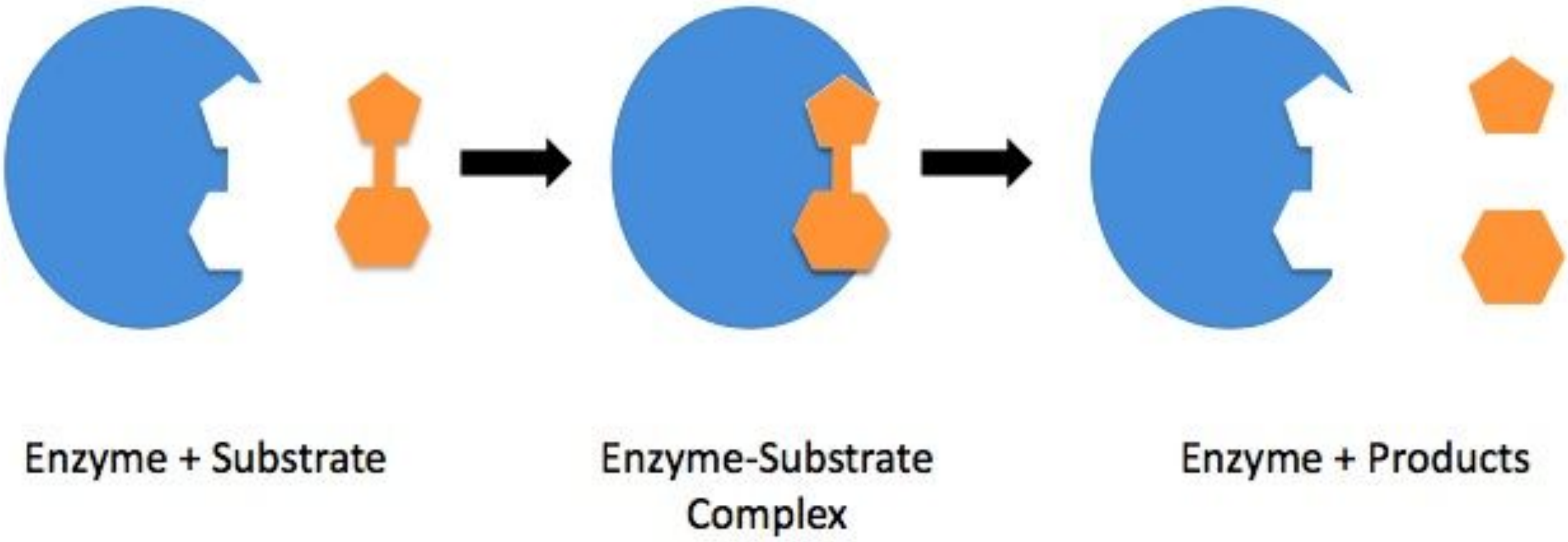
Enzymes



Topics:
Enzymes: General properties;
Classification and mechanism..

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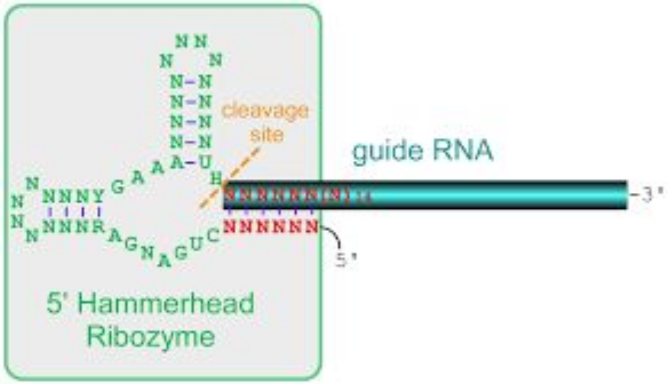
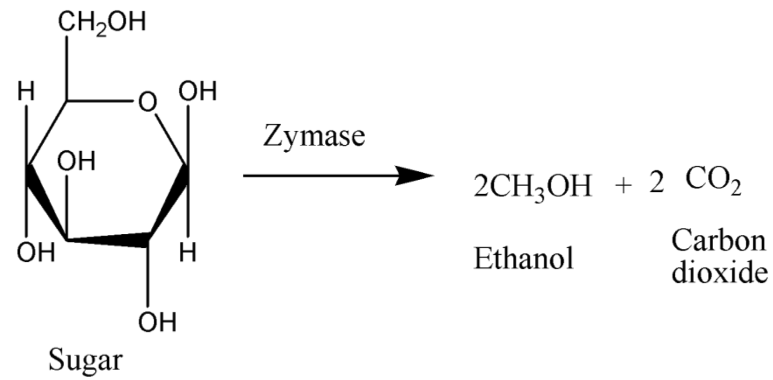
Enzymes- Introduction

- Enzymes are ***biological catalysts*** that speed up the rate of the biochemical reaction.
- Most enzymes are ***three dimensional globular proteins*** (tertiary and quaternary structure).
- Some special RNA species also act as enzymes and are called ***Ribozymes*** e.g. hammerhead ribozyme.

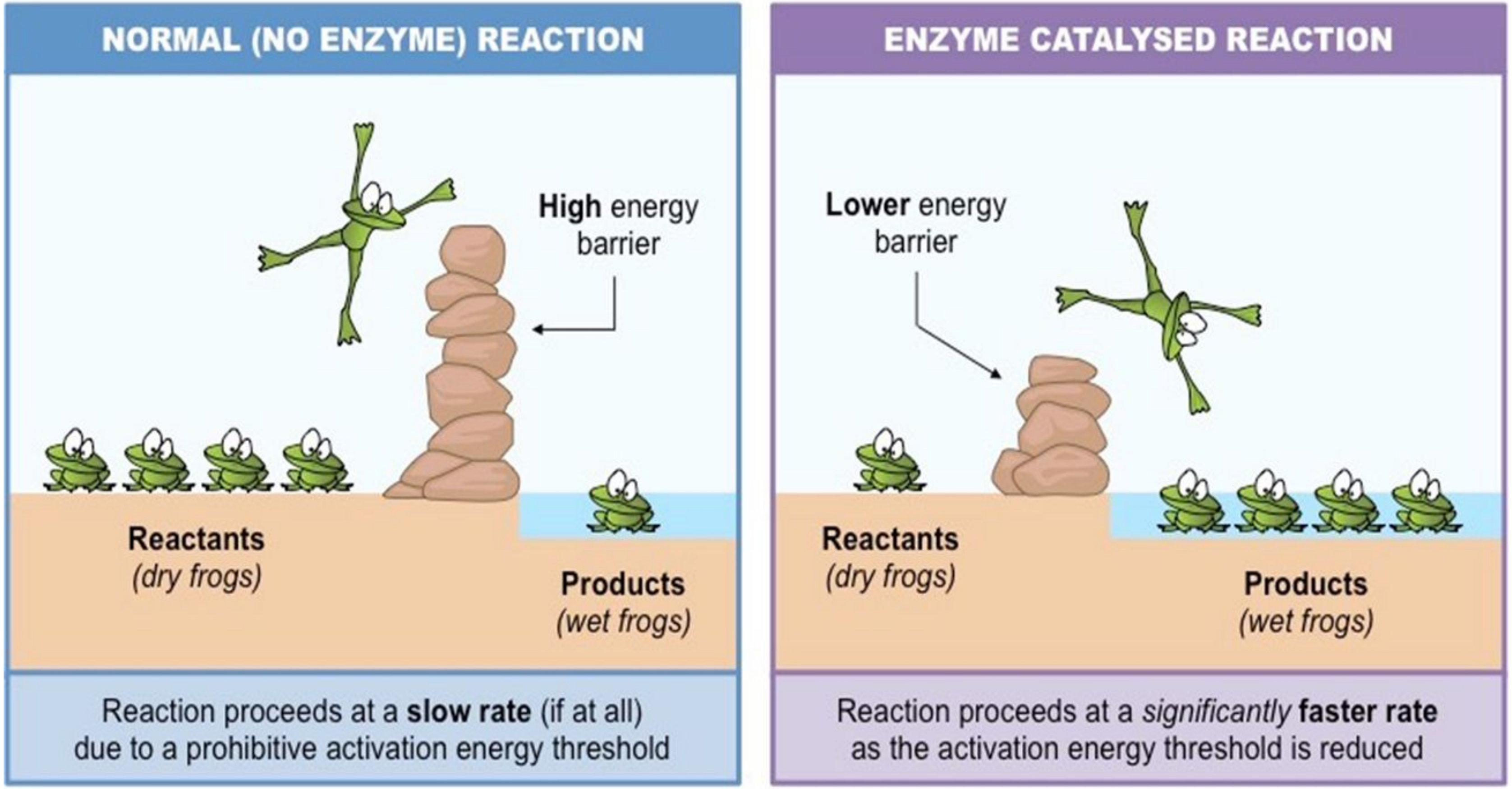


Historical background

- Berzelius in 1836 coined the term catalysis
- In 1878, Kuhne give term enzyme (Greek-in yeast)
- Isolation of enzyme system from cell free extract of yeast was achieved in 1883 by Buchner. He named the active principle as *zymase* which could convert sugar into alcohol
- In 1926, James Sumner first achieved the isolation and crystallization of the enzyme *urease* from lack bean and identified it as a protein



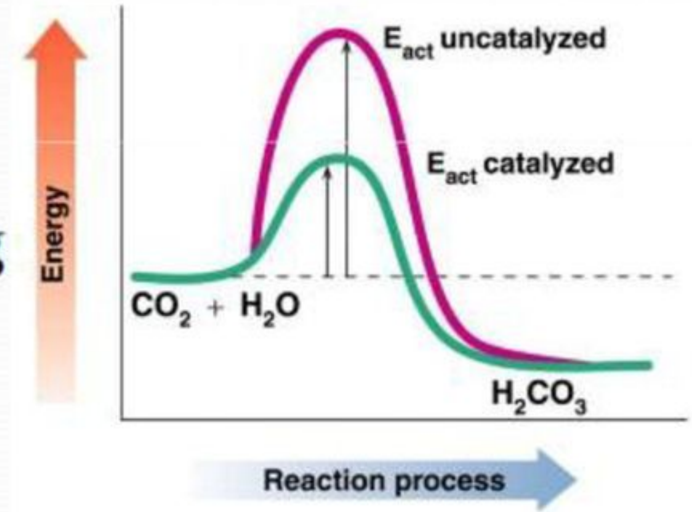
Enzyme Action



Enzymes are Biological Catalysts

Enzymes are proteins that:

- **Increase the rate of reaction by lowering the energy of activation.**
- **Catalyze nearly all the chemical reactions taking place in the cells of the body.**
- **Have unique three-dimensional shapes that fit the shapes of reactants.**

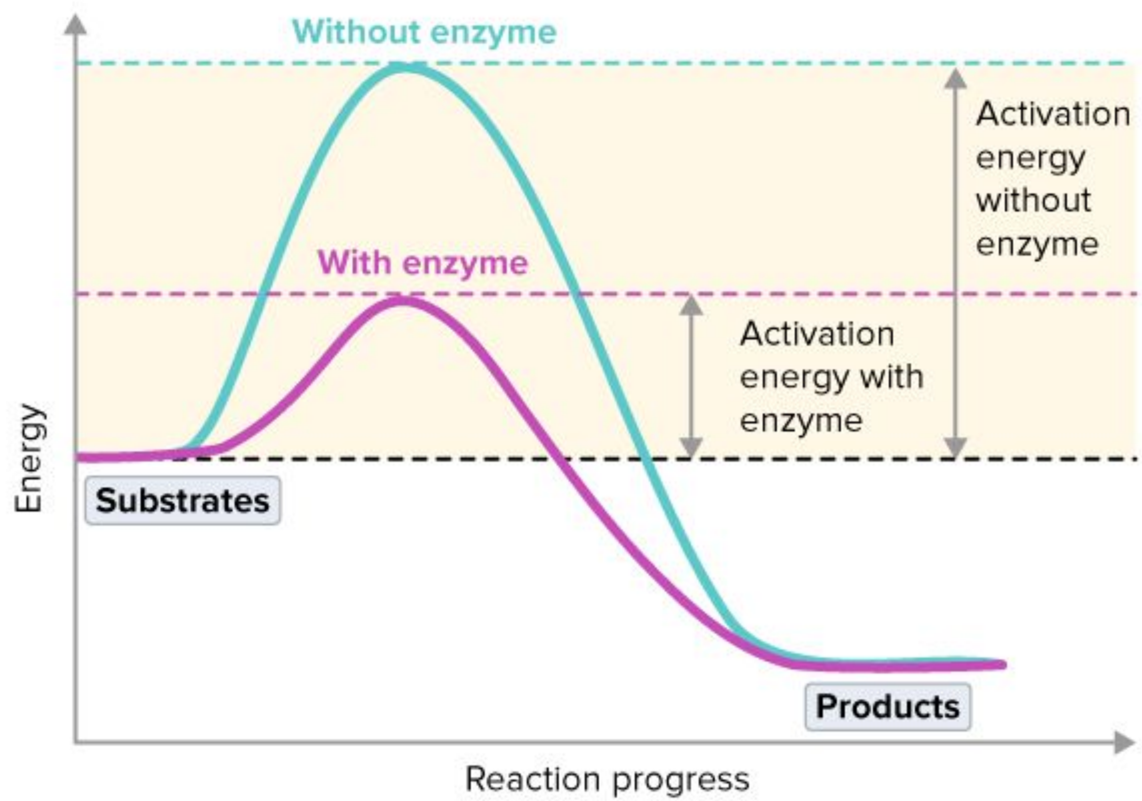


Activation Energy

Activation energy is the minimum energy required to cause a process (such as a chemical reaction) to occur.

Enzymes perform the critical task of lowering a reaction's activation energy—

that is, the *minimum amount of extra energy required by a reacting molecule to get converted into a product*..



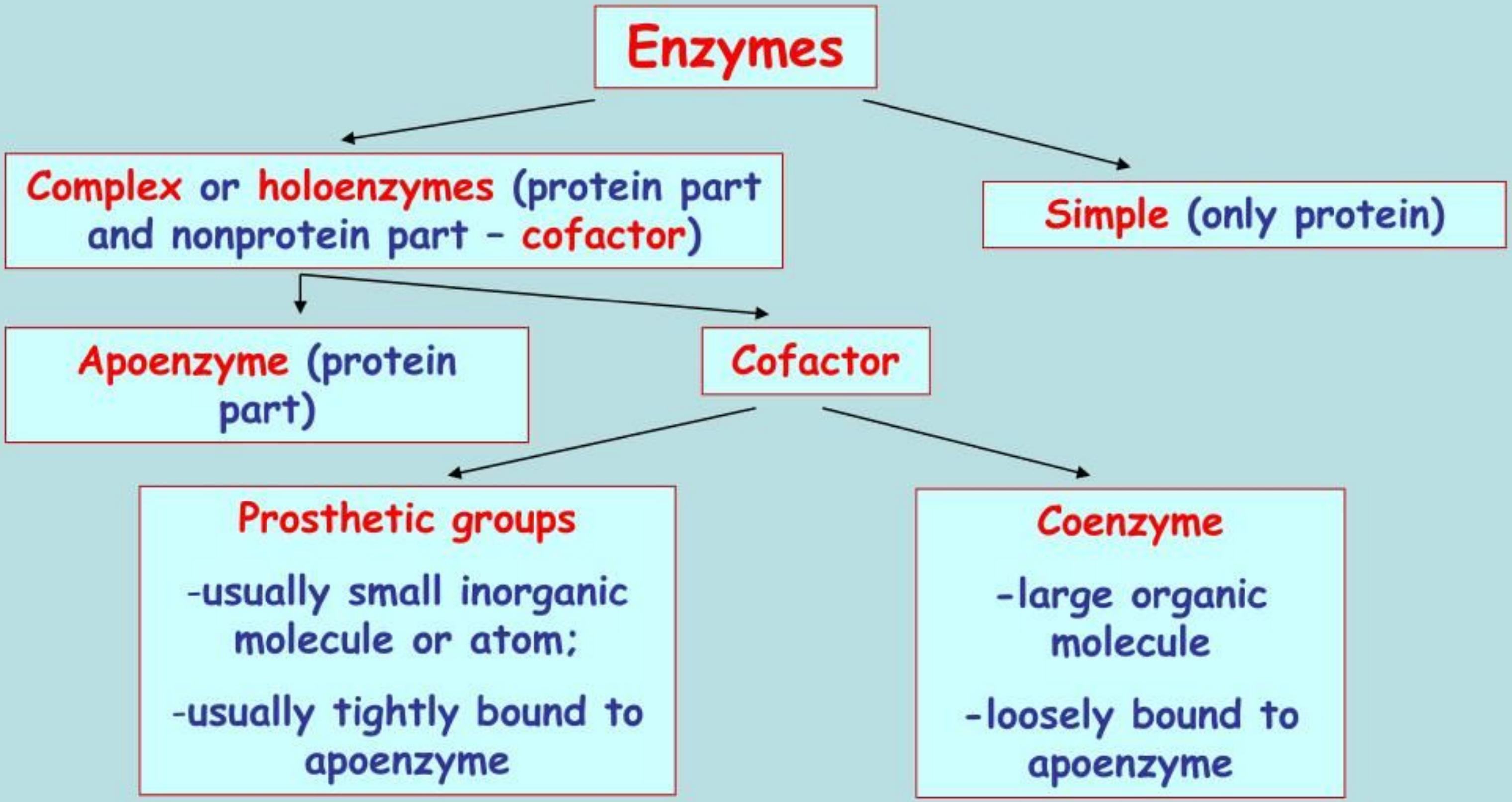
Structure of enzymes

1.Composition of Enzyme Molecules

- enzymes
  - Simple enzymes——proteins
  - Conjugated enzymes (holoenzyme)
    - apoenzyme
    - cofactor
      - prosthetic group
      - coenzyme

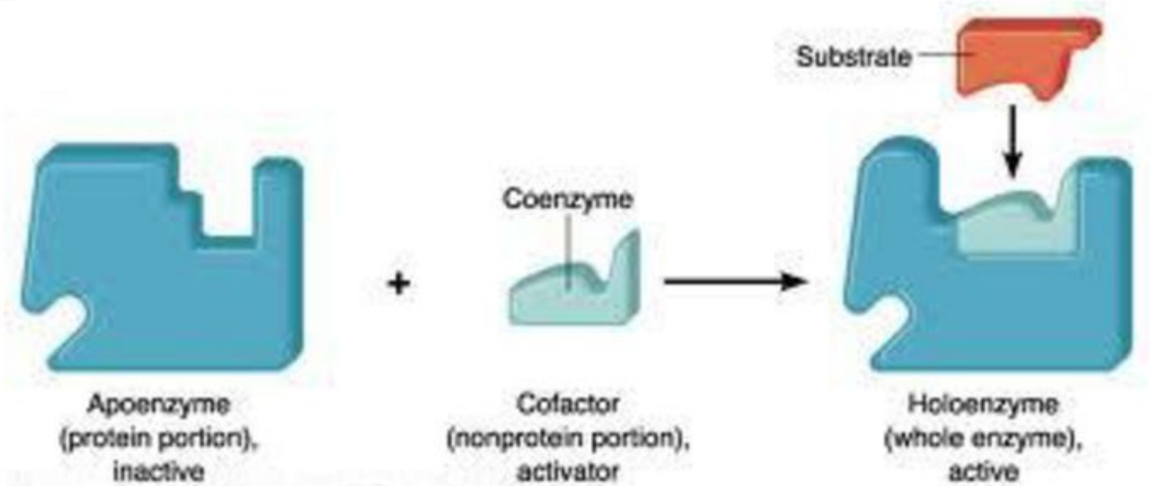
Holoenzyme = Apoenzyme + Cofactors

Structure of enzymes



APOENZYME and HOLOENZYME

- The enzyme without its non protein moiety is termed as apoenzyme and it is inactive.
- Holoenzyme is an active enzyme with its non protein component.



Types of Cofactors

- **Coenzyme:**
  The non-protein component, loosely bound to apoenzyme by non-covalent bond.
- **Examples : vitamins or compound derived from vitamins.**
- **Prosthetic group**
  The non-protein component, tightly bound to the apoenzyme by covalent bonds is called a Prosthetic group.

Nomenclature of Enzymes

- An enzyme is named according to the name of the substrate it catalyses.
- Some enzymes were named before a systematic way of naming enzyme was formed.

    Example: pepsin, trypsin and rennin
- By adding suffix ***-ase*** at the end of the name of the substrate, enzymes are named.
- Enzyme for catalyzing the hydrolysis is termed as hydrolase.

    Example :

$$\text{maltose + water} \xrightarrow[\text{maltase}]{} \text{glucose + glucose}$$

Examples

substrate	enzymes	products
lactose	lact**ase**	glucose + galactose
maltose	malt**ase**	Glucose
cellulose	cellul**ase**	Glucose
lipid	lip**ase**	Glycerol + fatty acid
starch	amyl**ase**	Maltose
protein	prote**ase**	Peptides + polypeptide

CHARACTERISTICS

- Enzymes *speed up* the reaction by lowering the activation energy of the reaction.
- Their presence *does not effect* the nature and properties of *end product*.
- They are *highly specific* in their action that is each enzyme can catalyze one kind of substrate.
- Small amount of enzymes can accelerate chemical reactions.
- Enzymes are *sensitive* to change in pH, temperature and substrate concentration.
- *Turnover number* is defined as the number of substrate molecules transformed per minute by one enzyme molecule.

Catalase turnover number = 6 x106/min

Classification of Enzymes

- A systematic classification of enzymes has been developed by *International Enzyme Commission*.

- This classification is based on the type of reactions catalyzed by enzymes.

- There are *six* major classes.

- Each class is further divided into sub classes, sub sub-classes and so on, to describe the huge number of different enzyme-catalyzed reactions.

Classification of Enzymes

1. Oxidoreductases

Enzymes involved in oxidation-reduction reactions. Eg. Alcohol dehydrogenase

2. Transferases

Enzymes involved in transfer of groups from one molecule to another. Eg. Hexokinase

3. Hydrolases

Enzymes that bring about hydrolysis by addition of water. Eg. Lipase

4. Lyases

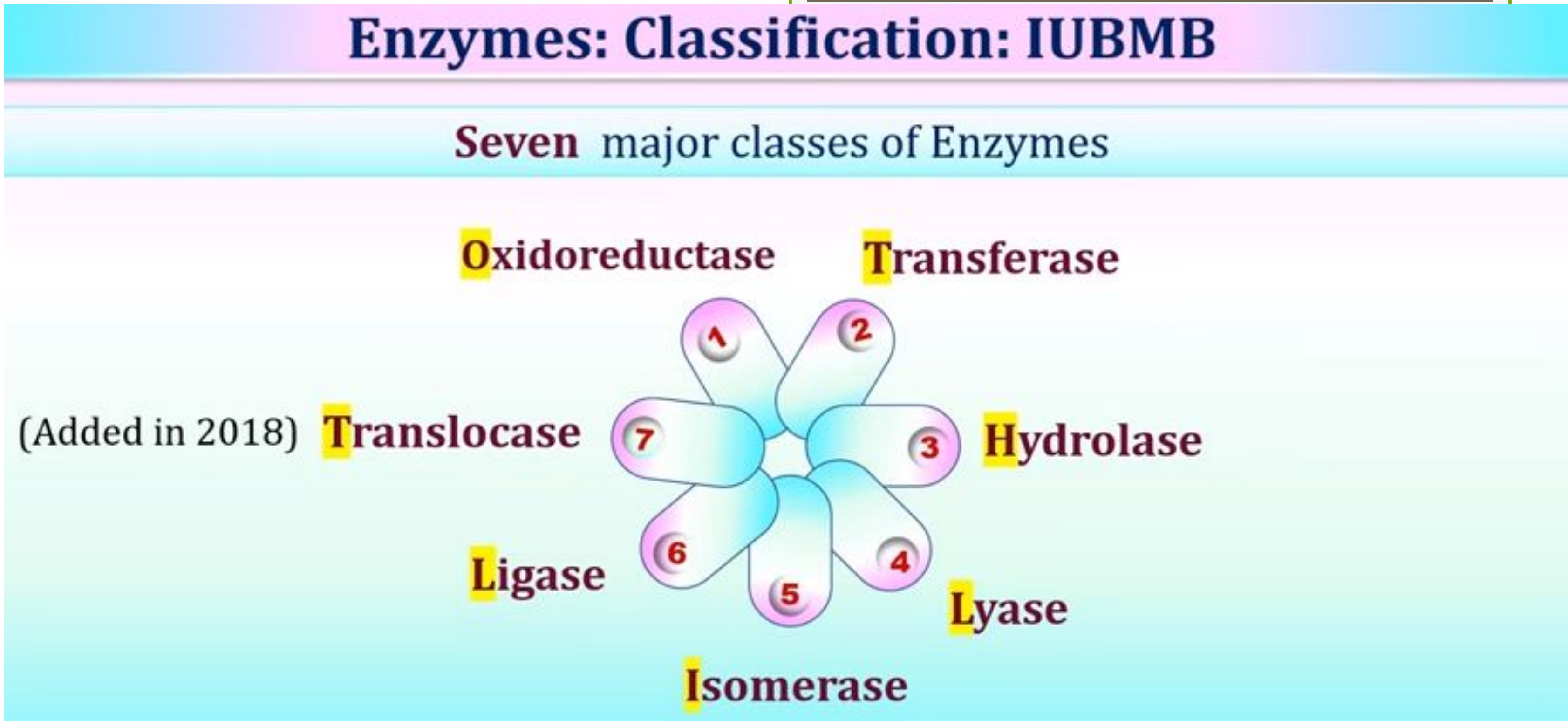
Enzymes that catalyze the breaking of a chemical bond through means not involving hydrolysis, and forms a double bond or adds a group to a double bond. Eg. Fumarase

5. Isomerases

Enzymes involved in all kinds of isomerization reactions. Eg. Phosphohexose isomerase

6. Ligases

Enzymes catalyzing the joining of two molecules with hydrolysis of ATP. Eg. Glutamine synthetase



Recently, a new class, the *Translocases (EC 7*), has been added, which incorporates enzymes that catalyse the movement of ions or molecules across membranes or their separation within membranes.

Mechanism of Enzyme Catalysis

substrate

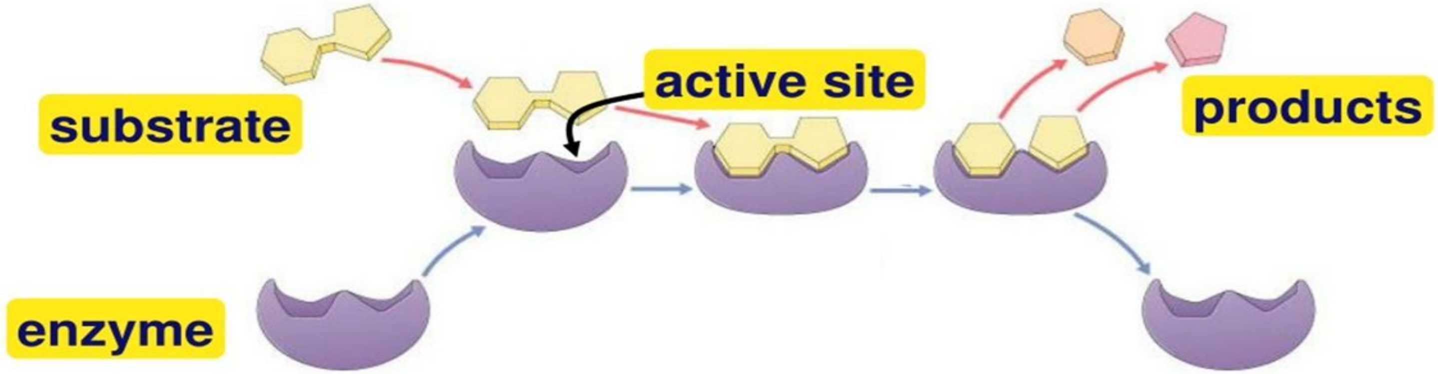
- reactant which binds to enzyme
- enzyme-substrate complex: temporary association

product

- end result of reaction

active site

- enzyme's catalytic site; substrate fits into active site

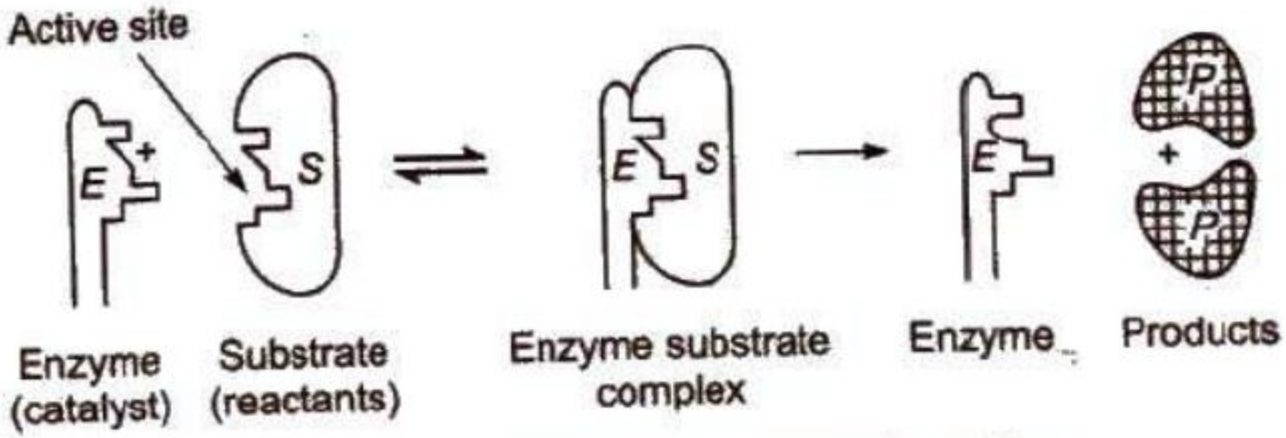


Mechanism of Enzyme Catalysis

Mechanism of Enzyme Catalysis

Step I $E + S \longrightarrow ES$

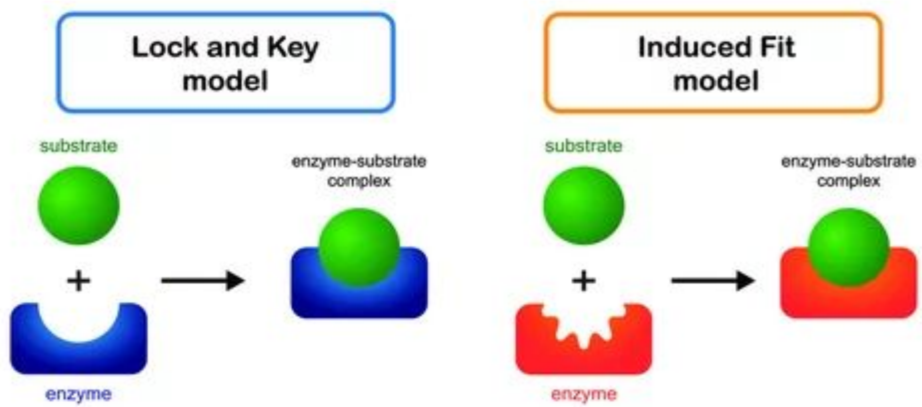
Step II $ES \longrightarrow E + P$



Mechanism of enzyme catalysed reaction

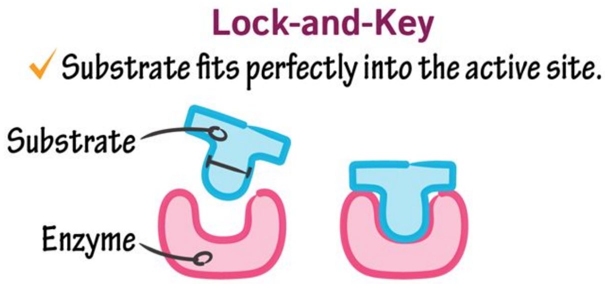
Mechanism of Enzyme Catalysis

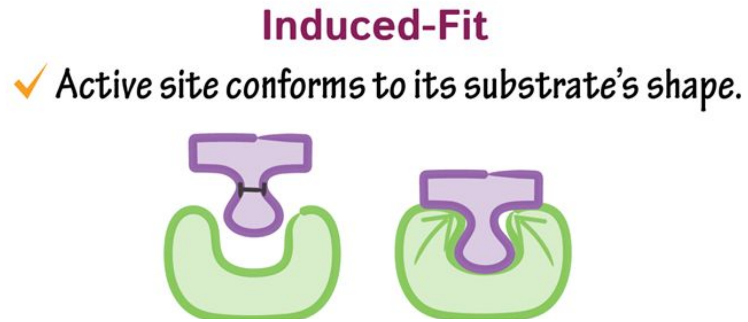
- Converts **substrate** into **product**
- Highly **specific** for their substrate
- Accelerate specific chemical reactions without being consumed in the process



Model of enzyme action

Two models to explain the actions of enzymes with substrates are the Lock and Key model & Induced fit model

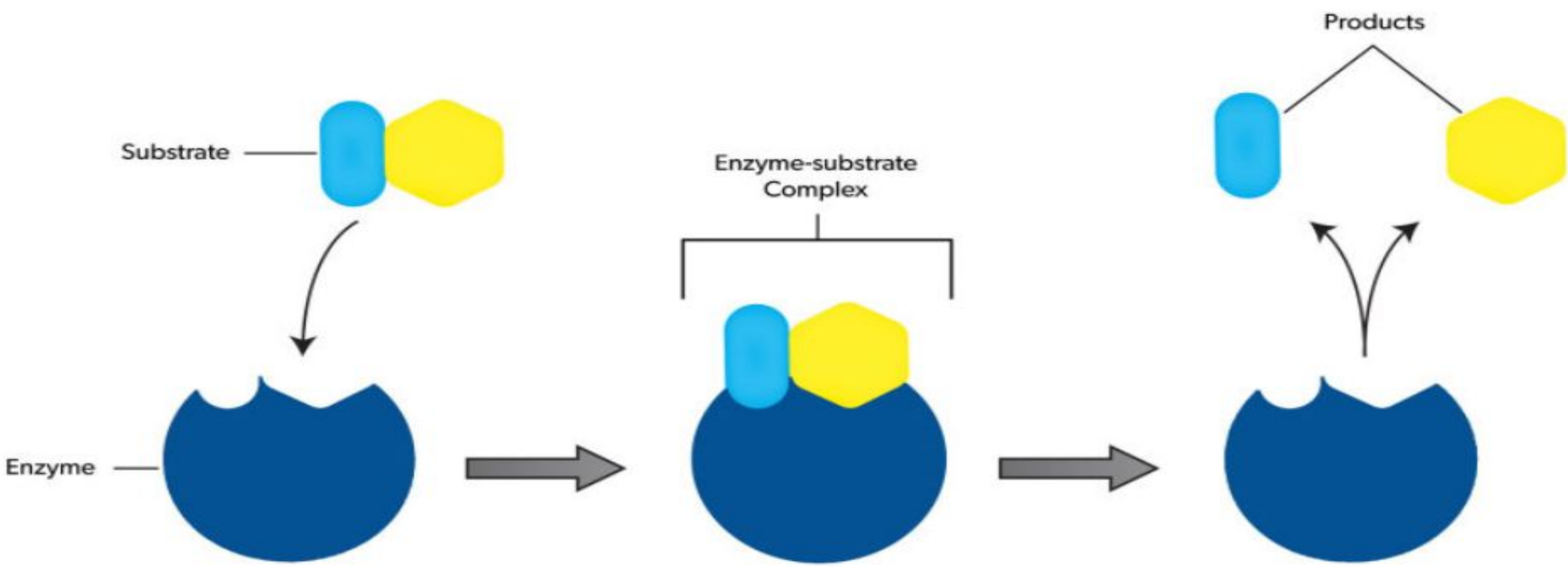




Lock and Key hypothesis (1894)	Induced Fit Hypothesis (1958)
The active site is like a "lock" to which substrate fits like a "key" The enzymes active site and substrate should fit like lock & key to initiate a reaction (E-S complex)	•"a hand in a glove model" •Binding of substrate induces a conformational change in the active site & both adjust their shapes to provide optimal fit

Lock and Key Model

- A Lock and Key analogy may be used to describe the fundamental action of a single substrate enzyme.
- In this case, the enzyme is the lock, and the substrate is the key.
- The *active site of an enzyme is structured to fit a specifically shaped substrate*. Once the substrate binds to the active site, the enzyme will facilitate the reaction and release products of the reaction.



Induced-fit Model

In the induced-fit model of enzyme action:

- The active site is flexible, not rigid.
- The shapes of the enzyme, active site, and substrate adjust to maximum the fit, which improves catalysis.
- There is a greater range of substrate specificity.

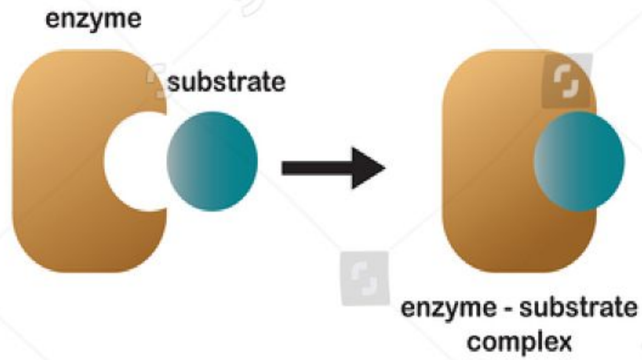
Induced fit model

Enzyme-substrate complex

Mechanism of ENZYME action

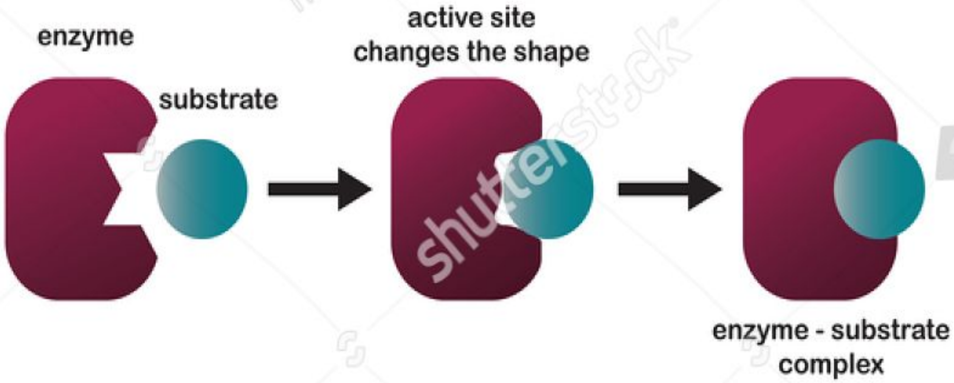
Lock and Key model

- Early theory for enzyme action
- Enzyme-substrate have specific shape to fit exactly into another



Induced Fit model

- Enzymes are flexible structures
- Active site can change the shape to fit with substrate
- Better, widely accepted theory




Thank you!