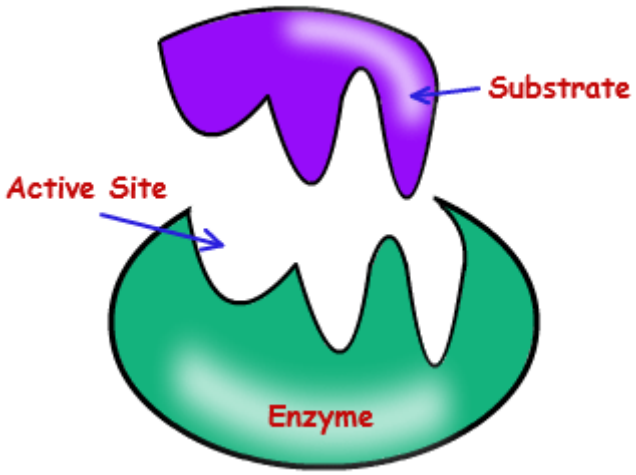
Enzymes are found all around us, they are found in every plant and animal. Any living organism needs enzymes for its functioning. All living being are controlled by chemical reactions. Chemical reactions that are involved in growth, blood coagulation, healing, combating disease, breathing, digestion, reproduction, and everything else are catalyzed by enzymes. Our body contains about 3,000 enzymes that are constantly regenerating, repairing and protecting us.

Enzymes are powerhouses that are able to perform variety of functions in the human body. Enzymes are wondrous chemicals of nature. Enzymes are used in supplement form in medical arena. Although our bodies can make most of the enzymes, our body can wreak havoc the body's enzyme system and cause enzyme depletion due to poor diet, illness, injury and genetics.

Enzymes are large biomolecules that are responsible for many chemical reactions that are necessary to sustain life. Enzyme is a protein molecule and is biological catalysts. Enzymes increase the rate of the reaction. Enzymes are specific; they function with only one reactant to produce specific products. Enzymes have a three-dimensional structure and they utilize organic molecules like biotin and inorganic molecules like metal ions (magnesium ions) for assistance in catalysis.

Substrate is the reactant in an enzyme catalyzed reaction. The portion of the molecule that is responsible for catalytic action of enzyme is the *active site*.



Properties of enzymes:

There are many properties of enzymes, which are written below,

1. Specificity
2. Protein nature
3. The direction of enzyme reactions

4. Isoenzymes

Specificity:

Enzymes are specific in their action which means that an enzyme will act on only one substrate or group of closely related substrate. For example, hexokinase catalyses the conversion of hexoses like glucose, fructose and mannose to their 6-phosphate derivatives but glucokinase is specific for the glucose only. This is very important property of enzyme.

Protein Nature:

Enzymes with few exceptions are protein in nature. They are produced by living cells but act in vivo as well as in vitro. **Vivo** means, chemical reaction occur within living organism. **Vitro** means. Chemical reaction occurs outside the living organism.

The Direction of Enzymes Reaction:

Most enzymatic reactions are reversible. For example, the same enzymes can catalyze reactions in both directions. Forward going reaction can go reverse by applying some conditions on it. Backward going reaction can also go forward at any instance, by applying the conditions.

Isoenzymes:

These are the enzymes from the same organism which catalyze the same reaction, but are chemically and physically distinct from each other. They catalyze the same reaction in same order and speed, but they are different with each other. They are different in shape and structure, and also the chemically.

Factor Affecting Enzymes Activity:

There are many factors by which the enzymes activity can affect,

1. Enzyme concentration
2. Temperature
3. Effect of pH
4. Effect of products
5. Effect of ions
6. Effect of light
7. Radiation
8. Enzyme inhibitors

Enzyme Concentration:

The rate of an enzymatic reaction is directly proportional to the concentration of the substrate. The rate of reaction is also directly proportional to the square root of the concentration of enzymes. It means that the rate of reaction also increases with the increasing

concentration of enzyme. And the rate of reaction can also decreased by with the decreasing in the concentration of enzyme.

Temperature:

The enzymatic reaction occur best at or around 37 degree Celsius which is the average normal body temperature. The rate chemical reaction is increased by a rise in temperature but this is true only over a limited range of temperature. The enzymes usually destroy at high temperature. The activity of enzymes is reduced at low temperature. The temperature at which the enzymes occurs the fastest is called **Optimum temperature**.

Effect of pH:

Just like the temperature, there is also a pH at which an enzyme will catalyze the reaction at the maximum rate. For example, the optimum pH of salivary amylase is 6.4 to 6.9. Every enzyme has different pH value. The enzyme cannot start its function beyond the range of its pH value.

Radiation:

Generally enzymes are readily inactivated by exposure to high intensity radiations. Examples are ultraviolet light, beta rays, gamma rays and X-rays. Although, they are invisible but they are very intensive. Their intensity usually affects the activity of enzymes.

Effect of Products:

When the product is more in the reaction mixture, then the rate of reaction decreases due to feedback inhibition.

Effect of Light:

The speed of activity of various enzymes changes in different wavelength of light ex. blue light enhances the activity of salivary amylase whereas, U.V. light decreases the velocity.

Effect of Ions:

Presence or absence of particular ions enhances or reduces the activity of enzymes ex. Pepsinogen is converted to pepsin in presence of H^+ ions. Kinases act in presence of Mg^{+2} ions.

Effect of Inhibitors:

The interaction between the substrate and the enzyme takes place in a particular region of the enzyme molecule called the active site.

In many instances compounds other than the normal substrate for a particular enzyme-catalyzed reaction may bind to the enzyme's active site, and this has a significant effect on the kinetics of the normal reaction.

One possible consequence of this phenomenon is the inhibition of normal enzyme activity, and such compounds are therefore called enzyme inhibitors.

- ✓ Inhibitors are substances that decrease the activity of the enzyme or inactivate it.
- ✓ Competitive inhibitors are substances that reversibly bind to the active site of the enzyme, hence blocking the substrate from binding to the enzyme.
- ✓ Incompetitive inhibitors are substances that bind to any site of the enzyme other than the active site, making the enzyme less active or inactive.
- ✓ Irreversible inhibitors are substances that from bonds with enzymes making them inactive.

Importance of Enzymes:

Enzymes are of great biological importance and are of great help in the diagnosis of certain disease. Some examples are, alkaline phosphatase is raised in rickets and obstructive jaundice, lactic dehydrogenase or LDH-1 is raised in heart diseases. Many enzymes have proved useful as drugs. For example; thrombin is used locally to stop bleeding. Many enzymes are used for cancer treatment, for example, L-asparaginase has proved very useful in the treatment of blood cancer in children.

Enzyme Classification:

The current system of nomenclature of enzymes uses the name of the substrate or the type of the reaction involved, and ends with "-ase". Example: 'Maltase'- substrate is maltose. 'Hydrolases'- reaction type is hydrolysis reaction.

Classification of enzymes:

Enzymes are classified based on the reactions they catalyze into 6 groups: Oxidoreductases, transferases, hydrolases, lyases, isomearses and ligases.

1. **Oxidoreductases** - Oxidoreductase are the enzymes that catalyze oxidation-reduction reactions. These enzymes are important as these reactions are responsible for the production of heat and energy.

   Example: Pyruvate + NADH—lactate dehydrogenase → Lactate + NAD^+

   Glutamic acid + NAD—glutamate dehydrogenase → α-ketoglutarate + NH_3 + NADH
2. **Transferases** - Transferases are the enzymes that catalyze reactions where transfer of functional group between two substrates takes place.

   Example:

   (α-Ketoglutarate +Alanine—alanine aminotransferase→Glutamate + Pyruvate

   Aspartate + α-Ketoglutarate —aspartate aminotransferase Oxaloacetate + Glutamate

3. **Hydrolases** - Hydrolases are also known as hydrolytic enzymes; they catalyze the hydrolysis reactions of carbohydrates, proteins and esters. Those enzymes which catalyse the breakage of bonds with addition of water (hydrolysis). All the digestive enzymes are hydrolases. Ex. Pepsin, trypsin, amylase, maltase.
4. **Lyases** - Lyases are enzymes that catalyze the reaction involving the removal of groups from substrates by processes other than hydrolysis by the formation of double bonds.

   Example:

   Fructose-1-6-diphosphate—ALDOLASE → Glyceraldehyde-3-phosphate + DHAP
5. **Isomerases** - Isomerases are enzymes that catalyze the reactions where interconversion of cis-trans isomers is involved.

   Example:

   Glyceraldehyde-3-phosphate—ISOMERASE → Dihydroxyacetone phosphate
6. **Ligases** - Ligases are also known as synthases, these are the enzymes that catalyze the reactions where coupling of two compounds is involved with the breaking of pyrophosphate bonds.

   Example:

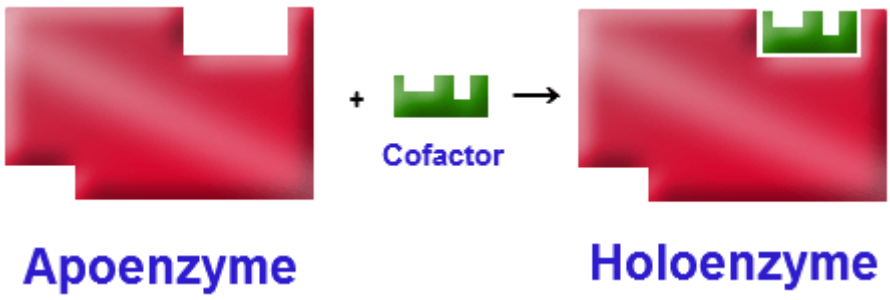
   Pyruvate + CO_2 + ATP—pyruvate carboxylase Oxaloacetate + ADP + Pi

Structure of Enzymes:

Enzymes are proteins, like the proteins the enzymes contain chains of amino acids linked together. The characteristic of an enzyme is determined by the sequence of amino acid arrangement. When the bonds between the amino acid are weak, they may be broken by conditions of high temperatures or high levels of acids. When these bonds are broken, the enzymes become non-functional. The enzymes that take part in the chemical reaction do not undergo permanent changes and hence they remain unchanged to the end of the reaction.

Enzymes are highly selective, they catalyze specific reactions only. Enzymes have a part of a molecule where it just has the shape where only certain kind of substrate can bind to it; this site of activity is known as the *'active site'*. The molecule that reacts and binds to the enzyme is known as the *'substrate'*.

Most of the enzymes consist of the protein and the non protein part called the '*cofactor'*. The proteins in the enzymes are usually globular proteins. The protein parts of the enzymes are known '*apoenzyme'*, while the non-protein part is known as the cofactor. Together the apoenzyme and cofactors are known as the '*holoenzyme'*.



Cofactors may be of three types: prosthetic groups, activators and coenzymes.

- ✓ ***Prosthetic*** *groups* are organic groups that are permanently bound to the enzyme. Example: Heme groups of cytochromes and biotin group of acetyl-CoA carboxylase.
- ✓ ***Activators*** are cations- they are positively charged metal ions. Example: Fe - cytochrome oxidase, CU - catalase, Zn - alcohol dehydrogenase, Mg - glucose - 6 - phosphate, etc.
- ✓ ***Coenzymes*** are organic molecules, usually vitamins or made from vitamins. they are not bound permanently to the enzyme, but they combine with the enzyme-substrate complex temporarily. Example: FAD - Flavin Adenine Dinucleotide, FMN - Flavin Mono Nucleotide, NAD - Nicotinamide Adenine Dinucleotide, NADP - Nicotinamide Adenine Dinucleotide.

Function of Enzymes:

Biological Functions of Enzymes:

- ✓ Enzymes perform a wide variety of functions in living organisms.
- ✓ They are major components in signal transduction and cell regulation, kinases and phosphatases help in this function.
- ✓ They take part in movement with the help of the protein myosin which aids in muscle contraction.
- ✓ Also other ATPases in the cell membrane acts as ion pumps in active transport mechanism.
- ✓ Enzymes present in the viruses are for infecting cell.
- ✓ Enzymes play an important role in the digestive activity of the enzymes.
- ✓ Amylases and proteases are enzymes that breakdown large molecules into absorbable molecules.
- ✓ Various enzymes work together in a order forming metabolic pathways. Example: Glycolysis.

Industrial Application of Enzymes:

- ✓ Food Processing - Amylases enzymes from fungi and plants are used in production of sugars from starch in making corn-syrup.
- ✓ Catalyze enzyme is used in breakdown of starch into sugar, and in baking fermentation process of yeast raises the dough.
- ✓ Proteases enzyme help in manufacture of biscuits in lowering the protein level.
- ✓ Baby foods - Trypsin enzyme is used in pre-digestion of baby foods.
- ✓ Brewing industry - Enzymes from barley are widely used in brewing industries.
- ✓ Amylases, glucanases, proteases, betaglucanases, arabinoxylases, amyloglucosidase, acetolactatedecarboxylases are used in prodcution of beer industries.
- ✓ Fruit juices - Enzymes like cellulases,pectinases help are used in clarifying fruit juices.
- ✓ Dairy Industry - Renin is used inmanufacture of cheese. Lipases are used in ripening blue-mold cheese. Lactase breaks down lactose to glucose and galactose.
- ✓ Meat Tenderizes - Papain is used to soften meat.
- ✓ Starch Industry - Amylases, amyloglucosidases and glycoamylases converts starch into glucose and syrups.
- ✓ Glucose isomerases - production enhanced sweetening properties and lowering calorific values.
- ✓ Paper industry - Enzymes like amylases, xylanases, cellulases and liginases lower the viscosity, and removes lignin to soften paper.
- ✓ Biofuel Industry - Enzymes like cellulases are used in breakdown of cellulose into sugars which can be fermented.
- ✓ Biological detergent - proteases, amylases, lipases, cellulases, asist in removal of protein stains, oily stains and acts as fabric conditioners.
- ✓ Rubber Industry - Catalase enzyme converts latex into foam rubber.
- ✓ Molecular Biology - Restriction enzymes, DNA ligase and polymerases are used in genetic engineering, pharmacology, agriculture, medicine, PCR techniques, and are also important in forensic science.