Enzymes

Definitions, properties, nomenclature & mode of action

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Enzymes

Definitions:

Enzymes are organic colloidal biological catalysts of protein nature synthesized by living cells to catalyze metabolic reactions without being consumed in the reaction or affecting the end point.

Biological catalysts: Organic compounds essential to lower the amount of activation energy required for the molecules in living cells to react.

Substrate: It is the substance upon which an enzyme acts; the enzyme will convert the substrate into the product or products.

Properties of Enzymes:

1. Almost all enzymes are proteins. Enzymes follow the physical and chemical reactions of proteins.

i. They are heat labile.

ii. They are water-soluble.

iii. They can be precipitated by protein precipitating reagents

iv. They contain 16% weight as nitrogen.

2. Highly specific in their action.

3. They remain **chemically unchanged** during the reaction.

4. They are **live substances**.

Enzyme nomenclature (Terminology): There are many ways:

1. Adding the suffix -ase to the name of the substrate e.g. . . .

i. Lactase act on lactose.

ii. Lipase act on lipid.

2. Adding their function to the name of the substrate: e.g.

* lactate dehydrogenase; remove hydrogen from lactic acid.

3. Trivial names (which may be non-informative):

Pepsin, trypsin & chemotrypsin.

Classification of Enzymes:

I – Classification of Enzymes According to Function:

Class 1: Oxidoreductases:

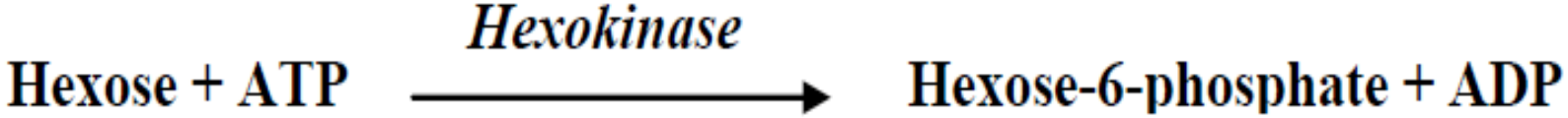
- These enzymes will catalyze oxidation of one substrate with simultaneous reduction of another substrate or co-enzyme.

$$AH2 + B \longrightarrow A + BH2$$

$$\text{Alcohol} + NAD^{+} \xrightarrow[\text{dehydrogenase}]{\text{Alcohol}} \text{Aldehyde} + NADH + H^{+}.$$

I – Classification of Enzymes According to Function:

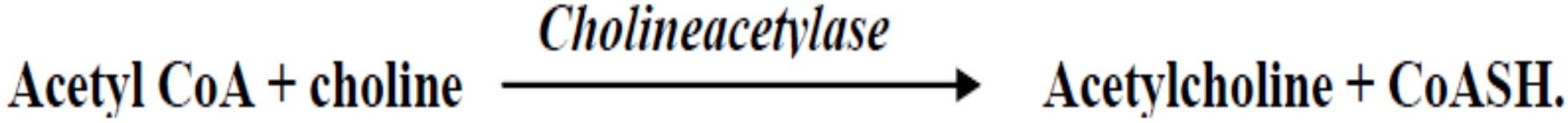
Class 2: Transferases: transfer chemical group (other than hydrogen) from one substrate to another substrate.



1. **Phospho-transferases:** transfer the phosphate group from one compound to another.
2. **Transaminases:** transfer amino (NH2) group from an α- amino acid to an α-keto acid to produce a new α- amino acid and a new α-keto acid without production of ammonia. e.g.

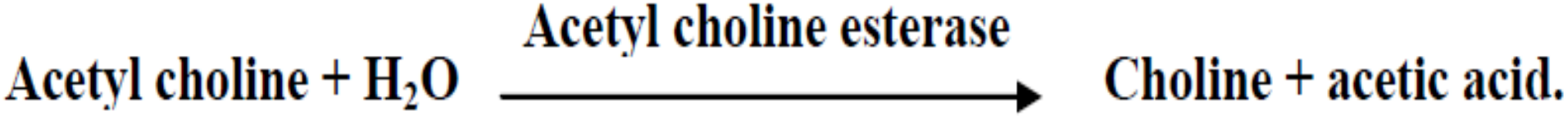
- ***SGOT (AST):*** serum glutamate-oxaloacetate transaminase (Aspartate transferase).
- ***SGPT (ALT):*** serum glutamate-pyruvate transaminase (Alanine transferase)

3. Acyl-transferases: transfer acyl group from one compound to another

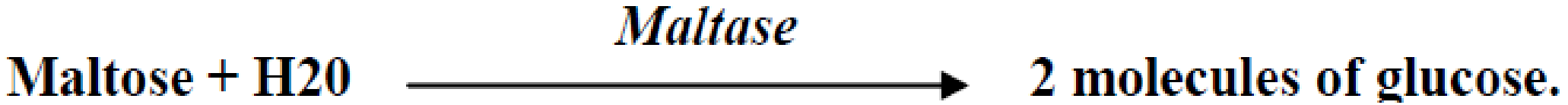


I – Classification of Enzymes According to Function:

Class 3: Hydrolases: hydrolyse ester, ether, peptide or glycosidic bonds by adding water and then breaking the bond



All digestive enzymes are hydrolases e.g. Maltase, lipase.



I – Classification of Enzymes According to Function:

Class 4: Lyases: remove groups from substrates or break bonds by mechanisms other than hydrolysis.

Fructose 1, 6 bisphosphate $\xrightarrow{\textit{Aldolase (A)}}$ **Glyceraldehyde-3-P + Dihydroxy acetone P**

Class 4: Isomerases: can produce optical, geometric or positional isomers of substrates. They are racemases, epimerases, cis-trans isomerases, mutases and aldose - ketose isomerase

Glyceraldehyde-3- P $\xrightarrow[\textit{isomerase}]{\textit{Triose phosphate}}$ **Dihydroxy acetone P**

Class 5: Ligases: link 2 substrates together, with simultaneous hydrolysis of ATP

$$\text{Acetyl Co A} + CO_2 + \text{ATP} \xrightarrow[\text{Biotin, } Mn^{2+}]{\textit{Acetyl CoA carboxylase}} \text{Malonyl CoA} + \text{ADP} + \text{Pi}$$

II – Classification of Enzymes the site of action:

A. Intracellular: Most of the enzymes are secreted inside the cells and perform their actions inside them.

B. Extracellular: These are a certain group of enzymes which are secreted by certain cells but their action is performed extracellular e.g. gastrointestinal enzymes.

II – Classification of Enzymes the Enzyme Specificity:

1. **Absolute Specificity:** The enzyme acts on one substrate only.

   Urea to ammonia and carbon dioxide is catalyzed by urease. Urea is the only substrate for urease.

   Glucose oxidase will oxidize only beta-D-glucose & no other isomeric form.

2. **Bond Specificity:** Most proteolytic enzymes are bond specific.

   Trypsin can hydrolyse peptide bonds formed by carboxyl groups of arginine or lysine residues in any proteins.

3. **Group Specificity:** One enzyme can catalyze the same reaction on group of structurally similar compounds

   Hexokinase can catalyze phosphorylation of glucose, galactose & mannose

III – Classification of Enzymes the Enzyme Specificity:

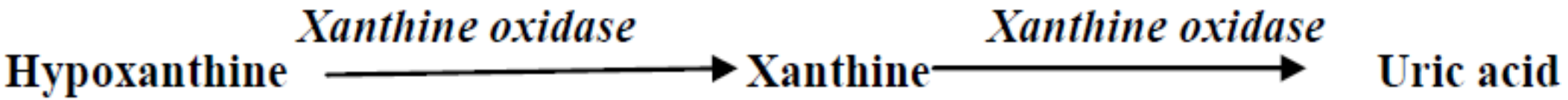
4. Stereo- or Optical Specificity: The enzyme works on one of 2 isomers

Human enzymes are specific for L-amino acids and D-carbohydrates.

1. L – amino acid oxidase acts on L – amino acids only.
2. Enzymes of glycolysis act on D – sugars only.

5. Dual specificity: The enzyme has 2 substrates and catalyzes 1 reaction as

Xanthine oxidase or has 1 substrate and catalyzes 2 reactions as isocitrate dehydrogenase.



IV – Chemical Classification of Enzymes:

As enzymes are protein in nature, they can be classified chemically into:

A. Simple protein enzymes: only proteins e.g. Maltase, amylase, lipase.

B. Conjugated protein enzymes: are holoenzymes consisting of protein part and non protein part.

1. **Protein part (apoenzyme)**
2. **Non protein part**; may be loosely attached to the protein part **(coenzyme)**, and firmly attached (**Prosthetic group)**

Co-enzyme	Group transferred
Thiamine pyrophosphate (TPP)	Hydroxyethyl
Pyridoxal phosphate (PLP)	Amino group
Biotin	Carbon dioxide
Coenzyme-A (Co-A)	Acyl groups
Tetra hydrofolate (FH4)	One carbon groups
Adenosine triphosphate (ATP)	Phosphate

IV – Chemical Classification of Enzymes:

Coenzyme	Prosthetic group
Organic	Inorganic
Loosely attached to protein part.	Firmly attached to protein part.
Dialyzable	Non Dialyzable.
Usually derived from a vitamin e.g. FAD, NAD etc	Usually a metal e.g. Copper, iron etc

Metalloenzymes:

Metal	Enzyme containing the metal
Zinc	Carbonic anhydrase, alcohol dehydrogenase
Magnesium	Hexokinase, phospho fructo kinase, enolase, glucose-6-phosphatase
Manganese	Phospho gluco mutase, hexokinase, enolase, glycosyl transferases
Copper	Tyrosinase, cytochrome oxidase, lysyl oxidase, superoxide dismutase
Iron	Cytochrome oxidase, catalase, peroxidase, xanthine oxidase
Calcium	Lecithinase, lipase
Molybdenum	Xanthine oxidase

Co-factors: a term used as a collective term to include co-enzymes & metal ions.

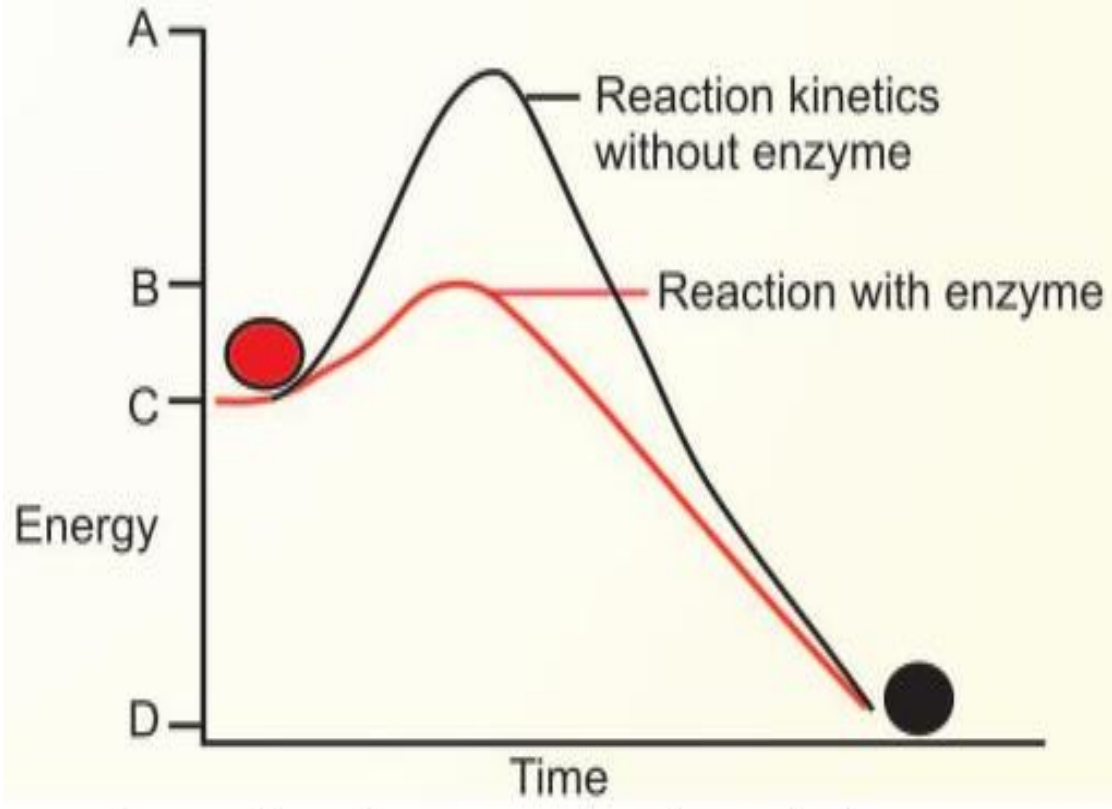
MODE OF ACTION OF ENZYMES:

A. Lowering of Activation Energy: Enzymes lower the energy of activation.

1. Activation energy is defined as the energy required to convert all molecules of a reacting substance from ground state to transition state.

2. Enzymes reduce the magnitude of this activation energy.

Red circle = substrate
Black circle = product.
C = energy level of substrate.
D= energy level of product.
C to A= activation energy in absence of Enz
C to B= activation energy in presence of Enz
B to A= lowering of activation energy by Enz

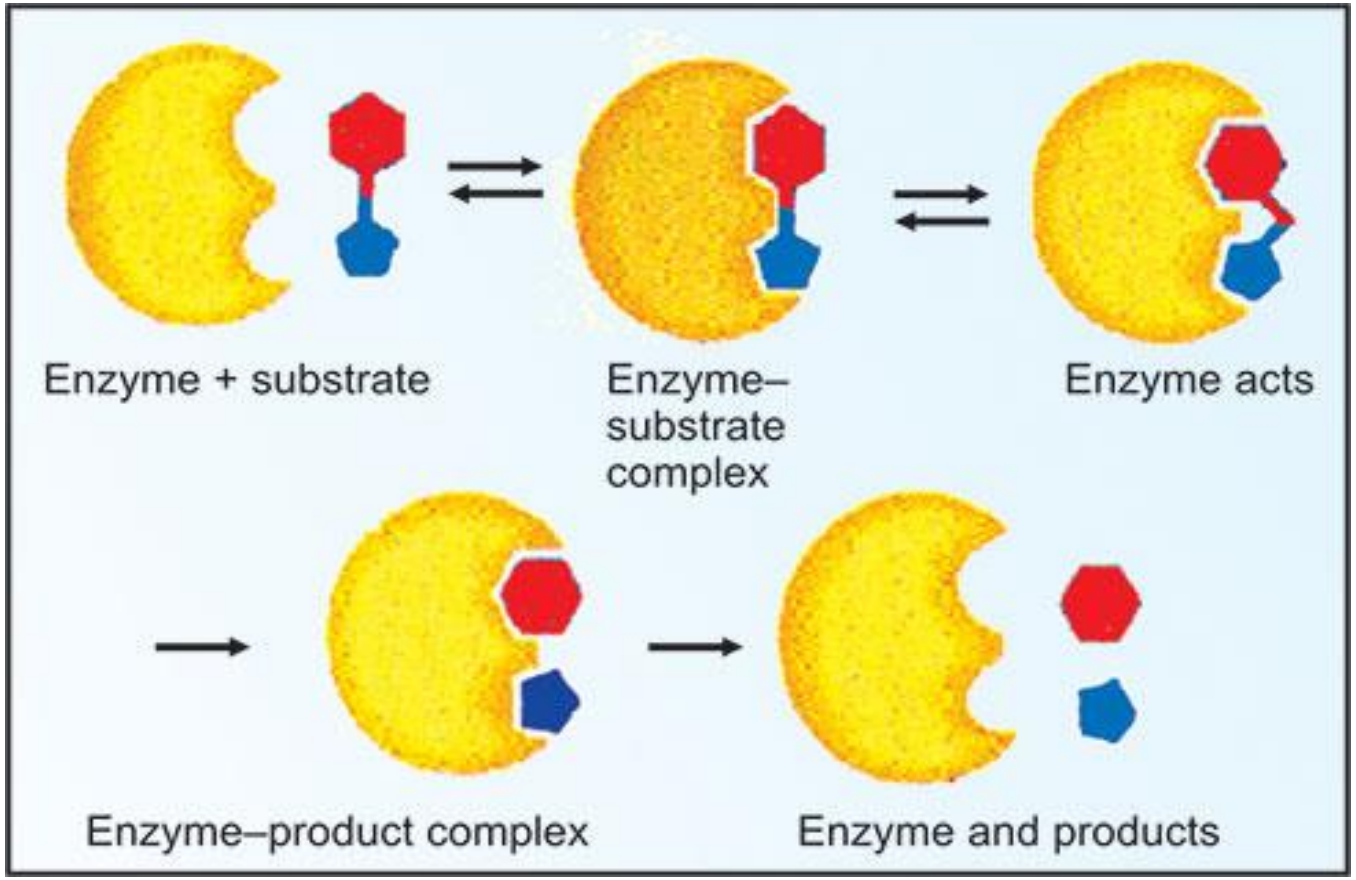


MODE OF ACTION OF ENZYMES:

B. Michaelis and Menten theory:

Michaelis and Menten put forward the Enzyme-Substrate complex theory. Accordingly, the enzyme (E) combines with the substrate (S), to form an enzyme-substrate (ES) complex, which immediately breaks down to the enzyme and the product (P).

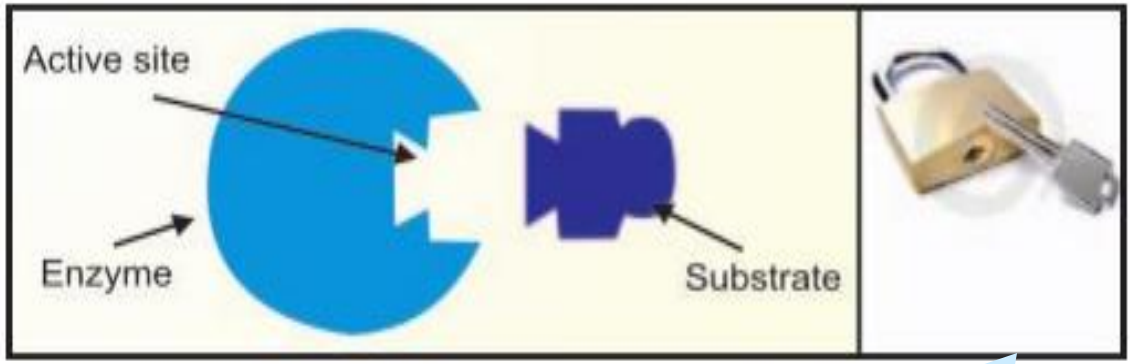
$$\mathbf{E + S \leftrightarrow E\text{-}S\ Complex \rightarrow E + P}$$

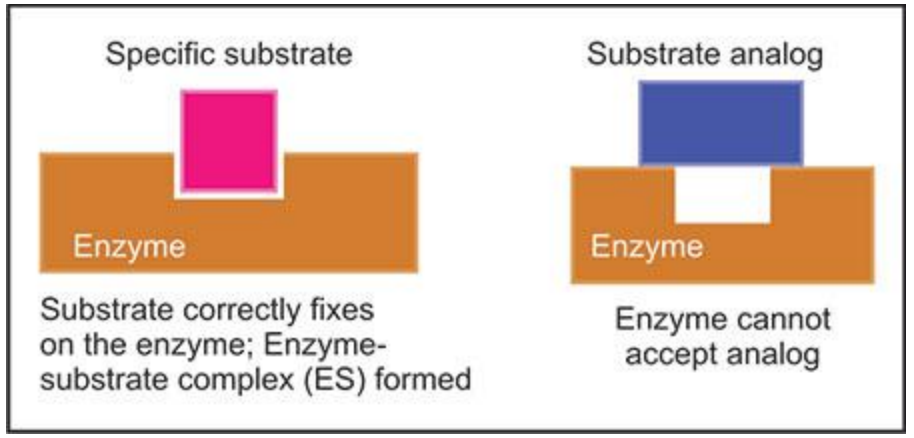


MODE OF ACTION OF ENZYMES:

C. FISCHER'S template theory:

It states that the three dimensional structure of the active site of the enzyme is complementary to the substrate. Thus enzyme and substrate fit each other. Substrate fits on the enzyme, similar to lock and key. The lock can be opened by its own key only.





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