5th Sem Major

Classification & Biological Significance of Proteins

BY-

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Definition

Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acid residues. Proteins perform a vast array of functions within organisms, including catalyzing metabolic reactions, DNA replication, responding to stimuli, providing structure to cells, and organisms, and transporting molecules from one location to another. Proteins differ from one another primarily in their sequence of amino acids, which is dictated by the nucleotide sequence of their genes, and which usually results in protein folding into a specific 3D structure that determines its activity.

A linear chain of amino acid residues is called a polypeptide. A protein contains at least one long polypeptide. Short polypeptides, containing less than 20–30 residues, are rarely considered to be proteins and are commonly called peptides, or sometimes oligopeptides. The individual amino acid residues are bonded together by peptide bonds and adjacent amino acid residues. The sequence of amino acid residues in a protein is defined by the sequence of a gene, which is encoded in the genetic code. In general, the genetic code specifies 20 standard amino acids; but in certain organisms the genetic code can include selenocysteine and—in certain archaea— pyrrolysine.

Biochemistry

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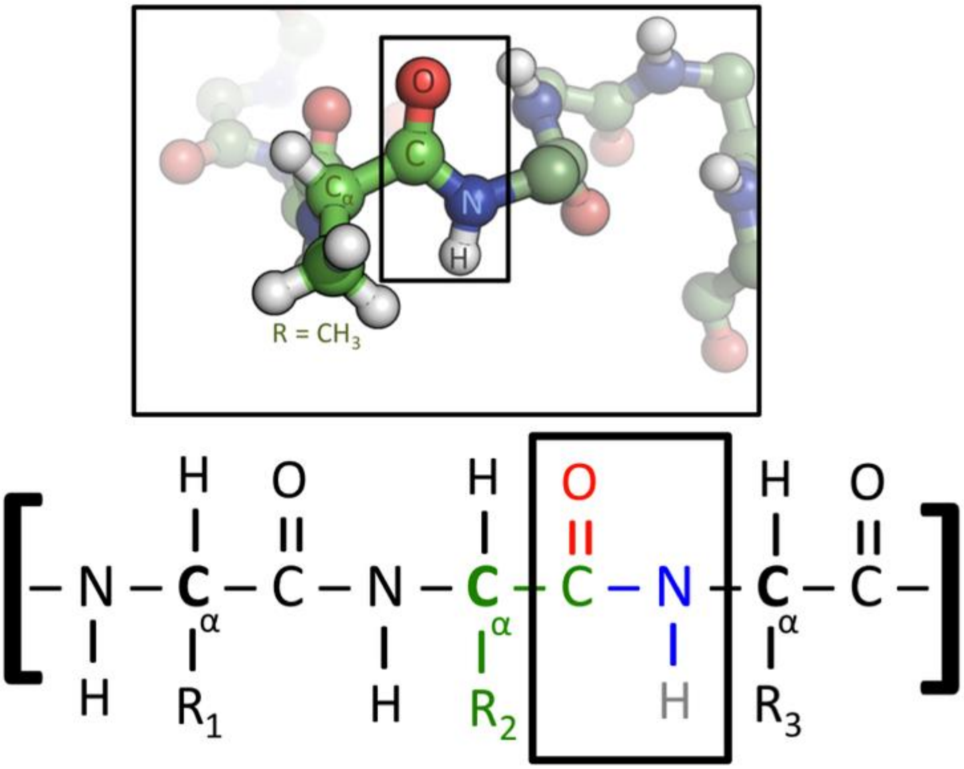
The side chains of the standard amino acids, detailed in the list of standard amino acids, have a great variety of chemical structures and properties; it is the combined effect of all of the amino acid side chains in a protein that ultimately determines its three-dimensional structure and its chemical reactivity.[24] The amino acids in a polypeptide chain are linked by peptide bonds. Once linked in the protein chain, an individual amino acid is called a residue, and the linked series of carbon, nitrogen, and oxygen atoms are known as the main chain or protein backbone.



Chemical structure of the peptide bond (bottom) and the three-dimensional structure of a peptide bond between an alanine and an adjacent amino acid (top/inset). The bond itself is made of the CHON elements.

Classification of Proteins

Proteins are classified on following three categories

Based on structure

Based on composition

Based on function

ON STRUCTURE

1. Fiborous

2.Globular

3Intermediate

ON COMPOSITION

1,Simple

2.Conjugated

ON FUNCTION

1.Structural

ON STRUCTURE

1. Fiborous

- They are linear (long fibrous) in shape.
- Secondary structure is the most important functional structure of fibrous proteins.
- Usually, these proteins do not have tertiary structures.
- Physically fibrous proteins are very tough and strong.
- They are insoluble in the water.
- Long parallel polypeptide chains cross linked at regular intervals.
- Fibrous proteins form long fibres or sheaths.
- Functions of fibrous proteins: perform the structural functions in the cells.
- Examples of fibrous proteins: Collagen, Myosin, Silk and Keratin.

B. Globular Proteins

- Globular proteins are spherical or globular in shape.
- The polypeptide chain is tightly folded into spherical shapes.
- Tertiary structure is the most important functional structure in globular proteins.
- Physically they are soft than fibrous proteins.
- They are readily soluble in water.
- Most of the proteins in the cells belong to the category of globular proteins.
- Functions: Form enzymes, antibodies and some hormones.
- Example: Insulin, Haemoglobin, DNA Polymerase and RNA Polymerase

C. Intermediate Proteins

- Their structure is intermediate to linear and globular structures.
- They are short and more or less linear shaped proteins
- Unlike fibrous proteins, they are soluble in water.
- Function: blood clotting proteins
- Example: Fibrinogen

(II). Classification of Proteins based on Composition:

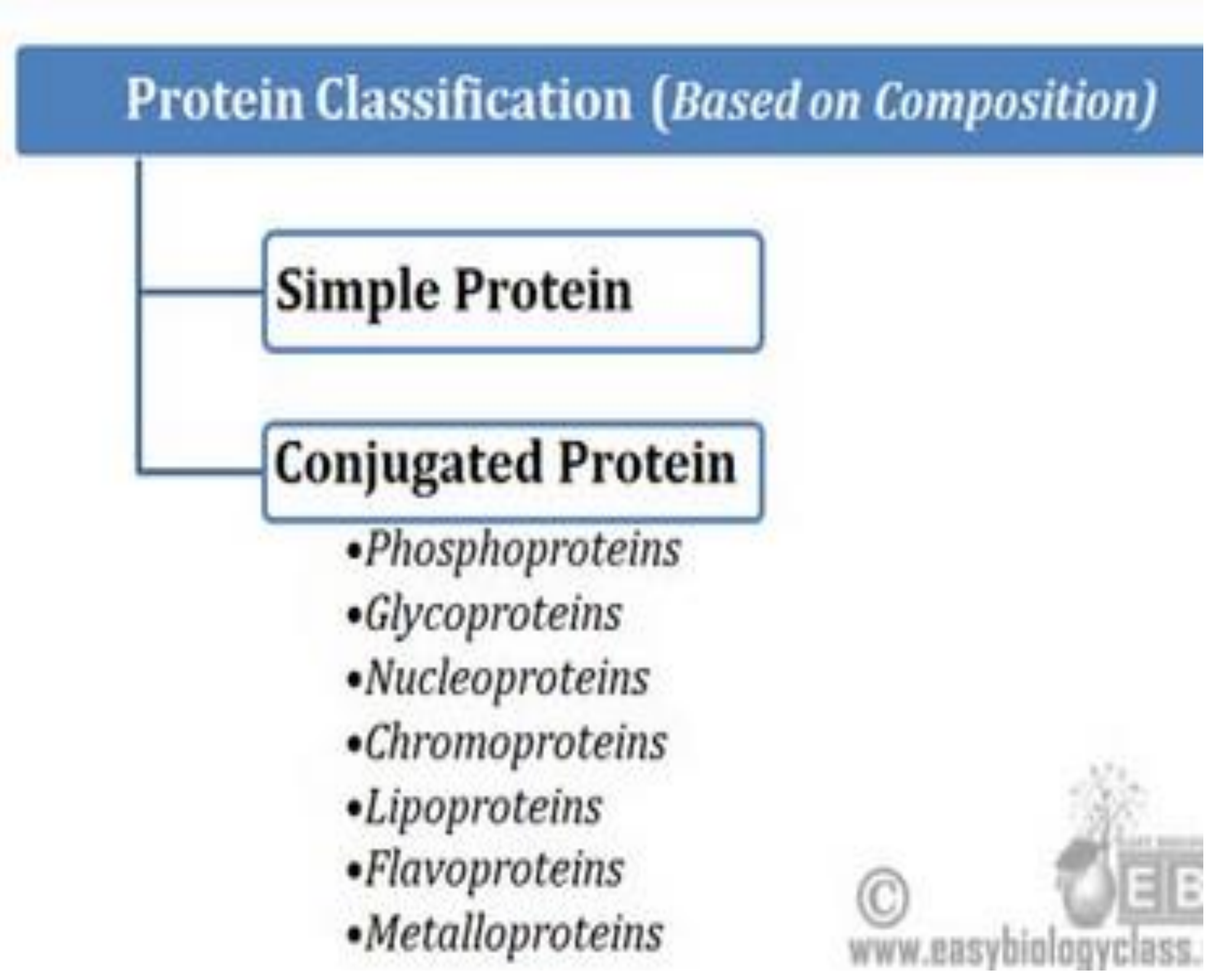
- Two broad categories of proteins according to its composition, they are:
  A. Simple Proteins

(A). Simple Proteins

- Simple proteins composed of ONLY amino acids.
- Proteins may be fibrous or globular.
- They possess relatively simple structural organization.
- Example: Collagen, Myosin, Insulin, Keratin

(B). Conjugated Proteins

- Conjugated proteins are complex proteins.
- They contain one or more non-amino acid components.
- Here the protein part is tightly or loosely bound to one or more non-protein part(s).
- The non-protein parts of these proteins are called prosthetic groups.
- The prosthetic group may be metal ions, carbohydrates, lipids, phosphoric acids, nucleic acids and FAD.


Protein Classification (Based on Composition)
Simple Protein
Conjugated Protein
•Phosphoproteins
•Glycoproteins
•Nucleoproteins
•Chromoproteins
•Lipoproteins
•Flavoproteins
•Metalloproteins
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Ø Based on the nature of prosthetic groups, the conjugated proteins are further classified as follows:

$ **Phosphoprotein:** Prosthetic group is phosphoric acid, Example- Casein of milk, Vitellin of egg yolk.

$ **Glycoproteins:** Prosthetic group is carbohydrates, Example – Most of the membrane proteins, Mucin (component of saliva).

$ **Nucleoprotein:** Prosthetic group is nucleic acid, Example – proteins in chromosomes, structural proteins of ribosome.

$ **Chromoproteins:** Prosthetic group is pigment or chrome, Example: Haemoglobin, Phytochrome and Cytochrome.

$ **Lipoproteins:** Prosthetic group is Lipids, Example: Membrane proteins

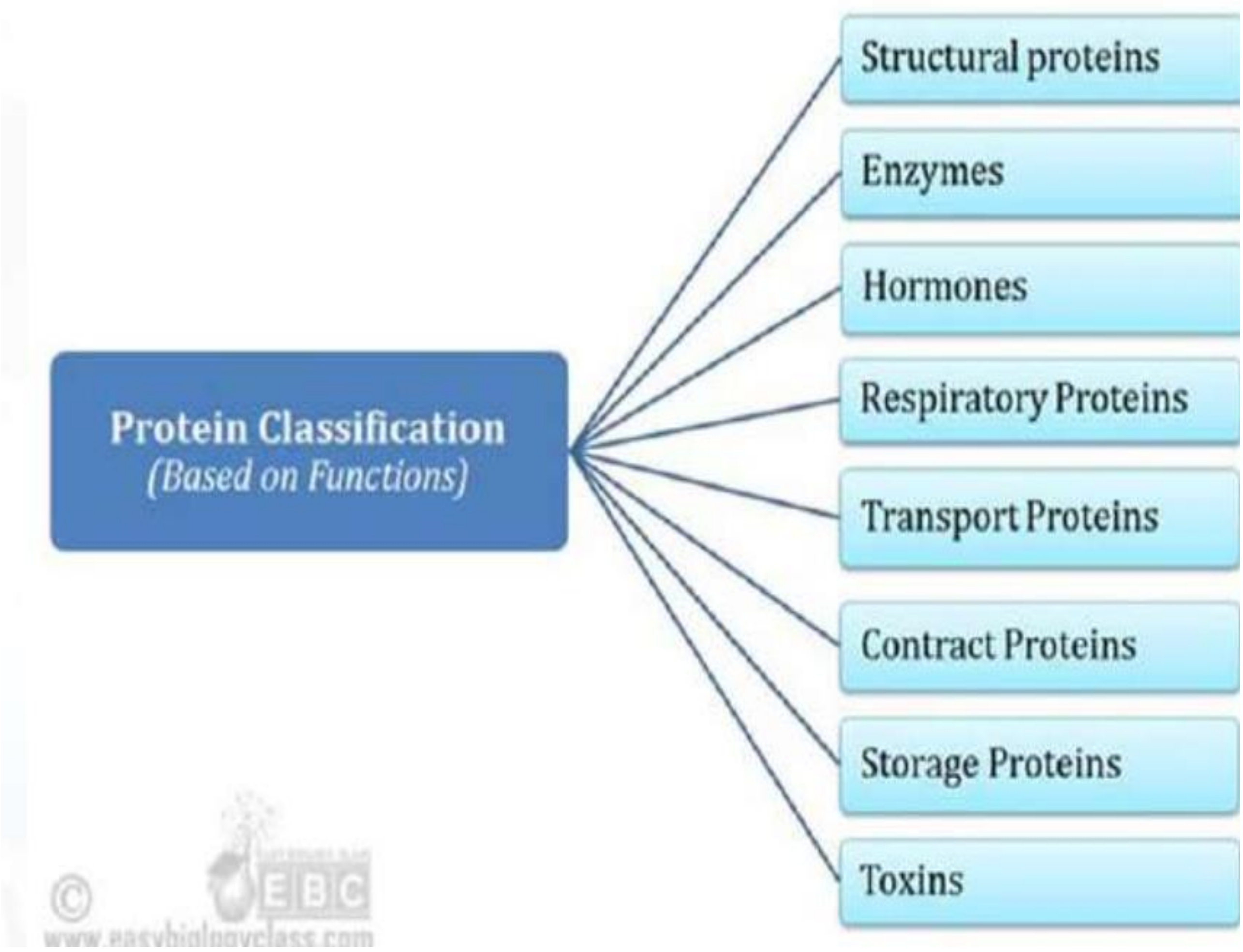
$ **Flavoproteins:** Prosthetic group is FAD (Flavin Adenine Dinucleotide), Example: Proteins of Electron Transport System (ETS).

$ **Metalloproteins:** Prosthetic group is Metal ions, Example: Nitrate Reductase.

3. Classification of Protein based on Functions:

(A). Structural Proteins:

- Form the component of the connective tissue, bone, tendons, cartilage, skin, feathers, nail, hairs and horn.
- Most of them are fibrous proteins and are insoluble in water.
- Example: Collagen, Keratin and Elastin.



- The prosthetic group is essential for the biological functions of these proteins.
- Conjugated proteins are usually globular in shape and are soluble in water.
- Most of the enzymes are conjugated proteins.
- Based on the nature of prosthetic groups, the conjugated proteins are further classified as follows:
  - Phosphoprotein: Prosthetic group is phosphoric acid, Example- Casein of milk, Vitellin of egg yolk.
  - Glycoproteins: Prosthetic group is carbohydrates, Example – Most of the membrane proteins, Mucin (component of saliva).

- Nucleoprotein: Prosthetic group is nucleic acid, Example – proteins in chromosomes, structural proteins of ribosome.
- Chromoproteins: Prosthetic group is pigment or chrome, Example: Haemoglobin, Phytochrome and Cytochrome.
- Lipoproteins: Prosthetic group is Lipids, Example: Membrane proteins
- Flavoproteins: Prosthetic group is FAD (Flavin Adenine Dinucleotide), Example: Proteins of Electron Transport System (ETS).
- Metalloproteins: Prosthetic group is Metal ions, Example: Nitrate Reductase.

(B). Enzymes:

- They are the biological catalysts.
- Enzymes reduce the activation energy of reactants and speed-up the metabolic reactions in the cells.
- Most of them are globular conjugated proteins
- Example: DNA Polymerase, Nitrogenase, Lipase

(c). Hormones:

- They include the proteinaceous hormones in the cells.
- Example: Insulin, Glucagon, ACH

D). Respiratory Pigments

- They are coloured proteins
- All of them are conjugated proteins and they contain pigments (chrome) as their prosthetic group.
- Example: Haemoglobin, Myoglobin

(E). Transport Proteins

- They transport the materials in the cells
- They form channels in the plasma membrane
- They also form one of the components of blood and lymph in animals.
- Example: Serum albumin

(F). Contractile proteins

- They are the force generators of muscles
- They can contract with the expense of energy from ATP molecules.
- Example: Actin, Myosin

(G). Storage Proteins

- They act as the store of metal ions and amino acids in the cells.
- Found in seeds, egg and milk
- Abundantly seen in pulses (legume seeds).
- Example: Ferritin which stores iron, Casein, Ovalbumin, Gluten of Wheat

(F). Toxins

- They are toxic proteins
- Example: Snake venom

2. Enzyme

3. Hormone

4.Respiratory

5.Transport

6,Toxin

7.contract

8. Storage

Proteins- Properties, Structure, Classification and Functions

Proteins are the most abundant biological macromolecules, occurring in all cells.

It is also the most versatile organic molecule of the living systems and occur in great variety; thousands of different kinds, ranging in size from relatively small peptides to large polymers.

Proteins are the polymers of amino acids covalently linked by the peptide bonds.

The building blocks of proteins are the twenty naturally occurring amino acids.

Thus, proteins are the polymers of amino acids.

Proteins

$$\text{Proteins} \xrightarrow{\text{hydrolysis}} \text{Peptides} \xrightarrow{\text{hydrolysis}} \text{Amino acids}$$

Properties of Proteins
Solubility in Water

The relationship of proteins with water is complex.

The secondary structure of proteins depends largely on the interaction of peptide bonds with water through hydrogen bonds.

Hydrogen bonds are also formed between protein (alpha and beta structures) and water. The protein-rich static ball is more soluble than the helical structures.

At the tertiary structure, water causes the orientation of the chains and hydrophilic radicals to the outside of the molecule, while the hydrophobic chains and radicals tend to react with each other within the molecule (hydrophobic effect).

Denaturation and Renaturation

Proteins can be denatured by agents such as heat and urea that cause unfolding of polypeptide chains without causing hydrolysis of peptide bonds.

The denaturing agents destroy secondary and tertiary structures, without affecting the primary structure.

If a denatured protein returns to its native state after the denaturing agent is removed, the process is called renaturation.

Some of the denaturing agents include

Physical agents: Heat, radiation, pH

Chemical agents: Urea solution which forms new hydrogen bonds in the protein, organic solvents, detergents.

Coagulation

When proteins are denatured by heat, they form insoluble aggregates known as coagulum. All the proteins are not heat coagulable, only a few like the albumins, globulins are heat coagulable.

Isoelectric point

The isoelectric point (pI) is the pH at which the number of positive charges equals the number of negative charges, and the overall charge on the amino acid is zero.

At this point, when subjected to an electric field the proteins do not move either towards anode or cathode, hence this property is used to isolate proteins.

Molecular Weights of Proteins

The average molecular weight of an amino acid is taken to be 110.

The total number of amino acids in a protein multiplied by 110 gives the approximate molecular weight of that protein.

Different proteins have different amino acid composition and hence their molecular weights differ.

The molecular weights of proteins range from 5000 to 109 Daltons.

Posttranslational modifications

It occurs after the protein has been synthesized on the ribosome.

Phosphorylation, glycosylation, ADP ribosylation, methylation, hydroxylation, and acetylation affect the charge and the interactions between amino acid residues, altering the three-dimensional configuration and, thus, the function of the protein.

Chemical Properties

1. Biuret test:

When 2 ml of test solution is added to an equal volume of 10% NaOH and one drop of 10% CuSO4 solution, a violet colour formation indicates the presence of peptide linkage.

2. Ninhydrin test:

When 1 ml of Ninhydrin solution is added to 1 ml protein solution and heated, formation of a violet colour indicates the presence of α-amino acids.

Protein Structure- Primary, Secondary, Tertiary and Quaternary

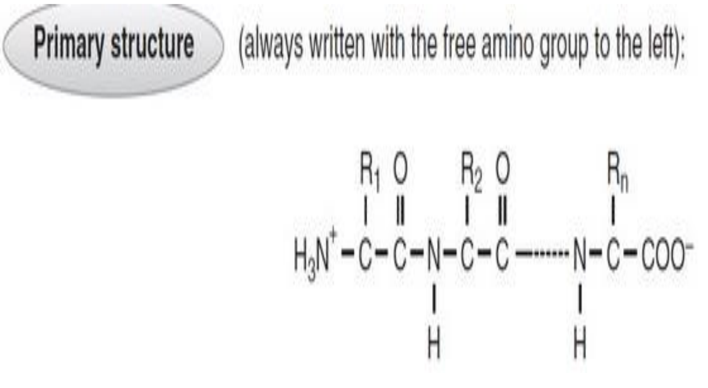
A. PRIMARY STRUCTURE

PRIMARY STRUCTURE refers to the order of the amino acids in the peptide chain.

1. The free α-amino group, written to the left, is called the amino-terminal or N-terminal end.

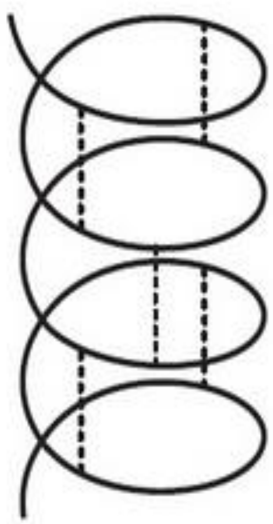
2. The free α-carboxyl group, written to the right, is called the carboxyl-terminal or C-terminal end.

Primary Structure of Protein

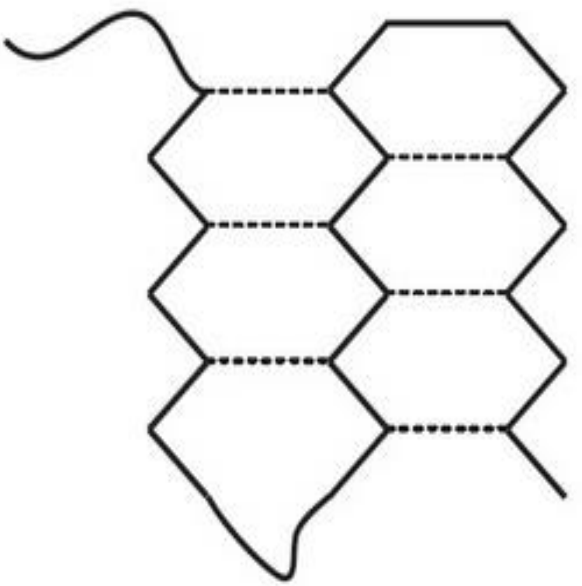


B. SECONDARY STRUCTURE

SECONDARY STRUCTURE is the arrangement of hydrogen bonds between the peptide nitrogens and the peptide carbonyl oxygens of different amino acid residues.



α-Helix
(intramolecular hydrogen bonds)



β-Pleated sheet
(intramolecular hydrogen bonds)

1. In helical coils, the hydrogen-bonded nitrogens and oxygens are on nearby amino
acid residues.

a. The most common helical coil is a right-handed α-helix.
b. α-keratin from hair and nails is an α-helical protein.
c. Myoglobin has several α-helical regions.
d. Proline, glycine, and asparagine are seldom found in α-helices; they are "helix breakers."

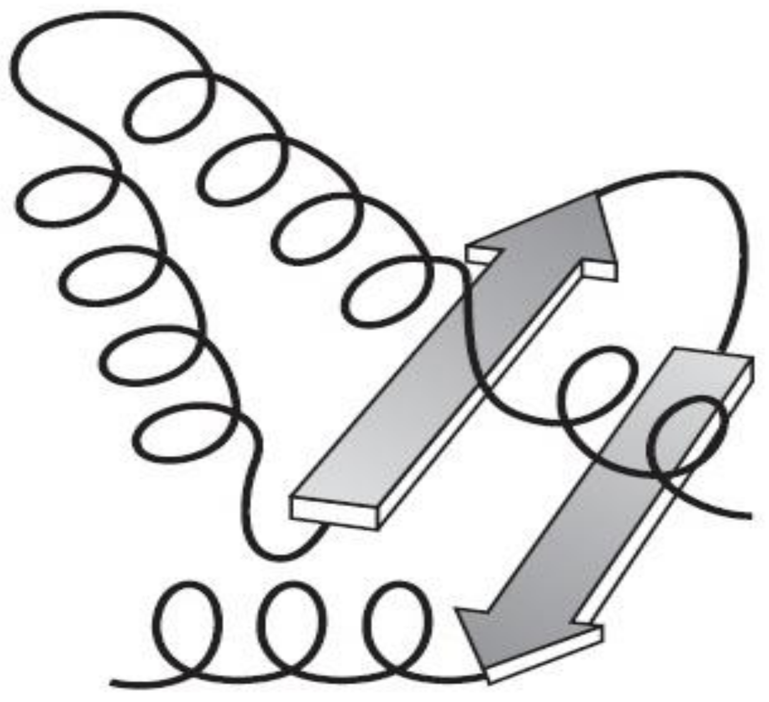
2. In β-sheets (pleated sheets), the hydrogen bonds occur between residues on neighboring peptide chains.

a. The hydrogen bonds may be on different chains or distant regions of the same chain.
b. The strands may run parallel or antiparallel.
c. Fibroin in silk is a β-sheet protein.

C. TERTIARY STRUCTURE

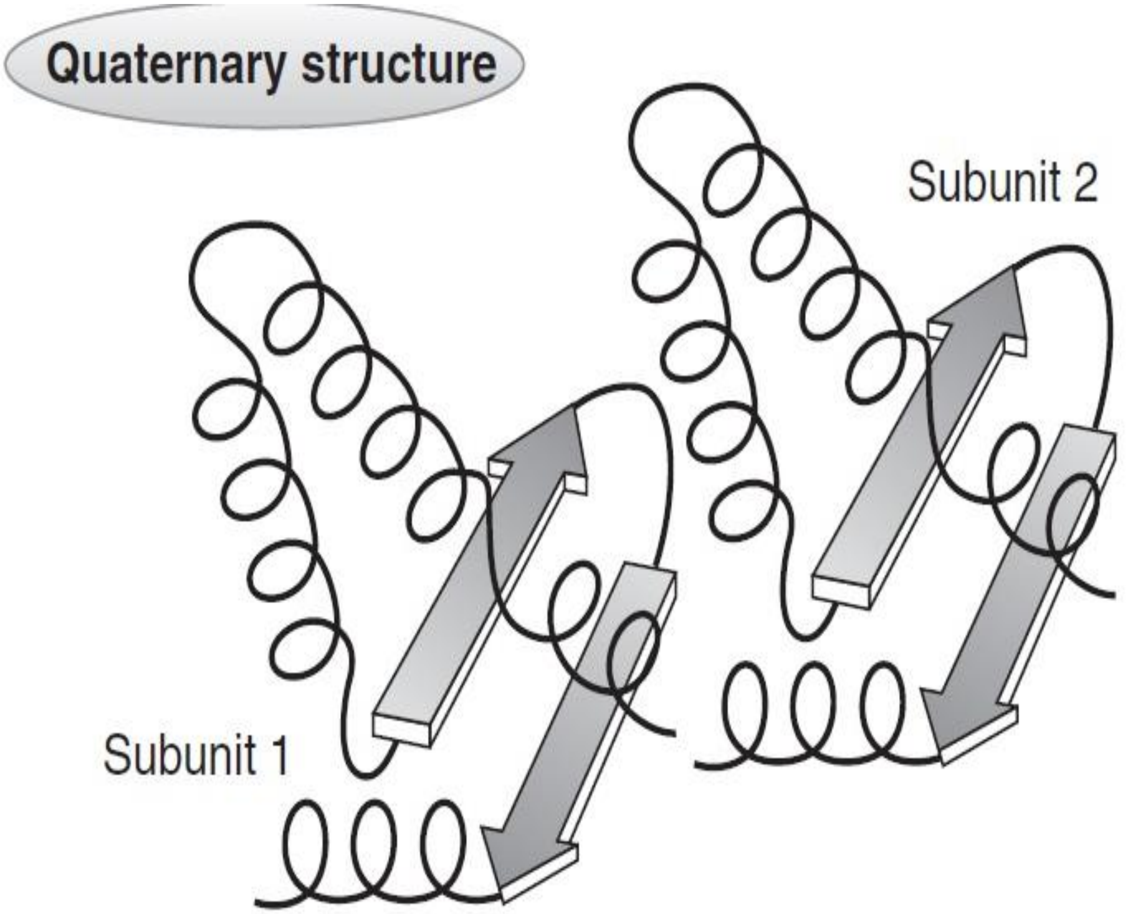
TERTIARY STRUCTURE refers to the three-dimensional arrangement of a polypeptide chain that has assumed its secondary structure. Disulfide bonds between cysteine residues may stabilize tertiary

structure.



D. QUATERNARY STRUCTURE

QUATERNARY STRUCTURE is the arrangement of the subunits of a protein that has more than one polypeptide chain.



E. LEFT-HANDED HELICAL STRANDS

LEFT-HANDED HELICAL STRANDS are wound into a supercoiled triple helix in collagen. The major structural protein in the body, collagen makes up 25% of all vertebrate protein.

a. The primary structure of collagen includes long stretches of the repeating sequence glycine-X-Y, where X and Y are frequently proline or lysine. The high proportion of proline residues leads to formation of the left-handed helical strands.

b. Only glycine has an R-group small enough to fit into the interior of the righthanded triple helix.

c. Collagen also contains hydroxyproline and hydroxylysine. The hydroxyl groups are added to proline and lysine residues by post-translational modification.