SNS COLLEGE OF ALLIED HEALTH SCIENCES

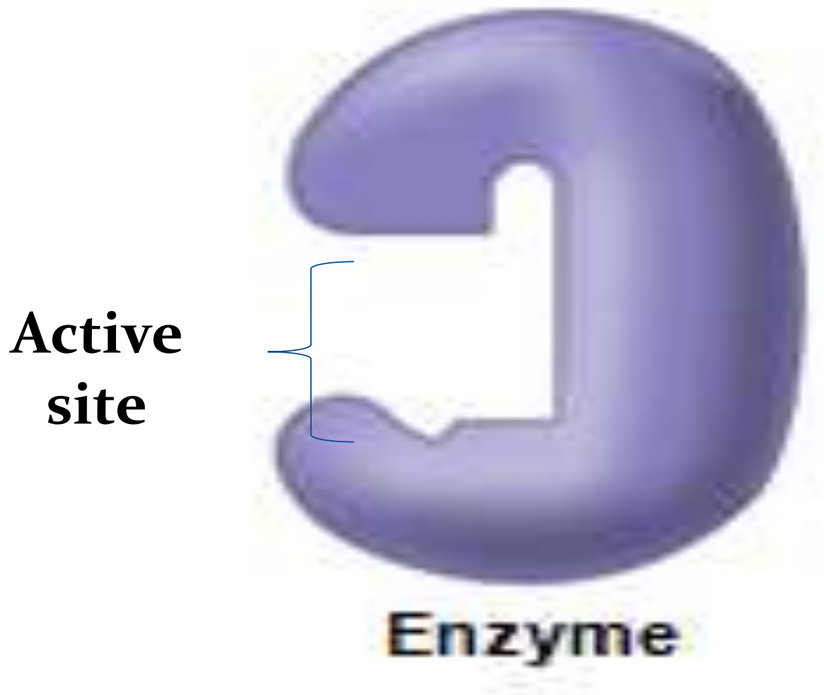
SNS Kalvi Nagar, Coimbatore - 35

Affiliated to Dr MGR Medical University, Chennai

COURSE NAME : BIOCHEMISTRY

TOPIC : ENZYMES

ENZYMES



- It is a globular protein which functions as a biological catalyst, speeding up reaction rate by lowering activation energy without being affected by the reaction it catalyse.
- Enzymes are highly specific for the type of the reaction they catalyze and for their substrate.

Enzymes

- Enzymes are energy barriers separating the reactants (substrates) and the products.
- Virtually all reactions in the body are mediated by enzymes, which are protein catalysts that increase the rate of reactions without being changed in the overall process.

Definitions:

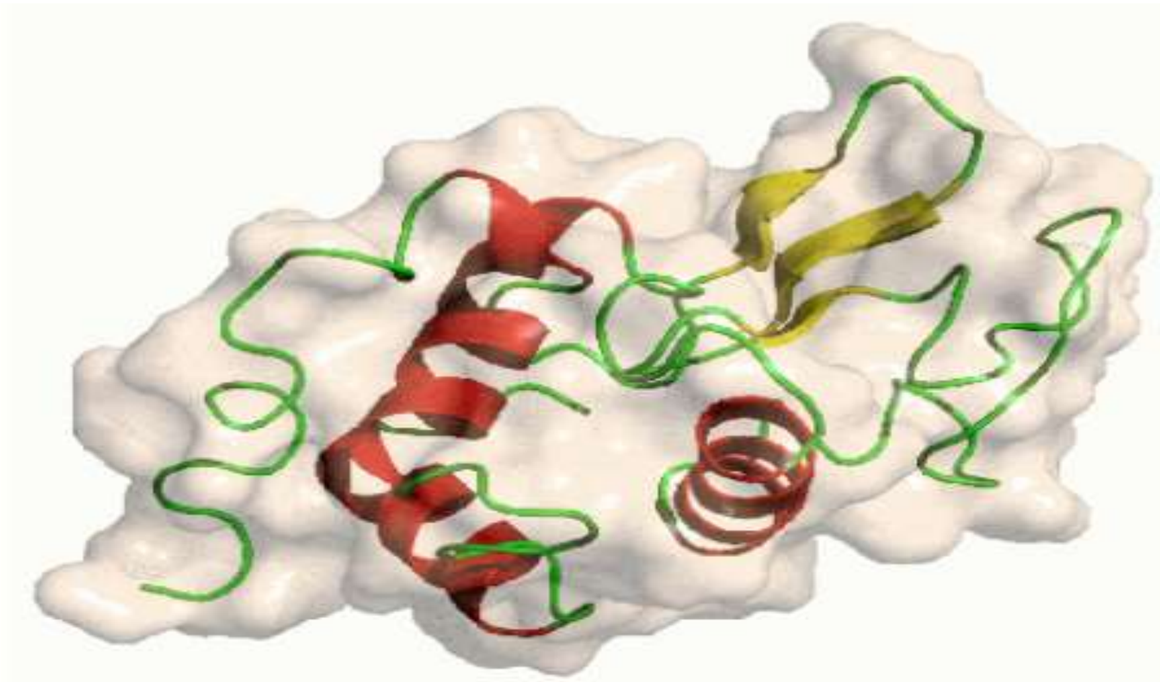
- **A. Enzymes**: These are

  - **1.** Accelerate the ra
  - **2.** Enzyme structure is not changed by entering the reactions,
  - **3.** Enzyme does not affect the equilibrium constant (i.e. end products) of the reactions.
- **B. Substrate:** Is the substance upon which the enzyme acts.

Enzymes are protein in nature

- Globular protein.
- Ribozymes are RNA molecule with enzymatic activity.
- Catalytic behaviour of any enzyme depends upon its primary, secondary, tertiary or quaternary structure.
- Enzymes of digestive tract and those found in blood are present in inactive form called **zymogen or proezymes.**

- Enzymes are biological catalysts that increase the reaction rate of biochemical reactions.



The enzyme shown is lysozyme

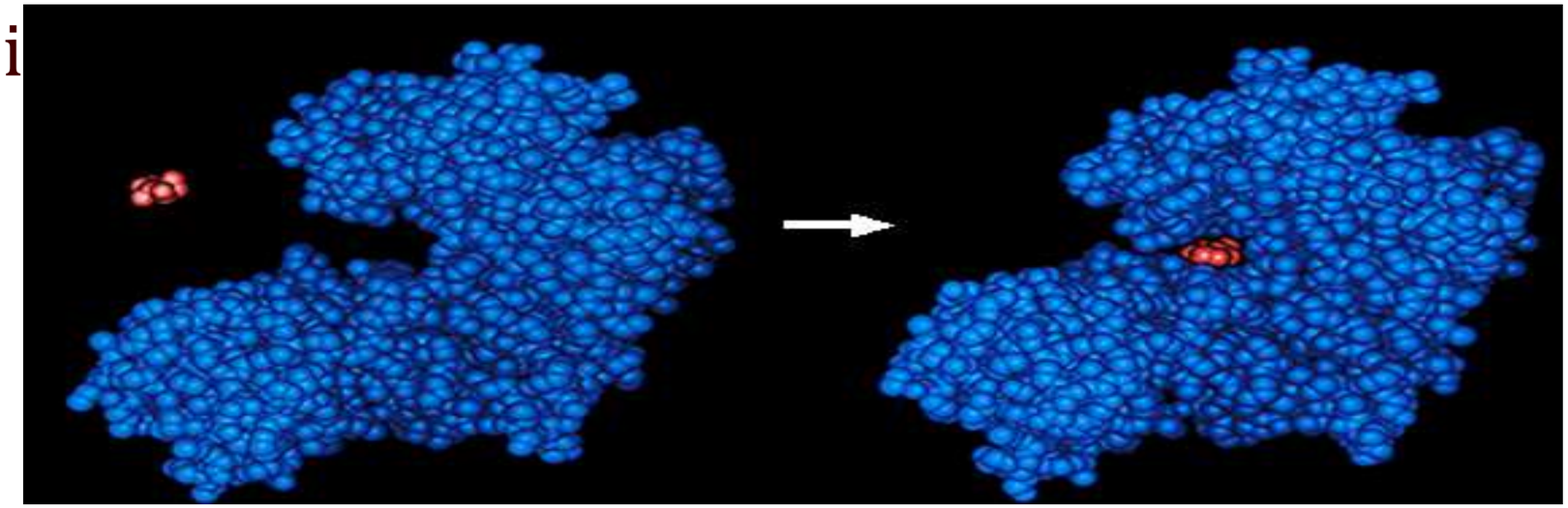
Characteristics of enzymes

A. Made of proteins (or RNA).

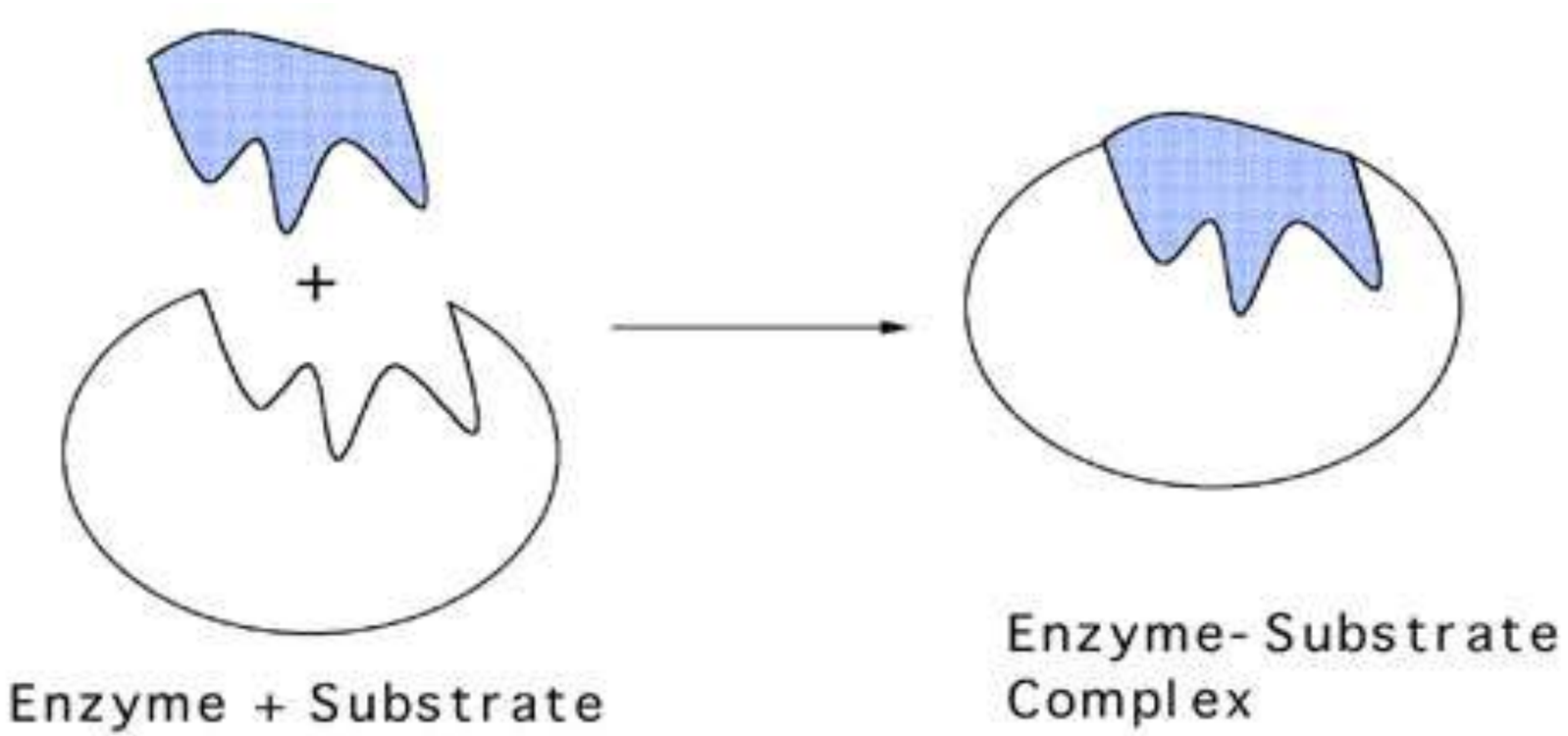
B. They are very specific and only work with a certain set of reactants or substrates that fit on their active site.

C. Enzymes can be used over and over again.

D. When an enzyme binds with the substrate, the substrate interacts with the enzyme causing it to change shape. This change in shape facilitates the chemical reaction to occur. This is called the i



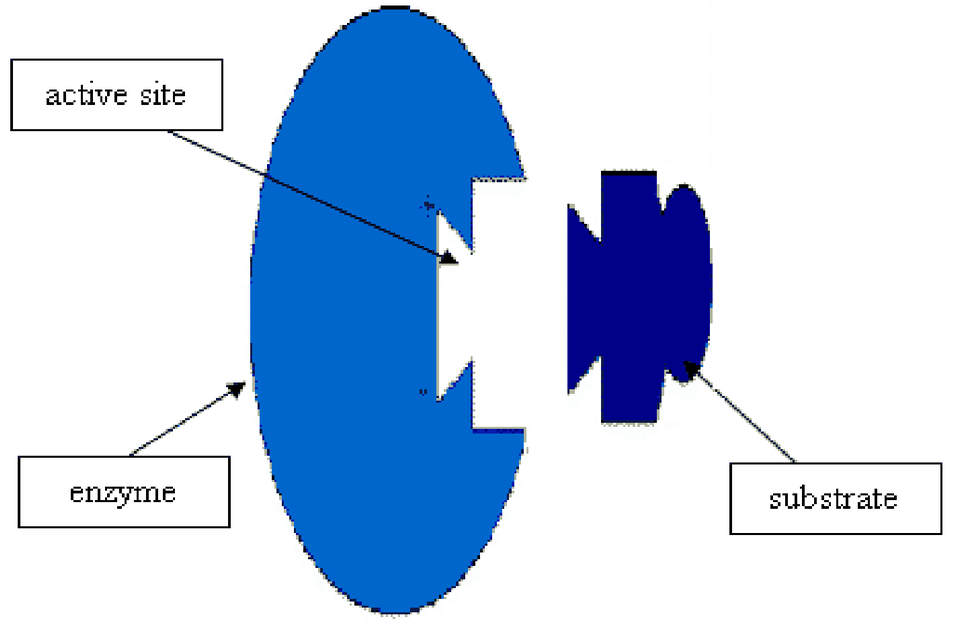
When an enzyme is interacting with it's substrate, during the chemical reaction, together they are referred to as the …



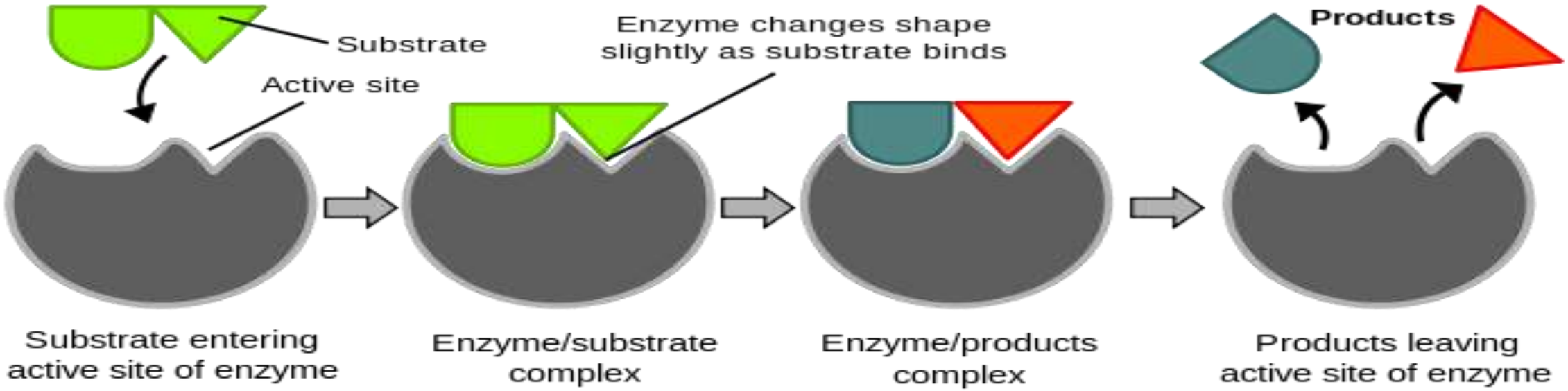
Active site

- Enzymes are composed of long chains of amino acids that have folded into a very specific three-dimensional shape which contains an active site.

- An **active site** is a region on the surface of an enzyme to which substrates will bind and catalyses a chemical reaction.



Enzymes


Substrate
Active site
Enzyme changes shape slightly as substrate binds
Products
Substrate entering active site of enzyme
Enzyme/substrate complex
Enzyme/products complex
Products leaving active site of enzyme

Some enzyme require non protein molecule for their activity. So enzymes are conjugated proteins known as **Holoenzyme**.

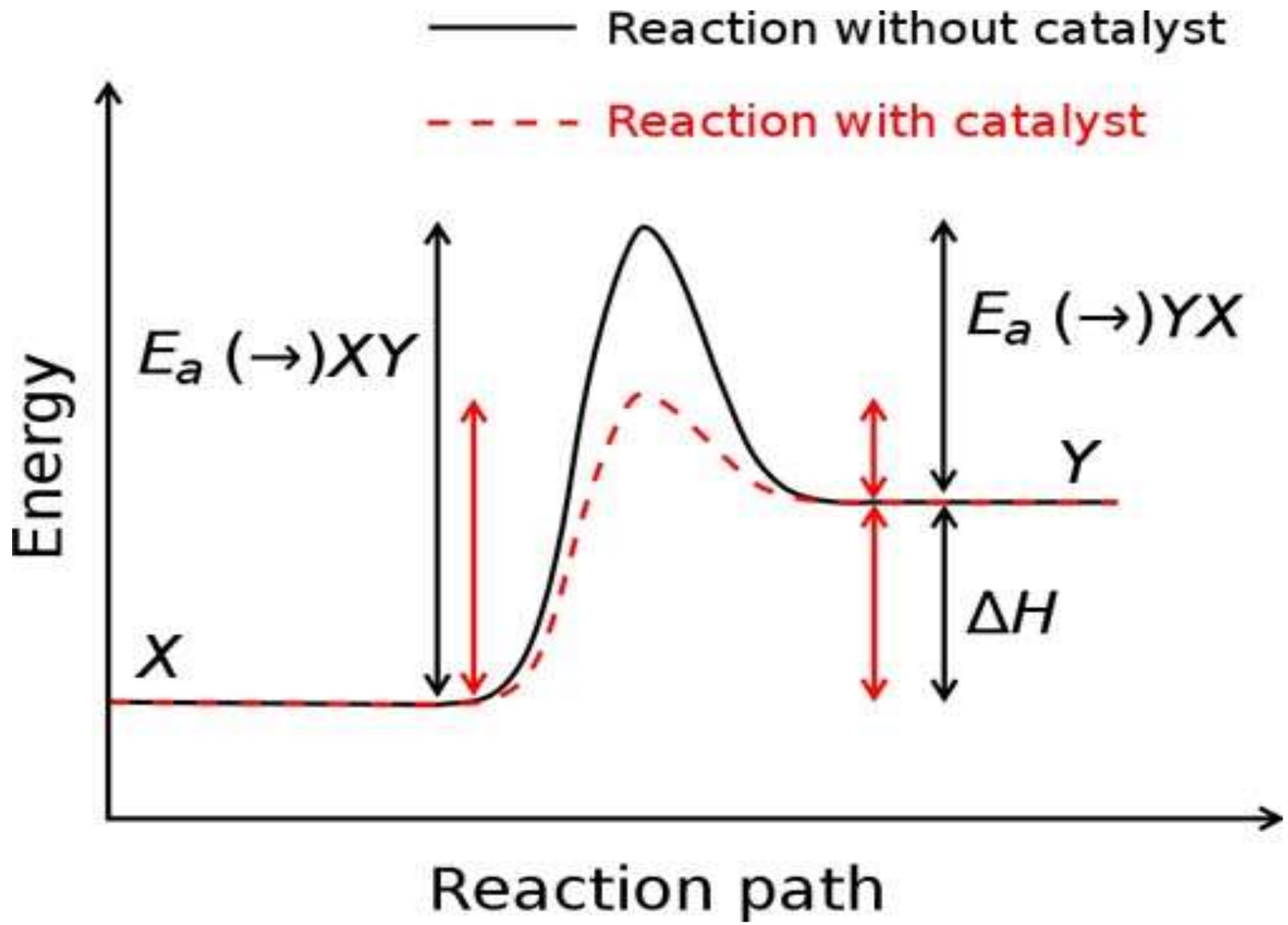
Holoenzyme = Apoenzyme + Cofactor/coenzyme

Enzyme without non protein part is inactive and called apoenzyme.

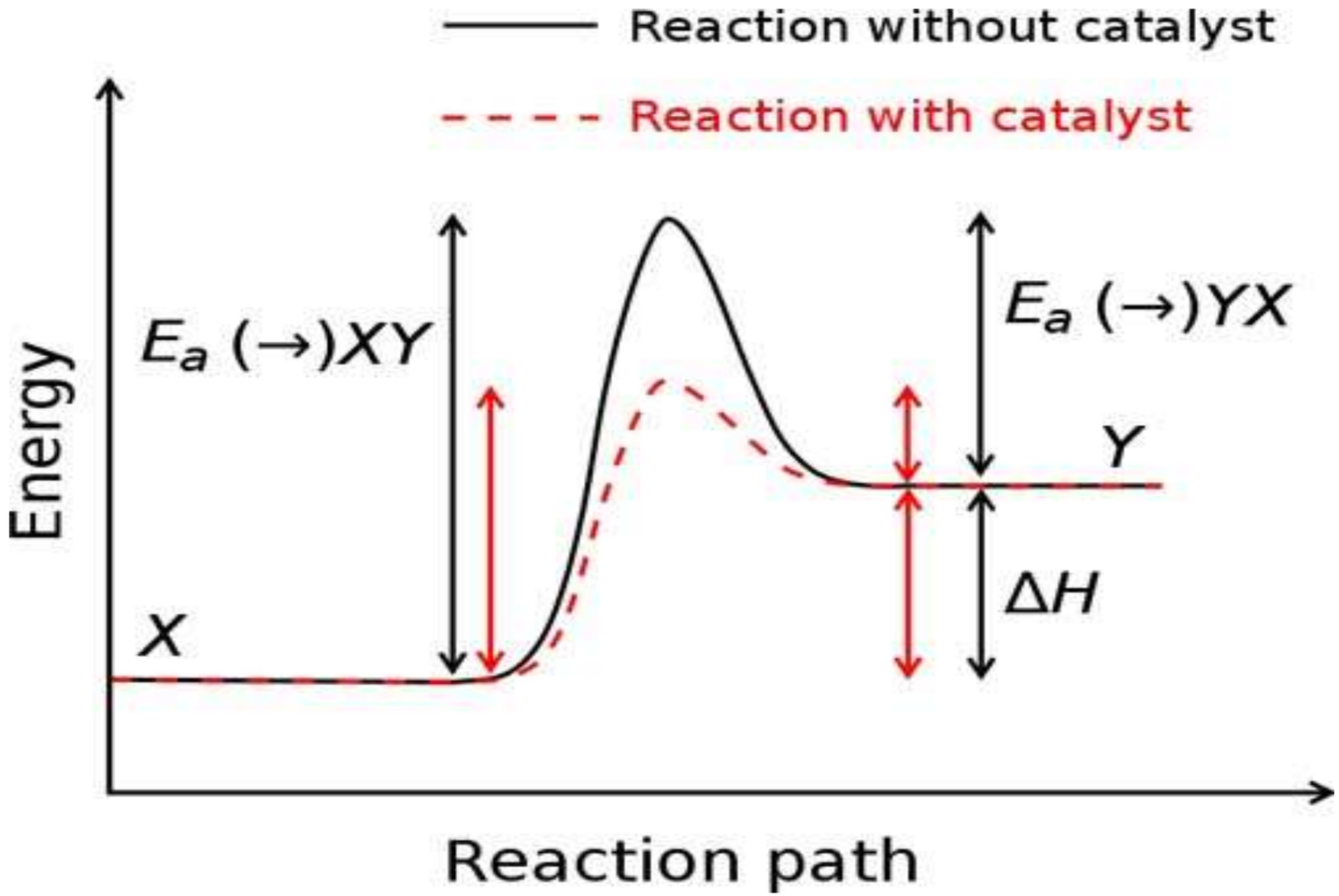
Cofactors can be either inorganic or organic compounds .

What do enzymes do?

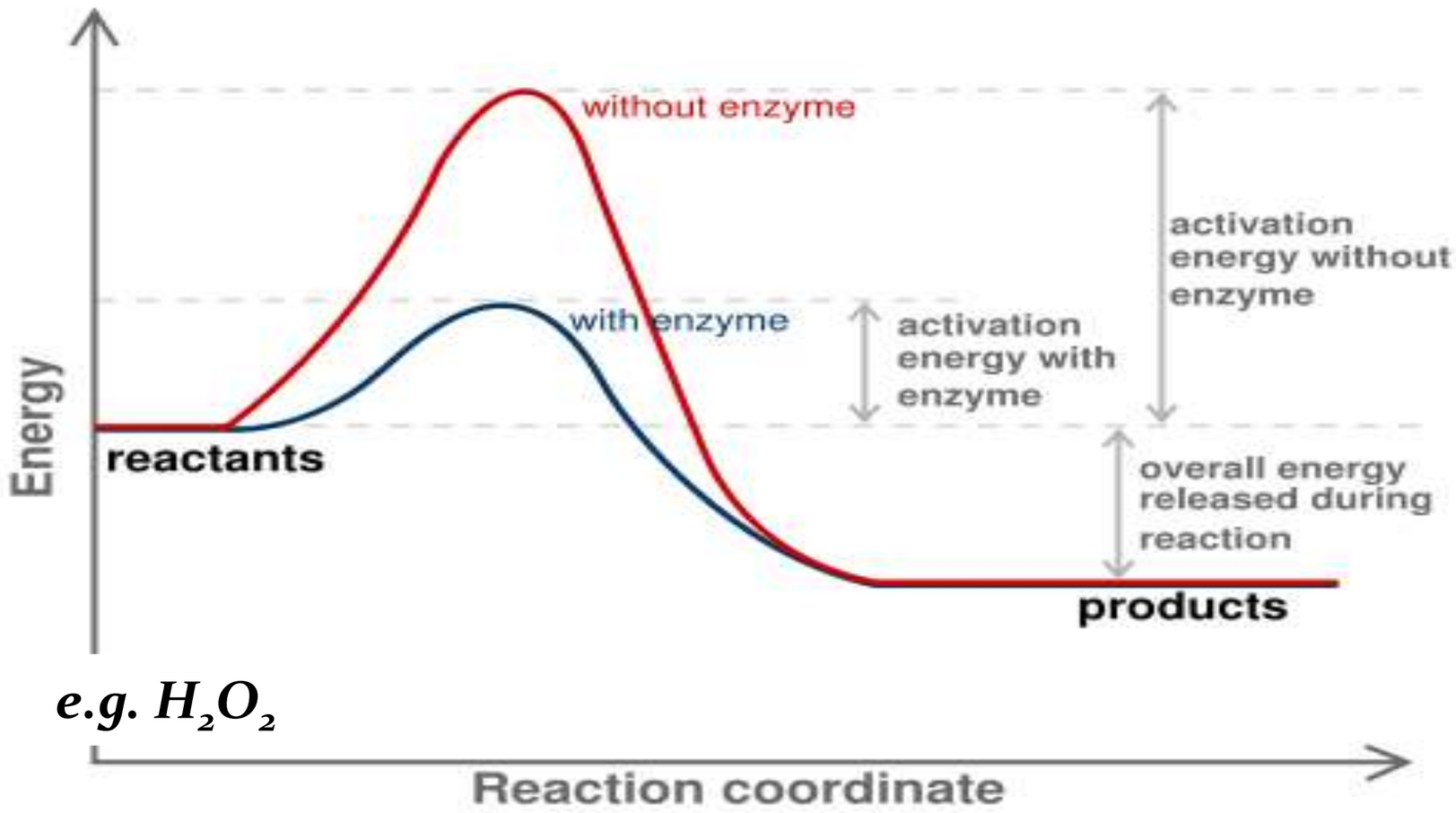
Enzymes act as **catalysts** in cellular reactionsnnn



How do enzymes work?



Enzymes catalyze reactions by weakening chemical bonds, which lowers **activation energy**.



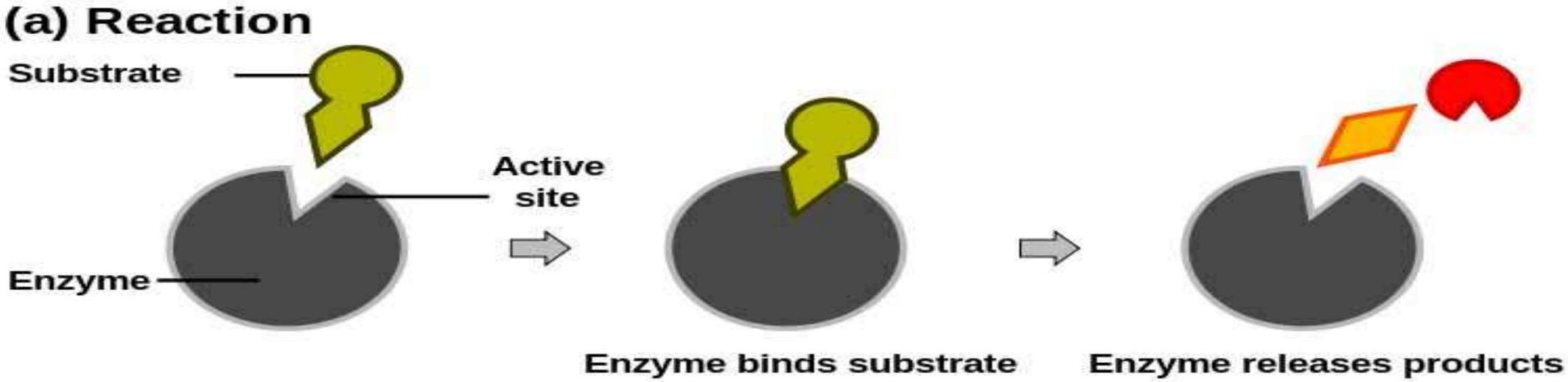
e.g. H_2O_2

Progress of Reaction

e.g. $O_2 + H_2O$

How do enzymes work?

- Each enzyme has a unique 3-D shape, including a surface groove called an **active site**.
- The enzyme works by binding a specific chemical reactant (**substrate**) to its active site, causing the substrate to become unstable and react.
- The resulting **product**(s) is then released from the active site.



Nomenclature / enzyme classification

IUBMB has recommended system of nomenclature for enzymes & according to them each enzyme is assigned with two names:

- ✓**Trivial name** (common name, recommended
- ✓name).

- ✓**Systemic name** (official name).

Systemic name

Each enzyme is characterized by a code no.called Enzyme Code no. or **EC number** and contain four Figure (digit) separated by a dot.

e.g. **EC m. n. o. p**

First digit represents the class;

Second digit stands for subclass ;

Third digit stands for the sub-sub class or subgroup;

Fourth digit gives the serial number of the particular enzyme in the list.

e.g. **EC 2.7.1.1 for hexokinase.**

Systemic name……

According to the IUBMB system of enzyme nomenclature enzymes are grouped into 6 major classes

EC 1 OXIDOREDUCTASES

EC 2 TRANSFERASES

EC 3 HYDROLASES

EC 4 LYASES

EC 5 ISOMERASES

EC 6 LIGASES

Classification of enzymes:

There are 6 classes of enzymes which are:

A. Oxidoreductase: This group of enzymes catalyzes an oxidation-reduction reaction between two substrates:

S (oxidized) + Y *(reduced)* → S *(reduced)* + Y (oxidized).

1. Oxidoreductases are further classified according to the substrate oxidized and to the mechanism of oxidation.

2. The mechanism of oxidation is either by removal of hydrogen (dehydrogenase&) or by addition of oxygen (oxidases).

B. Transferase: This group of enzymes catalyzes the transfer of a group other than hydrogen from one substrate to another:

1. They are further classified according to the group transferred into: phosphotransferases, transaminases, transketolases, transacylase, transformylases and transmethylases. Synthase enzymes are transferase enzymes.

2. Example:

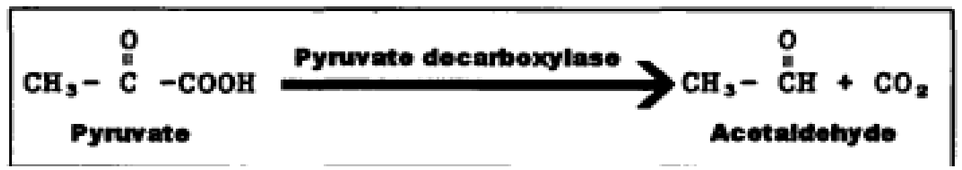
a) **Phosphotransferases: Kinases:**

b) **Acyltransferases: syntheses:**

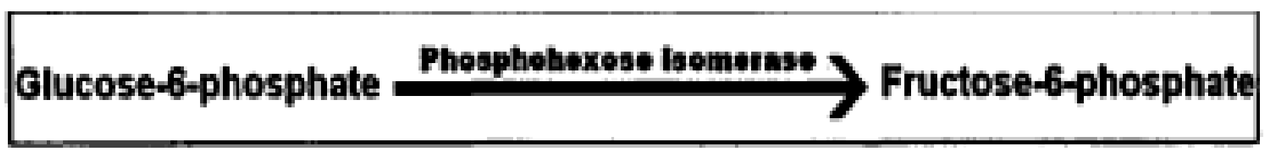
- **C. Hydrolase**: this group catalyzes hydrolysis i.e. breakdown of a chemical bond by addition of water: A·B HOH • AH + BOH

  Example: peptidase:

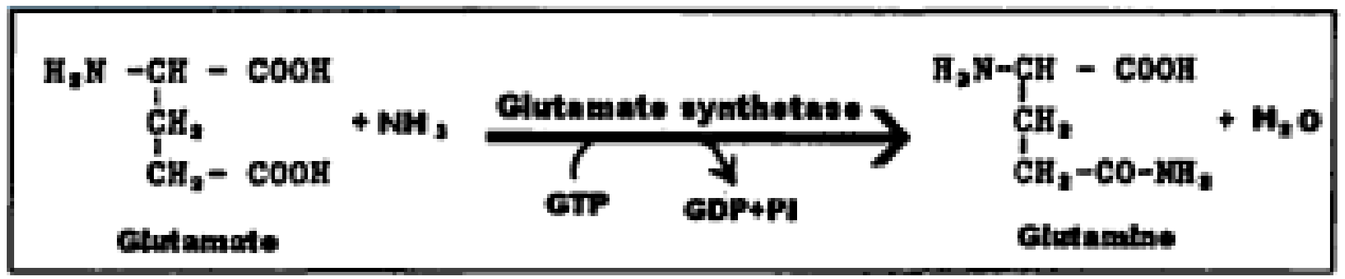
D. Lyases: This group of enzymes catalyzes addition of carbon dioxide, water and ammonia across double bonds, or removes these elements to produce double bonds. Example: Decarboxylase:



- **E. Isomerases:** This group of enzymes catalyzes the Interconversion of one isomer into another. This group Includes: Isomerases, mutases and eplmerases. Example: phosphohexose Isomerase:



- **F. Ligases for synthetases**: This group of enzymes catalyzes joining of two substrates using the energy from ATP or GTP. Example: Glutamine synthetase.



Factors affecting enzyme activity

Temperature

Hydrogen ion concentration (pH)

Substrate concentration

Enzyme concentration

Products of the reaction

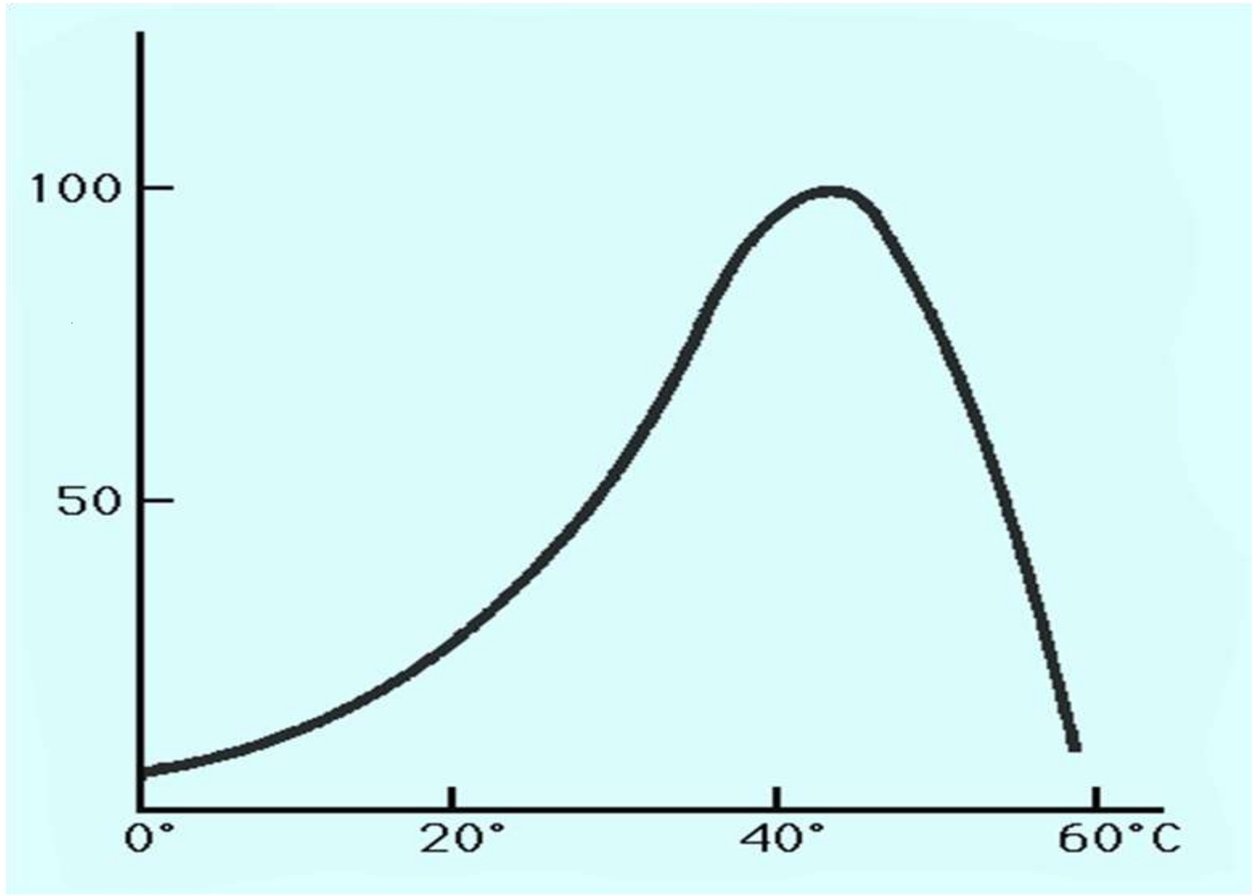
Presence of activator/inhibitor

Cofactors & Coenzymes

Allosteric effects

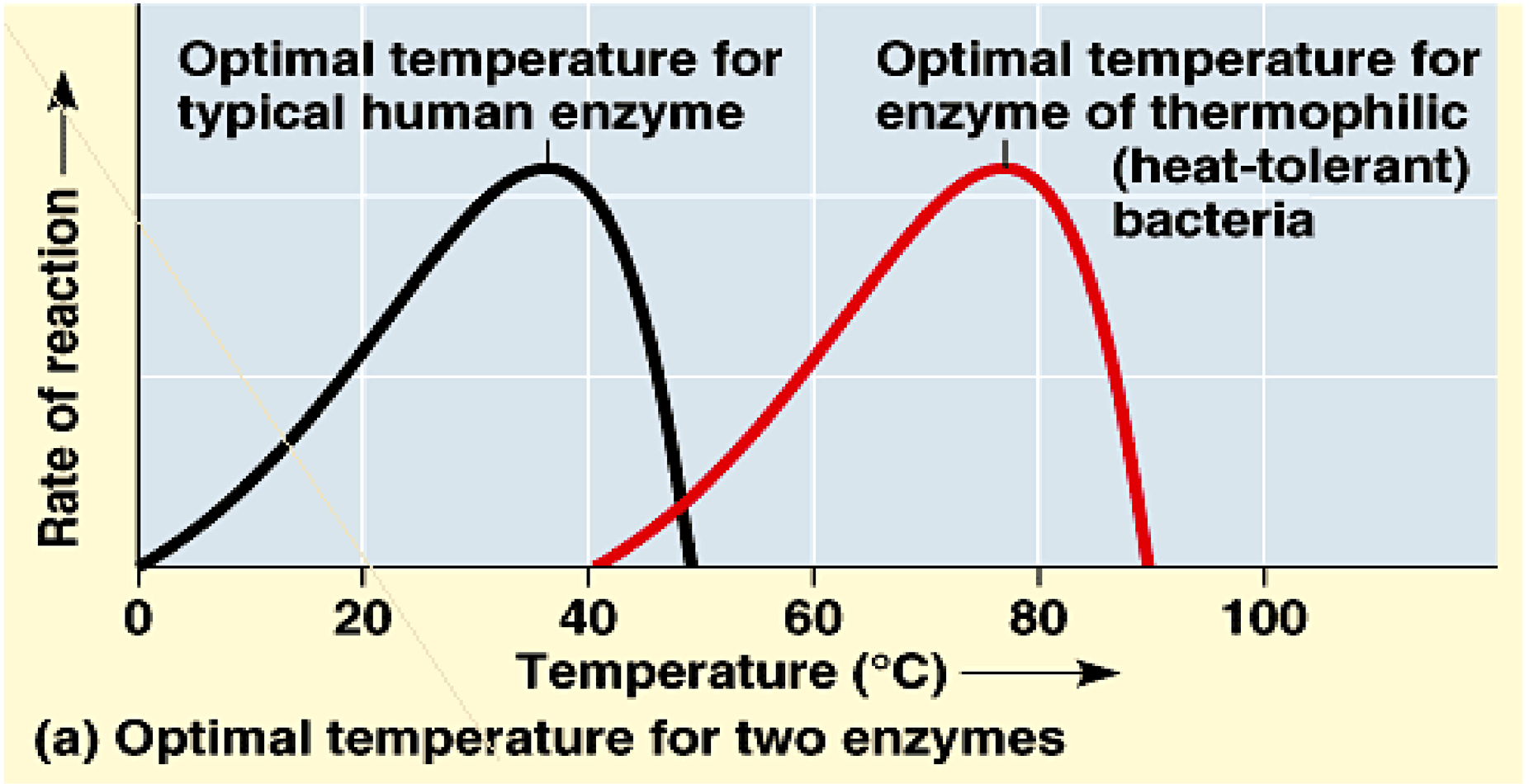
Time

Effect of Temperature



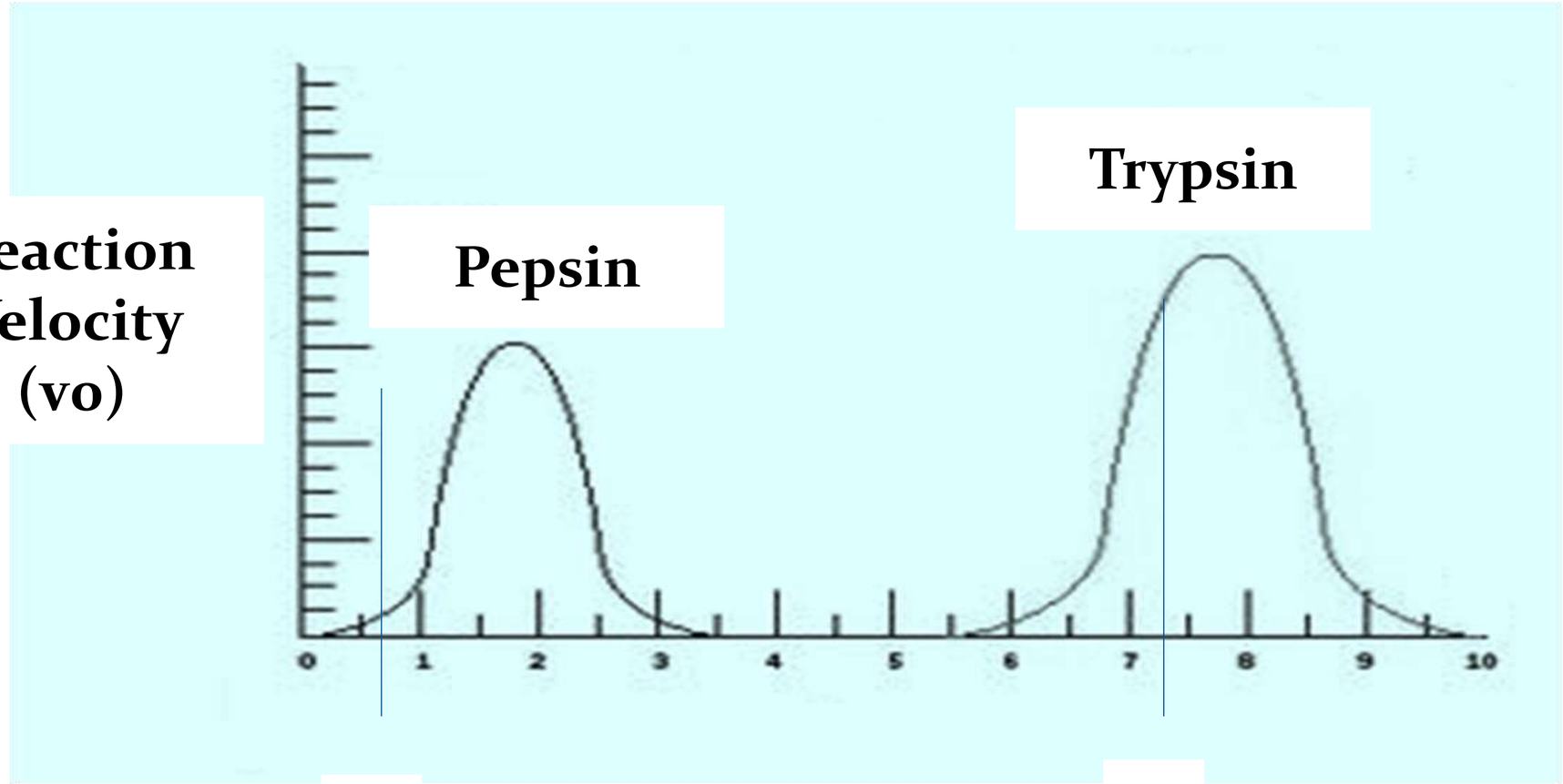
Reaction Velocity (vo)

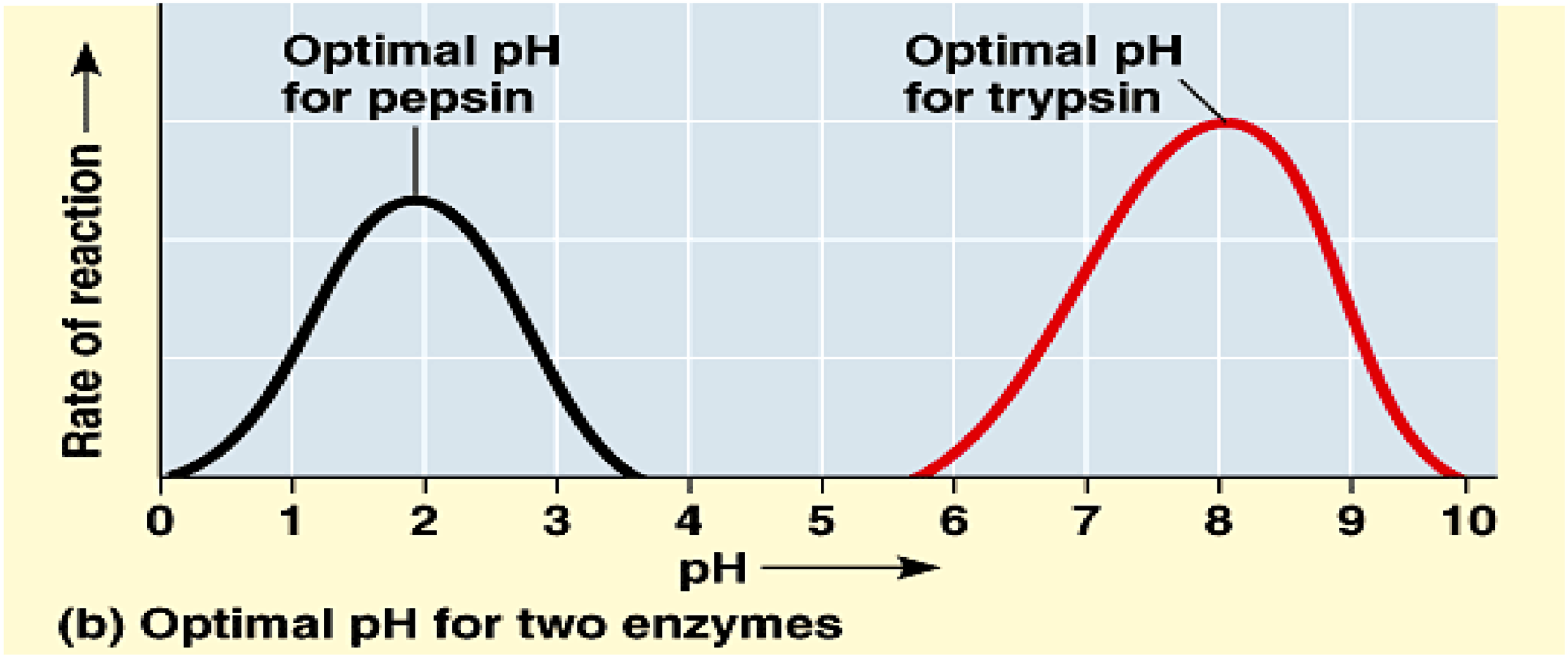
Temperature(°C)



(a) Optimal temperature for two enzymes

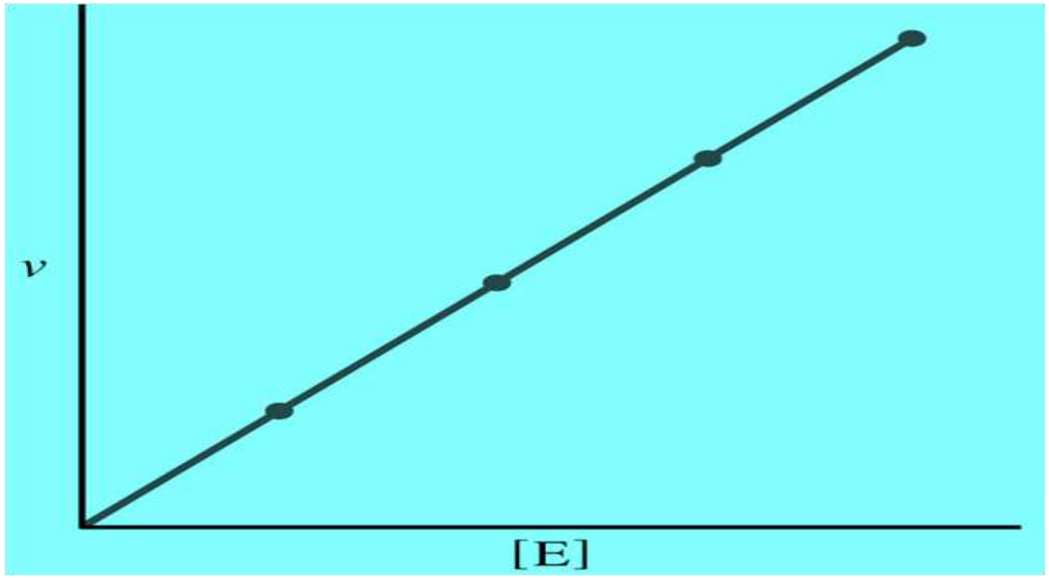
Effect of pH





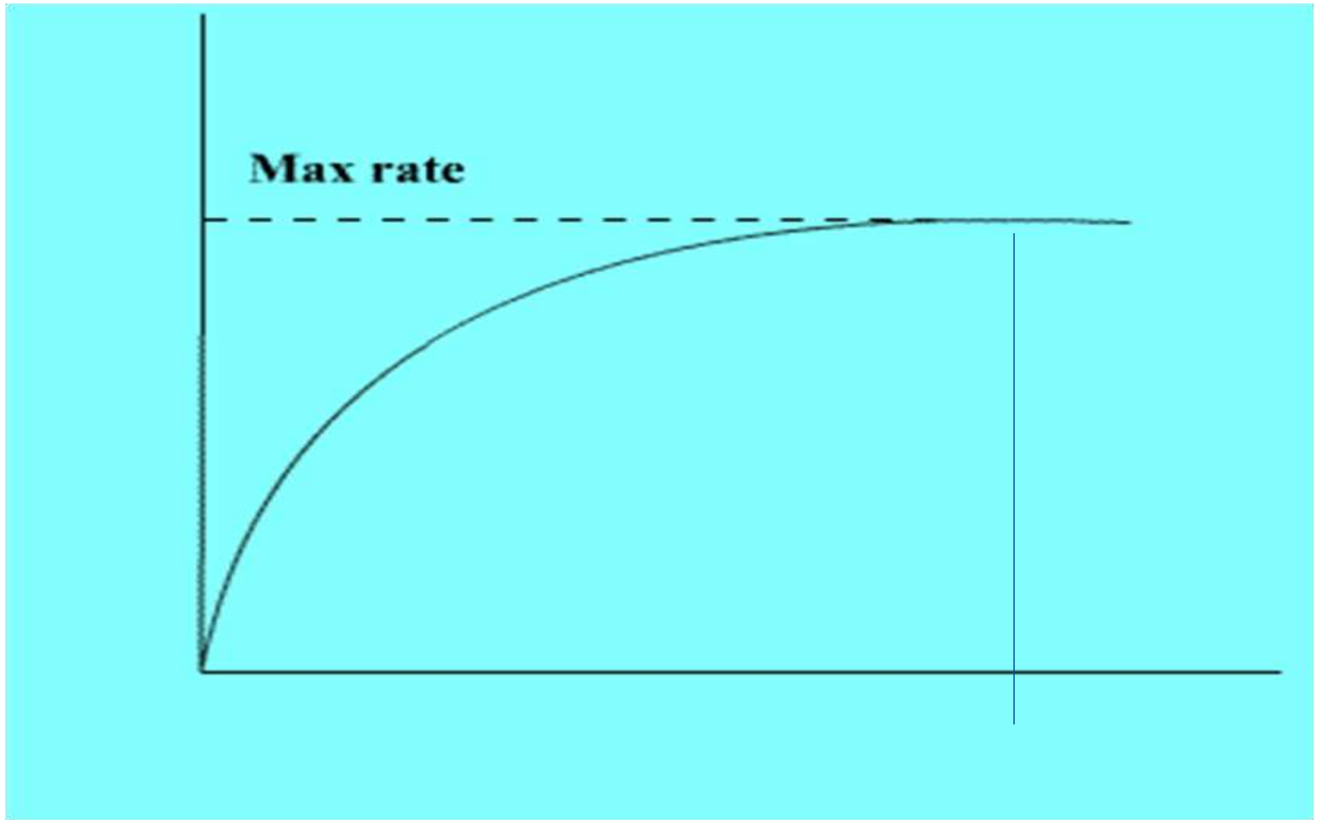
(b) Optimal pH for two enzymes

- Rate of the reaction or velocity is directly propotional to the Enzyme Concentration when sufficient substrate is present.

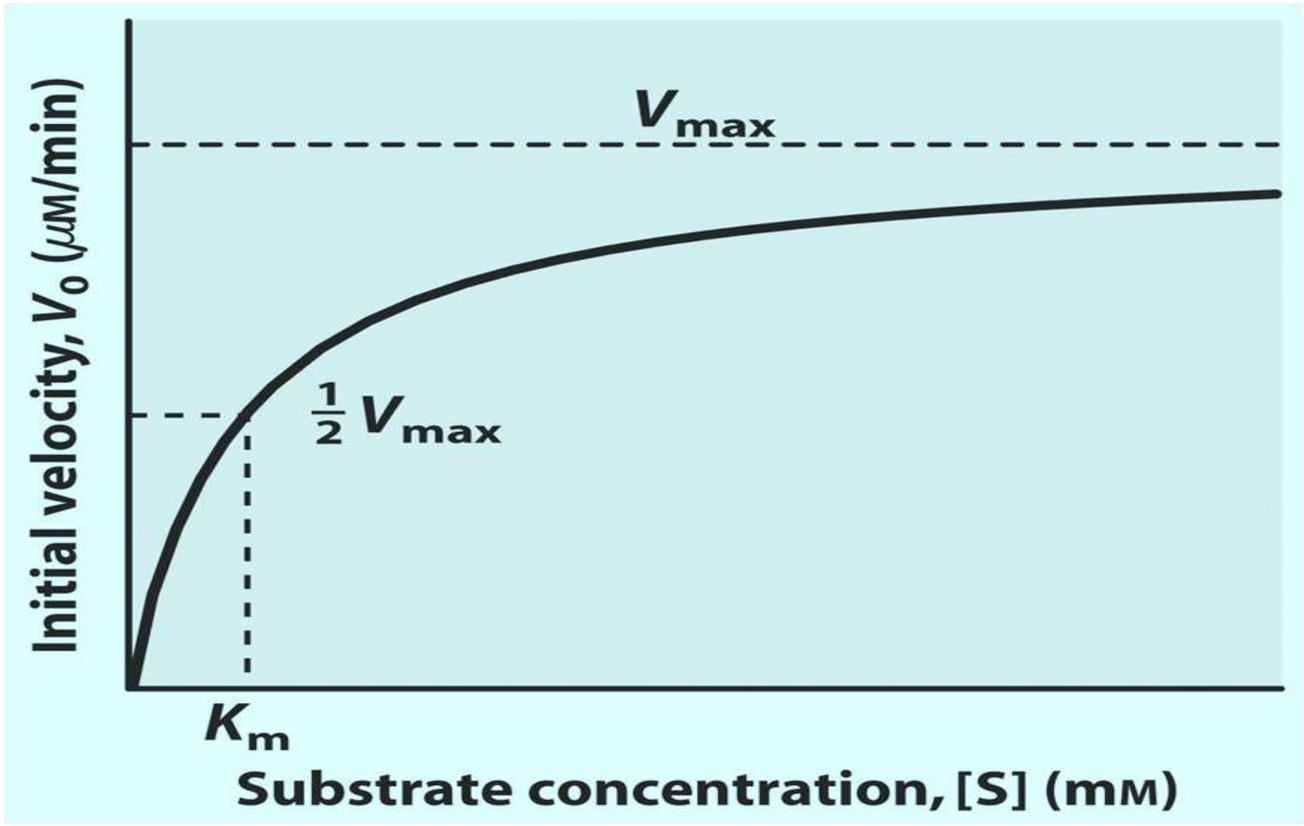


- Accumulation of Product in a reaction causes inhibition of enzyme activity.

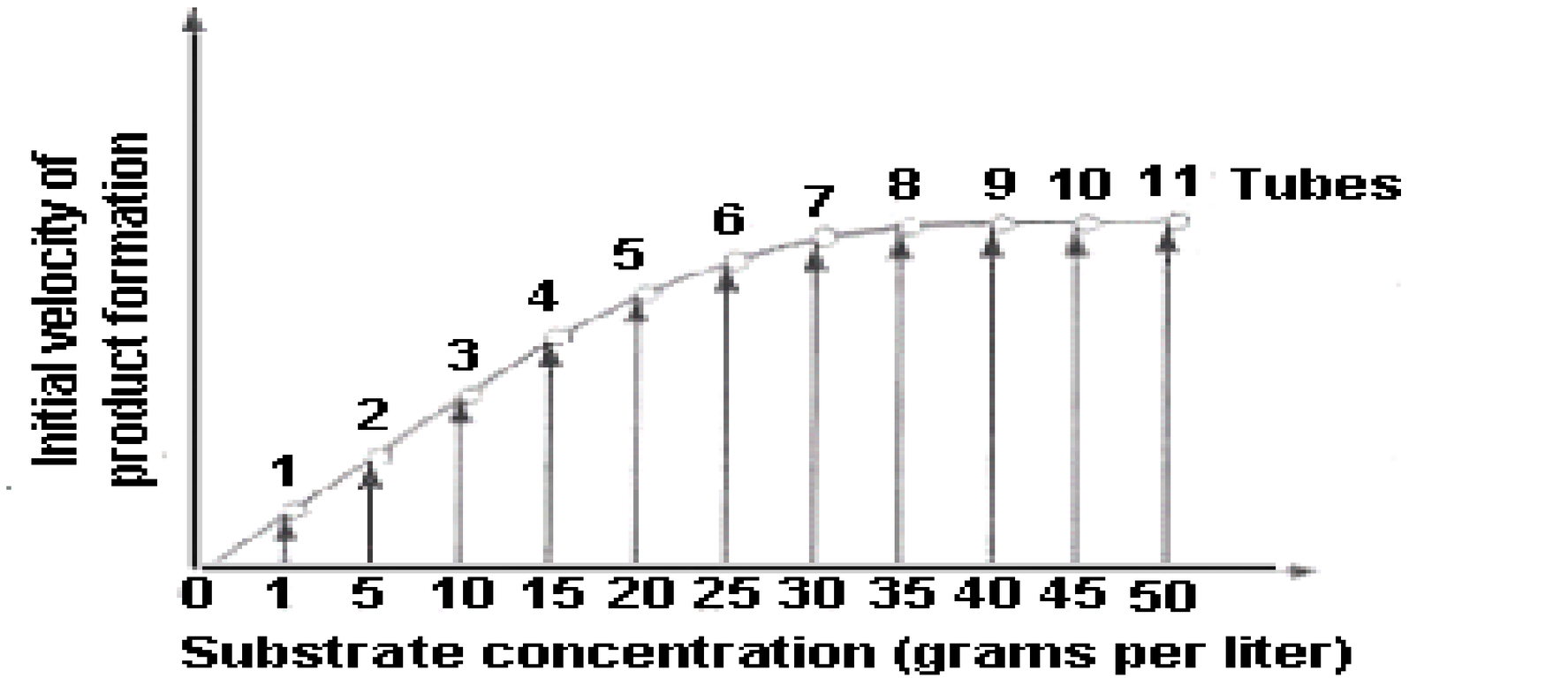
Effect of Substrate Concentration



Effect of Substrate Concentration on Reaction Velocity



Effect of Increasing Substrate Concentration



Fixed amount of enzyme, but increasing amounts of substrate carried out in eleven test tubes

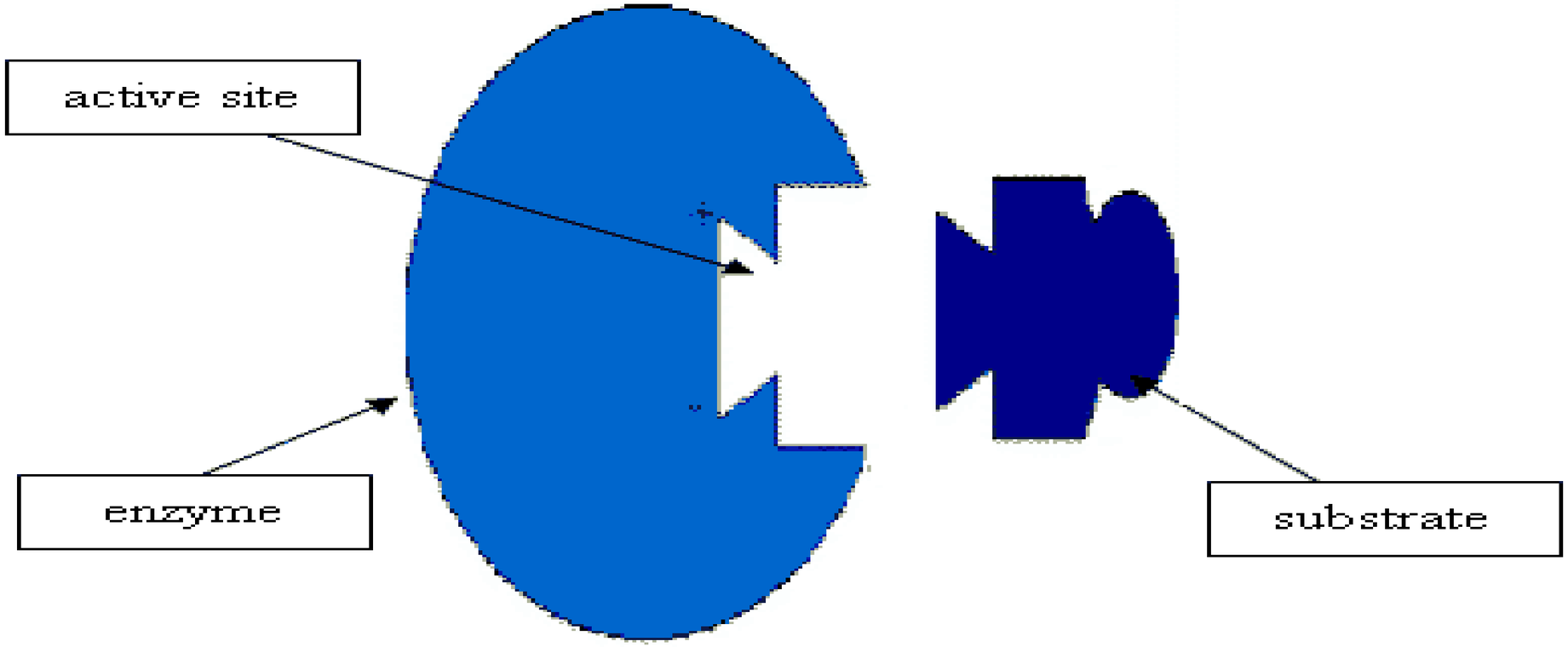
Mechanism of enzyme action

The enzymatic reactions takes place by binding of the substrate with the active site of the enzyme molecule by several weak bonds.

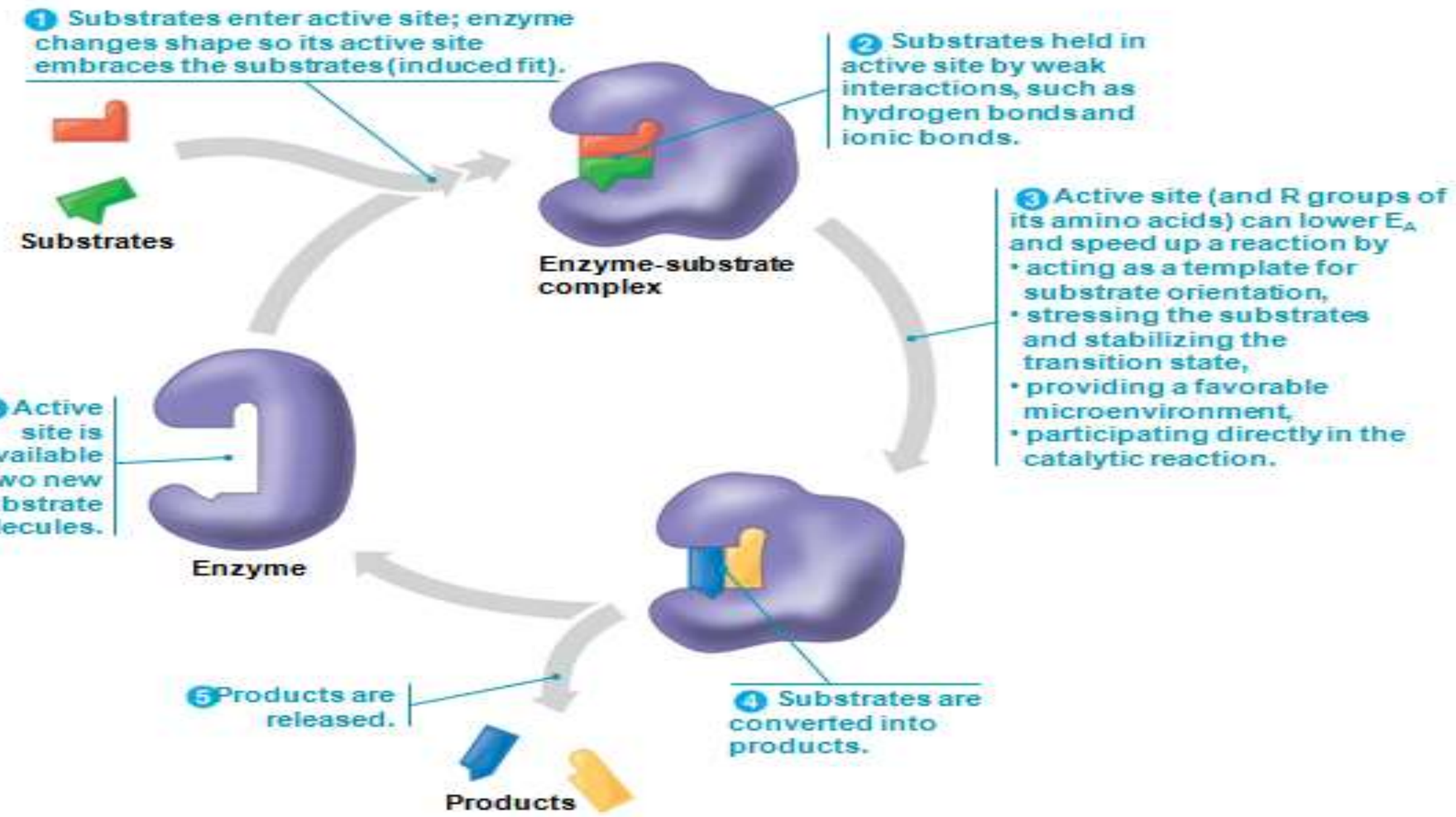
E + S ‹--------› ES --------› E + P

Formation of ES complex is the first step in the enzyme catalyzed reaction then ES complex is subsequently converted to product and free enzyme.

"Lock and key" or Template model



Induced-fit model



Enzyme Inhibiton

- Any substance that can diminish the velocity of an enzyme catalyzed
- These include drugs, antibiotics, poisons, and anti-metabolites.
- Useful in understanding the sequence of enzyme catalyzed reactions, metabolic regulation, studying the mechanism of cell toxicity produced by toxicants.
- Forms the basis of drug designing.

Enzyme Inhibitors

Blocking an enzyme's activity can kill a pathogen or correct a metabolic imbalance.

Many **medications** are enzyme inhibitors.

Enzyme inhibitors are also used as **herbicides** and **pesticides**.

EXAMPLE:

- Another example of competitive inhibition is **protease inhibitors**.
- They are a class of **anti-retroviral drugs** used to treat HIV.
- The structure of the drug ritonavir *(say ri-TAHN-a-veer)* **resembles the substrate of HIV protease**, an enzyme required for HIV to be made.

Types of Enzyme Inhibiton

- Reversible inhibitors
- Irreversible inhibitors

Reversible inhibitors can be classified into :

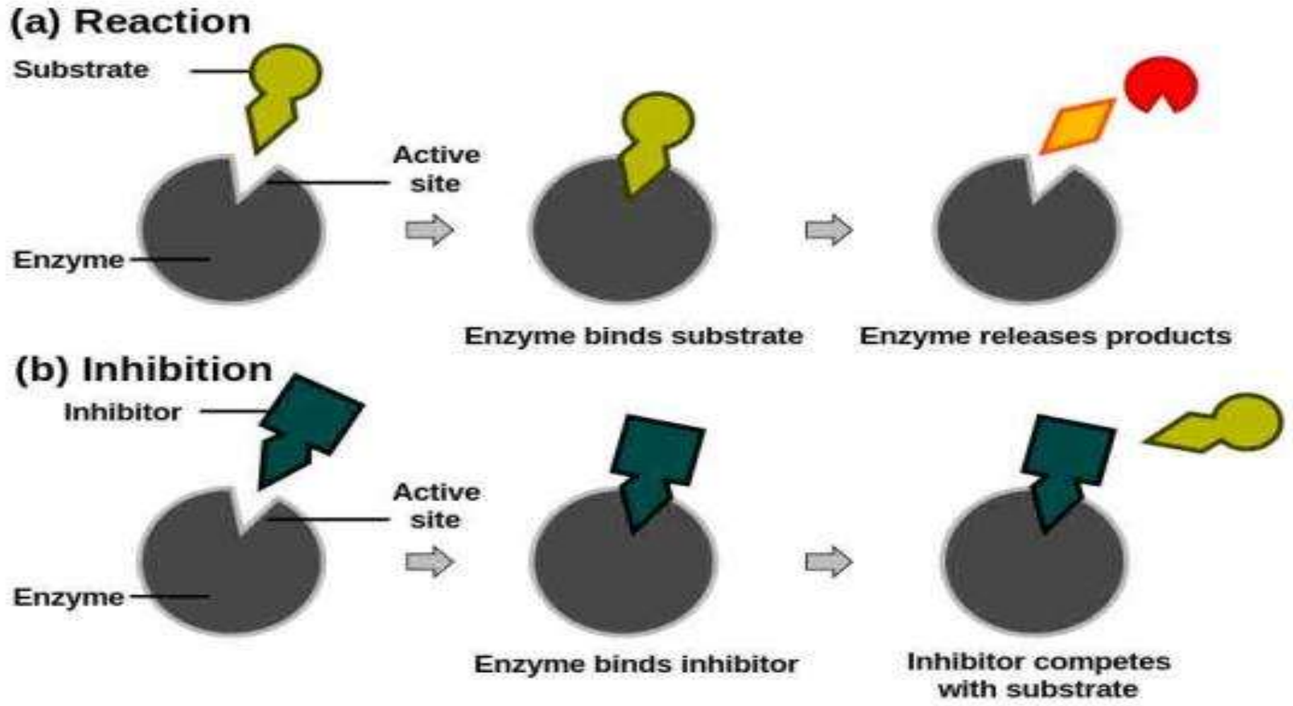
- **Competitive**
- **Non-competitive**
- **Un-competitive**

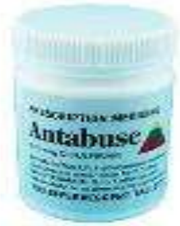
Two Types of Enzyme Inhibitors

1. Competitive inhibitor

Chemicals that resemble an enzyme's normal substrate and compete with it for the active site.

Reversible depending on concentration of inhibitor and substrate.





EXAMPLE: The drug **Antabuse** is used to help alcoholics quit drinking. Antabuse ***inhibits aldehyde oxidase***, resulting in the accumulation of acetaldehyde during the metabolism of alcohol. Elevated acetaldehyde levels cause symptoms of nausea and vomiting.

Competitive Inhibition

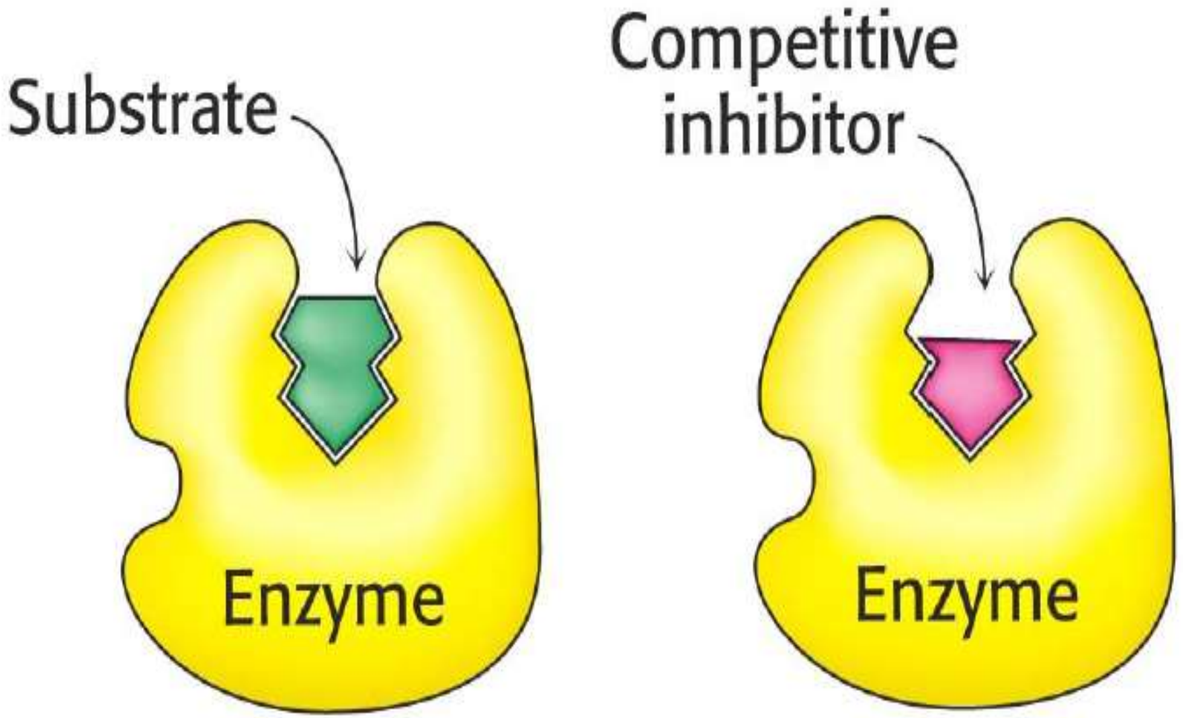
$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} P + E$$

$$+$$

$$I$$

$$K_I \Downarrow \Uparrow$$

$$EI + S \longrightarrow \text{NO REACTION}$$




Substrate
Active site
(a) A substrate can normally bind to the active site of an enzyme.

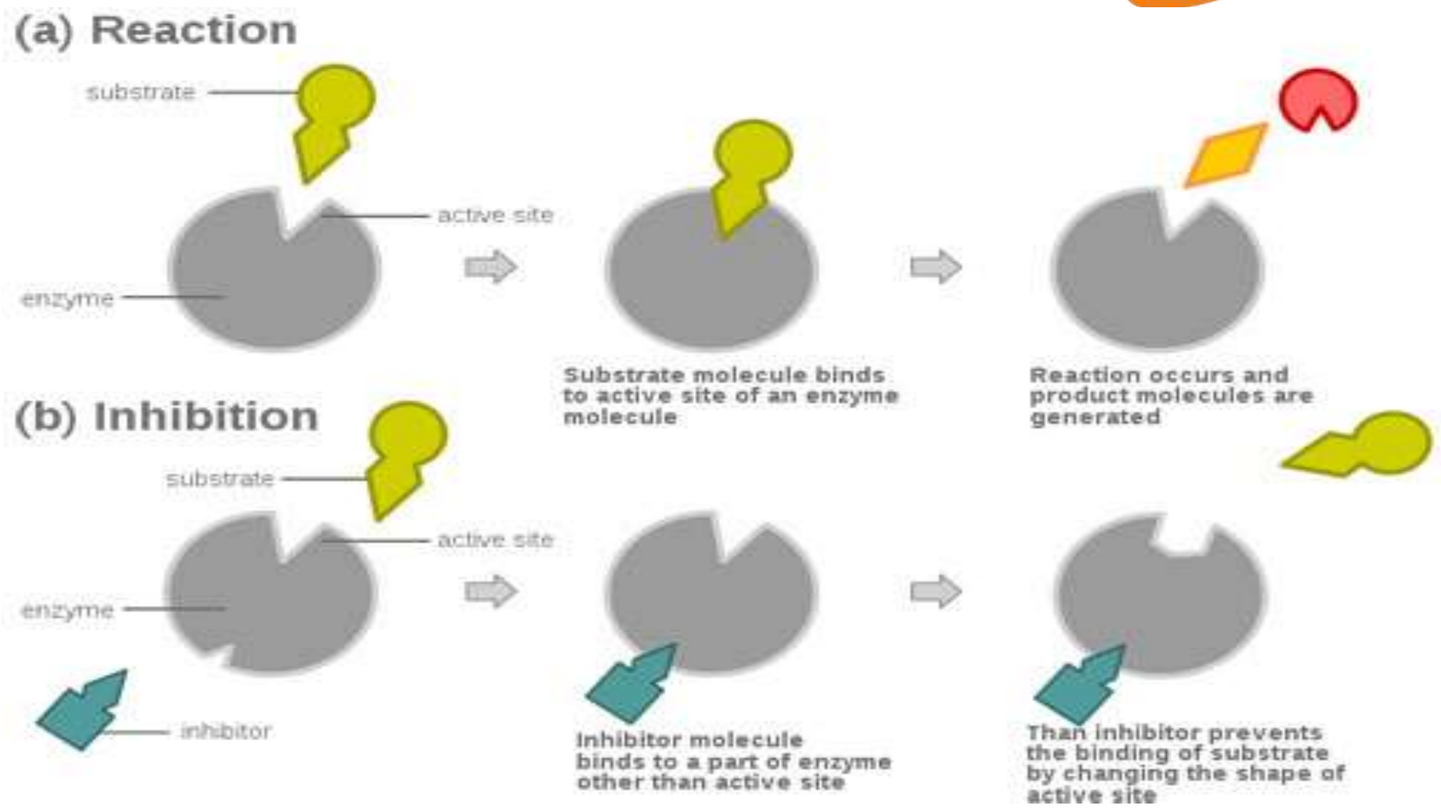

Competitive inhibitor
(b) A competitive inhibitor

Two Types of Enzyme Inhibitors

2. Non-competitive inhibitor

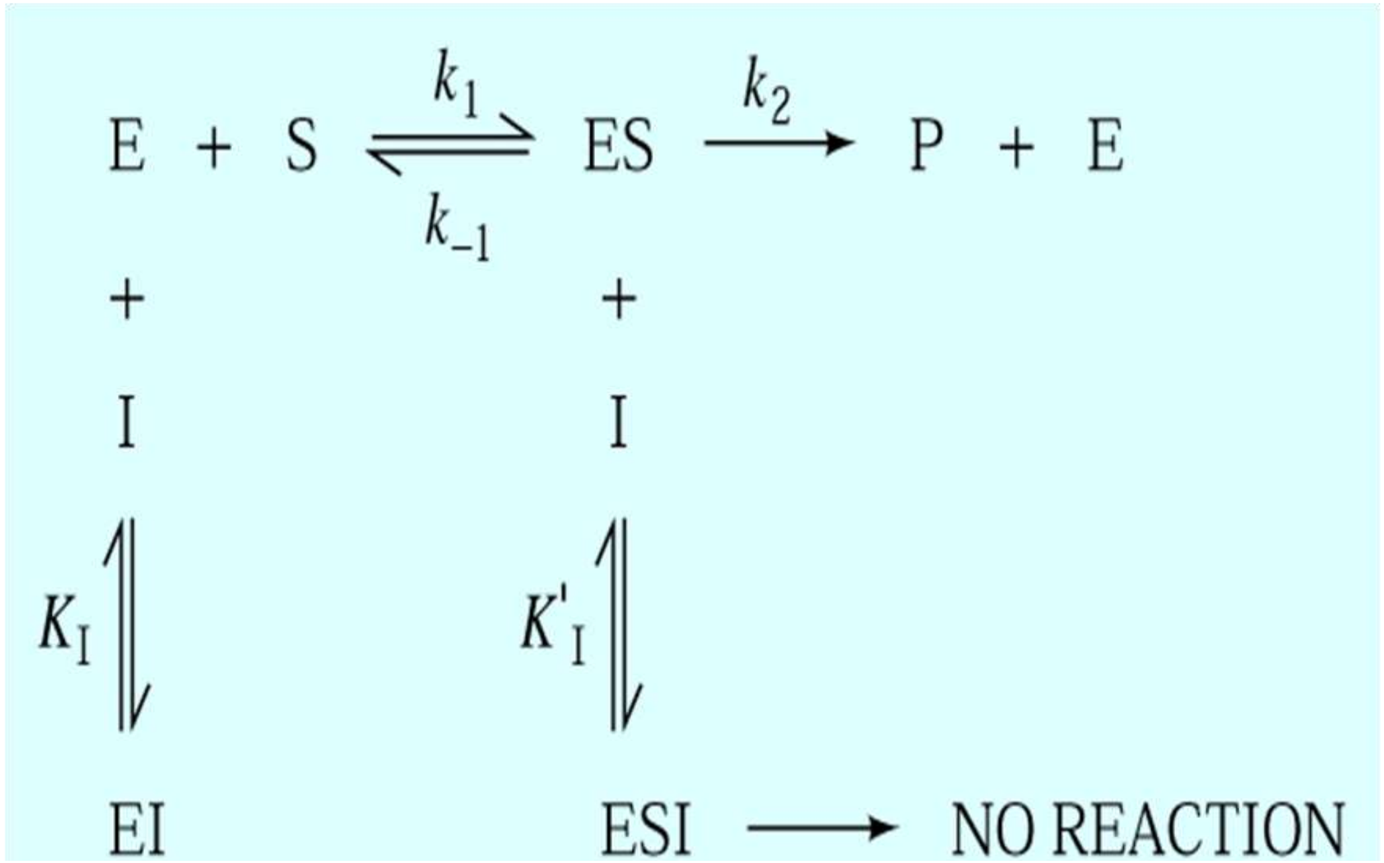
Do not enter active site, but bind to another part of the enzyme, causing the enzyme & active site to change shape.

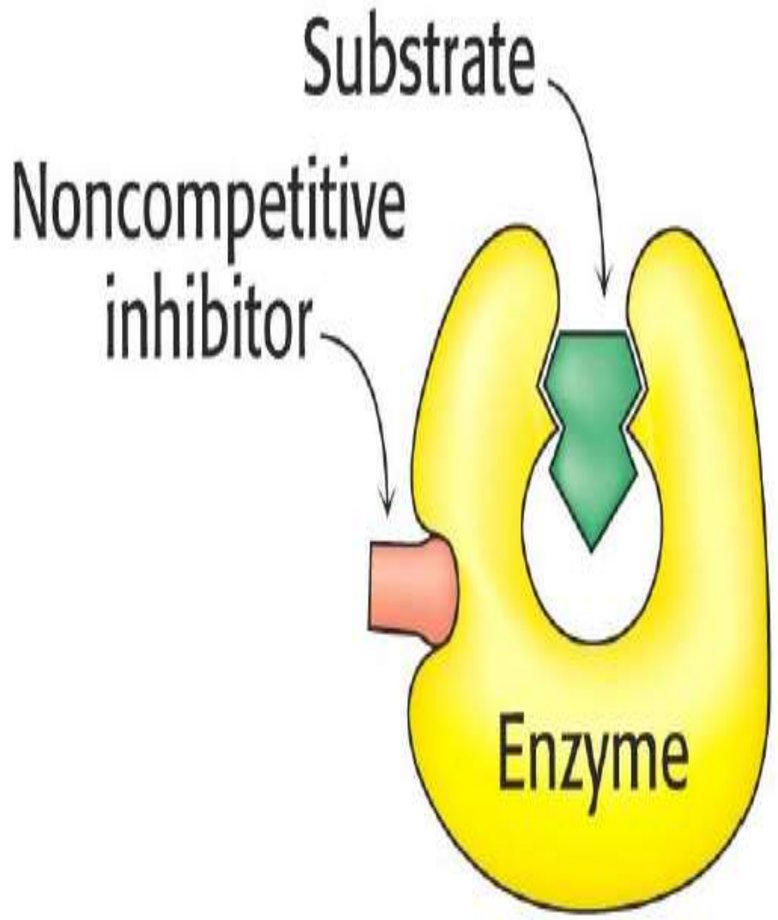
Usually reversible, depending on concentration of inhibitor & substrate.



EXAMPLE: Compounds containing **heavy metals** such as lead, mercury, copper or silver are **poisonous**. This is because ions of these metals are non-competitive inhibitors for several enzymes.

Non-Competitive Inhibition



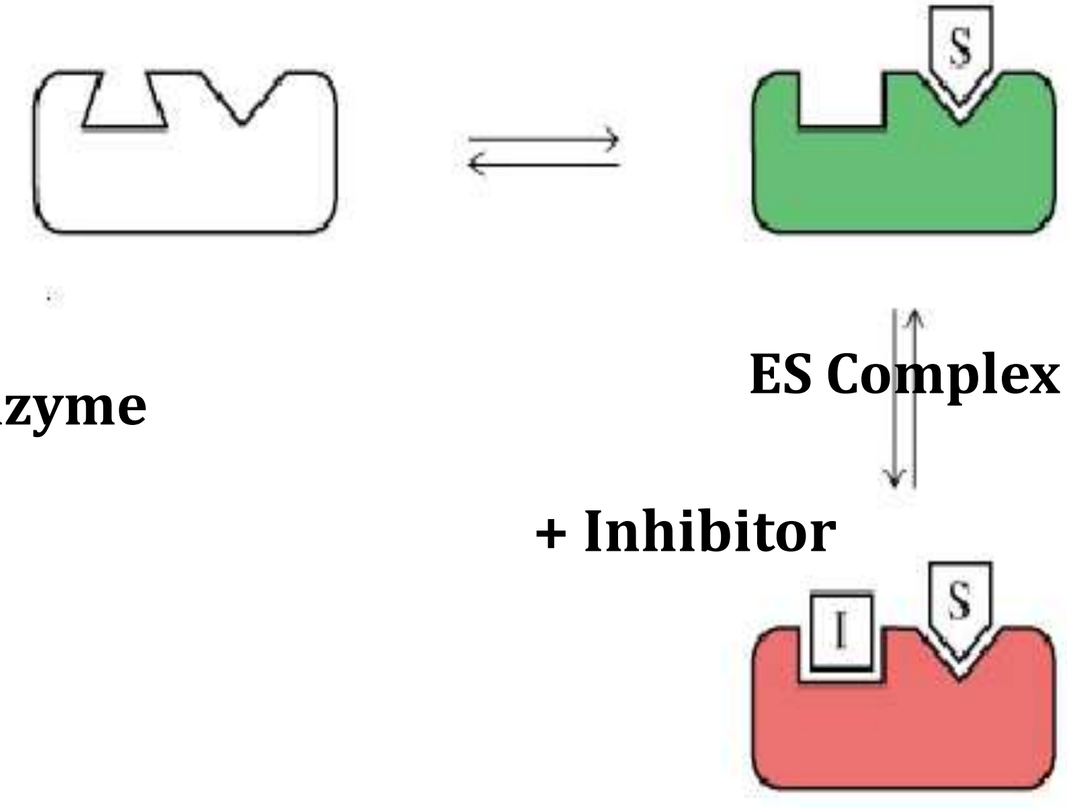



Substrate
Active site
(a) A substrate can normally bind to the active site of an enzyme.
(c) A noncompetitive inhibitor
Noncompetitive inhibitor

Un-competitive Inhibiton

- Binds only to the enzyme-substrate complex.
- Does not have the capacity to bind to the free enzyme.
- Not overcome by increasing substrate concentration.
- Both the K_m and V_{max} are reduced.

Un-competitive Inhibiton



THANK YOU