Protein Structure Levels

Primary (1°)

Amino acid sequence connected by peptide bonds

Secondary (2°)

Local folding patterns: α-helix and β-sheet

Tertiary (3°)

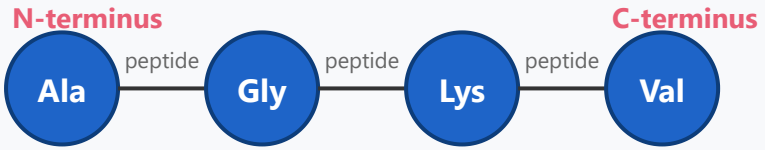
Overall 3D structure of single polypeptide chain

Quaternary (4°)

Assembly of multiple polypeptide subunits

Detailed Descriptions and Examples

Primary Structure (1°)



Amino Acid Sequence Connected by Peptide Bonds

Definition

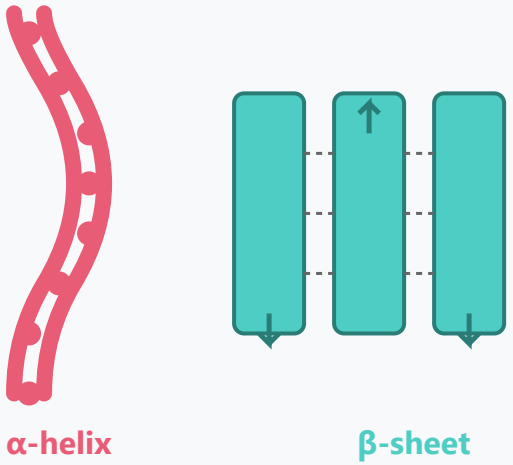
The linear sequence of amino acids connected by peptide bonds.

Key Features

- The most fundamental structure of proteins
- Arranged from N-terminus to C-terminus direction
- Determined by the DNA sequence of genes
- Even a single amino acid change can significantly impact protein function
- Peptide bonds: Formed by condensation reactions between amino acids

> ***Example:*** *Insulin consists of 51 amino acids and comprises two polypeptide chains (A-chain and B-chain). Sickle cell anemia is caused by a single amino acid substitution where glutamic acid at position 6 is replaced by valine in hemoglobin.*

Secondary Structure (2°)



Definition

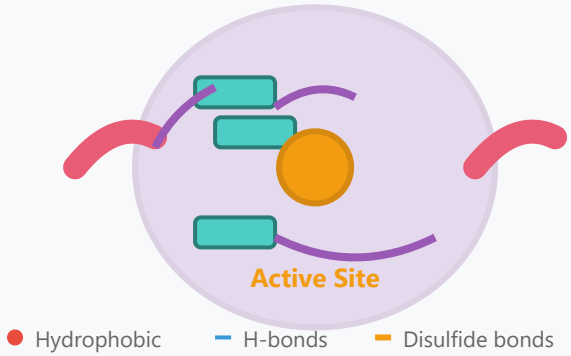
Local folding patterns formed by hydrogen bonding in the backbone, creating regular structures.

Major Types

- **α-helix:** A spiral structure where hydrogen bonds form between backbone C=O and N-H groups. Contains 3.6 amino acids per turn.
- **β-sheet:** Extended polypeptide strands arranged side by side, forming either parallel or antiparallel structures.
- **Turns & Loops:** Irregular structures connecting α-helices and β-sheets, important for directional changes in the protein.

> ***Example:*** *Keratin (hair, nails, skin) is rich in α-helices, while fibroin (silk) contains abundant β-sheet structures. Collagen forms a unique triple helix structure.*

Tertiary Structure (3°)



Definition

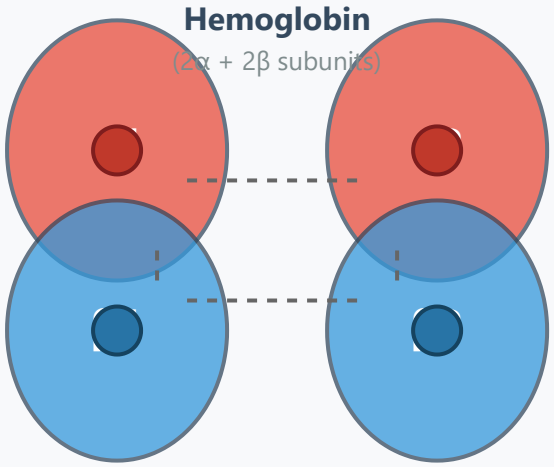
The overall three-dimensional structure of a single polypeptide chain, formed by various chemical interactions.

Formation Principles

- **Hydrophobic interactions:** Hydrophobic (nonpolar) amino acids tend to cluster in the protein interior, away from water
- **Hydrogen bonds:** Weak bonds between polar side chains
- **Ionic bonds (salt bridges):** Electrostatic attraction between oppositely charged side chains
- **Disulfide bonds (S-S):** Covalent bonds between two cysteine residues, the strongest type of bond
- **Van der Waals forces:** Weak attractive forces between atoms

> ***Example:*** *Myoglobin's 8 α-helices fold to form a pocket that encloses a heme group for oxygen binding. Ribonuclease is stabilized by 4 disulfide bonds.*

Quaternary Structure (4°)



Definition

A complex structure formed by the assembly of two or more polypeptide subunits. Not all proteins have quaternary structure.

Key Features

- **Subunits:** Polypeptide chains that each have their own independent tertiary structure
- **Binding mechanism:** Mainly connected by non-covalent bonds (hydrogen bonds, ionic bonds, hydrophobic interactions)
- **Cooperativity:** Structural changes in one subunit affect other subunits
- **Functional advantages:** Easy regulation, increased stability, diverse functional capabilities

> ***Example:*** *Hemoglobin consists of 2 α-subunits and 2 β-subunits (4 total) that cooperatively bind and transport oxygen. Immunoglobulin (antibody) is composed of 4 polypeptides (2 heavy chains and 2 light chains).*