Enzymes

Active Site ................................................................. 2
Substrate .................................................................. 2
Co-factor .................................................................. 2
Prosthetic group ..................................................... 2
Co-enzyme ................................................................ 2
Activator .................................................................. 2
Apo-enzyme .............................................................. 2
Holo-enzyme .............................................................. 2
Characteristic of Enzymes .......................................... 2
Mechanism of Enzyme Action (Catalysis) ...................... 3
Lock and Key Model .................................................. 3
Induced-fit Theory ...................................................... 4
Factors affecting the rate of enzyme action .................... 4
Enzyme concentration ............................................... 4
Substrate Concentration ............................................ 4
Temperature ............................................................... 5
pH Value .................................................................. 5
Inhibitors .................................................................. 6
Irreversible Inhibitors .................................................... 6
Reversible inhibitors ...................................................... 6
Enzyme Classes ............................................................. 7
Enzymes

Any protein which originates from living cells and is capable of producing certain chemical changes in organic substances by catalytic action. For example, pepsin which helps in digestion. Without enzymes the reaction would proceed at very slow speed making life impossible.

Active Site
The catalytic activity of enzyme is restricted to small portion of the globular protein which is called active site. It consists of few amino acids only. The rest of bulk of amino acids maintains the globular structure of protein. It is further divided into

- Binding site (that help in the recognition and binding of proper substrate)
- Catalytic site (transforms the substrate into product(s))

Substrate
The reactant that attaches to the active site of protein is called substrate.

Co-factor
The non-protein part attach to the enzyme which is important for proper function of enzyme is called co-factor. The co-factor acts as a bridge between substrate and enzyme. Co-factor sometimes acts as source of chemical energy for the catalytic reaction.

Prosthetic group
If the non-protein part (co-factor) is covalently bonded to the protein part, it is known as prosthetic group.

Co-enzyme
If the non-protein (co-factor) is loosely attached to protein part, it is known as co-enzyme. E.g. NAD, FAD

Activator
The detachable co-factor is known as activator, if it is an inorganic ion, e.g. Mg²⁺ and Fe²⁺.

Apo-enzyme
An enzyme with its coenzyme, or prosthetic group removed is designated as apoenzyme.

Holo-enzyme
An activated enzyme consisting of a polypeptide chain and a cofactor is known as holoenzyme.

Characteristic of Enzymes
1. All enzymes are globular proteins.
2. They increase the rate of reaction without themselves being used.
3. Their presence does not affect the nature or properties of end products.
4. Small amounts of an enzyme can accelerate chemical reaction.
5. They are very specific in nature.
6. They are sensitive to even a minor change in pH, temperature, substrate concentration.
7. Some enzymes require a co-factor for their proper functioning.
8. They lower the activation energy of the reactions.
9. They are produced by living cells for use in or near the site of production.
10. Many enzymes are simply dissolved in cytoplasm, while others are tightly bound to certain subcellular organelles.

**Mechanism of Enzyme Action (Catalysis)**

Every enzyme is specific in its action which reacts with a specific substrate to form an intermediate which is enzyme-substrate complex. This complex is then converted into product. For example:

Maltose (substrate) + Maltase (enzyme) ⇄ maltase maltose complex ⇄ 2 Glucose (product) + Maltase (enzyme)

**Lock and Key Model**

The specific action of an enzyme with a single substrate can be explained using a Lock and Key analogy first postulated in 1894 by Emil Fischer. In this analogy, the lock is the enzyme and the key is the substrate. Only the correctly sized key (substrate) fits into the key hole (active site) of the lock (enzyme).

Smaller keys, larger keys, or incorrectly positioned teeth on keys (incorrectly shaped or sized substrate molecules) do not fit into the lock (enzyme). Only the correctly shaped key opens a particular lock. Which means only the specific enzyme reacts with the specific substrate.
According to Lock and Key Model the active site is rigid and there is no flexibility in the active site before, during or after the enzyme action and it is used as template. Later studies did not support this model in all reaction.

**Induced-fit Theory**

The induced-fit theory assumes that the substrate plays a role in determining the final shape of the enzyme and that the enzyme is partially flexible. This explains why certain compounds can bind to the enzyme but do not react because the enzyme has been distorted too much. Other molecules may be too small to induce the proper alignment and therefore cannot react. Only the proper substrate is capable of inducing the proper alignment of the active site.

**Factors affecting the rate of enzyme action**

**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 double the reaction rate is double.

By increasing the enzyme molecules there is increase in the number of active site which will convert the substrate molecules into product in the given period of time. After a certain limiting concentration the rate of reaction no longer depend upon this increase.

![Graph showing rate of reaction versus enzyme concentration](image)

**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 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.
Temperature
The rate of enzyme action may increase with increase in temperature but up to a certain limit. All enzymes can work at their maximum rate at specific temperature called the optimum temperature. For enzymes of human body 37°C is the optimum temperature.

Heat provides activation energy and therefore, chemical reactions are accelerated at high temperature. Heat also supplies kinetic energy to reacting molecules, causing them to move rapidly. Thus the reactant move more quickly and chances of their collision with each other are increase. 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.

pH Value
Every enzyme functions most effectively over a narrow range of pH known as optimum pH.

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.

<table>
<thead>
<tr>
<th>Enzyme</th>
<th>Optimum pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pepsin</td>
<td>2.00</td>
</tr>
<tr>
<td>Sucrase</td>
<td>4.50</td>
</tr>
<tr>
<td>Enterokinase</td>
<td>5.50</td>
</tr>
<tr>
<td>Salivary amylase</td>
<td>6.80</td>
</tr>
<tr>
<td>Catalase</td>
<td>7.60</td>
</tr>
<tr>
<td>Chymotrypsin</td>
<td>7.00-8.00</td>
</tr>
<tr>
<td>Pancreatic lipase</td>
<td>9.00</td>
</tr>
<tr>
<td>Arginase</td>
<td>9.70</td>
</tr>
</tbody>
</table>

**Inhibitors**

An inhibitor is a chemical substance which can react in place of substrate with the enzyme but is not transformed into product and this blocks the active site temporarily or permanently. This process is called *enzyme inhibition*.

**Example**

Poisons like cyanide, antibiotics, anti–metabolites and some drugs are example of inhibitors.

**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.

**Reversible inhibitors**

They form weak linkages with the enzyme. Their effect can be neutralized completely or partially by an increase in the concentration of the substrate. They are further divided into

**Competitive Inhibitors**

Because of the structure similarity with the substrate they may be selected by the binding site, but are not able to activate the catalytic site, thus there is no production of any product.

**Non-competitive Inhibitors**

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Enzyme Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oxidoreductases</td>
<td>Catalyze the transfer of reducing equivalents from one redox system to another (require co-enzyme)</td>
</tr>
<tr>
<td>2</td>
<td>Transferases</td>
<td>Catalyze the transfer of other groups from one molecule to another (require co-enzyme)</td>
</tr>
<tr>
<td>3</td>
<td>Hydrolases</td>
<td>Catalyze the transfer of groups from one molecule to another but the acceptor is always water molecule</td>
</tr>
<tr>
<td>4</td>
<td>Lyases (synthases)</td>
<td>Catalyze reactions involving either the cleavage formation of chemical bonds with double bonds either arising or disappearing</td>
</tr>
<tr>
<td>5</td>
<td>Isomerasases</td>
<td>Move groups within a molecule, without changing the gross composition of the substrate</td>
</tr>
<tr>
<td>6</td>
<td>Ligases (synthetases)</td>
<td>Are energy dependent and are therefore always coupled to the hydrolysis of nucleoside triphosphate</td>
</tr>
</tbody>
</table>