Unit - 4.3

LIPIDS

Definition: The lipids are a large and diverse group of naturally occurring organic substances that are related by their solubility in nonpolar organic solvents (e.g. ether, chloroform, acetone & benzene) and general insolubility in water. Lipids are an important component of living cells. Together with carbohydrates and proteins, lipids are the main constituents of plant and animal cells. Examples of lipids include fats, oils, waxes, certain vitamins (such as A, D, E and K), hormones and most of the cell membrane that is not made up of protein

Structure of lipids:

Lipids are composed of a glycerol molecule bonded to long hydrocarbon chain(s) and depending on the lipid to other molecules such as a phosphate group (phospholipids).

The most commonly occurring lipids are triglycerides and phospholipids. Triglycerides have a glycerol backbone bonded to three fatty acids. If the three fatty acids are similar then the triglyceride is known as simple triglyceride. If the fatty acids are not similar, then the triglyceride is known as mixed triglyceride. (Fig 1)

Lipids are nonpolar and insoluble in water. This is because their structure does not have a more electronegative ~~end~~ or electropositive end. Water, however is polar in comparison. When lipids mix with water, the lipids will closely associate and clump up instead of dissolving evenly into the water. Some lipids have additional parts such as phosphates that make them amphipathic. This means that they will have a hydrophilic end, such as the phosphate and a hydrophobic end, such as the lipid's carbon chain. This is how cell membranes form. (Fig. 2)

Classification of lipids:

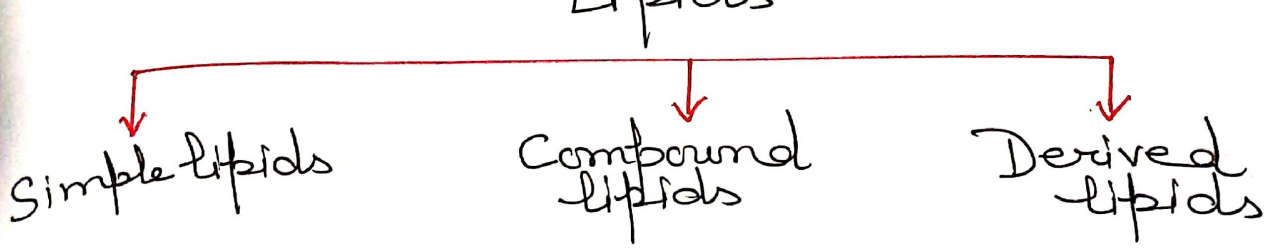
Lipids can be broadly classified into two major classes:

1. Saponifiable lipids
2. Non-saponifiable lipids

Saponifiable lipids: A saponifiable lipid contains one or more ester groups allowing it to undergo hydrolysis in the presence of an acid, base or enzymes. These include steroids, prostaglandins and terpenes.

Non-saponifiable lipids: A non-saponifiable lipid can not be broken up into smaller molecules by hydrolysis, which includes triglycerides, waxes, phospholipids and sphingolipids.

Classification of lipids based upon their chemical composition as proposed by Bloor (1943)



1. Simple lipids : These are the esters of fatty acids with various alcohols

(a) Fats: Although the term "lipid" is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides Fats are the esters of fatty acids with glycerol. Oils are the fats in the liquid state.

(b) Waxes: These are the esters of fatty acids with higher molecular weight monohydric alcohols. e.g. Beeswax.

2. Compound lipids: These are esters of fatty acids containing groups in addition to alcohol and a fatty acid.

(a) Phospholipids : These are lipids containing a phosphoric acid residue in addition to fatty acids and alcohol. They frequently have nitrogen containing bases and other subtituents The structure of phospholipids molecule generally consist of 2 hydrophobic fatty acid "tails" and a hydrophilic "head".

The head group consists of a phosphate residue that is esterified with a second alcoholic compound. e.g. In glycerophospholipids the alcohol is glycerol (lecithin, cephalin) and in sphingophospholipids the alcohol is sphingosine (sphingomyelin) (Fig. 3)

b, Glycolipids : These are the lipids containing a fatty acid sphingosine and a carbohydrate.

c, Other complex lipids : These are the lipids such as sulpholipids and amino lipids. Lipoproteins may also be placed in this category. Lipoproteins are complexes of lipids and proteins that occur in blood as plasma lipoproteins.

3. Derived lipids : These include fatty acids, glycerol, steroids, terpenes, carotenoids, lipid soluble vitamins and hormones. These compounds are produced by the hydrolysis of simple and complex lipids.

a, Steroids : These do not contain fatty acids

and are not hydrolysed on heating. These are quite different in chemical structure from simple lipids. The steroid nucleus contains three 6-membered and one 5-membered carbon rings. Steroids perform many vital functions in the body and make up things like hormones and some vitamins. Many steroids also have a hydroxyl (-OH) group and are then called <u>sterols</u> (<u>cholestrol</u>). Sterols are widely distributed in the plasma membranes of animals, plants and fungi but not in bacteria. These are disposed in between the fatty acid chain of lipid bilayer in the membranes and appear to prevent the compactness of the membrane under low temperature conditions. Many animal hormones like oestrogen, androsterone, progestrone etc. are steroids. (fig 4)

b, <u>Terpenes</u> : The terpenes include certain fat-soluble vitamins (such as vit A, E & K), carotenoids (pigments of plant cells that are involved in photosynthesis) and

certain coenzymes (such as coenzyme Q, ubiquinone). All the terpenes are synthesised from various numbers of a five carbon building block called an isoprene unit. The isoprene units are bonded together in a head-to-tail organization. Two isoprene units form a monoterpene, four form a diterpene, six a triterpene and so on. The monoterpenes are responsible for the characteristic odors and flavors of plants (e.g., geraniol from geranium, menthol from mint and limonene from lemons.) (fig. 5)

Role of lipids :

It was previously known that lipids played the role of storage of energy or forming cell membranes alone. Researchers have found that lipids have a much more diverse and widespread biological role in the body in terms of intracellular signalling or local hormonal regulation etc.

Lipids have several roles in the body, these include acting as chemical messengers, storage and provision of energy and so forth.

1. Chemical messengers :

All multicellular organisms use chemical messengers to send information between organelles and to other cells. Since lipids are small molecules insoluble in water, they are esccellent candidates for signalling. The signalling lipids, in their esterified form can infiltrate membranes and are transported to carry signals to other cells. These may bind to certain proteins as well and are inactive until they reach the site of action and encounter the appropriate receptor.

2. Storage and provision of energy :

Storage lipids are triacylglycerols. These are inert and made up of three fatty acids and a glycerol. Fatty acids in non esterified form are released from

triacylglycerols during fasting to provide a source of energy and to form the structural components for cells.

3. Maintenance of temperature:

Layers of subcutaneous fat under the skin also help in insulation and protection from cold. Maintenance of body temperature is mainly done by brown fat as opposed to white fat. Babies have a higher concentration of brown fat.

4. Membrane lipid layer formation:

Linoleic and linolenic acids are essential fatty acids. These form arachidonic, eicosapentaenoic and docosahexaenoic acids. These form membrane lipids. Membrane lipids are made up of polyunsaturated fatty acids. Polyunsaturated fatty acids are important as constituents of the phospholipids where they appear to confer several important properties to the membrane. One of the most important properties are fluidity and flexibility of the membrane.

5. Cholestrol formation:

Much of the cholestrol is located in cell membranes. Cholestrol maintains the fluidity of membranes by interacting with their complex lipid components, specifically the phospholipids such as phosphatidylcholine and sphingomyelin. Cholestrol also is the precursor of bile acids, vitamin D and steroidal hormones.

6. Prostaglandin formation and role in inflammation:

The essential fatty acids, linoleic acids and linolenic acids are precursors of many different types of eicosanoids. These play an important role in pain, fever, inflammation and blood clotting.

7. The "fat-soluble" vitamins (A, D, E and K) are essential nutrients with numerous functions. Acyl-carnitines transport and metabolize fatty acids in and out of mitochondria. Polyprenols and their phosphorylated derivatives help on transport of molecules across membranes. Cardiolipins activate enzymes involved with oxidative phosphorylation.

In addition, lipids perform many (11) other important functions in plants. Lipids help seeds and spores in thermal insulation, protection from ultraviolet radiations and loss of water. Waxes protect the floating leaves of aquatic plants against wetting. In land plants, they reduce the rate of transpiration.