CHAPTER - 09
BIOMOLECULES

CONTENTS :

Biomolecules are the molecules present in the living system (**protoplasm**). They are essential for the metabolic activities and for the existence of life. So called as **metabolites.**

All biomolecules present in protoplasm forms a **cellular pool**. About **40** different elements present in it.

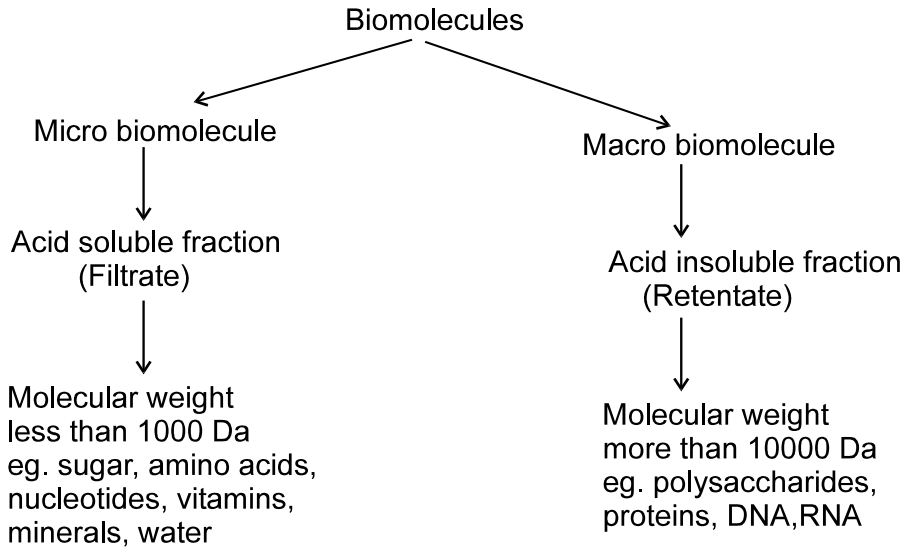
O > **C** > **N** > **H** are the most important elements of the living world.

Element	% Wt in the earth crust	% Wt in human body
Oxygen	46.60%	65%
Carbon	0.03%	18.50%
Nitrogen	negligible	3.30%
Hydrogen	0.10%	0.50%

Biomolecules may be organic or inorganic. An **ash test** helps to seperate them.

Based on the molecular weight biomolecules are two types, micro and macro.

An **acid fraction test** with trichloro acetic acid (Cl_3CCOOH) helps to seperate macro and micro biomolecules.



Lipid is a micromolecule (wt less than 800 Da) but present in the retentate

Percentage weight of biomolecules in protoplasm

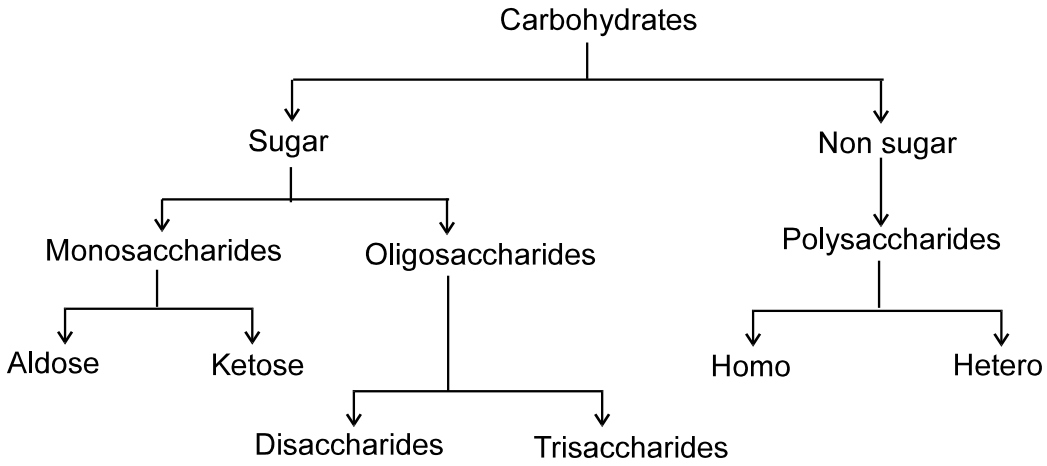
Biomolecules	% Wt in protoplasm
Water	70 - 90%
Protein	10 - 15 %
Nucleic acids	5 - 7 %
Carbohydrates	3%
Lipids	2%
Inorganic ions	1%

Some biomolecules have no major role in metabolism of the producer, are known as **secondary metabolites**. They are generally present in plants **(absent in animals)**. Most of the secondary metabolites are useful to human welfare.

Pigments	Anthocyanin, carotinoids
Alkaloids	Morphine, codein, nicotin
Drugs	Vinblastin, curcumin, reserpin
Oils	Lemongrass oil, eucalyptus oil
Terpenoids	Monoterpens, diterpenes
Toxins	Ricin, abrin
Polymeric substances	Rubber, gums, cellulose
Lectins	Concanavalin-A, jacalin

CARBOHYDRATES

The organic biomolecules formed from **C,H** and **O** in **1:2:1** ratio. They are polyhydroxy aldose/ ketose or their derivatives. Carbohydrates are the main energy providers of living system. The physiological fuel value is **4 Kcal/gm**

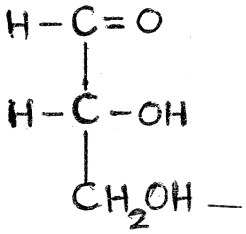


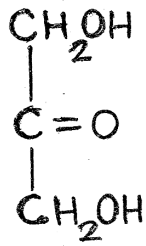
Monosaccharides ($C_nH_{2n}O_n$)

Simple sugars which cannot hydrolyse in to other sugar molecules. They have **3 to 7** carbons. Based on the number of carbon monosaccharides are **five types**

1. **Triose (3 carbons) (C3H6O3)**

eg: Glyceraldehyde (aldose) **Dihydroxy acetone (ketose)**





(No optical isomer)

2. **Tetrose (4 carbons) ($C_4H_8O_4$)**

eg: Erythrose (aldose) **Erythrulose (ketose)**

Erythrose is the raw material for the synthesis of **lignin** and **anthocyanin**

3. **Pentose (5 carbons) ($C_5H_{10}O_5$)**

eg: Ribose (aldose) **Ribulose (ketose)**

Ribose is the structural part of nucleic acids. Ribulose present in RuBisCO

4. **Hexose (6 carbons) ($C_6H_{12}O_6$)**

   eg: Glucose, Galactose (aldose) Fructose (ketose)

   Most of the organisms derives energy from glucose.

5. **Heptose (7 carbons) ($C_7H_{14}O_7$)**

   eg : Sedoheptulose, Mannoheptulose (ketose)

Glucose

Glucose is a **hexose, aldose, reducing sugar**.

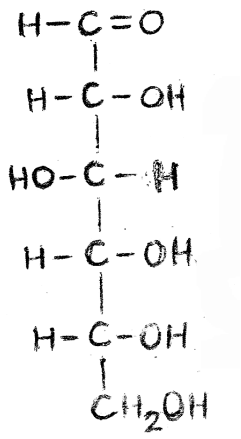
It is a **pyranose** (hexagonal ring structure)

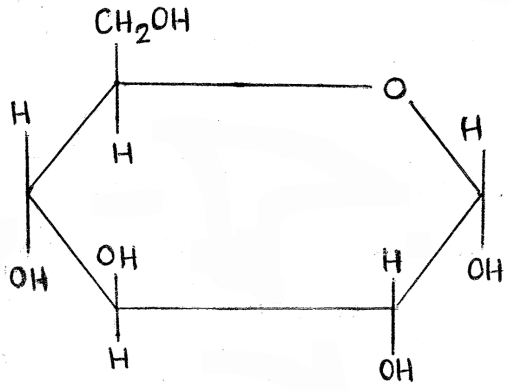
Due to the dextro rotatory nature glucose is known as **dextrose**.

Glucose is the main end product of carbohydrate digestion

Grape sugar and **blood sugar** are the other names of glucose, universal sugar

Change in the orientation of OH group in **4th** carbon of glucose can change it as **galactose**





Fructose

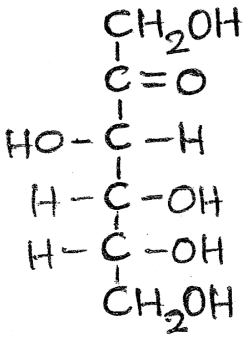
Fructose is a **hexose, ketose, reducing sugar**

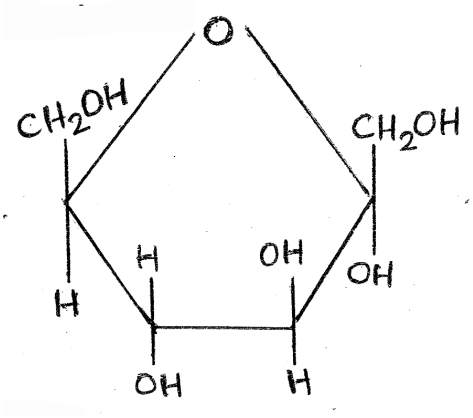
It is the **sweetest** known sugar and mainly present in fruits (**fruit sugar**)

It is a **furanose** sugar (pentagonal ring structure)

Due to the levo rotatory nature fructose also known as **levulose**

Human sperm derives energy from fructose present in the semen





Disaccharides

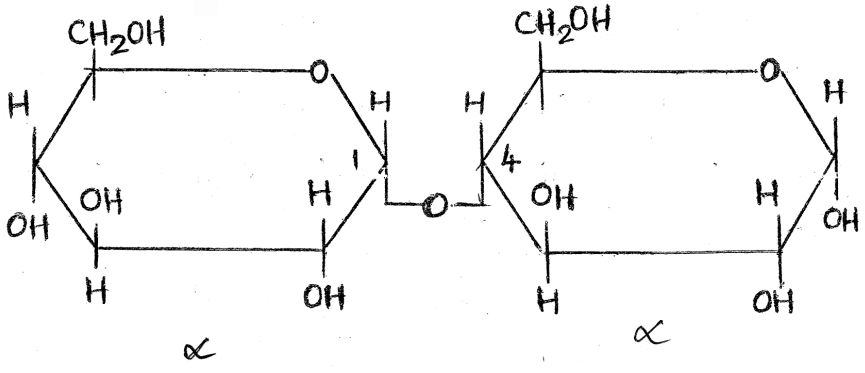
The group of carbohydrates formed from two monosaccharides. They are linked by **glycosidic bond.** It is a C - C bond formed through dehydration (condensation)

Maltose

Maltose is a reducing sugar formed by condensation of **two glucose units**.

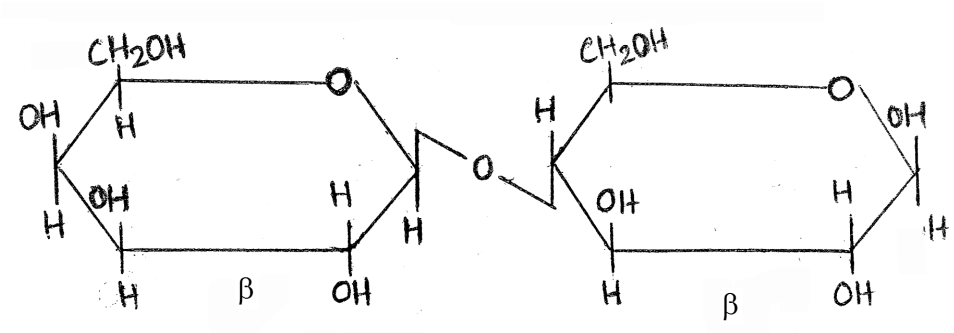
It is present in germinating seed and malted grain of Barley (**malt sugar**).

In maltose the glucose units are connected by **á 1 - 4 glycosidic linkage**.



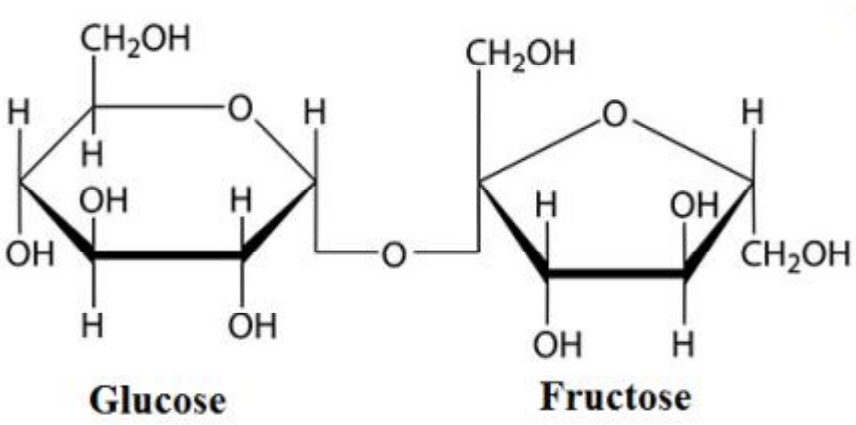
Lactose

It is a reducing sugar formed from one **glucose unit and one galactose**. They are connected by **â1 - 4 glycosidic linkage**. Lactose is a soluble sugar present in milk.



Sucrose

Sucrose is a disccahride of **glucose and fructose**. They connected by α1β2 **glycosidic linkage**. Sucrose is the main transporting form of carbohydrate in plants because of its **non reducing** nature. Sucrose also known as **cane sugar, table sugar, invert sugar** and **intex sugar**.



Trisaccharides

Sugar formed by the condensation of three monosaccharies

eg: **Raffinose - glucose + galactose + fructose**

Kestose - glucose + fructose + fructose

Gentianose - glucose + glucose + fructose

Polysaccharides

Polysaccharides are macrobiomolecules formed by the polymerisation of monosaccharides. These are insoluble, tasteless, amorphous compounds. Left end of a polysaccharide chain is the **non reducing end** and right end is the **reducing end**.

Homo polysaccharides - polymer of one type monosaccharides (Starch)

Hetero polysaccharides - polymerof more than one type monosaccharides (Heparin)

Cellulose

It is a **structural and supporting polysaccharide** in plants and some microbes.

Cellulose is an **unbranched homopolymer of glucose** units, connected by

β **1 - 4 glycosidic** linkage.

Each glucose chain has about 3000 - 6000 molecules.

Cellulose is strong , insoluble polysaccharide and animals cannot digest it.

It is the **most abundant polysaccharide** in the Biosphere

Purest form of cellulose is present in **cotton**

Chitin

Chitin is the **second most abundant polysaccharide**.

It is a **structural polysaccharide** present in the exoskeleton of Arthropods.

Chitin is an **unbranched homopolymer of N - acetyl glucosamine**.

Starch (Amylum)

Starch is the main **storage polysaccharide** of plants.

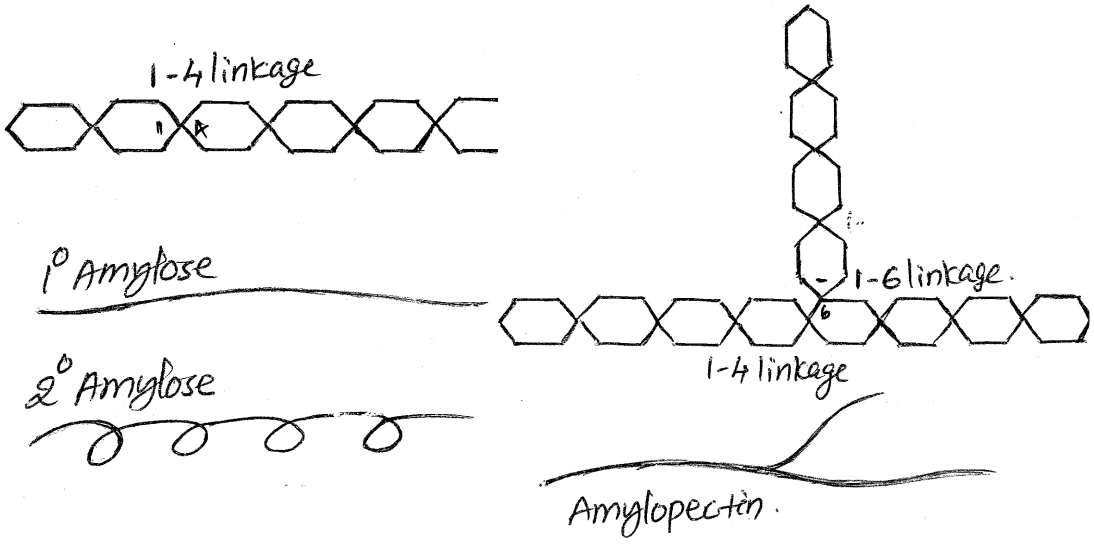
It is a **homopolymer of glucose**.

Amylose is the unbranched glucose chains present in starch. Each chain has 200 - 2000 glucose units, connected by α **1 - 4 glycosidic linkage**.

Secondary form of amylose can change **iodine** in to **deep blue colour**.

Amylopectins are branched chains of glucose. α **1 - 4 and** α **1 - 6 linkage** present in it.

Amylose is partially soluble in hot water but amylopectin is insoluble.



Glycogen

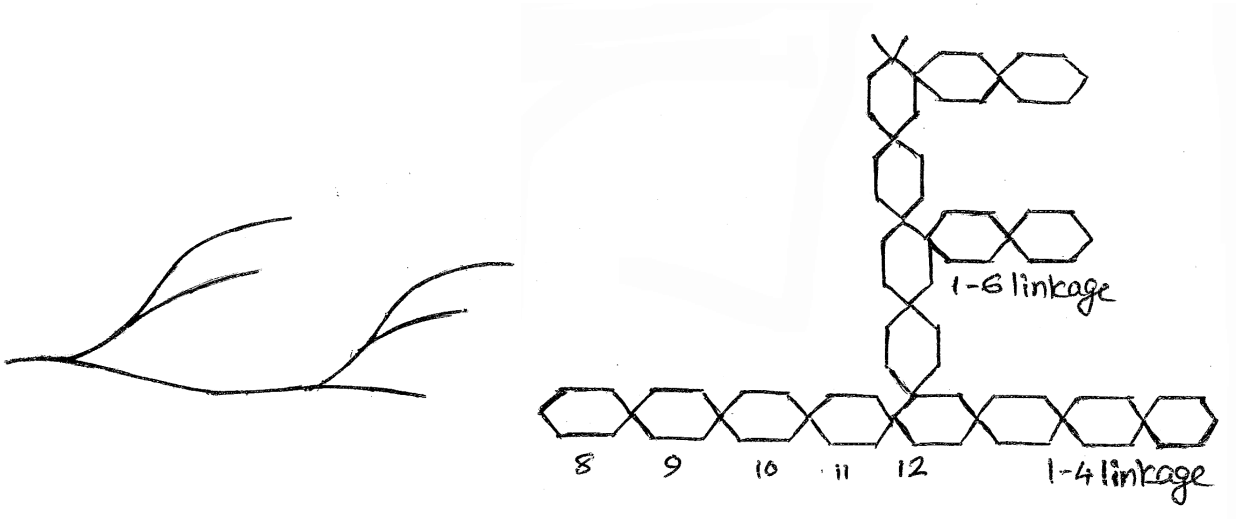
Glycogen is a highly **branched homopolymer of glucose**.

It is a **storage polysaccharide** in animals (**animal starch**)

The glucose units are connected by α **1 - 4 and** α **1 - 6 glycosidic linkage**

Glycogen synthesized in the liver by the help of **insulin**

Glycogen is insoluble and it can change the colour of **iodine in to red.**



Inulin

Inulin is an unbranched homopolymer of fructose

It is the smallest polysaccharide and is soluble in water

Due to the soluble nature it is useful in kidney function test

Inulin is commonly known as Dahlia starch

Hetero polysaccharides

Heparin: A sulphated hetero polysaccharide present in mammalian blood.

It has the **maximum negative charge density** and it inhibits the blood clotting.

Heparin is polymer of **glucuronic acid & sulphated glucosamine**.

Hyaluronic acid: A hetero polymer of **D - glucuronic acid** and **N- acetyl glucosamine**.

It is a component of **synovial fluid, vitreous humor** & **corona radiata**.

PROTEINS

Proteins are organic biomolecules formed from **C,H,O,N** and **S.** These are the **most abundant and most diverse** organic compounds.The term protein was proposed by **Berzalius** from the Greek word **proteios**. The physiological fuel value of protein is **4 Kcal/gm**.

Most abundant protein in the Biosphere is **RuBisCO** (**Ribulose Bisphosphate Carboxylase Oxgenase**)

Collagen is the most abundant animal protein

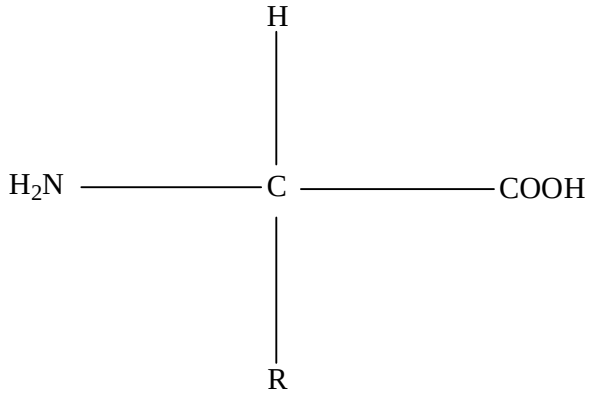
Titin is the longest animal protein, which connets the muscle fibres.

Proteins are macromolecules and **hetero polymers of amino acids**.

Amino acids are **substituted methanes.**

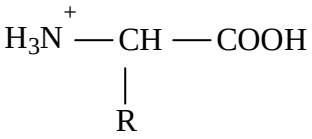
Each amino acid is **amphoteric** due to the presence of basic **amino group** (- NH_2) and acidic **carboxylic group** (- COOH)

L form of amino acid



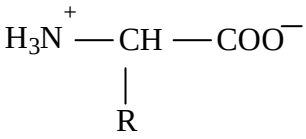
In liquid medium amino acids can exist in three defferent ionic forms.

Cation



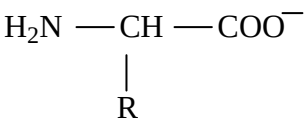
(Acidic medium)

Zwitter ion



(Isoelectric medium)

Anion



(Alkaline medium)

Generally 20 proteinacious amino acids present in the nature known as **standard amino acids** (**magic 20**). Based on the necessity in animal body they classified in to three groups.

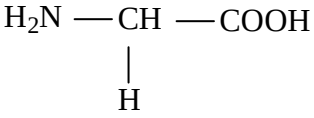
Non essential (Synthesized in animals)	**Essential (Not synthesized in animals)**	**Semi essential (Synthezised after maturity)**
Alanine	Leucine	Arginine
Asparagine	Lysine	Histidine
Aspartic acid	Isoleucine	
Glycine	Methionine	
Glutamine	Phenyl alanine	
Glutamic acid	Threonine	
Cystein	Tryptophan	
Tyrosine	Valine	
Proline		
Serine		

(Creatin, Citrulline, Ornithine, Histamine etc are non proteinaceous amino acids)

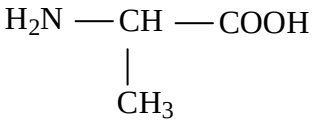
Based on number of amino and carboxylic groups there are neutral, acidic and basic amino acids.

Neutral amino acids : **Glycine, Alanine, Valine , Leucine**

Glysine

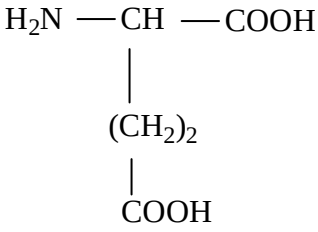


Alanine



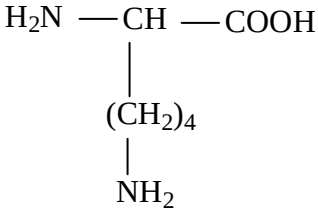
Acidic amino acids: Glutamic acid, Aspartic acid

Glutamic acid

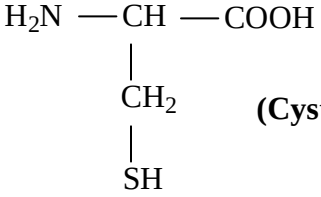


Basic amino acids : Lysine, Arginine

Lysine

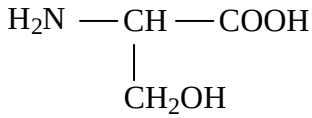


Cystein and Methionine have **sulphur compound** in the side chain



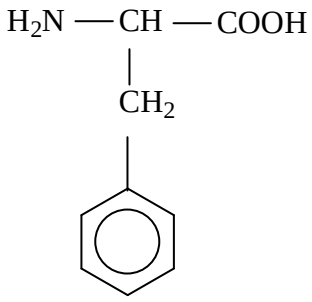
(Cystein)

Serine and Threonine have **hydroxyl group (-OH)**in the side chain



(Serine)

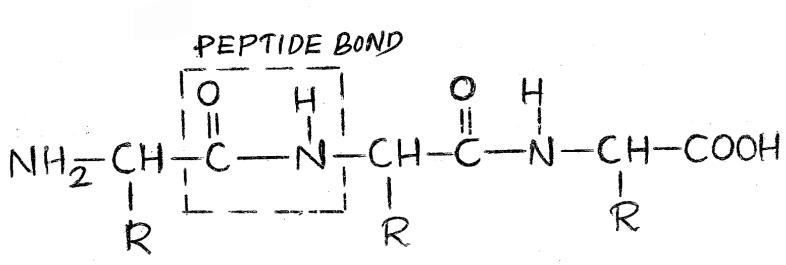
Phenyl alanine, Tyrosine and Tryptophan have **heterocyclic compounds** in the side chain**.** They are **aromatic amino acids.** These amino acids can absorb light have **wave length 280nm (λ max)**



Proteins are the polymers of amino acids, which are synthesized in ribosomes. There are four structural levels in proteins.

1. <u>Primary structure</u>:

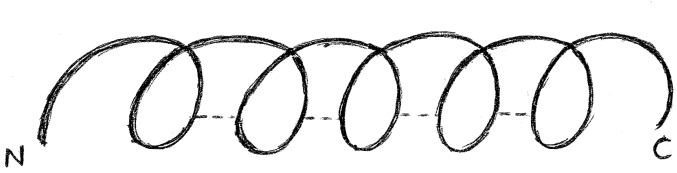
It is a linear chain of amino acids, called **polypeptide**. The amino acids are connected by **peptide bond**. It is a partial double bond between **N** and **C**. For peptide bond the first amino acid provides the -COOH group and the second one provides -NH_2 group. The left end of polypeptde is the **N - terminal** and right end is the **C - terminal**. Primary structure is unstable.



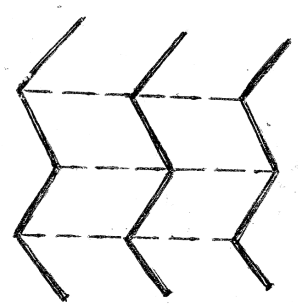
2. <u>Secondary structure:</u>

It is more stable than primary structure due to the presence of additional hydrogen bonds. These bonds formed between oxgen of -COOH group and hydrogen of -NH_2 group.

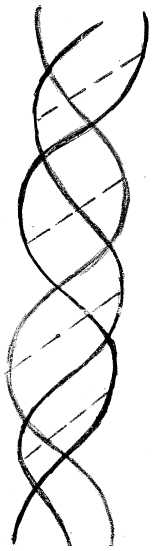
α **<u>- helix</u>** - intra hydrogen bonding in a polypeptide leads to its right handed twist. It becomes an α - helical protein. eg: α **- Keratin present in hair and nails.**



β **- pleated -** Inter hydrogen bonding between two or more polypeptides leads to β - pleated structure. eg: β **- keratin in feathers and fibroin (sil)**



The most abundant animal protein **collagen** has **triple helical structure**. It is expaind by the Indian Biologist **G.N.Ramachandran**.



3.Tertiary structure:

It is the maximum coiled form of a polypeptide. Tertiary proteins are stable due to the presence of five type bonds

Peptide bonds, hydrogen bonds, ionic bonds, disulphide bonds and hydrophobic bonds

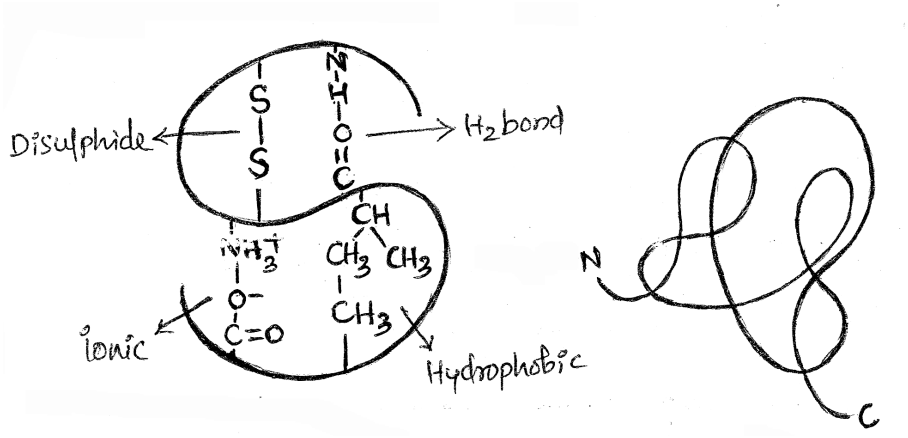
Peptide and disulphide bonds are stronger than the other three ;

Hydrophobic amino acids try to aggregate at the centre, which coils the polypeptide.

Highly reactive hydrophilic amino acids present on the surface becomes **active sites.**

All **enzymes** have tertiary structure because it is the **most reactive form** of protein

eg: Myoglobin, antobodies , enzymes



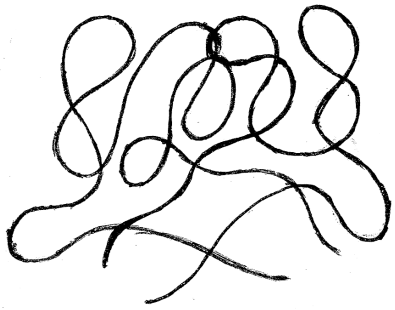
4. Quarternary structure :

It the most stable structure of proteins.

More than one polypeptides present in these proteins.

All the polypeptides present in maximum coiled form due to the five type bonds and they connected by inter hydrogen bonds.

eg: Haemoglobin



Types of protein

On the basis of their constitution, proteins are classified in to two main groups

1. Simple proteins:

The protein contains only amino acids.

Fibrous proteins are long stranded insoluble simple proteins. eg: **collagen, keratin**
Globular proteins are more or less soluble spherical proteins. eg: **globulins, enzymes**

2. Conjugated proteins:

The protein has amino acids and non- protein groups**.**

Such proteins are again classified on the basis of their non - protein part.

a. Chromoproteins : cytochrome, rodopsin , haemoglobin

b. Glycoproteins : Mucin , transferrin

c. Lipoproteins : HDL, chylomicrons

d. Nucleoproteins : histones, SnRNPs

e. Phosphoproteins : vitalline, casein

Functions of proteins

Function	Examples
Structural & supporting proteins	Collagen, Elastin, Keratin
Catalytic proteins (enzymes)	Pepsin, Lipase, Ligase
Regulatory proteins (Hormones)	Insulin, Glucagon, Adrenalin
Sensory or receptor proteins	Rodopsin, Iodopsin
Locomotory proteins	Actins, Myosins
Protective or defensive proteins	Antibody, Histamins
Transporting or carrier proteins	GLUT-4 , Aquaporin
Storage proteins	Albumin, Glutelin

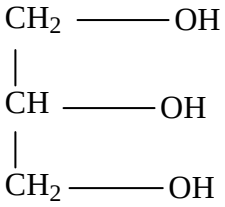
LIPIDS

The organic biomolecules formed from **C, H** and **O**. Oxygen is less than Carbon and Hydrogen in number. Lipids are insoluble in polar solvents. They have **low density** and **low melting point**. Lipids are the reserve food in living system and is a structural component. The term lipid was introduced by **Bloor** .

The physiological fuel value of lipid is **9 Kcal/gm.**

Lipids are esters of glycerol and fatty acids.

Glycerol is a tryhydroxy propane.



Fatty acids are long chain hydrocarbons with a carboxylic group. If all Carbon atoms are connected by **single bonds** the fatty acid becomes **saturated**.

General formula of a saturated fatty acid is $\mathbf{C_n H_{2n} O_2}$

eg: Palmitic acid (16 C) $CH_3 — (CH_2)_{14} — COOH$

Stearic acid (18 C) $CH_3 — (CH_2)_{16} — COOH$

In **unsaturated** fatty acids one or more double bonds present among the Carbon atoms.

Their general formula is Cn H2n-2x O2 (x is the number of double bonds**)**

Mono unsaturated amino acid (**MUFA**) posses one double bond.

eg: Oleic acid (18C) $CH_3 — (CH_2)_7 — CH = CH — (CH_2)_7 — COOH$

Poly unsaturated fatty acid **(PUFA)** has more than one double bonds.

eg: Arachidonic acid , Lenoleic acid

Unsaturated fatty acids have a low melting point than saturated fatty acids.

Melting point & stability are inversely proportional to the number of double bonds.

Omega 3 fatty acids (PUFA) involved in various metabolic activities.

CD Ratio

It is the ratio between number of **Carbon** and **double bonds** . CD ratio helps to find out the saturated or unsaturated condition of fatty acids.

Palmitic acid - 16 : 0

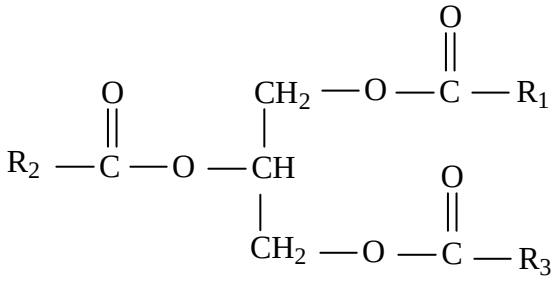
Stearic acid - 18 : 0

Oleic acid - 18 : 1

Lenoleic acid - 18 : 2
Lenolenic acid - 18:3
Arachidonic acid - 20 : 4
] These 3 are not synthesized in animals (essential fatty acids)

Simple lipids

The lipid molecule contains only glycerol and fatty acids. Three fatty acids (saturated or unsaturated) combines with a glycerol in simple lipid. So the lipid molecule is a **triglyceride**.



Glycerol and fatty acids connected by **ester bonds** (each bond can release H_2O)

Fat, wax, and **shellac** are solid forms of simple lipid and **oils** are the liquid form.

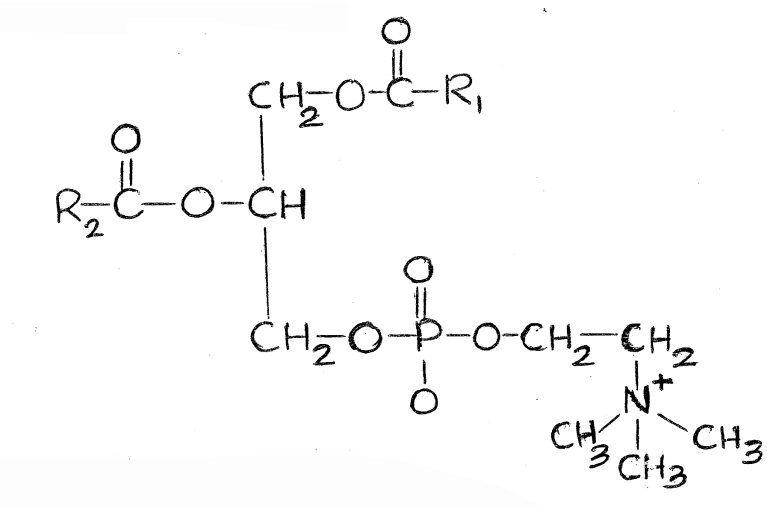
Compound lipids

Lipid molecules formed from glycerol, 2 fatty acids and an additional molecule.

In **phospholipids** phosphate group present as the third molecule.

Phospholipids are **amphipathic** due to the polar head and non - polar tails. They act as the main **structural component of plasma membrane**.

Lecithin and **Cephalin** are two major forms of phospholipids. Lecithin present on alveoli act as a **surfactant** (reduces surface tension)



In **glycolipids** sugar residues act as the third molecule.

Cerebrosides and **Gangliosides** are two major forms of glycolipids.

They present on the surface of cell membrane and have major roles in brain development , synaptic transmission etc

Galactose is the main monosaccharide present in cerebrosides, which commonly known as the **brain sugar**.

Derived lipids

These are the organic compounds derived from the dietary lipids. **Glycerol, fatty acids, sterols and eicosanoids** example of lipid derivatives**.**

Eicosanoids are hormone like derived lipids. **Prostaglandins** are the main form of eicosanoids. They derived from 20 carbon fatty acids (**arachidonic acid**). Prostaglandins involved in inflammations, contraction of smooth muscles and reproduction

Sterols : The derived lipid contains hydrocarbon rings and hydrocarbon chains.

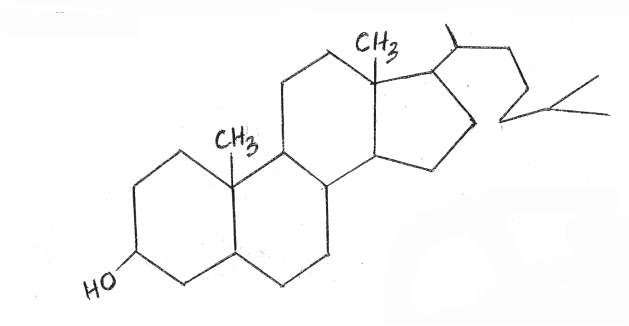
Cholesterol is the major form of sterol in animals.

It is essential for the stability and permeability of plasma membrane.

Steroid hormones and **bile salts** are synthesized from cholesterol.

Good form of cholesterol is **HDL (high density lipoprotein).**

LDL (low density lipoprotein) is the bad cholesterol, which has the tendency to stick on blood capillaries.



Ergosterol is a form of sterol present on the cell membrane of fungi.

NUCLEIC ACIDS

The macro biomolecules formed from **C, H, O, N** & **P.**

DNA and **RNA** are two forms of nucleic acids which related to heredity and variations. Nucleic acids are hetero polymers of **nucleotides**. Each nucleotide formed from **pentose sugar, nitrogen base** and **phosphate group** .

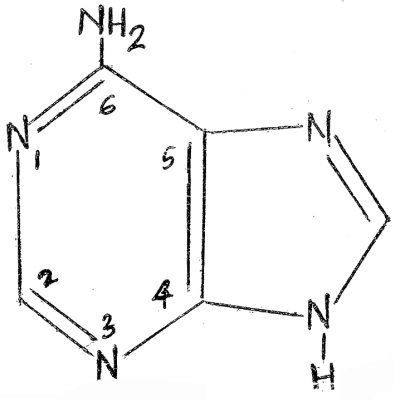
The sugar is **ribose** or **2' deoxyribose**

Nitrogen bases are heterocyclic nitrogen compounds. **Double cyclic** compounds are **purines** and **single ring** compounds are **pyrimidines**.

Purines are two types

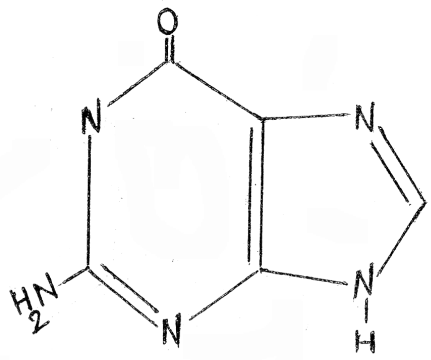
Adenine

(6 amino purine)



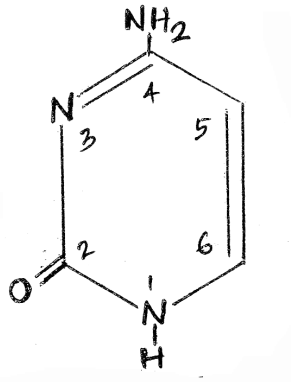
Guanine

(2 amino 6 oxo purine)

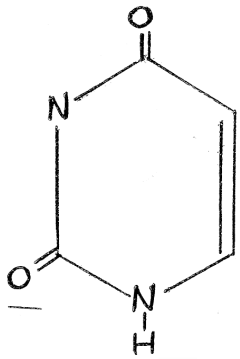


Pyrimidines are three types

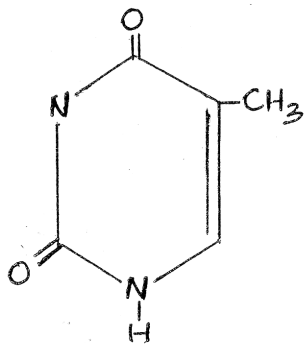
Cytosine
(4 amino 2 oxo pyramidine)



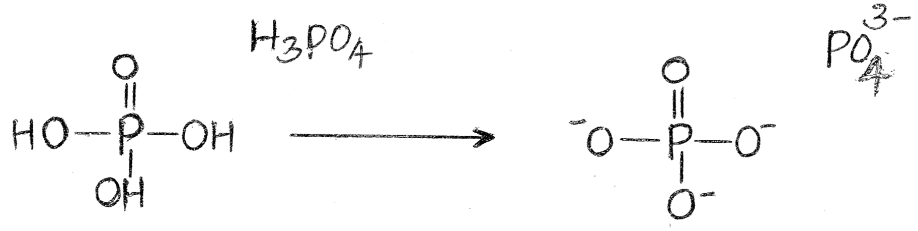
Uracil
(2, 4 dioxo pyramidine)



Thymine
5 methyl, 2, 4 dioxo pyramidine
(5 methyl uracil)



Phosphate group (from phosphoric acid)



Nucleoside

The organic molecule formed from pentose sugar and nitrogen base.

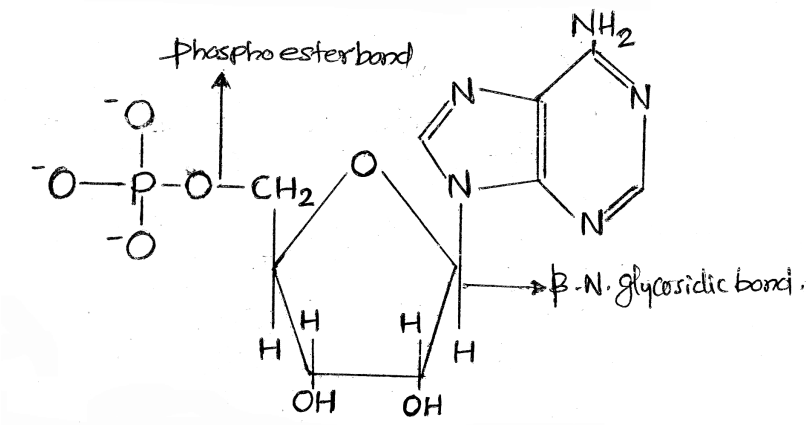
Nitrogen base connected to the first carbon of sugar by β **N - glycosidic bond**.

RNA	DNA
Ribose + adenine - Adenosine	Deoxy ribose + adenine - Deoxy adenosine
Ribose + guanine - Guanosine	Deoxy ribose + Guanosine - Deoxy guanosine
Ribose + cytosine - Cytidine	Deoxy ribose + cytosine - Deoxy cytidine
Ribose + uracil - Uridine	Deoxy ribose + thymine - Deoxy thymidine

Nucleotide

The monomer of nucleic acid formed from nucleoside and phosphate group.

Phosphate group connected to the 5th carbon of sugar by **phosphoester linkage**.



RNA

Adenosine + phosphate - Adenylic acid or adenosine mono phosphate (AMP)

Guanosine + phosphate - Guanylic acid or guanosine mono phosphate (GMP)

Cytosine + phosphate - Cytidylic acid or cytidine mono phosphate (CMP)

Uridine + phosphate - Uridylic acid or uridine mono phosphate (UMP)

DNA

Deoxy adenosine + phosphate - d adenylic acid or d adenosine mono phosphate (dAMP)

Deoxy guanosine + phosphate - d guanylic acid or d guanosine mono phosphate (dGMP)

Deoxy cytidine + phosphate - d cytidylic acid or d cytidine mono phosphate (dCMP)

Deoxy thymidine + phosphate - d thymidylic acid or d thymidine mono phosphate (dTMP)

Structure of DNA

In 1953 James Watson & Francis Crick proposed the double helical structure of DNA.

Two strands of DNA are made up of sugar and phosphate groups. Nitrogen bases present inside the strands. The strands are **anti parallel** .

Nucleotides of each strand are liked by **phospho diester bonds**.

Both strands of DNA are interconnected by the nitrogen base pairs. The pairing by **hydrogen bonds** (**A T, G C**)

The base pairing and right hand twist gives a **twisted ladder shape**.

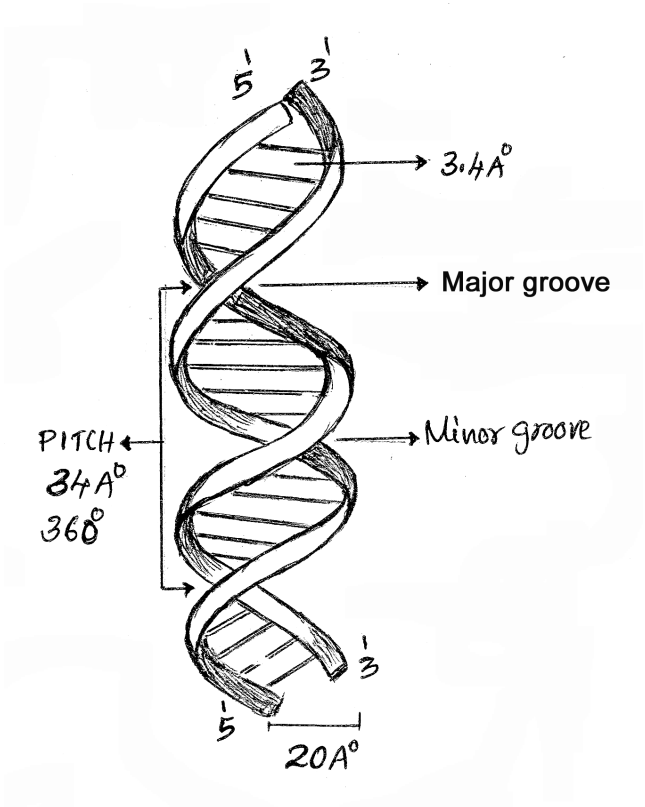
Part of DNA with a complete twist is a **pitch of DNA**.

The pitch has **360°** angle of turn and **10 base pairs**.

The ascent angle between two base pairs is **36°** .

Distance between two adjacent base pairs is **3.4** $\mathring{A}$. So the length of pitch is **34** $\mathring{A}$.

The width (distance between DNA strands) is **20** $\mathring{A}$.



CONCEPT OF METABOLISM

The biomolecules keep changing from one form to the other form, called the **turn over**

It takes place through **metabolism**, which is the sum total of all biochemical reactions that occur within the cell.

The product formed in each step of metabolism is a **metabolite**.

The metabolic pathways are similar to the automobile traffic in a city.

This interlinked metabolic traffic is called the **dynamic state** of body constituents.

Every metabolic reaction is catalysed by the biocatalysts called **enzymes**.

Anabolism and **Catabolism** are to metabolic pathways.

Anabolism is the **biosynthetic pathway** (synthesis of complex compounds from simple substances) **eg: Protein synthesis , starch synthesis.**

Catabolism is the **degradation pathway** (conversion of complex molecules in to simple products) **eg: Glycolysis , breakdown of muscle protein.**

The energy liberated during degradation store in the form of chemical bonds in **ATP** molecules **(energy currency)**

THE LIVING STATE

There is a number of biochemical reactions in living cells.

These reactions have the tendency to proceed towards a state of **equilibrium**.

The steady state of cell is in a non equilibrium state, which has a **metabolic flux**.

So living state is a **non - quilibrium steady state** to be able to perform work.

Living process is a constant effort to prevent falling in to equilibrium.

When a living system reach in equilibrium, it stops all metabolism and becomes **dead**.

ENZYMES

Enzymes are **biological catalysts** because they can speed up the rate of metabolism.

Most of the enzymes are derivatives of **tertiary proteins**.

Sometimes nucleic acids behave like enzymes called **ribozyme** (23S rRNA)

The term enzyme is proposed by **Willy Kuhne**

Edward Buchner discovered the first enzyme **(zymase)** from yeast

The catalytic nature of enzyme first explained by **Berzalius**.

J.B.Sumner isolated the first enzyme **urease**.

Simple enzymes have a protein part only eg: **pepsin**

Conjugated enzymes have a protein part (**apo enzyme**) and a non protein (**co - factor**)

Functional enzyme (Holo enzyme) = apo enzyme + co- factor

Co- factors are three types

1. **Co- enzyme** : An organic compound loosely attached to the apo enzyme . Most of the co-enzymes are vitamin derivatives. eg: **NAD, FAD, NADP, FMN, Acetyl CoA**

2. **Prosthetic group:** A non protein tightly bounded to the apo enzyme. It may be organic or inorganic. eg: **Heam** is prosthetic group of **catalase & peroxydase**

3. **Activator** : The metal ions loosely attached to the apo enzyme

   eg: Zn - Carbonic anhydrase, Carboxy peptidase,

   Alcohol dehydrogenase

   Ca - Lipase, Thrombokinase

   Mg - Hexokinase , DNA polymerase

Non functional form of enzyme is pro enzyme (zymogen)

Two structurally different enzymes catalyse same reaction is known as iso enzymes

Properties of enzymes

Enzymes are highly specific to their substrate and reaction.

Enzymes are highly sensitive to temperature and pH variations.

Each enzyme has an optimum temperature and pH for its maximum action.

Below 0^{o} C enzyme becomes inactive and above 80^{o} C they get denatured.

The change in rate of enzyme action due to the variation in 10^{o} C within optimum range is the **temperature coefficient** (**Q10 value**). For most of the enzymes it is **2**.

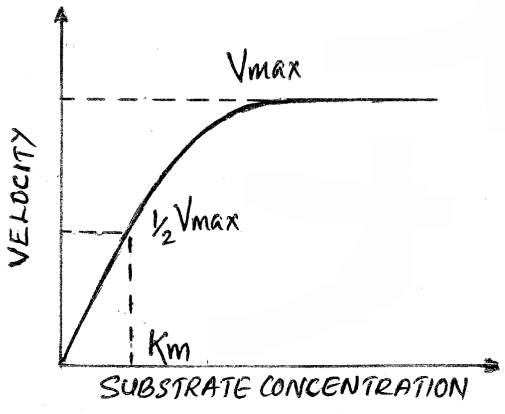
The graph of temperature or pH relation with speed of enzyme action has **parabolic** shape.

Substrate concentration has a great influence in the rate enzyme action.

In the beginning both are directly proportional. But after a limit substrate concentration has no effect in the rate of enzyme. This limit is known as **Vmax**.

The substrate concentration required for 1/2 Vmax is called Km constant (Michaelis constant). It is a measure of enzyme's affinity to the substrate.

$$\text{Km constant } \alpha = \frac{1}{\text{affinity to the substrate}}$$



The number of substrate molecules converted in to product by an enzyme per unit time is known as the **turn over number (TON) (Kcat)**

TON α efficiency of enzyme

The turn over number is maximum for carbonic anhydrase.

It is 360 lakh/min or 6 lakh/sec.

Role of enzyme in a reaction

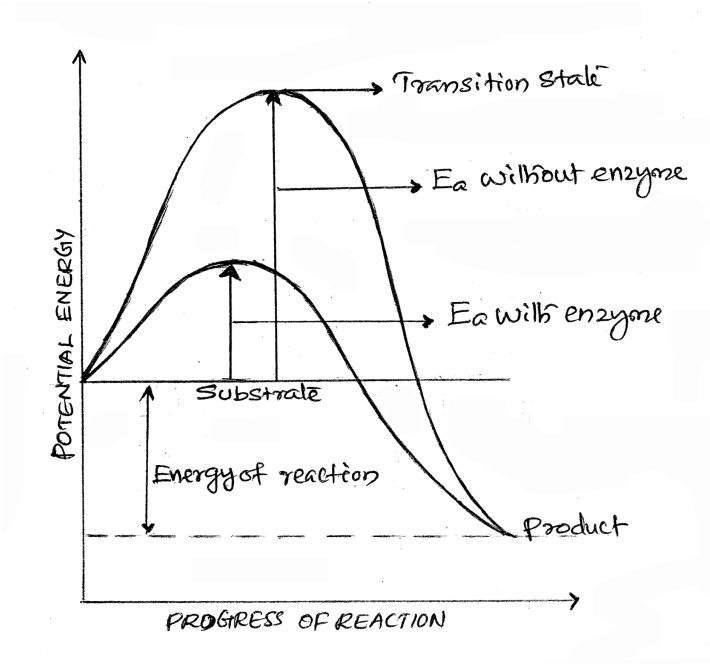
All biochemical reactions have a potential energy barrier.

The substrate must overcome this barrier to complete the reaction.

The substrate molecules with sufficient energy collides and can reach in a high energy **transition state**. By the release of energy the transition state becomes product.

An enzyme can lower the level of activation energy. So the reaction attains transition state (enzyme substrate complex) in a short period. It speed up the rate of reaction.

The difference in the energy of substrate and product is the energy of reaction.



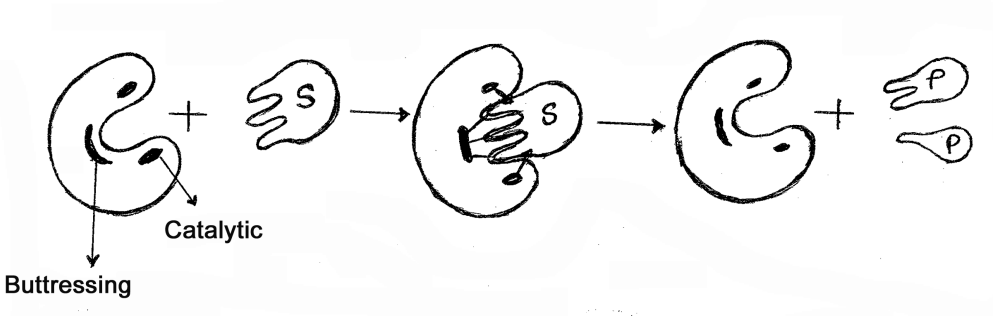
Induced fit hypothesis

Koshland proposed this theory to explain enzyme action.

Enzyme has highly reactive **active sites** for attachment of substrate.

The active site can change its shape according to the shape of sustrate. So it is **flexible**.

Enzyme has a **buttressing group** to hold the sustrate and a **catalytic group** to convert substrate in to product.



Lock and key hypothesis

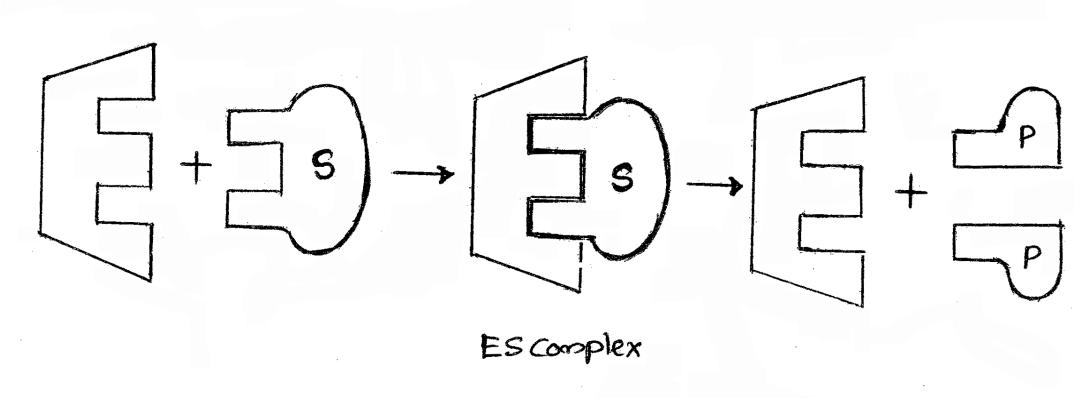
Emil Fischer proposed the lock and key theory to explain the mechanism behind enzyme action.

The action of an enzyme on substrate is similar to the action of a key on a lock.

Enzyme has **active sites** for the attachment of sustrate.

The active site is not flexible. So the sustrate with suitable shape can attach to the active site.

Enzyme firmly hold the sustrate and break its bonds. Substrate converts in to product and enzyme remains unchanged.



Enzyme inhibition

Any obstruction in enzyme action is an enzyme inhibition. Based on the nature of inhibitor inhibitions are three types.

1. Competitive inhibition:

The inhibitor is **structural analogue** of substrate. There is competition between substrate and inhibitor for the active site. It reduces the affinity of enzyme towards the substrate. This type of inhibition is **reversible** . It can increase the **Km value** without changing **Vmax**.

eg: **Malonic acid (malonate**) is a competitive inhibitor of **succinate dehydrogenase**.

2. Non - competitive inhibition:

The inhibitor is a poisonous substance. It can attach to any part of enzyme or enzyme substrate complex and blocks the enzyme action. This type of inhibition is **irreversible** . It can **reduce value of Vmax**.

eg: **Cyanides**

3. Allosteric inhibition:

The inhibitor attach to the enzyme at a site other than the active site, called the allosteric site. Sometimes the end product of enzyme action, act as the allosteric inhibitor. It is also known as **feedback inhibition**.

eg: Glucose $\xrightarrow[\text{Hexokinase}]{}$ Glucose 6 phosphate

Feed back

Classification of enzymes

On the basis of reaction they performed, enzymes are classified in to six major groups. The classification was done by **IUB (nternational Union for Biochemistry)**

1. Oxido reductase : Catalyse oxidation and reduction reactions. These are the most abundant form of enzyme.

S oxidised + S' reduced ⟶ S reduced + S' oxidised

eg: Cytochrome oxidase, Alcohol dehydrogenase

2. Transferase : Catalyse the transfer of a group from one substrate to another

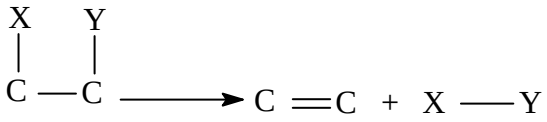
S - G + S' ⟶ S + S' - G

eg: Peptidyl transferase, Carbonic anhydrase

3. Hydrolases : Catalyse the hydrolytic breakdown of complex sustrate. All digestive enzymes are hydrolases.

eg: Amylase, ATPase

4. Lyases : Induce the cleavage without hydrolysis and addition of double bonds.



eg: Adenyl cyclase, Decarboxylase

5. Isomerase : Catalyse the rearrangement of molecular structure and formation of isomer.

eg: Hexophosphate isomerase, Alanine recemase

6. Ligase : Catalyse the formation of linkage or bonds

eg: DNA ligase, RNA ligase

Each enzyme has a specific four digit code named EC number (enzyme commission number). It indicates the group, subgroup and substrate of enzyme.

eg: EC 1111 - Alcohol dehydrogenase

EC 3113 - Amylase

EC 2777 - DNA polymerase

EC 6111 - tRNA ligase

BIOMOLECULES NCERT SOLUTIONS

4. Structure of different microbiomlecules are in the note

Compound	Manufacturer	Buyer
Starch products	Premier starch products pvt LTD Bangaluru	Research laboratories, educational institutes Other industries
Liquid glucose	A.B.Enterprises , Mumbai	
Various enzymes	Infinita Biotech pvt LTD Vadodara	

5. Yes, we can connect the information to the purity of proteins.

An acurate sequence of amino acids is very important for the functioning of protein.

Any change in the sequence can alter the structure and function of protein.

By using the information we can determine the correct amino acid sequence and can compare it with another proteins.

The changes in sequence can be linked with to the purity or homogeneity of a protein.

6. Proteins are commonly used in cosmetics, therapeutics

Thrombin & fibrinogen — blood clotting

Insulin — helps to maintain blood glucose level

Antibody — immunity , blood transfusion

Renin — osmoregulation

8. Milk has many globular proteins (casein). When milk converts in to curd or yoghurt, these complex proteins denatured in to simple fibrous proteins. These primary proteins are e a s l y digestable. So curd & yoghurt are better food items than milk.

10. Treating a neutral or basic amino acid against a weak base will dissociate one functional group (-COOH). Titration between acidic amino acid and weak base will dissociate two or more functional groups.

12. Gums are hetero polysaccharides. They are made from two or more monosaccharides. Fevicol is polyvinyl alcohol glue. It is not a polysaccharide.

13. Protein — Biuret's test

Lipids — Grease spot test (solubility test)

Amino acids — Ninhydrin test

14. Approximately, 100 billion tonnes of cellulose made per year by all plants.

About 2 million cellulose used in paper industry. 17 full grown trees to make one ton of paper. Trees also used for timber, food, medicines etc. These exploitations leads to huge loss of vegitation.

15.
- ♦ Enzymes are complex macro biomolecules
- ♦ They are generally protein derivatives (tertiary protein)
- ♦ Enzyme cannot start a reaction , but can catalyse it
- ♦ They are specific to substrate and reaction
- ♦ They are sensitive to temperature changes
- ♦ Optimum pH range of enzyme is 6 - 8
- ♦ Substrate concentration can influence the rate of enzyme action
- ♦ Enzyme reamains unchanged at the end of reaction