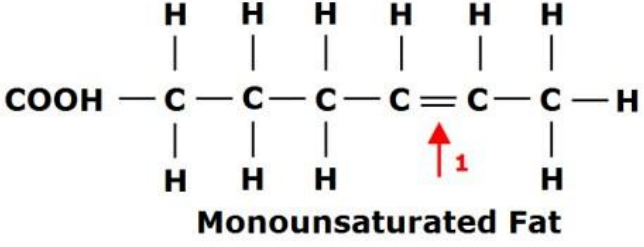


Lauric acid with 12 carbon atoms

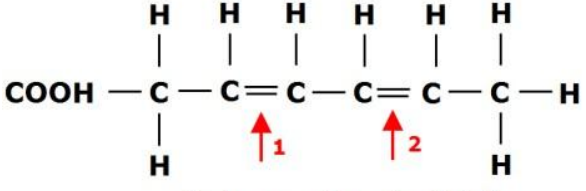


Unsaturated fats have double bonds between some of the carbon atoms, reducing the number of places where hydrogen atoms can bond to carbon atoms. These have a lower melting point and are more likely to be liquid at room temperature.

Examples of unsaturated fatty acids are palmitoleic acid, oleic acid, myristoleic acid, linoleic acid, and arachidonic acid. Foods containing unsaturated fats include avocado, nuts, and vegetable oils such as canola and olive oils. Meat products contain both saturated and unsaturated fats



Monounsaturated Fat



Polyunsaturated Fat

Rancidification, the product of which can be described as **rancidity**, is the process which causes a substance to become rancid, that is, having a rank, unpleasant smell or taste. Specifically, it is the hydrolysis and/or autoxidation of fats into short-chain aldehydes and ketones which are objectionable in taste and odour

Rancidification can also detract from the nutritional value of food,

WAXES

Esters of FA with higher molecular weight monohydric alcohols

EXAMPLES

- ✔ Lanolin
- ✔ Beeswax
- ✔ Whale sperm oil

COMPLEX LIPIDS

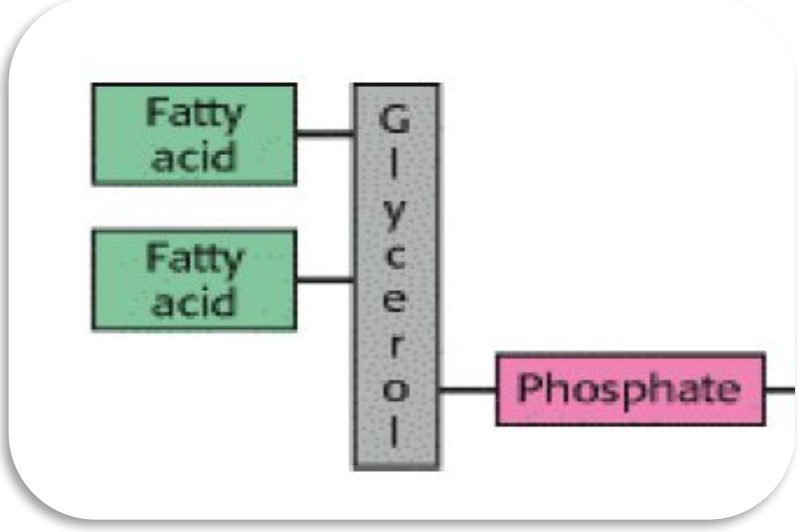
These are esters of FA with alcohol containing additional[prosthetic] groups.

Subclassified according to the type of prosthetic group

- Phospholipids
- Glycolipids
- Lipoproteins

PHOSPHOLIPIDS

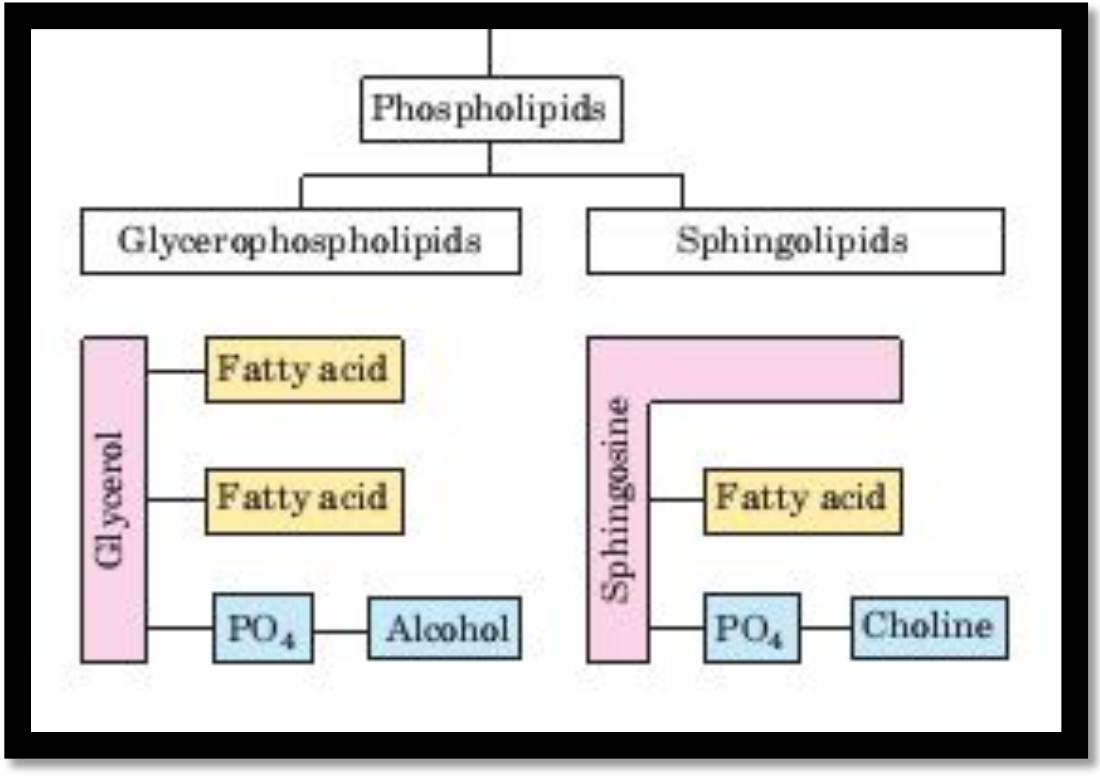
FA + ALCOHOL + PHOSPHORIC ACID



They frequently have nitrogen containing bases

PHOSPHOLIPIDS

Phospholipids may be classified on the basis of the type of alcohol present



A. Glycerophospholipids

ALCOHOL IS GLYCEROL

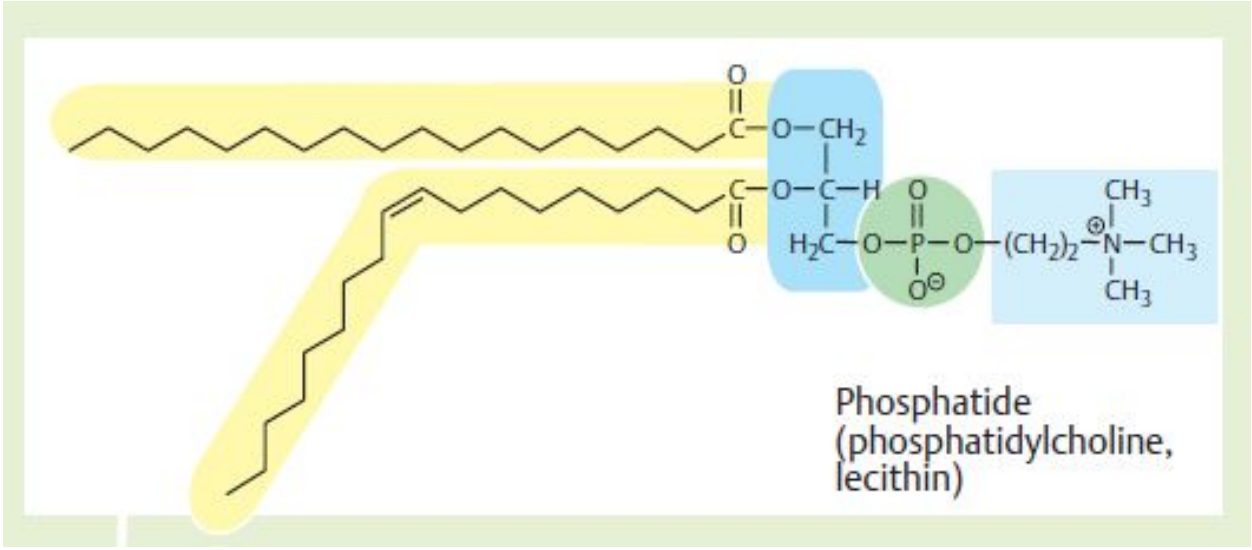
- ✔ Phosphatidylcholine
- ✔ Phosphatidyl ethanolamine
- ✔ Phosphatidyl serine
- ✔ Phosphatidyl inositol
- ✔ Plasmalogens
- ✔ Cardiolipins

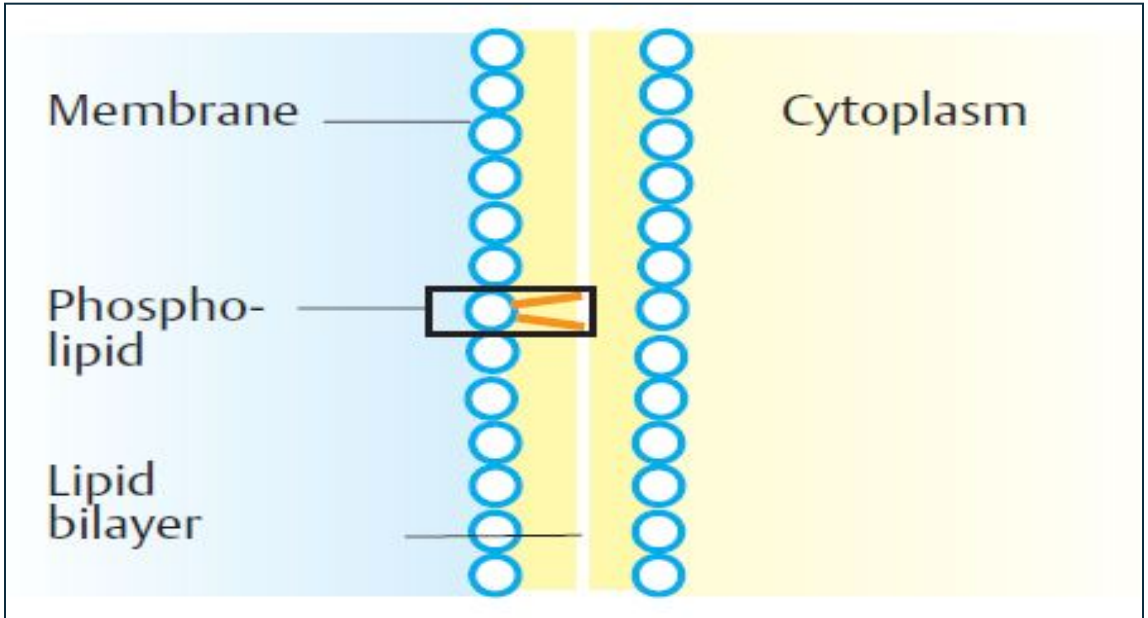
B. Spingophospholipids

ALCOHOL IS SPINGOSINE

- ✔ Spingomyelins

Sphingosine (2-amino-4-octadecene-1,3-diol) is an 18-carbon amino alcohol with an unsaturated hydrocarbon chain, which forms a primary part of sphingolipids, a class of cell membrane lipids that include sphingomyelin, an important phospholipid


Phosphatide
(phosphatidylcholine,
lecithin)


Membrane
Cytoplasm
Phospho-
lipid
Lipid
bilayer

GLYCOLIPIDS

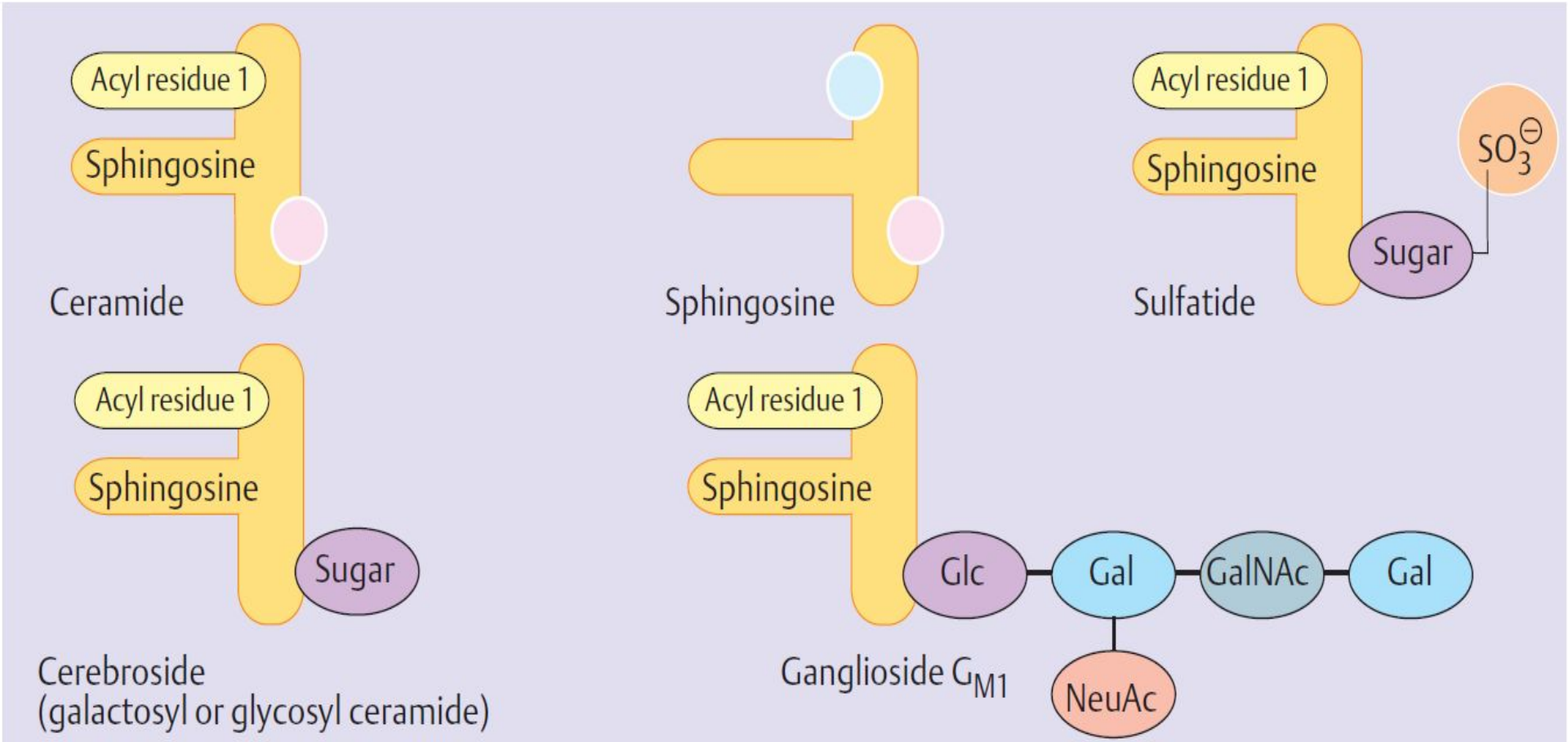
FA + ALCOHOL[SPINGOSINE] +CARBOHYDRATE WITH NITROGEN BASE

- **They do not contain phosphate group**

Example

- ✔Cerebrosides
- ✔Gangliosides

GLYCOLIPIDS



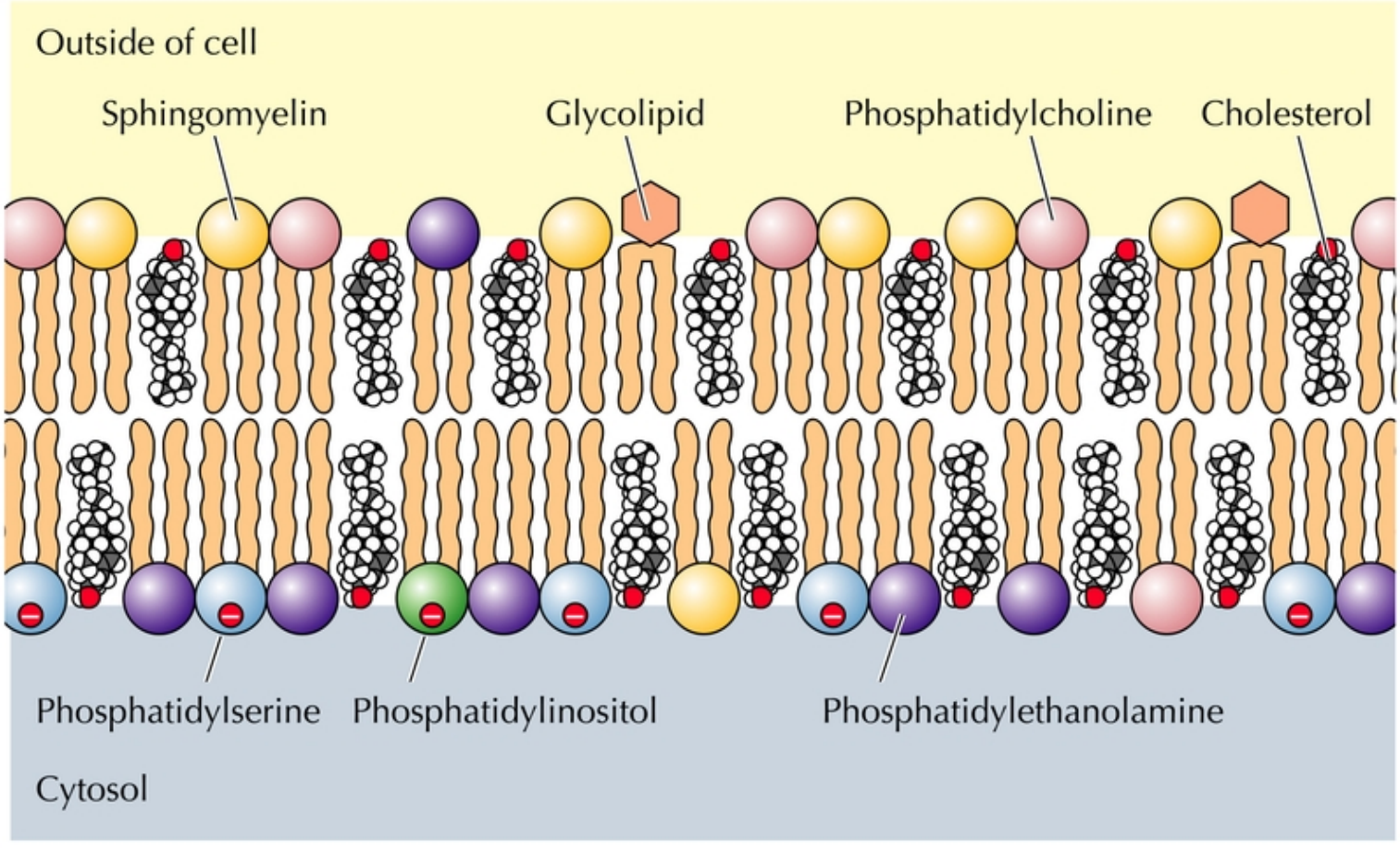
3. Sphingolipids

LIPOPROTEINS

Lipid with prosthetic group PROTEIN

- Chylomicrons
- Very low density lipoprotein (VLDL)
- Low density lipoprotein (LDL)
- High density lipoprotein (HDL)

Total cholesterol Less than 200 mg/dL
LDL ("bad" cholesterol) Less than 100 mg/dL
HDL ("good" cholesterol) 40 mg/DL or higher
Triglycerides Less than 150 mg/dL

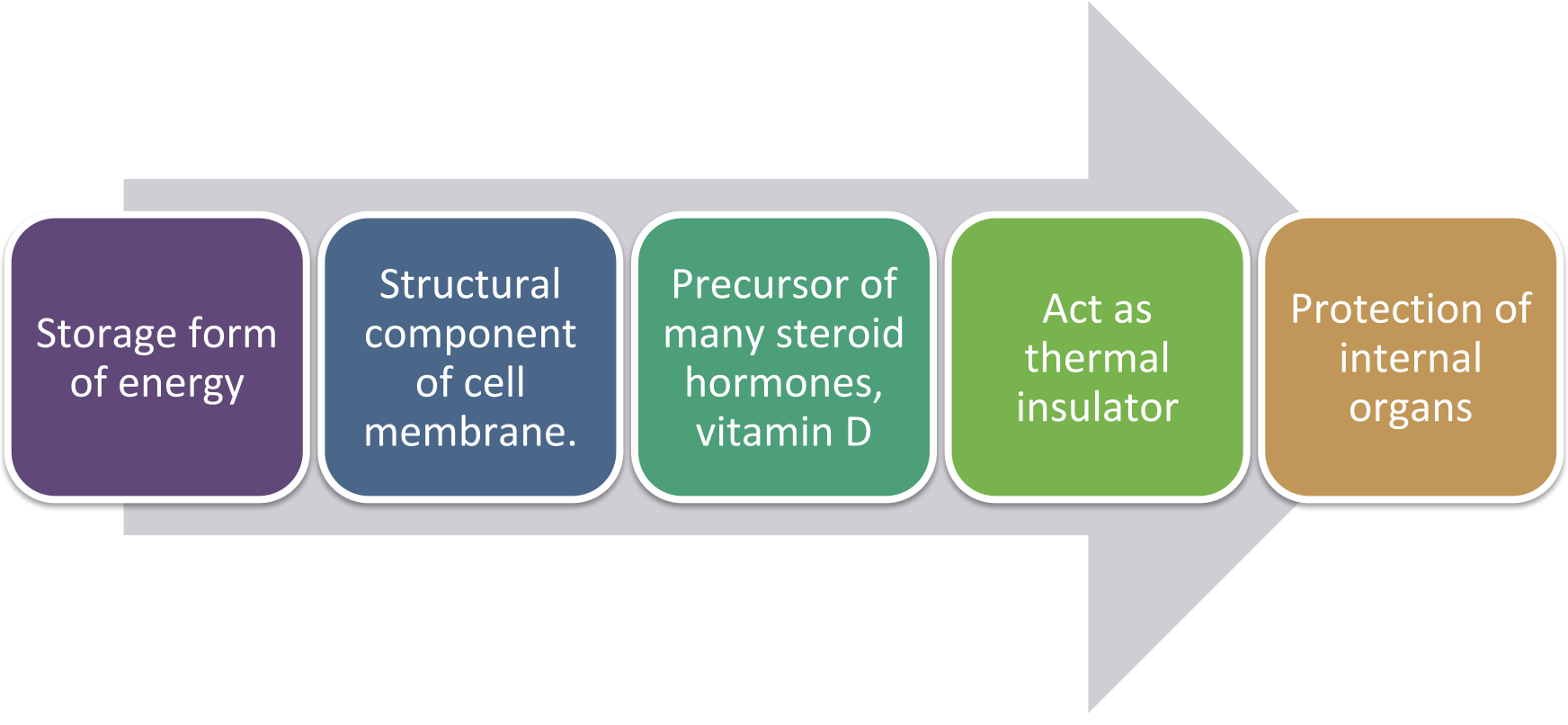


DERIVED LIPIDS

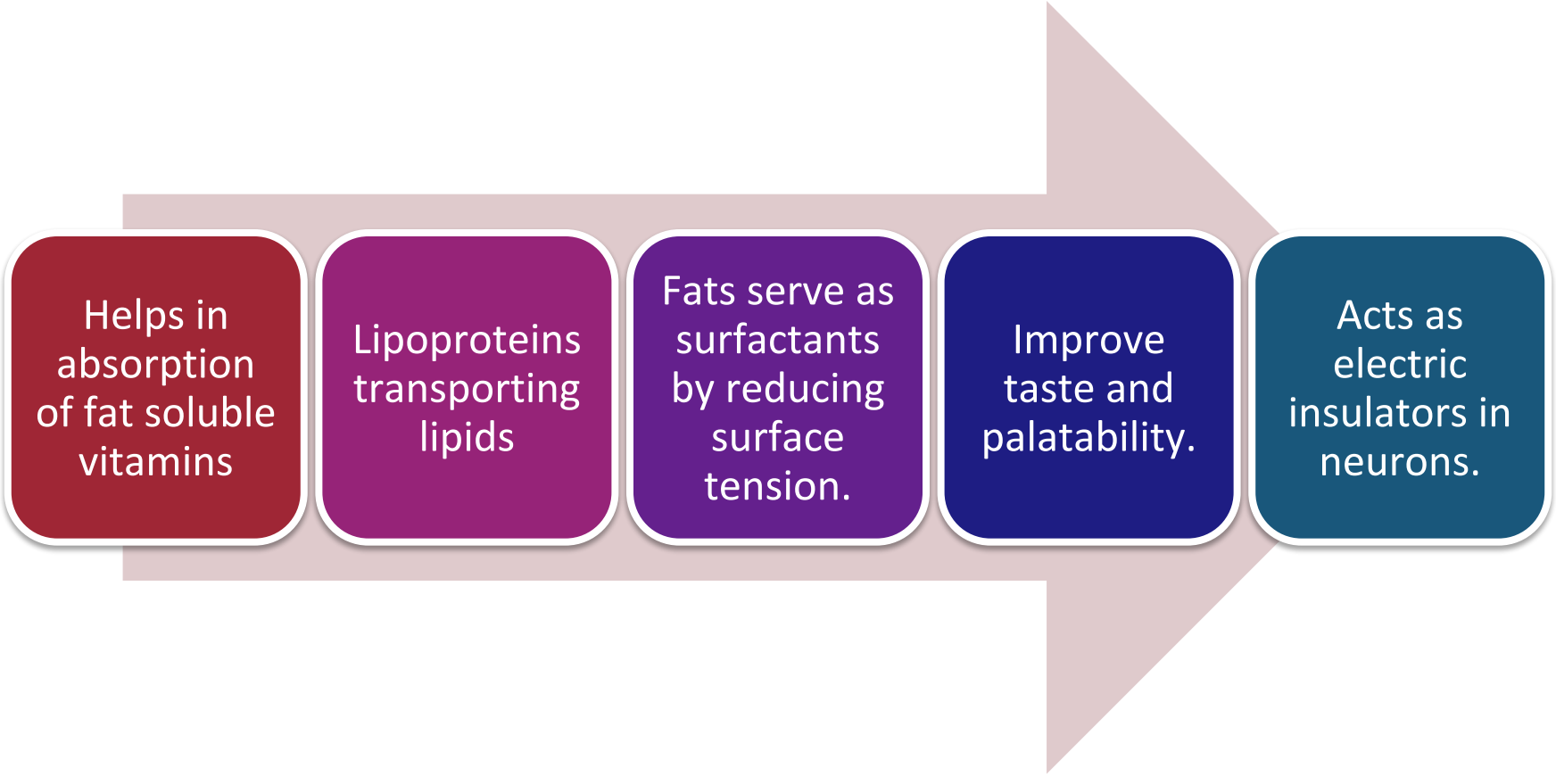
Derived from lipids (simple or complex)or precursors of lipids

Example			
Fatty acids	Steroids	Cholesterol	Vitamin A and D

FUNCTIONS OF LIPIDS



FUNCTIONS OF LIPIDS



Biological Importance of Lipids:

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

7-Stored lipids "deposit fat" is stored in all human cells acts as:

- A store of energy.
- A pad for the internal organs to protect them from outside shocks.
- A subcutaneous thermal insulator against loss of body heat.

8-Lipoproteins, which are complex of lipids and proteins, are important cellular constituents that present both in the cellular and subcellular membranes.

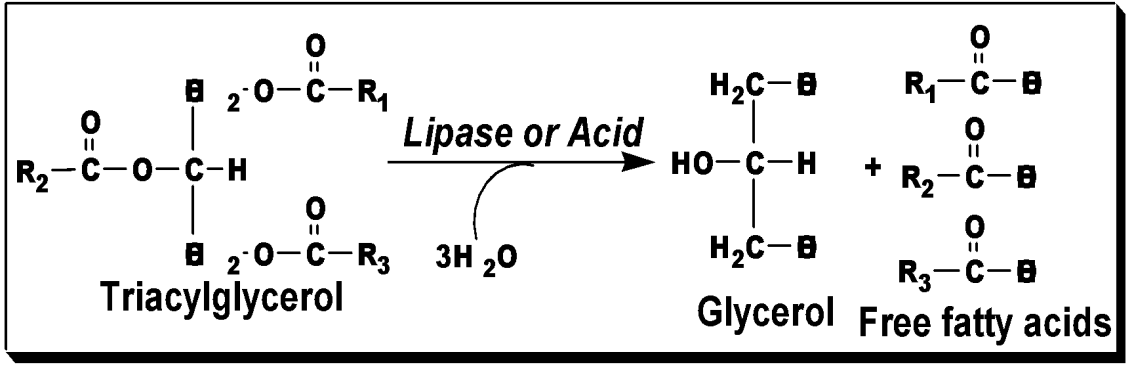
9-Cholesterol enters in membrane structure and is used for synthesis of adrenal cortical hormones, vitamin D3 and bile acids.

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

Chemical Properties of fats and oils:

1-Hydrolysis:

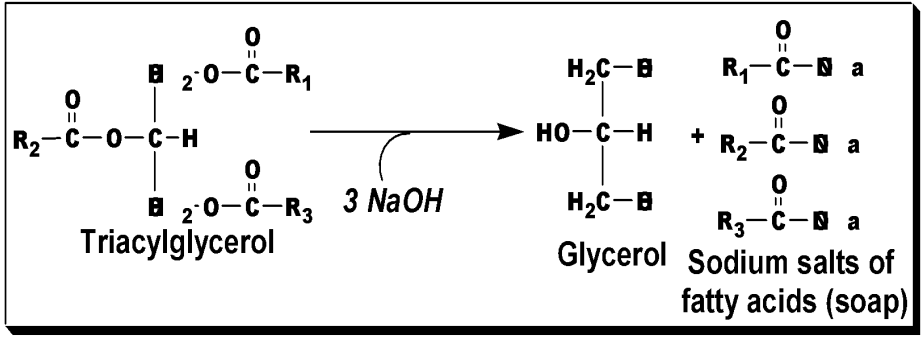
- hydrolyzed into their constituents (fatty acids and glycerol) by heated steam, acid, alkali or enzyme (e.g., lipase of pancreas).
- - During their enzymatic and acid hydrolysis glycerol and free fatty acids are produced.



2-Saponification.

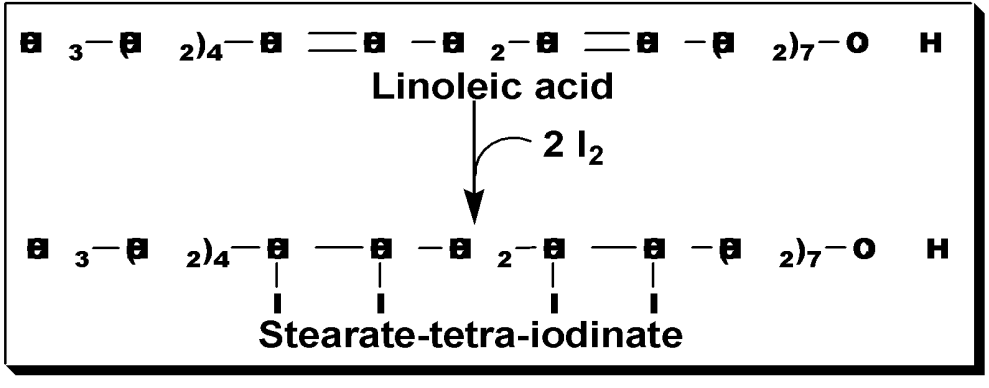
> Alkaline hydrolysis produces glycerol and salts of fatty acids (soaps).

- Soaps cause emulsification of oily material this help easy washing of the fatty materials



3-Halogenation

- Neutral fats containing unsaturated fatty acids have the ability of adding halogens (e.g., hydrogen or hydrogenation and iodine or iodination) at the double bonds.
- very important property to determine the degree of unsaturation of the fat or oil that determines its biological value



4-Hydrogenation or hardening of oils:

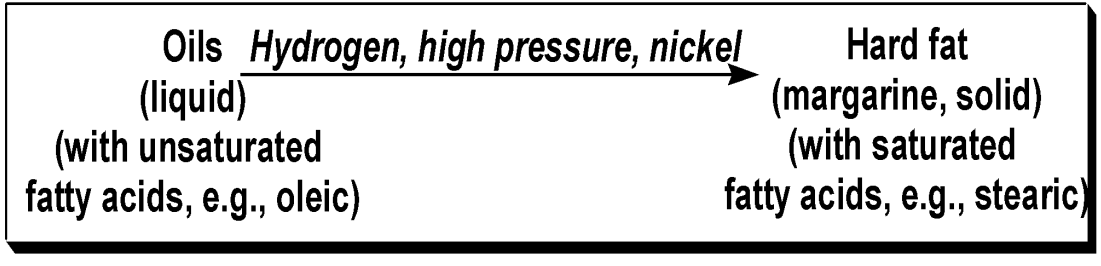
- It is a type of addition reactions accepting hydrogen at the double bonds of unsaturated fatty acids.
- The hydrogenation is done under high pressure of hydrogen and is catalyzed by finely divided nickel or copper and heat.
- It is the base of hardening of oils (margarine manufacturing), e.g., change of oleic acid of fats (liquid) into stearic acid (solid).
- It is advisable not to saturate all double bonds; otherwise margarine produced will be very hard, of very low biological value and difficult to digest.

Advantages for hydrogenated oil or fat are as follows:

1. It is more pleasant as cooking fat.
2. It is digestible and utilizable as normal animal fats and oils.
3. It is less liable to cause gastric or intestinal irritation.
4. It is easily stored and transported and less liable to rancidity.

Disadvantages of hydrogenated

- fats include lack of fat-soluble vitamins (A, D, E and K) and essential fatty acids



5-Oxidation (Rancidity)

- This toxic reaction of triglycerides leads to unpleasant odour or taste of oils and fats developing after oxidation by oxygen of air, bacteria, or moisture.
- Also this is the base of the drying oils after exposure to atmospheric oxygen.

  Example is linseed oil, which is used in paints and varnishes manufacturing

= RANCID

Rancidity

Definition:

- physico-chemical change
- development of unpleasant odor or taste or abnormal color particularly on aging
- exposure to atmospheric oxygen, light, moisture, bacterial or fungal contamination and/or heat.
- Saturated fats resist rancidity more than unsaturated fats that have unsaturated double bonds.

Types and causes of Rancidity:

1. Hydrolytic rancidity
2. Oxidative rancidity
3. Ketonic rancidity

1-Hydrolytic rancidity:

- from slight hydrolysis of the fat by lipase
- bacterial contamination leading to the liberation of free fatty acids and glycerol at high temp and moisture.
- Volatile short-chain fatty acids have unpleasant odor.

Hazards of Rancid Fats:

1. The products of rancidity are toxic, i.e., causes food poisoning and cancer.
2. Rancidity destroys the fat-soluble vitamins (vitamins A, D, K and E).
3. Rancidity destroys the polyunsaturated essential fatty acids.
4. Rancidity causes ***economical loss*** because rancid fat is inedible.

B-Waxes

- **Definition**: **Waxes are solid simple lipids containing a monohydric alcohol (with a higher molecular weight than glycerol) esterified to long-chain fatty acids. Examples of these alcohols are palmitoyl alcohol, cholesterol, vitamin A or D.**
- **Properties of waxes: Waxes are insoluble in water, but soluble in fat solvents and are negative for acrolein test.**
- **Waxes are not easily hydrolyzed as the fats and are indigestible by lipases and are very resistant to rancidity.**
- **Thus they are of no nutritional value.**

Type of Waxes:

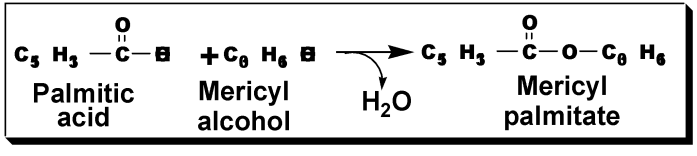
- - Waxes are widely distributed in nature such as the secretion of certain insects as bees-wax, protective coatings of the skins and furs of animals and leaves and fruits of plants. They are classified into true-waxes and wax-like compounds as follows:

A-True waxes: include:

- **Bees-wax** is secreted by the honeybees that use it to form the combs. It is a mixture of waxes with the chief constituent is mericyl palmitate.

B-Wax-like compounds:

- **Cholesterol esters: Lanolin (or wool fat) is prepared from the wool-associated skin glands and is secreted by sebaceous glands of the skin.**
- **It is very complex mixture, contains both free and esterified cholesterol, e.g., cholesterol-palmitate and other sterols.**



Differences between neutral lipids and waxes:

	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 fatty acids
3-Type of fatty acids:	Fatty acid mainly palmitic or stearic acid.	Long and short chain fatty acids.
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:	Bee & carnuba waxes.	Butter and vegetable oils.

2-Compound Lipids

Definition:

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

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

A-Phospholipids

Definition: **Phospholipids or phosphatides are compound lipids, which contain phosphoric acid group in their structure.**

Importance:

1. **They are present in large amounts in the liver and brain as well as blood. Every animal and plant cell contains phospholipids.**
2. **The membranes bounding cells and subcellular organelles are composed mainly of phospholipids. Thus, the transfer of substances through these membranes is controlled by properties of phospholipids.**
3. **They are important components of the lipoprotein coat essential for secretion and transport of plasma lipoprotein complexes. Thus, they are lipotropic agents that prevent fatty liver.**
4. **Myelin sheath of nerves is rich with phospholipids.**

5-Important in digestion and absorption of neutral lipids and excretion of cholesterol in the bile.

6-Important function in blood clotting and platelet aggregation.

7-They provide lung alveoli with surfactants that prevent its irreversible collapse.

8-Important role in signal transduction across the cell membrane.

9-Phospholipase A2 in snake venom hydrolyses membrane phospholipids into hemolytic lysolecithin or lysocephalin.

10-They are source of polyunsaturated fatty acids for synthesis of eicosanoids.

Sources: They are found in all cells (plant and animal), milk and egg-yolk in the form of lecithins.

Structure: phospholipids are composed of:

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

- **Classification of Phospholipids are classified into 2 groups according to the type of the alcohol present into two types:**

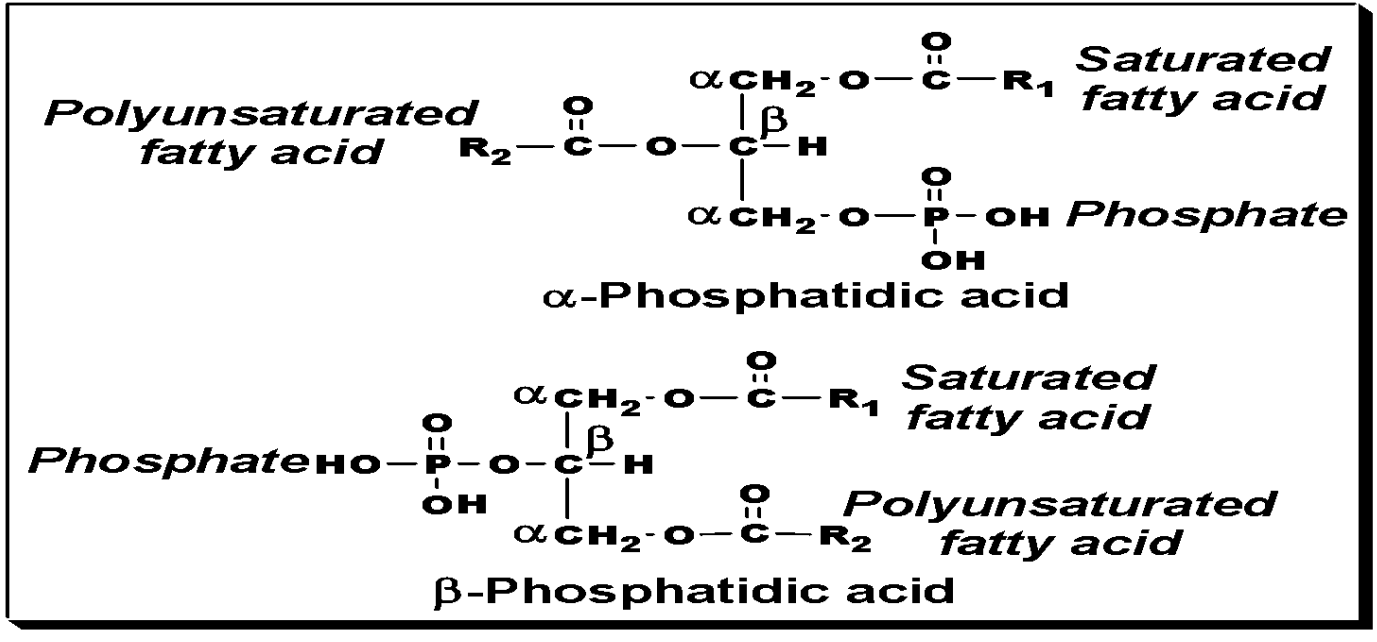
A-**Glycerophospholipids:** They are regarded as derivatives of phosphatidic acids that are the simplest type of phospholipids and include:

1. Phosphatidic acids.
2. Lecithins
3. Cephalins.
4. Plasmalogens.
5. Inositides.
6. Cardiolipin.

B-Sphingophospholipids: They contain sphingosine as an alcohol and are named Sphingomyelins.

A-Glycerophospholipids

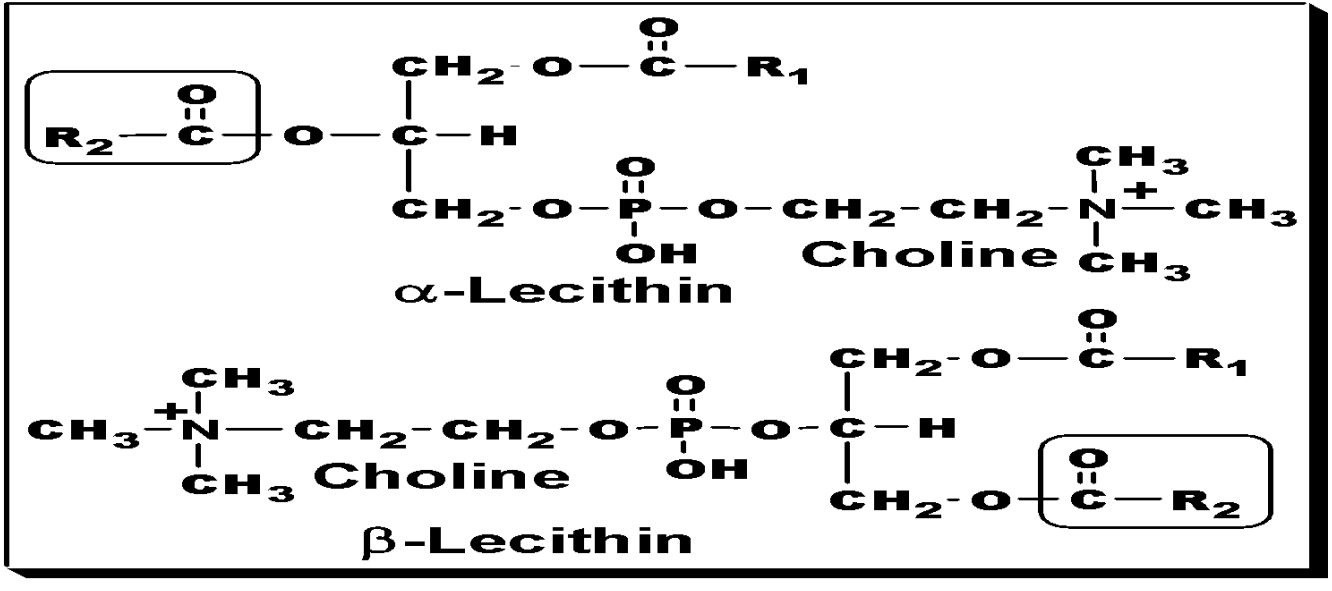
1-Phosphatidic acids: They are metabolic intermediates in synthesis of triglycerides and glycerophospholipids in the body and may have function as a second messenger. They exist in two forms according to the position of the phosphate



2-Lecithins:

- **Definition**: Lecithins are glycerophospholipids that contain choline as a base beside phosphatidic acid. They exist in 2 forms α- and β-lecithins. Lecithins are a common cell constituent obtained from brain (α-type), egg yolk (β-type), or liver (both types). Lecithins are important in the metabolism of fat by the liver.
- **Structure:** Glycerol is connected at C2 or C3 with a polyunsaturated fatty acid, at C1 with a saturated fatty acid, at C3 or C2 by phosphate to which the choline base is connected. The common fatty acids in lecithins are stearic, palmitic, oleic, linoleic, linolenic, clupandonic or arachidonic acids.

Lysolecithin causes hemolysis of RBCs. This partially explains toxic effect of snake venom,. The venom contains lecithinase, which hydrolyzes the polyunsaturated fatty converting lecithin into lysolecithin. Lysolecithins are intermediates in metabolism of phospholipids.



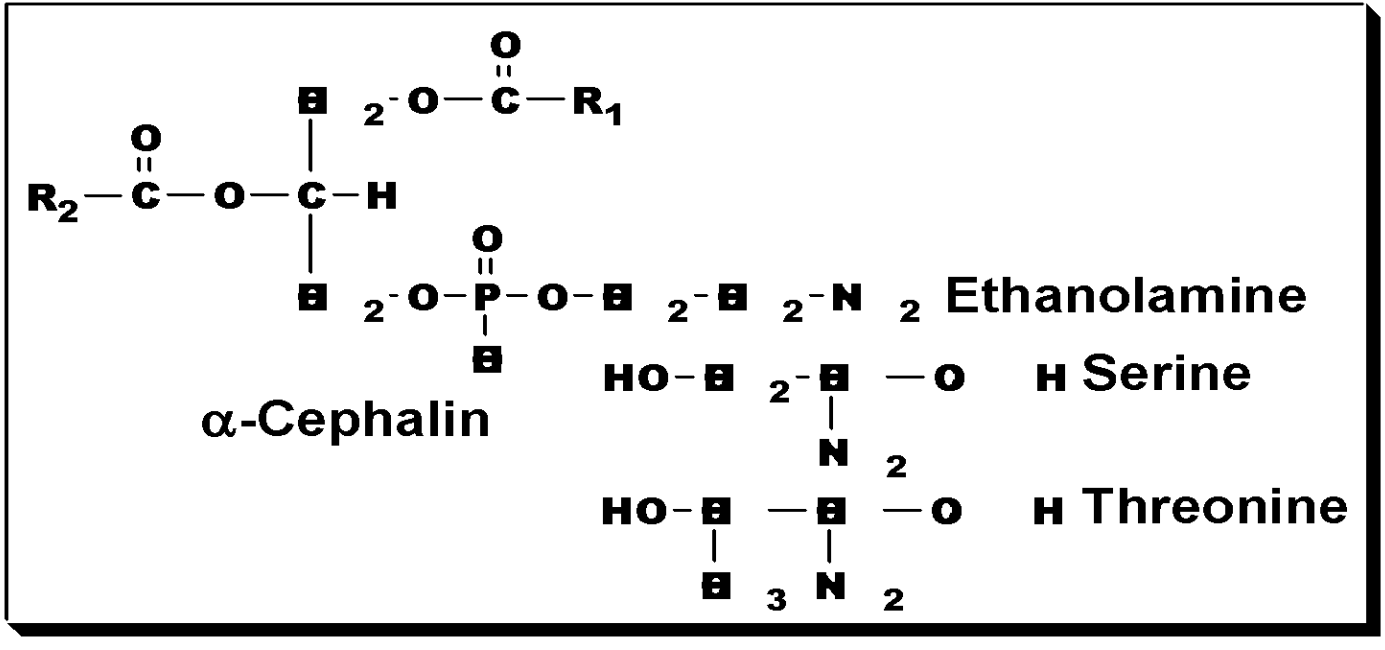
Lung surfactant

- Is a complex of dipalmitoyl-lecithin, sphingomyelin and a group of apoproteins called apoprotein A, B, C, and D.
- It is produced by type II alveolar cells and is anchored to the alveolar surface of type II and I cells.
- It lowers alveolar surface tension and improves gas exchange besides activating macrophages to kill pathogens.
- In premature babies, this surfactant is deficient and they suffer from respiratory distress syndrome.
- Glucocorticoids increase the synthesis of the surfactant complex and promote differentiation of lung cells.

3-Cephalins (or Kephalins):

- **Definition**: **They are phosphatidyl-ethanolamine or serine. Cephalins occur in association with lecithins in tissues and are isolated from the brain (Kephale = head).**
- **Structure: Cephalins resemble lecithins in structure except that choline is replaced by ethanolamine, serine or threonine amino acids.**

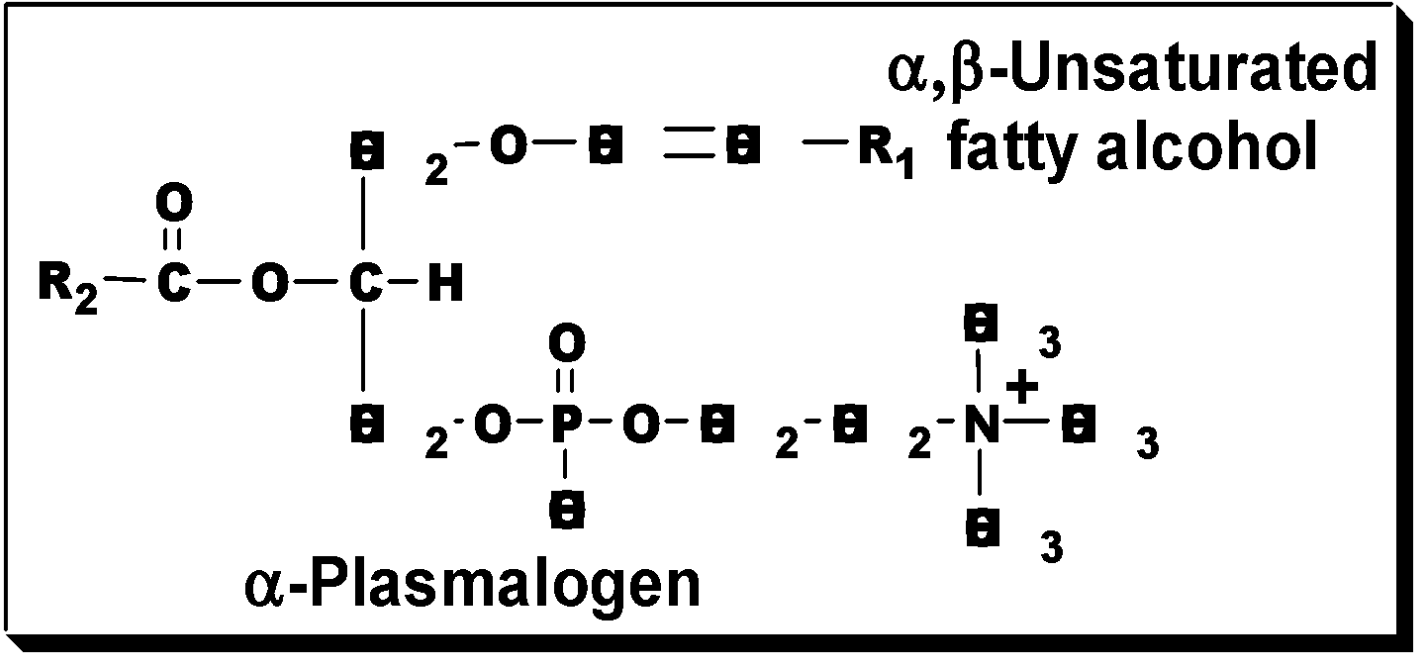
- Certain cephalins are constituents of the complex mixture of phospholipids, cholesterol and fat that constitute the lipid component of the lipoprotein "thromboplastin" which accelerates the clotting of blood by activation of prothrombin to thrombin in presence of calcium ions.



4-Plasmalogens:

- **Definition:** Plasmalogens are found in the cell membrane phospholipids fraction of brain and muscle (10% of it is plasmalogens), liver, semen and eggs.
- **Structure**: Plasmalogens resemble lecithins and cephalins in structure but differ in the presence of **α,β-unsaturated fatty alcohol** rather than a fatty acid at C1 of the glycerol connected by ether bond.
- At C2 there is an unsaturated long-chain fatty acid, however, it may be a very short-chain fatty acid

●Properties: Similar to lecithins.



B-Sphingophospholipids

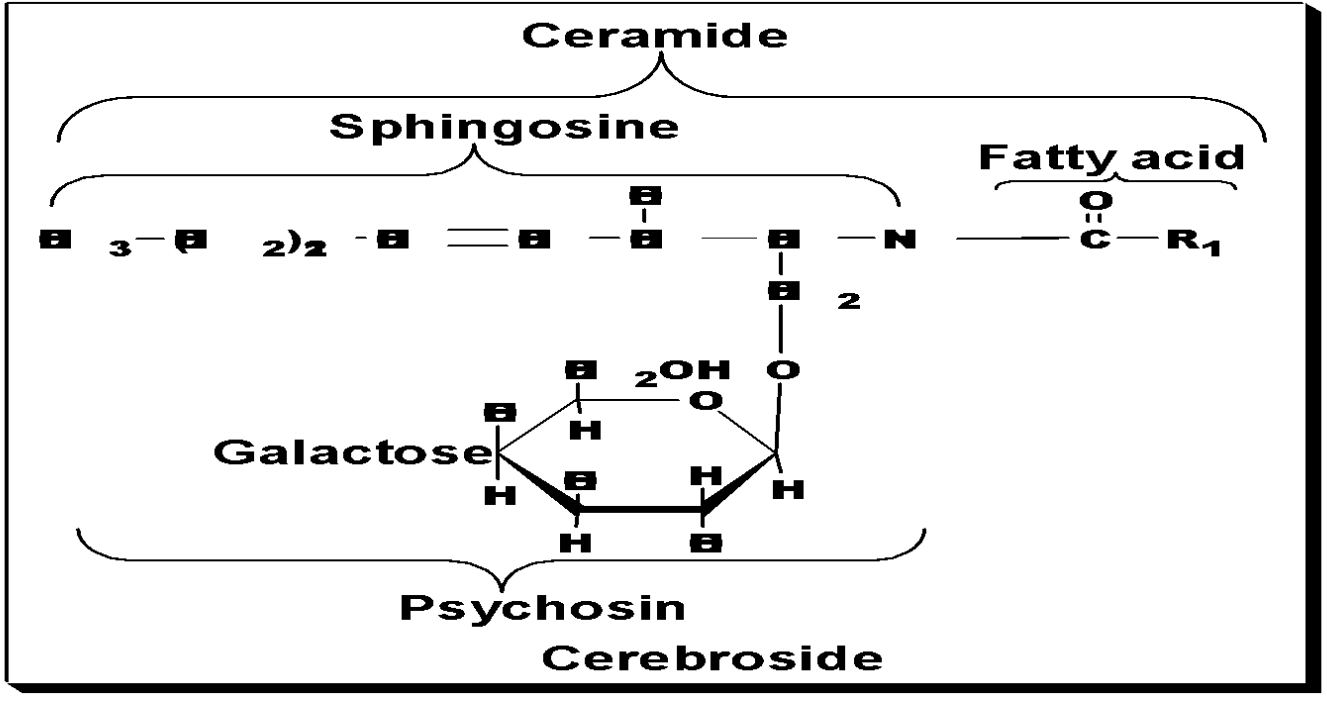
1-Sphingomyelins

- **Definition:** Sphingomyelins are found in large amounts in brain and nerves and in smaller amounts in lung, spleen, kidney, liver and blood.

- **Structure:** Sphingomyelins differ from lecithins and cephalins in that they contain sphingosine as the alcohol instead of glycerol, they contain two nitrogenous bases: sphingosine itself and choline.
- Thus, sphingomyelins contain sphingosine base, one long-chain fatty acid, choline and phosphoric acid.
- To the amino group of sphingosine the fatty acid is attached by an amide linkage.

1-Cerebrosides:

- **Occurrence:** They occur in myelin sheath of nerves and white matter of the brain tissues and cellular membranes. They are important for nerve conductance.
- **Structure:** They contain sugar, usually β-galactose and may be glucose or lactose, sphingosine and fatty acid, but no phosphoric acid.



C-Lipoproteins

- **Definition: Lipoproteins are lipids combined with proteins in the tissues. The lipid component is phospholipid, cholesterol or triglycerides. The holding bonds are secondary bonds.**
- **They include:**

1. **Structural lipoproteins: These are widely distributed in tissues being present in cellular and subcellular membranes. In lung tissues acting as a surfactant in a complex of a protein and lecithin. In the eye, rhodopsin of rods is a lipoprotein complex.**

- **Transport lipoproteins:**
- **These are the forms present in blood plasma. They are composed of a protein called apolipoprotein and different types of lipids. (Cholesterol, cholesterol esters, phospholipids and triglycerides). As the lipid content increases, the density of plasma lipoproteins decreases**

- **Plasma lipoproteins can be separated by two methods:**

1. **Ultra-centrifugation: Using the rate of floatation in sodium chloride solution leading to their sequential separation into chylomicrons, very low density lipoproteins (VLDL or pre-β-lipoproteins), low density lipoproteins (LDL or β-lipoproteins), high density lipoproteins (HDL or α-lipoproteins) and albumin-free fatty acids complex.**
2. **Electrophoresis: is the migration of charged particles in an electric field either to the anode or to the cathode. It sequentially separates the lipoproteins into chylomicrons, pre-β-, β-, and α-lipoprotein and albumin-free fatty acids complex.**

a) Chylomicrons: They have the largest diameter and the least density. They contain 1-2% protein only and 98-99% fat. The main lipid fraction is triglycerides absorbed from the intestine and they contain small amounts of the absorbed cholesterol and phospholipids.

b) Very low-density lipoproteins (VLDL) or pre-β-lipoproteins: Their diameter is smaller than chylomicrons. They contain about 7-10% protein and 90-93% lipid. The lipid content is mainly triglycerides formed in the liver. They contain phospholipid and cholesterol more than chylomicrons.

c**) Low-density lipoproteins (LDL) or β-lipoproteins**: They contain 10-20% proteins in the form of apolipoprotein B. Their lipid content varies from 80-90%. They contain about 60% of total blood cholesterol and 40% of total blood phospholipids. As their percentage increases, the liability to atherosclerosis increases.

d) High-density lipoproteins (HDL) or α-Lipoproteins: They contain 35-55% proteins in the form of apolipoprotein A. They contain 45-65% lipids formed of cholesterol (40% of total blood content) and phospholipids (60% of total blood content). They act as cholesterol scavengers, as their percentage increases, the liability to atherosclerosis decreases. They are higher in females than in males. Due to their high protein content they possess the highest density.

e) Albumin-free fatty acids complex: It is a proteolipid complex with 99% protein content associated with long-chain free fatty acids for transporting them.

Cholesterol:

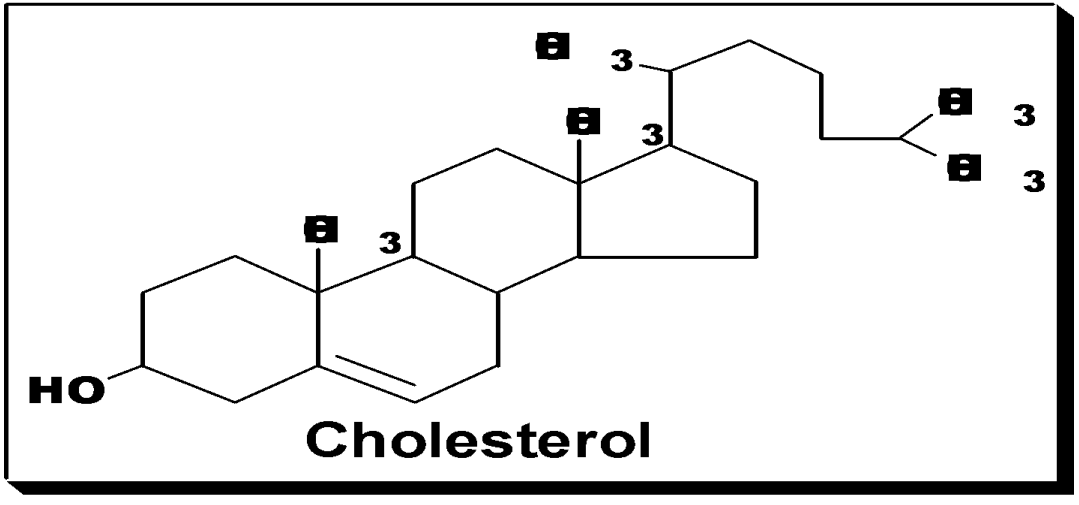
Importance: -

- It is the most important sterol in animal tissues as free alcohol or in an esterified form (with linoleic, oleic, palmitic acids or other fatty acids).
- Steroid hormones, bile salts and vitamin D are derivatives from it.
- Tissues contain different amounts of it that serve a structural and metabolic role, e.g., adrenal cortex content is 10%, whereas, brain is 2%, others 0.2-0.3%.

Source: - It is synthesized in the body from acetyl-CoA (1gm/day, cholesterol does not exist in plants) and is also taken in the diet (0.3 gm/day as in, butter, milk, egg yolk, brain, meat and animal fat).

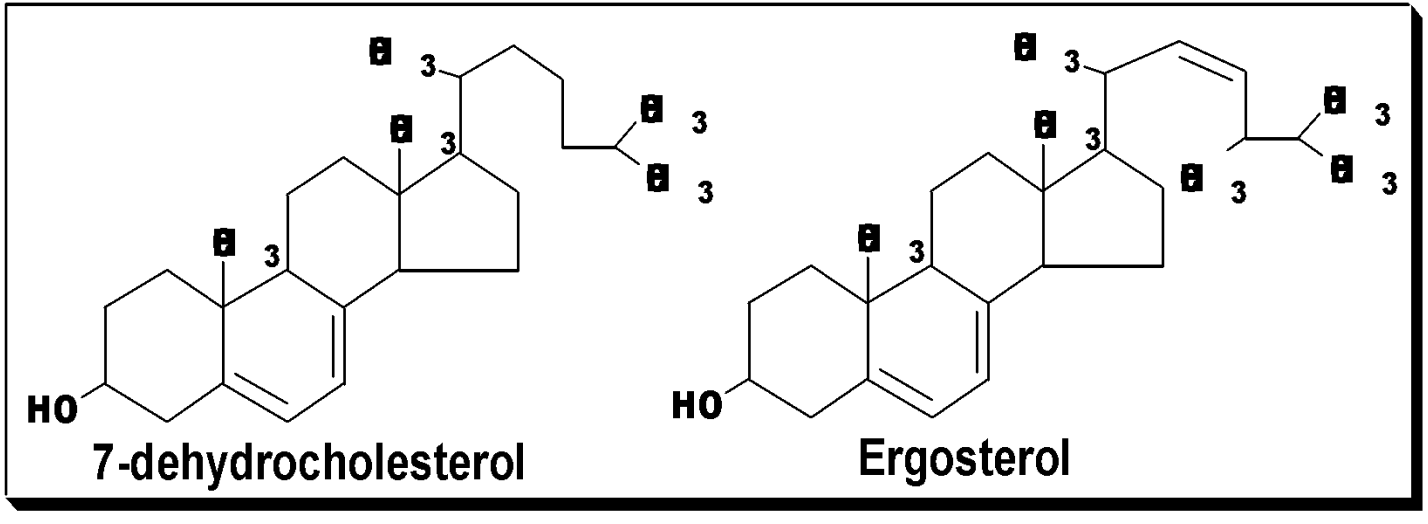
Physical propeties: It has a hydroxyl group on C3, a double bond between C5 and C6, 8 asymmetric carbon atoms and a side chain of 8 carbon atoms.

- It is found in all animal cells, corpus luteum and adrenal cortex, human brain (17% of the solids).
- In the blood (the total cholesterol amounts about 200 mg/dL of which 2/3 is esterified, chiefly to unsaturated fatty acids while the remainder occurs as the free cholesterol.



Cholesterol

- **Ergosterol** differs from 7-dehydrocholesterol in the side chain. Ergosterol is converted to vitamin D2 by irradiation with UV Ergosterol and 7- dehydrocholesterol are called Pro-vitamins D or precursors of vitamin D.
- - It was first isolated from ergot, a fungus then from yeast. Ergosterol is less stable than cholesterol (because of having 3 double bonds).



Steroids

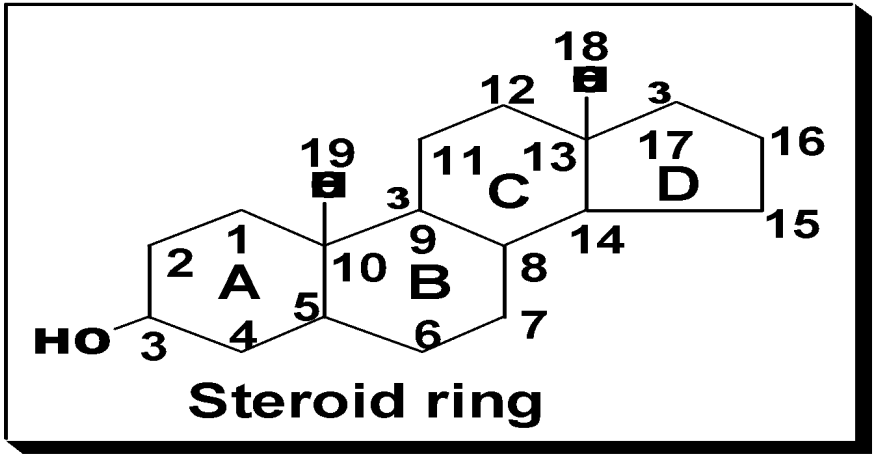
- Steroids constitute an important class of biological compounds.
- Steroids are usually found in association with fat. They can be separated from fats after saponification since they occur in the unsaponifiable residue.
- They are derivatives of cholesterol that is formed of steroid ring or nucleus.
- Biologically important groups of substances, which contain this ring, are:

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

- **General consideration about naturally occurring steroids**:

  A typical member of this group is cholesterol. Certain facts have to be considered when drawing steroid formula:

1) **There is always oxygen in the form of hydroxyl or ketone on C3.**
2) **Rings C and D are saturated (stable).**
3) **Methyl groups at C18 C19. In case of vitamin D, the CH3 group at C19 becomes a methylene group (=CH2) and the ring B is opened, whereas, this methyl group is absent in female sex hormones (estrogens).**
4) **In estrogens (female sex hormones) ring A is aromatic and there is no methyl group on C10.**



Steroid ring

Bile acids:

- They are produced from oxidation of cholesterol in the liver producing cholic and chenodeoxycholic acids that are conjugated with glycine or taurine to produce glycocholic, glycochenodeoxycholic, taurocholic and taurochenodeoxycholic acids. They react with sodium or potassium to produce sodium or potassium bile salts.
- Their function is as follows:

1. Emulsification of lipids during digestion.
2. Help in digestion of the other foodstuffs.
3. Activation of pancreatic lipase.
4. Help digestion and absorption of fat-soluble vitamins.
5. Solubilizing cholesterol in bile and prevent gall stone formation.
6. Choleretic action (stimulate their own secretion).
7. Intestinal antiseptic that prevent putrefaction

REVIEW QUESTIONS

Long Essay (10 marks)	Define lipids, classify lipids with suitable examples and mention their functions.
Short Essay (5 marks)	Phospholipids
	Glycolipids