

# Enzymes

Enzymes are organic catalysts produced by living organisms. Hence they are called biocatalysts. Previously it was thought that all enzymes are protein in nature but later it was proved that there are some non-protein enzymes like ribozymes which are RNA ses. An enzyme may be a simple protein or a complex protein.

## Characteristics of enzymes.

1. Enzymes are biocatalysts. Hence they are not destroyed during an enzyme action. In other words, they are regenerated at the end of the reaction.
2. They can only speed up the reaction but can't initiate the reaction. They speed up the reaction by  $10^7$  to  $10^{14}$  times. These reactions occur even without enzymes but at a very slow pace. Time factor is very critical for biological reactions. Hence enzymes play a vital role.
3. Enzymes do not alter the equilibrium constant of a reaction but alters the rate at which equilibrium is reached. A non enzymatic reaction may take several years to reach equilibrium, while an enzymatic reaction takes a fraction of a second.
4. Enzymes are very specific. Their specificity is with regard to substrate and the reaction they catalyse.



## Role of enzyme in regulating metabolic reactions.

An enzyme is a macromolecule; which acts as a biological catalyst. Enzymes are produced in living cells.

### General characteristics of an enzyme

- Most of the enzymes are globular proteins
- Enzymes are biological catalysts. They lower the activation energy of the reaction they catalyze (increases rate of reaction)
- Most enzymes are heat liable/sensitive.
- Their presence does not alter the nature or properties of the end products of any reaction.
- Enzymes are highly specific to the substrate
- Most enzymes catalyzed reactions are reversible
- The rate of enzyme activity is affected by pH, temperature and substrate concentrations.
- They are not being used up during the reaction
- Enzymes possess active sites where the reaction takes place.
- Some enzymes need non-proteinous components to catalyze the reaction which are known as Cofactors.

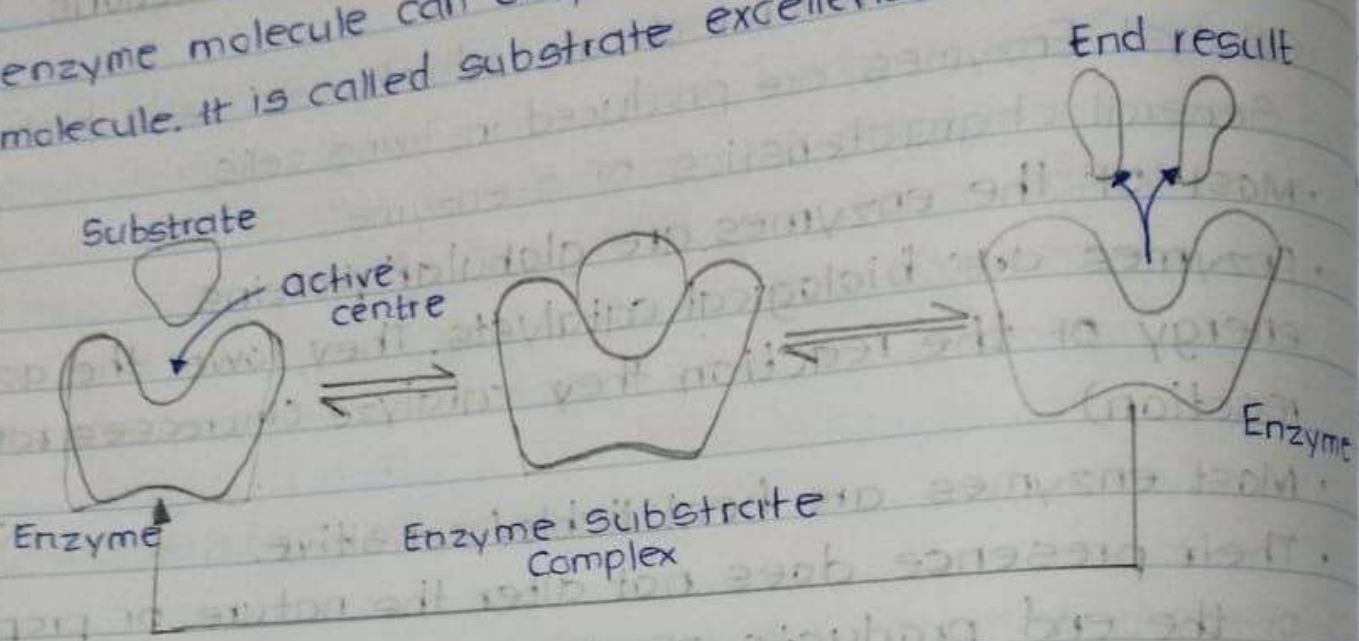
### Substrate excellence of enzymes

In a biochemical reaction catalyzed by enzymes, the substrate (reactant molecule or molecules) must bind to the enzyme molecule for the catalytic action to take place.

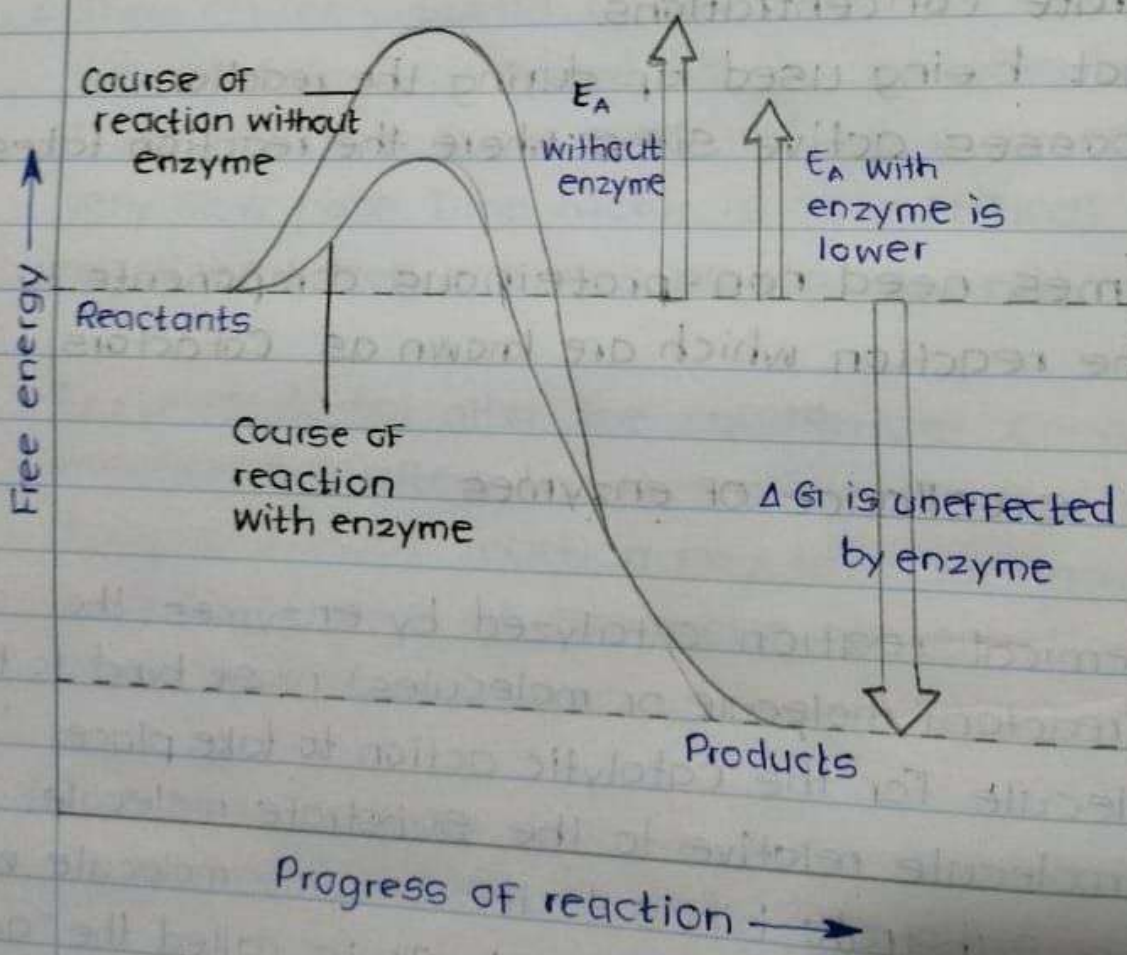
An enzyme molecule relative to the substrate molecule. Therefore the substrate binds to the enzyme molecule with a very small area of enzyme molecule. It is called the "active centre" of the enzyme molecule. The shape of the active centre of an enzyme molecule is complementary to the shape of the substrate molecule to which it binds. Therefore, a particular



enzyme molecule can only work with one type of substrate molecule. It is called substrate excellence of enzymes.



The relationship between activation energy and the enzyme





## Factors affecting the rate of enzymatic reactions

01. Temperature
02. pH
03. Substrate concentration
04. Enzyme concentration
05. Inhibitors

### Temperature

- At  $0^{\circ}\text{C}$  enzymes are not active
- Then with gradual increase of temperature the reaction rate also getting increase but in low temperature rate of reaction is low.
- The best temperature range for enzymes is  $5^{\circ}\text{C}$  -  $40^{\circ}\text{C}$ .
- With the increase of each  $10^{\circ}\text{C}$  of temperature the reaction rate will be increased in double.
- The maximum temperature, having the maximum reaction rate of enzyme is called as optimum temperature. Normally it is close to  $40^{\circ}\text{C}$  temperature.
- The temperature of the human body is close to optimum temperature of enzymes.
- When the temperature exceed the optimum temperature some of the properties of enzymes is destroyed therefore the reaction rate lowers.
- At  $60^{\circ}\text{C}$  the enzymic reaction will be stopped, due to loss of the properties of enzymes.

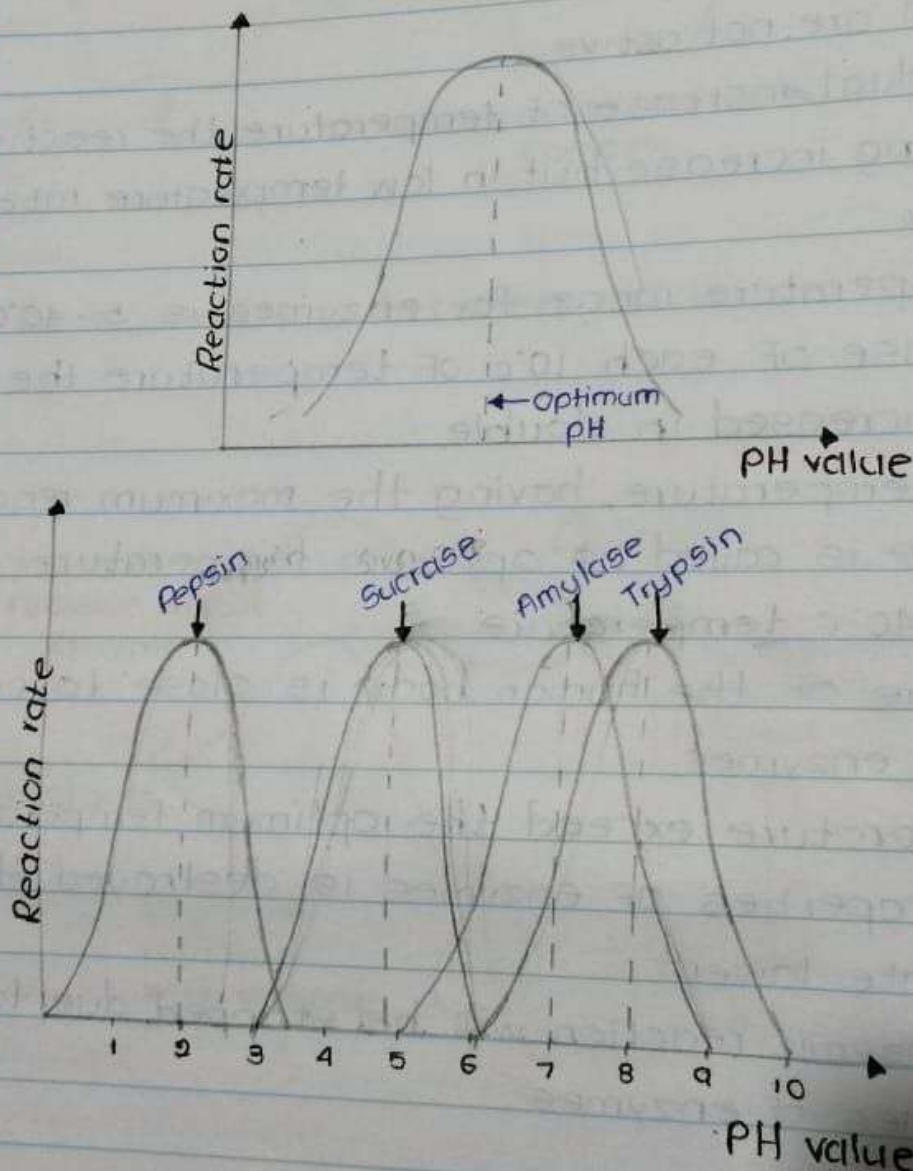
### pH value

- There is a specific pH range for enzymic reaction. No any enzyme will active when exceeding this pH range.
- In the given pH range there is a maximum pH value having the maximum enzymic reaction. It is called optimum pH value.
- The optimum pH value falls on 6-8 for many enzymes. But



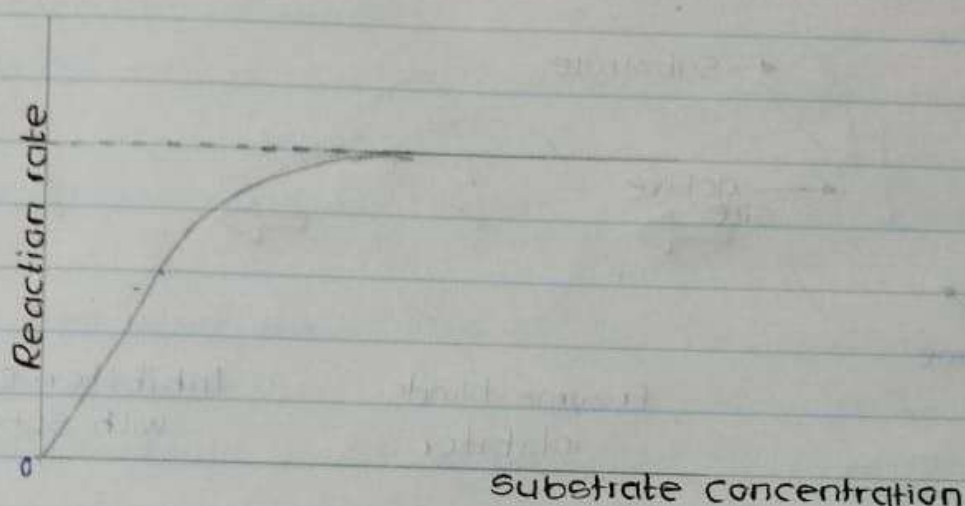
For some other enzyme this optimum value and the range might be changed

ex:- The pepsin, produced by stomach in the human digestive tract, is active in an acidic pH range while most enzymes produced in the small intestine are active in neutral pH range.



## Substrate Concentration

- As the substrate concentration increases the reaction rate also increases gradually.
- Even if the substrate concentration is increased, after a certain point, the reaction rate does not increase further and remains constant.



### ▲ Effect of Substrate concentration on enzyme activity

- This is because the number of active sites that can participate in the reaction is constant. (Because enzymic concentration does not increase)

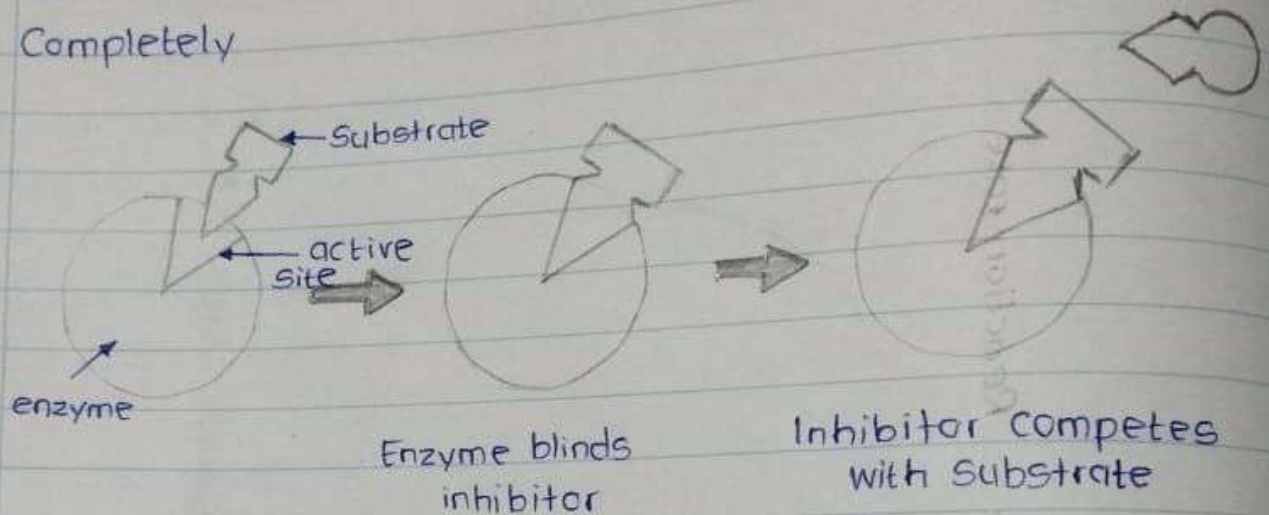
## Enzymic Concentration

- The reaction rate increases as the enzyme concentration increases. The reason is the increase in the number of active sites in the enzyme molecule that can participate in the reaction.
- Reaction rate at enzymic concentration increases when substrate is unlimited, but in case of low substrate, the reaction rate will not increase any longer.



## Inhibitor

- Inhibitors are certain molecules or ions that bind to enzyme molecule temporarily or permanently, preventing the formation of enzyme substrate complex.
- The rate of enzyme reaction by inhibitors reduce or stop completely



- Some inhibitors slow down the enzymic reaction because inhibitory molecules, temporarily bind to enzyme's active sites. Then the substrate molecules cannot bind to the active sites of the enzymes, so the reaction rate decreases. Such inhibitors are called as Competitive inhibitors.  
ex:- Drugs used against micro-organisms.

- Some other inhibitors stop enzyme reactions because the inhibitor molecule binds to a different site on the enzyme and permanently change the shape of active sites then the reaction stops completely. Such inhibitors are called as non-competitive inhibitors.  
ex:- poison



## Use of enzymes in Industry and their Advantages.

- Enzyme activities are unique to one another.
  - So there is no production of unwanted byproducts.
  - A single enzyme catalyzes only one bio-chemical reaction.
- Enzymes are bio-degraded
  - Therefore no environmental pollution occurs.
- Enzymes are active under normal physical and chemical conditions.
  - That is enzymes are active under normal temperature, neutral pH values and normal atmospheric pressure. Therefore products in industries can be obtained at normal temperature and pressures.
  - It is not necessary to provide special environmental conditions. (High temperature and high pressure)
- Reducing the amount of energy used for those processes.
  - Therefore it saves energy.
  - No energy wasted to provide special conditions.
- Enzymes can be used repeatedly for reactions.
  - At the end of reaction the original amount of enzymes used remains unchanged. Therefore large amount of product can be obtained with a small amount of enzymes.
- Reduce the need for expensive equipment



# Practical applications of enzyme.

Application	Enzyme	use
Detergents	Proteas lipase Amylase	<ul style="list-style-type: none"> <li>• Protein in clothing.</li> <li>• Removes dirt in oil.</li> <li>• Converts maltose to sugar</li> </ul>
Brewing (Alcoholic beverages including beer and wine)	Amylase	<ul style="list-style-type: none"> <li>• Proteins are broken down into amino acids</li> <li>• Yeast growth</li> <li>• Eliminates coagulant nature of beer</li> </ul>
Baking Industry	Amylase	<ul style="list-style-type: none"> <li>• Turns wheat starch into sugar. (white bread and buns)</li> </ul>
Dairy Industry	Proteas Renin	<ul style="list-style-type: none"> <li>• Protein breakdown (biscuit production)</li> <li>• To coagulate milk in cheese production</li> </ul>
Textile Industry	Amylase	<ul style="list-style-type: none"> <li>• In textile manufacturing, to remove starch to prevent damage to machines during weaving.</li> </ul>
Leather Industry	Cellulase Trypsin	<ul style="list-style-type: none"> <li>• To soften fabric</li> <li>• To tan leather</li> </ul>
Medicine	Strepto-kinase Trypsin	<ul style="list-style-type: none"> <li>• To dissolve blood clots.</li> <li>• To remove blood clots while cleaning wounds.</li> </ul>
Paper Manufacturing	lignase	<ul style="list-style-type: none"> <li>• To remove lignin prior to applying cellulose in paper production pulp from woods</li> </ul>
Meat / Food Industry	Trypsin Proteas	<ul style="list-style-type: none"> <li>• To soften meat (For baby foods)</li> <li>• Used in the pre-digestion of proteins in baby food production. Then it is easy for the baby to absorb the proteins contained in the food</li> </ul>



Pectinase	• For partial digestion of Fruits and vegetables in baby Food and For extracting fruit or Vegetable juices.
Carbohydrate	• To Convert less expensive starches into more expensive sugars. (eg:- In Sport drinks)

## Vitamins

- A group of organic compound which are important For maintaining normal health.
- An essential ingredient in food.
- Not required in large quantities daily or required in milligram quantities.
- Can be divided into 2 types according to solubility.
  - 1) Water Soluble vitamins  
ex: Vitamin B and vitamin C
  - 2) Non - Water Soluble Vitamins / Lipid soluble vitamins  
ex:- Vitamin A, D, E and K
- Vitamin A is produced in the human liver.
- Store insoluble vitamins like A, D, E and K in the human liver.
- Vitamin D synthesis in the subcutaneous fat layer of human layer when it receives ultraviolet rays from the Sun.



- Biotin, Folic acid and vitamin K belongs to vitamin group produced in human intestine with the help of some bacterial species but long term use of antibiotics can kill these bacteria.
- Vitamins play an important role as co-enzymes required for the activity of enzymes in the human body.
- Vitamin K is essential for blood clotting in the human body.
- Various deficiency diseases occur when vitamins are deficient
  - ex:-) Rickets (Bone deformity due to vitamin D deficiency)
  - 2) Blindness (Due to vitamin A deficiency)