MODULE-01

CELL BASIC UNIT OF LIFE

Cell Definition: A cell is defined as the smallest, basic unit of life that is responsible for all of life's processes.

Structure and functions of a cell

- All living organisms need to respire, digest food for obtaining energy, and get rid of metabolic wastes.
- Cells are capable of performing all the metabolic functions of the body.
- Hence, cells are called the functional units of life.
- An organelle is a subcellular structure that has one or more specific jobs to perform in the cell, much like an organ does in the body.
- Classified as Prokaryotic & Eukaryotic cells.

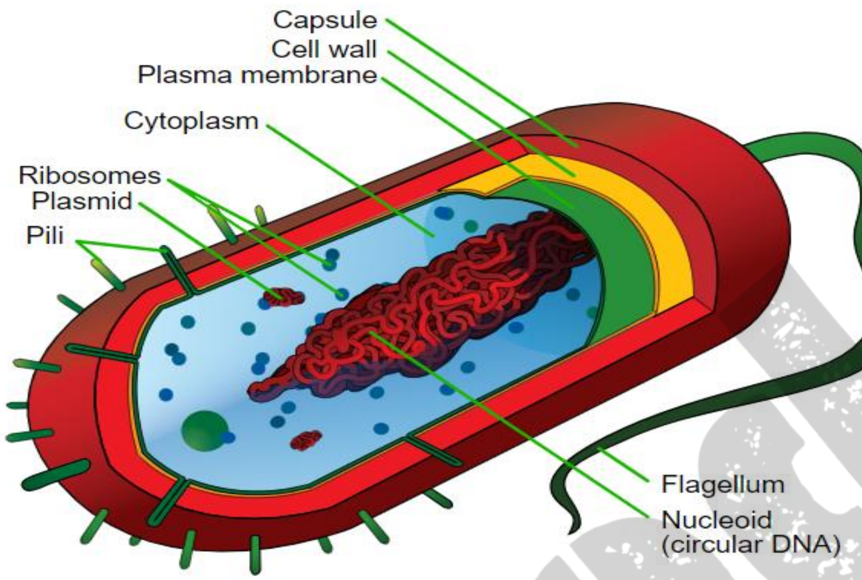
Prokaryotic cells –

1. A cell which is having no nucleus, instead some bacteria have a region within the cell where the Generic material is freely suspended, this region is called Nucleoid.
2. They are single celled microorganisms. ex: archaea, bacteria & cyanobacteria.
3. Prokaryotic generally reproduce by binary fission, a form of asexual reproduction. They are also known as conjugation. Which is often seen as the Prokaryotic equivalent to sexual reproduction
4. The cell size ranges from 0.1- 0.5µm in diameter.

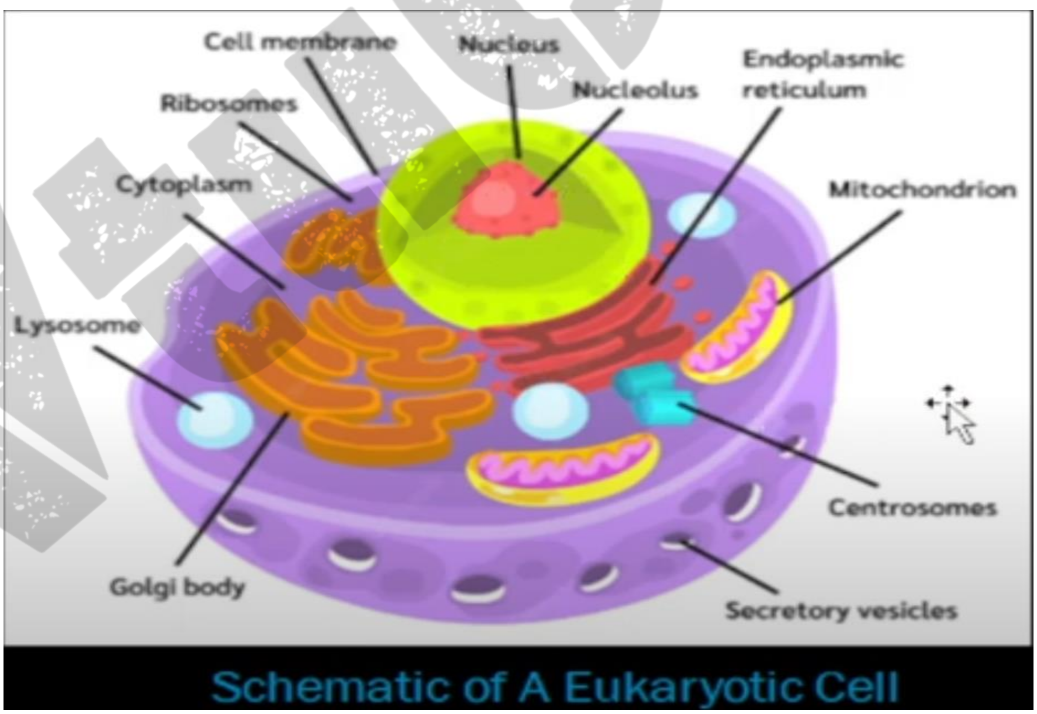
Eukaryotic Cells

1. Eukaryotic cells are characterized by a true nucleus.
2. This broad category involves plants, fungi, protozoans & animals.
3. The plasma membrane is responsible for monitoring the transport of nutrients & electrolytes in and out of the cells.
4. It Is also responsible for cell to cell communication.
5. They reproduce sexually as well as asexually.
6. They are some contrasting features btw plant & animal cells.
7. Ex: plant cell contains chloroplast, central vacuoles, and other plastids, whereas the animal cell do not.
8. The cell size ranges from 10- 100µm in diameter.

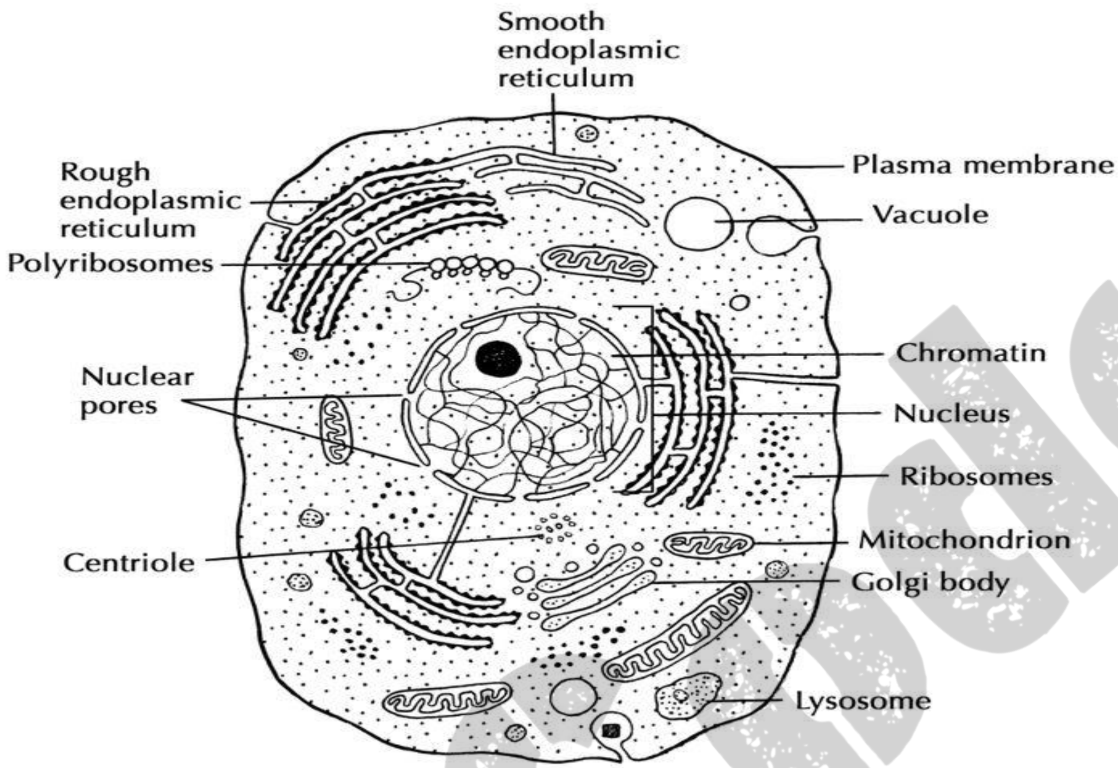
Prokaryotic cell



Eukaryotic Cells



Structure of the Cell



The cell structure comprises individual components with specific functions essential to carry out life's processes. These components include- cell wall, cell membrane, cytoplasm, nucleus, and cell organelles. Read on to explore more insights on cell structure and function.

Cell Membrane

- The cell membrane supports and protects the cell. It controls the movement of substances in and out of the cells. It separates the cell from the external environment. The cell membrane is present in all the cells.
- The cell membrane is the outer covering of a cell within which all other organelles, such as the cytoplasm and nucleus, are enclosed. It is also referred to as the plasma membrane.
- By structure, it is a porous membrane (with pores) which permits the movement of selective substances in and out of the cell. Besides this, the cell membrane also protects the cellular component from damage and leakage.

- It forms the wall-like structure between two cells as well as between the cell and its surroundings.
- Plants are immobile, so their cell structures are well-adapted to protect them from external factors. The cell wall helps to reinforce this function.

Cell Wall

- The cell wall is the most prominent part of the plant's cell structure. It is made up of cellulose, hemicellulose and pectin.
- The cell wall is present exclusively in plant cells. It protects the plasma membrane and other cellular components. The cell wall is also the outermost layer of plant cells.
- It is a rigid and stiff structure surrounding the cell membrane.
- It provides shape and support to the cells and protects them from mechanical shocks and injuries.

Cytoplasm

- The cytoplasm is a thick, clear, jelly-like substance present inside the cell membrane.
- Most of the chemical reactions within a cell take place in this cytoplasm.
- The cell organelles such as endoplasmic reticulum, vacuoles, mitochondria, ribosomes, are suspended in this cytoplasm.

Nucleus

- The nucleus contains the hereditary material of the cell, the DNA.
- It sends signals to the cells to grow, mature, divide and die.
- The nucleus is surrounded by the nuclear envelope that separates the DNA from the rest of the cell.
- The nucleus protects the DNA and is an integral component of a plant's cell structure.

Cell Organelles

Cell Organelles and their Functions
Nucleolus
The nucleolus is the site of ribosome synthesis. Also, it is involved in controlling cellular activities and cellular reproduction.
Nuclear membrane
The nuclear membrane protects the nucleus by forming a boundary between the nucleus and other cell organelles.
Chromosomes
Chromosomes play a crucial role in determining the sex of an individual. Each human cells contain 23 pairs of chromosomes.
Endoplasmic reticulum
The endoplasmic reticulum is involved in the transportation of substances throughout the cell. It plays a primary role in the metabolism of carbohydrates, synthesis of lipids, steroids and proteins.
Golgi Bodies
Golgi bodies are called the cell's post office as it is involved in the transportation of materials within the cell.
Ribosome
Ribosomes are the protein synthesizers of the cell.
Mitochondria
The mitochondrion is called "the powerhouse of the cell." It is called so because it produces ATP – the cell's energy currency.
Lysosomes
Lysosomes protect the cell by engulfing the foreign bodies entering the cell and help in cell renewal. Therefore, they are known as the cell's suicide bags.
Chloroplast
Chloroplasts are the primary organelles for photosynthesis. It contains the pigment called chlorophyll.
Vacuoles
Vacuoles store food, water, and other waste materials in the cell.

Functions of Cell

A cell performs major functions essential for the growth and development of an organism. Important functions of cell are as follows:

Provides Support and Structure

All the organisms are made up of cells. They form the structural basis of all the organisms. The cell wall and the cell membrane are the main components that function to provide support and structure to the organism. For eg., the skin is made up of a large number of cells. Xylem present in the vascular plants is made of cells that provide structural support to the plants.

Facilitate Growth Mitosis

In the process of mitosis, the parent cell divides into the daughter cells. Thus, the cells multiply and facilitate the growth in an organism.

Allows Transport of Substances

Various nutrients are imported by the cells to carry out various chemical processes going on inside the cells. The waste produced by the chemical processes is eliminated from the cells by active and passive transport. Small molecules such as oxygen, carbon dioxide, and ethanol diffuse across the cell membrane along the concentration gradient. This is known as passive transport. The larger molecules diffuse across the cell membrane through active transport where the cells require a lot of energy to transport the substances.

Energy Production

Cells require energy to carry out various chemical processes. This energy is produced by the cells through a process called photosynthesis in plants and respiration in animals.

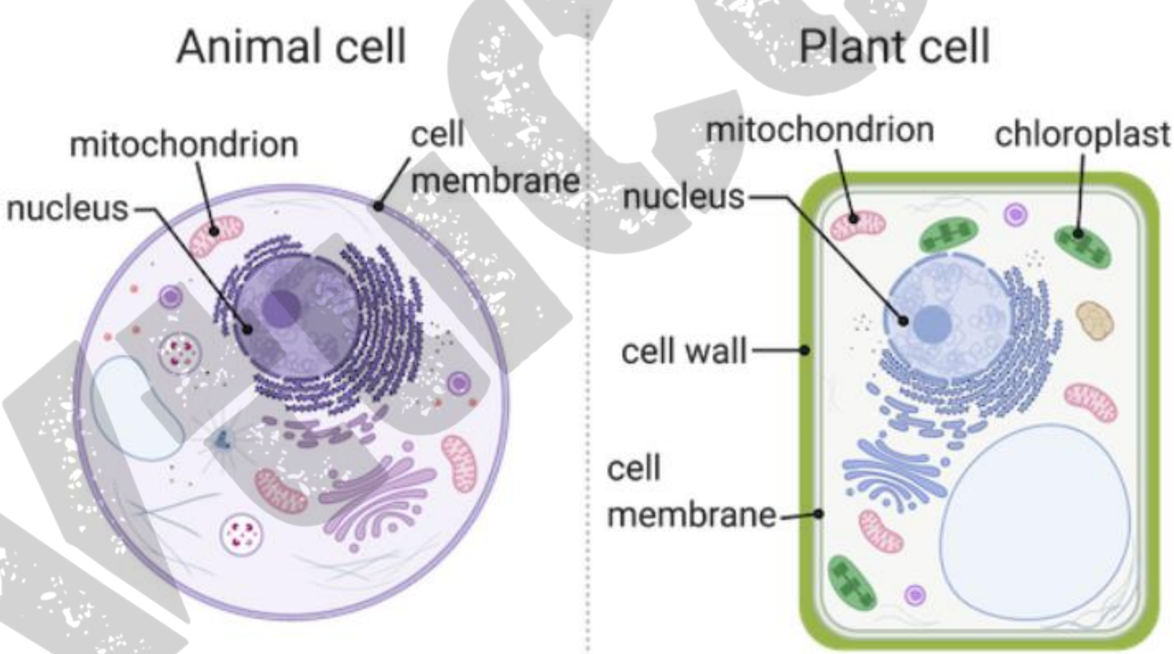
Aids in Reproduction

A cell aids in reproduction through the processes called mitosis and meiosis. Mitosis is termed as the asexual reproduction where the parent cell divides to form daughter cells. Meiosis causes the daughter cells to be genetically different from the parent cells.

Thus, we can understand why cells are known as the structural and functional unit of life. This is because they are responsible for providing structure to the organisms and perform several functions necessary for carrying out life's processes.

Difference between plant cell & animal cell

- The plant cells have a cell wall which surrounds the cell membrane. on the other hand, the animal cells only have a cell membrane.
- In the plant cells, there are chloroplasts which are helpful in photosynthesis.
- In the plant cells, there is a larger vacuole (it is like fluid rack) in comparison to the animal cell.
- The animal cells are blobby. on the other hand, the cells in the plants are most structured because of the presence of a cell wall.
- It forms a lattice like structure which helps with rigidness.



Stem cells and their application

Stem cells also have the ability to repair damaged cells. These cells have strong healing power. They can evolve into any type of cell.Research on stem cells is going on, and it is believed that stem cell therapies can cure ailments like paralysis and Alzheimer's as well. Let us have a detailed look at stem cells, their types and their functions.

Types of cells

Stem cells are of the following different types:

- Embryonic Stem Cells
- Adult Stem Cells
- Induced Pluripotent Stem Cells
- Mesenchymal stem cells

Embryonic Stem Cells

The fertilized egg begins to divide immediately. All the cells in the young embryo are totipotent cells. These cells form a hollow structure within a few days. Cells in one region group together to form the inner cell mass. This contains pluripotent cells that make up the developing foetus.

The embryonic stem cells can be further classified as:

- **Totipotent Stem Cells:** These can differentiate into all possible types of stem cells.
- **Pluripotent Stem Cells:** These are the cells from an early embryo and can differentiate into any cell type.
- **Multipotent Stem Cells:** These differentiate into a closely related cell type. E.g., the hematopoietic stem cells differentiate into red blood cells and white blood cells.
- **Oligopotent Stem Cells:** Adult lymphoid or myeloid cells are oligopotent. They can differentiate into a few different types of cells.
- **Unipotent Stem Cells:** They can produce cells only of their own type. Since they have the ability to renew themselves, they are known as unipotent stem cells. E.g., Muscle stem cells.

Adult Stem Cells

These stem cells are obtained from developed organs and tissues. They can repair and replace the damaged tissues in the region where they are located. For eg., hematopoietic stem cells are found in the bone marrow. These stem cells are used in bone marrow transplants to treat specific types of cancers.

Induced Pluripotent Stem Cells

These cells have been tested and arranged by converting tissue-specific cells into embryonic cells in the lab. These cells are accepted as an important tool to learn about the normal development, onset and progression of the disease and are also helpful in testing various drugs. These stem cells share the same characteristics as embryonic cells do. They also have the potential to give rise to all the different types of cells in the human body.

Mesenchymal Stem Cells

These cells are mainly formed from the connective tissues surrounding other tissues and organs, known as the stroma. These mesenchymal stem cells are accurately called stromal cells. The first mesenchymal stem cells were found in the bone marrow that is capable of developing bones, fat cells, and cartilage.

There are different mesenchymal stem cells that are used to treat various diseases as they have been developed from different tissues of the human body. The characteristics of mesenchymal stem cells depend on the organ from where they originate.

Applications of Stem Cells

Following are the important applications of stem cells:

Tissue Regeneration

This is the most important application of stem cells. The stem cells can be used to grow a specific type of tissue or organ. This can be helpful in kidney and liver transplants. The doctors have already used the stem cells from beneath the epidermis to develop skin tissue that can repair severe burns or other injuries by tissue grafting.

Treatment of Cardiovascular Disease

A team of researchers have developed blood vessels in mice using human stem cells. Within two weeks of implantation, the blood vessels formed their network and were as efficient as the natural vessels.

Treatment of Brain Diseases

Stem cells can also treat diseases such as Parkinson's disease and Alzheimer's. These can help to replenish the damaged brain cells. Researchers have tried to differentiate embryonic stem cells into these types of cells and make it possible to treat diseases.

Blood Disease Treatment

The adult hematopoietic stem cells are used to treat cancers, sickle cell anaemia, and other immunodeficiency diseases. These stem cells can be used to produce red blood cells and white blood cells in the body.

Sources of Stem Cells

Stem Cells originate from different parts of the body. Adult stem cells can be found in specific tissues in the human body. Matured cells are specialized to conduct various functions. Generally, these cells can develop the kind of cells found in tissues where they reside.

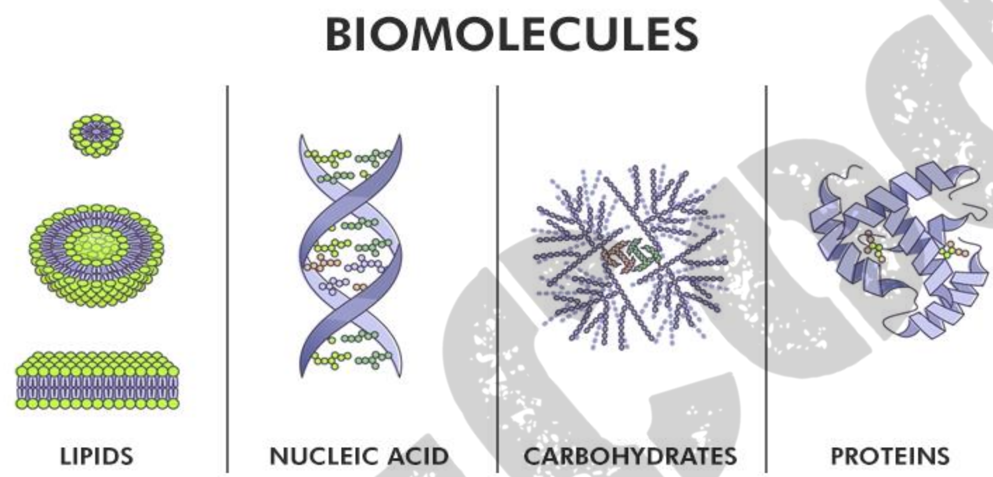
Embryonic Stem Cells are derived from 5-day-old blastocysts that develop into embryos and are pluripotent in nature. These cells can develop any type of cell and tissue in the body. These cells have the potential to regenerate all the cells and tissues that have been lost because of any kind of injury or disease.

Biomolecules

What are 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.

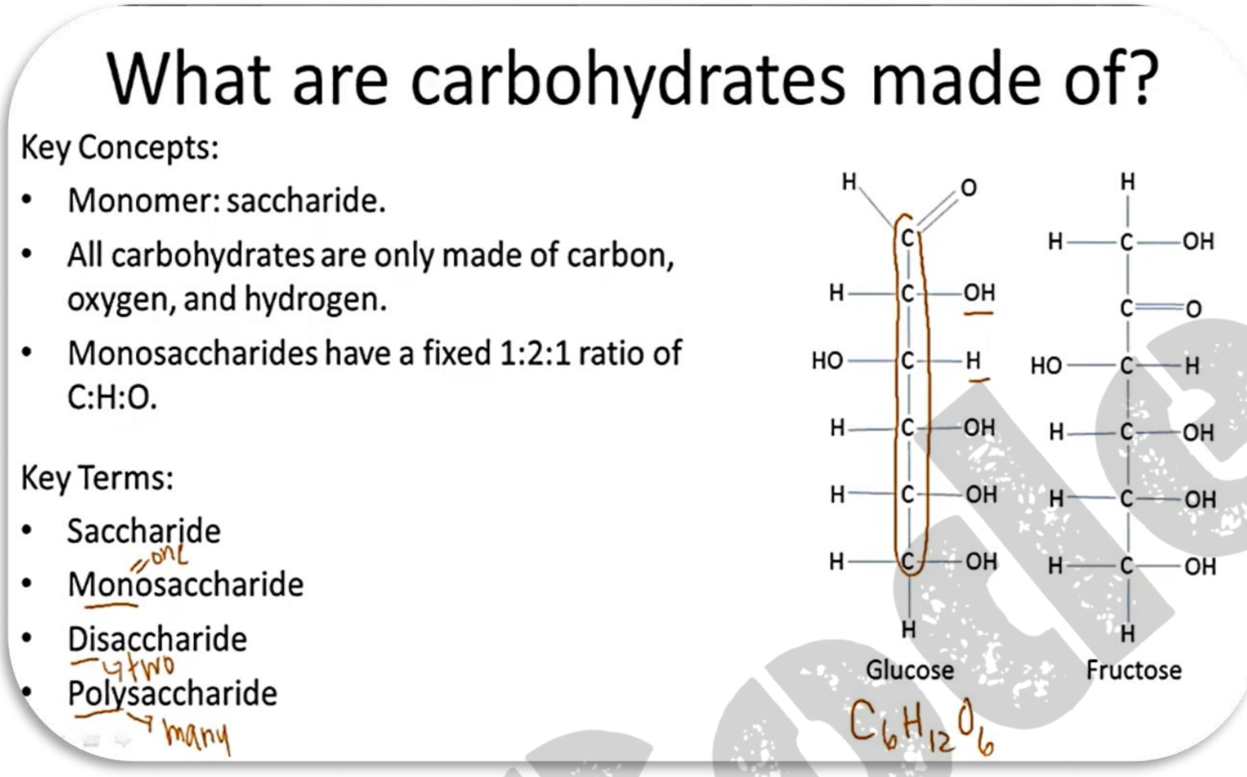
Types of Biomolecules



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 (Greek: sakcharon = sugar). 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.

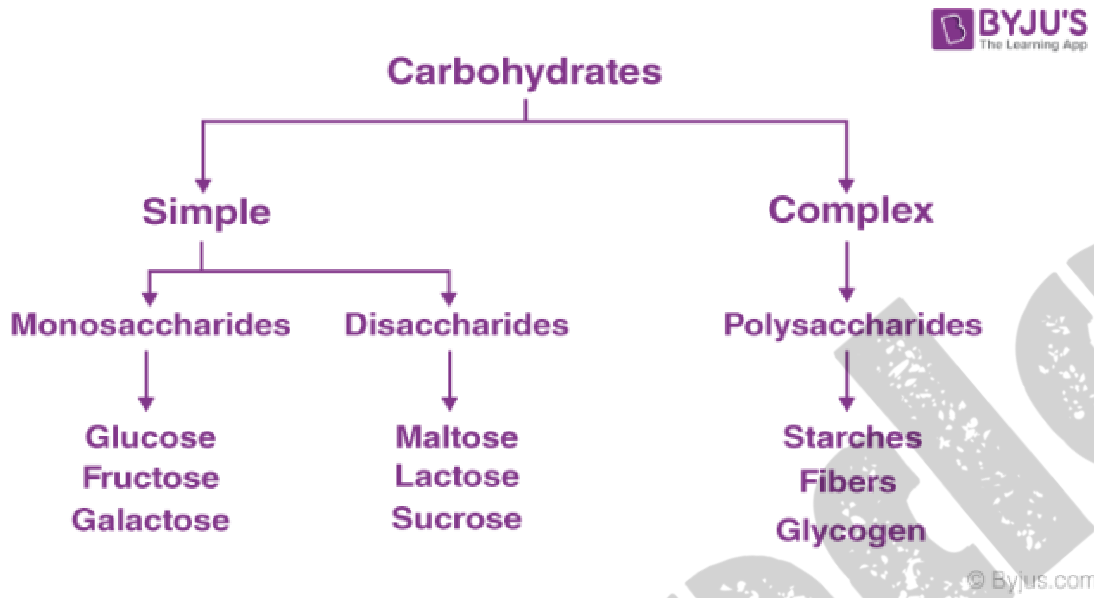


Sources of Carbohydrates

We know carbohydrates are an important part of any human's diet. Some common sources of carbohydrates are:

1. *Potatoes*
2. *Maze*
3. *Milk*
4. *Popcorn*
5. *Bread*

Types of Carbohydrates



Simple Carbohydrates

Simple carbohydrates are the basic type of carbs. Soft drinks, candy, cookies and other sweet snacks contain simple carbohydrates. These foods are often made with white sugar, a form of processed sugar.

Simple carbohydrates also are found in natural sugars. Fruit, milk and vegetables contain natural sugars. Honey is a natural sugar as well. People eat natural sugar in its original form. Simple carbohydrates are easier to handle because they are less (or simpler) complex. They come from fruit and sugar stuff, as well as pretty much anything else that's sweet. The human body can rapidly break down these things, and that is where some of the problems lie.

There is only one sugar unit in the monosaccharides, so they are the smallest of the carbohydrates. "The small size of monosaccharides gives them a special role in digestion and metabolism. (The prefix" mono- "means" one.) Before they can be ingested into the gastrointestinal tract, food carbohydrates have to be broken down into monosaccharides and they also flow in monosaccharide form in the blood.

Complex Carbohydrates

Complex carbohydrates represent an important energy source for your body. They provide the sustained fuel your body needs for exercise, daily living activities and even rest.

Complex carbohydrates are often single units (monosaccharides), which are bound together. The oligosaccharides contain two to ten simple units of sugar. Polysaccharides contain hundreds and thousands of monosaccharides which are related. Complex carbohydrates have fairly long-lasting energy.

The different types of carbohydrates can be classified on the basis of their behaviour in hydrolysis. They are mainly classified into three groups:

1. ***Monosaccharides***
2. ***Disaccharides***
3. ***Polysaccharides***

1. Monosaccharides

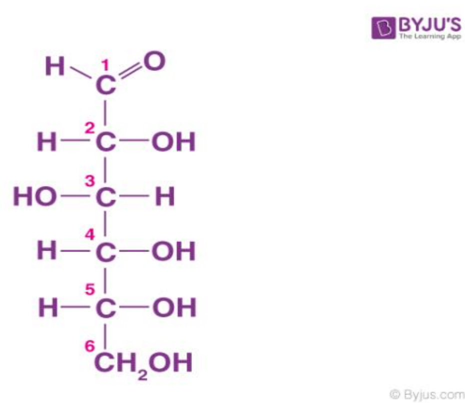
Monosaccharide carbohydrates are those carbohydrates that cannot be hydrolyzed further to give simpler units of polyhydroxy aldehyde or ketone. If a monosaccharide contains an aldehyde group then it is called aldose and on the other hand, if it contains a keto group then it is called a ketose.

Structure of Carbohydrates – Glucose

One of the most important monosaccharides is glucose. The two commonly used methods for the preparation of glucose are

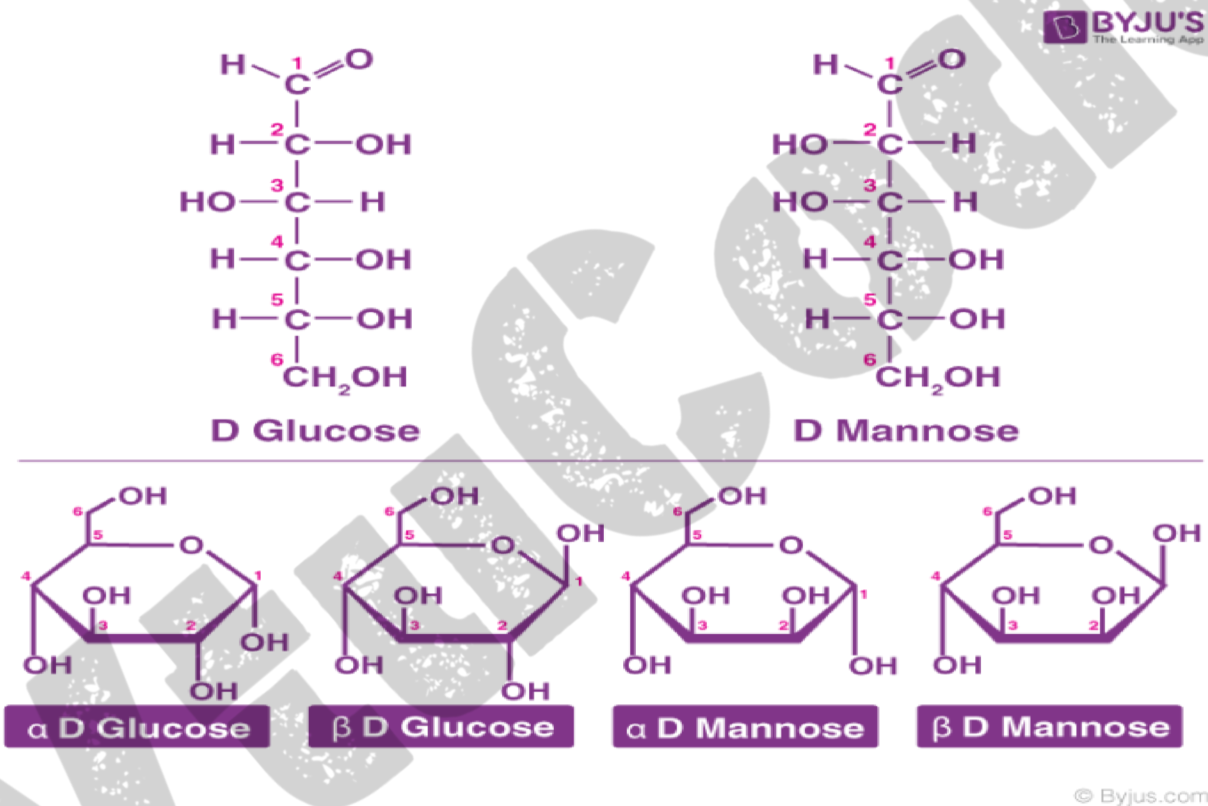
- **From Sucrose:** If sucrose is boiled with dilute acid in an alcoholic solution then we obtain glucose and fructose.
- **From Starch:** We can obtain glucose by hydrolysis of starch and by boiling it with dilute H_2SO_4 at 393K under elevated pressure.

Glucose is also called aldohexose and dextrose and is abundant on earth.



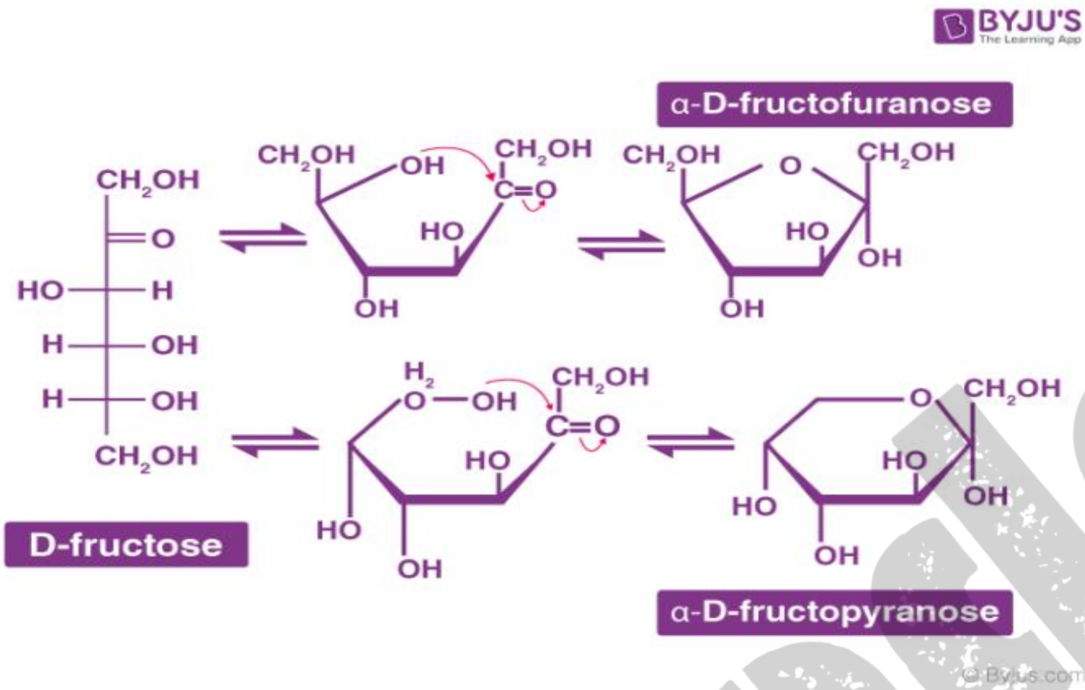
- Glucose is named as D (+)-glucose, D represents the configuration whereas (+) represents the ***dextrorotatory*** nature of the molecule.
- The ring structure of glucose can explain many properties of glucose which cannot be figured by open-chain structure.
- The two cyclic structures differ in the configuration of the hydroxyl group at C1 called anomeric carbon. Such isomers i.e. α and β form are known as anomers.
- The cyclic structure is also called pyranose structure due to its analogy with pyran.

The cyclic structure of glucose is given below:



Structure of Carbohydrates – Fructose

It is an important ketohexose. The ***molecular formula of fructose is $C_6H_{12}O_6$ and contains a ketonic functional group at carbon number 2 and has six carbon atoms in a straight chain.*** The ring member of fructose is in analogy to the compound Furan and is named furanose. The cyclic structure of fructose is shown below:



Examples of Carbohydrates

Here are a few examples of where you'll find the most carbs:

- **Dairy Products –** Yogurt, Milk, Ice cream
- **Fruits –** Fruit juice or Whole fruit
- **Grains –** Cereal, Bread, Wheat, Rice
- **Legumes –** Plant-based proteins, Beans
- **Starchy Vegetables** – Corn, Potatoes

2. Disaccharides

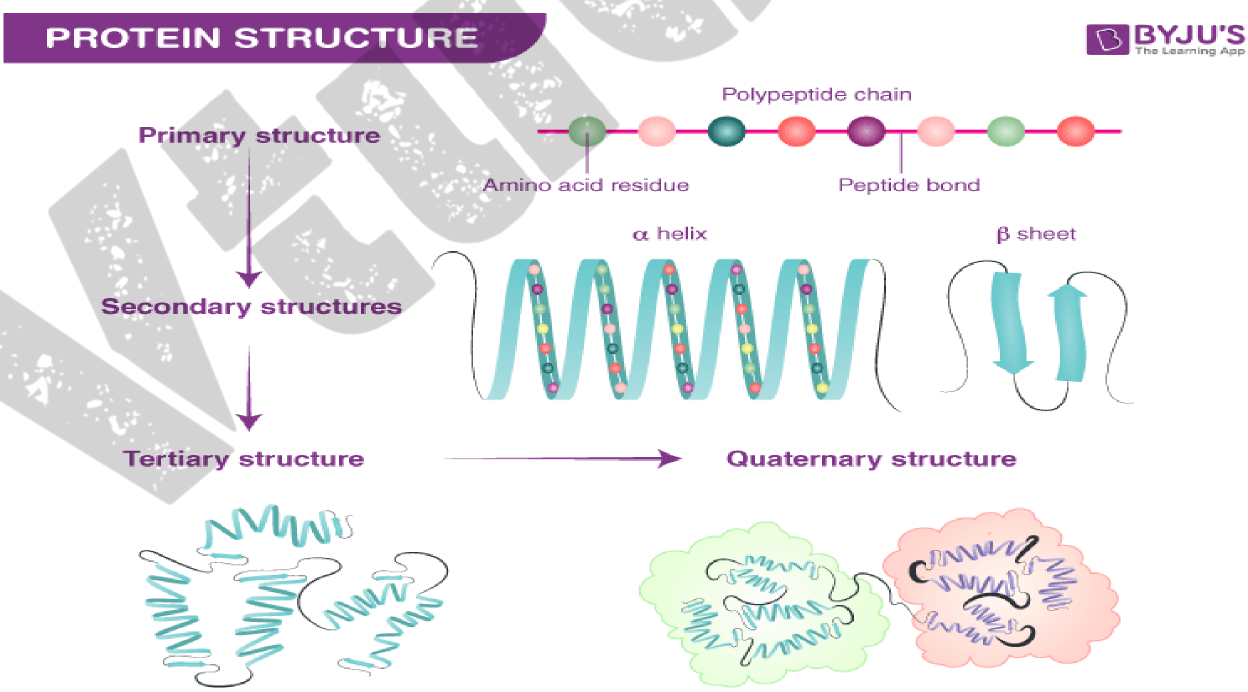
- On hydrolysis, disaccharides yield two molecules of either the same or different monosaccharides.
- The two monosaccharide units are joined by oxide linkage which is formed by the loss of water molecule and this linkage is called glycosidic linkage.
- Sucrose is one of the most common disaccharides which on hydrolysis gives glucose and fructose.
- Maltose and Lactose (also known as milk sugar) are the other two important disaccharides.
- In maltose, there are two α-D-glucose and in lactose, there are two β-D-glucose which are connected by an oxide bond.

3. Polysaccharides

- Polysaccharides contain long monosaccharide units joined together by glycosidic linkage.
- Most of them act as food storage for e.g. Starch. Starch is the main storage polysaccharide for plants.
- It is a polymer of α glucose and consists of two components-Amylose and Amylopectin.
- Cellulose is also one of the polysaccharides that are mostly found in plants.
- It is composed of β-D- glucose units joined by a glycosidic linkage between C1 of one glucose unit and C4 of the next glucose unit.

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.

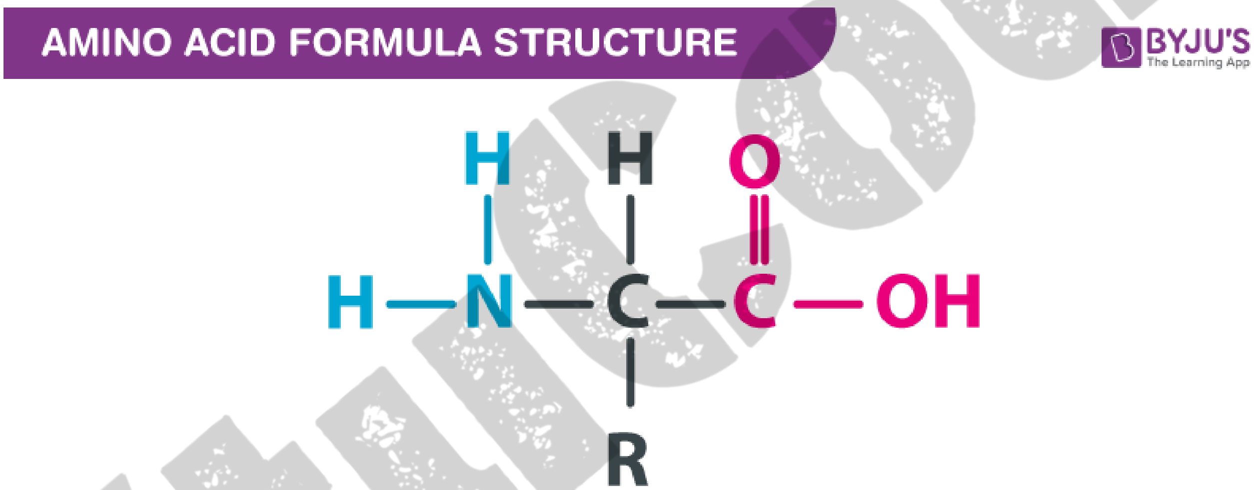


They make up the majority of the cells in all living things. Aside from cells, proteins make up the majority of the body's structural, regulatory, and enzyme components. They are therefore crucial for an individual's growth and development.

Food like eggs, pulses, milk and other milk products form the major high-protein foods for the body.

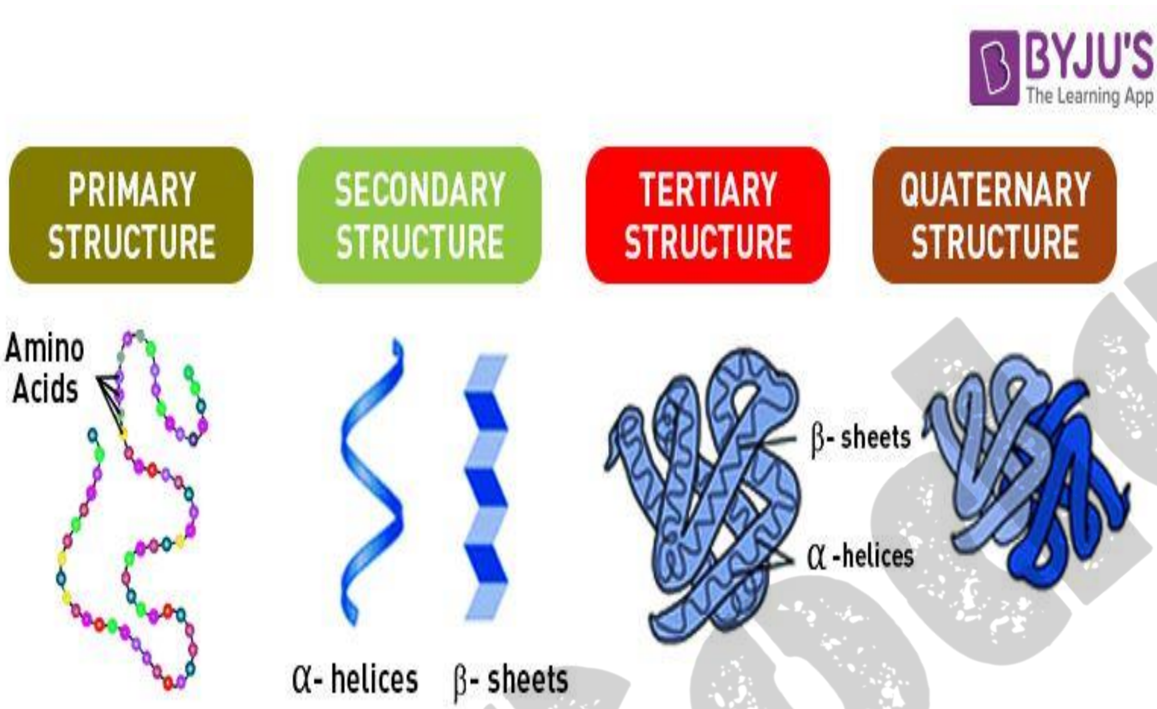
Proteins Structure

A polymeric chain of amino acid residues constitutes proteins. A protein's structure is primarily made up of long chains of amino acids. The arrangement and placement of amino acids give proteins certain characteristics. All amino acid molecules contain an amino (-NH2) and a carboxyl (-COOH) functional group. Hence, the name "Amino-Acid".



Polypeptide chains are synthesized by linking together amino acids. A protein is created when one or more of these chains fold in a specific way. Methane is substituted by amino acids, with hydrogen, amino groups, carboxyl groups, and a variable R-group filling the first three valencies of the – alpha carbon. There are many sorts of amino acids depending on the R-group, and a polypeptide chain contains 20 of them. The final structure and purpose of proteins are determined by all these characteristics of amino acids.

The structure of the protein is classified at 4 levels:-



- **Primary** – The primary structure of a protein is the linear polypeptide chain formed by the amino acids in a particular sequence. Changing the position of even a single amino acid will result in a different chain and hence a different protein.
- **Secondary** – The secondary structure of a protein is formed by hydrogen bonding in the polypeptide chain. These bonds cause the chain to fold and coil in two different conformations known as the α-helix or β-pleated sheets. The α-helix is like a single spiral and is formed by hydrogen bonding between every fourth amino acid. The β-pleated sheet is formed by hydrogen bonding between two or more adjacent polypeptide chains.
- **Tertiary** – The tertiary structure is the final 3-dimensional shape acquired by the polypeptide chains under the attractive and repulsive forces of the different R-groups of each amino acid. This is a coiled structure that is very necessary for protein functions.
- **Quaternary** – This structure is exhibited only by those proteins which have multiple polypeptide chains combined to form a large complex. The individual chains are then called subunits.

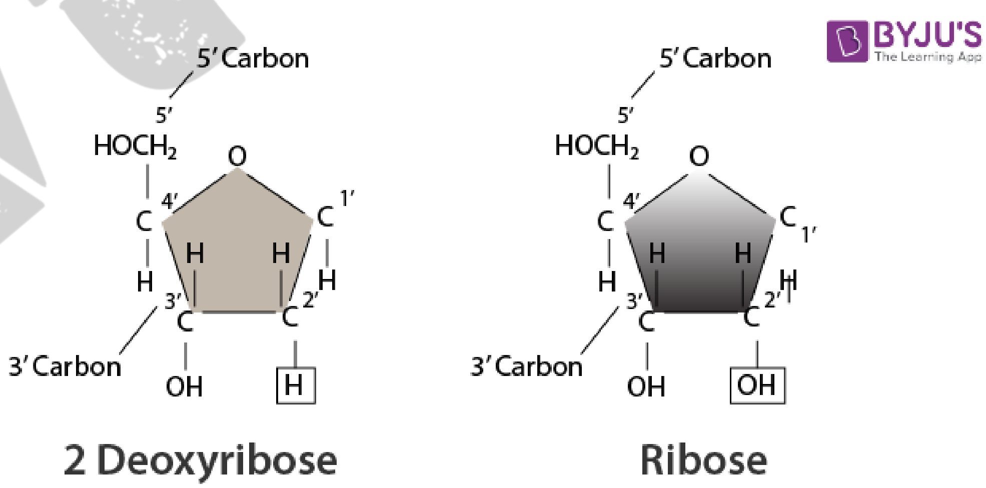
Functions of Proteins

The body uses proteins for a variety of purposes, and their structure determines how they work. Several notable functions include:

1. **Digestion** – The digestive enzymes, which are primarily proteinaceous in origin, carry out digestion.
2. **Movement** – Muscles include a protein called myosin, which helps muscles contract, allowing for movement.
3. **Structure and Support** – The structural protein known as keratin is what gives humans and other animals hair, nails, and horns.
4. **Cellular communication** – Through receptors on their surface, cells can communicate with other cells and the outside world. These receptors are made of proteins.
5. **Act as a messenger** – These proteins serve as chemical messengers that facilitate communication among cells, tissues, and organs.

Nucleic Acids

Nucleic acids are long-chain polymeric molecules. The monomer or the repeating unit is known as the nucleotides and hence sometimes nucleic acids are referred to as polynucleotides. Nucleic acids can be defined as organic molecules present in living cells. It plays a key factor in transferring genetic information from one generation to the next. Nucleic acids are composed of DNA-deoxyribonucleic acid and RNA-ribonucleic acid that form the polymers of nucleotides.



In the nucleus, nucleotide monomers are linked together comprising of distinct components namely a Phosphate Group, Nitrogenous Bases or Ribose and Deoxyribose. Pyrimidines and Purines are two types of nitrogenous bases. Pyrimidines are composed of cytosine and thymine. Purines are composed of guanine and adenine. Thymine is replaced by Uracil in ribonucleic acid whereas deoxyribonucleic acid comprises of all four bases.

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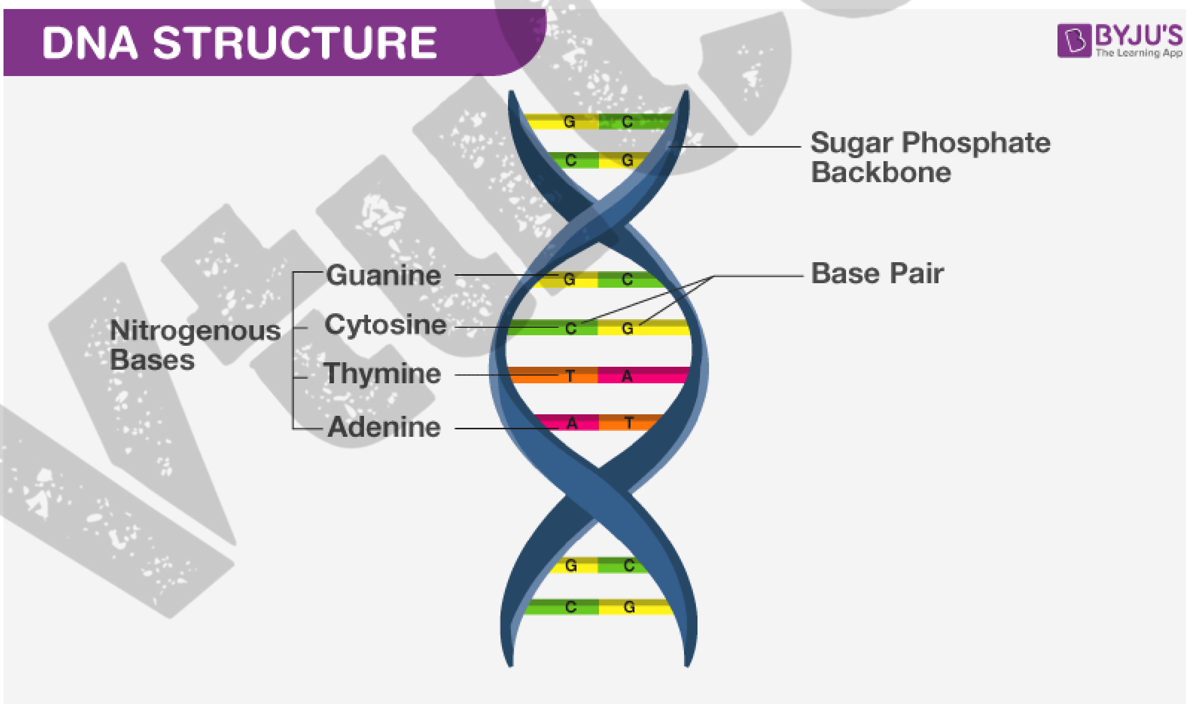
DNA Structure

DNA consists of instructions that monitor the performance of all cell functions. It is a cellular molecule that is organized into chromosomes. They are present in the nucleus of the cells and contain cellular activities.



It is a double helix formed by 2 polynucleotide chains that are twisted. There are 2 strands of DNA which are parallel to each other. Hydrogen bond binds two helices and the bases are bundled within the helix. Due to the presence of phosphate groups, DNA is negatively charged.

Chemically, DNA is composed of a pentose sugar, phosphoric acid and some cyclic bases containing nitrogen. The sugar moiety present in DNA molecules is β-D-2-deoxyribose. The cyclic bases that have nitrogen in them are adenine (A), guanine (G), cytosine(C) and thymine (T). These bases and their arrangement in the molecules of DNA play an important role in the storage of information from one generation to the next one.

RNA Structure

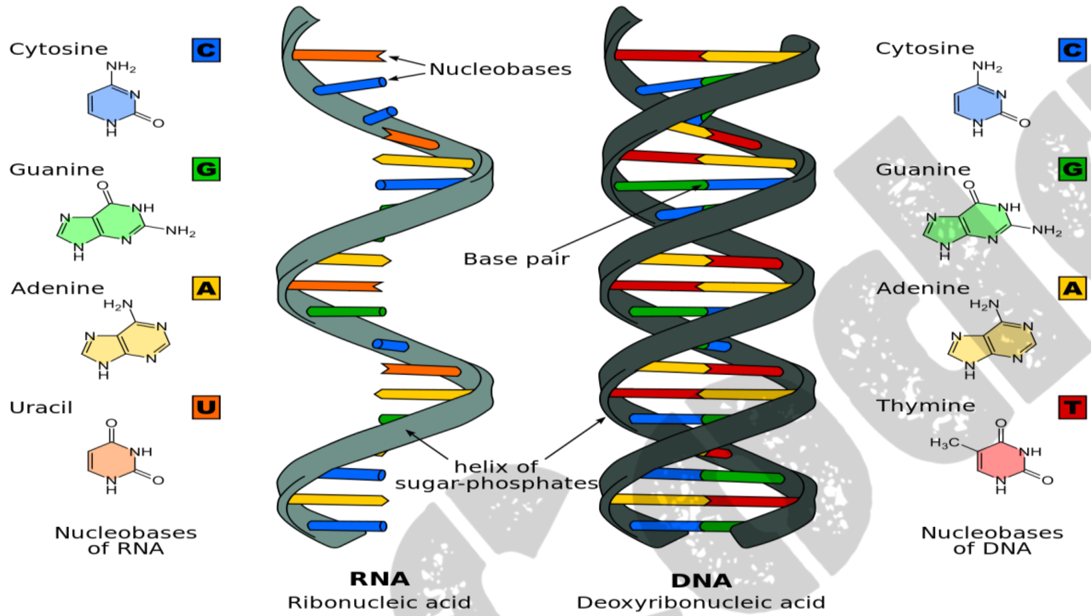
RNA plays a vital role in the synthesis of proteins that mainly involves decoding and translation of genetic code and transcription to produce proteins.

RNA molecules are also composed of phosphoric acid, a pentose sugar and some cyclic bases containing nitrogen. RNA has β-D-ribose in it as the sugar moiety. The heterocyclic bases present in RNA are adenine (A), guanine (G), cytosine(C) and uracil (U). In RNA the fourth base is different from that of DNA. The RNA generally consists of a single strand which sometimes folds back.

There are several different types of RNA and each has a specific function.

- **Ribosomal RNA** – It is one of the components of ribosomes that are involved in protein synthesis.
- **Transfer RNA** – It is essential for the translation of mRNA in protein synthesis.

- **Micro RNAs** – It is the smallest among all RNA that helps in regulating gene expressions.
- **Messenger RNA** – It is the RNA transcript that is produced during DNA transcription.



Functions of Nucleic Acids

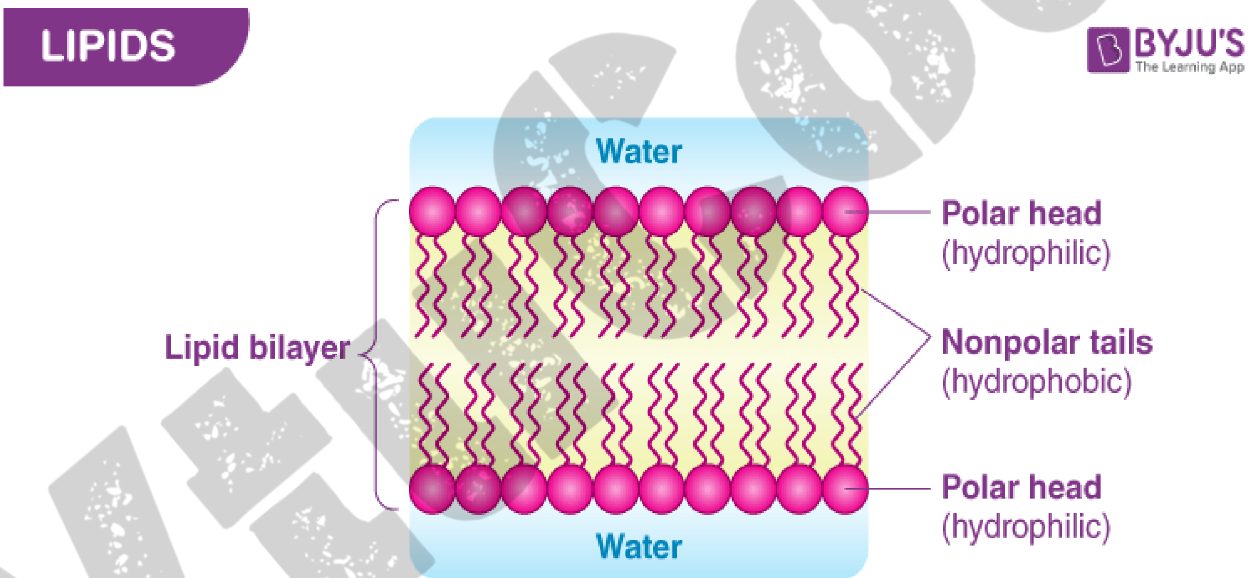
- Nucleic Acid is responsible for the synthesis of protein in our body
- RNA is a vital component of protein synthesis.
- Loss of DNA content is linked to many diseases.
- DNA is an essential component required for transferring genes from parents to offspring.
- All the information of a cell is stored in DNA.
- DNA fingerprinting is a method used by forensic experts to determine paternity. It is also used for the identification of criminals. It has also played a major role in studies regarding biological evolution and genetics.

Lipids

Lipids are organic substances that are insoluble in water, soluble in organic solvents, are related to fatty acids and are utilized by the living cell. They include fats, waxes, sterols, fat-soluble vitamins, mono-, di- or triglycerides, phospholipids, etc. Unlike carbohydrates, proteins, and nucleic acids, lipids are not polymeric molecules. Lipids play a great role in the cellular structure and are the chief source of energy.

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

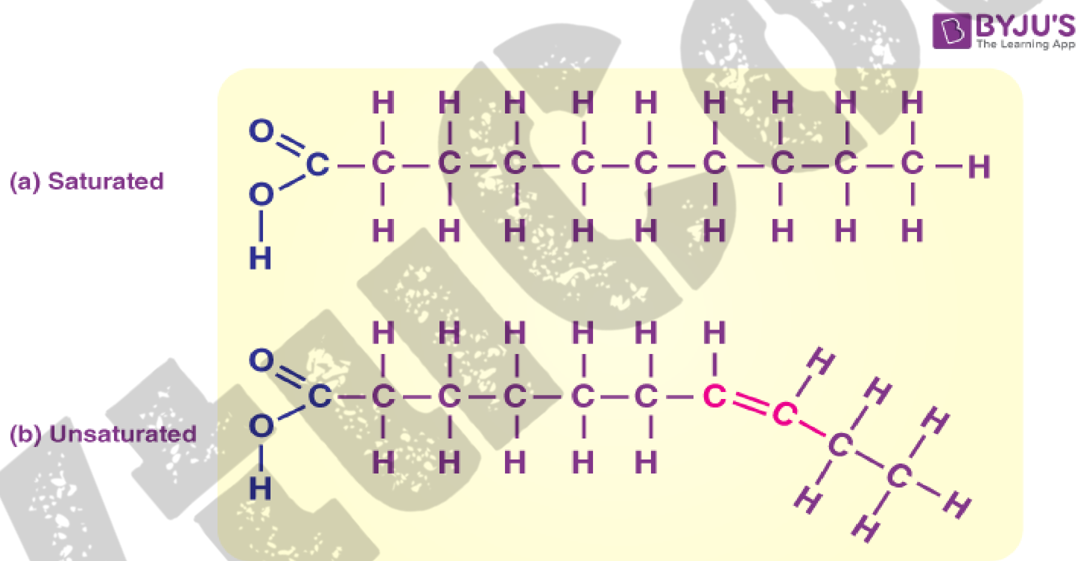
Lipids are a family of organic compounds, composed of fats and oils. These molecules yield high energy and are responsible for different functions within the human body. Listed below are some important characteristics of Lipids.

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 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:



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, which are 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 fatty acid.

1. **Phospholipids**: These are lipids containing, in addition to fatty acids and alcohol, phosphate group. 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.

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.

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.

Waxes

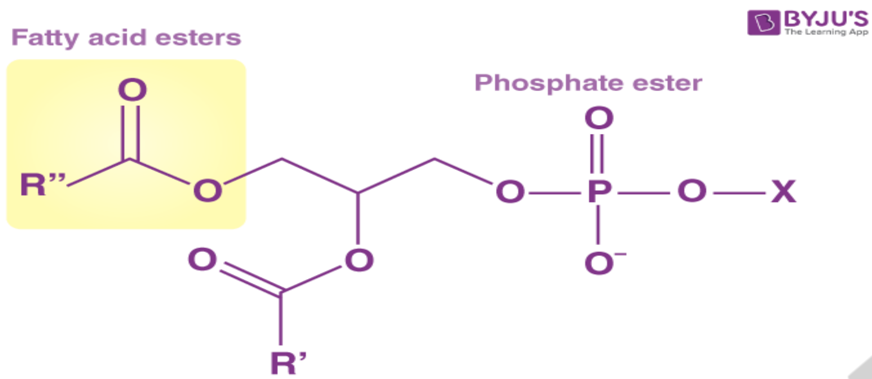
Waxes are “esters” (an organic compound made by replacing the hydrogen with acid by an alkyl or another organic group) formed from long-alcohols and long-chain carboxylic acids.

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.

Importance of special biomolecules:

Enzymes

The human body is composed of different types of cells, tissues and other complex organs. For efficient functioning, our body releases some chemicals to accelerate biological processes such as respiration, digestion, excretion and a few other metabolic activities to sustain a healthy life. Hence, enzymes are pivotal in all living entities which govern all the biological processes.

What Are Enzymes?

"Enzymes can be defined as biological polymers that catalyze biochemical reactions."

The majority of enzymes are proteins with catalytic capabilities crucial to perform different processes. Metabolic processes and other chemical reactions in the cell are carried out by a set of enzymes that are necessary to sustain life.

The initial stage of metabolic process depends upon the enzymes, which react with a molecule and is called the substrate. Enzymes convert the substrates into other distinct molecules, which are known as products.

The regulation of enzymes has been a key element in clinical diagnosis because of their role in maintaining life processes. The macromolecular components of all enzymes consist of protein, except in the class of RNA catalysts called ribozymes. The word ribozyme is derived from the ribonucleic acid enzyme. Many ribozymes are molecules of ribonucleic acid, which catalyze reactions in one of their own bonds or among other RNAs.

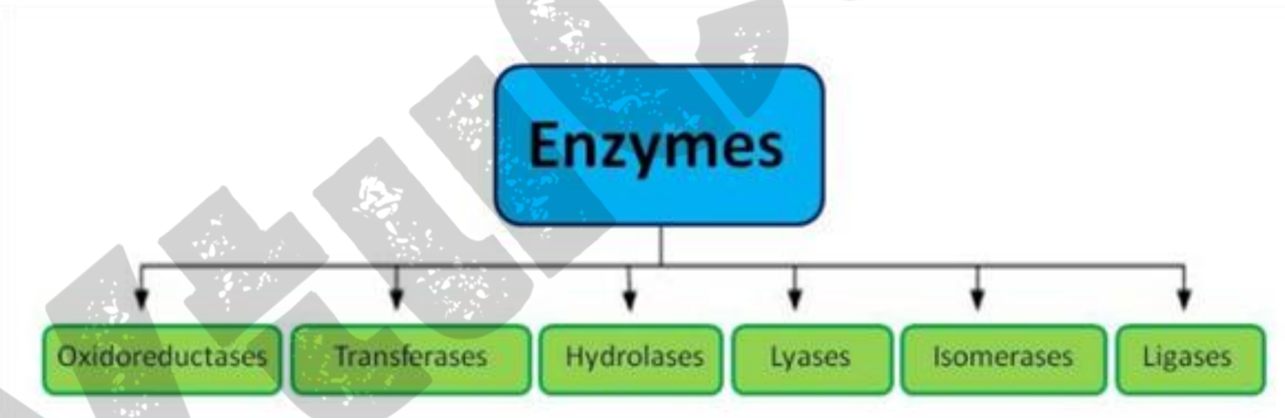
Enzymes are found in all tissues and fluids of the body. Catalysis of all reactions taking place in metabolic pathways is carried out by intracellular enzymes. The enzymes in the plasma membrane govern the catalysis in the cells as a response to cellular signals and enzymes in the circulatory system regulate the clotting of blood. Most of the critical life processes are established on the functions of enzymes.

Enzyme Structure

Enzymes are a linear chain of amino acids, which give rise to a three-dimensional structure. The sequence of amino acids specifies the structure, which in turn identifies the catalytic activity of the enzyme. Upon heating, the enzyme's structure denatures, resulting in a loss of enzyme activity, which typically is associated with temperature.

Compared to its substrates, enzymes are typically large with varying sizes, ranging from 62 amino acid residues to an average of 2500 residues found in fatty acid synthase. Only a small section of the structure is involved in catalysis and is situated next to the binding sites. The catalytic site and binding site together constitute the enzyme's active site. A small number of ribozymes exist which serve as an RNA-based biological catalyst. It reacts in complex with proteins.

Enzymes Classification



Earlier, enzymes were assigned names based on the one who discovered them. With further research, classification became more comprehensive.

According to the International Union of Biochemists (I U B), enzymes are divided into six functional classes and are classified based on the type of reaction in which they are used to catalyze. The six kinds of enzymes are hydrolases, oxidoreductases, lyases, transferases, ligases and isomerases.

Listed below is the classification of enzymes discussed in detail:

Types	Biochemical Property
Oxidoreductases	The enzyme Oxidoreductase catalyzes the oxidation reaction where the electrons tend to travel from one form of a molecule to the other.
Transferases	The Transferases enzymes help in the transportation of the functional group among acceptors and donor molecules.
Hydrolases	Hydrolases are hydrolytic enzymes, which catalyze the hydrolysis reaction by adding water to cleave the bond and hydrolyze it.
Lyases	Adds water, carbon dioxide or ammonia across double bonds or eliminate these to create double bonds.
Isomerases	The Isomerases enzymes catalyze the structural shifts present in a molecule, thus causing the change in the shape of the molecule.
Ligases	The Ligases enzymes are known to charge the catalysis of a ligation process.

Oxidoreductases

These catalyze oxidation and reduction reactions, e.g. pyruvate dehydrogenase, catalysing the oxidation of pyruvate to acetyl coenzyme A.

Transferases

These catalyze transferring of the chemical group from one to another compound. An example is a transaminase, which transfers an amino group from one molecule to another.

Hydrolases

They catalyze the hydrolysis of a bond. For example, the enzyme pepsin hydrolyzes peptide bonds in proteins.

Lyases

These catalyze the breakage of bonds without catalysis, e.g. aldolase (an enzyme in glycolysis) catalyzes the splitting of fructose-1, 6-bisphosphate to glyceraldehyde-3-phosphate and dihydroxyacetone phosphate.

Isomerases

They catalyze the formation of an isomer of a compound. Example: phosphoglucomutase catalyzes the conversion of glucose-1-phosphate to glucose-6-phosphate (phosphate group is transferred from one to another position in the same compound) in glycogenolysis (glycogen is converted to glucose for energy to be released quickly).

Ligases

Ligases catalyze the association of two molecules. For example, DNA ligase catalyzes the joining of two fragments of DNA by forming a phosphodiester bond.

Cofactors

Cofactors are non-proteinous substances that associate with enzymes. A cofactor is essential for the functioning of an enzyme. The protein part of enzymes in cofactors is apoenzyme. An enzyme and its cofactor together constitute the holoenzyme.

There are three kinds of cofactors present in enzymes:

- **Prosthetic groups**: These are cofactors tightly bound to an enzyme at all times. FAD (flavin adenine dinucleotide) is a prosthetic group present in many enzymes.
- **Coenzyme**: A coenzyme binds to an enzyme only during catalysis. At all other times, it is detached from the enzyme. NAD is a common coenzyme.
- **Metal ions**: For the catalysis of certain enzymes, a metal ion is required at the active site to form coordinate bonds. Zinc is a metal ion cofactor used by a number of enzymes.

Examples of Enzymes

Following are some of the examples of enzymes:

Beverages

Alcoholic beverages generated by fermentation vary a lot based on many factors. Based on the type of the plant's product, which is to be used and the type of enzyme applied, the fermented product varies.

For example, grapes, honey, hops, wheat, cassava roots, and potatoes depending upon the materials available. Beer, wines and other drinks are produced from plant fermentation.

Properties of Enzymes

- Enzymes are complex macromolecules with high molecular weight.
- They catalyze biochemical reactions in a cell. They help in the breakdown of large molecules into smaller molecules or bring together two smaller molecules to form a larger molecule.
- Enzymes do not start a reaction. However, they help in accelerating it.
- Enzymes affect the rate of biochemical reaction and not the direction. Most of the enzymes have a high turnover number.

Functions of Enzymes

The enzymes perform a number of functions in our bodies. These include:

1. Enzymes help in signal transduction. The most common enzyme used in the process includes protein kinase that catalyzes the phosphorylation of proteins.
2. They break down large molecules into smaller substances that can be easily absorbed by the body.
3. They help in generating energy in the body. ATP synthase is the enzyme involved in the synthesis of energy.
4. Enzymes are responsible for the movement of ions across the plasma membrane.

5. Enzymes perform a number of biochemical reactions, including oxidation, reduction, hydrolysis, etc. to eliminate the non-nutritive substances from the body.
6. They function to reorganize the internal structure of the cell to regulate cellular activities.

Vitamins

This topic is about **Vitamins – classification and functions**. It is a known fact that we require energy in order to perform different activities. We get these energies from the food we eat. Apart from the normal food that we take, our body requires a certain number of compounds in small amounts for proper functioning and deficiency of these compounds may cause diseases. These compounds are known as vitamins.

Vitamins are chemical compounds that are required in small amounts with our regular diet in order to carry out certain biological functions and for the maintenance of our growth.

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Classification of Vitamins

Vitamins are generally classified as water-soluble vitamins and fat-soluble vitamins.

1. Fat-Soluble Vitamins

Vitamin A, D, E and K are fat-soluble. These are stored in adipose tissues and hence are called fat-soluble vitamins.

2. Water-Soluble Vitamins

Vitamins in B-group and vitamin C are water-soluble and cannot be stored in our bodies as they pass with the water in urine. These vitamins must be supplied to our bodies with regular diets.

Functions of Vitamins

Based on their role in biological processes and their effect different vitamins have different functions, their function can be best understood by knowing about their deficiency diseases. Given below is the list of vitamins and their deficiency diseases:

1. **Vitamin A –** Hardening of the cornea in the eye, night blindness.
2. **Vitamin B1 –** Deficiency may cause beriberi and dwarfism.
3. **Vitamin B2 –** Deficiency can cause disorders in the digestive system, skin burning sensations, and cheilosis.
4. **Vitamin B6 –** Deficiency of B6 causes convulsions, conjunctivitis, and sometimes neurological disorders.
5. **Vitamin B12 –** Its deficiency can cause pernicious anaemia and a decrease in red blood cells in haemoglobin.
6. **Vitamin C –** It is a water-soluble vitamin, its deficiency causes bleeding in gums and scurvy.
7. **Vitamin D –** It is obtained by our body when exposed to sunlight. Its deficiency causes improper growth of bones, soft bones in kids, and rickets.
8. **Vitamin E –** Deficiency of vitamin E leads to weakness in muscles and increases the fragility of red blood cells.
9. **Vitamin K –** It plays an important role in blood clotting. The deficiency of vitamin K increases the time taken by the blood to clot. Severe deficiency may cause death due to excessive blood loss in case of a cut or an injury.

Although these compounds are required in very small quantities by our body to perform several biological functions, and their deficiency may lead to severe diseases.

Hormones

Hormones Definition

"Hormones are chemicals synthesized and produced by the specialized glands to control and regulate the activity of certain cells and organs. These specialized glands are known as endocrine glands."

As stated above, hormones are chemicals that essentially function as messengers of the body. These chemicals are secreted by special glands known as the endocrine glands.

These endocrine glands are distributed throughout the body. These messengers control many physiological functions as well as psychological health. They are also quite important in maintaining homeostasis in the body.

Cell Signaling

The effects of hormones depend on how they are released. Hence, signalling effects can be classified into the following:

- **Autocrine**: The hormone act on the cell that secreted it.
- **Paracrine**: The hormone act on a nearby cell without having to enter the blood circulation.
- **Intracrine:** The hormone is produced in the cell and acts intracellularly means inside the cell.
- **Endocrine**: The hormone act on the target cells once it is released from the respective glands into the bloodstream.

Types of Hormones

To regulate various functions, different types of hormones are produced in the body. They are classified as follows:

- Peptide Hormones
- Steroid Hormones

Peptide Hormones

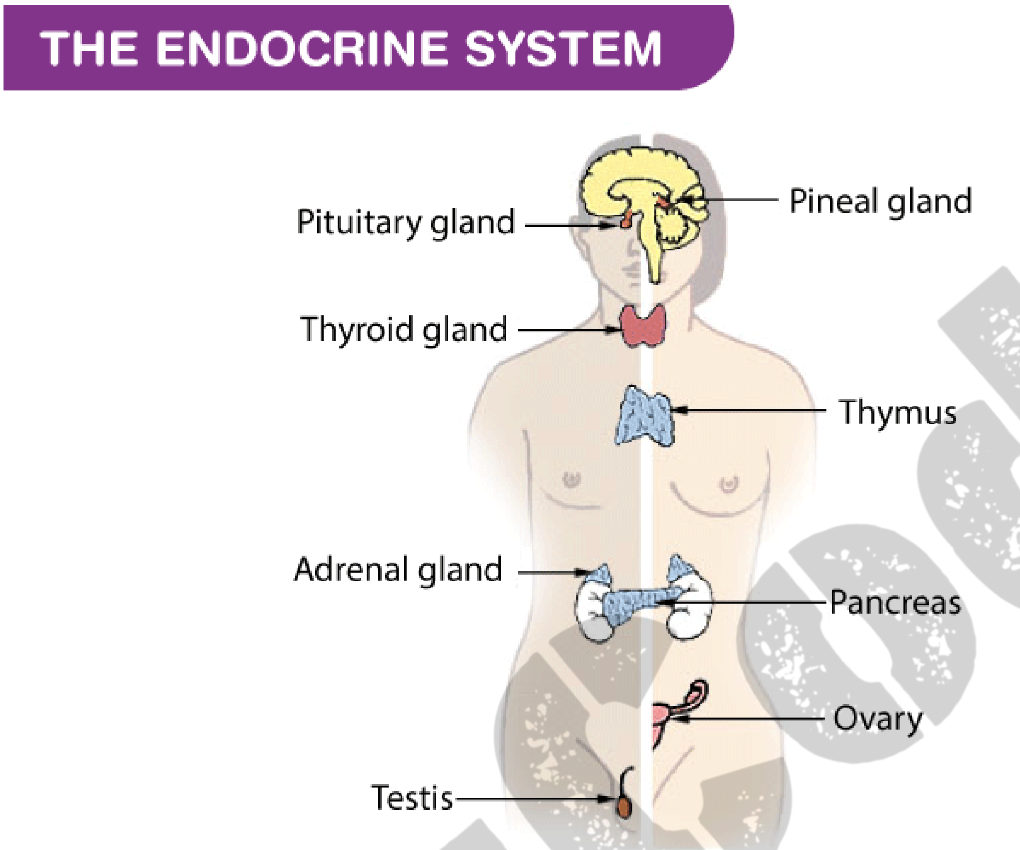
Peptide hormones are composed of **amino acids** and are soluble in water. Peptide hormones are unable to pass through the cell membrane as it contains a phospholipid bilayer that stops any fat-insoluble molecules from diffusing into the cell. Insulin is an important peptide hormone produced by the pancreas.

Steroid Hormones

Unlike peptide hormones, steroid hormones are fat-soluble and are able to pass through a cell membrane. Sex hormones such as testosterone, estrogen and progesterone are examples of steroid hormones.

Endocrine Glands and the Hormones Secreted

As stated before, hormones are released by the [endocrine glands](). These are different from other glands of the human body as they are ductless.



- **Hypothalamus:** It controls the body temperature, regulates emotions, hunger, thirst, sleep, moods and allow the production of hormones.
- **Pineal**: Pineal is also known as the thalamus. It produces serotonin derivatives of melatonin, which affects sleep patterns.
- **Parathyroid**: This gland helps in controlling the amount of calcium present in the body.
- **Thymus**: It helps in the production of T-cells, functioning of the adaptive immune system and maturity of the thymus.
- **Thyroid:** It produces hormones that affect the heart rate and how calories are burnt.
- **Adrenal**: This gland produces the hormones that control the sex drive, cortisol and stress hormone.

- **Pituitary**: It is also termed as the “master control gland,”. This is because the pituitary gland helps in controlling other glands. Moreover, it develops the hormones that trigger growth and development.
- **Pancreas**: This gland is involved in the production of insulin hormones, which plays a crucial role in maintaining blood sugar levels.
- **Testes:** In men, the testes secrete the male sex hormone, testosterone. It also produces sperm.
- **Ovaries**: In the female reproductive system, the ovaries release estrogen, progesterone, testosterone and other female sex hormones.

All these glands work together to produce and manage the hormones of the body.

List of Important Hormones

1. **Cortisol** – It has been named as the “stress hormone” as it helps the body in responding to stress. This is done by increasing the heart rate, elevating blood sugar levels etc.
2. **Estrogen-**This is the main sex hormone present in women which bring about puberty, prepares the uterus and body for pregnancy and even regulates the menstrual cycle. Estrogen level changes during menopause because of which women experience many uncomfortable symptoms.
3. **Melatonin** – It primarily controls the circadian rhythm or sleep cycles.
4. **Progesterone** – It is a female sex hormone also responsible for menstrual cycle, pregnancy and embryogenesis.
5. **Testosterone** – This is the most important sex hormone synthesized in men, which cause puberty, muscle mass growth, and strengthen the bones and muscles, increase bone density and controls facial hair growth.

Functions of Hormones

Following are some important functions of hormones:

- Food metabolism.
- Growth and development.
- Controlling thirst and hunger.
- Maintaining body temperature.

- Regulating mood and cognitive functions.
- Initiating and maintaining sexual development and reproduction.

Hormonal Diseases

Several hormonal diseases occur when there is a malfunctioning of the endocrine glands. Common hormonal issues are associated with hypothalamus, adrenal and **pituitary glands.** An increase or decrease in the secretion of these hormones can severely affect growth, metabolism and development.

Diseases such as hyperthyroidism, osteoporosis, and diabetes are caused due to hormonal imbalance. The factors responsible for hormonal diseases can be genetic, environmental, or related to diet.

Why are Hormones called Chemical Messengers?

The prominent role of hormones is that of a messenger. Hypothalamus is a part of forebrain where a numerous amount of neurosecretory cells are present. These neurosecretory cells are specialized in the secretion of a hormone called neurohormones. They stimulate the anterior lobe of the pituitary to produce various other hormones.

Sometimes, hormones act more than a regulator than a messenger. The changes in the level of hormone production lead to certain changes in the body. Thus, hormone as a regulator maintains the homeostasis of the body. Once the hormones meet their target, their production needs to be controlled and this is attained by a mechanism called feedback control mechanism. The feedback mechanism could either be positive or negative.