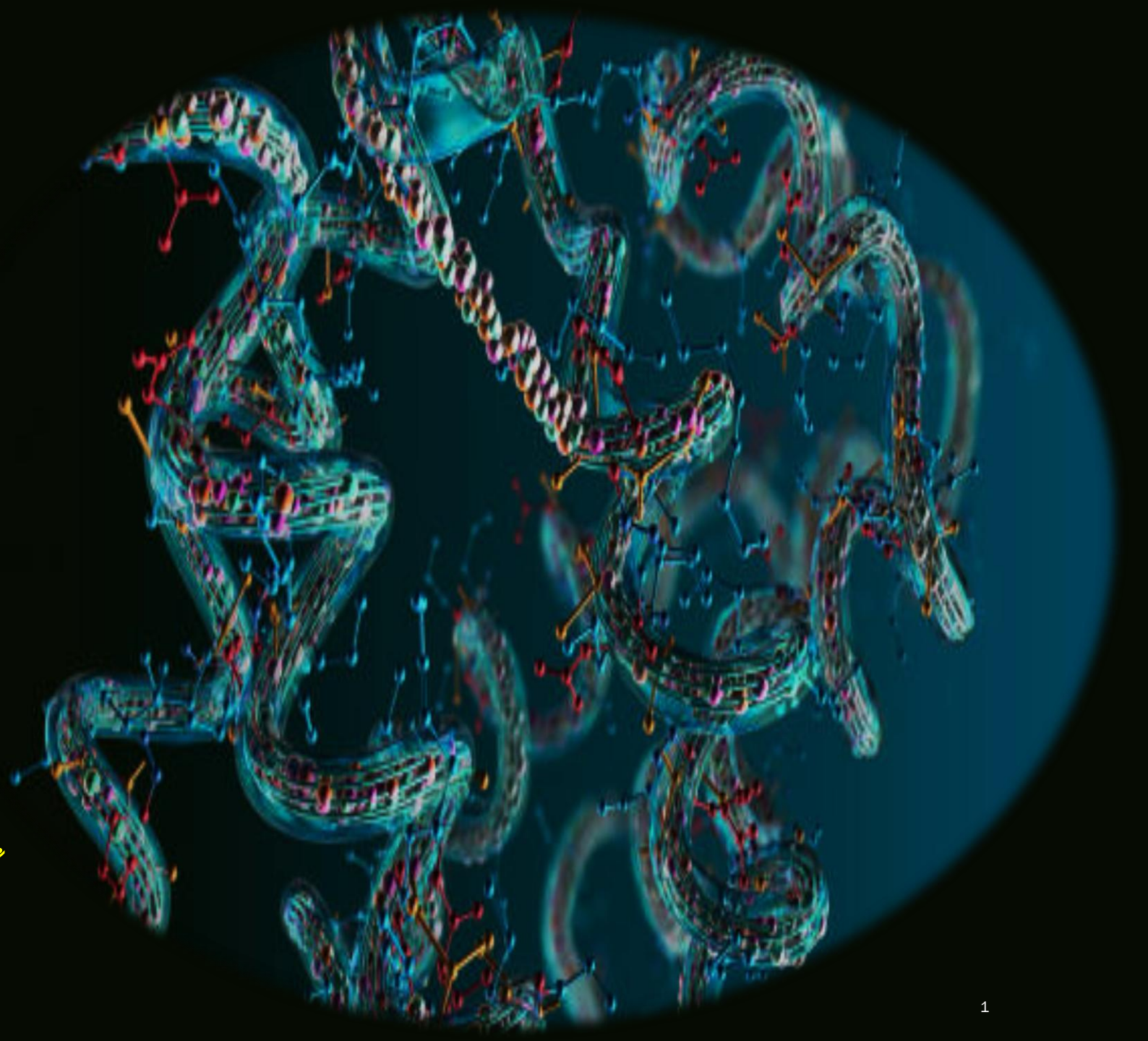
Enzymes



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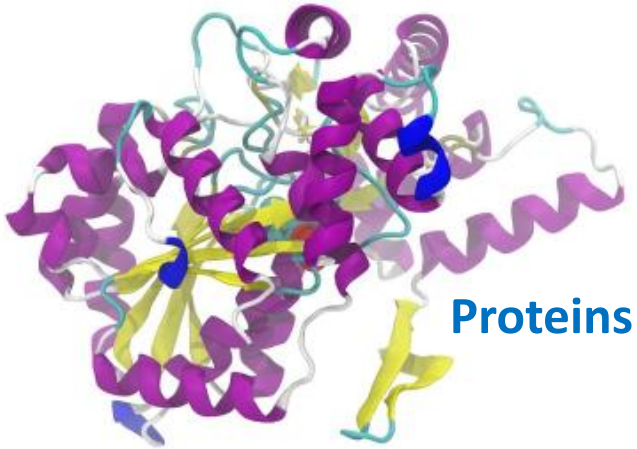
Biochemistry Lec. (5)

Overview

- What are enzymes ?
- Structure of Enzymes
- Classification
- Factors Affecting Enzyme Action

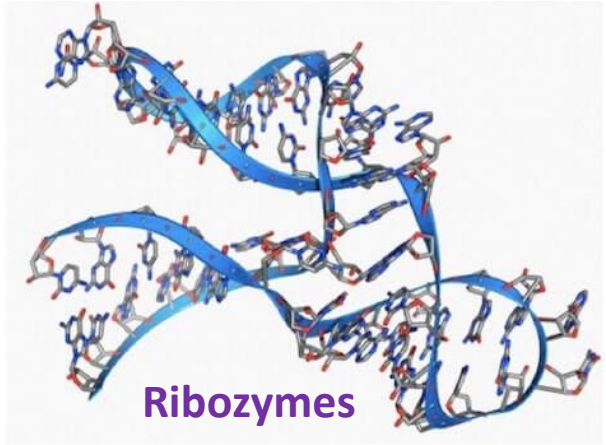
Definition of Enzyme

Enzymes are biocatalysts present in cells that speed up biochemical reactions without getting itself destroyed in the reaction

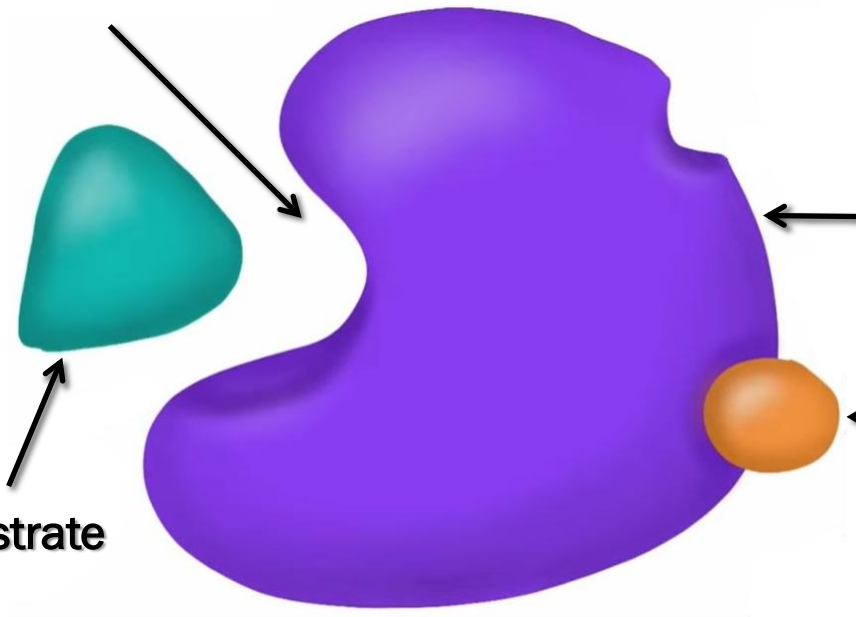


✓- Enzymes are typically **proteins** (tertiary and quaternary structure).

✓- Certain some special RNA species can also act as enzymes. and are called **Ribozymes**.



Structure of Enzymes



Apo Enzyme
Protein
(inactive)

Non-Protein

Holo Enzyme
(Active)

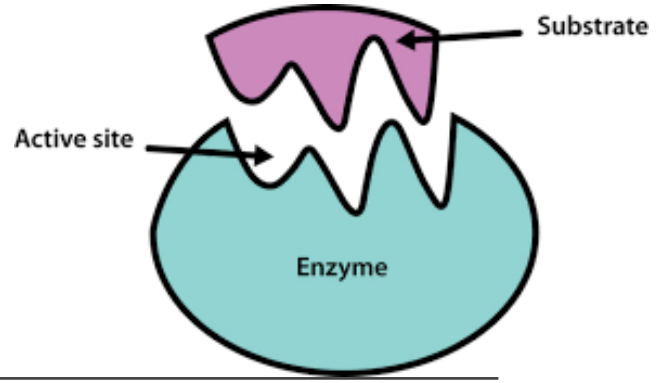
Coenzyme

Cofactor
(Cu, Mg, Fe, Zn, Se)

Prosthatic Group
(Premanent)
B-Vit

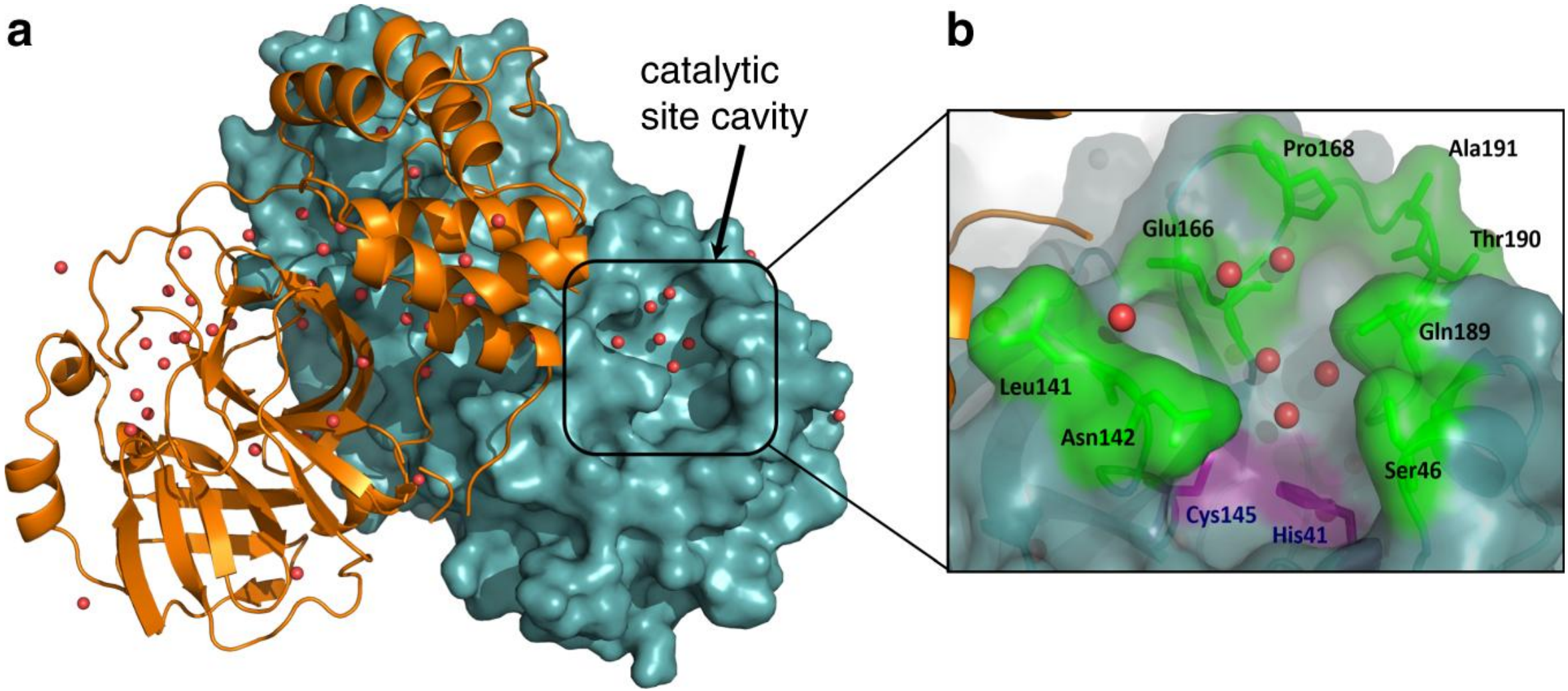
Co-Substrate
(Transient)
(NAD+, NADP, FMN)

Active sites of enzymes



- The active site of an enzyme is the region that binds **substrates**, also known as catalytic activity site
- **One** or **more** regions on the enzyme molecules where the substrate can bind.
- Shape of the enzyme molecule is such that it will **expose some amino acids so that substrate molecules can bind to it** for necessary catalytic function
- Active sites generally occupy less than 5% of the total surface area of enzyme.
- A change in the shape of protein affects the **shape of active site and function of the enzyme.**

Active sites of enzymes



Cofactors

Cofactors "helper molecules" – non-protein compounds that are bound to a protein and required for the protein's biological activity.

- Cofactors include **Cu**, **Mg**, **Fe**, **Zn** and **Se** ions
  - **e.g: Hexokinase has co-factor Mg**

Coenzyme

❖ - Many reactions of substrate are catalyzed by enzymes only in the presence of non-protein organic molecule called coenzyme.

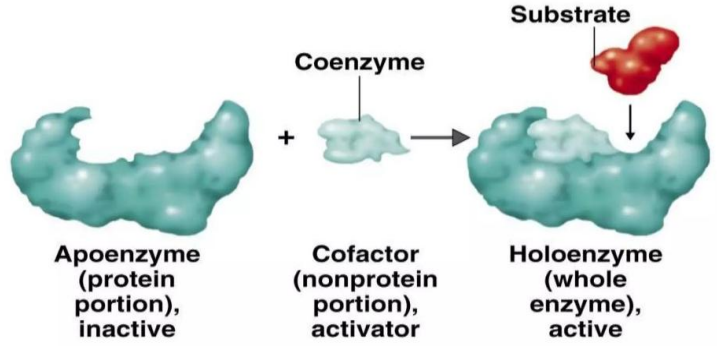
Coenzyme are of two types:

Prosthetic group describes a complex in which the small organic molecule is **permanently bound** to the apoenzyme by **covalent bonds**

e.g. **Flavins**, **heme groups** and **biotin.**

Cosubstrate occurs when it is **transiently** attached.

Coenzymes are often derivatives of vitamins (NAD,NADP, CoA)



- **Coenzyme** combines with the **Apoenzyme** (protein part) to form Holoenzyme.

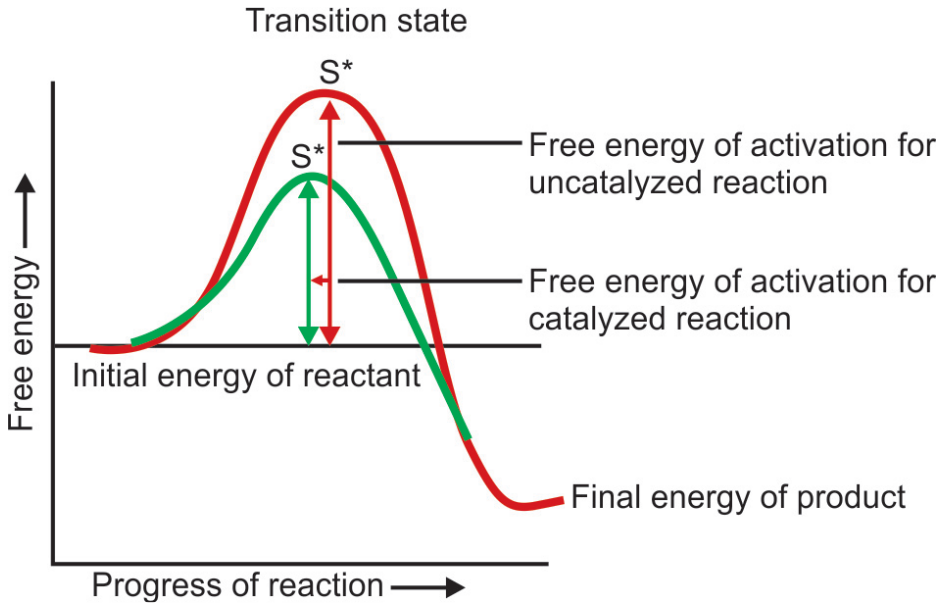
How Enzymes Work

❖- Energy Changes Occur During the Reaction

- - Virtually all chemical reactions have an energy barrier, separating the reactants and the products.
  - ✓- This barrier, called the *free energy of activation*.

S ⇌ S* ⇌ P

(Reactant) (Product)



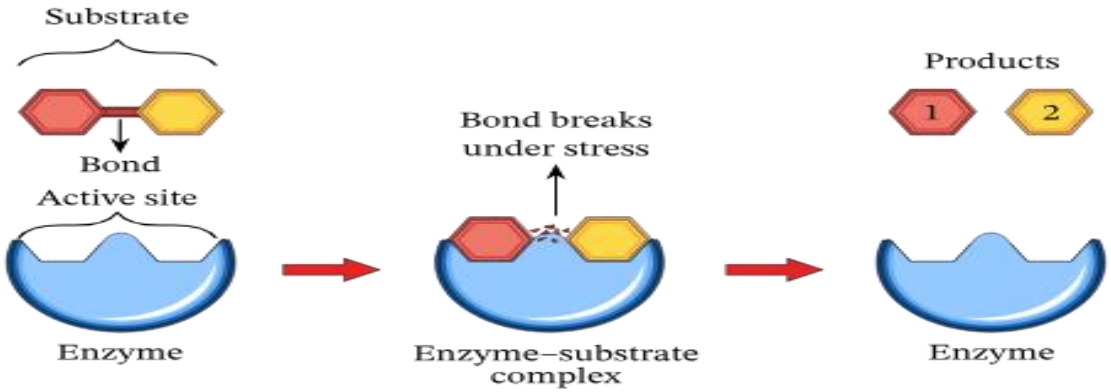
- ✓ - An enzyme lowers the energy required for activation to the transition state.
- ✓ - Without a catalyst, the reaction will occur only if enough heat energy is added to the reaction system.
- ✓ - With an enzyme as a catalyst, the reaction may easily proceed at the normal physiological temperature.

Figure 5.1 shows the changes in energy during the conversion of a molecule of reactant 'S' to product 'P' through the transition state S*.

Mechanism of Enzyme Action

- Formation of an **Enzyme-Substrate (ES)** complex is the first step in enzymatic catalysis.

- Substrate is bound through multiple noncovalent interactions at the **active site** of the enzyme forming an enzyme-substrate (ES) complex which is subsequently converted to product and free enzyme.



Two models for substrate binding to the active site of the enzyme, have been proposed to explain the specificity that an enzyme has for its substrate:

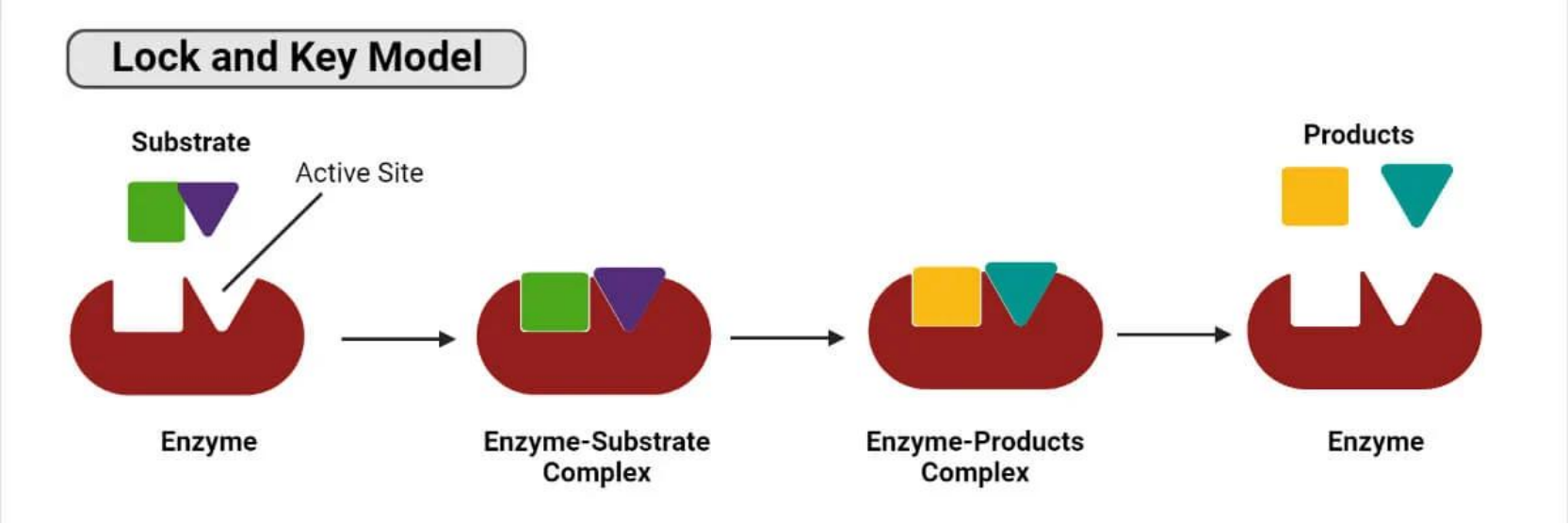
1. Lock and key model or rigid template model of Emil Fisher.
2. Induced fit model or hand-in-glove model of Daniel E Koshland.

Lock and Key Model or Rigid Template

Model of Emil Fisher

- In this model, enzyme is preshaped and the active site has a rigid structure that is complementary to that of the substrate .

- This model is called lock and key model, because in this model the substrate fits into the active site in much the same way that a key fits into a lock.



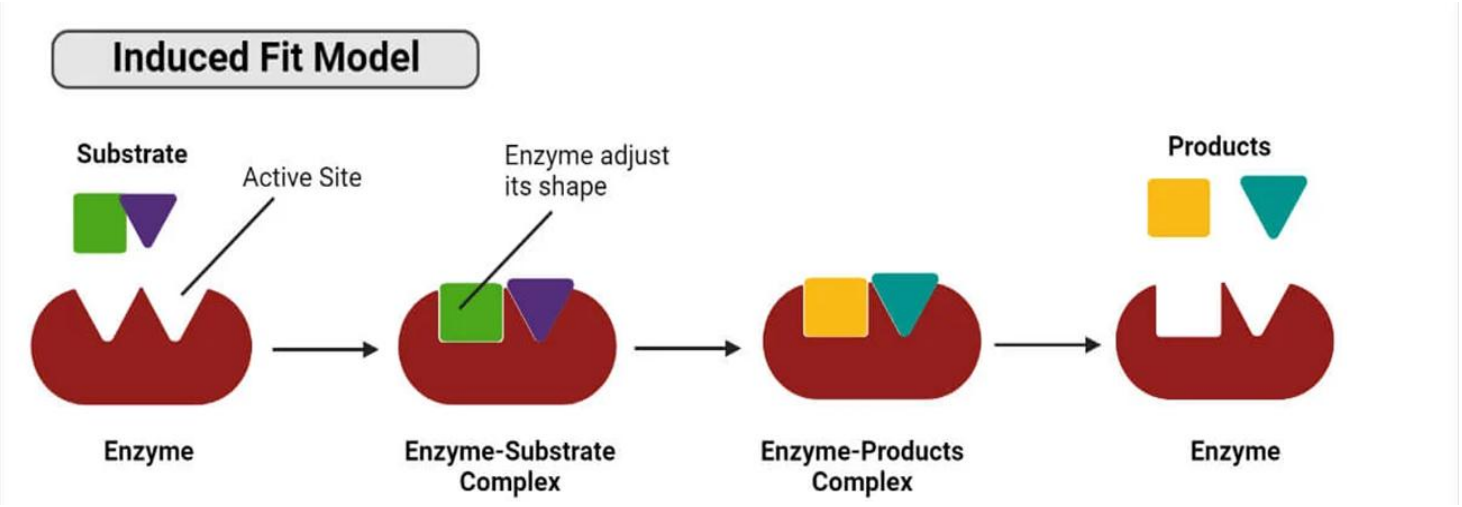
Induced Fit Model or Hand-in-glove

Daniel E Koshland

- In the induced fit model, the substrate induces a conformational change in the enzyme, in the same manner in which placing a hand (substrate) into a glove (enzyme) induces changes in the glove's shape. Therefore, this model is also known as hand-in glove model.

- Conformational change in enzyme in turn induces reciprocal changes in its bound substrate that alters their orientation and configuration and strains the structure of the bound substrate. Due to such changes energy is librated, which is called intrinsic binding energy.

- This intrinsic binding energy due to the substrate enzyme interaction is made available for the transformation of the substrate into product.



Classification of enzymes

Enzymes are classified into six categories (EC number classification) by the International Union Of Biochemists (IUB) **on the basis of the types of reactions that they catalyze**:

EC 1. Oxidoreductases

EC 2. Transferases

EC 3. Hydrolases

EC 4. Lyases

EC 5. Isomerases

EC 6. Ligases

EC.1. Oxidoreductases

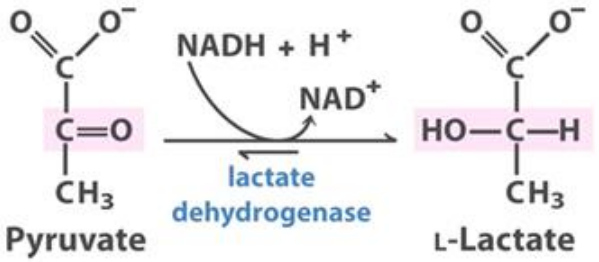
Oxidation-reduction (redox) reactions - **hydrogen** or **oxygen** atoms or electrons are transferred between molecules.

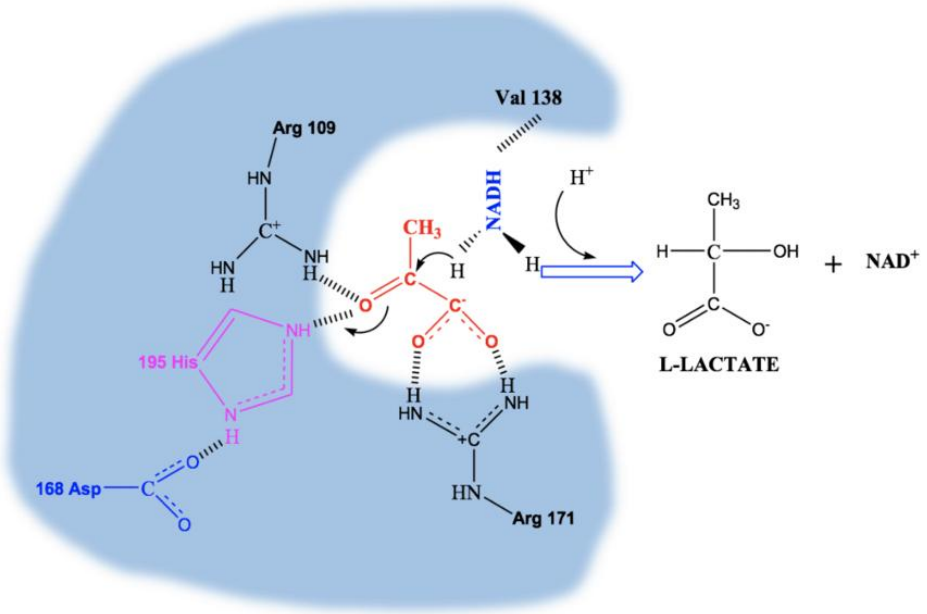
Example: dehydrogenases, oxidases, oxygenases and peroxidases

EC 1.1.1.27

Common name: Lactate dehydrogenase

Systematic name: Lactate : NAD+ oxidoreductase



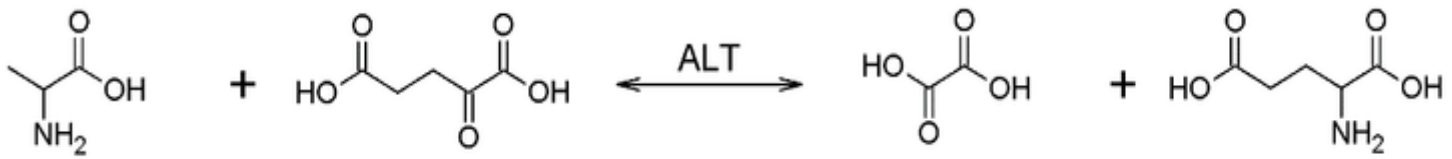


EC.2. Transferases

- These enzymes catalyse the **transfer of a group** between substrates.
  - - E.g: **transfer of** acyl, alkyl, amino, phosphate and glycosyl.

EC 2.6. 1.2

- Common name: **alanine transaminase**
- Systematic name: **alanine:glutarate aminotransferase**

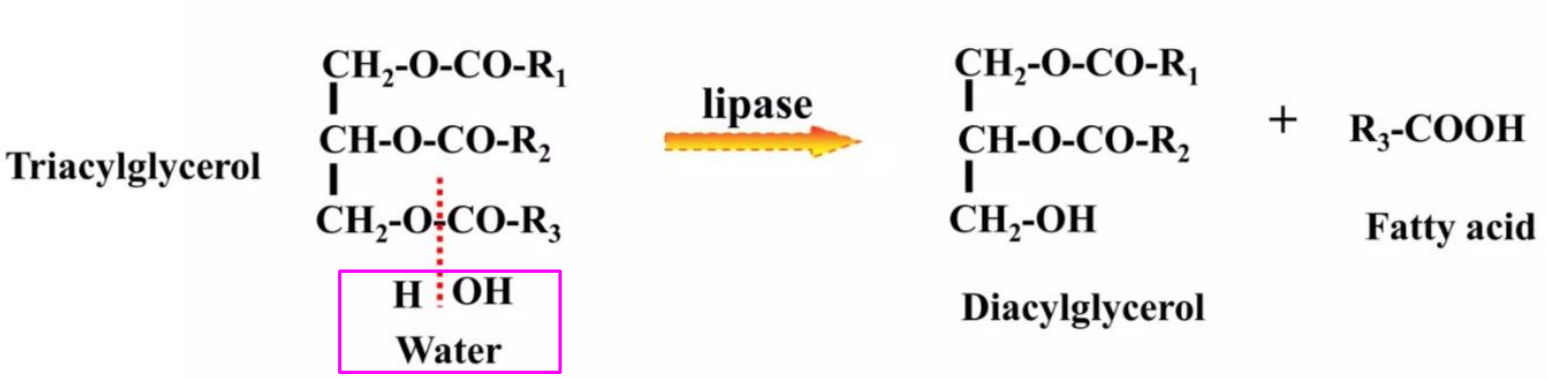


EC.3. Hydrolases

Enzymes of this class catalyze the cleavage of **C-O**, **C-N**, **C-C** and **some other bonds with the addition of water**.

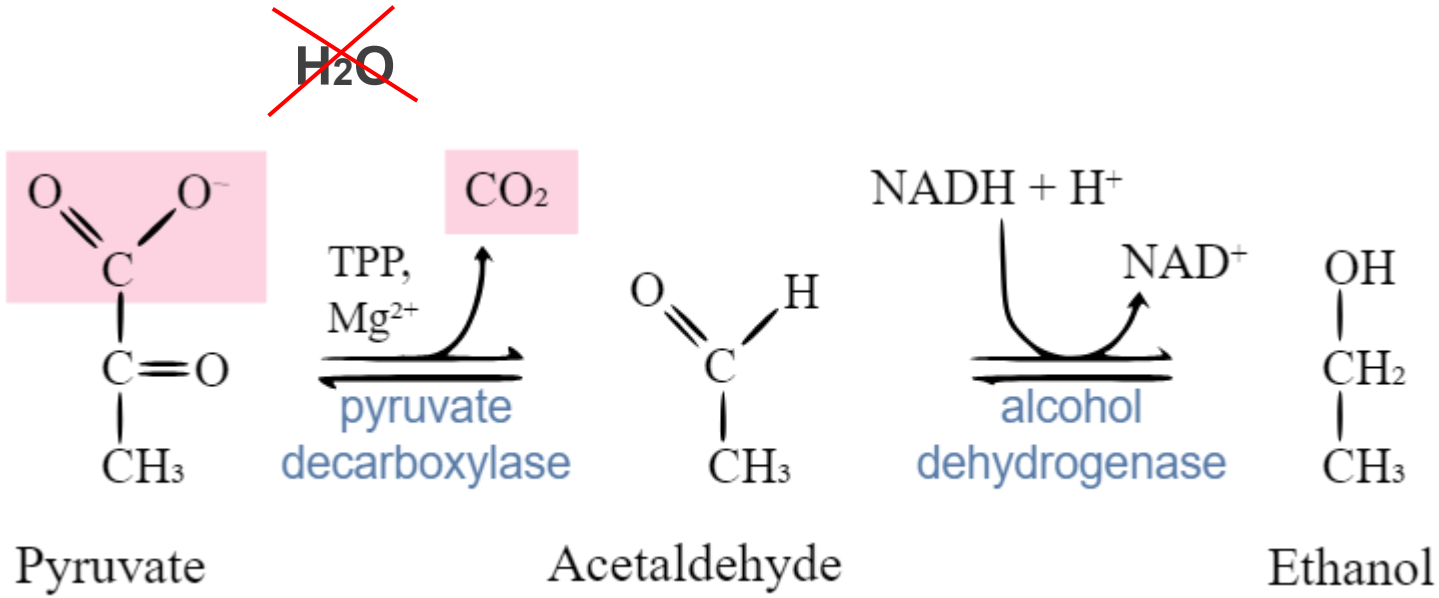
❖ **- Some common enzymes in this category are:**

- All digestive enzymes like **α-amylase**, **pepsin**, **trypsin**, **chymotrypsin**, etc.
- Acid phosphatase



EC.4. Lyases

Lyases catalyze the cleavage of **C-O**, **C-C** and **C-N** bonds by means other than hydrolysis or oxidation, giving rise to compound with double bonds or catalyze the reverse reaction, **by the addition of group to a double bond.**

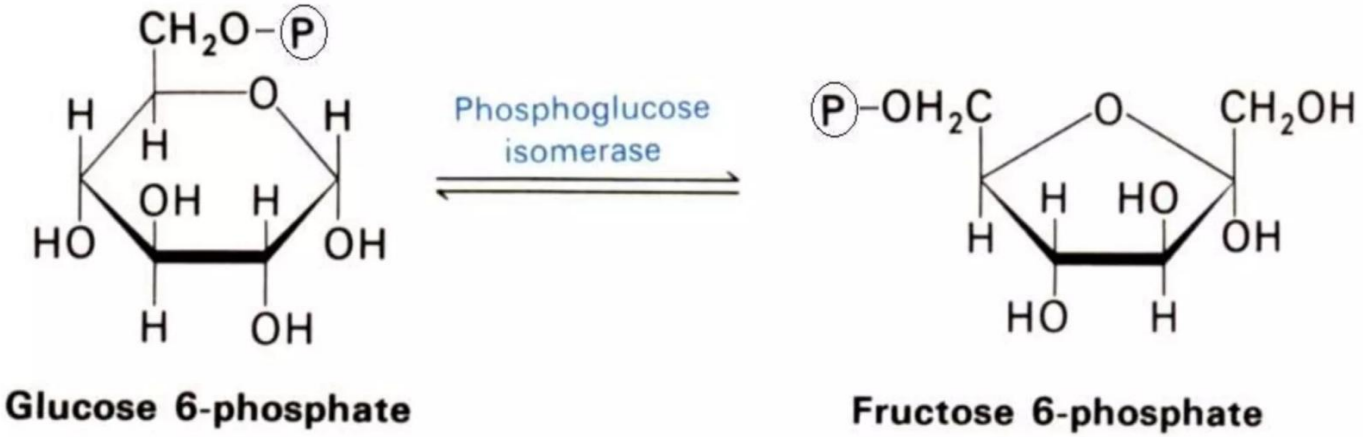


EC.5. Isomerases

Isomerases **catalyze intramolecular structural rearrange ment in a molecule**.

- They are called **epimerases**, **isomerases** or **mutases**, depending on the type of isomerism involved.

Example : Triosephosphate isomerase and **phosphoglucose**

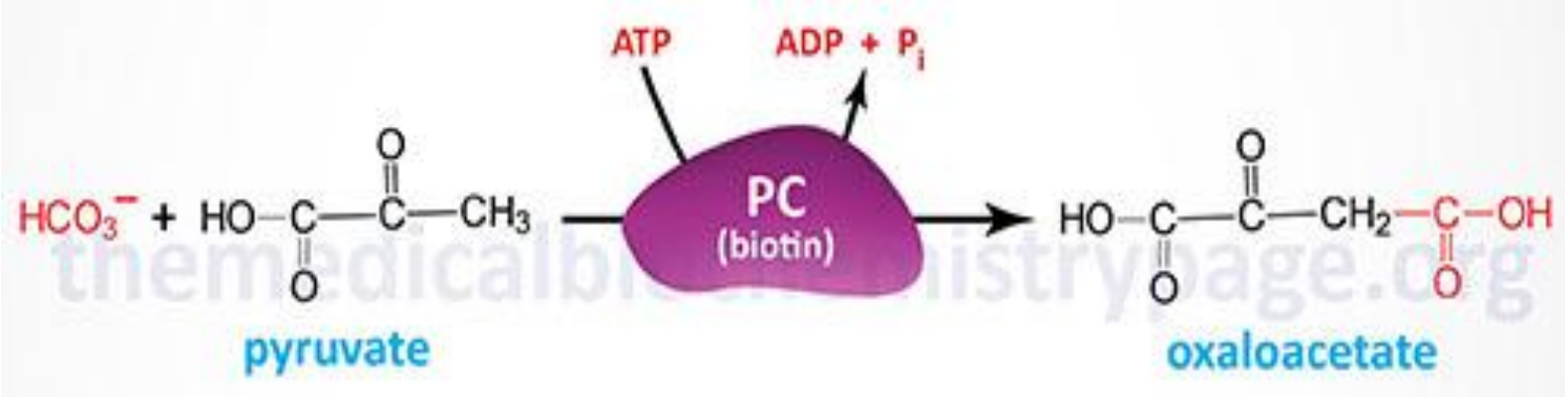


Glucose 6-phosphate **Fructose 6-phosphate**

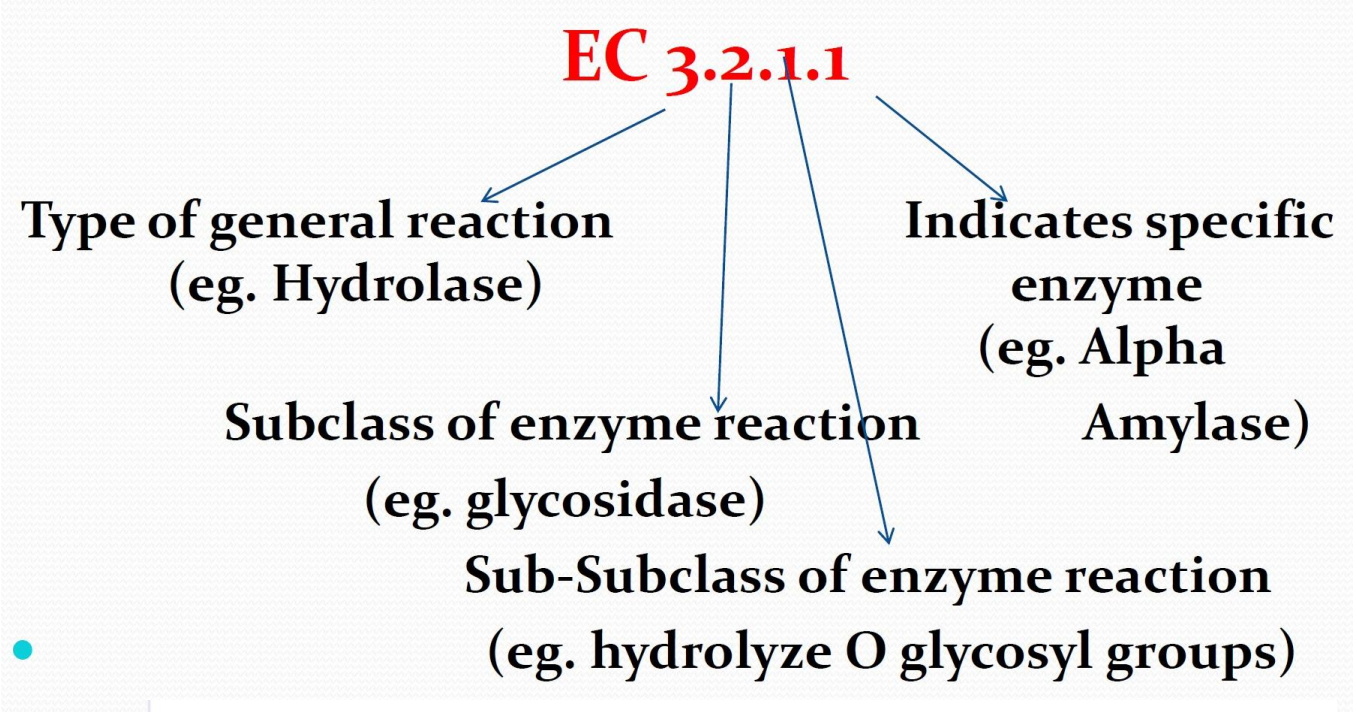
EC.6. Ligases

Ligases catalyze the joining of two molecules coupled with the hydrolysis of ATP.

Exp: Pyruvate Carboxylase



Enzyme Nomenclature



- *example:*

ATP : D-glucose phosphotransferase (EC 2.7.1.2)

→ transfers (2) phosphate (7) to an alcohol group (1)

ATP + D-Glc → ADP + D-Glc-6-phosphate

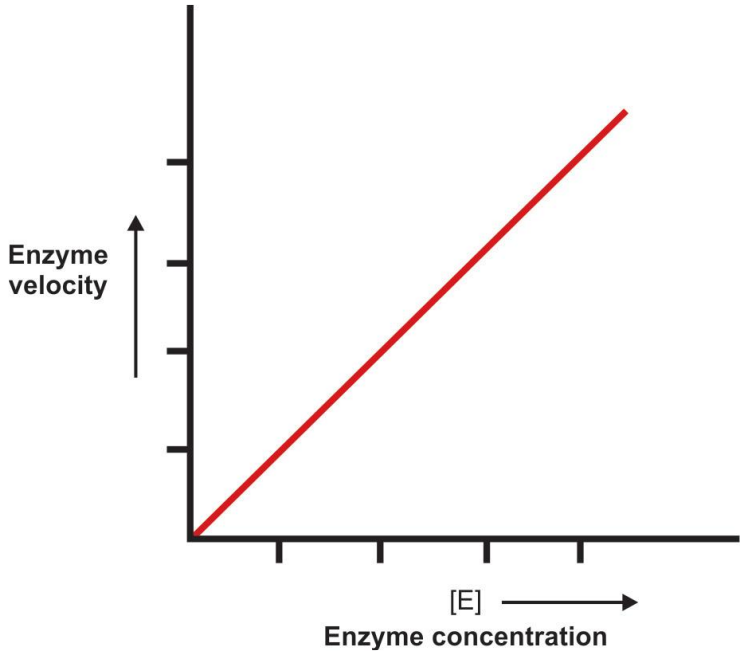
(Glc-6-P)

Factors affecting Enzyme

1. **Concentration of enzyme**
2. **Concentration of substrate**
3. **Effect of temperature**
4. **Effect of pH**

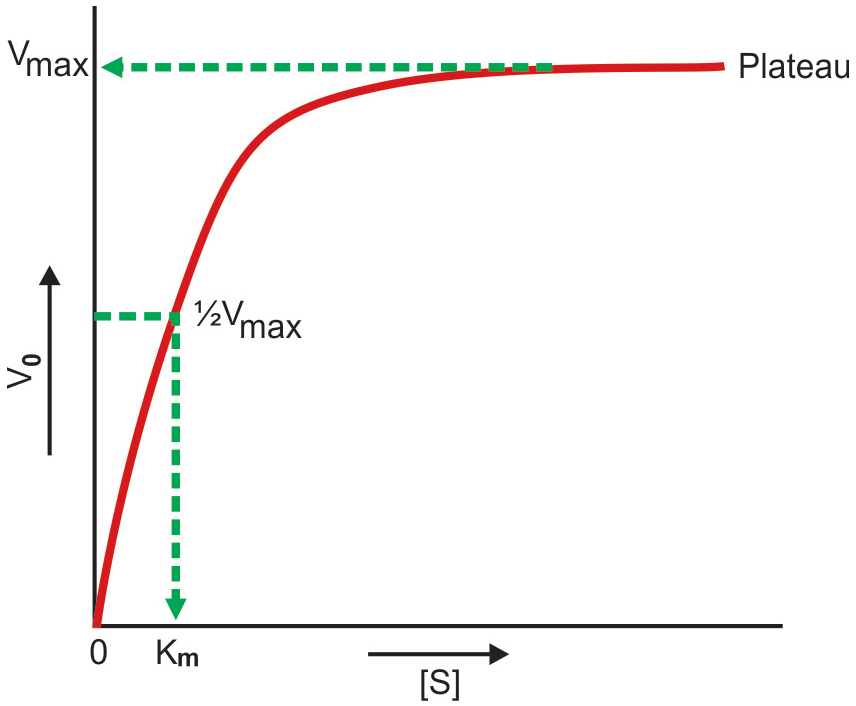
Concentration of enzyme

- As the concentration of the enzyme is increased, the velocity of the reaction proportionately increases Factors affecting Enzyme



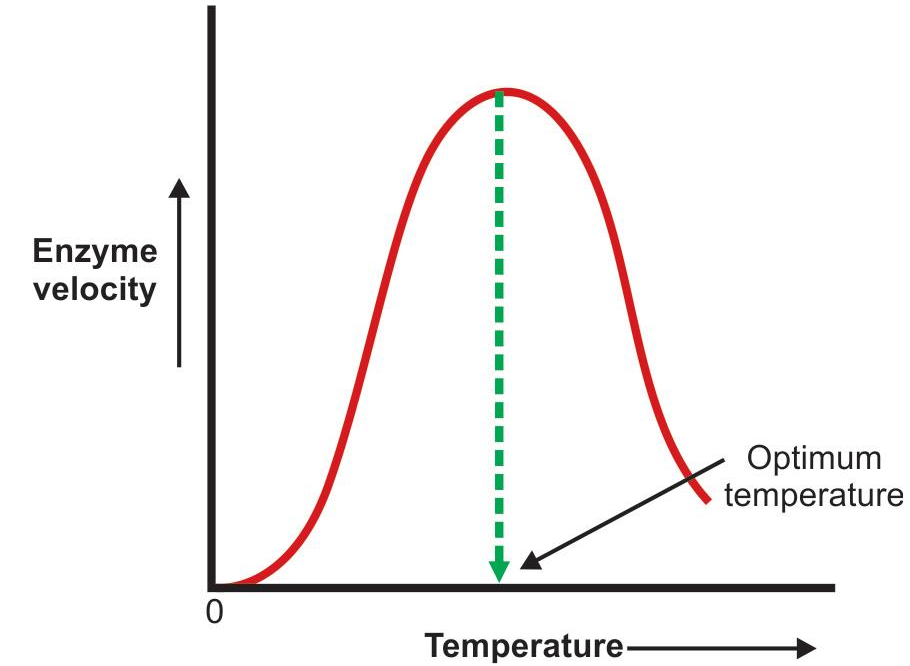
Concentration of substrate

- Increase in the substrate concentration gradually increases the velocity of enzyme reaction within the limited range of substrate levels.
- A rectangular hyperbola is obtained when velocity is plotted against the substrate concentration . Factors affecting Enzyme



Effect of temperature

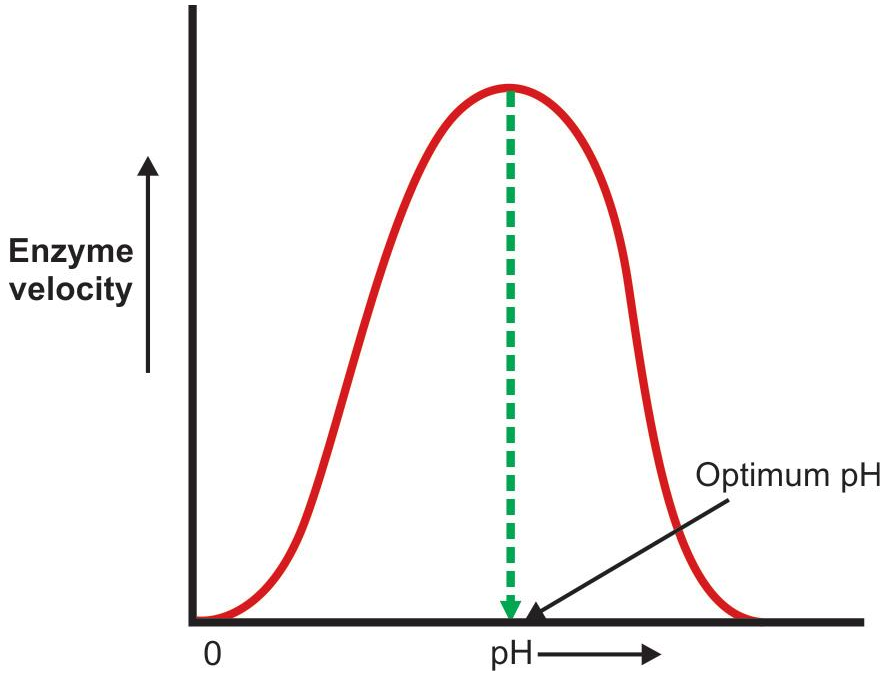
- Velocity of an enzyme reaction increases with increase temperature up to a maximum and then declines.
- A bell-shaped curve is usually observed .
- Temperature coefficient or Q10 is defined as increase in enzyme velocity when the temperature is increased by 10°C.



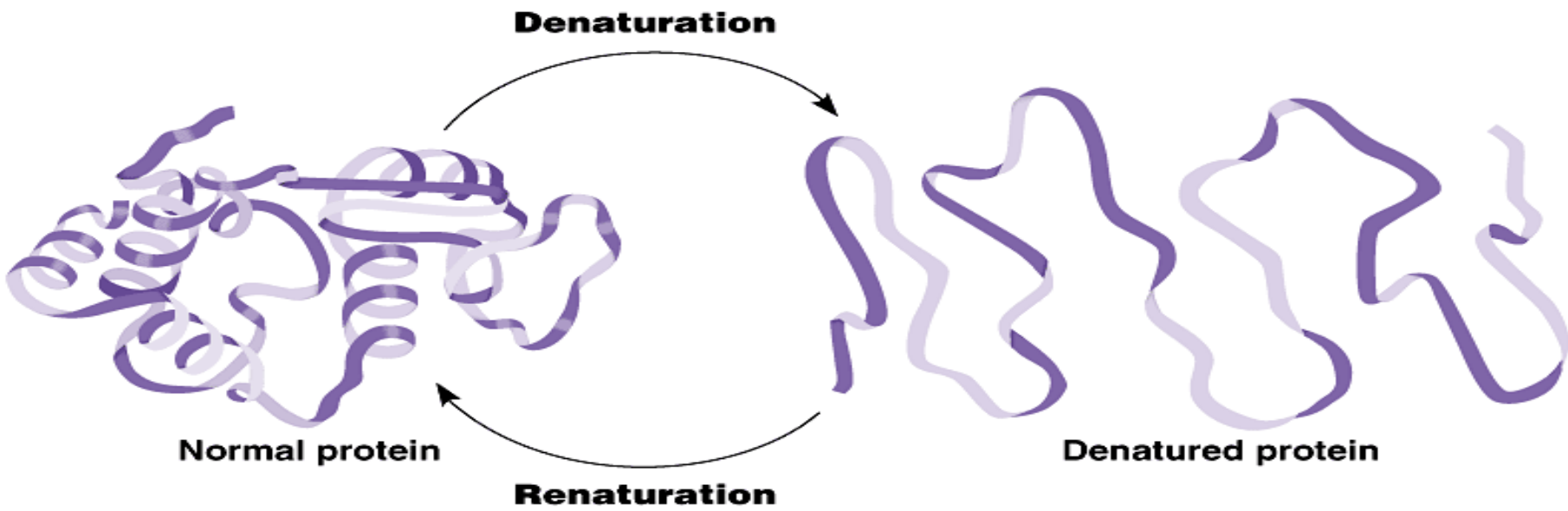
Effect of pH

- Increase in the hydrogen ion concentration (pH) considerably influences the enzyme activity and a bell-shaped curve is normally obtained

- Each enzyme has an optimum pH at which the velocity is maximum. Below and above this pH, the enzyme activity is much lower and at extreme pH, the enzyme becomes totally inactive.



Denaturation- an enzyme shape is changed and can no longer do its job.



Thanks For Listening ..