Learning Objective :

- ✓ **Understand the general structure of Ouaternary protein and it's function**

❖ Quaternary Structure: Hemoglobin

While many proteins are biologically active as tertiary structures, some proteins require two or more tertiary structures to be biologically active. When a biologically active protein consists of two or more polypeptide chains or subunits, the structural level is referred to as a **quaternary structure**. **Hemoglobin,** a globular protein that transports oxygen in blood, consists of four polypeptide chains: two α-chains with 141 amino acids, and two β-chains with 146 amino acids. Although the α-chains and β-chains have different sequences of amino acids, they both form similar tertiary structures with similar shapes (**see Figure 2.10).**

In the quaternary structure, the subunits are held together by the same interactions that stabilize tertiary structures, such as **hydrogen bonds, salt bridges, disulfide links, and hydrophobic interactions between R groups.** Each subunit of the hemoglobin contains a heme group that binds oxygen. In the adult hemoglobin molecule, all four subunits ($\alpha_2\beta_2$) *must* be combined for hemoglobin to properly function as an oxygen carrier. Therefore, the complete quaternary structure of hemoglobin can bind and transport four molecules of oxygen.

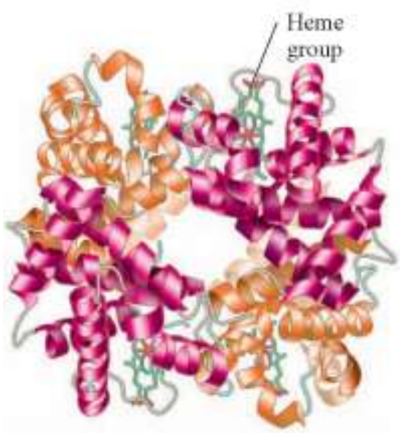


Figure 2.10: In the ribbon model of hemoglobin, the quaternary structure is made up of four polypeptide subunits, two (orange) are α-chains and two (red) are β-chains. The heme groups (green) in the four subunits bind oxygen

Hemoglobin and myoglobin have similar biological functions. Hemoglobin carries oxygen in the blood, whereas myoglobin carries oxygen in muscle. Myoglobin, a single polypeptide chain with a molar mass of 17 000, has about one-fourth the molar mass of hemoglobin 167 0002. The tertiary structure of the single polypeptide myoglobin is almost identical to the tertiary structure of each of the subunits of hemoglobin. Myoglobin carries one molecule of oxygen, whereas hemoglobin carries four oxygen molecules. **Table 2.1 and Figure 2.11** summarize the structural levels of proteins.

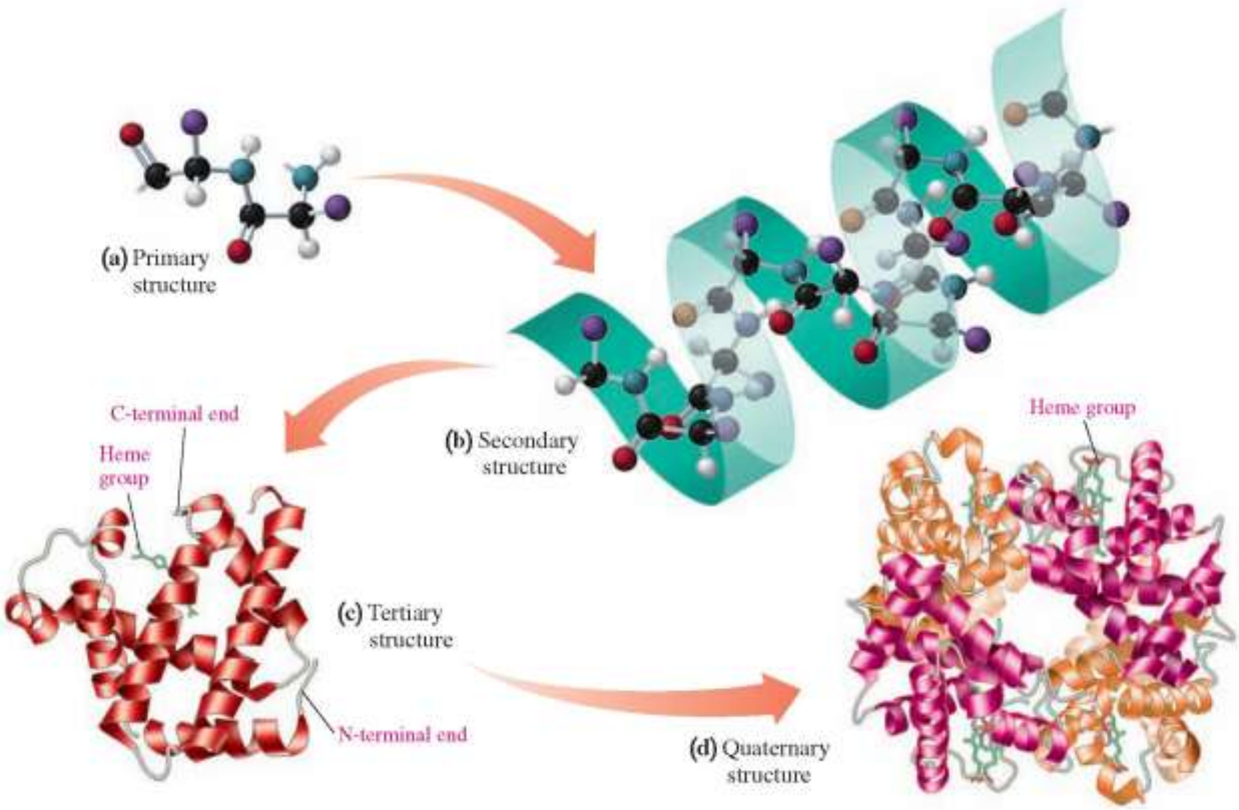


Figure 2.11 : The structural levels of protein are (a) primary, (b) secondary, (c) tertiary, and sometimes (d) quaternary.

Table 2.1 : Summary of Structural Levels in Proteins

Structural Level	Characteristics
Primary	Peptide bonds join amino acids in a specific sequence in a polypeptide.
Secondary	The coiled α helix, β-pleated sheet, or a triple helix forms by hydrogen bonding between peptide bonds along the chain.
Tertiary	A polypeptide folds into a compact, three-dimensional shape stabilized by interactions between R groups of amino acids to form a biologically active protein.
Quaternary	Two or more protein subunits combine to form a biologically active protein.

Question : Identifying Protein Structure: Indicate whether the following conditions are responsible for primary, secondary, tertiary, or quaternary protein structures:

a. disulfide bonds that form between portions of a protein chain

b. peptide bonds that form a chain of amino acids

c. hydrogen bonds between the H of a peptide bond and the O of a peptide bond four amino acids away.

SOLUTION

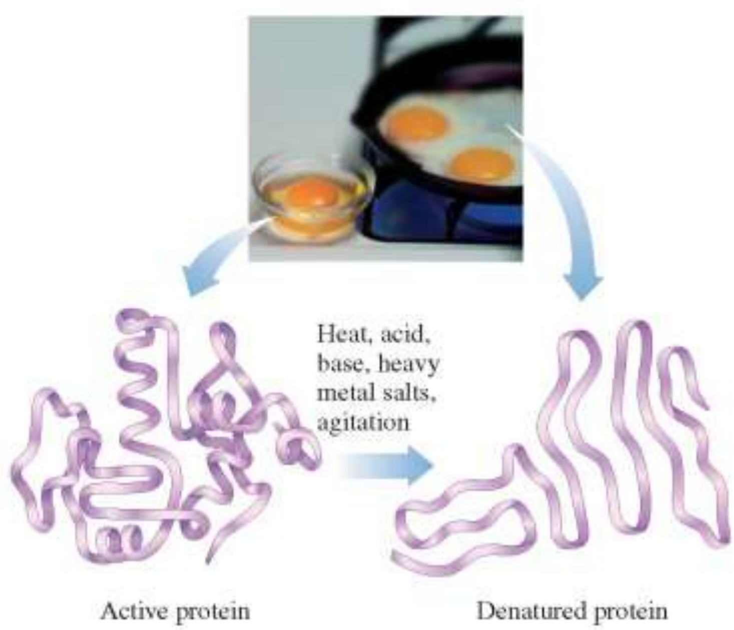
	Structural Level	Characteristics
ANALYZE THE PROBLEM	Identify as: primary, secondary, tertiary, quaternary	Look for: peptide bonds, hydrogen bonds in peptide, R group interactions, two or more subunits

- ✓ a.Disulfide bonds are a type of interaction between R groups found in the tertiary and quaternary levels of protein structure.
- ✓ **b.** The peptide bonds in the sequence of amino acids in a polypeptide form the primary level of protein structure.
- ✓ **c.** Hydrogen bonding between peptide bonds forms the secondary level of protein structure.

Denaturation of Proteins

Denaturation of a protein occurs when there is a change that disrupts the interactions that stabilize the secondary, tertiary, or quaternary structure. However, the covalent amide bonds of the primary structure are not affected. The loss of secondary and tertiary structures occurs when conditions change, such as increasing the temperature or making the pH very acidic or basic. If the pH changes, the basic and acidic R groups lose their ionic charges and cannot form salt bridges, which causes a change in the shape of the protein. Denaturation can also occur by adding certain organic compounds or heavy metal ions or by mechanical agitation **(see Table 2.7).**

When the interactions between the R groups are disrupted, a globular protein unfolds like a loose piece of spaghetti. With the loss of its overall shape (tertiary structure), the protein is no longer biologically active.



Denaturation of egg protein occurs when the bonds of the secondary and tertiary structures are disrupted.

Table 2.2: Protein Denaturation

Denaturing Agent	Bonds Disrupted	Examples
Heat Above 50 °C	Hydrogen bonds; hydrophobic interactions between nonpolar R groups	Cooking food and autoclaving surgical items
Acids and Bases	Hydrogen bonds between polar R groups; salt bridges	Lactic acid from bacteria, which denatures milk protein in the preparation of yogurt and cheese
Organic Compounds	Hydrophobic interactions	Ethanol and isopropyl alcohol, which disinfect wounds and prepare the skin for injections
Heavy Metal Ions Ag^{+}, Pb^{2+}, and Hg^{2+}	Disulfide bonds in proteins by forming ionic bonds	Mercury and lead poisoning
Agitation	Hydrogen bonds and hydrophobic interactions by stretching polypeptide chains and disrupting stabilizing interactions	Whipped cream, meringue made from egg whites

Case Study : Sickle-cell anemia is a disease caused by an abnormality in the shape of one of the subunits of the hemoglobin protein . Try to find out causes of this disease?

Write your Answer in isolated paper and introduce it to ur teacher .