ENZYMES

Study Material for

B.Sc. Part III
Botany Hons.
Paper V

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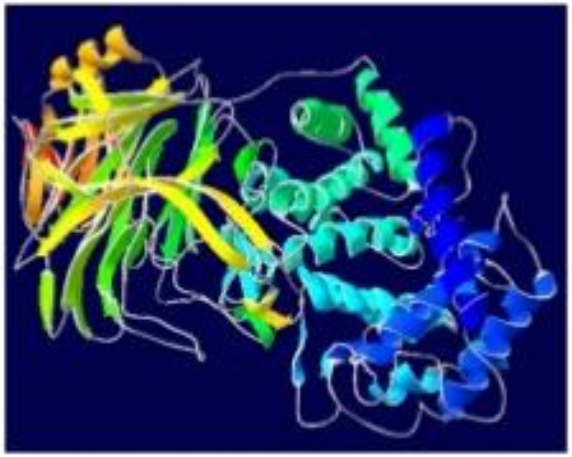
ENZYMES

- Enzymes are specialized proteins which act as biocatalysts and enhance the rate of chemical reaction without affecting the equilibrium
- It was discovered by Edward Buchner
- The term ENZYME was coined by Freidrich W. Kuhne

ENZYME EXAMPLES



3D molecular structures for the enzymes **pepsin** (top) and **hyaluronidase** (bottom).

Enzyme	Role
Pepsin	Stomach enzyme used to break protein down into peptides. Works at very acidic pH (1.5).
Proteases	Digestive enzymes which act on proteins in the digestive system
Amylases	A family of enzymes which assist in the breakdown of carbohydrates
Lipases	A family of enzymes which breakdown lipids

CHARACTERISTIC FEATURES OF ENZYMES

Enzymes catalyze biochemical reactions in living cell.

Enzymes accelerate the velocity of a biochemical reaction

Enzymes decrease the energy of activation of substrates.

Enzyme does not change the equilibrium constant of a reaction

The chemical nature of an enzyme is not changed by entering a biochemical reaction

PROPERTIES OF ENZYMES

- CATALYTIC PROPERTY
- SPECIFICITY
- REVERSIBILITY
- SENSITIVENESS TO HEAT AND INHIBITORS
- COLLOIDAL NATURE

CATALYTIC PROPERTY OF ENZYME

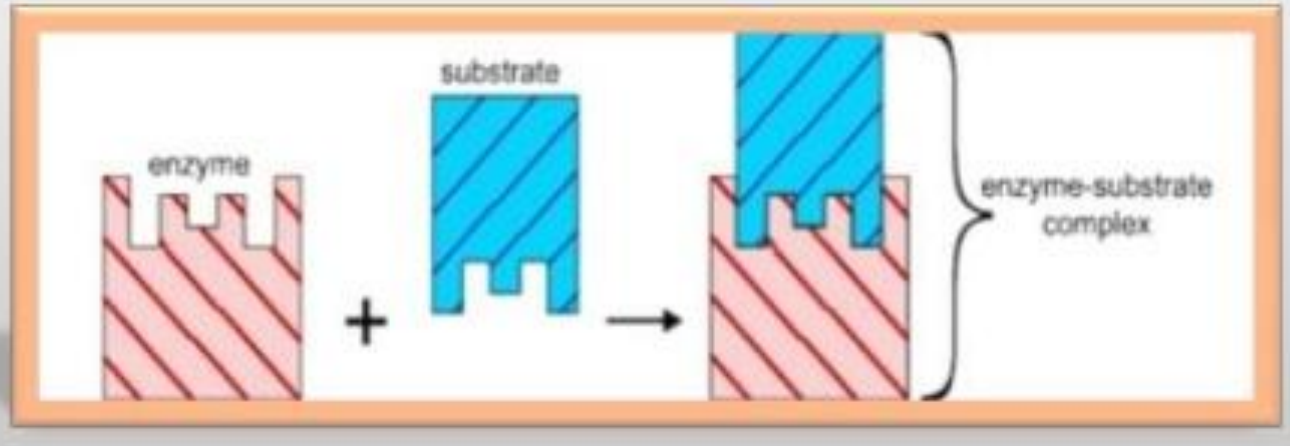
- enzymes are characterized by two fundamental properties.
- 1- First, they increase the rate of chemical reactions without themselves being consumed or permanently altered by the reaction.
- 2-Second, they increase reaction rates without altering the chemical equilibrium between reactants and products,
- a molecule acted upon by an enzyme is called substrate [*S*]
- substrate [*S*] is converted to a **product** (*P*)

ENZYME SPECIFICITY

- Enzymes are highly specific in nature, interacting with one or few substrates and catalyzing only one type of chemical reaction.
- Substrate specificity is due to complete fitting of active site and substrate .

Example:

- Oxydoreductase do not catalyze hydrolase reactions and hydrolase do not catalyze reaction involving oxidation and reduction.

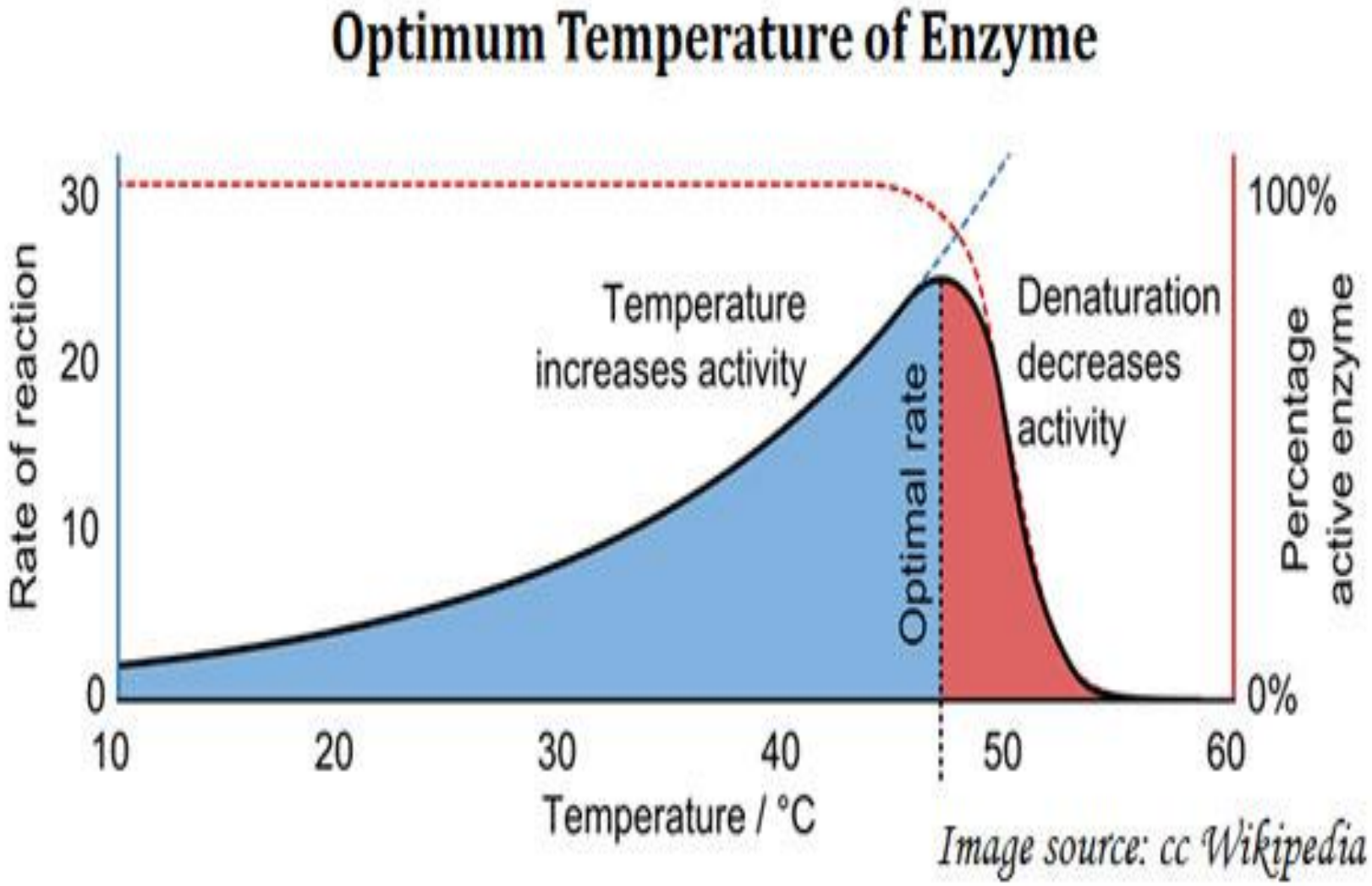


Types of enzyme specificity

- Enzymes show different degrees of specificity:

- Bond specificity.
- Group specificity.
- Absolute specificity.
- Optical or stereo-specificity.
- Dual specificity.

HEAT SENSITIVITY



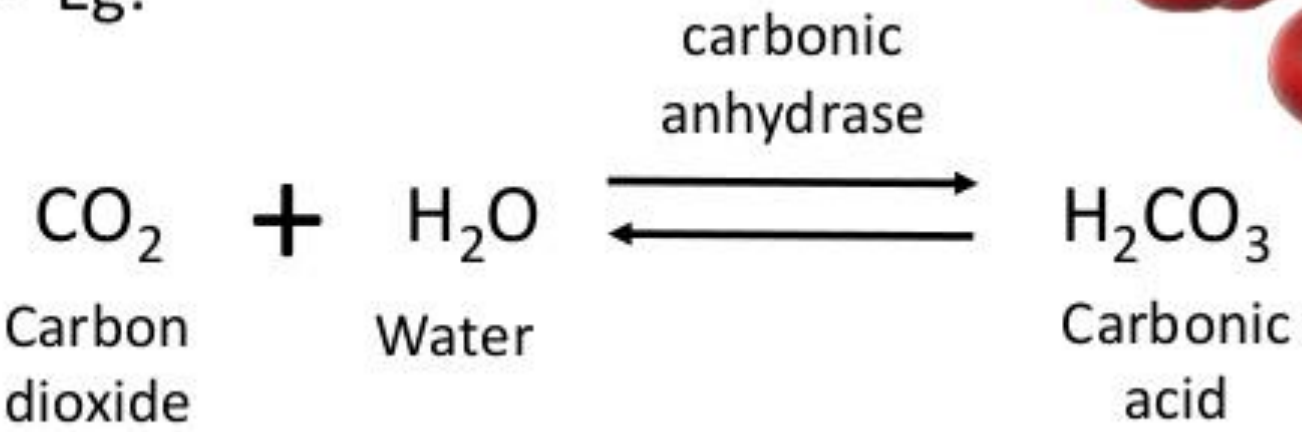
Ph SENSITIVITY

Optimum pH values of Some Common Enzymes			
Enzyme	**Substrate**	**Optimum pH**	**Location**
Pepsin	Peptide Bond	1.5 to 2.0	Stomach
Sucrase	Sucrose	6.2	Small Intestine
Amylase	Amylose	6.7 to 7.0	Pancreas
Urease	Urea	7.0	Liver
Trypsin	Peptide Bond	7.7 to 8.0	Small Intestine
Lipase	Lipids	8.0	Pancreas

REVERSIBILITY

- Reactions can proceed in forward and backward direction

- Eg:



NOMENCLATRE AND CLASSIFICATION OF ENZYMES

- To facilitate scientific communication and to maintain uniformity, Enzymes are categorised and named by an International Code of Enzyme Nomenclature (ICEN)
- The classification of enzyme is done on the basis of the specific action of enzymes and the substrates, enzyme is acting upon
- Enzymes are Grouped under six major classes

CLASSIFICATION OF ENZYMES

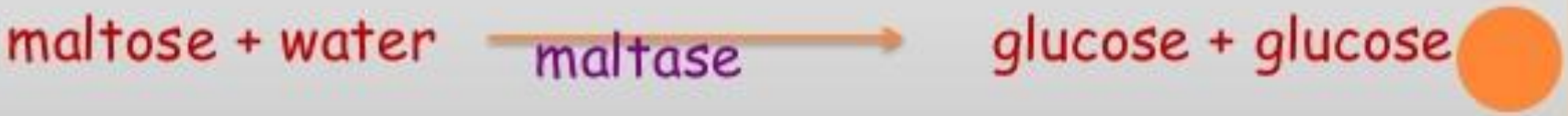
ENZYME CLASS	REACTION TYPE	EXAMPLES
Oxidoreductases	Reduction-oxidation (redox)	Lactate dehydrogenase
Transferases	Move chemical group	Hexokinase
Hydrolases	Hydrolysis; bond cleavage with transfer of functional group of water	Lysozyme
Lysases	Non-hydrolytic bond cleavage	Fumarase
Isomerases	Intramolecular group transfer (isomerization)	Triose phosphate isomerase
Ligases	Synthesis of new covalent bond between substrates, using ATP hydrolysis	RNA polymerase

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.

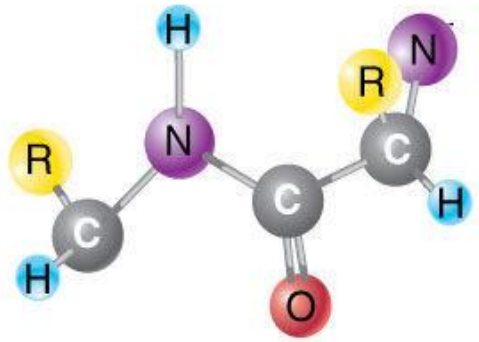
  Example :



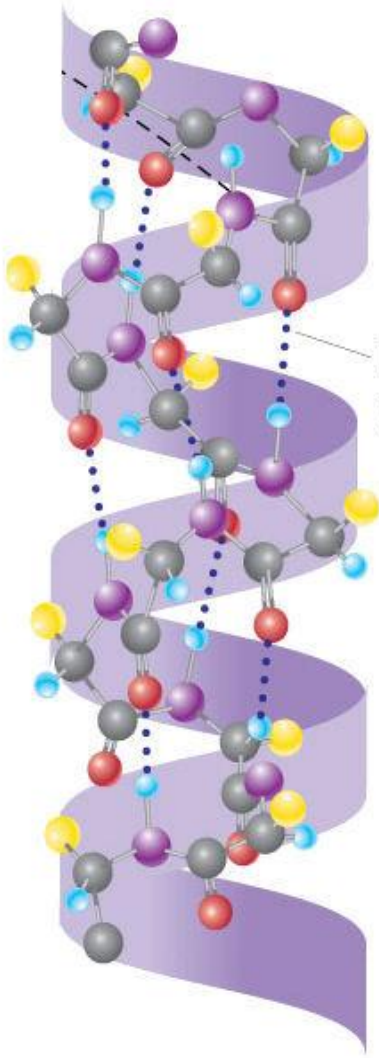
EXAMPLES

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

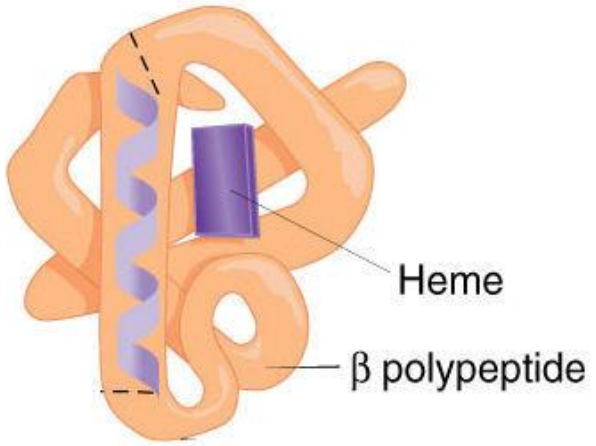
STRUCTURE OF PROTEIN



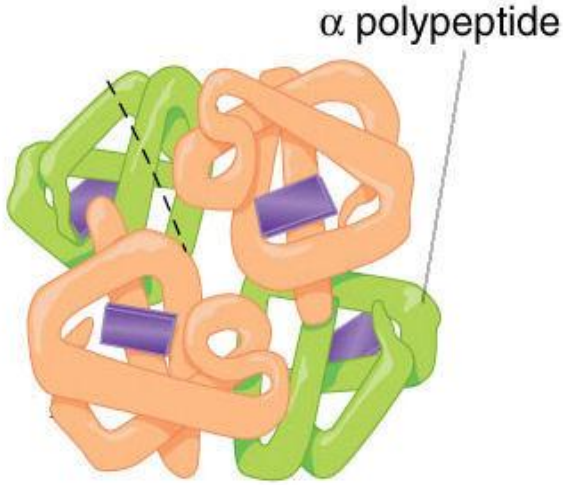
(a) Primary structure



(b) Secondary structure

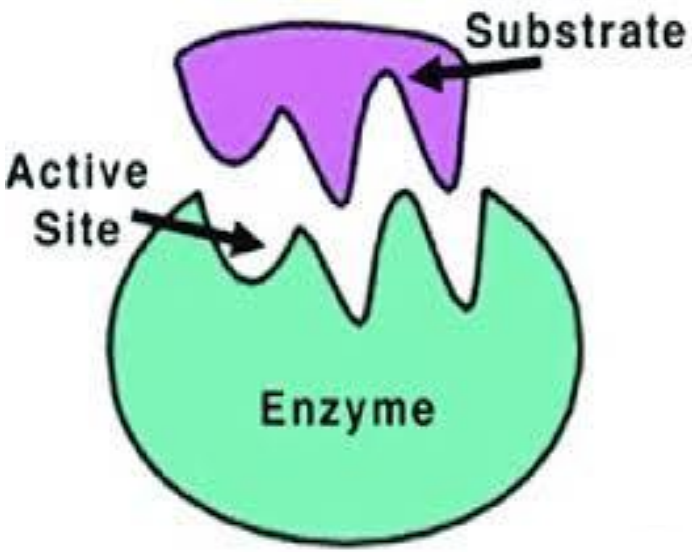


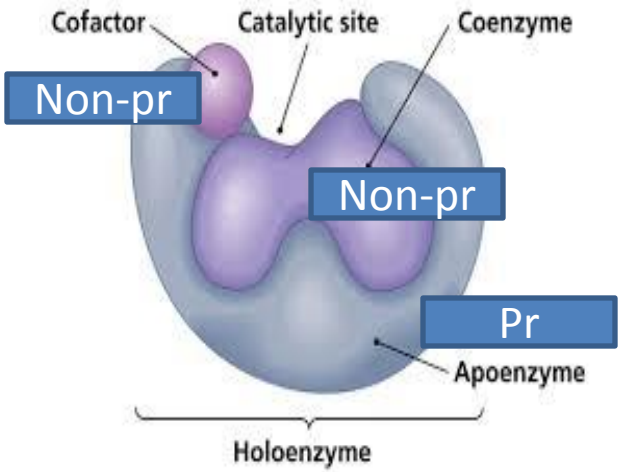
c) Tertiary structure

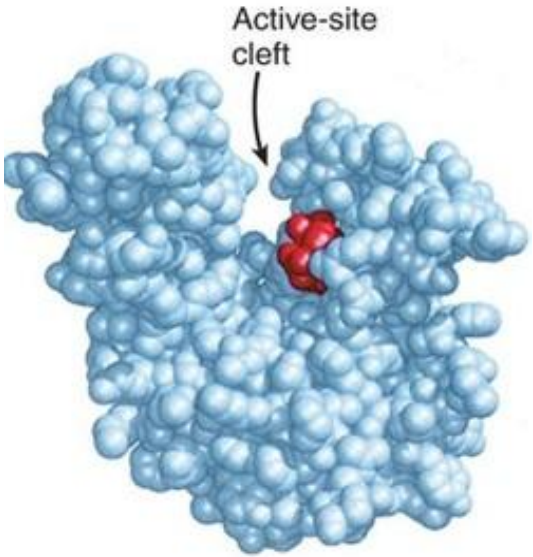


(d) Quaternary structure–

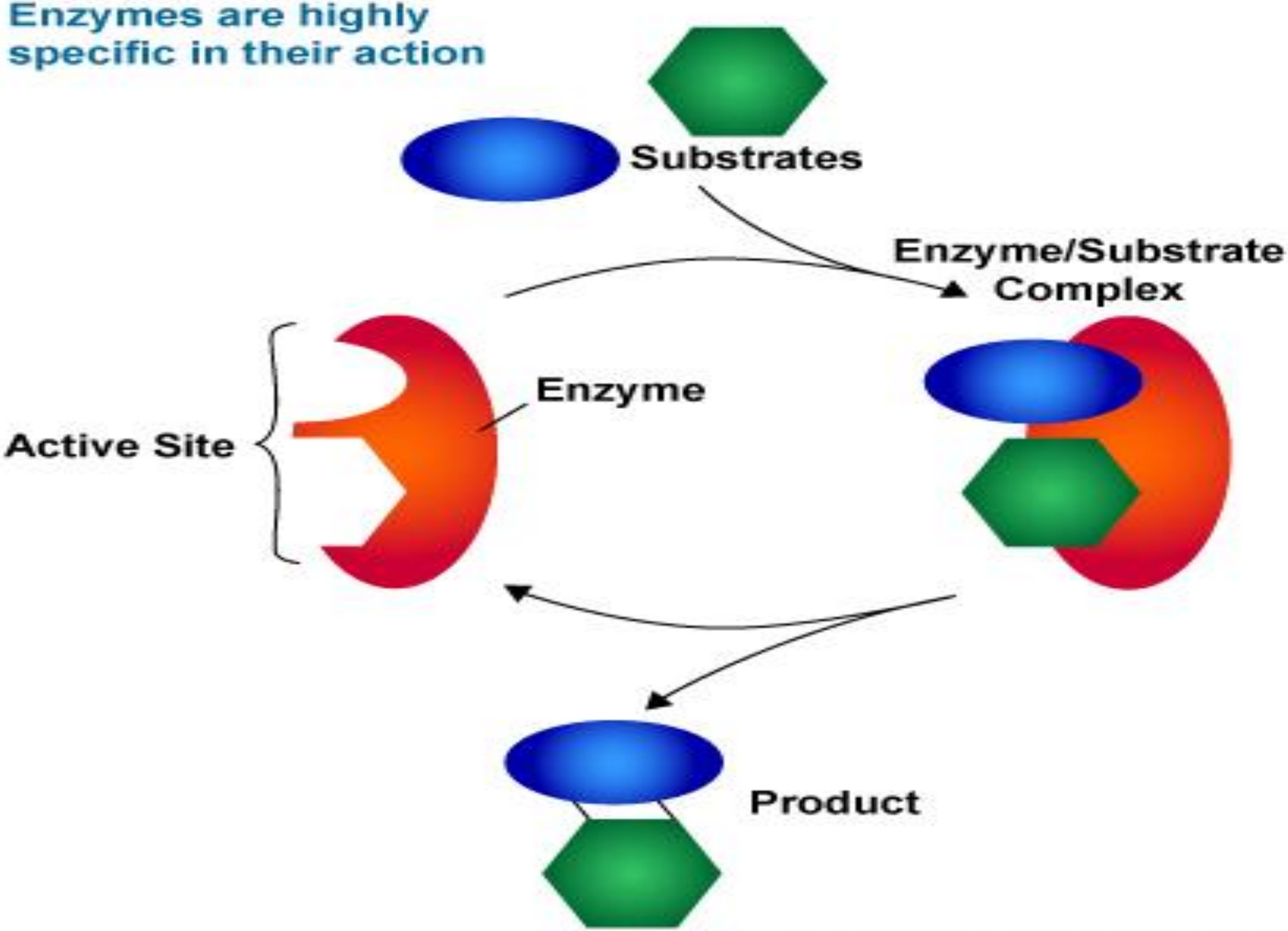
STRUCTURE OF ENZYMES







Enzymes are highly specific in their action



REGULATION OF ENZYME ACTIVITIES

- The regulation or inhibition of enzyme activity takes place mainly by three methods:

  i) Competitive Inhibition

  ii) Non- Competitive Inhibition

  iii) Feedback inhibition

***Apart from all these three methods the action of enzyme gets inhibited by means of denaturation of Proteins**

COMPETITIVE INHIBITION

In **competitive inhibition** a molecule very close in shape to the true substrate competes for the active site of the enzyme. This means less enzyme is available to act on the actual substrate and the reaction is slowed down.

Competitive inhibition is reversible

Tip - You can tell if an enzyme is competitive by changing the concentration of the **substrate** .

Explanation - Rate of reaction can be increased by adding more of the substrate so that the enzyme is more likely to collide with correct substrate molecule.

A common mechanism for controlling the rate of enzyme reactions in cells uses end products which compete with the substrate for active sites. This is called 'End Product Inhibition' and is a special example of competitive inhibition

Competitive Inhibition

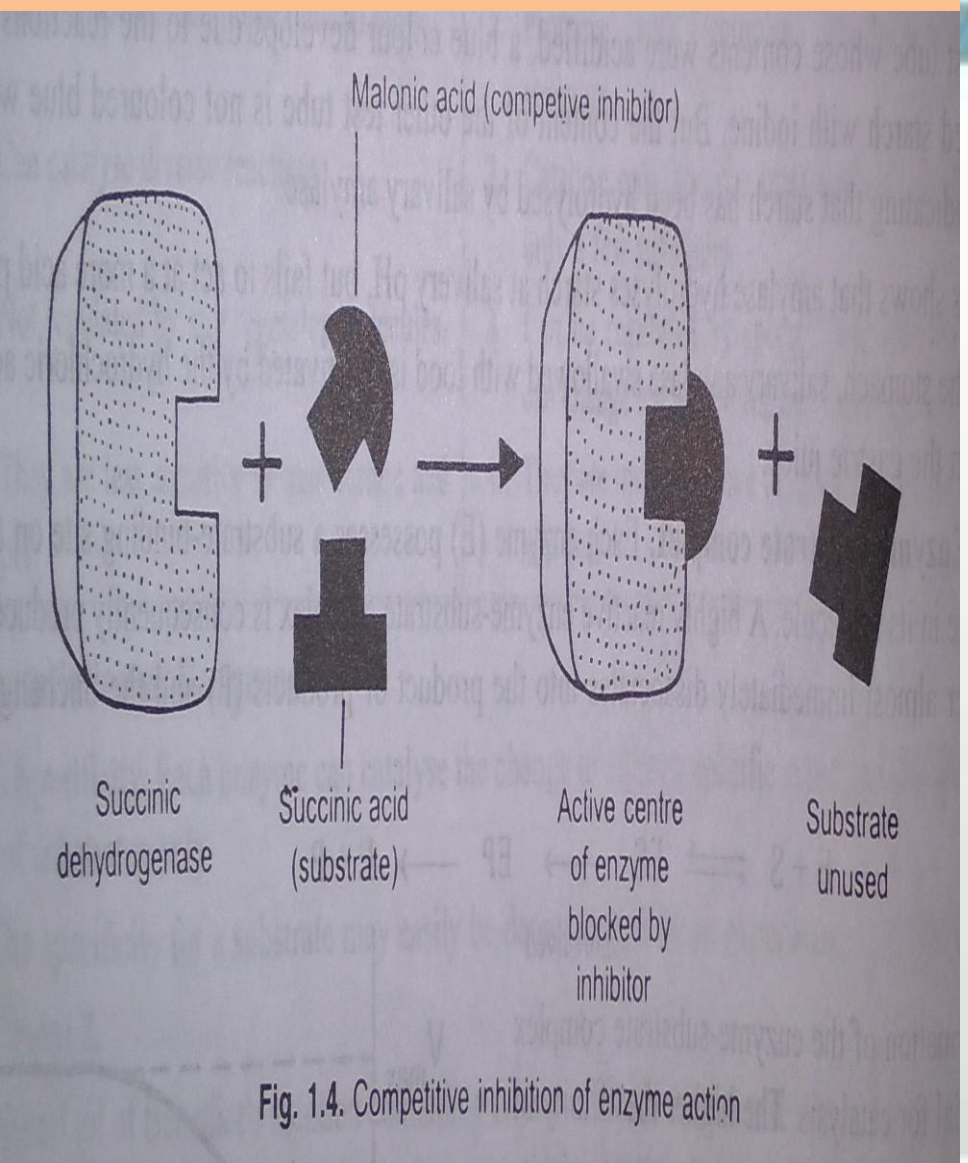
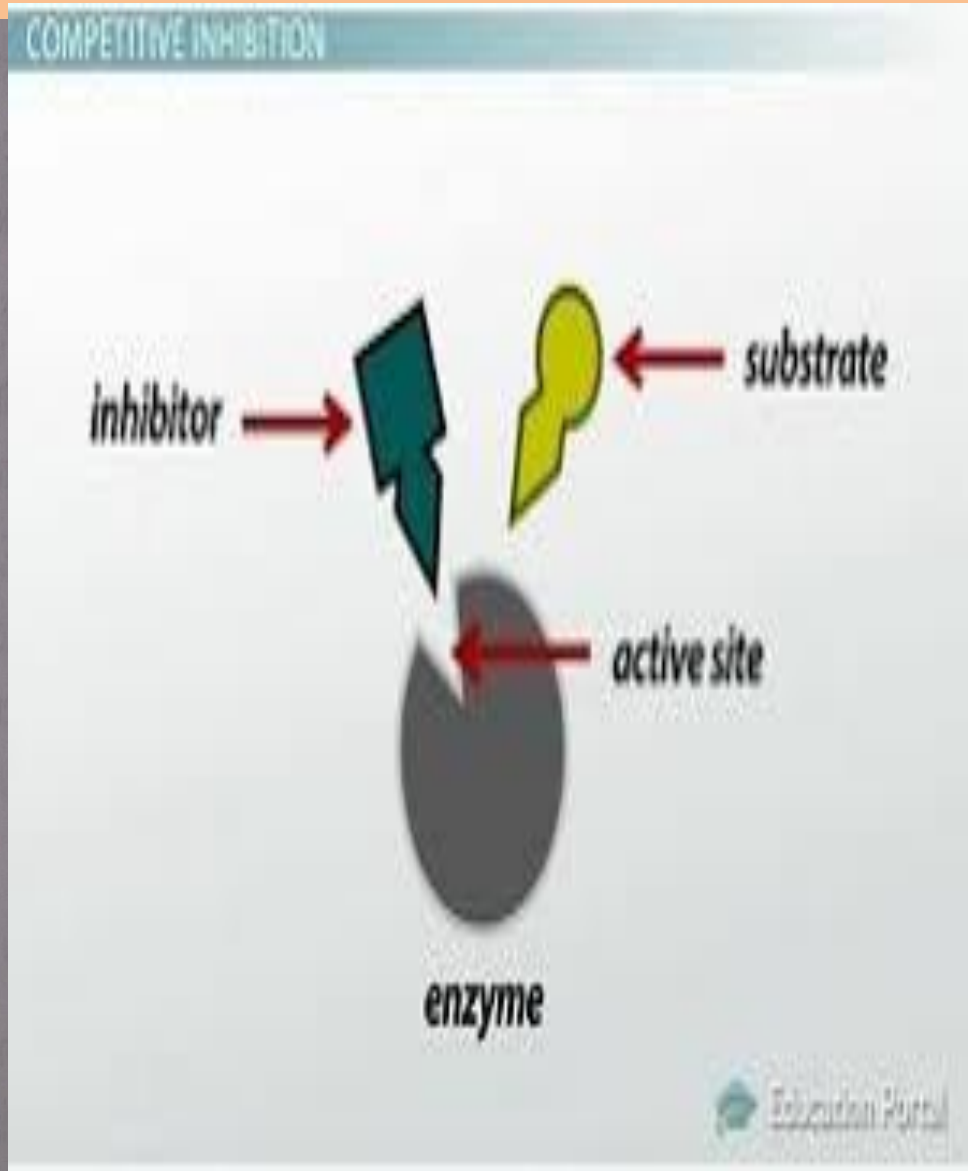


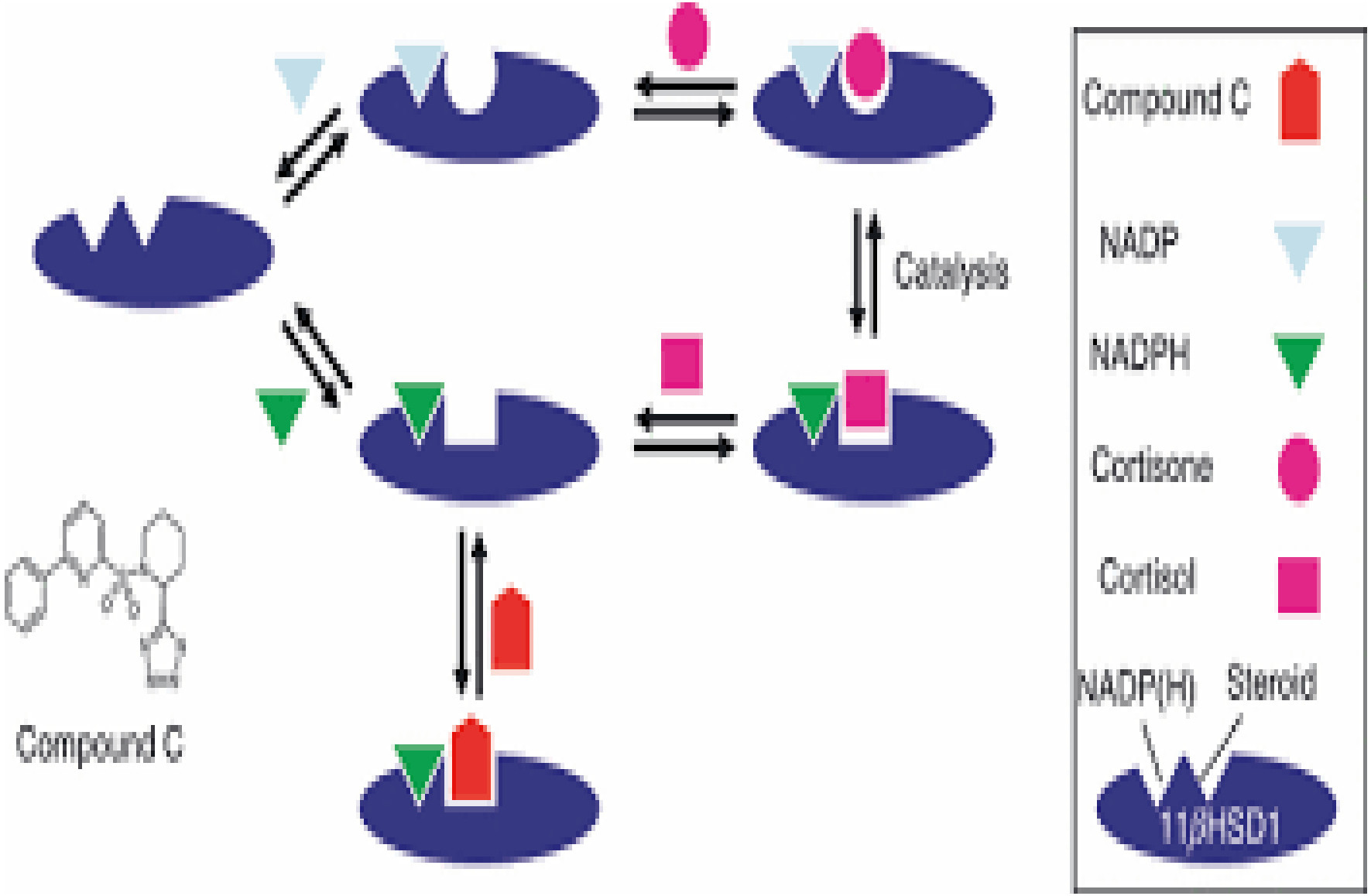
Fig. 1.4. Competitive inhibition of enzyme action



Non- Competitive Inhibition

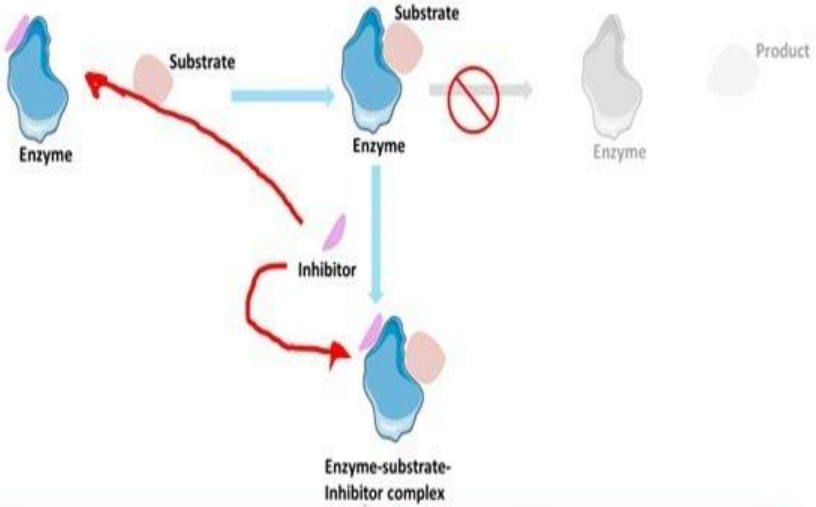
- Non-competitive binding takes place other than active site
- They have no structural similarity
- Inhibits the activity of enzymes
- For e.g. Cyanide

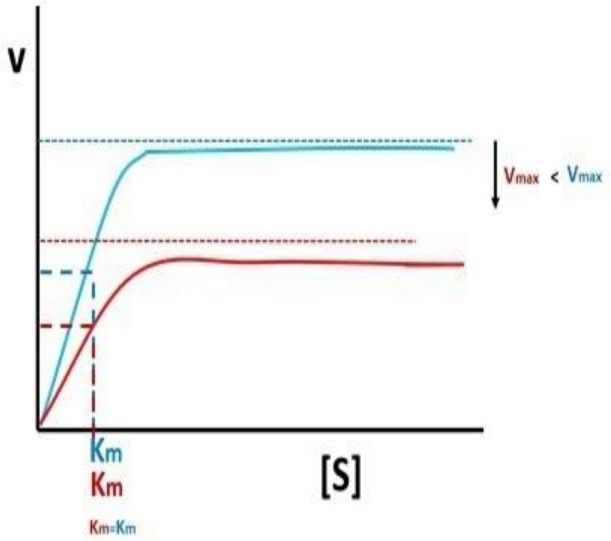
NON COMPETITIVE INHIBITION



NON COMPETITIVE INHIBITION

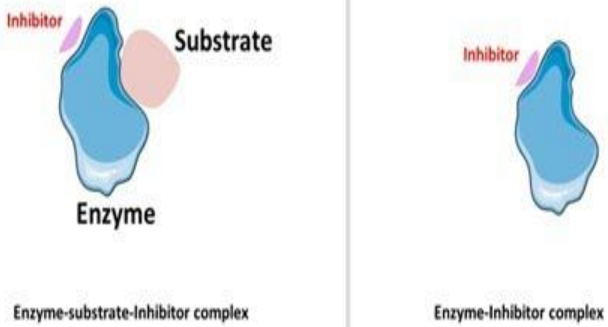
Non-competitive inhibition is distinguished from general mixed inhibition in that the inhibitor has an equal affinity for the enzyme and the enzyme-substrate complex.

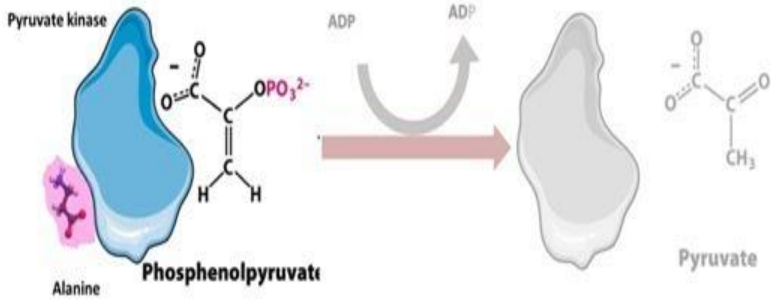




In non competitive inhibition inhibitor binds to a site other than active site (it could be an allosteric site)

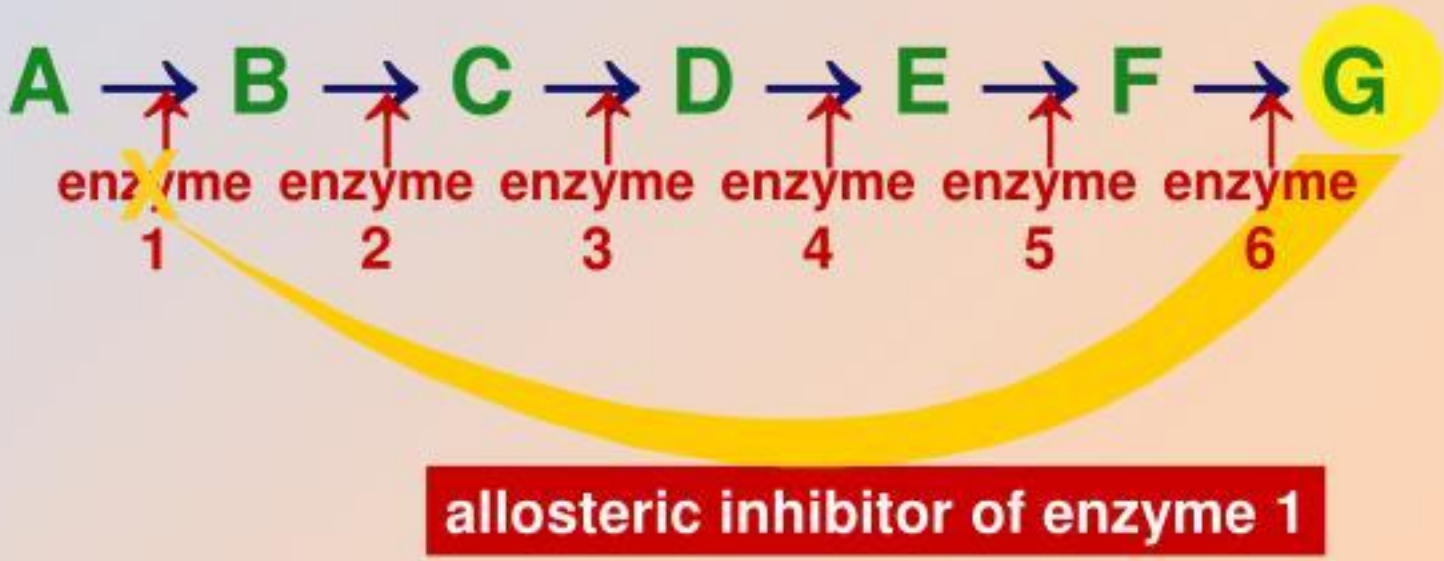
The amino acid alanine noncompetitively inhibits the enzyme pyruvate kinase.





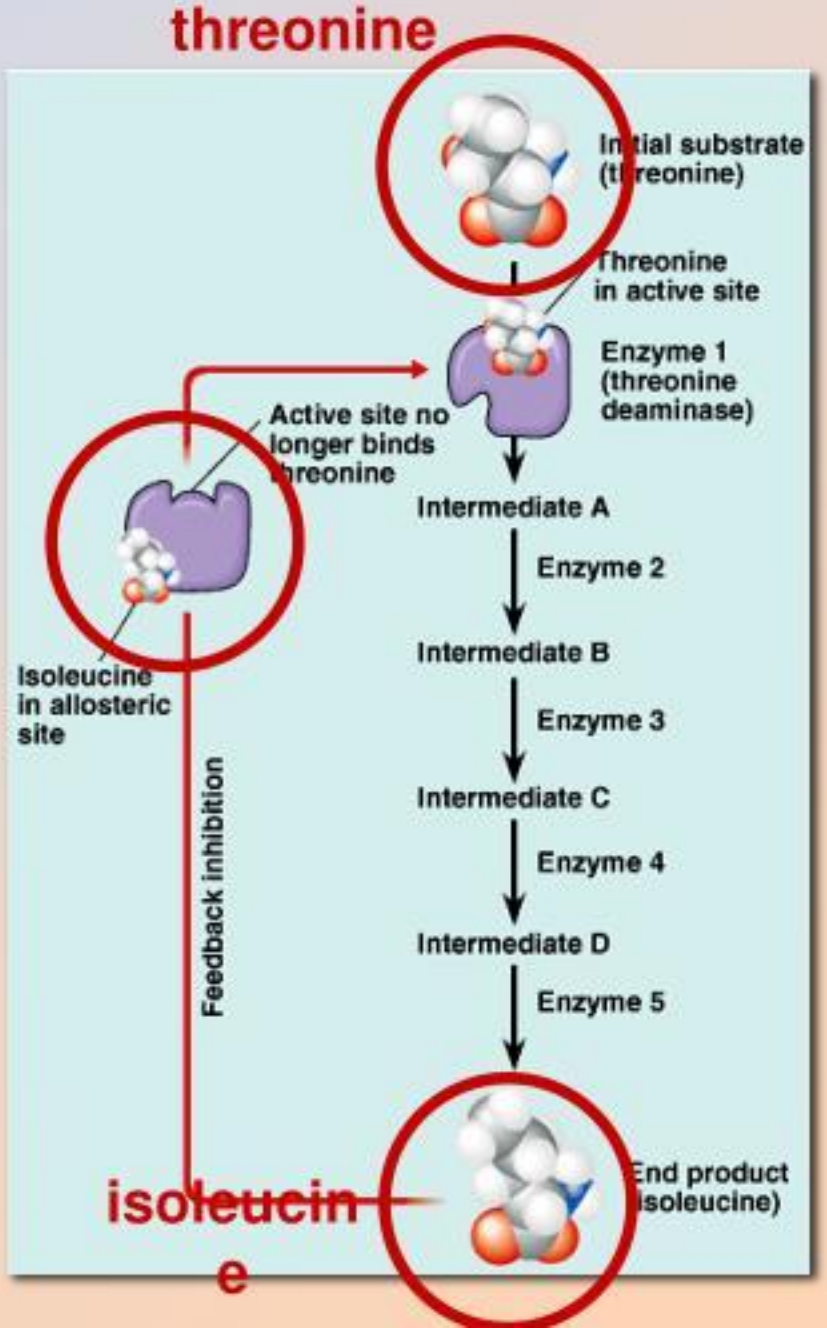
Feedback Inhibition

- Regulation & coordination of production
  - product is used by next step in pathway
  - final product is inhibitor of earlier step
    - allosteric inhibitor of earlier enzyme
    - feedback inhibition
  - no unnecessary accumulation of product



Feedback inhibition

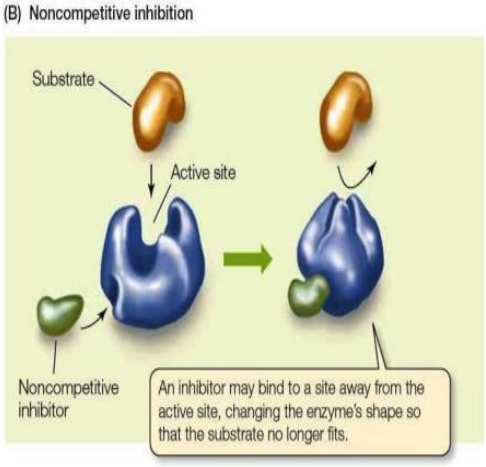
- Example
  - synthesis of amino acid, isoleucine from amino acid, threonine
  - isoleucine becomes the allosteric inhibitor of the first step in the pathway
    - as product accumulates it collides with enzyme more often than substrate does

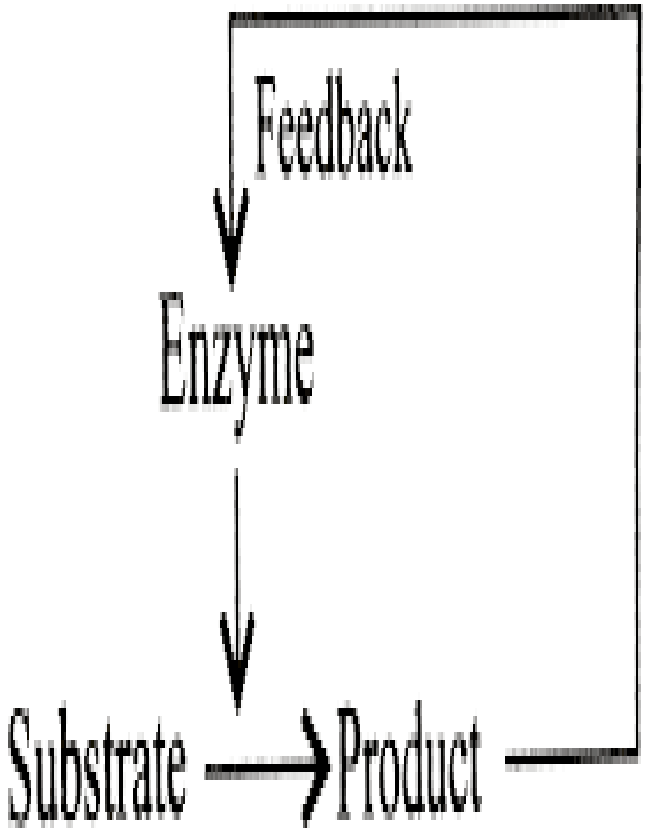


Feedback inhibition

Allosteric Inhibitor

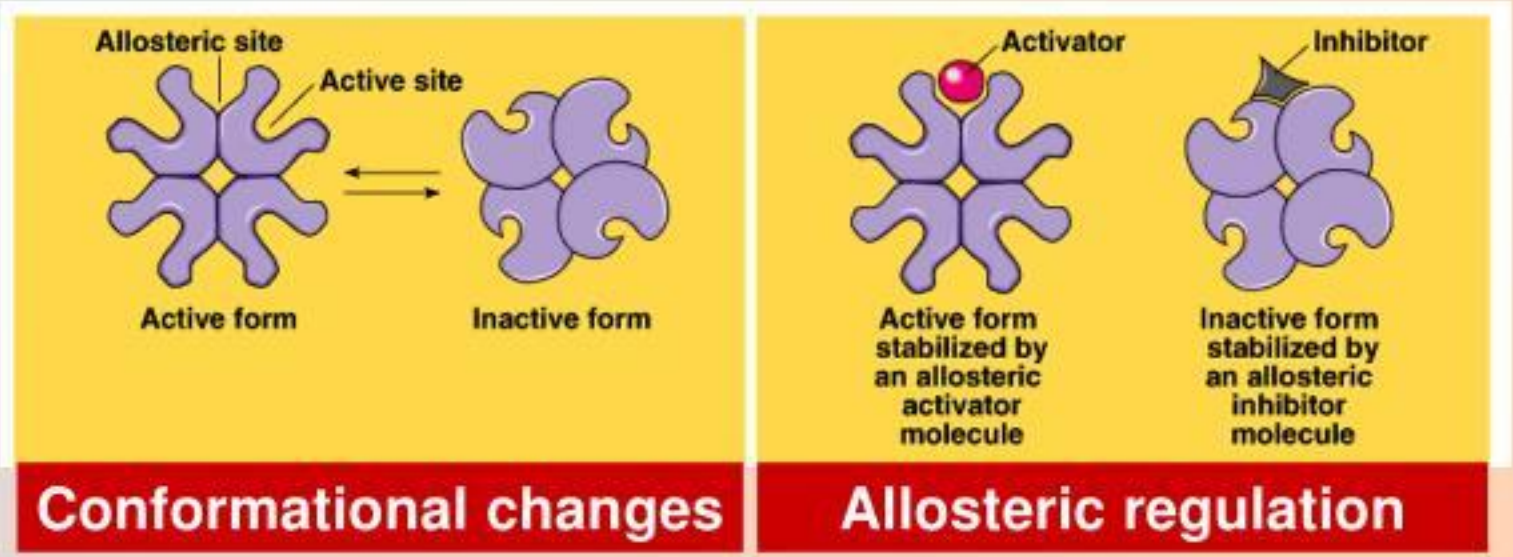
- The change in enzyme shape due to noncompetitive inhibitor binding is an example of allostery (allo, “different”; stery, “shape”).
- Binding of the inhibitor induces the protein to change its shape.
- More common are enzymes that already exist in the cell in more than one possible shape.



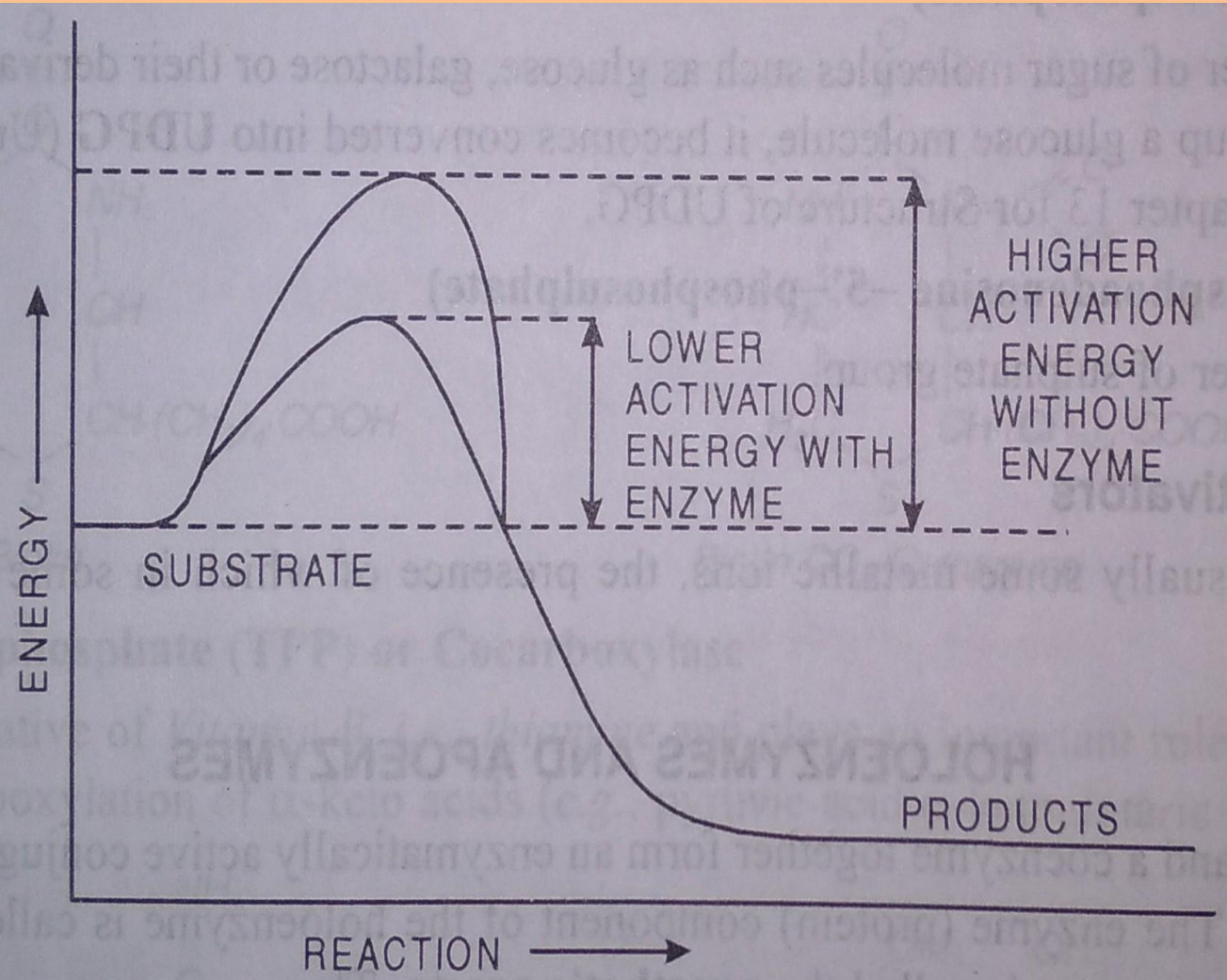


Allosteric regulation

- Conformational changes by regulatory molecules
  - inhibitors
    - keeps enzyme in inactive form
  - activators
    - keeps enzyme in active form



MECHANISM OF ENZYME ACTION



. Activation energy of an enzyme catalysed reaction is lower than that of an uncatalysed reaction.

Michaelis constant (K_m)

- Michaelis constant (K_m): Michaelis constant (Km) of an enzyme is the substrate concentration at which the reaction attains its maximum velocity. It is the measure of affinity of the enzyme for its substrate.

MICHAELIS-MENTEN MODEL & EFFECTS OF SUBSTRATE CONCENTRATION

- Michaelis-Menten Model:

"According to this model the enzyme reversibly combines with substrate to form an ES complex that subsequently yields product, regenerating the free enzyme."

where:

- S is the substrate
- E is the enzyme
- ES-is the enzyme substrate complex
- P is the product
- K1,K-1 and K2 are rate constants

Michaelis-Menten Equation

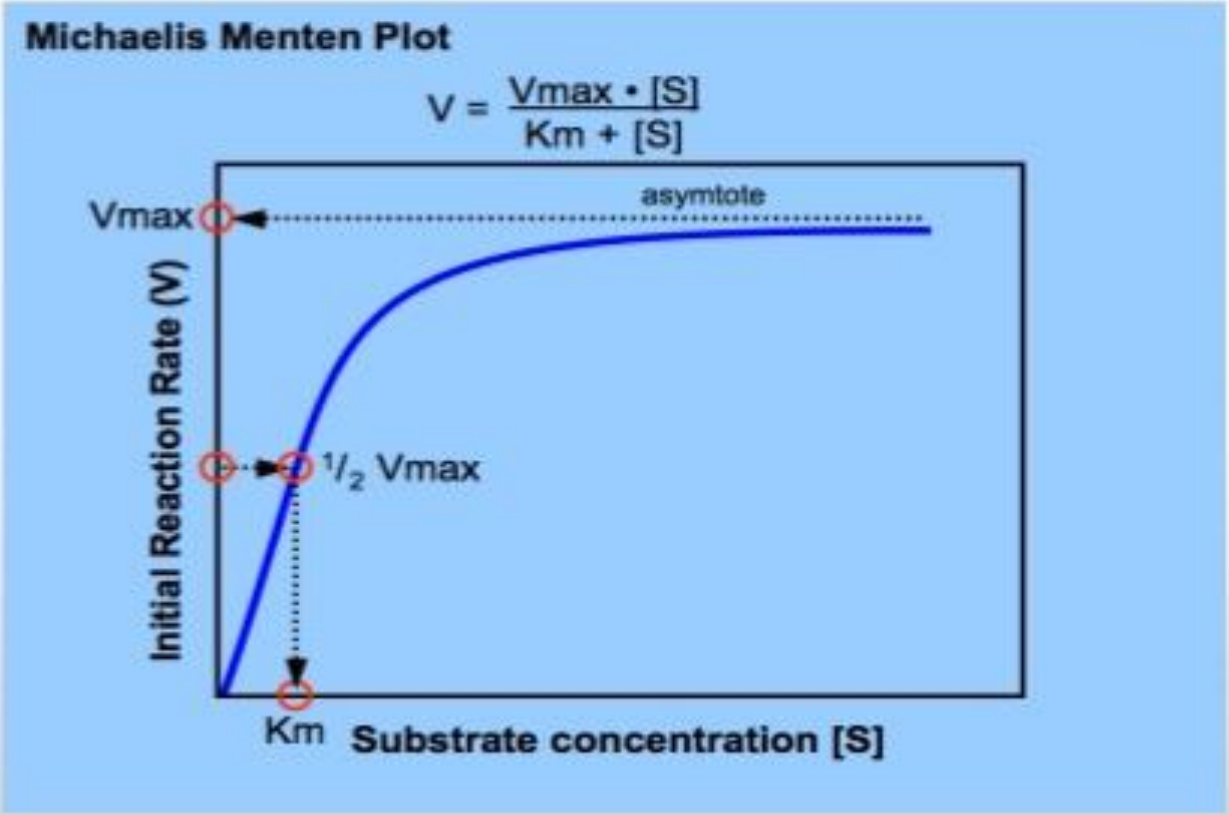
- Michaelis-Menten Equation:

"It is an equation which describes how reaction velocity varies with substrate concentration."

$$V_o = \frac{V_{max}\,[S]}{K_m + [S]}$$

- Where
  - V_o is the initial reaction velocity.
  - V_{max} is the maximum velocity.
  - K_m is the Michaelis constant = $(k_{-1}+k_2)/k_1$.
  - [S] is the substrate concentration.

SUBSTRATE CONCENTRATION



FACTORS AFFECTING ENZYME ACTIVITY

- Temperature
- Ph
- Water
- Concentration of the substrate
- Enzyme concentration
- Inhibitors*
- Accumulation of end product*

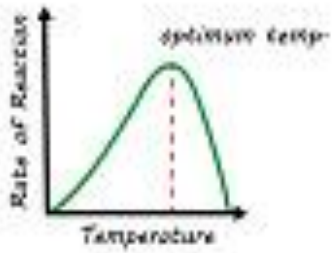
Biochemistry

Factors affecting ENZYME activity

Temperature

BIG influence

More heat = More kinetic energy

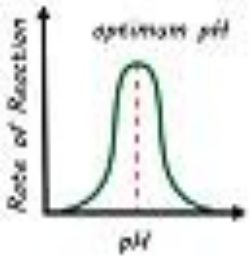


But if too high

enzyme is denatured

pH

Enzymes have optimum pH

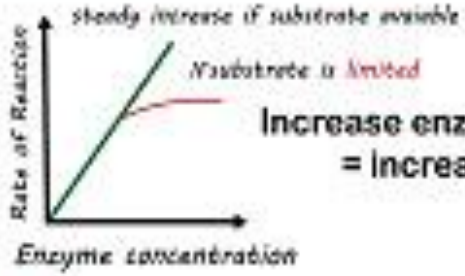


If higher/lower

H+ in acid / OH- in alkaline

can interfere enzyme structure

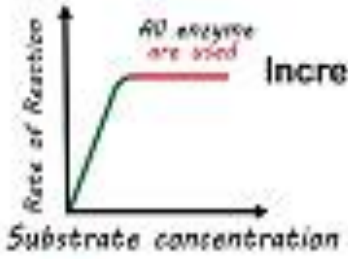
Enzyme concentration



Increase enzyme concentration
= increase rate of reaction

Until substrates amount are limited

Substrate concentration

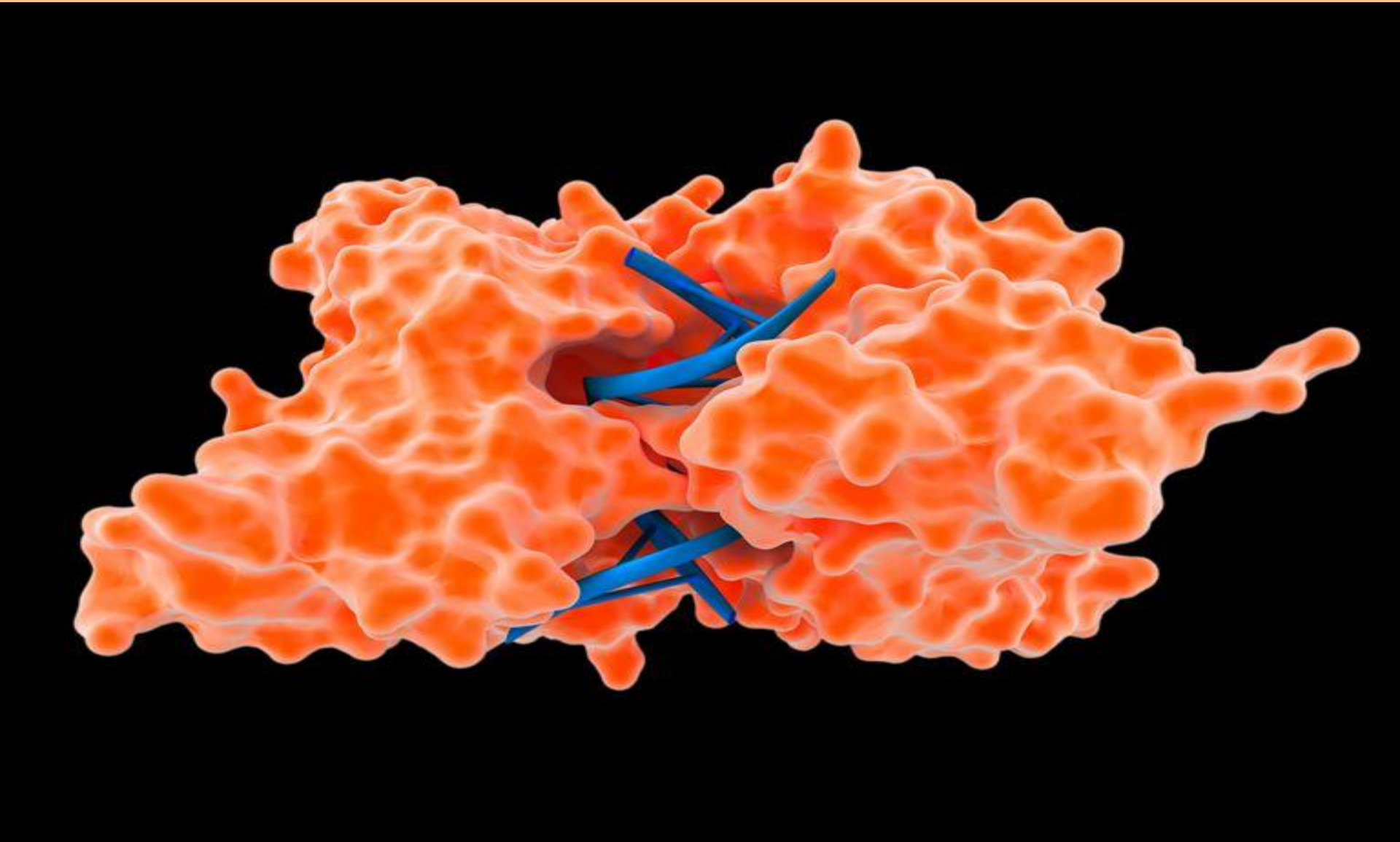


Increase substrate concentration
= increase rate of reaction

Until active site of enzyme are used

* MENTIONED IN ABOVE SLIDES

THANK YOU



- **Students are requested to share their queries on Whatsapp group: MMC Botany (D3)**

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  OR

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