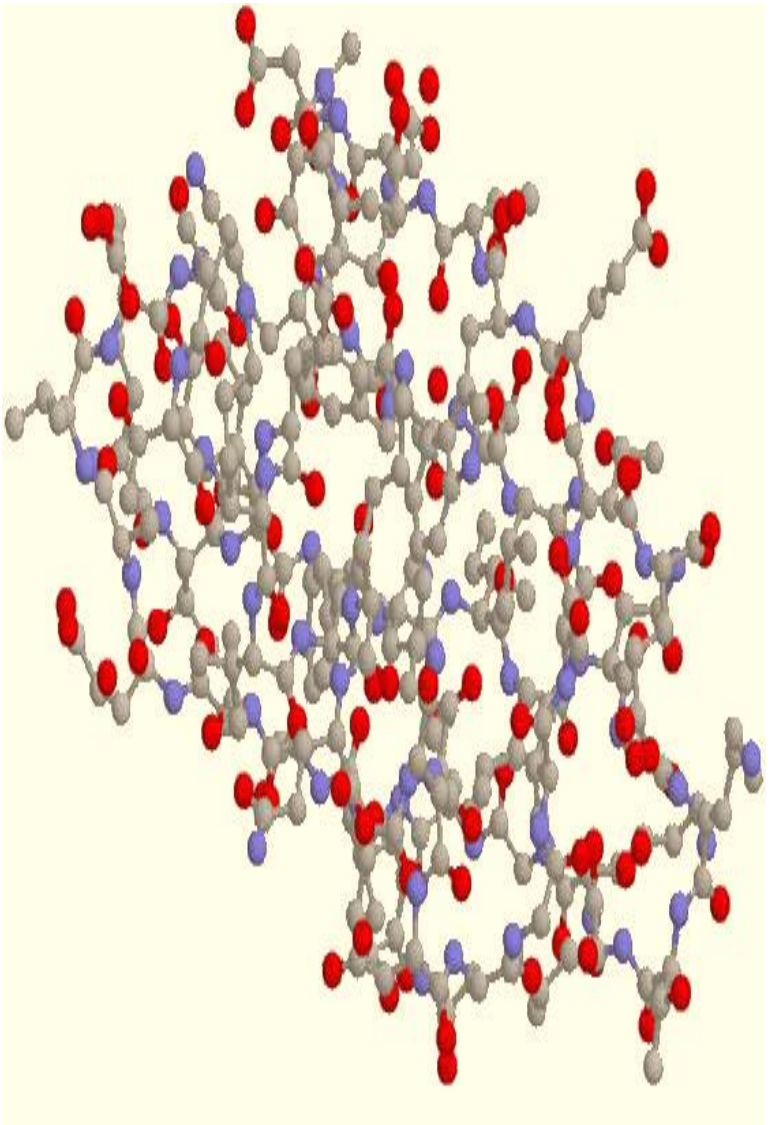
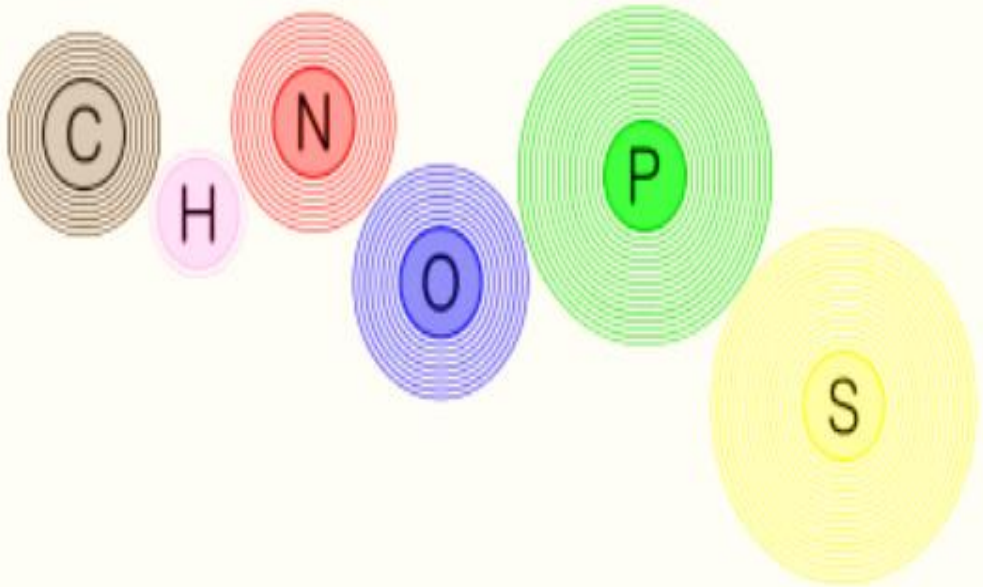


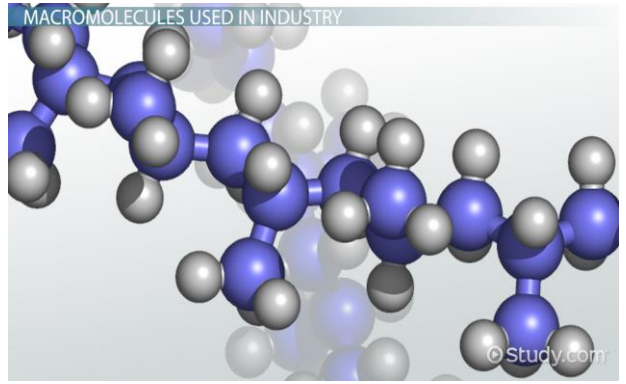
Biological Macromolecules



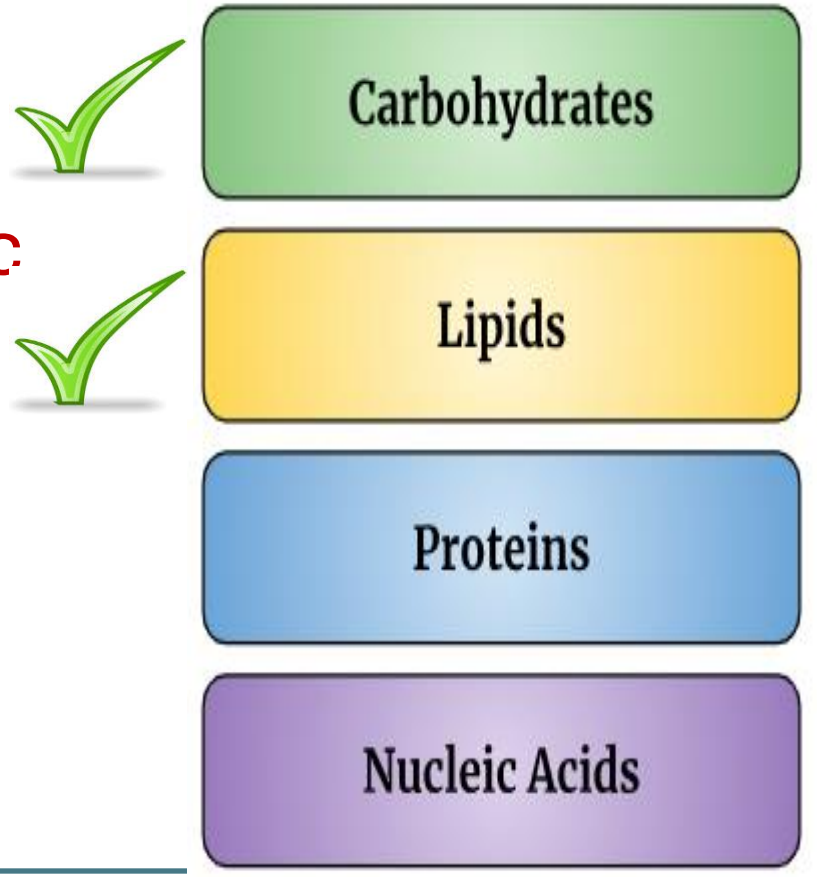
Prepared by:

Dr/ Aya El-Hanafy

Remember: The Molecules of Life



- All living things are made up of four classes of large molecules (Macromolecules): carbohydrates, lipids, proteins, and nucleic acids.



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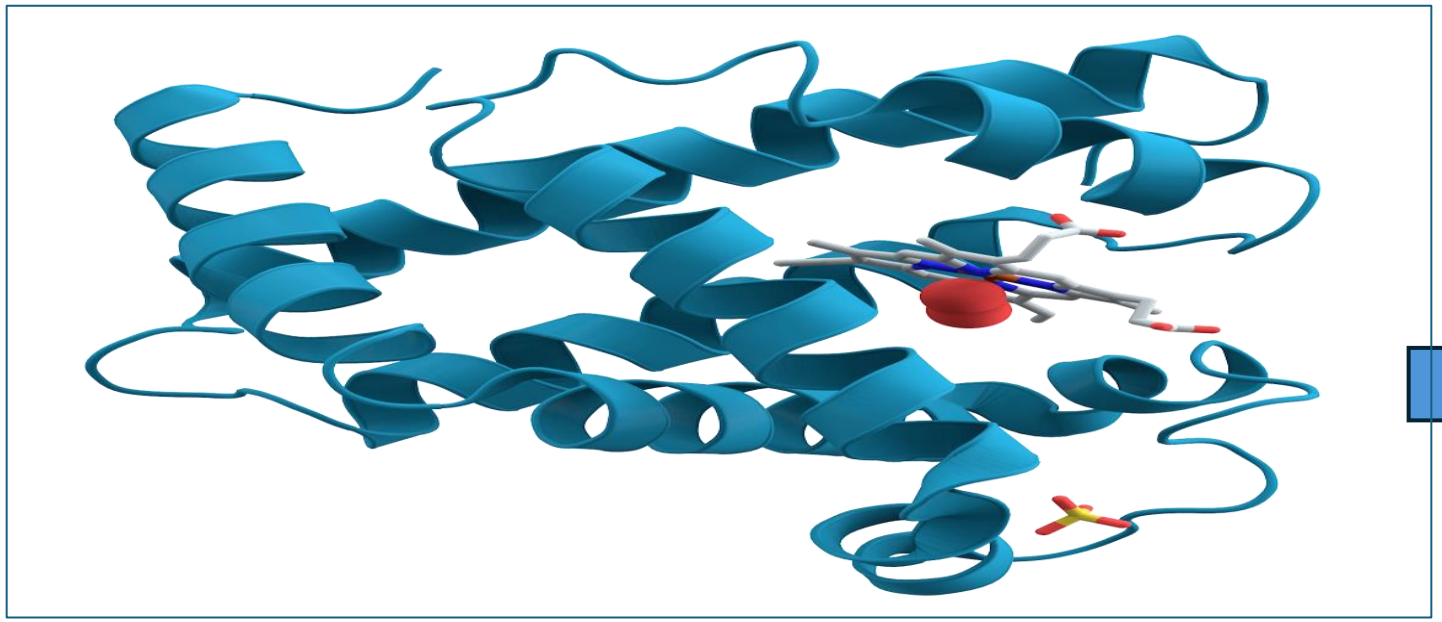
III. Proteins



- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids

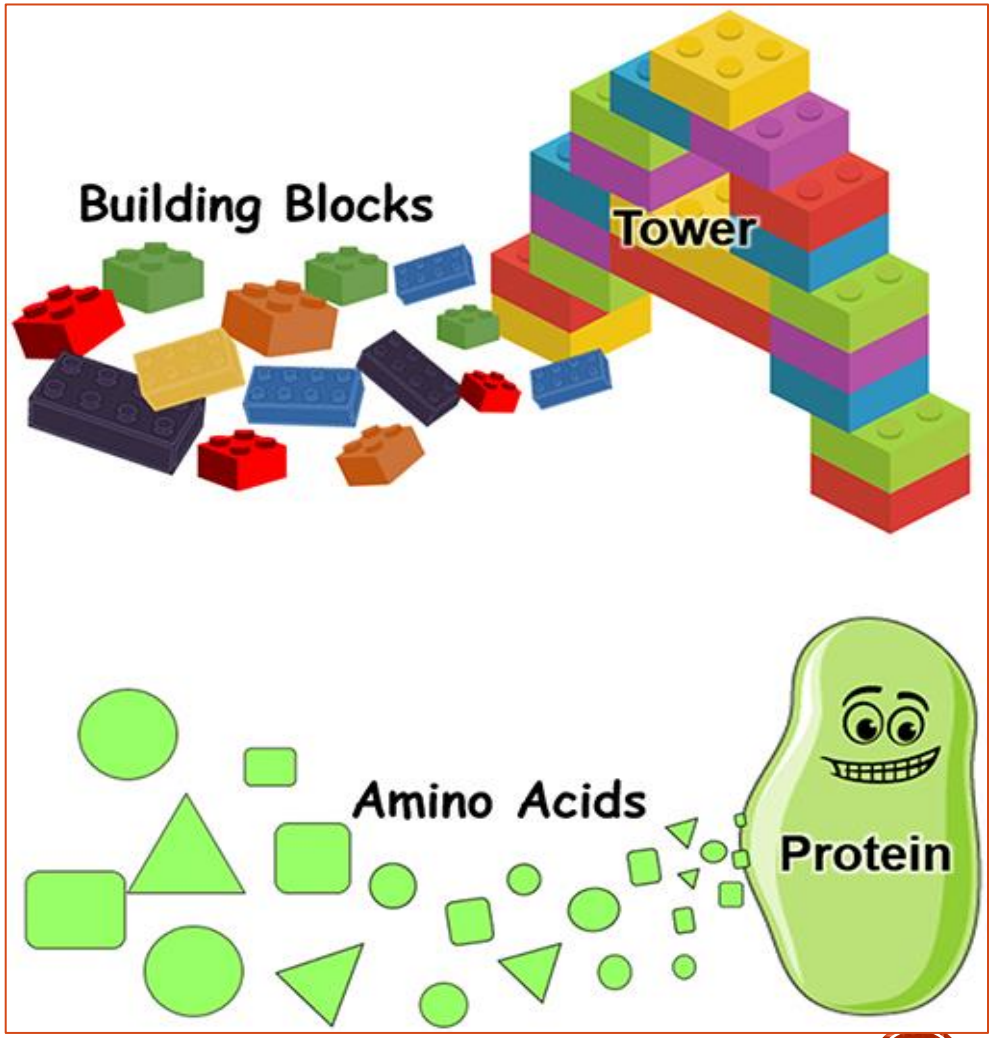
Definition & general structure of Proteins

Proteins are:

- Organic complex **nitrogenous** compounds
- Formed of C,H,O,**N** (+/- S)
- Forming **polymers** (chains) of amino acids= (polypeptides)
- Ends of the polypeptide chain:
  - ✓ **COOH group**: at one end → called **C-terminal**
  - ✓ **NH2 group**: at the other end → called **N-terminal**

General structure of Proteins: Amino acids

- ✓Amino acids are the **structural units** (building block) of proteins.
- ✓**They** are obtained from protein by acid , alkali or enzymatic hydrolysis.
- ✓There are **20** known amino acids
  (21 after adding selenocysteine aa)



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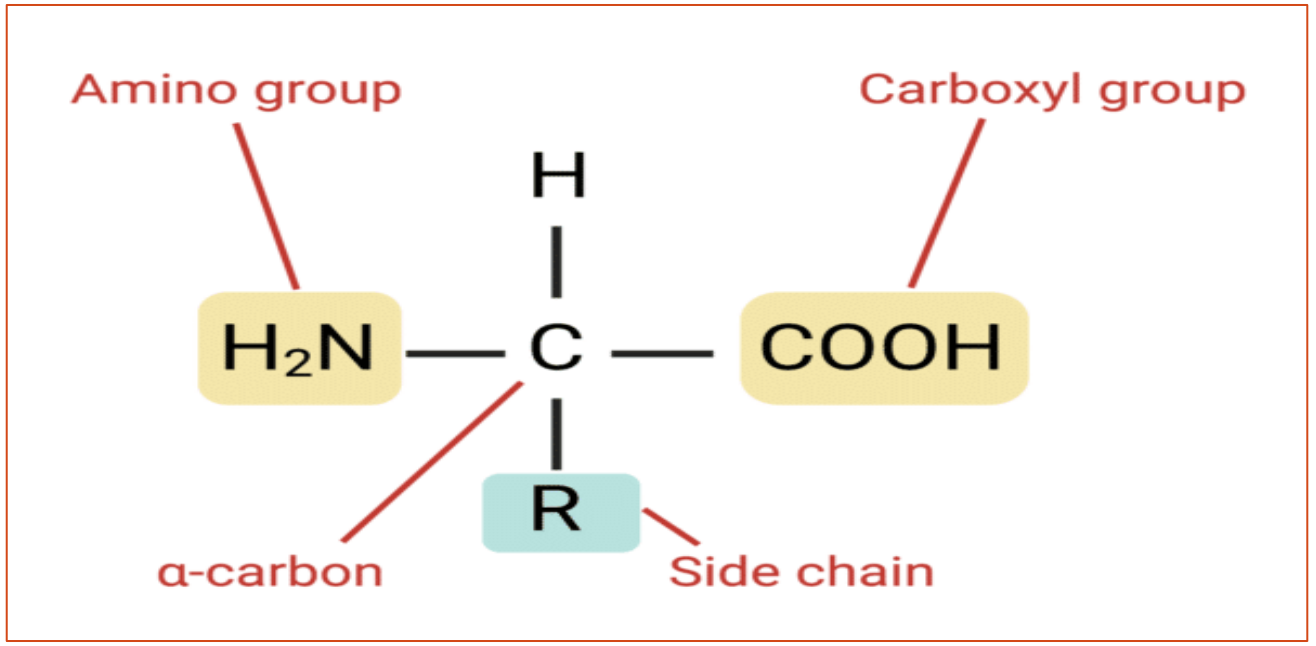
General structure of amino acids

- **Amino acids** are organic molecules with carboxyl and amino groups
- Amino acids differ in their properties due to differing side chains, called R groups

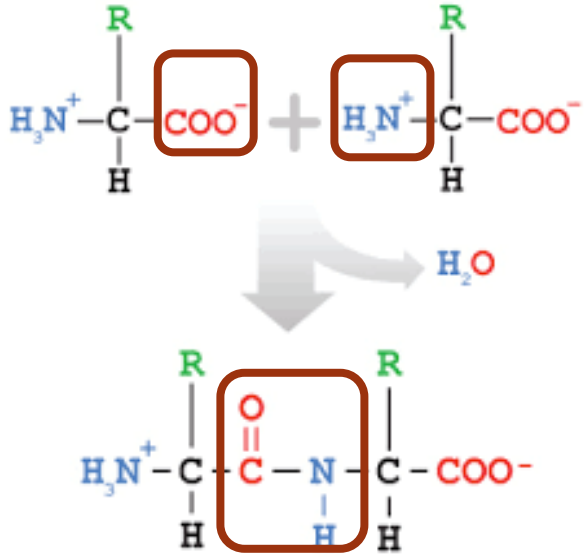
general structure of amino acids

Amino Acid Monomer

- **COOH group**
- **NH2 group**
- **Side Chain (R)** — which is **characteristic** for each amino acids.

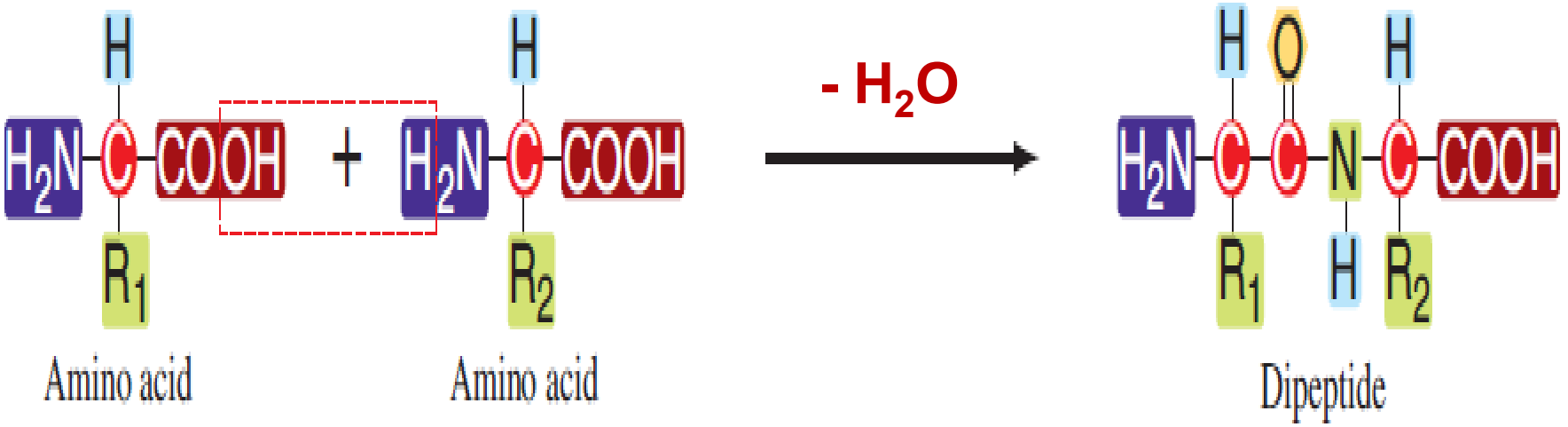


General structure of Proteins: Peptide bond



- The amino acids are connected together by **peptide** (-CO-NH-).
- **Formation of Peptide bond:**

(**COOH gp** of the **1st AA** unites with the **NH2 gp** of the **2nd AA** with **loss of water,** and so on)



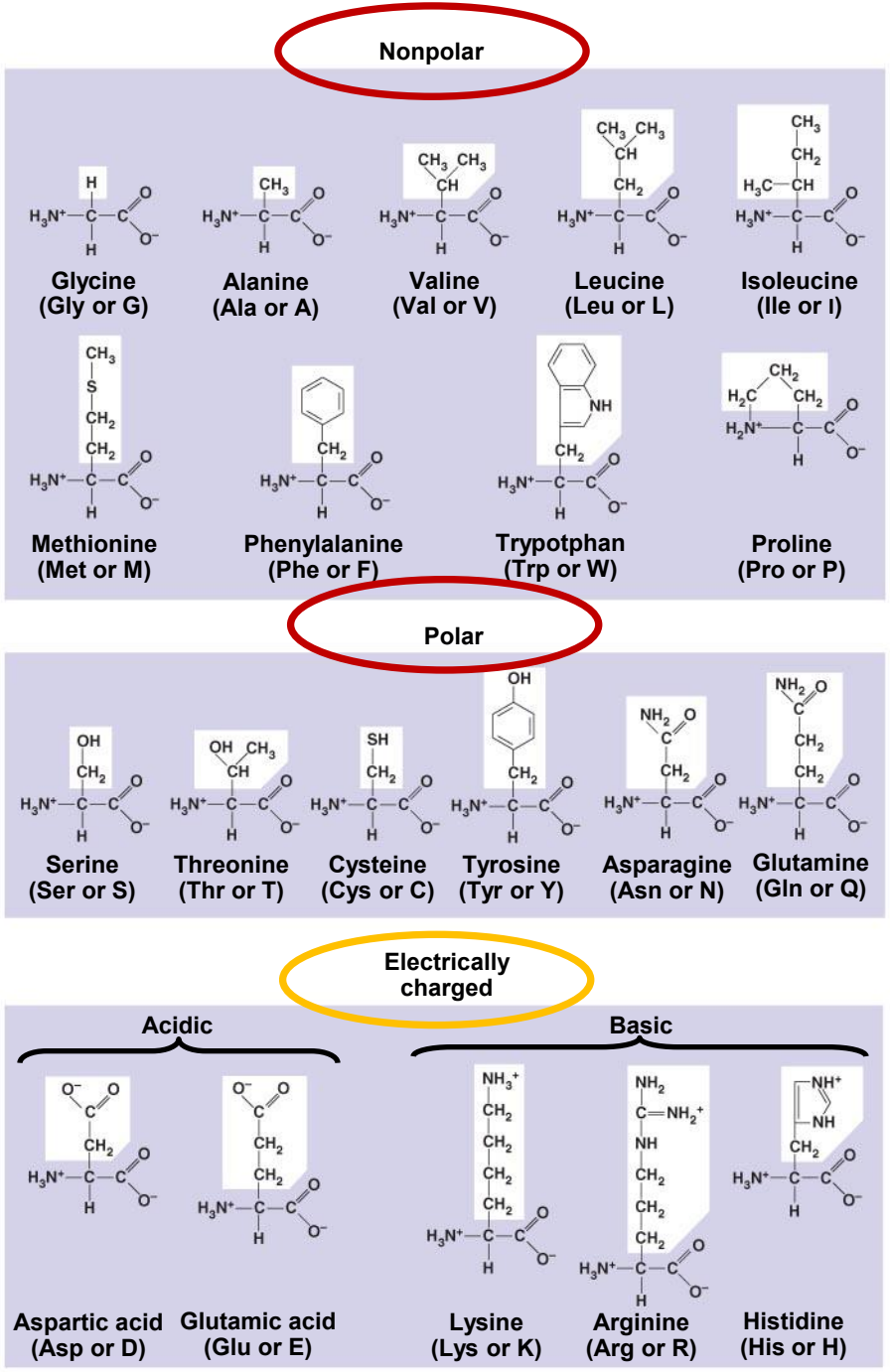
❑ *Amino Acid Polymers*

- A polypeptide is a polymer of amino acids
- Polypeptides range in length from a few to more than a thousand monomers
- Each polypeptide has a unique linear sequence of amino acids

❑ Polypeptides

- **Polypeptides** are polymers built from the set of 20 amino acids
- A **protein** consists of one or more polypeptides

The 20 amino acids of proteins



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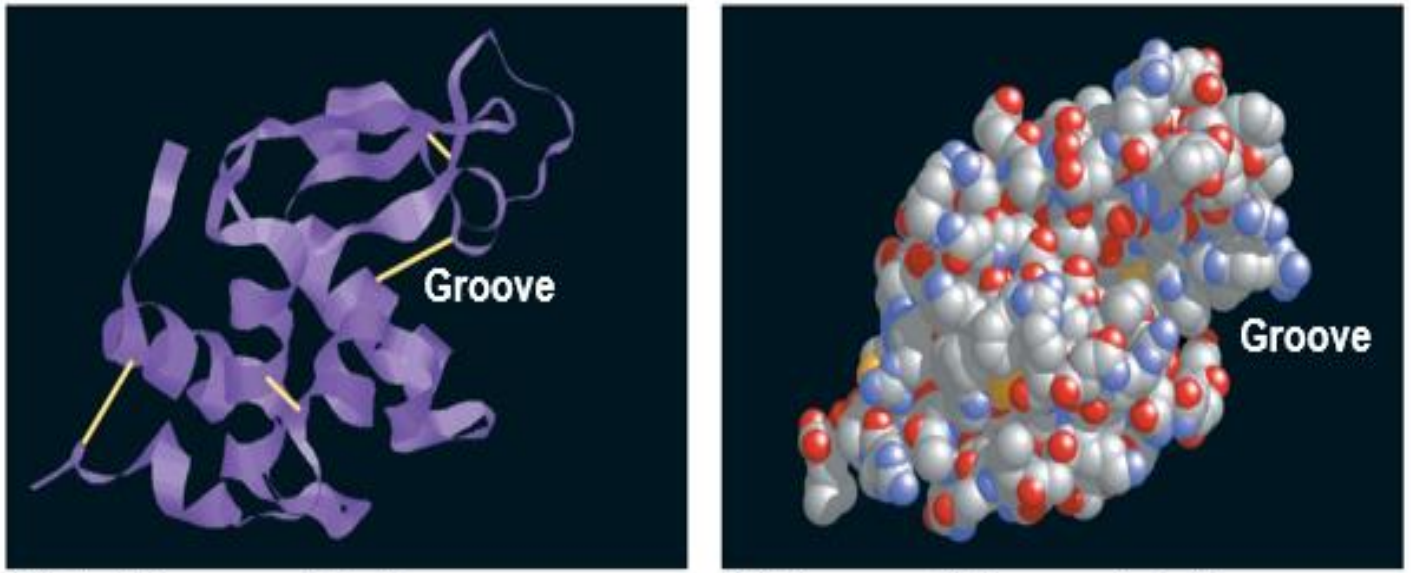
Protein Structure and Function

- A functional protein consists of one or more polypeptides twisted, folded, and coiled into a unique shape



(a) A ribbon model of lysozyme

(b) A space-filling model of lysozyme

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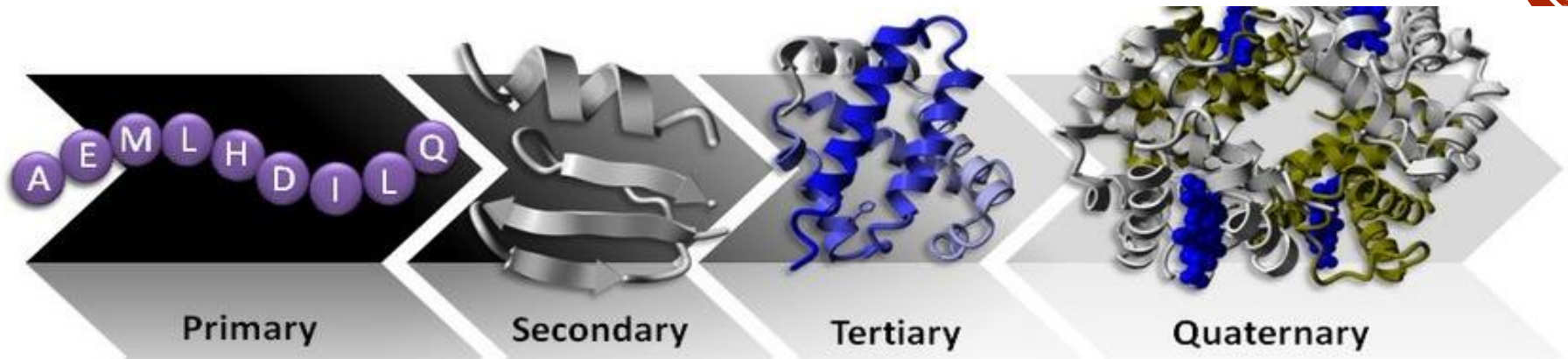
Levels of protein structure

1. Primary structure
2. Secondary structure
3. Tertiary structure
4. Quaternary structure



Protein Folding

Definition:

- ✓ Protein folding is a **process by which a polypeptide chain folds to become a biologically active protein in its native 3D structure**.

Importance

- ✓ Protein structure is crucial to its function.

Stabilizination of the folded protein

- ✓ Folded proteins are held together by various bonds / forces.
- ✓ **Chaperonins** are protein molecules that assist the proper folding of other proteins

Levels (Stages) of protein folding

- ✓ The folding of a protein is a complex process,
- ✓ It involving four stages **(Levels),** arranged, from a primary to quaternary structure.
- ✓ The wide **variation in AAs** sequences → **different** conformations (**shapes**)of proteins

Four Levels of Protein Structure

- **The primary structure** of a protein is its unique sequence of amino acids
- **Secondary structure**, found in most proteins, consists of coils and folds in the polypeptide chain
- **Tertiary structure** is determined by interactions among various side chains (R groups)
- **Quaternary structure** results when a protein consists of multiple polypeptide chains

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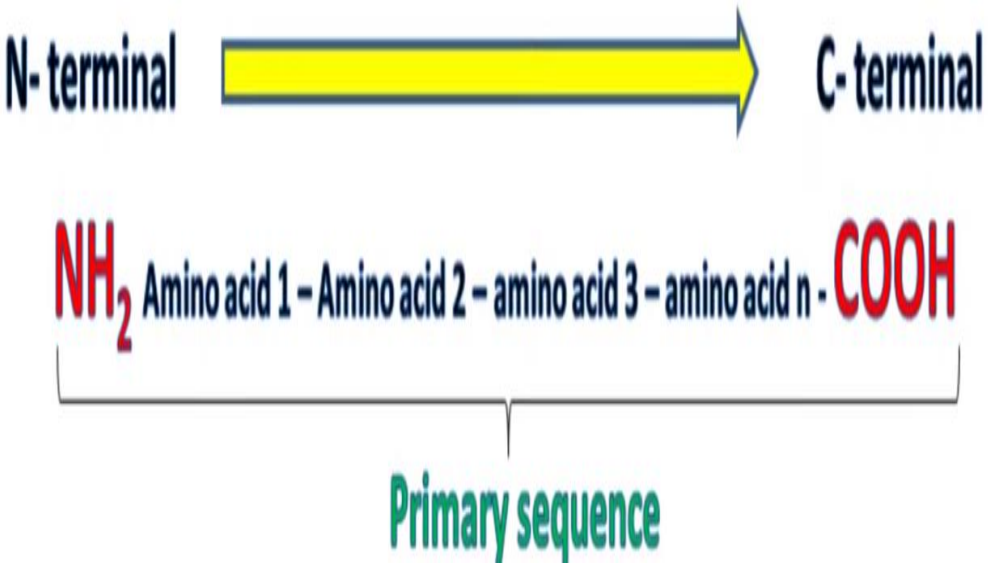
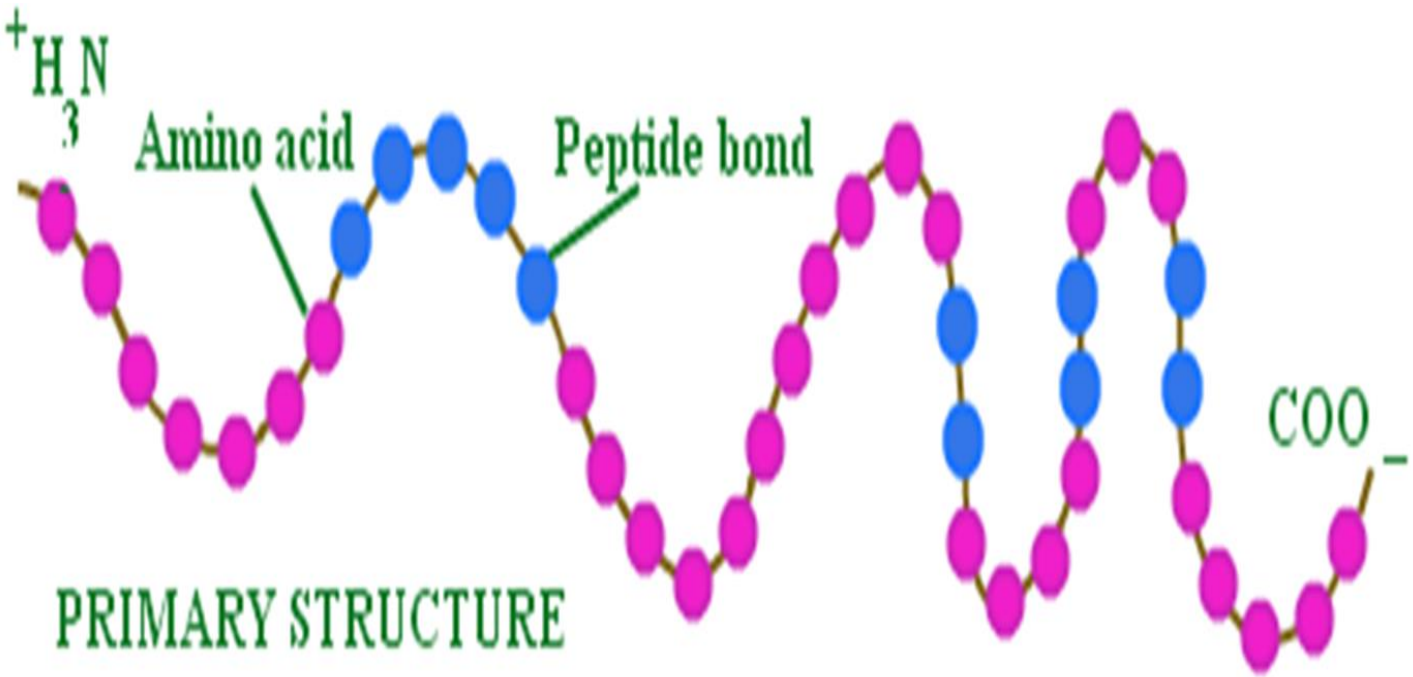
1. Primary structure

- ✓It is the **number, type and sequence** of AAs in the polypeptide chain.
- ✓Main bond: **Peptide bond** (-**CO-HN**-)
- ✓the sequence of amino acids in a protein, is like the order of letters in a long word
- ✓Primary structure is determined by inherited genetic information
- ✓Any **change in** 1 AA→ **physiological** defect.
- ✓**Bioinformatics** uses computer programs to predict protein structure from amino acid sequences

1. Primary structure

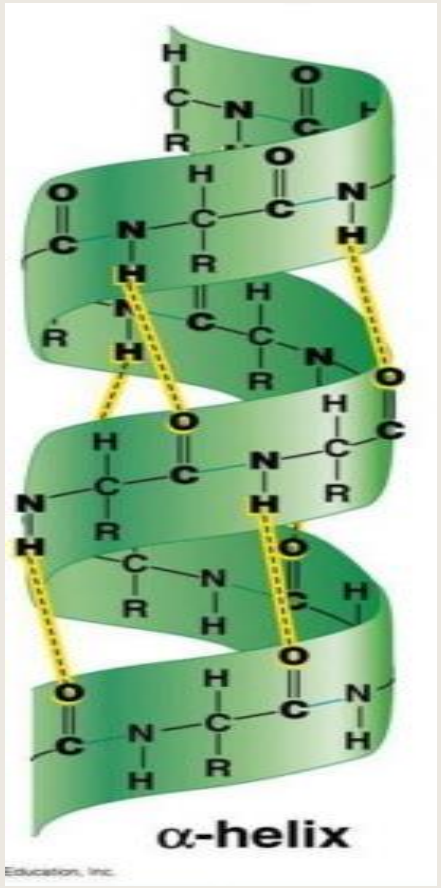
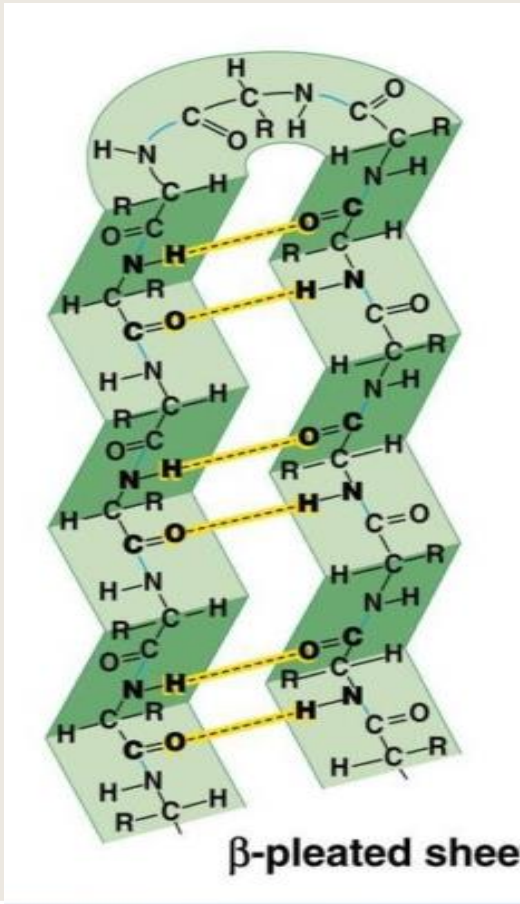
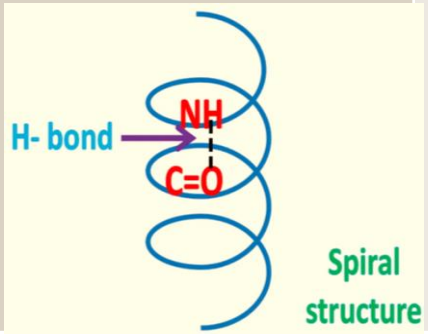
- ✓The free -**NH2 group** of the **1st AA** is called as **N-** terminal end
- ✓The free -**COOH end** of the **last AA** is called as **C-** terminal end
- ✓We count the AAs from the **N terminal**





2. Secondary structure

1ry structure (The polypeptide chain) will be folded by hydrogen bonds between specific atoms to give specific shape /form which may be:

	α-Helix		β-Sheets	
Shape	**Helix** (**coiled**) (spiral) peptide chain • Each turn contains 3.6 AA		**Pleated** (**Zigzag**) peptide chain • Arranged side by side	
Stabilized (held together) by:	**Hydrogen bond** • between peptide bonds in the **same chain** 		**Hydrogen bonds** • between **adjacent 2 polypeptide** chains • or different segment of the **same chain**	

3. Tertiary structure

- ✓ **Definition: It is three-dimensional (3D) shape of a protein (**polypeptide chain)
- ✓ **Formed of :Secondary structures (α and β)** are arranged to form **final functional 3D** structure of protein.
  - 3ry structure is the **final order** of organization of protein.
  - The **function of a protein** depend on its tertiary structure→ If it is disrupted → protein loses its activity

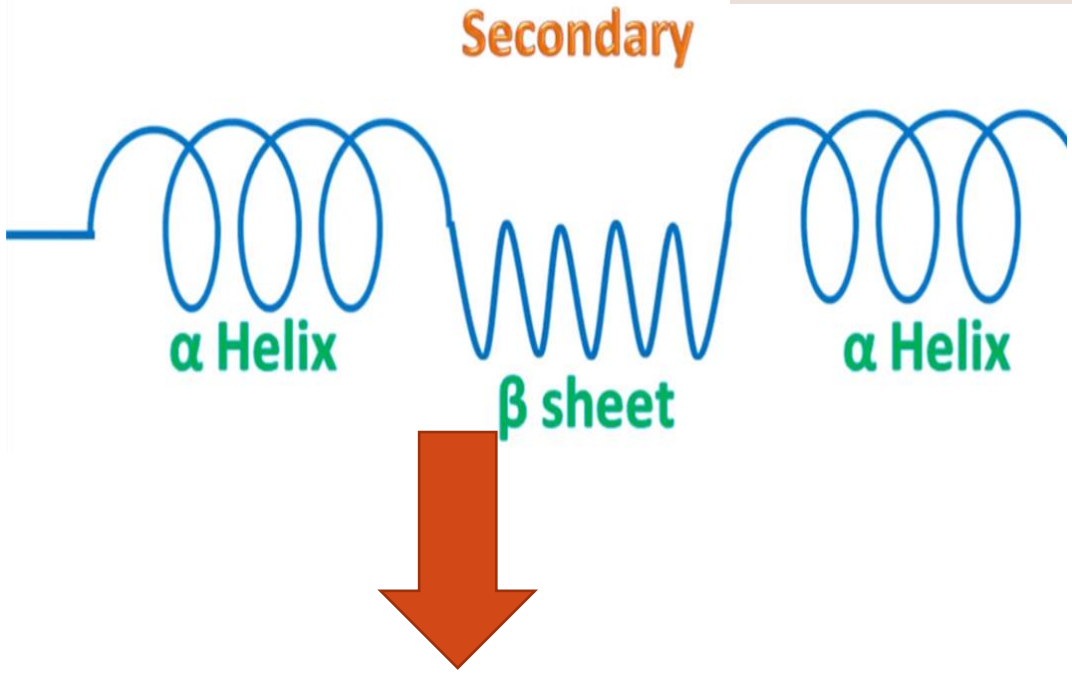
3. Tertiary structure

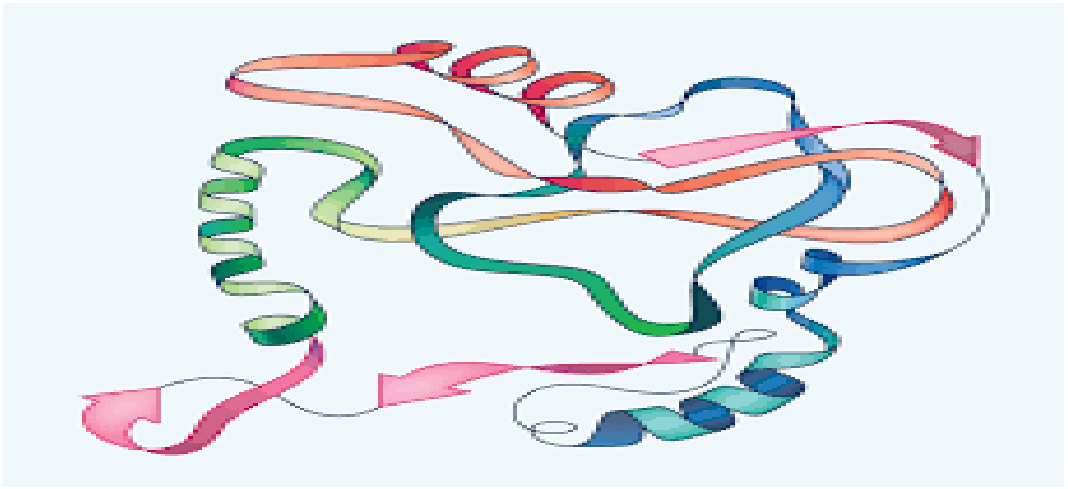
✓ **Bonds (Forces) stabilizing this 3ry structure**

- Bonds occur due to interaction between **side chains (R)** gp of AAs
- Several bonds (forces) like:

1. **Hydrogen bonds: between polar side chains of AA**
2. **Hydrophobic forces: between the non-polar (R) groups of AAs**
3. **Ionic bonds (Electrostatic forces): between oppositely charged (R) of AAs**
4. **Disulfide bonds (Covalent bond) : between sulfur AA (cysteine) .**

3ry structure





Nonpolar R

HYDROPHOBIC INTERACTION

POLYPEPTIDE BACKBONE

HYDROGEN BOND

Polar R

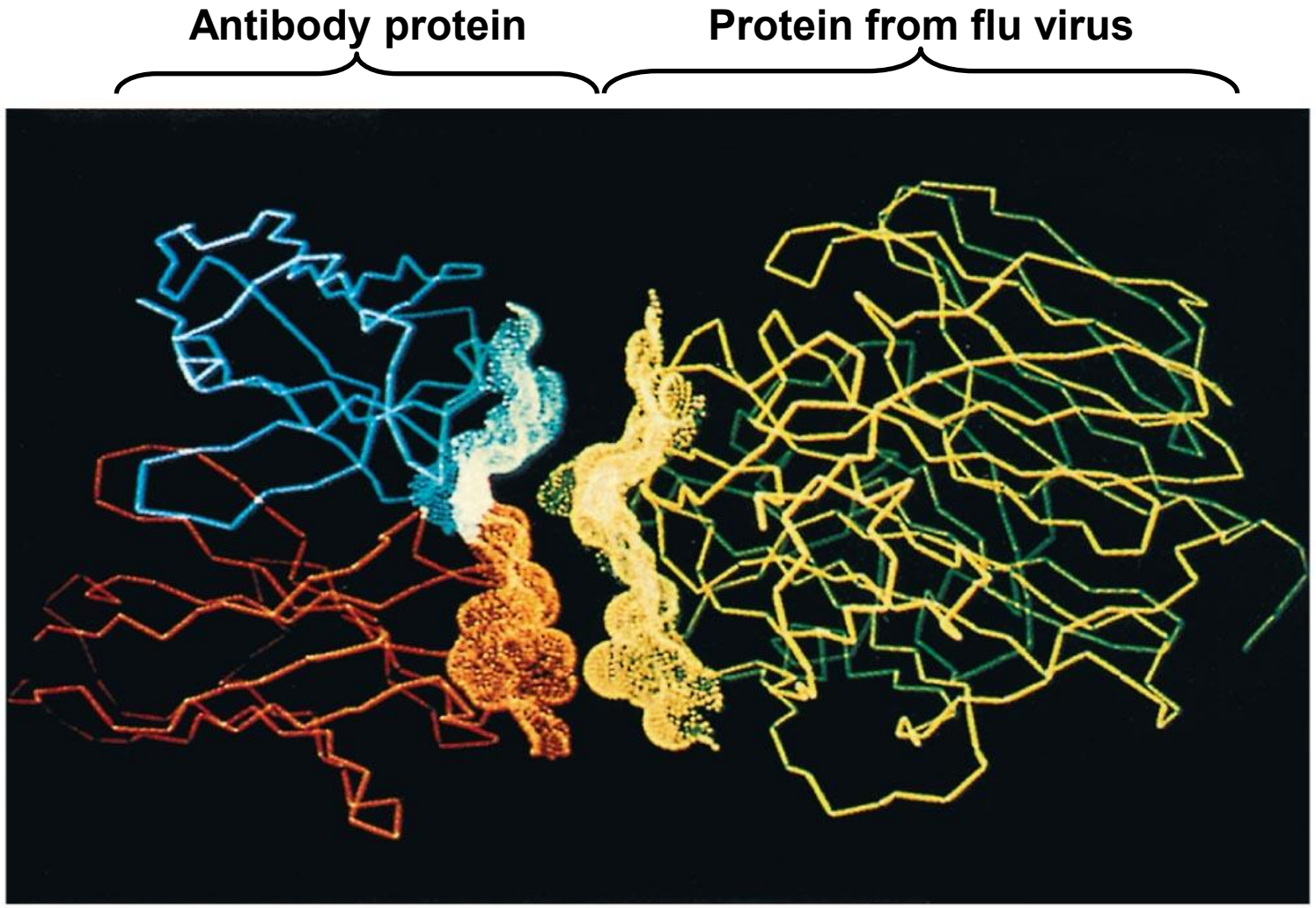
DISULIFIDE BRIDGE

S containing aa

ICONIC BOND

Oppositely charged aa

Figure : An antibody binding to a protein from a flu virus



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4. Quaternary Structure

✓ **Definition**:

- it is the association (arrangement) of several polypeptide chains or **subunits** into a closely packed arrangement.
- results when two or more polypeptide chains (**subunits**) form one macromolecule.
- Each of the subunits has **its own** **primary, secondary, and tertiary** structure.

✓ **Examples**

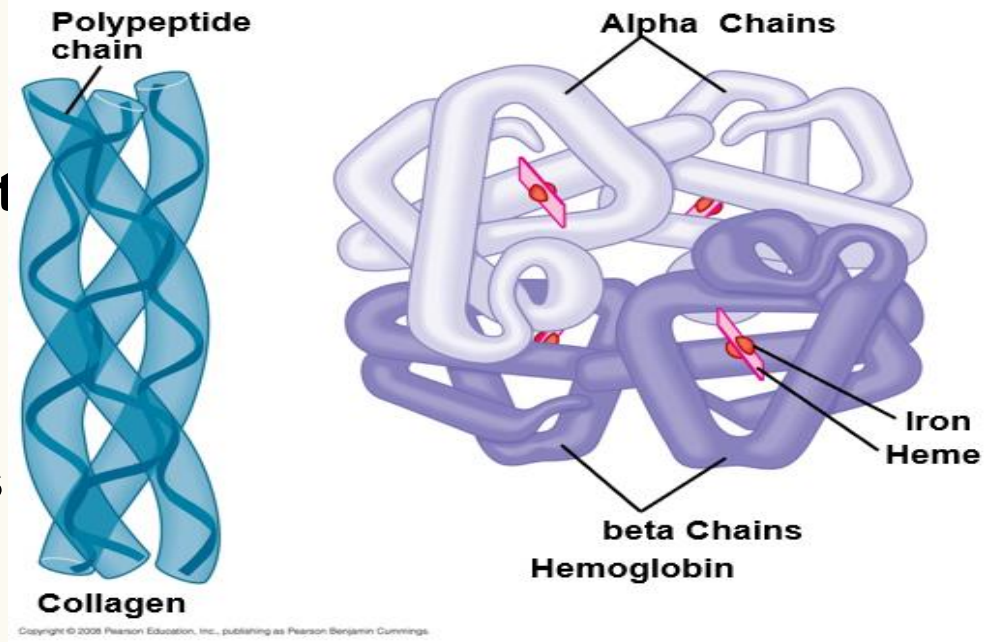
1-Haemoglobin:

is a globular protein **tetramer (formed of 4 subunit**

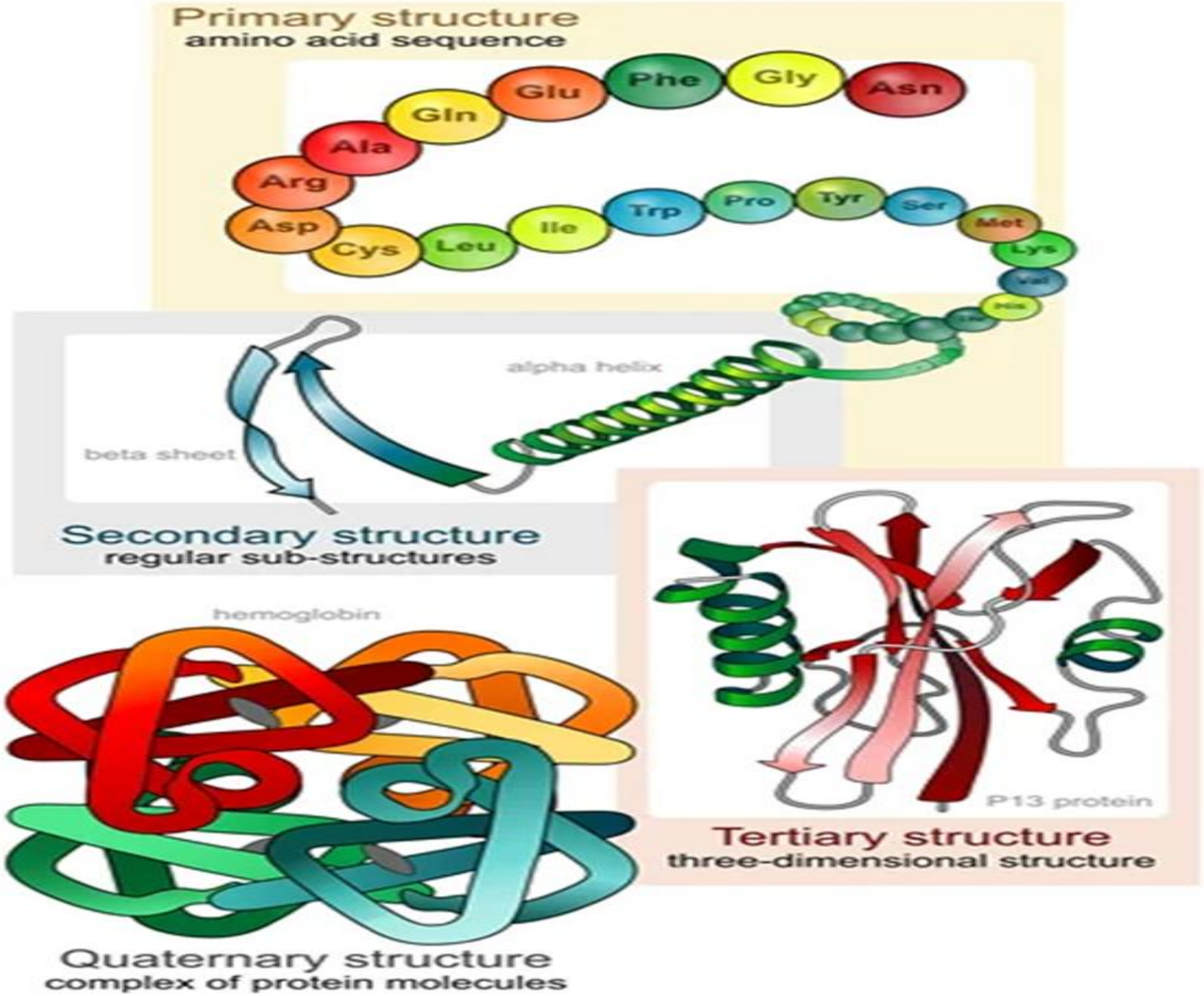
: two alpha and two beta chains

2. Collagen

is a fibrous protein consisting of three polypeptides coiled like a rope

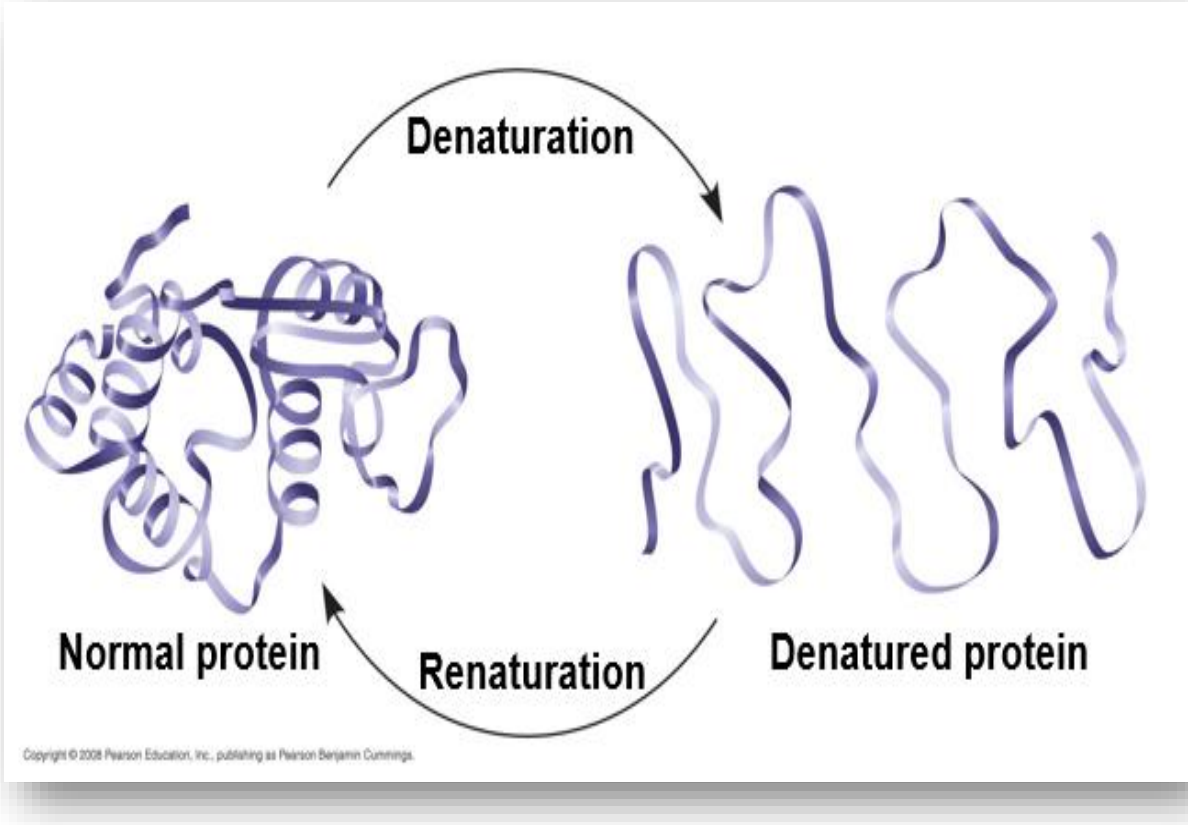


Summary


Primary structure
amino acid sequence
Glu
Phe
Gly
Asn
Gln
Ala
Arg
Asp
Cys
Leu
Ile
Trp
Pro
Tyr
Ser
Met
Lys
alpha helix
beta sheet
Secondary structure
regular sub-structures
hemoglobin
Quaternary structure
complex of protein molecules
P13 protein
Tertiary structure
three-dimensional structure

What also Determines Protein Structure?

- Physical and chemical conditions can also affect protein structure
- Alterations in **pH, salt concentration, temperature**, or other environmental factors can cause loss of a protein's native structure, called **denaturation.**
- A denatured protein is biologically inactive



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Protein misfolding

Definition

- Proteins that are **not** able to form **stable 3D structure** recognized as **misfolded proteins**
- **The misfolded protein→ aggregates** (large size, insoluble) → loss its structure and function

Example of diseases related to misfolded protein:

1. Alzheimer's disease

- characterized by **dense plaques** in the brain caused by misfolding of the **β-sheets**
- **Memory loss, lack of recognition**

2. Cystic fibrosis (CF)

- caused by misfolding of (**CFTR)** protein.

Biological importance of Proteins

Proteins have many structures, resulting in a wide range of functions

- Protein functions include structural support, storage, transport, cellular communications, movement, and defense against foreign substances

- Ex: Formation of:
  1. Enzymes
  2. Hormones (protein hormones)
  3. Hemoglobin
  4. Plasma protein (lipoproteins)
  5. Immunoglobulins (antibodies)
  6. Supporting structure (cartilage, skin, nail, hair, etc)

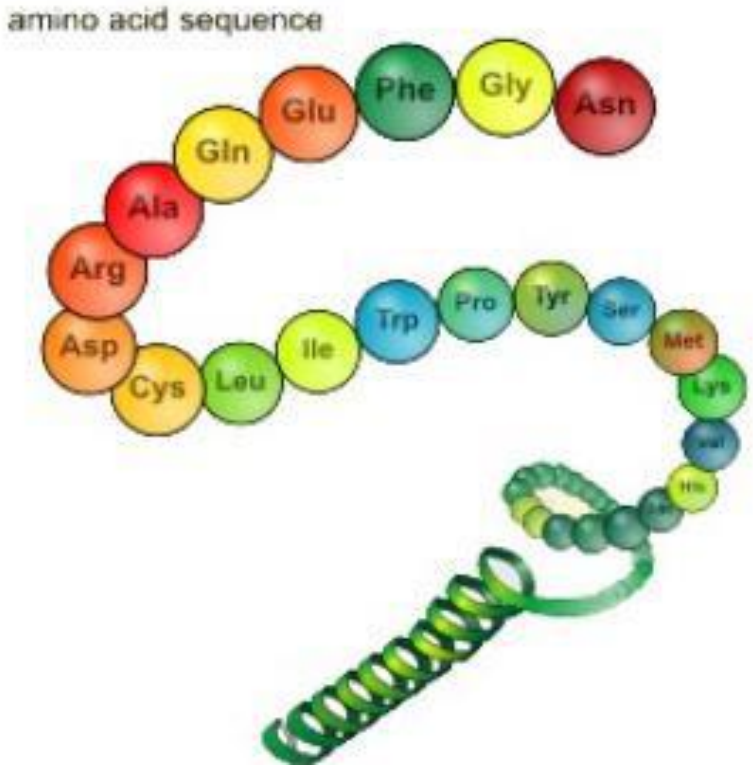

Table 5.1 An Overview of Protein Functions

Type of Protein	Function	Examples
Enzymatic proteins	Selective acceleration of chemical reactions	Digestive enzymes
Structural proteins	Support	Silk fibers; collagen and elastin in animal connective tissues; keratin in hair, horns, feathers, and other skin appendages
Storage proteins	Storage of amino acids	Ovalbumin in egg white; casein, the protein of milk; storage proteins in plant seeds
Transport proteins	Transport of other substances	Hemoglobin, transport proteins
Hormonal proteins	Coordination of an organism's activities	Insulin, a hormone secreted by the pancreas
Receptor proteins	Response of cell to chemical stimuli	Receptors in nerve cell membranes
Contractile and motor proteins	Movement	Actin and myosin in muscles, proteins in cilia and flagella
Defensive proteins	Protection against disease	Antibodies combat bacteria and viruses.

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Enzymes

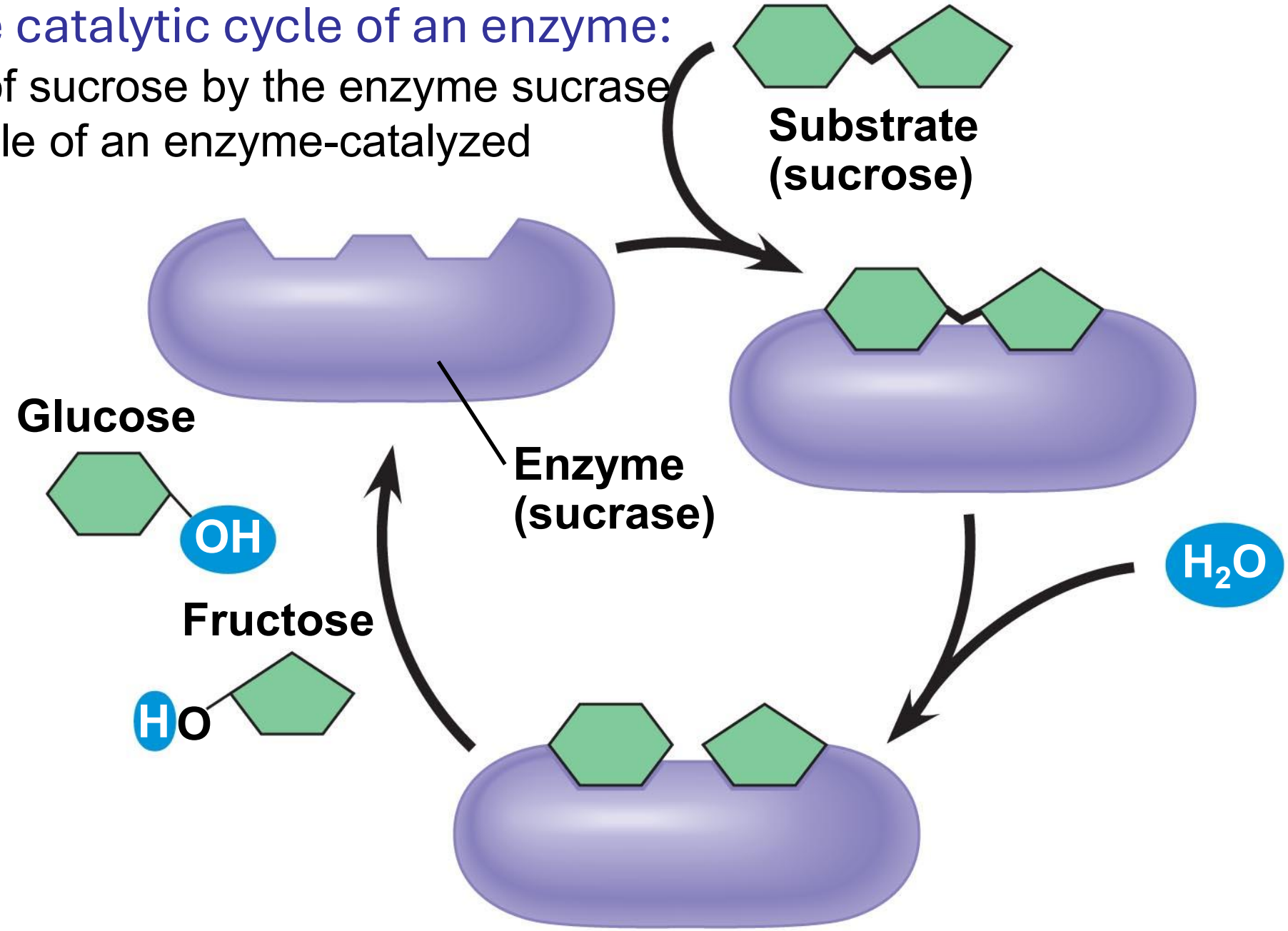
- ✓Enzymes are a type of protein that acts as a **catalyst** to speed up chemical reactions.
- ✓ **Catalyst** is a substance that:
  - ➢**increase the rate** of chemical reaction.
  - ➢without **change** or **being consumed** in the reaction.
- ✓ Without enzyme the chemical reaction will proceed with a **very slow rate**

Without enzymes

With enzymes

Figure :The catalytic cycle of an enzyme:

Hydrolysis of sucrose by the enzyme sucrase is an example of an enzyme-catalyzed reaction



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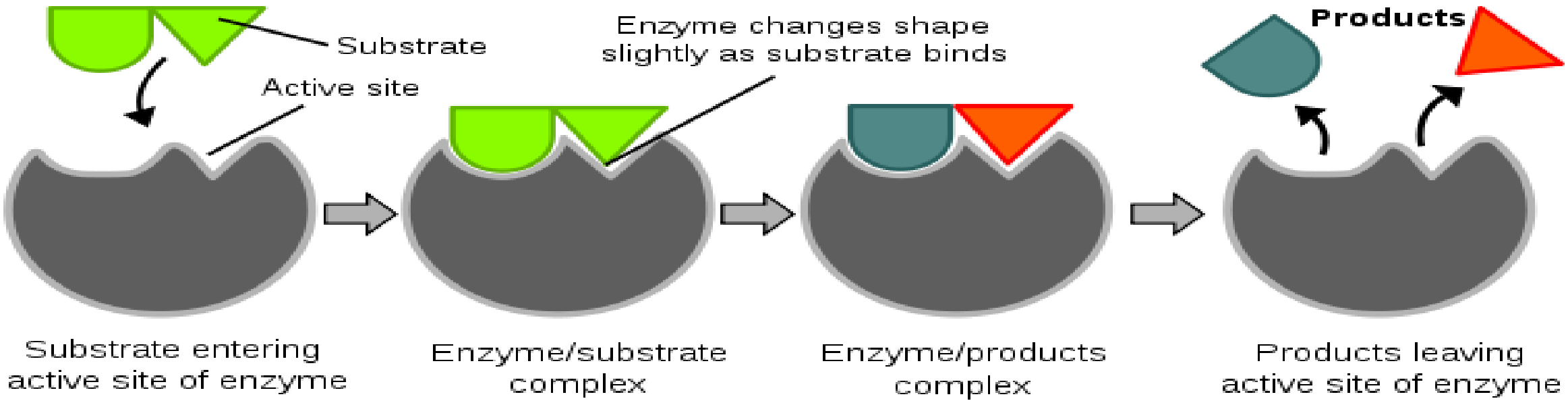
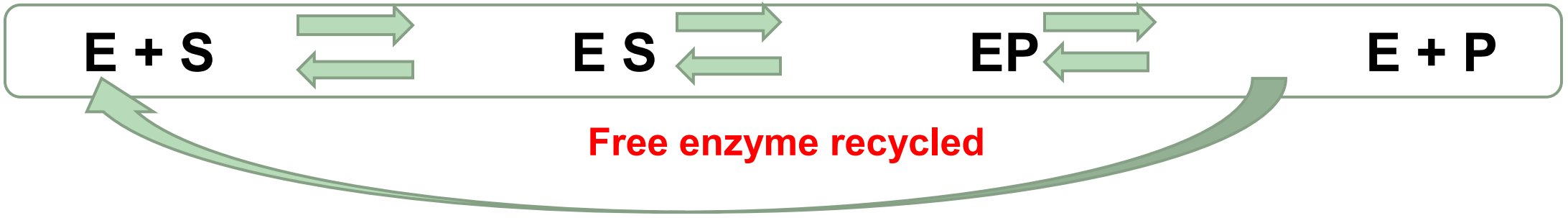
Steps (mechanism) of enzymatic reaction

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)**





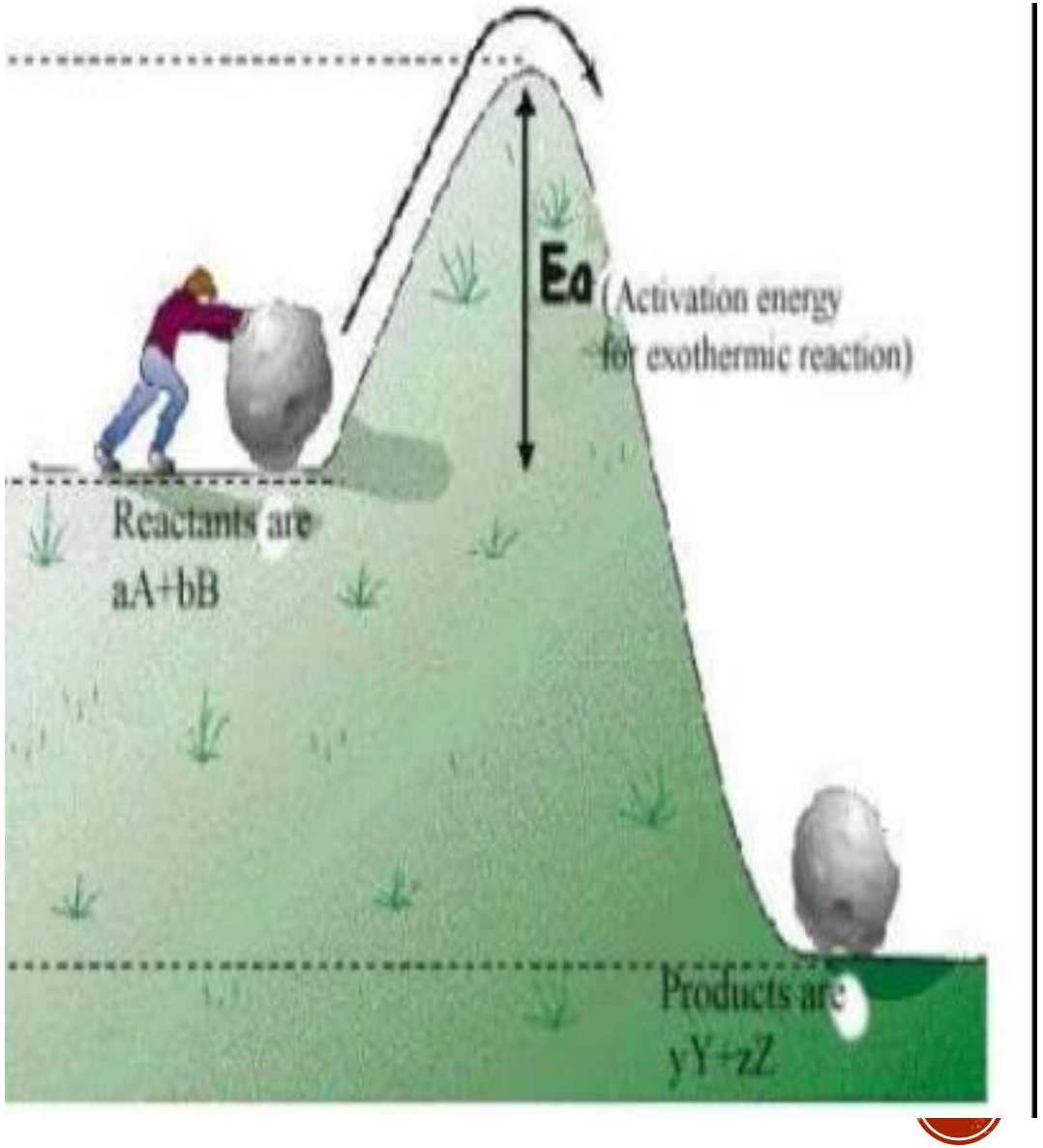
7. Enzyme action

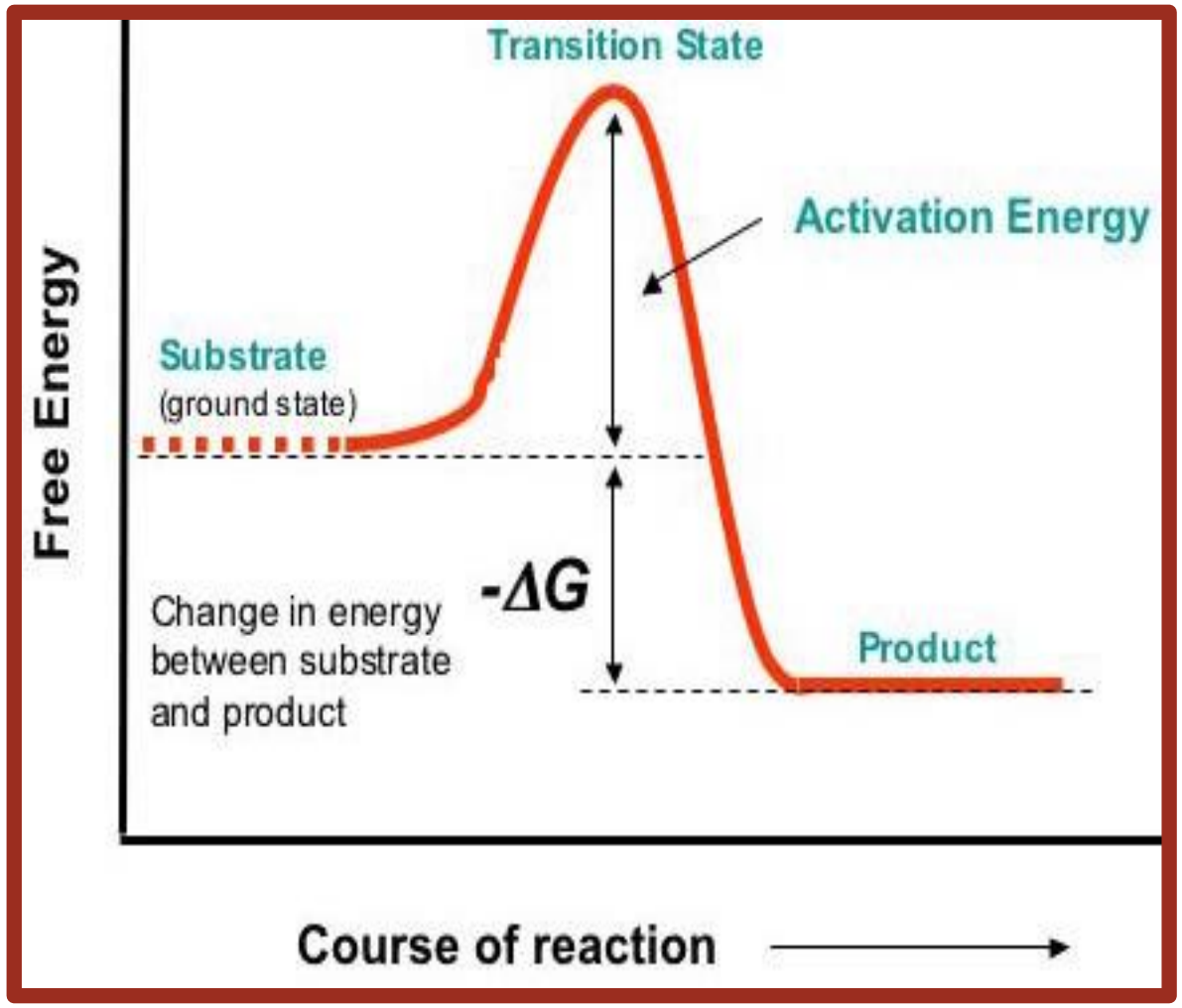
In non-enzymatic reactions:

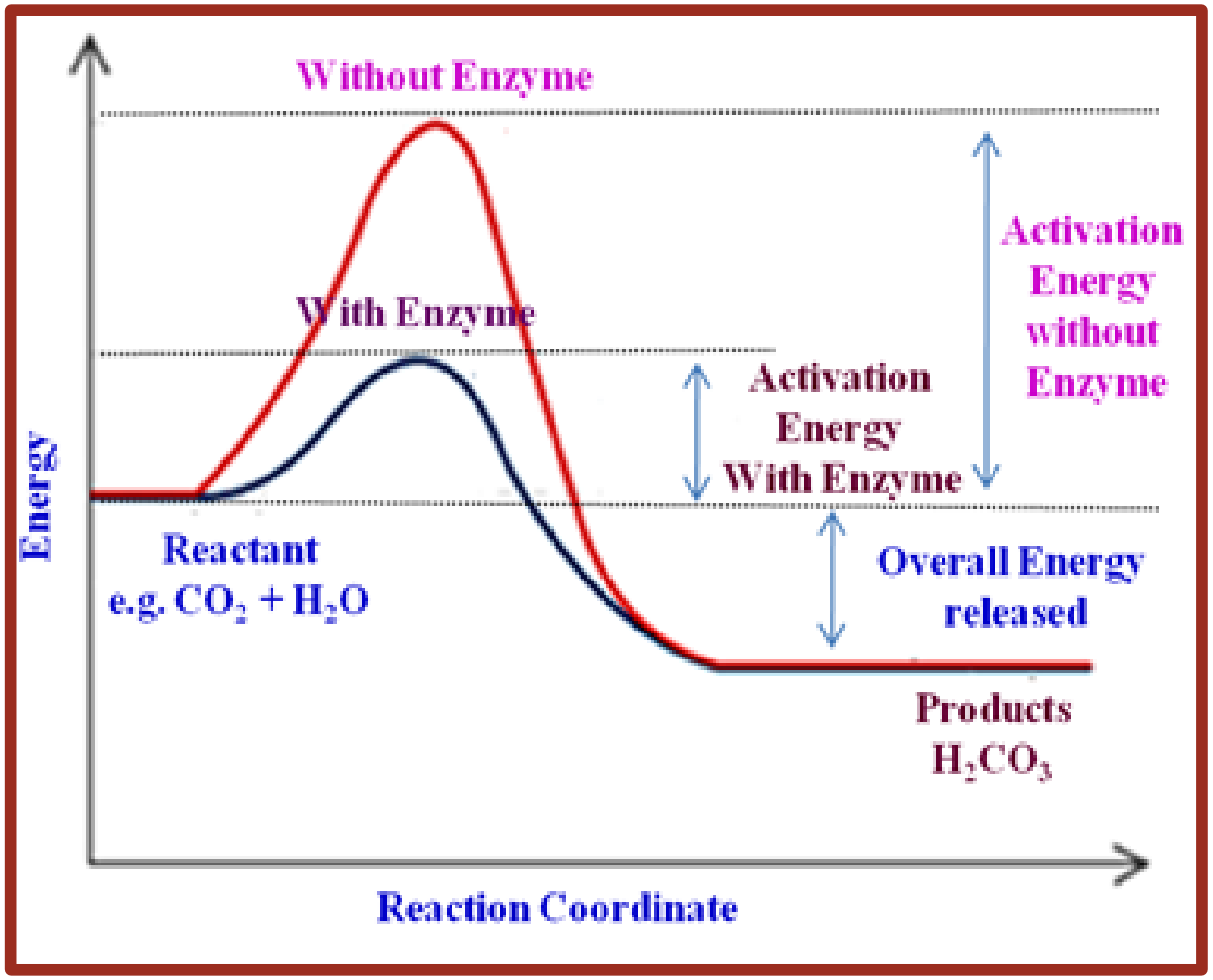
- ✓ There is an **energy barrier** between reactants and end products.
- ✓So, to start a chemical reaction, a certain amount of energy is needed to **overcome** this barrier.
- ✓This amount of energy is called **activation energy**

Enzymes

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



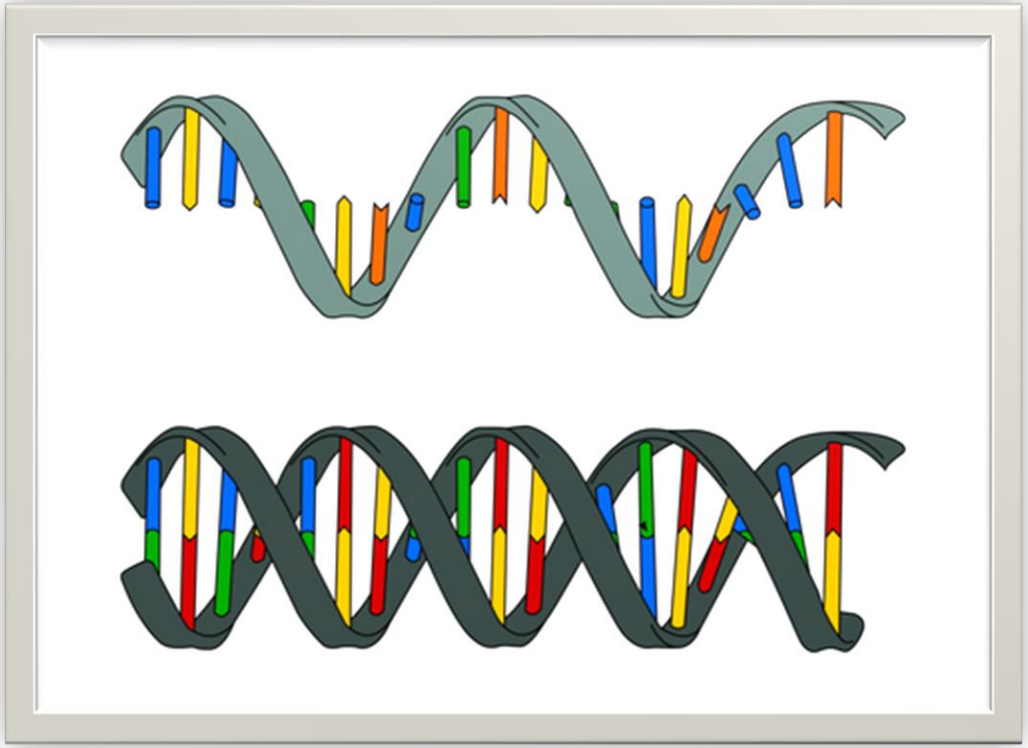




- ✓ **Activation energy:** it is the **energy barrier** between reactants and end products
- ✓ **Overall energy (ΔG): change in energy** between substrate and product

- ✓ **Enzyme:**
  - **lower activation energy**
  - **But it doesn't affect the overall energy (Δ*G*)**

IV. Nucleic Acids



Carbohydrates

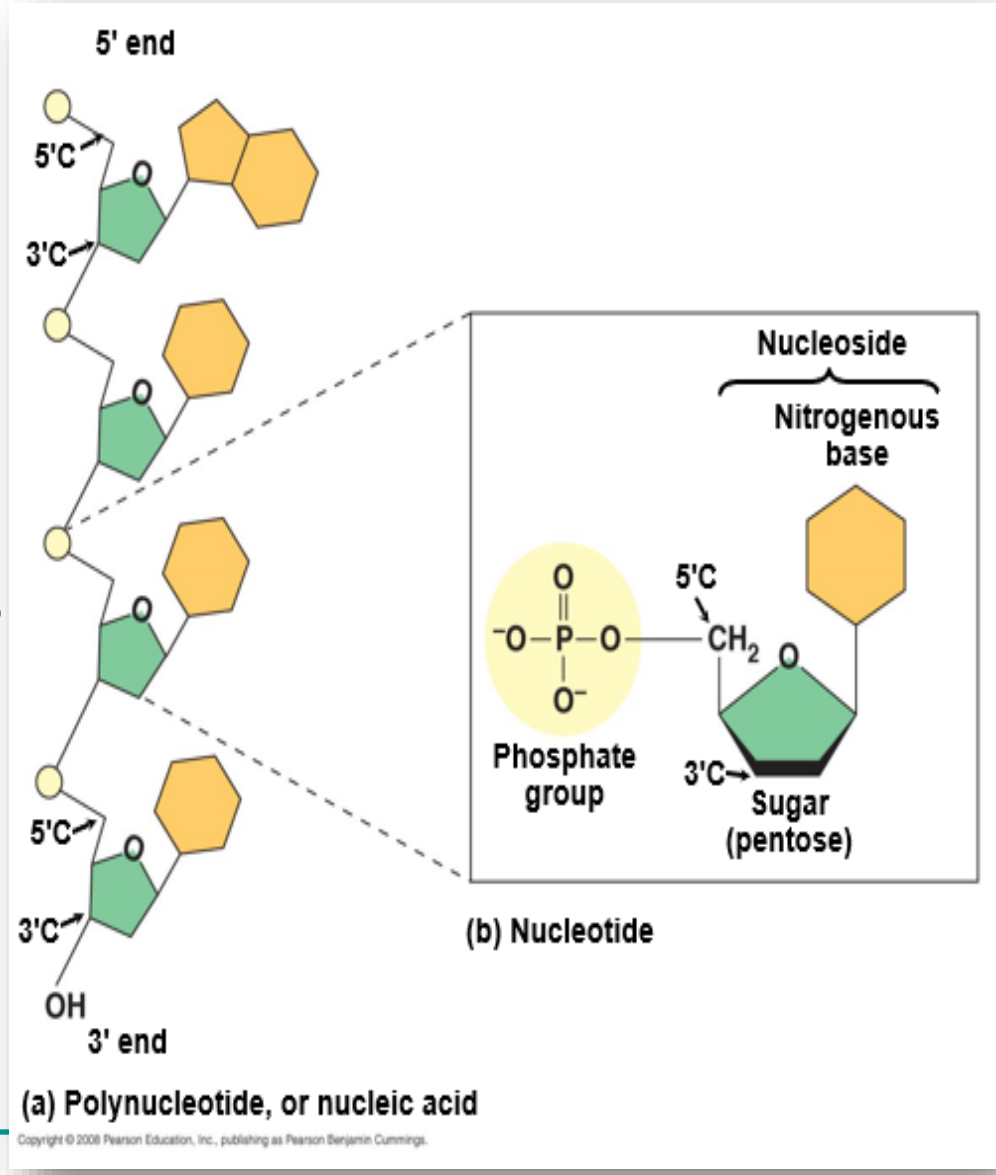
Lipids

Proteins

Nucleic Acids

The Structure of Nucleic Acids

- Nucleic acids are polymers called **polynucleotides**
- Each polynucleotide is made of monomers called **nucleotides**
- Each nucleotide consists of a nitrogenous base, a pentose sugar, and a phosphate
- The portion of a nucleotide without the phosphate group is called a *nucleoside*



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The Roles of Nucleic Acids

- There are two types of nucleic acids:
  - **Deoxyribonucleic acid (DNA)**
  - **Ribonucleic acid (RNA)**
- Nucleic acids store and transmit hereditary information

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Activity

- **Direction:** On a clean sheet of paper, answer the following questions.

Proteins	**Nucleic Acid**
What elements are they composed of? What is the monomer? What is its function for the body? Write two examples:	What elements are they composed of? What is the monomer? What is its function for the body? Write two examples:


BELIEVE IN
YOURSELF.