# Lesson - 02

## Biomolecules

- All the carbon compound present in the living organisms is called biomolecules.
- An analysis of plant tissue, animal tissue and microbial mass indicates that they are made up of almost similar ~~components~~ types of elements and compounds.
- Elemental analysis of earth crust also represent the presence of all elements that are present in the sample of living tissue but relative abundance of carbon, hydrogen, oxygen, nitrogen is higher in any living organisms.

### How to analyse chemical composition

- Living organism have both organic and inorganic compounds (organic which has C, H backbone)
- To know the type of organic and inorganic compounds found in the living organisms chemical analysis is done

i Acid solubility test (to know the organic compound)
ii Ash analysis (to know the type of inorganic compound)

### Acid solubility test :-

- Take a living tissue (Plant or animal)
- Grind it with trichloroacetic acid ($Cl_3CCOOH$) using motar and pestle
- We obtain a thick slurry
- Filter it through the filter paper
- We obtain two fractions
- One is called filtrate or acid soluble pool and the other is Relentate / acid insoluble pool
- The larger organic molecules are found in acid insoluble pool.
- The smaller organic molecules are found in acid soluble pool

- A Comparision of elements present in Non living and Living matter

| Element | % weight of | |
|---|---|---|
| | Earths crust | Human body |
| Hydrogen (H) | 0.14 | 0.5 |
| Carbon (C) | 0.03 | 18.5 |
| Oxygen (O) | 46.6 | 65.0 |
| Nitrogen (N) | Very little | 3.3 |
| Sulphur (S) | 0.03 | 0.3 |
| Sodium (Na) | 2.8 | 0.2 |
| Calcium (Ca) | 3.6 | 1.5 |
| Magnesium (Mg) | 2.1 | 0.1 |
| Silicon (Si) | 27.7 | Negligible |

* Adapted from C.N.R. Rao, Understanding Chemistry, Universities Press, Hyderabad

- A List of Representative Inorganic Constituents of Living Tissues

| Component | Formula |
|---|---|
| Sodium | $Na^+$ |
| Potassium | $K^+$ |
| Calcium | $Ca^{++}$ |
| Magnesium | $Mg^{++}$ |
| Water | $H_2O$ |
| Compounds | NaCl, $CaCO_3$ $PO_4^{3-}$, $SO_4^{2-}$ |

Note :-

- The acid insoluble pool consists of macromolecules like protein, nucleic acid and polysaccharides

## Ash analysis

- Take the sample (Animal / plant tissue)
- Weigh the sample
- Dry the tissue sample and weigh
- Subject the sample into the plane
- The tissue will burn and ash is obtained
- Now inorganic elements are found

## Primary and Secondary metabolites

- Sum total of all the biochemical reaction is called metabolism.
- The product or intermediate product formed during metabolism is called metabolites
- Primary metabolites are synthesised by plants, animals and microbes which has significant role in growth and development (Physiology)
- Primary metabolites are synthesised and utilised by the body.

Eg Amino acids, sugar, lactic acid

- Secondary metabolites are the organic compound produced through the modification of primary metabolites. It is synthesised in plants ~~which~~ it do not have role in growth and development but they improve economy (human welfare)

Eg Pigments, rubber, drug, spices, scents

- Some secondary metabolites have ecological importance including defense mechanisms, antibiotics

## Some Secondary Metabolites

| | |
|---|---|
| Pigments | Carotenoids, Anthocyanins, etc |
| Alkaloids | Morphine, Codeine |
| Terpenoids | monoterpenes, Diterpenes |
| Essential oils | Lemon grass oil |
| Toxins | Abrin, Ricin |
| Lectins | Concanavalin A |
| Drugs | Vinblastin, curcumin |
| Polymeric substances | Rubber, gums, cellulose |

## Biomacromolecules :-

- Biomolecules based on molecular weight are classified into two types :-

### Biomicromolecules :-

- The bio molecules whose molecular weight is less than 1000Da
- They are found in acid soluble pool
- Biomolecule found in acid soluble pool has molecular weight varying from 18–800Da

### Biomacromolecules :-

- The biomolecules whose molecular weight is more than 1000Da
- They are found in acid insoluble pool.
- Polysaccharides, Nuclic acid, proteins are found in acid insoluble fraction whose molecular weight is more than 1000Da
- Lipid is a organic compound which is present in cell membrane and othere membrane has a molecular weight less than 800Da and are still present in acid insoluble fraction because the lipids do not dissolve in water hence they remain back in acid insoble pool along

with other polymeric substance.

- Lipid is not strictly a macromolecule

## Average composition of Cell

| Component | % of the total cellular mass |
|---|---|
| Water | 70 - 90 |
| Proteins | 10 - 15 |
| Carbohydrates | 3 |
| Lipids | 2 |
| Nucleic acid | 5 - 7 |
| Ions | 1 |

- The acid soluble pool has the cytoplasmic composition.
- The acid insoluble ~~pool~~ fraction has both cytoplasm and cell organelle together they form entire chemical composition of living tissue and organism.
- Water is more abundant chemical of living organisms

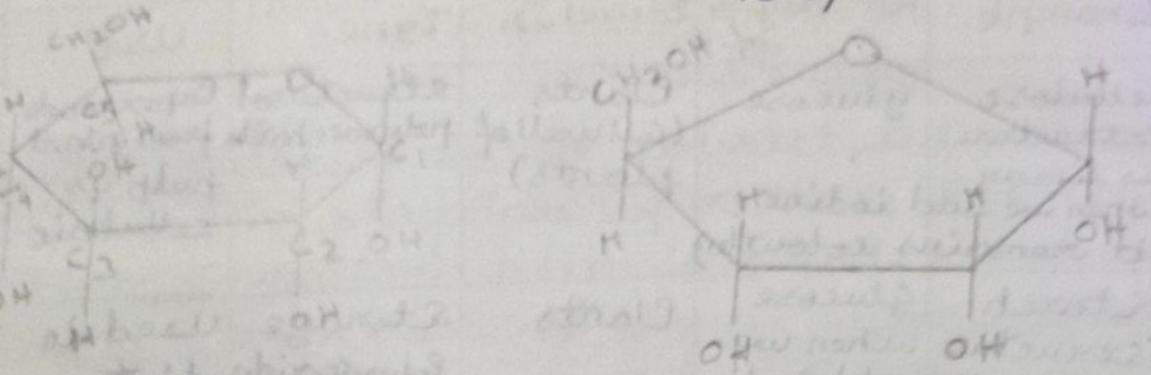
## Carbohydrates :-

- They are organic compound, polyhydroxy, aldehydes or ketone.
- General formula is: $(CH_2O)_n$ is always greater than 2.
- They are called as Saccharides which means sugar.
- Based on the number of sugar units Carbohydrates are classified into
- Monosaccharides
- Dissaccharides (Oligosaccharides)
- Polysaccorides

i Monosaccharides :-

. They are made up of one sugar units

Eg Ribose ($C_5H_{10}O_5$), Glucose ($C_6H_{12}O_6$)



Glucose

ii Dissaccharides :-

. They are made up of 2 sugar units

Eg maltose, lactose, sukrose.

iii Polysaccharides :-

. The carbohydrates which are made up of more than 10 sugar units which appear like a cotton thread.

. They are the organic compound found in acid insoluble fraction

. They are made up of different type of sugar

. Based on type of sugar unit present polysaccharides are of two types :-

. Homopolysaccharides

. Heteropolysaccharides

i Heteropolysaccharides :-

. They are made up of different sugar units

Eg Agar, Petticglycan

ii Homopolysaccharides :-

. They are made up of same type or one type of sugar units

Eg

## Example of Homopolysaccharides

| Example | Homopolymer of | Found in | Type | Use |
|---|---|---|---|---|
| 1 Cellulose (structure is linear when we add iodine it remains colourless) | Glucose | Plants (Cell wall of plants) | structural polysaccharide | Paper made from plant pulp is cellulosic |
| 2 Starch (structure is helical) | Glucose when we add iodine it turns blue. | Plants | Storage Polysaccharides | Used in diet |
| 3 Glycogen | Glucose | Animals | Storage polysaccharide | Reserve food material |
| 4 Inulin | Fructose | bulb of onion & tuber of dhalia | Storage polysaccharide | — |

Note :-

- Structure of Glycogen is unbranched or branched.
- The right end of the chain is called reducing end and left side is called non-reducing end.

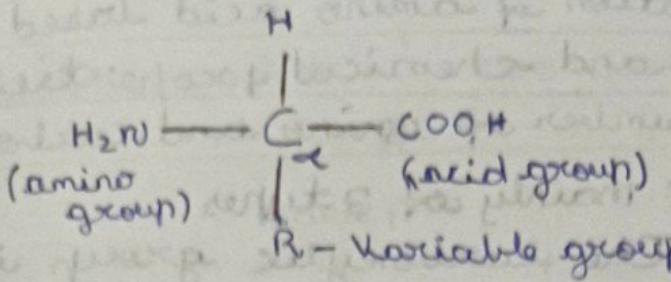
Complex Polysaccharides :-

- They are modified sugar with the amino group (where glucose is in the form of glucosamine and galactose as N-acetyl galactosamine)

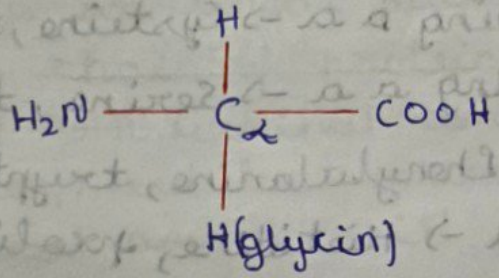
Eg Chitin found in exoskeleton of Arthropoda and the cell wall of fungi is a complex homopolymer of glucosamine.

Amino Acids :- (1439)

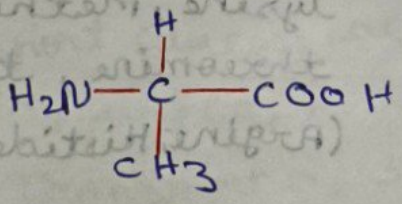
- It is a organic compound containing the amino group and the acid group attached to the same carbon. The carbon in known as $\alpha$ carbon hence they are called $\alpha$ amino acids




- Amino acids are called substituted methanes because the structure of methane has 4 hydrogen which in amino acid is substituted by amino group, carboxyl group, Hydrogen group and variable group called R group.
- Based on the nature of R group there are many amino acids, but those which occurs in proteins are only 20 types.
- If R group is replaced by Hydrogen then amino acid is called glycin.




- If R group is replaced be methyle group then the amino acid is called alanine




- If the R group is replaced by $CH_2OH$ then it is called serine

Classification of amino acid based on their physical and chemical properties (it depends on the number of amino and carboxylic group)

- There are mainly of 3 types

i Acidic :- The carboxylic group is more than that of amino group

Eg Glutamic acid aspartic acid

ii Basic :- The amino group is more than that of carboxylic group.

Eg Lysine, Arginine

iii Neutral :- The amino group and carboxylic group are equal

Eg Glycine, Valine, alanine

Note :-

4 Sulphur containing a a -> Cysteine, methionine

5 Alcohol containing a a -> Serine, threonine

6 Aromatic a a -> Phenylalanine, tryptophan, tyrosine

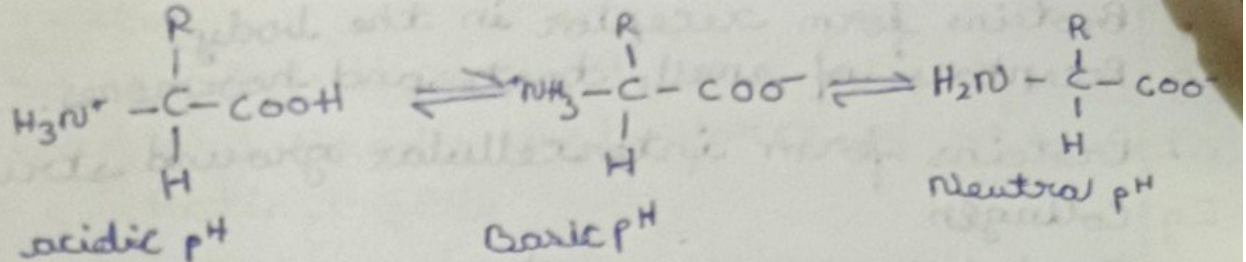
7 Heterocyclic a a -> Histidine, proline.

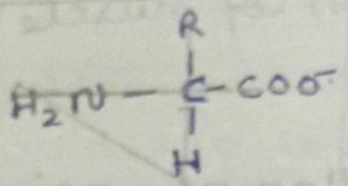
Classification of amino acid based on Essentiality

1 Essential :- are not synthesised in our body but required to our body.
Leucin, valine, Isoleucin, lysine, methionise, phenylalanin threomine, tryptopham.
(Argine, Histide) - semi essential

2 Non essential :- These are synthesised and also used by the body
Glycine, alanine, Serine, Cysteine, aspartic acid, Glutamic acid, glutamine, tyrosine, proline

- A particular property of amino acid is the ionisable nature of $-NH_2$ & $-COOH$ group. In different pH the structure of amino acid changes. zwitter ion They are dipolar ions, which attain both charges at neutral pH.




## Proteins :-

- Proteins are polypeptides because amino acids are linked by peptid bond.
- There are 20 amino acids found in protein.
- Proteins are always heteropolymers (they are made up of different types of amino acid).
- It is always ~~a~~ linear ~~pair~~ chain of amino acid.
- In a long chain of protein first amino acid is termed as N terminal amino acid as it has 3 amino group and last amino acid is termed as C terminal amino acid as it has free carboxylic group

## Biological significance of proteins

- Protein acts as transport molecule

Eg Glut 4 -> Transport Glucose across cell

Haemoglobin -> $O_2$ and $CO_2$ is transported

Myoglobin -> Transport $O_2$ to muscle

- Proteins fights against infectious agent

Eg Antibodies - Immunoglobins

- Some proteins act as hormone

Eg Insulin (maintain blood sugar level)

Glucose $\xrightarrow{\text{Insulin}}$ Glycogen

- Proteins make enzymes or enzymes are made up of protein

Eg Trypsin / Pepsin

- Proteins form receptor in the body
Eg Receptors of smell, taste and harmones.
- Proteins form intercellular ground structu
Eg Collagen
- Proteins help in contraction of muscle and relaxation of muscles.
Eg Actin and myosin
- most abundant protein is Collagen in animal
- most abundant protein present in the biosphere is RuBisCO (Ribulose Bisphosphate carboxylase oxygenase)

Imp **Structure of Protein**

- Arrangment of polyphetided chain will give us diffrent structures of proteins like primary, secondary, tertiary and quarternary.

i **Primary Structure of Protein:-**

- The amino acid in a polypheptide is arrange in the linear fassion which gives the information of the position of amino acid
- The first amino acid is called N terminal and last amino acid is C terminal

Eg:- Insulin

ii **Secondary Structure:-**

- The polypheptide undergo coiling or folding which is stebilized by hydrogen bond.
- The coiled structure is called $\alpha$ helical structure which resembles the revolving staircase and folded structure is called $\beta$ pleated sheat

iii Eg:- Fibring silk ($\alpha$ helical), Keratin ($\beta$ pleated)

iii **Tertiary Structure:-**

- The polypheptide gets folded upon itself like a wollen ball giving it a 3D view which is necessary for the biological activities of

proteins.
- It is stabilized by H bond, disulfhide bond and Vander Walls force of attraction
Eg: Actin, myosin

iv Quaternary structure :-
- When more than 1 polypeptide chain undergo coiling and folding to form the structure called quaternary structure
Eg: Adult human haemoglobin
- It has 4 subunits, 2 $\alpha$ chain and 2 $\beta$ chain

Lipids :-
- They are organic compound found in acid insoluble pool.
- Molecular weight is less than 800Da (micromolecules) found in macromolecular fraction.
- They are insoluble in water.
- Lipids are Esters of fatty acid and glycerol.
- Glycerol is trihydroxy propane.
- Fatty acids are long chain of carbon
- Fatty acid has carboxil group (COOH) attatched to an R group (Variable group). The R group may be methyl ($CH_3$) or Ethyl ($C_2H_5$) or higher number of $CH_2$ group (1-19C)

Eg: i] Palmitic acid (Has 16C including carboxyl C).

$$HOOC-(CH_2)_{14}-CH_3$$

ii] Arachidonic acid (has 20C including carboxyl C)

$$HOOC-(CH_2)_{18}-CH_3$$

| Saturated fatty acids | Unsaturated fatty acids |
|---|---|
| • It is solid in room temperature. | • It is liquid at room temperature. |
| • They are having single bond between carbon atom | • They are having more than one double bond between carbon atom |

Eg Stearic acid, palmitic acid.

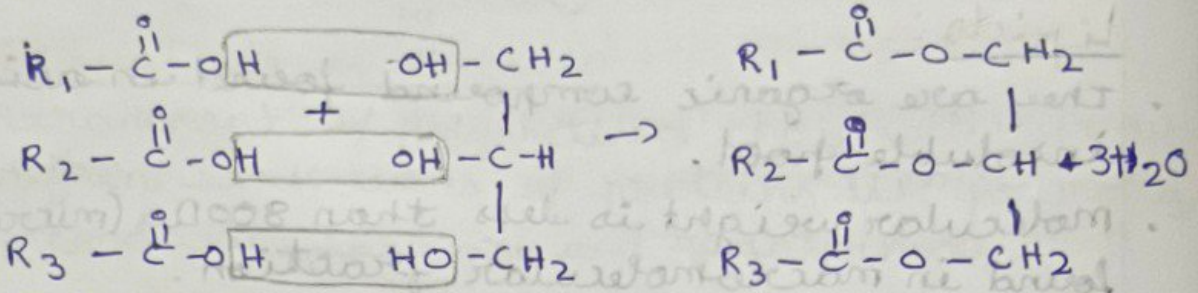
- C-C-C

Eg: Oleic acid, Linolenic acid.

- C=C-C=

- The fatty acids are Esterified with the glycerol to form monoglycerides, diglycerides and triglycerides.

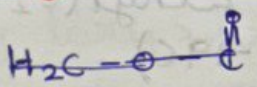
1 - Fatty acid + glycerol → monoglycerides
2 - Fatty acid + glycerol → Diglycerides
3 - Fatty acid + glycerol → Triglycerides



Fatty acid Glycerol Triglycerides

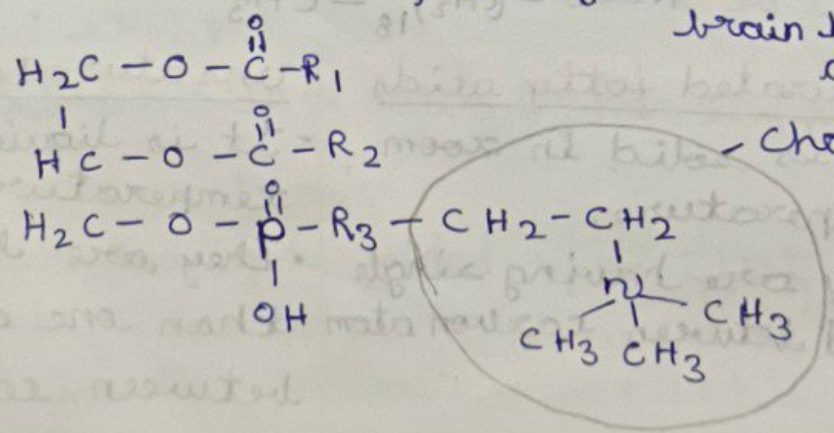
- Based on melting point they are called as oil and fats
- oils have low melting point, fats have high melting point.

## Conjugate lipid



- Lipid + non lipid is called conjugate lipid
- Phospolipid → lipid + phosphate/phospho related group.

Eg Leuthin - Cell membrane, sphingolipid - neuron of brain has more complex.



# Nitrogen Basics and Nucleic Acid

- They are carbon compound with heterocyclic ring structure (Nitrogen).
- They are of two types based on number of rings.

i Purines
ii Pyranidines

## i Purines :-

- Double ringed structure
- They are of 2 types :-

i Adinine (A)
ii Guanine (G)

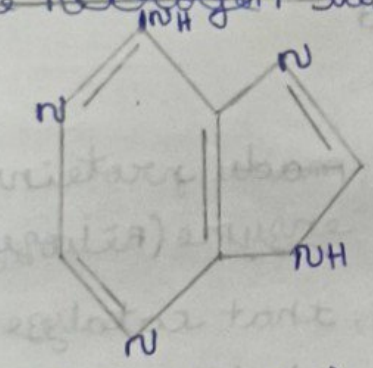
## ii] Pyranidines :-

- single ringed structure
- They are of 3 types :-

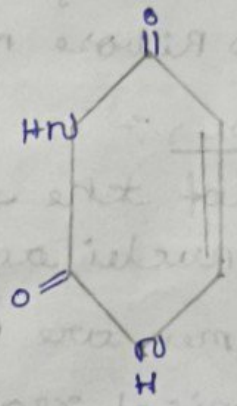
i) Thymine (T)
ii] Cystosine (C)
iii] Uracil (U)

- Nitrogen basis present in DNA are AGTC
- Nitrogen basis present in RNA are AGCU

~~The nitrogen basis along~~



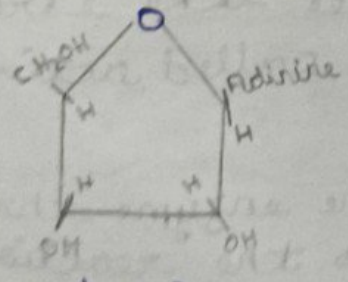
Adenine (Purine)



Uracil

## Nucleosides

- Nitrogen base + Sugar → Pentose sugar (Ribose/deoxyribose)
- Adenine + Ribose sugar → Adenosine
  Guanosine
  Cytiotine
  Thymustine
  Uridine

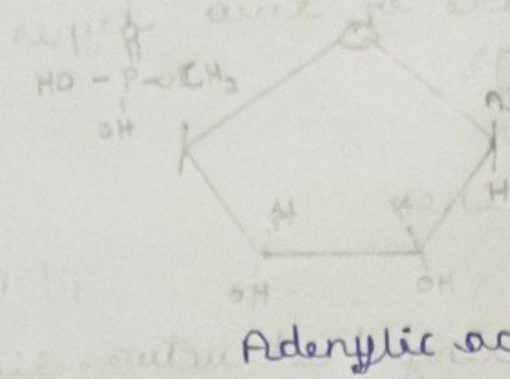


Adenosine

## Nucleotides

- Nitrogen Base + Sugar + Phosphate group
  Nucleosides + Phosphate group → Imparts acidic properties

Eg Adenylic acid
Guanylic acid
Cytidylic acid
Uridylic acid
Thymidylic acid



Adenylic acid

- Nuclei acids are the polynucleotides found in acid insoluble fraction. They are the macromolecules which is made up of nitrogen base, sugar (Ribose / 2' ~~point~~ deoxyribose) and a phosphate group or phosphoric acid.
- There are two types of nuclei acid

i DNA → Deoxyribose nucleic Acid
ii RNA → Ribose nucleic Acid

## Enzymes :-

- most of the enzymes are ~~made~~ proteins
- Some nuclei acid act as enzyme (Ribozyme)
- "Enzymes are Biocatalyst, that catalyze the Biochemical reaction without themselves being changed".
- Since most enzymes are proteins they have primary, secondary and tertiary structure.
- In tertiary structure of enzymes the protein chain folds itself, the chain chiss crosses itself forming a pocket like structure. There are many services or pocket like structure formed. One such pocket is called activesite

### Note :-

- The substrate binds to the enzyme through the active site to catalys the reaction at the high rate.

Enzyme catalyst :- (organic catalyst) differ from inorganic catalysts in many ways but on important point to be studied is their thermal stability

- Inorganic catalyst work efficiently at high temperature and high pressure while enzyme get damaged at high temperature. ie, above 40°C
- The enzymes isolated from the organism who live in the high temperature and pressure (hot vents and sulphur springs). are thermally stable which retain their catalytic power even at high temperature upto (80-90°C)

Eg Taq polymerase is a enzyme is used in the PCR technique which works efficiently even above 80°C it is extracted from Thermophilis aquaticus.

Note :- Thermal stability is thus and important quality of such enzymes isolated from thermophylic enzyme.

## Chemical Reactions

- The changes that occur in the chemicals by the external factors or by formation and the breaking of bonds is called chemical reaction.
- The chemical reaction leads to physical or chemical change.

I Physical change :- It refers to change in the shape without breaking of bonds.

- Physical change also leads to the change in matter like melting of ice into water (solid to liquid) or vaporisation of water (liquid to gas) these are the physical process.

II Chemical Change :-

- During the transformation if the bonds are broken or new bonds are formed which leads to the change in chemicals
- They may be organic or inorganic chemical reaction

Eg. Organic chemical reaction :- starch → Glucose

Conversation of Glucose → Glycogen

- Inorganic chemical reaction :-

$$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$$

- The rate of the reaction is calculated by the amount of product formed per unit time ie, $\text{Rate} = \frac{\delta P}{\Delta T}$. If the direction is specified rate can be called as velocity.
- The factors that influence rate of reaction are temperature and enzyme (catalyst)

Temperature :-

- That follows general thumb rule where increase in temperature by 10°C will double the rate of reaction, decrease in 10°C will reduce the rate of reaction to half.

Enzyme :-

- Catalysed reaction proceed at higher rates than that of uncatalysed ones.

Eg :- $CO_2 + H_2O \rightarrow \underset{\text{carbonic acid}}{H_2CO_3}$ → outside the body it forms 200 molecules/hr

within the cytoplasm,

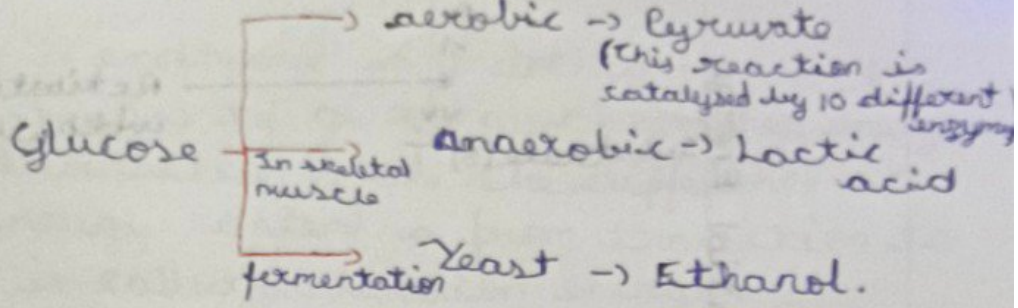
$$CO_2 + H_2O \xrightarrow[\text{anhydrase}]{\text{carbonic}} H_2CO_3$$ 6,00000 molecules are formed/sec

The enzyme as accelerated the reaction rate by about 10 million times.

## Metabolic Pathway :-

The steps involved in the metabolism which are catalysed by either same enzymes or different enzymes leads to different types of metabolic pathways.

Eg :-




## Nature of Enzyme Action :-

- Each enzyme has a substrate (s) binding site in its molecule so that the highly ~~enzyme~~ reactive enzyme substrate complex (ES) is produced. This complex is short lived and dissociates into its product(s) P and the unchanged enzyme with an intermediate formation of enzyme product complex
- The formation of the ES complex is essential for catalyst.

$$E + S \quad ES \rightarrow EP \rightarrow E + P$$

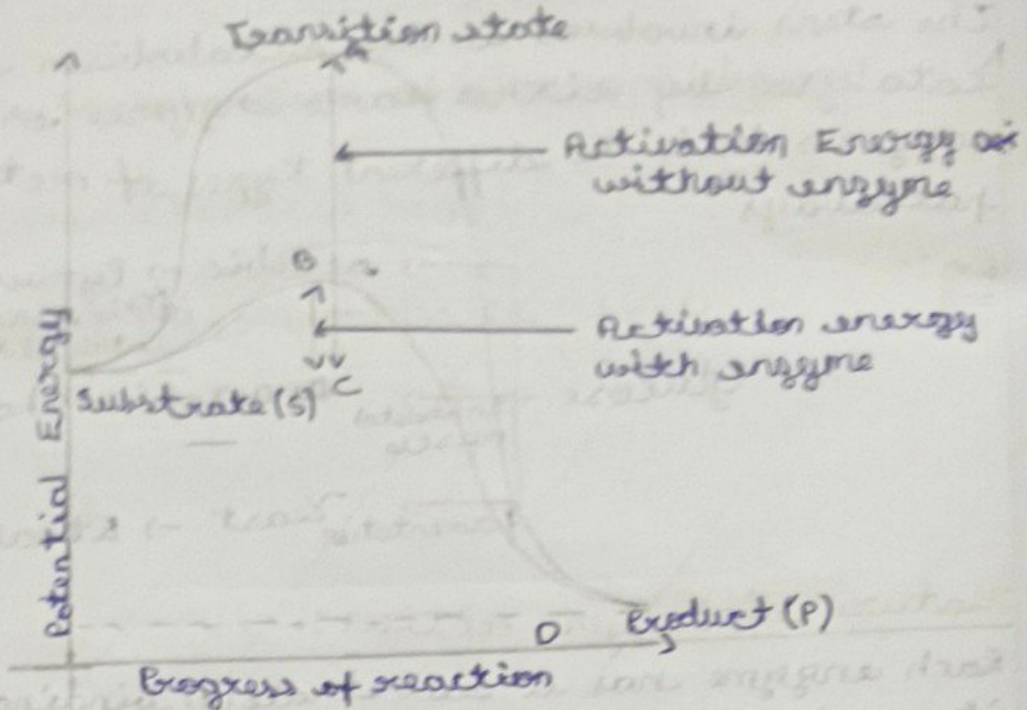
- The catalytic cycle of an enzyme action can be described in the following steps.

i First, the substrate binds to the active site of the enzyme fitting into the active site.

ii The binding of the substrate induces the enzyme to alter its shape fitting more tightly around the substrate.

iii The ative site of the enzyme, now in close proximity of the substrate breaks the chemical bond of the substrate and the new enzyme product complex is formed

iv The enzyme releases the products of the reaction and the free enzyme is ready to bind to another molecule of the substrate and run through the catalytic cycle once again.




- Enzyme is a protein which has 3 dimensional structure with active site to which the substrate comes and binds and gets converted into product.
- The chemical which is converted into the product is called substrate
- As substrate binds to enzyme it forms ES complex which is an transient phenomenon (the new structure of substrate named transition state structure is formed during transient phenomenon). Transient state structure is a unstable structure which keeps on changing until the product is formed. ~~The energy~~
- The energy status of this reaction can be explained using the graph called activation energy graph.
- In the graph Y axis represents potential energy x axis represents progressive reaction

Note :-

C - Energy of substrate
D - Energy of product
B-C - Activation energy with enzyme
A-C - Activation energy without enzyme
A-B - Diff Activation energy in the absence of enzyme

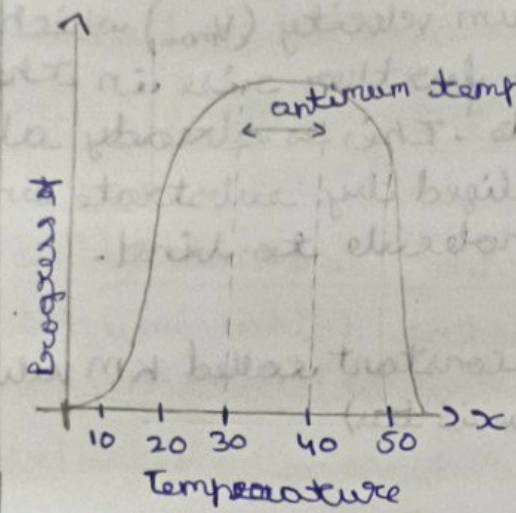
looking at the energy difference between the substrate and product. If the product is lower level than the substrate the reaction is called exothermic reaction (It do not require the supply of energy.

Note:-

whether it is exothermic or endothermic reaction the substrate has to go to much higher energy state or transition state. The difference in average energy content from transition to substrate is called activation energy.

## The factors affecting enzyme activity

1 Temperature
2 pH
3 Concentration of substrate
4 Inhibitors




### 1 Temperature

The enzyme generally functions in narrow range of temperate where it shows its highest activity at a particular temperature which is called optimum temperature. Below the optimum temperature enzymes remain inactive. Above optimum temperature the protein gets denatured which destroys the enzyme activity.

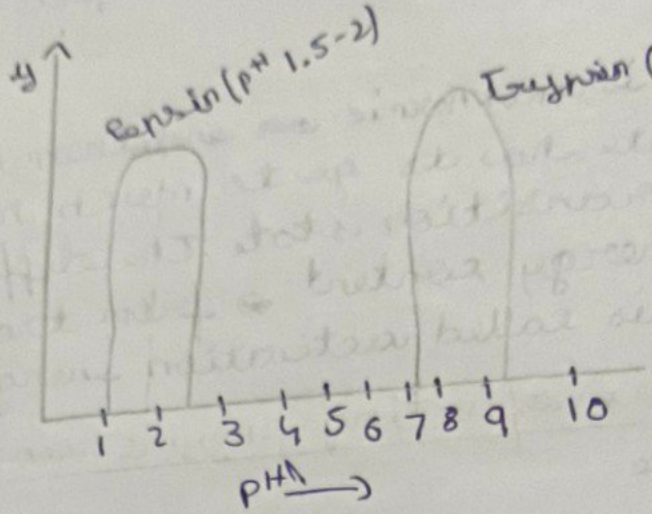
Note:-

optimum temperature of an enzyme is 30-40/45°C

### 2 pH

Enzymes shows its highest activity at a particular pH called optimum pH (It differs from enzyme to enzyme

Eg Pepsin is enzyme present in the stomach which has optimum pH of 1.5 - 2 where trypsin is enzyme found in intestine which has optimum pH of 8 - 8.2

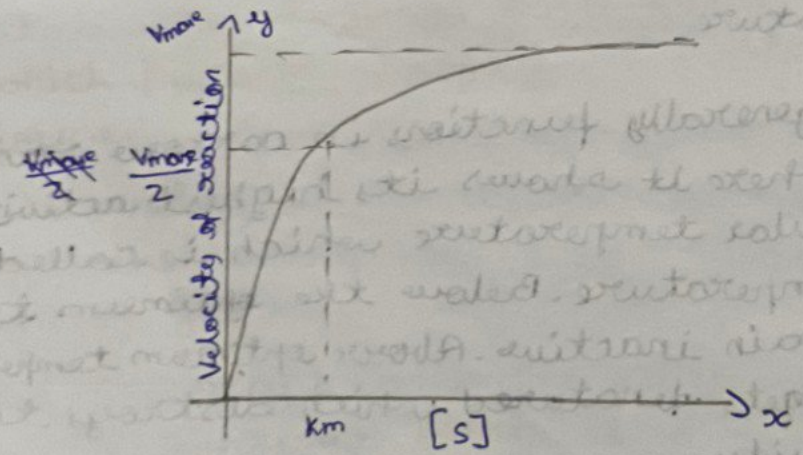


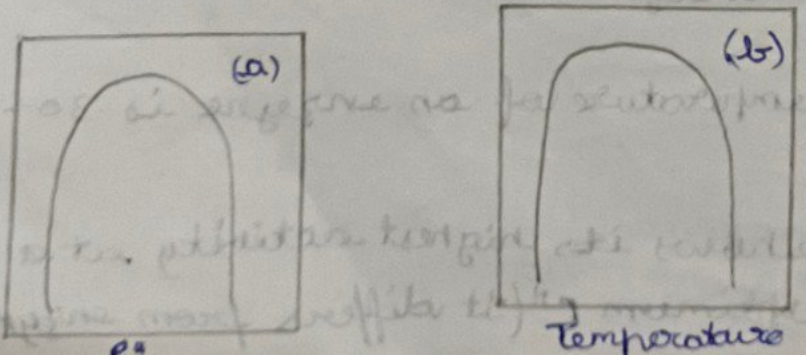

## 3 Concentration of substrate

- As the substrate concentration increases the velocity of enzyme action also increases at first which ultimately reaches maximum velocity ($V_{max}$) which is not exceeded by any ~~rise~~ further rise in the concentration of substrate. This is already all the enzymes are already utilized by substrate and there is no free enzyme molecule to bind.

**To know:**

- Half of $V_{max}$ gives us the constant called Km value (If $V_{max}$ value is more Km value is less)



4 Inhabitors

- These are the chemicals which has a similar structure to substrate. When these chemicals binds to enzyme it shuts off enzyme activity.
- This process is called as inhabition and chemical is called as inhabitors.

i Competative Inhabitors :-

- These inhabitors resemble its molecular structure with a substrate and inhabite the activity of enzymes.
- Due to the structural similarity inhabitors can bind to a with a active site of an enzyme.

Eg Inhabition of succinate dehydrogenase, by malonate which closely resembles the substrate succinic in structure.

- Such competative inhabitors are often used in the control of bacterial pathogens.

5 marks Classification of Enzymes

- Enzymes are classified into 6 classes :-

i oxidoreductases/dehydrogenases :-

- Enzyme which catalyse oxidoreduction between 2 substrate (~~is called S reduced + S' oxidised~~)

Eg S reduced + S' oxidised → S oxidised + S' reduced.

ii Transferaces :-

- Enzyme catalysing the transfer of groups between substrate

Eg $S\,G + S' \rightarrow S + S'G$

iii Hydrolases :-

- Enzyme catalysing hydrolysis of ester, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.

iv Lyases :-

- Enzyme that catalyse removal of groups from substrate by mechanism other than hydrolysis having double bonds.

v Ligases :-
. Enzyme catalysing linking of 2 compounds
Eg Enzyme catalyses the joining of C-O, C-S, C-N, P-O

vi Isomerases :-
. Enzyme catalyses interconversion of optical, geometric or positional isomers.

## Co-Factors

. The entire enzyme ~~is called~~ with catalytic power is called holoenzyme.
. Holoenzyme has 2 part :-
i A protein part called apoenzyme
ii Non-protein part called co-factor (these co-fac make the enzyme catalytically active)
. There are 3 types of co-factors :-
i Prostatic group
ii Co-Enzymes
iii metal ions

### i Prosthetic group :-

. These are the organic compound which are tightly bound to Apoenzyme.
Eg Breakdown of $H_2O_2$ into $H_2O$ & O is catalysed b enzymes peroxidase & catalase which has the prosthetic group called Heam.

### ii Co Enzymes :-

. They are also organic compound. But their association with apoenzyme is only transient.
. Usually occurs during the course of catalysi
Eg The Co-enzyme Nicotinamide adenine dinucleot & NADP contain the vitamin niacin.

iii Metal Ions :-

- These are required for the activities of enzymes which forms the coordination bond with the side chains at the active and and the other end at substrate.

Eg Zn is a co-factor for the enzyme ~~carboxypeptidase~~ carboxypeptidase.

Note :-

- Catalytic activity is lost when co-factor is removed from the enzyme