ENZYMES

- These are **biocatalysts** or **organic catalysts.**
- These are proteins of living organisms that catalyse thermodynamically possible reactions.
- **Dixon** and **Web** defined them as 'Proteins with catalytic properties due to the power of their specific activation.
- **Louis Pasteur** called the substances of yeasts responsible for conversion of sugar into alcohol as **Ferments**.
- **Edward Buchner** named the cell free enzymes of yeasts involved in conversion of sugars into alcohol as **Zymase**.
- **James Sumner** crystalised the enzyme of **Urease** from **Jack Bean** and postulated enzymes as Proteins.
- **John Northrop** crystalised the enzymes **Trypsin** and **Pepsin** and convincingly proved the protein nature of enzymes.
- **J.B.S. Haldane** published a treatise on enzymes that provides basic information on enzymes.
- About **2000** enzymes have been discovered, purified and characterised.

Properties

1. Catalytic property

- Enzymes speed up the rate of biochemical reaction without being involved and altering the balance of the biochemical reaction.

2. Protein Nature

- Most of the enzymes are proteins.
- Enzymes with only protein part are called as **simple** enzymes.
- The protein part of conjugated enzyme is called as **Apoenzyme** and non-protein part as **Co-factor.**
- Co-factor may be metallic ion (Ex: **Fe** in catalase, **Mg** in hexokinase and **Zn^{2+}** in carbonic anhydrase) or Organic co-factor.
- Organic co-factor that associates loosely with the apoenzyme is called as Co-enzyme (NAD, NADP, FAD, FMN and TPP).
- Tightly associated organic co-factor is called as **Prosthetic group** (Haeme moity of Peroxidase).

3. Colloidal Property

- Enzymes are hydrophilic colloids and **provide larger surface area** to the substrate for biochemical reactions.

4. Specificity

- An enzyme acts on only one type of substrate but not several types of substrates. **Ex**: Sucrase acts on only sucrose and Maltase on only maltose. These are also reaction specific.

Active in Minute quantity

- A small amount of enzyme is sufficient to convert large amount of substrate.
- Number of substrate molecules converted into its products in one minute by an enzyme molecule is called as **Turn Over Number.**

6. High Molecular Weight

- Since enzymes are proteins, they have high molecular weight. It ranges from **10,000** to more than **10,00,000** daltons.

7. Thermolabile

- Since enzymes are proteins and colloidal, they are heat sensitive and denatured at higher temperatures.
- The optimum temperature is **25 – 30°C**. These are inactive at lower temperatures.

8. Sensitivity to pH

- Since enzymes are proteins and made of amino acids, they are sensitive to pH. The extent of sensitivity is dependent on its extent of dissociation and charge.
- Most of the enzymes show maximum activity at neutral pH. With decrease or increase in pH from its optimum level, the enzyme activity also decreases.
- The pH of **Pepsin** is 2, **Peroxidase** 5, **Amylase, Urease** and **Catalase** 7 and **Trypsin** 8.

NOMENCLATURE

- An enzyme name ends with suffix **– ase. e.g.** Cellulase, Amylase
- Enzyme name may be based on the type of biochemical reaction. **e.g.** Carboxylase, dehydrogenase, isomerase etc.
- Name may also be based on the name of substrate. **e.g.** Cellulase, Maltase, Sucrase
- Enzyme name may be given on the basis of type of biochemical reaction as well as substrate name. **e.g.** Pyruvic decarboxylase.

- Some enzymes are arbitrarily named. **e.g.** Catalase, trypsin, pepsin etc.

Classification of Enzymes

- Previously enzymes are classified into two groups known as **Desmolases** and **Hydrolases.**

1. Hydrolysing enzymes : They cause the breakdown of substrates by addition of water molecules. They are of four types.

- i) **Carbohydrases** : (Hydrolysis of carbohydrates) e.g. Amylase, Cellulase.
- ii) **Proteases** : (Hydrolysis of proteins) e.g. Pepsin
- iii) **Esterases** : (Hydrolysis of ester bonds) e.g. Lipase, chlorophyllase
- iv) **Amidases :** (Hydrolysis of amides) e.g. Urease

Desmolysing Enzymes :

- i) **Aldolases** :
  (Addition or removal of carbon atoms)
  e.g. Aldolase, Transaldolase
- ii) **Dehydrogenases ;** (Removal of hydrogen)
  e.g : Malic dehydrogenase, Succinic dehydrogenase
- iii) **Hydrases :** (Addition of water)
  e.g. Fumerase
- iv) **Transaminases :**
  (Transfer of amino (NH_2) group)
  e.g. Aspartic acid transaminase
- v) **Carboxylases** : (Addition of carbondioxide)
  e.g. RUBISCO
- vi) **Oxidases :** (Addition of oxygen)
  e.g. Cytochrome C-oxidase
- vii) **Peroxidases :**
  (Reduction of H_2O_2 without the liberation of O_2)
  e.g. Peroxidase
- viii) **Catalase :**
  (Reduction of H_2O_2 involving the liberation of O_2) e.g. Catalase
- ix) **Isomerases :**
  (Intramolecular shift or Rearrangement of molecules in an atom) e.g. Phosphohexose isomerase, phosphoglycero mutase.
- In 1964, **International Union of Biochemistry** appointed a commission to name enzymes.
- This commission classified enzymes into **6** classes.
- Each class is classified into 3 – 14 **sub-**classes.
- Each sub-class into several **sub-sub** classes.
- In each sub-sub class enzymes are arranged in numerical order.
- Each enzyme is given a 4 digit code known as Enzyme code. The first digit indicates the **class**, the second **digit sub-class**, the third digit **sub-sub** class and the fourth digit the number of enzyme in that sub-sub class.

1. Class oxidorecuctases

- These enzymes catalyse oxidation reduction reactions which usually involve hydrogen transfer.
- These are divided into 3 sub-classes.

a) **Dehydrogenases:** These enzymes transfer hydrogen atom from the substrate to coenzyme such as NAD^+.

Ex: Malate + NAD^+ $\xrightarrow{\text{malate dehydrogenase}}$ Oxaloacetic acid + NADH + H^+

b) **Reductases:** These enzymes either remove oxygen atoms from the substrate or add hydrogen atoms to the substrate.

Ex: NO_3^- $\xrightarrow{\text{Nitrate reductase}}$ NO_2^-

c) **Oxidases**: These enzymes transfer hydrogen from the substrate to O_2

Ex: Glycolic acid + O_2 $\xrightarrow{\text{Glycolic acid oxidase}}$ Glyoxylic acid + H_2O_2

2. Transferases

- These enzymes are involved in the transfer of groups from one substrate to another substrate.

a) Transaminases: These enzymes transfer amino group from an aminoacid to a keto acid to form a new amino acid and a new keto acid.

Ex: Aspartic acid + α-ketoglutaric acid $\xrightarrow{\text{Transaminase}}$ Oxaloacetic acid + Glutamic acid

b) **Kinases**: These are involved in transfer of Phosphate group from ATP to substrate.

Ex: Glucose + ATP $\xrightarrow{\text{Hexokinase}}$ Glucose – 6 – Phosphate + ADP

3. Hydrolases

- These enzymes are involved in the breakage of substrate into simpler products by addition of water.

a) **Phosphatases**: These are involved in the removal of Phosphate from the substrate.

Ex: Fructose- 1,6 – bisphosphate $\xrightarrow{\text{Fructose - 1,6 - bisphosphatase}}$ Fructose – 6–phosphate

b) **Peptidase**: these are involved in the cleavage of peptide bonds.
Ex: Hydrolysis of protein to peptides by proteolytic enzymes like **pepsin** and **trypsin**

4. Lyases

- These enzymes split the substrate into simpler products without the involvement of water.

Ex: Arginosuccinic acid $\xrightarrow{\text{Arginosuccinase}}$ Arginine + Fumaric acid

5. Isomerases

- These enzymes bring about shift in the position of atoms of a molecule.

Ex: Ribose – 5 – Phosphate $\xrightarrow{\text{Ribose 5 phospho isomerase}}$ Ribulose–5 – Phosphate

6. Ligases

- These enzymes are involved in the formation of new bonds using energy liberated during ATP hydrolysis. These are also known as synthetases.

Ex: Glutamic acid + NH_3 + ATP $\xrightarrow{\text{Glutamine synthetase}}$ Glutamine

- In the enzyme code 2.7.1.2., the first digit 2 represents the class **transferases**, the second digit 7 represents the sub-class **kinases**, the third digit 1 represents the sub-sub class that indicates the **transfer of Phosphate group to –OH group** of the substrate. The fourth digit 2 indicates the number of enzyme in that sub-sub class.