3.6. Enzyme Catalysis

An enzyme is a protein or a protein like substance with catalytic properties. Enzymes show high specificity in their

catalytic activity toward one substrate; and they involve no complicating side reactions. An enzyme is named by adding '–ase' after the major part of the name of the substrate (or the reactant). For example, enzyme that catalyses decomposition of urea is called 'urease' and the enzyme that catalyses hydrolysis of 'sucrose' is called 'sucrase'. The catalytic effect of enzymes is, by far, startling. For example, compare the catalytic effect of hydrogen ions with that of the enzyme sucrase on hydrolysis of sucrose at the blood temperature (37°C). The activation energy of the hydrogen ion catalysed reaction is 107 kJ/mol, while that of the enzyme catalysed reaction is 36kJ/mol. These figures correspond to 10^{12} times rise in the reaction rate due to the presence of enzyme.

Following are general characteristics of the enzyme catalysed reactions.

1. At the end of the reaction, enzyme is neither consumed nor produced.
2. Enzymes catalyse only those reactions which in their absence will occur, but at much slower rate.
3. Enzymes are highly specific in their catalytic behaviour. It is rare that the same enzyme may catalyse two reactions with different substrates.
4. The enzyme catalysed reactions do not require extreme conditions of low or high temperature, instead they occur in a moderate temperature range.
5. Enzyme catalysed reactions involve no side reactions and therefore, they produce no undesired products.

There are three kinds of the enzyme catalysed reactions:

(I) soluble enzyme – soluble substrate type
(II) soluble enzyme – insoluble substrate type
(III) insoluble enzyme – soluble substrate type

Type (I) reactions are homogeneous and the other two are heterogeneous. Type (III) reactions have gained interest due to their growing applications in industry. But, the greatest

importance of the enzyme reactions is due to their vast applications in reactions in living cells. These reactions generally occur in homogeneous liquid phase. We shall restrict our theoretical discussion to the homogeneous enzyme catalysis. The results of these discussions may apply to the other two types of reactions also.

Steady state Enzyme Kinetics

2.24 COENZYMES AND COFACTORS AND THEIR ROLE IN BIOLOGICAL REACTIONS

There are some enzymes which cannot perform their role alone. They require the presence of centain substances to perform their role. These substances are called coenzymes and co-factors.

Coenzymes are organic carrier molecules which help the enzymes to function properly.

Cofactors are inorganic substances which assist with the catalytic action of enzymes.

Enzymes make the reaction ttake place faster by lowering the activation energy as shown in the figure 2.15.

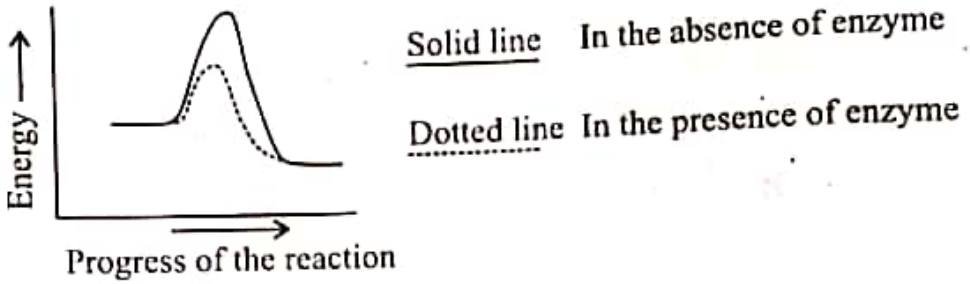

Fig. 2.15: Effect of enzyme on the rote of reaction

When the enzymes thmselves cannot function properly. They require the presence of coenzymes/cofactors. Their role is illustrated in Fig. 2.16.

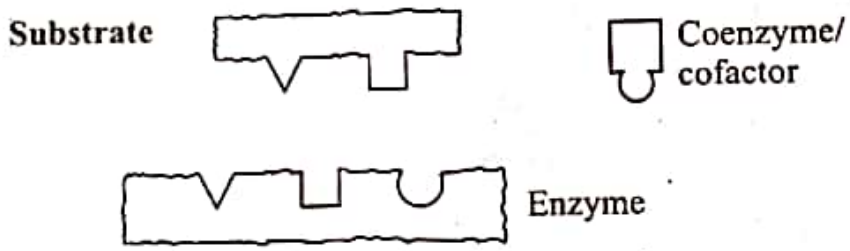

Fig. 2.16: Role of coenzymes and cofactors

The substrate and coenzyme/cofactor fit into similar depressions in the enzyme, come closer and react with each other and give the products faster.

Examples of Coenzymes

Some examples are given below:

1. NADH are electron carriers

$$NADH \rightleftharpoons NAD^+ + H^-$$

2. NADH also converts pyruvate into lactic acid

$$\text{Pyruvate} + NADH \rightleftharpoons \text{Lactic acid} + NAD^+$$

3. Coenzyme CoA holds onto acyl or acetyl groups as under:

$$CoAS\text{-}\overset{O}{\overset{\|}{C}}\text{-} + H_2O \rightleftharpoons \text{-}\overset{O}{\overset{\|}{C}}\text{-}OH + CoA - SH$$

It happens quite often in metabolic reactions where it carries two carbon acetyl groups from one molecule to the other. Thus coenzymes are used in transferring different species from one molecule to the other.

Cofactors: Cofactors are substances involved in catalysis and help the reaction convert substrate into the products. Minerals and vitamins act as cofactors.

1. Mg^{2+} ions act as cofactors in the function of DNA polymerase. There are negative charges on the molecule of DNA because of the presence of phosphate groups on DNA. Mg^{2+} ions neutralize the negative charges on DNA and make it possible for DNA polymerase to function properly.
2. Vitamins and minerals are cofactors in the following reactions

   Vit. B_3 ⟶ NIACIN ⟶ NAD

   Vit. B_5 ⟶ CoA

   NIACIN which is vitamin B_3 is the precursor of NAD and vitamin B_5 is the cofactor of CoA.