- **Denaturation** of proteins involves irreversible precipitation of proteins. The complex three dimensional structure of proteins changes by change in pH, temperature, presence of salts or certain chemical compounds. Denaturation does not change primary structure but changes secondary and tertiary structures of proteins e.g., coagulation of albumin present in white part of egg when egg is boiled.

ENZYMES

- **Enzymes** are naturally occurring simple or conjugate proteins produced by living cells. Enzymes are biocatalysts which catalyse the biochemical reactions in living organisms.
- Most active enzymes are associated with some non-protein components required for their activity. These are called **prosthetic groups**. The prosthetic group which is covalently attached with the enzyme molecule is known as **cofactor**.
- The prosthetic groups which get attached to the enzyme at the time of reaction are known as **coenzymes**.

Properties

- Have high efficiency.
- Required in very small quantities.
- They are highly specific in nature.
- They are active at a temperature of 37°C and pH ≈ 7.
- Enzyme activity is controlled by various mechanisms and are inhibited by various organic acids and inorganic molecules.
  - **Active site** : The region on the surface of the enzyme to which the reactant molecules (substrates) bind is called the active site. The active site of a given enzyme is so shaped that only its specific substrates can fit into it. Therefore, enzymes are very specific in their action.
  - **Mechanism of enzyme action** : The enzyme reacts with substrate to form $E-S$ complex.

$$E + S \rightarrow E - S$$

Enzyme-substrate complex changes to E–I (enzyme-intermediate complex)

$$E - S \rightarrow E - I$$

$E - I$ complex changes to $E - P$ (enzyme-product complex.)

$$E - I \rightarrow E - P$$

$E - P$ complex decomposes to product and enzyme is regenerated.

$$E - P \rightarrow E + P$$

HORMONES

- Hormones are chemical substances that are produced in minute quantities by some specialised organs called ductless or endocrine glands. The hormones produced by these glands move to the different parts of the body through blood stream. Hormones play an important role in regulating metabolic processes and sex characteristics. Hormone deficiency leads to abnormal metabolic processes.
  - **Steroid Hormones :** Steroids are such compounds whose structure is based on a four-ring network having three cyclohexane rings and one cyclopentane ring. A steroid nucleus is present in some drugs, bile acids, vitamins and hormones. Steroid alcohols are called sterols. An important sterol is cholesterol. Some important steroids include sex hormones. Some other steroids include cortisone, corticosterone and aldosterone.
  - **Peptide Hormones :** These are hormones which are secreted by the posterior lobe of the pituitary gland. Oxytocin and Vasopressin are the two examples. These are nanopeptides i.e. peptides which are made up from nine amino acid residues.

Hormones	Organ of secretion of hormone	Uses
1. Steroid hormones		
• Androsterone and testosterone	Testes	It regulates the development and normal functioning of male sex organs.
• Estrone and estradiol	Ovary	It regulates the development and normal functioning of female sex organs.
• Cortisone	Adrenal cortex	It regulates the metabolism of water, carbohydrates, fats and mineral salts
2. Peptide hormones		
• Insulin	Pancreas	It regulates the metabolism of glucose.
• Oxytocin	Posterior pituitary gland	It releases mother milk from mammary glands and controls the contraction of uterus during child birth.
• Vasopressin (ADH)	Posterior pituitary gland	It controls the reabsorption of water in the kidney.
3. Amine compounds		
• Thyroxine	Thyroid gland	It controls the metabolism of proteins, carbohydrates and lipids.
• Adernaline or epinephrine (also called emergency hormone)	Adrenal medulla	It releases glucose from glycogen and fatty acids from fats. It also increases the pulse rate and blood pressure.

VITAMINS

- **Vitamins** are organic compounds other than carbohydrates, proteins, fats or a group of biomolecules, which must be supplied in small amounts in diet for maintaining a normal health, growth and nutrition.
- Multiple deficiencies caused by lack of more than one vitamins is known as **avitaminosis**.

Classification

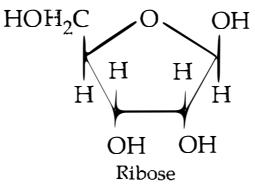
- Vitamins are generally classified into two broad categories.
  - **Water soluble vitamins:** Those vitamins which are soluble in water are called water soluble vitamins, *e.g.*, vitamins B group, vitamin C, etc.
  - **Fat soluble vitamins:** Those vitamins which are soluble in fats are called fat soluble vitamins, *e.g.*, vitamins A, D, E and K. Excess intake of these vitamins may cause **hypervitaminosis**.

Name	Classification	Functions	Sources	Deficiency diseases
Vitamin A (Retinol)	fat soluble	(i) helps in proper growth and normal skeletal development. (ii) maintains proper vision, essential for healthy teeth, helps in maintaining healthy skin.	Butter, liver, carrot, spinach	Night blindness
Vitamin B_1 (Thiamine)	water soluble	(i) carbohydrate metabolism. (ii) functioning of heart, nerves and muscles.	Milk, pulses, green vegetables	Beri-beri
Vitamin B_2 (Riboflavin)	water soluble	(i) helps in utilising oxygen. (ii) carbohydrate and protein metabolism. (iii) helps in keeping healthy skin and normal functioning of eyes.	Meat, whole grains and pulses.	Cheilosis
Vitamin B_5 (Niacin)	water soluble	(i) metabolism of carbohydrates, fats and proteins. (ii) healthy skin, sound mental health.	Milk, fish, legumes.	Pellagra
Vitamin B_6 (Pyridoxine)	water soluble	essential for fat synthesis and energy production.	Rice bran, yeast, fish, egg yolk.	Dermatitis, anaemia
Vitamin B_{12} (Cyanocobalamin)	water soluble	(i) metabolism of nervous tissue. (ii) healthy blood and proper growth.	Liver, cheese, milk, eggs	Pernicious anaemia
Vitamin C (Ascorbic acid)	water soluble	(i) keeps teeth, gums and joints healthy. (ii) metabolism of amino acids (iii) healing of cuts and wounds.	Tomatoes, oranges, lemon	Scurvy
Vitamin D (Calciferol)	fat soluble	(i) keeps the bones and teeth healthy.	Cod liver oil, butter, milk	Rickets
Vitamin E (Tocopherol)	fat soluble	(i) protection of vitamin A, carotene and ascorbic acid. (ii) necessary for normal reproduction and protection of liver.	Green leafy vegetables, eggs, nuts, milk.	Sterility
Vitamin K (Phylloquinone)	fat soluble	(i) clotting of blood.	Green leafy vegetables, soya bean.	Haemorrhages

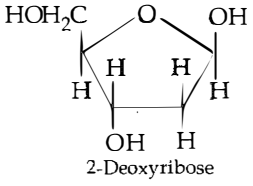
NUCLEIC ACIDS

- Nucleic acids are biologically important polymers, present in all living cells.
- The repeating units of nucleic acids are **nucleotides**, thus they are also regarded as **polynucleotides**.
- The three chemical components of a nucleotide are:
  - A nitrogen containing heterocyclic base
  - A five carbon sugar
  - A phosphate group
- There are two types of nitrogenous bases, purines and pyrimidines. Adenine (A) and guanine (G) are substituted purines and cytosine (C), thymine (T) and uracil (U) are substituted pyrimidines.
- There are two types of nucleic acids :
  - DNA (deoxyribonucleic acid)
  - RNA (ribonucleic acid)

- The sugar present in RNA is *D*-ribose and in DNA is *D*-2-deoxyribose.



Ribose



2-Deoxyribose

Base + Sugar = Nucleoside

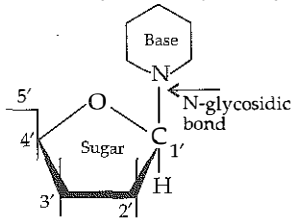
Base + Sugar + Phosphate = Nucleotide

For RNA, ribose (sugar) + uracil (base) = Nucleoside

For DNA, deoxyribose (sugar) + thymine (base) = Nucleoside

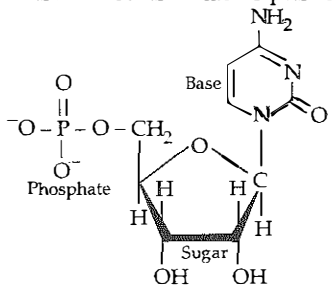
- **Structure of nucleic acids :** A unit formed by attachment of a base to 1′ position of sugar is known as nucleoside.

The sugars are numbered as 1′, 2′, 3′, etc in order to distinguish from bases. When nucleoside is linked to phosphoric acid at 5′ position of sugar moiety, we get as nucleotide.



Base-sugar linkage

Nucleotides are joined together by phosphodiester linkages between 5′ and 3′ carbon atoms of pentose sugar.

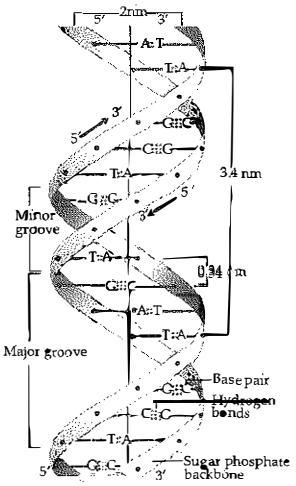


Nucleotide

The information regarding the sequence of nitrogenous bases in the chain of a nucleic acid is called its **primary structure**.

Structure of DNA (Double Helix Structure)

- The sequence of bases along the DNA and RNA chain establishes its primary structure which controls the specific properties of the nucleic acid. An RNA molecule is usually a single chain of ribose-containing nucleotides. On the basis of X-ray analysis of DNA, J.D., Watson and F.H.C. crick (shared noble prize in 1962) proposed a three dimensional secondary structure for DNA. DNA molecule is a long and highly complex, spirally twisted, double helix, ladder like structure. The two polynucleotide chains or strands are linked up by hydrogen bonding between the nitrogeneous base molecules of their nucleotide monomers. Adenine (purine) always links with thymine (pyrimidine) with the help of two hydrogen bonds and guanine (purine) with cytosine (pyrimidine) with the help of three hydrogen bonds. Hence, the two strands extend in opposite directions, *i.e.,* are antiparallel and complimentary.



Differences between DNA and RNA

	Deoxyribonucleic acid (DNA)	Ribonucleic acid (RNA)
1.	Occurs in the nucleus of the cell.	Occurs in the cytoplasm.
2.	Sugar present is 2-deoxy-*D*-(−)-ribose.	Sugar present is *D*-(−)-ribose.
3.	Contains cytosine and thymine as pyrimidine bases, guanine, adenine as purine bases.	Contains cytosine and uracil as pyrimidine bases and guanine and adenine as purine bases.
4.	Double-stranded α-helix structure.	Single-stranded α-helix structure.
5.	Undergoes replication.	Does not undergo replication.

Biological Functions of Nucleic acids

- Two important biological functions of nucleic acids are : **replication** and **protein synthesis**.
- **Replication :** The process by which a single DNA molecule produces two identical copies of itself. Replication is an enzyme catalysed process and starts with the partial unwinding of double helix structure through breaking of the hydrogen bonds. Each strand then acts as the template (or pattern) for the synthesis of two new strands of DNA.
- Protein synthesis occurs in two steps, *i.e.*, transcription and translation.
  - **Transcription** is the process of synthesis of RNA.
  - The synthesis of proteins occur in the cytoplasm of the cell. The *m*-RNA directs protein synthesis with the help of *r*-RNA and *t*-RNA. This process is called **translation**.
- **Genetic code :** Linear sequence of three nucleotides (triplets) in DNA or RNA that determines the specific amino acid sequence in the synthesis of proteins is called genetic code. It is the biochemical basis of heredity and nearly universal in all organisms.
- **Mutation :** A change in nitrogenous base sequence of DNA molecule which leads to the synthesis of proteins with an altered sequence of amino acids. Mutation may cause genetic disorders or diseases.