WELCOME TO

Biochemistry | Chapter-6

Enzymes

- **Definition, properties and IUB and MB classification**
- **Factors affecting enzyme activity**
- **Mechanism of action of enzymes, Enzyme inhibitors**
- **Therapeutic and pharmaceutical importance of enzymes**

Enzymes:

An enzyme is a biomolecule that can be synthesized biologically (naturally occurring) or through other processes (synthetically). Its main function is to act as a catalyst to speed up a reaction without itself being changed in the process.

Properties:

- Enzymes are specific in action.
- Enzymatic activity decreases with increase in temperature.
- They show maximum activity at an optimum pH of 6 – 8.
- Enzymes are complex macromolecules with high molecular weight.
- They catalyze biochemical reactions in a cell. They help in the breakdown of large molecules into smaller molecules or bring together two smaller molecules to form a larger molecule.
- Enzymes do not start a reaction. However, they help in accelerating it.
- Enzymes affect the rate of biochemical reaction and not the direction. Most of the enzymes have a high turnover number. Turnover number of an enzyme is the number of molecules of a substance that is acted upon by an enzyme per minute. High turnover number of enzymes increases the efficiency of the reaction.

Classification of Enzymes:

Classification of Enzymes by IUB System

- Enzymes are classified by complex system, suggested by commission on enzymes of International Union of Biochemistry (IUB). Based on their action they are divided into 6 major classes.

1. **Oxido-Reductases:**
   Enzymes in this class are involved in Oxidation-Reduction reactions.
   Example: Alcohol Dehydrogenase.
2. **Transferases:**
   Enzymes that catalyze transfer of Functional groups are called as Transferases.
   Example: Phosphorylases

3. **Hydrolases:**
   These are enzymes that bring about hydrolysis of various compounds.
   Example: Lipase
4. **Lyases:**
   Enzymes specialized in addition or removal of water.
   Example: Aldolase
5. **Isomerases:**
   The Isomerases enzymes catalyze the structural shifts present in a molecule, thus causing the change in the shape of the molecule.
   - Enzymes involved in all isomerization reactions.
     Example: Phosphotriose Isomerase.
6. **Ligases:**
   The Ligases enzymes are known to charge the catalysis of a ligation process.

Enzymes catalyzing synthetic reactions where two molecules are joined together and ATP are used.
Example: Succinate thiokinase

Factors affecting enzyme activity

Enzyme activity can be affected by several factors, including:

1. **Temperature:** Enzymes have optimal temperatures at which they function best. An increase in temperature can increase enzyme activity, but excessive heat can denature the enzyme, rendering it inactive.
2. **pH:** Enzymes have optimal pH levels at which they function best. A change in pH can affect the shape of the enzyme, making it unable to bind to its substrate, and therefore less active.
3. **Substrate concentration**: As the concentration of substrate increases, the rate of enzyme-catalyzed reactions also increases, up to a point. Beyond that point, the enzymes become saturated and the reaction rate levels off.
4. **Enzyme concentration**: Increasing the amount of enzyme present will increase the rate of the reaction, up to a point. Beyond that point, the reaction rate levels off.
5. **Inhibitors:** Compounds that bind to enzymes and prevent them from functioning properly are called inhibitors. They can be competitive or non-competitive, and can be reversible or irreversible.
6. **Co-factors:** Many enzymes require small, non-protein molecules, called cofactors, to function. Cofactors can be metal ions or organic molecules, and if they are not present, the enzyme will not function.

The mechanism of action of enzymes can be broken down into several steps:

1. **Binding:** The enzyme and substrate bind to form an enzyme-substrate complex. The binding process is specific, with the enzyme's active site (a specific region on the enzyme's surface) fitting the substrate like a lock and key.
2. **Catalysis:** Once the enzyme and substrate are bound, the enzyme catalyzes a chemical reaction that converts the substrate into a product. The enzyme does this by lowering the activation energy required for the reaction to occur.
3. **Release:** After the reaction is complete, the product is released from the enzyme's active site. The enzyme is then free to bind to another substrate and repeat the process.
    - It's important to note that enzymes are not consumed or changed in the reaction and can be used again.

Mechanism of action of enzymes:

- Enzymes catalyze reactions by lowering the activation energy required for the reaction to occur. Enzymes do this by binding the substrate at the active site, a specific region on the enzyme where the substrate binds, and bringing the substrate into a favorable conformation for the reaction to occur.

Enzyme inhibitor

- Enzyme inhibitors are molecules that bind to enzymes and decrease their activity. There are several types of enzyme inhibitors, including competitive inhibitors, non-competitive inhibitors, and irreversible inhibitors.
- Competitive inhibitors bind to the active site of an enzyme and prevent substrate molecules from binding, while non-competitive inhibitors bind to a different site on the enzyme and alter its conformation, making it less active.
- Irreversible inhibitors covalently bind to the enzyme and permanently inactivate it.
- Enzyme inhibitors are commonly used in medicine to target specific enzymes involved in disease processes and in the development of pesticides.

Therapeutic and pharmaceutical importance of enzymes

Enzymes play a critical role in many biological processes and are therefore important targets for the development of therapeutics and pharmaceuticals.

- **Metabolic disorders:** Enzymes involved in metabolic pathways, such as those involved in the breakdown of sugars and lipids, can be targeted to treat metabolic disorders such as diabetes and hyperlipidemia.
- **Cancer:** Many enzymes are involved in the growth and proliferation of cancer cells, and targeting these enzymes can be an effective strategy for cancer treatment. For example, the enzyme EGFR is often overexpressed in certain types of cancer, and drugs that target EGFR have been developed to treat these cancers.

- **Inflammation:** Enzymes involved in the inflammation process can be targeted to reduce inflammation and treat inflammatory diseases such as rheumatoid arthritis and inflammatory bowel disease.
- **Synthesis of drugs:** Enzymes are used in the synthesis of many drugs, including antibiotics, hormones, and vaccines. For example, enzymes such as penicillin amylase and recombinant DNA technology are used to produce many drugs.
- **Pesticides:** Enzymes involved in the growth and survival of pests can be targeted for the development of pesticides. For example, enzymes such as chitin synthase and acetyl cholinesterase are targeted for the development of pesticides.
- **Antibiotics:** Enzymes play a critical role in bacterial growth and survival, and targeting these enzymes can be an effective strategy for the development of antibiotics.
- **Enzyme replacement therapy:** Some diseases are caused by the lack of a specific enzyme, such as Gaucher disease, Fabry disease and Pompe disease, these disorders can be treated by administering the missing enzyme.

Overall, enzymes are important targets for the development of therapeutics and pharmaceuticals because they are involved in a wide range of biological processes and their inhibition can have a significant impact on disease processes.