

Chapter:

# Biochemistry



## Lipids

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Chemistry with MJS

Chemistry Preparation by MJS

# LIPIDS

Lipids are the heterogeneous group compounds related to fatty acids.

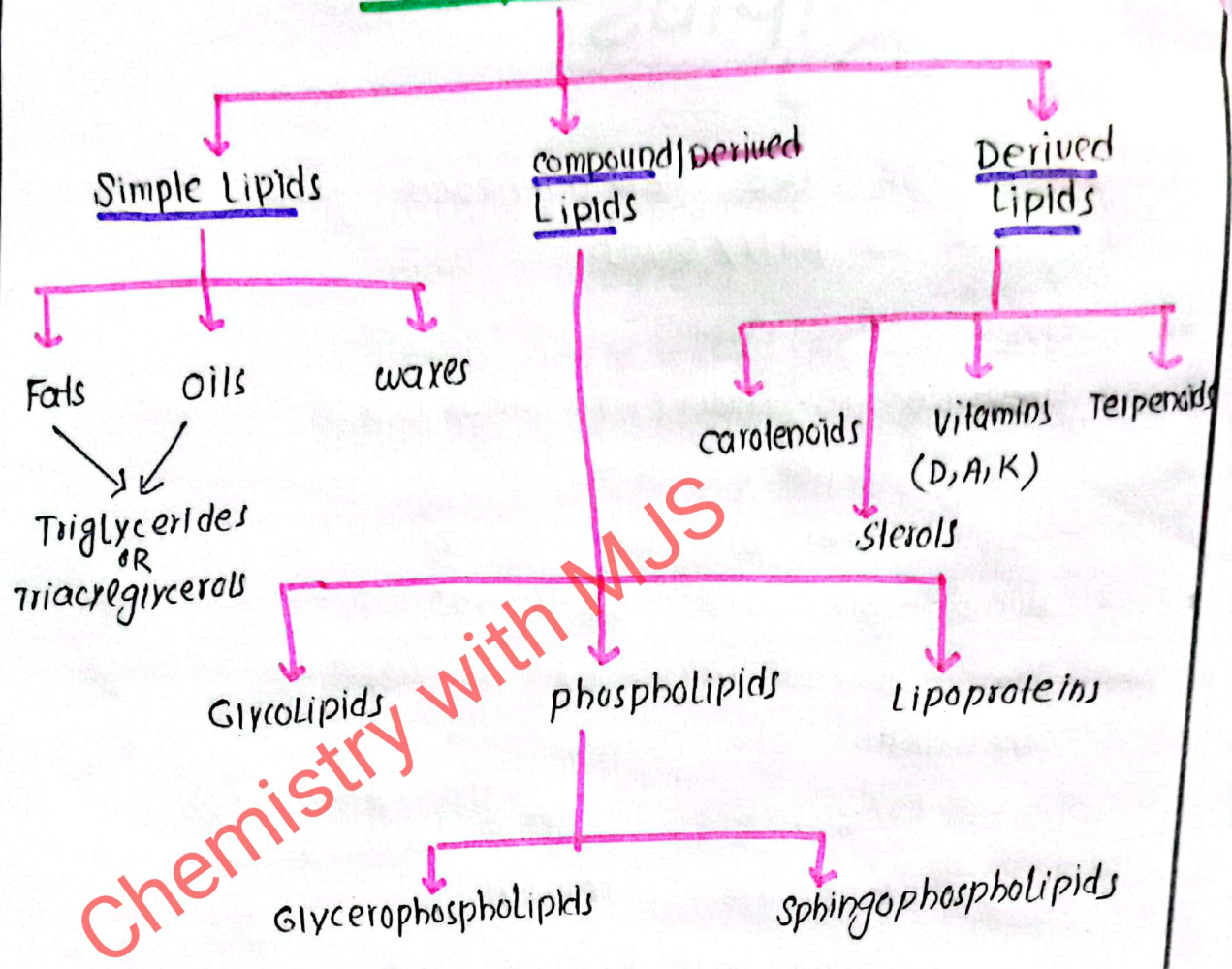
## General properties:

- Insoluble in water (hydrophobic), but soluble in non-polar solvents e.g. chloroform, diethyl ether, acetone, benzene & ether.
- Hydrophobic nature of lipids is due to the predominance of hydrocarbon chains in their structure.

## Importance:

- Important dietary constituent
- Source of high energy value.
- contain fat soluble vitamins.
- contain essential fatty acids.
- Lipids in adipose tissue serve as a storage of energy.
- Act as thermal insulator
- Important part of lipoproteins e.g. structure of cell membrane & mitochondria

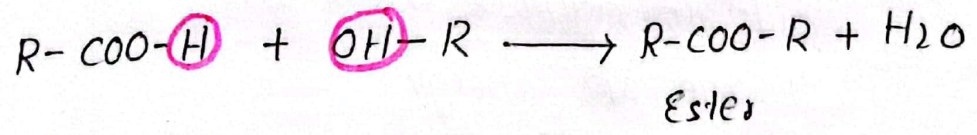
# CLASSIFICATION



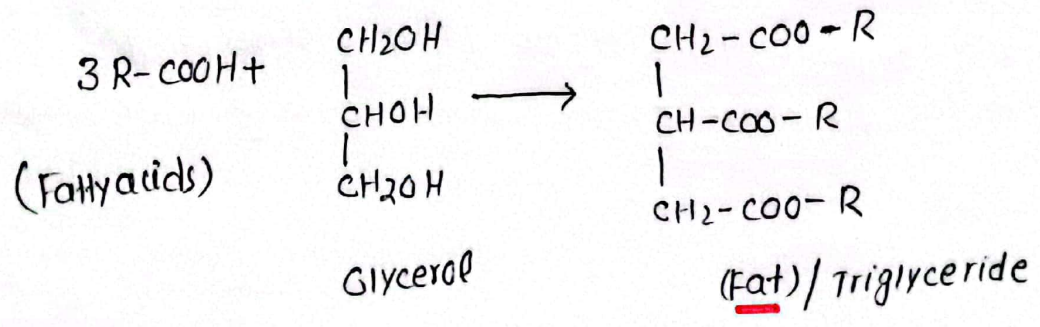
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## 1) Simple Lipids:

Simple Lipids are the Esters of Fatty acids with various Alcohols.



**Fats:** (Esters of Fatty Acid + Glycerol)



# Fatty Acids

Aliphatic mono-carboxylic acids

- \* water insoluble long-chain hydrocarbons
- \* Short Fatty acids 2C (Acetic Acid) & 4-C (Butyric acid) are soluble in water
- \* Long chain fatty acids are insoluble in water but soluble in non-polar solvents
- \* Melting & B.P → depends on the length of chain of Fatty Acids & degree of unsaturation

{ SHORT chain F.A → Liquids at Room T°  
Long chain F.A → Solid at Room T°

## Saturated Fatty acids

- NO Double bond
- Name ends by SUFFIX (-anoic)
- e.g. palmitic acid (16-C)
- General Formula  $CH_3-(CH_2)_n-COOH$

## Unsaturated Fatty acids

- one or more double bonds
- General Formula  $C_n H_{2n-1} - COOH$
- Name ends by SUFFIX (-enoic)
- e.g. oleic acid (C-18)

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## ✓ Saturated Fatty acids:

<u>Common Names</u>	<u>No. of C</u>	<u>Formula</u>
Acetic acid	2	$C_2H_4O_2$
Butyric acid	4	$C_4H_8O_2$
Caproic acid	6	$C_6H_{12}O_2$
Caprylic acid	8	$C_8H_{16}O_2$
Capric acid	10	$C_{10}H_{20}O_2$
Lauric acid	12	$C_{12}H_{24}O_2$
Myristic acid	14	$C_{14}H_{28}O_2$
Palmitic acid	16	$C_{16}H_{32}O_2$
Stearic acid	18	$C_{18}H_{36}O_2$
Arachidic acid	20	$C_{20}H_{40}O_2$
Behenic acid	22	$C_{22}H_{44}O_2$
Lignoceric acid	24	$C_{24}H_{48}O_2$

## ✓ Unsaturated Fatty acids:

<u>Common Name</u>	<u>No. of C</u>	<u>No. of D.B</u>	<u>Formula</u>	<u>Symbol &amp; Name</u>
1. palmitoleic acid	16	1	$C_{15}H_{29}COOH$	16:1 $\Delta^9$ cis 9-Heptadecenoic acid
2. Oleic acid	18	1	$C_{17}H_{33}COOH$	18:1 $\Delta^9$ cis 9-Octadecenoic acid
3. Linoleic acid	18	2	$C_{17}H_{31}COOH$	18:2 $\Delta^{9,12}$ all cis
4. $\alpha$ -Linolenic acid	18	3	$C_{17}H_{29}COOH$	18:3 $\Delta^{9,12,15}$ All cis
5. Arachidonic acid	20	4	$C_{19}H_{31}COOH$	20:4 $\Delta^{5,8,11,14}$ All cis

## Waxes:

Esters of Fatty acids with long chain Alcohol other than Glycerol.

\* Excreted extracellularly in some plants & animals and has a protective function as a Bee wax, cuticles of leaves.

\* Same physical properties as Fat.

\* Gives Negative acrolein test b/c they have no glycerol.

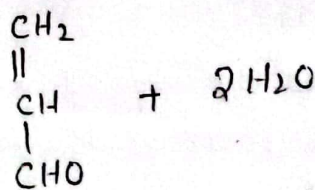
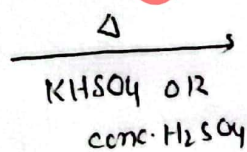
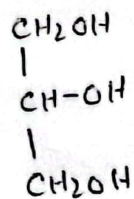
\* Not digested by Lipase Enzyme.

Solids at room temperature.

## Chemical properties of Triglycerol (oils & fats)

### Acrolein test:

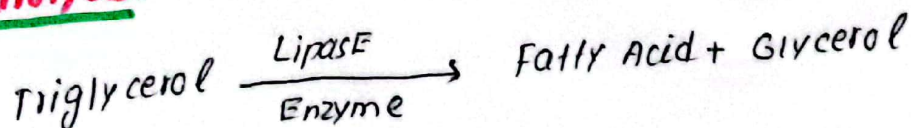
All triglycerols contain glycerol. So All give +ve acrolein test



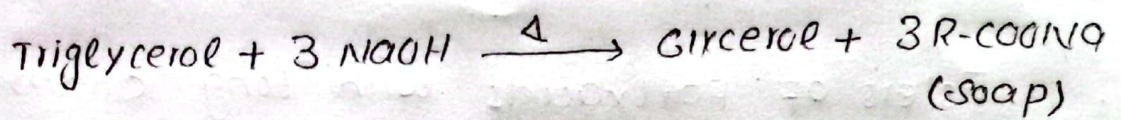
acrolein (characteristic)  
pungent smell

\* Waxes do not give this test  
b/c lack of glycerol

### Hydrolysis:

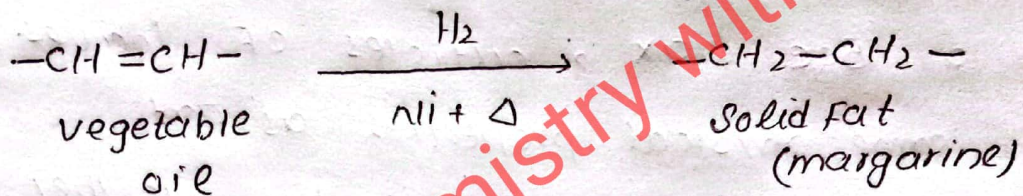


Saponification: → carried out by NaOH



\* Soaps cause emulsification

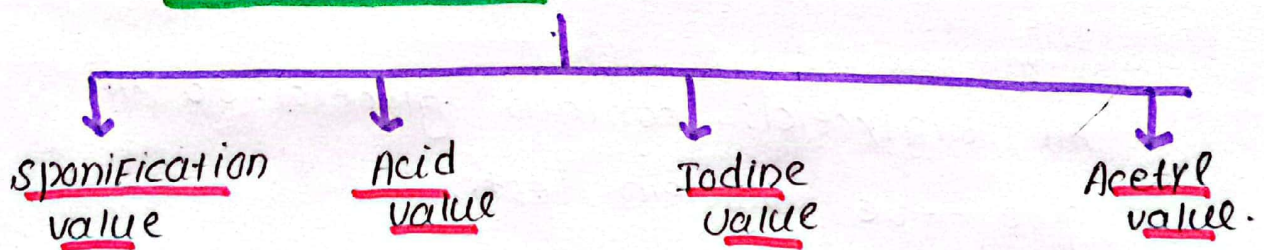
Hydrogenation:



Rancidity:

- Toxic Reaction of triacylglycerols.
- Leads to unpleasant odour of oils & Fats after oxidation by  $\text{O}_2$  / Bacteria or moisture.

Fat constants:



Saponification value:

No. of mg of KOH necessary to saponify all fatty acids present in 1g of fat.

- Fats containing (SHORT chain F. Acids) has Greater saponification no. than long chain F. Acids.  
e.g. Human Fat → 195-200 (Solid long chain)  
e.g. coconut oil → 250-260

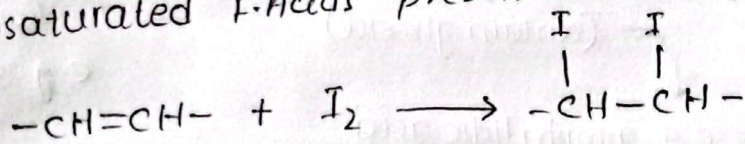
## Acid value:

No. of mg of KOH necessary to neutralize the free fatty acids present in 1g of Fat.

- Important for the detection of rancidity.
- After Rancidity FFA are produced in excess
- Higher Acid No. value unfit for consumption.

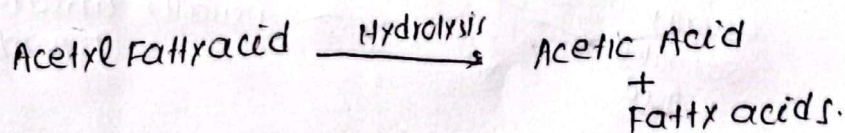
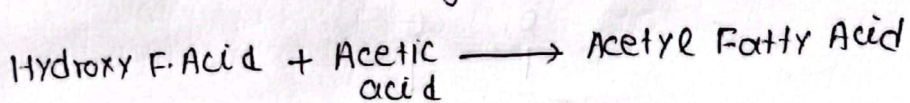
## Iodine value:

No. of grams of iodine necessary to saturate the unsaturated F-Acids present in 100g of Fat.



- Gives idea about degree of unsaturation of F-Acids in Fat. \* Glyceraldehyde with no double bonds  
↓  
zero iodine number  
e.g Fat
- Butter  $\longrightarrow$  25-28 (I.No)
- Sunflower oil  $\longrightarrow$  125-135 (I.No)

**Acetyl value:** (No. of mg of KOH to neutralize Acetic Acid of 1g of Acetylated Fat)



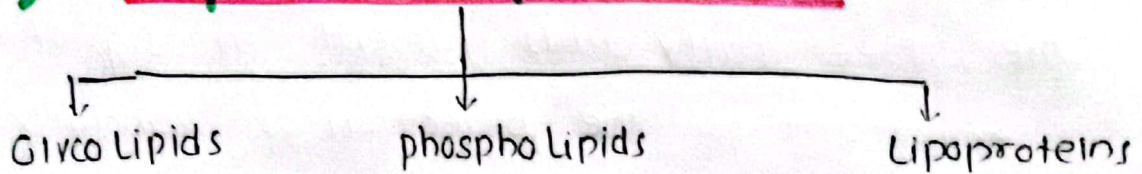
- Used to detect the presence of Hydroxy Fatty acids

castor oil  $\longrightarrow$  145-150 (Acetyl No.)

cotton seed oil  $\longrightarrow$  20-25 (Acetyl No.)

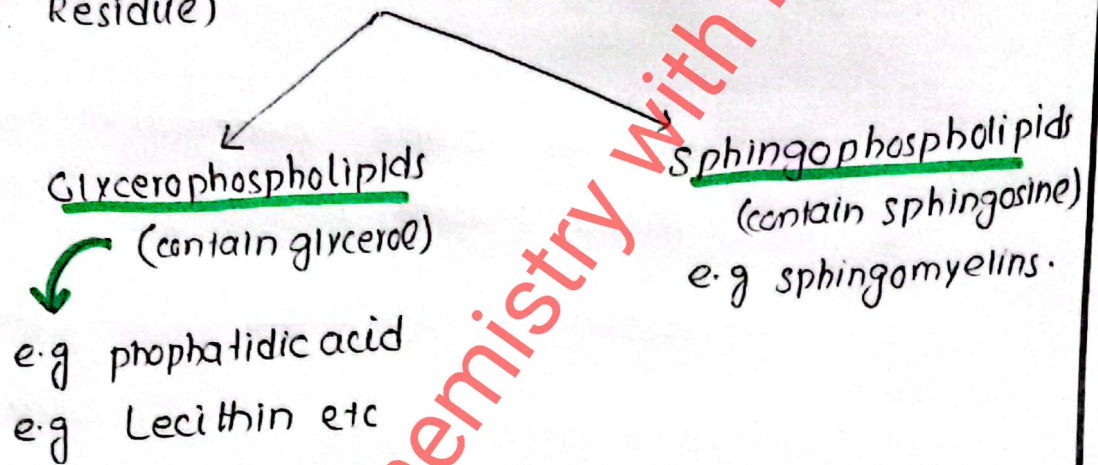


## 2) Compound (complex) Lipids:



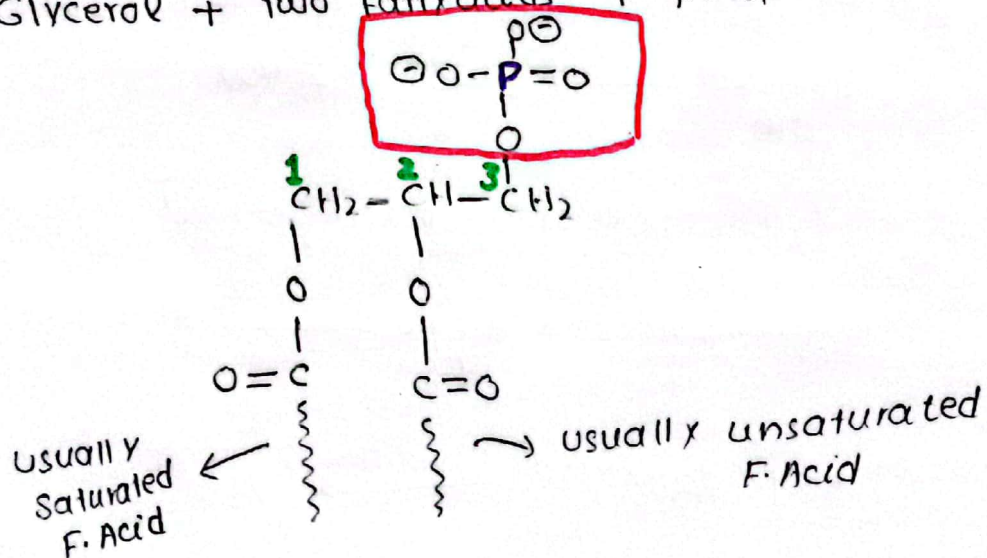
### 1. Phospho Lipids:

Diester of phosphoric acid (phosphoric acid residue)



### \* phosphatidic acid:

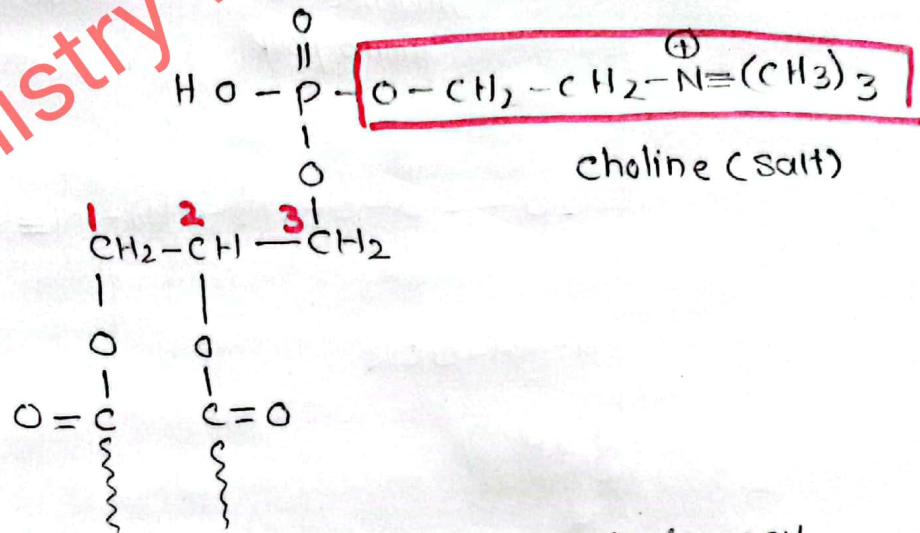
Glycerol + two Fatty acids + phosphoric acid



- produced as an intermediate in the synthesis of Triacylglycerol + phospholipids

## Lecithin: (phosphatidyl choline)

- Choline Attached at C-3 in phosphatidic acid
- choline is a Nitrogenous base

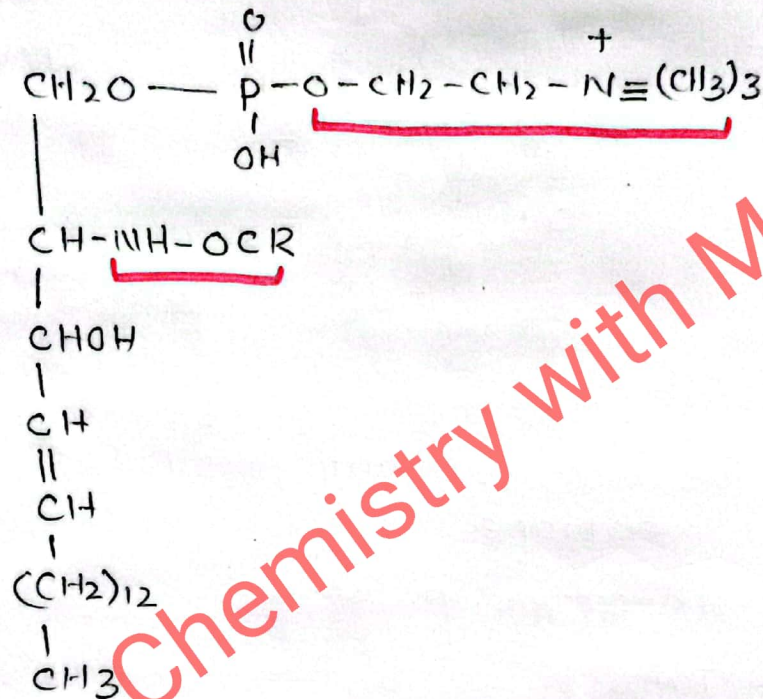


- The most abundant phospholipid in cell membrane.
- Hygroscopic in nature
- Turns brown on exposure of light
- Surface active agents (emulsification of fats)
- important in nerve transmission.
- Non-toxic, when ingested.
- Act as spreading agents & anti-oxidants in Textile, Rubber & other industries.
- in paint industry, Lecithins form protective coatings
- Help as a Rust inhibitor

Sphingophospholipids: (containing sphingosine than glycerol)

Sphingomyelins:

Sphingosine + Fatty acid + phosphoric acid  
↓ Attached to Amino group      Attached to choline BASE



- It is present in High concentration in Brain & Nerve tissues

## 2. Glycolipids

Complex Lipids containing carbohydrate molecule.

Also contain sphingosine-

Examples;

cerebrosides = sphingosine + F. Acid + Sugar (galactose or glucose)

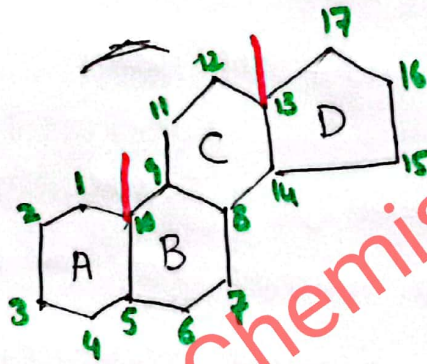
### 3. Lipoproteins:

- complex lipids containing protein part.
- Found in cell membrane, mitochondria
- Synthesized by Liver.
- Facilitate the transport of lipids B/w blood & different tissues.

### 3) Derived Lipids:

#### Sterols & Steroids:

- cyclic compounds containing cyclopentanoperhydrophenanthrene ring.



- AT C-3 → -OH group OR  $\text{C}=\text{O}$  keto group
- AT C-10 & C-13 → -CH<sub>3</sub> group
- AT C<sub>17</sub> → side chain

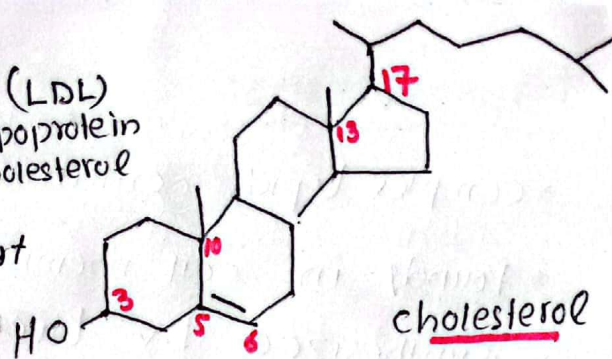
\* steroids & sterols differ in the nature of side chain (AT C-17)

#### Imp. steroids & sterols:

- cholesterol
- Ergosterol
- vitamin D (D<sub>2</sub> & D<sub>3</sub>)
- Bile salts
- Steroid Hormones

## 1. Cholesterol: (LDL)

- called Low Density Lipoprotein  
Also known as Bad-cholesterol
- High level of LDL Cholesterol, risk of Heart Disease & Stroke



- present in All cells especially Adrenal cortex, Liver, Kidney, Brain & nerve tissues.
- Occurs in Blood Free Form & Esterified Form
- Normally Blood cholesterol level is less than 220 mg/dl
- increased level Above 220 mg/dl called Hypercholesterolemia.
- It gives +ve Lieberman's Test

cholesterol + Acetic Acid + conc.  $H_2SO_4$

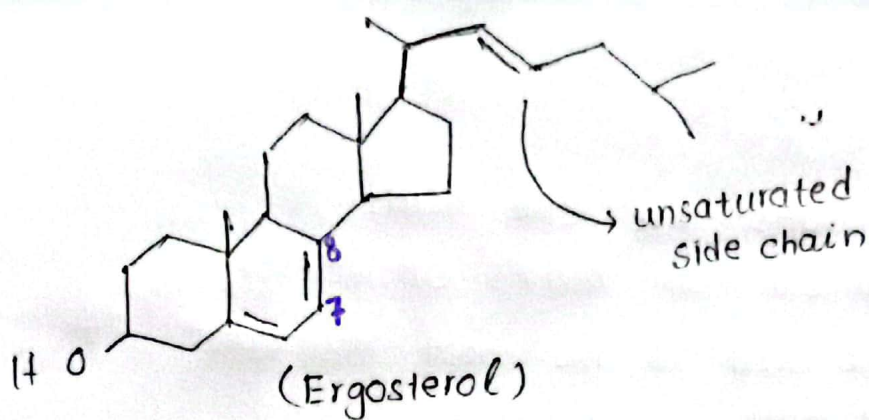


Bluish green colour

- present only in Animals not in plants
- precursor of All Steroid Hormones
- oxidized in Liver to give choleic acid
- which forms Bile salts.
- convert sunshine to vitamin-D<sub>3</sub>

## 2. Ergosterol:

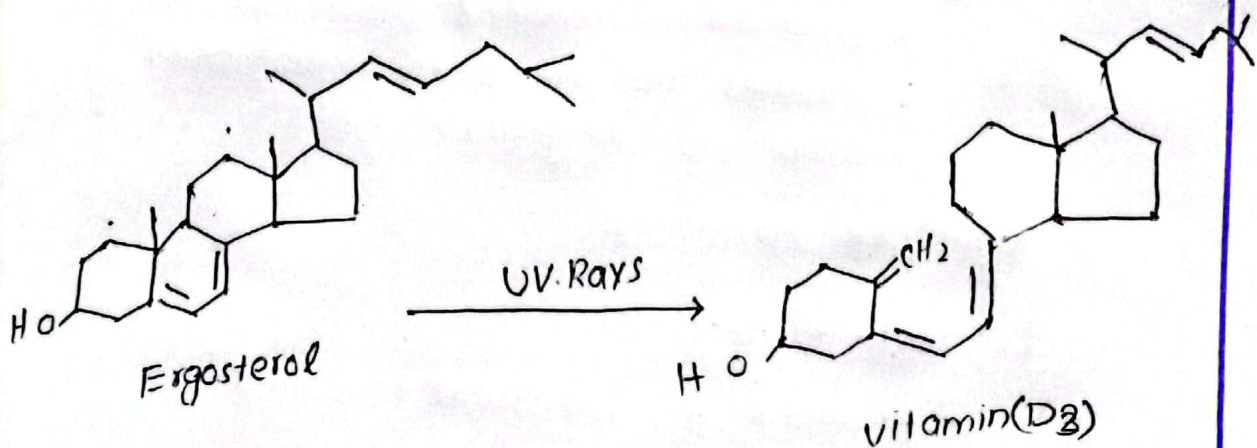
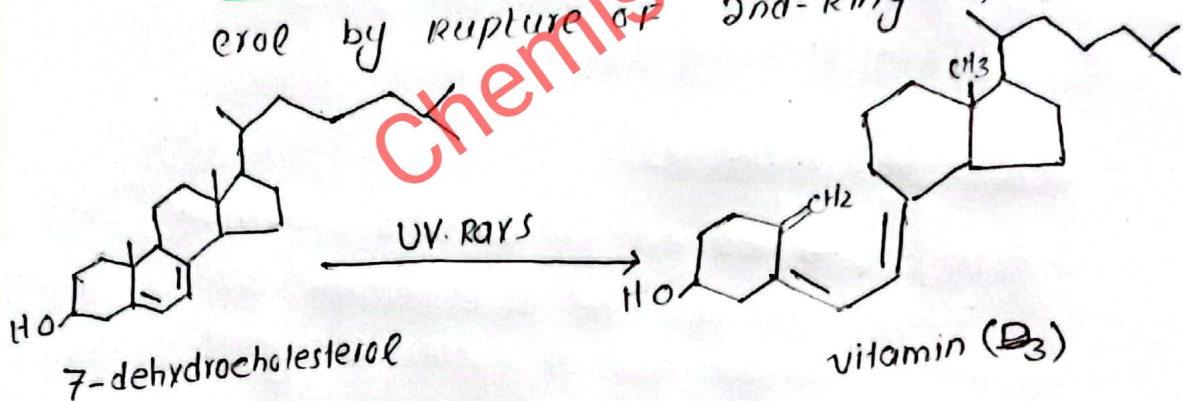
- Similar structure to cholesterol But Double Bond b/w C<sub>7</sub> & C<sub>8</sub>
- side chain is unsaturated & has Extra methyl group.
- called plant sterol. Also Sterol of fungi & yeast.
- Gives vitamin D<sub>2</sub> by UV-rays



### 3. Vitamin D<sub>2</sub> & D<sub>3</sub>:

- vitamin D<sub>2</sub> is derived from Ergosterol by the rupture of second-ring by UV-rays.

- vitamin D<sub>3</sub> is derived from 7-dehydrocholesterol by rupture of 2nd-ring by UV-rays.



- vitamin D-deficiency  $\rightarrow$  leads to a loss of bone density causes osteoporosis & fractures can cause rickets

#### 4. Bile Salts:

- Bile salts are Bile Acids
- produced from body's cholesterol
- cholic acid is the most abundant of Bile Acids
- Act as emulsifying agents.
- promote the transport of lipid through aqueous media.
- important for digestion & absorption of Lipids.

#### 5. Steroid Hormones:

##### ✓ Female Sex hormones

1. Estrogens → produced in ovary & placenta.  
stimulate the development of female sex characters & organs

##### 2. progesterone:

- produced in ovary & placenta.
- prepares the uterus for implantation.
- stabilizes pregnancy

##### ✓ Male sex Hormones:

##### 1. Testosterone:

- produced in interstitial cells of Leydig of testis in male
- Adrenal cortex in both male & female.
- stimulates the development of male sex characters & organs.

 Good Luck   
MJS