

**K. T. S. P. Mandal's  
Hutatma Rajguru Mahavidyalaya  
Rajgurunagar 410 505.**

**Department of Zoology**

**T. Y. B. Sc.**

**ZO 353: Biological Chemistry  
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**By**

**Prof. P. P. Shindekar.**

# Lipids

## Introduction of lipids

### Lipids Definition

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

### What are Lipids?

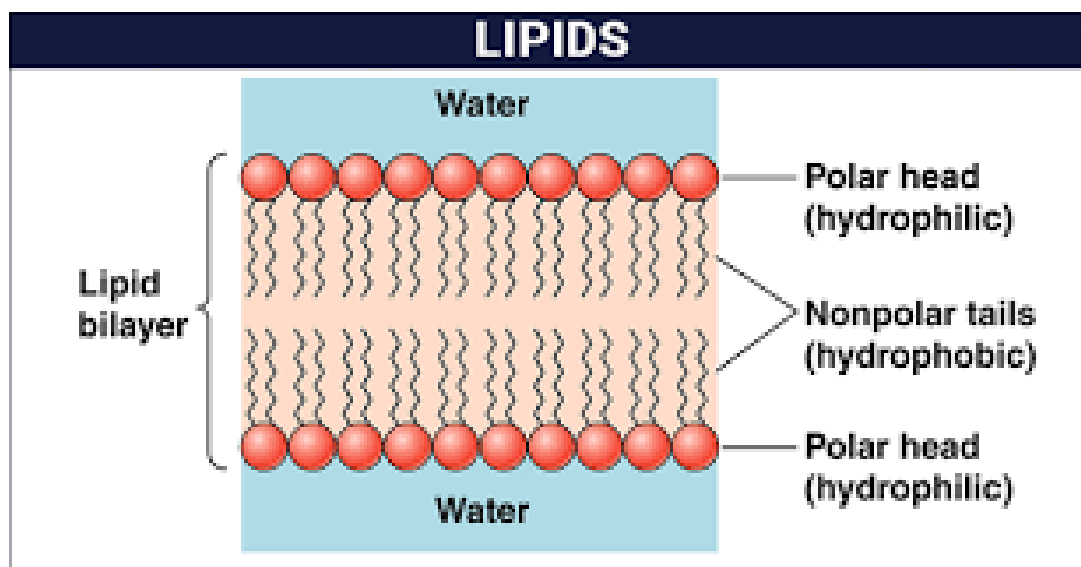
These organic compounds are nonpolar molecules, which are soluble only in nonpolar solvents and insoluble in water because water is a polar molecule. In the human body, these molecules can be synthesized in the liver and are found in oil, butter, whole milk, cheese, fried foods and also in some red meats.

Let us have a detailed look at the lipid structure, properties, types and classification of lipids.

### 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 characterised 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:

Lipid Structure – Saturated and Unsaturated Fatty Acids

## Classification of Lipids

Lipids can be classified into two main classes:

- Nonsaponifiable lipids
- Saponifiable lipids

### Nonsaponifiable Lipids

A nonsaponifiable lipid cannot be disintegrated into smaller molecules through hydrolysis. Nonsaponifiable lipids include cholesterol, prostaglandins, etc

### Saponifiable Lipids

A saponifiable lipid comprises one or more ester groups, enabling it to undergo hydrolysis in the presence of a base, acid, or **enzymes**, including waxes, triglycerides, sphingolipids and phospholipids.

Further, these categories can be divided into non-polar and polar lipids.

Nonpolar lipids, namely triglycerides, are utilized as fuel and to store energy.

Polar lipids, that could form a barrier with an external water environment, are utilized in membranes. Polar lipids comprise sphingolipids and glycerophospholipids.

Fatty acids are pivotal components of all these lipids.

## Types of Lipids

Within these two major classes of lipids, there are numerous specific types of lipids important to life, 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

### Complex Lipids

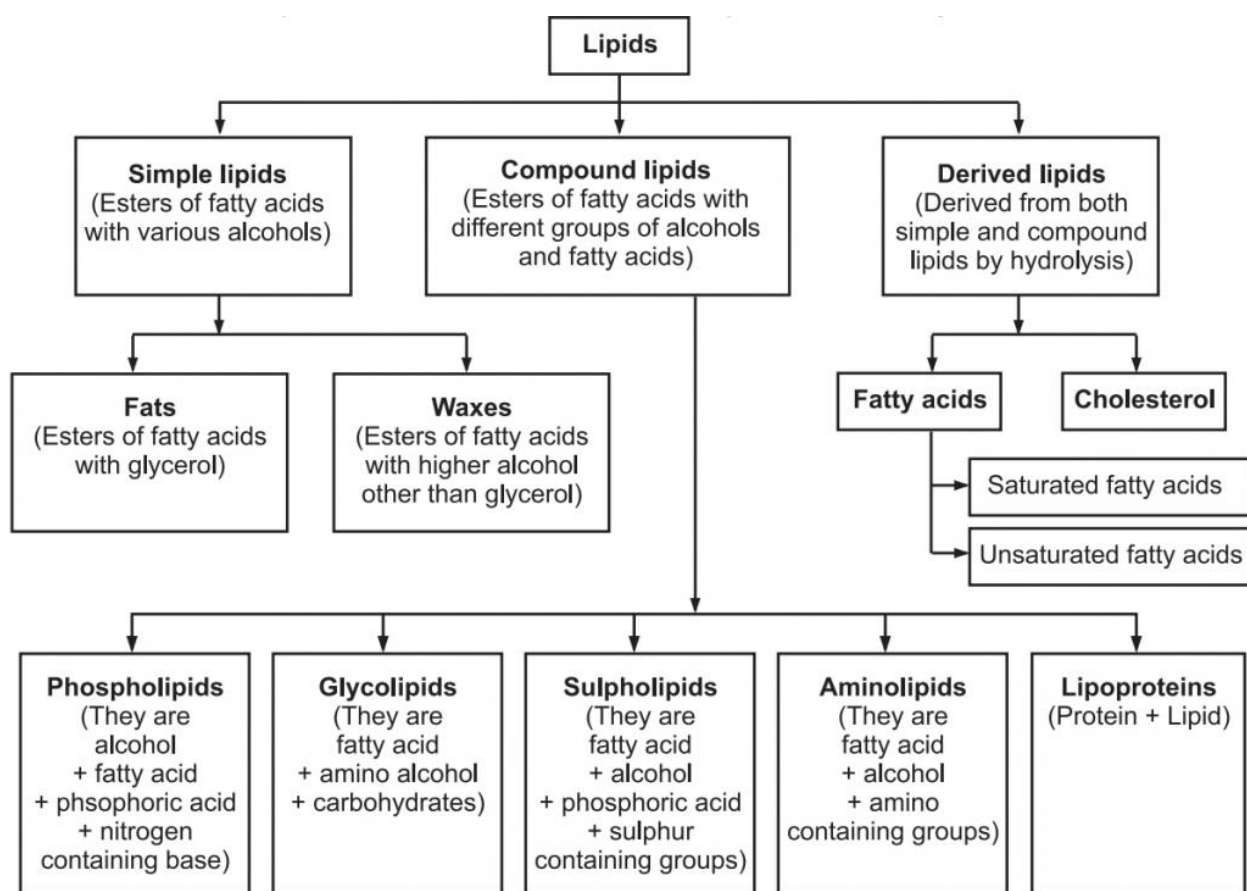
Esters of fatty acids containing groups in addition to alcohol and a fatty acid.

1. **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.
2. **Glycolipids (glycosphingolipids):** Lipids containing a fatty acid, sphingosine and carbohydrate.
3. **Other complex lipids:** Lipids such as sulfolipids and amino lipids. Lipoproteins may also be placed in this category.

## Precursor and Derived Lipids

These include fatty acids, glycerol, steroids, other alcohols, fatty aldehydes, and ketone bodies, hydrocarbons, lipid-soluble vitamins, and hormones. Because they are uncharged, acylglycerols (glycerides), cholesterol, and cholesteryl esters are termed neutral lipids. These compounds are produced by the hydrolysis of simple and complex lipids.

Some of the different types of lipids are described below in detail.



## Fatty Acids

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

- **Saturated fatty acids**

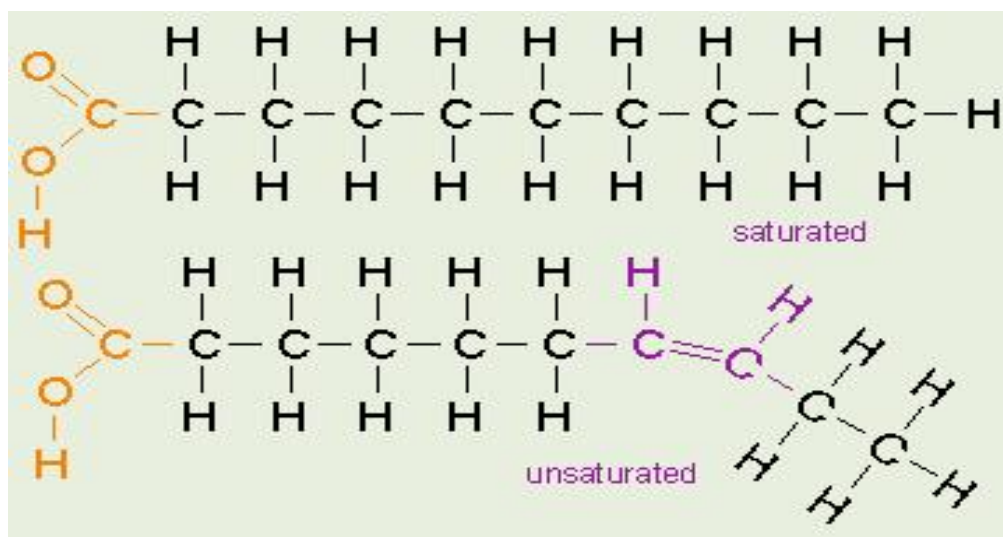
Lack of carbon-carbon double bonds indicate that the fatty acid is saturated. The saturated fatty acids have higher melting points compared to unsaturated acids of the corresponding size due to their ability to pack their molecules together thus leading to a straight rod-like shape.

- **Unsaturated fatty acids**

Unsaturated fatty acid is indicated when a fatty acid has more than one double bond.

“Often, naturally occurring fatty acids possess 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 kink that disables them to group their molecules in straight rod-like shape.



## 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.

## Waxes

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. The 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 the same coatings serving as water repellants.

Carnauba wax is known for its water resistance and toughness (significant for car wax).

## Phospholipids

Membranes are primarily composed of phospholipids that are Phosphoacylglycerols.

Triacylglycerols and phosphoacylglycerols are the same, but, the terminal OH group of the phosphoacylglycerol is esterified with phosphoric acid in place of fatty acid which results in the formation of phosphatidic acid.

The name phospholipid is derived from the fact that phosphoacylglycerols are lipids containing a phosphate group.

## Steroids

Our bodies possess chemical messengers known as **hormones**, which are basically organic compounds synthesized in glands and transported by the bloodstream to various tissues in order to trigger or hinder the desired process.

Steroids are a kind of hormone that is typically recognized by their tetracyclic skeleton, composed of three fused six-membered and one five-membered ring, as seen above. The four rings are assigned as A, B, C & D as observed in the shade blue, while the numbers in red indicate the carbons.

## Cholesterol

- Cholesterol is a wax-like substance, found only in animal source foods. Triglycerides, LDL, HDL, VLDL are different types of cholesterol found in the blood cells.
- Cholesterol is an important lipid found in the cell membrane. It is a sterol, which means that cholesterol is a combination of steroid and alcohol. In the human body, cholesterol is synthesized in the liver.
- These compounds are biosynthesized by all living cells and are essential for the structural component of the cell membrane.
- In the cell membrane, the steroid ring structure of cholesterol provides a rigid hydrophobic structure that helps boost the rigidity of the cell membrane. Without cholesterol, the cell membrane would be too fluid.
- It is an important component of cell membranes and is also the basis for the synthesis of other steroids, including the sex hormones estradiol and testosterone, as well as other steroids such as cortisone and vitamin D.

## Examples of Lipids

There are different types of lipids. Some examples of lipids include butter, ghee, vegetable oil, cheese, cholesterol and other steroids, waxes, phospholipids, and fat-soluble vitamins. All these compounds have similar features, i.e. insoluble in water and soluble in organic solvents, etc.