Enzymes

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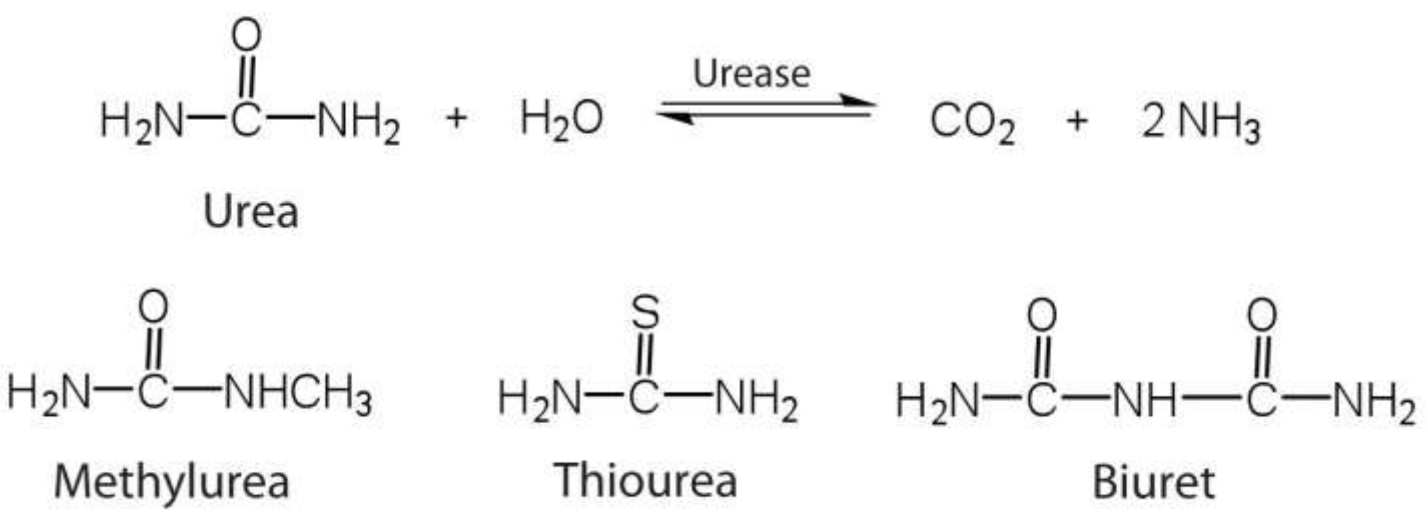
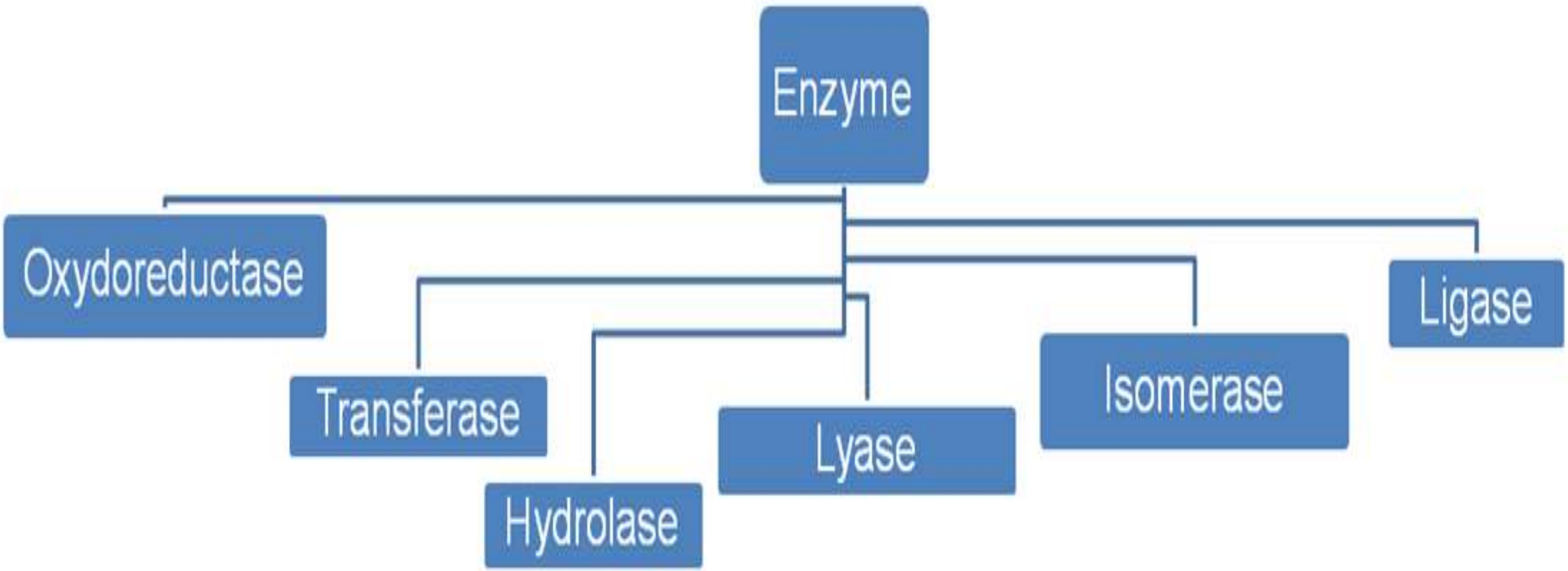
Enzyme

- An enzyme is generally **a protein that acts as a biological catalyst** which accelerates chemical reactions without being consumed in the process.
- The **molecules** on which enzymes act are called **substrates**, which are converted into **products**.
- Enzyme molecules are always shows behaviours like **reaction specificity**, **substrate specificity**, **regiospecificity** (attack at the same site of subsrate) and **stereospecificity** (attack on specific stereoisomers)
- Metabolic processes and other chemical reactions in the cell are carried out by a set of enzymes that are necessary to sustain life.

Enzyme as substrate specificity

- Some enzymes act on a single substrate, while other enzymes act on any of a group of related molecules containing a similar functional group or chemical bond.
- Urease, for example, is an enzyme that catalyzes the hydrolysis of a single substrate—urea—but not the closely related compounds methyl urea, thiourea, or biuret. The enzyme carboxypeptidase, on the other hand, is far less specific. It catalyzes the removal of nearly any amino acid from the carboxyl end of any peptide or protein.




Enzyme
Oxydoreductase
Transferase
Hydrolase
Lyase
Isomerase
Ligase

Types	Biochemical Property
Oxidoreductase	The enzyme Oxidoreductase catalyzes the oxidation reaction where the electrons tend to travel from one form of a molecule to the other. e.g. pyruvate dehydrogenase, catalysing the oxidation of pyruvate to acetyl coenzyme A.
Transferase	The Transferases enzymes help in the transportation of the functional group among acceptors and donor molecules. e.g. transaminase, which transfers an amino group from one molecule to another.
Hydrolase	Hydrolases are hydrolytic enzymes, which catalyze the hydrolysis reaction by adding water to cleave the bond and hydrolyze it. e.g. the enzyme pepsin hydrolyzes peptide bonds in proteins.

Types	Biochemical Property
Lyase	Adds water, carbon dioxide or ammonia across double bonds or eliminate these to create double bonds. e.g. aldolase (an enzyme in glycolysis) catalyzes the splitting of fructose-1, 6-bisphosphate to glyceraldehyde-3-phosphate and dihydroxyacetone phosphate.
Isomerase	The Isomerases enzymes catalyze the structural shifts present in a molecule, thus causing the change in the shape of the molecule. e.g. phosphoglucomutase catalyzes the conversion of glucose-1-phosphate to glucose-6-phosphate (phosphate group is transferred from one to another position in the same compound)
Ligase	The Ligases enzymes are known to charge the catalysis of a ligation process. e.g. DNA ligase catalyzes the joining of two fragments of DNA by forming a phosphodiester bond.

Cofactors

- An apoenzyme is the inactive protein part of an enzyme, a cofactor is the non-protein helper (like a metal ion or organic molecule), and a holoenzyme is the complete, catalytically active enzyme formed when an apoenzyme binds to its required cofactor. Thus,

  Apoenzyme + Cofactor = Holoenzyme

- There are three kinds of cofactors present in enzymes:
  - **Prosthetic groups**: These are cofactors tightly bound to an enzyme at all times. FAD (flavin adenine dinucleotide) is a prosthetic group present in many enzymes.
  - **Coenzyme**: A coenzyme binds to an enzyme only during catalysis. At all other times, it is detached from the enzyme. NAD is a common coenzyme.
  - **Metal ions**: For the catalysis of certain enzymes, a metal ion is required at the active site to form coordinate bonds. Zinc is a metal ion cofactor used by a number of enzymes.

Mechanism of Enzyme Reaction

The enzyme action basically happens in two steps:

Step1: Combining of enzyme and the reactant/substrate.

$$E+S \rightarrow [ES]$$

Step 2: Disintegration of the complex molecule to give the product.

$$[ES] \rightarrow E+P$$

Thus, the whole catalyst action of enzymes is summarized as:

$$E + S \rightarrow [ES] \rightarrow [EP] \rightarrow E + P$$

Lock and key model

- The active site of an enzyme possesses a unique conformation (including correctly positioned bonding groups) that is complementary to the structure of the substrate, so that the enzyme and substrate molecules fit together in much the same manner as a key fits into a tumbler lock. In fact, an early model describing the formation of the enzyme-substrate complex was called the lock-and-key model (as shown in Figure). This model portrayed the enzyme as conformationally rigid and able to bond only to substrates that exactly fit the active site.

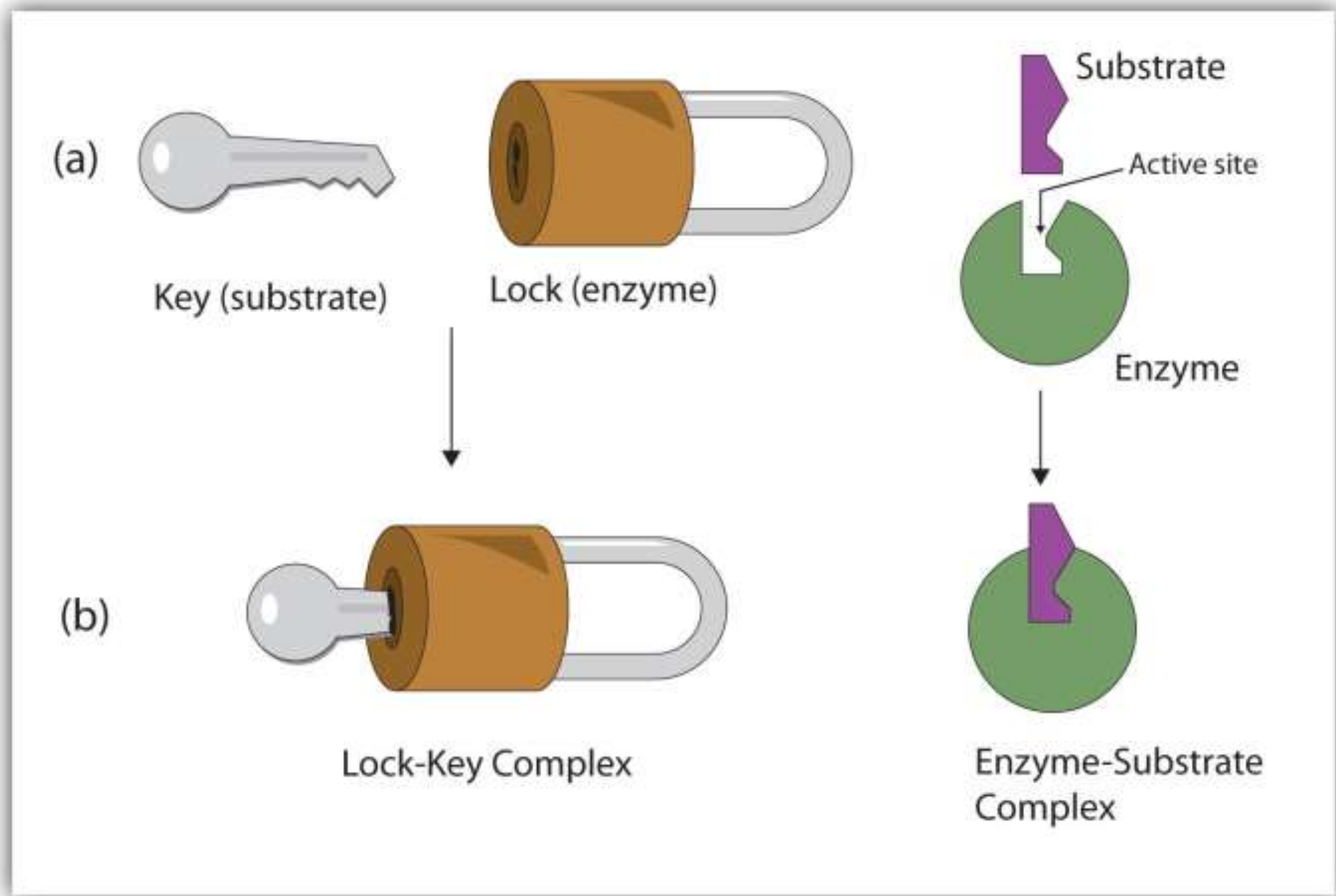


Figure : The Lock-and-Key Model of Enzyme Action. (a) Because the substrate and the active site of the enzyme have complementary structures and bonding groups, they fit together as a key fits a lock. (b) The catalytic reaction occurs while the two are bonded together in the enzyme-substrate complex.

Induced fit model

- Working out the precise three-dimensional structures of numerous enzymes has enabled chemists to refine the original lock-and-key model of enzyme actions. They discovered that the binding of a substrate often leads to a large conformational change in the enzyme, as well as to changes in the structure of the substrate or substrates. The current theory, known as the **induced-fit model**, says that enzymes can undergo a change in conformation when they bind substrate molecules, and the active site has a shape complementary to that of the substrate only after the substrate is bound, as shown for hexokinase in Figure. After catalysis, the enzyme resumes its original structure.

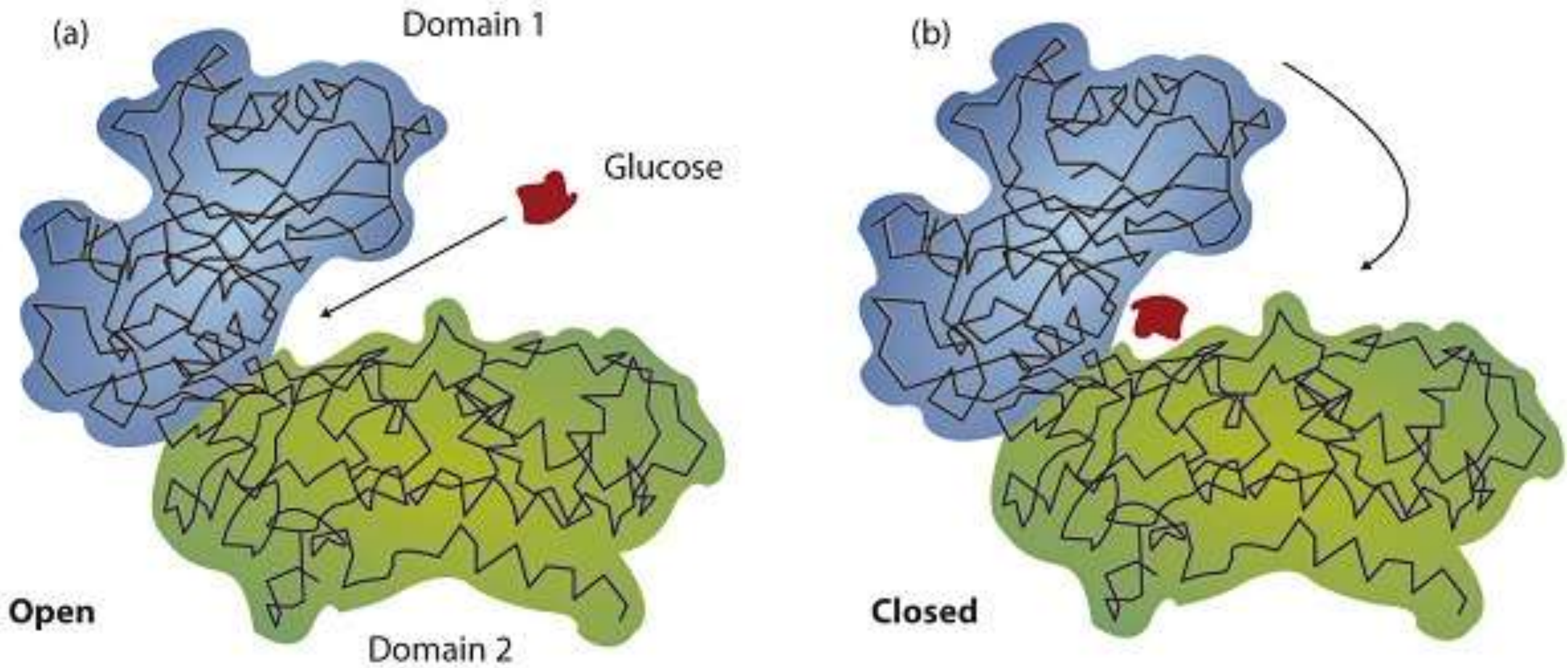


Figure: The Induced-Fit Model of Enzyme Action. (a) The enzyme hexokinase without its substrate (glucose, shown in red) is bound to the active site. (b) The enzyme conformation changes dramatically when the substrate binds to it, resulting in additional interactions between hexokinase and glucose.

Functions of Enzymes

- The enzymes perform a number of functions in our bodies. These include:
- Enzymes help in signal transduction. The most common enzyme used in the process includes protein kinase that catalyzes the phosphorylation of proteins.
- They break down large molecules into smaller substances that can be easily absorbed by the body.
- They help in generating energy in the body. ATP synthase is the enzyme involved in the synthesis of energy.
- Enzymes are responsible for the movement of ions across the plasma membrane.
- Enzymes perform a number of biochemical reactions, including oxidation, reduction, hydrolysis, etc. to eliminate the non-nutritive substances from the body.
- They function to reorganize the internal structure of the cell to regulate cellular activities.

Frequently Asked Questions

Q1 **Almost all enzymes are proteins, so which enzyme is not a protein?**

- Ribozyme.

  With the exception of ribozymes, all enzymes are protein-based.

Q2 **Define enzymes.**

____

Q3 **What are the examples of enzymes in plants?**

- Examples of plant-derived enzymes include amylase, protease and peroxidase.

Frequently Asked Questions

Q4 **Can an enzyme be called a polymer?**

Ans: Yes, most enzymes are made up of proteins which are polymers of amino acids.

Q5 **What are the types of enzymes present?**

Ans: The types of enzymes are:

- Oxidoreductases
- Transferases
- Hydrolases
- Lyases
- Ligases
- Isomerases

Q6 **What is an active site of an enzyme?**

Ans: The enzyme's active site is a cleft or a pocket within the enzyme where the substrate molecule binds and undergoes chemical reactions to be converted into the product.

Frequently Asked Questions

Q 7. What type of interaction would occur between an OH group present on a substrate molecule and a functional group in the active site of an enzyme?

Ans: An OH group would most likely engage in hydrogen bonding with an appropriate functional group present in the active site of an enzyme.

Q8. Suggest an amino acid whose side chain might be in the active site of an enzyme and form the type of interaction you just identified.

Ans: Several amino acid side chains would be able to engage in hydrogen bonding with an OH group. One example would be asparagine, which has an amide functional group.

Frequently Asked Questions

Q 9. Distinguish between the lock-and-key model and induced-fit model of enzyme action.

Ans: The lock-and-key model portrays an enzyme as conformationally rigid and able to bond only to substrates that exactly fit the active site. The induced fit model portrays the enzyme structure as more flexible and is complementary to the substrate only after the substrate is bound.

Q 10. Which enzyme has greater specificity—urease or carboxypeptidase? Explain.

Ans: Urease has the greater specificity because it can bind only to a single substrate. Carboxypeptidase, on the other hand, can catalyze the removal of nearly any amino acid from the carboxyl end of a peptide or protein.

Frequently Asked Questions

Q 11. What type of interaction would occur between each group present on a substrate molecule and a functional group of the active site in an enzyme?

a) COOH
b) NH_3^+
c) OH
d) $CH(CH_3)_2$

Ans:

a) hydrogen bonding
b) ionic bonding
c) hydrogen bonding
d) dispersion forces

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Ans:

a) hydrogen bonding
b) ionic bonding
c) hydrogen bonding
d) intermolecular forces between nonpolar ends/groups called Van der Waals force