CHAPTER 3

Q.1: Define enzymes. Give chemical composition of enzymes.

→ What is enzyme highlight its importance in context of chemical composition.

Ans: Enzymes

Definition

All those biological molecules (proteins), which catalyze biological reactions and remain unchanged after completion of reaction, are called enzymes.

Chemical Composition of Enzymes

(1) Amino Acids

Enzymes are composed of hundreds of amino acids joined together and coiled upon them to form globular structure. The catalytic activity is restricted to a small portion of the structure known as the ***active site.*** The reactant called **substrate** is attached to the active site consisting of only a few amino acids, while rest of the bulk of the amino acids maintains the globular structure of enzyme.

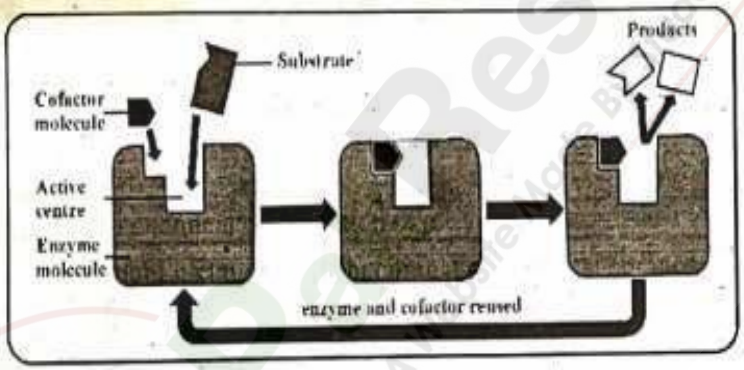


Fig: Substrate molecules will not fit correctly at the active and there will be no catalytic action unless the co-factor molecule is also present

(2) Co-factor

Q: Define Apoenzyme and to factor. (SWL-G1)-16

Non-protein part of the enzyme is called a co-factor.

(i) A co-factor is essential for the proper functioning of the enzymes

(ii) Co-factor acts as a bridge between the enzyme and its substrate.

(iii) Sometimes it contributes directly to the chemical reactions, which brings about catalysis.

(iv) Sometimes provides a source of chemical energy, helping to drive reactions which would be difficult or impossible.

Some enzymes use metal ions as co-factor is also known as co-factors like Mg^{2+}, Cu^{2+}, Zn^{2+} etc.

Types of Co-factor

If the non-protein part is covalently bonded, it is known as **prosthetic group.**

If non-protein part is loosely attached to the protein part, it is known as **coenzyme** and is closely related to vitamins. Vitamins act as essential raw materials for the formation of coenzymes. As coenzymes are used again and again, so essential vitamins for them are required in small amounts.

Detachable co–factor is also known as an **activator** if it is an inorganic ion.

(3) Coenzyme, Apoenzyme and Holoenzyme

An enzyme with its coenzyme or prosthetic group has been removed is known as **apoenzyme.**

An activated enzyme which consists of polypeptide chain and a co-factor is known as **holoenzyme.**

Q: Define Apoenzyme.(GUJ-G1,2)-14 (BWP-G1), (MTN-G1), (GUJ-G2), (LHR-G2)-15,(MTN-G1),(LHR-G2)-16 (LHR-G1)-17

Location and Production of Enzymes

- ★ Enzymes are produced by living cells for use in or near the site of their production.
- ★ Many enzymes are simply dissolved in the cytoplasm. Other some are tightly bound to certain subcellular organelles. For example, enzymes for photosynthesis are found in chloroplast and enzymes involved in cellular respiration are found in mitochondria. Those, which are involved in the synthesis of proteins, are found in mitochondria. Those, which are involved in the synthesis of proteins, are integral part of ribosomes.
- ★ As related to their production, they are produced by living cells for use in or near the site of their production.
  - Enzymes secreted inside the cell are called **intracellular** enzymes.
  - Enzymes secreted outside the cell in cavity e.g. gut are called **extracellular** enzymes.

CHARACTERISTICS OF ENZYMES

Q.2: Give characteristics of enzymes.

Ans. Enzymes, the biochemical catalysts, possess the following important characteristics.

(1) All enzymes are ***globular proteins.***

(2) They ***increase the rate of reaction*** without themselves being used up.

(3) Their presence ***does not affect the nature*** or properties of end products.

(4) Even a ***small amount*** of an enzyme can bring about the ***change in a large amount*** of the substrate by accelerating chemical reactions.

Q: Write down eight characteristics of Enzymes. (MTN-GII-2011)
Q: What are the characteristics of Enzymes? (RWP-GII-2012)

(5) They are very ***specific*** in their action; generally a single enzyme catalyzes only a single substrate or a group of related substrates.

(6) They are ***sensitive*** to even a minor change in pH, temperature and substrate concentration.

(7) Some enzymes require a ***co-factor*** for their proper functioning.

(8) They ***lower the activation energy*** of the reactants.

(9) Some enzymes are ***potentially damaging*** if they become active in the wrong place. For example pepsin is a powerful protein digesting enzymes and is capable to destroy the cell's internal structure and thus is produced in inactive pepsinogen formed by the cell in membrane-bounded bodies called lysosomes.

Q: Why some enzyme are produced in active form. (SGD-G1)-17

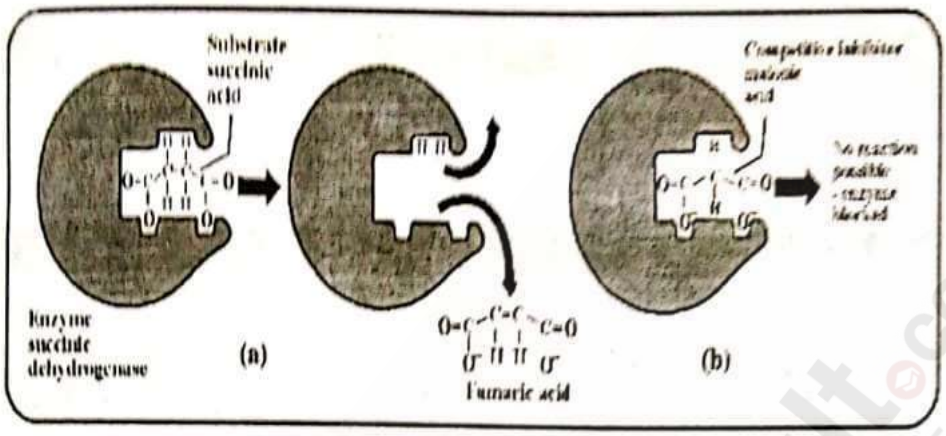
(10) Enzymes ***require aqueous medium*** for their activity.

Competitive Inhibitors

They have structural similarity with substrate, so selected by binding sites, but are unable to activate the alytic sites. Thus products are not formed. Example is malonic acid.

Non-Competitive Inhibitors

They form enzyme-inhibitor complex at point other than active site. They alter structure of enzyme in such a nner that even if genuine substrate binds the active site, catalysis fails to take place.



g: Mechanism of competitive inhibition. (a) Formation of enzyme-substrate complex resulting in the formation of product. (b) Inhibitor malonic acid does not fit the active site, hence no product s formed.

What is the importance of enzymes in life.

IMPORTANCE OF ENZYMES

Enzymes are the sparks that start the essential chemical reactions our bodies need to live. They are necessary digesting food, for stimulating the brain, for providing cellular energy, and for repairing all tissues, organs, and s.

There are three types of enzymes: metabolic enzymes, digestive enzymes, and food enzymes.

Metabolic enzymes catalyze, or spark, the reactions within the cells. The body's organs, tissues, and cells are by metabolic enzymes. Without them our bodies would not work. Among their chores are helping to turn sphorus into bone, attaching iron to our red blood cells, healing wounds, thinking, and making a heartbeat.

Digestive enzymes break down foods, allowing their nutrients to be absorbed into the bloodstream and used ody functions. Digestive enzymes ensure that we get the greatest possible nutritional value from foods.

Food enzymes are enzymes supplied to us through the foods we eat. Nature has placed them there to aid in digestion of foods. This way, we do not use as many of the body's "in-house" enzymes in the digestive process.

- One of the roles of enzymes in the body is detoxification -- breaking down toxic substances so that they are excreted and cannot build up to possibly cause harm.
- Synthesis of all complex molecules of life such as nucleic acid, protein, starch, glycogen, lipid etc is not possible without enzymes.
- Respiration and photosynthesis are the most important process for all living things are controlled by series of enzymes working in an arranged and step-wise orderly system.
- In other words it can be said that no metabolic reaction take place without enzymes without metabolism no life exists.

Most enzymes do not float about in a kind of cytoplasmic soup but are attached to membrane systems inside the cell in specific and orderly arrangements. Mitochondria and chloroplast are good example of this.

Q: Describe the mechanism of enzyme action. (MTN-GI-2010)

Q: Example the mechanism of enzyme action in detail. (SGD-G1)-15

Q: Write the lock and they model. (GUJ-G1), (LHR-G2)

Lock and Key Model of Enzyme Action

Emil Fischer (1890) proposed a Lock and Key model to visualize substrate and enzyme interaction. According to this model, as one specific key can open only a specific lock, in the same manner a specific enzyme can transform only one substrate into products.

According to Lock and Key Model, the active site is a rigid structure. There is no modification or flexibility in the active site before, during or after the enzyme action and is used only as a template. Later studies did not support this model in all reactions.

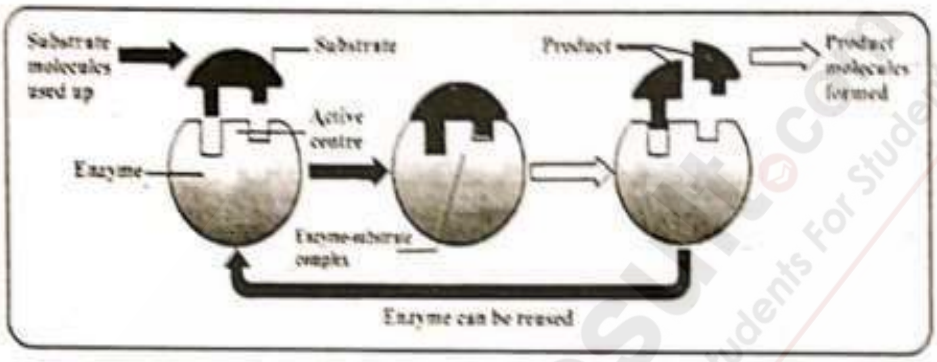


Fig. Diagrammatic representation of an enzyme-substrate reaction (Lock and Key Model)

Induce fit Model of Enzyme Action

Koshlandproposed Induce Fit Model in1959 .He argued that when a substrate combines with an enzyme, it induces changes in the enzyme structure. The change in structure enables the enzyme to perform its catalytic activity more effectively.

Q: What is Koshland Enzyme model. (SWL-G1)-14, (LHR-G2), (BWP-G1)-15, (MTN, AJK-G2)-16

FACTORS AFFECTING THE RATE OF ENZYME ACTION

Q.4: Give the factors affects the rate of enzyme action.

➔ Give the effect of pH and temperature on the efficacy of an enzyme action.

Ans. The functional specificity of every enzyme is the consequence of its specific chemistry and configuration. Any factor that can alter the chemistry and shape of an enzyme can affect its rate of catalysis. Some of the important factors that can affect the rate of enzyme action are given below.

Q: Give the effect of pH and temperature on the efficiency of Enzyme actions. (RWP-GI-2011)

Q: With the help of graphic / diagrammatic representation discuss the role of substrate concentration in an Enzyme reaction. (MTN-GI-2014, 15)

(1) Enzyme Concentration

The rate of reaction depends directly on the amount of enzyme present at a specific time at unlimited substrate concentration.

- ★ If the amount of enzyme is increased by two fold, the reaction rate is doubled. By increasing the enzyme molecules, an increase in number of active sites takes place. More active sites will convert the substrate molecules into products, in the given period of time.
- ★ When concentration of substrate is increased to a limit, then rate of reaction no longer depends on the increase in enzyme concentration.

Q: Discuss the Enzyme concentration in affecting rate of enzyme action. (DGK-G2)-15, (SGD-G1)-16 (GUJ-G1)-17

(2) **Substrate Concentration**

- At low concentration of substrate, the reaction rate is directly proportional to the substrate available.
- If the enzyme concentration is kept constant and the amount of substrate is increased, a point is reached when a further increase in the substrate does not increase the rate of the reaction any more. This is because at high substrate level all the active sites of the enzyme are occupied and further increase in the substrate does not increase the reaction rate.

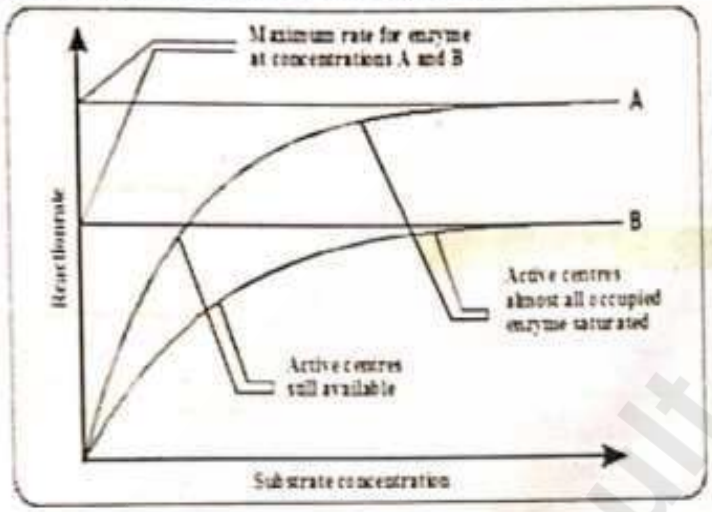


Fig: Effect of the substrate concentration on the rate of enzyme catalyzed reaction.

(3) **Temperature**

The rate of enzyme –controlled reaction may increase with increase in temperature but up to a certain limit.

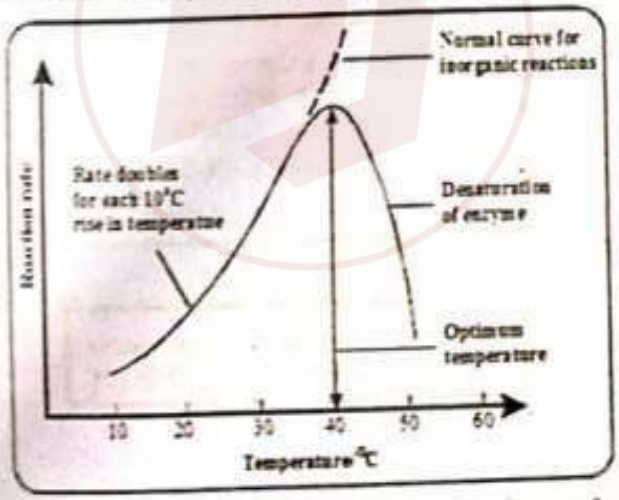
Q: What is effect of temperature on Enzyme action. (LHR-G2), (DGK-G1)-16, (AJK-G1)-16

Optimum Temperature

All enzymes can work at their maximum rate at a specific temperature called as optimum temperature. Optimum value of a factor is that value on which the enzyme show maximum rate of reaction. For example, for enzymes of human body 37°C is the optimum temperature.

Effect of Alterations

Heat provides activation energy and therefore, chemical reactions are accelerated at high temperatures. Heat also supplies kinetic energy to the reacting molecules, causing them to move rapidly. Thus the reactants move more quickly and chances of their collisions with each other are increased. However, further increase in heat energy also increases the vibrations of atoms which make up the enzyme molecule. If the vibrations become too violent, globular structure essential for enzyme activity is lost and the enzyme is said to be denatured.



Q: How pH effect the rate of Enzyme. (FBD-G1), (GUJ-G2), (RWP-G1)(RWP-G2)-16

Fig: Effect of temperature on the rate of an enzyme catalyzed reaction

(4) **pH Value**

Every enzyme functions most effectively over a narrow range of pH known as the optimum pH as shown in table below:

Effect of Alterations

A slight change in pH can change the ionization of the amino acids at the active site. Moreover, it may affect the ionization of the substrates. Under these changed conditions, enzyme activity is either retarded or blocked completely.Extreme changes in pH cause the bonds in the enzyme to break, resulting in the enzyme denaturation.

ROLE ENZYME ACTIVATOR

Enzyme activator co-factor is known as an activator. It is inorganic metal ions used by enzyme for their proper functioning

Example: Mg^{+2}, Fe^{+2}, Zn^{+2} etc.

Q: Give role of Enzyme activator. (SWL-G1)-14

Table: Optimum pH values for some enzymes

Enzyme	Optimum pH
Pepsin	2.00
Sucrase	4.50
Enterokinase	5.50
Salivary Amylase	6.80
Catalase	7.60
Chymotrypsin	7.00 – 8.00
Pancreatic Lipase	9.00
Arginase	9.70

Q: Give pH value of pepsin and pancreatic lipare.(SWL-G1)-16

INHIBITORS

Q.5: Write a note on inhibitors of enzymes.

➔ Write a note on different types of inhibitors.

Ans. Definition

"An inhibitor is a chemical substance, which can react (in place of substrate) with enzyme but is not transformed into products and thus blocks the active site temporarily or permanently"

Examples

For example poisons like cyanide, antibodies, anti-metabolites and some drugs.

Types

Inhibitors can be divided into two types:

(i) Irreversible (ii) Reversible

Q: What are Enzyme Inhibitors? Explain different types of Inhibitors. (LHR-G1)-14, (RWP-G1)-15, (LHR-G1,G2)-15 (LHR-G1)-16

(1) Irreversible Inhibitors

They check the reaction rate by occupying the active sites or destroying the globular structure. They occupy the active sites by forming covalent bonds or they may physically block the active sites e.g. cyanide and some drugs.

(2) Reversible Inhibitors

Q: How irreversible inhibitor inhibit Enzyme activity (FBD-G1)-16

They form weak linkages with the enzyme. Their effect can be neutralized completely or partly by an increase in the concentration of the substrate.

They are further subdivided into two major types: competitive and non-competitive.

MECHANISM OF ENZYME ACTION (CATALYSIS)

: Describe in details the mechanism of enzyme action.
Briefly explain catalysis with key Model of Enzyme Action.

s. An enzyme is a three dimensional globular protein that has specific chemical composition due to its component amino acids and a specific shape.

Q: What is Enzyme and how they accerlate reaction. (GUJ-G1)-16

cificity of Enzymes

Every enzyme by virtue of its specificity recognizes and reacts a special chemical substance called ***substrate***. Any enzyme, efore, reacts only with its specific substrate and transforms it into ***ducts***. It is then released and thus can be used again and again.

Q: Define active site. (RWP-G1), (DGK-G1)-15, (SGD-G1), (SWL-G1)-16

$$\underset{\text{Enzyme}}{E} + \underset{\text{Substrate}}{S} \rightleftharpoons \underset{\text{Enzyme substrate complex}}{ES} \rightleftharpoons \underset{\text{Enzyme}}{E} + \underset{\text{Product}}{P}$$

ple Mechanism of Enzyme Action

An enzyme and its substrate react with each other through definite charge bearing sites called ***active sites.***

(i) The **active site** of an enzyme is a three-dimensional cavity bearing a specific charge by which the enzyme reacts with its substrate. The charge and shape of the active site is formed by some amino acids present in the polypeptide chain of the enzyme. These amino acids are brought closer and are arranged in a specific way by coiling and folding of the polypeptide chain within the globular symmetry of the enzyme (Fig).

(ii) The active site of the enzyme is made up of two definite regions i.e. the binding site and the catalytic site.

- ★ The **binding site** helps the enzyme in the recognition and binding of a proper substrate to produce an ES complex.
- ★ This reaction activates the **catalytic site.** Activated catalytic site catalyzes the transformation of the substrate into products.

Q: What is Enzyme to Enzyme chain. (SWL-G1)-14, (SGD-G1)-16

Enzyme, after catalysis detaches itself from the products hanged. Enzyme requires aqueous medium for its activity.

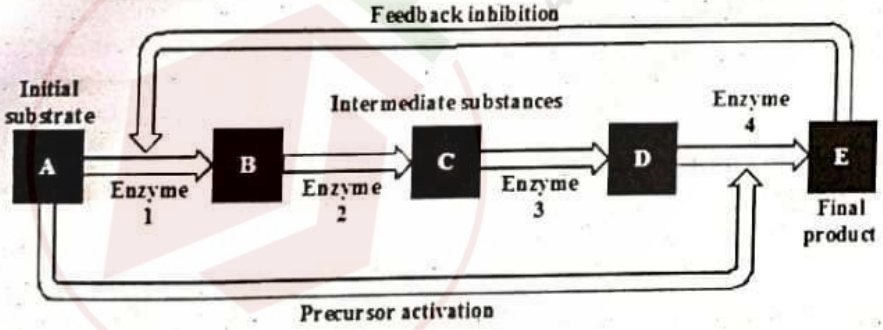


Fig: Enzyme to enzyme chain (association)

hanism in Complex Reactions

In certain cases enzymes act in a series of chemical reactions in a particular order to complete metabolic way such as respiration or photosynthesis. The successive enzymes containing these reactions are normally ent together in a precise order of reaction such that substrate molecule can be literally 'handed on' from one yme to another forming an enzyme-coenzyme chain. In this way, the products from one step in pathway are sferred to the enzyme catalyzing the next step and final product block the active site of first enzyme as a result le process is stopped e.g. Glycolysis.