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Biochemistry

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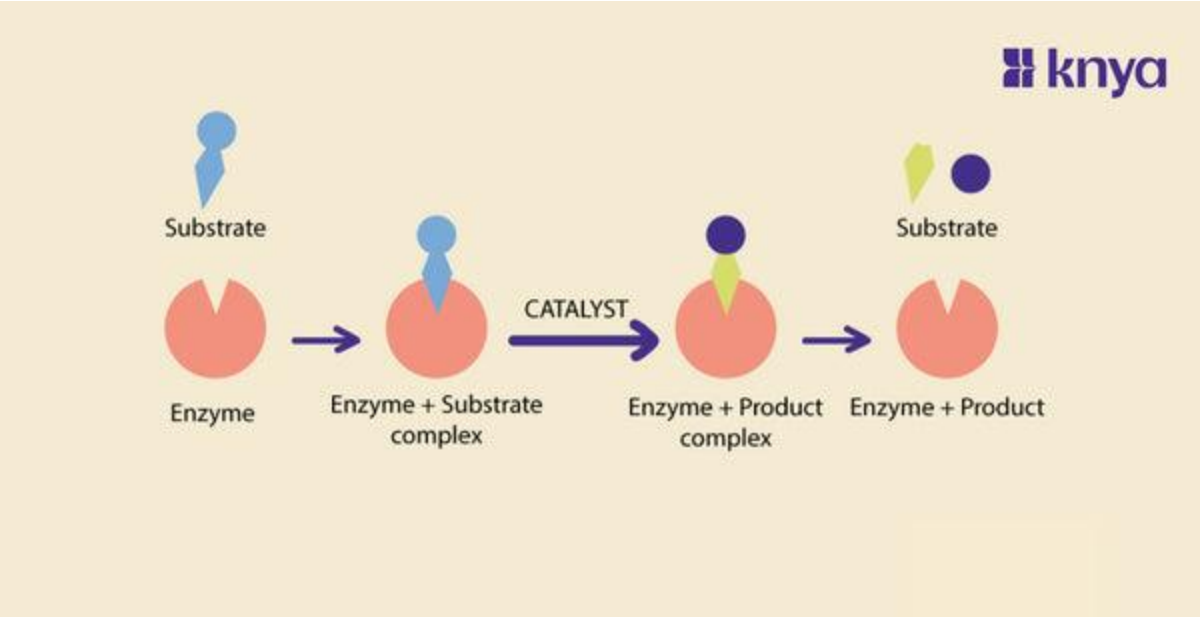
Enzymes Biological Catalysts that Speed up Chemical Reactions

- Enzymes are biological catalysts which speed up the rate of a chemical reaction without being itself changed in the process
- With the exception of some biocatalysts RNA molecules, called ribozymes that catalyze their own splicing,
- All enzymes are proteins
- Enzymes are known to catalyze more than 5000 biochemical reaction types

- Enzymes can increase the rate of a reaction by a factor of up to 10^{20} over an uncatalyzed reaction
- Chemically, enzymes are like any catalyst and are **not consumed** in chemical reactions, **nor do they alter the equilibrium of a reaction**. Enzymes differ from most other catalysts by being much more specific



Naming Enzymes

Enzymes names can be formed in Four ways

1-Depend of the reacting substance (substrate)

Usually ends in **ase** add to the substrate .

Ex: sucrase catalyzes the hydrolysis of sucrose

2- Depend on the function reaction of the enzyme .

Ex: oxidases catalyze oxidation reactions

3-Depend on both the substrate and the function

Ex: alcohol dehydrogenase oxides ethanol

4-Sometimes common names are used particularly for the digestion enzymes such as pepsin and trypsin

Types of enzymes

1-Endoenzymes

Enzymes that function within the cells. Most of the enzymes are these types e.g metabolic enzymes cytochrome oxidase found mitochondria of eukaryotes (catalyzes the reduction of molecular oxygen to water)

2-Exoenzymes

Enzymes that are liberated by cells and catalyse reactions outside the cell e.g digestive enzymes amylase, lipase, protease (catalyzes proteolysis, the breakdown of proteins into smaller polypeptides or single amino acids

Enzyme Structure

1. Simple enzymes only protein structure

2. Complex enzymes (holoenzyme) Protein structure

(Apoenzyme + cofactor)

The protein part of the holoenzyme is known as the apoenzyme, which is inactive. The non-protein part is called a cofactor and is necessary for the catalytic function of the enzymes. Cofactor can be

A. **Inorganic element** : Zn^2 Mn^2 Mg^2 Fe^2 Cu^2

B. **Organic molecule:**

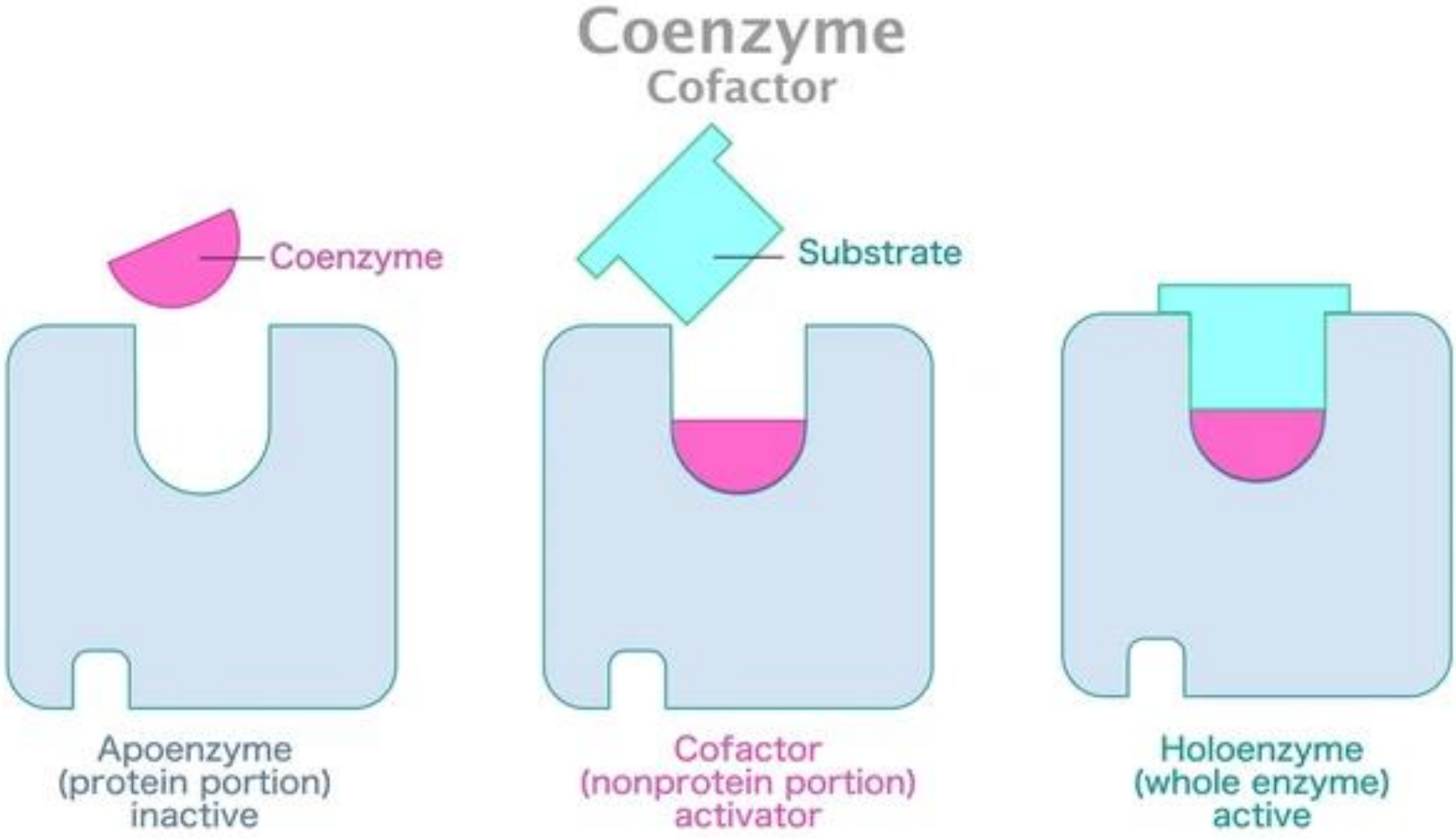
a)Coenzymes

- ❖ Small non proteins slightly bound to the enzyme
- ❖ Undergo a chemical change and are released

Ex: Coenzyme A acyl transfer ,Flavins redox reaction, (nicotinamide adenine dinucleotide) NAD^+ , $(NADP)^+$, redox reactions ,Vitamins derivatives of B vitamins (B_1 ,B_2 ,B_6 ,B_{12} , niacin, folic acid, riboflavin)

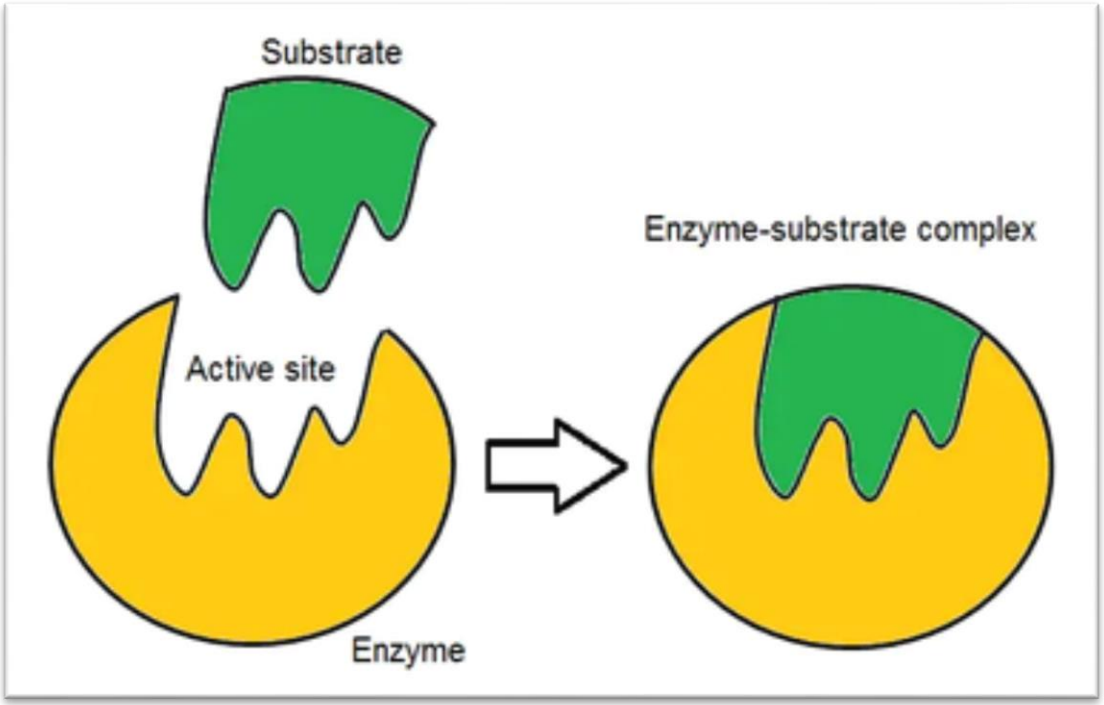
b)Prosthetic groups

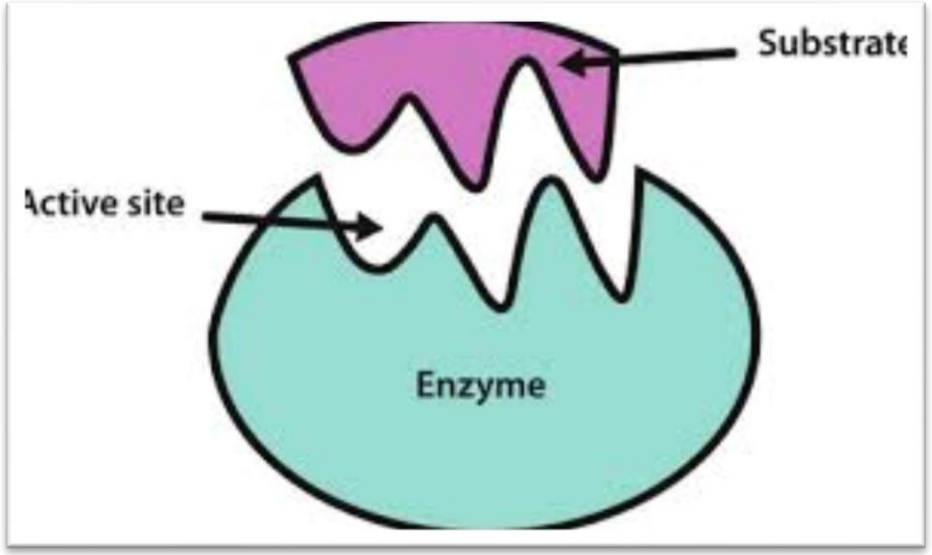
- ❖ Large complex tightly bound to the enzyme
- ❖ Remain associated with enzyme during reaction :Heme, biotin, flavin, iron sulphides, copper, and ubiquinone are examples of prosthetic groups,


Coenzyme
Cofactor
Coenzyme
Substrate
Apoenzyme
(protein portion)
inactive
Cofactor
(nonprotein portion)
activator
Holoenzyme
(whole enzyme)
active

Enzyme Active Site and Substrate Specificity

- **Substrate** : A **reactant** in a chemical reaction is called a **substrate** when acted upon by an enzyme
- **Active site** :The active site is the part of an enzyme to which substrates bind and where a reaction is catalyzed. Since enzymes are proteins, this site is composed of a unique combination of amino acid residues .Size of amino acids (large or small), properties of amino (acids weakly acidic or basic hydrophilic or hydrophobic and positively charged, negatively charged, or neutral in addition to the positions, sequences, structures, of these residues create a very specific chemical environment within the active site specific with unique substrate


Substrate
Enzyme-substrate complex
Active site
Enzyme


Substrate
Active site
Enzyme

Substrates binding:

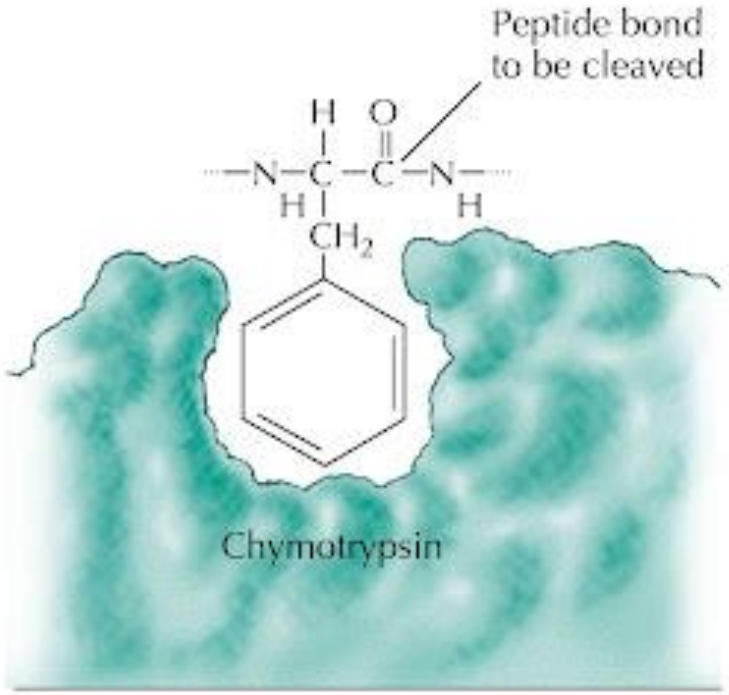
A specific chemical substrate matches this and makes the enzyme specific to its substrate.

Substrate binding to active site using the usual forces of interaction.

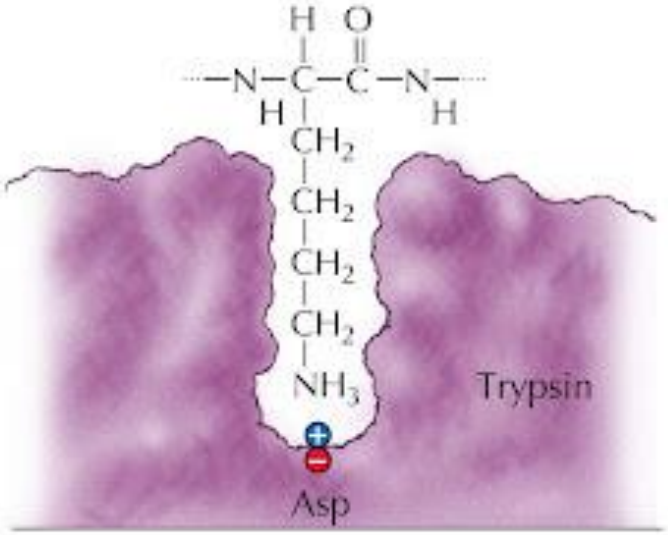
1. Ionic
2. H -bonding
3. Dispersion forces (vanderwale)
4. Dipole- Dipole
5. Covalent bonds
6. Pi stacking (noncovalent interactions between aromatic rings)

Ex: Binding of pyruvic acid in LDH (lactic dehydrogenase enzyme)

Ionic bonding , H bonding , dispersion forces



Hydrophobic interaction

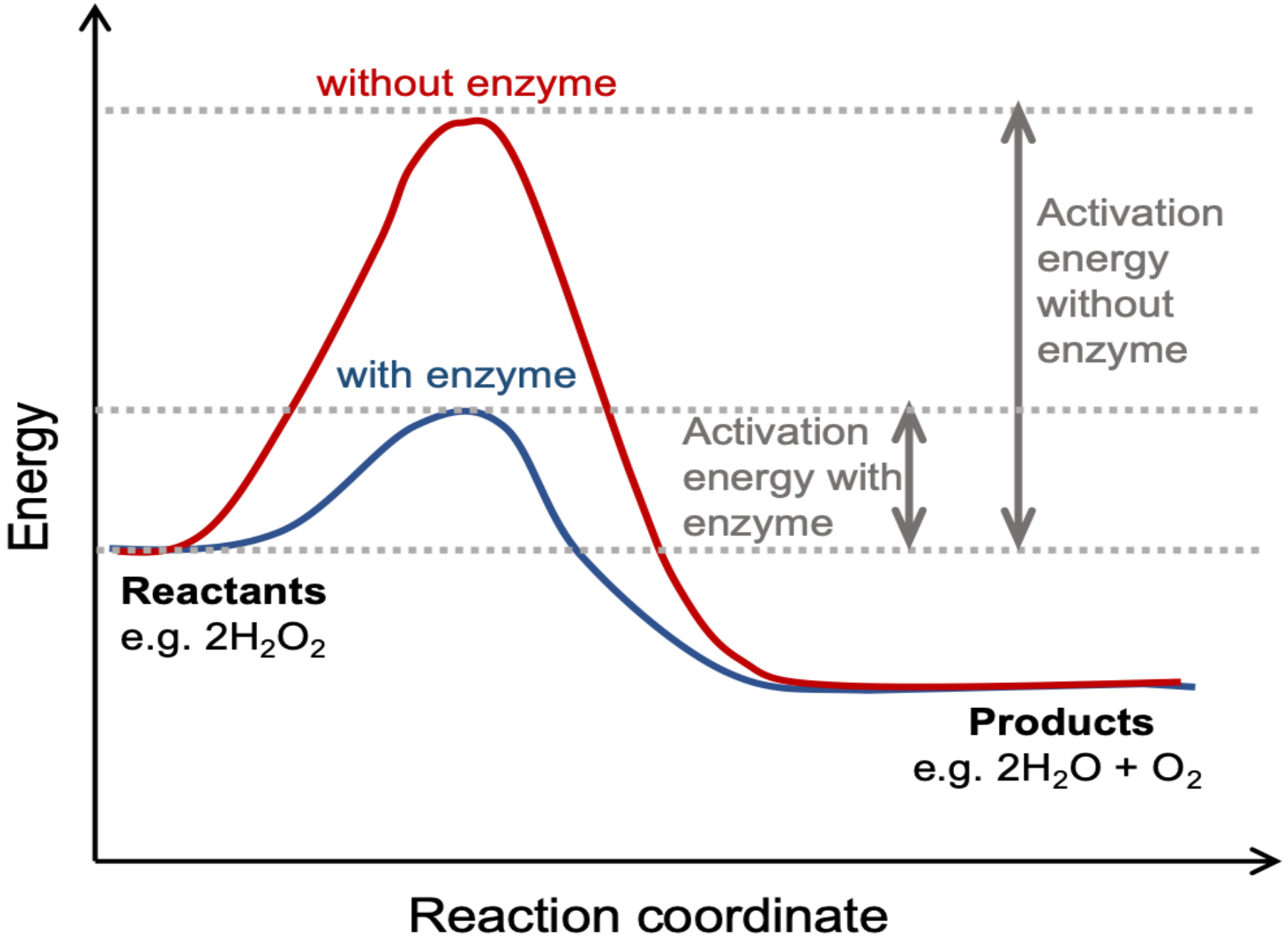


Ionic interaction

Enzyme catalyze the reaction

Enzymes are catalyst that accelerate the rate of biochemical reaction by decreasing the energy of activation

- Every chemical reaction have energy barrier that must be crossed by the **reactant molecules** in order to convert itself into **the product**
- The amount of energy supplied to reactant molecules in order to cross the energy barrier to from product is known as **energy of activation**
- If energy of activation is **higher**, rate of reaction is **slower** and if it is **lower**, the rate of reaction is **faster**
- The role of enzyme in biochemical reaction is to reduce the amount of energy of activation such that the rate of reaction increases


without enzyme
with enzyme
Activation energy without enzyme
Activation energy with enzyme
Energy
Reactants
e.g. $2H_2O_2$
Products
e.g. $2H_2O + O_2$
Reaction coordinate

Factors affecting enzyme activity

1- **Temperature** Raising temperature generally speeds up a reaction, and lowering temperature slows down a reaction However, extreme high temperatures can cause an enzyme to lose its shape (and stop working

2- **pH** Each enzyme has an optimum pH range Changing the pH outside of this range will slow enzyme activity Extreme pH values can cause enzymes to denature

3- **Enzyme concentration** Increasing enzyme concentration will speed up the reaction, as long as there is substrate available to bind to

4-**Substrate concentration** Increasing substrate concentration also increases the rate of reaction to a certain point


Thank
You