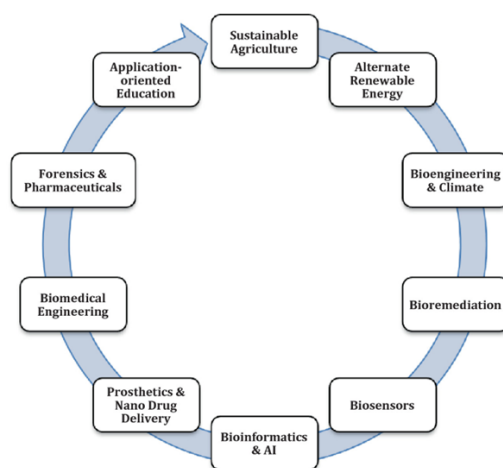


MODULE 1: CELL BASIC UNIT OF LIFE**Syllabus**

1. Introduction. Structure and functions of a cell.
2. Stem cells and their application.
3. Biomolecules: Properties and functions of
 - I. Carbohydrates
 - II. Nucleic acids
 - III. Proteins
 - IV. Lipids
4. Importance of special biomolecules: Properties and functions of
 - I. Enzymes,
 - II. Vitamins and
 - III. Hormones

Introduction: Biology is the study of all aspects of life. In many ways, the last 1000 years have seen a meteoric rise in the study of biology as natural science. For a long time, biology was thought to deal with only the classification of all known living organisms, animal behaviour, and habitats. So, in short, biology is the detailed study of living organisms. This includes the genetic, chemical, physical, ecological and evolutionary aspect of life.



Applications of Biology

Cell

Definition: A cell is the structural and fundamental unit of life.

The study of cells from its basic structure to the functions of every cell organelle is called Cell Biology. Robert Hooke was the first Biologist who discovered cells. All organisms are made up of cells. They may be made up of a single cell, or many cells. Mycoplasmas are the smallest known cells. Cells are the building blocks of all living beings. They provide structure to the body and convert the nutrients taken from the food into energy. Cells are complex and their components perform various functions in an organism. They are of different shapes and sizes, pretty much like bricks of the buildings. Our body is made up of cells of different shapes and sizes. From organism to organism, the count of cells may vary. Humans have a greater number of cells compared to that of bacteria. Cells comprise several cell organelles that perform specialized functions to carry out life processes.

Structure of cell:

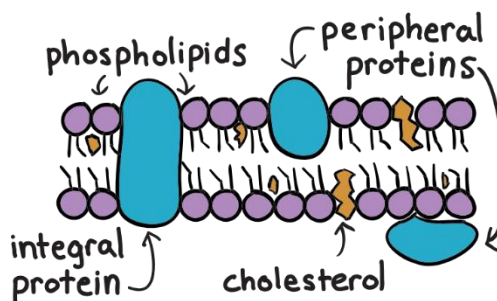
The cell structure comprises individual components with specific functions essential to carry out life's processes.

Cell Membrane:

- ✓ The cell membrane supports and protects the cell.
- ✓ By structure, it is a porous membrane (with pores) which permits the movement of selective substances in and out of the cell.
- ✓ 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.

Functions:

1. It controls the movement of substances in and out of the cells.
2. It separates the cell from the external environment.



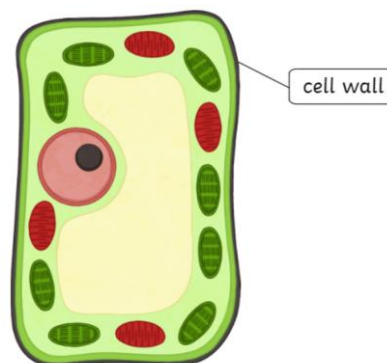
Structure of Cell membrane

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 also the outermost layer of plant cells.
- ✓ It is a rigid and stiff structure surrounding the cell membrane.

Functions:

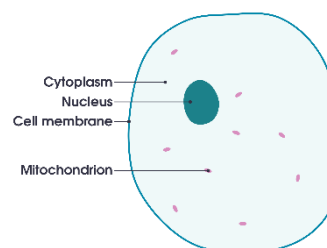
1. It provides shape and support to the cells and protects them from mechanical shocks and injuries.
2. It protects the plasma membrane and other cellular components.



Structure of Cell Wall

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.



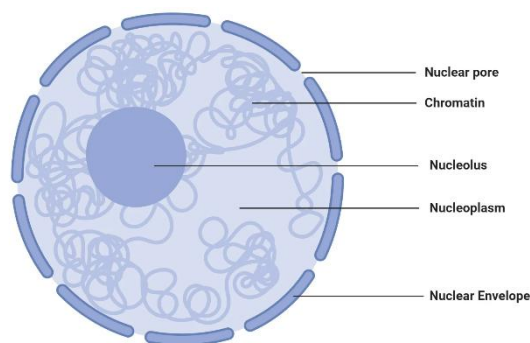
Structure of Cytoplasm

Functions:

1. It supports and suspend organelles,
2. It acts as a medium for metabolic processes, facilitates movement of materials and cellular waste,
3. It plays a role in protein synthesis and cell division

Nucleus:

- ✓ This is a spherical structured organelle found majorly at the centre of a cell surrounded by a double-layered nuclear membrane separating it from the cytoplasm.
- ✓ The nucleus is surrounded by the nuclear envelope that separates the DNA from the rest of the cell.

**Structure of Nucleus****Functions:**

1. The nucleus contains the hereditary material of the cell, the DNA.
2. It sends signals to the cells to grow, mature, divide and die.
3. The nucleus protects the DNA and is an integral component of a plant's cell structure.

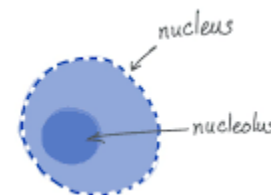
Cell Organelles:

Cells are composed of various cell organelles that perform certain specific functions to carry out life's processes.

The different cell organelles, along with its principal functions, are as follows:

Nucleolus:

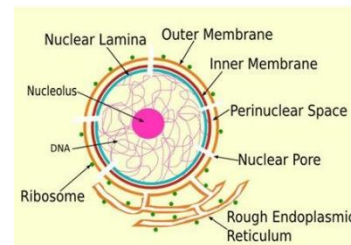
- ✓ Nucleolus, spherical body within the nucleus of most eukaryotic cells, involved in the synthesis of ribosomal RNA (rRNA) and the formation of ribosomes.
- ✓ The nucleolus contains the genes that encode rRNA.
- ✓ Also, it is involved in controlling cellular activities and cellular reproduction.

**Nuclear membrane:**

- ✓ Every nucleus is encircled and covered by a double-layered membrane, known as the nuclear envelope or nuclear membrane.

Functions:

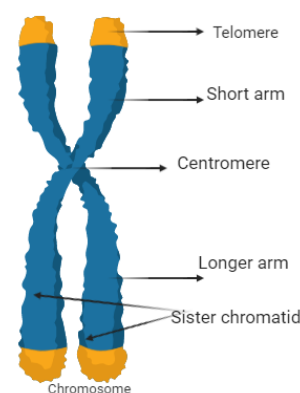
- ✓ It separates the nucleoplasm (the fluid present in the nucleus), from the cytoplasm.

**Structure of Nuclear membrane****Chromosomes:**

- ✓ Chromosomes are threadlike structures made of protein and a single molecule of DNA that serve to carry the genomic information from cell to cell.
- ✓ In plants and animals (including humans), chromosomes reside in the nucleus of cells. Chromosomes play a crucial role in determining the sex of an individual.
- ✓ Each human cells contain 23 pairs of chromosomes.

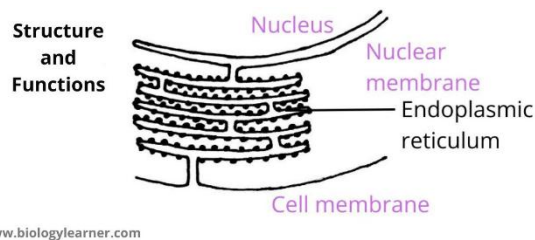
Functions:

1. They carry genetic information to be passed on from one generation to another.
2. Chromosomes are also responsible for gene regulation, protein synthesis, and cellular replication.

**Structure of Chromosomes**

Endoplasmic reticulum:

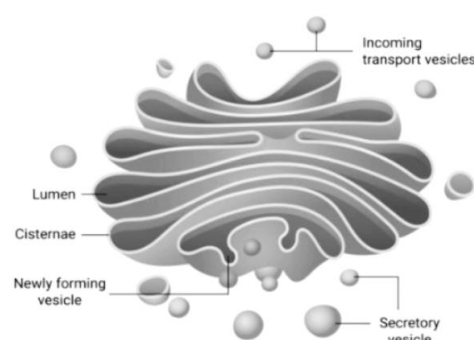
- ✓ This is a continuous folded membranous organelle found in the cytoplasm.
- ✓ It is made up of a thin network of flattened interconnected compartments (sacs) that connects from the cytoplasm to the cell nucleus.

**Structure of Endoplasmic reticulum****Functions:**

1. The endoplasmic reticulum is involved in the transportation of substances throughout the cell.
2. It plays a primary role in the metabolism of carbohydrates, synthesis of lipids, steroids and proteins.

Golgi Bodies:

- ✓ These are membrane-bound cell organelles found in the cytoplasm of a eukaryotic cell, next to the endoplasmic reticulum and near the nucleus.
- ✓ Golgi bodies are supported together by cytoplasmic microtubules and held by a protein matrix.
- ✓ Golgi bodies are called the cell's post office as it is involved in the transportation of materials within the cell.

**Structure of Golgi Bodies****Functions:**

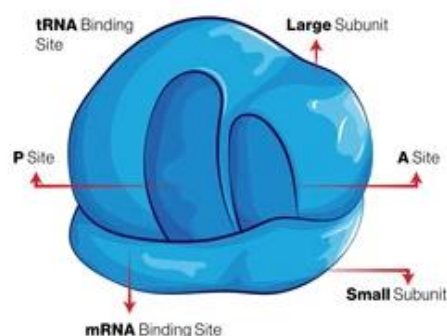
1. They involved in transport, sorting and modification of both protein and lipid, and the protein composition of the organelle reflects these functions.
2. Also involved in creating the lysosomes.

Ribosomes:

- ✓ These are small organelles majorly made up of 60% RNA cytoplasmic- granules and 40% proteins.
- ✓ All living cells contain ribosomes, which may be freely circulating in the cytoplasm and some are bound to the endoplasmic reticulum.

Functions:

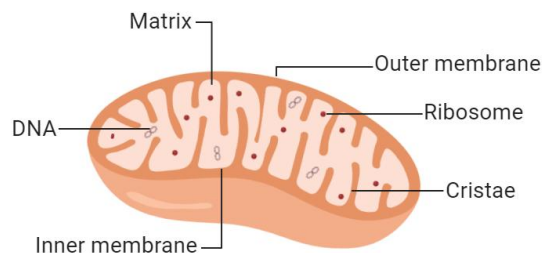
1. It assembles amino acids to form proteins that are essential to carry out cellular functions.
2. It is the site for protein synthesis.

**Structure of Ribosomes****Mitochondria:**

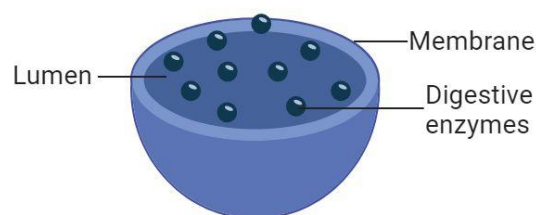
- ✓ These are membrane-bound organelles located in the cytoplasm of all eukaryotic cells.
- ✓ The number of mitochondria found in each cell varies widely depending on the function of the cell it performs.
- ✓ The mitochondrion is called “the powerhouse of the cell.”
- ✓ It is called so because it produces ATP the cell's energy currency.

Functions:

1. It regulates the metabolic activity of the cell.
2. It promotes the growth of new cells and cell multiplication.
3. It helps in detoxifying ammonia in the liver cells.
4. It plays an important role in apoptosis or programmed cell death.

**Structure of Mitochondria****Lysosomes:**

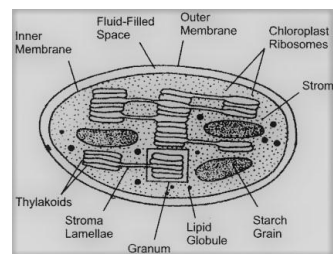
- ✓ They are round subcellular organelle found in almost all eukaryotic cells.
- ✓ Lysosomes are very acidic organelles containing the digestive enzymes and therefore each of the lysosomes is surrounded by a membrane to protect it from the outer environment.

**Structure of Lysosomes****Functions:**

1. 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.
2. They help in the breakdown/digestion of macromolecules (carbohydrates, lipids, proteins, and nucleic acids), cell membrane repairs, and responses against foreign substances such as bacteria, viruses and other antigens.

Chloroplast:

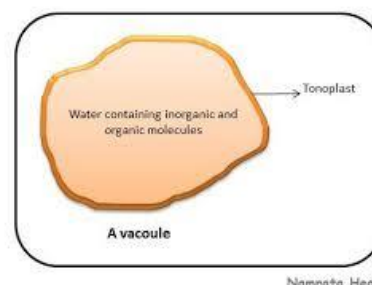
- ✓ A chloroplast is a type of organelle known as a plastid, predominantly found in plant cells and algae.
- ✓ It is the site of photosynthesis, a process where light energy is converted into chemical energy, fueling the organism's activities.
- ✓ It contains the pigment called chlorophyll.

**Structure of Chloroplast****Functions:**

1. They convert light energy into chemical energy (photosynthesis), produce oxygen as a byproduct, and generate sugars and other essential molecules for plant growth.
2. Chloroplasts are responsible for the biosynthesis of active compounds such as amino acids, phytohormones, nucleotides, vitamins, lipids, and secondary metabolites

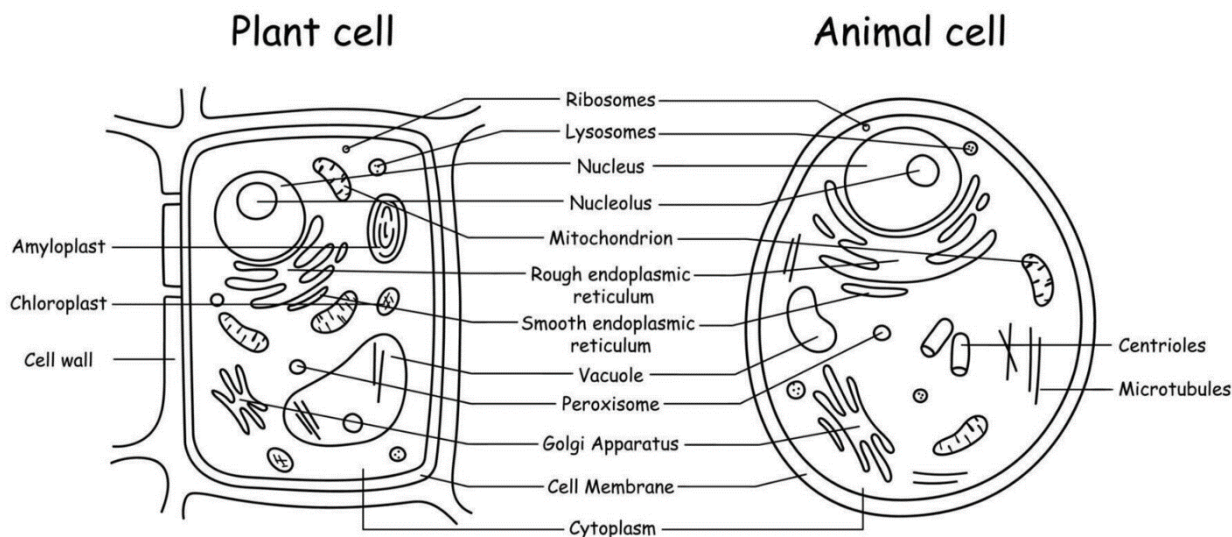
Vacuoles:

- ✓ They are membrane-bound sacs found within the cell cytoplasm.
- ✓ The vacuole sac has a single membrane surrounding known as a tonoplast and this membrane resembles the plasma membrane.

**Structure of Vacuoles**

Functions:

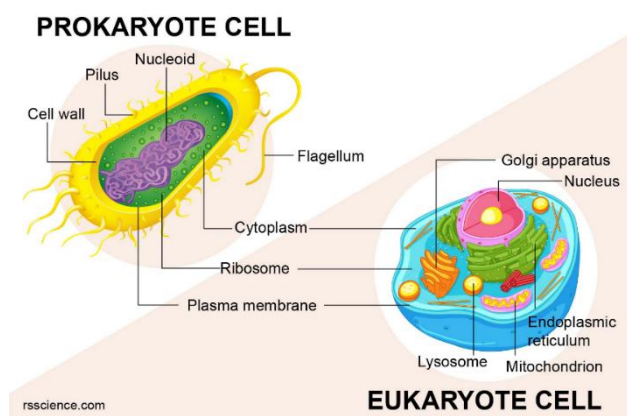
1. Vacuoles store food, water, and other waste materials in the cell.
2. They also remove toxic substances and waste materials from the cell as a protection strategy.

Structure of Plant cell and Animal cell**Types of cells:**

Cells are primarily classified into two types, namely Prokaryotic cells and Eukaryotic cells.

Prokaryotic cells have no nucleus. Instead, some prokaryotes such as bacteria have a region within the cell where the genetic material is freely suspended. This region is called the nucleoid. They all are single-celled microorganisms. Examples include archaea, bacteria, and cyanobacteria.

Eukaryotic cells are characterized by a true nucleus. This broad category involves plants, fungi, protozoans, and animals. The plasma membrane is responsible for monitoring the transport of nutrients and electrolytes in and out of the cells. There are some contrasting features between plant and animal cells. For e.g., the plant cell contains chloroplast, central vacuoles, and other plastids, whereas the animal cells do not.



Structure of Prokaryotic cell and Eukaryotic cell

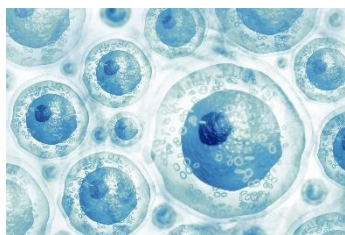
Functions of cell:

A cell performs major functions essential for the growth and development of an organism.

1. **Metabolism:** Chemical processes that sustain life, including energy production, biosynthesis of molecules and nutrient breakdown.
2. **Protein synthesis:** Involves transcription of DNA into mRNA in the nucleus, followed by translation of mRNA into proteins on ribosomes.
3. **Provides Support and Structure:** The cell wall and the cell membrane provide support and structure to the organism. For e.g., the skin is made up of a large number of cells. Xylem present in the vascular plants provide structural support to the plants.
4. **Facilitate Growth of Mitosis:** In the process of mitosis, the parent cell divides into the daughter cells i.e. multiply and facilitate the growth in an organism.
5. **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.
6. **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.
7. **Reproduction:** Cells also help in reproduction.

Stem cells and their application:

“Stem cells are special human cells that can develop into many different types of cells, from muscle cells to brain cells.” 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.



Stem cells

Types of cells:

Stem cells are of the following different types

1. **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:
 - a. *Totipotent Stem Cells:* These can differentiate into all possible types of stem cells.
 - b. *Pluripotent Stem Cells:* These are the cells from an early embryo and can differentiate into any cell type.
 - c. *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.
 - d. *Oligopotent Stem Cells:* Adult lymphoid or myeloid cells are oligopotent. They can differentiate into a few different types of cells
 - e. *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.

- 2. 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.
- 3. 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.
- 4. 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.

Applications of Stem Cells:

Following are the important applications of stem cells:

1. 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.

2. 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.

3. 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.

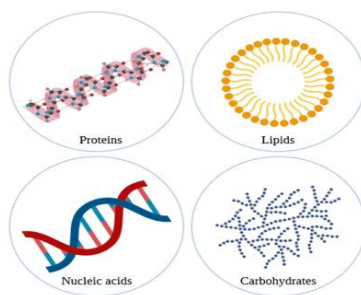
4. Blood Disease Treatment:

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.

Biomolecules:

Biomolecules are the most essential organic molecules, which are found in living organisms and involved in the maintenance and metabolic processes of living organisms. Biomolecules are the building blocks of life and perform important functions in living organisms. Biomolecules have a wide range of sizes and structures.

Examples; Carbohydrates, Proteins, Nucleic acids and Lipids, Enzymes, Vitamins, Hormones.



Biomolecules

Carbohydrates:

Introduction: Carbohydrates are macronutrients and are one of the three main ways by which our body obtains its energy. They are called carbohydrates as they contain **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.

Carbohydrates are chemically defined as polyhydroxy aldehydes or ketones or compounds which produce them on hydrolysis. 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.

Properties of Carbohydrates:

1. **Stereoisomerism:** Compound having the same structural formula but they differ in spatial configuration. Example: Glucose has two isomers with respect to the penultimate carbon atom. They are D-glucose and L-glucose.
2. **Optical Activity:** It is the rotation of plane-polarized light forming (+) glucose and (-) glucose.
3. **Diastereo isomers:** It is the configurational changes with regard to C₂, C₃, or C₄ in glucose. Example: Mannose, galactose.
4. **Anomerism:** It is the spatial configuration with respect to the first carbon atom in aldoses and the second carbon atom in ketoses.
5. **Osazone formation:** Osazones are carbohydrate derivatives when sugars are reacted with an excess of phenylhydrazine. e.g. Glucosazone
6. **Benedict's test:** Reducing sugars when heated in the presence of an alkali get converted to powerful reducing species known as enediols. When Benedict's reagent solution and reducing sugars are heated together, the solution changes its color to orange-red/ brick red.
7. **Oxidation:** Monosaccharides are reducing sugars if their carbonyl groups oxidize to give carboxylic acids. In Benedict's test, D-glucose is oxidized to D-gluconic acid thus, glucose is considered a reducing sugar.
8. **Reduction to alcohols:** The C=O groups in open-chain forms of carbohydrates can be reduced to alcohols by sodium borohydride, NaBH₄, or catalytic hydrogenation (H₂, Ni, EtOH/H₂O). The products are known as "alditols".

Functions of Carbohydrates:

Carbohydrates are widely distributed molecules in plant and animal tissues. In plants and arthropods, carbohydrates form the skeletal structures, they also serve as food reserves in plants and animals. They are important energy sources required for various metabolic activities; the energy is derived by oxidation.

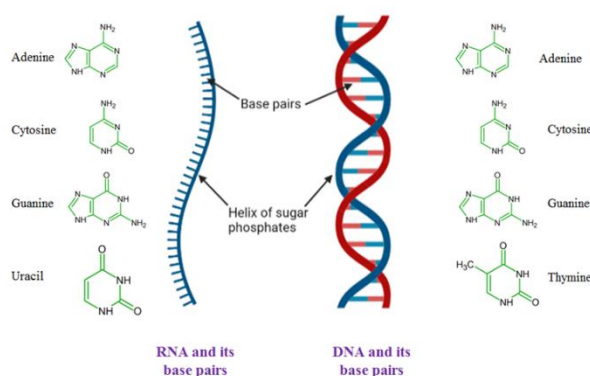
Some of their major functions include

1. Carbohydrates are helpful in performing many functions such as breakdown of protein molecules, dehydration as well as eliminating ketosis.
2. Carbohydrates serve as primary energy sources.
3. Carbohydrates provide energy.
4. Carbohydrates help in the regulation of blood glucose.
5. Carbohydrates provide the carbon skeleton for the synthesis of some non-essential amino acids. Carbohydrates are intermediates in the biosynthesis of fats and proteins.
6. Carbohydrates aid in the regulation of nerve tissue and is the energy source for the brain.

7. Carbohydrates get associated with lipids and proteins to form surface antigens, receptor molecules, vitamins, and antibiotics.
8. Formation of the structural framework of RNA and DNA (ribonucleic acid and deoxyribonucleic acid).
9. Carbohydrates that are rich in fiber content help to prevent constipation.

Nucleic acids:

Introduction: Nucleic acids are long-chain polymeric molecules, the monomer (the repeating unit) is known as the nucleotides and hence sometimes nucleic acids are referred to as polynucleotides. Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are two major types of nucleic acids. DNA and RNA are responsible for the inheritance and transmission of specific characteristics from one generation to the other. There are prominently two types of nucleic acids known to us.



Nucleic acids

Properties of Nucleic acids:

1. The basic nucleic acid structure is similar to a chain of molecules composed of identical series of nucleotides.
2. Single nucleotide, the base property of nucleic acid, comprises a nitrogen-containing fragrant base affixed to a five-carbon sugar connected to a phosphate group.
3. Every nucleic acid encompasses four of five possible nitrogen-containing bases, which are, uracil (U), adenine (A), thymine (T), guanine (G), and cytosine (C).
4. Among these nitrogen-containing bases, C, U, and T are classified as pyrimidines and A and G are classified as purines.
5. An artificially synthesized polymer is also named Peptide Nucleic Acid (PNA), similar to DNA or RNA. Peptide Nucleic Acid might be similar to DNA and RNA. Its function varies from that of both.
6. Generally, all nucleic acids contain the bases G, A, and C. But T is specifically found in DNA while U is in RNA.

Functions of Nucleic acids:

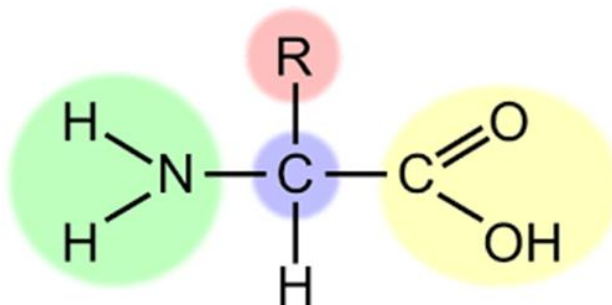
The basic function of nucleic acid is mentioned below:

1. **Stores Information:** These acids are responsible for both carrying and transmitting information in the human body. Both copying and reading the information stored in DNA relies on base pairing between two nucleic acids.
2. **Protects Information:** Apart from storing these molecules, it also protects the transmitted information. It protects the information from being lost by storing in a safer place.
3. **Determination of inherited characteristics:** These acids are responsible for DNA in a human being and eventually determines their inherited characteristics from one generation to another.

- 4. DNA fingerprinting:** It is a method used by forensic experts to determine paternity. It is also used for the identification of criminals.
- 5. In research:** It has also played a major role in studies regarding biological evolution and genetics.

Proteins:

Introduction: Proteins are macromolecules made up of monomers called amino acids. Amino acids are the building block of all proteins. An amino acid is a simple organic compound consisting of a basic group ($-\text{NH}_2$), an acidic group ($-\text{COOH}$), and an organic R group that is unique to each amino acid. The term amino acid is short for alpha-amino carboxylic acid. Each molecule has a central carbon atom, called the α -carbon to which both the groups are attached. The remaining two bonds for the central carbon are satisfied by the hydrogen atom and an organic R group. The organic R group can be as simple as a hydrogen atom (H) or a methyl group ($-\text{CH}_3$) or a more sophisticated group. Thus, the α -carbon in all the amino acids is asymmetric except in glycine where the α -carbon is symmetric with a hydrogen atom as an R group. Because of this asymmetry, the amino acids (except glycine) exist in two optically active forms: those having $-\text{NH}_2$ group to the right are designated as D-forms, and those having $-\text{NH}_2$ group to the left as L-forms. The property to exist in two optically different forms is termed as chirality. Amino acids are amphoteric compounds with both acidic and alkaline groups. These also always exist as ions except at the isoelectric point.



Empirical structure of amino acids

Properties of Proteins:

- 1. Solubility in water:** The relationship of proteins with water is complex. The secondary structure of proteins depends largely on the interaction of peptide bonds with water through hydrogen bonds. Hydrogen bonds are also formed between protein (alpha and beta structures) and water. The protein-rich static ball is more soluble than the helical structures. At the tertiary structure, water causes the orientation of the chains and hydrophilic radicals to the outside of the molecule, while the hydrophobic chains and radicals tend to react with each other within the molecule (hydrophobic effect).
- 2. Denaturation:** Partial or complete unfolding of the native (natural) conformation of the polypeptide chain is known as denaturation. This is caused by heat, acids, alkalies, alcohol, acetone, urea, beta- mercaptoethanol.
- 3. Coagulation:** When proteins are denatured by heat, they form insoluble aggregates known as coagulum. All the proteins are not heat coagulable, only a few like the albumins, globulins are heat coagulable.
- 4. Isoelectric pH (pH):** The pH at which a protein has equal number of positive and negative charges is known as isoelectric pH. When subjected to an electric field the proteins do not move either towards anode or cathode, hence this property is used to isolate proteins.
- 5. Molecular Weights of Proteins:** Different proteins have different amino acid composition and hence their molecular weights differ. The average molecular weight of an amino acid is taken to be 110. The total number of amino acids in a protein multiplied by 110 gives the approximate molecular weight of that protein.

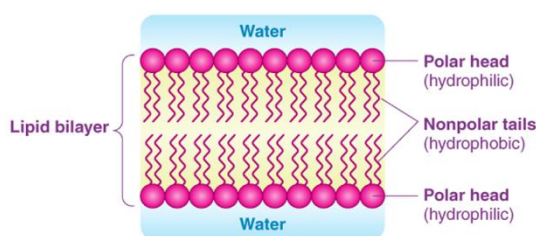
Functions of Proteins:

- 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.

Lipids:

Introduction: “Lipids are organic compounds that contain hydrogen, carbon and oxygen atoms, which form 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. Lipids are the polymers of fatty acids that contain a long, non-polar hydrocarbon chain with a small polar region containing oxygen.



Lipid bilayer structure

Properties 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.
6. Lipids are generally hydrophobic, meaning they repel water and do not dissolve in it.

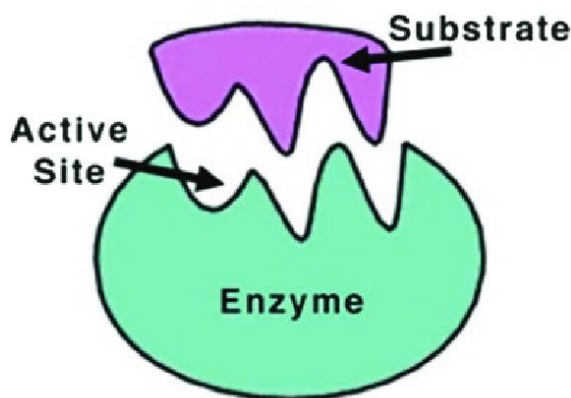
Functions of Lipids:

1. Lipids, like adipose tissue, act as insulators and help to maintain body temperature by reducing heat loss.
2. Lipids, especially triglycerides, act as energy storage in organisms, providing a reserve of metabolic fuel.
3. Lipids protect the plant leaves from direct heat and drying.
4. Steroid hormones, derived from cholesterol, play vital roles in regulating various physiological processes, including metabolism, growth, and reproduction.
5. In plants, lipids can be stored as oils in seeds, providing a source of energy for germination and early growth.
6. Lipids form waterproofing structures, such as the waxy cuticle on plant leaves or the oil on the feathers of water birds.
7. It provides color to many fruits and vegetables with the presence of carotenoid pigment.

8. Lipids serve as signalling molecules; They are catalysts of electrical impulse activity within the brain. Nerve response in myelinated neurons (right) propagate faster than in unmyelinated neurons (left). Myelin is a mixture of proteins and phospholipids that insulates nerves. The myelin coating is ~70% lipids.

Enzymes:

Introduction: “Enzymes can be defined as biological polymers that catalyse 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. Enzymes are found in all tissues and fluids of the body.



Enzyme action

Properties of Enzymes:

1. Enzymes are complex macromolecules with high molecular weight.
2. They catalyse biochemical reactions in a cell.
3. They help in the breakdown of large molecules into smaller molecules or bring together two smaller molecules to form a larger molecule.
4. Enzymes do not start a reaction. However, they help in accelerating it.
5. Enzymes affect the rate of biochemical reaction and not the direction.
6. Most of the enzymes have a high turnover number. Turnover number of an enzyme is the number of molecules of a substance that is acted upon by an enzyme per minute.
7. High turnover number of enzymes increases the efficiency of the reaction.
8. Enzymatic activity decreases with increase in temperature.
9. They show maximum activity at an optimum pH of 6 – 8.

Functions of Enzymes:

1. Enzymes like kinases & phosphatases are important for cell regulation & signal transmission.
2. The activation and inhibition of enzymes resulting in a negative feedback mechanism adjust the rate of synthesis of intermediate metabolites.
3. They catalyse post-translational modifications involving phosphorylation, glycosylation, and cleavage of the polypeptide chain.
4. Some enzymes are also involved in the regulation of enzyme levels by changing the rate of enzyme degradation.
5. Since a tight regulation of enzymes is essential for homeostasis, any changes in the enzyme structure and production might result in diseases.

- Enzymes synthesized in various organisms are also utilized in various industries for wine production, cheese production, bread whitening, and designing fabrics.

Vitamins:

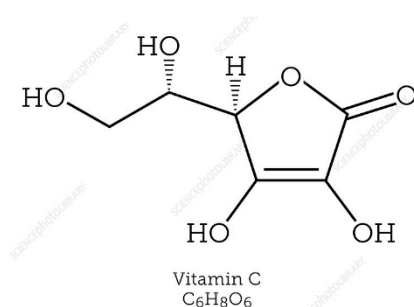
Introduction: Vitamins are chemical compounds that are required in small amounts with our regular diet in order to carry out certain biological functions and for the maintenance of our growth. There are 13 essential vitamins. This means that these vitamins are required for the body to work properly. 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.



Molecular structure of vitamin C

Properties of Vitamins:

- The vitamins are organic, low molecular weight substances that have key roles in metabolism.
- Few are single substances; most are families of chemically-related substances sharing biological activities.
- The vitamins comprising a vitamin family may vary in biopotency.
- Otherwise, vitamin families are chemically heterogeneous; therefore, it is convenient to classify the vitamins according to their physical properties.
- Some vitamins are fat-soluble; the others are water-soluble.
- The water-soluble vitamins (C, thiamin, riboflavin, pyridoxine, biotin, pantothenic acid, folate, B12) tend to have one or more polar or ionizable groups, whereas the fat-soluble vitamins (A, D, E, and K) have predominantly aromatic and aliphatic characters.
- These traits determine the nature of their absorption, transport, tissue distribution, and metabolic function. Vitamins function as antioxidants, effectors of gene transcription, H^+ / e^- donors/acceptors, hormones, and coenzymes.

Functions of Vitamins:

Each of the vitamins listed below has an important job in the body. A vitamin deficiency occurs when you do not get enough of a certain vitamin. Vitamin deficiency can cause health problems.

- Vitamin B6 is also called pyridoxine. Vitamin B6 helps form red blood cells and maintain brain function. This vitamin also plays an important role in the proteins that are part of many chemical reactions in the body. The more protein you eat the more pyridoxine your body requires.
- Vitamin B12, like the other B vitamins, is important for metabolism. It also helps form red blood cells and maintain the central and peripheral nervous systems.

3. Vitamin C, also called ascorbic acid, is an antioxidant that promotes healthy teeth and gums. It helps the body absorb iron and maintain healthy tissue. It is also essential for wound healing.
4. Vitamin D is also known as the "sunshine vitamin," since it is made by the body after being in the sun. Ten to 15 minutes of sunshine 3 times a week is enough to produce the body's requirement of vitamin D for most people at most latitudes.
5. Vitamin E is an antioxidant also known as tocopherol. It helps the body form red blood cells and use vitamin K.
6. Vitamin K is needed because without it blood would not coagulate normally. Some studies suggest that it is important for bone health.
7. Niacin is a B vitamin that helps maintain healthy skin and nerves. It also has triglyceride-lowering effects at higher doses.

Hormones:

Introduction: These are chemicals that coordinate different functions in your body by carrying messages through your blood to our organs, skin, muscles and other tissues. These signals tell our body what to do and when to do it. Hormones are essential for life. As stated above, hormones are chemicals that essentially function as messengers. 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.

Properties of Hormones:

- The significant properties of hormones are –
- They have a low molecular weight; thus, they can easily pass through capillaries.
- Hormones always act in low concentration.
- They are soluble in water so that they can be transported via blood.
- The importance of hormones is that they are non-antigenic.
- They are organic catalysts. Hormones act as coenzymes of other enzymes in the human body.
- Hormones, in their first action, cause a limited number of reactions and do not influence any metabolic activities of a cell directly.
- A significant characteristic of hormones is that, after their function is over, they are readily destroyed, excreted or inactivated.
- Hormonal activities are not hereditary.

Functions of Hormones:

different hormones have different functions.

Hormones are created by glands, which are part of the endocrine system. The main hormone-producing glands are:

1. **Hypothalamus:** The hypothalamus is responsible for body temperature, hunger, moods and the release of hormones from other glands; and also controls thirst, sleep and sex drive.
2. **Parathyroid:** This gland controls the amount of calcium in the body.
3. **Thymus:** This gland plays a role in the function of the adaptive immune system and the maturity of the thymus, and produces T-cells.
4. **Pancreas:** This gland produces the insulin that helps control blood sugar levels.
5. **Thyroid:** The thyroid produces hormones associated with calorie burning and heart rate.
6. **Adrenal:** Adrenal glands produce the hormones that control sex drive and cortisol, the stress hormone.
7. **Pituitary:** Considered the "master control gland," the pituitary gland controls other glands and makes the hormones that trigger growth.

8. **Pineal:** Also called the thalamus, this gland produces serotonin derivatives of melatonin, which affects sleep.
9. **Ovaries:** Only in women, the ovaries secrete estrogen, testosterone and progesterone, the female sex hormones.
10. **Testes:** Only in men, the testes produce the male sex hormone, testosterone, and produce sperm.

Important questions

1. Explain any five cell organelles.
2. Explain the functions of a cell.
3. Explain differences between Prokaryotic cells and Eukaryotic cells.
4. What are stem cells? Explain any four functions of stem cells.
5. Explain the any five functions of Proteins.
6. What are lipids? Explain any five properties of Lipids.
7. What are Carbohydrates? Explain the properties of Carbohydrates.
8. Explain any five functions of Vitamins.
9. What are Hormones? Explain the properties of Hormones.
10. What are biomolecules? Mention the properties of Nucleic acids.
11. What are enzymes? Explain the functions of Enzymes.