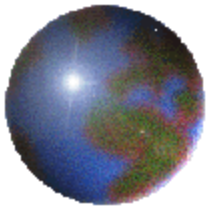


Ch5: Macromolecules

Proteins

Essential Knowledge

- 4.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule
  - A. Structure and function of polymers are derived from the way their monomers are assembled
    2. In proteins, the specific order of amino acids in a polypeptide (primary structure) interacts with the environment to determine the overall shape of the protein, which also involves secondary, tertiary, and quaternary structure and, thus, its function.

Essential Knowledge

2. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, and ionic), and the interactions of these R groups determine structure and function of that region of the protein.

Essential Knowledge

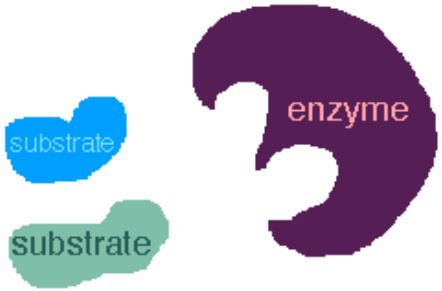
- B. Directionality influences structure and function of the polymer.
  2. Proteins have an amino (NH_2) end and a carboxyl (COOH) end, and consist of a linear sequence of amino acids connected by the formation of peptide bonds by dehydration synthesis between the amino and carboxyl groups of adjacent monomers

Proteins - General

- Instrumental in nearly everything organisms do
- Account for 50% of the dry mass of most cells
- Most structurally & functionally diverse group of macromolecules

- **Functions:**
  - Chemical reactions (enzymes)
  - Structure (keratin, collagen)
  - Carriers & transport (hemoglobin)
  - Signaling (hormones, insulin)
  - Receptors & binding (cell surface receptors)
  - Contractile & motor (actin, myosin)
  - Defense (antibodies)

Proteins - Enzymes

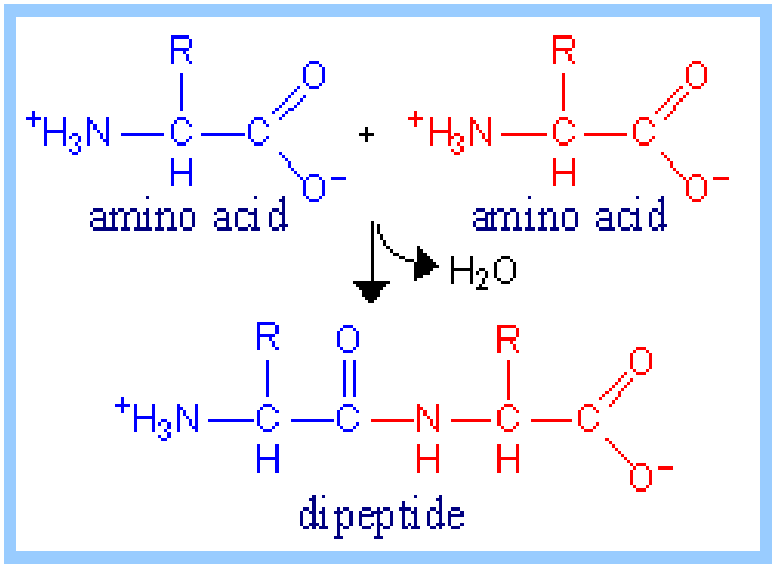


- Regulate metabolism by acting as catalysts
- Most important protein in the body

- Catalysts speed up chemical reactions
- Not consumed (used up by reaction)

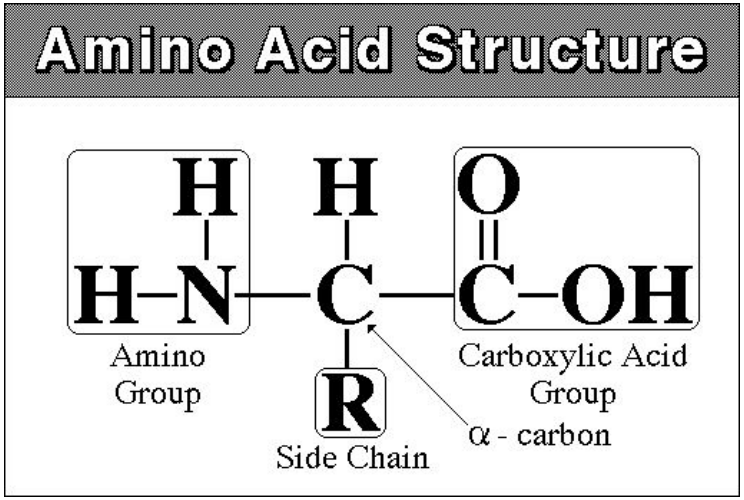
Protein structure

- **Monomer = amino acids**
  - Constructed from 20 different amino acids
- **Polymer = polypeptides**
  - Dehydration reactions
  - Protein can be 1 or more polypeptide chains folded and joined together
  - Peptide bonds (covalent bond)
    - carboxyl group to amino group (polar)



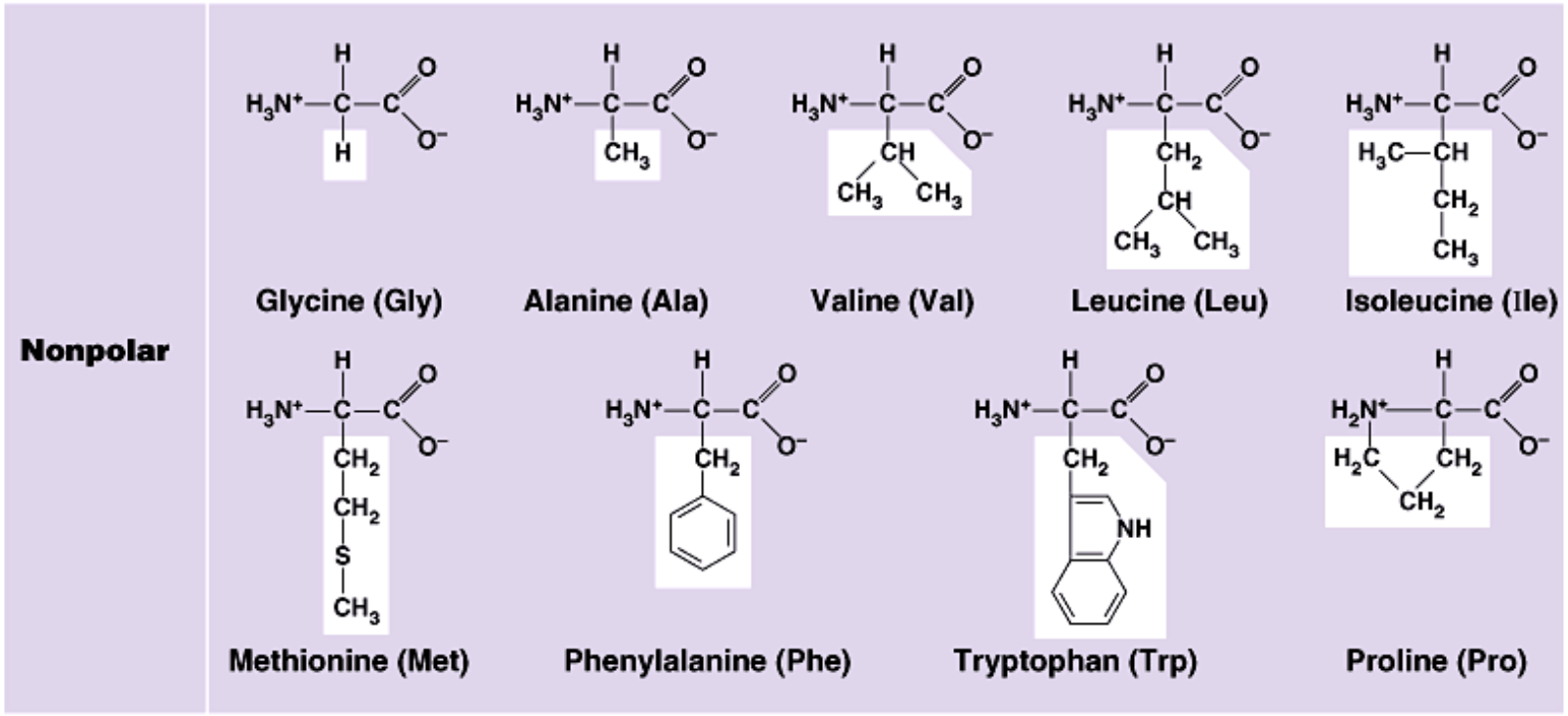
Amino Acid Structure

- Central Carbon = α carbon
- Attached to α carbon:
  - Carboxyl (-COOH)
  - Amino group (NH_2)
  - H atom
  - Side chain (R group)
    - Can be as simple as an H atom
    - Determines unique characteristics of the amino acid
    - Polar (hydrophilic), nonpolar (hydrophobic), acid or base

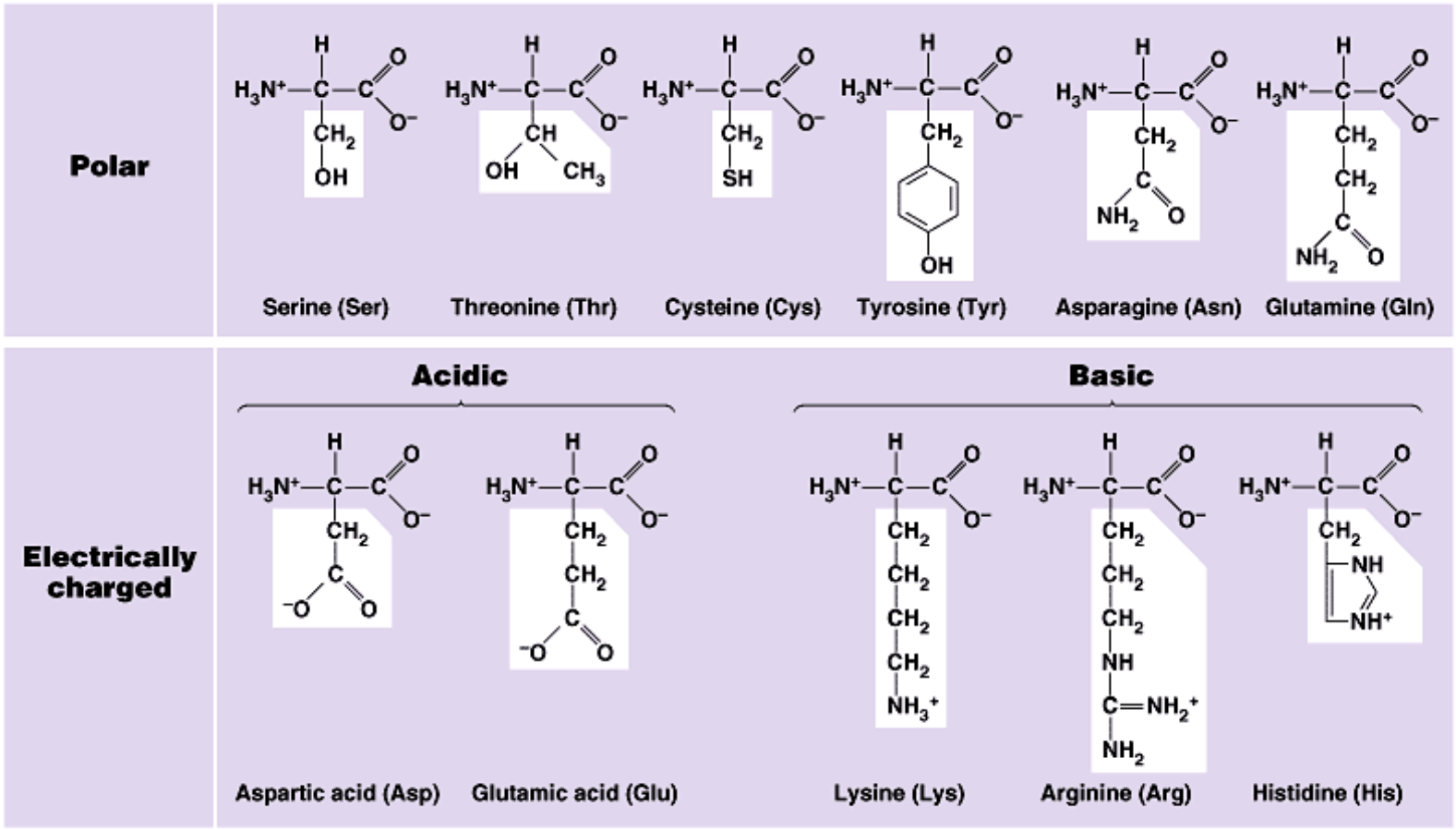


Non Polar Amino Acids

- Amino acids are grouped according to their side chains (R-group)

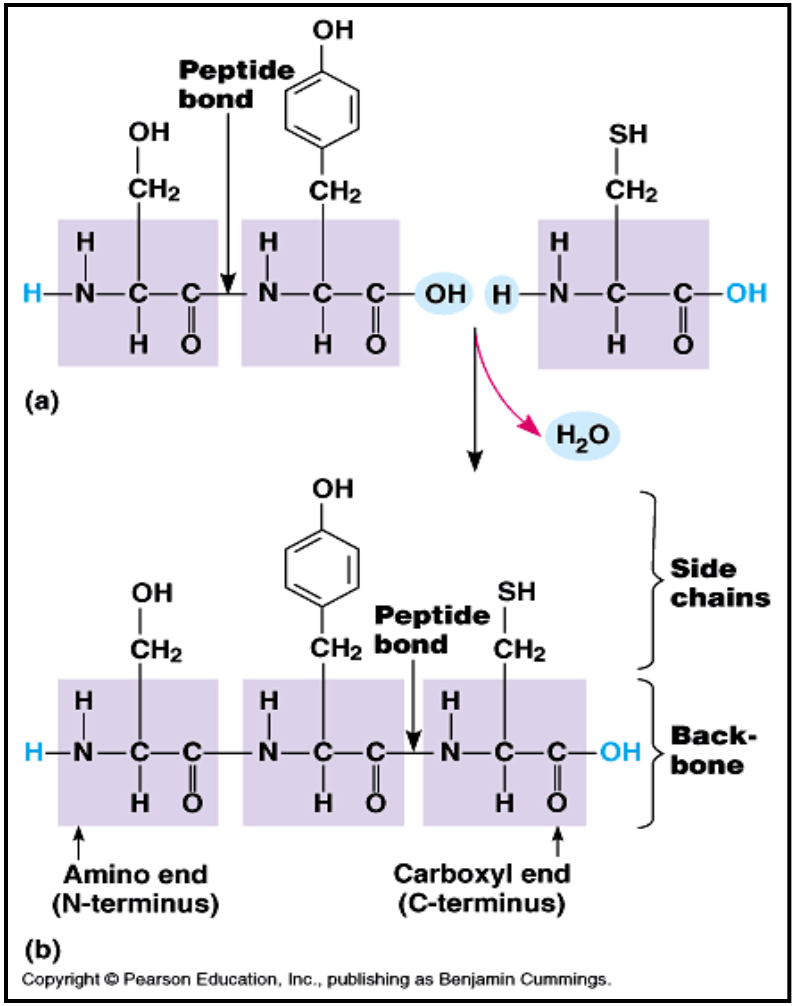


Polar/Charged & Hydrophilic Amino Acids



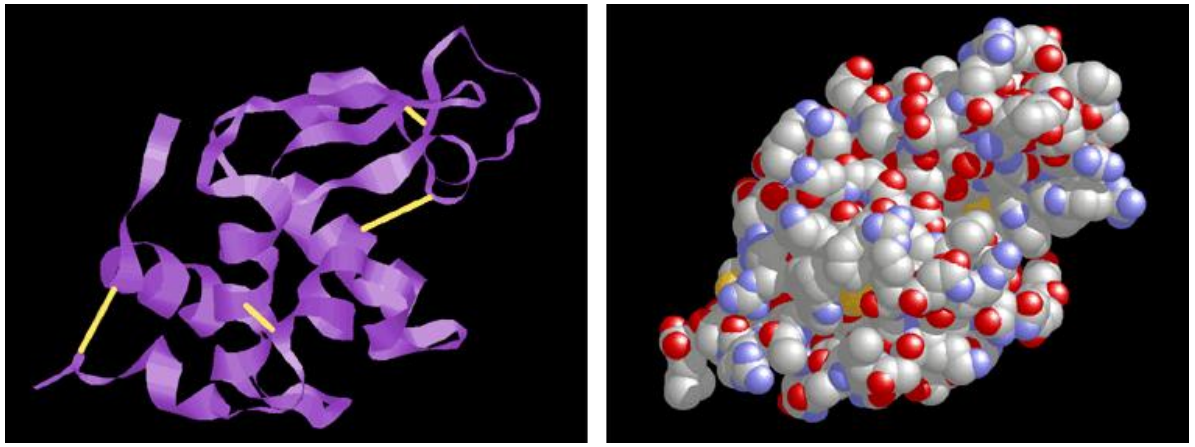
How to build proteins

- Dehydration synthesis of 2 or more amino acids
- (-COOH) and (NH_2) group are joined by a covalent **peptide bond** (C-N)
- One end of polypeptide is free (NH_2) = N-terminus
- One end of polypeptide is free (-COOH) = C-terminus
- Grow from N-term → C-term
- **Repeated N-C-C sequence is backbone of polypeptide chain**



Protein Structure & Function

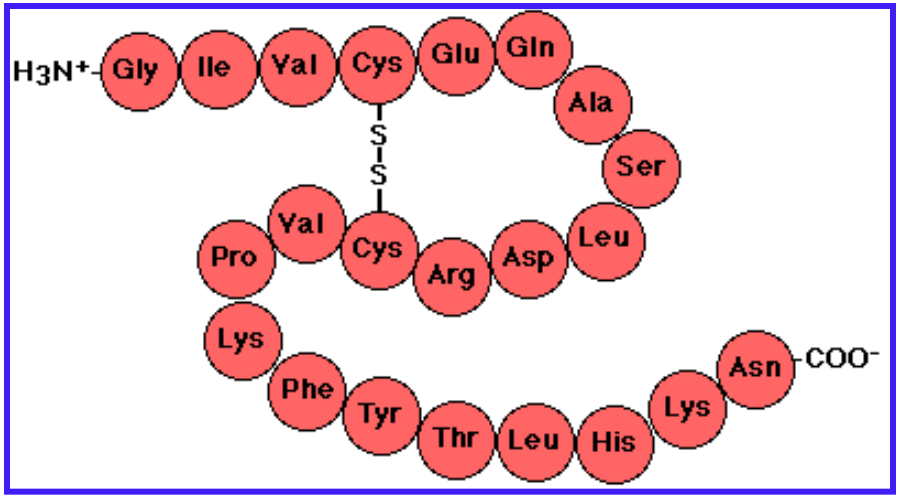
- **Function depends on structure** – all starts with amino acid sequence
- Proteins are folded, twisted, and coiled into specialized shape
- There are **4 levels** of protein structure

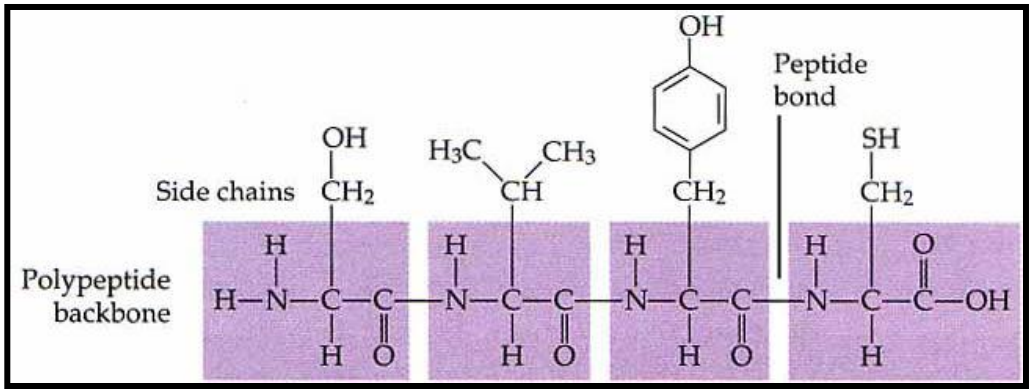


Enzyme, lysozyme is present in our tears, saliva, & sweat – prevents infection.

Protein Structure - Primary

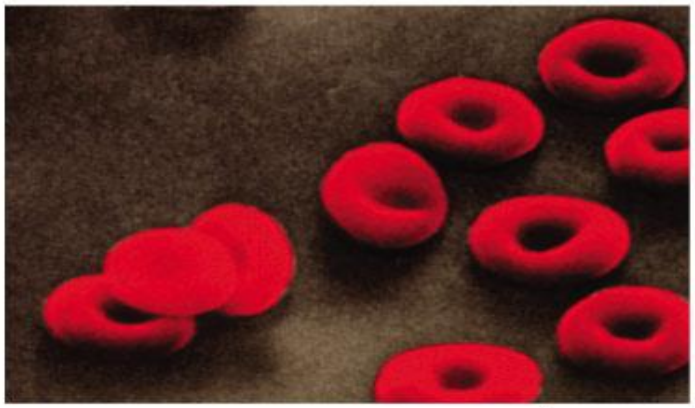
- Conformation: linear structure based on order of amino acids and peptide bonds
- Each type of protein has a unique primary structure of amino acids
- How is the amino acid sequence determined?
  - By the DNA sequence





Sickle Cell Anemia

- Result of only one amino acid change in primary structure of hemoglobin.

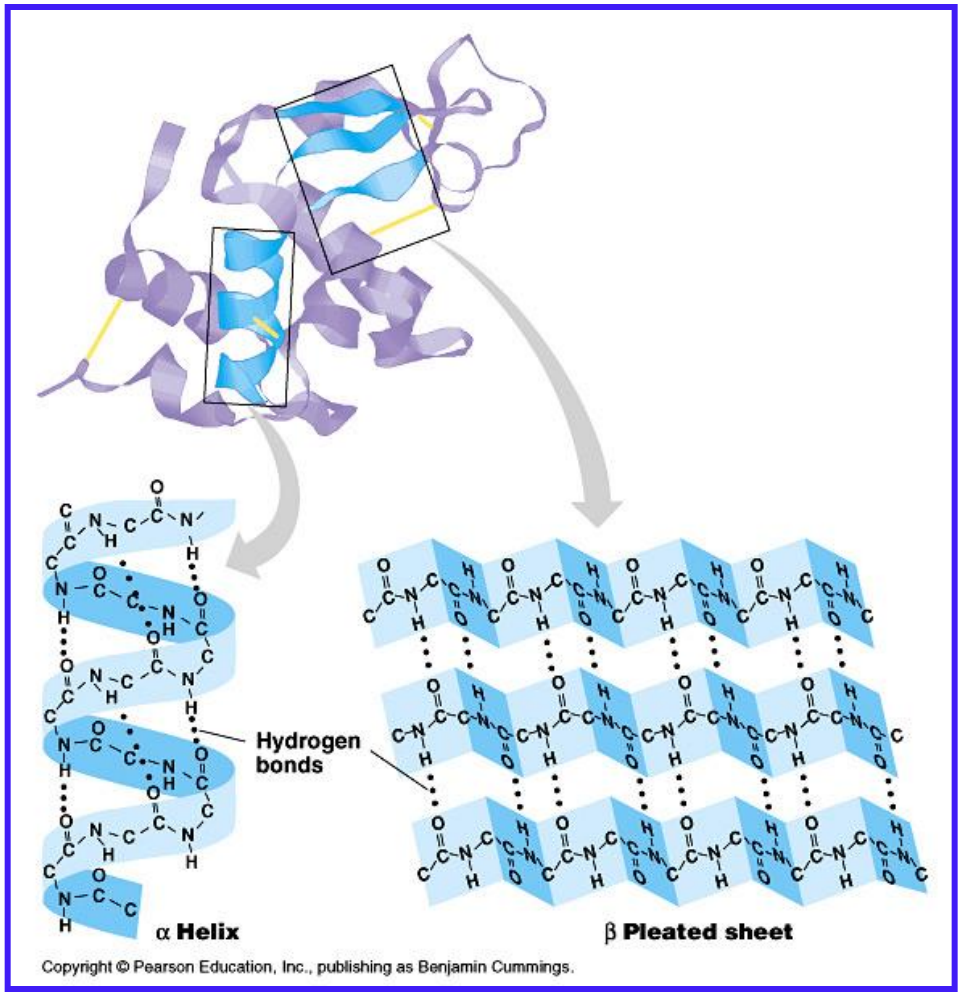


(a) Normal red blood cells and the primary structure of normal hemoglobin

(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

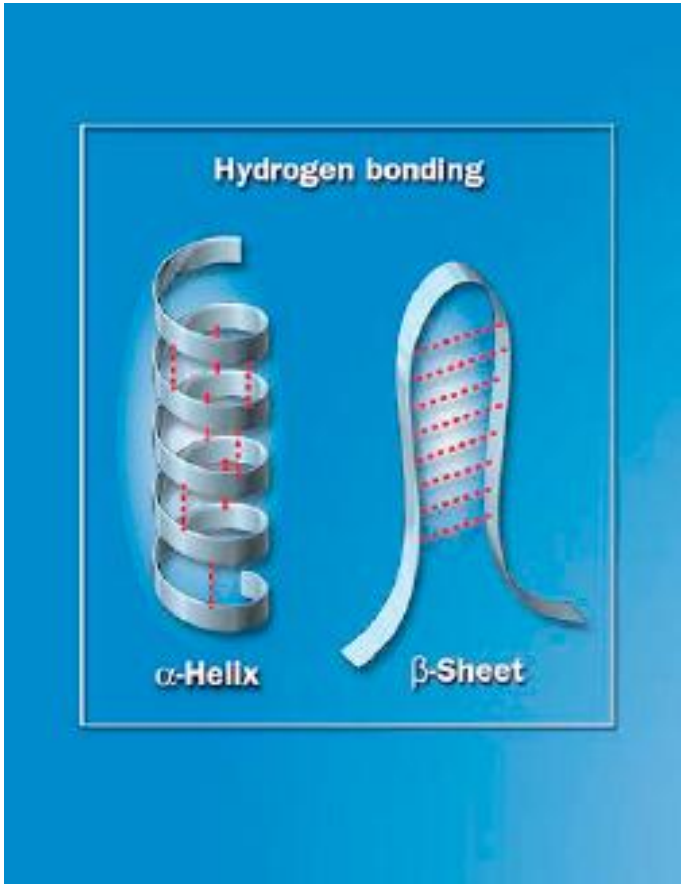
Protein Structure - Secondary

- Conformation: folding and coiling of the amino acid chain
  - Can be an alpha (**α**) helix or beta (**β**) pleated sheet
    - Ex: alpha (**α**) = keratin and beta (**β**) = silk
  - Folds are result of H-bonds between R-groups

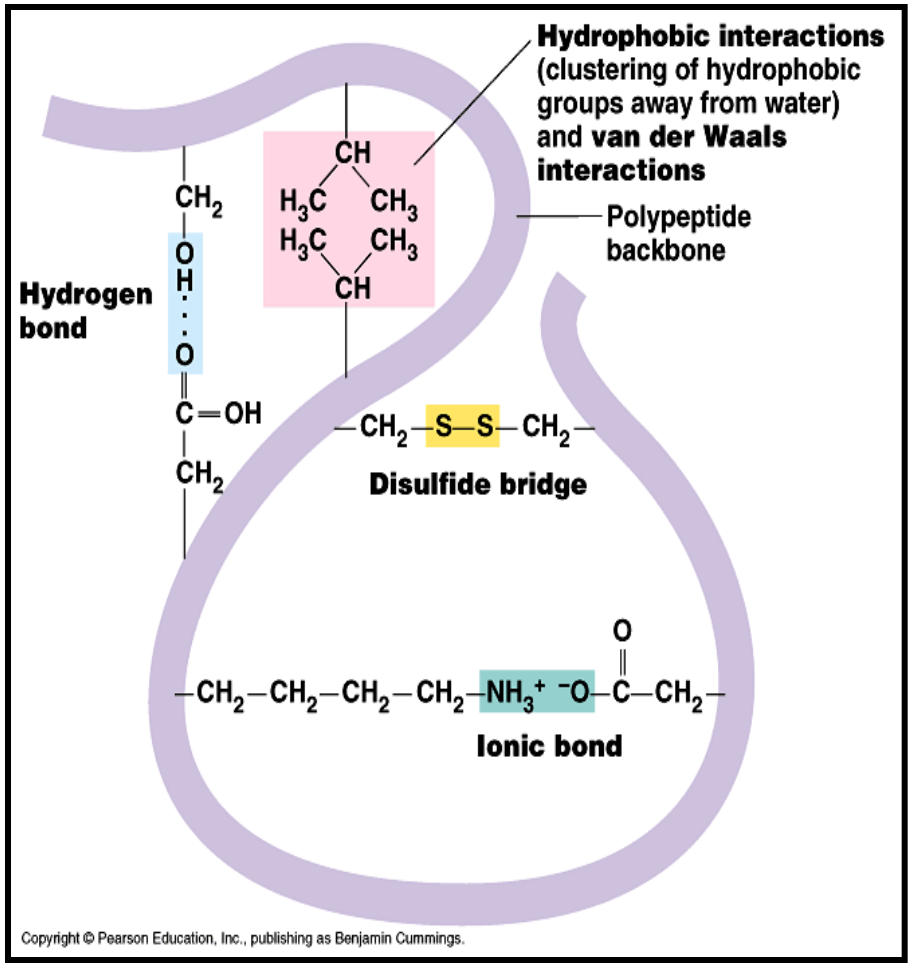


Protein Structure – Secondary

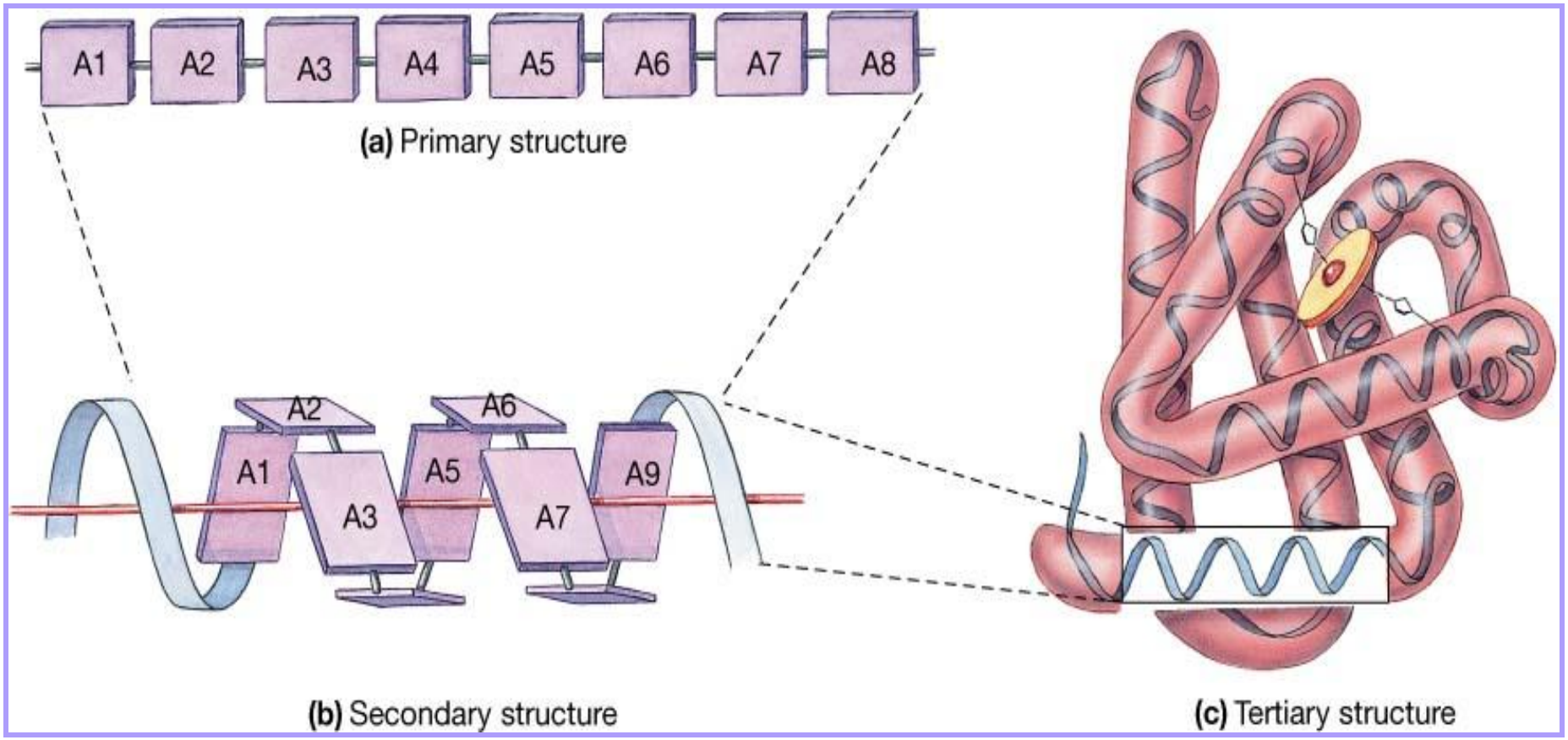
Spider silk: a structural protein containing beta (**β**) pleated sheet



Protein Structure – Tertiary

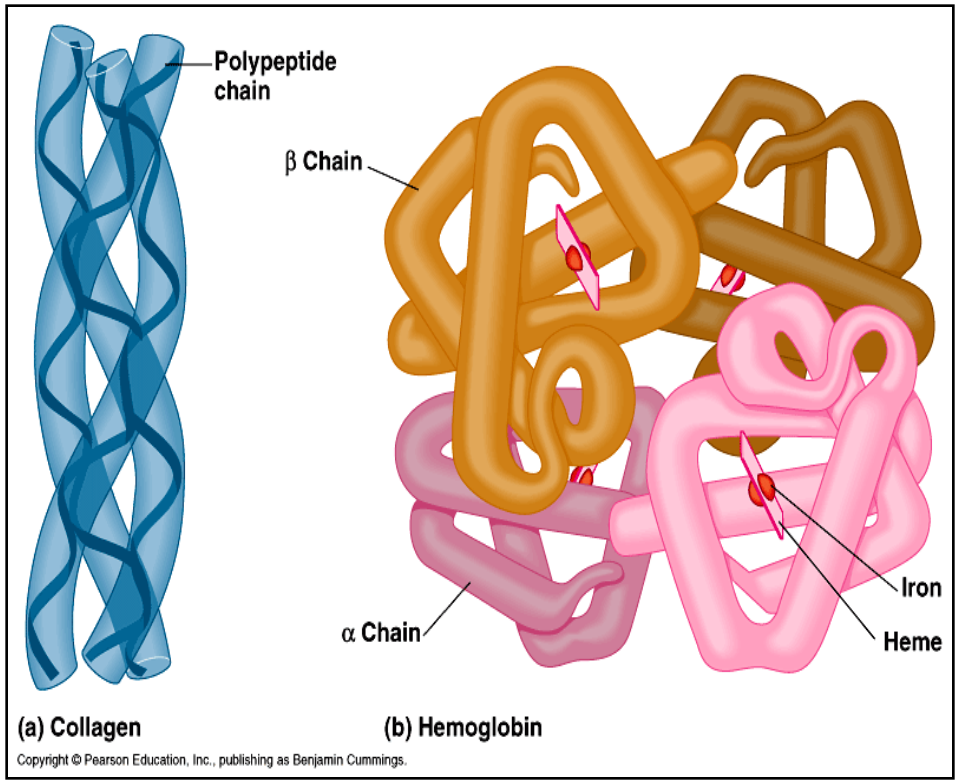


- Conformation: Determined by interactions and bonding between R-groups
  - Hydrophobic & Hydrophilic interactions due to water
  - H-bonds
  - Disulfide bridges
  - Ionic bonds
  - Van der Waals interactions

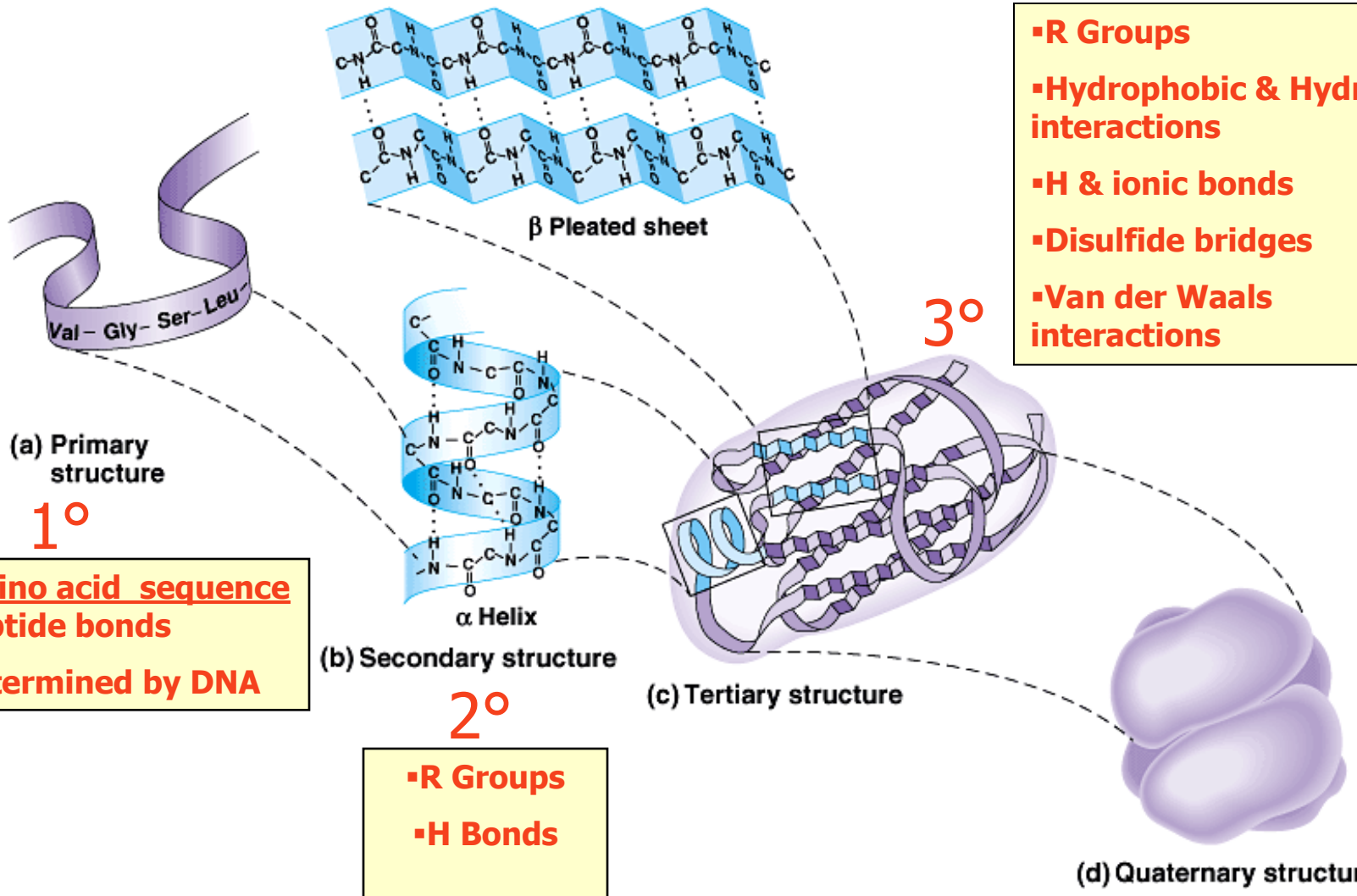

A1
A2
A3
A4
A5
A6
A7
A8
(a) Primary structure
A2
A6
A1
A5
A9
A3
A7
(b) Secondary structure
(c) Tertiary structure

Protein Structure – Quaternary

- Conformation: 2 or more polypeptide chains joined together causing the overall protein structure
  - Ex: Collagen – fibrous protein
    - helical subunits twisted into one large subunit
  - Ex: Hemoglobin – oxygen binding protein of red blood cells
    - 4 polypeptide subunits
    - Two α chains
    - Two β chains



Protein Structure Review



1°

Amino acid sequence
peptide bonds

Determined by DNA

2°

- **R Groups**
- **H Bonds**

3°

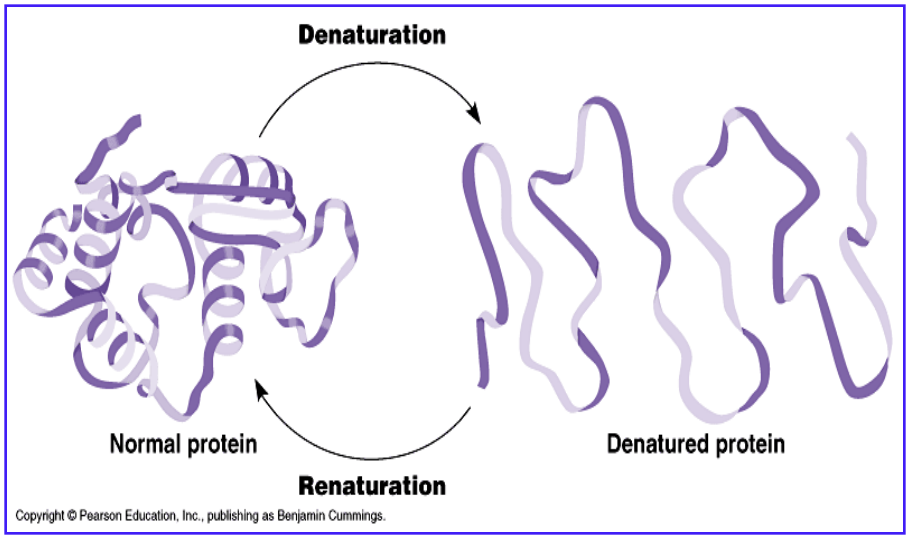
- **R Groups**
- **Hydrophobic & Hydrophilic interactions**
- **H & ionic bonds**
- **Disulfide bridges**
- **Van der Waals interactions**

4°

- **Multiple polypeptides**

Other Factors Affecting Protein Structure

- Depends on physical and chemical conditions
- Affect 3° structure:
  - pH
  - Salt concentration
  - Temperature
- If the environment is not "just right" a protein will **<u>denature</u>** (unravel, lose confirmation, become dysfunctional)
  - Ex: cooking an egg denatures the egg white



Chaperonins

- Protein molecules that assist the proper folding of other proteins.
- Aids the folding process by providing shelter from cytoplasmic influences.