



University of Al-Qadisiyah

College of Medicine



Medical Chemistry/ Part 1-Biochemistry

1st year / (2022-2023) / 1st Semester

L 4 – Proteins

((Structures, Functions, Classification))



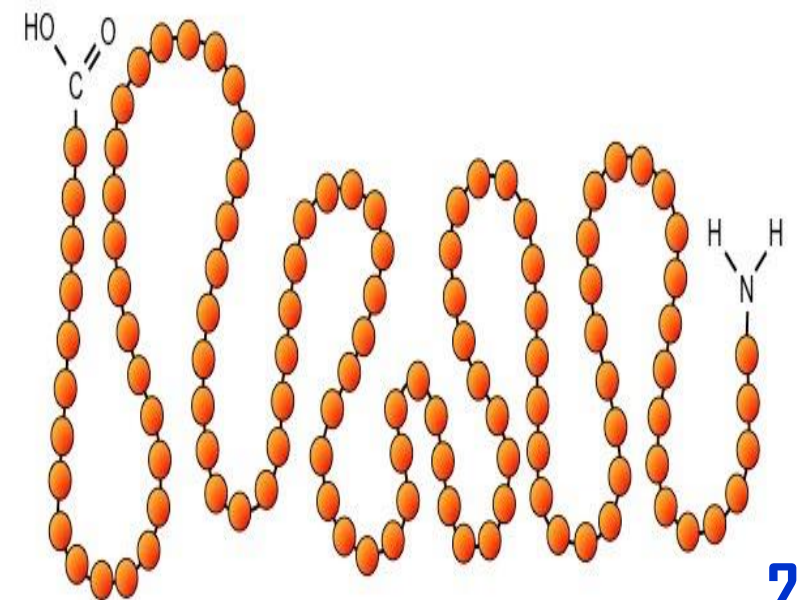
Dr. Ahmed Ghdhban Al-Ziaydi
PhD. Medical Biochemistry



Proteins

Proteins are the polymers of L- α -amino acids. The structure of proteins is rather complex which can be divided into 4 levels of organization

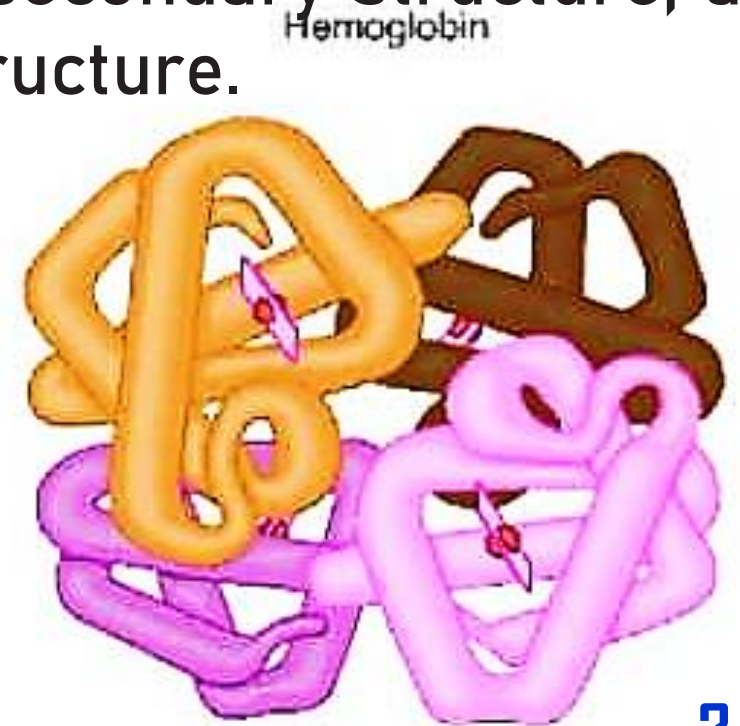
1. **Primary structure** : The linear sequence of amino acids forming the backbone of proteins (polypeptides).
2. **Secondary structure** : The spatial arrangement of protein by twisting of the polypeptide chain.
3. **Tertiary structure** : The three dimensional structure of a functional protein.



4. Quaternary structure : Some of the proteins are composed of two or more polypeptide chains referred to as subunits. The spatial arrangement of these subunits is known as quaternary structure.

The structural hierarchy of proteins is comparable with the structure of a building. The amino acids may be considered as the bricks, the wall as the primary structure, the twists in a wall as the secondary structure, a full-fledged self-contained room as the tertiary structure.

A building with similar and dissimilar rooms will be the quaternary structure. The term protein is generally used for a polypeptide containing more than 50 amino acids



Quickly
understand

Structure of Proteins

Primary



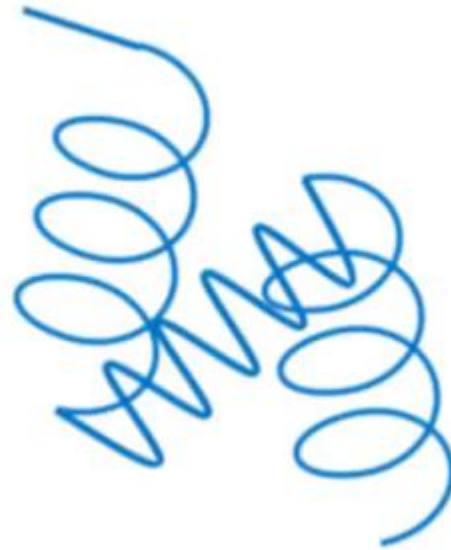
α Helix



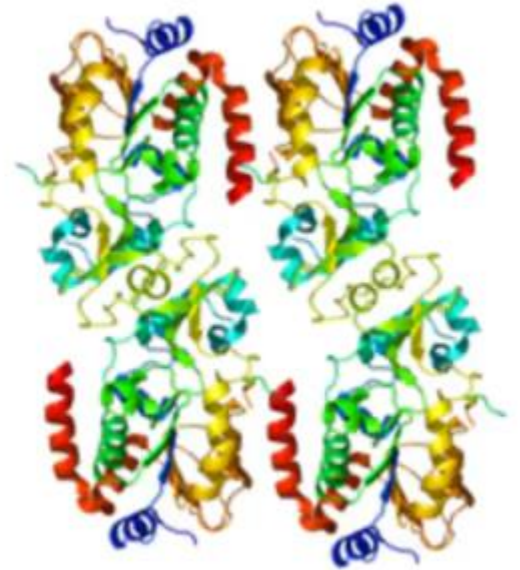
β sheet

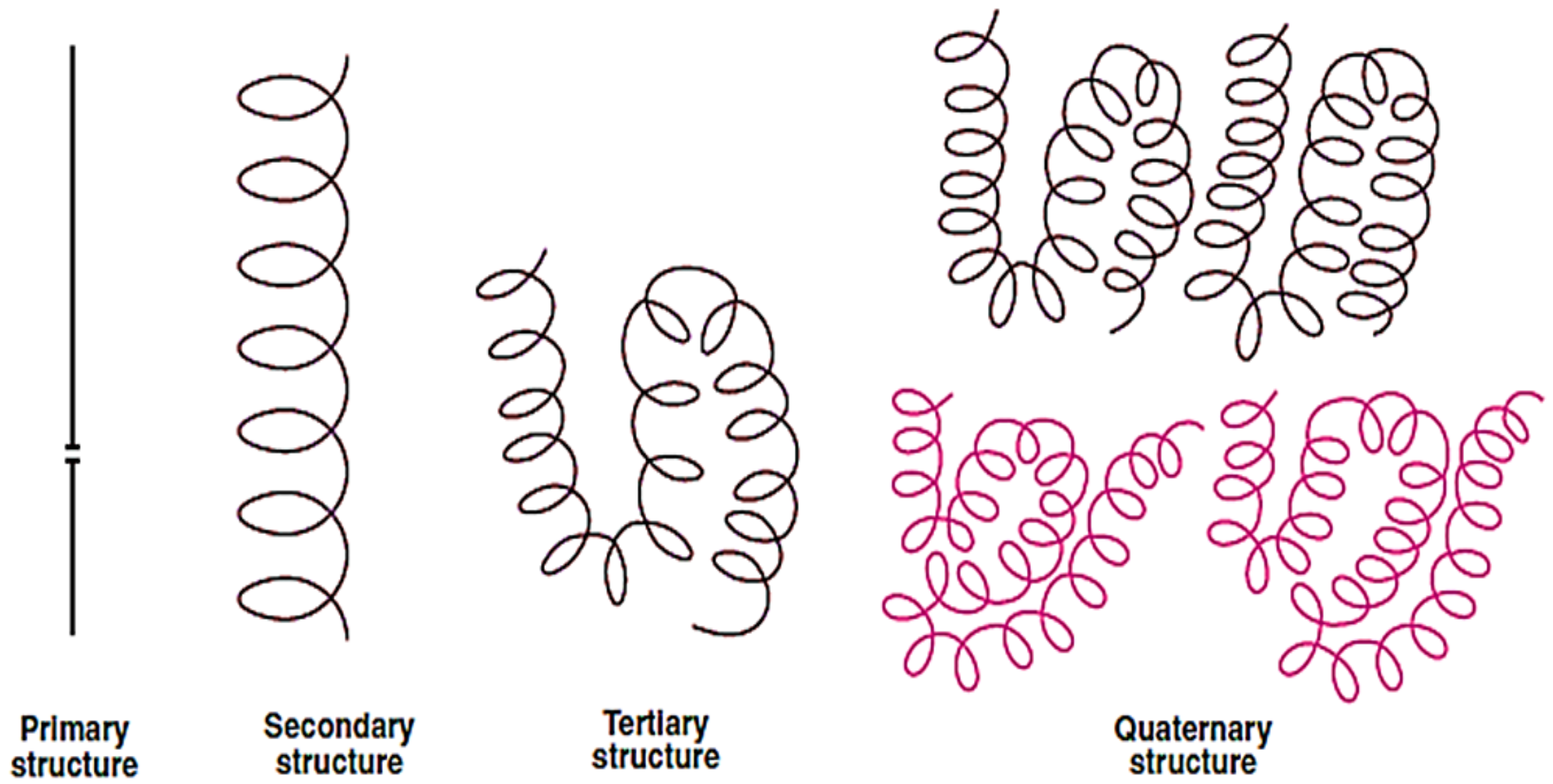


Tertiary



Quaternary





Primary structure

Secondary structure

Tertiary structure

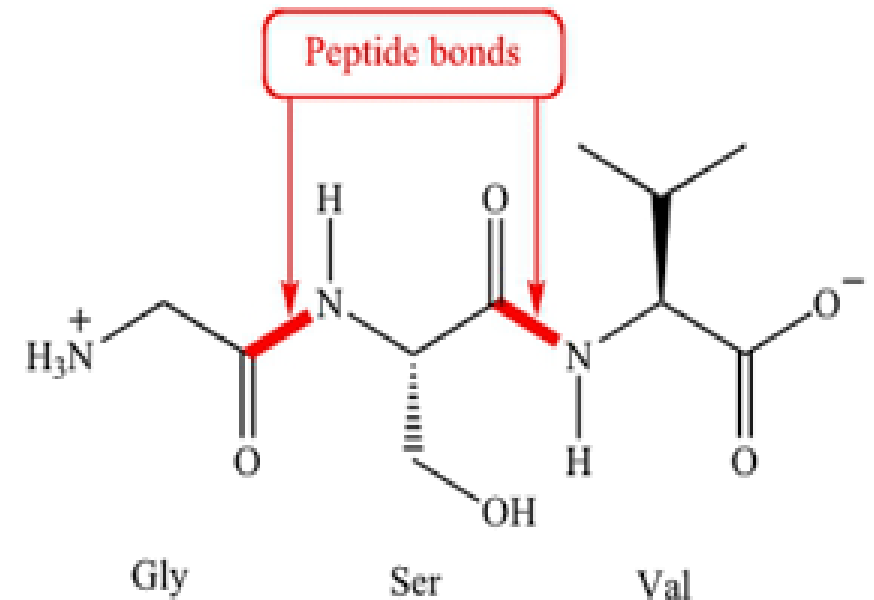
Quaternary structure

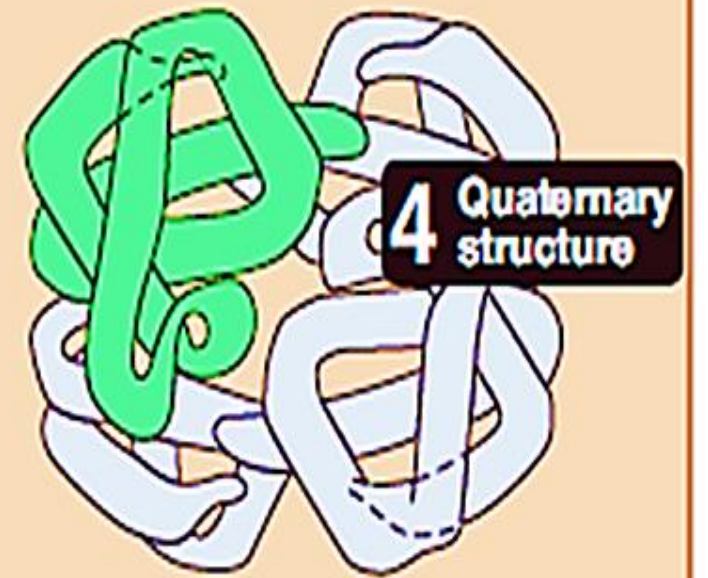
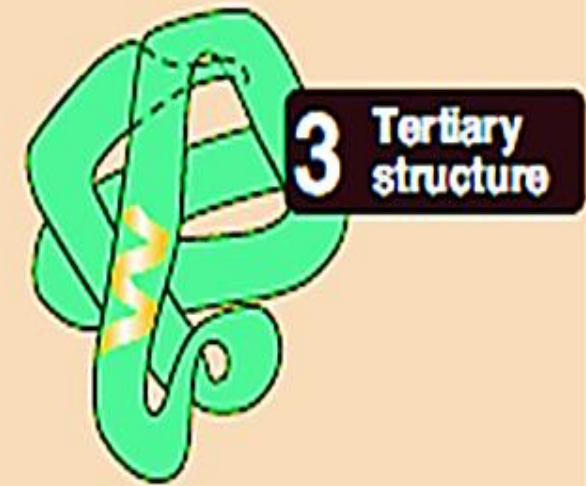
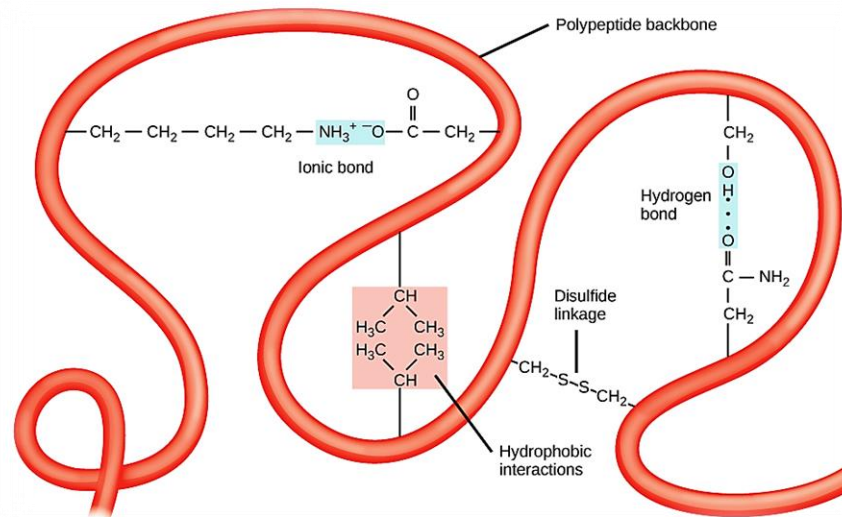
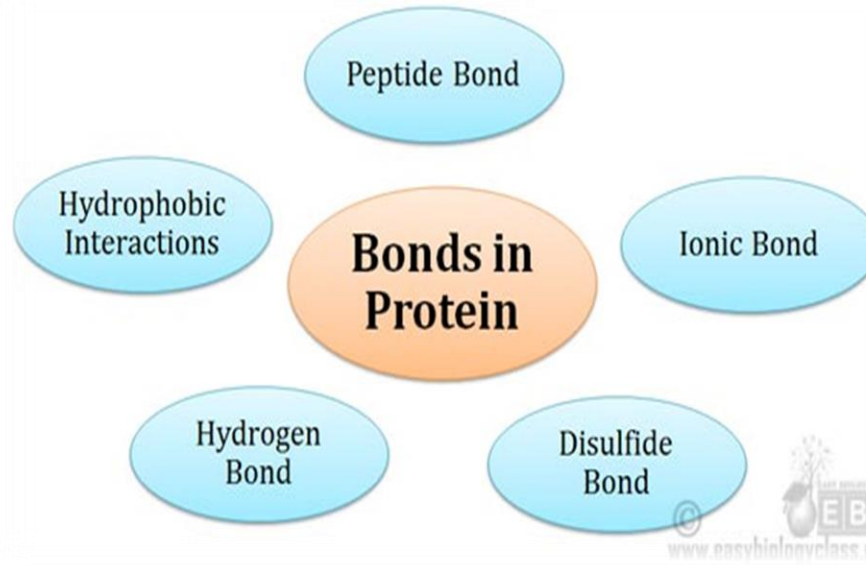
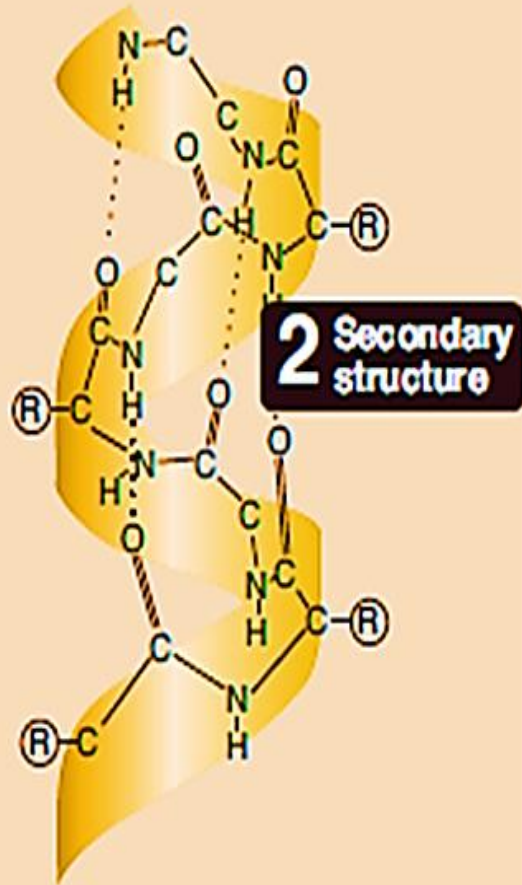
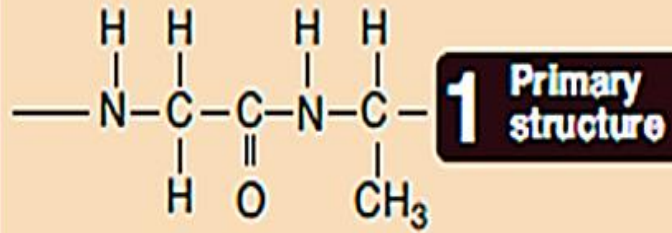
Fig. 4.4 : Diagrammatic representation of protein structure

Primary Structure of Protein: Each protein has a unique sequence of amino acids which is determined by the genes contained in DNA. The primary structure of a protein is largely responsible for its function.

A vast majority of genetic diseases are due to abnormalities in the amino acid sequences of proteins i.e. changes associated with primary structure of protein. The amino acid composition of a protein determines its physical and chemical properties.

Peptide bond: The amino acids are held together in a protein by covalent peptide bonds or linkages. These bonds are rather strong and serve as the cementing material between the individual amino acids (considered as bricks).





Formation of a peptide bond : When the amino group of an amino acid combines with the carboxyl group of another amino acid, a peptide bond is formed (Fig. 4). Note that a dipeptide will have two amino acids and one peptide (not two) bond. Peptides containing more than 10 amino acids (decapeptide) are referred to as polypeptides.

Characteristics of peptide bonds : The peptide bond is rigid and planar with partial double bond in character. It generally exists in trans configuration. Both -C=O and -NH groups of peptide bonds are polar and are involved in hydrogen bond formation.

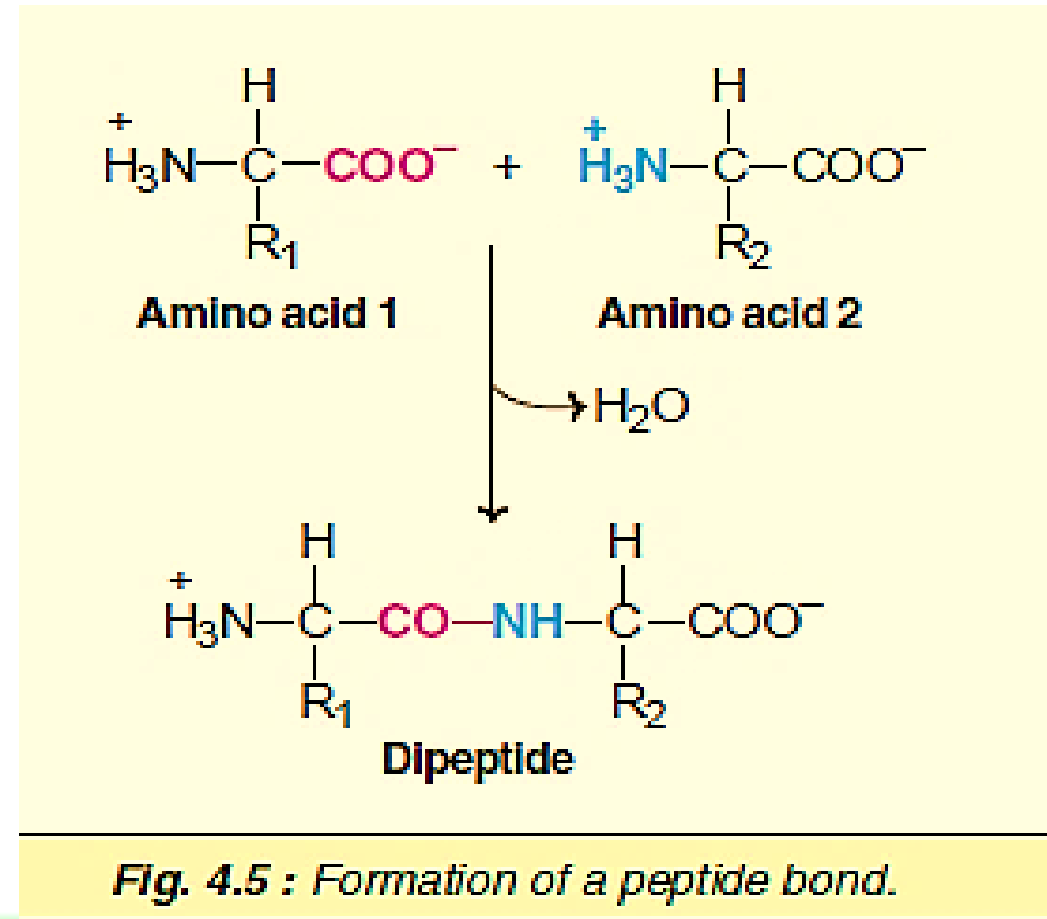
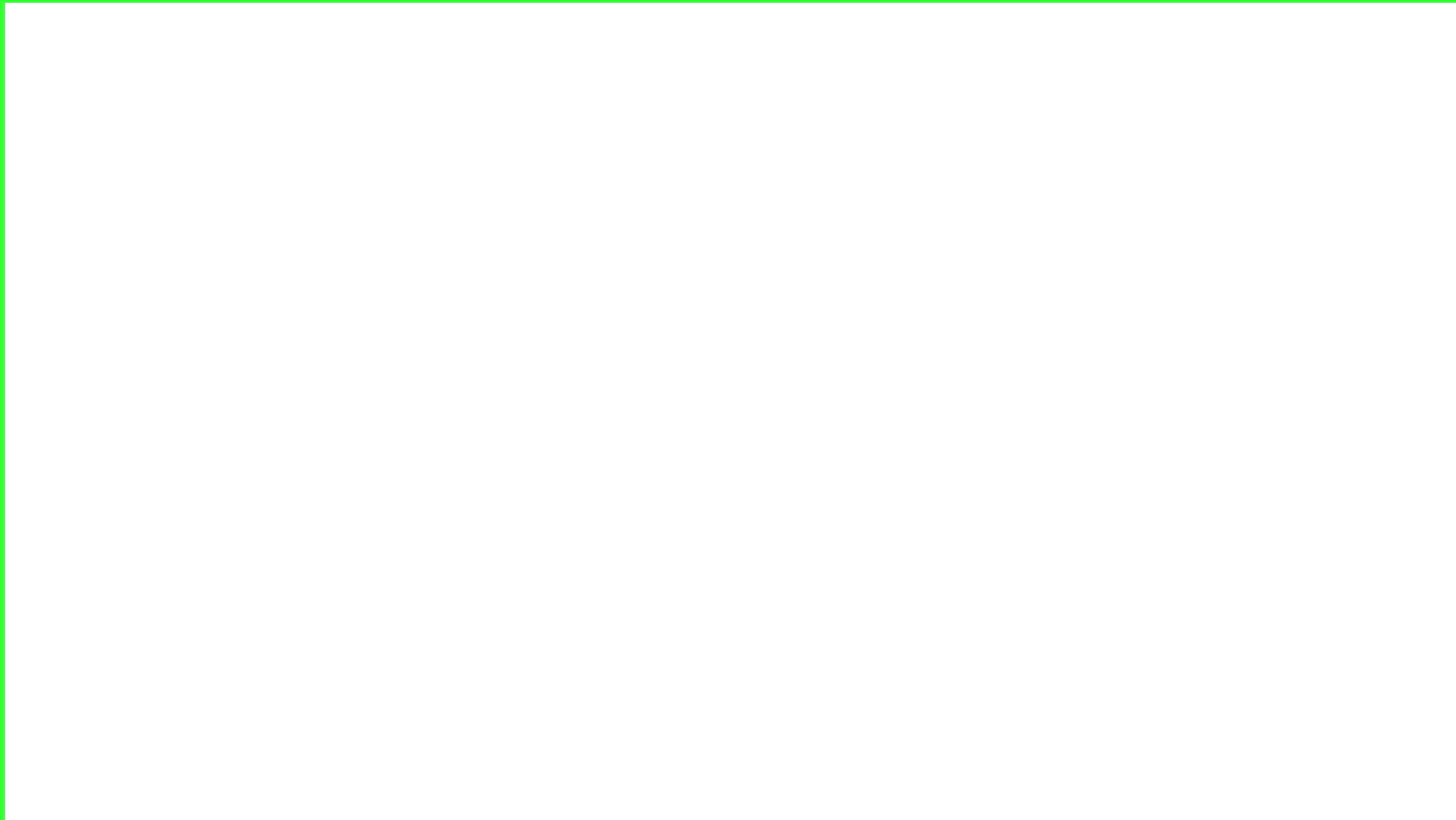
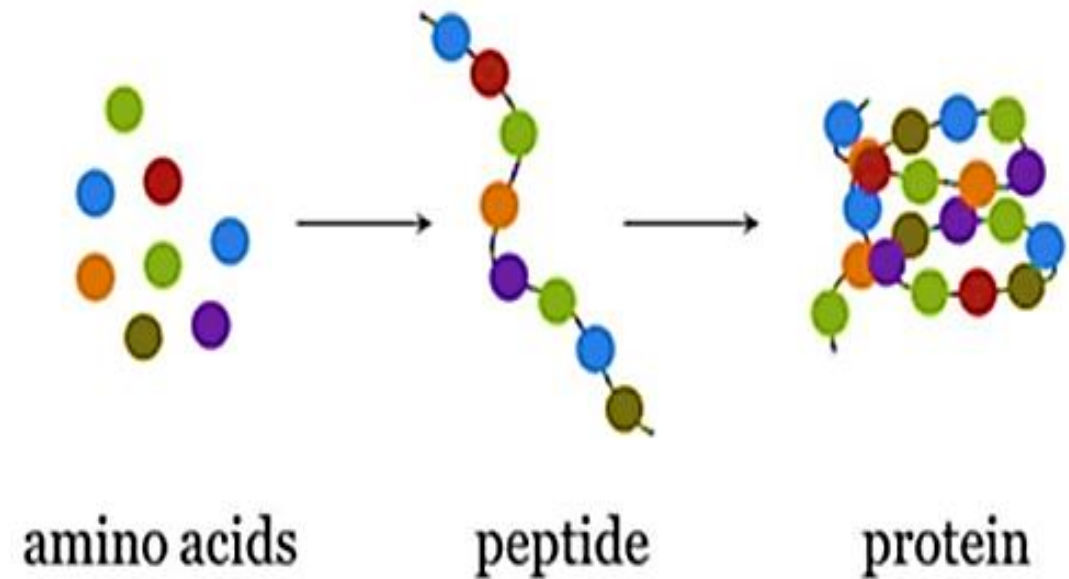
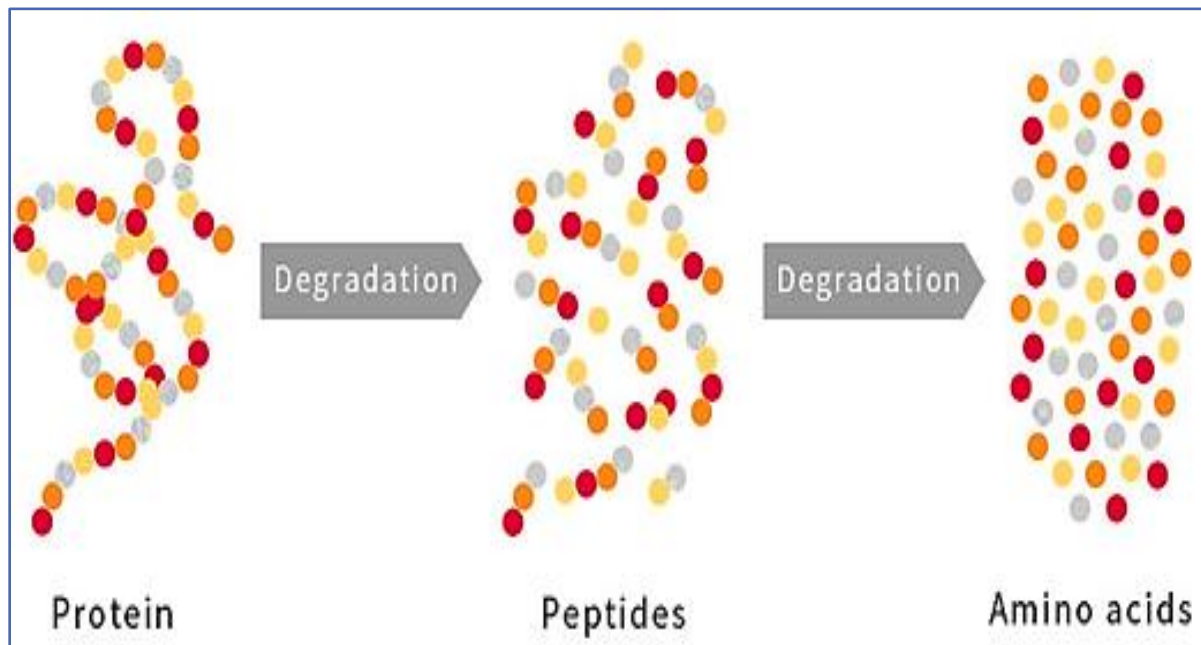


Fig. 4.5 : Formation of a peptide bond.



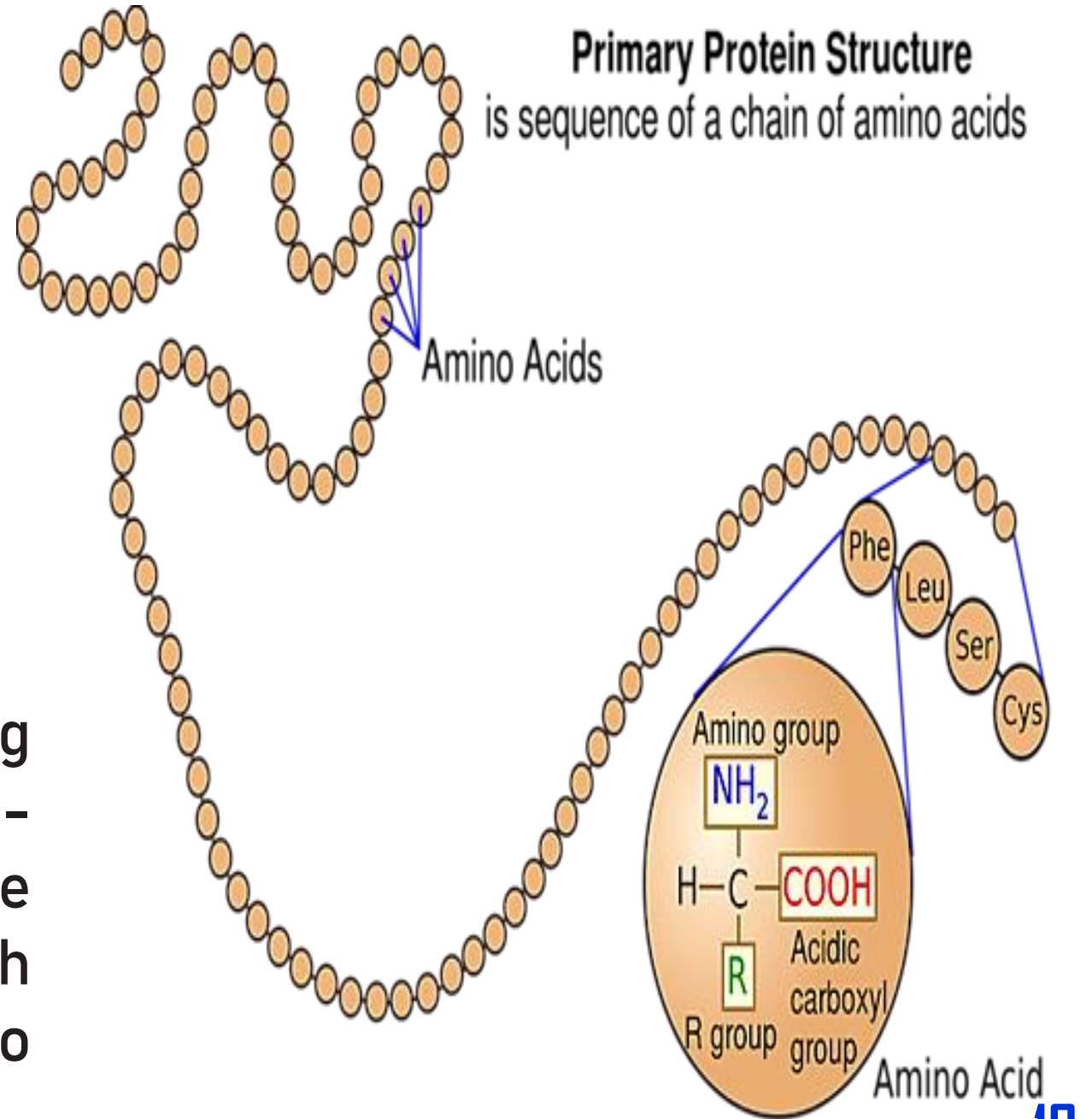
Writing of peptide structures : Conventionally, the peptide chains are written with the free amino end (N-terminal residue) at the left, and the free carboxyl end (C-terminal residue) at the right.

The amino acid sequence is read from N-terminal end to C-terminal end. The protein biosynthesis also starts from the N-terminal amino acid.



Shorthand to read peptides : The amino acids in a peptide or protein are represented by the 3-letter or one letter abbreviation. This is the chemical shorthand to write proteins.

Naming of peptides : For naming peptides, the amino acid suffixes -ine (glycine), -an (tryptophan), -ate (glutamate) are changed to -yl with the exception of C-terminal amino acid.



Thus a tripeptide composed of an N-terminal glutamate, a cysteine and a C-terminal glycine is called glutamyl-cysteinyl-glycine. In the Fig 4.6, the naming and representation of a tripeptide are shown.

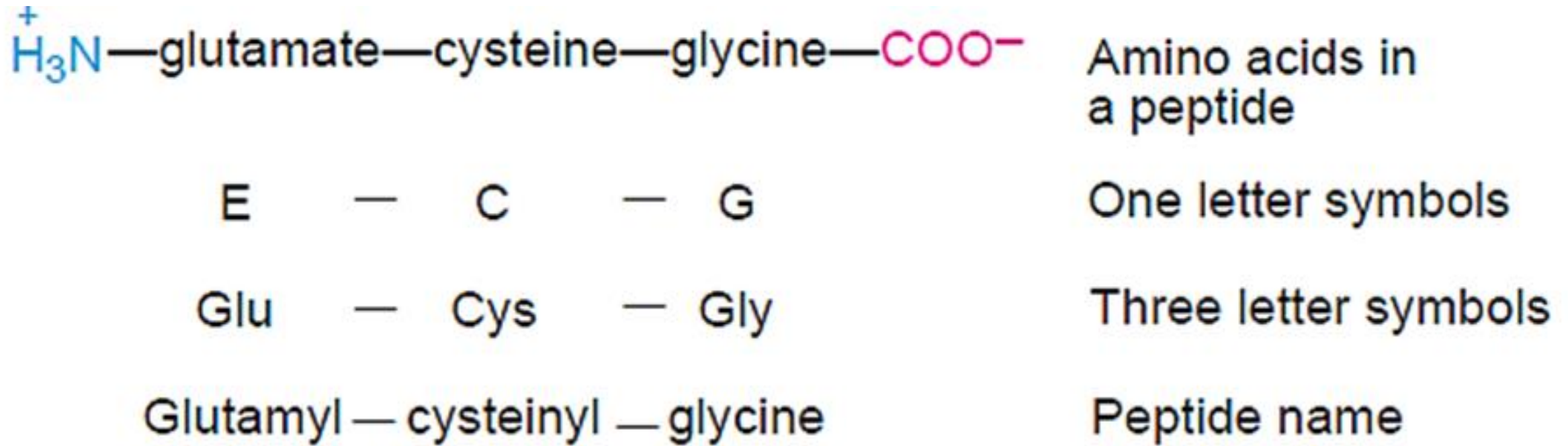
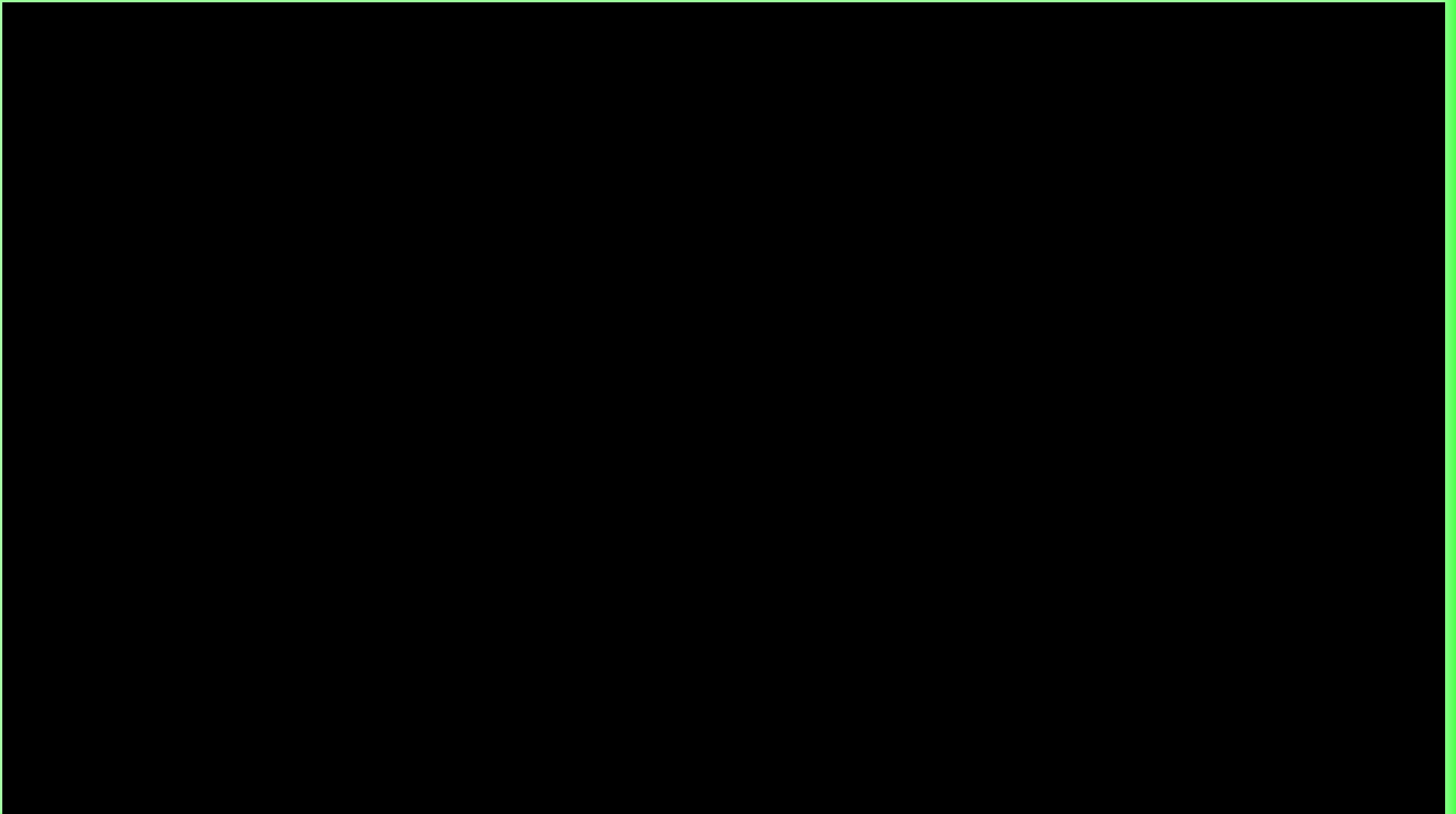


Fig. 4.6 : Use of symbols in representing a peptide
(Note : A tripeptide with 3 amino acids and two peptide bonds is shown; Free —NH_3^+ is on the left while free —COO^- is on the right).

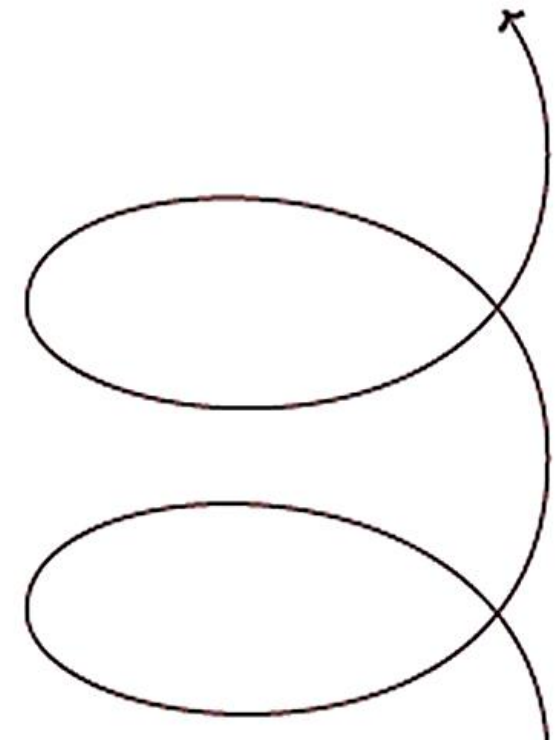
Secondary Structure of Protein: The conformation of polypeptide chain by twisting or folding is referred to as secondary structure. The amino acids are located close to each other in their sequence.

Two types of secondary structures, α -helix and α -sheet, are mainly identified. Indian scientist Ramachandran made a significant contribution in understanding the spatial arrangement of polypeptide chains.

α -Helix: α -Helix is the most common spiral structure of protein. It has a rigid arrangement of polypeptide chain. α -Helical structure was proposed by Pauling and Corey (1951) which is regarded as one of the milestones in biochemistry research. The salient features of α -helix (Fig. 9) are given below:



1. The α -helix is a tightly packed coiled structure with amino acid side chains extending outward from the central axis.
2. The α -helix is stabilized by extensive hydrogen bonding. It is formed between H atom attached to peptide N, and O atom attached to peptide C. The hydrogen bonds are individually weak but collectively, they are strong enough to stabilize the helix.
3. All the peptide bonds, except the first and last in a polypeptide chain, participate in hydrogen bonding.
4. Each turn of α -helix contains 3.6 amino acids and travels a distance of 0.54 nm. The spacing of each amino acid is 0.15 nm.



5. α -Helix is a stable conformation formed spontaneously with the lowest energy.

6. The right handed α -helix is more stable than left handed helix.

7. Certain amino acids (particularly proline) disrupt the α -helix. Large number of acidic (Asp, Glu) or basic (Lys, Arg, His) amino acids also interfere with α -helix structure.

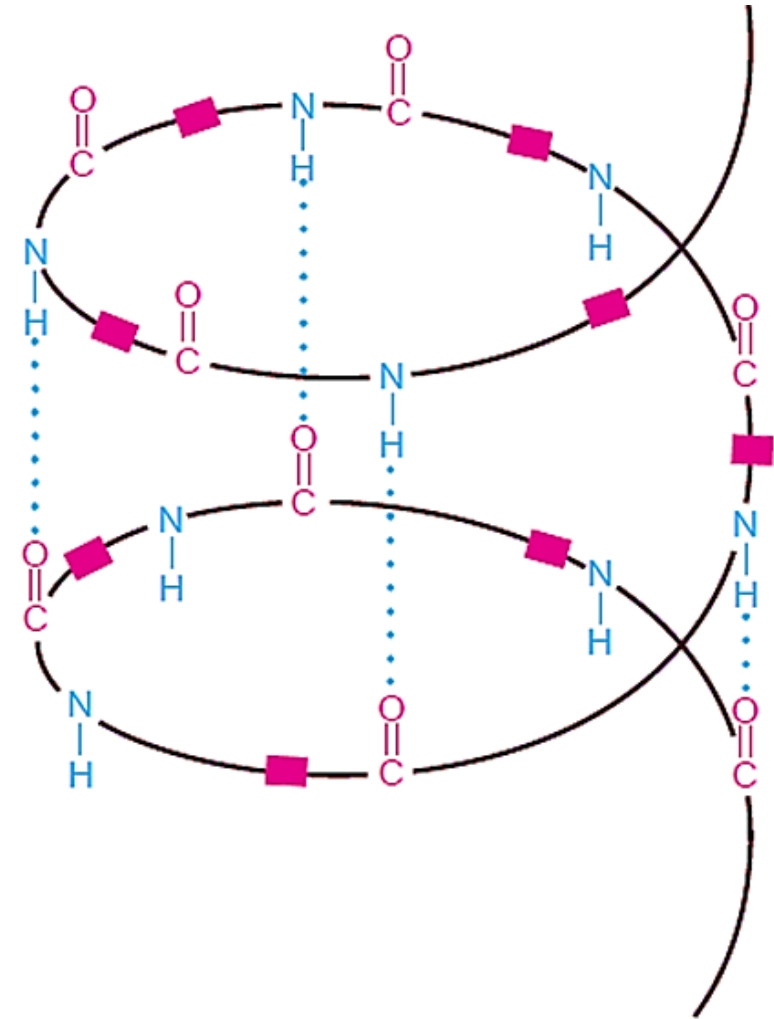


Fig. 4.9 : Diagrammatic representation of secondary structure of protein—a right handed α -helix

(■ -Indicate $\begin{array}{c} \text{H} \\ | \\ -\text{C}-\text{R} \end{array}$ groups of amino acids;
dotted blue lines are hydrogen bonds;

β -Pleated sheet: This is the second type of structure (hence β after α) proposed by Pauling and Corey. β -Pleated sheets (or simply β -sheets) are composed of two or more segments of fully extended peptide chains (Fig. 10).

In the β -sheets, the hydrogen bonds are formed between the neighboring segments of polypeptide chain(s).

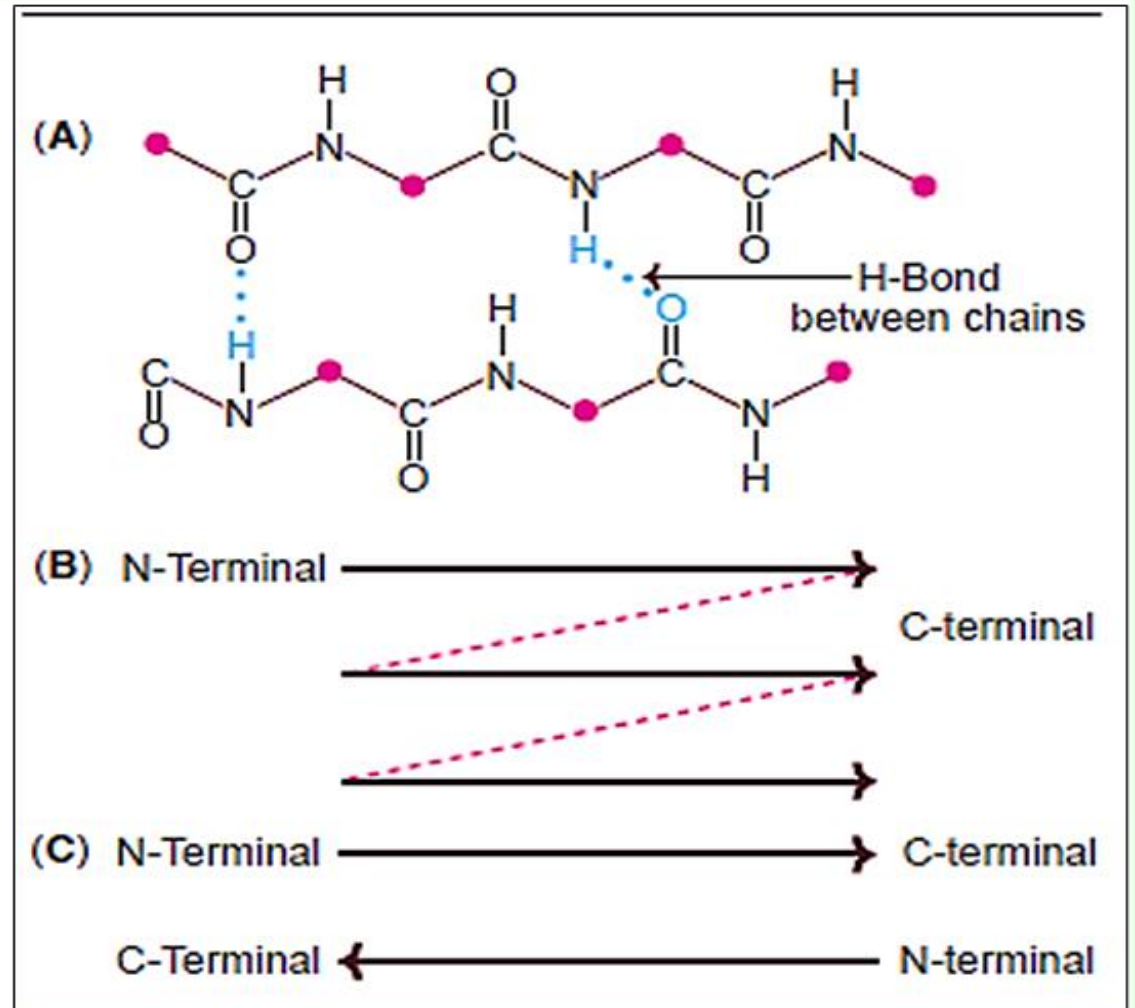
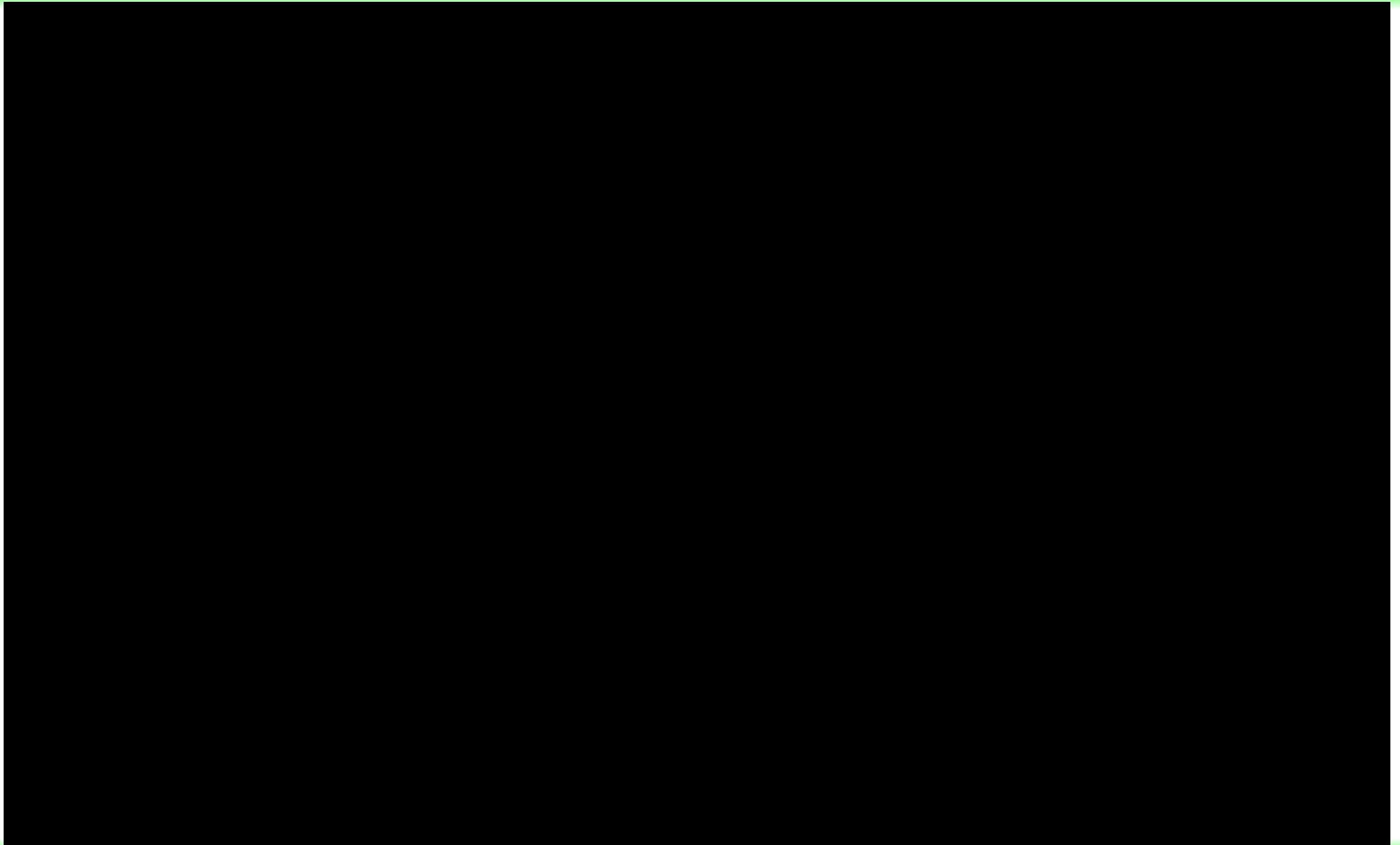


Fig. 4.10 : Structure of β -pleated sheet (A) Hydrogen bonds between polypeptide chains (B) Parallel β -sheet (C) Antiparallel β -sheet. (Note : Red circles in A

represent amino acid skeleton— $\begin{array}{c} \text{H} \\ | \\ \text{C} \\ | \\ \text{R} \end{array}$ —).



Parallel and anti-parallel β -sheets: The polypeptide chains in the β -sheets may be arranged either in parallel (the same direction) or anti-parallel (opposite direction). This is illustrated in (Fig. 10.)

β -Pleated sheet may be formed either by separate polypeptide chains (H-bonds are interchain) or a single polypeptide chain folding back on to itself (H-bonds are intrachain).

Occurrence of β -sheets : Many proteins contain β -pleated sheets. As such, the α -helix and β -sheet are commonly found in the same protein structure (Fig. 11). In the globular proteins, β -sheets form the core structure.

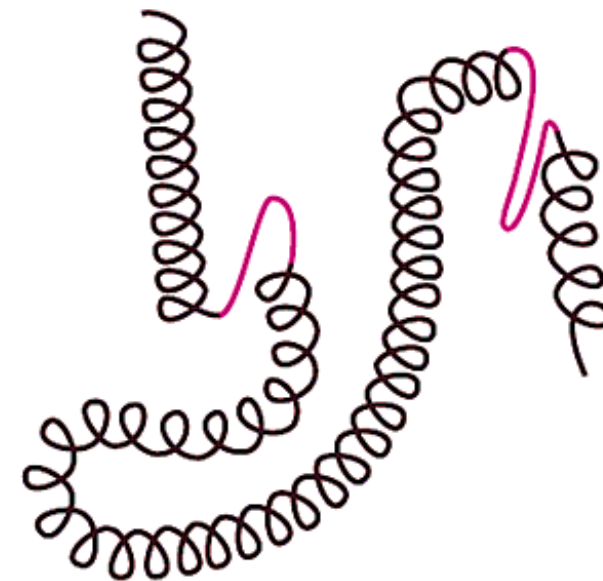


Fig. 4.11 : Diagrammatic representation of a protein containing α -helix and β -pleated sheet (blue).

function of protein

Proteins serve many functions in cells. They act as enzymes that catalyze chemical reactions, provide structural support, regulate the passage of substances across the cell membrane, protect against disease, and coordinate cell signaling pathways.

You need protein in your diet to help your body repair cells and make new ones. Protein is also important for growth and development in children, teens, and pregnant women.

Repair and Maintenance. Protein is termed the building block of the body.

Energy. Protein is a major source of energy.

Hormones. Protein is involved in the creation of some hormones.

Enzymes. Transportation and Storage of Molecules. Antibodies.





For your listening..



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