# Biochemistry

## For the students of Pharmacy Technicians (Category-B)

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# Dedication

To

Prof. Dr. Naim Anwar Muzaffar “The Father of Pharmacy”

Whose Dedications Toward Pharmacy Education Are Priceless.

# Acknowledgement

I am very grateful to **Ch. Muhammad Shamoon**, Secretary, Punjab Pharmacy Council, Lahore, who allowed me to compile BIOCHEMISTRY Book for the students of Pharmacy Technician.

I am very thankful to my teacher **Dr. Asma Razzq** who generously contributed their time and efforts to help me make this book as accurate and as useful as possible.

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# Contents

## BIOCHEMISTRY

Biochemistry, sometimes called biological chemistry, is the study of chemical processes within and relating to living organisms. Biochemistry deals with chemical or metabolic processes which take place in tissue cells. These metabolic reactions take place in the material called protoplasm which is the basis of all forms of life. As long as these reactions take place in an organized form we remain healthy.

Much of biochemistry deals with the structures, functions and interactions of biological macromolecules, such as proteins, nucleic acids, carbohydrates and lipids, which provide the structure of cells and perform many of the functions associated with life.

### WHAT IS BIOCHEMISTRY USED FOR?

- Biochemistry is used to learn about the biological processes which take place in cells and organisms.

- Biochemistry may be used to study the properties of biological molecules, for a variety of purposes. For example, a biochemist may study the characteristics of the keratin in hair so that a shampoo may be developed that enhances curliness or softness.
- Biochemists find uses for biomolecules. For example, a biochemist may use a certain lipid as a food additive.

- Biochemists can help cells to produce new products. Gene therapy is within the realm of biochemistry. The development of biological machinery falls within the realm of biochemistry.

- Biochemistry has been explaining the mechanisms of many physiological processes which were unknown in mystery.

- Physiology, pharmacology, bacteriology and pathology and even therapeutics have also greatly benefited from new discoveries in biochemistry.

- Biochemistry has assumed an increasingly important role in various branches of medicines and biochemists have frequently been called upon to provide the special techniques and knowledge to the solution of clinical problems.

- Biochemical investigations can lead quite directly to the suggestion of remedies. For example, the discovery of specific biochemical deficiencies in rickets, pellagra, beriberi, scurvy and pernicious anemia led rapidly to the successful therapy by a rational method.

- The biochemist has provided vitamins and hormones in pure conditions and has aided in the preparation of vaccines, antitoxins, sera, etc. the fields of enzyme inhibitors, recombinant DNA technology, genetic engineering, gene mapping.

- DNA profiling and cloning have opened a new era in medicine. Last but not the least it has provided a large number of chemical tests as aids in the diagnosis of diseases.

# Biochemical Principles

## Hydrogen Ion Concentration

Water is most abundant substance in human body making up to 65% to 70% body mass hydrogen bonding exists in water molecule.

Pure water is very slightly dissociated therefore called weak electrolyte. At 25c only one of every molecule in pure water is ionized at any instant.

$H_2O$ □ $H^+ + OH^-$

## pH

pH is a unit of measure which describes the degree of acidity or alkalinity of a solution. It is measured on a scale of 0 to 14.

The term pH is derived from "p", the mathematical symbol of the negative logarithm, and "H", the chemical symbol of Hydrogen. The formal definition of pH is the negative logarithm (or negative log) of the Hydrogen ion activity.

**pH = -log[H+]**

Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH very close to 7 and blood has a pH 7.35.

## Buffer Solution

Buffer is the compound or mixture of compounds that resist to changing pH of any solution on slight addition of acidic or basics solution or compound.

## The Colloidal State

The word colloid means glutinous or resembling glue and was first used for solutions of certain substances such as proteins, starch and gums which do not diffuse through most of the membranes.

## Crystalloids

A crystallizable substance that dissolve in liquid and passes easily through membrane is called crystalloids.

## Colligative Properties of Solutions

Colligative properties are those which depend on the number of solute particles. The following four changes in the colligative properties are seen as the number of particles increases in a solution.

- The osmotic pressure is increased
- Boiling point is raised
- Freezing point is depressed
- Vapor pressure is decreased

## Adsorption

The process by which molecules of a substance such as gas or liquid collect on the surface of another substance such as solid is called adsorption. Or

The condensation or adhesion of a gas, vapor, liquid or dissolved substances on the surface of a solid or liquid is called adsorption.

## Ion Exchange Resins

There is a very important group of substances called ion exchange resins that are widely used for the adsorption of negatively and positively charged ions from solutions in the laboratory in industry and in medicine. These substances are insoluble synthetic polymers of two types, cation and anion exchange resins, which contain acidic and basic groups respectively.

## Diffusion

Diffusion is the process in which ions or molecules move from a region of higher concentration to a region of lower concentration.

## Passive Transport

Passive transport is the transport of ions or molecules across a cell membrane by diffusion. Molecules moves from a region of high concentration to one of lower concentration. It does not require energy for diffusion process.

## Active Transport

Active transport is the transport of ions or molecules across a cell membrane from a region of lower concentration to one of higher concentration assisted by enzymes and requiring energy.

## Osmosis

The process by which a solvent passes from a solution of lower solute concentration to a solution of higher solute concentration through a semi-permeable membrane.

### Semi-Permeable Membrane

A membrane, which is permeable to the solvent but not to the solute particles e.g. natural membranes.

### Osmotic Pressure

Osmotic pressure of a solution is defined as the equivalent to the hydrostatic pressure which is produced when the solution is separated from a solvent by a semi-permeable membrane.

### Surface Tension

Surface tension is a contractive tendency of the surface of a liquid that allows it to resist an external force. The cohesive forces among liquid molecules are responsible for the phenomenon of surface tension.

### Viscosity

Viscosity can be described as “it is the internal resistance of the molecules of any liquid to flow called viscosity.

## CARBOHYDRATES

The definition of the carbohydrates is given as “carbohydrates are polyhydroxy aldehydes or ketones or their complex substances which on hydrolysis give polyhydroxy aldehydes or ketones. Or

A carbohydrate is a large biological molecule, or macromolecule, consisting of carbon (C), hydrogen (H), and oxygen (O) atoms, usually with a hydrogen, oxygen atom ratio of 2:1 (as in water). Or

The carbohydrates are the organic compounds. They are made up of carbon, hydrogen, oxygen. The literally meanings of carbohydrates are the hydrated carbons. Carbohydrates also called sugar. Or

Carbohydrates are aldehyde or ketone compounds with multiple (two or more) hydroxyl groups.

(Breakdown of water molecule in any compound is called hydrolysis)

### GENERAL FORMULA

As the carbohydrates are the hydrated carbons so the number of water molecules attach to the carbon are equal in number to the no of carbon atoms.

Thus the general formula is given as **Cn ($H_2O$)n**. here “n” is the whole number.

### Exception to the general formula and definition

There are some such carbohydrates which contain nitrogen, phosphorous or sulpher in addition to carbon.

Also all the compounds having formula **Cn($H_2O$)n** may not be carbohydrates formic acetic and lactic acids are some examples of such compounds.

## CHARACTERISTICS OF CARBOHYDRATES

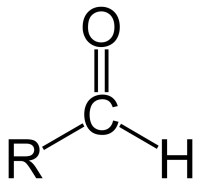
In general, carbohydrates are white solids, sparingly soluble in organic liquids but except for certain polysaccharides are soluble in water. Many carbohydrates of low molecular weight have a sweet taste.

## FUNCTIONAL GROUPS OF CARBOHYDRATES

The carbohydrates have two major categories on the basis of function group.

**ALDEHYDE GROUP**

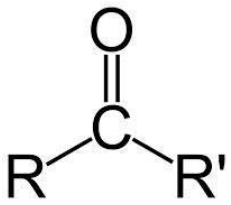
CHO it is on the first carbon the carbohydrate with aldehyde group is called aldoses (aldose sugar).




**Aldehyde Group**

**KETO GROUP**

Is on the second carbon the sugars with ketonic group are called ketoses (Keto-sugar).




**Keto Group**

## SOURCE OF CARBOHYDRATES

Carbohydrates are the natural compounds and their basic source is plants. The chief source of carbohydrates is the cereals (a grain used for food, e.g. wheat). Starch is the abundant in the cereals.

**The other source of carbohydrates is:**

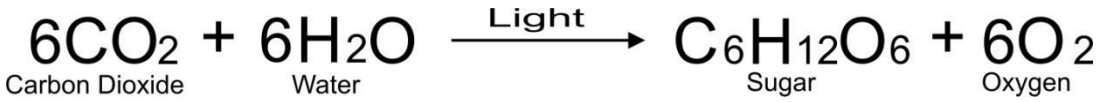
- Vegetables: e.g. potato, carrot
- Legumes: e.g. peanut
- Fruits: both sweet and non-sweet fruits provide carbohydrates.

## OCCURRENCE OF CARBOHYDRATES

Carbohydrates are the 2nd most occurring substance in nature after water. The surprising quantity of carbohydrates can be known by considering the point that cell wall of all plants made up of cellulose 50-80% of dry weight of plants is due to cellulose.

## NATURAL PRODUCTION OF CARBOHYDRATES

The carbohydrates are prepared by the plants by the process of photosynthesis. The photosynthesis involves the following reaction.




**CARBOHYDRATES MAJOR SOURCE OF ENERGY**

Carbohydrates are the macronutrients as 55% of our daily calories come from carbohydrates. 1g of carbohydrates provides 4 cal.

"When the molecules are oxidized so produced a high amount of energy" this is the principle used by carbohydrates to give energy. The process of oxidation of carbohydrates (also all other nutrients) is called respiration.

The reaction involve in respiration

**$C_6H_{12}O_6 + O_2$ ---------- $CO_2 + H_2O + E$**

**HOW CARBOHYDRATES SUPPLY ENERGY**

The simple sugars are absorbed directly by the small intestine into blood stream. But the disaccharide and polysaccharide do not absorbed in blood directly first convert into monosaccharide. This bond breaking also provides energy. Then the monosaccharides are absorbed by blood.

(Glucose stored in muscles & liver in the form of glycogen)

## FUNCTION OF CARBOHYDRATES

The carbohydrates perform the following major role in the living body.

- Carbohydrates are mainly utilized by the body for fulfilling the major part of the energy needs
- The main function of carbohydrate is to supply energy for the body processes. A greater part of the energy in the diet (more than 50-80%) is supplied by carbohydrates.
- Construction of body organs.
- Assist body in absorption of calcium.
- Helps in lowering cholesterol level.
- Provides nutrients to the friendly bacteria in digestive track that help in digestion.
- Balance water mineral balance.
- Oligosaccharides are present in the molecule of integral protein of al cell membranes.

### Sweetness in carbohydrates

Carbohydrates that has lower molecular mass are sweet in taste. as the molecular mass increases the sweetness decreases.

## Classification of Carbohydrates

There is no single satisfactory classification of carbohydrates. One commonly described classification is given below

1. **Monosaccharide**
2. **Disaccharide**
3. **Polysaccharide**

## Monosaccharide

These are simple sugars which cannot be further hydrolyzed and have empirical formula (**CH2O)n**, where **n=3** or larger number.

Monosaccharides are the most basic units of carbohydrates. They are the simplest form of sugar and are usually colorless, water-soluble, crystalline solids. Some monosaccharides have a sweet taste.

Examples of monosaccharides include glucose (dextrose), fructose (levulose) and galactose. Monosaccharides are the building blocks of disaccharides (such as sucrose) and polysaccharides (such as cellulose and starch).

**Mono=one**
**Saccharide=sugar**

- They are sweet in taste
- It cannot further hydrolyse
- Generally they are water soluble
- Two types of functional group are present in it, Aldehyde group or Keto group

### Classification of Monosaccharide

Monosaccharide can be classified on the basis of functional group.

1. **Aldose**
2. **Ketose**

Monosaccharides are either aldoses (containing aldehyde group) or ketoses (containing ketone group).

Glucose, dextrose, ribose are examples of aldose monosaccharides, while fructose is a ketoses monosaccharide.

## DISACCHARIDES

Two joined monosaccharides are called a disaccharide. Or we can say disaccharides give two monosaccharides on hydrolysis.

- Disaccharides give two monosaccharides on hydrolysis
- Disaccharides occur naturally
- They are less sweet than monosaccharide
- They are soluble in (H2O) water
- Their molecular mass greater than monosaccharide

## CLASSIFICATION OF DISACCHARIDES

1. **Homogeneous Disaccharides**
2. **Heterogeneous Disaccharides**

### HOMOGENEOUS

If all sugar molecules in disaccharides are same it is called homogeneous disaccharides e.g. maltose.

### HETEROGENEOUS

If all sugar molecules are different in disaccharides then it is called heterogeneous e.g. sucrose.

### Examples of Disaccharides

Sucrose (table sugar): (glucose + fructose)

Lactose (milk sugar): (glucose +galactose)

Maltose (fruit sugar): (glucose + glucose)

## POLYSACCHARIDES

Having more than ten sugar molecules and give disaccharides on hydrolysis and on further hydrolysis the monosaccharides are met.

- Many saccharides join to form polysaccharides
- They are tasteless and not optically active
- Polysaccharide serves as stores of fuel and also forms structural elements of cells

- Their molecular mass greater than monosaccharide or disaccharide

## Classification of Polysaccharides

There are two types of polysaccharide.

1. **Homopolysaccharides**
2. **Heteropolysaccharides**

### Homopolysaccharides

The polysaccharides which yield one type of monosaccharide on hydrolysis is called homopolysaccharides e.g. starch, Glycogen

### Heteropolysaccharides

The polysaccharides which yield different types of monosaccharide on hydrolysis called heteropolysaccharides e.g. Mucilage's, Hemi cellulose

### Examples of Polysaccharides

- **Cellulose:** most abundant on earth present in cell wall of plants.
- **Starch:** it is stored food material in plants in corns, grains etc.
- **Glycogen:** it mainly occurs in animal muscles and liver.
- **Starch:** it occurs in grains seeds and tubers

## LIPIDS

The lipids are organic substances occurring in plant and animal tissues belong to a very heterogeneous group of substances.

Lipids include fats, oils, waxes, steroids & defined as substances having the following properties.

- They are insoluble in water (hydrophobic) but soluble in non-polar solvents (ether, chloroform, benzene)
- Their primary building blocks are fatty acids, glycerol
- In most cases they can be utilized by the living organisms
- Most common lipid is fat in animals & plants

(Fatty acid = an organic acid with a long straight hydrocarbon chain and even number of carbon atoms e.g. oleic acid, stearic acid, butyric acid)

(Glycerol = a sweet colorless or yellowish syrupy alcohol)

## CLASSIFICATION OF LIPIDS

These are classified as

1. **Simple Lipids**
2. **Compound Lipids or Complex Lipids**
3. **Derived Lipids**

## SIMPLE LIPIDS

Naturally occurring oils, fats and waxes are collectively known as “simple lipids". Simple lipids are the esters of long chain fatty acids with alcohols. Or

Simple lipids are esters of fatty acids with various alcohols. They contain mainly fatty acids and alcohols alone.

**Note:** Ester is a chemical compound formed by the interaction of acid and alcohol

### FATS AND OILS

These are esters of fatty acids with glycerol (Trihydroxy alcohol). Fat is also called triglyceride A fat in liquid state called oil

## WAXES

These are esters of fatty acids with long chain monohydric alcohols.

### Occurrence

Waxes are wide spread in nature as secretion of certain insects as protective coating of skin e.g. honey bee wax, fur of animals, certain animal oil & whale largely composed of waxes. Sebum is a secretion of human skin having waxes. It helps skin to be moist and flexible.

## COMPOUND OR COMPLEX LIPIDS

These are the esters of glycerol with two saturated or unsaturated fatty acids and some other compound such as carbohydrate, amino acid, phosphoric acid or protein etc. They are also known as complex or conjugated lipids.

(Fatty acid = an organic acid with a long straight hydrocarbon chain and even number of carbon atoms e.g. oleic acid, stearic acid, butyric acid)

### Compound or complex lipids are subdivided as follows

#### GLYCOLIPIDS ALSO CALLED GLYCOSPHINGOLIPIDS

These contain sphingosine, fatty acid, and a monosaccharide or an oligosaccharide unit.

#### SULFOLIPIDS

These contain sphingosine, fatty acids, sugar and a sulfate group.

#### PHOSPHOLIPIDS

These lipids contain phosphoric acid, fatty acid, nitrogenous base and alcohol.

#### LIPOPROTEINS

These are the macromolecular complexes of lipids with proteins.

## DERIVED LIPIDS

These lipids are obtained on hydrolysis of simple and complex lipids. These lipids contain glycerol and other alcohols. This class of lipids includes steroid hormones, ketone bodies, hydrocarbons, fatty acids, fatty alcohols etc.

## Functions of Lipids

- Lipids are good source of energy.
- Lipids are essential for the absorption of fat soluble vitamins like vitamin A, D, E and K.
- The dietary lipids decrease gastric motility and have a high satiety (a feeling or condition of being full after eating food) value.
- Body fat gives anatomical stability to organs.
- Fats are good reservoir in the body. Adipose tissue is best suited for this purpose due to its very little water content.
- Lipids exert an insulating effect on the nervous tissue.
- Lipids are integral part of cell protoplasm and cell membranes.
- Some lipids act as precursors of very important physiological compounds e.g. cholesterol is precursor of steroid hormones.

## Proteins

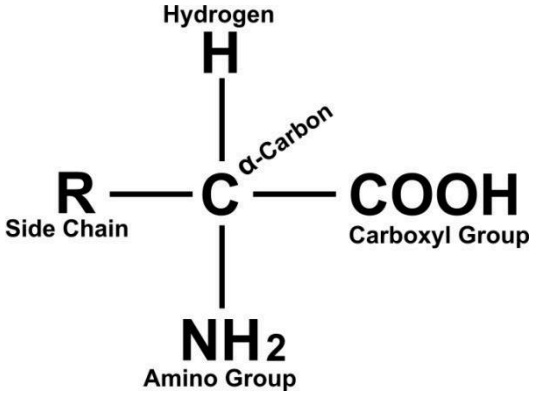
The proteins are extremely complicated molecules and are nitrogenous compound made up of a variable number of amino acids joined to each other by specific type of covalent bond called peptide bond or peptide linkage.

(Peptide Bond = A molecule consisting of two or more amino acid linked by bond between the amino group (-NH) and carboxyl group (-CO) this bond is known as a peptide bound)

Or simple we can say that “Proteins are polymers of amino acids”

(Polymer = a natural or artificial substance made from many small molecules)

## General Formula of Amino Acid




## Functions of Proteins

- Protein is termed the building block of the body. It is called this because protein is vital in the maintenance of body tissue, including development and repair.
- Protein is a major source of energy.
- Protein is involved in the creation of some hormones.
- Enzymes are proteins that increase the rate of chemical reactions in the body.
- Protein is a major element in transportation of certain molecules. For example, hemoglobin is a protein that transports oxygen throughout the body.
- Protein is also sometimes used to store certain molecules.
- Protein forms antibodies that help prevent infection, illness and disease.
- Many of the hormones which regulate the chemicals and other process of the body are also protein in nature.
- Plasma proteins take part in blood coagulation and transport of substances such as hormones, drugs, metal like iron and copper.
- They perform hereditary transmission by nucleoproteins of the cell nucleus.

## Structure of Proteins

Each type of proteins contains a specific number of amino acids. Different kinds of proteins have different shapes are related to their particular function in life processes. Proteins molecules have different several different level of structure.

(Polypeptide = A molecule consisting of three or more amino acids linked together by peptide bond is called polypeptide or polypeptide chain)

(Peptide Bond = A molecule consisting of two or more amino acid linked by bond between the amino group (-NH) and carboxyl group (-CO) this bond is known as a peptide bond)

### Primary Structure of Proteins

Linear sequence of Amino acids is called primary structure, in it, amino group (NH2) is on left side and carboxylic group (COOH) is on right side

### Secondary Structure

The folding of the polypeptide chain into a specific coiled structure held together by Hydrogen bond is called secondary structure.

### Tertiary Structure

The tertiary structure of a protein means it's over all three dimensional shape (3D). Complex secondary structure will take on three dimensional structures, in which there is folding looping and binding of chain including all of its secondary structure. The final shape may be a globe or an irregular shape.

### Quaternary Structure

When a protein molecule is made up of more than one polypeptide chains subunit, each of which has its own primary, secondary and tertiary structure, the number as well as the arrangement of these polypeptide subunits is called the quaternary structure.

## Classification Of Proteins

Proteins are divided into three main classes

1. **Simple Proteins**
2. **Conjugated or Compound Proteins**
3. **Derived Proteins**

### Simple Proteins

On hydrolysis these proteins yield only amino acids or their derivatives.

### Conjugated or Compound Proteins

Conjugated proteins are composed of simple proteins combined with a non-proteinous substance. The non-proteinous substance is called prosthetic group or cofactor.

### Derived Proteins

This class of proteins includes substances which are derived from simple and conjugated proteins. We can say that these are not naturally occurring proteins and are obtained from simple proteins by the action of enzymes and chemical agents.

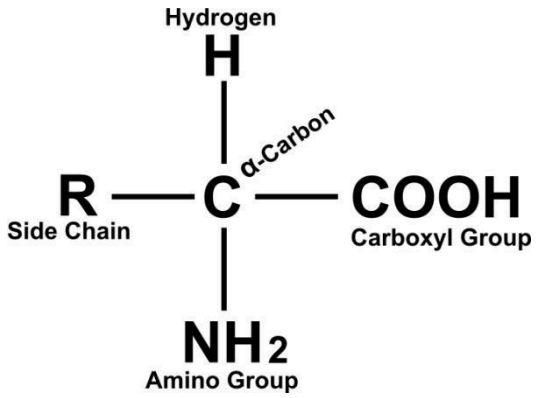
## Amino Acids

Amino acids are the building blocks of proteins. They form protein by a biochemical bond called peptide bond or peptide linkage. Various number of amino acid joins to one another with peptide bond to form “protein”. There are twenty different kinds of amino acids but with different combination they form different kinds of protein.

Amino acids can be used to produce energy, but their primary job is building proteins. Some amino acids also fill non-protein-building roles, such as forming neurotransmitters and hormones.

### Structure

Amino acid has very simple structure. It contained a central alpha carbon (The carbon attached with the functional Group is called alpha carbon). There is carboxlic acid present on one side and an amino group on other side of alpha carbon. Hydrogen is present on alpha carbon with R group. The R group may vary to produce different types of Amino acids.




### Standard Amino Acids

Although more than 300 naturally occurring amino acids are known but only twenty amino acids take part in the formation of all types of proteins plant as well as animal in origin. These twenty amino acids are called primary standard or normal amino acids.

### Non-Standard Amino Acids

The non-standard amino acids are those amino acids which do not take part in protein synthesis but many of them play important role in the body.

### Essential Amino Acids

Essential amino acids are those amino acids which are not produced by our body and must be taken in diet.

## Non-essential Amino Acids

Non-essential amino acids are those amino acids that can be synthesized by our body.

## Functions of Amino Acids

**"Amino acids are building blocks of proteins"**

So all the functions which proteins perform are the function of amino acids

**Roles and Functions of Proteins or Amino Acids**

- Protein is termed as the building block of the body. It is called this because protein is vital in the maintenance of body tissue, including development and repair.
- Protein is a major source of energy.
- Protein is involved in the creation of some hormones.
- Enzymes are proteins that increase the rate of chemical reactions in the body.
- Protein is a major element in transportation of certain molecules. For example, hemoglobin is a protein that transports oxygen throughout the body.
- Protein is also sometimes used to store certain molecules.
- Protein forms antibodies that help prevent infection, illness and disease.
- Many of the hormones which regulate the chemicals and other process of the body are also protein in nature.
- Plasma proteins take part in blood coagulation and transport of substances such as hormones, drugs, metal like iron and copper.
- They perform hereditary transmission by nucleoproteins of the cell nucleus.

## Nucleic Acids

Nucleic acids are large biological molecules, essential for all known forms of life. Nucleic acids, which include DNA (deoxyribonucleic acid) and RNA (ribonucleic acid), are made from monomers known as nucleotides.

**Two types of nucleic acids**

1. **DNA or Deoxyribonucleic Acid**
2. **RNA or Ribonucleic Acid**

### Nucleotides

Nucleotides are the building blocks of all nucleic acids. Each nucleotide has three components, 5-carbon sugar, a phosphate group, and a nitrogenous base.

(The combination of a Nitrogen Base and 5-Carbon Sugar is called a *nucleoside*, when phosphate is added to a nucleoside; the molecule is called a nucleotide).

## Components of Nucleic Acids or Nucleotides

- **Nitrogen Base (Pyrimidine or Purine)**
- **5-Carbon Sugar or Pentose Sugar (Ribose or Deoxyribose)**
- **Phosphate Group**

### Nitrogenous Bases

Purines and pyrimidines are the two categories of nitrogenous bases. Adenine and guanine are purines. Cytosine, thymine, and uracil are pyrimidines. In DNA, the bases are adenine (A), thymine (T), guanine (G), and cytosine (C). In RNA, the bases are adenine, thymine, uracil, and cytosine,

- Purines: These include adenine and guanine which are abbreviated as A and G respectively.
- Pyrimidines: These include cytosine, uracil, and thymine, abbreviated as C, U, and T respectively.

### 5-Carbon Sugar

Two kinds of 5-carbon sugar fond in nucleic acid or nucleotides

1. **Ribose**
2. **Deoxyribose**

Both ribose and deoxyribose are 5-csrbon sugars or pentose sugar. If the sugar is ribose, the polymer is RNA, if the sugar is Deoxyribose, the polymer is DNA.

### Phosphate Group

A phosphate group consists of a central phosphorous surrounded by four oxygen ($PO_4$).

## Types and function of RNA

There are actually several types of ribonucleic acid or RNA, but most RNA falls into one of three categories

1. **mRNA or Messenger RNA**
2. **rRNA or Ribosomal RNA**
3. **tRNA or Transfer RNA**

### mRNA or Messenger RNA

Messenger RNA (mRNA) carries the genetic information copied from DNA into a form that can be read and used to make proteins. mRNA carries genetic information from the nucleus to the cytoplasm of a cell.

### rRNA or Ribosomal RNA

rRNA is located in the cytoplasm of a cell, where ribosomes are found. rRNA directs the translation of mRNA into proteins.

### tRNA or Transfer RNA

Like rRNA, tRNA is located in the cellular cytoplasm and is involved in protein synthesis.

## Functions of DNA

- All known cellular life and some viruses contain DNA.
- The main role of DNA in the cell is the long-term storage of information.
- DNA contains the "programmatic instructions" for cellular activities.
- DNA provides the information needed to make a new living cell by cell division.
- When a cell divides, its DNA is copied and passed from one cell generation to the next generation.
- DNA control everything in the cells, the response to external agents, the regulation of proteins, ribosome and RNA.
- DNA holds the instructions for an organism's or each cell's development and reproduction and ultimately death.
- DNA is vital for all living beings even plants. It is important for inheritance, coding for proteins and the genetic instruction guide for life and its processes.
- DNA carries the codes for proteins. However, the actual protein differs a lot from the codes present on the DNA.
- DNA is important in terms of heredity. It packs in all the genetic information and passes it on to the next generation. The basis for this lies in the fact that DNA makes genes and genes make chromosomes.
- DNA contains the genetic information that gives rise to the chemical and physical properties of living organisms.
- Apart from coding for proteins, DNA also replicates. This helps in a variety of functions including reproduction to maintenance and growth of cells, tissues and body systems.

# HORMONES

All the physiological activities are regulated by two major systems in the body

1. **Nervous System**
2. **Endocrine System**

These two systems interact with one another and regulate the body functions.

## ENDOCRINE SYSTEM

The endocrine system is the system of glands, each of which secretes different types of hormone directly into the bloodstream to regulate the body. The endocrine system does not include exocrine glands such as salivary glands, sweat glands and glands within the gastrointestinal tract.

## CHEMICAL MESSENGERS

The chemical messengers are the substances involved in cell signaling, these messengers are mainly secreted form endocrine glands.

Some chemical messengers are secreted by nerve endings and the cells of several other tissues. Generally the chemical messengers are classified into two types

- **Classical Hormones**
- **Local Hormones**

(Classical hormones secreted by endocrine glands)
(Local hormones secreted from other tissues)

## ENDOCRINE GLANDS

Endocrine glands are glands, which synthesize and release the classical hormones into the blood. The endocrine glands are also called ductless glands because the hormones secreted by them are released directly into the blood without any duct.

These hormones are transported by blood to the target organs or tissues in different parts of the body where the actions are executed.

## THE MAIN ENDOCRINE GLANDS INCLUDE

- Pineal gland
- Pituitary gland

- Thyroid gland
- Parathyroid gland
- Adrenal gland
- Pancreas
- Ovaries (in female only)
- Testes (in male only)

## HORMONES INTRODUCTION

These are chemical substances released by a cell or a gland into the bloodstream and have a physiological control effect on other cells of the body.

Some important hormones are growth hormone (GH), Testosterone, Estrogen, Progesterone, Oxytocin, Calcitonin, Aldosterone, Cortisol, and Insulin. Or

Hormones are the chemical messengers of the body. They are defined as organic substances secreted into blood stream to control the metabolic and biological activities. These hormones are involved in transmission of information from one tissue to another and from cell to cell.

These substances are produced in small amounts by various endocrine (ductless) glands in the body. They are delivered directly to the blood in minute quantities and are carried by the blood to various target organs where these exert physiological effect and control metabolic activities. Thus frequently their site of action is away from their origin.

## Classification of hormones

1. **Based on the site of production/ accumulation**
2. **Based on the chemical nature**

## Classification of hormones based on the site of production/ accumulation

### Hormones of Pituitary Glands

#### Hormones of Anterior Pituitary Flands

- Growth hormone
- Thyroid stimulating hormone

#### Hormones of Posterior Pituitary Flands

- Oxytocin hormone
- Antidiuretic hormone (ADH)

### Hormones of Thyroid Glands

- Tri-iodothyronine (T3)
- Tetraiodothyronine (T4)
- Calcitonin

### Hormones of Parathyroid Glands

- Parathormone (PTH)

### Hormones of Adrenal Gland

- Aldosterone hormone
- Cortisol hormone

### Hormones of Ovary Gland

- Estrogen hormone
- Progesterone hormone

### Hormones of Testis

- Testosterone hormone
- Dihydrotestosterone hormone

### Hormone of Pancreas

- Insulin

## Classification Of Hormones Based On The Chemical Nature

Chemically, most hormones belong to one of three major groups…

1. **Steroid Hormones**
2. **Protein Hormones**
3. **Derivative of the Amino Acid Called Tyrosine**

### Steroid Hormones

These are hormones formed from cholesterol or its derivatives, e.g. testosterone, aldosteron, estrogen, progesterone.

Steroid hormones help control metabolism, inflammation, immune functions, salt and water balance, development of sexual characteristics.

### Protein Hormones

These are large or small peptide, e.g. growth hormone, oxytocin, insulin. Several important peptide hormones are secreted from the pituitary gland.

### Derivative of the Amino Acid Called Tyrosine

These are derivatives of amino acid, e.g. dopamine, adrenaline.

## Hormonal Actions

Hormone does not act directly on the cellular structures. First the hormone combine with transmembrane (transmembrane existing or occurring across a cell membrane) receptors present on the target cells and forms a hormone-recapture complex. This hormone-receptor complex induces various changes or reactions in the target cells.

The hormones receptors are situated either in cell membrane, cytoplasm or nucleus of the cells.

**Cell Membrane**

Receptors of protein hormones are situated in the cell membrane.

**Cytoplasm**

Receptors of steroid hormones are situated in cytoplasm of target cells.

**Nucleus**

Receptors of the thyroid hormones are in the nucleus of the cell.

Generally when a hormone is secreted in excess, the number of receptors of that hormone decreases this process is called down-regulation. During the deficiency of hormones, the number of receptors increases which is called up-regulation.

Proteins and peptides cannot enter the cell and so act via cell membrane receptors, producing their effects by 'second messengers', which are activated in the cell as soon as the hormone binds to the receptor. Thus peptide hormones can produce quite rapid responses. Steroid and thyroid hormones, by contrast, can enter the cell and bind to intracellular receptors, producing their effects by stimulating the production of new proteins. There is therefore a relatively long lag period before the response to these hormones is seen.

## GROWTH HORMONE (GH)

Growth hormone (GH) is a peptide hormone that stimulates growth, cell reproduction and regeneration in humans and other animals. Growth hormone is a 191-amino acid, single-chain polypeptide that is synthesized, stored, and secreted by anterior pituitary gland. Its half life is about 20 minutes.

### NORMAL FUNCTIONS OF GH

Effects of growth hormone on the tissues of the body can generally be described as anabolic (building up). Like most other protein hormones, GH acts by interacting with a specific receptor on the surface of cells. Increased height during childhood is the most widely known effect of GH.

### EFFECT ON PROTEIN METABOLISM

Growth hormone has predominately anabolic effects on skeletal and cardiac muscles. It stimulates the synthesis of protein, RNA, DNA.

It promotes amino acid entry into cells.

It decreases the catabolism of protein because growth hormone mobilizes free fatty acids to supply energy.

### EFFECTS ON CARBOHYDRATE METABOLISM

Growth hormone is one of an important chemical substance that maintains blood glucose within a normal range. Growth hormone is often said to have anti-insulin activity

### Effects on Fat Metabolism

Growth hormone enhances the utilization of fat by stimulating triglyceride breakdown and oxidation in adipose tissues.

### Effects on Inorganic Metabolism

Growth hormone increases the retention of the phosphorus and calcium. It also causes the retention of sodium, potassium, and magnesium.

### Effects on Bone, Cartilage, and Soft Tissues

- It acts on cartilage and bone to stimulate the growth.
- It increases the deposition of connective tissue.
- It increases the thickness of skin.
- It increases the growth of important organs of the body like liver and kidney etc.
- It increases milk secretion in lactating animals.

## Vasopressin/ Antidiuretic Hormone (ADH)

The Antidiuretic hormone is the hormone of the posterior pituitary gland. It prevents excessive urine production. ADH is a polypeptide, containing 9 amino acids. Its half life is 18-20 minutes.

Vasopressin is responsible for regulating the body's retention of water by acting to increase water absorption in the collecting ducts of the kidney nephron.

It increases the permeability of the collecting tubules and ducts to water, increasing water absorption from the lumen of the collecting tubules and ducts.

ADH can also raise blood pressure by bringing about constriction of arterioles. It causes the contraction of all smooth muscles in the body such as the GIT, Bile Duct, and Uterus.

## Oxytocin (OT)

Oxytocin (OT) is traditionally thought of as a ‘female’ hormone due to its role in milk ejection. However, OT is recognized as having roles in male reproduction. It is secreted in both males and females. Oxytocin is best known for its roles in sexual reproduction, in particular during and after childbirth.

This is a hormone of the posterior pituitary gland. It is polypeptide containing 8 amino acids. Its half-life is about 6 minutes.

#### Action in Females

In females, oxytocin acts on mammary glands and uterus. It causes ejection of milk from the mammary glands.

Oxytocin causes contraction of uterus and helps in the expulsion of fetus. It is released in large quantity just prior to delivery.

#### Action in Males

In male, the release of oxytocin increases during ejaculation. It facilitates release of sperm into urethra by causing contraction of smooth muscles fibers in reproductive tract.

## Insulin

Insulin is a peptide hormone, produced by beta cells of the pancreas, which acts to lower the blood glucose level, regulating carbohydrate and fat metabolism in the body.

### Chemical Nature

Insulin is small soluble protein containing 51 amino acids.

### Effects of Insulin

#### Effects of Insulin on Carbohydrate Metabolism

- It increases the entry of glucose into cells by stimulating the process of facilitated diffusion, especially in muscles, adipose tissue, the heart, smooth muscles, of the uterus by activating glucokinase. But on the other hand insulin does not facilitate glucose entry into the brain and RBCs.
- It increases utilization of glucose for energy.
- It increases glycogen storage in cells
- It increases the conversion of glucose into fat to be stored in adipose tissues.

#### Effects of Insulin on Fat Metabolism

- Insulin forms fatty acids from excess liver glucose.
- Fatty acids are utilized from triglycerides which are stored in adipose tissues.
- It inhibits hydrolysis of triglycerides in fat cells by inhibiting hormone sensitive lipase.

#### Effects of Insulin on Protein Metabolism

- It causes active transport of amino acids into cells.
- It promotes translation of mRNA in ribosomes to form new proteins.
- It promotes transcription of DNA in nucleus to form mRNA.
- It inhibits protein catabolism.

### Effects of Insulin on Growth

Insulin is essential for growth as it increases protein formation.

## Testosterone

This is the principle hormone of the testes which consists of 19 carbon atoms. It is responsible for the proper development of male sexual characteristics. Testosterone is also important for maintaining muscle bulk, adequate levels of red blood cells, bone growth, a sense of well-being, and sexual function.

### Nature

Steroid in nature

## Effects of Testosterone

### Effect on the Male Reproductive System

During intrauterine life, testosterone is secreted by the genital ridge. Later on it is secreted by the placenta. At this stage it causes the development of male sex organs including the penis, scrotum prostate, seminal vesicle, and male genital duct.

This hormone also causes descent of the testes (during last 2 months of gestation) and suppresses the formation of female genital organs.This hormone causes the enlargement of the male sexual organs. It acts on different male sex organs, increasing spermatogenesis and maintaining the motility and fertilizing power of sperm.

### Effects on Secondary Sex Characteristics

The effects of testosterone on secondary sex characteristics are as follow. Growth of hairs on the face, chest, and pubis are increases, while decreased on top of the head, voice becomes deeper. Testosterone causes thickness of the skin, roughness of the subcutaneous tissue. Testosterone is also responsible for aggressive moods, active attitudes and interest in the opposite sex.

### Effect on Protein Mmetabolism

- It increases protein synthesis and build up the musculature.
- Causes positive N- balance.
- Decreases blood urea levels.

### Effect on Bone

- Increases thickness of bones

- Increases total quantity of bone matrices.
- Increases the deposition of calcium salts in bones.
- Narrows the length of the male pelvis outlet.
- Increases the length of the male pelvis and makes it funnel shaped.
- Increases the strength of the pelvis and makes it strong.

### Effect on RBCs

Testosterone increases the number of RBCs (15-20%). However this difference may be due to the increased metabolic rate following testosterone administration rather than to a direct effect of testosterone on RBC production.

### Effect on Electrolyte and Water Balance

Testosterone can increase the reabsorption of NA+ and water in the distal tubules of the kidneys. This effect of testosterone is of a minor degree.

## Estrogen

Estrogen is a group of hormones that play an important role in the normal sexual and reproductive development in women. They are also called sex hormones. The woman's ovaries produce most estrogen hormones, although the adrenal glands also produce small amounts of the hormones.

**Nature**

An 18 carbon steroid

### Actions of Estrogens

- Increases the size of the vagina
- Increases the size of the uterus
- Causes growth of the uterine glands
- Causes enlargement of the musculature of the walls of the vagina
- Increases the size of the llitoris and labia minora
- Promotes the development of the tubular duct system
- Increases vascularity of the skin. Causes softness and smoothness of the skin (This is why estrogen is used in creams, soaps and oils for cosmetic purposes)
- The larynx of a female retains its prepubertal, so size the voice remains high pitched
- Causes broadness of the pelvis
- Increases the synthesis and deposition of proteins
- Increases the synthesis of fat

- Increases the deposition of fat in subcutaneous tissue especially the breasts medial side of the thigh and buttocks
- It increases the retention of Na+ and water increasing the E.C.F.
- This hormone is responsible for the proliferative phase of the menstrual cycle
- Decreases blood cholesterol levels

## ENZYMES

### DEFINITIONS

Enzymes are biological molecules that catalyze chemical reactions.

Enzymes are important group of bio-molecules synthesized by the living cells. They are catalysts of biological systems, colloidal, thermo-labile and protein in nature.

### CATALYSTS

A catalyst is an agent, which in minute amount increases the velocity of a reaction without appearing in the final product of the reaction.

### SUBSTRATES

Substances on which enzymes act to convert them into products are called substrates.

### PROPERTIES OF ENZYMES

- Catalytic property
- Enzymatic property
- Solubility
- pH
- Temperature
- Specificity
- Protein nature

**Catalytic Property**

Small amount of enzyme can catalyze the large amount of substrate in biological reactions.

**Enzymatic Property**

The velocity of the enzymatic reaction increase as the concentration of the substrate increases up to certain maximum. But after certain period of time it decreases.

**Solubility**

Enzymes are mostly soluble in water and diluted alcohol solution. The enzymes can precipitate in concentrated Alcohol, Ammonium Sulphate, Tricholoro Acetic Acid.

**pH**

**Acid:**

Acid deactivates those enzymes that act at alkaline pH, e.g Trypsin. At acidic pH, it will destroy, (Trypsin is very important enzyme that secreted by Pancreas and very important for proper digestion of food).

**Base:**

Base deactivates the enzymes that act at acidic pH, e.g. Pepsin, at alkaline pH, it will destroy.

**Temperature**

Optimum temperature for enzymatic activity is 35° C to 40° C.

| | |
|---|---|
| At 0° C | inactive |
| At 10° C to 20° C | very little active |
| At 35° C to 40° C | max. Active |
| At 50° C | inactive |
| At 60° C | destroy |

In solid condition, it may be stable up to 100° C.

**Specificity**

Enzymes are usually very specific as to which reactions they catalyze and the substrates that are involved in these reactions.

**Protein Nature**

In general with the exception of “Ribozymes, which are few RNA molecules with enzymatic activities” all enzymes are protein in nature with large molecular weight.

## Mechanism of Enzyme Reactions

The three dimensional structure of enzyme permits them to recognize their substrates in a specific manner.

According to the most acceptable hypothesis, the enzyme molecule (E) first combine with a substrate (S) to form a enzyme-substrate complex (ES) which further dissociate to form product (P) and enzyme (E) back.

Enzyme once dissociated from the complex is free to combine with another molecule of substrate and form product in a similar way.

**General Reaction**

E + S □ ES □ EP □ E + P

## Chemical Nature of Enzyme

In general, with the exception of Ribozymes which are few RNA molecules with enzymatic activity, all the enzymes are either pure proteins (simple protein) or contain protein as essential components (conjugated protein).

Few enzymes are simple proteins while some are conjugated proteins. In such enzymes (conjugated protein) the non-protein part is called prosthetic group or coenzyme and the protein part is called apoenzyme.

(The complete structure of apoenzyme and prosthetic group is called holoenzyme)

**Holoenzyme = apoenzyme** (protein part) **+ coenzyme** (non-protein part/ prosthetic group)

Certain enzymes with only one polypeptide chain in their structure are called monomeric enzyme e.g. Ribonuclease, several enzymes possess more than one polypeptide chain and are called oligomeric enzymes e.g. Lactate Dehydrogenase.

(Polypeptide = a condensation of amino acids that forms a protein molecule, or a molecule consisting of three or more amino acid linked together by peptide bonds.)

### Coenzyme

Certain enzymes require a specific thermostable, low molecular weight, non-protein organic substances called coenzymes. A coenzyme may bind covalently or non-covalently to the apoenzyme. The term prosthetic group denotes a covalently bonded enzyme.

## Classification of Enzymes

Enzymes are generally named after adding the suffix “ase” to the name of the substrate, e.g. enzymes acting on “nucleic acid” are known as “nuclease”. Even-though few exceptions such as Trypsin, Pepsin, and Chymotrypsin are still in use. Further, few enzymes exist in their inactive forms and called as Proenzymes or Zymogens e.g. Pepsin has Pepsinogen as its zymogen.

There are six main classes of enzymes

1. **Oxidoreductases**
2. **Transferases**
3. **Hydrolases**
4. **Lyases**
5. **Isomerases**
6. **Ligases**

(Catch words to remember the classification of enzymes = OTH-LIL)

## OXIDOREDUCTASES

These enzymes catalyze oxidation-reduction reactions, e.g. Alcohol dehydrogenase, Lactate dehydrogenase.

This group is further divided into six-subgroups

- **Oxidases**
- **Reductases**
- **Aerobic Dehydrogenases**
- **Anaerobic Dehydrogenases**
- **Hydroperoxidases**
- **Oxygenases**

## TRANSFERASES

Enzymes that catalyze the transfer of a functional group (e.g., a methyl or phosphate group) from one molecule (called the donor) to another (called the acceptor).

For example, an enzyme that catalyzes this reaction would be a transferase

**A–X + B → A + B–X**

In this example, A would be the donor, and B would be the acceptor. The donor is often a coenzyme.
There are many types of transferases, some important are

- **Transaminases**
- **Phosphotransferases**
- **Transmethylases**
- **Transpeptideases**

### Hydrolases

These enzymes catalyze hydrolysis, e.g Pepsin, Trypsin

They have many subgroups some important are

- **Carbohydrases**
- **Aminohydrolases**
- **Lipids Hydrolyzing Enzymes**

### Lyases

Enzymes that facilitate removal of small molecules from a large substrate, e.g. Histidine Decarboxylase, Carbonic Anhydrase.

### Isomerases

Enzymes involved in isomerization of substrate, e.g. Retinal Isomerase.

### Ligases

Enzymes involve in joining together two substrates, e.g. RNA synthetase, Glutamine Synthetase.

## Factor Affecting Enzyme Activities

Following factors affect enzyme activities

- Enzyme concentration
- Substrate concentration
- Product concentration
- Effect of temperature
- Effect of pH
- Effect of activator and coenzyme
- Effect of inhibitors
- Effect of time

**Enzyme Concentration**

The rate of reaction is directly proportional to the amount of enzyme present.

**Substrate Concentration**

The rate of reaction is directly proportional to the substrate concentration. However this is true up to a certain concentration of substrate.

**Product Concentration**

Excess of product may lower the enzymatic reaction by occupying the active site of the enzyme. It is also possible that, certain conditions, on high concentration of products a reverse reaction may be favored forming back the substrate.

**Effect of Temperature**

Optimum temperature for enzymatic activity is 35° C to 40° C.

| | |
|---|---|
| At 0° C | inactive |
| At 10° C to 20° C | very little active |
| At 35° C to 40° C | max. Active |
| At 50° C | inactive |
| At 60° C | destroy |

In solid condition, it may be stable up to 100° C. some plant enzymes act best at temperature around 60° C.

**Effect of pH**

Optimum pH is required for the proper function of enzyme

**Acid:**

Acid deactivates those enzymes that act at alkaline pH, e.g Trypsin. At acidic pH, it will destroy, (Trypsin is very important enzyme that secreted by Pancreas and very important for proper digestion of food).

**Base:**

Base deactivates the enzymes that act at acidic pH, e.g. Pepsin, at alkaline pH, it will destroy.

**Effect of Activator and Coenzyme**

The activity of certain enzymes is greatly dependent of activators and coenzymes.

**Effect of Inhibitors**

Enzymes are protein and they can be inactivated by the agents that denature them. The chemical substances which inactive the enzymes are called as inhibitors and the process is called enzyme inhibition. Certain substances inhibit the enzyme activities.

**Effect of Time**

The time required for completion of an enzyme reaction increase if the optimum temperature and pH is not present.

## FUNCTIONS OF ENZYMES

Enzyme plays a vital role in our daily life. They perform following important functions.

- Decrease in activation energy
- Digestion
- Cheese making
- Sweetener
- As detergent
- As drug
- For cancer treatment
- Curing of diseases
- Blood clotting
- Alcoholic beverages
- Meat tenderizing

**Decrease in Activation Energy**

Enzymes decrease activation energy.

**Digestion**

Enzymes play important role in digestion for the conversion of large complex and non-diffusible molecules into smaller, simple and diffusible molecules, e.g. Trypsin, Lipase, Amylase.

**Cheese Making**

Enzymes are also used in the manufacturing of cheese.

**Sweetener**

Some enzymes are used as sweetener,

E.g. Sucrose $\xrightarrow{\text{(glucosidase enzyme)}}$ Glucose + Fructose

Glucose is 72% sweeter while fructose is 132% sweeter than sucrose.

**As Detergent**

Carbohydrate and protein breaking enzymes are heat stabilizer and are used as detergent, e.g. Proteases

**As Drug**

Some enzymes are used as drugs if there is any disturbance in the digestive system.

**For Cancer Treatment**

Some enzymes are used for cancer treatment, e.g. L. Asparginase

**Curing of Diseases**

Enzymes are also play important role in curing of diseases such as rickets and jaundice, for heart problem Lactate Dehydrogenase, and for liver problem certain Kinases are used.

**Blood Clotting**

Enzymes also cause blood clotting by protein thrombin.

### Alcoholic Beverages

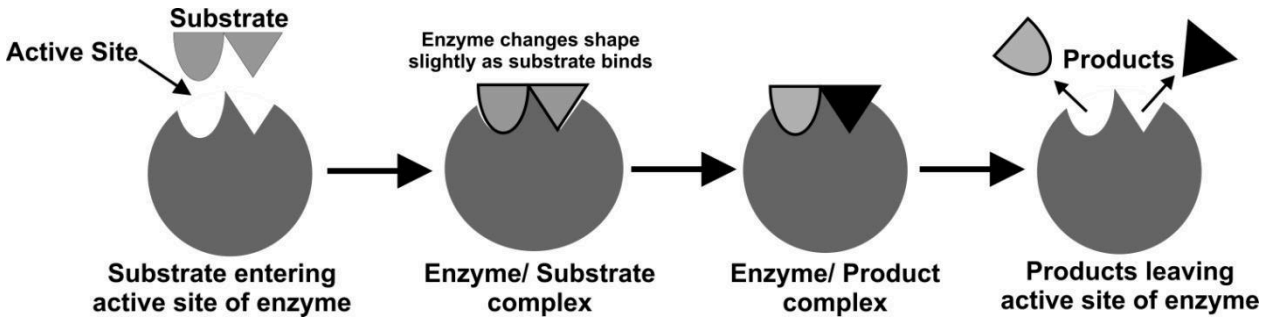
Amylase is used in manufacturing of alcoholic beverages.

### Meat Tenderizing

Trypsin, Pepsin and Papain are meat tenderizing to facilitate the process of digestion.

## "Lock and Key" Model

The specific action of an enzyme with a single substrate can be explained using a Lock and Key model. Enzymes are very specific, and it was suggested by chemist that this was because both the enzyme and the substrate possess specific complementary geometric shapes that fit exactly into one another. This is often referred to as "the lock and key" model.



# VITAMINS

## DEFINITION

A vitamin is defined as naturally occurring essential organic constituents of the diet which in minute amount aids in maintaining the normal metabolic activities of the tissues.

## GENERAL PROPERTIES OF VITAMINS

- Vitamins are complex organic substances
- The molecular weight is low
- Essential vitamins for one species may not be essential for another
- Some vitamins are synthesized in the body
- Vitamins are not destroyed in the digestive processes and are absorbed as such
- The daily requirement for any vitamin is increased during growth pregnancy and lactation

## CLASSIFICATION OF VITAMINS ON THE BASIS OF SOLUBILITY

Based on their solubility, vitamins are classified into fat soluble vitamins and water soluble vitamins

### FAT SOLUBLE VITAMINS

- Vitamin A
- Vitamin D
- Vitamin E
- Vitamin K

### WATER SOLUBLE VITAMINS

- Vitamin C
- Vitamin B complex

## CLASSIFICATION OF VITAMINS ON THE BASIS OF HEAT STABILITY

Based on the heat stability, vitamins are classified into thermo labile vitamins and thermo stable vitamins

### THERMO LABILE VITAMINS

- Thiamine (Vitamin–B1)
- Antithetic Acid (Vitamin –B3)

## Thermo Stable Vitamins

- Riboflavin (Vitamin–B2)
- Pyridoxine (Vitamin–B6)
- Niacin / Niacinamide (Vitamin–B3)
- Biotin (Vitamin–B7)
- Folic Acid (Vitamin–B9)
- Cobalamin Vitamin–B12)

## Vitamin-A

Vitamin-A is a fat soluble vitamin, it is a complex alcohol and is now a day called retinol. Its derivatives called retinal or retin-aldehyde.

### Synonyms

- Retinol
- Retinal
- Retinoic Acid

### Chemistry of Vitamin-A

1. The precursor provitamin "A" is the carotenoid pigments of certain plant known chemically as carotene.
2. Vitamin A is a complex alcohol found in following two forms
   Vitamin-A1
   Vitamin- A2

### Source

- **Animal:** Fish liver oil, milk, butter, egg yolk, kidney and muscles etc.
- **Plant:** They are the sources of provitamin-A as Carotene e.g. (yellow/ red colored vegetable like carrot, corn, apricot, sweet potato, tomatoes, etc.

## Physiological Function

### Eyes

Vitamin-A is actively involved in the maintenance of normal visual process of eyes serious problem of the vision and eyes are found in various degrees of deficiencies of Vitamin-A like night blindness. Vitamin-A participates both in dark/light vision as well as in color vision

### Reproduction

Retinol and Retinal forms of Vitamin-A are concerned with the normal reproduction. In male they facilitate the process of spermatogenesis. In female they prevent fatal resorption.

**Epithelial Tissues**

Vitamin-A is appeared to be the essential factor for maintenance of normal healthy epithelial surfaces. Several changes have been observed especially to epithelial linings of salivary glands, tongue, pharynx, mouth and respiratory tract in its deficiency.

**Bones and Teeth**

It is essential for the normal growth and Development of bones and teeth.

**Carbohydrate Metabolism**

Various experiments on animals have done that Vitamin-A is engaged in conversion of sugar into glycogen.

**Prevention of Infections**

By keeping body surfaces/lining healthy been said as A – infective vitamin.

**Miscellaneous Functions**

- Involved in protein synthesis
- Involved in nucleic acid metabolism

## Clinical Features Associated With Deficiency of Vitamin-A

**Eyes**

- **Xerophthalmia**
- Xerophthalmia caused by a severe Vitamin-A deficiency. Xerophthalmia is a medical condition in which the eye fails to produce tears.

- **Keratinizing Metaplasia**
- Keratinizing metaplasia is a condition affecting the epithelial surfaces of cornea and conjunctiva. It is caused by a dietary deficiency of Vitamin-A

- **Keratomalacia**
- Keratomalacia is an eye disorder that results from Vitamin-A deficiency. Vitamin-A is required to maintain specialized epithelia (such as in the cornea and conjunctiva)

**Epithelial Tissues**

Various epithelial linings of the body are affected they become dry. Keratinized and stratified. Nasal passage, respiratory tract, oral cavity and uro-genital tract are usually affected.

**Skin**

Skin become dry, scaly and thick keratinized

**Miscellaneous**

- Increased chances of stone formation in urinary tract
- Increased chances of infections especially in oral cavity, nasal, sinuses, and respiratory passage
- Generalized growth failure
- Delayed Dentition
- Malformation of teeth and bones

### Toxicity of Vitamin-A

- **Acute:** headache, nausea and vomiting
- **Chronic:** dry skin, cracking of lips, bone pain, fragility, brittle nails, hair loss, gingivitis and portal hypertension.

## Vitamin-D

Vitamin-D is a fat soluble vitamin that enhances the absorption of calcium and phosphorus from the intestine. Its deficiency may cause rickets in children and osteomalacia (softening of the bones) in adults.

**Synonyms**

- Calciferol
- Ergosterol (D2)
- Anti-ricketic vitamin.

**Chemistry of Vitamin-D**

These are sterols which are precursor of Vitamin-D. There are about 10 compounds of Vitamin-D and are named as D1, D2, D3, D4, D5, D6, D7, D8, D9, and D10, out of these only 2 have anti-ricketic property e.g. Ergosterol and Calciferol Vitamin-D2 is of vegetable and Vitamin-D3 is of animal sources.

**Source**

Vitamin-D is not well distributed in nature. The few rich sources are Liver, viscera of fish, liver of the animals which feed fish, eggs, butter, fortified milk, halibut liver oil, cod liver oil. Vitamin-D formed in the skin of human beings by ultraviolet-rays.

### Functions of Vitamin D

**Absorption of Calcium in Gut**

Vitamin D promotes the Ca++ absorption from the intestine

**Phosphate Absorption**

Intestinal absorption of phosphate is increased by Vitamin-D.

**Growth of Bones**

Promote endochondral growth of long bones. It ensures that Ca++ is deposited in the bones.

**Parathyroid Activity**

Activity of parathyroid hormone is exhibited only in the presence of Vitamin-D

**Teeth**

Vitamin-D helps in normal teeth formation if Vitamin-D is lacking malformation of teeth occurs such as

- Cavity formation
- Hypoplastic teeth
- Defective enamel &dentine formation

## Effect of Vitamin D deficiency

Deficiency of Vitamin-D may cause rickets in children and Osteomalacia in adults.

**Rickets**

It is a disease primarily due to deficiency of dietary intake of Vitamin-D, but an inadequate supply of calcium, phosphorus and sunlight may also play a part in it.

The deficiency of Vitamin-D results in a lowered plasma calcium level, which stimulates the secretion of parathyroid hormone (PTH), which acts to restore the plasma calcium at the expense of bone calcium.

**Osteomalacia**

Osteomalacia is the softening of the bones caused by defective bone mineralization, secondary to inadequate amounts of available phosphorus and calcium. The most common cause of the disease is a deficiency in Vitamin-D, which is normally obtained from the diet and/or from sunlight exposure.

## Toxicity of Vitamin-D

Too much Vitamin-D can cause an abnormally high blood calcium level, which could result in nausea, constipation, confusion, abnormal heart rhythm, and even kidney stones.

## VITAMIN-E

Vitamin-E is a fat soluble vitamin; it is most important vitamin to maintain the normal process of reproduction.

### Synonyms

- Tocopherol
- Anti sterility factor
- Anti oxidant factor

### Chemistry of Vitamin-E

- Fat soluble and heat stable vitamin
- Alpha- Tocopherol is the most active form of Vitamin-E.
- These are all methyl derivatives of compound Tocol.
- It is acid stable alkali and oxidation labile.

### Source

- **Animal:** Egg yolk, milk (Human milk contains more than Cow's milk) liver, cheese, butter etc.
- **Plant:** Cotton seed oil, peanut oil etc

## FUNCTIONS OF VITAMIN-E

### Anti- Oxidant

Vitamin-E is a strong anti-oxidant. It provides protection against diseases such as cancer and cardiovascular diseases.

### Act as Co-Enzyme

In certain tissues, it acts as co enzyme.

### DNA Synthesis

It controls the rate of synthesis of DNA.

### Muscles

It is essential for the normal functions of muscles

### Care of RBCs

Vitamin-E looks after RBCs and prevents them from haemolysis (breakdown of RBCs)

### Act as Activator

Vitamin-E acts as activation for enzyme system

**Reproduction**

It is necessary for normal process of reproduction. It keeps the layers of the embryo healthy and is useful in prevention of habitual abortion.

**Act as Drug**

Vitamin-E is used in angina pectoris and in coronary insufficiency.

### Effect of Vitamin-E Deficiency

Vitamin-E deficiency is rare and is almost never caused by a poor diet. The deficiency of Vitamin-E may cause following disorders.

- Rupture (bursting) of RBCs membrane due to increased lipid per oxidation
- Its deficiency can cause edema (abnormal accumulation of fluid in the tissues) especially in new born.
- Vitamin-E deficiency causes neurological problems due to poor nerve conduction.
- Signs of Vitamin-E deficiency include neuromuscular problems
- Reproduction failure
- In male, testicular dystrophy and defective spermatogenesis.
- In Female, infertility due to abnormalities in menstrual cycle. (resorption of fetus) Abortion
- Liver necrosis
- Premature infants. Growth and development retardation.

### Toxicity of Vitamin-E

Most studies have shown that Vitamin-E has not toxic effects. However, high doses of Vitamin-E increase the risk of bleeding. Vitamin-E reduces the blood's ability to form clots after a cut or injury. High doses of Vitamin-E may also cause serious bleeding in the brain.

## Vitamin-K

Vitamin-K is a fat soluble. The name K stands for coagulation vitamin, a substance that prevent hemorrhagic tendency

**Synonyms**

- Anti-Hemorrhagic vitamin
- Coagulation vitamin

**Chemistry of** Vitamin-K

- Fat soluble and heat stable
- Chemically there are three forms of Vitamin-K
- Vitamin-K1 is Plant Origin
- Vitamin-K2 Bacterial Origin
- Vitamin-K3 Synthetically Preparation

**Sources**

- **Plant:** Green leafy vegetables such as Alfalfa, Spinach, Cauliflower, Cabbage, Tomato, Soybeans etc.
- **Animals:** Fish, meat, milk, egg yolk, Endogenous synthesis, by intestinal bacteria

## Functions of Vitamin-K

**Blood Clot Formation**

**Prothrombin Formation**

The most important function of Vitamin-K is that it helps in the formation of prothrombin by liver.

(prothrombin is a plasma protein produced in the liver in the presence of Vitamin-K)

**Respiratory Mechanism**

Vitamin-K is an essential component of respiratory mechanism of cells. In plants, Vitamin-K is an essential component of photosynthetic process.

**Healthy Bones**

Vitamin-K2 plays an important role in bone formation. It is also involved in the prevention of bone loss. Vitamin-K modifies the protein osteocalcin.

**Cell Growth**

Growth Arrest–Specific 6 (GAS6) is a protein that is important for regulating cell growth, proliferation and preventing cell death. Its function is dependent on Vitamin-K

**Cardiovascular Disease**

Vitamin-K prevents some cardiovascular diseases.

## Effect of Vitamin-K Deficiency

- Deficiency of vitamin-K results in serious complications such as prolonged blood clotting time and an increased risk to hemorrhage.
- Appearance of blood in urine or stool and experiencing, heavy bleeding during menstrual cycle are also signs of vitamin-K deficiency.
- Deficiencies of vitamin-K are not very common among adults, but newborns are found to be at a higher risk as breast milk is typically low in vitamin-K and the infant's natural vitamin-K cycle may not be fully developed.
- Signs of vitamin-K deficiency include weakening of bones, osteoporosis, and fractures.
- Other symptoms of vitamin-K deficiency are hardening of heart valves, accumulation of calcium salts in a body tissue and neural tube defects.

### Toxicity of Vitamin-K

The effects of vitamin-K toxicity can include jaundice in newborns, hemolytic anemia, and hyperbilirubinemia (too much bilirubin in the blood, Bilirubin is a yellowish pigment found in bile). Toxicity also blocks the effects of oral anticoagulants.

## Thiamine

Thiamine or thiamin or Vitamin-B1 is a water soluble vitamin, its deficiency is characterized by beriberi.

**Synonyms**

- Vitamin-B1
- Thiamine
- Anti-Beriberi factor

**Source**

- **Animal:** Egg yolk, liver, milk, kidney, heart and liver of fish
- **Plant:** Whole cereal, yeast, whole wheat flour, pulses, fresh fruits and vegetables.

### Functions of Thiamine

**Beriberi**

The most important use of thiamine is to treat beriberi, which is caused by not getting enough thiamine in your diet. Symptoms include swelling, tingling, or burning sensation in the hands and feet, confusion, trouble breathing because of fluid in the lungs, and uncontrolled eye movements called nystagmus.

**Act as Carboxylase**

Vitamin-B1 plays an important role in various decarboxylase reactions

**Growth**

Vitamin-B1 is essential for the normal growth and development of body just like other vitamins.

**Cardio Vascular System**

Due to deficiency of Vitamin-B1 congestive heart failure can occur

### Effect of Thiamine Deficiency

Symptoms of vitamin-B1 deficiency are fatigue, irritability, depression and abdominal discomfort. People with vitamin-B1 deficiency also have trouble digesting carbohydrates.

## Riboflavin

Riboflavin or Vitamin-B2 is a water soluble heat stable vitamin its deficiency is characterized by Ariboflavinosis (A condition caused by a riboflavin deficiency, characterized by angular stomatitis and a magenta-colored tongue). Vitamin-B2, or riboflavin, works together with the family of B-complex vitamins to provide the body with energy by metabolizing carbohydrates, fats, and proteins.

**Synonyms**

- Vitamin-B2
- Riboflavin
- Lactoflavin

**Source**

- **Animal:** Well distributed in the nature excellent sources are liver kidney heart fish eggs milk
- **Plant:** Fresh fruits root vegetable like carrot also synthesized by intestinal bacteria to some extent.

### Functions of Riboflavin

Riboflavin is used for cervical cancer, and migraine headaches. It is also used for treating, acne, muscle cramps, burning feet syndrome. Some people use riboflavin for eye conditions including eye fatigue, cataracts, and glaucoma.

Other uses include increasing energy levels; boosting immune system function; maintaining healthy hair, skin, mucous membranes, and nails.

### Effect of Riboflavin Deficiency

Signs and symptoms of riboflavin deficiency include cracked and red lips, inflammation of the lining of mouth and tongue, mouth ulcers, cracks at the corners of the mouth and a sore throat. A deficiency may also cause dry and scaling skin.

## Pantothenic Acid

Pantothenic acid or vitamin-B5 is a water-soluble vitamin; it is among the most important of the B vitamins for the basic processes of life

**Synonyms**

- Vitamin-B5
- Pantothenate

**Source**

It is widely found in both plants and animals including meat, vegetables, cereal grains, legumes, eggs, and milk.

### Functions of Pantothenic Acid

- Pantothenic acid is used in the synthesis of coenzyme A (CoA).
- To break down fats as fuel, Pantothenic acid via the CoA is necessary for building fats for storage.
- Without Pantothenic acid, you would be unable to use fats, carbohydrates, or proteins as energy sources. You would be unable to make hormones and your immune system would collapse.
- Pantothenic acid is also used for treating dietary deficiencies, acne, alcoholism, allergies, baldness, asthma and heart failure. It is also taken by mouth for dandruff, depression, diabetic nerve pain, enhancing immune function, improving athletic performance.

### Effect of Pantothenic Acid Deficiency

Pantothenic acid deficiency is exceptionally rare. However some deficiency symptoms are disorders of the nervous system, gastrointestinal, and immune systems, reduced growth rate, skin lesions and changes in hair coat, and alterations in lipid and carbohydrate metabolism.

## Niacin

Niacin or Vitamin-B3 is water soluble, thermo-stable vitamin. Its deficiency is characterized by pellagra (Skin rash, nerve disorder and diarrhea).

**Synonyms**

- Vitamin-B3
- Nicotinic acid
- Niacin amide (Nicotinamide)
- Pellagra preventing factor

**Source**

This vitamin is widely distributed both in animal and plant.

- **Animal:** Liver, Kidney, Meat, Fish, Eggs, Milk
- **Plants:** Dried yeast, dried legumes whole wheat, peanuts, tomatoes, leafy vegetables etc.

## Functions of Niacin

**Act as Co-Enzymes**

It is the most important function of niacin, as it acts as “H” acceptor in various “Redox” reactions in the form of NAD & NADP. They worked in association with dehydrogenises and act as “H” acceptor Co-Enzyme.

**Prevents Pellagra**

Niacin prevents pellagra by keeping various “Redox Reactions”

**Growth**

Like other vitamins Niacin is essential for the normal growth and development.

**Act as CNS Stimulator**

It has stimulatory effect on CNS.

## Effect of Niacin Deficiency

Severe deficiency, called pellagra, can cause symptoms related to the skin, digestive system, and nervous system. They include

- Thick, scaly pigmented rash on skin exposed to sunlight
- Swollen mouth and bright red tongue
- Vomiting and diarrhea
- Headache
- Fatigue
- Depression

If not treated, pellagra can lead to death.

## Pyridoxal Phosphate

Pyridoxal Phosphate or Vitamin-B6 is water soluble heat stable vitamin; it is widely distributed in nature.

### Synonyms

- Vitamin-B6
- Pyridoxine
- Pyridoxamine
- Pyridoxa

### Source

- **Animal:** Egg yolk, meat, fish, milk, yeast etc
- **Plant:** Whole grains, cabbage, legume, cauliflower etc

## Functions of Pyridoxal Phosphate

- Vitamin B6 is used by the body for many functions, including uses with metabolism, the nervous system and oxygen transport in the blood.
- Vitamin B6 is used by the body in many places including the metabolism of protein and the release of glucose from glycogen, both necessary for energy production in the body.
- Vitamin B6 is also important to the body because it is required for the synthesis of many neurotransmitters including serotonin, epinephrine and dopamine along with histamine.
- The other major function of Vitamin B6 is its important role with hemoglobin and oxygen transport. Vitamin B6 is used in two very different ways that both have an impact on your body ability to transport oxygen to cells. First, Vitamin B6 is used by the body to create hemoglobin, which is used inside red blood cells to carry oxygen. Once the hemoglobin is created, the body also later uses Vitamin B6 to increase the effectiveness of the oxygen-carrying capacity of the red blood cells.

## Effect of Pyridoxal Phosphate Deficiency

- Pyridoxal Phosphate deficiency can cause a form of anemia.
- Confusion
- Depression
- Irritability
- Mouth and tongue sores

## Biotin

Biotin or vitamin-B7 is water soluble, heat stable, and an important vitamin for growth.

### Synonyms

- Vitamin-B7
- Co-Enzyme-R

### Source

- **Animal:** Liver, Kidney, milk eggs
- **Plants:** Fruits, vegetables, tomatoes

### Functions of Biotin

It acts as co-enzyme for various carboxylation reactions it is involved in the formation of carbonyl phosphate from NH3 and CO2 and ATP in urea cycle.

### Effect of Biotin Deficiency

Deficiency of biotin may cause following clinical features.

- Lassitude
- Anemia
- Increased cholesterol level
- Muscular pain
- Dermatitis
- Retardation of growth
- Fall of hairs

## Folic Acid

Folic acid or vitamin-B9 is water soluble, heat stable and antianemic factor.

### Synonyms

Vitamin-B9

### Source

It is widely distributed in nature; It is named folic acid because it occurs especially in foliage of **plants.**

- **Animals:** Liver, Kidney, Yeast
- **Plant:** Root vegetables. It is also synthesized by intestinal micro organisms.

## Functions of Folic Acid

Folic acid is used for preventing anemia (Megaloblastic anemia) Folic acid is also used for other conditions commonly associated with folic acid deficiency, including ulcerative colitis, liver disease, alcoholism, and kidney dialysis.

Women who are pregnant or might become pregnant take folic acid to prevent miscarriage and “neural tube defects,” birth defects that occur when the fetus’s spine and back don’t close during development.

Some people use folic acid to prevent colon cancer or cervical cancer. It is also used to prevent heart disease and stroke, as well as to reduce blood levels of a chemical called homocysteine.

## Effect of Folic Acid Deficiency

- Bone marrow depression
- Pancytopenia
- Megaloblastic anemia
- Reproductive detects
- Growth retardation
- Diarrhea
- Weakness
- Fatigue

## Ascorbic Acid

Ascorbic acid or Vitamin-C or L-ascorbic acid is water soluble, white crystalline, odorless and sour taste vitamin.

**Synonyms**

Vitamin-C

**Chemistry**

- In human body vitamin-C is found as L- Ascorbic Acid.
- Human body is unable to synthesize vitamin-C
- It is a strong reducing agent and therefore readily oxidized in the body to dehydrate ascorbic acid
- Freezing and dehydration retains the vitamin-C
- Stable in solid form and in acidic solution but rapidly destroyed in alkaline solution

**Source**

- **Plant:** Fresh Fruits: orange, lemon, grapes, guava, apple, strawberry etc. fresh Vegetables: tomatoes, cauliflower, cabbage, onion, lettuce, green peas, beans etc.
- **Animal:** Liver, kidney, adrenal glands etc.

## Functions of Ascorbic Acid

**Intercellular Substance**

Ascorbic acid is required for the functional activities of fibroblast (connective tissue cell) and osteoblast and consequently for the formation of collagen fibers (connective tissue fiber) and mucopolysaccharide of connective tissues and osteoid tissues collagen.

**Wound Repair**

Vitamin C takes active part in wound repair. It lays down the connective tissue which helps in healing of wound.

**Haematopoiesis (**the process of blood cell formation)

Vitamin C has a stimulating effect on haematopoiesis because anemia usually accompanies scurvy.

**Growth**

It is probably involved in the growth process of a child.

**Bones & Teeth**

Vitamin C helps in the deposition of Ca and $PO_4$ in the bones and teeth.

**Synthesis of Protein Matrix**

It helps in the synthesis of protein matrix. It also plays an important role in certain amino acid metabolism.

**Iron Absorption and Mobilization**

Vitamin C is one of the factors influencing the absorption of iron from the food.

**Oxidation-Reduction**

Vitamin C is possible to involve in various oxidation-reduction systems of the body.

**Detoxification**

Vitamin C helps in the detoxification of certain poisonous substance that's why it is given in large amount in all types of infections and after burns.

## Effect of Ascorbic Acid Deficiency

- A severe form of vitamin C deficiency is known as scurvy. Scurvy causes general weakness, anemia, gum disease, and skin hemorrhages.
- Loose teeth

- Superficial bleeding
- Fragility of blood vessels
- Poor healing
- Compromised immunity
- Mild anemia

**Non Specific Symptoms**

This includes

- Weakness
- Weight loss
- Restlessness
- Drowsiness

**Toxicity**

Vitamin C toxicity is usually caused by taking too many supplements. It is usually not caused by getting too much vitamin C from food. Vitamin C toxicity can cause diarrhea, nausea, stomach cramps. Vitamin C toxicity is usually not serious and is treated by stopping vitamin C supplements.

## CYANOCOBALAMIN

Cyanocobalamin or Vitamin-B12, also called cobalamin, is a water-soluble vitamin with a key role in the normal functioning of the brain and nervous system, and for the formation of blood.

**Synonyms**

- Vitamin-B12
- Cobalamin
- Cyanocobalamin
- Antipernicious anemia factor

**Source**

Coblamine is present in liver whole milk kidney eggs fish cheese and muscle. It is not found in plants

It is synthesized by micro organisms.

## FUNCTIONS OF CYANOCOBALAMIN

**Erythropoiesis**

Erythropoiesis is the process by which red blood cells (erythrocytes) are produced. Along with folic acid vitamin B12 is actively involved in the development of RBCs.

### WBCs Maturation

It is required for the normal maturation of WBCs and thrombocytes.

### Protein Synthesis

Vitamin B12 activates amino acid for the synthesis of protein.

## Effect of Cyanocobalamin Deficiency

Cyanocobalamin deficiency can have a number of possible causes. Typically it occurs in people whose digestive systems do not adequately absorb the vitamin from the foods they eat. This can be caused by Pernicious anemia and Atrophic gastritis (thinning of the stomach lining).

Its deficiency may also causes symptoms such as

- Weakness, tiredness or light-headedness
- Rapid heartbeat and breathing
- Sore tongue
- easy bruising or bleeding, including bleeding gums
- Stomach upset and weight loss
- Diarrhea or constipation

## INTRODUCTION TO BIOTECHNOLOGY

'Biotechnology', the term was coined by a Hungarian engineer, Karl Ereky and is defined as per the UN convention on biological diversity as,

**"Any technological application that uses biological system or living organisms to make or modify the process or products for specific use."**

Simply we can say that Biotechnology is the use of living systems and organisms to develop or make useful products.

Biotechnology has touched almost every aspect of human life. Biotechnology dealing with medical and health care is termed as Red biotechnology. It is Green biotechnology when it concerns about agricultural processes, White biotechnology when comes to industrial processes and Blue biotechnology when dealing with marine and freshwater organisms.

1. **Red Biotechnology** ***(Dealing with medical and health care)***
2. **Green Biotechnology** ***(Dealing with agricultural processes)***
3. **White Biotechnology** ***(Dealing with industrial processes)***
4. **Blue biotechnology** ***(Dealing with marine and freshwater organisms)***

### RED BIOTECHNOLOGY

Biotechnology applied to the medical and health care field is termed as 'Red Biotechnology'. Intensive research in this field has not only assured a ray of hope for various life threatening diseases but has also enhanced the quality of life.

Red biotechnology deals with pharmacogenomics, designing organisms to produce antibiotics and vaccines, clinical research and trials, gene therapy and diagnostics. The technology is useful in veterinary science and poultry farming as well.

Commonly the areas covered by red biotechnology is

- Genetic Engineering
- Pharmacogenomics and Medicines
- Produce antibiotics and vaccines
- Cloning
- Stem cell Therapy

## GREEN BIOTECHNOLOGY

Biotechnology has brought a revolution in the field of agriculture. It is now common to hear about genetically modified fruits, vegetables available in any season and offering you specific nutritions.'Trans-genetic plants' modified for increased resistance to pests and diseases, improved flavor and enhanced growth in adverse weather conditions have started occupying place in our refrigerators. Not just this, but there is much more that green biotechnology also known as Plant Biotechnology has done especially alleviating the pains of farmers.

Main research areas and applications include...

- Plant tissue culture
- Plant Genetic Engineering
- Bio fertilizers and bio pesticides
- Hybridization

## WHITE BIOTECHNOLOGY

With the distinguished potential witnessed in medical and agriculture sectors, the industrial processes cannot remain untouched. When dealing with industrial processes, it is termed as White biotechnology. It deals with the production of various products, from bread to biodiesel. Enzymes and organisms are employed for the processing and production of chemicals and other products. Such fermentation and enzymatic processes are also economical and eco-friendly as compared to their physical and mechanical processes.

White Biotechnology is significantly affecting chemical, textile, paper, food, mining and cosmetics industries, by introducing environment friendly biological processes in place of traditional methods dependent on petroleum based synthetics. The use of enzymes for washing processes at textile industries is a good example, where biological processes have reduced the cost and energy employed. It is also used for purification of water with certain bacteria, production of bio degradable plastics, enzymes in food manufacturing, insulin production and many more.

White Biotechnology is also concerned with production of alternative energy resources. Production of ethanol as a substitute of gasoline, from starch and carbohydrates begun the era of Bio fuels. Ongoing research in this field is promising and we can hope for a future fuelled by eco friendly Bio fuels; changing 'hydrocarbon economy' to 'carbohydrate economy'.

## BLUE BIOTECHNOLOGY

Blue biotechnology is concerned with the application of molecular biological methods to marine and freshwater organisms. It involves the use of these organisms, and their derivatives, for

purposes such as increasing seafood supply and safety, controlling the proliferation of noxious water-borne organisms, and developing new drugs.

## Future of Biotechnology

Biotechnology has the potential to change our world. Coming years may witness the whole new way of growing crops, dealing with deadly disease and handling future of Biotechnology environmental problems.

From our medicines to our food, biotechnology offers all new healthier ways to every aspect of life. In the future age of biotechnology, children will be produced in hatchery rather than born. Moreover, parents will be able to choose which of their gene combination they want to hand down to their children.

Many techniques like Crytogenetics, Xenotransplantation, Proteomics, DNA microarrays are ready to add new horizons to the advancement of biotechnology.

## Genetic Engineering

Genetic engineering is the process of transferring specific genes from the chromosome of one organism and transplanting them into the chromosome of another organism in such a way that they become a reproductive part of the new organism. Or

Genetic engineering is the process of removing a gene from one organism and putting it into another. Often, the removed genes are put into bacteria or yeast cells so that scientists can study the gene or the protein it produces more easily. Sometimes, genes are put into a plant or an animal.

## Applications of Genetic Engineering

Genetic engineering has applications in medicine, research, industry and agriculture and can be used on a wide range of plants, animals and micro organisms.

### Genetic Engineering and Medicine

In medicine genetic engineering has been used to mass-produce insulin, human growth hormones, treating infertility, human albumin, monoclonal antibodies, vaccines and many other drugs.
The first two commercially prepared products from recombinant DNA technology were insulin and human growth hormone, both of which were cultured in the E. coli bacteria.

Gene therapy is the genetic engineering of humans by replacing defective human genes with functional copies. Gene therapy has been successfully used to treat multiple diseases, including X-linked SCID, chronic lymphocytic leukemia (CLL), and Parkinson's disease.

### Genetic Engineering and Research

Genetic engineering is an important tool for natural scientists. Genes and other genetic information from a wide range of organisms are transformed into bacteria for storage and modification, creating genetically modified bacteria in the process.

Bacteria are cheap, easy to grow, clonal, multiply quickly, relatively easy to transform and can be stored at -80 °C almost indefinitely. Once a gene is isolated it can be stored inside the bacteria providing an unlimited supply for research.

### Genetic Engineering and Industry

Using genetic engineering techniques one can transform microorganisms such as bacteria or yeast, or transform cells from multi-cellular organisms such as insects or mammals, with a gene

coding for a useful protein, such as an enzyme, so that the transformed organism will over express the desired protein.

One can manufacture mass quantities of the protein by growing the transformed organism in bioreactor equipment using techniques of industrial fermentation, and then purifying the protein.

### Genetic engineering and Agriculture

One of the best-known and controversial applications of genetic engineering is the creation and use of genetically modified crops. There are four main goals in generating genetically modified crops.

1. Protection from environmental threats, such as cold or pathogens, such as insects or viruses. There are also fungal and virus resistant crops developed or in development.

2. Modify the quality of the agriculture products, for instance, increasing the nutritional value or providing more industrially useful qualities or quantities of the products.

3. Accelerating the growth of crops

4. Reduce the usage of chemicals, such as fertilizers and pesticides, and therefore decrease the severity and frequency of the damages produced by this chemical pollution.

## Electrolytes of Body

Electrolytes are minerals in your blood and other body fluids that carry an electric charge. Electrolytes affect the amount of water in your body, the acidity of your blood (pH), your muscle function, and other important processes. You lose electrolytes when you sweat. You must replace them by drinking fluids.

**Common electrolytes include:**

- Calcium
- Chloride
- Magnesium
- Phosphorous
- Potassium
- Sodium

### Electrolyte Balance

Electrolyte balance, or salt balance, is necessary in controlling fluid movements within the body. Salts are lost in perspiration, urine, feces and may be lost excessively in diarrhea, vomiting and sweating. Sodium is the most important electrolyte in maintaining electrolyte balance. Regulating the balance between sodium input and output is an important renal function.

## Acid- Base Balance:

Acid-base balance is the part of human homeostasis concerning the proper balance between acids and bases, also called body pH. The body is very sensitive to its pH level, so strong mechanisms exist to maintain it. Outside the acceptable range of pH, proteins are denatured and digested, enzymes lose their ability to function, and death may occur.

The body's acid-base balance is tightly regulated by buffering system of our body. Arterial blood must be kept at a pH of 7.35 to 7.45. When the pH rises above 7.45 or falls below 7.35. The quickest way (less than 1sec) that blood pH is adjusted by buffering system of our body.

There are three important buffer systems in our bodies

1. **Bicarbonate Buffer System**
2. **Phosphate Buffer System**
3. **Protein Buffer System**

### Bicarbonate Buffer System

The bicarbonate buffering system is an important buffer system in the acid-base homeostasis of living things, including humans. As a buffer, it tends to maintain a relatively constant plasma pH and counteract any force that would alter.

### Phosphate Buffer System

The phosphate buffer system operates in the internal fluid of all cells. This buffer system consists of Dihydrogen Phosphate ions ($H_2PO_4^-$) as Hydrogen-ion donor (acid) and Hydrogen Phosphate ions ($HPO_4^{2-}$) as Hydrogen-ion acceptor (base). If additional hydrogen ions enter the cellular fluid, they are consumed in the reaction with $HPO_4^{2-}$. If additional hydroxide ions enter the cellular fluid, they react with $H_2PO_4^-$ and maintain the pH.

### Protein Buffer System

The protein buffer system is the most important and widely operating buffer in the body fluid. An example of a protein buffer is hemoglobin. Protein molecules possess basic and acidic groups which act as H+ acceptors or donors respectively if H+ is added or removed.

**Course Outline Biochemistry**

1. General introduction and basic biochemical principles.
2. General introduction, basic chemistry, nature and classification and functions of carbohydrates, Lipids, Proteins and Amino acids, Nucleic acids, Vitamins, Hormones, Enzymes.
3. Role of vitamins, Physiological role of Fat-soluble Vitamins (A, D, E and K) and Water-soluble vitamins (Thiamin, Riboflavin, Pantothenic acid, Niacin, Pyridoxal phosphate, Biotin Folic acid, Cyanocobalamin-members of B complex family and Ascorbic acid).
4. Introduction to Biotechnology and Genetic Engineering.
5. Acid Base and electrolyte balance in human body.