UNIT-4
LIPIDS

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- Structure and properties of triglycerides (oils and fats)
- Fatty acid classification - Based on chemical and nutritional requirements with examples
- Structure and functions of cholesterol in the body
- Lipoproteins - types, composition and functions in the body
- Qualitative tests and functions of lipids

LIPIDS

"Lipids are organic compounds that contain hydrogen, carbon, and oxygen atoms, which forms the framework for the structure and function of living cells."

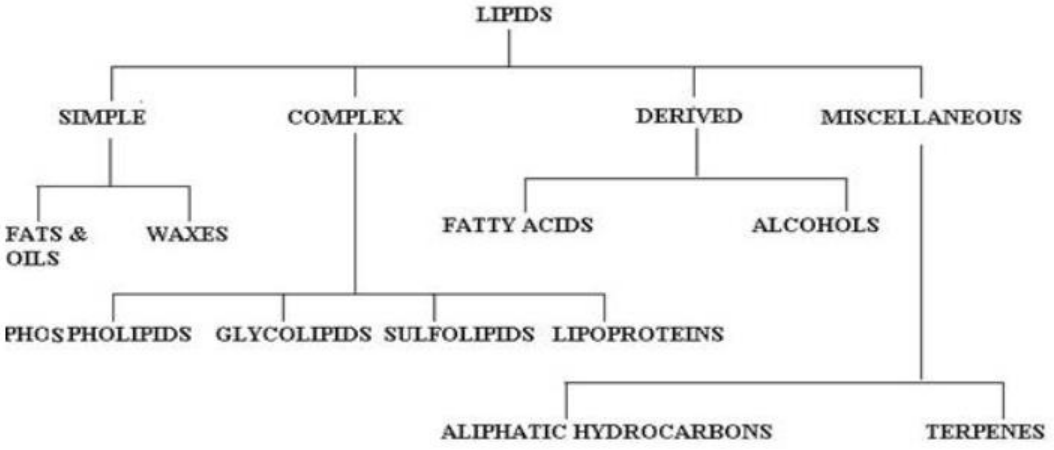
Properties of Lipids

Lipids are a family of organic compounds, composed of fats and oils. These molecules yield high energy and are responsible for different functions within the human body. Listed below are some important characteristics of Lipids.

1. Lipids are oily or greasy nonpolar molecules, stored in the adipose tissue of the body.
2. Lipids are a heterogeneous group of compounds, mainly composed of hydrocarbon chains.
3. Lipids are energy-rich organic molecules, which provide energy for different life processes.
4. Lipids are a class of compounds characterized by their solubility in nonpolar solvents and insolubility in water.
5. Lipids are significant in biological systems as they form a mechanical barrier dividing a cell from the external environment known as the cell membrane.

Lipid Structure

Lipids are the polymers of fatty acids that contain a long, non-polar hydrocarbon chain with a small polar region containing oxygen. The lipid structure is explained in the diagram below:



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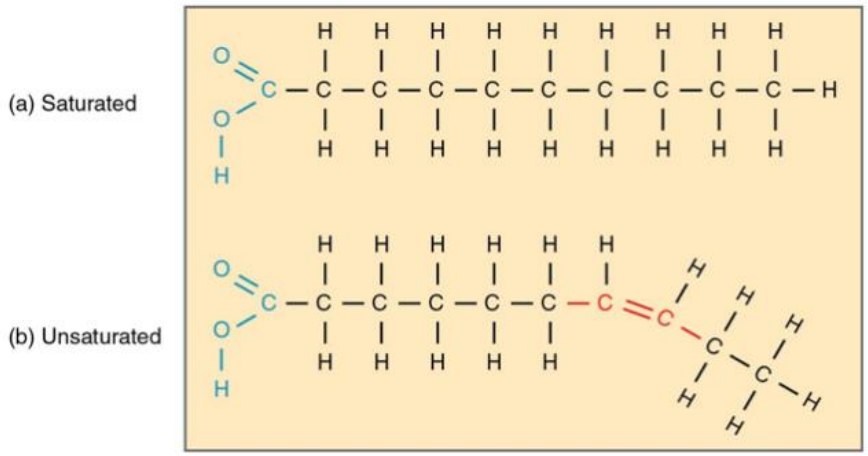


Lipid Structure – Saturated and Unsaturated Fatty Acids

Classification of Lipids

Within these two major classes of lipids, there are numerous specific types of lipids important to live, including fatty acids, triglycerides, glycerophospholipids, sphingolipids and steroids. These are broadly classified as simple lipids and complex lipids.

Simple Lipids

Esters of fatty acids with various alcohols.

1. **Fats:** Esters of fatty acids with glycerol. Oils are fats in the liquid state.
2. **Waxes**: Esters of fatty acids with higher molecular weight monohydric alcohols.

- Waxes are “esters” (an organic compound made by replacing the hydrogen with acid by an alkyl or another organic group) formed from long-alcohols and long-chain carboxylic acids.
- Waxes are found almost everywhere. Fruits and leaves of many plants possess waxy coatings that can safeguard them from small predators and dehydration.

- Fur of a few animals and the feathers of birds possess same coatings serving as water repellants.
- Carnauba wax is known for its water resistance and toughness (significant for car wax).

Complex Lipids

Esters of fatty acids containing groups in addition to alcohol and a fatty acid.

Phospholipids: These are lipids containing, in addition to fatty acids and alcohol, a phosphoric acid residue.

- They frequently have nitrogen-containing bases and other substituents, eg, in glycerophospholipids the alcohol is glycerol and in sphingophospholipids the alcohol is sphingosine.
- Membranes are primarily composed of phospholipids that are Phosphoacylglycerols. They are hetergenous group of compounds, which contain one or more phosphoric acid residues and a polar group that may be nitrogenous base, amino acid or poly-hydroxy alcohol.

Glycolipids (glycosphingolipids): Lipids containing a fatty acid, sphingosine and carbohydrate.

Other complex lipids: Lipids such as sulfolipids and amino lipids. Lipoproteins may also be placed in this category.

Derived Lipids

Fatty Acids

Fatty acids are carboxylic acids (or organic acid), usually with long aliphatic tails (long chains), either unsaturated or saturated.

Saturated fatty acids

- It ends in word "-anoic" e.g. octadecanoic acid (18 C atom).
- Lack of carbon-carbon double bonds indicate that the fatty acid is saturated.
- The saturated fatty acids have higher melting points compared to unsaturated acids of the corresponding size due to their ability to pack their molecules together thus leading to a straight rod-like shape.

Unsaturated fatty acids

- It ends in word "-enoic" e.g. octadecenoic acid. (oleic acid)
- Unsaturated fatty acid is indicated when a fatty acid has more than one double bond.
- "Often, naturally occurring fatty acids possesses an even number of carbon atoms and are unbranched."
- On the other hand, unsaturated fatty acids contain a cis-double bond(s) which create a structural link that disables them to group their molecules in straight rod-like shape.

Alcohol

- It includes molecules with OH group as functional group. It also varies from simple straight chain alcohol like glycerol to complex cyclic alcohols like cholesterol.

Role of Fats

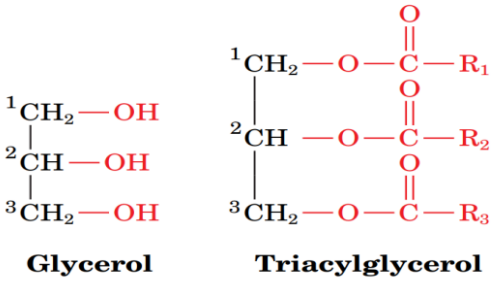
Fats play several major roles in our body. Some of the important roles of fats are mentioned below:

- Fats in the correct amounts are necessary for the proper functioning of our body.

- Many fat-soluble vitamins need to be associated with fats in order to be effectively absorbed by the body.
- They also provide insulation to the body.
- They are an efficient way to store energy for longer periods.

STRUCTURE AND PROPERTIES OF TRIGLYCERIDES

- Triacylglycerols (formerly triglycerides) are the esters of glycerol with fatty acids.
- The fats and oils that are widely distributed in both plants and animals are chemically triacylglycerols.
- They are insoluble in water and non-polar in character and commonly known as neutral fats. Fats (solid at room temperature) and oils (liquid at room temperature) are complex mixtures of triacylglycerols whose fatty acid compositions vary with the organism that produced them. Plant oils are usually richer in unsaturated fatty acid residues than animal fats, as the lower melting.
- Solid triglycerols (Fats) have high proportions of saturated fatty acids.
- Liquid triglycerols (Oils) have high proportions of unsaturated fatty acids.



Properties of TG

1. Hydrolysis of triglycerols

Triglycerols like any other esters react with water to form their carboxylic acid and alcohol– a process known as hydrolysis.

2. Saponification

Triacylglycerols may be hydrolyzed by several procedures, the most common of which utilizes alkali or enzymes called lipa-ses. Alkaline hydrolysis is termed saponifica-tion because one of the products of the hydrolysis is a soap, generally sodium or potassium salts of fatty acids.

3. Hydrogenation

The carbon-carbon double bonds in unsaturated fatty acids can be hydrogenated by reacting with hydrogen to produce saturated fatty acids.

4. Halogenation

Unsaturated fatty acids, whether they are free or combined as esters in fats and oils, react with halogens by addition at the double bond(s). The reaction results in the decolorization of the halogen solu-tion.

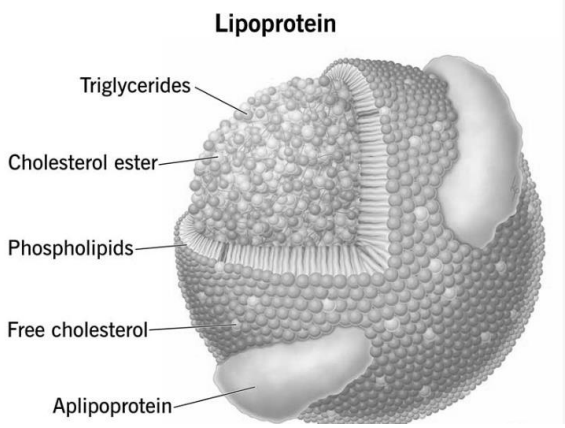
5. Rancidity

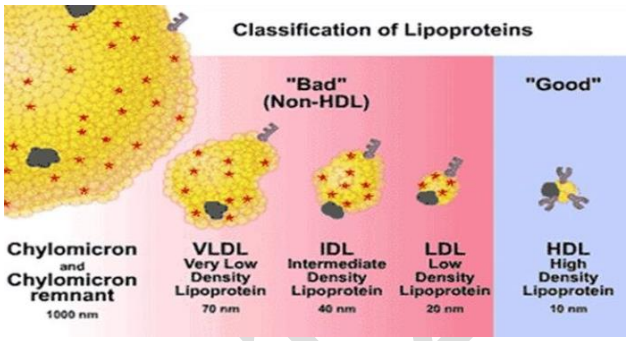
The term rancid is applied to any fat or oil that develops a disagreeable odor. Hydrolysis and oxidation reactions are responsible for causing rancidity. Oxidative rancidity occurs in triacylglycerols containing unsaturated fatty acids.

LIPOPROTEINS

(Lipoproteins - types, composition and functions in the body)

Lipoproteins





Lipoproteins are round particles made of fat (lipids) and proteins that travel in your bloodstream to cells throughout your body. Cholesterol and triglycerides are two types of lipids found in lipoproteins.

Types

There are five main types of lipoproteins:

High-density lipoprotein (HDL)

- It is the "good cholesterol." It carries cholesterol back to liver to be flushed out of body.
- High levels of HDL reduce your risk of cardiovascular (heart) disease.

Low-density lipoprotein (LDL)

- It is the "bad cholesterol.
- It increases your risk of coronary artery disease, heart attacks and stroke.

- LDL carries cholesterol that accumulates as plaque inside blood vessels.
- Plaque buildup can make blood vessels too narrow for blood to flow freely. This condition is atherosclerosis.
- Lipoprotein (a) or LP(a) is a type of LDL ("bad cholesterol"). A second protein called apolipoprotein or apo(a) loops around it in segments called kringles. Apolipoprotein makes the LDL particles stickier. As a result, LP(a) builds up in blood vessels, increasing the risk of cardiovascular problems. High levels of LP(a) are a risk factor for atherosclerosis.

Very low-density lipoproteins (VLDL)

- They are another type of "bad cholesterol."
- VLDLs carry triglycerides — and to a lesser degree, cholesterol — to the tissues.

Intermediate-density lipoproteins (IDL)

- They are created when VLDLs give up their fatty acids.
- They're then either removed by the liver or converted into LDL.

Chylomicrons are very large particles that also transport triglycerides.

Function of Lipoprotein

1. Lipoproteins perform three major functions:
2. Transport of dietary fat from the intestine to other tissues
3. Transport of endogenous triglycerides and cholesterol to other tissues
4. Transfer of cholesterol from extrahepatic tissues to the liver.

Qualitative tests of lipids

1. Solubility

- Solubility of Lipid in organic solvents depends on length of hydrocarbon chain of the fatty acids attached to glyceride.
- Lipids are soluble in solvents like- Chloroform, ether, alcohol, hexane etc.

2. Formation of translucent spot-on paper/Spotting effects

- All the lipids are greasy in nature therefore the test may be taken as group test for lipids. So, take 3ml of ether in a test tube and dissolve 5 drops of oil in test tube.
- The put a drop of the solution on the filter/ normal paper and let it dry.
- A translucent spot on the filter paper observed and this indicates the greasy character of lipids.

3. Emulsification

- When oil or liquid fat is shaken with water. It is finely divided and is displayed in the water to form what is known as emulsion.
- Shake a drop of oil with little water in a test tube.
- The oil becomes finally divided forming an emulsion.

4. Iodine absorption test

- This test is for unsaturated fatty acids for fat. A drop of iodine is added to fat (Fat some is prepared in chloroform) and shaken.
- This solution will decolorize if unsaturated fatty acid is present.