15. BIOMOLECULES

v) LIPIDS

- **Lipids:** The constituents of animals and plants soluble in organic solvents (ether, chloroform, carbon tetrachloride, hexane, benzene etc) but insoluble in water are called lipids.
- Lipids are naturally occurring carbon compounds related to fatty acids and esters of fatty acids.
- Lipids are important dietary components due to their high calorific value.
- One gram of lipids yields 9.3 k.cal of heat while one gram of carbohydrate (or) protein yields 4.5 k.cal only.
- The common lipids are fats, oils, waxes, steroids, terpens, phospholipids and glycolipids.
- The above lipids are stored in adipose tissues and are present in all organism including viruses.
- Lipids occur in seeds, nuts and fruits of plants.
- Lipids occur in adipose tissues, bone marrows and nervous tissues of animals.
- In the living cells lipids are present in cytoplasm and plasma membrane.
- In the body lipids are deposited in specialised areas as depots of fat.
- Fat depots are formed from food fat, carbohydrates and proteins.
- Animal sources of fats are ghee, butter curd and fish oils. These fats contains more saturated fatty acids.
- Vegetable sources of fats are ground nut oil, gingerly oil, mustard oil, cotton seed oil, sunflower oil etc. These fats contains more unsaturated fatty acids.
- Depot fats are mixed triglycerides.

Classification and Structures of Lipids:

- Lipids are classified into three groups
  1) Simple lipids (Homo lipids)
  2) Compound lipid (hetero lipids)
  3) Derived lipids (obtained from simple and compound lipids)

Simple Lipids:

- Simple lipids are alcohol esters of fatty acids which include neutral fats and waxes.
- These fatty acids contain even number of carbon atoms and are both saturated and unsaturated carboxylic acids.
- Simple lipids are known as triglycerides (or) triacyl glycerols.
- Some simple lipids are solids (or) liquids at room temperature.
- Solids are called fats and liquids are called oils.
- The structure of simple lipid is

$$\begin{array}{l} CH_2 - OCOR^1 \\ | \\ CH - OCOR^2 \\ | \\ CH_2 - OCOR^3 \end{array}$$

R^1, R^2, R^3 = Alkyl groups of fatty acids

R^1, R^2, R^3 = may be same (or) different.

Simple neutral lipids:

- $CH_2-OCOC_{15}H_{31}$
  $CH-OCOC_{15}H_{31}$
  $CH_2-OCOC_{15}H_{31}$
  Tripalmitin (saturated)

  In tripalmitin palmitic acid is present ($C_{15}H_{31}COOH$)
- $CH_2-OCOC_{17}H_{35}$
  $CH-OCOC_{17}H_{35}$
  $CH_2-OCOC_{17}H_{35}$
  Tristearin (saturated)

  In tristearin stearic acid is present ($C_{17}H_{35}COOH$)
- $CH_2-OCOC_{17}H_{33}$
  $CH-OCOC_{17}H_{33}$
  $CH_2-OCOC_{17}H_{33}$
  Triolein (unsaturated)

  In triolein oleic aicd is present ($C_{17}H_{33}COOH$)

  $CH_2-OCOC_{17}H_{29}$
  $CH-OCOC_{17}H_{29}$
  $CH_2-OCOC_{17}H_{29}$
  Trilinolenin (unsaturated)

  In trilinolenin linolenic acid in present ($C_{17}H_{29}COOH$)
- If the fat contains different fatty acids then it is called mixed fat.

  E.g. Dipalmito stearin (Two palmitic acid molecules and one stearic acid molecule)

  $CH_2-OCO.C_{15}H_{31}$
  $CH-OCO.C_{15}H_{31}$
  $CH_2-OCO.C_{15}H_{31}$
  Dipalmito stearin
- If two fatty acids only are present then it is called diglyceride.
- If the acids are attached to first two carbon atoms the fat is called 1, 2 fat (or) α, β fat.

  $CH_2-O-COC_{15}H_{31}$
  $CH-O-COC_{15}H_{31}$
  CH_2-OH
  Dipalmitin (1,2 palmitin)
- If the acids are attached to 1 and 3 carbon atoms the fat is called 1,3 fat (or) α, α' fat

$CH_2 - O - COC_{15}H_{31}$
|
$CH - OH$
|
$CH_2 - O - COC_{15}H_{31}$

1, 3 palmitin

- If only one acid molecule is attached to the carbon atom the fat is called monoglyceride. It is called 1-mono fat (or) 2-mono fat depending on the carbons.

$CH_2 - OCOC_{15}H_{31}$
|
$CH - OH$
|
$CH_2 - OH$

Monopalmitin (or) 1-palmitin

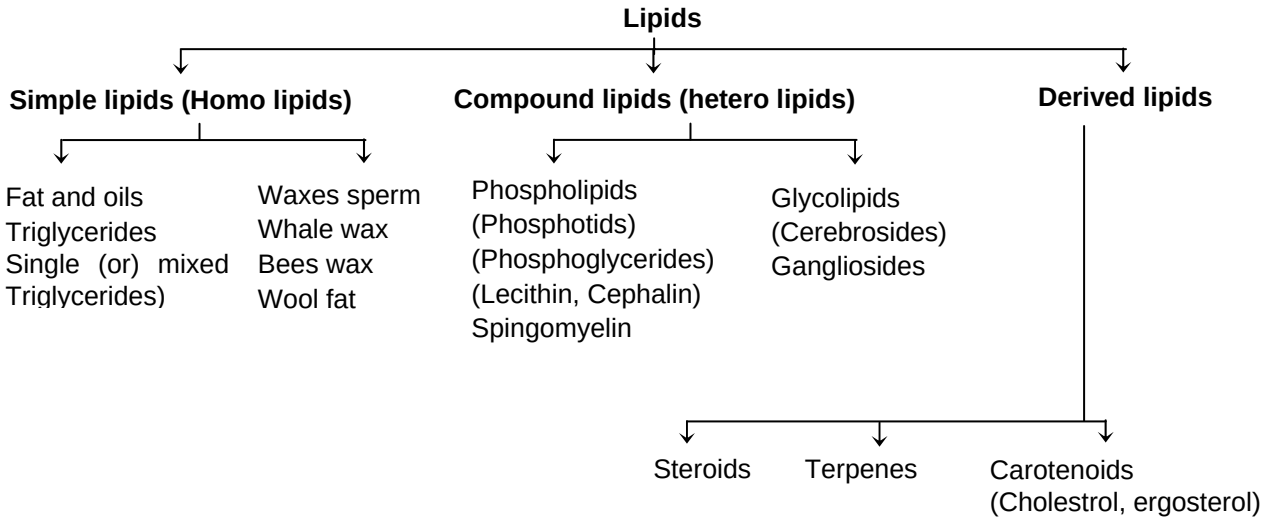
$CH_2 - OH$
|
$CH - OCOC_{15}H_{31}$
|
$CH_2 - OH$

Monopalmitin (or) 2-palmitin

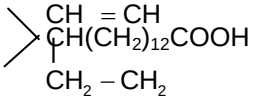
- The fat may also contain one molecule each of oleic acid, palmitic acid and stearic acid.
- The fat is called α-oleo, β-palmito, α' stearin.

$CH_2 - OCOC_{17}H_{33}$
|
$CH - OCOC_{15}H_{31}$
|
$CH_2 - OCOC_{17}H_{35}$

- In most unsaturated acids double bond is present at carbon-9. This is designated as Δ^9.
- Some acids contain more than one double bond which are not conjugated.



Some important fatty acids present in fats.

Acid	No. of C-atoms	Formula	Nature	Fat
Butyric acid	4	$CH_3(CH_2)_2COOH$	Saturated	Butter
Caproic acid	6	$CH_3(CH_2)_4COOH$	Saturated	Butter oil
Caprylic acid	8	$CH_3(CH_2)_6COOH$	Saturated	Coconut oil
Capric acid	10	$CH_3(CH_2)_8COOH$	Saturated	Coconut oil
Palmitic acid	16	$CH_3(CH_2)_{14}COOH$	Saturated	Animal fat
Stearic acid	18	$CH_3(CH_2)_{16}COOH$	Saturated	Animal fat
Arachidic acid	20	$CH_3(CH_2)_{18}COOH$	Saturated	Groundnut oil
Cerotic acid	26	$CH_3(CH_2)_{24}COOH$	Saturated	Wool fat
Linoleic acid	18	$CH_3(CH_2)_4CH = CH_2OH = CH(CH_2)_7COOH$	Unsaturated	Cotton seed oil
Oleic acid	18	$CH_3(CH_2)_7CH = CH(CH_2)_7COOH$	Unsaturated	Animal fat
Chaulmoogric acid	18		Unsaturated	Chaurmoogri oil

Waxes:

- Waxes are insect secretions (or) protective coatings on animal furs and plant leaves.
- Waxes are chemically esters of long chain saturated (or) unsaturated fatty acids with long chain monohydric alcohols.
- The fatty acids range between C_{14} & C_{36}
- The alcohols range between C_{16} & $C_{36.}$
- Free fatty acids, alcohols and some hydrocarbons are also present mixed with the ethers.
- Waxes have higher melting points than neutral fats.

  Examples :–

  1) Bee's wax :- Secreted by bees. It is a palmitic acid ester of myricyl alcohol. (C_{30} H_{61} OH)
  2) Spermaceti:- Palmitic acid ester of cetyl alcohol ($C_{16}H_{33}OH$). It is obtained from sperm whale oil.
  3) Lanoline wool (or) fat :– Palmitic acid (or) Stearic acid (or) oleic acid ester of cholesterol. It is obtained from wool.

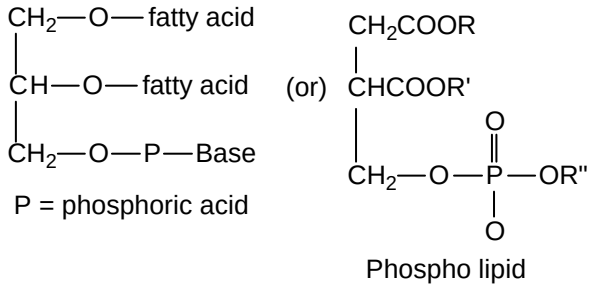
Compound lipids:

- Compound (or) Heterolipids contain additional groups such as phosphoric acid, nitrogen containing bases and other substituents.
- Compound lipids are classified into

  1) phospholipids 2) Glycolipids 3) Terpenes.

Phospholipids

- Phospholipids contain phosphoric acid, nitrogen containing bases and other substituents as additional groups.



Phospho lipid

- The common examples of phospholipids are Lecithins and Cephalins which are found principally in the brain, nerve cells, and liver of Animals.
- Phospholipids are also found in egg yolks, yeast, soyabeans & other foods.
- Phospholipids are also used as detergents to emulsify fat for transport within the body.

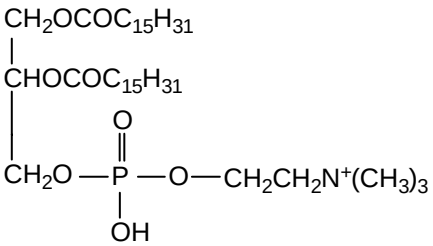
  Phospholipids are further classified into

  1) Glycerophosphatides

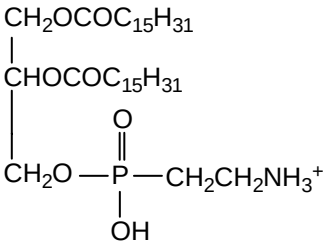
  2) Phosphoinositides

  3) Phosphosphingosides.
- **Glycerophosphatides** contain glycerol, Fatty acids, phosphoric acid and a base. The base may be choline, ethanolamine, serine (amino acid).
- **In phosphoinositides** the cyclic hexahydric alcohol (inositol) replaces the base.
- In phosphosphringosides glycerol is replaced by complex amino alcohol (sphingol).
- **Glycolipids** esters of fatty acids with carbohydrates and may contain nitrogen but no phosphorous.

Structure of some phospholipids



Lecithin



Cephalin

Derived fats:-

- **Terpenes** are polymers of 5-carbon unit called Isoprene. The side chains of A, E and K and the carotenes belong to this group.
- Derived fats are hydrolysis products of simple and compound lipids. The products include Glycerol, fatty acids, sphingosine (amino alcohol), steroids, terpens & Carotenoids.
- Sterol means solid Alcohol.
- Cholestrol, ergosterol, bile acids, sex harmons, D–vitamin are the some of sterol derivatives.
- Sours of cholestrol are solid alcohol from bile, brain, nervous tissues, adrenal glands and egg yolk.
- Formula of cholestrol is C_{27} H_{45} OH.
- Ergosterol:- Solid alcohol present in fungi, yeast and ergot.
- Formula of Ergosterol is C_{28} H_{43}OH.

Biological importance of lipids:-

- Fats are important food reserves of animals and plant cells.
- Simple lipids acts as important sources of energy in our food supply.
- Phospholipids serve as structural materials of cells and tissues such as cell membrane.
- Phospholipids are used as detergents to emulsify fat for transport within the body.
- Cholestrol is the principal sterol of higher animals and abundant in nerve tissues and gallstones.
- Simple lipids can acts as heat insulators and shock absorbers for the living organism.
- Lipids are essential for the absorption or fat soluble vitamin like A, D, E & K.
- Enzyme activators.