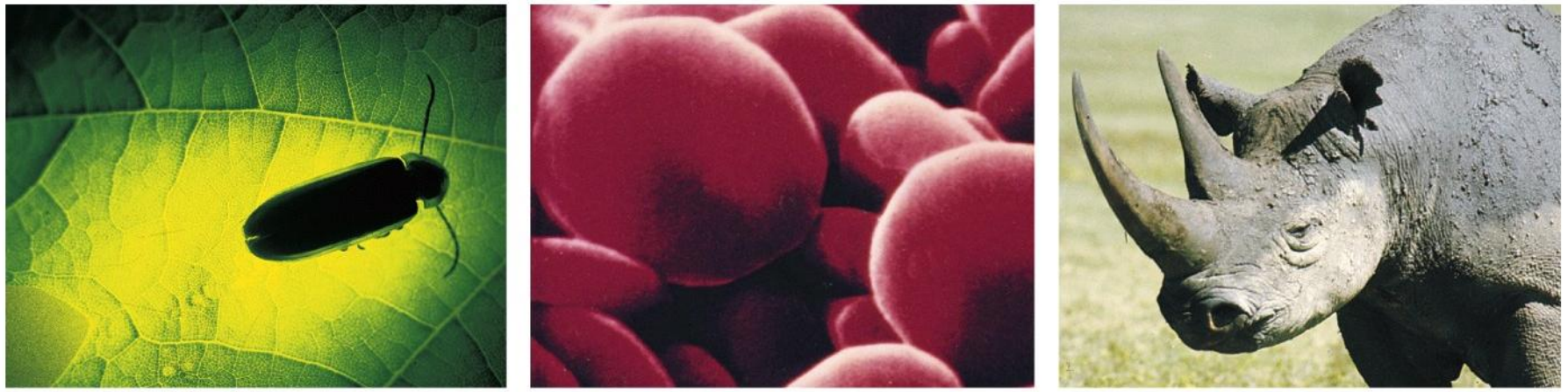
# PROTEINS



(a) (b) (c)

**Figure 3-1**
***Lehninger Principles of Biochemistry, Fifth Edition***


(a) The light produced by fireflies is the result of a reaction involving the protein luciferin and ATP, catalyzed by the enzyme luciferase.
(b) Erythrocytes contain large amounts of the oxygen-transporting protein hemoglobin.
(c) The protein keratin, formed by all vertebrates, is the chief structural component of hair, scales, horn, wool, nails, and feathers. The black rhinoceros is nearing extinction in the wild because of the belief prevalent in some parts of the world that a powder derived from its horn has aphrodisiac properties. In reality, the chemical properties of powdered rhinoceros horn are no different from those of powdered bovine hooves or human fingernails.

# Protein Classification based upon Biological functions

- Enzymes
- Transport Proteins (Hb, lipoproteins)
- Nutrient and Storage Proteins (casein)
- Contractile or Motile Proteins (actin, myosin, tubulin)
- Structural Proteins (keratin, collagen)
- Defense Proteins (immunoglobulins, thrombin, fibrinogen)
- Regulatory Proteins (insulin, glucagon)
- OTHERS

# Protein Classification based upon Physicochemical Properties

## 1. Simple Proteins

Enzymes: ribonuclease, chymotrypsinogen, albumin, globulins

## 2. Compound/Conjugated Proteins-prosthetic group

Glycoprotein, lipoproteins, chromoprotein (Hb), phosphoproteins (casein)

| Class | Prosthetic group | Example |
|---|---|---|
| Lipoproteins | Lipids | lipoprotein of blood |
| Glycoproteins | Carbohydrates | Immunoglobulin G |
| Phosphoproteins | Phosphate group | Casein of milk |
| Hemoproteins | Heme | Hemoglobin |
| Metalloproteins | iron | Ferritin |

# Protein Classification Based upon Molecular length and Shape

**Axial Ratio (AR) : Mol.Length/Mol.Width**

- **Fibrous Proteins**

Long threads; forming cables or filaments or sheets, AR is > 10, Tough, insoluble proteins which are insoluble in water.

**Examples:** Collagen, elastin, keratin

- **Globular Proteins**

Spherical or oval in shape, AR < 10, soluble in water and/or dilute salt solutions.

**Examples:** Albumins, globulins

## Structure of Proteins

- All proteins in all species regardless of their biological activity are built from the same set of 20 amino acids
- Each protein has a distinctive number and specific sequence of amino acid residues
- Amino acids are alphabets of protein structure. They can be arranged in an infinite number of sequences to make an infinite number of different proteins
- A specific sequence of amino acids form a unique 3-D structure & this structure determines function of protein
- Complexity of protein structure is best analyzed by considering the molecule in terms of four organizational levels, namely, primary, secondary, tertiary and quaternary

- Certain structural elements are repeated in a wide variety of proteins, suggesting that there are general "rules" regarding the ways in which proteins fold

- Repeated structural elements: simple combinations of α-helix, β-sheets, motifs

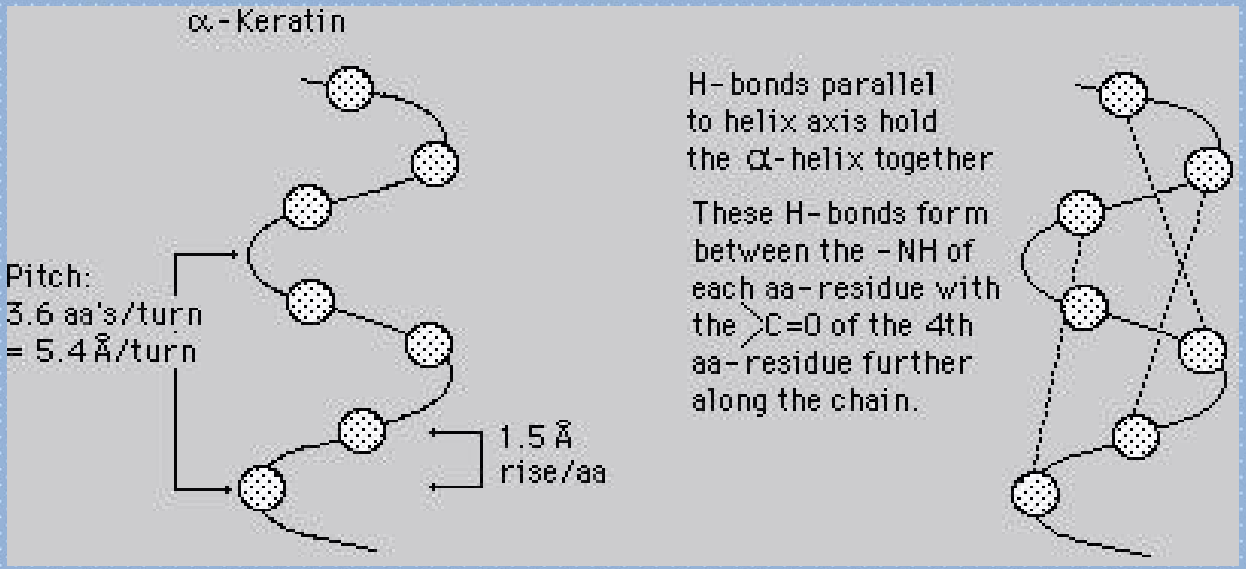
**1. Primary Structure**

Refers to the number & linear sequence of amino acids

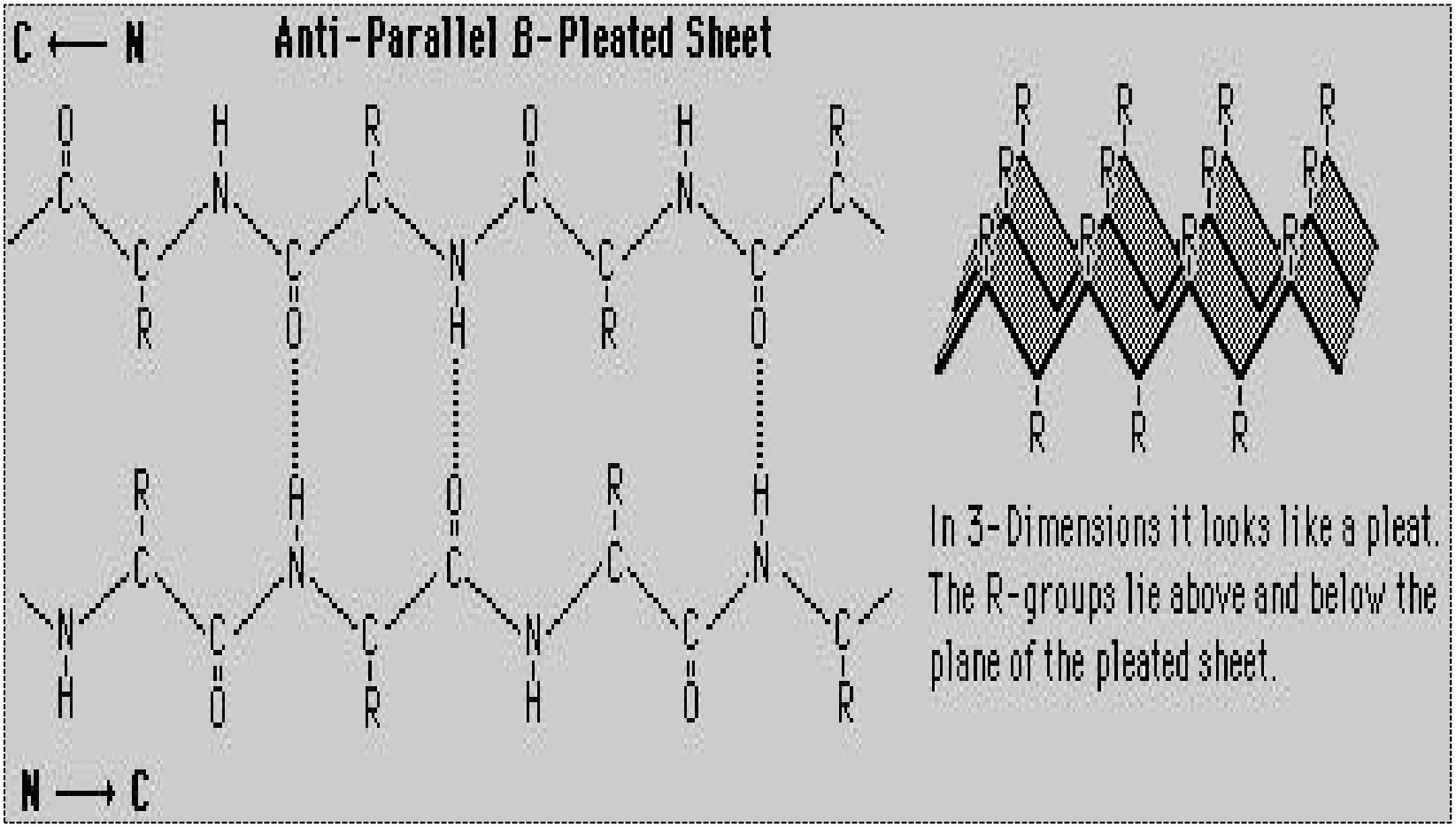
**Lys Gly Gly Leu Val**

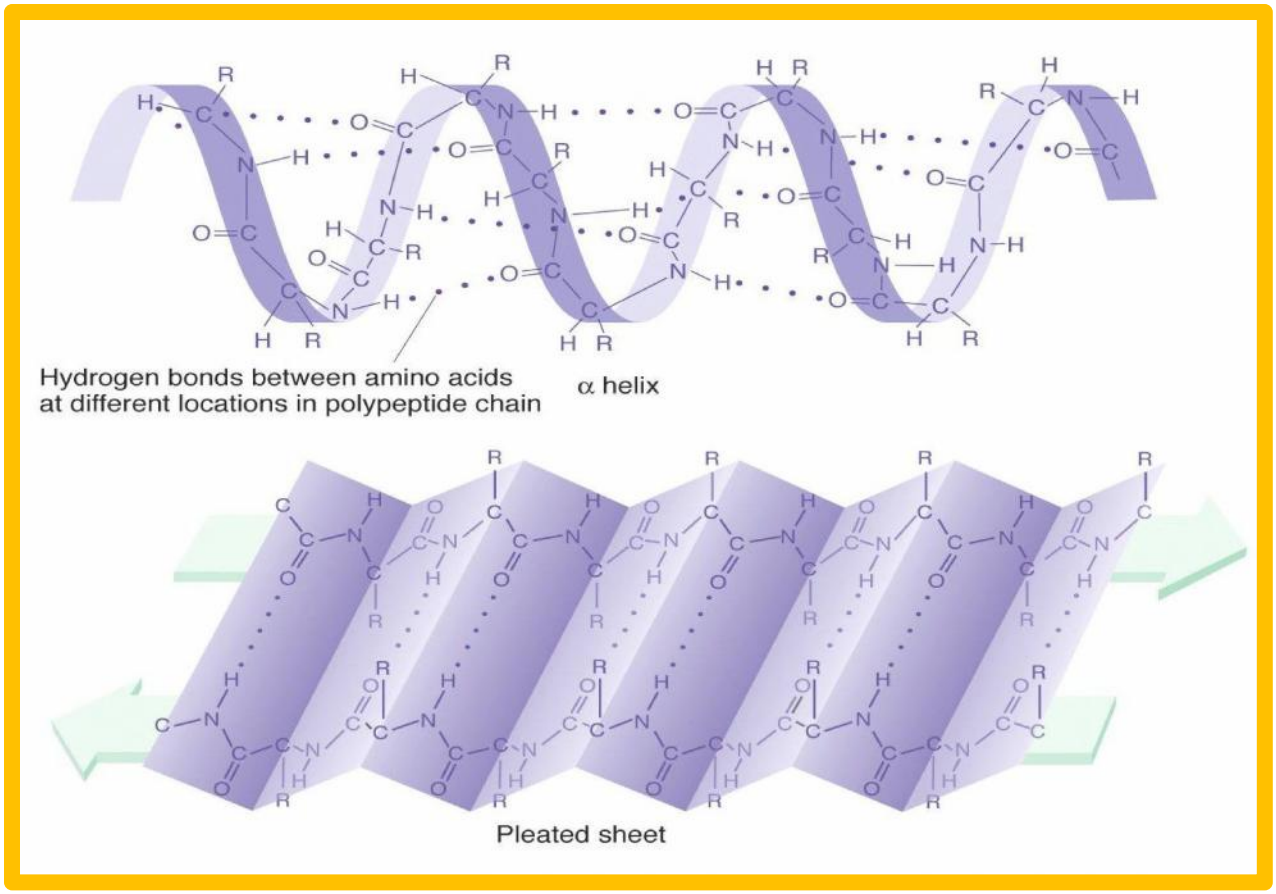
## 2. Secondary Structure

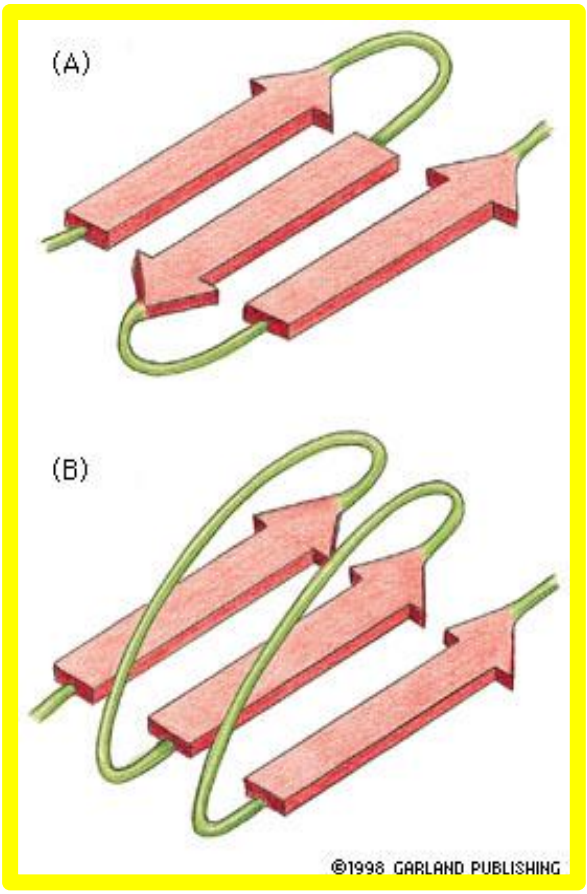
- Folding of polypeptide to form certain specific structure with specific configuration is called secondary structure
- Polypeptide backbone forms regular arrangements of amino acids that are located near to each other in the linear sequence
- α-helix and β-sheet are examples of secondary structure frequently encountered in proteins.



- β-sheet – parallel, antiparallel




Hydrogen bonds between amino acids
at different locations in polypeptide chain
α helix
Pleated sheet


(A)
(B)
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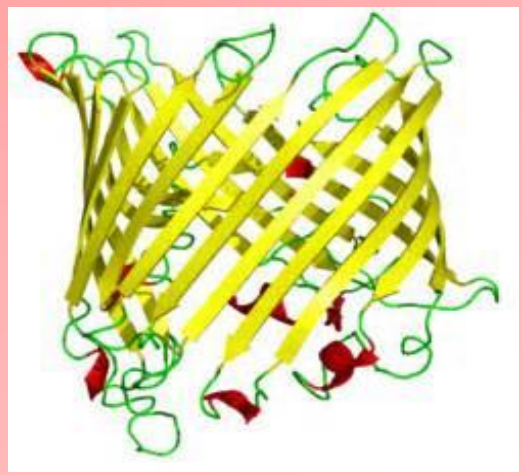
## β-Bends (reverse turns)

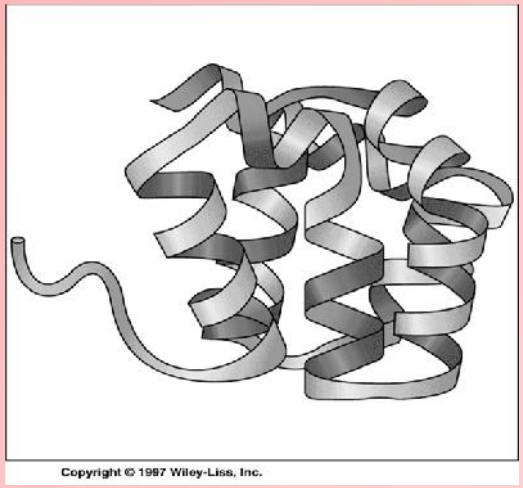
- Reverse the direction of polypeptide chain (helping it to form a compact, globular shape)
- Given this name (i.e. **reverse turns**) because they often connect successive strands of antiparallel β-sheets
- Are generally composed of four amino acids, one of which may be proline – the imino acid that causes a "kink" in the polypeptide chain
- Have H-bonds (Intra- and interchain hydrogen bond)
- Glycine, the amino acid with smallest R group, is also frequently found in β-bends.
- Stabilized by H-bond & ionic bond

## 3. Tertiary Structure

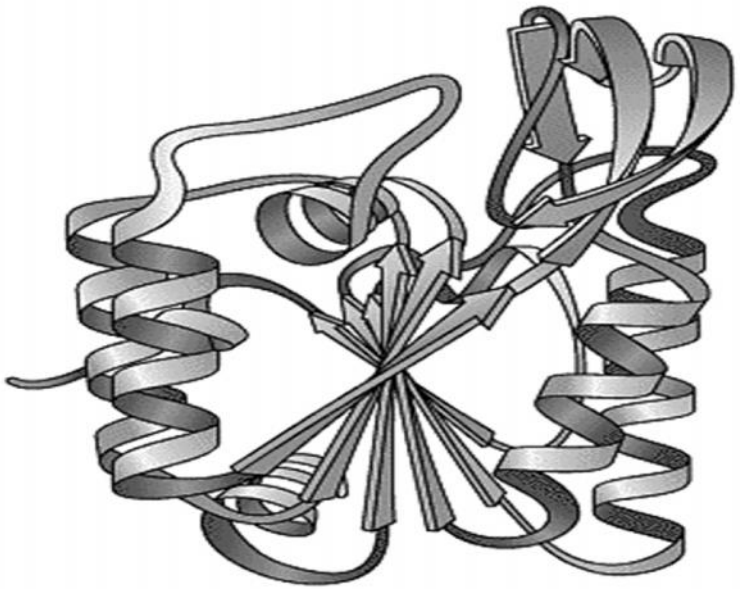
- Spatial relationship among all Amino Acids in a polypeptide, Refers to DOMAINS
- Complete 3-D structure of polypeptide
- Disulfide bond, Hydrophobic interactions

  H-bond, Ionic interactions
- Domains – 3 types: Mostly α-Helix, Mostly β-Sheet, Mixed (α-Helix + β-Sheet)





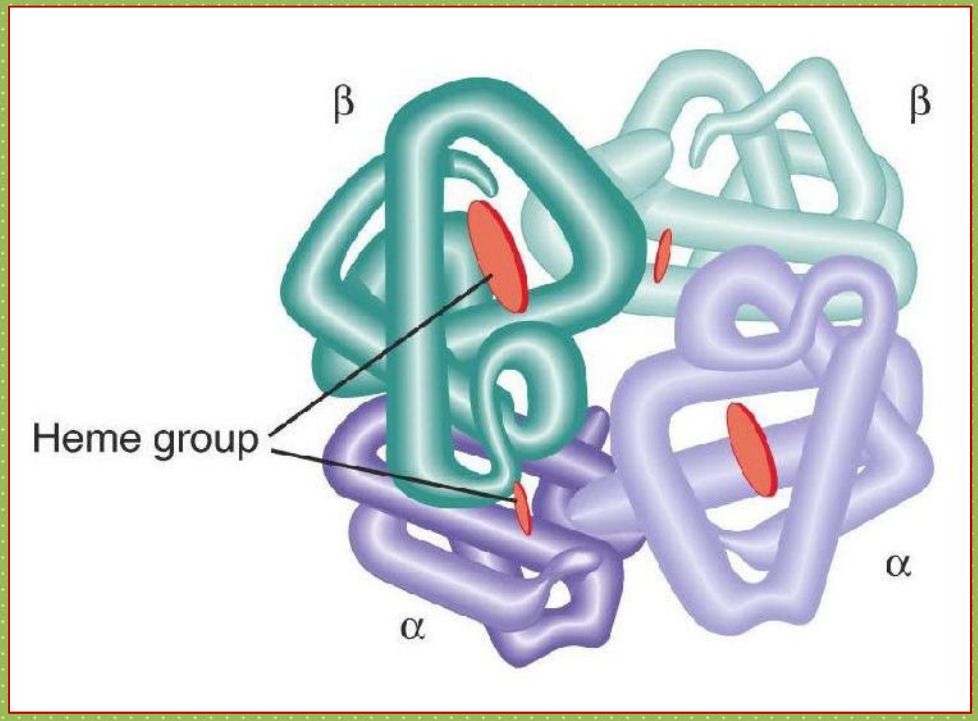
Lactate Dehydrogenase domain 1

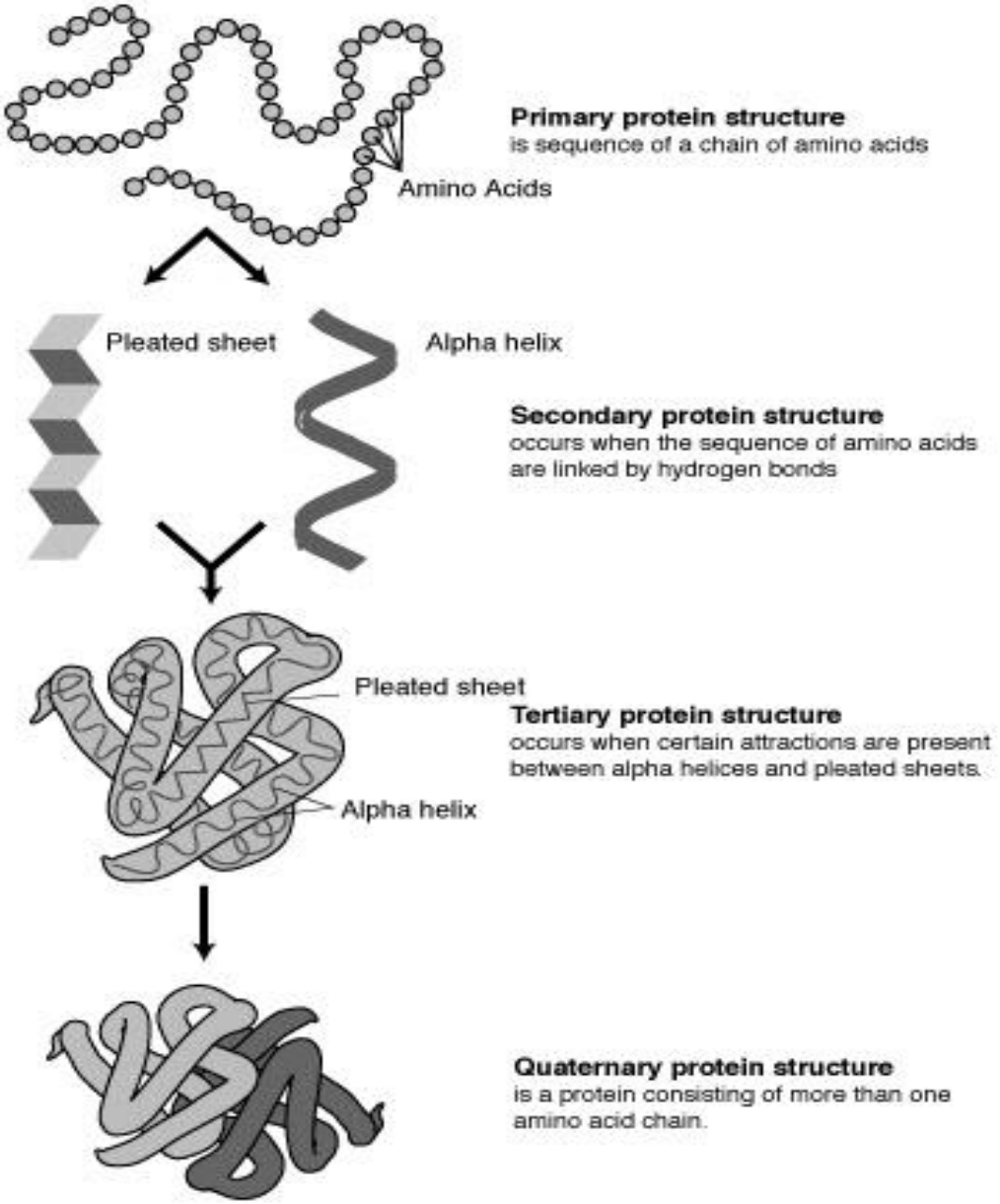


Phosphoglycerate Kinase domain 2

# 4. Quaternary Structure

- Spatial relationship of the polypeptides, or subunits, within the protein
- Hydrophobic interaction, hydrogen bond, ionic bond




Amino Acids
Primary protein structure
is sequence of a chain of amino acids
Pleated sheet
Alpha helix
Secondary protein structure
occurs when the sequence of amino acids
are linked by hydrogen bonds
Pleated sheet
Alpha helix
Tertiary protein structure
occurs when certain attractions are present
between alpha helices and pleated sheets.
Quaternary protein structure
is a protein consisting of more than one
amino acid chain.

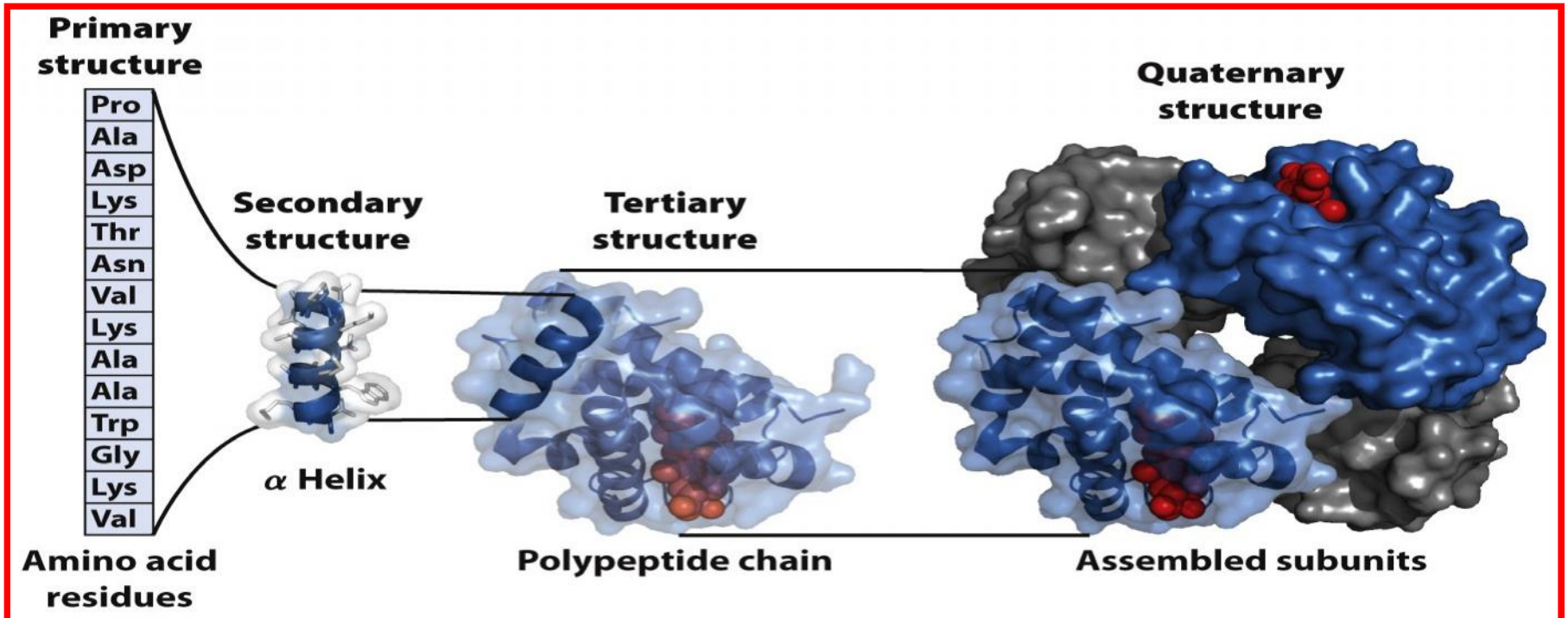



**Figure 3-23**
*Lehninger Principles of Biochemistry, Fifth Edition*


## Levels of structure in proteins

The *primary structure* consists of a sequence of amino acids linked together by peptide bonds and includes any disulfide bonds.

The resulting polypeptide can be arranged into units of *secondary structure*, such as an alpha- helix.

The helix is a part of the *tertiary structure* of the folded polypeptide, which is itself one of the subunits that make up the *quaternary structure* of the multisubunit protein, in this case hemoglobin.