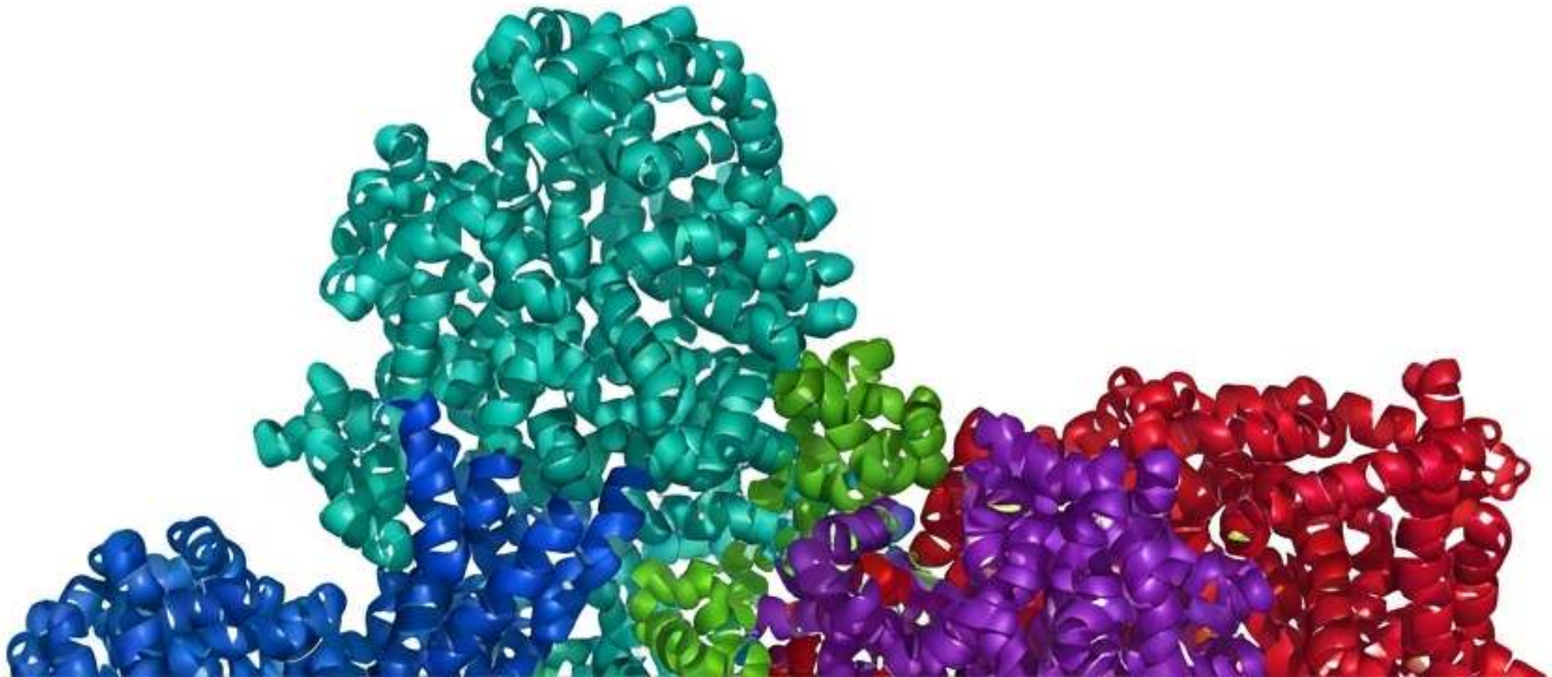
كلية طب الأسنان
Faculty Of Dental Medicine

Structure and Functions of Enzymes

Department of Dental Medicine | Pierre and Marie Curie Centre | Academic Year 2025/2026

Dr. BOUAICHI Dihia



Introduction: The Biological Necessity

The Living Condition

Chemical reactions in living systems occur under strict physiological conditions:

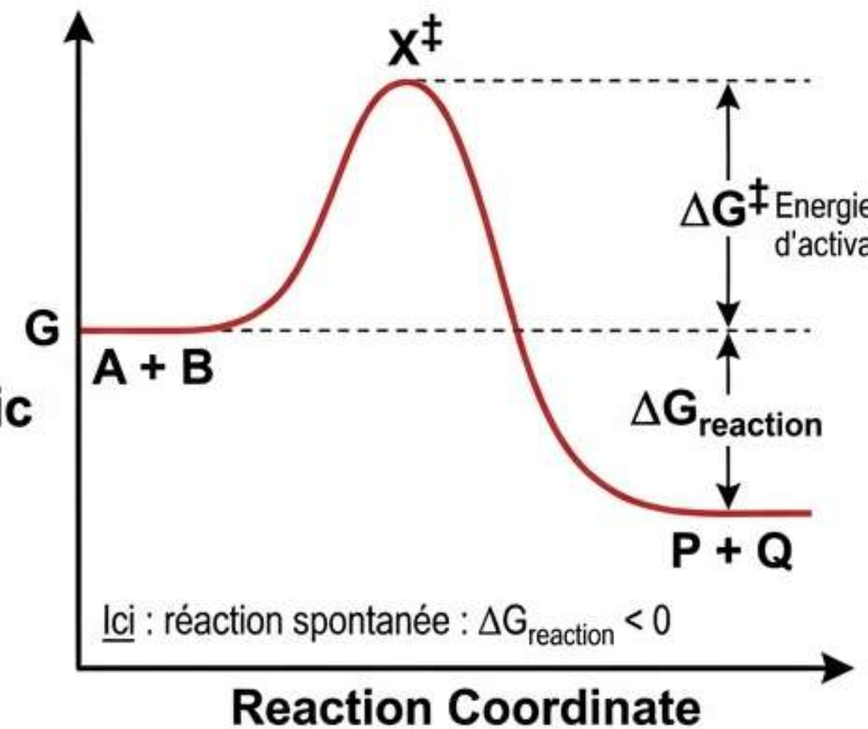
- Defined Pressure
- Defined Temperature
- Defined pH

Thermodynamics vs. Speed

Biochemical reactions can occur spontaneously if they are **Exergonic** (Delta G < 0). However, spontaneity does not equal speed. Without assistance, these processes are often too slow to sustain life.

The Solution: Biocatalysts (Enzymes)

Enzymes are biocatalysts that increase reaction speed.

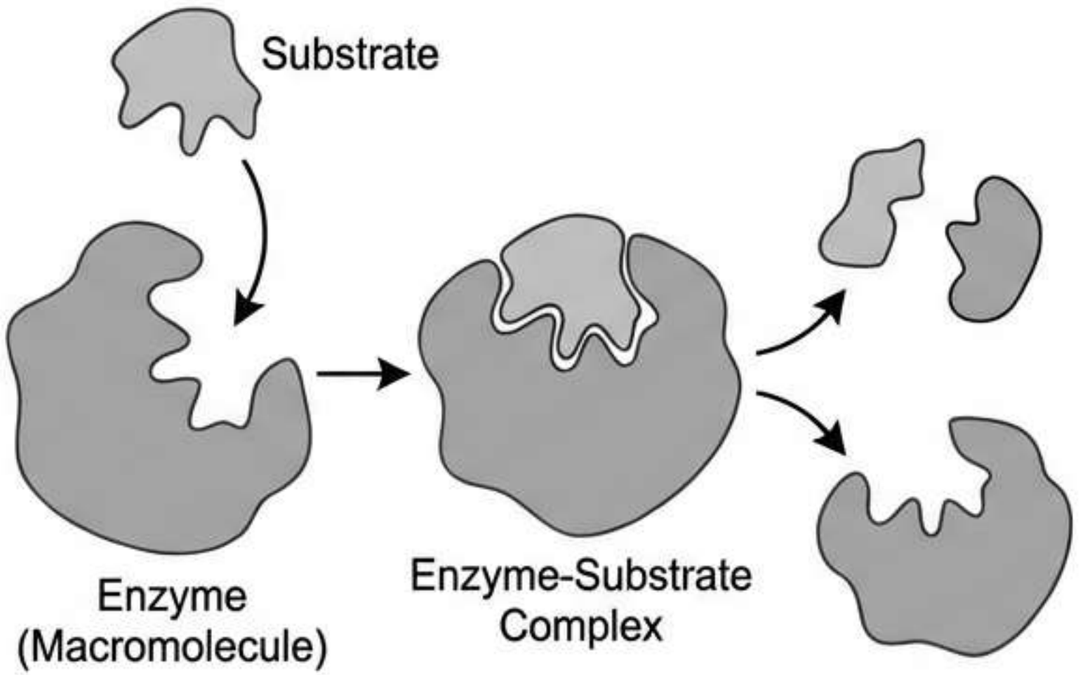


Crucial Property:
They are NOT modified themselves during the process. (Ref: Q43)

They act at **very small concentrations.** (Ref: Q43)

Definition of an Enzyme

- **Nature:** Highly concentrated macromolecule.
- **Composition:** Essentially protein in nature. (Ref: Q1, Q3, Q4)



- **Function:** Possesses catalytic activity.
- **Mechanism:** Acts on a specific substrate to form a product.

- **Outcome:** Remains intact at the end of the reaction.
- Increases speed without changing the final equilibrium.

The Nature of Enzymes: The RNA Exception

General Rule: Enzymes are proteins.

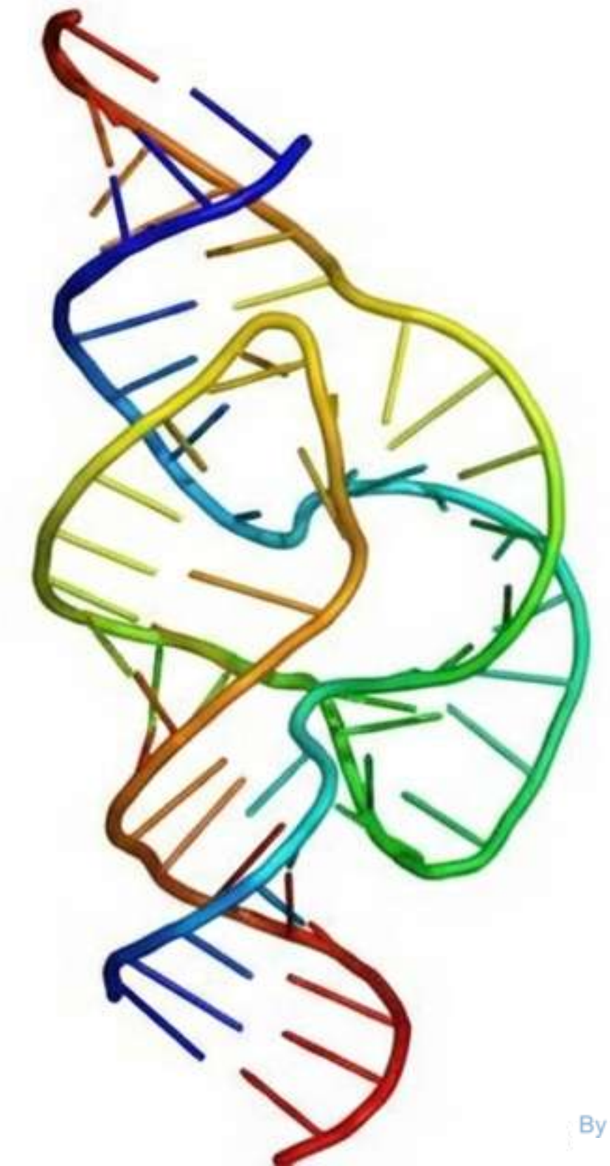
The Exception:

Ribozymes (Catalytic RNA)

- Example: Ribonucleases.
- These are **Nucleic Acids**, not proteins.

Ribozyme Functions:

- Highly specific catalytic activity.
- Catalyze transesterification and phosphodiesterase bond hydrolysis.
- Key role in **intron splicing** steps.

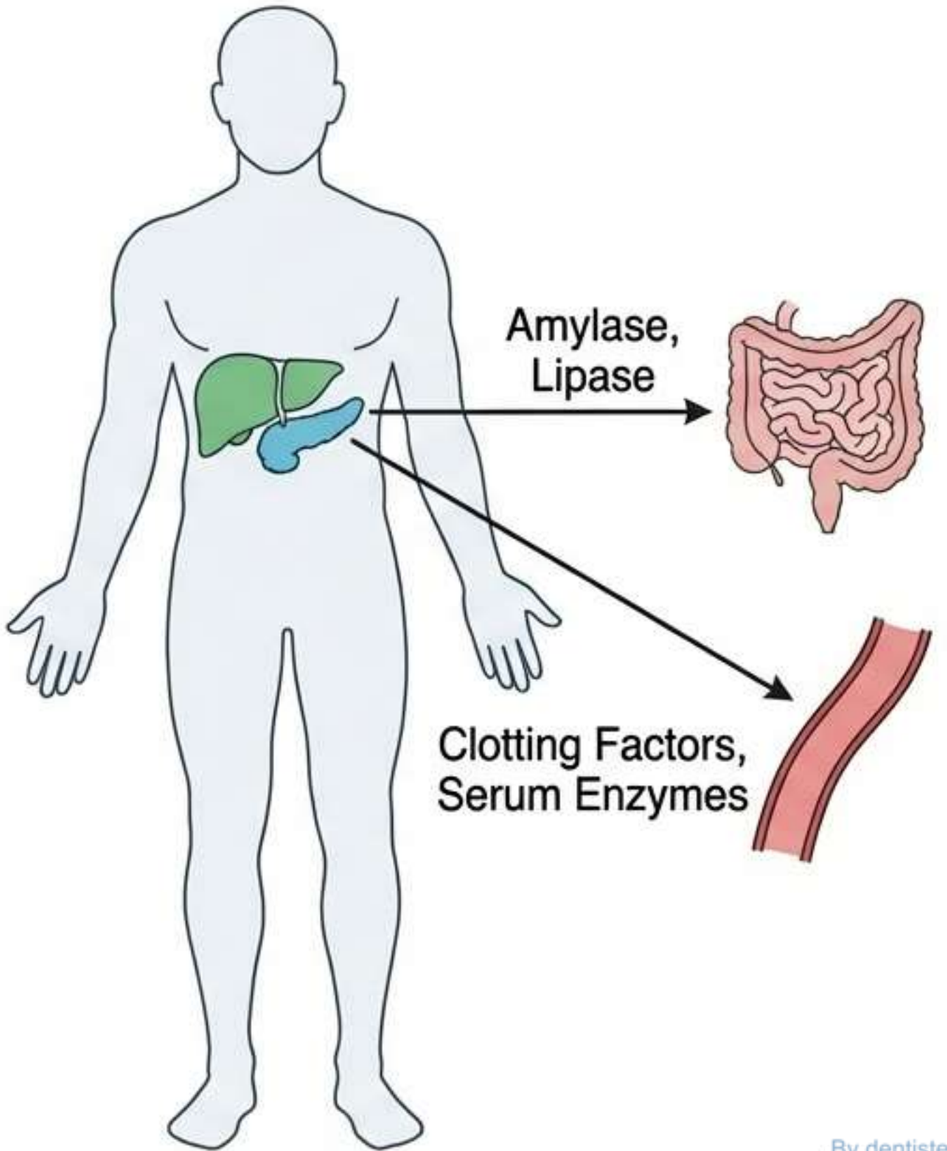


Localization: Tissue Specificity

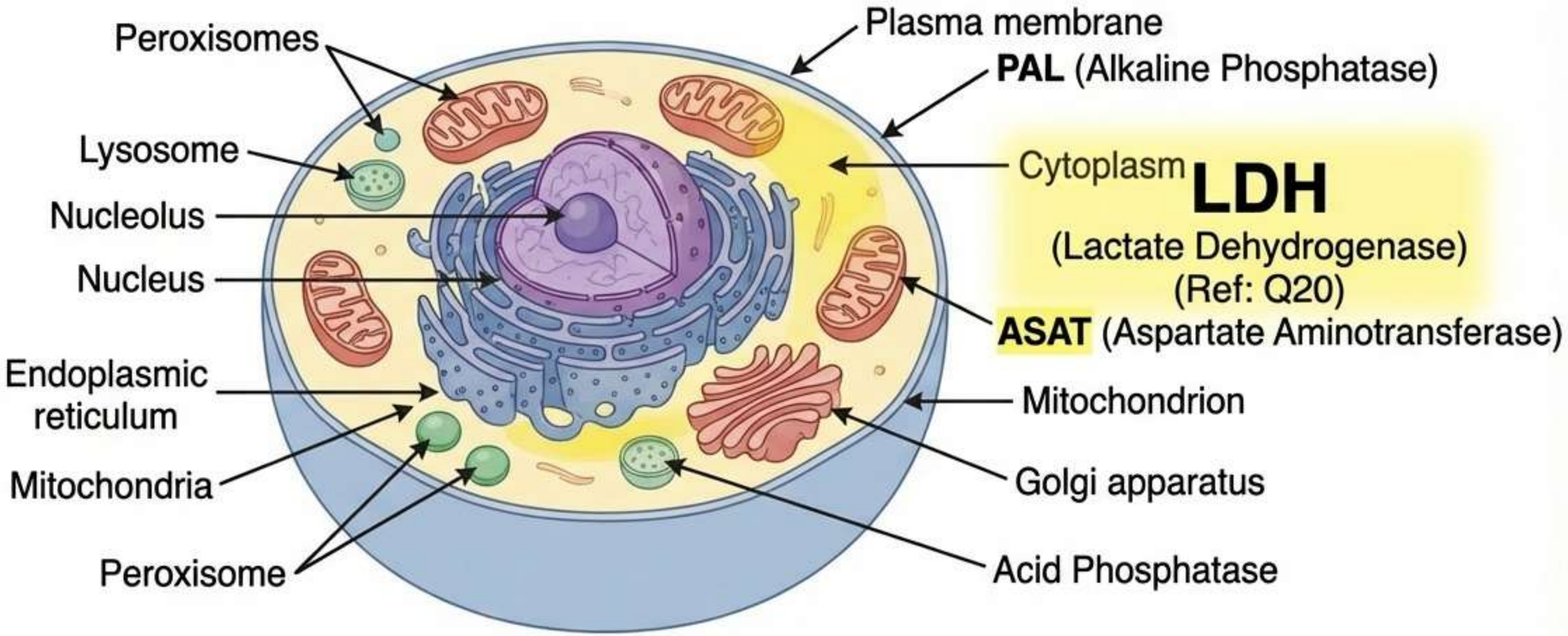
Tissue Markers: Each tissue has enzymatic equipment adapted to its function. Some enzymes are ubiquitous, while others are specific tissue markers.

Extracellular Locations:

1. **Exocrine Secretions:** e.g., Pancreas secreting digestive enzymes (Amylase, Lipase).
2. **Endocrine Secretions:** e.g., Liver secreting enzymes into the blood.



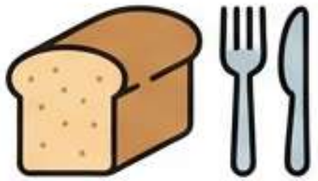
Intracellular Localization



Physiological Presence in Blood:

- Due to cellular renewal (RBCs, liver, platelets).
- Due to muscular activity (release of enzyme pool).

The Role of Enzymes in Metabolism



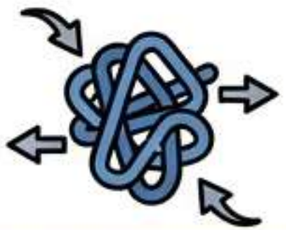
Nutrient Catabolism

Breaking down food sources

Energy

Transformation and conservation of energy

Enzymatic Action



Macromolecule Management

Synthesis and Catabolism of endogenous molecules

Cellular Repair

Fixing damage (e.g., DNA repair)

Clinical Application: Diagnosis & Prognosis

Dosage of serum enzymes orients the diagnosis of pathologies.

Enzyme	Serum Location	Pathology
ASAT, ALAT	Serum	**Hepatitis** (Liver) (Ref: Q9)
PAL	Serum	**Bone and Liver damage**
Lipase, Amylase	Serum	**Pancreatitis**

Therapeutic Application:
- **Statins:** Inhibitors of HMG-CoA Reductase. - **Antimetabolites:** Cancer chemotherapy.

Analytical & Industrial Applications

Analytical

Used for identification and quantification of biomolecules.

- **Colorimetric:** Hexokinase for blood glucose.
- **Immunological:** ELISA.

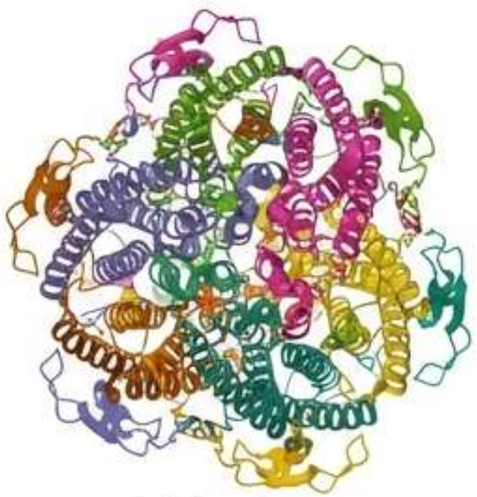
Industrial

- Evaluate food quality.
- Verify sterilization/pasteurization.
- Synthesis of hormones and drugs.

Classification: The 6 Classes (EC 1-3)

1. Oxidoreductases

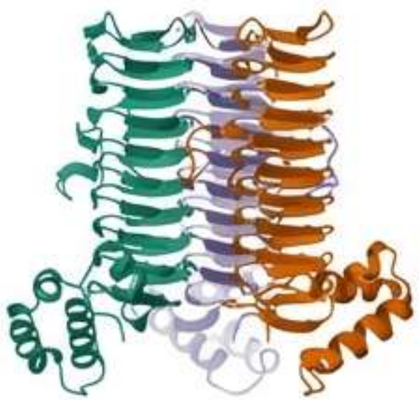
- Catalyze electron or proton transfer.
- *Ex*: Alcohol Dehydrogenase (Ethanol + NAD^+ → Ethanal + NADH + H^+).



Oxidoreductase

2. Transferases

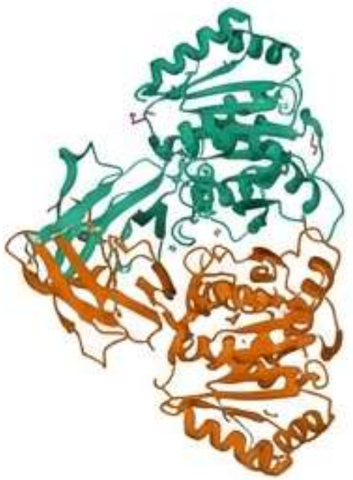
- Transfer groups from one molecule to another.
- **Kinases** are Transferases (Phosphotransferases). (Ref: Q59)
- *Ex*: Phosphofructokinase.



Transferase

3. Hydrolases

- Hydrolysis reactions (using water).
- *Ex*: Alpha-amylase (starch).
- **Cholesterol Esterase** (Ref: Q9).

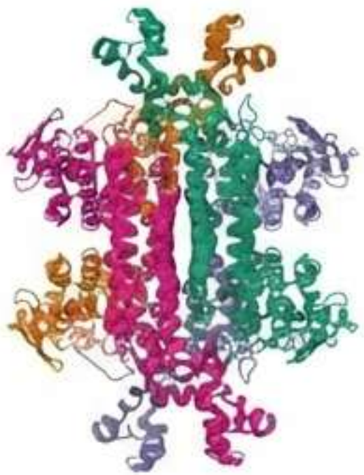


Hydrolase

Classification: The 6 Classes (EC 4-6)

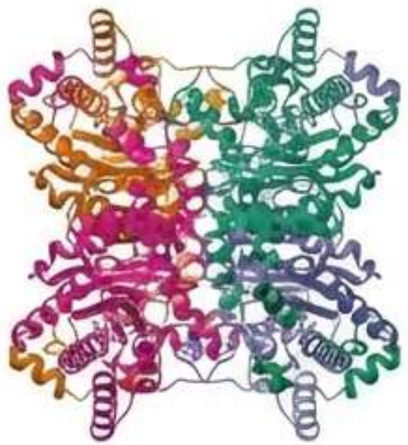
4. Lyases

- Addition/removal of groups to double bonds.
- *Ex*: Fumarase (L-Malate → Fumarate + H2O).



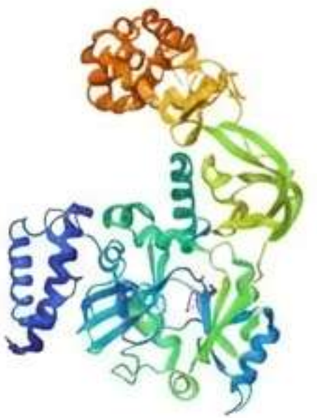
5. Isomerases

- Intramolecular transfer to produce isomers.
- *Ex*: Racemases (Alanine racemase).

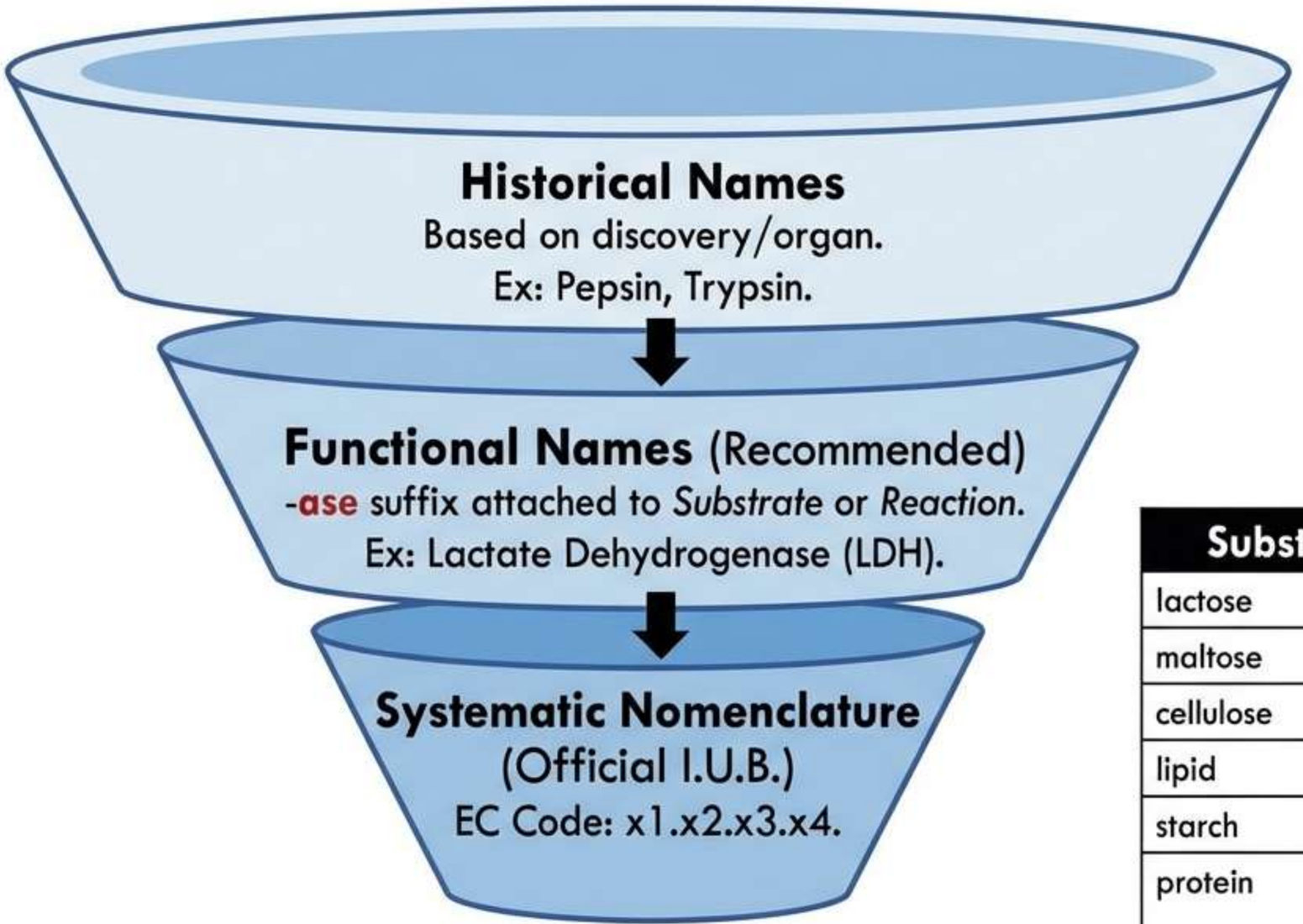


6. Ligases

- Form bonds (**C-C, C-S, C-O, C-N**) between 2 molecules. (Ref: Q32)
- **Requirement**: Consumes Energy (ATP).
- *Ex*: Glutamine Ammonium Ligase.



Nomenclature Systems



Decoding the Code

(Example: Hexokinase EC 2.7.1.1)

2: Transferase

7: Phosphorus group transferred

1: Alcohol group acceptor

1: Specific enzyme number

Substrate	Enzymes	Products
lactose	lactase	glucose + galactose
maltose	maltase	Glucose
cellulose	cellulase	Glucose
lipid	lipase	Glycerol + fatty acid
starch	amylase	Maltose
protein	protease	Peptides + polypeptide

General Structure: **Apoenzyme** vs. **Holoenzyme**

Apoenzyme
(Protein, Inactive)

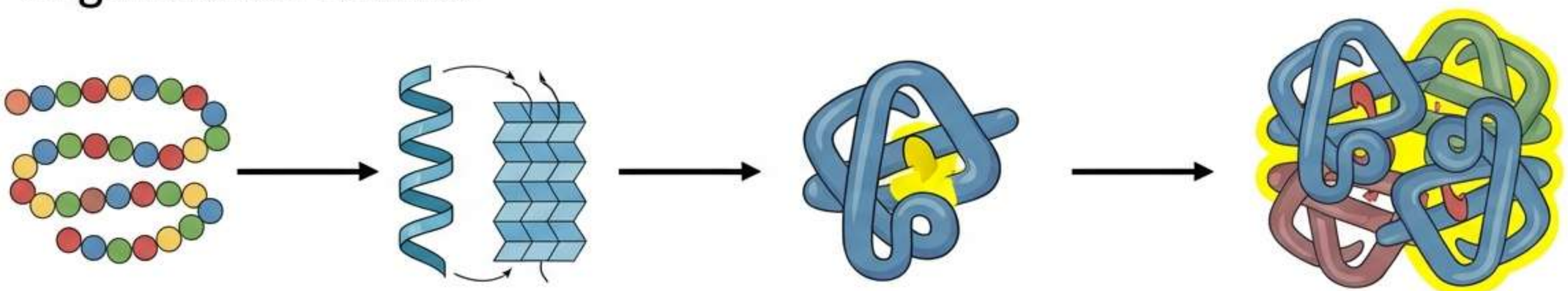
+

Cofactor
(Non-protein)

→

Holoenzyme
(Active)

- **Holo**enzymes (**Heteroprotein**):
  - **Apoenzyme** + **Cofactor** (Ref: Q18)
- Organization **Levels**:



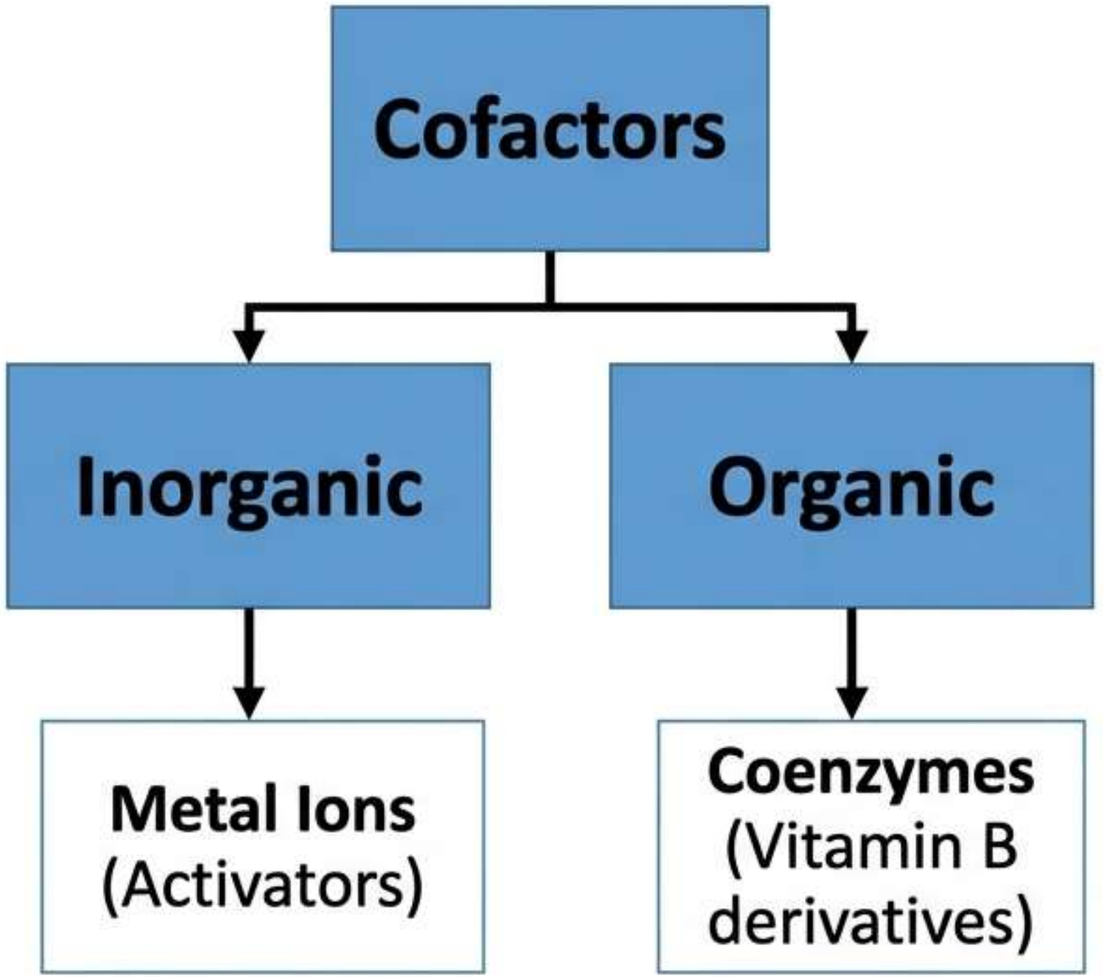
Primary
(AA sequence)

Secondary
(helices/sheets)

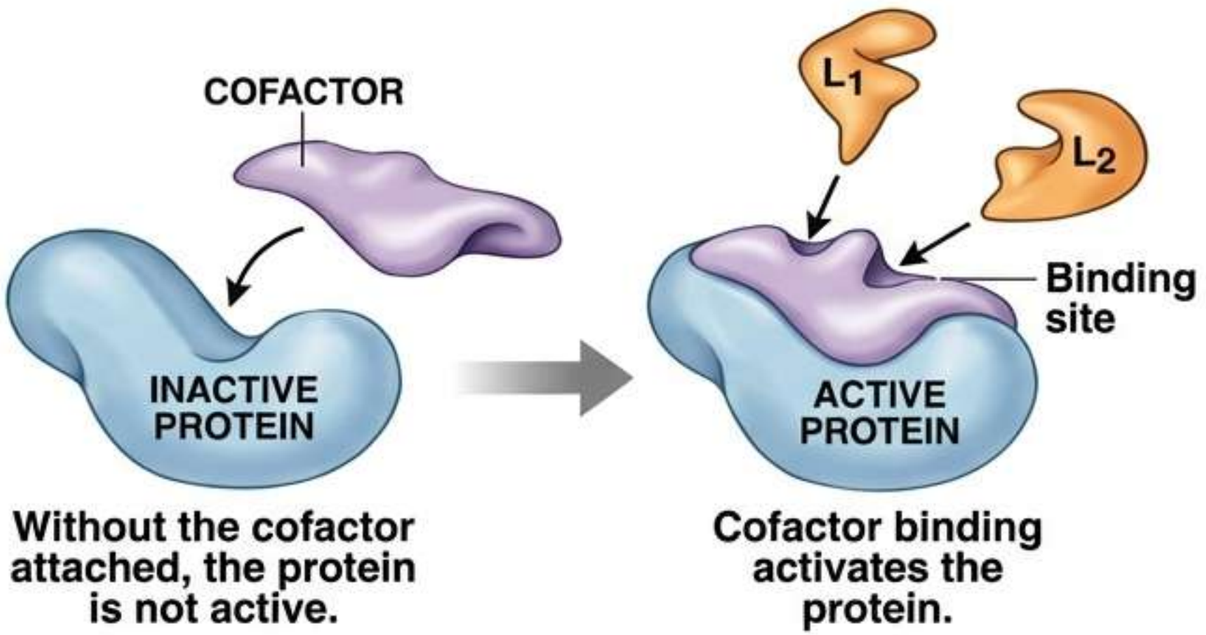
Tertiary
Appearance of **Catalytic Function** (Active Site). (Ref: Q1)

Quaternary
Appearance of **Regulatory Function** (Subunits). (Ref: Q1)

Cofactors: The Essential Helpers



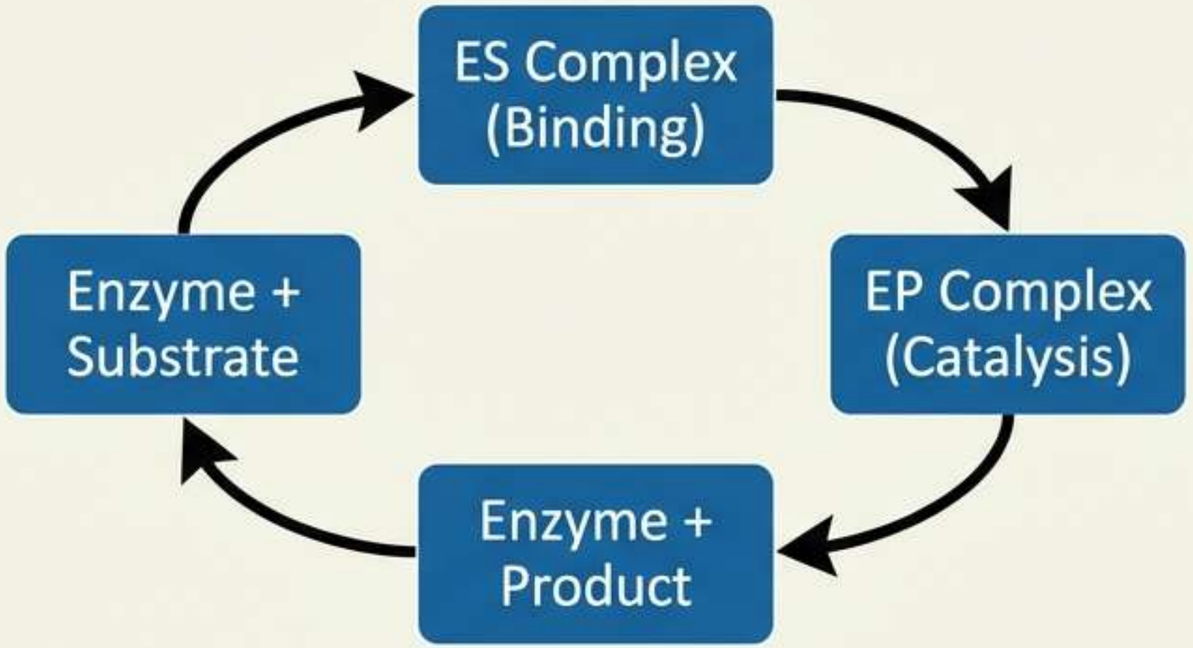
- **Role:** Essential for reaction (transport substrates, stabilize structure).
- Coenzymes are non-protein, thermostable, low molecular weight. (Ref: Q23)
- NOT responsible for specificity. (Ref: General)

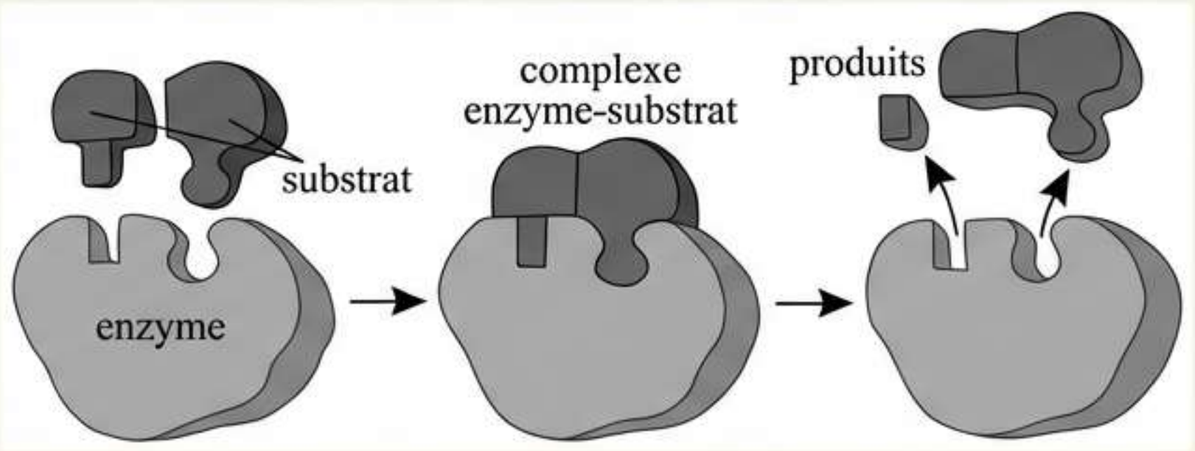


Coenzymes: Free vs. Bound

Free Coenzymes (Co-substrates)	**Bound Coenzymes** (Prosthetic Groups)
• Highlight in Yellow: Form **weak** bonds. (Ref: Q2) • Highlight in Yellow: **Dissociate** after each reaction. (Ref: Q2) • Highlight in Yellow: Act **stoichiometrically**. (Ref: Q23) • Concentration != Enzyme concentration.	• Highlight in Yellow: Form **strong** bonds. (Ref: Q12) • Highlight in Yellow: Do **NOT** dissociate. (Ref: Q12) • Example: FAD, Heme.

Enzymatic Catalysis: The Mechanism

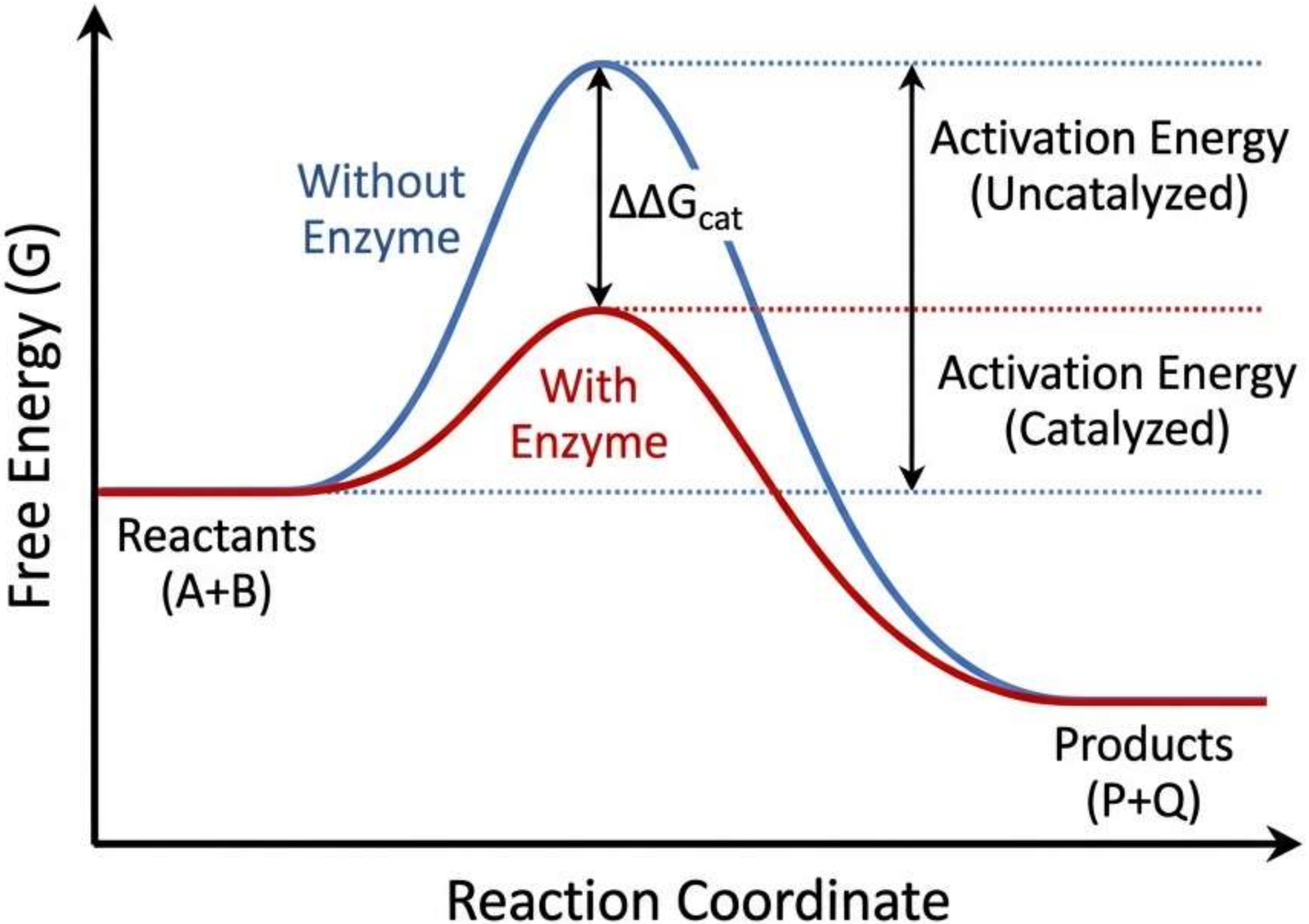




Catalysis Principle:

- Highlight in Yellow: Catalysis increases the rate of equilibrium, NOT the equilibrium itself. (Ref: Q3, Q43)
- It does not change the Delta G of the reactants/products.

Thermodynamics: Lowering the Barrier

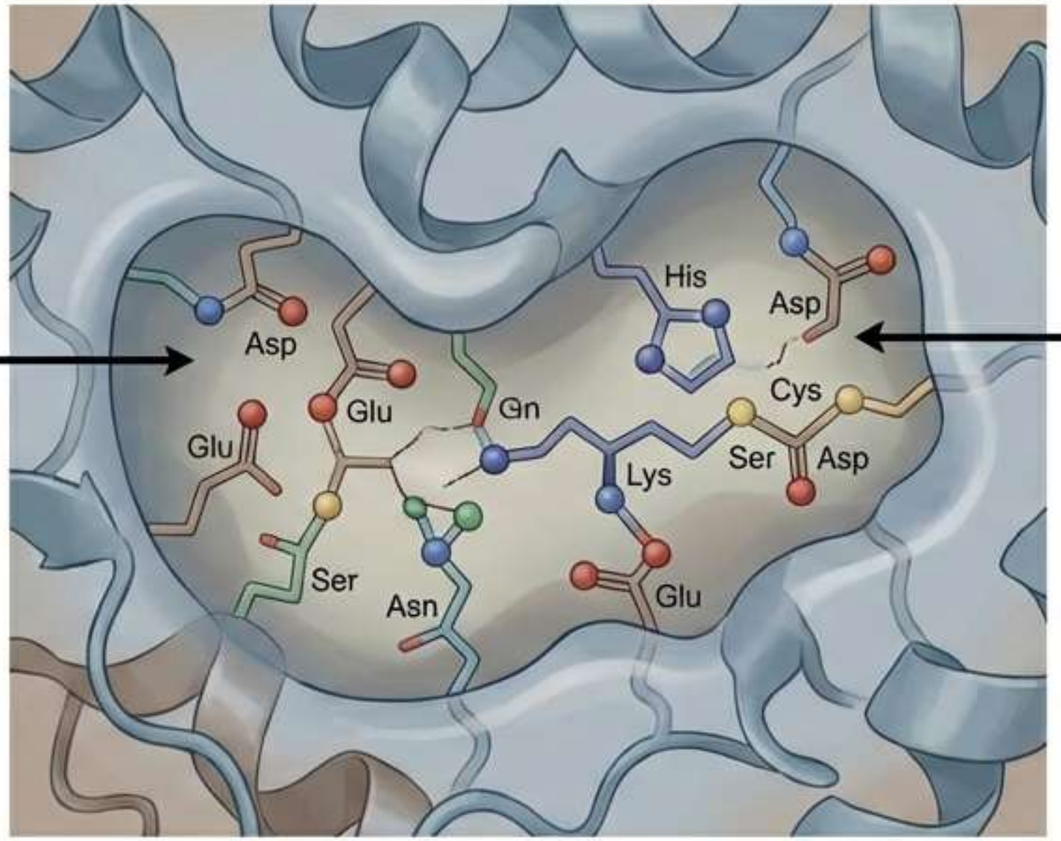


- **Mechanism:**
  - Enzymes **LOWER** the Activation Energy. (Ref: Q21, Q26, Q41)
  - They facilitate the transition state.
- **Example (H_2O_2):**
  - No Catalyst: 75 kJ/mol
  - **Catalase: ~8 kJ/mol**

The Active Site: Anatomy

Binding Site:

Substrate recognition and orientation.

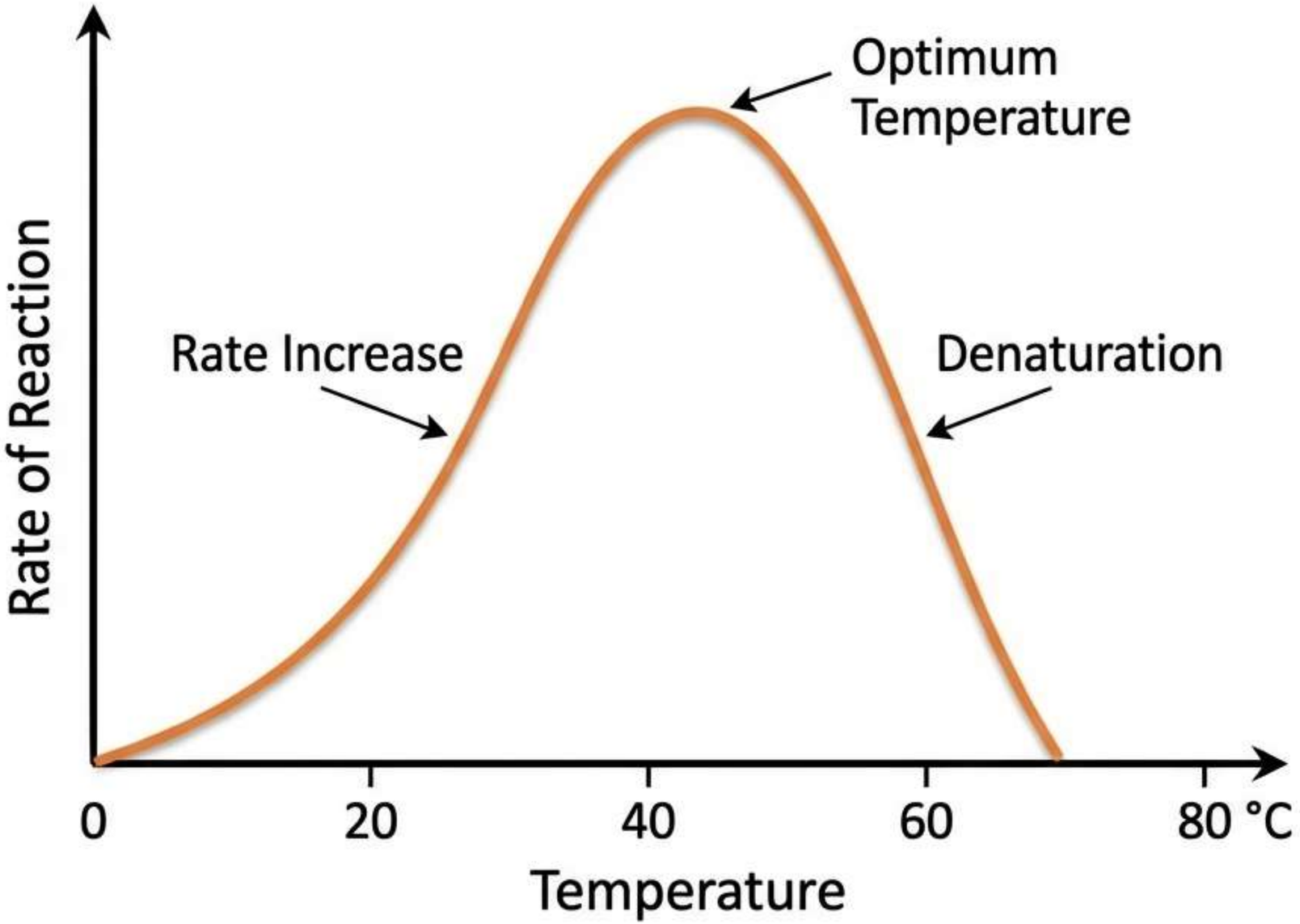


Catalytic Site:

Bond breaking/forming residues (His, Lys, Cys, Ser, Asp, Glu).

- **Definition:** 3D cavity formed by bringing distant amino acids together via folding.
- **Environment:** Hydrophobic pocket with specific polar residues.

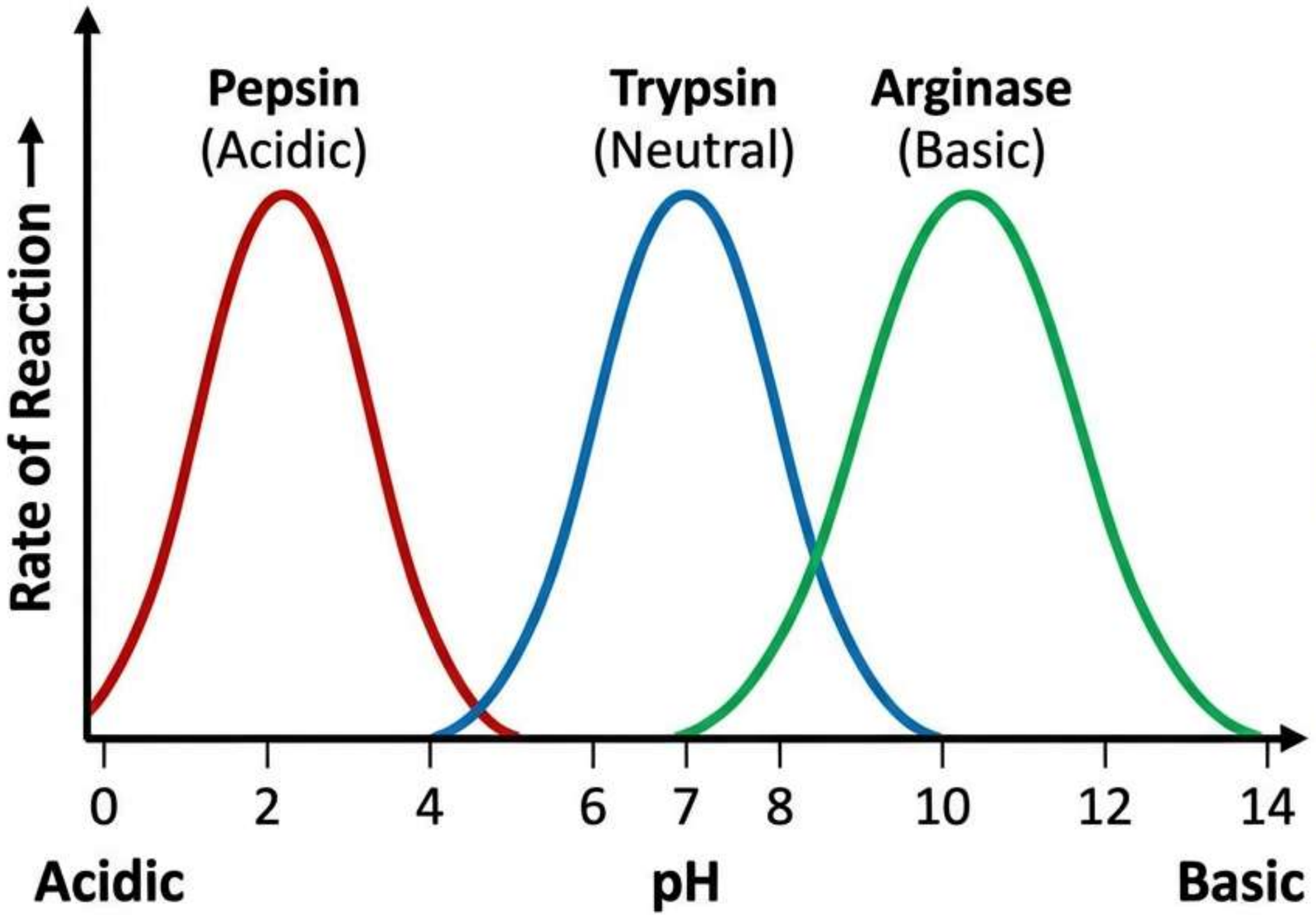
Factors Influencing Catalysis: Temperature



- **Dual Effect:**
  1. **Acceleration**: Heat provides activation energy.
  2. **Denaturation**: Heat breaks secondary/tertiary bonds = **Deactivation**. (Ref: Q1, Q4)

- **Optimum** temperature varies from one enzyme to another. (Ref: Q3, Q41)

Factors Influencing Catalysis: pH



- **<u>Mechanism</u>:** pH alters the **ionization state** of AA side chains in the active site.

Maximal activity at specific **Optimum pH**. (Ref: Q4)

Extreme values lead to **Denaturation**. (Ref: Q4)