**QUICK REVISION NOTES**
**For NEET**
**BIOLOGY CLASS 11**

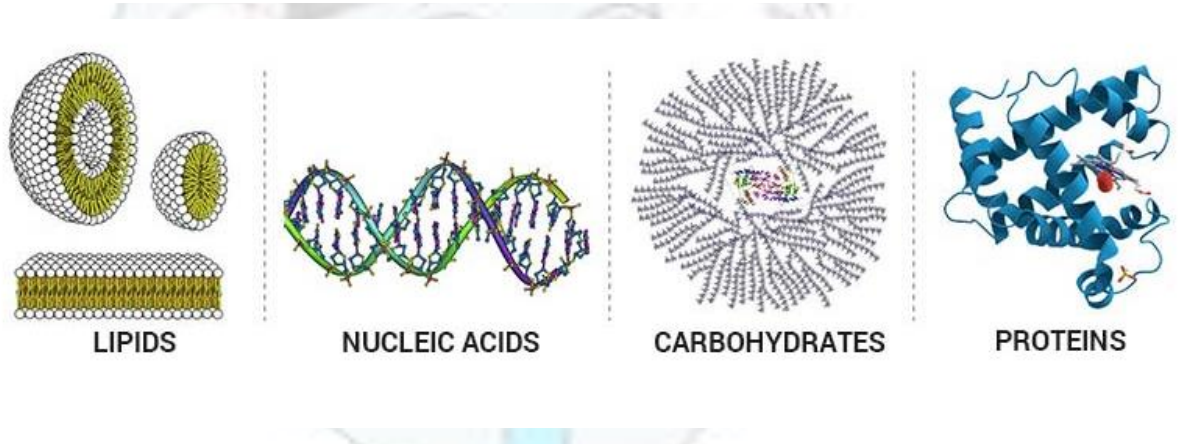
# Biomolecules

Biomolecules are the most essential organic molecules, which are involved in the maintenance and metabolic processes of living organisms. These non-living molecules are the actual foot-soldiers of the battle of sustenance of life. They range from small molecules such as primary and secondary metabolites and hormones to large macromolecules like proteins, nucleic acids, carbohydrates, lipids etc.

Let us study them in brief.

Also, read – Biomolecules in Living Organisms

**Types of Biomolecules**




There are four major classes of Biomolecules – Carbohydrates, Proteins, Nucleic acids and Lipids. Each of them is discussed below.

**Carbohydrates**

Carbohydrates are chemically defined as polyhydroxy aldehydes or ketones or compounds which produce them on hydrolysis. In layman's terms, we acknowledge carbohydrates as sugars or substances that taste sweet. They are collectively called as saccharides. Depending on the number of constituting sugar units obtained upon hydrolysis, they are classified as monosaccharides (1 unit), oligosaccharides (2-10 units) and polysaccharides (more than 10 units). They have multiple functions' viz. they're the most abundant dietary source of energy; they are structurally very important for many living organisms as they form a major structural component, e.g., cellulose is an important structural fibre for plants.

Carbohydrates are macronutrients and are one of the three main ways by which our body obtains its energy. They are called carbohydrates as they comprise ***carbon***, ***hydrogen*** and ***oxygen*** at their chemical level. Carbohydrates are essential nutrients which include sugars, fibers and starches.

They are found in grains, vegetables, fruits and in milk and other dairy products. They are the basic food groups which play an important role in a healthy life.

The food containing carbohydrates are converted into glucose or blood sugar during the process of digestion by the digestive system.

Our body utilizes this sugar as a source of energy for the cells, organs and tissues. The extra amount of energy or sugar is stored in our muscles and liver for further requirement. The term 'carbohydrate' is derived from a French term '***hydrate de carbone***' meaning '*hydrate of carbon*'. The general formula of this class of organic compounds is $\mathbf{C_n(H_2O)_n}$.

Classification of Carbohydrates

The carbohydrates are further classified into simple and complex which is mainly based on their chemical structure and degree of polymerization.

Simple Carbohydrates (Monosaccharides, Disaccharides and Oligosaccharides)

Simple carbohydrates have one or two sugar molecules. In simple carbohydrates, molecules are digested and converted quickly resulting in a rise in the blood sugar levels. They are abundantly found in milk products, beer, fruits, refined sugars, candies, etc. These carbohydrates are called empty calories, as they do not possess fiber, vitamins and minerals.

Plants, being producers, synthesize glucose ($C_6H_{12}O_6$) using raw materials like carbon dioxide and water in the presence of sunlight. This process of photosynthesis converts solar energy to chemical energy. Consumers feed on plants and harvest energy stored in the bonds of the compounds synthesized by plants.

Also, read more about Photosynthesis

1. Monosaccharides

Glucose is an example of a carbohydrate monomer or monosaccharide. Other examples of monosaccharides include mannose, galactose, fructose, etc. The structural organization of monosaccharides is as follows:

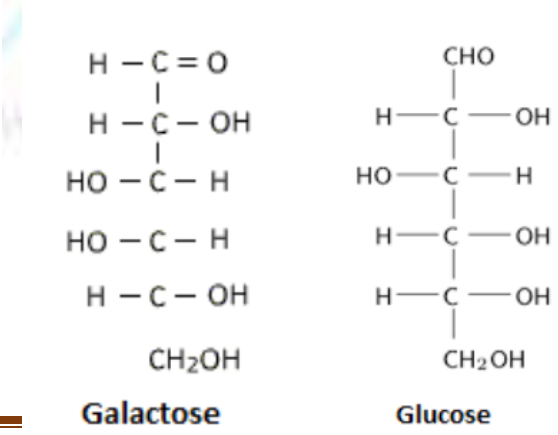
Monosaccharides may be further classified depending on the number of carbon atoms:

**(i)Trioses ($C_3H_6O_3$):** These have three carbon atoms per molecule. Example: Glyceraldehyde

**(ii)Tetroses ($C_4H_6O_4$):** These monosaccharides have four carbon atoms per molecule. Example: Erythrose.

Similarly, we have-

**(iii) Pentoses**,

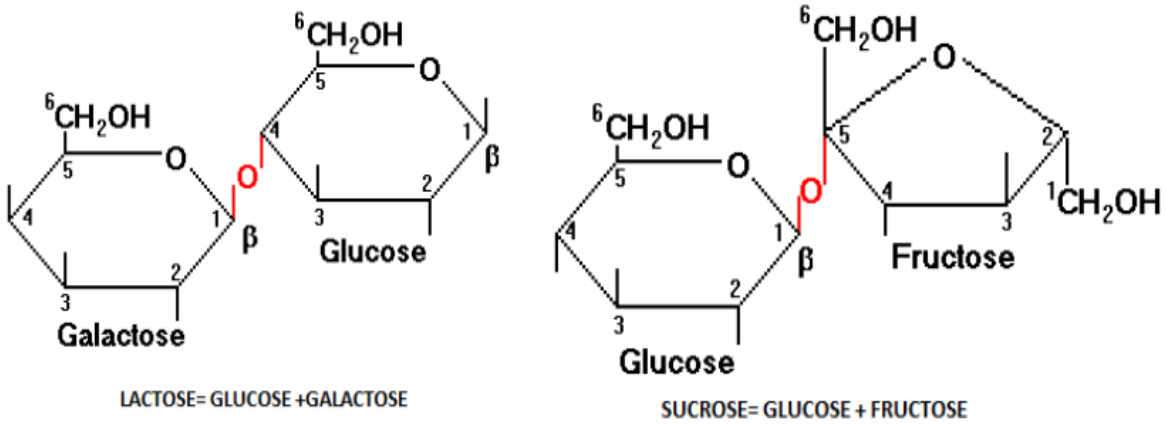


**(iv) Hexoses,** and

**(v) Heptoses**

2. Disaccharides

Two monosaccharides combine to form a disaccharide. Examples of carbohydrates having two monomers include- Sucrose, Lactose, Maltose, etc.

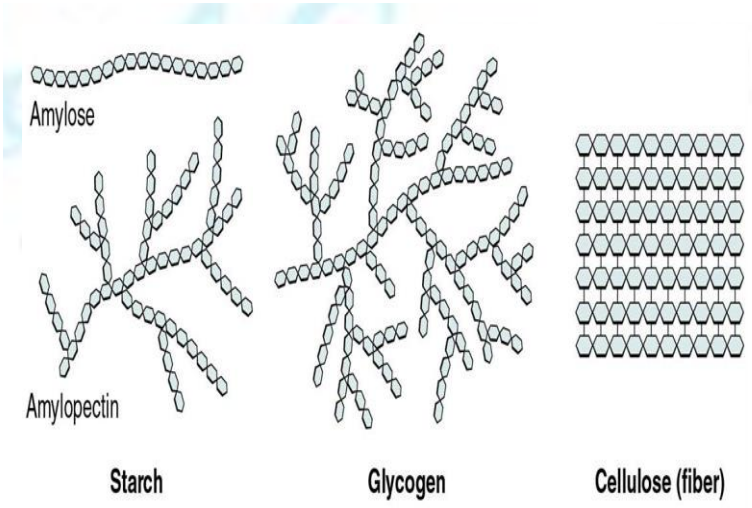



3. Oligosaccharides

Carbohydrates formed by the condensation of 2-9 monomers are called oligosaccharides. By this convention, trioses, pentoses, hexoses are all oligosaccharides.

Complex Carbohydrates (Polysaccharides)

Complex carbohydrates have two or more sugar molecules, hence they are referred to as starchy foods. In complex carbohydrates, molecules are digested and converted slowly compared to simple carbohydrates. They are abundantly found in lentils, beans, peanuts, potatoes, peas, corn, whole-grain bread, cereals, etc.




Polysaccharides are complex

carbohydrates formed by the polymerization of a large number of monomers. Examples of polysaccharides include starch, glycogen, cellulose, etc. which exhibit extensive branching and are homopolymers – made up of only glucose units.

1. Starch is composed of two components- amylose and amylopectin. Amylose forms the linear chain and amylopectin is a much-branched chain.
2. Glycogen is called animal starch. It has a structure similar to starch, but has more extensive branching.
3. Cellulose is a structural carbohydrate and is the main structural component of the plant cell wall. It is a fibrous polysaccharide with high tensile strength. In contrast to starch and glycogen, cellulose forms a linear polymer.

Functions of Carbohydrates

The main function of carbohydrates is to provide energy and food to the body and to the nervous system.

Carbohydrates are known as one of the basic components of food, including sugars, starch, and fibre which are abundantly found in grains, fruits and milk products.

Carbohydrates are also known as starch, simple sugars, complex carbohydrates and so on.

It is also involved in fat metabolism and prevents ketosis.

Inhibits the breakdown of proteins for energy as they are the primary source of energy.

An enzyme by name amylase assists in the breakdown of starch into glucose, finally to produce energy for metabolism.

Sources of Carbohydrates

1. Simple sugars are found in the form of fructose in many fruits.
2. Galactose is present in all dairy products.
3. Lactose is abundantly found in milk and other dairy products.
4. Maltose is present in cereal, beer, potatoes, processed cheese, pasta, etc.
5. Sucrose is naturally obtained from sugar and honey containing small amounts of vitamins and minerals.

These simple sugars that consist of minerals and vitamins exist commonly in milk, fruits, and vegetables. Many refined and other processed foods like white flour, white rice, and sugar, lack important nutrients and hence, they are labelled "***enriched***." It is quite healthy to use vitamins, carbohydrates and all other organic nutrients in their normal forms.

Carbohydrate Foods

Eating too much sugar results in an abnormal increase in calories, which finally leads to obesity and in turn low calories leads to malnutrition. Therefore, a well-balanced diet needs to be maintained to have a healthy life. That is the reason a balanced diet is stressed so much by dietitians.

Let us look into the differences between the good and bad carbohydrates.

| Good Carbohydrates | Bad Carbohydrates |
|---|---|
| High in Nutrients | Low in nutrients |
| Moderate in calories | High in calories |
| Low in sodium and saturated fats | High in sodium and saturated fats |
| Low in trans-fat and cholesterol | High in trans-fat and cholesterol |
| They are complex carbs. For instance: Legumes, vegetables, whole grains, fruits, and beans. | Foods considered bad carbs rarely have any nutritional value. Some of the foods include white flour, rice, pastries, sodas and processed foods. |

Examples of Carbohydrates

Glucose, Galactose, Maltose, Fructose, Sucrose, Lactose, Starch, Cellulose, Chitin etc.

Proteins

Proteins are another class of indispensable biomolecules, which make up around 50per cent of the cellular dry weight. Proteins are polymers of **amino acids** arranged in the form of polypeptide chains. The structure of proteins is classified as primary, secondary, tertiary and quaternary in some cases. These structures are based on the level of complexity of the folding of a polypeptide chain. Proteins play both structural and dynamic roles. Myosin is the protein that allows movement by contraction of muscles. Most enzymes are proteinaceous in nature.

Proteins are composed of amino acids, arranged into different groups. These fundamental amino acids sequences are specific and its arrangements are controlled by the DNA. Since our body cannot synthesize these essential amino acids by its own, we should have plenty of protein foods in our everyday diet to keep our body metabolisms stable.

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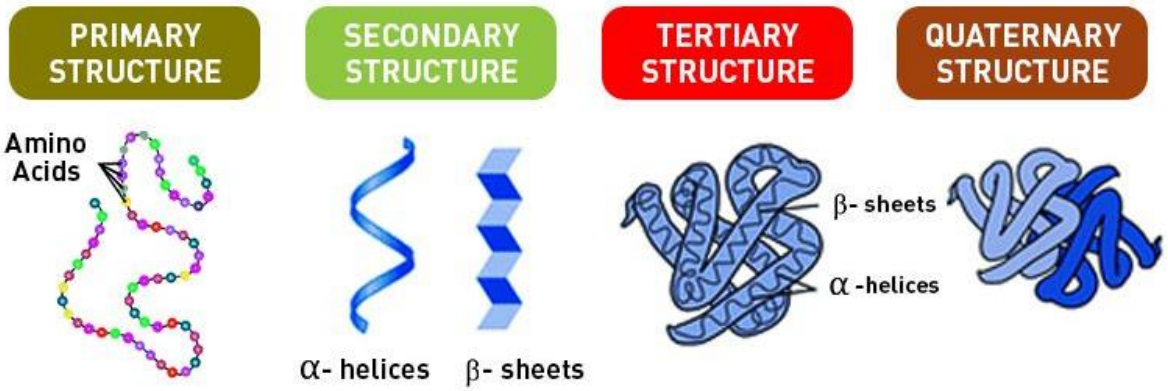
Protein Structure




In general, they are two types of protein molecules fibrous proteins and globular proteins. Fibrous proteins are insoluble and elongated. Globular proteins are soluble and compact. Fibrous and Globular proteins may comprise one or four types of protein structures and they include primary, secondary, tertiary and quaternary structure.

**Primary Structure:** It is a specific sequence of amino acids. The order of amino acids bonded together is detected by information stored in genes.

**Secondary Structure:** It is a three-dimensional form of a local segment of proteins. They are formed by hydrogen bonds between the atoms along the backbone of the polypeptide chain.

**Tertiary Structure:** It is determined by R-groups. It is a three-dimensional shape of a protein. Many numbers of tertiary structure fold to form Quaternary Structure.

**Quaternary Structure:** It is the arrangement of multiple folded protein subunits in a multi-subunit complex.

Protein Synthesis

Protein synthesis takes place through a process called translation. This process occurs in the cytoplasm. It involves the rendering of genetic codes. Ribosomes of a cell help in translating genetic codes into a polypeptide chain. These polypeptide chains become functioning proteins only after undergoing certain modifications.


Sources of Protein

Although there are debates about the intake of carbohydrates and fats in order to maintain a proper health, a minimum amount of daily protein intake is always a doctor's first recommendation. The most common food which has a higher amount of protein are eggs, almond, chicken, oats, fish and seafood, soy, beans and pulses, cottage cheese, Greek yogurt, milk, broccoli, and quinoa.

Functions of Proteins

1. **Enzymes:** Enzymes mostly carry out all numerous chemical reactions which take place within a cell. They also help in regenerating and creating DNA molecules and carry out complex processes.
2. **Hormones:** Proteins are involved in the creation of various types of hormones which help in balancing the components of the body. For example hormones like insulin, which helps in regulating blood sugar and secretin. It is also involved in the digestion process and formation of digestive juices.
3. **Antibody:** Antibody also known as an immunoglobulin. It is a type of protein which is majorly used by the immune system to repair and heal the body from foreign bacteria. They often work together with other immune cells to identify and separate the antigens from increasing until the white blood cells destroy them completely.
4. **Energy:** Proteins are the major source of energy that helps in the movements of our body. It is important to have the right amount of protein in order to convert it into energy. Protein, when consumed in excess amounts, gets used to create fat and becomes part of the fat cells.

Listed below are few functions of Proteins.

| **Aspect** | **Functions** | **Examples** |
|---|---|---|
| Storage | Legume Storage, albumin, and proteins. | Supplies food during the early stage of the seedling or embryo. |
| Hormone Signalling | Counterpart activities of different body parts. | Glucagon and Insulin. |
| Transport | It transport substances throughout the body through lump or blood cells. | Hemoglobin. |
| Contraction | To carry out muscle contraction. | Myosin. |
| Digestive Enzyme | Breaks down nutrients present in the food into smaller portions so that it can be easily absorbed | Pepsin, Amylase, and Lipase |

Nucleic Acids

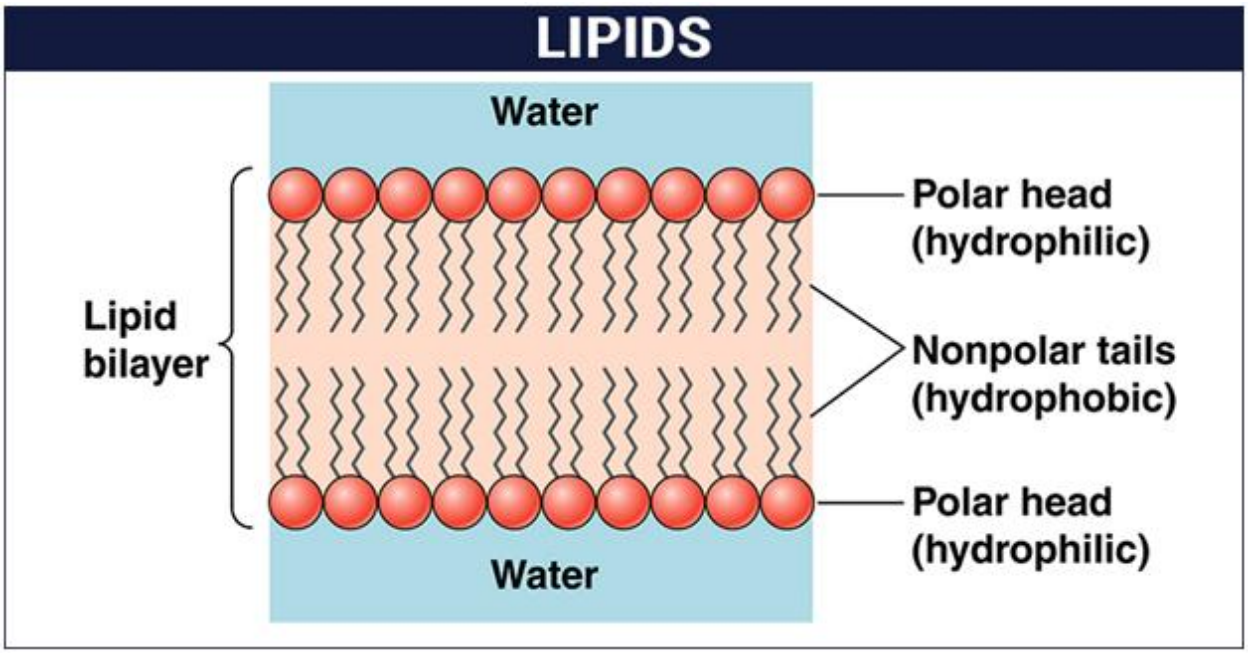
Nucleic acids refer to the genetic material found in the cell that carries all the hereditary information from parents to progeny. There are two types of nucleic acids namely, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). The main function of nucleic acid is the transfer of genetic information and synthesis of proteins by processes known as translation and transcription. The monomeric unit of nucleic acids is known as nucleotide and is composed of a nitrogenous base, pentose sugar, and phosphate. The nucleotides are linked by a 3' and 5' phosphodiester bond. The nitrogen base attached to the pentose sugar makes the nucleotide distinct. There are 4 major nitrogenous bases found in DNA: adenine, guanine, cytosine, and thymine. In RNA, thymine is replaced by uracil. The DNA structure is described as a double-helix or double-helical structure which is formed by hydrogen bonding between the bases of two antiparallel polynucleotide chains. Overall, the **DNA structure** looks similar to a twisted ladder.

Lipids

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

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.



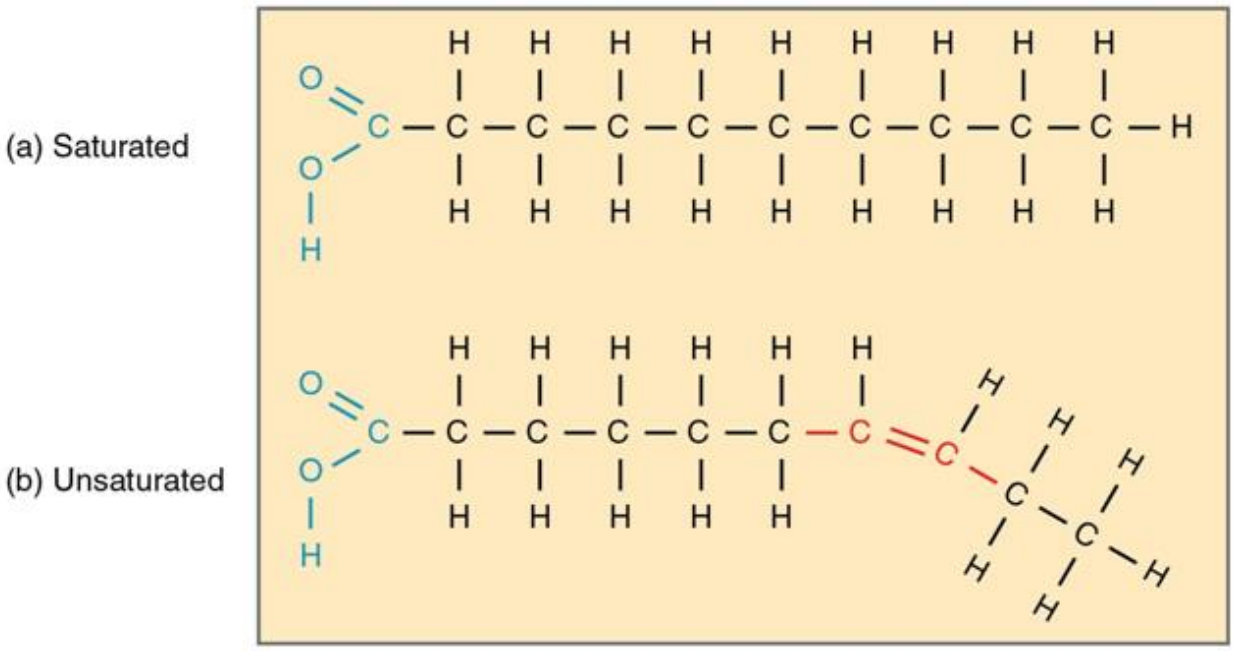
Properties of Lipids

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 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

**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.

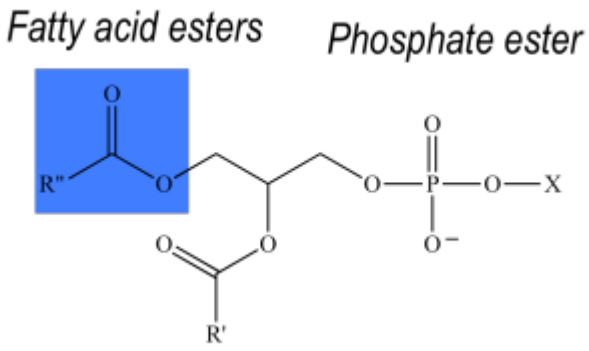
- **Unsaturated fatty acids**

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

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

**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.

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.