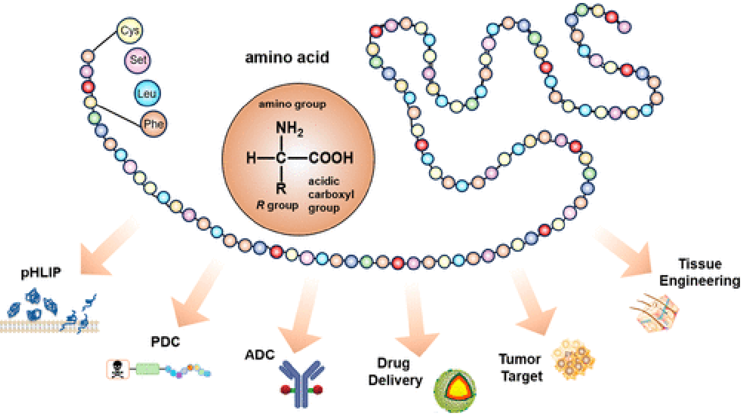
Tishk International University
Faculty of Applied Sciences
Nutrition and Dietetics Department
Principles of Food Science

Protein Structure and Functions in Food



Lecture No.: 5 Assistant Lecturer: Pary Ameer 2024-2025

Outlines

- Previous Lecture
- Food Protein
- Protein Structure
- Protein Function in Food

Learning Outcome

Understand the Chemical Structure of Proteins

Analyze the Role of Proteins in Food

Evaluate the Impact of Proteins on Health and Food Processing

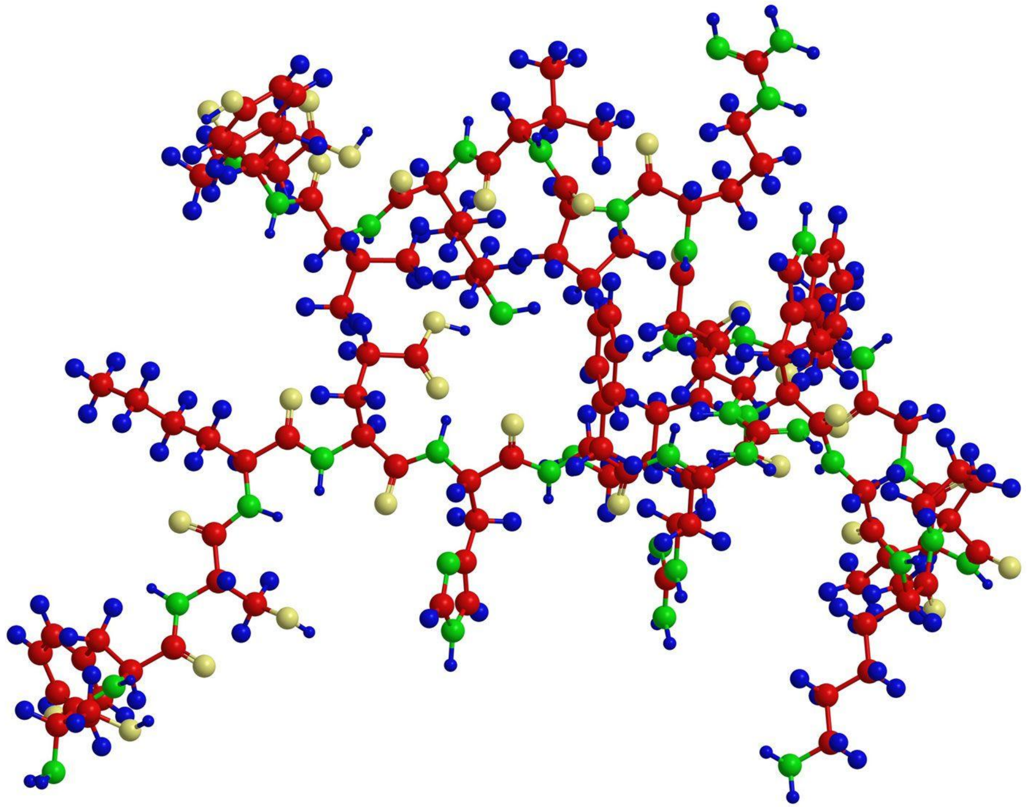
The Building Blocks of Life

Protein

Protein, highly complex substance that is present in all living organisms.

Proteins are of great nutritional value and are directly involved in the chemical processes essential for life.

Jöns Jacob Berzelius, who in 1838 coined the term protein, a word derived from the Greek *proteios*, meaning “holding first place.”



Introduction to Proteins

Proteins are complex macromolecules composed of amino acids.

They are essential for all life processes, playing crucial roles in various biological functions.

These functions include catalysis (enzymes), transport (hemoglobin), structure (collagen), signaling (hormones), and defense (antibodies).

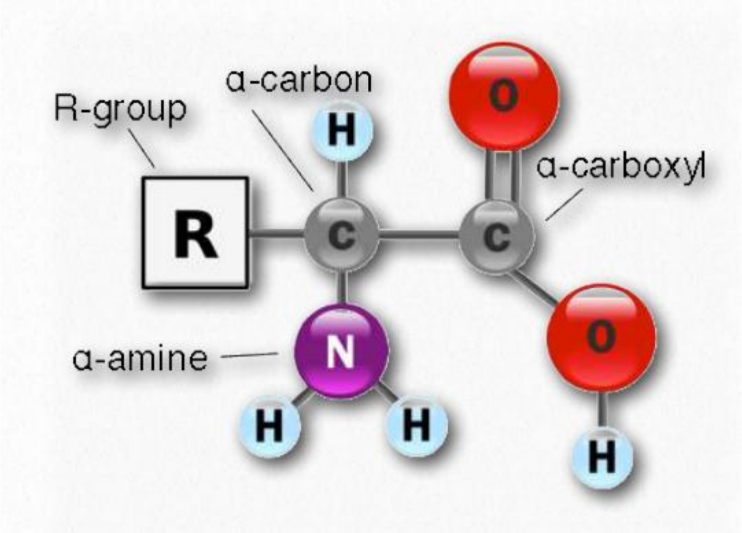
Amino Acids: The Building Blocks

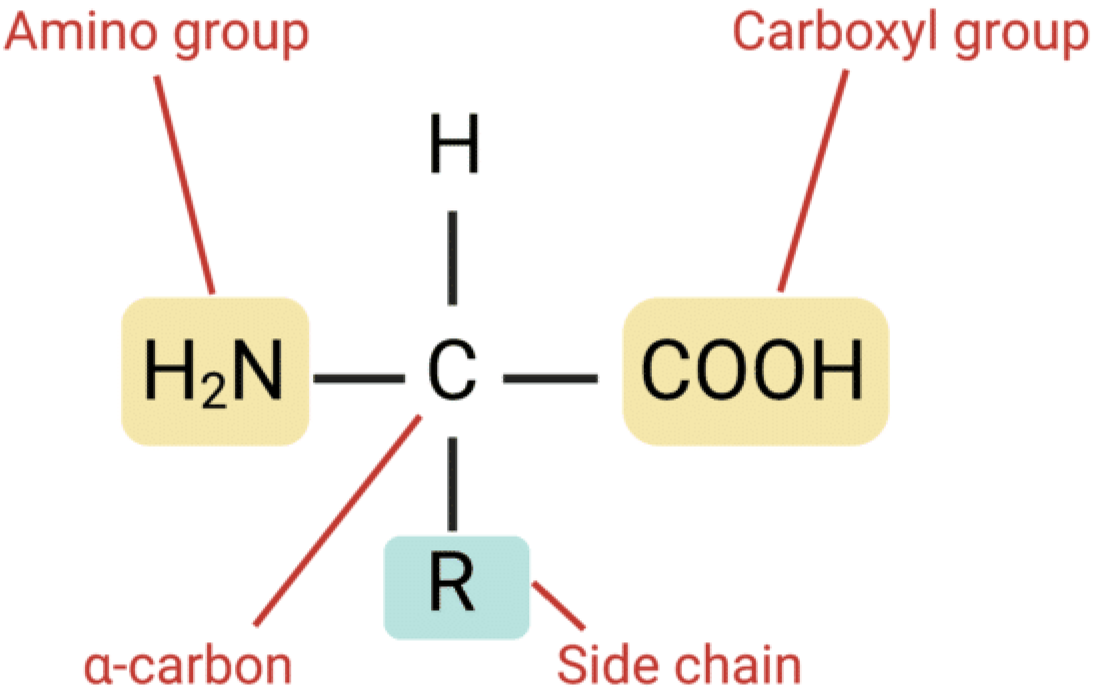
Amino acids are the monomers of proteins. Each has a central carbon atom.

This central carbon is bonded to an amino group (NH2), a carboxyl group (COOH), a hydrogen atom, and a side chain (R-group).

The R-group is unique to each amino acid and determines its chemical properties (polar, nonpolar, acidic, basic).

Show chemical structures of a few representative amino acids (e.g., alanine, glycine, phenylalanine).




Amino group
Carboxyl group
H
H2N
C
COOH
R
α-carbon
Side chain

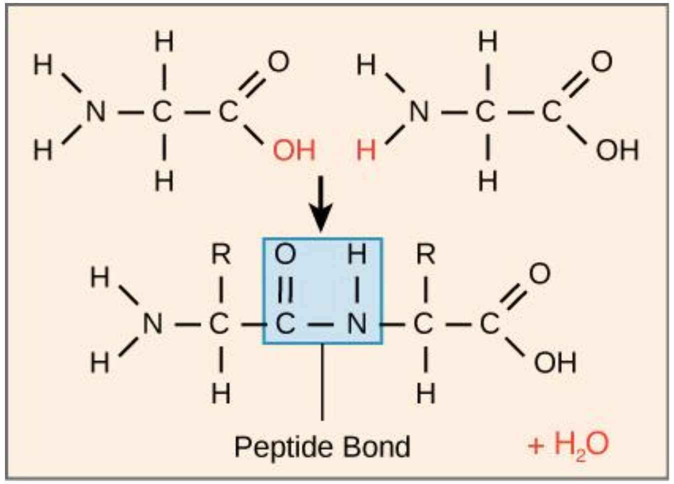
Peptide Bonds: Linking Amino Acids

Amino acids link together through peptide bonds, formed by a dehydration reaction.

This reaction occurs between the carboxyl group of one amino acid and the amino group of another.

The result is a polypeptide chain with a specific sequence of amino acids.

Polypeptide chains have directionality, from the N-terminus (amino group end) to the C-terminus (carboxyl group end).



Amino Acid Classification

Based on Chemical Properties of the R-group

Based on Nutritional Needs

Amino Acid Classification

Based on Chemical Properties of the R-group:

1. Nonpolar (Hydrophobic): These amino acids have R-groups that are mostly hydrocarbons, making them water-repelling. They tend to cluster inside proteins, contributing to protein folding and stability. Examples include:

- Alanine (Ala)
- Valine (Val)
- Leucine (Leu)
- Isoleucine (Ile)
- Phenylalanine (Phe)
- Methionine (Met)
- Tryptophan (Trp)
- Proline (Pro)

Amino Acid Classification

Based on Chemical Properties of the R-group:

2. Polar (Hydrophilic): These amino acids have R-groups that contain polar or charged atoms, making them water-attracting. They often reside on the protein surface, interacting with water and other polar molecules. Examples include:

- Serine (Ser)
- Threonine (Thr)
- Cysteine (Cys)
- Tyrosine (Tyr)
- Asparagine (Asn)
- Glutamine (Gln

Amino Acid Classification

Based on Chemical Properties of the R-group:

3. Acidic (Negatively Charged): These amino acids have R-groups with a carboxyl group (-COOH), giving them a negative charge at physiological pH. Examples include:

- Aspartic acid (Asp)
- Glutamic acid (Glu)

4. Basic (Positively Charged): These amino acids have R-groups with an amino group ($-NH_2$), giving them a positive charge at physiological pH. Examples include:

- Lysine (Lys)
- Arginine (Arg)
- Histidine (His)

Amino Acid Classification

Based on Nutritional Needs:

1. **Essential Amino Acids:** These amino acids cannot be synthesized by the human body and must be obtained from the diet. There are nine essential amino acids:

- Histidine (His)
- Isoleucine (Ile)
- Leucine (Leu)
- Lysine (Lys)
- Methionine (Met)
- Phenylalanine (Phe)
- Threonine (Thr)
- Tryptophan (Trp)
- Valine (Val)

Amino Acid Classification

Based on Nutritional Needs:

2. Nonessential Amino Acids: These amino acids can be synthesized by the body and are not required in the diet. Examples include:

- Alanine (Ala)
- Arginine (Arg)
- Asparagine (Asn)
- Aspartic acid (Asp)
- Cysteine (Cys)
- Glutamic acid (Glu)
- Glutamine (Gln)
- Glycine (Gly)
- Proline (Pro)
- Serine (Ser)
- Tyrosine (Tyr)

Amino Acid Classification

Based on Nutritional Needs:

3. Conditional Amino Acids: These amino acids are typically nonessential but may become essential during certain times, such as illness, stress, or rapid growth. Examples include:

- Arginine (Arg)
- Cysteine (Cys)
- Glutamine (Gln)
- Glycine (Gly)
- Proline (Pro)
- Tyrosine (Tyr)

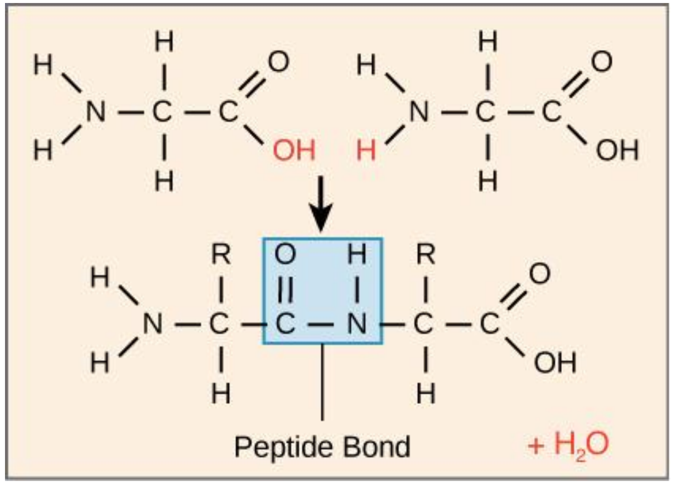
Protein Structure

Primary structure: Sequence of amino acids.

Secondary structure: Alpha-helices and beta-sheets.

Tertiary structure: 3D folding of polypeptide.

Quaternary structure: Multiple polypeptides forming a complex.

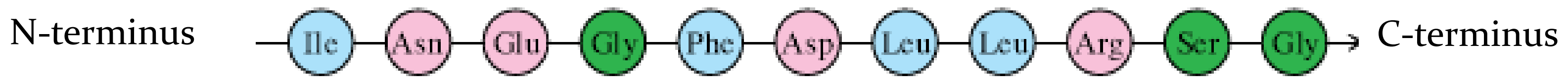


Primary Structure: The Amino Acid Sequence

The primary structure of a protein is its linear sequence of amino acids.

This sequence is crucial because it ultimately determines the protein's higher levels of structure and its function.

For example, the specific amino acid sequence of insulin is essential for its proper function in glucose regulation.



Secondary Structure: Local Folding

Secondary structure refers to local folding patterns within a polypeptide chain.

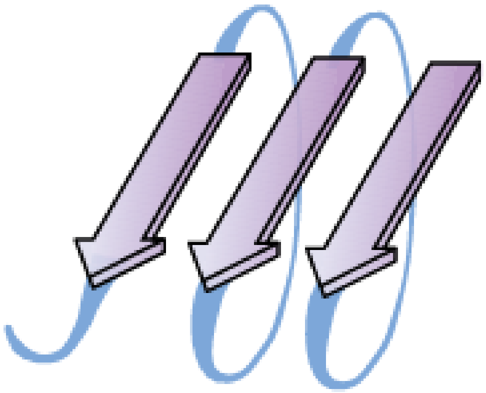
The two main types of secondary structure are alpha-helices (spiral) and beta-sheets (pleated).

These structures are stabilized by hydrogen bonds between backbone atoms.

Examples include the alpha-helix in myoglobin and the beta-sheet in silk fibroin.

3D structures of alpha-helix and beta-sheet should be displayed.

α helix



β sheet

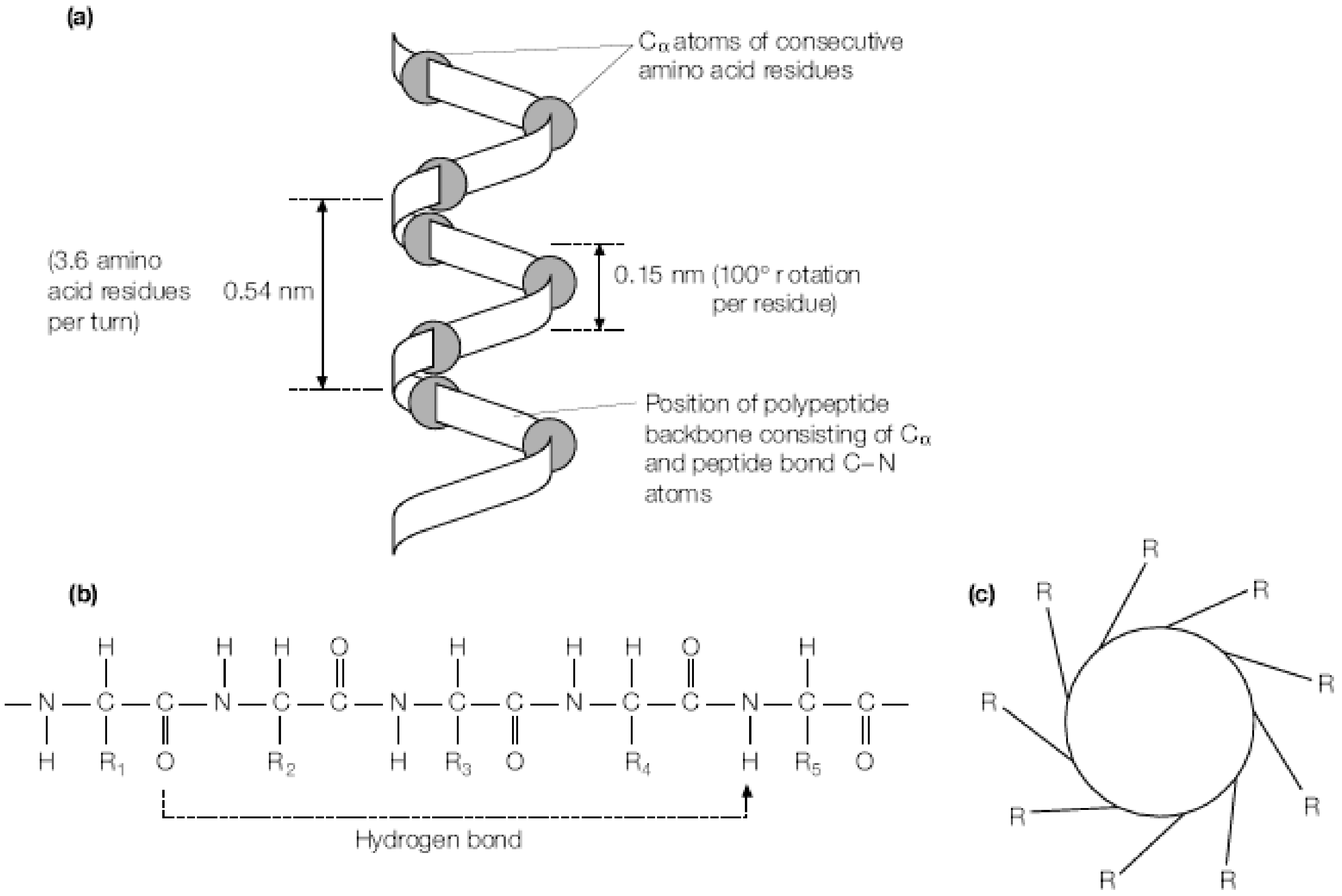
Tertiary Structure: Overall 3D Shape

Tertiary structure is the overall three-dimensional conformation of a single polypeptide chain.

It arises from interactions between the R-groups of amino acids, including hydrophobic interactions, ionic bonds, disulfide bonds, and hydrogen bonds.

Proteins often contain distinct functional regions called domains.

A 3D structure of a protein with labeled domains would be a good visual.


(a)
Cα atoms of consecutive amino acid residues
(3.6 amino acid residues per turn)
0.54 nm
0.15 nm (100° rotation per residue)
Position of polypeptide backbone consisting of Cα and peptide bond C–N atoms
(b)
Hydrogen bond
(c)
R

Quaternary Structure: Multi-subunit Proteins

Quaternary structure describes the arrangement of multiple polypeptide chains (subunits) into a larger protein complex.

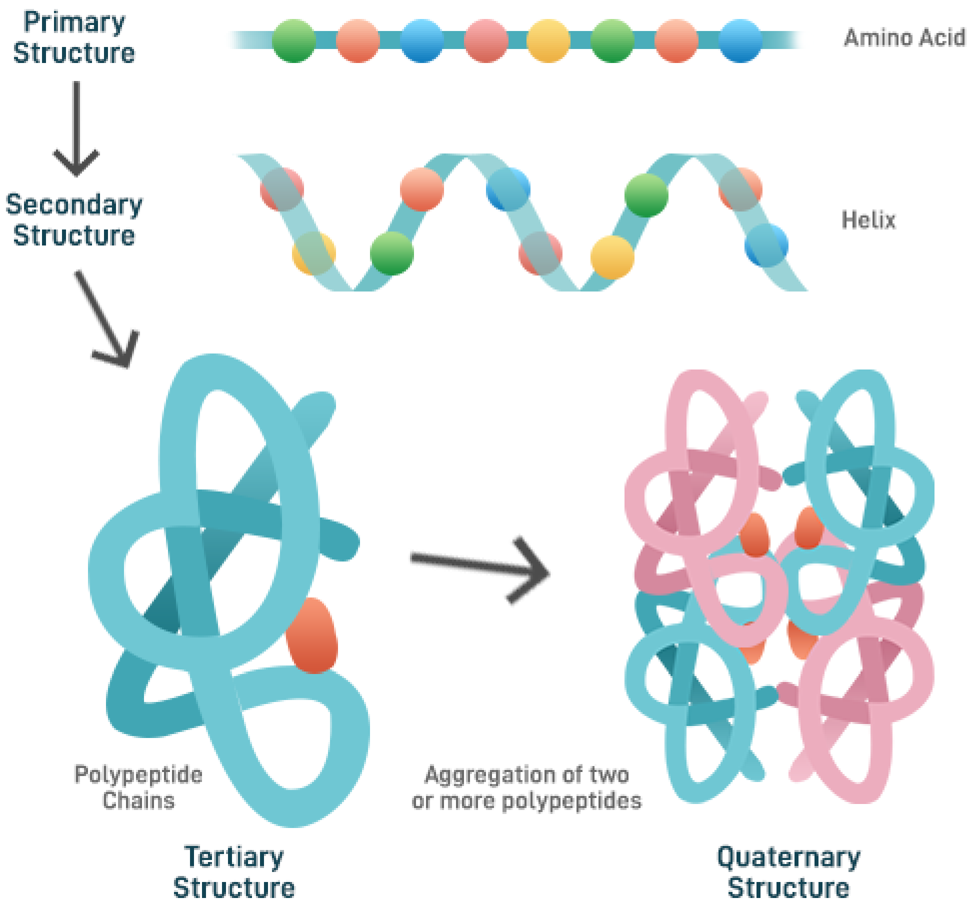
Not all proteins have quaternary structure. It's present in proteins made of more than one polypeptide chain.

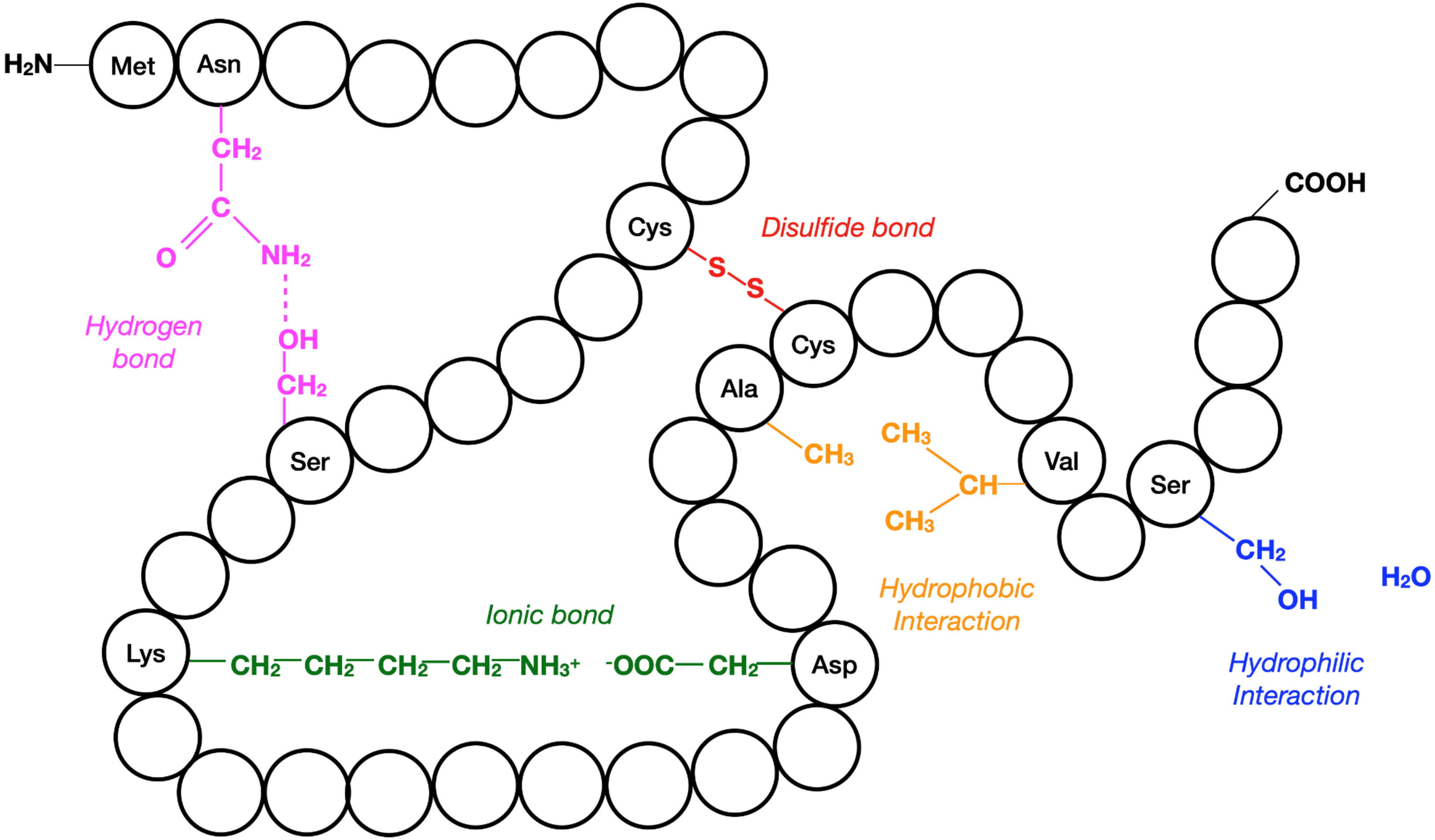
Examples include hemoglobin (four subunits) and antibodies.

Quaternary structure can enhance protein stability and functionality.

Show the 3D structure of a protein with multiple subunits.

PROTEIN STRUCTURE





H2N
Met
Asn
CH2
C
O
NH2
Hydrogen bond
OH
CH2
Ser
Cys
Disulfide bond
S
S
Cys
Ala
CH3
CH3
CH
CH3
Val
Ser
COOH
CH2
OH
H2O
Hydrophobic Interaction
Hydrophilic Interaction
Ionic bond
Lys
CH2 CH2 CH2 CH2 NH3+
-OOC CH2
Asp

Bonds in Proteins

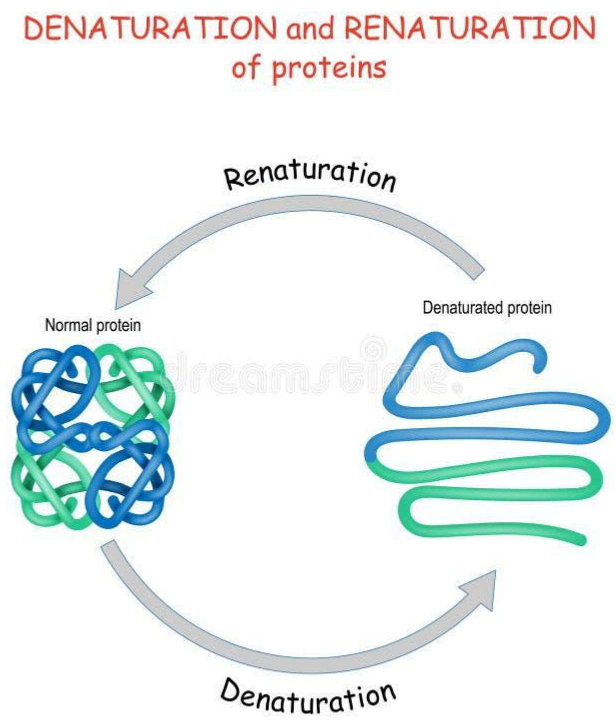
- **Primary structure**
  - Covalent bonds
    1. Peptide bond
    2. Di-sulphide bond
- **Secondary structure**
  1. Hydrogen bond
  2. Peptide bond
  3. Di-sulphide bond
- **Tertiary structure**
  1. Hydrophobic bonds
  2. Hydrogen bonds
  3. Ionic bonds
  4. Van der Walls forces
  5. Di-sulphide bonds
- **Quaternary structure**
  1. Hydrophobic bonds
  2. Hydrogen bonds
  3. Ionic bonds
  4. Van der Walls forces
  5. Di-sulphide bonds

Denaturation:

Most proteins can be denatured by heat, which affects the weak interactions in a protein (primarily hydrogen bonds) in a complex manner.

If the temperature is increased slowly, a protein's conformation generally remains intact until an abrupt loss of structure and function occurs over a narrow temperature range.

During cooking, this stress causes denaturation, which is typically due to heat, and ultimately, proteins get coagulated.



Protein Functions

Catalytic function: nearly all reactions in living organisms, "Enzymes"

transport :"Myoglobin in skeletal and cardiac muscle cells, Haemoglobin in RBC"

Storage: Iron is stored in the liver as a complex with the protein ferritin"

Support and shape cells and hence to tissue and organism, "Tubulin, actin and collagen-skin and bone"

Mechanical work: "movement of flagella, the separation of chromosomes and contraction of muscles"

Decoding information in the cell: "Translation and regulation of gene expression"

Some proteins are hormones and some are receptors for hormones.

Defending function: antibodies in vertabrates and toxins in bacteria.


thank you