

**Aim: What is the complex structure of a protein?**



# Primary Structure of Proteins

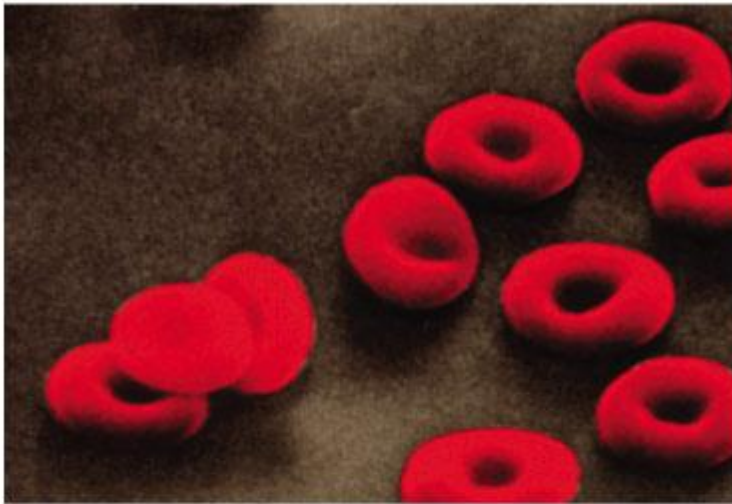
- ▶ Protein structure is complex and can be divided into *four* levels.
- ▶ **1. Primary structure = the sequence of amino acids in a polypeptide chain**
  - Genes determine primary structure.
    - May be straight chained or bent by disulfide bonds
    - There are  $20^{20}$  possible sequences possible (practically limitless)



# Primary Structure of Proteins

- ▶ Even a slight change in primary structure can affect a protein's conformation and ability to function.
- ▶ In individuals with sickle cell disease, abnormal hemoglobins (oxygen-carrying proteins) develop because of a single amino acid substitution.
  - These abnormal hemoglobins crystallize, deforming the red blood cells and leading to clogs in tiny blood vessels.

# Primary Structure of Proteins



10  $\mu\text{m}$

Val	His	Leu	Thr	Pro	Glu	Glu	...
1	2	3	4	5	6	7	

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



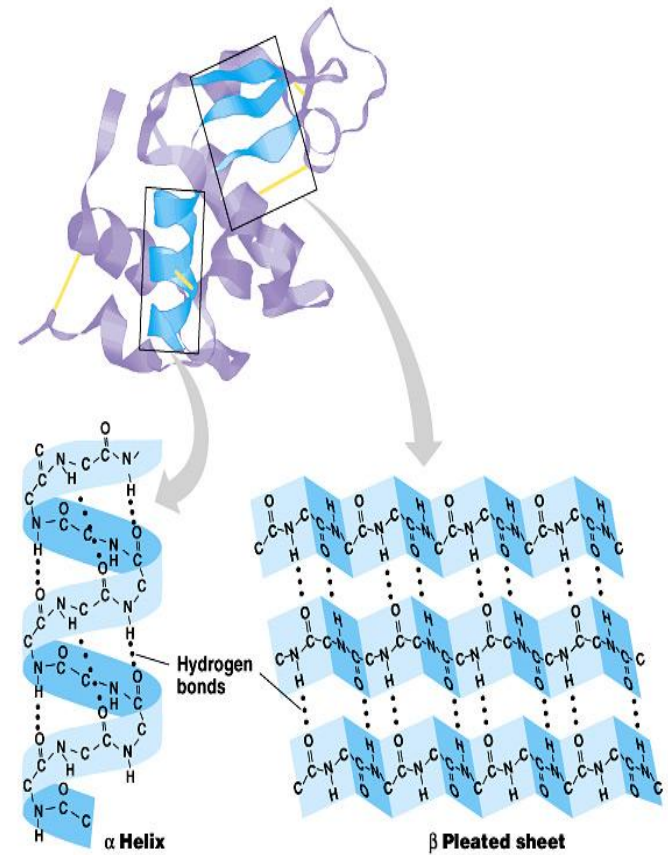
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Val	His	Leu	Thr	Pro	Val	Glu	...
1	2	3	4	5	6	7	

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

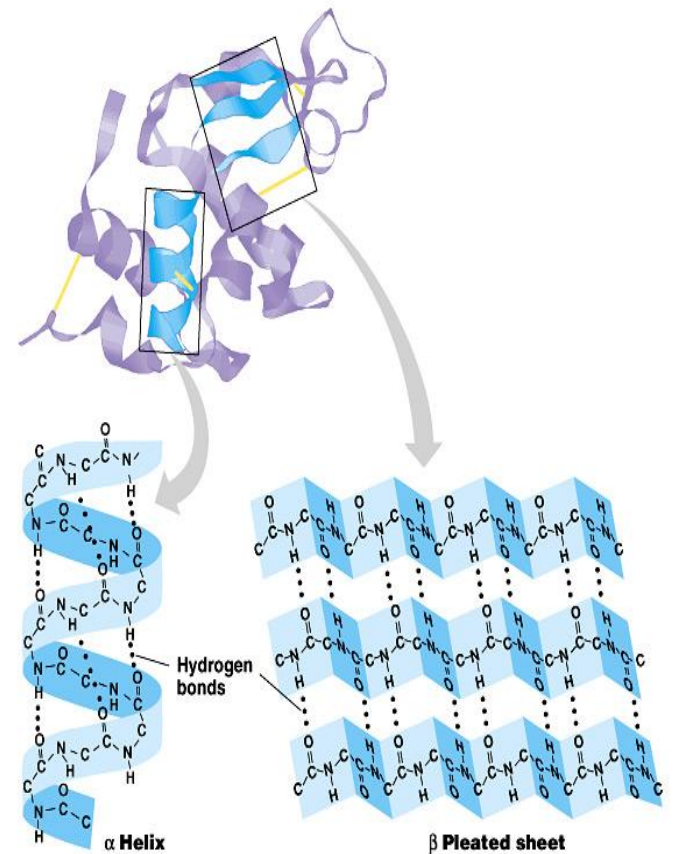
# Secondary Structure of Proteins

- ▶ A. Involves coiling of a primary chain
- ▶ B. Types of secondary structure include:
  - 1) alpha helix
  - 2) beta pleated sheets
  - 3) triple helix



# Secondary Structure of Proteins

- ▶ Alpha helix
- ▶ a) helical coil stabilized by hydrogen bonding between every fourth peptide bond
- ▶ b) discovered by Linus Pauling and Robert Corey in 1951
- ▶ c) can be easily broken by heating
- ▶ d) found in fibrous proteins (alpha keratin and collagen)



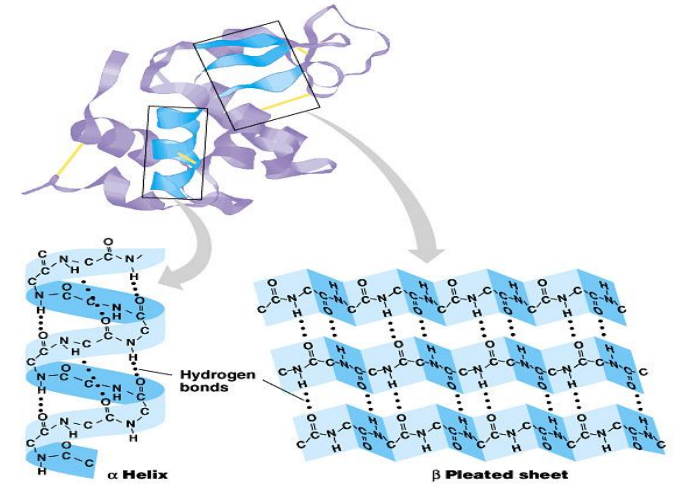
# Secondary Structure of Proteins

- ▶ Keratins are insoluble proteins that can be:
- ▶ 1) hard, brittle, nails, hooves, and horns made hard by many disulfide bonds (25 % cysteine)
- ▶ 2) soft, pliable hair or wool, which contains less cysteine. Can be made manageable by adding water, which breaks hydrogen bonds.



# Secondary Structure of Proteins

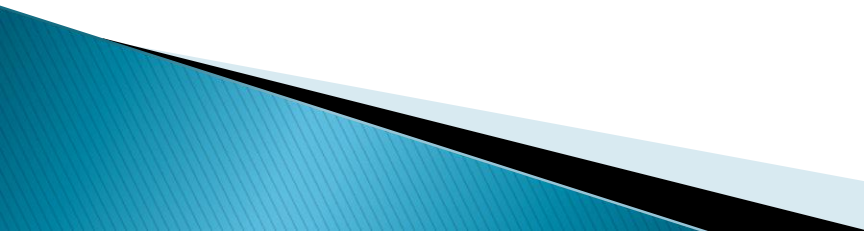
- ▶ Beta Pleated Sheets
- ▶ a) Side-by-side polypeptide chains held by interlocking hydrogen bonds
- ▶ b) Flexible but resists stretching.
- ▶ c) Includes silk, feathers, scales, claws, beaks



# Tertiary Structure of Proteins

- ▶ Tertiary Structure involves:
- ▶ A. a three dimensional *folding* of a helical secondary structure usually caused by the presence of the amino acid *proline*.
- ▶ B. makes up a special type of proteins called *globular proteins*

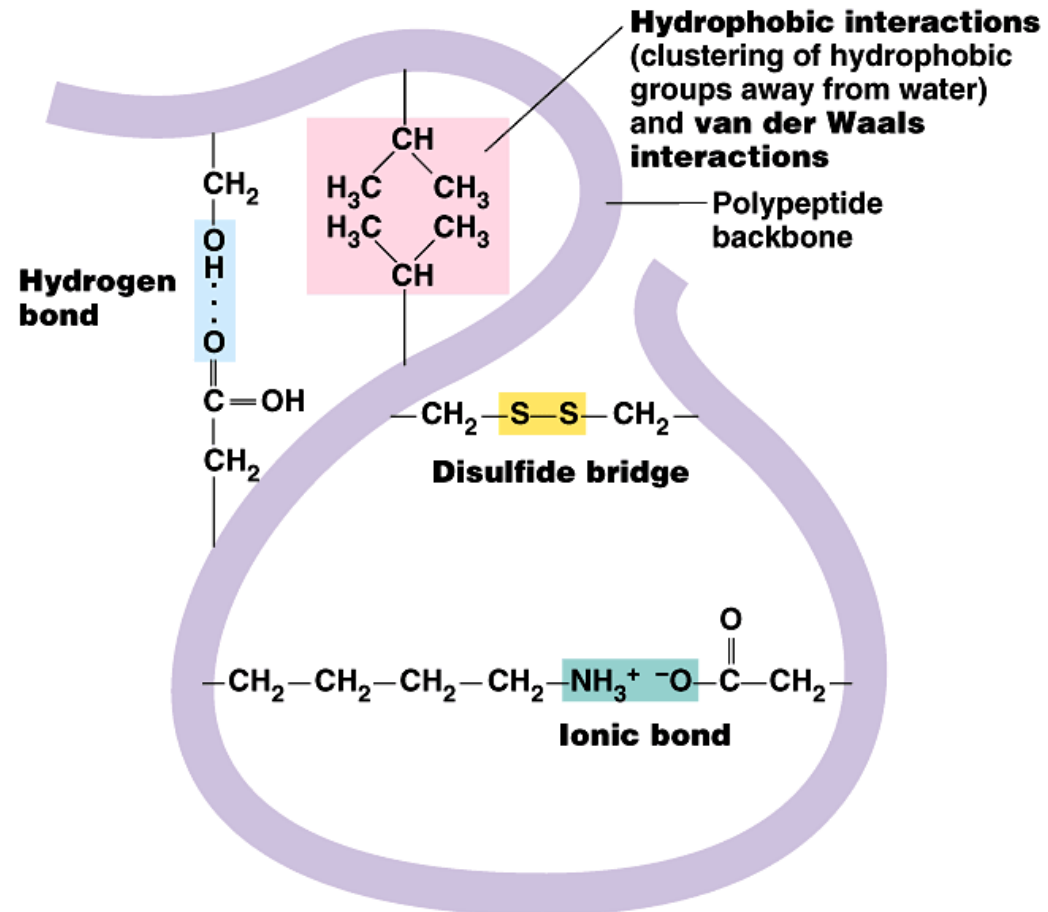
# Tertiary Structure of Proteins

- ▶ C. globular proteins include enzymes, hormones, antibodies, hemoglobin (oxygen carrier in red blood cells), myoglobin (oxygen carrier in muscles), and fibrinogen (a blood clotting protein)
  - ▶ D. globular proteins tend to be soluble
  - ▶ E. other substances such as iron or magnesium can “hide” inside the folds of a globular protein.
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# Tertiary Structure of Proteins

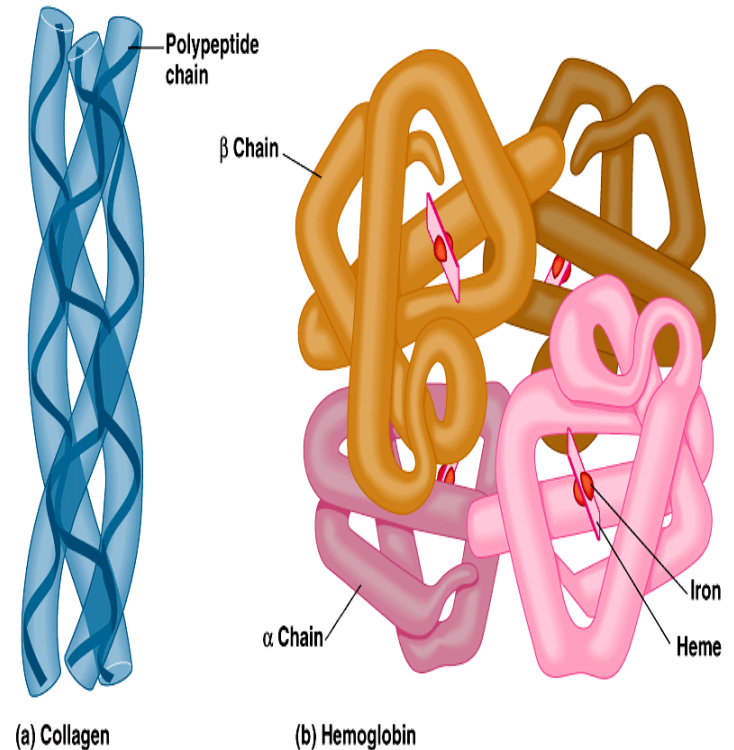
Tertiary structure is determined by the variety of reactions between R groups in the polypeptide chain.

Important R group interactions include hydrogen bonds, disulfide bonds and hydrophobic interactions.



# Quaternary Structure

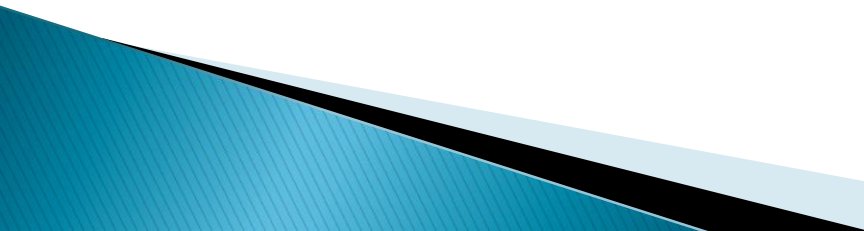
- ▶ Quaternary structure involves:
  - ▶ A) two or more globular proteins held loosely together such as hemoglobin super molecules
  - ▶ B) hydrophobic amino acids tend to orient inside the quaternary structure and away from the watery environment
  - ▶ C) Hydrophilic amino acids tend to orient themselves outside the quaternary structure near the watery environment.



# Quaternary Structure of Proteins

- ▶ *Triple Helix*
- ▶ a) three polypeptide chains held in a helix by hydrogen bonds
- ▶ b) found in collagen, the most abundant protein found in higher vertebrates (33 % of the body)
- ▶ collagen makes up skin, tendons, ligaments, bone connective tissue and the cornea of the eye.

# Denatured Proteins

- ▶ A) heat or a change in pH will cause a change in the secondary, tertiary or quaternary structure (hydrogen bonds are broken and rearrangement occurs)
  - ▶ B) denatured proteins have a different chemistry (raw versus cooked egg)
  - ▶ C) denatured proteins may lead to sickness or death (loss of enzyme function)
  - ▶ D) denatured proteins cannot usually revert to their original state
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# Summary of protein structure

- ▶ Proteins can be defined by their:
- ▶ 1) Primary structure – the arrangement of amino acids, length of amino acid chains, presence or absence of bending caused by disulfide bonds.



# Summary of protein structure

- ▶ 2) Secondary structure – the helical spiraling or pleating of a primary chain caused by hydrogen bonding. Examples include:
  - ▶
  - ▶ a) Alpha helix (alpha keratin) soft hair or hard nails
  - ▶ b) Beta pleated sheets (flexible but resist stretching ) – silk
  - ▶ Triple helix – collagen

# Summary of protein structure

- ▶ 3) Tertiary structure – the folding of a secondary structure (globular proteins) based on the type and presence of amino acid R groups

# Summary of protein structure

- ▶ 4) Quaternary structure – combining of two or more tertiary units usually with the addition of a prosthetic group (Fe or Mg)
  - ▶ The hemoglobin super molecule is an example of quaternary structure. The Fe within it is a prosthetic group.
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