Unit-1 Introduction to Biology

Introduction to Biology: The cell: the basic unit of life, Structure and functions of a cell. The Plant Cell and animal cell, Prokaryotic and Eukaryotic cell, Stem cells and their application. Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules; Enzymes (Classification (with one example each), Properties and functions), vitamins and hormones.

Introduction

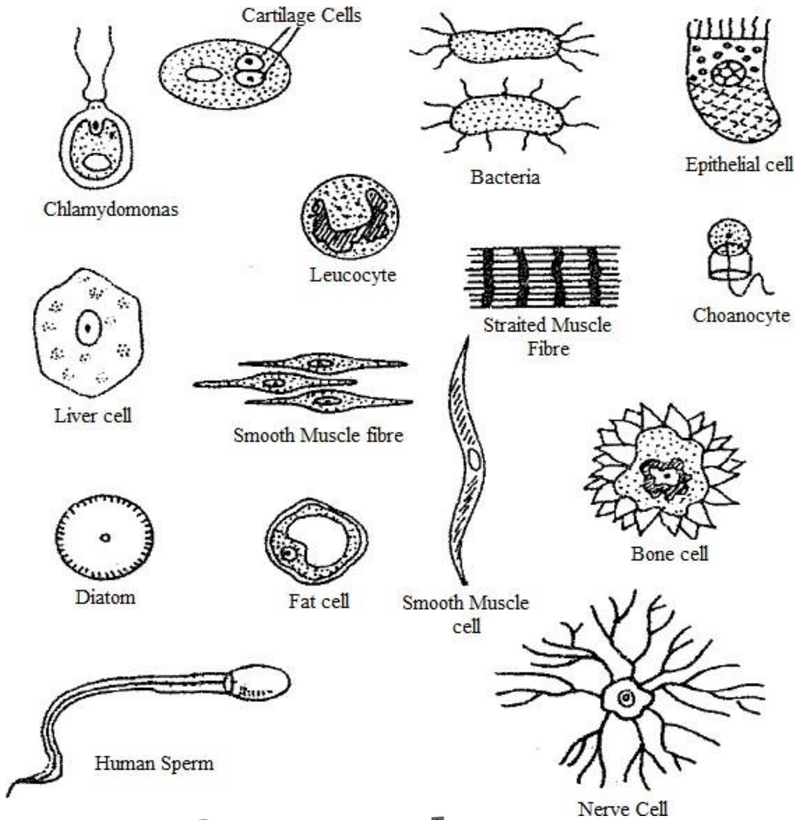
The basic structural and functional unit of cellular organization is the *cell*. Within a selective and relative semi permeable membrane, it contains a complete set of different kinds of units necessary to permit its own growth and reproduction from simple nutrients. All organisms, more complex than viruses, consist of cells, yet they consist of a strand of nucleic acid, either DNA or RNA, surrounded by a protective protein coat (the capsid). The word cell is derived from the Latin word *cellula*, which means small compartment. Hooke published his findings in his famouswork, *Micrographia*. He only observed cell walls because cork cells are dead and without cytoplasmic contents.

Features of a cell:

1- All known living things are made up of one or more cells.
2- All living cells arise from pre-existing cells by division.
3- The cell is the fundamental unit of structure and function in all living organisms.
4- The activity of an organism depends on the total activity of independent cells.
5- Energy flow (metabolism and biochemistry) occurs within cells.
6- Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.
7-All cells are basically the same in chemical composition in organisms of similar species.

Size and structure of the cell

There are many cells in an individual, which performs several functions throughout the life. The different types of cells include- prokaryotic cell, plant and animal cell (Eukaryotic cells). The size and the shape of the cell range from millimeter to microns, which are generally based on the type of function that it performs. A cell generally varies in their shapes. A few cells are in spherical, rod, flat, concave, curved, rectangular, oval etc. These cells can only be seen under microscope.



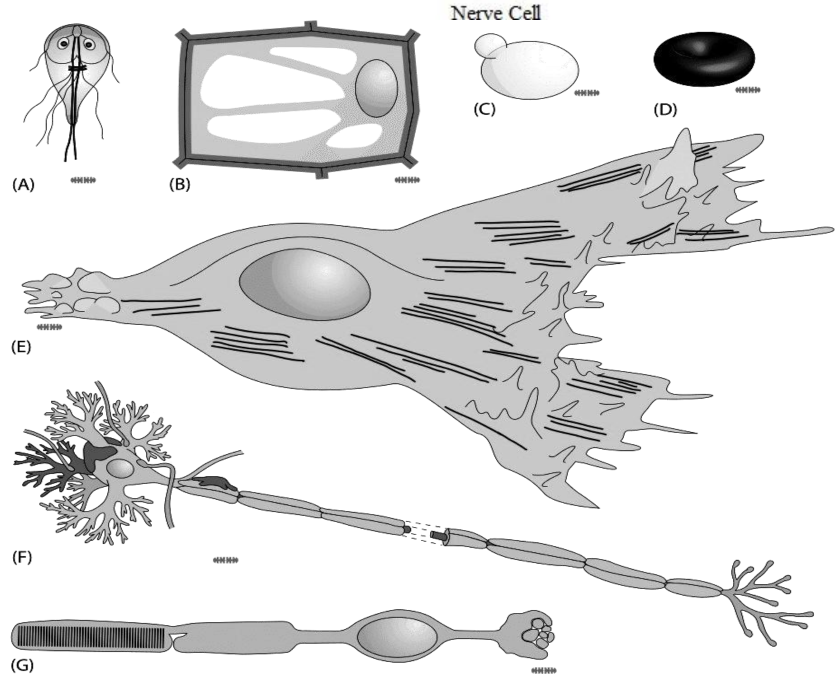


Figure : Several different types of cells all referenced to a standard *E. coli* ruler of 1 micron (A) The protist *Giardia lamblia*, (B) a plant cell, (C) a budding yeast cell, (D) a red blood cell, (E) a fibroblast cell, (F) a nerve cell, and (G) a rod cell from the retina.

Prokaryotic and Eukaryotic cell

Body of all living organisms except virus has cellular organization and may contain one or many cells. The organisms with only one cell in their body are known as unicellular (bacteria, protozoa etc.) and organisms with many cells in their body are known as multicellular organisms (most plants and animals). Any cellular organization may contain only one type of cell from the following types:

A- Prokaryotic cell
B- Eukaryotic cell

Prokaryotic cells

The prokaryotic (Gr., *pro*= primitive or before and *karyon* = nucleus) are small, simple, and most primitive organisms. They are probably first to come into existence perhaps 3.5 billion years ago. These cells occur in bacteria (i.e., Mycoplasma, Cyanobacteria etc). Prokaryotic cell is a one envelope system organized in depth. It consists of central nuclear components surrounded by cytoplasmic ground substance, with whole cell enveloped by a plasma membrane. The cytoplasm of prokaryotic cell lacks nuclear envelope, any other cytoplasmic membrane and well defined cytoplasmic organelles.

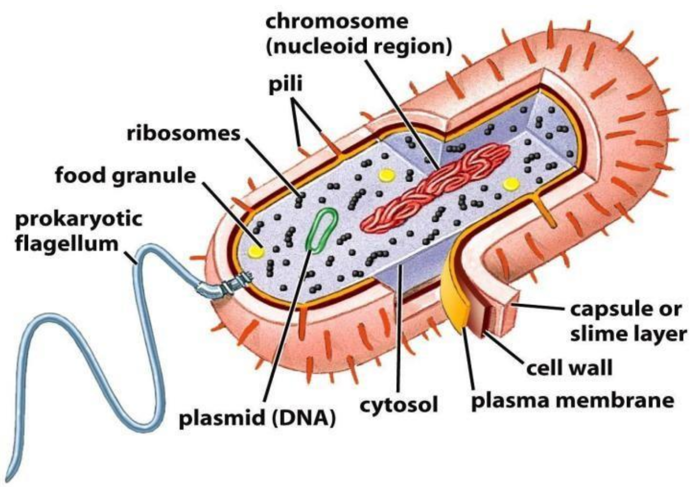


Figure: Structure of a prokaryotic cell-bacteria

Structure of Bacteria:

(i) Plasma membrane- It is an ultra thin membrane 6-8 nm thick, chemically comprised of molecules of lipids and proteins, arranged in a fluid mosaic pattern.

(ii) Cell Wall- It is strong and rigid and covers plasma membrane to provide chemical protection and characteristic shape of bacteria. It is made up of peptidoglycan and contains muramic acid.

(iii) Capsule- In some bacteria, cell wall is surrounded by an additional slime or gel layer called capsule that acts as protective layer against viruses and phagocytes.

(iv) Cytoplasm- It is the ground substance surrounded by plasma membrane and is site of all metabolic activities of bacteria. It consists of water, proteins, enzymes, different types of RNA molecules and reserve materials like glucogen, volutin and sulphur. The dense nuclear areas of cytoplasm contain 70S ribosomes granules, composed of RNA and protein at the site of protein synthesis.

(v) Nucleoids- The nuclear membrane includes a single, circular and double stranded DNA molecule often called as bacterial chromosome. It is not separated by nuclear membrane and is usually concentrated in a specific clear region of the cytoplasm called nucleoid. It has no ribosomes, nucleolus and histone proteins.

(vi) Plasmids – Many species of bacteria may also carry extrachromosomal genetic elements in the form of small, circular, and closed DNA molecules called plasmids. They produce antibiotically active protein or colicins which inhibit the growth of other bacterial strain in their vicinity.

(vii) Flagella- Many bacteria are motile and contain one or more flagella for cellular locomotion. They are 15-20nm in diameter and up to 20μm long. e.g., *E.coli* etc

<u>Eukaryotic Cell</u>

The Eukaryotic cells are essentially two envelope systems, and they are much larger than prokaryotic cells. Secondary membranes envelop the nucleolus and other internal organelles. The Eukaryotic cells are true cells which occur in the plants (from algae to angiosperms) and the animal

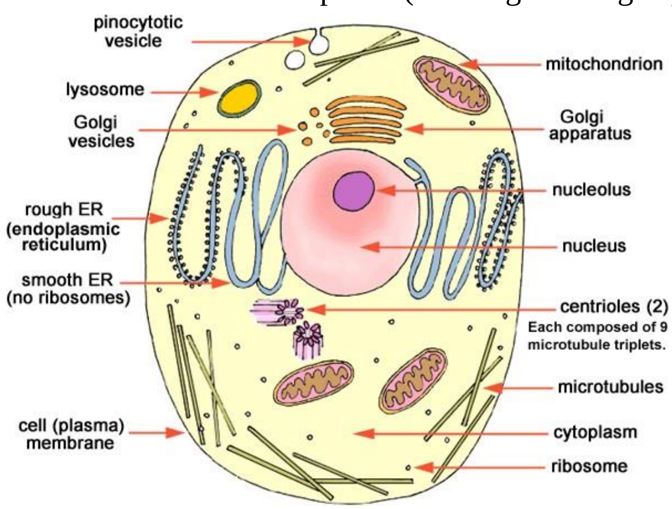


Figure: Structure of a Eukaryotic cell

(from Protozoa to mammals). Though the Eukaryotic cells have different shape, size, and physiology; all the cells are typically composed of plasma membrane, cytoplasm and its organelles, viz. Mitochondria, Endoplasmic reticulum, Ribosomes, Golgi apparatus etc; and a true nucleus. The nuclear contents, such as DNA, RNA, Nucleoproteins and Nucleolus remain separated from the Cytoplasm by the thin perforated nuclear membrane.

	Prokaryotes	**Eukaryotes**
Nucleus	Absent	Present
Membrane-bound organelles	Absent	Present
Cell structure	Unicellular	Mostly multicellular; some unicellular
Cell size	Smaller (0.1-5 µm)	Larger (10-100 µm)
Complexity	Simpler	More complex
DNA Form	Circular	Linear
Examples	Bacteria, archaea	Animals, plants, fungi, protists

1. **Cell Wall:** The outermost structure of most plant cells is a dead and rigid layer called cell wall. It is mainly composed of carbohydrates such as cellulose, pectin hemicelluloses and lignin and certain fatty substances like waxes. A major role of the cell wall is to form a framework for the cell to prevent over expansion. Cellulose fibers, structural proteins, and other polysaccharides help to maintain the shape and form of the cell.

2. **Plasma Membrane:** Every kind of animal cell is bounded by a living, extremely thin and delicate membrane called Plasma lemma, cell membrane or plasma membrane. The plasma membrane is selectively permeable membrane; its main function is to control selectively the entrance and exit of materials. This allows then cell to maintain a constant internalenvironment (Homeostasis). Molecules of water, oxygen, carbon-dioxide, glucose etc., are transported across the plasma membrane takes place by various means such as osmosis, diffusion, and active transportation. The plasma membrane consists of mainly lipids which form lipid bi-layers and different kinds of proteins. The plasma membrane are highly dynamic structures which undergo constant changes in their structures in accordance to the changes in the environment or intracellular activities. In addition, the cell membrane also acts in signal transduction, energy storage and transport.

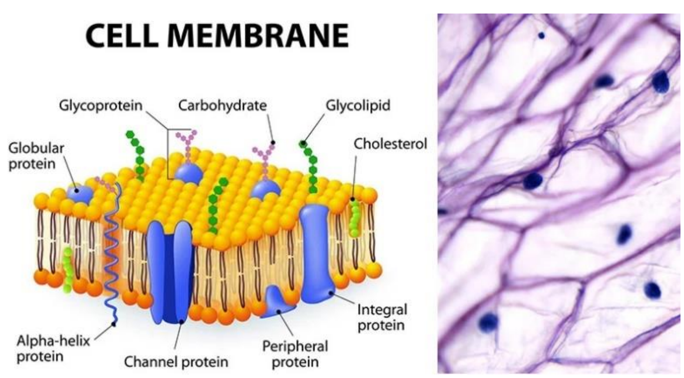


Figure: Plasma membrane structure

3. **Cytosol/ Cytoplasm:** The plasma membrane is followed by the colloidal organic fluid called matrix or cytosol. The cytosol is aqueous part of cytoplasm and nucleoplasm. Cytosol is particularly rich indifferentiation cells and many fundamental properties of cells are because of this part of cytoplasm. The cytosol serves to dissolve or suspend the great variety of small molecules concerned with cellular metabolism, e.g., glucose amino acids, nucleotides, vitamins, minerals, oxygen.

4. **Cytoskeleton**

The cytosol of cells also contains fibers that help to maintain cell shape and mobility and that probably provide anchoring points for the other cellular structures. These fibers are called cytoskeleton. At least three general classes of such fibers have been identified.

5. **Cytoplasmic Organelles**

Besides the separates fibrous systems cytoplasm is coursed by a multitude of internal membranous structures, the organelles. Cytoplasmic organelles performed specialized tasks:Generation of energy in the form of ATP molecules in Mitochondria; formation and storage of carbohydrates in plastids; protein synthesis in rough endoplasmic reticulum; lipid synthesis in soft endoplasmic reticulum; secretion by Golgi complex etc.

5.1 Endoplasmic Reticulum (ER): Within the cytoplasm of most animals cells in an extensive network of membrane – limited channels, collectively called Endoplasmic reticulum. The outer surface of rough endoplasmic reticulum has attached ribosomes, where as smooth endoplasmic reticulum don‘t have. Functions of smooth ER include lipid metabolism (Both catabolism and anabolism) glycogenolysis (degradation of glycogen) and drug detoxification.

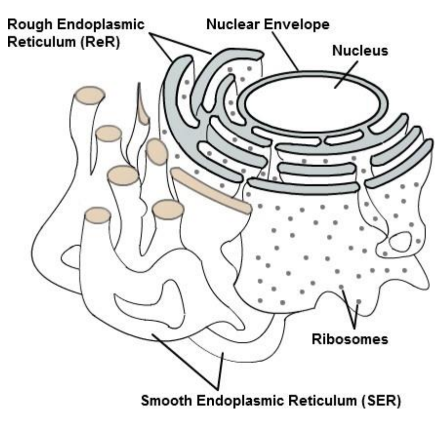


Figure: Endoplasmic reticulum

5.2 Golgi Apparatus: It is cup shaped organelle which is located near the nucleus in many typeof cells. Golgi apparatus consists of a set of smooth cisternae (i.e. close fluid –filled flattened membranous sacs or vesicles) which often are stacked together in parallel rows. It is surrounded by spherical membrane bound vesicles which appear to transport proteins to and from it.

Golgi apparatus perform the following functions:

1. Packaging of secretory materials.
2. Synthesis of certain polysaccharides and glycolipids.

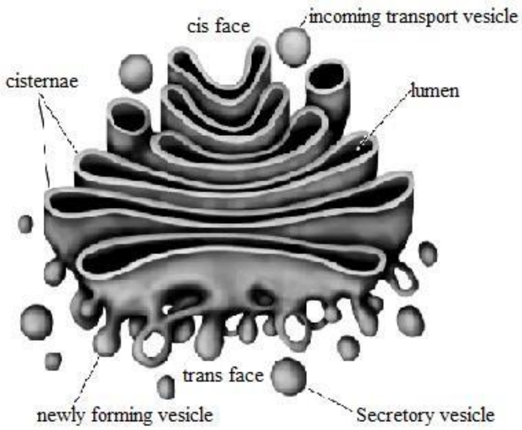


Figure : Golgi apparatus

5.3 Lysosomes: The cytoplasm of animals cells contains many tiny, spherical or irregular shape, membrane bounded vesicles known as lysosomes. They digest the material taken in by endocytosis, part of cells and extra cellular substances. Lysosomes have a high acidic medium (pH 5) and its acidification depends upon ATP dependent proton pumps which are present in lysosomes membrane.

5.4 Cytoplasmic Vacuoles: The cytoplasm of many plant and some animals‘ cell contain numerous small or large-sized hollow, liquid-filled structures, the vacuoles .The vacuoles of animals are bounded by a lipoproteinous membrane and their function is the storage, transmission of the materials and the maintenance of internal pressure of cell. The primary function of vacolules is storage of food in the form of glycogen and are present in higher quantity and size in plant cells

5.5 Mitochondria: Mitochondria are oxygen consuming ribbon shaped cellular organelles of immense importance. Each Mitochondria is bounded by two unit membranes, the outer Mitochondria membrane resembles more with the plasma membrane in structure and chemical composition.

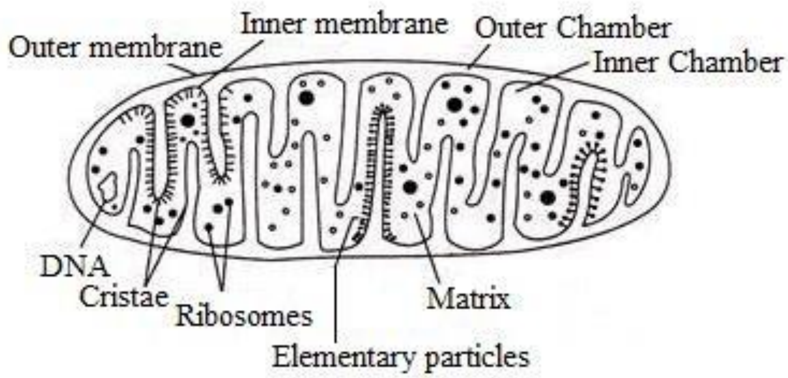


Figure: structure of mitocondria

Functions:

1. The mitochondria helps in thermolysis
2. The mitochondria is involving in Ca^{2+} ions sequestration
3. The mitochondria generates the energy in the form of ATP through electron transport chain (ETC cycle)

5.6 Ribosomes: They are dense, rounded, granular and smallest known electron microscopic Ribonucleoprotein (RNP) particles attached either on Rough endoplasmic reticulum (RER) or floating freely in the cytoplasm. These are the site of protein synthesis. They may exist either in free state in cytosol or attached to RER.

General features

1. Unlike most other organelles, ribosomes are not surrounded by a membrane.
2. Ribosomes are the site of protein synthesis in a cell.
3. They are the most common organelles in almost all cells.
4. Some are free in the cytoplasm (Prokaryotes) others line the membranes of rough endoplasmic reticulum (rough ER).
5. They exist in two sizes: 70S are found in all Prokaryotes, chloroplasts and mitochondria, suggesting that they have evolved from ancestral Prokaryotic organisms. They are free- floating. While 80S found in all eukaryotic cells.

5.7 Nucleus: The nucleus is a membrane-enclosed organelle found in eukaryotic cells. Eukaryotes usually have a single nucleus, but a few cell types, such as mammalian red blood cells, have no nuclei, and a few others have many.

Cell nuclei contain most of the cell's genetic material, organized as multiple long linear DNA molecules in complex with a large variety of proteins, such as histones, to form chromosomes. The genes within these chromosomes are the cell's nuclear genome and are structured in such a way to promote cell function. The nucleus maintains the integrity of genes and controls the activities of the cell by regulating gene expression—the nucleus is, therefore, the control center of the cell. The main structures making up the nucleus are the nuclear envelope, a double membrane that encloses the entire organelle and isolates its contents from the cellular cytoplasm, and the nuclear matrix (which includes the nuclear lamina), a network within the nucleus that adds mechanical support, much like the cytoskeleton, which supports the cell as a whole.

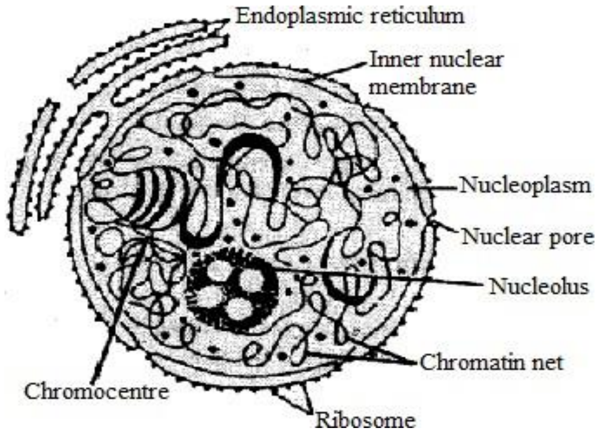


Figure: Eukaryotic nucleus

Difference between Animal and Plant cell

S.No	Animal cell	Plant cell
1.	Animal cells are generally small in size.	Plant cells are larger than animal cells.
2.	Cell wall is absent.	The plasma membrane of plant cells is surrounded by a rigid cell wall of cellulose.
3.	Except the protozoan *Euglena* no animal cell possesses plastids.	Plastids are present.
4.	Vacuoles in animal cells are many and small.	Most mature plant cells have a large central sap vacuole.
5.	Animal cells have a single highly complex Golgi	Plant cells have many simpler units of and prominent Golgi apparatus. apparatus, called dictyosomes.
6.	Animal cells have centrosome and centrioles.	Plant cells lack centrosome and centrioles.

Biomolecules, are the organic molecules that are produced by cells and living organisms. Biomolecules have a wide range of sizes and structures and perform a vast array of functions. The four major types of biomolecules are carbohydrates, lipids, nucleic acids, and proteins.

Carbohydrates
The term carbohydrate is a combination of the “hydrates of carbon”. They are also known as “Saccharides”, a derivation of the Greek word “Sakcharon”, which means sugar. “Optically active polyhydroxy aldehydes or ketones or substances formed during hydrolysis are known as carbohydrates”. Few of the most common carbohydrates that we come across in our daily lives are in the form of sugars. These sugars can be in the form of Glucose, Sucrose, Fructose, Cellulose, Maltose etc. The general formula for carbohydrates is Cx(H2O)y

Classification of Carbohydrates:

The main classification of carbohydrates is done based on hydrolysis. This classification is as follows:

1. Monosaccharides are the more straightforward form of carbohydrates that cannot be hydrolyzed into a more straightforward unit of polyhydroxy aldehyde or ketone called monosaccharides. Approximately twenty monosaccharides are known to occur in nature. For example, glucose and fructose. Their general formula is (CH2O)n. Some examples are glucose, Ribose, etc.

2. Oligosaccharides**:** Carbohydrates that, upon hydrolysis yield, two to ten smaller units or monosaccharides are called oligosaccharides. They are a large category and further divided into various subcategories.
3. Disaccharides**:** A further classification of oligosaccharides, gives two units of different or the same monosaccharides on hydrolysis. One example, sucrose on hydrolysis gives one molecule of glucose and fructose each. In contrast, maltose on hydrolysis gives two molecules of only glucose.
4. Trisaccharides**:** Carbohydrates that on hydrolysis give three molecules of monosaccharides, identical or different. An example is Raffinose.
5. Tetrasaccharides**:** As the name suggests, this carbohydrate on hydrolysis gives four molecules of monosaccharides. Stachyose is an example.
6. Polysaccharides**:** The last and final category of carbohydrates. These give a very large number of monosaccharides when they go through hydrolysis. These carbohydrates are not sweet and are also known as non-sugars. Some common examples are starch, glycogen etc.

Importance of Carbohydrates:

- They are responsible for storing chemical energy in living organisms. You must hear it all the time when athletes carbo-load before a game. This is to provide them with extra energy. They are also an essential constituent for supporting tissues in plants and even in some animals.
- Photosynthesis is a process by which plants use solar energy to produce food for themselves. With this process, plants fix CO_2 and synthesize carbohydrates.

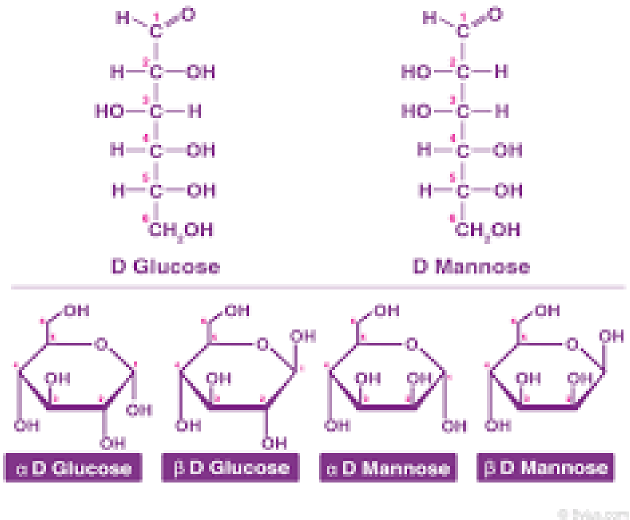


Figure: *Structure of carbohydrates*

Nucleic acids

The particles in the nucleus of the biological cell responsible for heredity are called chromosomes which are made up of proteins and other biomolecules called nucleic acids. Nucleic acids are polymers which are present in all human bodies.

- Nucleic acids play an essential role in the development and reproduction of every life form.
- Nucleic acid contains the elements carbon-oxygen, nitrogen and phosphorus.
- They have nucleotides as their repeating units.

Two types of nucleic acids:

- DNA (Deoxyribonucleic acid).
- RNA (Ribonucleic acid).

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are two major types of nucleic acids. DNA and RNA are responsible for inheriting and transmitting specific characteristics from one generation to the other.

Deoxyribonucleic Acid (DNA):

- Chemically, DNA comprises a pentose sugar, phosphoric acid and a few cyclic bases containing nitrogen.
- The sugar unit present in DNA molecules is β-D-2-deoxyribose.
- The cyclic bases that have nitrogen-containing in them are Adenine (A), guanine (G), thymine (T) and cytosine(C).
- These bases and their configuration in the molecules of DNA play an essential role in storing information from one generation to the next.
- DNA has a double-strand helical structure in which the strands complement each other.

Ribonucleic Acid (RNA):

- The RNA molecule is also composed of phosphoric acid, a pentose sugar and a few cyclic bases containing nitrogen.
- RNA has β-D-ribose in it as the sugar unit.
- The heterocyclic bases available in RNA are Adenine (A), guanine (G), cytosine(C) and uracil (U).
- In RNA, the fourth base varies from that of DNA.
- The RNA commonly consists of a single strand which sometimes folds back; that results in a double helix structure.

There are three different types of RNA molecules, each having a specific function:

1. Messenger RNA (mRNA).
2. Ribosomal RNA (rRNA).
3. Transfer RNA (t-RNA).

Nucleotides contain three chemical components:

- A heterocyclic base.
- A five-carbon sugar moiety.
- A phosphate group.

Structure of Nucleic acids:

1. Nitrogen-containing heterocyclic base: Purines and pyrimidines are two types of heterocyclic bases. For example, Adenine and guanine are purines. Cytosine, thymine, and uracil are pyrimidines.
2. Sugars: The two types of sugars are RNA and DNA.

iii. Phosphate group: Nucleotides are joined by these linkages.

1. Nucleoside: A nucleoside unit is produced when a nitrogen base is attached to a sugar molecule.

Base + sugar = nucleoside.

1. Nucleotide: When a nitrogen base is attached to a sugar molecule and phosphate, the unit forms a nucleotide.

Base+Sugar+phosphate → nucleotide.

Functions of nucleic acids

- Nucleic acids are responsible for transmitting inherent characteristics from parent to offspring. They are also responsible for the synthesis of protein in our bodies.
- DNA fingerprinting is a method that is used by forensic experts to determine paternity. This method is also used for the identification of criminals. It has also played a significant role in biological evolution and genetics studies.
- Replication: It is the characteristics of a bio-molecule to synthesize different molecules. For example, DNA has a specific property to replicate itself.
- Protein synthesis: Genetic information collected in DNA in a specific base sequence is expressed in the form of a specific base sequence.
- Gene and genetic code: Every segment of DNA molecule that codes for a specific protein or a polypeptide, known as the relationship between nucleotides triplets and the amino acids, is called the genetic code. This is what forms gene and genetic code.
- Mutation: A chemical process in a DNA molecule leads to the synthesis of proteins with a changed amino acid sequence. Radiation, viruses or chemical agents cause these changes. Special enzymes replicate most changes in DNA in the cell, but if there is a failure to repair by the enzymes, then it can cause mutation.

Proteins:

Proteins are higher in molecular weight, complex bio-polymers of alpha-amino acids found in all living organisms. They occur in all parts of the body and form the fundamental basis of the structure and functions of life. The term ‘Protein’ is derived from the Greek word ‘Protein’, which means ‘Primary importance’. Proteins are the amplest biomolecules of the living cell. The primary sources of proteins are milk, cheese, pulses, peanuts, fish etc. All living systems comprise biomolecules with high molecular mass, called amino acids.

Amino acids:

These acids are the building block units of proteins. These are the organic compounds which contain amino as well as carboxyl functional groups known as amino acids. Depending upon the relative position of the amino group concerning the COOH group, amino acids are Classified into alpha-beta, gamma delta and so on. Hydrolysis of proteins gives only alpha-amino acids represented as:

- The above unit may be connected to any carbon atom other than the -COOH group.
- The amino acids can also be classified based on their need and availability in the human body.

Essential Amino Acids:

These acids cannot be synthesized in our bodies and are essential amino acids that must be taken through diet. We must depend on food sources to obtain these amino acids. Some of the primary essential Amino Acids are as below:

- Leucine.
- Isoleucine.
- Lysine.
- Threonine.
- Methionine.
- Phenylalanine.
- Valine.
- Tryptophan.
- Histidine (conditionally essential).

Non-Essential Amino acids:

These acids are synthesized in our bodies by themselves. So we need not rely on external sources for them. They are produced in our bodies and also obtained from protein breakdowns.

Properties of Amino Acids:

We have seen the overall structure and types of amino acids. Based on this information, we can arrive at the properties of amino acids.

- Each amino acid has an acidic and fundamental group, as seen from its structure. Because of this reason they behave similar to salts.
- They exist as dipolar ions.
- Any amino acid in the dry state exists in crystalline form.
- The NH_2 group exists as a cation, and the COOH group exists as an anion. This dipolar ion has a unique name, *"Zwitterions'*.
- In an aqueous solution, alpha-amino acids exist in equilibrium between a cationic form, an anionic form and a dipolar ion.
- The isoelectric point (IEP) is the pH point at which the concentration of zwitterions is the highest, and the concentration of cationic and anionic forms is equal.
- This specific point is definite for every α-amino acid.
- They are generally water-soluble and also have high melting points.

Structure of proteins:

- Amino acids exist as a zwitterion, which is dipolar.
- The fundamental nature of the zwitterion is due to the -COO– ion.
- The acidic character of the zwitterion is due to the -NH3+ group.

Peptide linkage:

When two or more amino acids are attached, the resulting -CO-NH- link is termed peptide linkage of the peptide bond.

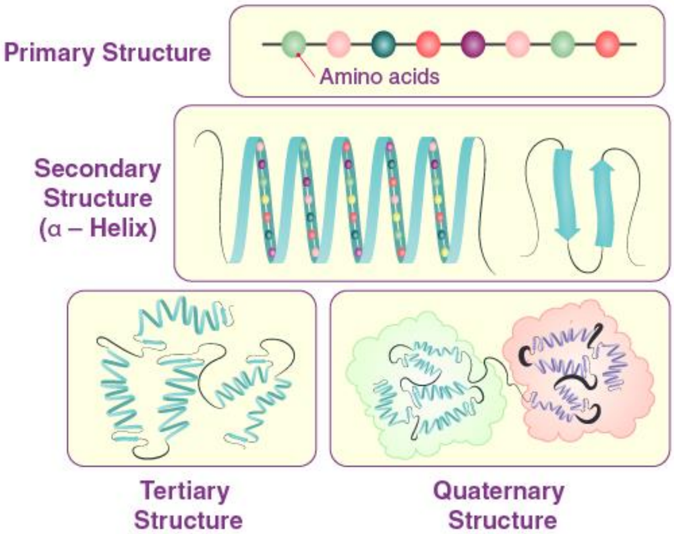


***Figure**: The various conformations of proteins*

Enzymes

Enzymes are the biological macromolecules which speed up the rate of biochemical reactions without undergoing any change. They are also called as biological catalysts. An enzyme is a highly selective catalyst that greatly accelerates both the rate and specificity of metabolic reactions. Enzymes are biological catalysts made up of large protein molecules. They speed up the chemical reactions inside the cell. The enzyme is made up of a combination of amino acids which for a chain of polypeptides between each other. Enzymes are similar to other chemical catalysts. They participate in the reaction without getting affected. In other words, they speed up the chemical reactions inside the cells without getting consumed.
They are also addressed as biocatalysts. All enzymes are catalysts but not all catalysts are enzymes.

Enzymes and catalysts both affect the rate of a reaction. In fact, all known enzymes are catalysts, but not all catalysts are enzymes. The difference between catalysts and enzymes is that enzymes are largely organic in nature and are biocatalysts, while non-enzymatic catalysts can be inorganic compounds. Neither catalysts nor enzymes are consumed in the reactions they catalyze.

Comparison of chemical catalyst and enzymes

	Catalyst	**Enzyme**
Function	Catalysts are substances that increase or decrease the rate of a chemical reaction but remain unchanged.	Enzymes are proteins that increase rate of chemical reactions converting substrate into product.
Molecular weight	Low molecular weight compounds.	High molecular weight globular proteins

Types	There are two types of catalysts – positive and negative catalysts.	There are two types of enzymes - activation enzymes and inhibitory enzymes.
Nature	Catalysts are simple inorganic molecules.	Enzymes are complex proteins.
Reaction type	Catalysts act on physical reactions	Enzymes act on biochemical reactions
Alternate terms	Inorganic catalyst.	Organic catalyst or bio catalyst.
Reaction rates	Typically slower	Several times faster
Specificity	They are not specific and therefore end up producing residues with errors	Enzymes are highly specific producing large number of good residues

Active site of the enzyme

The active site of an enzyme is the region that binds the substrate and converts it into product. It is usually a relatively small part of the whole enzyme molecule and is a three-dimensional entity formed by amino acid residues that can lie far apart in the linear polypeptide chain. The active site is often a cleft or crevice on the surface of the enzyme that forms a predominantly nonpolar environment which enhances the binding of the substrate. The substrate(s) is bound in the active site by multiple weak forces (electrostatic interactions, hydrogen bonds, van der Waals bonds, hydrophobic interactions, and in some cases by reversible covalent bonds. The properties and spatial arrangement of the amino acid residues forming the active site of an enzyme will determine which molecules can bind and be substrates for that enzyme.

Mechanism of action of Enzymes

The substrate(s) is bound in the active site by multiple weak forces which result into the enzyme-substrate complex. Once bound active residues within the active site of the enzyme act on the substrate molecule to transform it first into the transition state complex and then into product, which is released. The enzyme is now free to bind another molecule of substrate and begin its catalytic cycle again.

[E]+[S] [ES] [E]+[P]

Enzyme substrate Enzyme-substrate complex Enzyme + Product

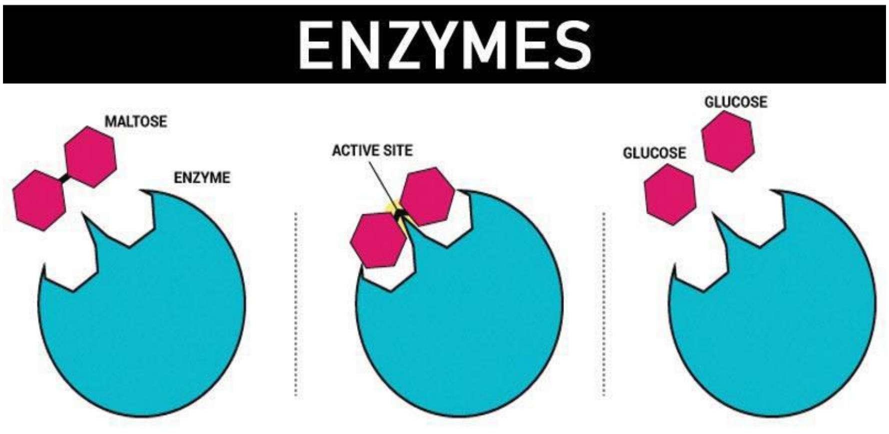


Figure: The binding of the substrate (maltose/glucose) onto the active site of the enzyme. The structure of the substrate is complementary to the enzyme

Properties of Enzymes

1. Nearly all enzymes are proteins, although a few catalytically active RNA molecules have been identified.
2. Enzyme catalyzed reactions usually take place under relatively mild conditions (temperatures well below 100$_o$C, atmospheric pressure and neutral pH) as compared with the corresponding chemical reactions.
3. Enzymes are catalysts that increase the rate of a chemical reaction without being changed themselves in the process.
4. Enzymes are highly specific with respect to the substrates on which they act and the products that they form.
5. Enzyme activity can be regulated, varying in response to the concentration of substrates or other molecules.
6. They function under strict conditions of temperature and pH in the body.

Nomenclature of the enzymes

Many enzymes are named by adding the suffix '-ase_' _to the name of their substrate. However, other enzymes, such as trypsin and chymotrypsin, have names that do not denote their substrate. Some enzymes have several alternative names. To rationalize enzyme names, a system of enzyme nomenclature has been internationally agreed. For example. Urease is the enzyme that catalyzes the hydrolysis of urea, and fructose-1,6-bisphosphatase hydrolyzes fructose-1,6-bisphosphate.

Classification of Enzymes

1. Oxidoreductases

Catalyze oxidation-reduction reactions where electrons are transferred. These electrons are usually in the form of hydride ions or hydrogen atoms. The most common name used is a dehydrogenase and sometimes reductase is used. An oxidase is referred to when the oxygen atom is the acceptor. Example-

2. Transferases

Catalyze group transfer reactions. The transfer occurs from one molecule that will be the donor to another molecule that will be the acceptor. Most of the time, the donor is a cofactor that is charged with the group about to be transferred. Example: Hexokinase used in glycolysis.

3. Hydrolases

Catalyze reactions that involve hydrolysis. It usually involves the transfer of functional groups to water. When the hydrolase acts on amide, glycosyl, peptide, ester, or other bonds, they not only catalyze the hydrolytic removal of a group from the substrate but also a transfer of the group to an acceptor compound. For example: Chymotrypsin.

4. Lyases

Catalyze reactions where functional groups are added to break double bonds in molecules or the reverse where double bonds are formed by the removal of functional groups. For example: Fructose bisphosphate aldolase used in converting fructose 1,6-bisphospate

5. Isomerases

Catalyze reactions that transfer functional groups within a molecule so that isomeric forms are produced. These enzymes allow for structural or geometric changes within a compound. For example: phosphoglucose isomerase for converting glucose 6-phosphate to fructose 6-phosphate. Moving chemical group inside same substrate.

6. Ligases

They are involved in catalysis where two substrates are ligated and the formation of carbon-carbon, carbon-sulfide, carbon-nitrogen, and carbon-oxygen bonds due to condensation reactions. These reactions are coupled to the cleavage of ATP.

Factors affecting the enzyme function-

There are several factors that affect the speed of an enzyme's action, such as the concentration of the enzyme, the concentration of the substrate, temperature, hydrogen ion concentration (pH), and the presence of inhibitors.

Vitamins:

Vitamins are organic compounds essential for the average growth of life for animals, some bacteria and microorganisms. These are the biomolecules which are not produced by the body and hence, need to be supplied in small amounts for necessary biological functions. Vitamins are an essential dietary factor.

A, B, C, D, E, & K vitamins are present in various food forms.

Classification of vitamins**:**

Vitamins are classified into two categories:

- Water-soluble vitamins: Water-soluble vitamins are vitamin B and C complex etc. These vitamins need to be transferred to the body from time to time.
- Fat-soluble vitamins**:** Vitamins only soluble in fat are called fat-soluble vitamins. A(Retinol), D(calciferol), E(Tocopherol), and K(Phylloquinone) vitamins are soluble in fat.

Particular vitamins are responsible for certain essential functions. Let us have a brief look at them.

- Vitamin A: Required to enable night vision in humans. Cells require Vitamin A for the transfusion of light.
- Vitamin B: Necessary for creating serotonin, myelin, dopamine and epinephrine. It also lowers cholesterol levels.
- Vitamin C: Increases the immune system and helps fatigued muscles.
- Vitamin D: The formation of RNA needs Vitamin D. It also helps bones absorb calcium to stay healthy and strong and reduces the risk of fractures
- Vitamin E has antioxidant properties that help our bodies get rid of free radicals and assist in the formation of red blood cells.
- Vitamin K: Essential in creating some crucial proteins, Various important vitamins, their sources and their deficiency diseases.

Name of vitamins	**sources**	**Deficiency diseases**
Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthalmia, Night blindness
Vitamin B1	Yeast, milk, cereals, green veggies	Beri Beri
Vitamin B2	egg white, milk, liver	Cheilosis
Vitamin B6	Yeast, milk, cereals and grams	convulsions
Vitamin B12	Meat, fish, egg and curd	Pernicious
Vitamin C	Citrus fruits, amla	scurvy
Vitamin D	Exposure to sunlight, fish	Rickets
Vitamin E	Vegetable oils like wheat germ oil	Increased fragility of RBC and muscular weakness
Vitamin K	Green leafy vegetables	Increased blood clotting time

Hormones:

Hormones are molecules which act as intracellular messengers. These are constructed by endocrine glands in the body and are poured directly into the bloodstream, which transports them to the site of action.

Hormones have various functions in the body. They help to adjust the balance of biological activities in the body.

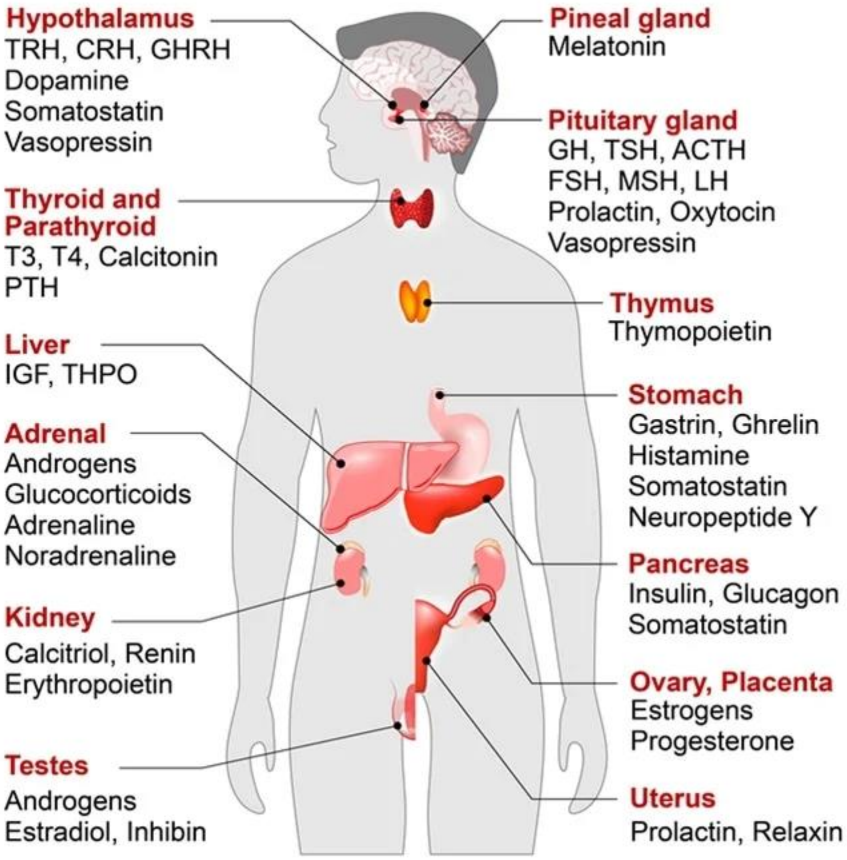


Figure: the site of origin of hormones

Gland	Hormone	Type	Action
Hypothalamus	Oxytocin	Peptide	Moves to posterior pituitary for storage
	Antidiuretic hormone	Peptide	Moves to posterior pituitary for storage
	Regulatory hormones of anterior pituitary hormones		Act on anterior pituitary to stimulate or inhibit hormone production
Pituitary gland			
Posterior	Oxytocin	Peptide	Initiates labor, initiates milk ejection
	Antidiuretic hormone	Peptide	Stimulates water resorption by kidneys
Anterior	Growth hormone	Protein	Stimulates body growth
	Prolactin	Protein	Promotes lactation
	Follicle-stimulating hormone	Glyco-protein	Stimulates follicle maturation and production of estrogen; stimulates sperm production
	Luteinizing hormone	Glyco-protein	Triggers ovulation and production of estrogen and progesterone by ovary; promotes sperm production
	Thyroid-stimulating hormone	Glyco-protein	Stimulates release of T_3 and T_4
	Adrenocorticotropic hormone	Peptide	Promotes release of glucocorticoids and androgens from adrenal cortex
Thyroid gland	T_3 (Triiodothyronine)	Amine	Increases metabolism, blood pressure, regulates tissue growth
	T_4 (Thyroxine)	Amine	Increases metabolism, blood pressure, regulates tissue growth
	Calcitonin	Peptide	Childhood regulation of blood calcium levels through uptake by bone
Parathyroid gland	Parathyroid hormone	Peptide	Increases blood calcium levels through action on bone, kidneys and intestine
Pancreas	Insulin	Protein	Reduces blood sugar levels by regulating cell uptake
	Glucagon	Protein	Increases blood sugar levels
Adrenal glands			
Adrenal medulla	Epinephrine	Amine	Short-term stress response: increased blood sugar levels, vasoconstriction, increased heart rate, blood diversion
	Norepinephrine	Amine	Short-term stress response: increased blood sugar levels, vasoconstriction, increased heart rate, blood diversion
Adrenal cortex	Glucocorticoids	Steroid	Long-term stress response: increased blood glucose levels, blood volume maintenance, immune suppression
	Mineralocorticoids	Steroid	Long-term stress response: blood volume and pressure maintenance, sodium and water retention by kidneys
Gonads			
Testes	Androgens	Steroid	Reproductive maturation, sperm production
Ovaries	Estrogens	Steroid	Reproductive maturation, regulation of menstrual cycle
	Progesterone	Steroid	Regulation of menstrual cycle
Pineal gland	Melatonin	Amine	Circadian timing
Thymus	Thymosin	Peptide	Development of T lymphocytes

Figure: The functions of the hormones