Proteins and types of proteins

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Proteins - Many Structures, Many Functions

1.Proteins are macromolecules (MW-6000-several hundred thousands)

2.A polypeptide is a polymer of amino acids connected to a specific sequence

2. A protein's function depends on its specific conformation

Introduction

- Abundant in living organisms –40-70% of the dry weight of living cells
- Proteins are instrumental in about everything that an organism does.
  - structural support,
  - storage
  - transport of other substances
  - intercellular signaling
  - movement
  - defense against foreign substances
  - Proteins are the main enzymes in a cell and regulate metabolism by selectively accelerating chemical reactions.
- Humans have thousands of different proteins, each with their own structure and function.

Proteins

- Proteins are the most structurally complex molecules known.
  - Each type of protein has a complex three-dimensional shape or conformation.
- All protein polymers are constructed from the same set of 20 monomers, called amino acids.
- There are about 300 amino acids occur in nature. Only 20 of them occur in proteins.
- Polymers of proteins are called polypeptides.

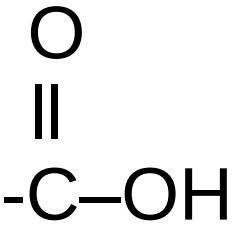
Proteins

- A protein consists of one or more polypeptides folded and coiled into a specific conformation(phenomenon of structural arrangement)
- A polypeptide is a polymer of amino acids connected in a specific sequence

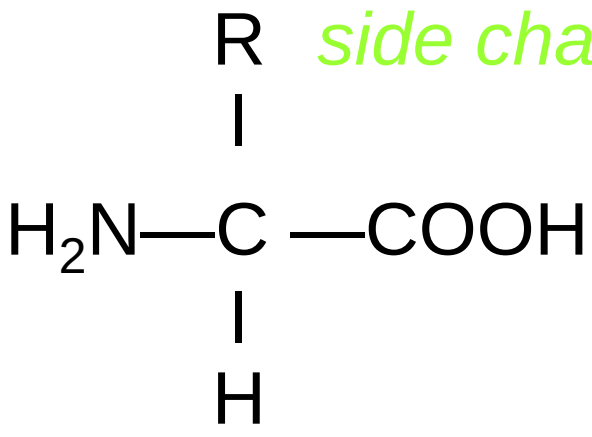
Structure of amino acids:

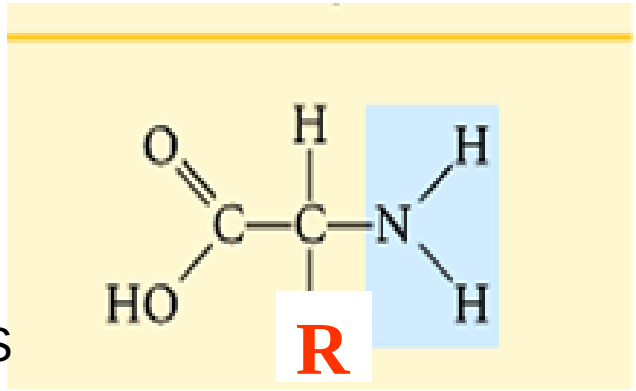
- Building blocks of proteins-alpha AA

AA are organic compounds with an Amino group($-H_2N$ or -HN) and a Carboxylic acid group



- Thus they have properties of both acids and bases
- Side group R gives unique characteristics



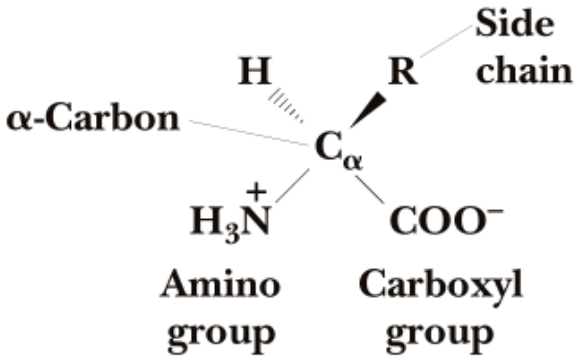


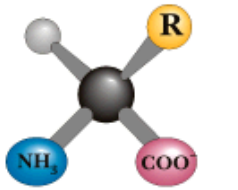
GAMMA CARBON ATOM

C-C—C-C- C-C-C-C—CO_2H

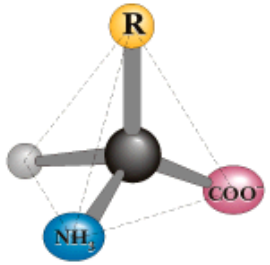
BETA C ARBON ATOM

ALPHA CARBON ATOM





Ball-and-stick model

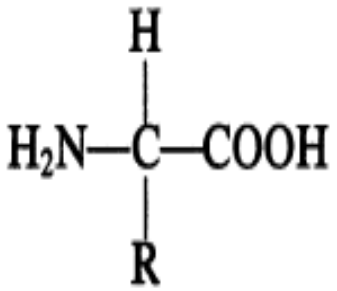


Amino acids are tetrahedral structures

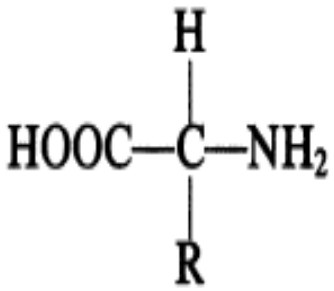
AA are optically active and occur in two isomeric forms; L and D forms ;

L -AA are found in proteins and D-AA are rare in nature ;

D-AA are only found in cell walls of some microbes and antibiotics



L-amino acid



D-amino acid

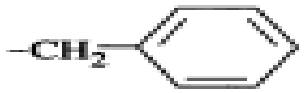
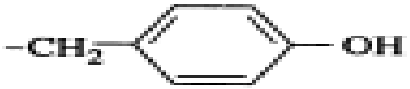
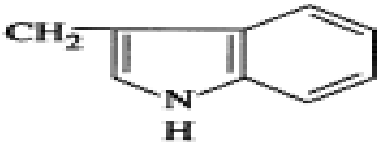
• Structure of amino acids:

- **Each amino acid has 4 different groups attached to α- carbon (which is C-atom next to COOH).**
- **These 4 groups are : amino group, COOH group,**

Hydrogen atom and side Chain (R)

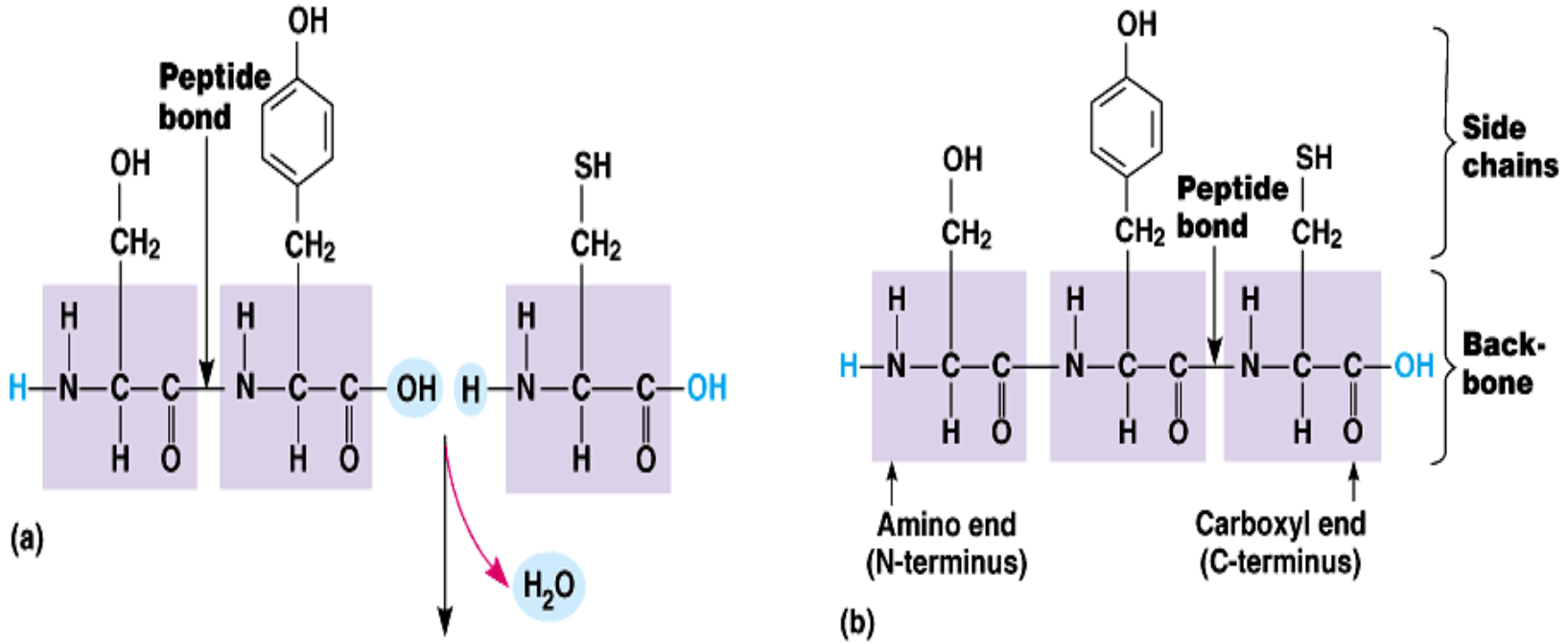
- Differences in R groups produce the 21 different
  amino acids.

Chemical structure of 21AA

R Group	Name	Abbreviation	Symbol	Class
—H	Glycine	GLY	G	Aliphatic
—CH_3	Alanine	ALA	A	
—$CH(CH_3)_2$	Valine	VAL	V	
—$CH_2CH(CH_3)_2$	Leucine	LEU	L	
—$CH(CH_3)CH_2CH_3$	Isoleucine	ILU	I	
—CH_2OH	Serine	SER	S	Hydroxyl or sulfur containing
—$CH(OH)CH_3$	Threonine	THR	T	
—CH_2SH	Cysteine	CYS	C	
—$(CH_2)_2SCH_3$	Methionine	MET	M	
—CH_2COOH	Aspartic acid	ASP	D	Acids and corresponding amides
—CH_2CONH_2	Asparagine	ASN	N	
—$(CH_2)_2COOH$	Glutamic acid	GLU	E	
—$(CH_2)_2CONH_2$	Glutamine	GLN	Q	
—$(CH_2)_3CH_2NH_2$	Lysine	LYS	K	Basic
—$(CH_2)_3NHCNHNH_2$	Arginine	ARG	R	
	Histidine	HIS	H	
	Phenylalanine	PHE	F	Aromatic
	Tyrosine	TYR	Y	
	Tryptophan	TRP	W	
	Proline	PRO	P	Imino acid
—CH_2—S—S—CH_2—	Cystine	—		Disulfide

- Amino acids are joined together when a dehydration reaction removes a hydroxyl group from the carboxyl end of one amino acid and a hydrogen from the amino group of another.

  - The resulting covalent bond is called a **peptide bond**.



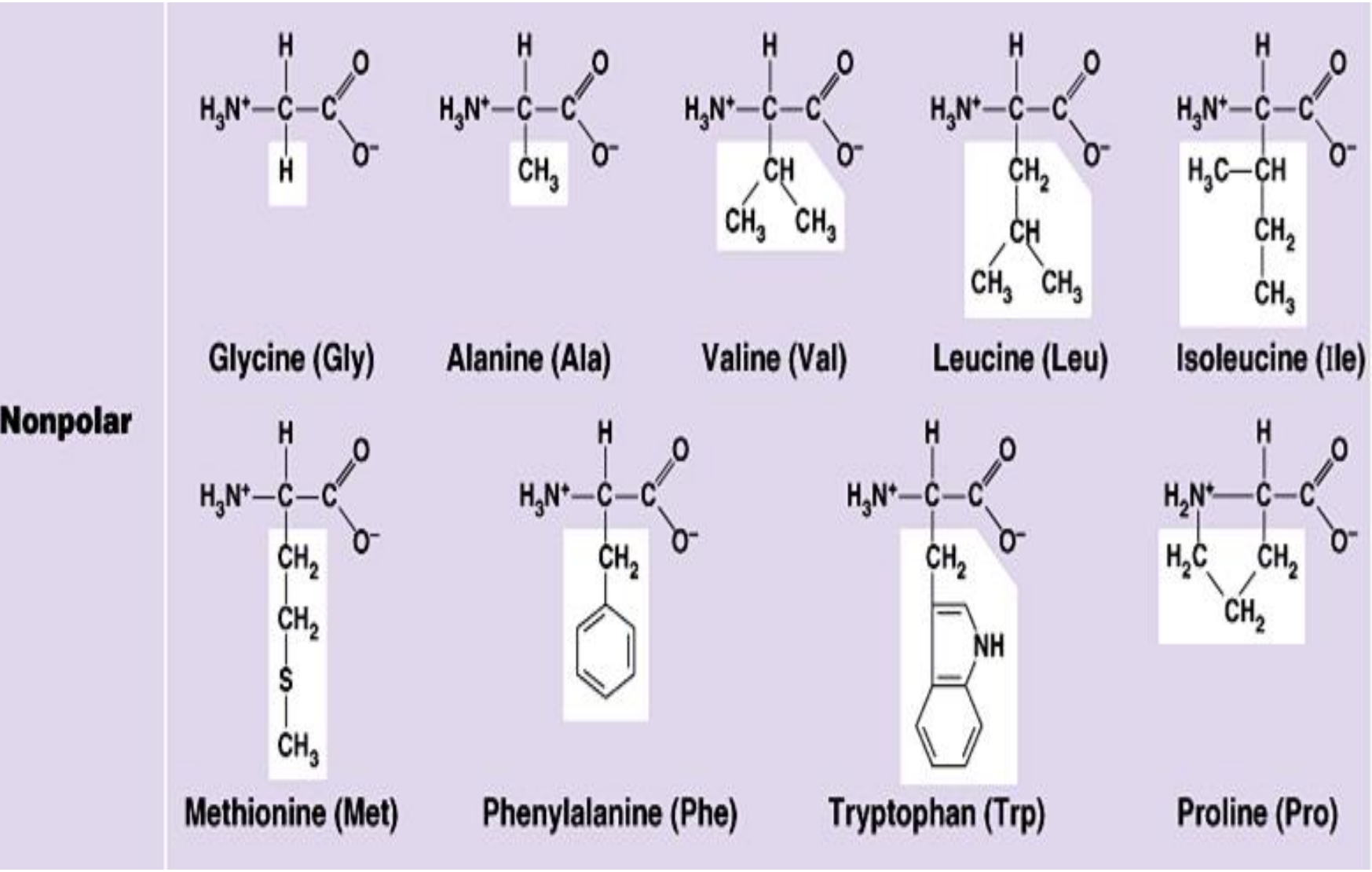
Proteins -structure

- Repeating the process over and over creates a long polypeptide chain.
  - At one end is an amino acid with a free amino group the (the N-terminus) and at the other is an amino acid with a free carboxyl group the (the C-terminus).
- The repeated sequence (N-C-C) is the polypeptide backbone.
- Attached to the backbone are the various R groups.
- Polypeptides range in size from a few monomers to thousands.

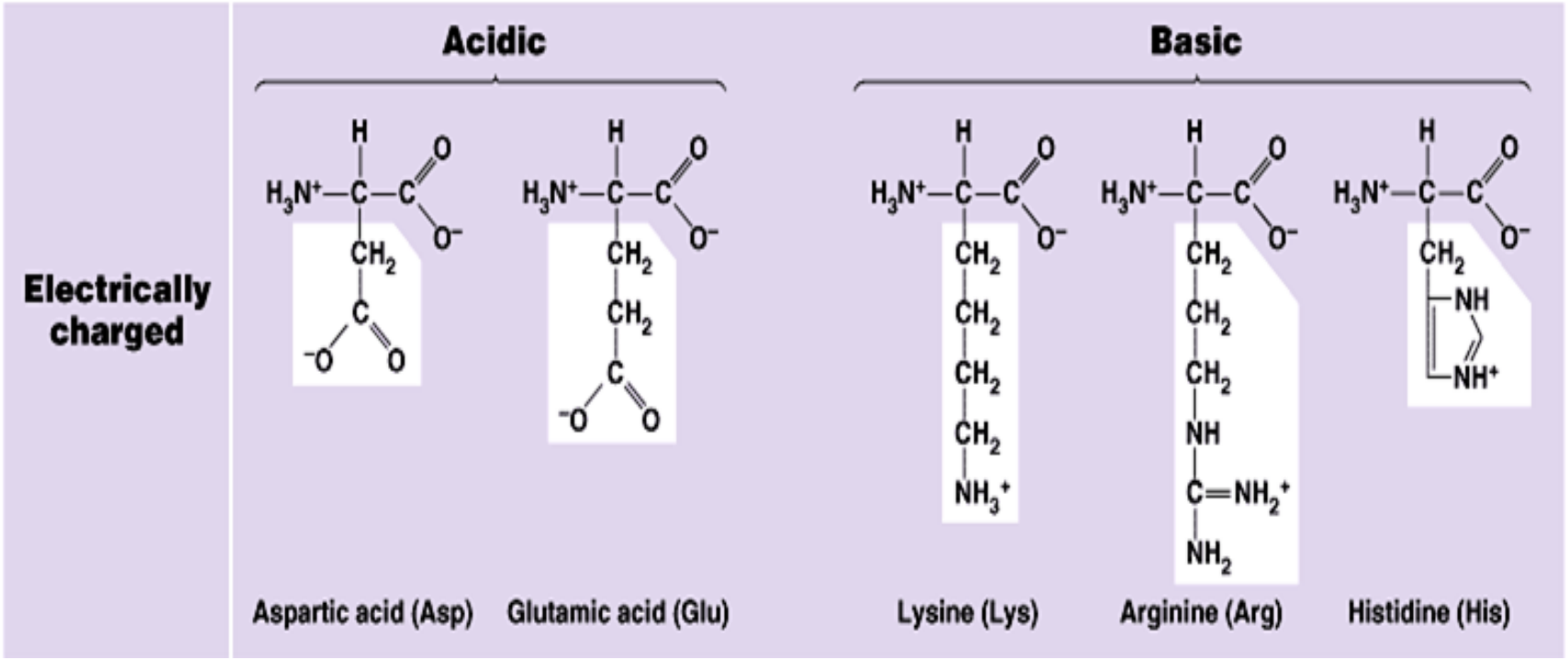
Proteins

- The twentyone different R groups may be as simple as a hydrogen atom (as in the amino acid glutamine) to a carbon skeleton with various functional groups attached.
- The physical and chemical characteristics of the R group determine the unique characteristics of a particular amino acid.

One group of amino acids has hydrophobic R groups.



- The last group of amino acids includes those with functional groups that are charged (ionized) at cellular pH.
  - Some R groups are bases, others are acids.



Classification of proteins

- **Based on their functions , chemical nature and solubility**
- **Functional classification**

1. **Structural proteins –Keratin of hair and collagen**
2. **Enzyme or catalytic proteins – Hexokinase , pepsin**
3. **Transport proteins –Haemoglobin and serum albumin**

4. Hormonal proteins –Insulin
5. Contractile proteins

Storage proteins
Ex: Nucleoproteins

Defense proteins-snake venom

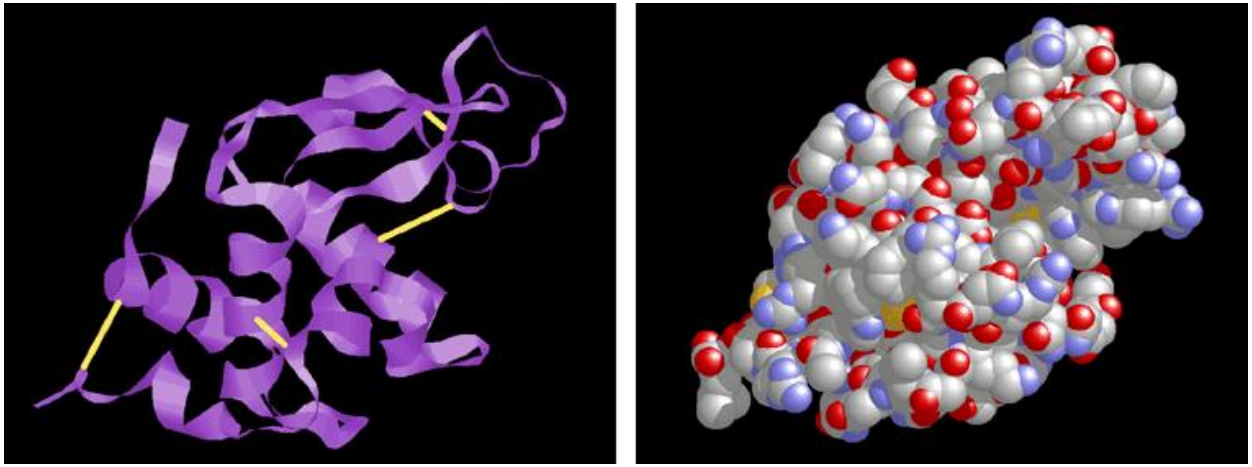
Others are:Immunoglobulins proteins, Receptor proteins

A protein's function depends on its specific conformation

- Sequence of AA determines a proteins primary structure,
- A functional proteins consists of one or more polypeptides that have been precisely twisted, folded, and coiled into a unique shape.
- It is the order of amino acids that determines what the three-dimensional conformation will be.

Structural proteins

- Conformation means structure
- Specific conformation dictates its function and binding strength



Conformation

A protein's specific conformation determines its function:

The function depends on its ability to recognize and bind to some other molecule.

i. Antibodies bind to particular foreign substances that fit their binding sites
ii. AEnzyme recognize and bind to specific substrates, facilitating a chemical reaction
iii. Neurotransmitters pass signals from one cell to another by binding to receptor sites on proteins in the membrane of the receiving cell

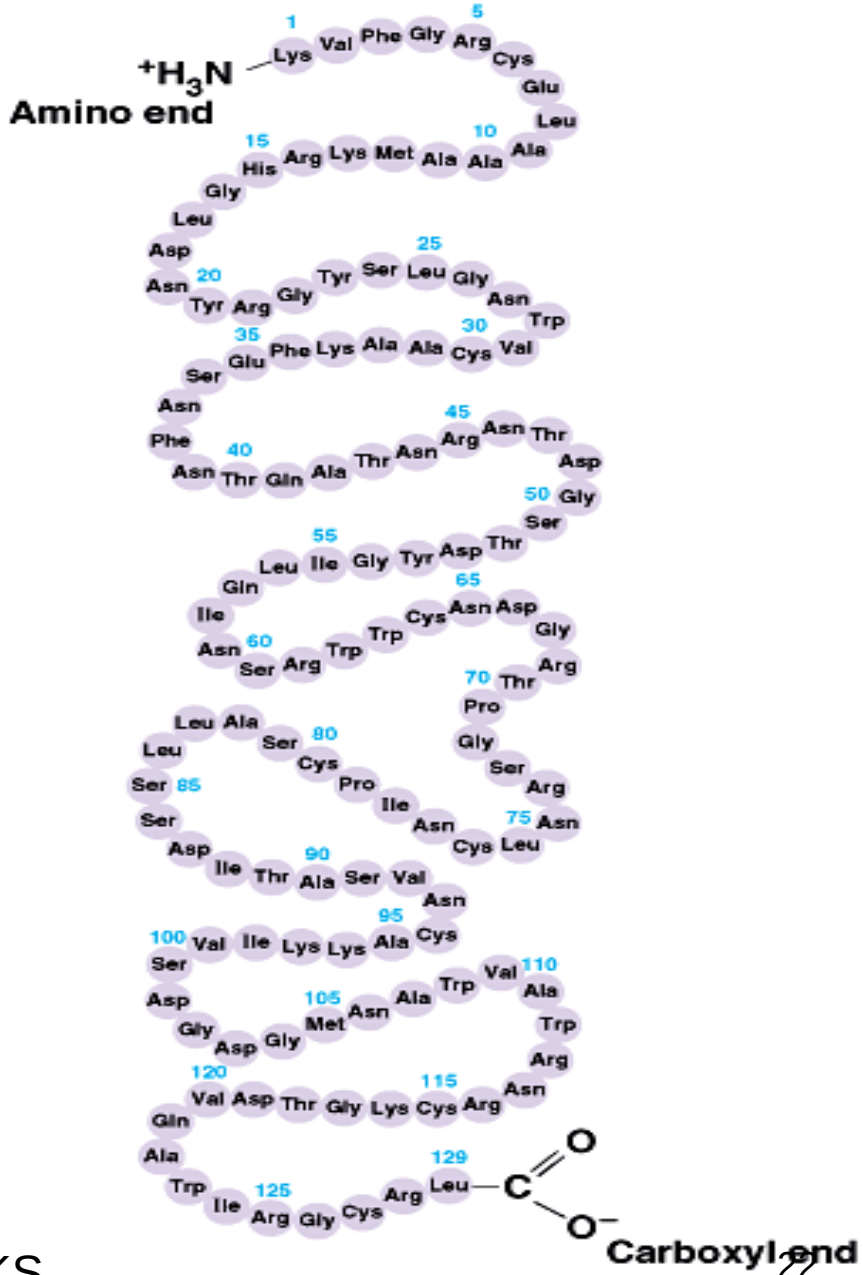
Levels of Protein Structure

1. Primary structure
2. Secondary structure
3. Tertiary structure
   - ➢ are used to organize the folding within a **single** polypeptide.
4. Quarternary structure arises when **two or more** polypeptides join to form a protein.

Primary structure

-The **primary structure** of a protein is its unique sequence of amino acids.

- Lysozyme, an enzyme that attacks bacteria, consists on a polypeptide chain of 129 amino acids.
- The precise primary structure of a protein is determined by inherited genetic information.

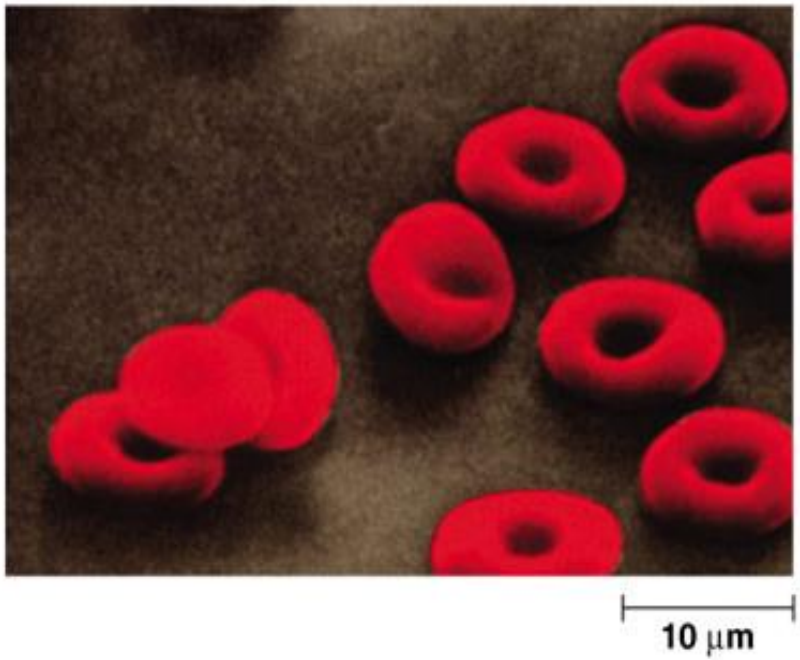


Primary structure

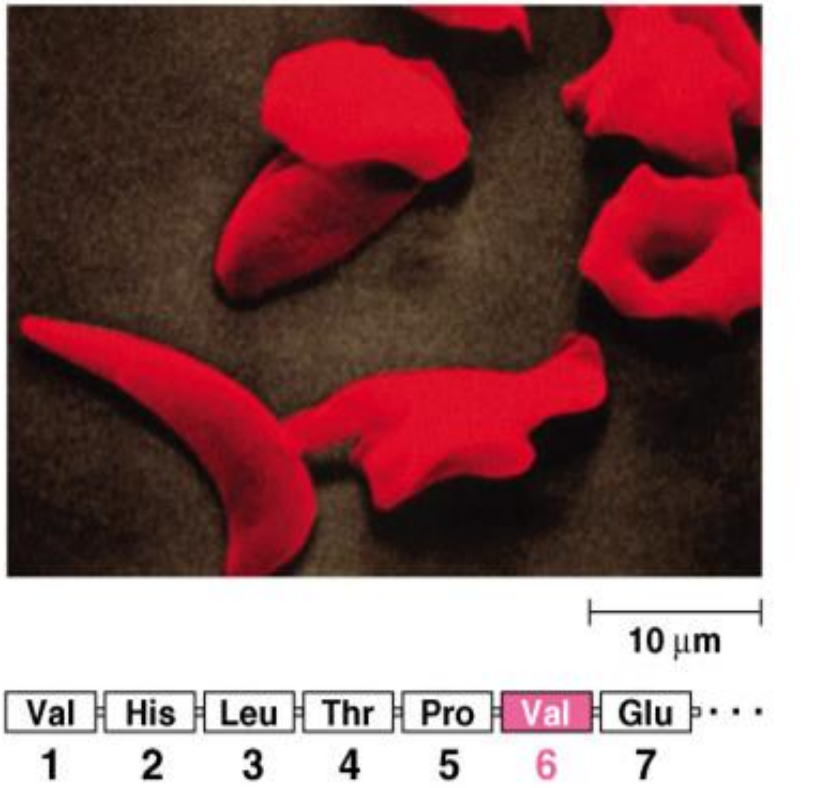
- A slight change in primary structure affects a protein's conformation and ability to function

Ex:In individuals with sickle cell disease, abnormal hemoglobins, oxygen-carrying proteins, develop because of a single amino acid substitution

Abnormal hemoglobins crystallize, deforming the red blood cells and leading to clogs in tiny blood vessels



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

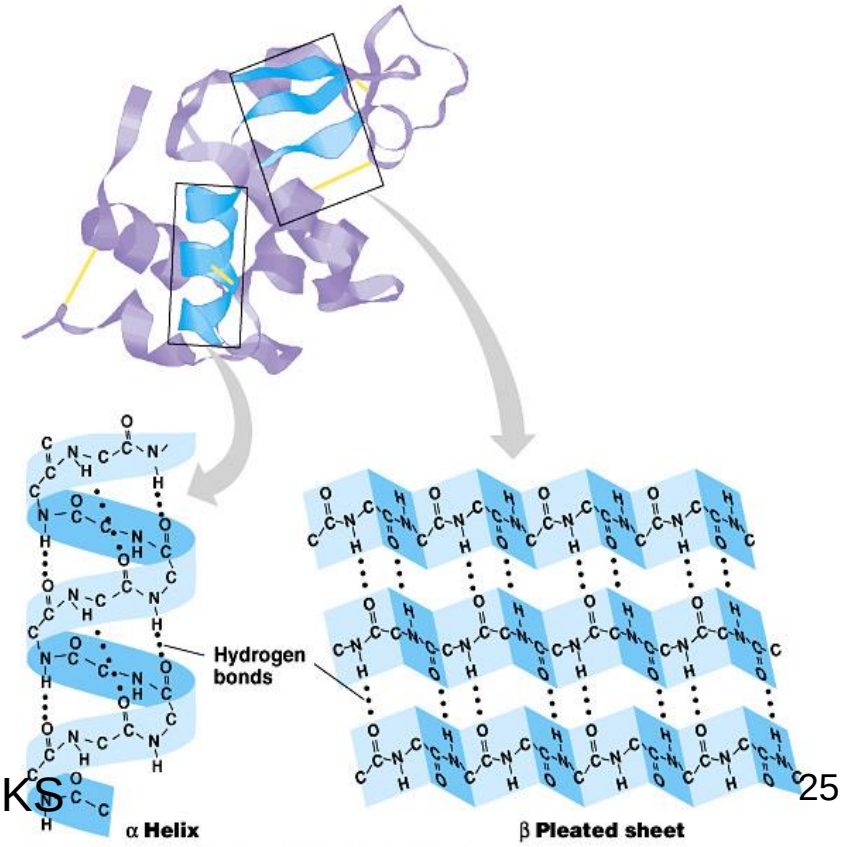


(b) Sickled red blood cells and the primary structure of sickle-cell hemoglobin

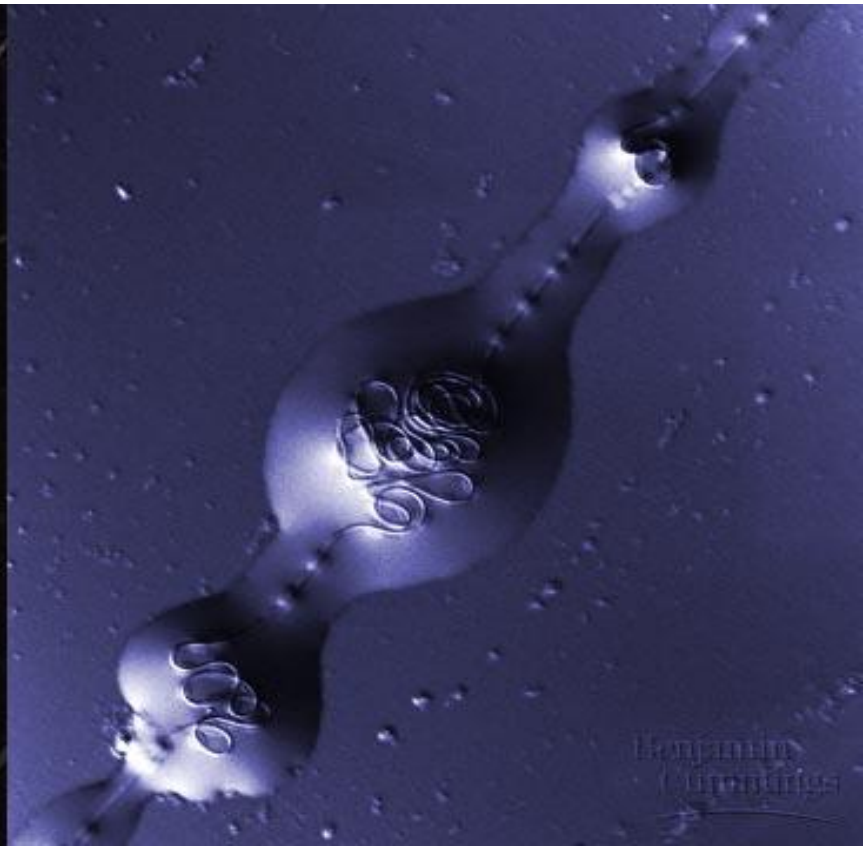
Secondary Structure

The **secondary structure** of a protein results from hydrogen bonds at regular intervals along the polypeptide backbone

Typical shapes that develop from secondary structure are coils (an alpha helix) or folds (beta pleated sheets).



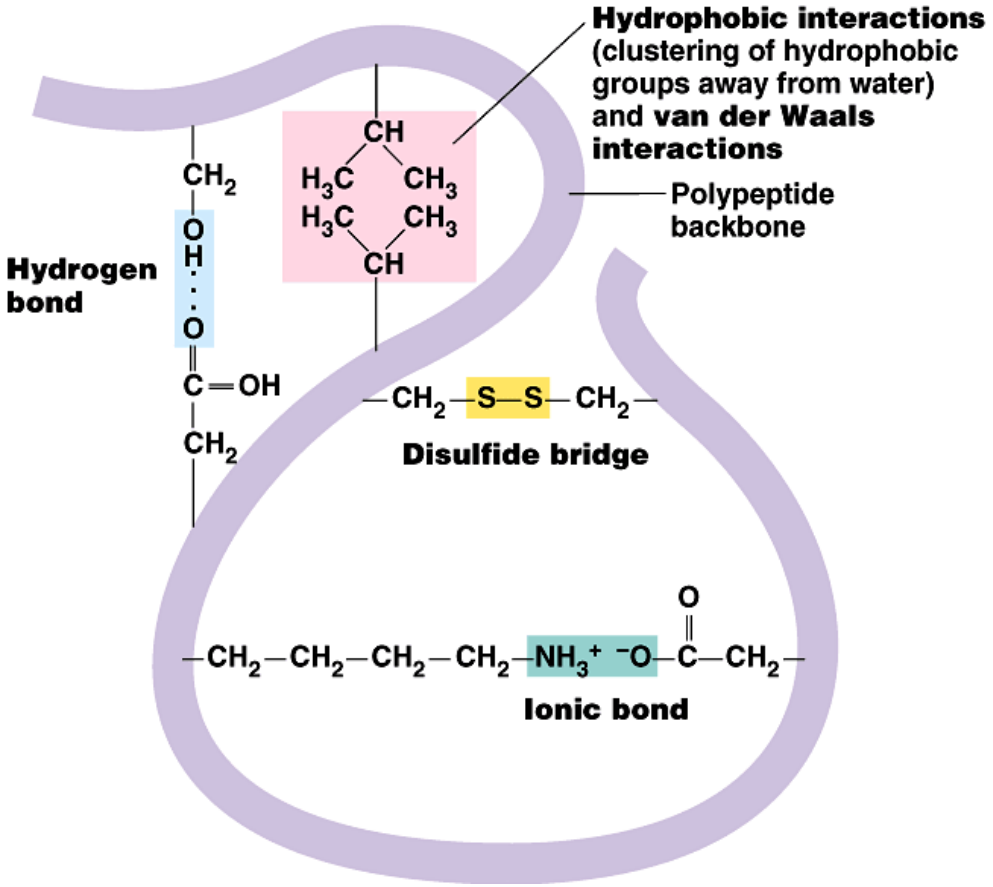
Structural properties of silk - beta pleated sheets
Numerous hydrogen bonds: silk fiber stronger than steel



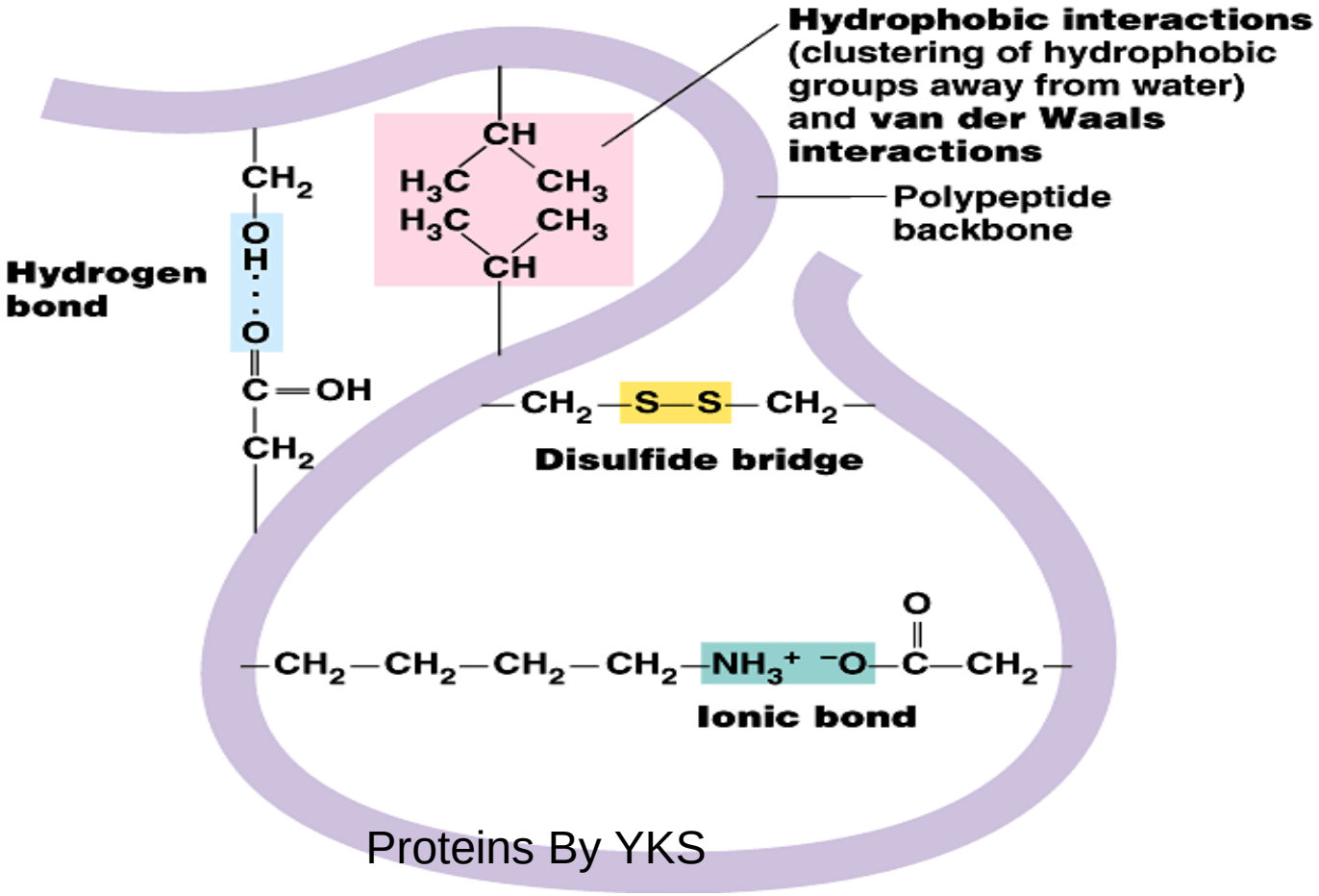
Tertiary structure

Tertiary structure is determined by a variety of interactions among R groups and between R groups and the polypeptide backbone.

-These interactions include hydrogen bonds among polar and/or charged areas, ionic bonds between charged R groups, and **hydrophobic interactions** and **van der Waals interactions** among hydrophobic R groups.



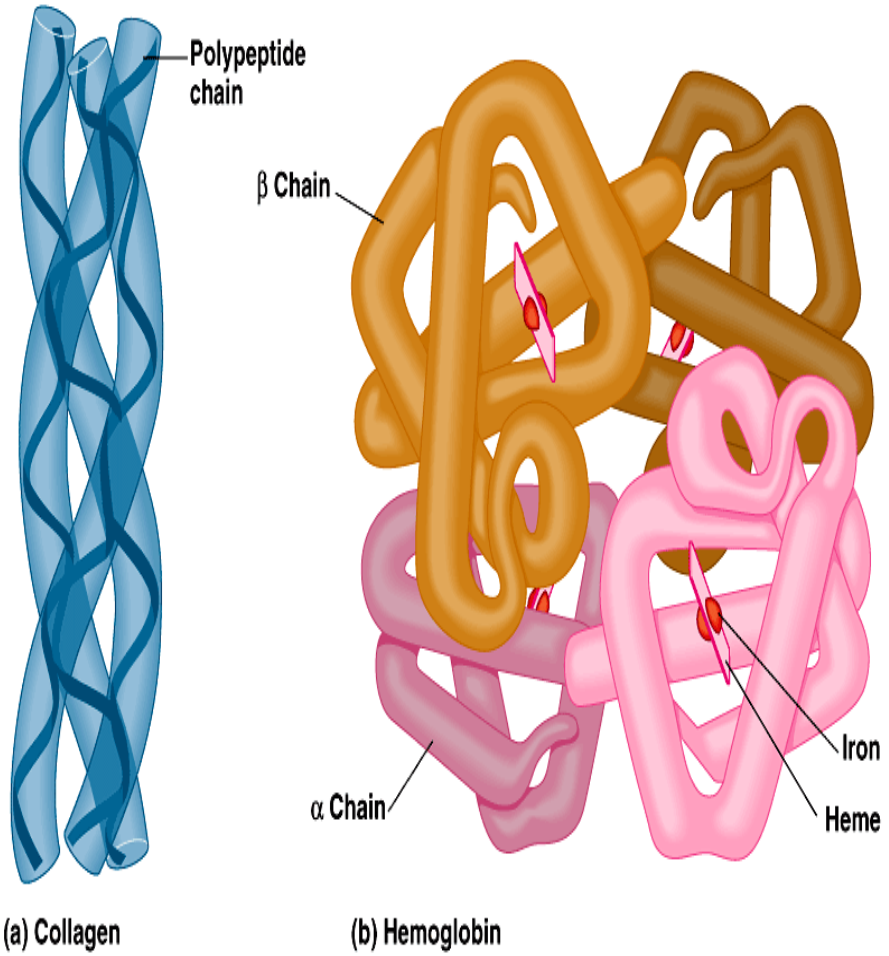
While these three interactions are relatively weak, **disulfide bridges**, strong covalent bonds that form between the sulfhydryl groups (SH) of cysteine monomers, stabilize the structure.

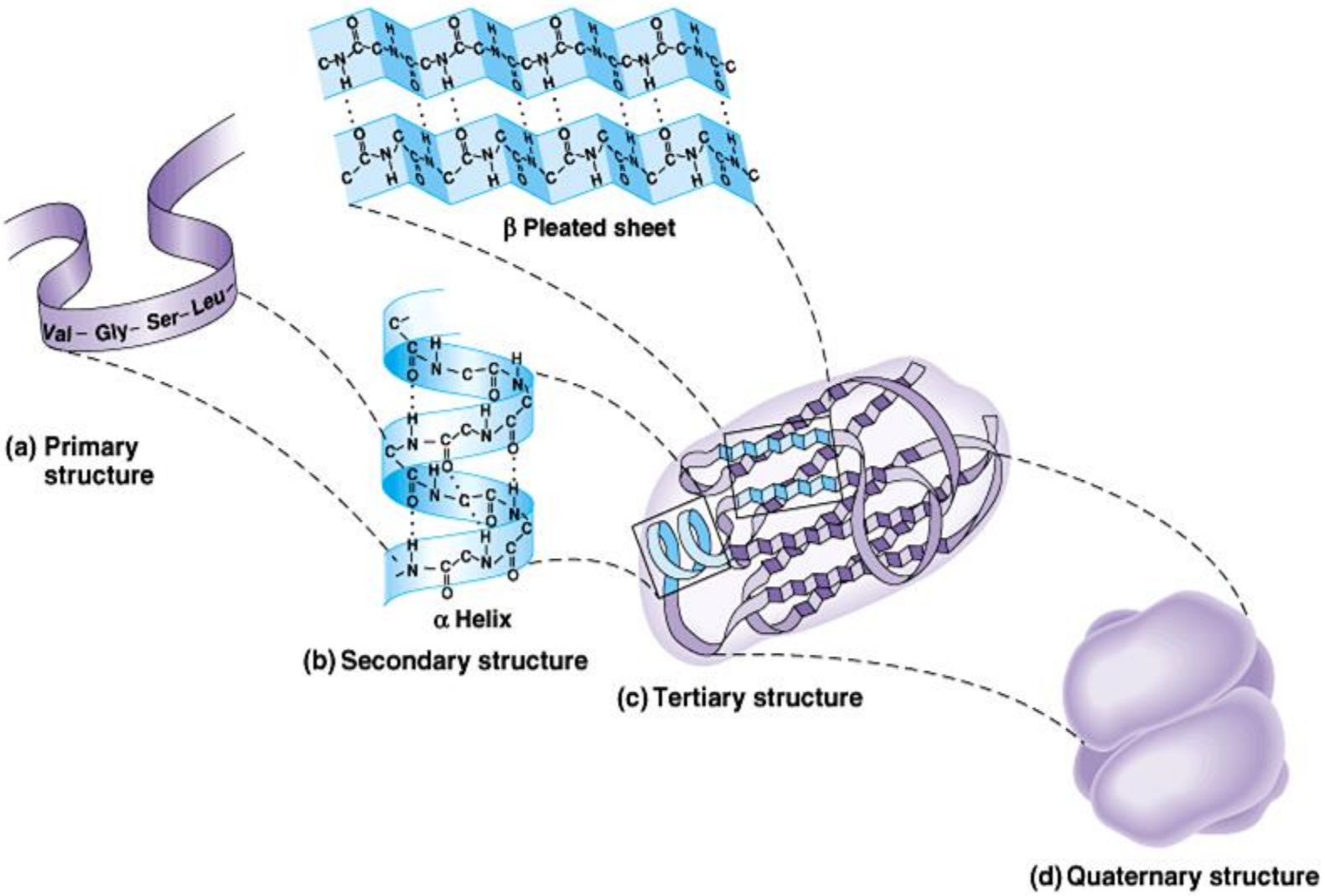


Quarternary structure

Quarternary structure results from the aggregation of **two or more** polypeptide subunits

- Collagen is a fibrous protein of three polypeptides that are supercoiled like a rope.
  - This provides the structural strength fo their role in connective tissue.
- Hemoglobin is a globular protein with **two copies of two kinds**

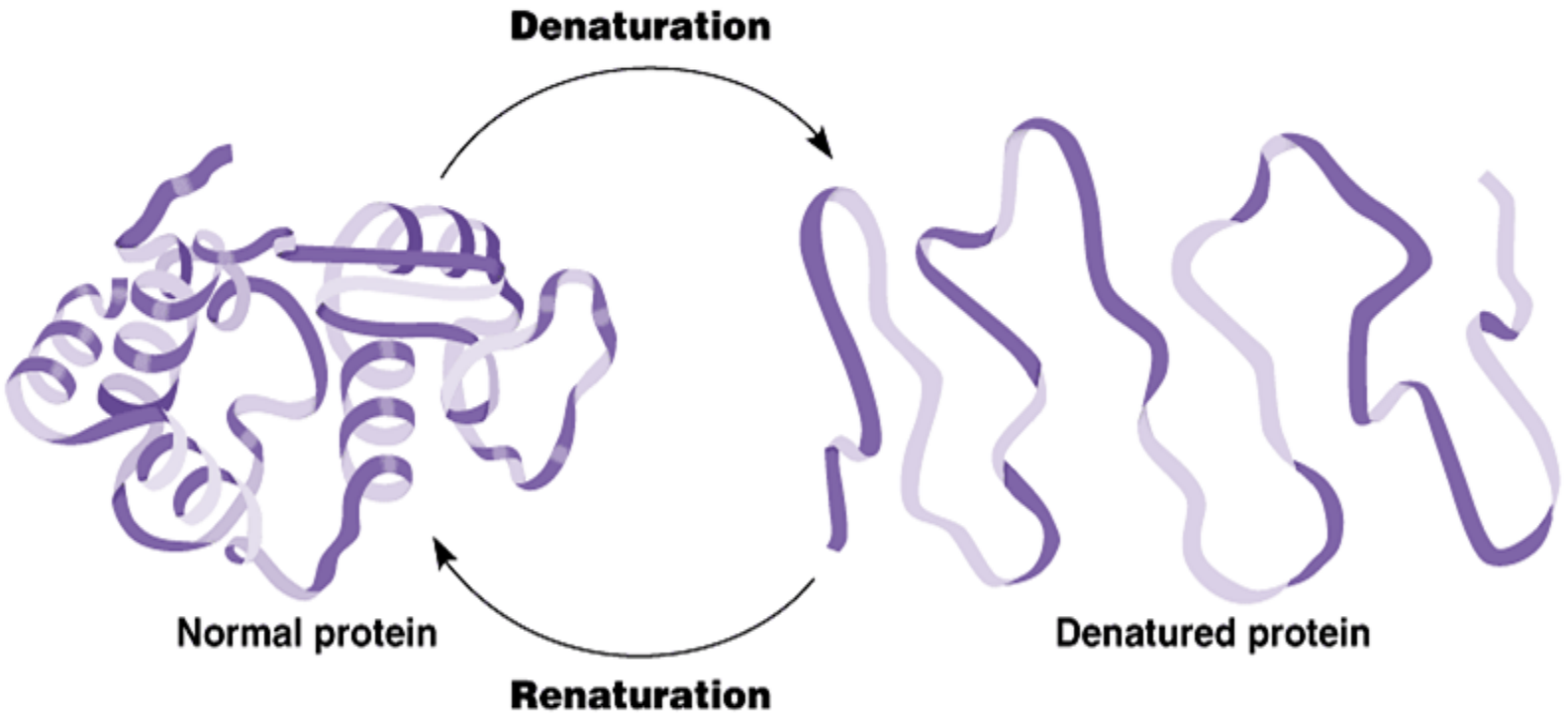



β Pleated sheet
Val – Gly– Ser–Leu–
(a) Primary structure
α Helix
(b) Secondary structure
(c) Tertiary structure
(d) Quaternary structure

Conformation of protein

A protein's conformation can change in response to the physical and chemical conditions.

- Changes in pH, salt concentration, temperature, or other factors can unravel or **denature** a protein.
  - These forces disrupt the hydrogen bonds, ionic bonds, and disulfide bridges that maintain the protein's shape.
- Some proteins can return to their functional shape after denaturation, but others cannot, especially in the crowded environment of the cell.
  - Usually denaturation is permanent


Denaturation
Normal protein
Denatured protein
Renaturation