CHAPTER 1

INTRODUCTION TO BIOCHEMISTRY

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. The moment there occurs disorganization in these reactions; we fall ill or even die.

It is amazing to note that all the elements that collectively give rise to living organisms are by themselves inanimate. However, when present in optimum amounts and in optimum combinations, they make life possible. An Urdu poet (Birj Narayan Chaksbat), a non-scientist, has best illustrated this in the following verse:-

Compared to other biological sciences, biochemistry is quite young. This is because investigators in this field had to wait for developments to take place in other branches of chemistry, i.e. inorganic, organic and physical. It is only in the second half of the twentieth century that biochemistry that started as an offshoot of physiology emerged as an independent discipline. In 21 st century it is one of the most dynamic sciences whose frontiers are expanding at a fantastic rate. This great leap forward in biochemistry has been of enormous help in providing explanations for the mechanisms of many physiological processes which were hitherto unknown or were shrouded in mystery. Other medical sciences, i.e. physiology, pharmacology, bacteriology and

pathology and even therapeutics have also greatly benefited from new discoveries in biochemistry. All these medical sciences have contributed to the great strides made in medicine and a major part of the credit goes to biochemistry.

Biochemistry has assumed an increasingly important role in various branches of medicine 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, he has provided a large number of chemical tests as aids in the diagnosis of diseases.

CHAPTER 2

CARBOHYDRATES

Definition

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"

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"

General formula

As the carbohydrates are the hydrated carbons so the no. 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 sulphur also in addition to carbon. Rhamnose has a Formula $C_6H_{12}O_5$.
Also all the compounds having formula $C_n(H_2O)_n$ 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 functional group. Two functional groups.

Aldehyde group: "-CHO" it is on the first carbon and the carbohydrate with aldehyde group is called aldoses (aldose suger)

Keto group:

$$\mathbf{R\text{-}\overset{\overset{\mathbf{O}}{\|}}{C}\text{-}R}$$

is on the second carbon, the sugars with ketonic group are called ketoses (keto-suger)

Source of carbohydrates

Carbohydrates are the natural compounds and their basic source is plants. The chief source of carbohydrates is the cereals. Starch is the abundant in the cereals.

The other source of carbohydrates is:

(i) **Vegetables**: e.g. potato, carrot, beats etc.

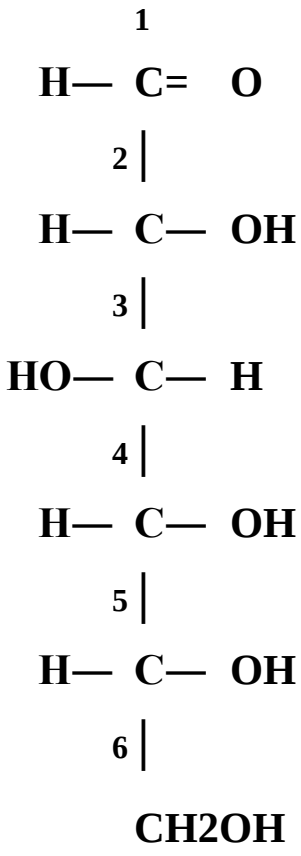
(ii) **Legumes:** e.g. peanut, lenticle etc.

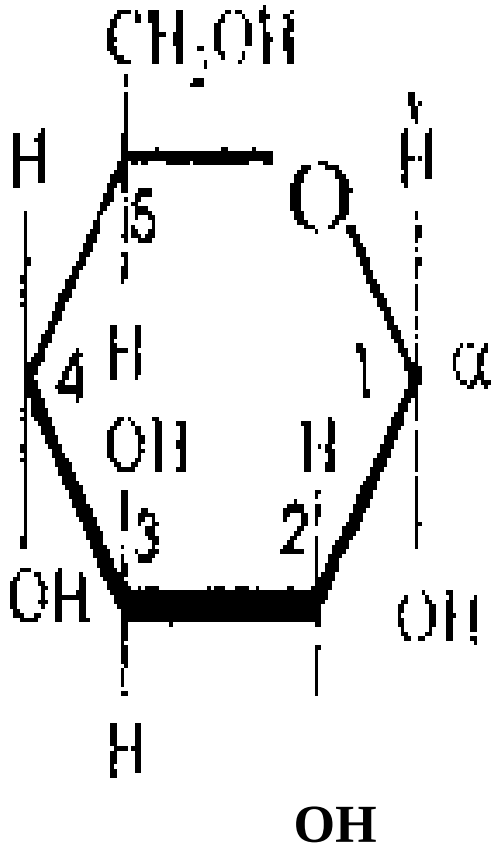
(iii) **Fruits:** both sweet and non-sweet fruits provide carbohydrates.

Chain or cyclic structure of carbohydrates

Carbohydrates are both in cyclic forms and chain forms and they both forms are in equilibrium state.

Straight chain carbohydrates → Cyclic 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.

$$CO_2 + H_2O \longrightarrow C_6H_{12}O_6 + O_2$$

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

$$\underset{\text{Glucose}}{\mathbf{C_6H_{12}O_6}} + \mathbf{O_2} \longrightarrow \mathbf{CO_2 + H_2O + E}$$

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.

Function of carbohydrates in animal body

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

- Construction of body organs.
- Assist in body's 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.

Sweetness in carbohydrates

Carbohydrates who has lower molecular mass are sweet in taste as the complexity and molar mass increases the sweetness decreases. In fruits the sweetness very from time to time sweetness increases as fruits ripen e.g. banana and apple b/c during ripening the starch converted to simple sugar.

Classification of carbohydrates

The carbohydrates are classified into three groups.

(i) **Monosaccharide :** having one sugar molecule and cannot hydrolyze to smaller units

(ii) **Disaccharide:** Having two sugar molecule and give two monosaccharide on hydrolysis.

(iii) **Oligosaccharides:** Having 3-10 sugar molecules. on hydrolysis yield 3-10 monosaccharides.

(iv) **Polysaccharide:** having more than ten sugar molecules and give disaccharide on hydrolysis and on further hydrolysis the monosaccharide are met.

Monosaccharide

Mono ----------one

Saccharides----------sugar

1. They are sweet in taste.
2. It cannot further hydrolysis.
3. Generally they are water soluble.
4. Two types of functional group are present in it.

i) Aldehyde group: **(–CHO)**

ii) Keto group:

Classification of monosaccharide

Monosaccharide can be classified on the basis of functional group

i) Aldose ii) Ketose

Aldose

i) Glucose: ($C_6H_{12}O_6$)

It is also called grape sugar. It is widely distributed in nature. It combines with other sugars to form important disaccharides such as sucrose, maltose, and lactose. It is commercially obtained from starch. It is the main sugar of human body. Normal blood glucose level of human in fasting 80_100mg% and in random is 100__120mg%.

Glucose is also called dextrose.

ii) Ribose:

iii) Erythrose:

iv) Glucoheptose:

Ketose

i) Fructose: ($C_6H_{12}O_6$)

The most common source of fructose is sucrose. It is sweetest of all the sugars. Pure honey contains fructose. It is present in appreciable amount in seminal fluid and act as source of energy for spermatozoa.

ii) Erythrulose:

iii) Ribulose:

iv) Sedoheptulose

Disaccharides

Definition:

Having two sugar molecules, give Two monosaccharide on hydrolysis Disaccharides occur naturally. They are less sweet than monosaccharide. The two monosaccharide units with glycosidic linkage they are white crystalline solids. They are soluble in (H_2O) water .Their molecular mass greater than monosaccharide.

Classification of 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 called heterogeneous e.g. sucrose.

Examples of disaccharides

Sucrose. (Glucose + fructose)

It is also called saccharine. It is a common table sugar.

Lactose. (Glucose + galactose)

It is also called milk sugar.

Maltose.

It is composed of two monosaccharide (glucose + glucose)

It is also called fruit sugar.

Oligosaccharides

On hydrolysis these sugars yield three to ten monosaccharide units.

Not important physiologically.

Polysaccharides

Definition

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

Many saccharides join to form poly saccharides. They are tasteless and not optically active

Classification of polysaccharides

There are two types of polysaccharide.

(i)**Homopolysaccharides:**

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

(ii) **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

Types **:** (i) Amylose (ii) Amylopection

CHAPTER 1

LIPIDS

INTRODUCTION

LIPO MEANS FAT

Definition
The lipids are organic substances occurring in plant and animal tissues belong to a very heterogeneous group of compounds related to fatty acids.
Lipids include fats, oils, waxes, steroids, & defined as substances having the following properties:

1. They are insoluble in water (hydrophobic) but soluble in non-polar solvents (ether, chloroform, benzene).
2. Their primary building blocks are fatty acids, glycerol, sphingosine and sterols.
3. In most cases, they can be utilized by the living organisms.
Most common lipid is fat in animals & plants
4.Lips used to store energy because of higher proportion of C-H bonds and very low proportion of oxygen , oxygen store double the amount of energy as compared to the same amount of any carbohydrates

CLASSIFICATION OF LIPIDS

These are classified as,

I. **Simple Lipids**
II. **Compound Lipids**
III. **Derived Lipids**

SIMPLE LIPIDS

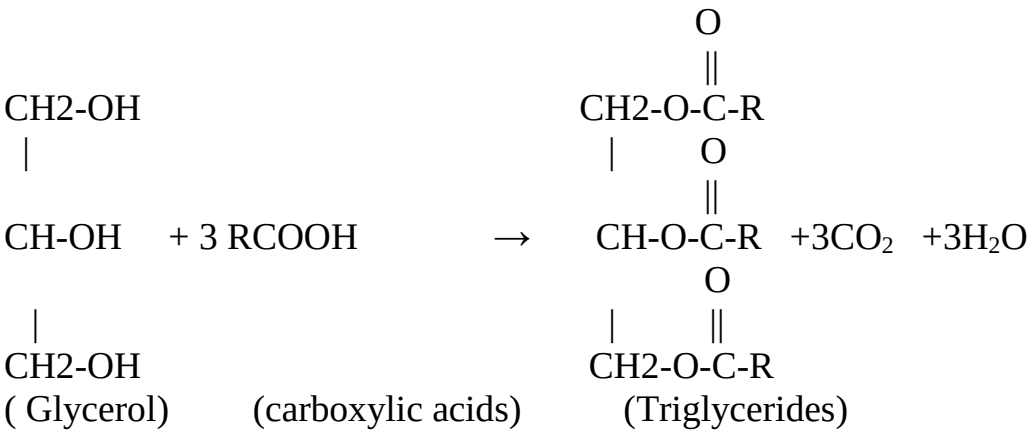
This class includes fats oil & waxes.

FATS AND OILS

These are esters of fatty acids with glycerol. (Trihydroxy alcohol).
They are known as triglyceride or triacylglycerol or fat.
A fat in liquid state called oil
Fats & oils are lighter than water and have specific gravity of about 0.8

Glycerol+3Carboxylic acid -------→Triglycerides+$3CO_2$+$3H_2O$

OR



WAXES

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

RCOOH + ROH —→ RCOOR + H_2O

Occurrence
Waxes are widespread 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.

Human secretion (sebum wax)

Sebum is a secretion of human skin having waxes. It helps skin to be moist and flexible.
Plant waxes present in cuticle of plant cell.

COMPOUND OR COMPLEX LIPIDS

Definition
These are esters of fatty acids containing groups in addition to an alcohol and fatty acids.
These are sub divided as follows:
1. Glycolipids also called Glycosphingolipids
These contain sphinogosine, fatty acid and a monosaccharide or an oligosaccharide unit.
2. Sulphosides
These contain sphingosine, fatty acids, a sugar & a phosphate group.
3. Phospholipids
These are lipids that contain an alcohol, fatty acid and phosphoric acid in addition they frequently have N-containing bases & other sustituents.
4. Lipoproteins
These are complex of lipid with proteins.

III. DERIVED LIPIDS

These include fatty acids, glycerol, steroids, sterols, fatty aldehyde, lipid soluble vitamins, ketones etc.

Fatty acids

Definition
Hydrolysis of fats is called fatty acid.
Fatty acid contain long hydrocarbon chain bonded to –COOH
Group.
"They are aliphatic monocarboxylic acids"

Classification

BIOCHEMISTRY

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Fatty acid may classified as,

1.Saturated Fatty acids

They do not contain double bond.
"Animal fat are usually saturated"
Fats containing saturated fatty acids are solids at room temperature

Example
Butyric acid C_3H_7COOH

2.Unsaturated fatty acids

They contain one or more double bond in their formula.
Plant fats are mostly unsaturated.
Fats containing unsaturated fatty acids are liquid at room temperature

Types

Monounsaturated fatty acids
i.e. Oleic acid $C_{18}H_{33}COOH$
Polyunsaturated fatty acids
i.e. Archidonic acid $C_{19}H_{31}COOH$

STEROIDS

A large number of compounds found in nature occurring in nonsaponifiable fraction of lipids belong to the class of compounds called steroids.

STEROLS

A sub group of steroids is sterols which contain one or more –OH groups and no carbonyl and carboxyl groups; their names end in -ol.
Examples
Some of natural compound belonging to steroids are cholesterol, ergosterol, bile acids, male and female sex hormones and the hormones of adrenal cortex.

CHOLESTEROLS

It is most abundant animal sterol.
It occurs in animal tissues most abundant in the adrenal gland followed by nervous system. Normal plasma level ranges from 150 to 220mg/dl.
Some 140 grams of cholesterol may be present in an adult human being.
It also present in plasma membranes of tissue cells & in plasma lipoproteins.

FUNCTIONS OF LIPIDS

Energy source

They are good source of energy.

Carrier of fat – soluble vitamins

Lipid in food also acts as a carrier of fat-soluble vitamins and nutritionally essential fatty acids.

Dietary Lipids

The dietary lipids decrease gastric motility and have a high satiety value.

Stability

Body fat gives anatomical stability to organs like kidney. When a person loses weight rapidly, his kidney is liable to become floating kidneys.

Good reservoir

Fats are good reservoir in the body. Adipose tissue is best suited for this purpose due to its very little water content.

Insulating Effect

Lipids exert an insulating effect on the nervous tissue.

Integral part

Lipids are integral part of cell protoplasm and cell membranes.

Precursor

Some lipids act as precursors of very important physiological compounds .e.g. cholesterol is precursor of steroid hormones.

CHAPTER 1

Proteins

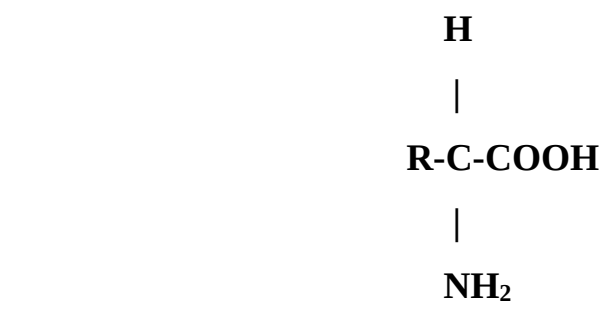
Definition

The proteins are extremely complicated molecules and are nitrogenous compound made up of a variable no. of amino acids joined to each other by specific type of covalent bond called peptide bond or peptide linkage.

Derivation

The name protein derived from Greek "protos" which means the first or the supreme. "Proteins are polymers of amino acids"

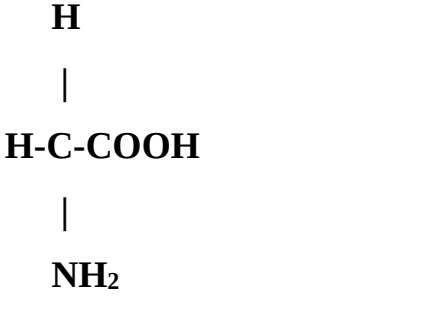
General formula of amino acid



Amino Acids have two characteristics functional groups the amino group _ NH_2. The functional group _COOH which is Carboxylic group.
R represents the side chain which varies from one Amino acid to other Most amino acid have one _NH_2 group and other _COOH group but some have more than one of these. They are 20 amino acid which have been found to occur in all proteins and for which genetic codons exist. If R changes the amino acid changes structurally

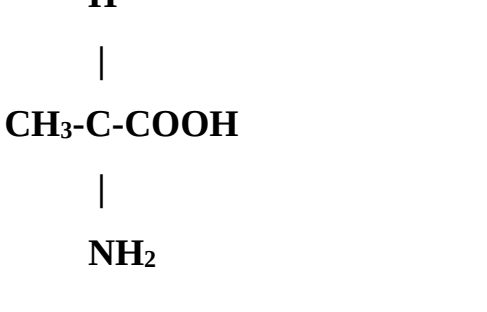
For Example

If R is H



GLYCINE

If R is CH_3



ALANINE

"Amino acids are building blocks of proteins"

Functions of proteins

Proteins present in cytoplasm as well as the cell membrane of cells with out exceptions.

Mammalian muscles contain	20%
Blood plasma	7%
Cows	3.5%
Cereals	12%

Beans, nuts, pulses, contain 20% proteins.

Besides forming structural elements of body and important food constituents as well. They are also present in daily use articles such as silk, leather, and wool. A group of substances called enzymes which are biocatalyst of the body,

"Enzymes are mainly protein in nature."

Hormonal effect

Many of the hormones which regulate the chemicals and other process or the body are also protein in nature.

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.

Primary structure of proteins

Definition

Linear sequence of Amino acids.

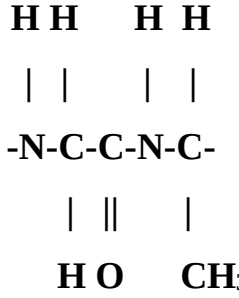
Amino group is in one side and left hand side and carboxylic group on right hand side.

Length

Length is vary according to proteins, length of chain depend upon type of proteins which is under discussion. But it must be polypeptide long chain.

No additional hydrogen bonding in primary structure of proteins and it is present in other structure.

Only covalent bond is present in primary structure.



Secondary structure

Definition

The regular arrangements of amino acid that are located near to each other in linear sequence these arrangements are termed as **Secondary structure** of polypeptide

Tertiary structure

Definition

The tertiary structure of a proteins means it's over all three "Dimensional shape" 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 and is entirely determined by intermolecular forces and bond polypeptides chain form a complex structure known as proteins structure.**e.g**

Myoglobin: It has been calculated that if the chain of myoglobin could be extended the length of its molecule would be 20 times its width.

Quaternary structure

Definition

- **Association of multiple polypeptides, not found in all proteins**.

The structure formed by aggregation of two or more polypeptide chain is called quaternary structure the aggregation of such polypeptides chain form one functional macromolecule. Each poly peptide chain is called subunit.

e.g. Hemoglobin, Collagen etc.

Biological role of Proteins

Proteins have following some important role:

1. Proteins as structural material

Proteins are the structural material for the plant and animal.

Protein form the major part of dry weight of plant and animal protein are the major part of all the membrane system of cell.

Proteins take an essential part in the formation of protoplasm which is the essence of all forms of life.

2. Energy source

Proteins provide energy to body proteins is breakdown into amino acid during digestion the deamination of these amino acid take place.

Ammonia is released and different compounds are formed.

The compound enters into the respiratory pathway (glycolysis and Kreb's cycle) at different points.

3. Defense of body

Proteins are used against disease in higher animals.

Antibodies and interferon are proteins in nature in they defend the body from attack of bacteria and viruses (immunoglobulin).

Protein is an integral part of all viruses which are very important from a pathogenic point of view.

4. Dietary protein

The supply of nitrogen and sulphur is regulated by dietary protein

e.g. each one gram of dietary protein furnishes 4.1 kcal or 4100cal.

5. Enzymes

Some proteins act as enzymes, enzymes play important role in metabolic reaction, and they enter and speed up specific chemical reaction.

6. Hormones

The hormones are protein in nature have great effect a metabolic and reproduction.

7. Reserve food

Most part of fruits and vegetables is composed of proteins. Thus proteins are as storage composed

e.g albumin is stored in egg white casein present in milk.

Certain proteins are present cell membrane bind vitamin hormones etc. to mediate the cellular action.

8. Contractility

Most proteins are involved in contractility e.g. dyne in cilia and flagella.

Tubulin in spindle fibres.

Actin and myosin in muscles.

9. Exchange of gases

They execute their activities in the transport of O_2 and CO_2 by hemoglobin. Some act as hormones e.g. insulin, growth hormones and parathyroid hormones etc.

Muscles proteins have a role in contraction of muscle fibres.e.g Antarctic fish contain antifreeze proteins which protect their blood from freezing.

Homeostatic control

The function is the homeostatic control of volume of the circulating blood and that of the interstitial fluids through plasma protein.
Plasma proteins take part in blood coagulation and transport of substances such as hormones drugs, metal like iron and copper.

Blood clotting

They are involved in blood clotting through thrombin fibrinogen and other protein factors.
The proteins present in blood plasma act as a colloidal particles and exert and osmotic pressure of 25_30mmHg.
The role of proteins in the plasma membranes where they act as transporting or carrier molecules and receptors.

Heredity transmission

They perform hereditary transmission by nucleoproteins of the cell nucleus.

Chromosomes movement

Movement of organs in plant cells is due to movement of chromosomes.
During anaphase of cell division

CLASSIFICATION OF PROTEINS

Proteins have been classified in several ways. The following classification is based upon physicochemical properties of proteins.

A protein may belong to one of the three types, i.e.

I. **Simple proteins.**

II. **Compound or conjugated proteins.**

III. **Derived proteins.**

SIMPLE PROTEINS

On hydrolysis, these proteins yield only amino acids or their derivatives. These consist of the following types.

1. Albumins:

These are water-soluble proteins and occur in both plant and animal kingdoms.

Examples are serum albumin, ovalbumin and lactalbumin m animals and legume in plants.

2. Globulins:

These are insoluble in water but soluble in dilute salt solutions and are heat-coagulable to a variable extent.

They are found in animals,

e.g. lactoglobulin, myosin in muscle, ovoglobulin, serum globulins and also in plants, e.g. legumin.

3. Globins

These are rich in histidine but are not basic. They unite with heme to form hemoglobin.

Hemoglobin of different species differs only with respect to globin, but the heme part is the same in all cases.

4. Prolamins

These are soluble in 70 to 80% ethanol but are insoluble in water and absolute alcohol. Examples are gliadin of wheat and zein of maize. These are rich in the amino acid proline but deficient in lysine.

5. Histones

These are very strongly basic proteins as they are rich in arginine. In combination with deoxyribonucleic acid (DNA) they form nucleoproteins (nucleohistones). The association of DNA and histones gives rise to complexes called nucleosomes.

6. Protamines

These are present in sperm cells like histones; they form nucleoproteins with nucleic acids and are rich in arginine. These proteins lack in both tyrosine and tryptophan.

7. Albuminoids

These are also called scleroproteins [sclero = hard] and occur only in animals; they do not occur in plants. These proteins includes

i) Collagen

ii) Elastin

iii) Keratin

COMPOUND OR COUNJUGATED PROTIENS

In these molecules the protein is attached or conjugated to some non – protein groups which are called prosthetic groups. The following types of proteins belongs this group.

i) Nucleoproteins.
ii) Phosphoprotien
iii) Lipoproteins
iv) Carbohydrate - containing proteins
v) Chromoproteins
vi) Metalloproteins

DERIVED PROTEINS

This class of proteins includes substances which are derived from simple and conjugated proteins. These proteins are sub divided into primary and secondary derived proteins.

i) **Primary derived proteins**: These are synonymous with denatured proteins. Denaturation takes place when some or all of the cross -linkages which normally keep the molecular structure of protein intact are split.

ii) **Secondary derived proteins**: These substances are intermediate formed in the progressive hydrolysis of protein molecule. The are of different sizes and different amino acid composition and are roughly grouped according to their molecular size into

a) Proteoses
b) Peptones
c) Peptides
d) Polypeptides
e) Oligopeptides

AMINO ACIDS

INTRODUCTION

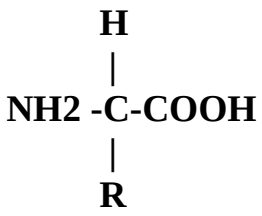
"Amino acids are the building blocks of proteins"

Amino acids are the monomer of a bio-polymer which is called as proteins. They form protein by a biochemical bond called Peptide bond or peptid 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.

STRUCTURE

Amino acid has very simple structure. It contain a central alpha carbon (The carbon attached with the functional Group is called alpha carbon).



There are present an acidic group on one side and an amino group on other side of alpha carbon. Hydrogen is present on alpha carbon with a R group. The R group may vary to produce different types of Amino acids. It means the kinds of all amino acids depend upon the nature of R group. So comprehensively we can say that (except glycine) all the amino acids.

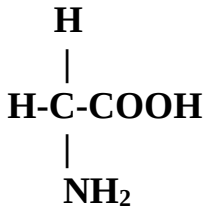
Contain following unit with alpha carbon.

1. R group
2. carboxylic group(_COOH)
3. Amino group (_NH2)
4. Hydrogen atom (_H)

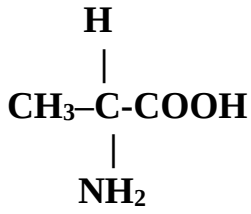
2. AMINO ACIDS OCCURRING IN PROTEIN MOLECULES

(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.



GLYCINE



ALANINE

Classification of Standard Amino Acids

This is based upon the type of side chain, i.e. R group present because it is the side chain which gives distinctive properties to amino acids.

1-Amino acids with non-polar aliphatic side chains

These include glycine Alanine, Valine. Leucine and Isoleucine.

2. Amino acids with aromatic side chains

These include phenylalanine tyrosine and tryptophan and are said to be relatively polar.

3. Side chain containing hydroxyl (-OH) group

These include serine and threonine.

4. Amino acids with side chains containing sulfur (S) atom

These include cysteine and methionine.

5. Amino acids with acidic side chains

These include glutamic acid and aspartic acid;

6. Amino acids with basic side chains

These include lysine, arginine and histidine.

7. Amino acid

The only example of this type is proline.

NON-STANDARD AMINO ACIDS

The non-standard amino acids are those amino acids which, contrary to the standard amino acids already described, do not take part in protein synthesis but many of them play important role in the body. There are several hundreds of such amino acids, a few of which having important physiological functions are given below.

1. **Citrulline**
2. **Ornithine**
3. **Argininosuccinic acid**

4.β-alanine

It is a part of the molecule of a vitamin namely pantothenic acid.

5. Pantothenic acid

It is a widely distributed vitamin; it forms a part of the of coemzyme A (abbreviated as CoA-SH or just CoA) which takes of metabolic reactions.

6. γ – Amino- Butyric Acid (GABA)

It occurred in brain and other tissues it has an important physiological role as neurotransmitter.

7. Dihydroxyphenylalanine

It is formed in tissues during the metabolism of phenylalanine and tyrosine. L- Dopa is being used in treating Parkinsonism as in the brain it give rise to dopamine which is a neurotransmitter.

8. Homocysteine

9. Iodinated amino acids

These are mono - iodotyrosine (MIT), di-iodotyrosine (D1T), tri-iodothyronine (T3) and tetra-iodothyronine (T4). The last two are thyroid hormones,

Functions of Amino acids

"Amino acids are building blocks of Proteins"
So all the functions which proteins perform are the function of amino acids

i) Proteins are present in cytoplasm as well as in the cell membrane of cells with out exceptions.

ii) Beans, nuts, pulses, contain 20% proteins.
iii) Besides forming structural elements of body and important food constituents as well. They are also present in daily use articles such as silk, leather, and wool.

iv) A group of substances called enzymes which are biocatalyst of the body, "Enzymes are mainly protein in nature.

v) Hormonal effect. Many of the hormones which regulate the chemicals and other process or the body are also protein in nature.

vi) They play role as:

- Hormone biosynthesis
- N2 metabolism
- Tolerance of certain environmental stresses e.g.
  Proline stores under salt stress condition in plants

NUCLEIC ACIDS

INTRODUCTION

Nucleic acids were first demonstrated in the nuclei of pus cells in 1869 and in sperm heads in 1872 by a Swedish doctor Friedrich Miescher and named as nucleon.

Nucleic acids are present in every living cell as well in viruses and have been found to be the essential substance of the genes and the apparatus by which the genes act.

Two types of nucleic acids

Deoxyribonucleic acid. i.e. DNA
Ribonucleic acid. i.e. RNA.

COMPONENTS OF NUCLEIC ACIDS

Both DNA and RNA are formed by joining together of a large number of nucleotide units or mononucleotides, each of which is a nitrogenous base-sugar-phosphoric acid complex.

In other words, nucleic acids are polynucleotide.

Nitrogenous bases

These are aromatic heterocyclic bases and include purine and pyrimidine derivatives.

Purines - These include adenine and guanine, which are abbreviated as A and G respectively.

Pyrimidines-These include cytosine, uracil, thymine abbreviated as C,U.T respectively.

Mononucleotides- In nucleotides, a phosphoric acid molecule forms an ester linkage with one of the hydroxyl groups of the sugar of a nucleoside,

Nucleotides-

A nucleotide is a nucleoside phosphate.

Nucleoside-

The combination of a Nitrogen Base and 5-Carbon Sugar

SOME OTHER BIOLOGICALLY IMPORTANT NUCLEOTIDES

Nucleotides which are not combined in nucleic acids are also found in tissues. They have important special functions. Some of these compounds are given below.

Derivatives of adenine

ATP, ADP and AMP - ATP has two high energy phosphate bonds.
NAD+, NADP+, FAD and coenzyme A.

Characteristics of RNA and DNA

Characteristics	RNA	DNA
i. Nitrogenous base (a) Purines	Adenine and Guanine	Adenine and Guanine
(b) Pyrimidines	Cytosine and Uracil	Cytosine and Thymine
2. Relative amounts of complementary bases	Highly variable	A is always equal to T and G is equal to C. Total purines = Total pyrimidines(Chargaffs law).
3. Sugar (as p-furanoside form)	Ribose	2 -Deoxyribose
4. Phosphoric acid	Present	Present
5. Location in the cell	Mainly cytoplasm; some in the nucleus	Mainly in the nucleus; some in the cytoplasm (mitochondria)
6. Molecular weight	Much smaller than DNA	Much larger than RNA;

7, Molecular shape .	**Single-stranded which may be coiled on itself and in certain cases has double helix parts. Rarely double stranded RNA has also been found even in humans.**	**Double-stranded forming a double helix;**

RIBONUCLEIC ACIDS (RN As)

There are three main types of RNA
Messenger or mRNA
Transfer or tRNA
Ribosomal or rRNA.

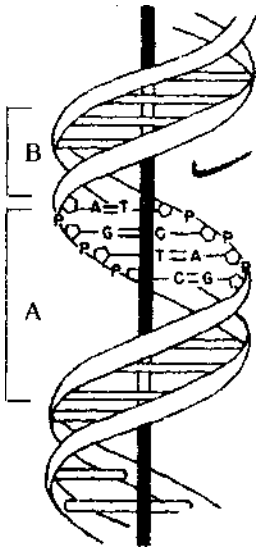
It is estimated that tRNA forms 10 to 15%, mRNA 5 to 10% and rRNA 75 to 80% of the total RNA of the cell.
mRNA encodes the amino acid sequence of one or more polypeptides specified by a gene or set of genes.
tRNAs read the information coded in the mRNA and transfer the appropriate amino acids to a growing polypeptide chain during protein synthesis.
rRNAs are constituents of ribosomes that synthesize proteins.
RNA is a polsynucleotide, i.e. it contains a large number of nucleotides in its molecule. The nucleotides forming RNA consist of the following components:-
1. A nitrogenous base which may be either a purine (adenine or guanine) or a pyrimidine (cytosine or uracil).
2. Ribose which actually is D-ribose.
3. Phosphoric acid.

DEOXYR1BONUCLEIC ACID (DNA)

DN A contains the genetic information that gives rise to the chemical and physical properties of living organisms The nucleotides in DNA are linked to each other in the same way as in RNA. However unlike RNA, DNA is a double-stranded molecule or a double helix and sugar present in it is 2'-deoxyribose. Moreover DNA has the pyrimidine thymine and not uracil.

Shape of DNA molecule :

Watson and Crick in 1953 hypothesized that the DNA molecule is a double helix. The double helix of DNA (nicknamed as coil of life) can be visualized as a spiral staircase wound around a cylindrical axis.
The bases are on the inside of the helix and the deoxyribose and phosphates on the outside. The helix in most of the DNA is of right handed type, i.e. the helix rises towards the right.
Double helix of DNA. A and B represent major and minor grooves respectively.
In DNA there are actually two antiparallel long molecules(each made up of a very long polydeoxyribonucleotide chain) which are wound on each other.These two chains are joined to each other throughout the whole length of the molecule through their respective nitrogenous bases. In this joining together a purines only joins with pyrimidines.
The helical structure repeats at intervals of 3.4 nm and therefore there are. 10 base pairs in each completed helixThe helix is 2 nm in diameter. The molecule shows a minor groove and a major groove.



Double helix of DNA A & B represents major & minor grooves respectively.

BIOLOGICAL ROLE OF DNA

DNA is the ultimate carrier of heredity in all eukaryotes and even most prokaryotes except certain viruses and phages.
Genes are composed f DNA in which the genetic information is contained in the form of codes.
The double helical structure of DNA.explains many of the properties of DNA.
DNA has two important properties;
to store genetic information and replicate, i.e. to synthesize double-stranded DNA exactly similar to the DNA originally present and
to produce mRNA (transcription) which will dictate the synthesis of proteins

Hormones

Hormones

These are chemical substances which are secreted into the body fluids by one cell or a group of cells and have a physiological control effect on other cells of the body.

ENDOCRINOLOGY

This is the science concerned with the structures and functions of the endocrine glands and the diagnosis and treatment of the disorders of the endocrine system.

Functions of hormones

1. Help to control the internal environment by regulating its chemical composition and volume.
2. Transport substances through the cell membrane.
3. Play a key role of growth and development.
4. Contribute to the basic processes of reproduction, Fertilization, nourishment of the embryo, and delivery of newborns.
5. Regulate metabolism and energy balance in the body.

Types

1. Local hormones: These have specific local effects on the body.

Example: Acetyl choline, secretin and Cholecystokinin.

2. General hormones: These affect body cells far away from their points of secretion. A few general hormones affect all the cells of the body, such as growth hormone and thyroid hormone. On the other hand, some hormones affect only on target cells because they have specific receptors for the hormone. **e.g.** ACTH, estrogen, and progesterone.

CLASSIFICATION OF HORMONE

BASED ON THE CHEMICAL NATURE

1. Peptides

- Anterior pituitary hormones - GH, ACTH, prolactin
- Posterior pituitary hormones - ADH, oxytocin
- Islets of langerhans - Insulin, glucagon, somatostatin
- Thyroid gland - calcitonin
- Parathyroid gland - parathyroid hormone
- Hormones of the GIT, i.e substance P
- Releasing and inhibitory hormones of the hypothalamus
- Ovaries - relaxin

2. Glycoproteins

HCG, TSH, LH, and erythropoietin

3. Steroids

(Cholestrol derivatives)

- Adrenal cortex (aldosterone, cortisol adrenal androgens)
- Ovaries (estrogen and progesterone
- Testes (testosterone)

4. Aminoacids

(Tyrosine derivative)

Thyroid gland - T3 - T4,

5. Amines

(Tyrosine derivatives)

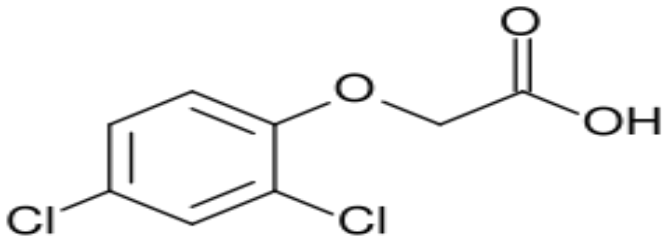
- Acetylcholine, epinephrine,

Nor-epinephrine and melatonin.

GROWTH HORMONE (GH)

Human growth hormone is a hormone of the anterior pituitary gland and is also known as somatotropin or somatotropic hormone (STH). Its basic function is to cause body cells to grow.

Nature GH is a small protein (peptide)



Functions of GH

1. Effects on protein metabolism:

a) GH has predominately anabolic effects on skeletal and cardiac muscles. It stimulates the synthesis of protein , RNA and DNA.

b) It promotes aminoacid entry into cells, as does insulin.

c) It decreases the catabolism of protein because G.H mobilize free fatty acids to supply energy.

2. Effects on carbohydrate metabolism: (Hyperglycemia)

GH is a diabetogenic hormone. Because of its anti-insulin effect, GH has a tendency to cause hyperglycemia.

3. Effects on fat metabolism the:

a) GH has an overall catabolic effect in adipose tissue. It stimulates the mobilization of fatty acids from adipose tissue, leading to decreased triglycerides content in fatty tissue and increased plasma levels of fatty acids and glycerol.

d) **Fatty liver:** This occurs due to excess mobilization of free fatty acids from adipose tissue.

4. Effects on inorganic metabolism:

a) GH increase the retention of the phosphorus and Ca++ in body fluids by increasing absorption from the GIT and renal tubules.

b) It also causes the retention of Na^+, K^+, Cl^- and Mg^{++}.

5. Effects on bone, cartilage, and soft tissues:

a).It acts on cartilage and bone, stimulating growth.

b) Increases the deposition of connective tissue.

c) Increases the thickness of skin.

d) Increases the growth of viscera (liver, kidney) etc.

e) Increases milk secretion in lactating animals.

OXYTOCIN

Introduction

This is a hormone of the posterior pituitary gland.

Chemical nature

Polypeptide containing 8- aminoacids.

Actions of Oxytocin

1. Effects on the uterus:

It stimulates contraction of the smooth muscles of the pregnant uterus.

It is released in large quantities just prior to delivery.

2. Effects on milk ejection:

It causes increase milk ejection in lactating breasts.

Stimulus for milk ejection:

i) Sucking of nipples of breasts by a baby

ii) Handling of breasts by a baby,

iii) Crying of a baby for feeding,

iv) Sight or sound of a baby.

3. Effects on fertilization:

Oxytocin is also released during coitus by a nervous reflex. It causes uterine contraction and has a sucking effect on seminal fluid. It accelerates transport of the seminal fluid towards the fallopian tubes, favoring fertilization.

4. Effects on blood vessels:

In large doses oxytocin causes vasodilatations and decreases blood pressure.

5. Effects on pituitary gland:

i) It causes prolactin secretion.

ii) It inhibits ADH secretion.

Clinical indications for use of oxytocin:

i) Inducing labor. ii) Treatment of uterine haemorrhage

INSULIN

Introduction

Insulin is a small protein which acts to lower the blood glucose level. This hormone is secreted by beta cells of the islets of Langerhans of the pancreas.

Chemical Nature

Insulin is small soluble protein containing 51 aminoacids.

Effects of insulin

1. On carbohydrate metabolism:

a) 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.

b) It increases utilization of glucose for energy.

c) It increases glycogen storage in cells.

d) It increases the conversion of glucose into fat to be stored in adipose tissues.

2. On fat metabolism:

a) Forms fatty acids from excess liver glucose by activating acetyle-s-CoA carboxylase.

b) Fatty acids are utilized from triglycerides which are stored in adipose tissues.

c) It inhibits hydrolysis of triglycerides in fat cells by inhibiting hormone sensitive lipase.

3. On protein metabolism:

a) It causes active transport of amino acids into cells.

b) It promotes translation of mRNA in ribosomes to form new proteins.

c) It promotes transcription of DN A in I nucleus to form mRNA.

d) It inhibits protein catabolism.

e) It inhibits gluconeogenesis from amino acids.

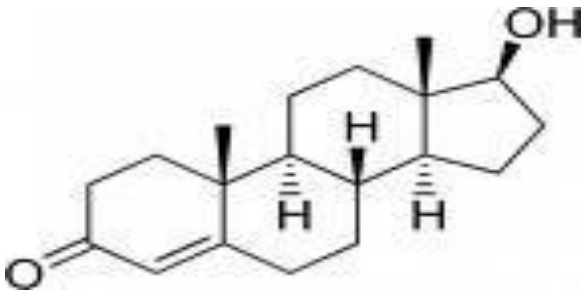
4. On growth:

a) Insulin is essential for growth, as it increases protein formation.

Testosterone

Introduction

This is the principle hormone of the testes which consists of 19 carbon atoms.



Nature : Steroid in nature.

Actions of testosterone

1. Effect on the male reproductive system

a) 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 2months of gestation) and suppresses the formation of female genital organs.
b) In adults testosterone is secreted by the Leydig cells of the testes. 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.

2. Effects on secondary sex characteristics

Introduction

These characteristics make their appearance under the influence of sex hormones at puberty. The effects of testosterone on secondary sex characteristics are:

a. Body hair: Increased growth of hairs on the face (beard and moustaches), chest, Axilla, and pubis (male pattern is convex while the female pattern is concave).

b. Baldness: Decreased growth of hairs on top of the head.

c) Voice: Testosterone causes hypertrophy of the laryngeal mucosa and enlargement of the larynx. It also increases the length and thickness of the vocal cords, the voice becomes deeper.

d) Skin: Testosterone causes thickness of the skin, roughness of the subcutaneous tissue, deposition of melanin in skin, and also increase sebaceous gland secretion (may result in acne during puberty).

e) Body changes: Testosterone causes

broadening of the shoulders and hypertrophy of muscles in males. It also decreases subcutaneous fat. This is why males have less subcutaneous fatty tissues as compared to females.

f) Behavioral changes: Testosterone is also responsible for aggressive moods, active attitudes, and interest in the opposite sex.

3. Effect on protein metabolism :

a) It increases protein synthesis and build up the musculature.

b) Causes positive N^2 balance.

c) Decreases blood urea levels.

4. Effect on CNS

Increases the libido by directly acting on CNS.

5. Effect on bone

a) Increases thickness of bones.

b) Increases total quantity of bone matrices.

c) Increases the deposition of calcium salts in bones.

d) Narrows the length of the male pelvis outlet.

e) Increases the length of the male pelvis and makes it funnel shaped.

f) Increases the strength of the pelvis and makes it strong.

6. Effect on body length

If testosterone is secreted in excessive amounts it decreases the length of the body due to the early fusion of the epiphyses.

7. Effect on BMR

It increases the BMR (12-16%) due to increased protein formation.

8. 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.

9. 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.

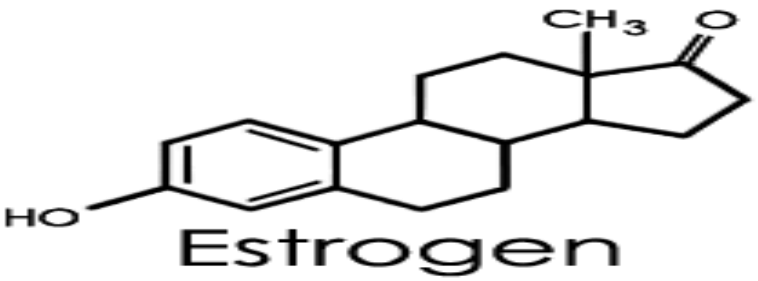
Estrogen

Introduction

Estrogen is a female sex hormone.

Nature An 18-carbon steroid.

Structure



Estrogen

Types: The naturally occurring estrogen is of three types:

i. 17- β - estradiol
ii. Estrone
iii. Estriol

Actions of estrogens

A. Effects on reproductive system**:**

1. Effects on the vagina

a) Increases the size of the vagina

b) Causes enlargement of the musculature of the walls of the vagina.

c) Changes the simple cuboidal epithelium to stratified epithelium, which is more resistant to trauma and infection.

d) Increases the deposition of glycogen.

e) The vaginal pH becomes more acidic due to conversion of glycogen into lactic acid by the bacteria.

2. Effects on external genitalia:

a) Increases the size of the clitoris and labia minora.

b) Increases the deposition of fat on the mons pubis and labia majora.

3. Effects on cervix:

a) Causes slight enlargement of cervix.

b) Epithelium becomes stratified.

c) Increases the alkaline secretion of the cervix to neutralize the acidic pH of the vagina.

4. Effects on the uterus:

a) Increases the size of the uterus.

b) Changes the cuboidai epithelium into columnar epithelium.

c) Causes growth of the uterine glands.

d) Increases vascularity.

e) Increases glycogen contents.

f) Increases the sensibility of myometrium to oxytocin.

5. Effects on the fallopian tubes:

a) Causes the proliferation of glandular tissue.

b) Increases the number and activity of ciliated epithelial cells.

c) Helps in fertilization by causing peristaltic contraction.

6. Effects on ovaries:

Estrogen inhibits LH and FSH secretion by a negative feed back mechanism, decreasing the ovarian function. It is used as an oral contraceptive.

B. Effects on secondary sexual characteristics:

1) Effects on breast:

a) Promotes the development of the tubular duct system.

b) Synergistic with progesterone in stimulating the growth of the lobuloalveolar portion of the glands. Increases the deposition of fat. C) c)Responsible for their smooth appearance.

2) Effects on the skin:

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)

3) Effects on the voice:

The larynx of a female retains its prepubertal so size the voice remains high pitched.

4) Effects on the skeleton:

a) Causes broadness of the pelvis.

b) Increases the osteoblastic activity.

C) Other effects:

1. Effects on protein metabolism:

Increases the synthesis and deposition of proteins.

Positive N_2 balance.

2. Effects on fat metabolism:

a) Increases the synthesis of fat.ss

b) Increases the deposition of fat in subcutaneous tissue, especially the breasts, medial side of the thigh, and buttocks.

3. Effect-, on water and electrolytes:

It increases the retention of Na+, Of, and water, increasing the E.C.F.

4. Effects on the menstrual cycle:

This hormone is responsible for the proliferative phase of the menstrual cycle.

5. Effects on blood/cholesterol:

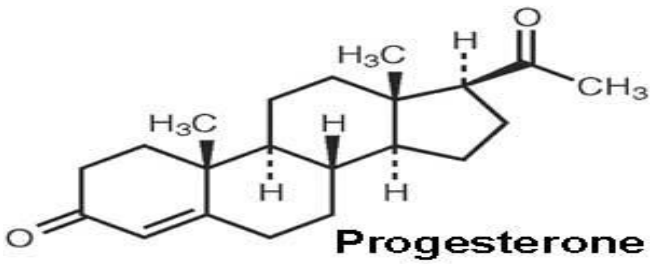
a) Decreases blood cholesterol levels (this is why females have a low risk of hear disease).

b) Raises fibrinogen levels.

Progesterone

Introduction:

Progesterone is a female sex hormone.



Progesterone

Nature:

Steroid.

Actions of progesterone:

1. Effects on uterus:

a) Promotes secretory changes in the uterine endometnum during the secretory phase of the menstrual cycle.

b) It prepares the uterus for implantation of the fertilised ovum.

c) Decreases the excitability and snsitivitv to oxytocin.

d) Decreases the frequency of uterine contractions, lengthening the period ot pregnancy (prevents expulsion of the implanted ovum).

2. Effects on Fallopian tubes:

a) Promotes secretory changes in the mucosu lining of the fallopian tubes for the nutritional needs of the fertilized ovuir.

b) Increases peristaltic movements from the ovary to the uterus, aiding fertilizatior.

3. Effects on cervix:

a) Causes relaxation of the cervix

b) Relaxin may act only in the presence of progesterone.

4. Effects on vagina:

a) Increases cellular proliferation

b) Increases mucous secretion.

5. Effects on breast:

a) Stimulates the development of tubules ancalveoli of the mammary glands

b) Causes the alveolar cells to proliferate, enlarge, and become secretory

6.Effects on ovulation:

Inhibits ovulation by inhibiting the release of LH and FSH. During pregnancy ovulation is inhibited by luteal and placental progesterone.

7. Effects on protein metabolism:

Mobilzes proteins during pregnancy for the use of the fetus.

8. Effects on electrolyte balance:

Large doses of progesterone produce natriuresi (excretion of abnormal amounts of Na" in urine). This probably occurs by blocking the action of aldosterone on the kidneys

9. Effects on skin:

a) Increases the secretion of sebum on the skin and makes the hair of the scalp more oily.

b) Responsible for premenstrual .icne and hair changes during pregnancv.

10. Effects on body temperature:

After 24 hours of ovulation the body temperature increases due to the secretion of progesterone from the corpus luteum.

ENZYMES

Enzymes

The enzymes can be defined as "These are the catalysts of biological system that are produced by the living cell which are capable of catalyzing the biological reaction between certain reactants to yield specific product"

OR

The enzymes are the organic catalysts produced by the living organisms that's why called as Biological Catalysts.

Catalysts

Catalyst is a chemical which is used to boost up chemical reaction but it is not utilized itself in the chemical reaction.

Substrates

These are the molecules on which enzymes can act.

PROPERTIES OF ENZYMES

- ## Catalytic Property

Small amount of enzymes can catalyzed the large amount of substrate in a Biological reaction.

Example

Sucrase enzyme in its small amount easily catalyzed the hydrolytic reaction of the **sucrose**.

- **Solubility**

Enzymes are mostly soluble in water and dilute alcohol solution. The Enzymes can precipitate in the following solvents.

- Concentrated Alcohol
- Ammonium Sulphate
- Tricholro Acetic Acid.

- **Enzymatic Property**

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

- **pH**

Acids:

Acids deactivate those enzymes that act at alkaline PH e.g. Trypsin act at alkaline PH 8.57. At acidic PH it will destroy. Trypsin is an enzyme that secreted by Pancreas and very important for proper digestion of food.

Bases:

Bases deactivate the enzymes that act at acidic pH e.g. pepsin act at acidic PH 1-2. At alkaline PH, it will destroy.

- **Temperature**

Optimum temperature is 96 F-to-99F. The optimum temperature for enzymatic activity is regard between
35 c - to - 40 c.

1. At 0 °c ---------- Inactive
2. 10° c-to-20° c ---------- Very little active
3. 35° c-to-40° c ---------- Maximum active
4. 50° c ---------- Inactive
5. 60° c ---------- Destroy
6. In solid Condition it may be stable up to 100 ° c.

The mechanism of enzyme reactions

Following are the stage in a typical enzyme _catalyzed reaction.

1. Formation of enzyme _substrate (ES) complex

The three dimensional structure of enzymes [E] permits them to recognize their substrates [S] in a specific manner and to form an enzyme _substrate complex,

i.e. enzyme substrate → enzyme _ substrate complex

or

E+ S → ES.

Active site

Definition:

The binding takes place between the substrate molecules and a place over the enzyme called the substrate site or active site.

or

The catalytic site can be considered to the function as cleft that can trap the substrate for which it has a high affinity and great specificity.

2. Conversion of the substrate(s) to the product (p) forming EP .

ES → EP

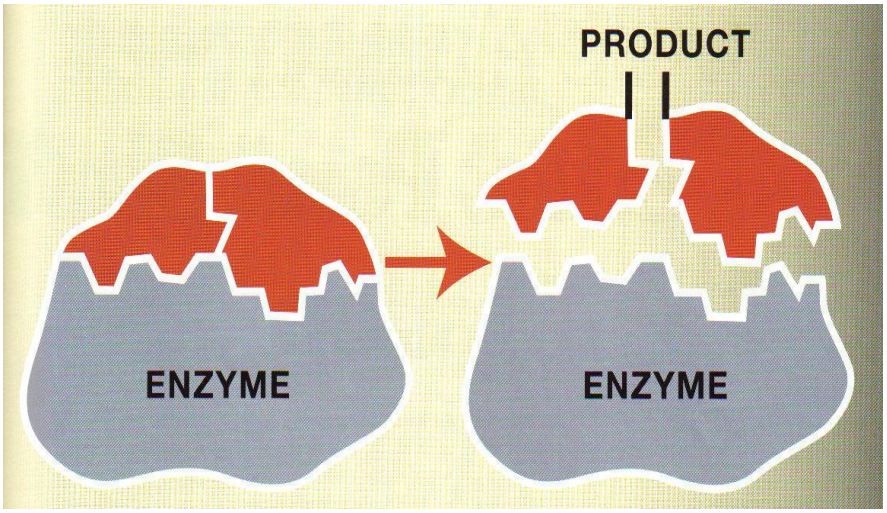
3. Release of the product from the enzyme.

E P → E+P

The sequence enzyme freed from the product can now on another molecule of the substrate and so on and on.

General reaction

E +S → ES → E P → E + P



(Enzyme Substrate Complex)

Chemical nature of enzyme

With a few exceptions (certain) RNA molecules called ribozymes)
Enzymes are either pure proteins or contain proteins as essential components and in addition require small non_protein molecules and metal ions which are also essential for their activity. In the latter case the protein component is called apoenzyme, while the non_ proteins Components is either a prosthetic group, a cofactor or coenzyme. The apoenzyme and the non_proteins component is either a prosthetic group, a cofactor or coenzyme.

Holo Enzyme

The apo enzyme and the non_ protein part together constitute the whole or complete enzyme termed holo enzyme.
Non_ protein components needed for enzymatic activity.
These include derivatives of B vitamins and metallic ions.

Cofactors

These are inorganic ions
e.g. Cu+2 (cytochrome oxidase), Fe+2 or Fe+3 (cytochrome oxidase)

Coenzymes

These are either organic or metallo _ organic molecules.

Prosthetic group

Those cofactors and coenzymes that are very tightly bound with the enzyme protein are designated as prosthetic groups.

Classification of enzymes

Enzymes have been named in many different ways. In many cases their names end in ht suffix as which is preceded by the name of its substrates, e.g. sucrase, lipase, urease, etc. in other cases their names describe the action of an enzymes, e.g. transmethylase, oxidase, in still other cases their names are trivial and don not at all point out their substrate or pancreatic lipase, other indicate some distinctive features of its action e.g. serine protease.

According to the enzyme commission (E.C) system, there are six main classes of enzymes and as mentioned above each one of these in further subdivided into subclasses and sub-classes. The main classes are the divided are the following.

i. Oxidoreductases. **ii. Transferases.**

iii. Hydrolases. **iv. Lyases.**

v. Isomerases. **vi. Ligases.**

Oxidoreductases

These enzymes, also called redox enzymes, catalyze oxidation – reduction reaction by transferring H atoms or hydride [H-] ions. This group is further divided into four subgroups,

i.e. oxidases, dehydrogenases, hydroperoxidases and oxygenases.

1. Oxidases

$H2O + O_2 \rightarrow H_2O_2$ $H_2O + O_2 \rightarrow H_2O_2$

Hypoxanthine → Xanthine → Uric Acid

2. Dehydrogenases

Pyruvic → lactic acid

3. Hydroperoxidases

4. Oxygenases

Transferases

Definition

These enzymes bring about a transfer of functional group such as phosphate, amino, acyl, methyl, from one molecule to an other molecule.

TYPES.

1. Transaminases
2. Phosphotransferases (Kinases)
3. Transmethylases
4. Transpeptidases
5. Transacylases

Hydrolases

Definition

These enzyme catalyze hydrolysis (added water is instant decomposed & functional group of substrate transferred to water)

Subgroups

1**. Protease** **2. Carbohydrases**

3. Lipid hydrolyzing enzymes **4. Deaminases**

5. Deamidases

Lyases

Definition

These enzymes catalyze the addition of NH_3, H_2O OR CO_2 to double bonds or removal of these groups leaving behind double bonds.

$$\text{Fumaric acid} + H_2O \xrightarrow{\text{fumarase}} \text{Malic acid}$$

Isomerases

Definition

These enzyme catalyze the structural change in a molecule by the transfer of group in it & formation of isomeric form of subsrate.

e.g

$$\text{Glucose 6-phosphate} \rightarrow \text{fructose 6-phosphate}$$

(The enzyme is phosphohehexose isomerase)

Ligases

Definition

These enzymes catalyze condensation reaction joining two molecules by forming C-O,C-S,C-N, & C-C bonds along with energy releasing hydrolysis or cleavage of high energy phosphate ,
e.g ATP, GTP.etc

Acetyle-coA → Molonyle-coA

(Acetyl-CoA carboxylase)

Factors affecting the enzyme Activity

1. Enzyme concentration

The rate of reaction is directly proportional to the concentration of enzyme Enzyme concentration in the body may fall or rise due to changes in the rate of its synthesis and /or degradation which are brought about many factors including hormones and metabolites.

2. Substrate concentration

The rate of reaction is directly proportional to the concentration of substrate upto the limit.

3. Effect of temperature

The rate of reaction increases with increase in temperature over limited range of temperatue and on reaching a certain high temperature the enzyme activity starts decreasing

Usually the enzyme reaction in man occur best at or round 37◦C which is the average normal body temperature.

Optimum Temperature

The temperature at which an enzyme reaction occurs fastest is called its optimum temperature.

Some plant enzymes act best at temperature around 60◦C e.g.

The enzyme DNA polymerase isolated from a bacterium named The rum aquaticus that grows in hot water springs is stable even at 90◦C.

4. Effect of pH

Optimum PH

Optimum PH is at which enzyme catalyzes the reaction at maximum rate.

e.g

Optimum PH of salivary amylase is 6.4 to 6.9 and that of trypsin is 8.0 to 9.0.

Extreme changes in pH may actually denature the enzyme.

5. Presence of cofactors, coenzymes and prosthetic groups are also essential for enzymatic activity

Presence of inhibitors

Inhibitors

Certain substances inhibit the enzyme activity called enzyme inhibitor

Types:

1. Reversible inhibition

2. Irreversible inhibition

Functions of enzymes

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

1. Decrease in activation Energy

They decrease activation energy. Most enzymes catalyzed reaction are highly efficient

Proceeding from 10^3 to 108 times faster than un catalyzed reaction.

$H_2O_2 \rightarrow H_2+O_2 \quad \Delta H=18000$cal per mole

If the reaction is catalyzed by enzyme then

$H_2O_2 \xrightarrow{\text{Enzyme}} H_2+O_2 \quad \Delta H=2000$cal per mole

2. Digestion

They play important role in digestion for the conversion of large complex & non diffusible molecules into smaller, simple and diffusible molecules e.g. Amylase, Trypsin, lipase etc

.3. Cheese Making

Enzymes are also used in the manufacturing of cheese

e.g

Chemosin is obtained from fungus & is used in cheese making

4. Sweetner

Some enzymes are used as sweetener

For example

Glucosidase

$$\text{Sucrose} \xrightarrow{\text{glucosidase}} \text{glucose+fructose}$$

Glucose is 70% sweeter while fructose is 60% sweeter than sucrose.

5. As detergent

Carbohydrate & protein breaking enzymes are heat stabilizer & are used as detergent

e.g proteases

6. As drugs

some enzymes are used as drugs if there is any disturbance in the digestive system,

for example if there is no formation of amylase,pepsin,trypsin or lipase in the stomach or intestine these are obtained from vegetables & other resources.

7.For cancer treatment

Some enzymes are used for cancer treatment for example L.asparginase

8.Curing of diseases

Enzymes are also play important role in curing of diseases such as rickets & jaundice etc

For heart problem lactate dehydrogenase & for liver problem certain kinases are used.

9. Blood clotting

Enzymes also cause blood clotting by protein thrombin.

10. Alcoholic Beverages

Amylase is used in manufacturing of alcoholic beverages i.e bear in breaking of barley by fermentation process.

11. Meat tenderizing

Some enzymes like Trypsin pepsin and Papain etc s meat tenderizing to facilitate the process of digestion

CHAPTER 3

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:

All are complex organic substances. Their 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. Are not act as antigenic.

Classification of vitamins

Fat Soluble Vitamins

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

Water Soluble Vitamins:

- Vitamin - C.
- Vitamin - B Complex

These are further divided, on the basis of heat stability.

Thermo labile Vitamins

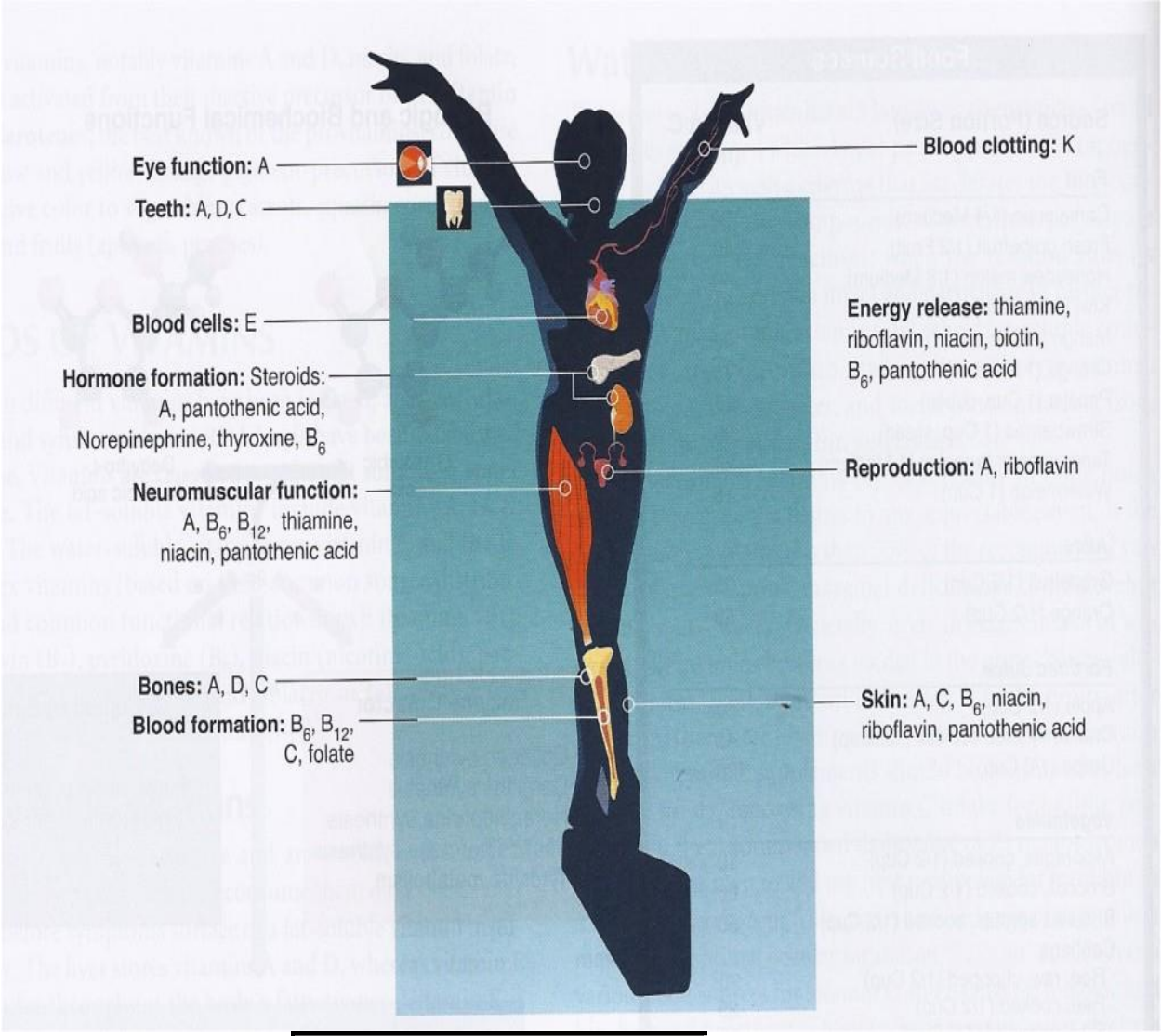
(Affected by heat)

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

Thermo stable Vitamins

(Unaffected by heat)

- Riboflavin (Vitamin - B2)
- Pyridoxine (Vitamin - B6)
- Niacin / Niacinamide
- Biotin
- Folic Acid
- Cobalamin (Vitamin - B12)
- Choline
- Inositol
- Para-amino-benzoic acid (PABA)
- Lopoic Acid



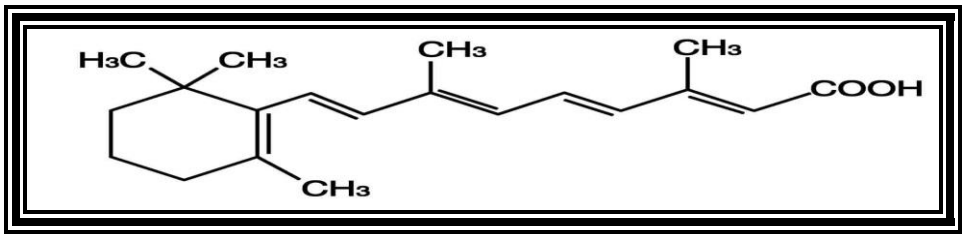
Vitamin — A (Retinol)

Vitamin A is a fat soluble vitamin; it is actively involved in the maintenance of normal visual process of eye. It is discovered by MC Collumin in 1915.

Synonyms

- Retinol.
- Retinal.
- Retinoic Acid.

Chemical Structure



Chemistry

1) The precursor or/provitamin "A" is the carotenoid pigment of certain plant know chemically as carotene.
2) Carotene is a hydrocarbon.
3) Vitamin A is quite heat stable but it is destroyed at high temperatures in the presence of O2 and air.
4) Vitamin A is a complex alcohol, found in following two forms

Vitamin – A1
Vitamin – A2

The relationship between Retinol, Retinal, and Retinoic acid is as follows:

$$\text{Retinol} \underset{\text{Reduction}}{\overset{\text{Oxidation}}{\rightleftarrows}} \text{Retinal} \xrightarrow{\text{Oxidation}} \text{Retinoic acid}$$

Source

1.Retinoid

Animal origin

- Retinol
- Retinal
- Retinoic Acid

➢ Occur as such in nature in Animal kingdom.Liver oils of certain species of fish e.g halibut, shark and Cod. Also occur in the livers of

other animals, egg yolk, butter, cheese, whole milk, kidney and muscles.

Carotenoids (provitamin A)

Plant origin

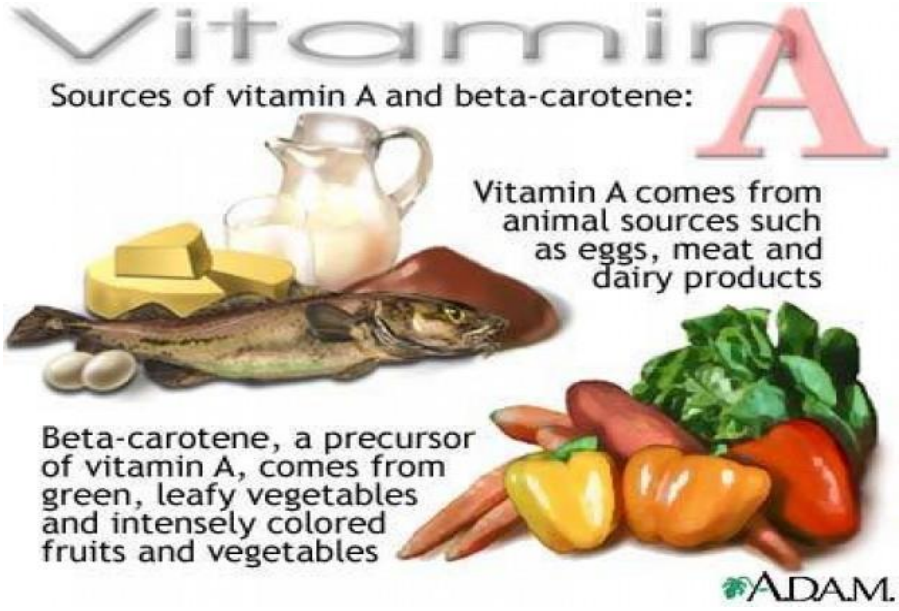
- Carotene
- Carotene(most efficient)
- Carotene

➢ Which are yellow-red pigments, found specially in carrots, yellow corn, sweet potato, turnip, peaches and spinach.
➢ No vitamin A activity but these are converted to vitamin A.
➢ Poor sources of Vitamin A (Not absorbed completely and their conversion is not 100%)
➢ Vitamin A not occur in vegetable oils.

Physiological Functions of Vitamin A

Eyes

Vitamin a is actively involved in the maintenanace of normal visual process of eye. Retinal occurs in the retina. Vitamin A is a component of visual pigments of rod and cone cells.It



combines with protein opsin to form rhodopsin which is essential for rod vision in dim light. Vitamin _ A participates both in dark/light vision as well as in colour vision

Reproduction

Retinol and Retinal forms of vitamin A are concerned with the normal Reproduction.
Male they facilitate the process of spermatogenesis.
Female they prevent fatal resorption.

Epithelial tissues

Vitamin-A, is appeared to be the essential factor for maintenance of normal healthy epithelial surfaces throughout the body. Essential for the formation of glycolipids and glycoproteins including those in goblet cells which secretes mucous.

Antioxidant role of B carotenes

These trap organic peroxide free radicals within its structure at low 0_2 concentration as compared to Vitamin E (acts at high 0_2 concentration).

Bones and teeth

It is essential for the normal growth and Development of bones and teeth. In some way it is construction of bones and teeth and also rates the process of mineralization.

Carbohydrate metabolism

Various experiments on animals have d that vitamin - A is engaged in conversion e sugar into glycogen.

Enhancement of immune system

Prevention of Infections

Vitamin A enhances the activity of immune system. Vitamin A deficient children are susceptible to complications of measles. Vitamin keeping body surfaces/lining healthy, said as "And - infective Vitamin.

Differentiation of immune system cells

Mild deficiency leads to increased susceptibility to infectious diseases.

Gene Expression

Vitamin A binds to transcription regulatory protein that controls gene expression.

Psoriasis and Acne treatment

Promote healthy skin and helps to regulate the skins process of shedding dead cells and fight with bacteria. Retinoic acid preparations are commonly employed.

Miscellaneous functions

- Involved in mucopolysaccharide synthesis.
- Involved in biosynthesis of gluco-corticoids.
- Involved in protein Synthesis.
- Involved in nucleic acid metabolism.

Clinical features associated with deficiency of Vitamin A

1. Eyes

Serious problem of the vision and eyes are found in various degrees of deficiencies of vitamin "A"

a. Nyctalopia

Night blindness due to disturbance in visual cycle.

b. **Xerophthalmia**

- Dry cornea, and mucous membranes of eye
- Atrophy of corneal epithelial cells
- Absence of tears
- Irritation to blinking

c. Keratomalacia

- Keratinization and degeneration of cornea -Defective vision.
- Dryness,
- Thickness and
- Change in normal epithelium of cornea and conjunctiva

2. Epithelial tissues

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

3. Skin

Skin become dry, scaly and thick keratinized.

1. Acne
2 Toad Skin. (irregular skin)

1) Follicular hyperkeratosis (Excessive development of keratin in hair follicles)
2) Psoriasis

4. Reproduction

Male:

- Atrophy of germinal epithelium of testis.
- Digospermia. (Low sperm count)

Female:

1) Disturbance in menstrual cycle.

5. Miscellaneous

2) Increased chances of stone formation in urinary tract
3) Increased chances of infections, especially in oral cavity, nasal sinuses, and respiratory passage,
4) Generalized growth failure,
5) Delayed Dentition,
6) Malformation of teeth and bones.

Toxicity of Vitamin A (Hypervitaminois A)

Acute: Headache, nausea and vomiting.
Chronic: Dry skin, cracking of lips, bone pain, fragility, brittle nails, hair Loss, gingivitis, hepatomegaly, ascites and portal hypertension.

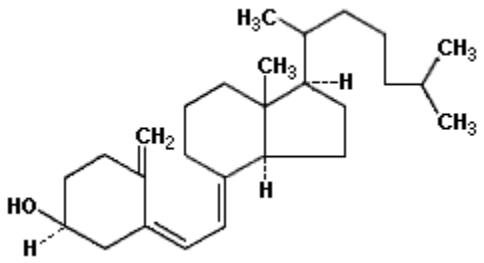
Vitamin D

Vitamin D is a fat soluble vitamin. Its deficiency may cause rickets in children and osteomalacia in adults.

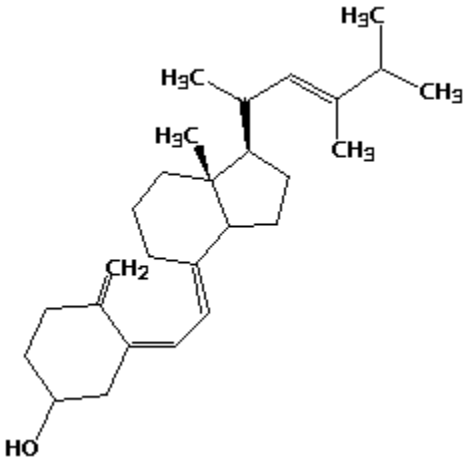
Synonyms

- Calciferol,
- Ergosterol.
- Anti-ricketic Vitamin.

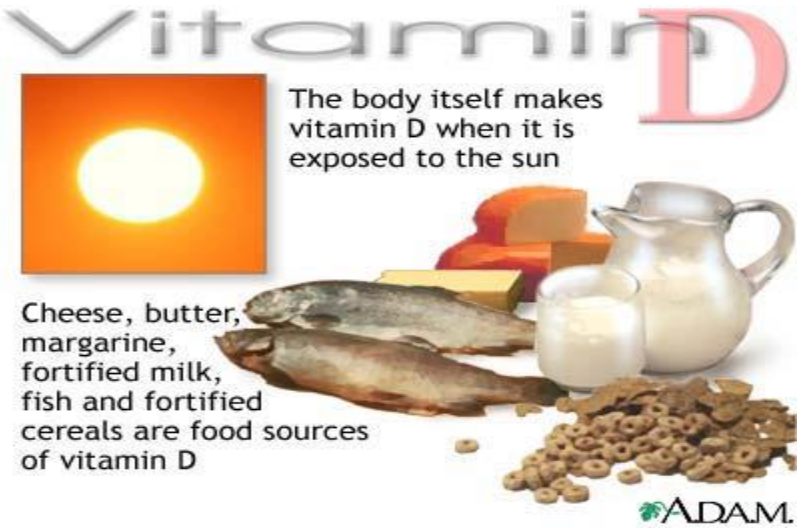
Chemical Structure



Vit. D3



Vit. D2



Chemistry

These are sterols, which are precursor of Vitamin D. There are about 10 compounds of Vitamin D and are named as Dl, D2, D3, D4, D5, D6, D7, D8, D9 and D10, out of these only 2 have anti-ricketic property e.g ergosterol and calciferol.

Ergosterol (Provitamin D2) — ⇩ UV irradiation → **Ergocalciferol (Vitamin D2)**

7-dehydrocholestrol (Provitamin D3) — ⇩ UV irradiation → **Cholecalciferol (Vitamin D3)**

Vegetable origin
First isolated from ergot

Animal origin
Human epidermis

D2 and D3 have same physiological actions in man.

Source

Vitamin D is not well distributed in nature, Cod and other fish liver oils are best sources, the few rich sources are liver of the animals which feed fish, eggs, butter, fortified milk . D3 content of milk depends on exposure to sunlight. Vitamin - D formed in the skin of human beings by ultraviolet-rays.

Activation of Vitamin – D

Vitamin D is not active as such.

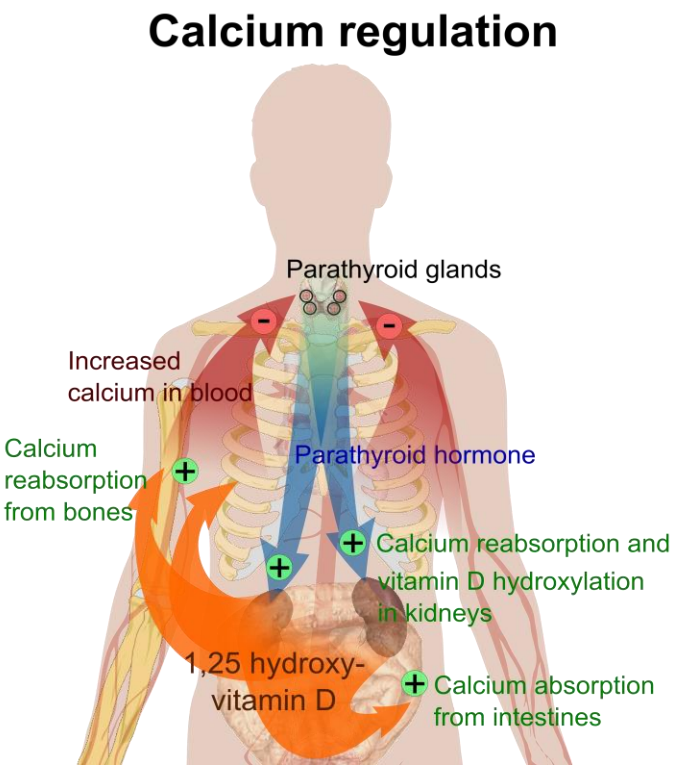
Cholecalciferol

⇩ Endoplasmic reticulum of liver cells

25-hydroxycholecalcifero (calcidiol)

⇩ Kidney

1,25 dihydroxycholecalciferol (calcitriol)



Factors regulating active Vitamin D3 formation

Stimulated by:

- Parathyroid hormone(PTH)
- Hypocalcemia
- Hypophosphatemia
- Estrogen, Progesterone

Suppressed by:

- High intake of Vitamin D
- Calcitriol
- Increase levels of plasma calcium and inorganic phosphate

Functions of Vitamin – D

Absorption of calcium in gut

Vitamin D promotes the Ca^{++} absorption from the intestine by:

- Increase the formation of Ca^{++} binding proteins in the intestine.

- Increase formation of Ca^{++}/ H^{+} ATPase pump in intestinal cells.

Phosphate absorption

Intestinal absorption of phosphate is increased by Vitamin D.

Serum Ca++ Level

Vitamin D, maintains the serum Ca^{++} level by

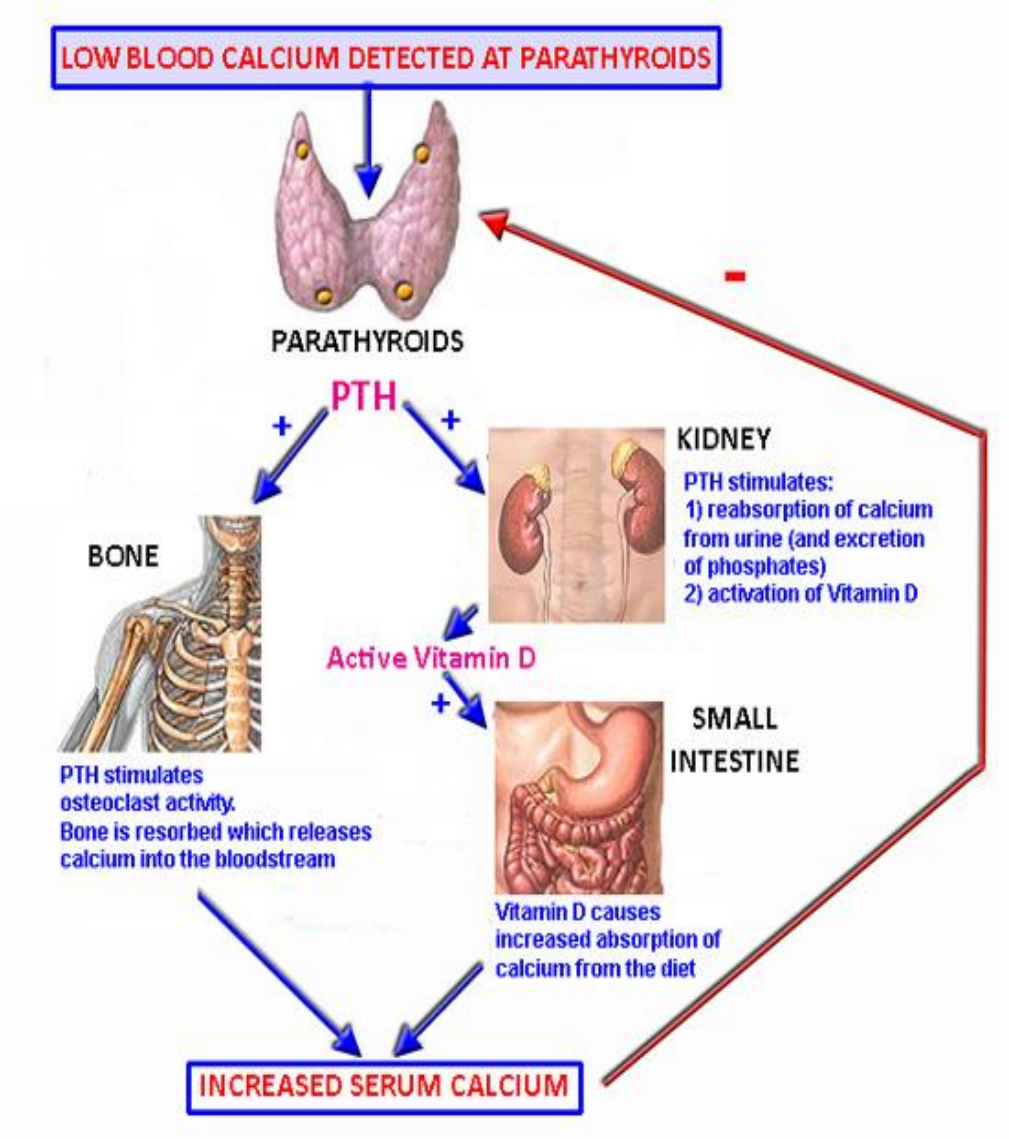
- Increased intestinal Ca^{++} absorption.
- Increase the mobilization of Ca^{++} from old bones.
- By increasing reabsorption of calcium and phosphate from renal proximal convulated tubule.

Growth of bones

Promote endochondral growth of long bones. Normal levels of calcium and phosphate favor bone mineralization. It ensures that Ca+ is deposited in the bones.

Parathyroid activity

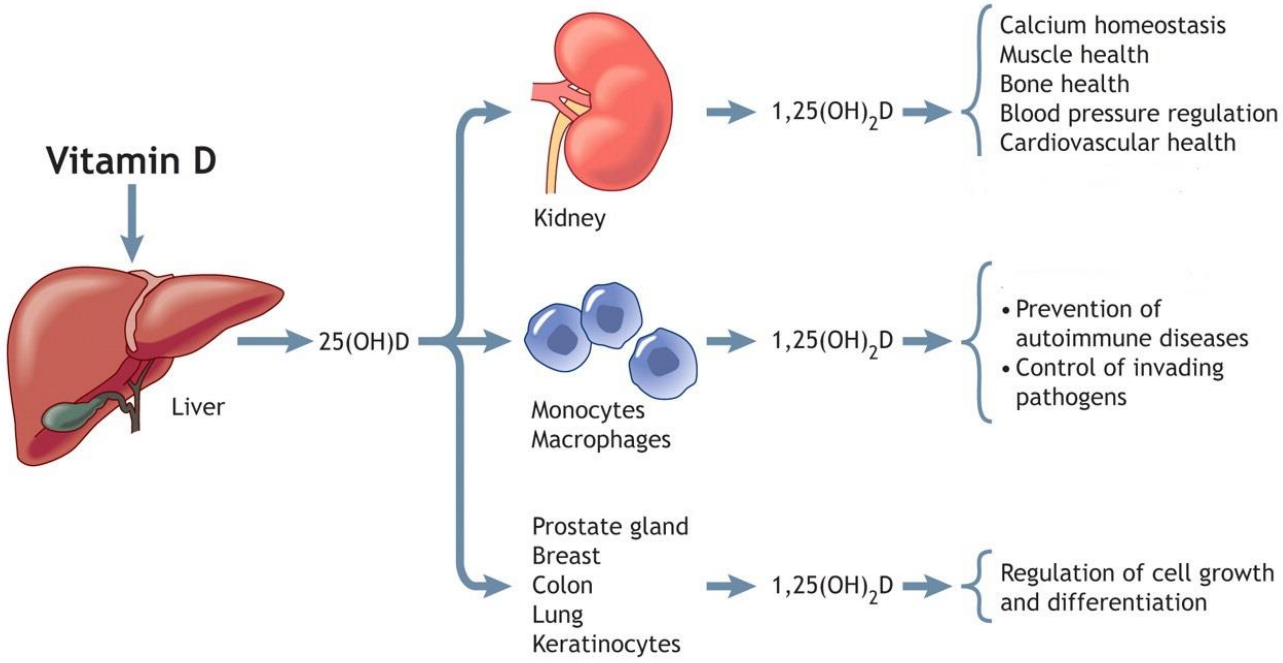
Activity of parathyroid hormone is stimulated in Vitamin D deficiency.
Hypercalcemia: Decreased the activity of parathyroid gland.
Hypocalcemia: Increased the activity of parathyroid gland



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.

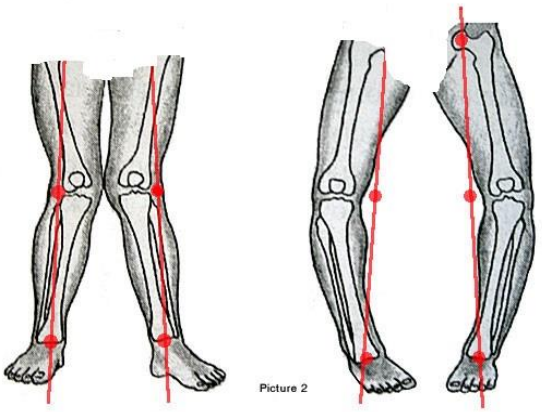
Rickets

It is a disease primarily due to a deficiency of dietary intake of vitamin D but an inadequate supply of calcium, phosphorus and sunlight may also play a part.
The deficiency of vitamin D results in a lowered calcium level which stimulates the secretion of PTH which acts to restore the plasma calciumat the expense of bone calcium. Serum Phosphate level is decreased to 1 -2 mg% (Normal = 4-6mg %), due to parathyroid hormone activity.
Rickets is also seen clinically when there is a defect in the conversion to calcitriol.

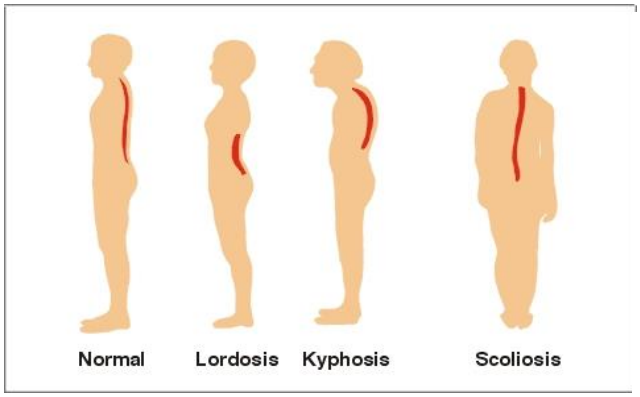
Bones

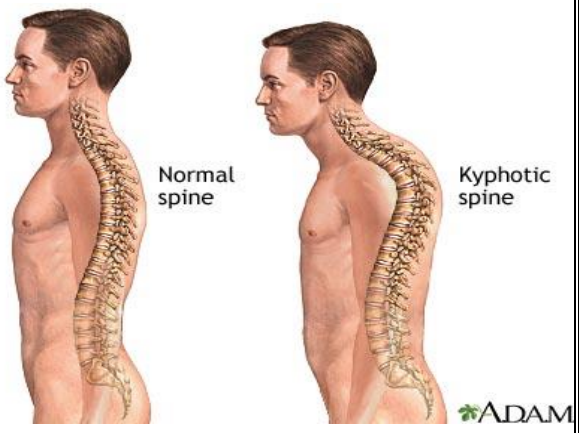
a. Osteoclastic activity,
b. Resorption of Ca^{++} from bones,
c. Bones become weak and fragile,
d. Newly laid bone is un-calcified,
e. Various skeletal deformities; - e.g.

- **Bow legs:** Tibia bends forward.



- **Rickety rosary:** Nodule develops at costochondral junction at wrist, ankles and knees.
- **Kyphosis:** backward protrude spine
- **Lordosis:** Side ward spine.
- **Scolosis:** Front ward spine.





- **Craniotabes:** Softness of skull bones
- **Harrison's sulcus:** Transverse groove in either side of bones.
- **Pigeons chest:** Sternum protrude forward
- Pot belly abdomen.

Teeth

- Delayed teething
- Malformed
- Defective enamel production, which exposes teeth to decay
- Ca^{+} : PO_4 ratio is misbalanced

Tetany

It may occur when serum Ca++ level falls to 1 mg% (Normal = 9-10 mg %).

Osteomalacia

"Adult Rickets".

- It mostly occurs in women who have little exposure to sunlight and are economically poor and undergone repeated pregnancies and lactation.
- Bone minerals are mobilized, X-ray shows less dense and less mineralized bones.Ca mobilization is greater than Pi mobilization.
- Bones are soft, weak and easy to get fracture.
- Bowing of legs (bending of lower leg bones).
- Looser's Zones is the characteristic radiographic feature.
- Muscular weakness : patient will find difficulty in climbing stairs and getting out of chair.
- Spontaneous fracture or collapse of vertebra are common.
- Tetany may be manifested by "carpopedal spasm" and facial twitching.

Toxicity of Vitamin – D (Hypervitaminosis D)

- Raised serum calcium and phosphate level
  Plasma cholesterol is raised
- Nausea, anorexia, vomiting, polyurea, polydipsia.
- G.I.T disturbances.
- Kidney stones formation.

- Calcification(deposition of calcium) of body soft tissues particularly arteries and kidneys.

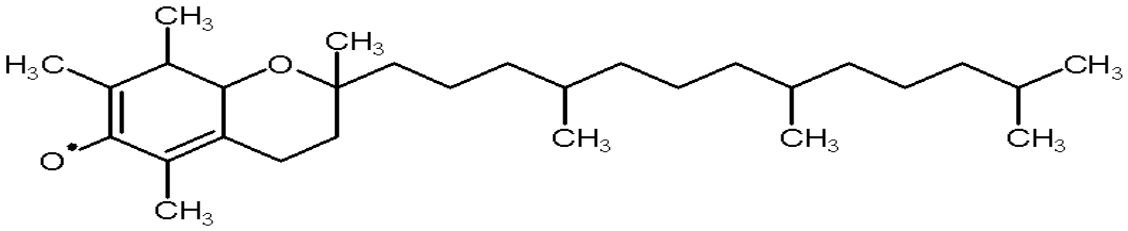
Vitamin – E

Vitamin E is a fat soluble vitamin; it is most important vitamin to maintain the normal process of reproduction. The origin of the name tocopherol is from "tocos" meaning childbirth and "phero" meaning to bear, implying a substance which increases fertility.

Synonyms

a. Tocopherol.
b. Anti sterility factor.
c. Anti oxidant factor.

Chemical Structure



Chemistry/Properties

- Fat soluble vitamin and stable to heat and acids.
- Alpha-Tocopherol is the most abundant and active form of vitamin E.
- These are all methyl derivatives of compound Tocol.

Source:

This vitamin occurs in the nature as light yellow oil.

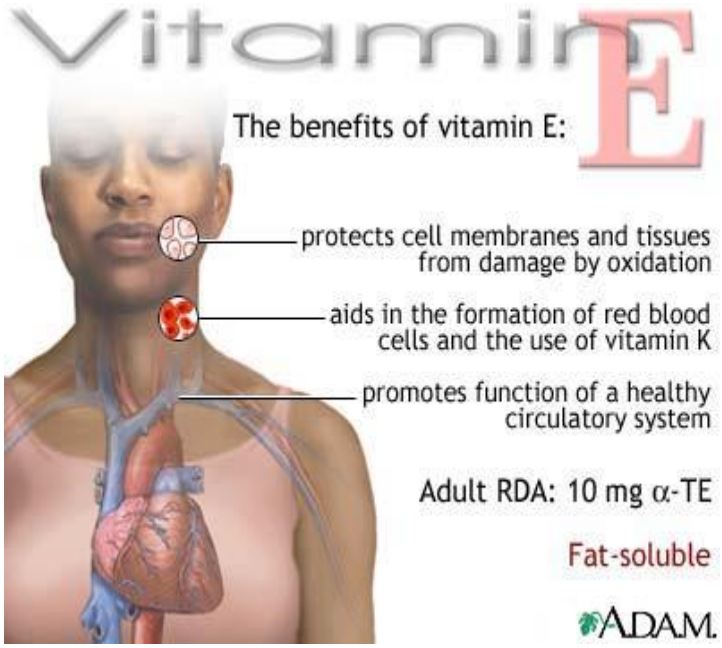
Animal:

Egg yolk, milk (Human milk contains more than Cow's milk) liver, cheese, butter etc.

Plant:

Wheat germ oil, cotton seed oil, peanut oil etc.

Functions of Vitamin E



1. Anti – Oxidant

a. The main function of Vitamin E is free radical trapping antioxidant in cell membranes and plasma lipoproteins. Thus helps in maintaining the integrity of lipid moiety of cell membranes and organelles.e.g mitochondria.

b.Vitamin E acts as antioxidant at high O_2 partial pressure e.g. RBC membrane, membrane of respiratory tract and retina.

2. Act as Co-Enzyme

In certain tissues it acts as co enzyme.

3. DNA synthesis

It controls the rate of synthesis of DNA.

4. Muscles

It is essential for the normal functions of muscles.

5. Care of RBCs

Vitamin E looks after RBCs and prevents them from heamolysis (By preventing membrane damage by various oxidants).

6. **Act as activator**

Acts as activation for enzyme system such as Cytochrome-C-reductase.

7. **Reproduction**

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

8. **Act as drug**

Used in Angina pectoris and in coronary insufficiency.

Deficiency of Vitamin E

The deficiency of vitamin E may cause following disorders:

1) **Haemolysis:** Rupture of RBC membrance due to increase lipid peroxidation.
2) **Oedema:** Specially in new born,
3) Muscular dystrophy
4) Reproduction failure
5) **Male:** Testicular dystrophy and defective spermatogenesis.
6) **Female**: I nfertility due to abnormalities in menstrual cycle, (resorption of fetus). Abortion:
7) Liver necrosis
8) Premature infants. Growth and Development retardation.

Uses

Recently vitamin E is used in following disorders:

i. Nocturnal muscle cramps,
ii. Intermittent claudication.
iii. Fibrocystic breast disease,
iv. Atherosclerosis.

Toxicity

Most studies have shown that, while taking loses of vitamin E, it has not shown toxic effects

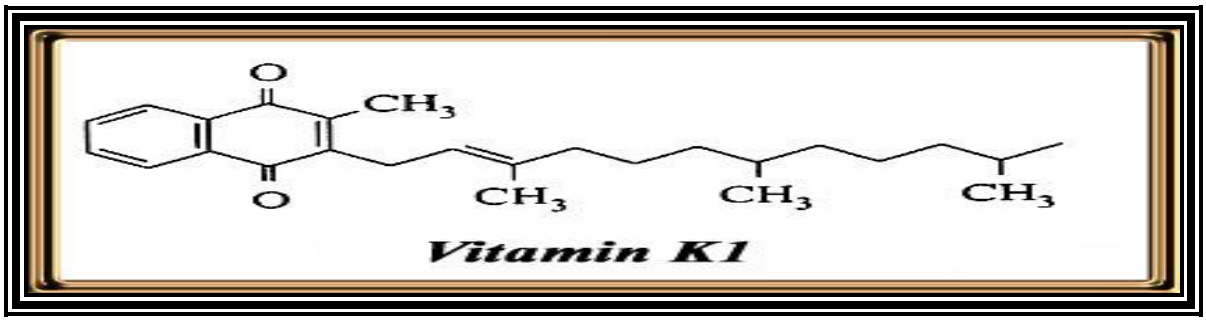
Vitamin K

The name vitamin K stands for **Koagulation vitamin** given by scientist to a substance that prevented Haemorrhage.
Its deficiency is characterized by hypoprothrombinemia and prolonged prothrombin time.

Synonyms

- Anti - Haemorrhagic Vitamin
- Coagulation Vitamin.

Chemical Structure



Vitamin K1

Chemistry

1. Vitamin K is a fat soluble and heat stable but is sensitive to light and oxidizing agents.

Chemically there are three forms of vitamin K.

2. K_1 (Plant Origin): Phylloquinone, isolated from alfalfa plant.

3. K_2 (Bacterial Origin): menaquinone.franoquinone
4. K_3 (Synthetic product) Menadione : converted in the body to one of menaquinones or phylloquinone. Vitamer(synthetic substances possessing vitamin activity)

Sources

- **Plant**

K_1: Green leafy vegetables such as Alfalfa, Spinach, Cauliflower, Cabbage, Tomato, Soybeans etc.

- **Animals**

  Fish, meat, milk, egg yolk, Liver

- **Endogenous Synthesis**

K_2: By Intestinal bacteria e.g E. coli.

Functions of Vitamin - K

Blood clotting Factors ii, vii, ix & x formation

The most important function of vitamin K is that it helps in the formation of blood clotting factors II(prothrombin), VII, IX and X by the liver. These factors are formed by liver in presence of Vitamin-K. Vitamin K is not the structural component of these compounds but bring about postranslational change necessary for their function.

Electron transport system

It appears to have some role in electron transport system, because its structure is similar to Co-Enzyme Q. In plant kingdom , vitamin K_1 is an essential component of the photosynthetic process.

Respiratory mechanism

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

Deficiency of Vitamin — K may cause

- Hypoprothrombinemia: A bleeding tendency of uncontrollable haemorrhage occurs.
- Prolongation of prothrombin time: Prothrombin time is prolonged up to 30 seconds. (Normal P.T = 12=15 Seconds)
- Abnormal clotting factors: In Vitamin K deficiency abnormal tests for coagulation factors ii, vii, ix & x may be demonstrated.
- Haemorrhagic status: An uncontrollable haemorrhage is the symptom of Vitamin – K deficiency,
- A new born child: May bleed from adrenal, brain, G.I.T and umbilicus.
- Clotting time is prolonged .
- In adults: Haemorrhage may also occur most commonly after operation on biliary tract.(Bile salts are needed for their absorption)

Causes of haemorrhage in new born

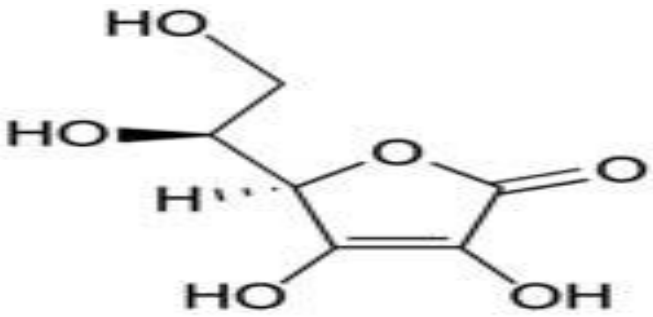
- In adequate intake of Vitamin - K by mother during pregnancy.
- Congenital absence of E-coli bacteria in the G.I.T.
- Decreased permeability of placenta for Vitamin - K during gestation.

Antagonists of Vitamin –K

Drugs having anti-vitamin K activity.

- Heparin.
- Warfarin
- Dicumerol.

Toxicity of Vitamin – K



- Hemolytic anemia in rats.
- Kernecterus in infants.
- Restlessness, irritability.
- Mental retardation.

Vitamin - C / Ascorbic Acid

Vitamin C is water soluble, anti scorbutic vitamin.(Inhibition of scurvy)

Chemical Structure

Chemistry

- In human body vitamin C is found as L-Ascorbic Acid.
- The active form of vitamin C is ascorbate acid
- Human body is unable to synthesize Vitamin - C.
- It is a strong reducing agent and therefore readily oxidized in the body to dehydro ascorbic acid.

- Freezing an dehydration retains the Vitamin-C.
- Stable in solid form, and in acidic solution but rapidly destroyed in alkaline solution.

Source

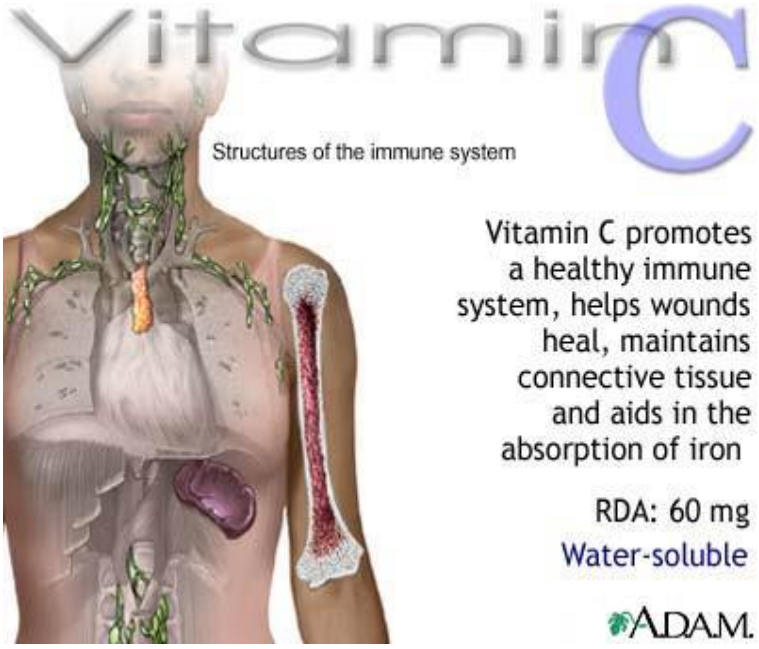
Plant Source

Fresh Fruits: orange, lemon, grapes, guava,apple, strawberry etc. Fresh Vegetables: tomatoes, cauliflower,cabbage, onion, lettuce, green peas, beans etc.

Animal Source

Animal tissues are not a good source

Liver, kidney, adrenal glands etc.



Functions

Intercellular substance

Ascorbic acid is required for the functional activities of fibroblast and osteoblast and consequently for the formation of collagen fibres 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

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

Antioxidant

It prevents injury to the body tissues from the toxic oxidation products.

Growth

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

Bones & teeth

Vitamin C helps in the deposition of Ca" and P04—in the bones and teeth.

Synthesis of protein matrix

It helps in the synthesis of protein matrix i.e by synthesising collagen and hydroxyproline. It also play an important role in certain amino acid metabolism such as phenylanaline and tyrosine.

Oxidation - Reduction;

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

Iron absorption and mobilization

Vitamin C helps in reducing Fe3+ to Fe2+ and helps in the absorption of iron from the intestine and its utilization (iron is absorbed in Fe2+ form) .

Conversion of folic acid

It is involved in the conversion of folic acid to its active form called tetra hydrofolate. Ascorbic acid also inhibits the oxidation of tetrahydrofolate. Its deficiency causes megaloblastic anemia due to non utilization of folic acid.

Reaction to Stress:

Increase loss of Vitamin C occurs in the fever and infections.

Act as Co-enzyme

It acts as co-enzyme for liver estrases and also acj|iyjdjren carrier.

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.

Scurvy (Scorbutus)

The deficiency of Vitamin C results in a disease called scurvy. Many of its symptoms can be attributed to deficient collagen synthesis. It bears following signs and symptoms.

Hemorrhagic tendencies

Disruption of adventitia, media and basal lamina of blood vessels.Various, small or large haemorrhagic lesions develop any whereon the body. Bleeding usually occurs from mucous membrane of Mouth, GI..T, Urinary tract and Skin. cerebral haemorrhage may cause death.

Wound healing

Failure of cells to deposit collagen fibrils and inter cellular Substances, results in delayed healing of wound.

Teeth and gum changes

Show Necrotic changes, spongy, swollen and purplish gums, redness, ulceration and bleeding tendencies. Teeth become lopse and fragile, might be fall off."

Skin changes

Follicular hyperkeratosis with coiled hairs and perifollicular haemorrhages, especially in the region of upper arms back and shins (anterior edge of tibia).

Bone growth

There is retardation in the growth of bone in the deficiency of Vitamin C.

Bones are weak, easy to get fractures and without formation of new matrix

G. I. T Changes

Haematemesis.

Nervous changes

In coordination of neuo-muscular junctions.

Non specific symptoms

This includes.

- Weakness
- Irritability
- Anorexia
- Weight loss
- Restlessness
- Drowsiness
- Excitability etc.

Toxicity

Have no well known toxicity but it may cause following effects:-

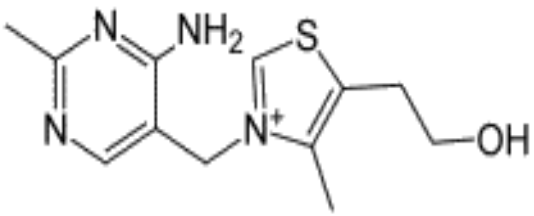
a. Erythrocytes of premature infants may be at greater risk for oxidative damage,
b. Excess ascorbic acid excreted in urine give a false +Ve test for sugar,
c. It has been implicated in the formation of urate and oxalate stones.

Vitamin - B1(Thiamin)

Vitamin - Bi is a water soluble vitamin, its deficiency is characterized by beriberi.

Synonyms Chemical Structure

a. Aneurine
b. Thiamine
c. Anti - Beri Beri factor
d. Anti Neuritic factor



Sources

It occurs in the outer layerof grains like bran and rice polishings.

Animal:

Egg yolk, liver, milk, kidney, heart and liver of fish.

Plant:

Whole cereal, yeast, whole wheat flour, pulses , nuts and fresh fruits. Vegetables contain it to a lesser extent.

Functions

Act as carboxylase:

Vitamin BI plays an Important role in various decarboxylase reactions.

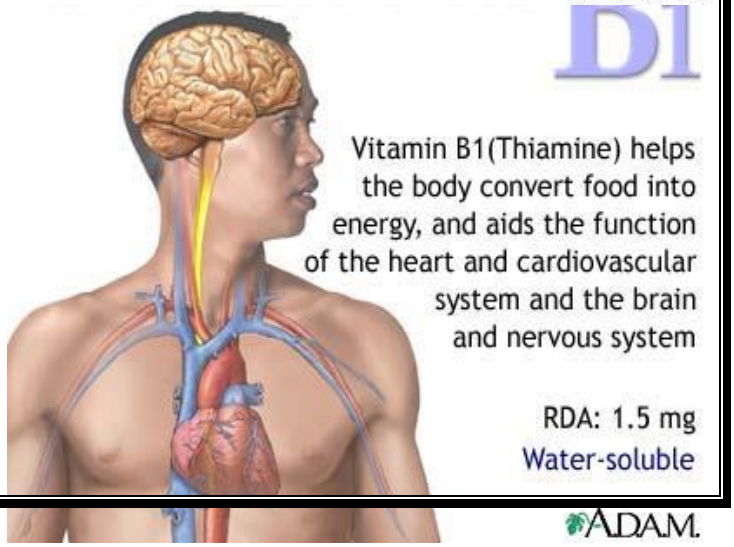
e.g:

a. Pyruvic Acid → Acetyl CO-A + C

b. Citric Acid → a-Ketogluteric Acid+CO

2. As Transketolase

Vitamin Bi acts as transketolase for pentose phosphate pathway. Its presence is necessary for enzyme action.



3. Conversion of Fat

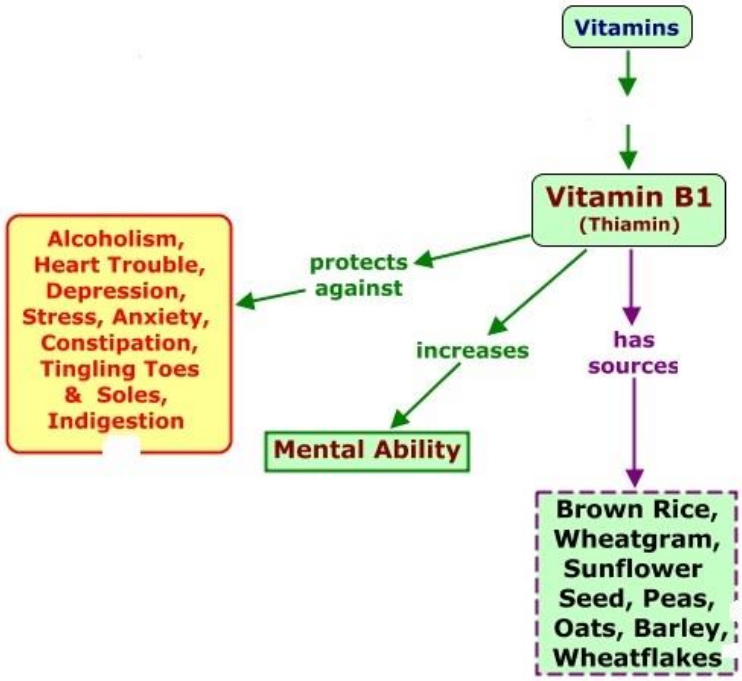
It helps the enzyme System which is responsible for the conversion of fat in carbohydrate & protein.

4. Growth

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

5. Action C.V.S

Various components of C.V.S specially the heart is dependent on carbohydrate for various functions, as amount of carbohydrate runs parallel to that of thiamine in body.



Beri Beri

Vitamin B1 deficiency causes a diseases called Beri Beri. Beri _Beri means I can not it reflects the severity of weakness and state of paralysis.

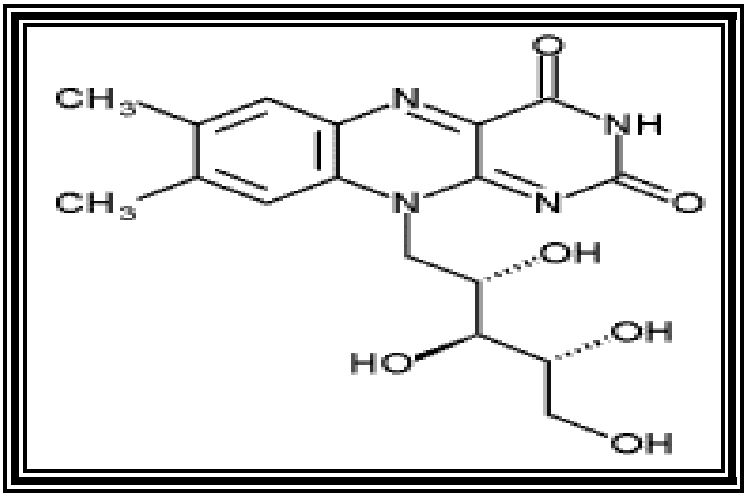
Vitamin_B2

Vitamin B2 is a water soluble heat stable vitamin its deficiency is characterized by ariboflavinosis.

Synonyms

a. Riboflavin
b. Lactoflavin

Chemical Structure



Sources

1) Animal

Well distributed in the nature excellent sources are liver kindney heart fish eggs milk

2) Plant

Fresh fruits root vegetable like carrot also synthesized by intestinal bacteria to some extent.

Functions

Oxidation – Reduction:

1) Riboflavin as such is not biologically active, in order to activate it must be phosphorylated, which takes place mainly in kidney and intestinal wall.

Deficiency of riboflavin

a. Mouth Lesions: Involve tongue, glottis, pharynx etc.
b. Weakness, drowsiness, Lassitude.
c. Redness and shiny appearance of lips
d. Cheilosis : Lesions at the angles of mouth.
e. Angular Stomatitis: painful fissures at the corners of lips.
f. Dermatitis : Skin becomes scaly, greasy and inelastic

Summary: Riboflavin

3) Water soluble vitamin, deficiency is characterized by flavinosis.
4) Stable in heat, acidic and neutral solutions, not stable in alkaline solutions.
5) Well distributed in animal and root vegetables.
6) Excreted in urine.
7) Act as co-enzyme.
8) Deficiency is characterized by glottis, cheilosis, angular stomatitis.

B3 Niacin

Niacin is a water soluble, thermostable vitamin, its deficiency is characterized by **pellagra.**

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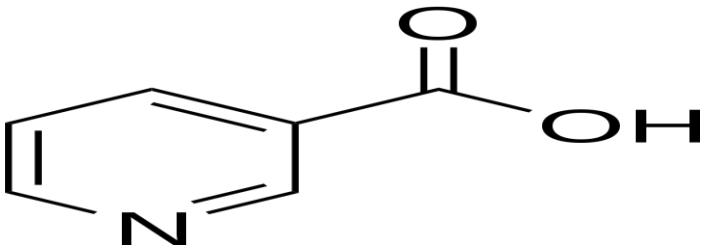


Synonyms

a. Nicotinic acid
b. Niacin amide (Nicotinamide)
c. Pellagra preventing factor

Chemistry

a. Chemically “NIACIN" is pyridine -3- Carboxylic acid
b. In the animal tissues it is usually found as amide form called "Nicinamide".
c. In the laboratory it can be prepared by oxidation of "nicotine" with strong oxidizing agent such as permanganate or fuming nitric acid.

Sources

This vitamin is widely distributed both in animal and plant,

1. **Animal**:

   Liver, Kidney, Meat, Fish, Eggs, Milk

2. **Plants:**

   Dried yeast, dried legumes whole wheat, peanuts, tomatoes, leafy vegetables etc.

Functions/biochemical role

1. Act as Co-Enzyme .

It is the most important function of niacin, as it act as "H" acceptor in various "Redox" reaction in the form of NAD & NADP. They worked in association with dehydrogenases, and act as "H" acceptor Co-enzyme..

2. **Prevents Pellagra**

Niacin prevents pellagra by keeping. Various "Redox Reactions" normal.

3. **Decreased blood Cholesterol Level**

Niacin is supposed to involve by some biochemical processes to lower the cholesterol level.

4. **Growth**

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

5. Act as CNS stimulator

It has stimulatory effect on CNS.

6. Vasodilator

Niacin is good vasodilator and Produces flushing which is accompanied with burruning and itching sensation.

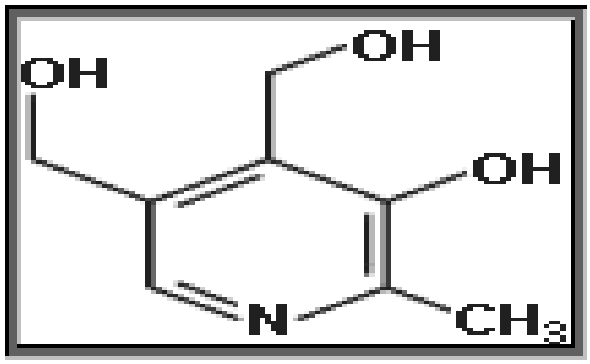
Vitamin - B6

Vitamin be is water soluble, heat stable vitamin, it is widely distributed in nature.

Synonyms

a. Pyridoxine
b. Pyridoxamine
c. Pyridoxa

Chemical Structure



Source

Plant:

Whole grains, cabbage, legume, cauliflower etc.

Animal :

Egg yolk, meat, fish, milk, yeast etc.

Functions/Biochemical Role

Decarboxylation

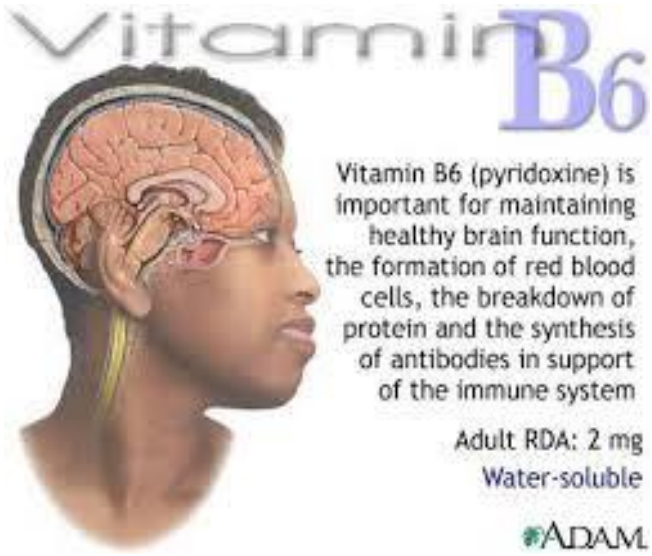
Vitamin - Basics is involve; in the decarboxylation reactions

Transamination

Oxaloacetate+glutamate as parate + ketoglutarate

Deamination

Serine ————— Pyruvate + NH3



Condensation

Glycine + Succinyl Co-A———>daltaamino levulinic acid

Fatty acid synthesis

It is involved in the synthesis of arachidonic acid and Linolenic acid

Glycogen phosphorylase

It appears to be the part of molecule of glycogen phosphorylase.

Amino Acid & K+ transport

Vitamin B6 helps in the entry of amino acid and K+ into the cell membrance

against the concentration gradient.

Deficiency of vitamin B6 Blood

Symptoms due to Vitamin B_6 deficiecy:

Blood

Hypochromic microcytic anemia Lymphocytopenia & Leukaemia

GIT

Young infants show digestive problems and convulsions

Growth

Growth retardation

Skin

Dermatitis

CNS

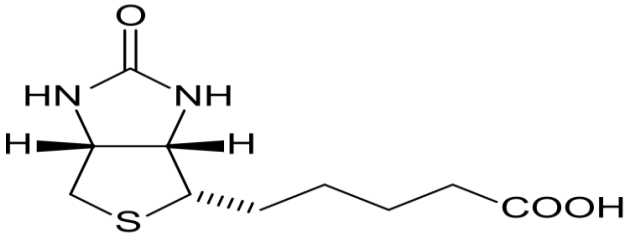
Peripheral neuritis depression

B7 Biotin

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

Synonyms

Vitamin – H
Co-enzyme – R



Sources

Animal:

Liver, kidney, milk eggs

Plants:

Fruits, vegetables, tomatoes

Functions

a) 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,

c. It takes part in the biosynthesis of purine and lipid in certain animals.
d. It catalyzes the deamination reaction of threoninene, serine and aspartic acid.

Deficiency

Deficiency of biotin may cause following clinical features.

- Lassitude.
- Anemia.
- Increase Cholesterol level.
- Muscular pain.
- Dermatitis.
- Retardation of growth.

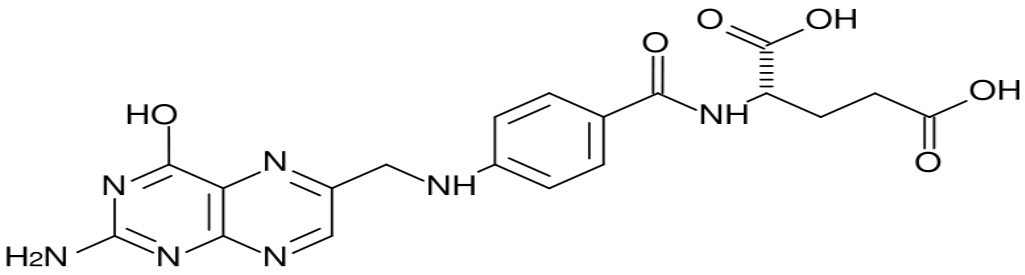
- Fall of hairs.

B9 Folic Acid

Folic acid is water soluble, heat stable and anti anemic factor.

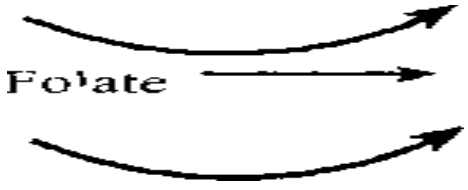
Synonyms

Vitamin - M.



Chemistry

a. The active form of folic acid is tetrahydrofolate.
b. Folic acid is pteroylmonoglutamic Acid
c. Its structure has **three** components has__ A pteridine nucleus linked to Para amino benzoic acid to form pteroic acid. This in turn is linked to glutamic acid.
d. Before functioning, F.A is reduced, first to 7. dihydrofolic acid(DHFA) and then to tetrahydrofolate(THFA).



Source

- Widely distributed in nature
- It is named folic acid, because it occurs especially in foliage of plants, also called folacine.

Animals:

Its chief dietary sources are Liver, kidney, beef .

Plants:

Cauliflower, wheat and root vegetables.

It is also synthesized by intestinal bacteria but this supply is not very significant. It is stored in the liver, of total body folic acid upto 60%present in liver

Functions

1. The most important function of folic acid is to carry out reactions involving transfer of one "C" moiety such as:
   a) Formyl - CHO
   b) Methyl - CH3
2. It is involved in the synthesis of choline.
3. It regulates the process of haematopoeisis along with vitamin –B_{12}
4. Maintain normal growth and development.
5. It has a significant role in histidine metabolism.

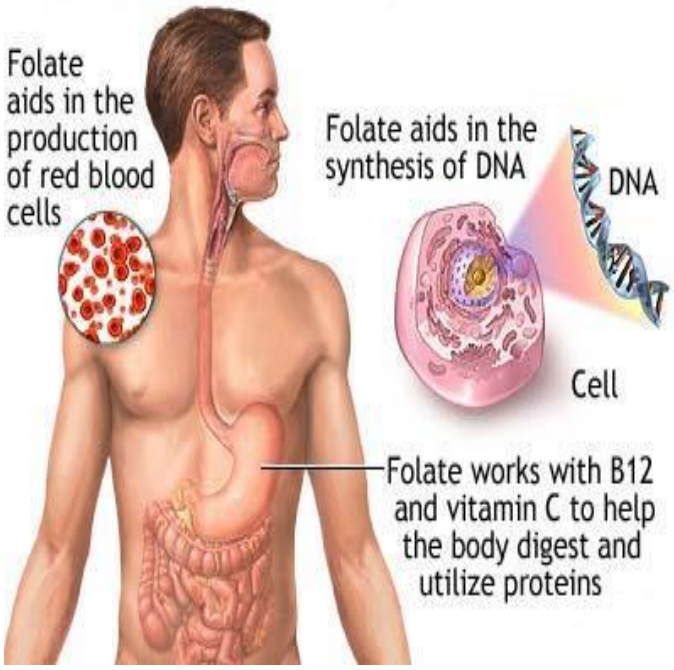
Deficiency / Symptoms

A. Haemopoetic defects:

- . Bone marrow depression.
- Pancytopenia.
- Megaloblastic anemia.

B. Reproductive defects.

Azoospermia and amenorrhea.



C. Growth retardation:

D. Generalized effects:

Diarrhoea, malabosorption, dermatitis, Weakness, lethargy and easy fatigue etc.

Vitamin B_{12}

Vitamin B_{12} is the most potent vitamin its deficiency cause the **pernicious anemia**.

Synonyms

Cobalamin
Cyanocobalamine
Cobamide
Cobalt amin
Antipernicious anemia factor

Sources

- This vitamin is synthesized by microorganisms.
- B_{12} found only in foods of animal origin. Liver and kidney are chief source but also occurs in whole milk, eggs fish cheese and muscle.
- It is not expected to be present in plant products, but a certain amount of B_{12} is present in legumes which have become contaminated with bacteria that can synthesize it.

Chemistry

- Vitamin B_{12} is the only naturally occurring organic compound which contains cobalt.
- It is water soluble
- Heat stable at neutral $_{P}H$ but not at alkaline $_{P}H$

Two different types of vitamin B12 that are used in therapeutics are:

1. **Hydroxycobalamin** (physiological form of vitamin)
2. **Cyanocobalamin** (produced during isolation of vitamin)

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Absorption of B_{12}

- ✓ On entry into the stomach vitamin first gets bound with a protein.
- ✓ From protein it is get released by gastric HCl and pancteatic proteases.
- ✓ Then it gets bound to the intrinsic factor(secreted by gastric mucosa present in highest concentration in the fundus of the stomach)
- ✓ The vitamin B_{12}- intrinsic factor complex is carried to ilium and released vitamin is absorbed into portal blood through ileal cells.
- ✓ Bile and HCO_3 are required for its absorption.

Functions

Erythropoiesis

Along with folic acid vitamin B12 is actively involved in the development of RBCs

W.B.C maturation

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

Protein synthesis

Vitamin B12 activates amino acid for the synthesis of protein

Isomerization reaction

Various isomerization reaction are influenced by cobalamin.

Formation of methionine

It is concerned with the synthesis of methionine

Recycling of folate pool

By transmethylation

Lipotropic factor

Vitamin B12 has lipotropic effect and regulate over all metabolism of fat

Synthesizing effect

It has synthesizing role in lipid nucleic acid amino acids and various other substances.

Vitamin B 12 deficiency causes Pernicious Anemia

The most common cause of pernicious anemia is failure of the absorption of vitamin B_{12} rather than dietary deficiency. This can be result of failure of intrinsic factor secretion or from production of anti-intrinsic factor antibodies. The anemia of vitamin B_{12} deficiency is really due to tissue folic acid deficiency. B_{12} deficiency impairs the metabolism of folic acid that disrupts erythropoiesis, causing immature precursors of erythrocytes (Megaloblastic anemia).

Conditions associated with poor absorption of B12 deficiency:

- Gastric resection (lack of intrinsic factor)
- Pancreatectomy
- Infestation with tapeworm (This worm utilizes B_{12} making less vitamin available for absorption).
- Sprue

- Drugs

CHAPTER 1

Introduction to Biotechnology

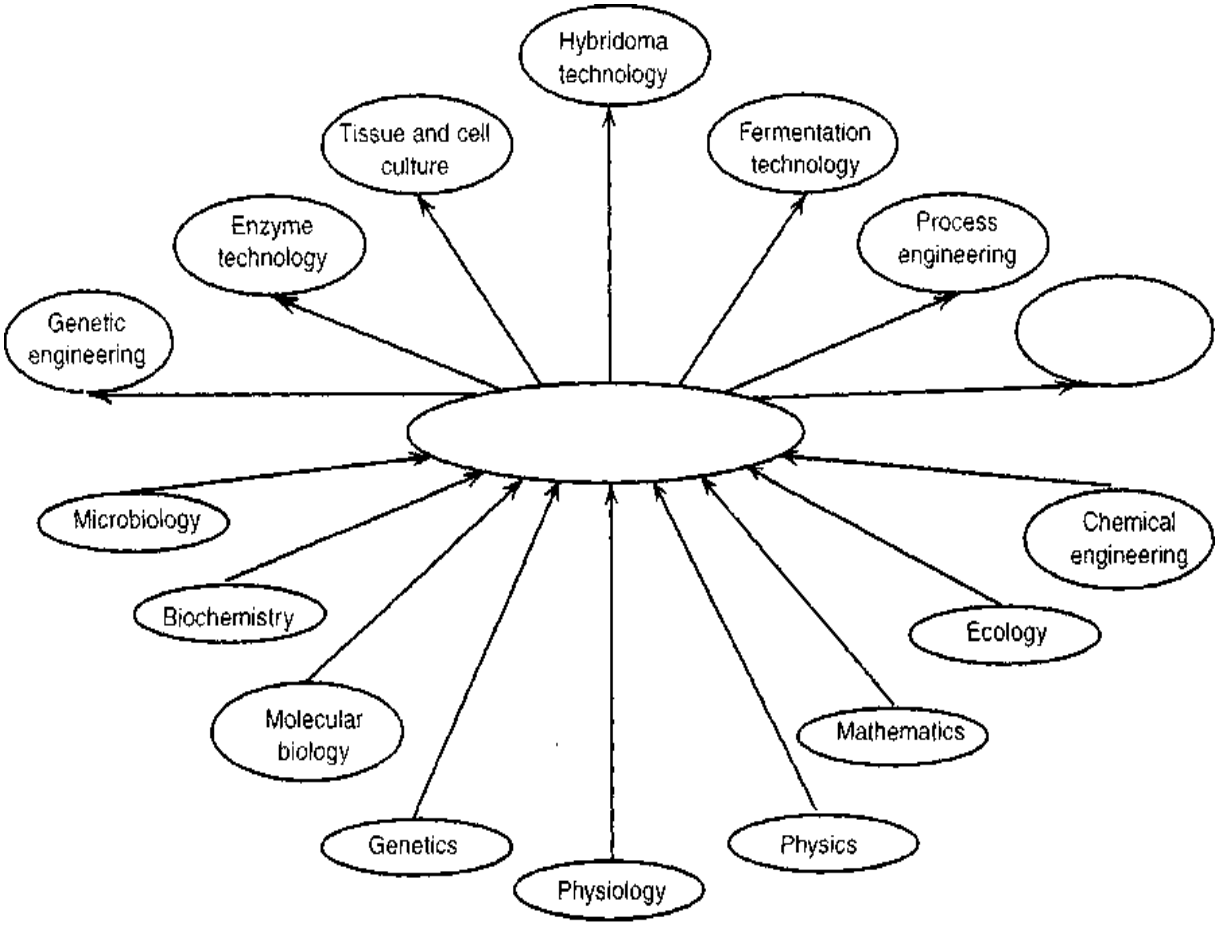
Biotechnology is a vast and rapidly growing branch of science. As the name indicates, biotechnology is the product of interactions between biology and technology. The British biotechnologists define biotechnology as
"The application of biological organisms, systems, or processes to the manufacturing and service industries". It is an integrated application of techniques to draw benefits from the properties and capacities of living organisms especially microorganisms, for the welfare of mankind. Hence, European Federation of Biotechnology defines the term biotechnology as "The integration of natural sciences in order to achieve the applications of organisms, cells, parts there of and molecular analogues for products and services.

Biotechnology is an applied science and has many basic sciences incorporated in it, Microbiology, Physiology, Genetics, Biochemistry, Immunology, Chemistry, Mathematics,. Physics, and Industrial technology are some of the basic sciences which are merged with each other to give birth to various branches of biotechnology

Importance of Biotechnology

Modern biotechnology has its roots in two arenas of science namely molecular biology and microbiology. Advancement in these two sciences has led to a better understanding of the biochemical processes and their inter

relation ship. This insight has been exploited for the development of biotechnology.



Many biotechnological products including drugs, vaccines, food products and enzymes, and techniques like new therapeutic methods (example: gene therapy)

Many Nobel laureates including Hargobind Kliorana and Walter Gilbert are associated with the development of biotechnology. Many pharmaceutical companies like Genentech, Cetus and Hybritech are involved in

biotechnology research and development.

Areas of Interest in Biotechnology

The field of biotechnology can be divided into eight major areas namely,

1. Recombinant DNA technology
2. Hybridoma technology
3. Enzyme and biocatalysts technology
4. Plant cell culture
5. Animal cell culture
6. Fermentation technologies
7. Waste treatment and utilization
8. Process engineering

APPLICATIONS OF BIOTECHNOLOGY

I) Perhaps the most exciting development in 1980's has been the development of methods in biotechnology to produce newer **drugs** and also to make known **chemotherapeutic agents** available in clinically useful quantities.

II) The techniques that are steering a revolution in drug therapy are hybridoma technology, recombinant DNA technology, tissue culture and cell culture technology and gene therapy.

III) The use of hormone replacement therapy for the persons who are deficient in a particular hormone is a well established method for the treatment of endocrine disorders. The non availability of these

hormones in sufficiently large quantities are a limitation. However, biotechnology has made it possible to get these hormones in large quantities in pure form. This has given a hope for treatment of these disorders with purer products. Some of the examples are biotechnologically produced hormones like insulin, somatostatin and human growth hormone (hGH).

IV) One of the most exciting applications of biotechnology is gene therapy. This involves removal of faulty genes from the cell and incorporation of correct gene in its place. Gene therapy promises cure to all genetic abnormalities including thalassemia, hemophilia and sickle cell anemia which were thought to be incurable till recent times. It also promises a better treatment to the infectious diseases like AIDS.

V) In the tissue culture technology, the plant cells or tissues are grown in a test tube or a conical flask. A specific cell line can be selected and developed artificially by using growth factors and plant growth hormones. The grown up cell line can be used for development of clones of plants, elimination of pathogens from plants, production of secondary metabolites, biotrans formation of substrates, and also for improvement of crops and their respective yield.

VI) The advent of Biotechnology has led to newer and improved treatments for many of the diseases. It has helped in the development of better and cheaper vaccines to counter the spread of infectious diseases. Recombinant DNA vaccines are being developed for viral, protozoal and bacterial infections.

VII) Biotechnology has created a revolution in the diagnosis of many epidemic diseases. Many rapid diagnostic tests and newer techniques for identification of the pathogens have been developed with the help of this science.

For example, plasmid profile analysis, genomic fingerprinting and multilocus enzyme electro-phoresis are some of the techniques that have been developed for identification of causative organisms. Nucleic acid hybridization, poly-merase chain reaction and ELISA are some of the techniques developed for diagnosis of genetic diseases.

Hence, the US National Science Foundation has appropriately defined biotechnology as

"Controlled use of biological agents such as microorganisms or cellular components for the benefit of mankind".

Introduction to Genetic Engineering

The gross structures and physical characteristics of each of the organisms have their origin in the genes, which are transferred from parents to offspring. The information for the development, organization and functions of living system is stored in these discrete units, called genes. These genes are located in the nucleus of each cell in the form of either chromosome or chromatin thread.

Transcription and translation

As mentioned earlier, the process of synthesis of RNA from the DNA with the same sequence of nucleotides as DNA is called as transcription. This process is catalyzed by an enzyme, DNA dependent RNA polymerase.

The process of transcription in prokaryotes differs slightly from that in eukaryotes. In prokaryotes, the exact copy of DNA is represented in RNA and it directly codes for amino acid sequence of the proteins.

Translation is the process of translating the nucleotide sequence mRNA into amino acid sequence of the protein. This occurs on the ribosomes which are present in cytoplasm. Translation occurs in 5 to 3 direction. The mRNA moves over the surface of ribosome, bringing successive groups of nucleotides that code for amino acid (codon) into position.

Concept of Genetic Engineering

Except few viruses, the genetic material in all the organisms is DNA. The process of DNA replication, transcription and translation occur in a similar manner in all the organisms. The genetic code, the triplet codon system and the enzymes are common in all organisms, from bacteria to human beings. The DNA of one organism can express its characters in an other organism also. This is the main idea of genetic engineering.

Changes that occur in the DNA molecules (mutations) may lead to genetic disorders. The important tools of genetic engineering are listed below:

- Enzymes
- Vectors
- cDNA clone bank or cDNA library
- gene bank or genomic library

Enzymes required for rDNA Technology

Many enzymes are used as biological tools in rDNA technology. They include:

i. Restriction endonucleases
ii. SI nuclease
iii. DNA ligases
iv. Alkaline phosphatase
v. Reverse transcriptase
vi. DNA polymerase

Acid-Base & Electrolyte Balance in Human body

The body fluids must maintain a constant balance of acids and bases. In solutions such as intracellular and extracelular fluids, acids are dissociated into hydrogen ions (H+) and anions on the other hand, bases are dissociated into hydroxyl ions (OH-) and cations.

Terms related with acid-base balance

Acid

This may be defined as a substance that dissociates into one or more hydrogen ions (H+) and one or more negative anions. It may also be defined as a proton donor or H+ donor.

Acidosis

This is the increase in H+ concentration or decrease in pH (pH below 7.4)

Base

This is the substance which combines with H+ and removes then - from a solution. It is also known as the proton acceptor.

Alkali

This is the combination of one of the alkaline e.g. sodium or potassium with a highly basic ion such as (OH-).

Alkalosis

This is a decrease in H+ concentration or an increase in pH (pH above 7.4)

pH

The pH may be defined as the negative log of H+ ion concentration.

$$pH = -\log (H+)$$

The pH of blood is regulated and controlled by various buffer systems, essentially consist of weak acids and its base of which the most important is bicarbonate-carbonic acid ratio HCO3: H2CO3 It is regulated by removal of CO2 by lungs and by excretion of both acids and bases by kidneys. The ratio of bicarbonate to carbonic acid is 20:1 alteration in this ratio alter the pH. A decrease in the ratio leads to increase in the acidity and vice versa.

Systems for Regulation of Acid-Base Balance

There are three systems which regulate acid-base balance in the body.

i) Acid-base buffer system
ii) Respiratory system
iii) Renal system

1. Acid-Base-Buffer System

This is the mechanism that maintains the homeostatic pH value in the body. The most important buffer system of the body consists of a weak acid and the salt of that acid, which functions as a weak base. The function of a buffer is to prevent rapid changes in the pH of a body fluid by changing strong acids and bases into weak acids and bases.

Time duration of buffer

Buffers work within fractions of a second.

Buffer systems of body fluids

The Principal Buffer systems of body fluids are:

i. Carbonic acid-bicarbonate system
ii. Phosphate system
iii.Hb-oxyhemoglobin system
iv.Protein system

Functions

Many naturally occurring acids are necessary for life. For example, hydrochloric acid is secreted by the stomach to assist with digestion. The chemical composition of food in the diet can have an effect on the body's acid-base production. Components that affect acid-base balance include protein, chloride, phosphorus, sodium, potassium, calcium, and magnesium.

In addition, the rate at which nutrients are absorbed in the intestine will alter acid-base balance.
Cells and body fluids contain acid-base buffers, which help to prevent rapid changes in body fluid pH over short periods of time, until the kidneys pulmonary systems can make appropriate adjustments. The kidneys and pulmonary system then work to maintain acid-base balance through excretion in the urine or respiration. Excess acid or base is then excreted in the urine by the renal system to control plasma bicarbonate concentration. Changes in respiration occur primarily in minutes to hours, while renal function works to alter blood pH within several days.

Electrolytes of body fluids

Electrolytes are electrovalent substances that form ions in solution which coduct electric current e.g. Sodium, Chloride, cupper, Sulphate, potassium nitrate

Functions

A summary of the most important functions of electrolytes present in body fluid are given bellow,

i) They are responsible for the maintenance of most of the osmotic pressure of body fluids.

ii) They provide an optimum ionic balance for tissues to perform their activities

iii) They participate in the regulation of the pH of body fluids

iv) They regulate the neuromuscular irritability or excitability.

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