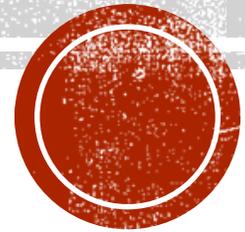


Enzymes & Mechanism of Enzyme Action



Students Learning Outcomes

❖ *By the end of this lecture, the students should be able to:*

- 1. Define enzyme, substrate, active site & allosteric site, and enzyme specificity**
- 2. Classify enzyme according to its chemical nature**
- 3. Illustrate the steps and mechanism of enzyme action**
- 4. Explain how enzyme speed up the chemical reaction**
- 5. Summarize factor affecting the rate of enzyme action**



Case Scenario

Hydrogen peroxide is a harmful by-product of many normal metabolic processes. To prevent damage, it must be quickly converted into other, less dangerous substances. **Catalase** is frequently used by cells to rapidly catalyze the decomposition of hydrogen peroxide into less reactive **gaseous oxygen and water molecules**. Catalase works at an **optimum temperature of 37 °C**, which is approximately the temperature of the human body.

1. **What is the enzyme in this case?**
2. **What is the substrate and the end products?**
3. **Predict what would happen to enzyme activity and the reaction if you change the temperature to over 100.**



1. Definition of Enzymes

- ✓ They are organic thermo-labile **catalysts**.
- ✓ **Catalyst** is a substance that:
 - **increase the rate** of chemical reaction.
 - without **change** or **being consumed** in the reaction.
- ✓ Without enzyme the chemical reaction will proceed with a **very slow rate**

Without
enzymes

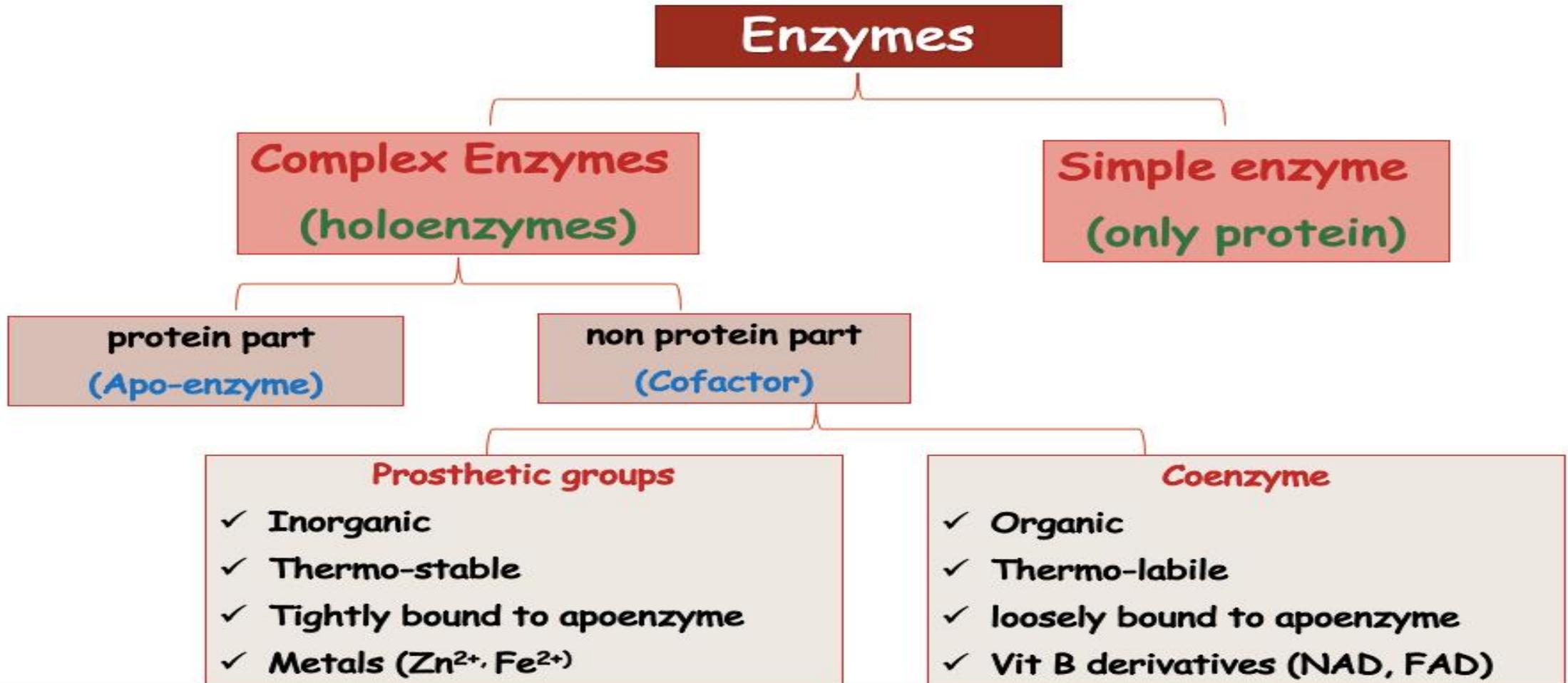


With
enzyme
s



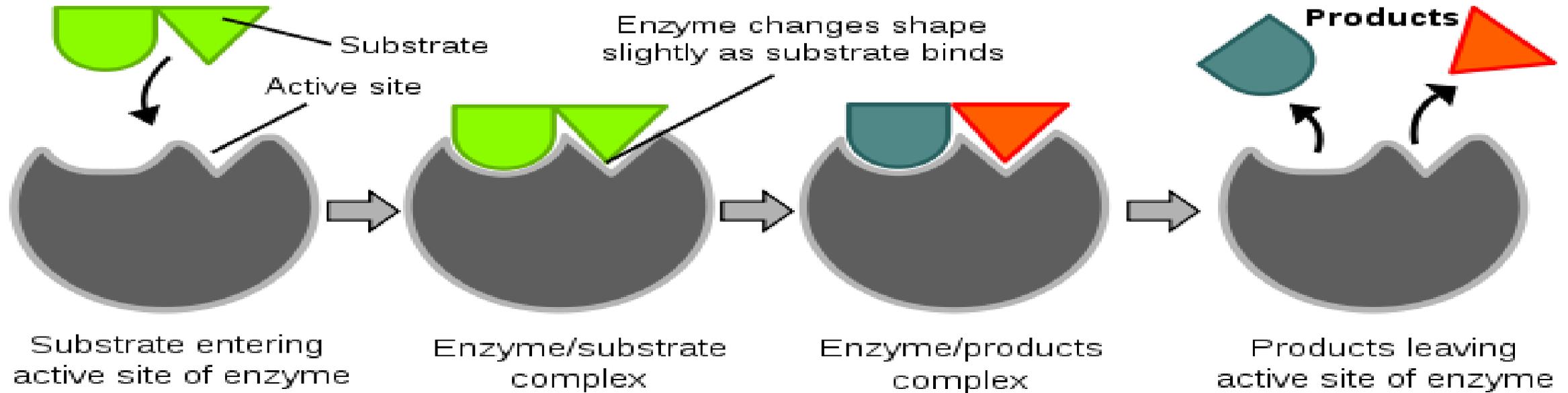
2. Chemical Nature of enzymes

All enzymes are **protein** in nature **except** ribozymes (**RNA in**



3.Steps (mechanism) of enzymatic reaction

The **substrate (S)** binds to the **enzyme (E)** at its active catalytic site to form activated intermediate (enzyme substrate complex) (ES) → then Enzyme Product complex → that cleaved to the **products (P)** and the **original enzyme (E)**



Free enzyme recycled



4. Substrate, Active site & Regulatory site

✓ Substrate:

- A reactant in a chemical reaction is called a substrate

✓ Active site

- **Definition:** The **site** on the **enzyme** where the substrate or **substrates attach**

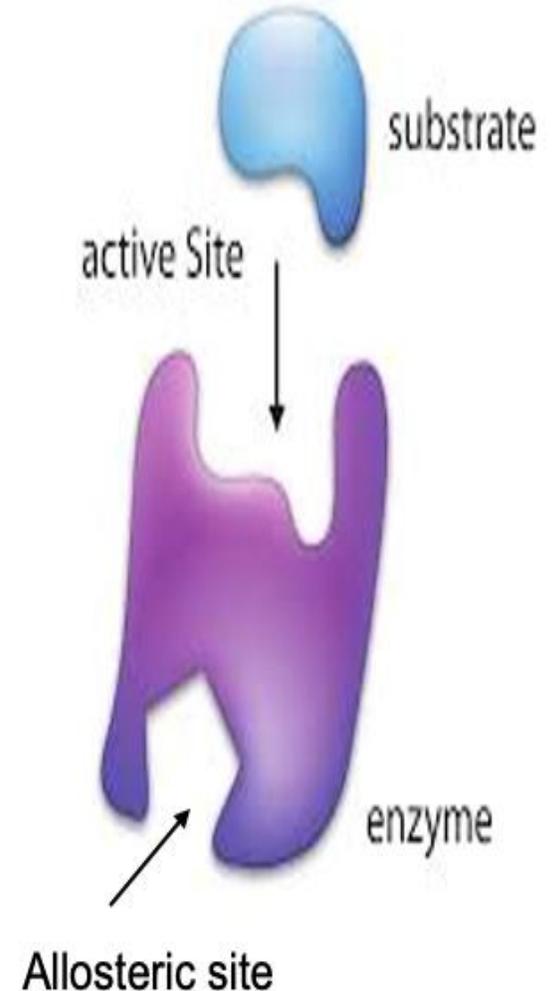
- **Classified into:**

a) **Binding site:** **bind** substrate

b) **Catalytic site:** perform **catalytic** action

✓ Regulatory (allosteric) site

- A site on an enzyme, **other than** the active site,
- At which certain molecules (effector, regulator) bind
- → thereby affecting the enzyme's activity.

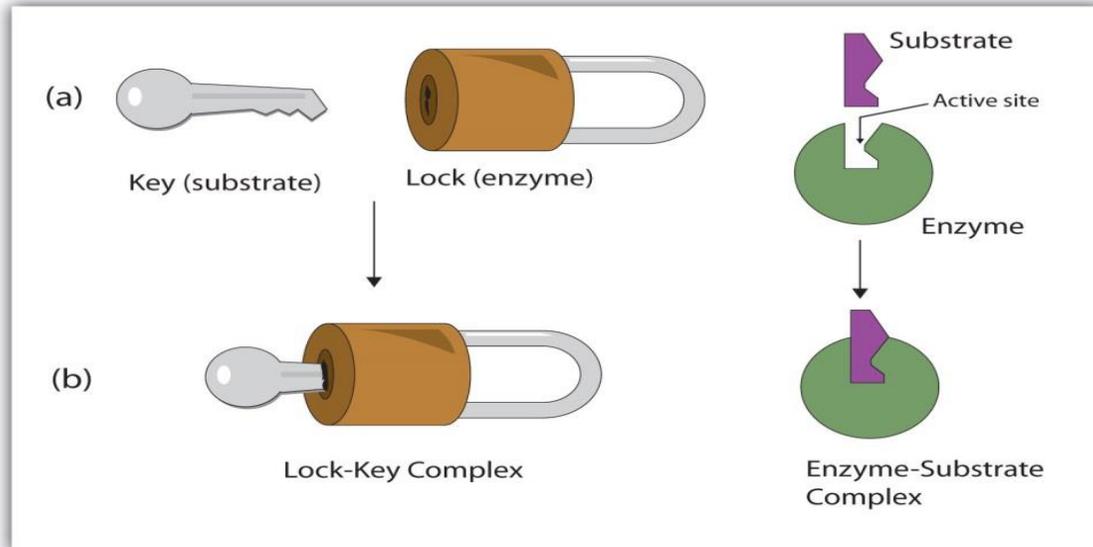


5. Models of enzyme substrate interaction at the active site

Lock and key model (Rigid model) (1890)

The enzyme is **rigid**

Only accepting a **specific** substrate that **fits** the **shape** of its active site.

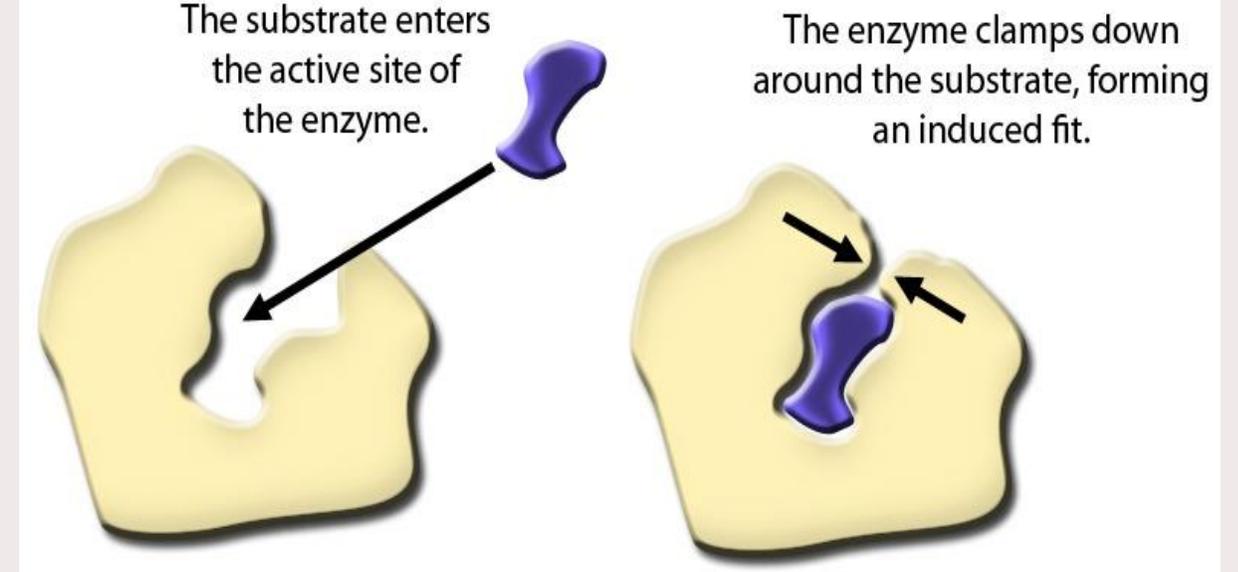


It **doesn't explain** the changes in the enzyme activity in the presence of **allosteric regulator**

Induced fit model (Flexible model) (1958)

The enzyme is **flexible**

The shape of the active site can be **modified** by the **binding** of the substrate



It **explain** the changes in the enzyme activity in the presence of **allosteric regulator**

6. Enzyme specificity

Enzymes are highly specific in nature; it interact with **one or few** substrates and catalyze **only one type** of chemical reaction.

Types pf enzyme specificity

Type	Reaction	Example
1. Absolute specificity	Catalyze one type of reaction For one substrate only	Urease (hydrolyze urea only)
2. Group specificity	Catalyze one type of reaction For similar substrates	Hexokinase (add P to hexoses)
3. Linkage specificity	Catalyze one type of reaction For specific type of bond	Chymotrypsin (hydrolyze the peptide bonds)

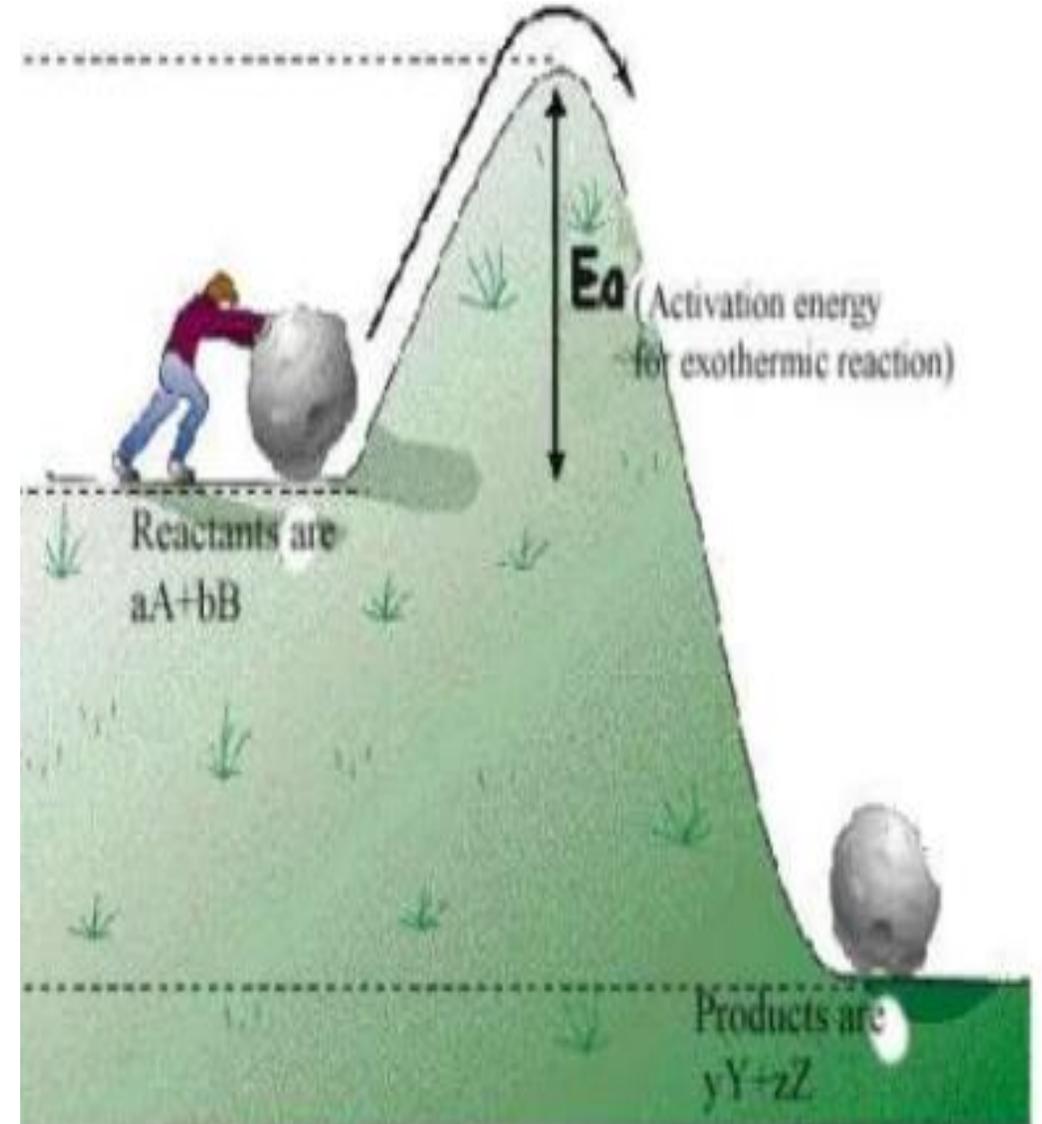
7. Enzyme action

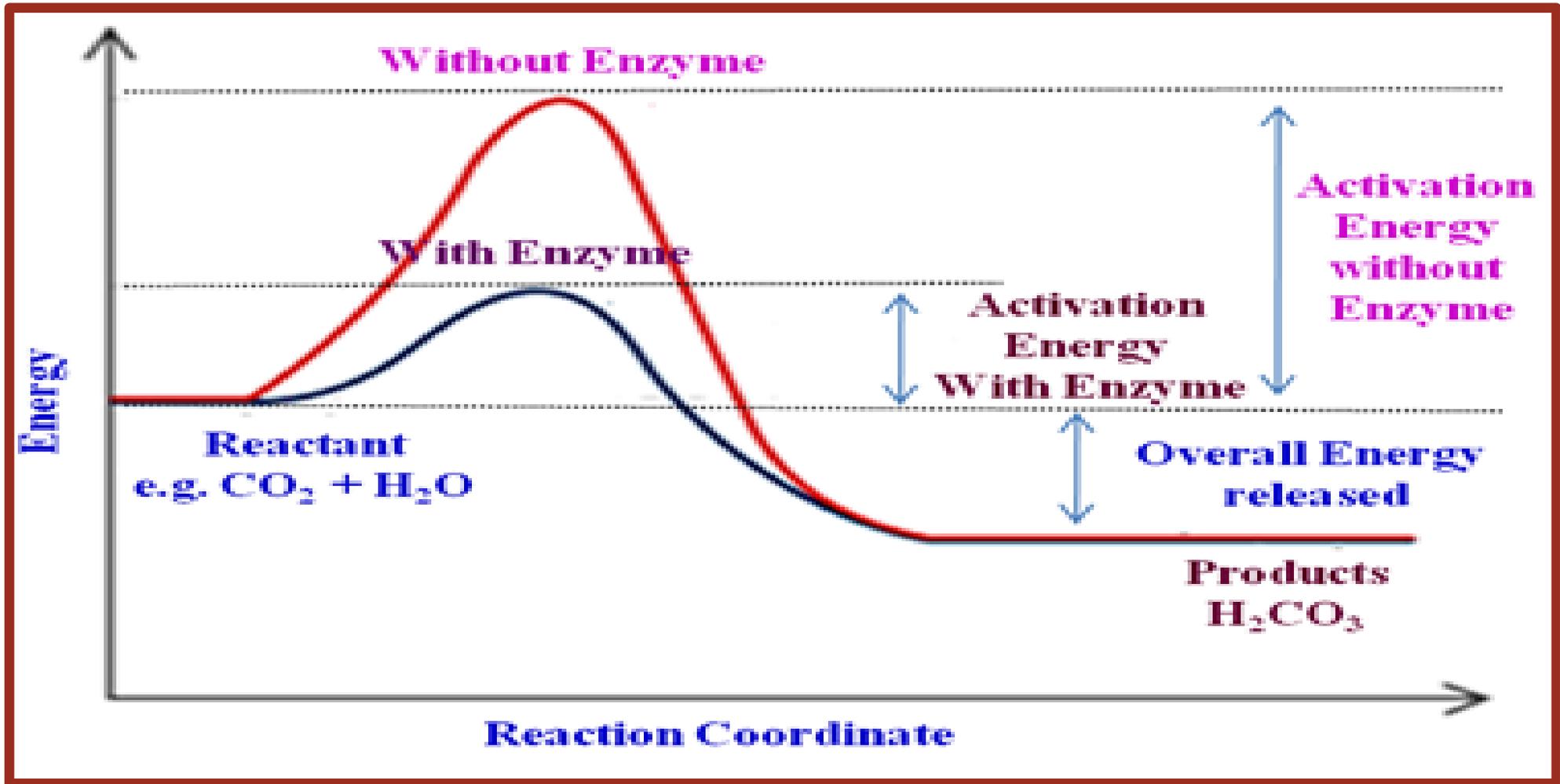
In non-enzymatic reactions:

- ✓ There is an **energy barrier** between reactants and end products.
- ✓ So, to start a chemical reaction, a certain amount of energy is needed to **overcome** this barrier.
- ✓ This amount of energy is called **activation energy**

Enzymes

- ✓ **Increase** the rate of reaction by
- ✓ **Decreasing activation energy** (energy barrier between reactants and end products)





✓ **Enzyme:**

- **lower** activation energy



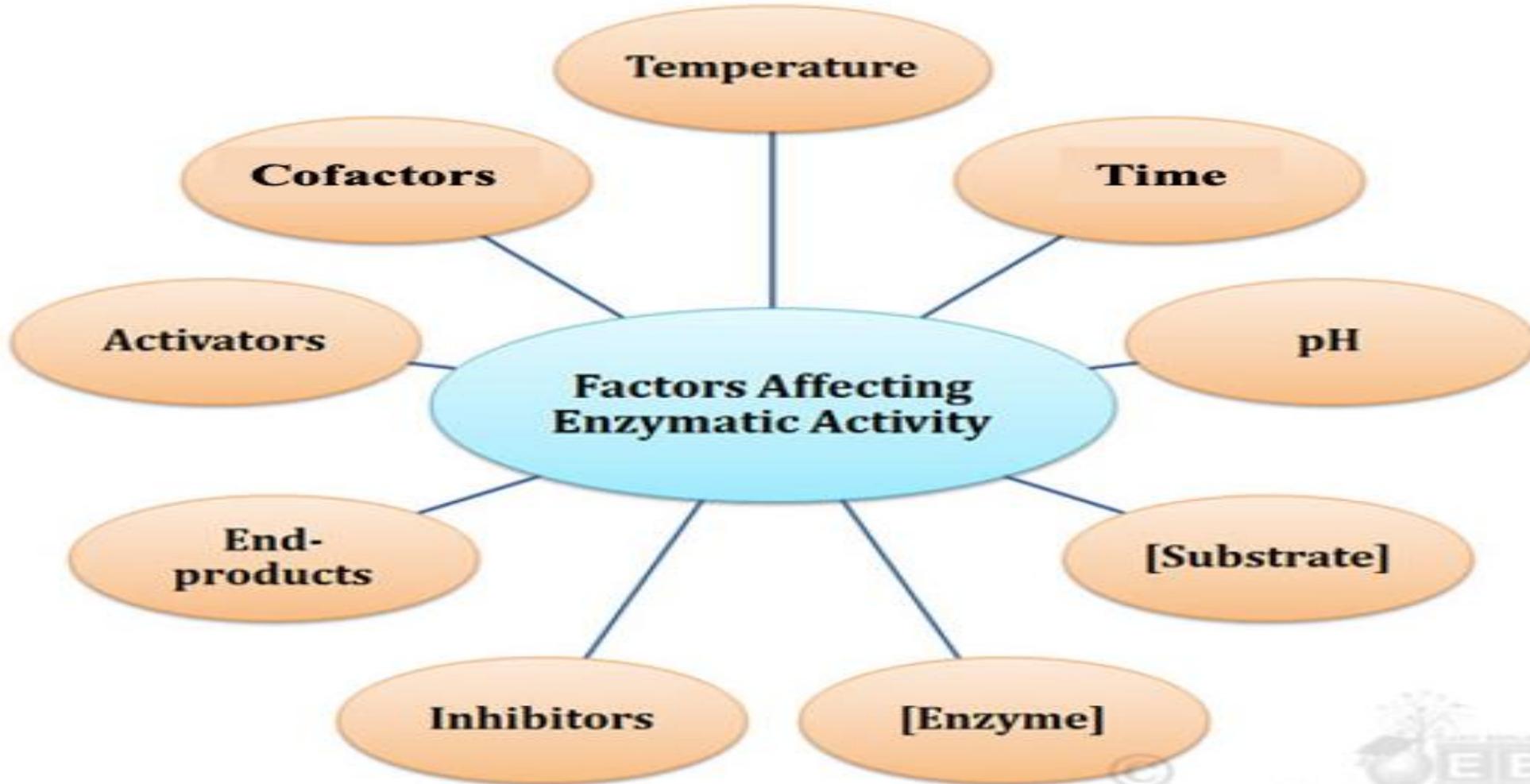
Catalysts and Activation Energy

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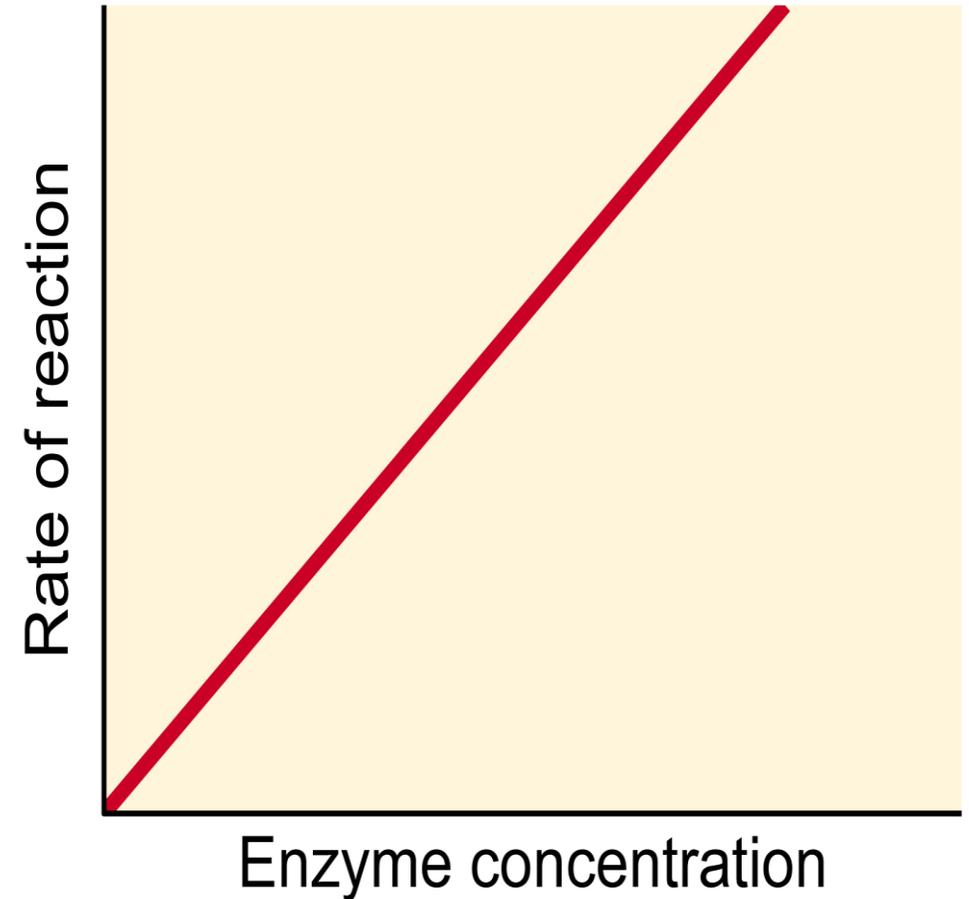
8. Factors affecting the rate of enzyme action

Factors Affecting Enzymatic Activity



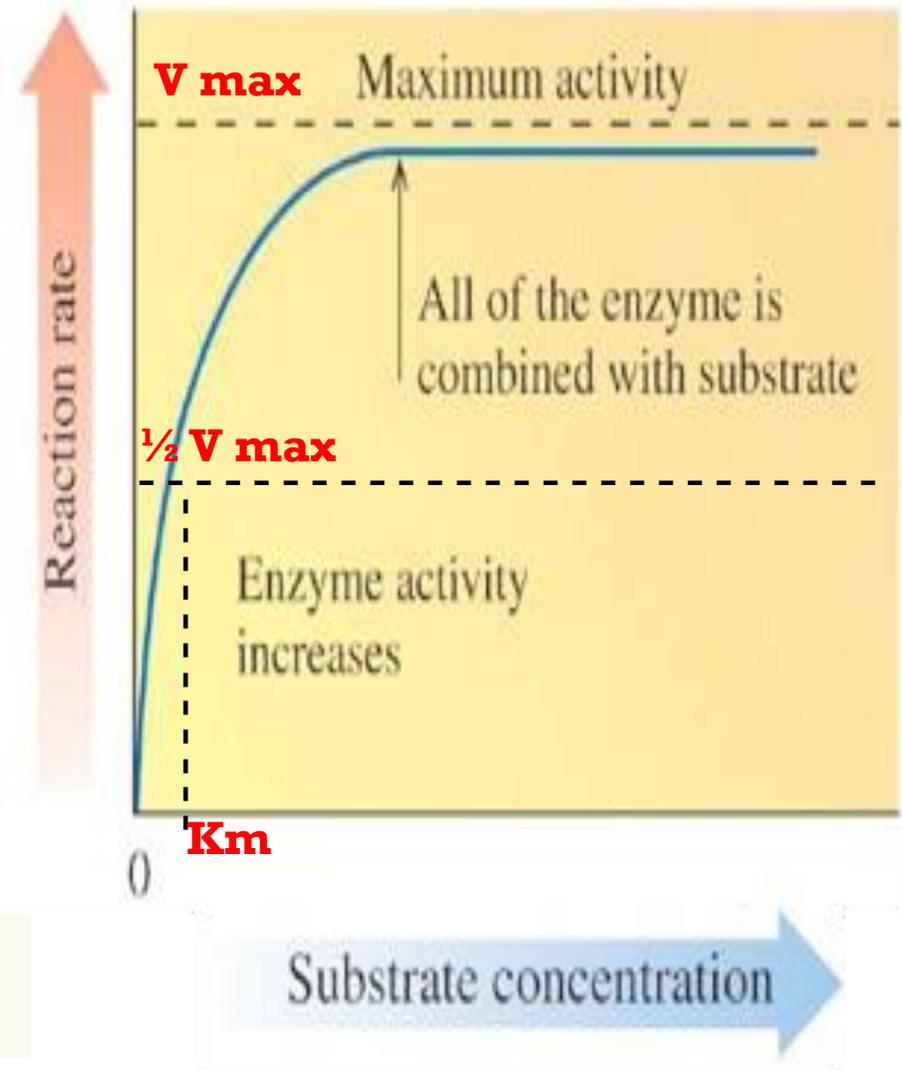
1) Effect of enzyme concentration

- ✓ **The rate of enzyme** action is **directly proportional** to the concentration of enzyme.
- ✓ **Provided that**, there are **sufficient** substrate & **constant** conditions.
- ✓ so, \uparrow conc. of enzyme \rightarrow \uparrow rate of enzyme action)



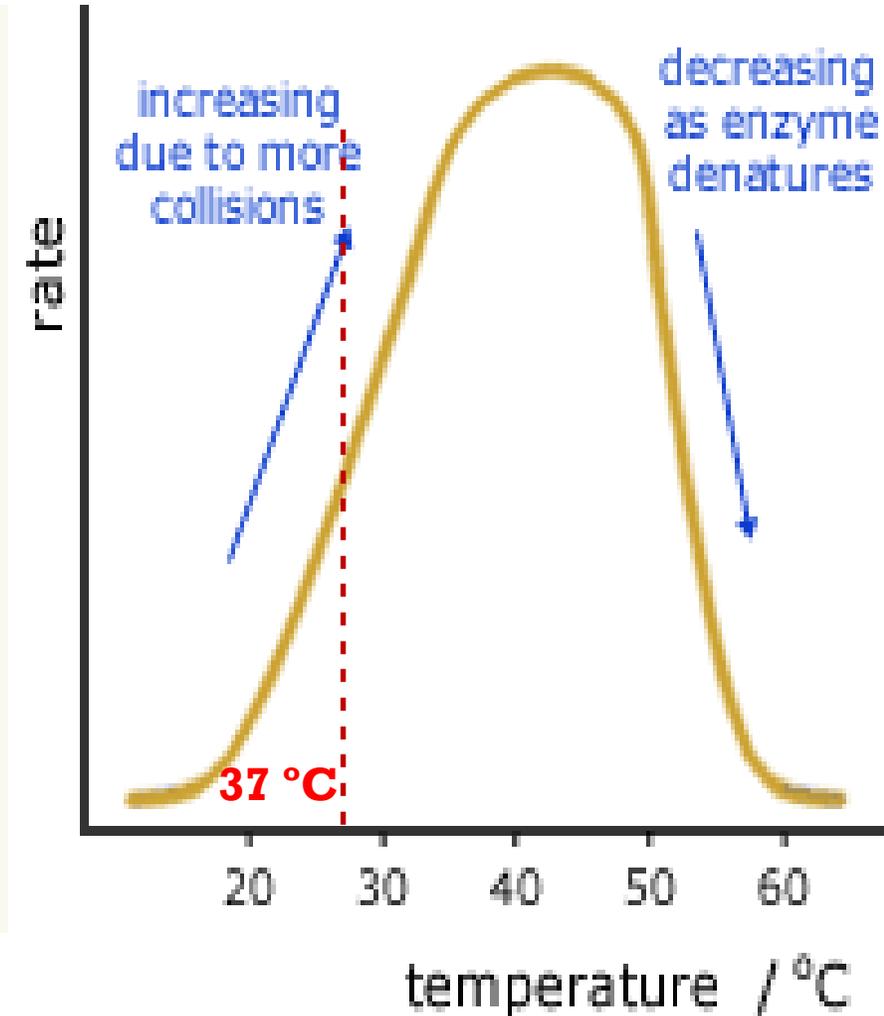
2) Effect of substrate concentration

- ✓ **↑ substrate conc.** → ↑ Velocity (rate) till V_{max} (maximum velocity) is reached.
- ✓ **At V_{max}** = enzyme is completely saturated with the substrate any increase in substrate concentration doesn't affect the reaction rate.
- ✓ **After V_{max}** : any ↑ in subs. → no more ↑ in rate of the reaction
- ✓ **Michaelis constant (K_m)**: It is the substrate conc. that produces half maximum velocity of enzyme



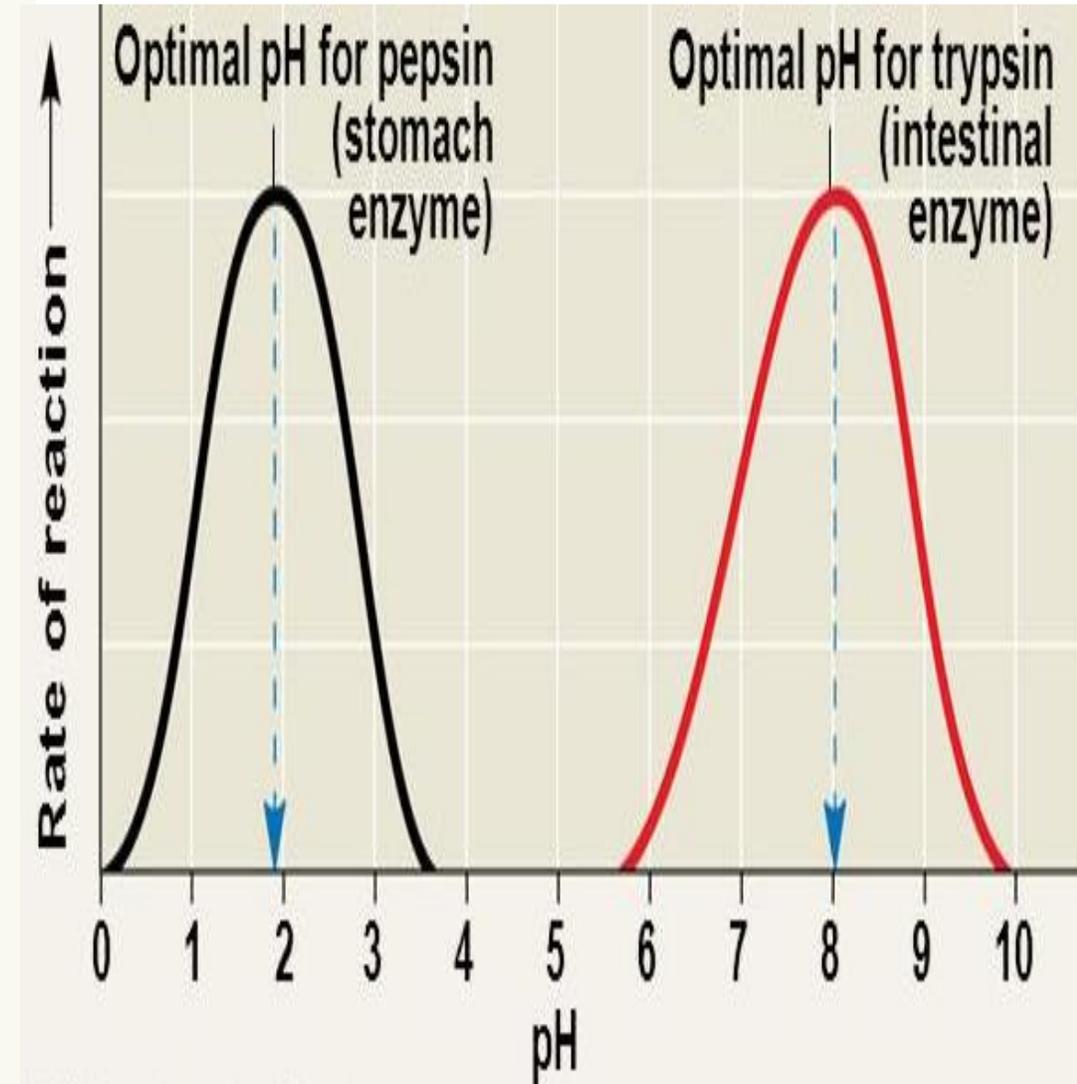
3) Effect of Temperature

- ✓ **↑ Temp** → ↑ Rate of reaction (**due to collision**) until reach a maximum rate at a certain temp, called **optimum temperature**.
- ✓ **After that** → rate ↓ → till stop at high temp (**due to enzyme denaturation**) at 60-65 °C).
- ✓ **The optimum temperature** in human is 37-40 °C



4) Effect of pH

- ✓ **Every enzyme** → **optimal pH** at which it function the best.
- ✓ **Changing pH** → ↓ enzyme activity dt:
 - Changing **ionization** of active site
 - **Denaturation** (at extreme pH change)
- ✓ **Optimum pH of:** Pepsin= 1.5-2
Pancreatic lipase = 7.5 - 8
Salivary amylase = 6.8



5) Other factors affecting rate of enzyme reaction

1- Concentration of cofactors:

Increase cofactors (coenzyme / metal ions activator) → increase the reaction rate.

2-Presence of enzymes inhibitor

Enzyme inhibitor → decreases or stops the enzyme activity

3- Effect of end products:

Accumulation of end products inhibit enzyme action.

4- Effect of time: the rate of reaction is decreased by time due to

1. ↓ substrate concentration.
2. Accumulation of the end products.
3. Change in PH than optimum pH.



REFERENCES

- ❑ **Chatterjea's Textbook of Medical Biochemistry, 8th edition.**
- ❑ **Vasudevan's Textbook of Biochemistry For Medical Students, 6th Edition.**
- ❑ **Lippincott's Illustrated Reviews: Biochemistry, 8th edition**
- ❑ **<https://www.youtube.com/watch?v=c5j6ExHLFD8>**

