35

ENZYMES

35.1 INTRODUCTION

Our body requires many compounds for its functioning These compounds are obtained mainly through diet in the form of carbohydrates, proteins, vitamins and fats These are then converted into various compounds necessary for the functioning of the cells in the body Carbohydrates, proteins and fats are too large to be taken up by the cell as it is Therefore they are first broken down into small simpler molecules that are utilized for the synthesis of other important compounds. Well, how these macromolecules are broken and coverted into other compounds? All these reactions are carried out by very important molecules of the cell called "*Enzymes*" Without enzymes living processes will be very slow For example, without the presence of enzymes in our digestive tract, it would take about 50 years to digest a single meal Enzymes make the reactions go at a very high rate in order to meet the requirement of the body. Thus enzymes are biological catalyst, which catalyses metabolic reactions. Each specific reaction requires a specific enzyme The activity of each enzyme is controlled. If any of the enzymes are not there or become defective, it becomes very difficult for the cell to manage its survival Thus many diseases accur due to defective enzymes Let us learn more about enzymes in this lesson

35.2 OBJECTIVES

After reading this lesson, you will be able to:

- define enzymes.
- name the enzymes
- explain the action of enzymes
- classify the enzymes
- write the characteristic features of enzymes
- [illegible] the use of enzymes in various aspects of life and industry

35.3 WHAT ARE ENZYMES ?

et us begin with a simpl ctivity wher ou can actually experience the action of an enzy

> **Activity:** Y u a experien ne breaking down of starch (presen chapatis tha o at) into g by an enzyme called amylase presen in saliva. You s mply have to your bite at least 40 times and th swee taste that yo xperience i glucose obtained from the breako n of starch.

Now that you have experienced an nzyme working in your body, let us defin

> **Enzymes a rotein catalysts for the biochemical reactions in all living cells.**

The term enzym is derived from Greek en=in; zyme=leaven or ferment. Yeast cell the first to reveal enzyme activity in living organisms.

35.4 NOMENCLATURE

Let us now learn to identify different enzymes carrying out differen reactio s or how the enzymes can be named?

> **Enzymes are mostly known by common names obtained by adding the suffix - ase to the name of the substrate or to the reaction the atalyze.**

For example, Glucose oxidase is an enzyme catalyzing the oxidation ose. Glucose-6-phosphatase carries out hydrolysis of phophate from gluc e-6-pho pha Proteinase, Deoxyribonuclease and ribonuclease hydrolyze proteins, Deoxyribonucleic acid and Ribonucleic acid, respectively.

Based on their activity, the enzymes are divided into six major classes:

a **Oxidoreductases**: Enzymes involved in oxidation and reduction.

b. **Transferases** : Transfer functional group (e.g. amino or phosphat groups between donor and acceptor.)

c. **Hydrolases**: Transfer water, that is, they catalyze the hydrolysis of a substrate.

d. **Lyases**: Add or remove the elements of water, ammonia or carbon dioxide.

e **Isomerases** Catealyze structural change within one molecule.

f **Ligases** Join two molecules together at the expense of a high energy phosphate bond adenosine triphosphate (ATP).

INTEXT QUESTIONS 35.1

1. What are enzymes?

.....

2. How are the enzymes named?

.....

3. Classify the enzymes according to their activity.

.....

35.5 ENZYMES ARE SPECIFIC IN THEIR ACTION

Enzymes exhibit specificity or activity towards only one particular type of compound. This is due to a particular shape of the enzymes, specific arrangement of amino acid in its active site and the strucutre of the substrate. The active site has two regions:

(i) **Binding site:** This includes the region of the active site which comes in contact with the substrate or where the substrate binds to the enzyme.

(ii) **Catalytic site:** This is the region within the active site and is responsible for catalysis.

The active site of an enzyme may be clefts or crevices with three dimensional entity. The substrates are bound to the binding site of the enzyme by relatively weak forces

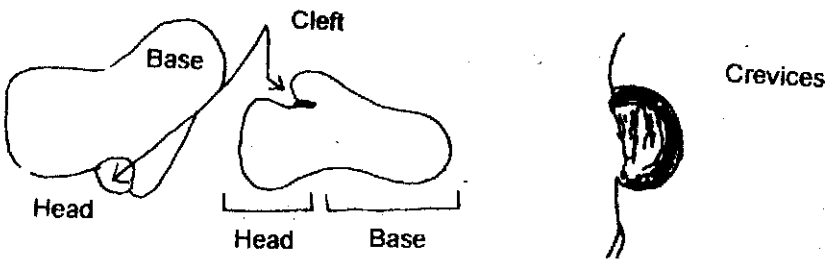

Fig. 5.1: **A diagrammatic representation of cleft and crevices in a model three dimensional structure of an enzyme.**

Two theories have been proposed to explain the specificity of enzyme action.

a. **Lock and Key theory:** In 1890, Emil Fisher proposed a model to explain the great specificity of enzymes. He explained the interaction between substrate and enzymes in terms of a "Lock and Key". According to this concept the catalytic site of the enzymes by itself is complementary in shape to that of the substrate. That means it fits each other as shown figure The enzymic reaction is possible if the substrate matches the active centre as the key fits the lock. If the substrate ("key") becomes slightly modified, it no longer fits the active centre ("lock") and no reaction takes place.

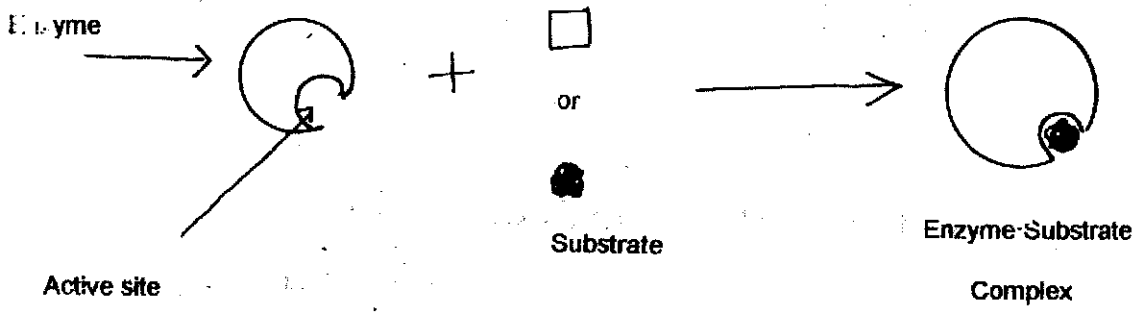

Fig. 35.2: **Representation of lock and key theory of enzyme substrate interaction.**

Note in fig. 35.2 that only the substrate that fits the active site binds to the enzyme and allows the reaction to take place. Note the substrate that does not have the complementary shape to the active site is not acted upon.

b. Induce-fit theory: This was proposed by D.E. Koshland. According to this theory, the enzyme changes shape upon binding the substrate. The final shape of the enzyme and the shape of the substrate are only complementary i.e. fit each other only after binding as shown in figure 35.3.

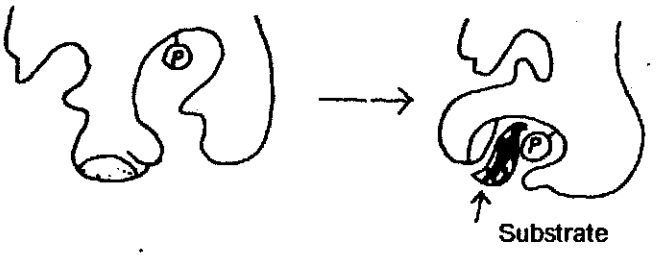

Fig. 35.3: **Representation of an induced fit by a conformational change in the protein strucutre.**

Once the substrate interacts with the enzyme, it just does not convert into a product and release it. The reaction is a multistep process and can be written as follows:

$$E + S \rightleftharpoons ES \rightleftharpoons EP \longrightarrow E + P$$

Where E is enzyme, S is substrate and P is product. For Example:

$$\text{Glucose} + \text{ATP} \xrightarrow[\text{Hexokinase}]{} \text{Glucose-6-phosphate} + \text{ADP}$$

In this reaction, glucose is the substrate (S) and glucose-6-phosphate is the final product (P). Hexokinase is the enzyme (E) catalyzing the phosphorylation of glucose.

INTEXT QUESTIONS 35.2

1 How many regions does the active site of an enzyme have? Name them

.....

2. What are the two theories that have been proposed to explain the specificity of an enzyme action?

.. ..

35.6 ENERGETICS OF ENZYME ACTION

For any reaction to occur, the two or more compounds involved in the reaction must come in contact or collide. Each participant of the reaction has some amount of the energy which is required to surmount a barrier separating the reactants from becoming the product. Let us consider going uphill and to the other side of the hill. Imagine there is a barrier right at the bottom before we start climbing. As we climb we require a definite amount of energy to cross the barrier and to reach the top of the hill from where going down to the other side will be easy. Enzyme also act in such a way. The energy required for the proton on a substrate to reach to an intermediate position (at this stage the energy of the system goes through a maximum), like the top of the hill, is called **activation energy** and the system is said to be in the **transition state**. Now, how do enzymes help the reaction go faster? They reduce the activation energy thus making the substrate go to the product state faster (Now the peak of the hill has become less steep and shorter, so we can reach the other side of the hill faster). The activation energy determines whether the reaction is fast or slow. Higher the activation energy, slower is the reaction.

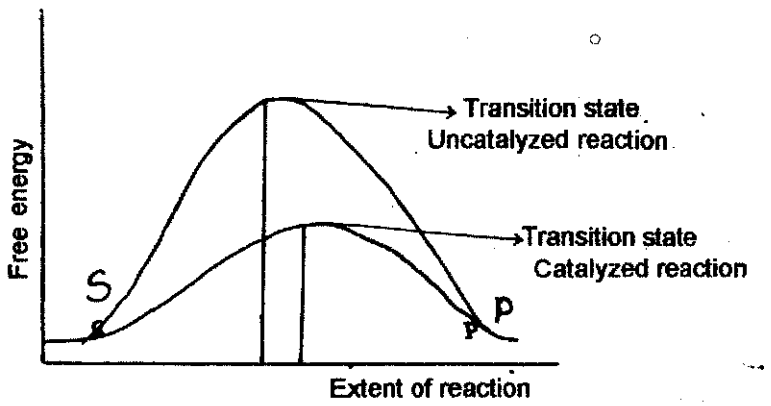

Fig. 35.4: **Diagrammatic representation of the free energy of activation of chemical reaction.**

In fig. 35.4 note that the energy required to reach the transition state is much lower in catalyzed reaction than that required in an uncatalyzed reaction In this figure S the substrate and P the product.

35.7 CHARACTERISTICS OF ENZYMES

Enzymes share some properties with chemical catalysts, but they also differ in several ways.

35.7.1 Properties that are common in chemical catalysts and enzymes

a Like chemical catalysts, enzymes are neither consumed nor produced during the course of a reaction

b. They also do not cause reaction to take place, but simply speed up the reaction that would otherwise take place at a much slower rate.

c Enzymes do not affect the equilibrium of a reversible reaction, rather accelerate both the forward and the backward reactions to the same extent.

d Enzymes catalyze energetically feasible reaction only.

35.7.2 Differences between enzymes and chemical catalysts

a Enzymes exhibit high specificity so that they carry out metabolic processes following strict pathways. The substrate specificity of the enzyme means that they utilize only one kind of substrate. Group specificity indicates that a presence of a chemical group on a substrate is must for the enzyme activity. Chemical catalysts on the other hand are more general and can act on various similar substrate molecules.

b. Enzymes catalyze the reactions under mild conditions i.e. at normal pressure, low temperature and pH close to neutral Since enzymes are of proteinaceous nature (besides the exception of some ribonucleic acids now known to catalyze some reactions) they are susceptible to temperature variation and to change of pH. Chemical catalysis occur ften at highe ι rature or pressure

c. Enzymes' activities are controlled It means that the activity of an enzyme changes according to various environmental factors and the need of the cell

d. The rate of an enzymatic reaction is proportional to the amount of enzyme

35.8 APPLICATIONS OF ENZYMES

You ha already learnt abo diffe nt types of enzymes Enzymes carrying out different functions are employed in various fi agriculture and industry Some of the applicatio of different enzymes are listed below

1 Amylase preparations prepared from extracts of mold fungi ar widely used fo starch hydrolysis. These ar sed fo baking high quality bread and alcoholic formulat starters in the making

2 Enzyme pectinase which tin of plant cell envelope is used in fruit juice, natural perfum oil and

3 Proteolytic enzymes eg re used in leather industries for tanning and bating processes L detergent industries

4 Enzyme glucose oxidas minating oxyg from c ned products and bottled soft drinks to prev erioration

Proteolytic enzymes are used as protein stain remover for clothes

6. Bacterial enzymes are used in the p odu tion artificial protein ... petrol products for feeding farm animals.

7. Digestive enzymes (pepsin and trypsin) are commonly u ed by people having difficulty in digestion or disease like dyspepsia.

8. Proteolytic enzymes (trypsin and chymotrypsin) are used in surgery for cleansing wounds and tissues streptokynase and eurokynase are enzymes which degrade blo d clots and used on patient suffering from thrombosis.

9. Immobilized enzymes are used in the technological synthesis of hormonal preparations and drugs of biological origin.

INTEXT QUESTIONS 35.3

1. How do enzymes increase the rate of a reaction.

 ....

2. What is the transition state of a chemical reaction?

 ....

3. Which group of enzyme catalyses the transfer of functional groups from one molecule to another?

 ....

4. two differences between a chemical catalyst and an enzym

 ....

5. enzymes are used in su ge for cleansin, wou and tissues?

 ....

6. nzyme s prepared from mold fungi and used in ba ing industry?

 ....

35.10 WHAT YOU HAVE LEARNT

- Enzymes are biologi al ca.alyst.
- Enzymes speed up reactions in our body.
- mes are named after the substrate they act u ... reaction they catalyze
- Enzymes catal ze only specific reaction and act upon speci .. substrat

- The specificity of the enzyme reaction is based on the structure of the substrate and th enzyme itsel

  Enzymes speed up the reaction by reducing the activation energy
- Enzymes are classified on the basis of the reaction they catalyze
- Enzymes share certain properties with chemical catlysts but also differ from them in certain ways
- Enzymes are used in many industries useful to us

35.11 TERMINAL EXERCISE

1. What is "Lock and Key theory"

   ....

2. Match the classes of the enzyme from Group A with the reaction they catalyze in Group B

A	B
i) transferases	a oxidation-reduction reaction
ii) hydrolases	b form or remove a double bond
iii) lyases	c breakdown of bonds by the addition of water
iv) isomerases	d) transfer of a functional group
v) oxidoreductases	e) change the form of a compound

3. List five applications of enzymes.

   ....

CHECK YOUR ANSWERS

Intext Questions 35.1

1. Enzymes are protein cat[illegible] tions in all living [illegible] Section 35 3
2. The enzymes hav[illegible] the substrate [illegible] reaction they catalyze [illegible]
3. [illegible]n enzymes have been divided into six groups [illegible] the [illegible] oxidoreductases transferases hydrolases lyases [illegible] Section

[illegible]s 35 2

1. The active site has two regions-bindi[illegible]

2. The two theories that have been proposed to explain the specificity of enzyme action are (i) Lock and Key Theory and (ii) Induce fit theory (Section 35 5)

Intext Questions 35.3

1. Enzymes increase the rate of reaction by decreasing the free activation energy (refer to Section 35.6 and Figure 35.4).
2. The transition state of a reaction is that when the proton on a substrate reaches an intermediate position i.e. the energy of the reaction is maximum (refer to Section 35.6)
3. Transferases catalyze the transfer of functional group from one molecule to another (refer to Section 35 7).
4. Refer to section 35.8.
5. Proteolytic enzymes trypsin and chymotrypsin.

TERMINAL EXERCISE

1. Refer to Section 35.5 and Figure 35.2.
2. A B
   i) d)
   ii) c)
   iii) b)
   iv) e)
   v) a)
3. Refer to Section 35.8.