

Lecture 5

Lipids

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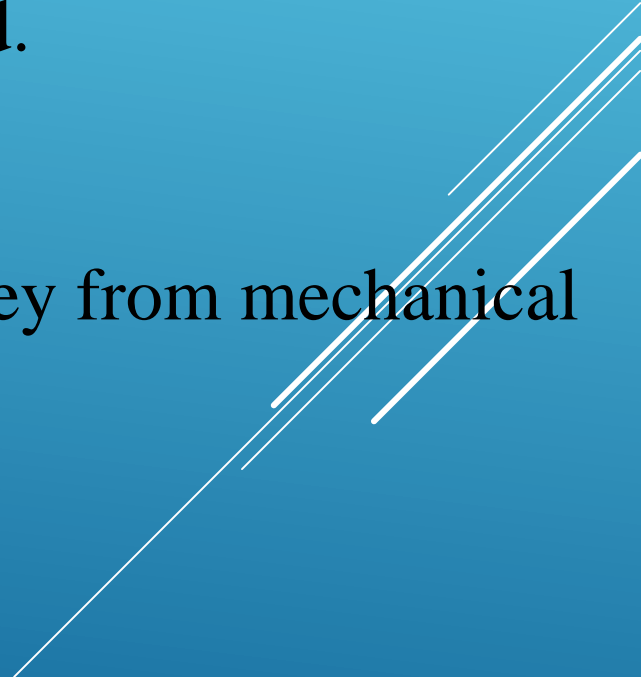
Lipids

Lipids are organic substances soluble only in organic solvents like chloroform, ether and benzene but insoluble in water.

Lipids are present in humans, animals, plants and micro-organisms to some extent.

Animal fat, egg yolk, butter and cheese are lipids of animal origin, vegetable or cooking oils and vanaspati are lipids of plant origin.

Functions of Lipids

1. Lipids are structural components of cell membrane and nervous tissue.
 2. Lipids present in myelinated nerves act as insulators for propagation of depolarization wave.
 3. Lipids present under skin act as thermal insulator against cold.
 4. Lipids are energy source for man like carbohydrates.
 5. Lipids like steroids function as hormones.
 6. Lipids present around kidney act as padding and protect kidney from mechanical injuries.
 7. Lipids serve as vitamins.
 8. Lipids are part of lipoproteins present in blood plasma.
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9. Absorption of fat soluble vitamins requires lipids.
10. Essential fatty acids a kind of lipids are essential for life.
11. Lipids act as microbicides and fungicides.
12. Some lipids function as surfactants.
13. Lipids are involved in immune response.
14. Lipids act as mitogens.
15. Some lipids serve as precursors for the formation of complex lipids.
16. Due to its high energy and water output on oxidation mammals including humans prefer to store energy in the form of lipid only.

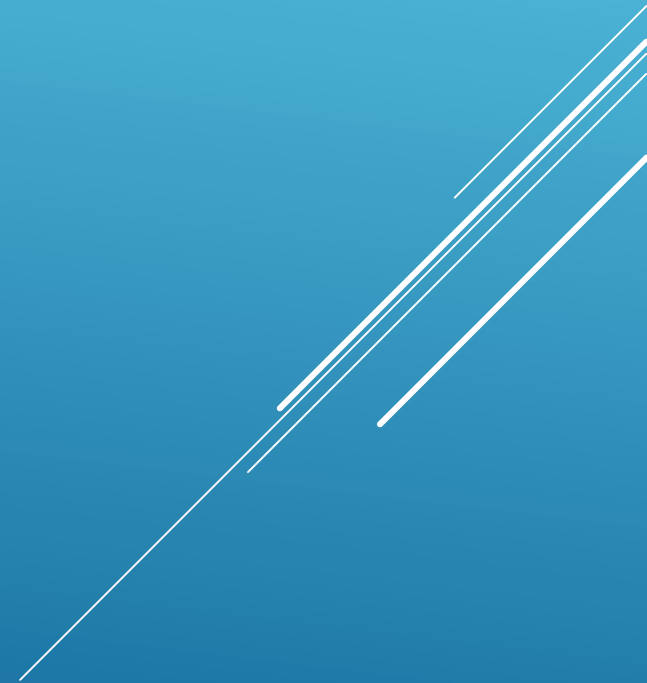
Classification of lipids

A. Classification: Based on composition lipids are classified into:

I. Simple lipids

II. Compound lipids and

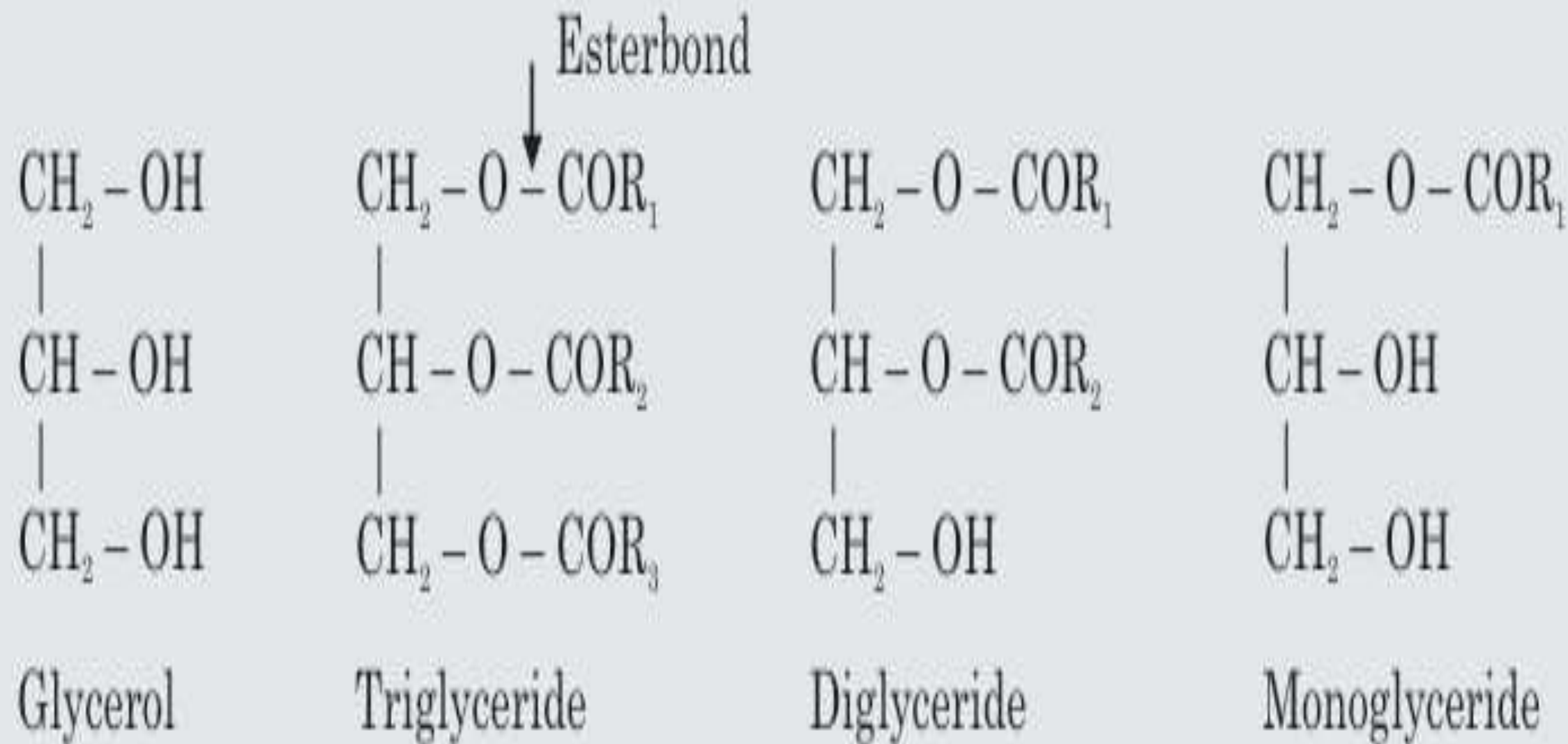
III. Derived lipids.



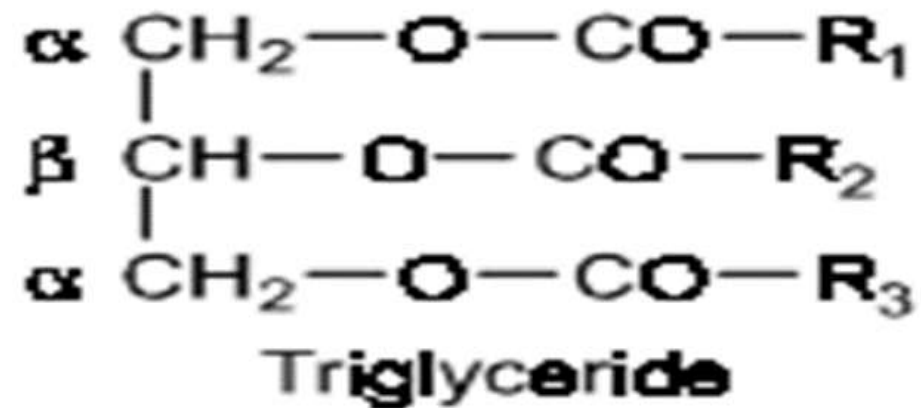
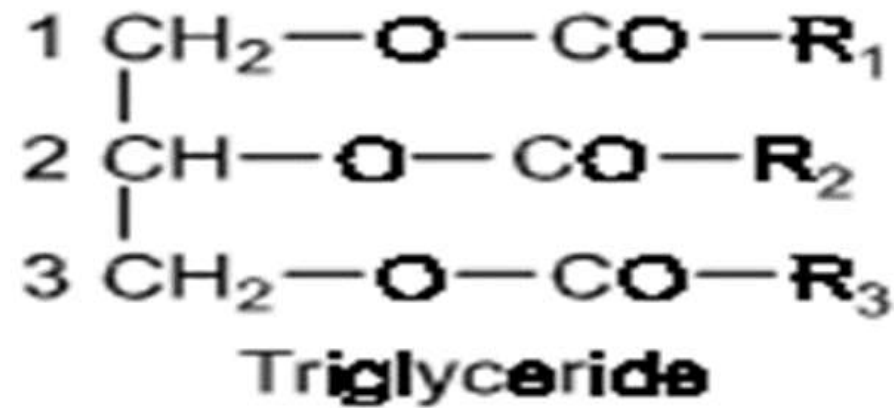
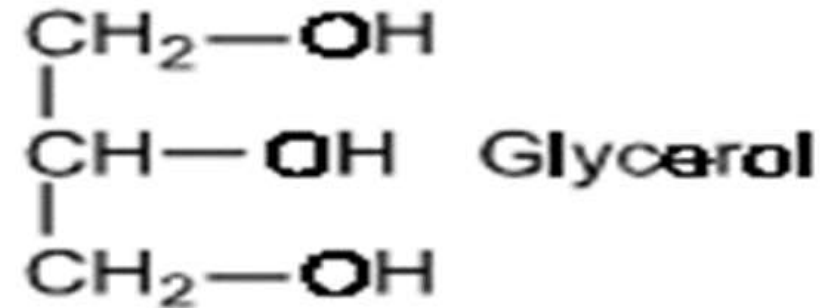
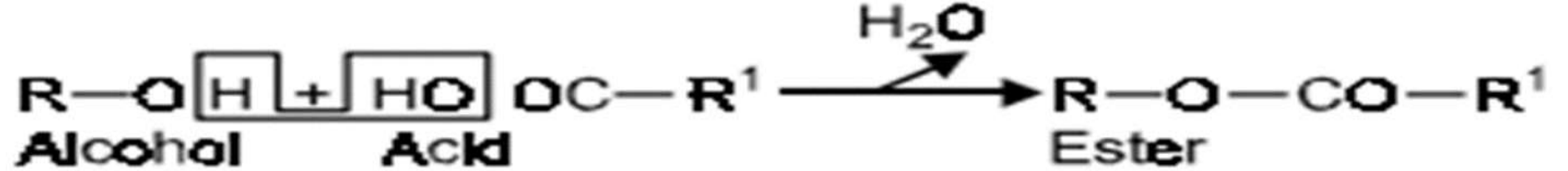
I. Simple lipids : Esters of fatty acids with alcohol are known as simple lipids. Fats and waxes are simple lipids.

a. Fats:

1. Are esters of fatty acids with glycerol.
2. Triglycerides, diglycerides and mono glycerides are fats.
3. Triglyceride is also called as tri acyl glyccrol.
4. In triglycerides three fatty acids are esterified to three hydroxyl groups of glycerol.
5. In diglycerides two of the hydroxyl groups of glycerol are esterified with glycerol.
6. Only one fatty acid is esterified to any one of hydroxyl group of glycerol in monoglycerides.

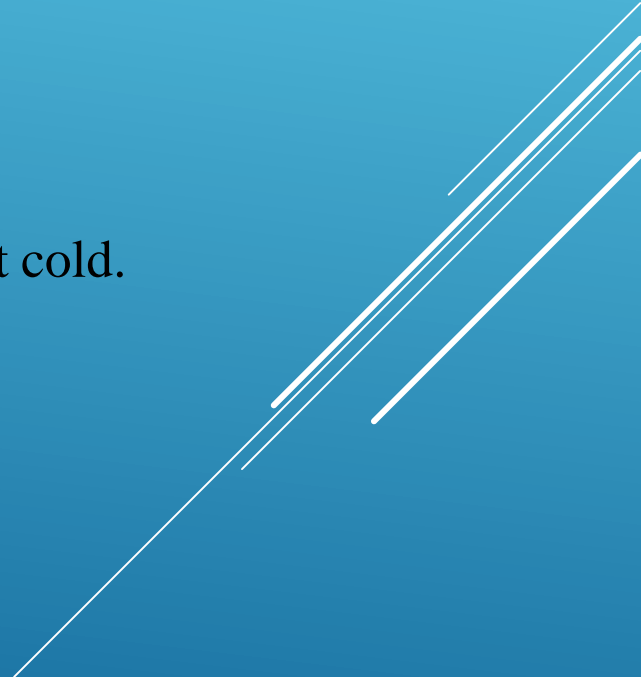


$\text{COR}_1, \text{COR}_2, \text{COR}_3$ - Acyl Groups

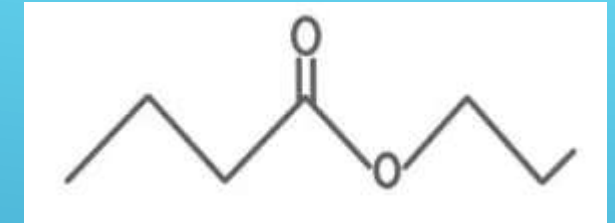


(a) Ester formation; R, R₁ -hydrocarbon chains. (b) Triglyceride is shown with Indo-Arabic numbers and Greek alphabets. R₁-CO-, R₂-CO-, R₃-CO- are three fatty acid groups.

Functions:

1. They are mainly involved in storage function.
 2. Adipose tissue present under skin contains triglycerides. In the abdomen, thighs and in mammary gland, adipose tissue containing triglycerides is present.
 3. Obese people contain more triglycerides.
 4. Women contain more triglycerides than men.
 5. In hibernating animals, seals and penguins triglycerides are more.
 6. Fat under the skin has dual roles. It function as energy store as well as insulator against cold.
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Waxes: Are esters of fatty acids with long chain alcohols. Wool and bees wax are waxes known well. Wool is ester of fatty acid with long chain alcohol lanosterol and agnosterol. Bees wax is an ester of fatty acid with myricyl alcohol.



Functions:

1. Waxes form protective layer over the skin, fur, feathers of animals. Shiny appearance of fruits, leaves of plants are due to waxes.
2. Waxes are hard at low temperature and soft at high temperature.
3. Wool a wax of animal origin is used as protection against low temperature or cold.
Woolen clothing protect us from cold for this reason.
4. Waxes act as water barrier for animal, plants, birds etc.

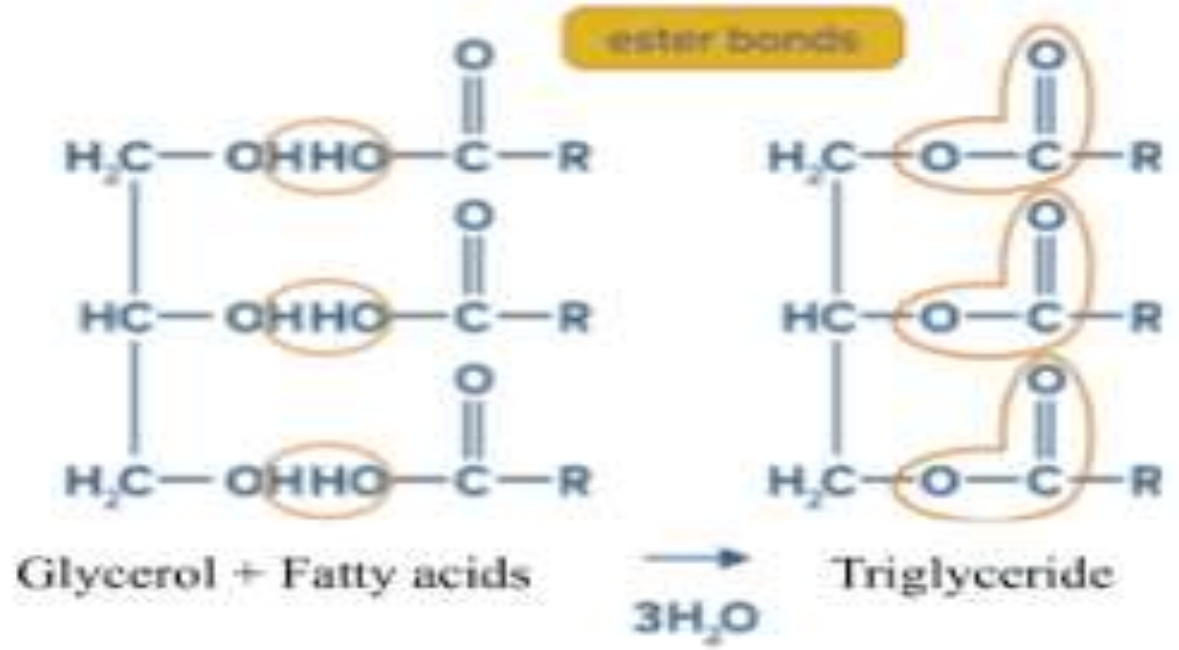
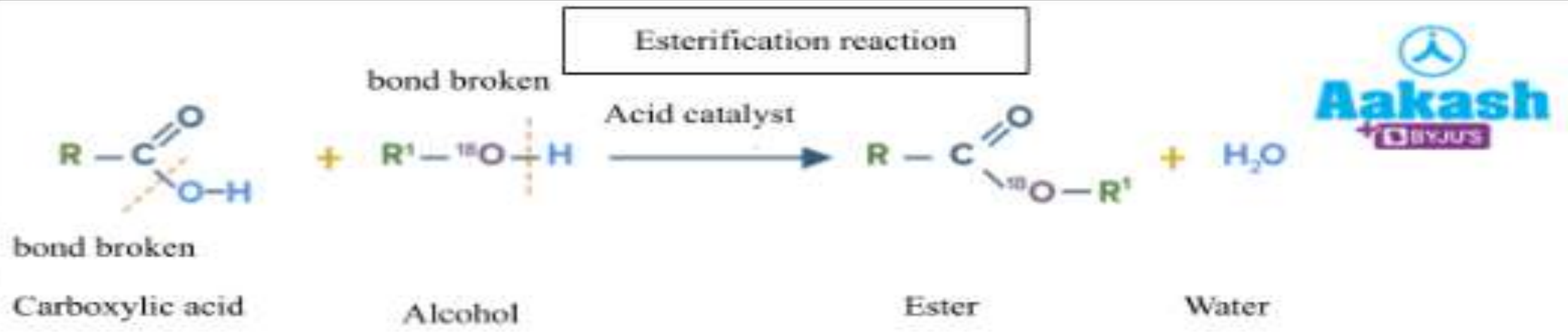
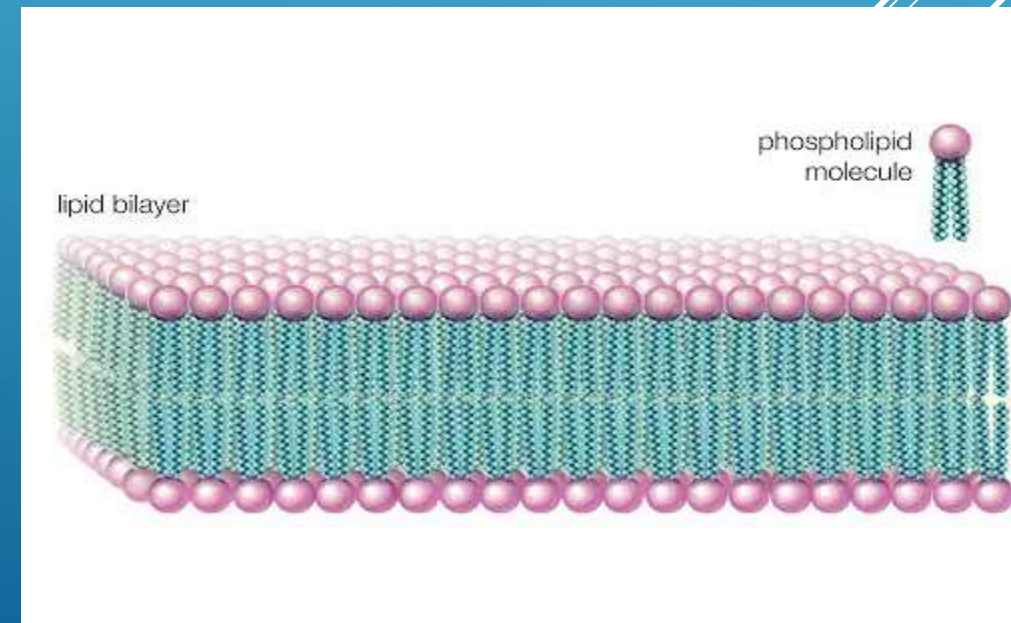


Fig: Formation of a glyceride

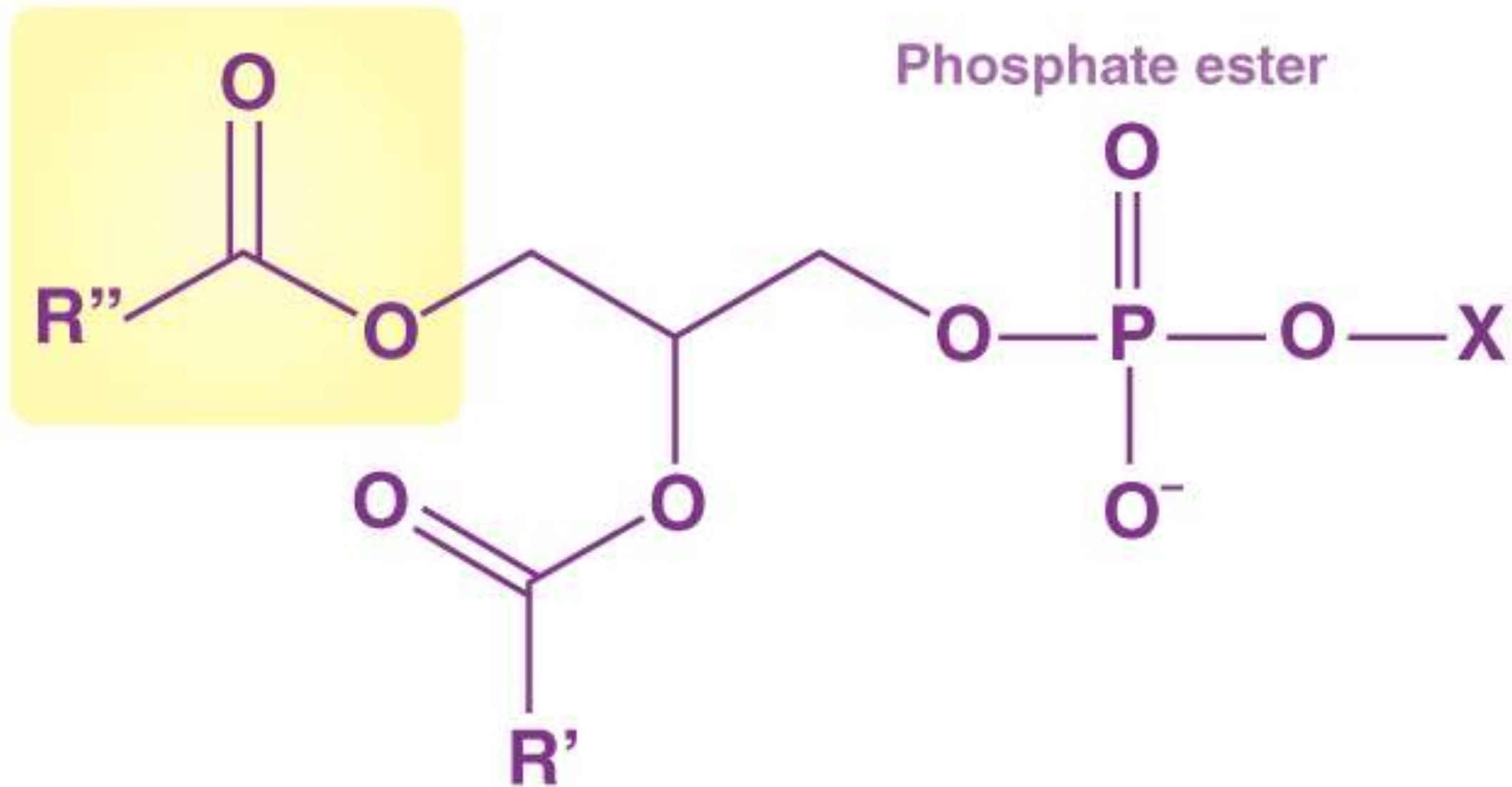
II. Compound lipids: Are esters of fatty acids with alcohol containing additional groups and nitrogenous bases. They are further subdivided based on alcohol present. They are **glycerophospho lipids** and **sphingolipids**. In **glycerophospholipids** glycerol is alcohol and sphingosine is alcohol in sphingolipids.

Glycerophospholipids:

1. In which two fatty acids are esterified to two hydroxyl groups and nitrogenous base bearing phosphate is esterified to third hydroxyl group of glycerol.
2. Glycerophospholipid lacking nitrogenous base is known as phosphatidic acid.
3. Some glycerophospholipids are considered as derivatives of phosphatidic acid and they are named accordingly.
4. Phosphatidyl choline, phosphatidyl serine, phosphatidyl ethanolamine and phosphatidyl inositol are examples for glycerophospholipids.
5. Due to the presence of phosphate they are often referred as phospholipids.



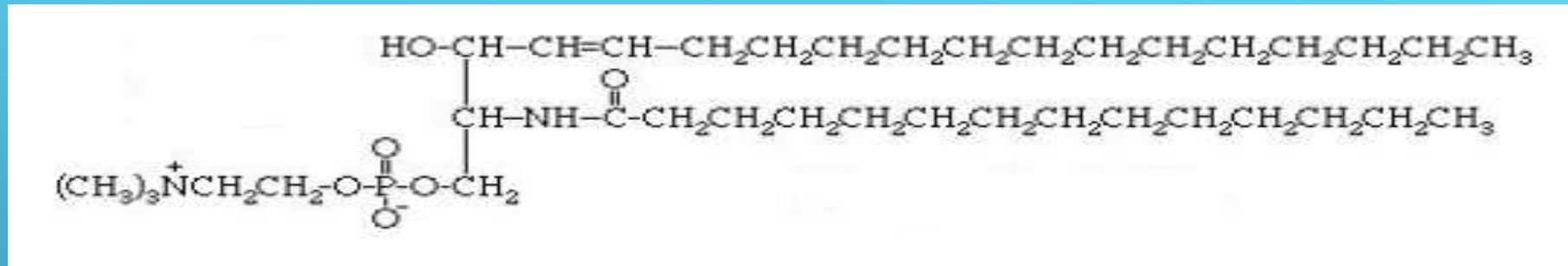
Fatty acid esters



Sphingolipids: They consist of an aminoalcohol sphingosine, fatty acid, nitrogenous base and additional groups. They are subdivided into :

a. Sphingomyelins.

b. Glycolipids.



III Derived lipids : Hydrolysis of simple and compound lipids produce derived lipids. Fatty acids, steroids, fat soluble vitamins and glycerol are examples for derived lipids.

Fatty acids : Hydrolysis of triglycerides yield fatty acids. They are acids containing long hydrocarbon chain. Many fatty acids are identified in nature. They are subdivided into

a. Saturated fatty acids.

b. Unsaturated fatty acids based on nature of hydrocarbon chain.

a. Saturated fatty acids:

1. The hydrocarbon chain of these fatty acids is saturated.

2. No double bonds occur.

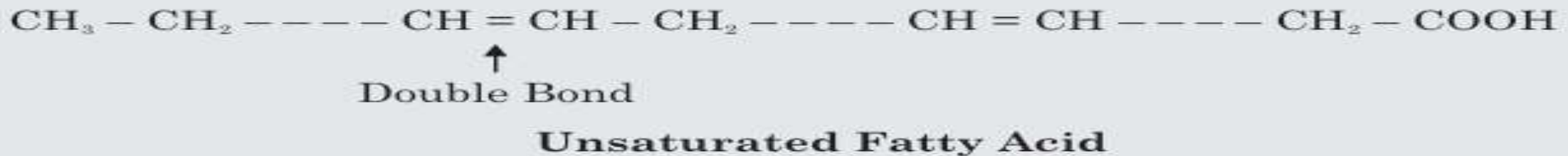
3. Saturated fatty acids containing up to 20 carbons are identified.

4. More important are palmitic acid, stearic acid and arachidonic acids.



b. Unsaturated fatty acids:

1. They contain double bonds in hydrocarbon chain.
2. Unsaturated fatty acids containing up to 30 carbons are identified.
3. They are subdivided into mono unsaturated fatty acids and polyunsaturated fatty acids (PUFA) based on number of double bonds.
4. Mono unsaturated fatty acids are palmitoleic acid and oleic acid. They contain one double bond.
5. Poly unsaturated fatty acids are linoleic, linolenic and arachidonic acids. They contain many double bonds.



(i) Oleic acid (most common unsaturated fatty acid) 18:1;9

(ii) Poly unsaturated fatty acids (PUFA) → Linoleic acid two (2) double bonds, Linolenic acid three (3) double bonds and Arachidonic acids four (4) double bonds.

The following polyunsaturated fatty acids are called essential fatty acids.

Linoleic \longrightarrow 18:2;9,12

(not synthesised in the body)

Linolenic \longrightarrow 18:3;9,12,15

(not synthesised in the body)

Arachidonic \longrightarrow 20:4;5,8,11,14

(semi essential. It can be synthesised from linoleic acid)

Functions:

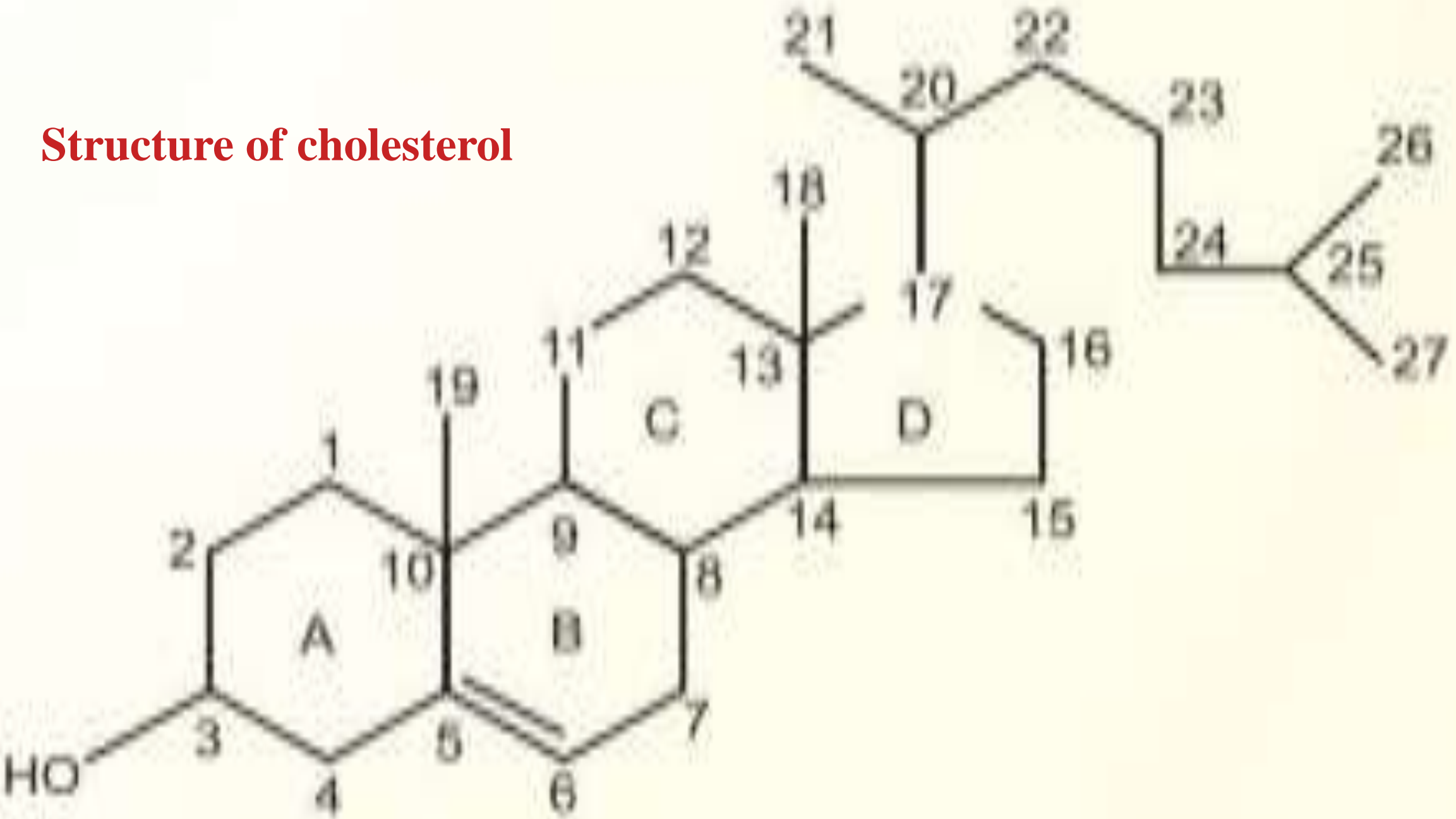
1. Fatty acids are source of energy for humans like glucose.
2. Fatty acids are components of nervous tissue, lipoproteins etc.
3. Poly unsaturated fatty acids are essential fatty acids.
4. They are required for the synthesis of eicosanoids.
5. They are also components of cell membrane.

Steroids : They contain complex fused ring system which is also known as steroid nucleus.
Fused ring system contains four rings collectively known as cyclopentanoperhydrophenanthrene ring.

Cholesterol is an example for steroid which is steroid alcohol. Functions :

1. It is most abundant steroid in animals.
2. About 200g of cholesterol is present in human adult.
3. Nervous tissue is rich in cholesterol.
4. Egg yolk is also rich in cholesterol.
5. Cholesterol is used for the formation of vitamins and steroid hormones.
6. Vit. D is derivative of cholesterol.

Structure of cholesterol



Examples of saturated fatty acids

Common name	Chemical structure	C:D ^[10]
<u>Palmitic acid</u>	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	16:0
<u>Stearic acid</u>	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	18:0
<u>Arachidic acid</u>	$\text{CH}_3(\text{CH}_2)_{18}\text{COOH}$	20:0

Examples of Unsaturated Fatty Acids

Common name	Chemical structure	Δ^x ^[11]	C:D ^[10]	IUPAC ^[12]	<i>n</i> -x ^[13]
<u>Palmitoleic acid</u>	$\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> - Δ^9	16:1	16:1(9)	<i>n</i> -7
<u>Oleic acid</u>	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis</i> - Δ^9	18:1	18:1(9)	<i>n</i> -9
<u>Linoleic acid</u>	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis,cis</i> - Δ^9,Δ^{12}	18:2	18:2(9,12)	<i>n</i> -6
<u>Linoelaidic acid</u>	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>trans,trans</i> - Δ^9,Δ^{12}	18:2	18:2(9t,12t)	<i>n</i> -6
<u>α-Linolenic acid</u>	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	<i>cis,cis,cis</i> - $\Delta^9,\Delta^{12},\Delta^{15}$	18:3	18:3(9,12,15)	<i>n</i> -3
<u>Arachidonic acid</u>	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_3\text{COOH}$ ^{NIST}	<i>cis,cis,cis,cis</i> - $\Delta^5,\Delta^8,\Delta^{11},\Delta^{14}$	20:4	20:4(5,8,11,14)	<i>n</i> -6

The End

