

Enzymes

Introduction to Enzymes

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- Enzymes are biological molecules, mostly proteins (and some RNA), that act as catalysts.
- They speed up chemical reactions in living organisms without being consumed in the process.
- **They play essential roles in many processes such as:**
 - Digestion
 - Metabolism
 - DNA replication and repair

Characteristics of Enzymes

1. Specificity

- Each enzyme is highly specific to a particular reaction or substrate.
- This specificity comes from the **active site**—a unique region where the substrate binds.

2. Efficiency

- Enzymes accelerate reaction rates by millions of times.
- They do this by lowering the activation energy required for the reaction.

3. Regulation

- Enzyme activity can be controlled by factors such as:
 - Temperature
 - pH
 - Inhibitors or activators
- This ensures that reactions occur at the right time and rate.

4. Reusability

- Enzymes are **not used up** during reactions.
- After the reaction, they can interact with new substrate molecules.

Types of Enzymes

Enzymes are classified into six major categories based on the type of reaction they catalyze:

1. **Oxidoreductases:** Catalyze oxidation-reduction reactions.
2. **Transferases:** Transfer functional groups from one molecule to another.
3. **Hydrolases:** Catalyze the hydrolysis of various bonds.

4. **Lyases:** Add atoms or groups to double bonds or form double bonds by removing atoms or groups.
5. **Isomerases:** Catalyze the rearrangement of atoms within a molecule.
6. **Ligases:** Catalyze the joining of two molecules with the input of energy (usually from ATP).

Importance of Enzymes

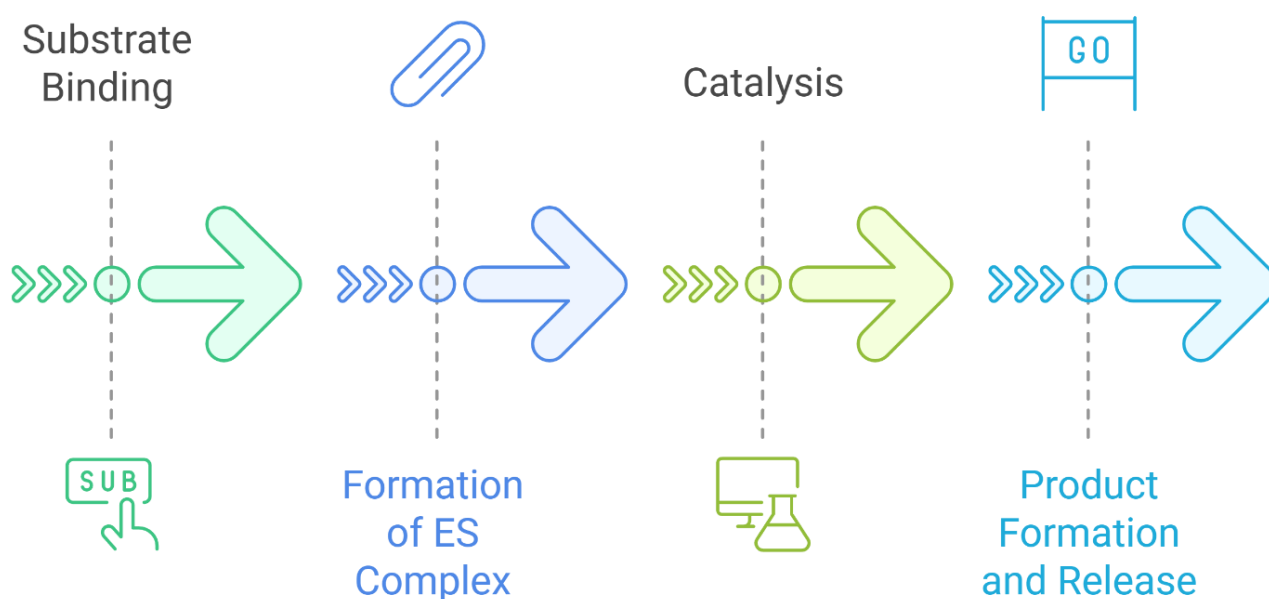
- Enzymes are essential for life because they control the speed of reactions that keep cells alive.
- Without enzymes, these reactions would be too slow to support life.
- Enzymes are also used in industries and medicine, for example:
 - Making medicines
 - Processing food
 - Diagnosing diseases

Enzyme Action (Mechanism of Enzyme Activity)

- The process by which enzymes catalyze reactions involves a series of steps.
- The most commonly accepted model is the induced fit model (modified from the lock-and-key model).

Basic Steps:

Enzyme-Substrate Interaction Sequence



1. Substrate Binding:

- The substrate binds to the **active site** of the enzyme.
- The **active site** is a specific region with complementary shape and charge to the substrate.

- According to the **induced fit model**, the enzyme **changes shape slightly** to accommodate the substrate better.

2. Formation of Enzyme-Substrate Complex (ES Complex):

- Temporary and reversible binding.
- This complex reduces the **activation energy** required for the reaction.

3. Catalysis (Transition State Formation):

- The enzyme stabilizes the high-energy **transition state**.
- Bonds are **broken and/or formed** to convert the substrate into the **product**.

4. Product Formation and Release:

- The product has **lower affinity** for the active site.
- The product is **released**, and the enzyme returns to its original state.

Energy Consideration: Activation Energy

- Enzymes **lower the activation energy** (E_a), allowing reactions to occur faster.
- They do **not** change the overall free energy (ΔG) of the reaction.

Factors Affecting Enzyme Activity

- Enzyme activity can be influenced by various internal and external factors.
- Each enzyme works best under specific conditions (called optimum conditions).

1. Temperature

- Enzymes have an optimum temperature (usually $\sim 37^\circ\text{C}$ for human enzymes).
- Below optimum: enzyme activity is reduced due to decreased molecular motion.
- Above optimum: enzymes may become denatured — their structure changes, and they lose activity.

2. pH

- Enzymes have an optimum pH (e.g., pepsin: $\sim \text{pH } 2$; trypsin: $\sim \text{pH } 8$).
- Changes in pH affect the ionization of amino acid residues, especially at the active site.
- Extreme pH can denature the enzyme.

3. Substrate Concentration

- Increasing substrate concentration increases enzyme activity **up to a point**.
- Beyond that, all enzyme active sites become saturated, and the rate **plateaus** (this is called **V_{max}**).



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