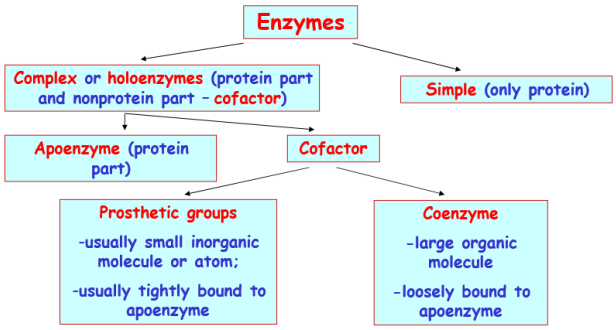
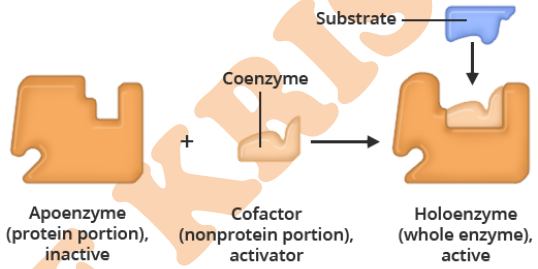
ENZYMES

❖ Definition

- **Enzyme** are proteins that act as biological catalysts by accelerating chemical reactions. The molecules upon which enzymes may act are called substrates, and the enzyme converts the substrates into different molecules known as products. Almost all metabolic processes in the cell need enzyme catalysis in order to occur at rates fast enough to sustain life. Metabolic pathways depend upon enzymes to catalyze individual steps.
- The study of enzymes is called *enzymology*
- *The enzyme term was invented by W. Kuhne in 1878.*

❖ Structure of enzyme





❖ Properties of enzyme

i) Physically, enzymes act as colloids or as high-molecular-weight compounds.
ii) At a temperature below the boiling point of the water, enzymes are killed or inactivated.
iii) Most enzymes in the liquid medium are inactivated at 60 degrees Celsius.
iv) Extracting dried enzymes can withstand temperatures of 100 degrees Celsius to 120 degrees Celsius or even higher. Enzymes are, therefore, thermos labile.
v) The optimum activity of each enzyme is always at a particular temperature, which typically varies from 25 degrees Celsius to 45 degrees Celsius. At 37 degrees Celsius, enzyme action is strongest and as temperatures rise above 60 degrees Celsius, enzymes become inactive.
vi) Enzymes are complex macromolecules with high molecular weight.
vii) 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.
viii) Enzymes do not start a reaction. However, they help in accelerating it.
ix) 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.
x) Enzymes are specific in action.
xi) Enzymatic activity decreases with increase in temperature.
xii) They show maximum activity at an optimum pH of 6 – 8.
xiii) The velocity of enzyme increases with an increase in substrate concentration and then, ultimately reaches maximum velocity.
xiv) In nature, all enzymes are proteins, but all proteins may not be enzymes.
xv) Enzymes remain unchanged after a reaction and therefore can work again.
xvi) They lowers the activation energy required for a chemical reaction to proceed.

❖ IUB and MB Classification (IUBMB-International union of biochemistry and molecular biology)

➢ Trivial Names of Enzymes

- The name of an enzyme: Usually ends in –ase. Identifies the reacting substance. For example, sucrase catalyzes the reaction of sucrose. Describes the function of the enzyme. For example, oxidases catalyze oxidation. Could be a common name, particularly for the digestion enzymes such as pepsin and trypsin.

➢ **IUB Classification of Enzymes**

Enzymes are classified according to the reaction they catalyze.

Class	Reactions catalyzed
i) Oxidoreductases	Oxidation-reduction
ii) Transferases	Transfer groups of atoms
iii) Hydrolases	Hydrolysis
iv) Lyases	Add atoms/remove atoms to/from a double bond
v) Isomerases	Rearrange atoms
vi) Ligases	Use ATP to combine molecules

➢ **Systematic Name**

- According to the International union Of Biochemistry an enzyme name has two parts: -First part is the name of the substrates for the enzyme. -Second part is the type of reaction catalyzed by the enzyme.This part ends with the suffix "ase". Example: Lactate dehydrogenase

❖ **EC number**

- Enzymes are classified into six different groups according to the reaction being catalyzed. The nomenclature was determined by the Enzyme Commission in 1961 (with the latest update having occurred in 1992), hence all enzymes are assigned an "EC" number. The classification does not take into account amino acid sequence (ie, homology), protein structure, or chemical mechanism.

➢ **EC numbers**

- EC numbers are four digits, for example a.b.c.d, where "a" is the class, "b" is the subclass, "c" is the sub-subclass, and "d" is the sub-sub-subclass. The "b" and "c" digits describe the reaction, while the "d" digit is used to distinguish between different enzymes of the same function based on the actual substrate in the reaction. Example: for Alcohol:NAD^+ oxidoreductase EC number is 1.1.1.1

EC Tree

1 Oxidoreductases

1.1 Acting on the CH-OH group of donors

1.1.1 With NAD^+ or $NADP^+$ as acceptor

1.1.1.1 alcohol dehydrogenase

➢ **The Six Classes**

EC 1. Oxidoreductases
EC 2. Transferases
EC 3. Hydrolases
EC 4. Lyases
EC 5. Isomerases
EC 6. Ligases

EC 1. Oxidoreductases

- Catalyze the transfer of hydrogen or oxygen atoms or electrons from one substrate to another.
- Since these are 'redox' reactions, an electron donor/acceptor is also required to complete the reaction.
- $AH_2 + B \rightarrow A + BH_2$
- Ex. Oxidases, Dehydrogenases, Reductases.

EC 2. Transferases

- Catalyze group transfer reactions, excluding oxidoreductases (which transfer hydrogen or oxygen and are EC 1).
- These are of the general form: $A\text{-}X + B \leftrightarrow BX + A$
- Ex: Transaminases (transfer amino group), Kinases (transfer Phosphate group)

EC 3. Hydrolases

- Catalyze hydrolytic reactions.
- A-X + H2O ↔ X-OH + A-H
- Ex: lipases, esterases, Amylases, peptidases/proteases, etc.

EC 4. Lyases

- Catalyze non-hydrolytic (covered in EC 3) removal of functional groups from substrates, often creating a double bond in the product; or the reverse reaction, ie, addition of function groups across a double bond.
- A-X +B-Y → A=B + X-Y
- Ex: Decarboxylases, Aldolases, Dehydrases, Deaminases, Synthases, etc.

EC 5. Isomerases

- Catalyzes isomerization reactions, including epimerizations and cis-trans isomerizations.
- A →A'
- Ex: Isomerases (Cis-Trans), Epimerases (D—L)

EC 6. Ligases

- Catalyzes the synthesis of various (mostly C-X) bonds, coupled with the breakdown of energy- containing substrates, usually ATP .
- A+B+ ATP → A-B+ ADP+iP
- Ex: Synthetases, Carboxylases

❖ **Enzyme Specificity**

- The ability of an enzyme to select a specific substrate from a range of chemically similar compounds is known as specificity. Since the enzyme and substrate exhibit complementary structural and conformational properties, specificity is a molecular identification process. Different enzymes exhibit different levels of substrate specificity.
- The specificity that enzymes show to the reactions they catalyse is one of the characteristics that makes them so useful as diagnostic and research tools. Only a selected few enzymes can catalyse a single reaction or they have perfect specificity.
- There are usually four different categories of specificity:
  i) Absolute specificity – The enzyme catalyses only one reaction.
  ii) Group specificity – The enzyme acts only on molecules having specific functional groups, like phosphate, amino, and methyl groups.
  iii) Linkage specificity – The enzyme acts on a specific type of chemical bond regardless of the remaining molecular structure.
  iv) Stereochemical specificity – The enzyme acts on a certain optical or steric isomer.