Proteins

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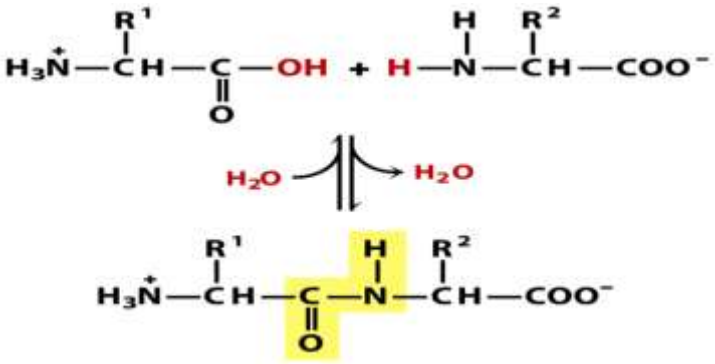
Proteins are complex, high-molecular-weight organic compounds that consist of amino acids linked by peptide bonds. The peptide bond is formed between the carboxyl group of one amino acid and the amino group of adjacent amino acid. Proteins are the most abundant biomolecules in cells, Major constituent of most cells (>50% dry weight).



Two amino acid molecules can be joined termed a dipeptide bond; three amino acids can be joined by two peptide bonds to form a tripeptide. Similarly, amino acids can be linked to form tetrapeptides and pentapeptides. When a few amino acids are joined, the structure is called an oligopeptide. When many amino acids are joined, the product is called a polypeptide. Protein and polypeptide may have thousands of amino acid residues.

Biological importance of proteins:

1. They serve as structural elements. Collagen is the structural protein in bones and tendons. Keratin is present in hair, skin, nails. Elastin is present in elastic connective tissue.

2. Most interesting importance of proteins is that acting as hormones which regulate the physiological activities such as growth by growth hormone, regulation of metabolism of carbohydrates by insulin etc.
3. Some proteins have a defensive function. Thrombin and fibrin are responsible for blood clotting and prevent loss of blood. Antibodies and immunoglobulins constitute the body's defense mechanism.
4. Transport function is conducted by some proteins. Hemoglobin carries - O2,. Lipo proteins transport lipids.
5. All enzymes are proteins; they catalyze different biochemical reactions in body.
6. Actin and Myosin are contractile proteins in muscle fibers.
7. Ovalbumin of egg white, casein of milk, ferritin storing iron etc. are storage proteins performing the function of storage.

Biological function of differ protein

Biological role	Proteins	Function
1- Structural protein	Collagen , keratins	Bone and hair
2- Storage of proteins	Ferritin	Storage form of iron in liver
3- Buffering proteins	Plasma protein and Hb	Maintains the pH of the body
4- Enzymes	Amylase, pepsin	Help in digestion of food
5- Hormones	Insulin , prolactin	Regulation the metabolism
6- Transport proteins	Hemoglobin	Transport of oxygen
7- Protein receptor	Hormone receptor	Insulin receptor on liver cell
8- Immune proteins	γ- globulin	Act against antigens
9- Contractile proteins	Actin, myosin	Muscle contraction

Classification of proteins

I. Classification of proteins according to composition:-

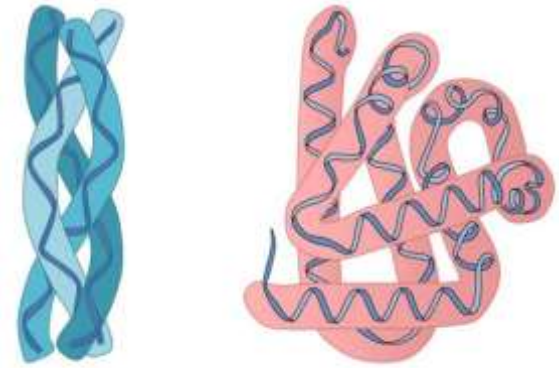
1. Simple proteins:- proteins made up of only amino acids are simple proteins for example:- albumin , and globulin
2. Conjugated (Complex) proteins:- they contain in addition to α-amino acid other materials (non protein part) example:-

Example for conjugated proteins	Non protein part present + protein
1- Hemoglobin (Hb)	Heme + globin
2- Nucleoprotein	DNA + histone
3-Lipoprotein	Lipids + apolipopotein
4- Casein (phosphoprotein)	Phosphate + protein
5- Glycoprotein (egg albumin)	Carbohydrate + protein

3. Derived proteins: - they are derived from simple or complex proteins.
   Example: - gelatin is formed from protein collagen+ peptone.

II. Classification of proteins based on the shape and size

1. Globular proteins: - these are globular or ovoid in shape (the presence of peptide chains folded and coiled) soluble in water and constitute of enzymes, oxygen carrying protein, hormones etc., e.g. hemoglobin, insulin, histone, most of enzymes and albumin.
2. Fibrous proteins: - they are long and fiber like; they are insoluble in water and highly resistant to enzyme digestion. e.g. α-keratin of hair, collagen, actin, myosin, and Intermediate filaments (in muscle cells).



Fibrous Protein Globular Protein

	Fibrous	Globular
Shape	Long and narrow	Round / spherical
Purpose	Structural	Functional
Acid Sequence	Repetitive amino acid sequence	Irregular amino acid sequence
Durability	Less sensitive to changes in pH, temperature, etc.	More sensitive to changes in pH, temperature, etc.
Examples	Collagen, myosin, fibrin, actin, keratin, elastin	Enzymes, haemoglobin, insulin, immunoglobulin
Solubility	(Generally) insoluble in water	(Generally) soluble in water

III. Classification of proteins based on Solubility

a) **Albumins**: These proteins such as egg albumin and serum albumin are readily soluble in water and coagulated by heat.

b) **Globulins**: these proteins are present in serum, muscle and other tissues and are soluble in dilute salt solution but moderately in water.

c) **Histones**: Histones are present in glandular tissues (thymus, pancreas etc.) soluble in water; they combine with nucleic acids in cells and during hydrolysis yield basic amino acids.

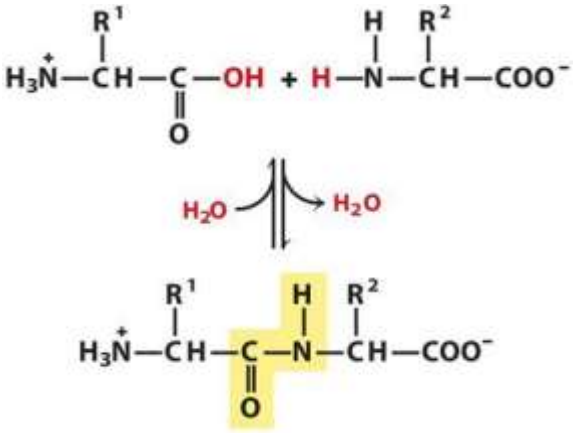
IV. Classification of proteins based on their Biological Functions

Proteins are sometimes described as the "workhorses" of the cell because they do so many things like:

- **Enzymes**: kinases, transaminases etc.
- **Storage proteins**: myoglobin, ferretin
- **Regulatory proteins**: peptide hormones, DNA binding proteins
- **Structural protein**: collagen, proteoglycan
- **Protective proteins** :blood clotting factors, Immunoglobins,
- **Transport protein**: Hemoglobin, plasma lipoproteins
- **Contractile or motile Proteins**: Actin, tubulin

Peptide Bond Formation

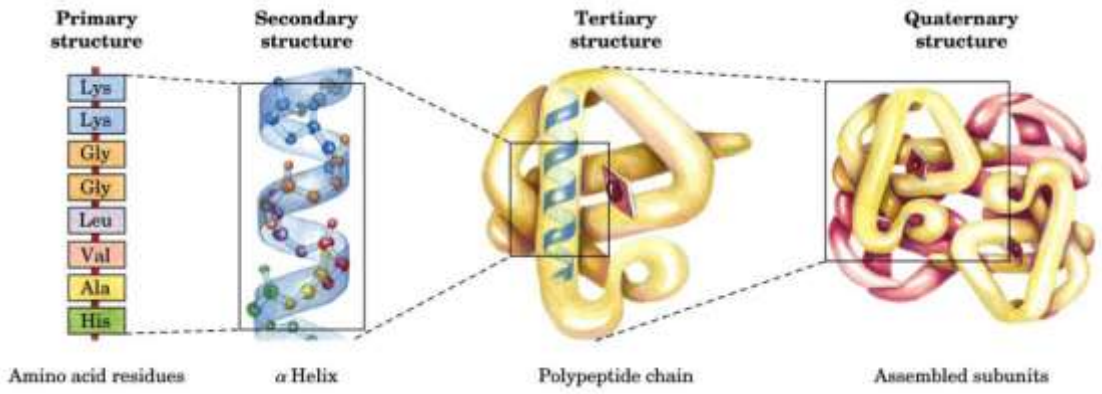
peptide bonds formed by linkage of α - carboxyl group of one amino acid with α- amino groups of the next amino acid by amide bonds. During the formation of a peptide bond, a molecule of water is eliminated



Structure of proteins

Four types of structural proteins:

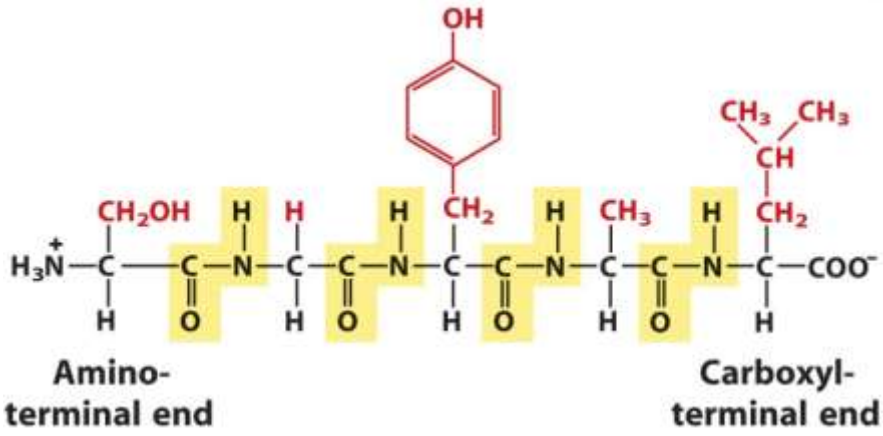
Primary, secondary, tertiary and quaternary

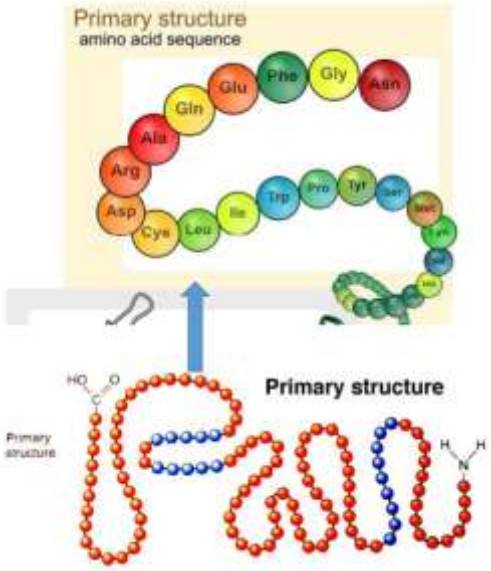


1. Primary structure:

The primary level of structure in a protein is the linear sequence of amino acids as joined together by peptide bonds. The amino acid with free NH_3^+ group is known as amino terminal or (N-terminal) amino acid, and the amino acid with free COO^- group is known as the carboxyl or (C-terminal) amino group. The amino acids in a polypeptide chain are numbered from the N-terminal end.

The amino acid composition of a peptide chain has a profound effect on its physical and chemical properties of proteins. Protein rich in polar amino acids are more water soluble. Proteins rich in aliphatic or aromatic amino groups are relatively insoluble in water.

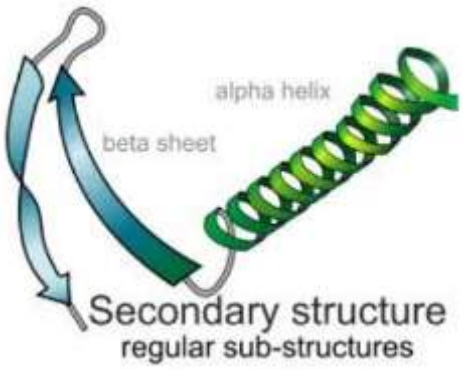




2. Secondary structure:

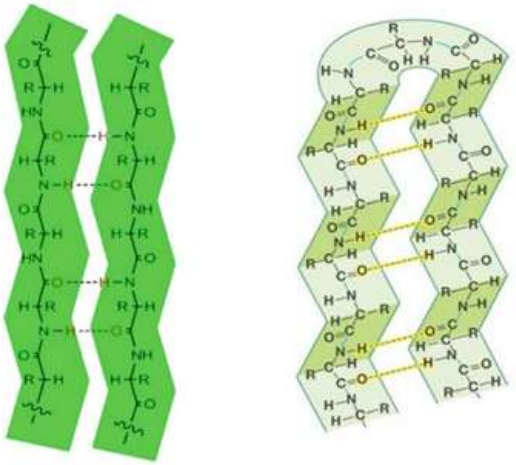
The secondary structure in a protein is the regular folding of polypeptide chain. The two most common types of protein fold are:

- α-helix
- B-sheet(Beta pleated sheet)

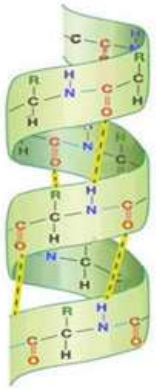


In the α-helix the amino acids arrange themselves in a regular helical conformation. The carbonyl oxygen of each peptide bond is form a hydrogen bond to the hydrogen on the amino group of the fourth amino acid. the hydrogen bonds running nearly parallel to the axis of the helix.

In a **β pleated sheet**, two or more segments of a polypeptide chain line up next to each other, forming a sheet-like structure held together by hydrogen bonds. The hydrogen bonds form between carbonyl and amino groups of backbone.



B-sheet (Beta pleated sheet)



α-helix

3. Tertiary (Ternary) structure:

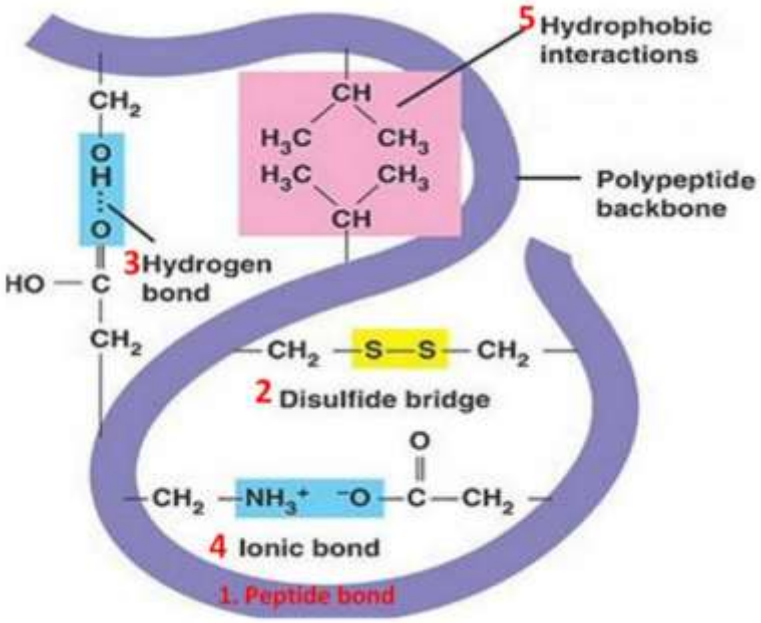
The three dimensional folded and biologically active conformation of a protein is referred to as tertiary structure. The three -dimensional tertiary structure of a protein is stabilized by interactions between side chains groups.

A. The weak interactions include:

- ✓ Hydrogen bonds among polar side chains
- ✓ Ionic bonds between charged R groups (basic and acidic amino acids).
- ✓ Hydrophobic interactions among hydrophobic (non-polar) R groups.

B. Strong covalent bonds include:

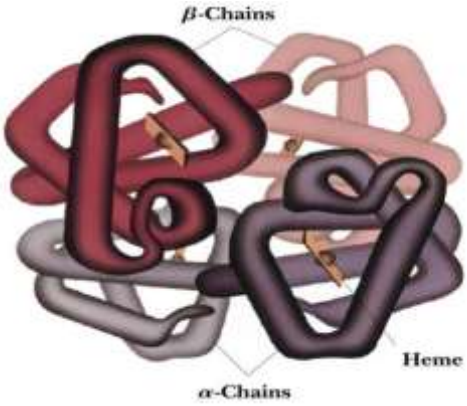
Disulfide bridges that form between the sulfide groups (SH) of cysteine

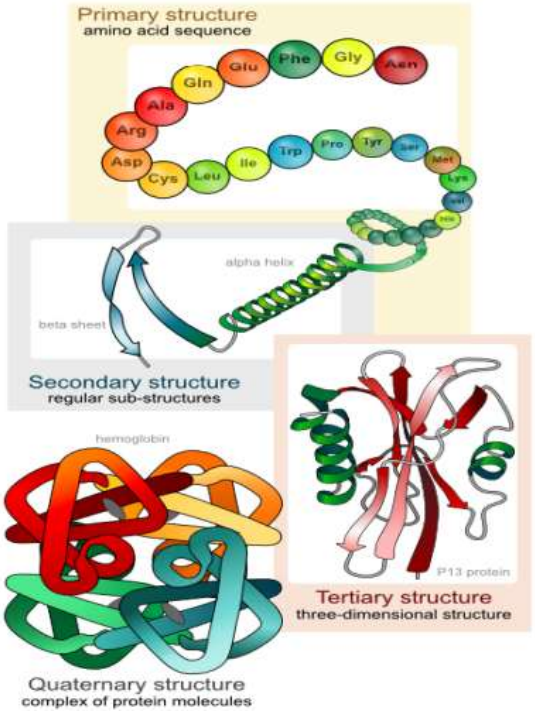


4. Quaternary structure:

Many proteins consist of a single polypeptide chain; these are monomeric proteins. But many others consist of two or more polypeptide chains that may be structurally identical or totally unrelated. The arrangement of these polypeptide subunits is called the quaternary structure of the protein. Quaternary structure refers to a complex or an assembly of two or more separate polypeptide chains that are held together by non- covalent or, in some case, covalent interactions. For instance insulin consists of A and B chain which are different. Hemoglobin has 4 chains, two of them are α and two are β.

The forces that hold the quaternary structure are (hydrogen bond, ionic bridge, van der Waals forces and disulfide bridge).





Denaturation of Proteins

Denaturation involves the destruction of the higher level structural organization (Secondary, Tertiary and Quaternary) of protein with the retention of the primary structure by denaturing agents. A denatured protein loses its native physico-chemical and biological properties since the bonds that stabilize the protein are broken down. Thus, the polypeptide chain unfolds itself and remains in solution in the unfolded state. The denatured protein may retain its biological activity by refolding (renaturing) when the denaturing agent is removed.

Factors that Affect Denaturation

1. **Physical factors:** Temperature, pressure, mechanical shear force, ultrasonic vibration and ionizing radiation causes the protein to lose its biological activity.
2. **Chemical factors:** Acids and alkalis, organic solvents (actone, ethanol), detergents (cleaning agents), certain amides urea, guandidine hydrochloride, alkaloids, and heavy metal salts (Hg, Cu, Ba, Zn, Cd…) Cause the denaturation