

PROTEINS

Biological Molecules

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graph TD; A[Biological Molecules] --- B[Carbohydrates]; A --- C[Lipids]; A --- D[Nucleic Acids]; A --- E[Proteins]
```

Carbohydrates

Lipids

Nucleic Acids

Proteins

(A Few of the Many) **Protein Functions**

- **Structural** - hair, nails, etc.
- **Movement** - muscle proteins
- **Enzymes** - speed up chemical reactions
- **Receptors** - cell-to-cell communication
- **Energy** - when carbs are not available

Hair and Nails

A protein called alpha-keratin forms your hair and fingernails, and also is the major component of feathers, wool, claws, scales, horns, and hooves.

Blood

The hemoglobin protein carries oxygen in your blood to every part of your body.

Muscles

Muscle proteins called actin and myosin enable all muscular movement—from blinking to breathing to rollerblading.

Brain and Nerves

Ion channel proteins control brain signaling by allowing small molecules into and out of nerve cells.

Cellular Messengers

Receptor proteins stud the outside of your cells and transmit signals to partner proteins on the inside of the cells.

Enzymes

Enzymes in your saliva, stomach, and small intestine are proteins that help you digest food.

Antibodies

Antibodies are proteins that help defend your body against foreign invaders, such as bacteria and viruses.

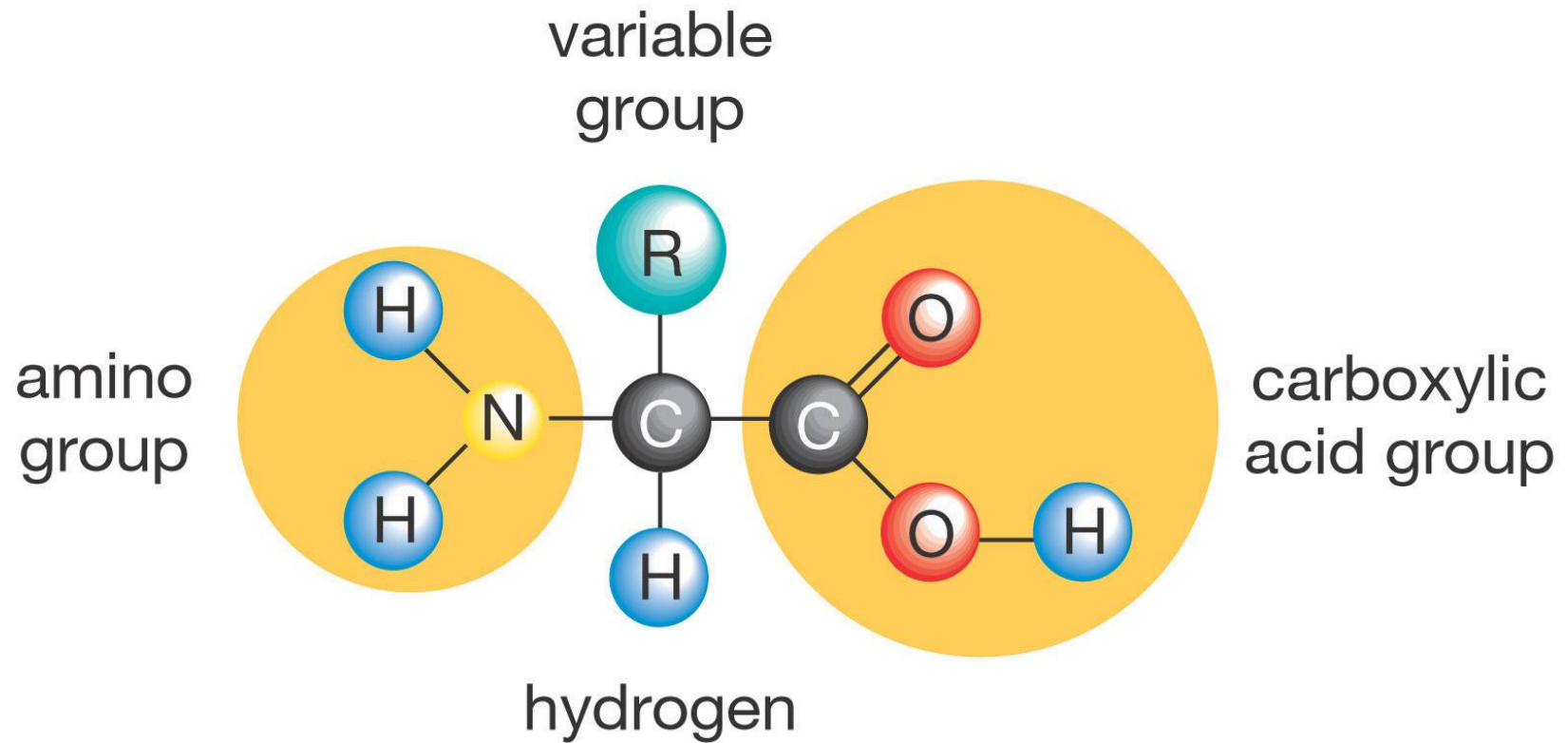
Cellular Construction Workers

Huge clusters of proteins form molecular machines that do your cells' heavy work, such as copying genes during cell division and making new proteins.



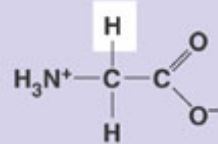
Biological Molecule	Monomer	Polymer(s)
Carbohydrates	Monosaccharide	Disaccharide, Polysaccharide
Lipids	None, but bigger lipid molecules are generally made of glycerol and fatty acid chains	Big molecules include: triglycerides, steroids, and phospholipids
Nucleic Acids	Nucleotide	DNA, RNA
Proteins	Amino Acid	Dipeptide, Polypeptide

Protein Monomer: AMINO ACID

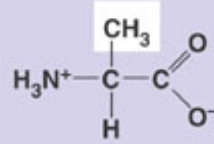


Amino Acids (Part 1 of 2)

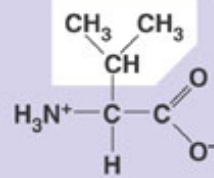
Nonpolar



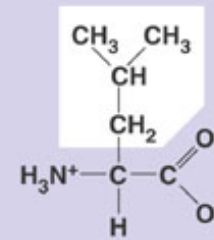
Glycine (Gly)



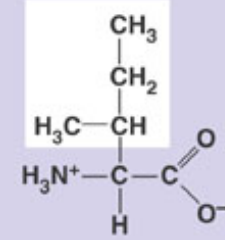
Alanine (Ala)



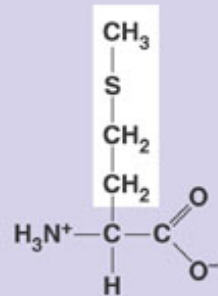
Valine (Val)



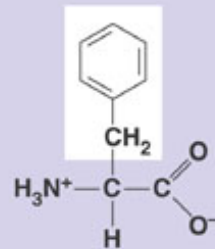
Leucine (Leu)



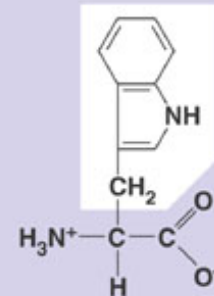
Isoleucine (Ile)



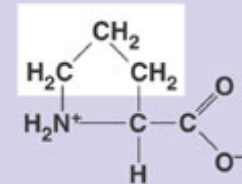
Methionine (Met)



Phenylalanine (Phe)



Tryptophan (Trp)



Proline (Pro)

Amino Acids (Part 2 of 2)

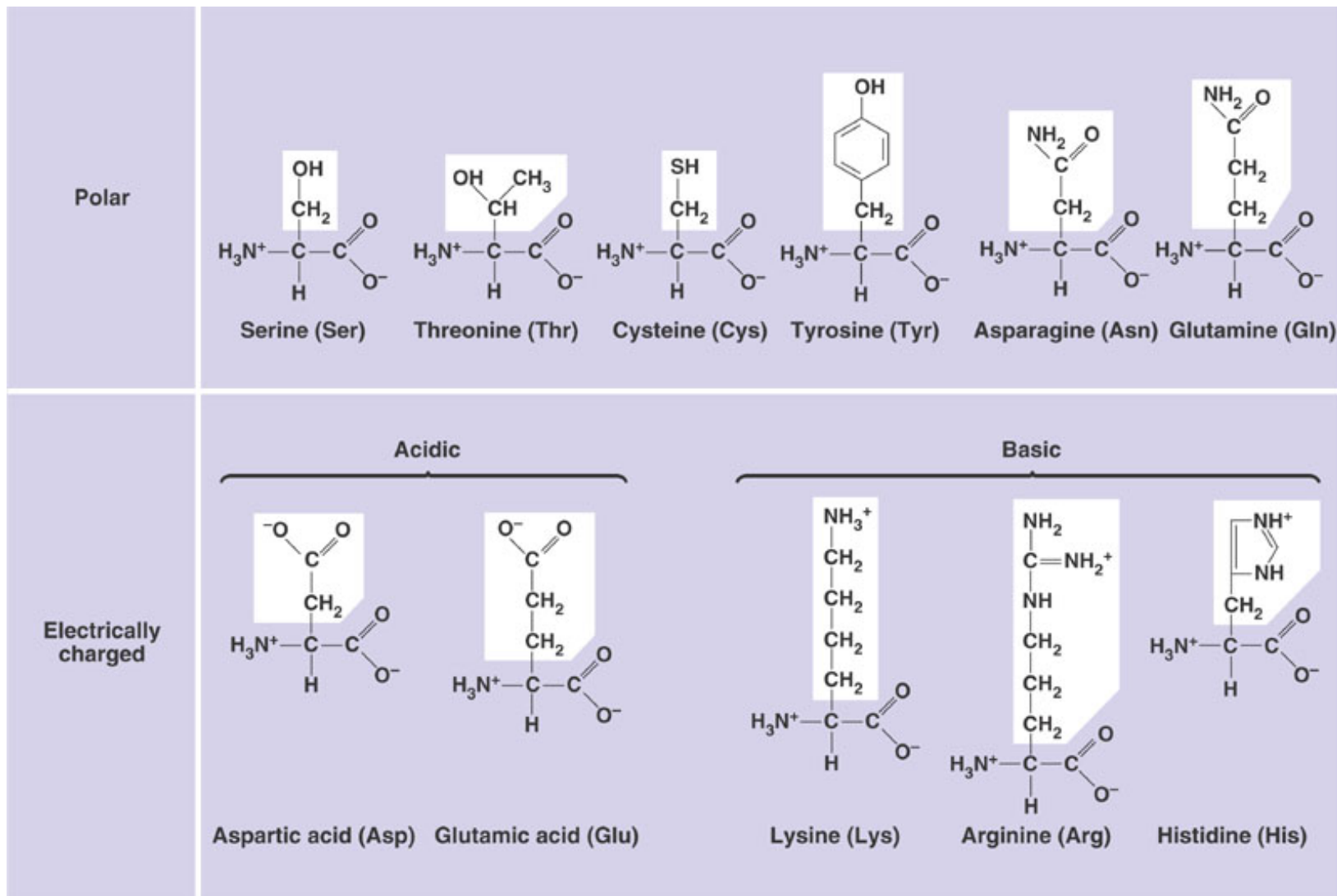
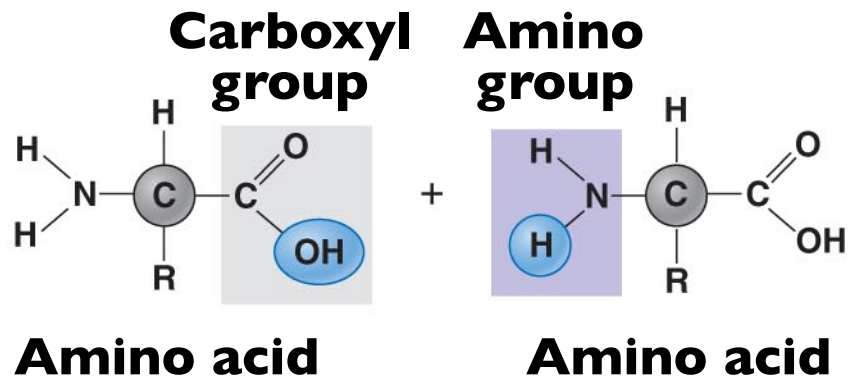
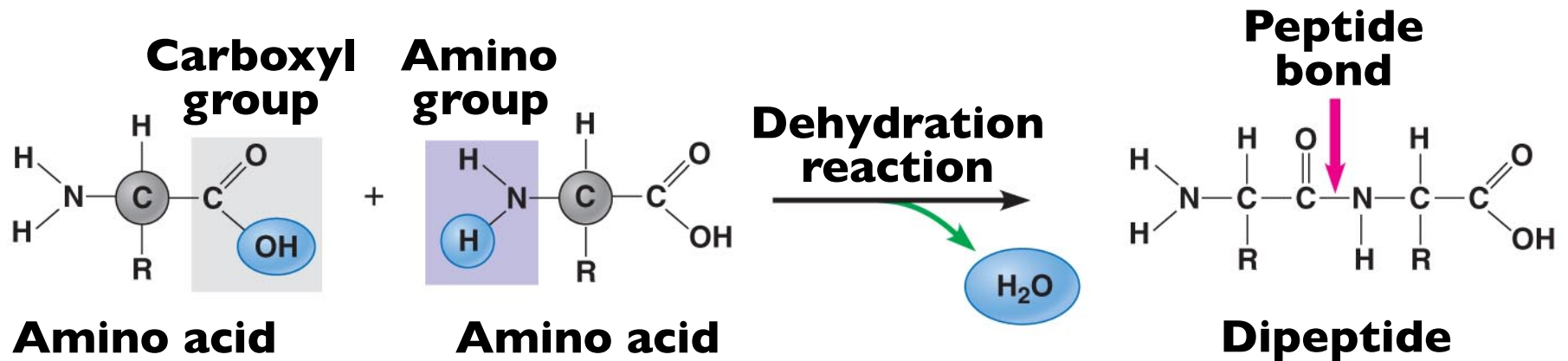


Fig. 3-12c-1

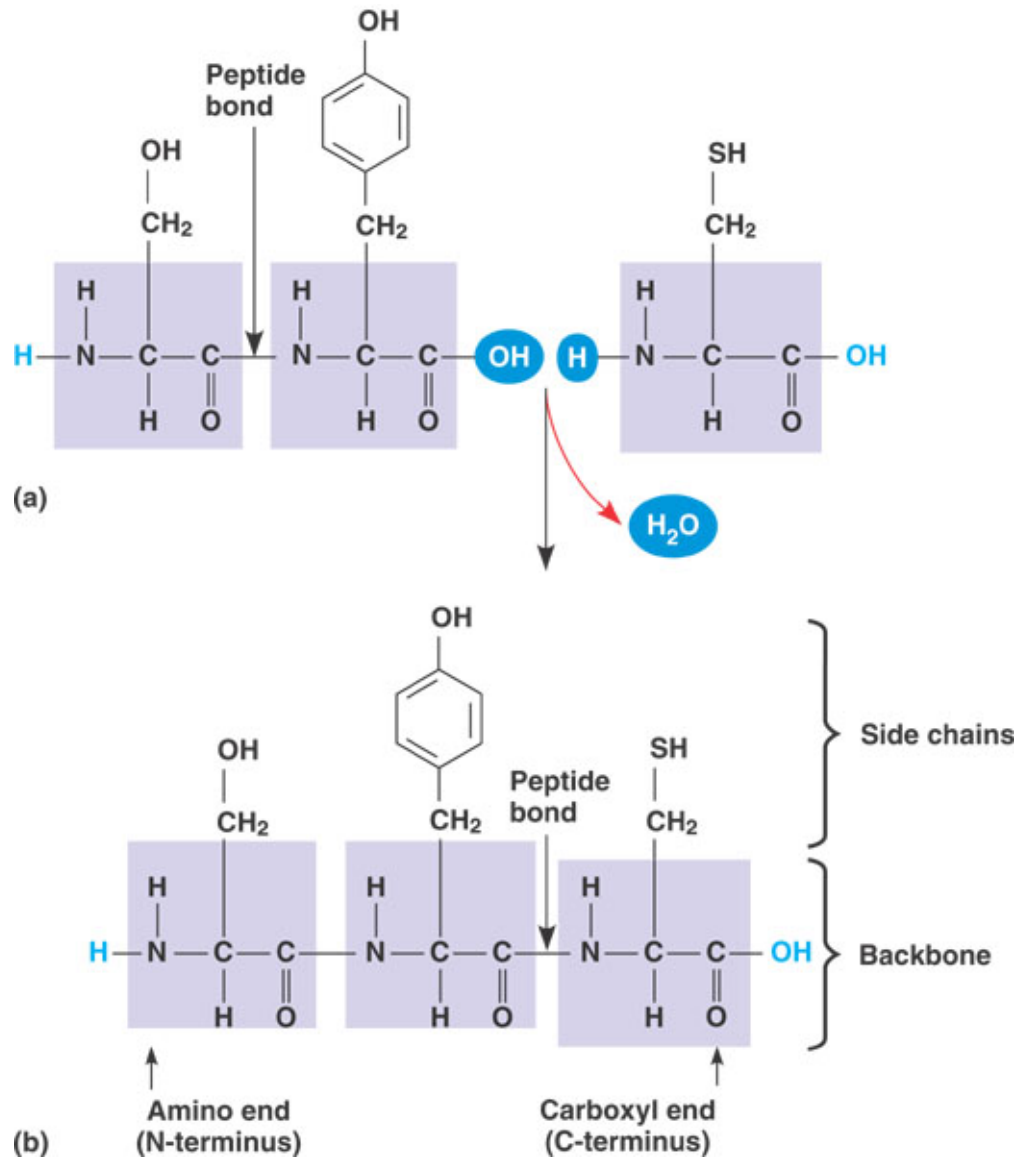
Formation of a dipeptide



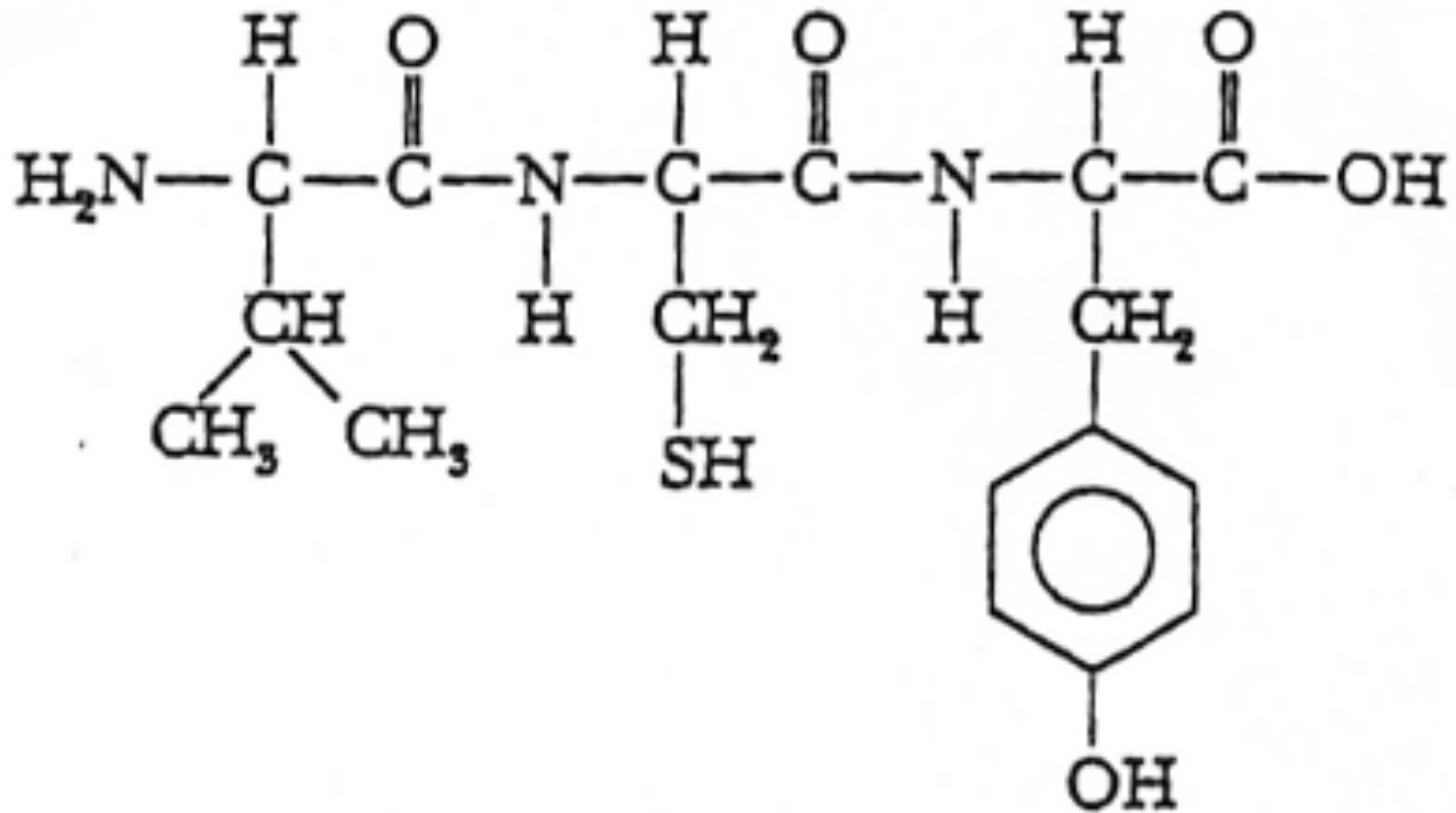
Formation of a dipeptide



Formation of a polypeptide



How many amino acids?



**PROTEIN
STRUCTURE**

=

**PROTEIN
FUNCTION**

Fig. 3-13a

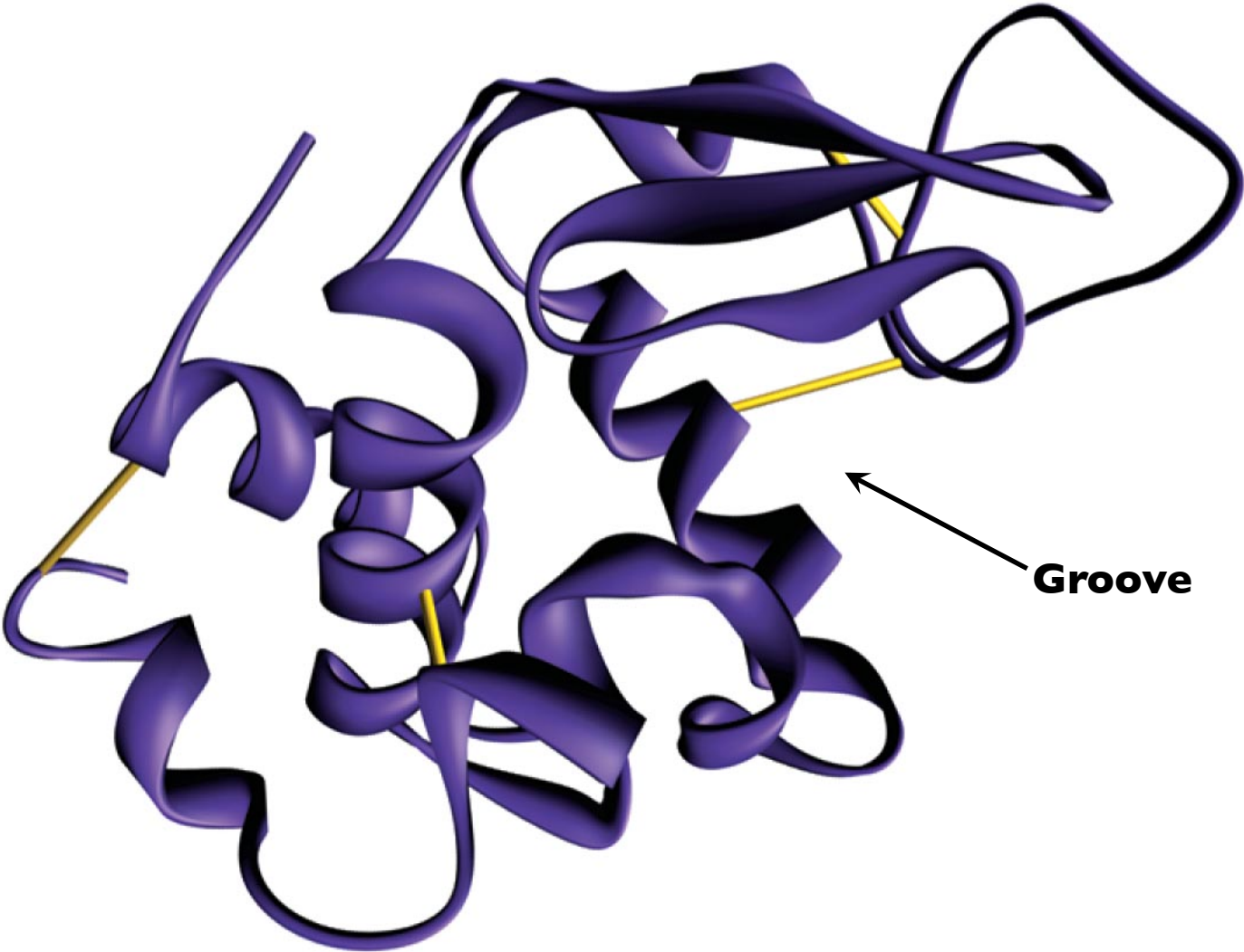


Fig. 3-13b

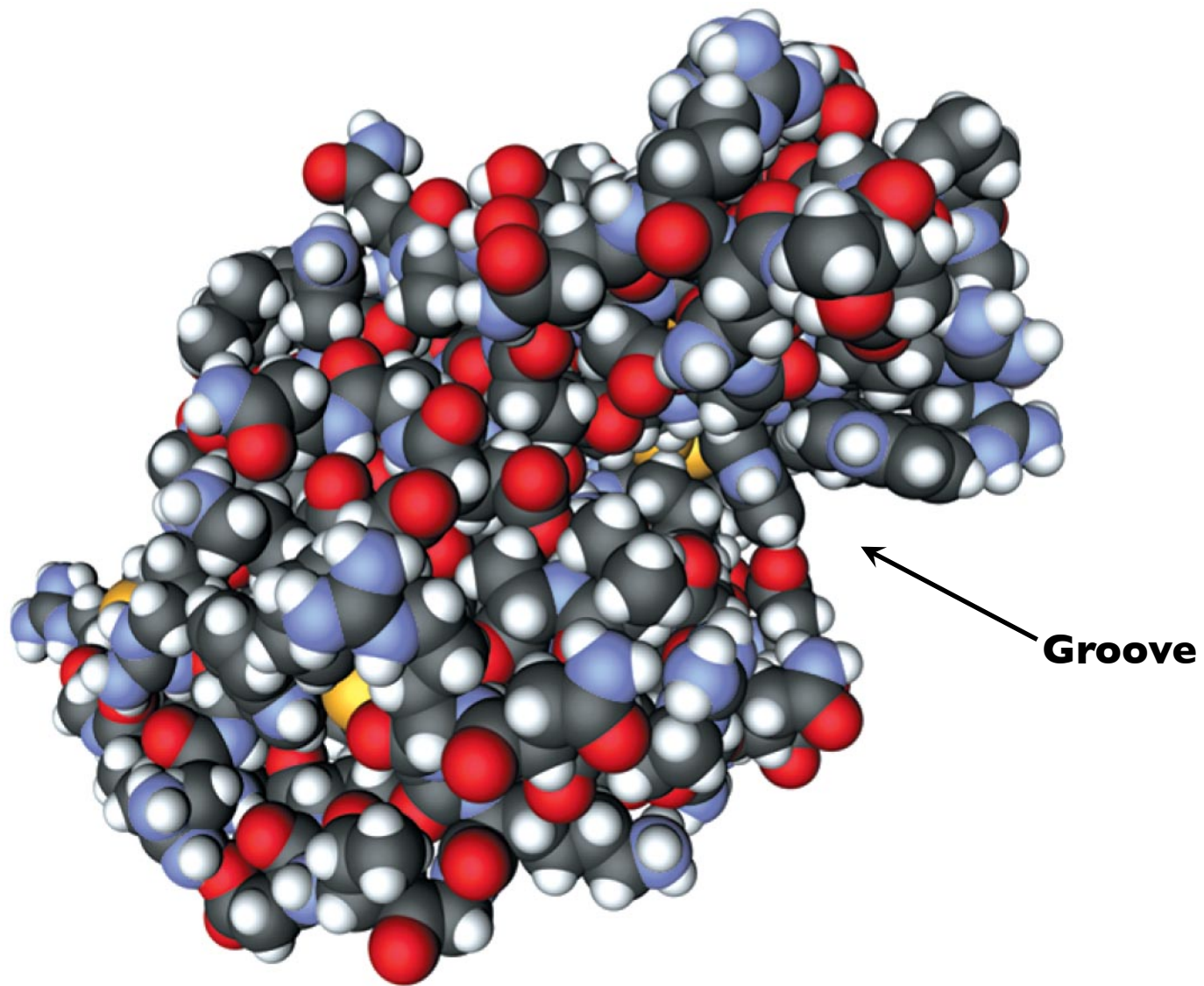


Fig. 3-14a-1

Primary structure

Four Levels of Protein Structure

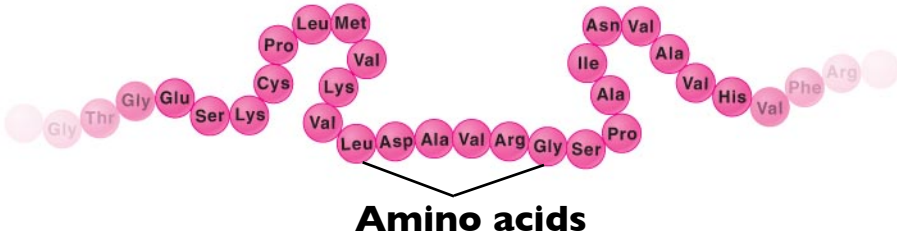
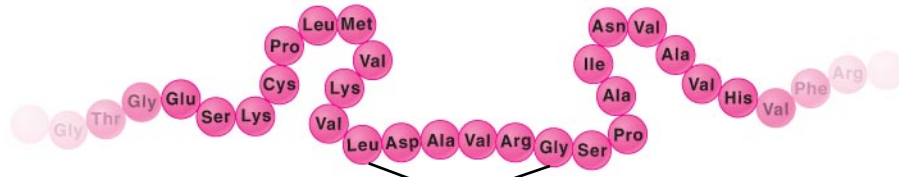


Fig. 3-14a-2

Four Levels of Protein Structure

Primary structure



Amino acids

Secondary structure

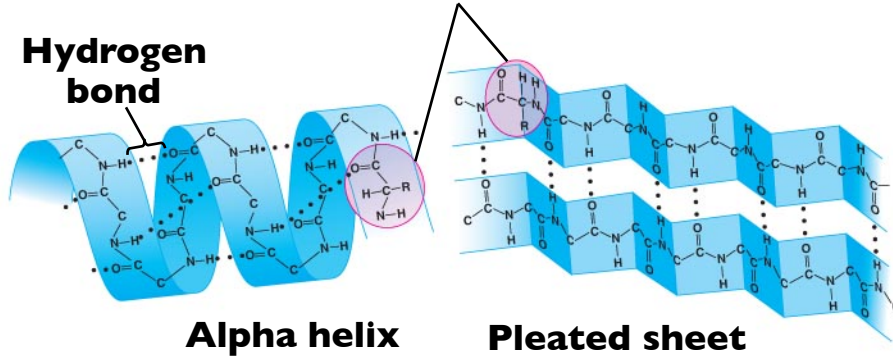
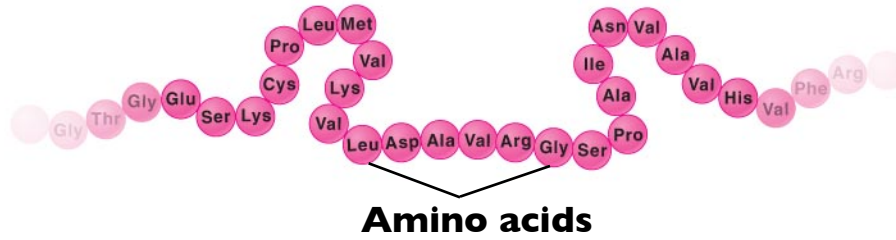


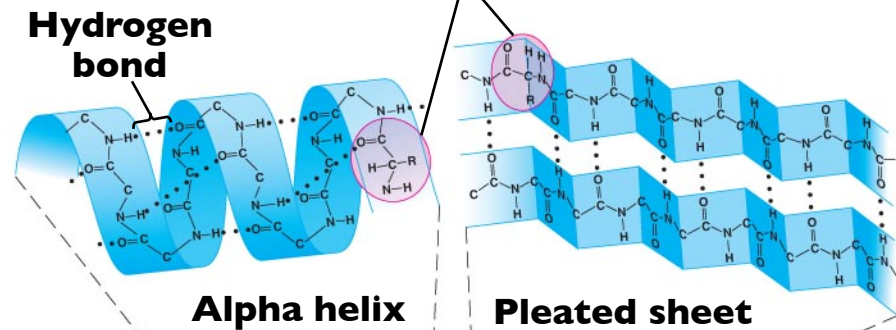
Fig. 3-14a-4

Four Levels of Protein Structure

Primary structure

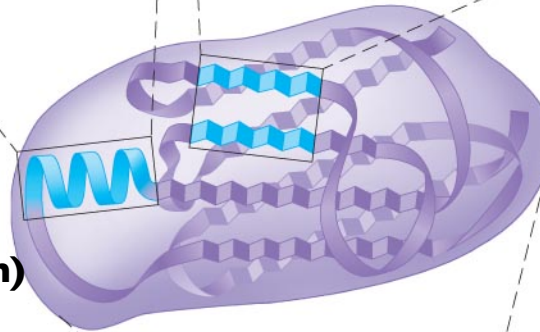


Secondary structure



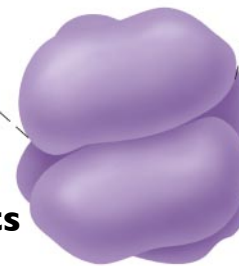
Tertiary structure

**Polypeptide
(single subunit
of transthyretin)**



Quaternary structure

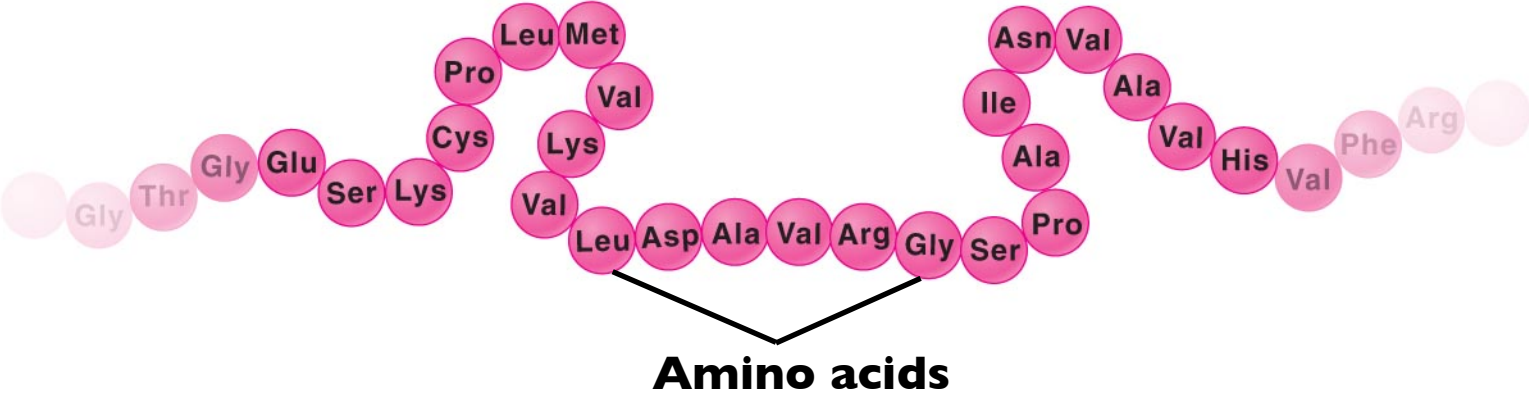
**Transthyretin, with
four identical
polypeptide subunits**



Levels of Protein Structure

- **Primary - linear sequence of amino acids held together by peptide bonds.**

Fig. 3-14aa



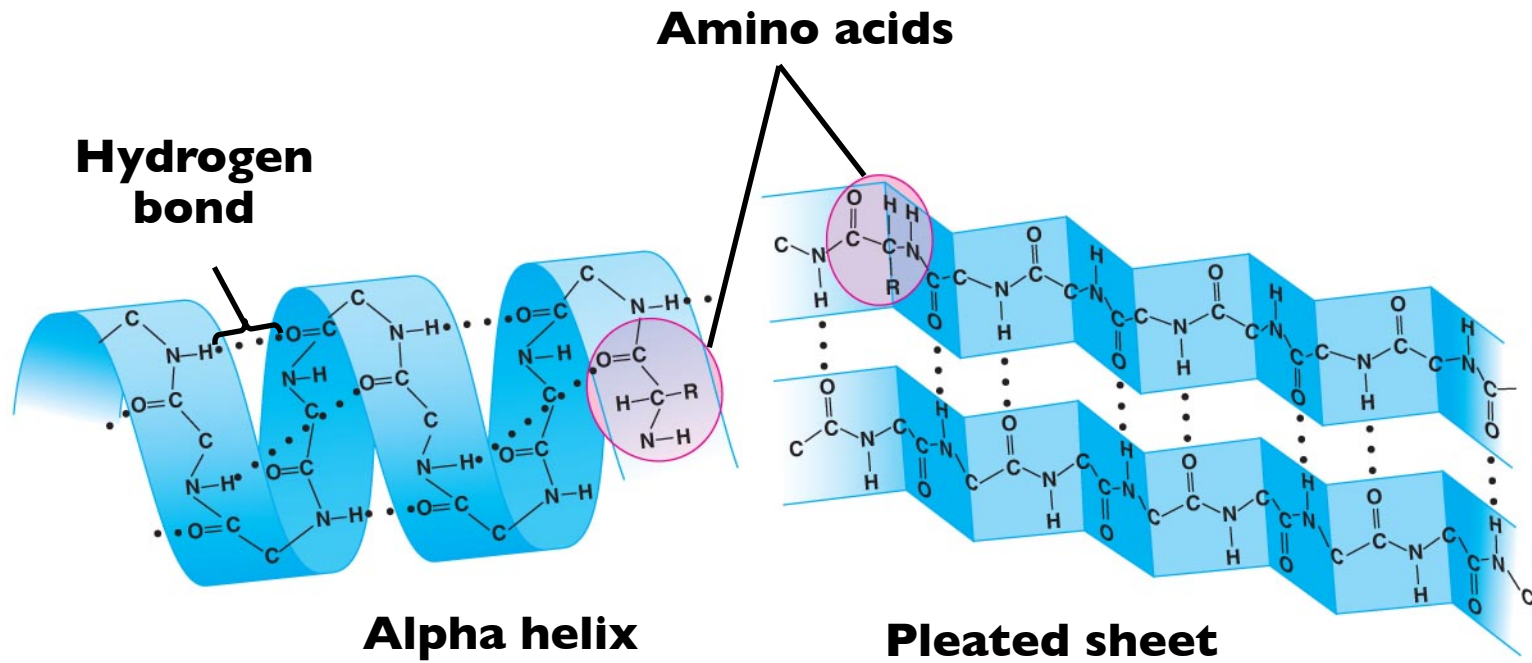
Primary structure

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Levels of Protein Structure

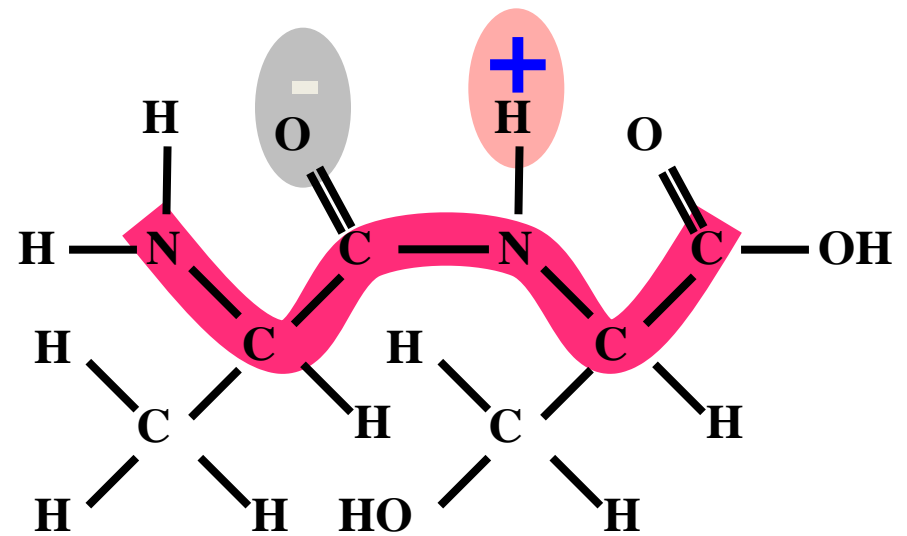
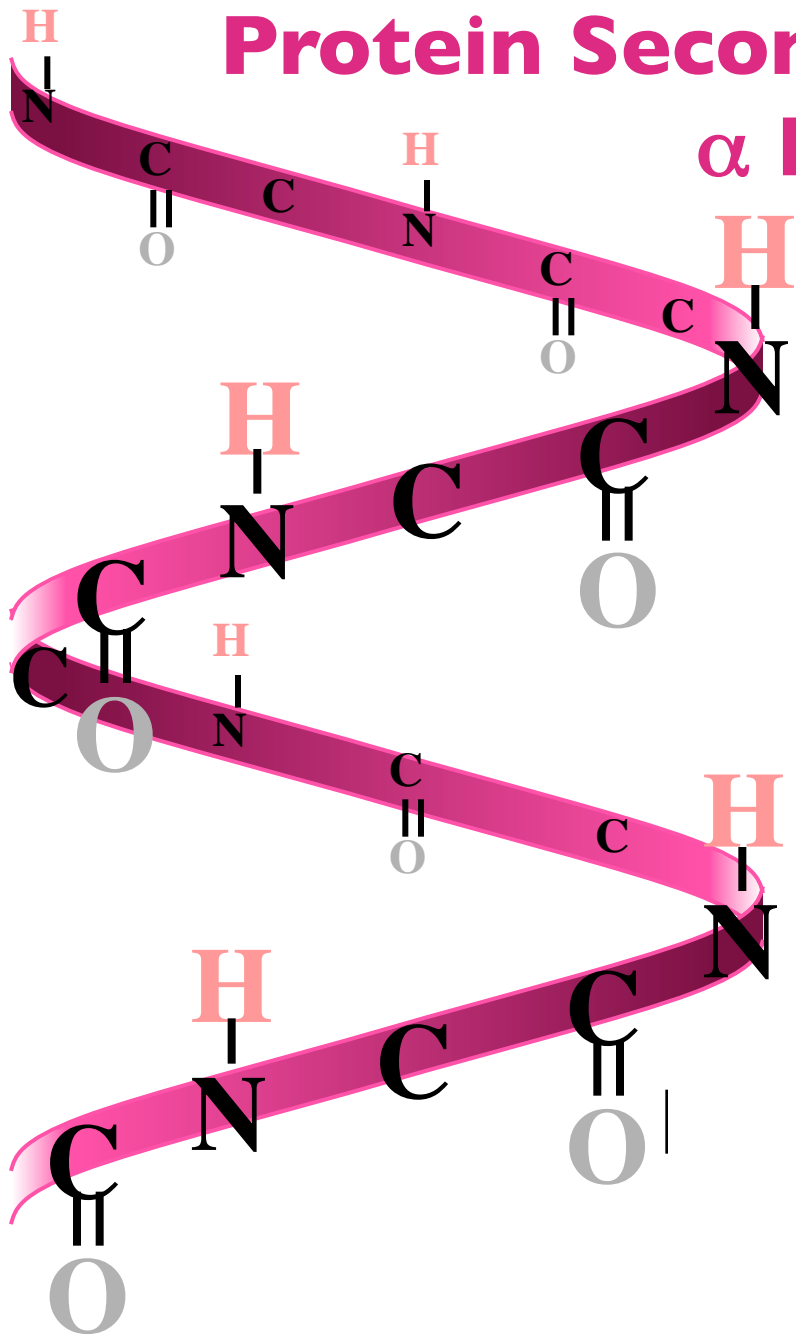
- **Primary** - linear sequence of amino acids held together by peptide bonds.
- **Secondary** - The formation of alpha helices and beta pleated sheets due to hydrogen bonding between atoms of the peptide backbone (*not* R-group interactions)

Fig. 3-14ab

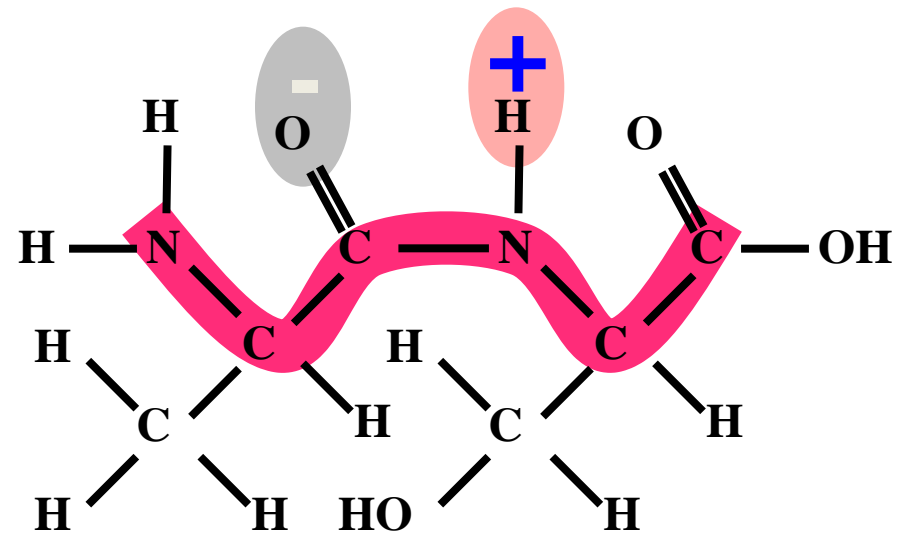
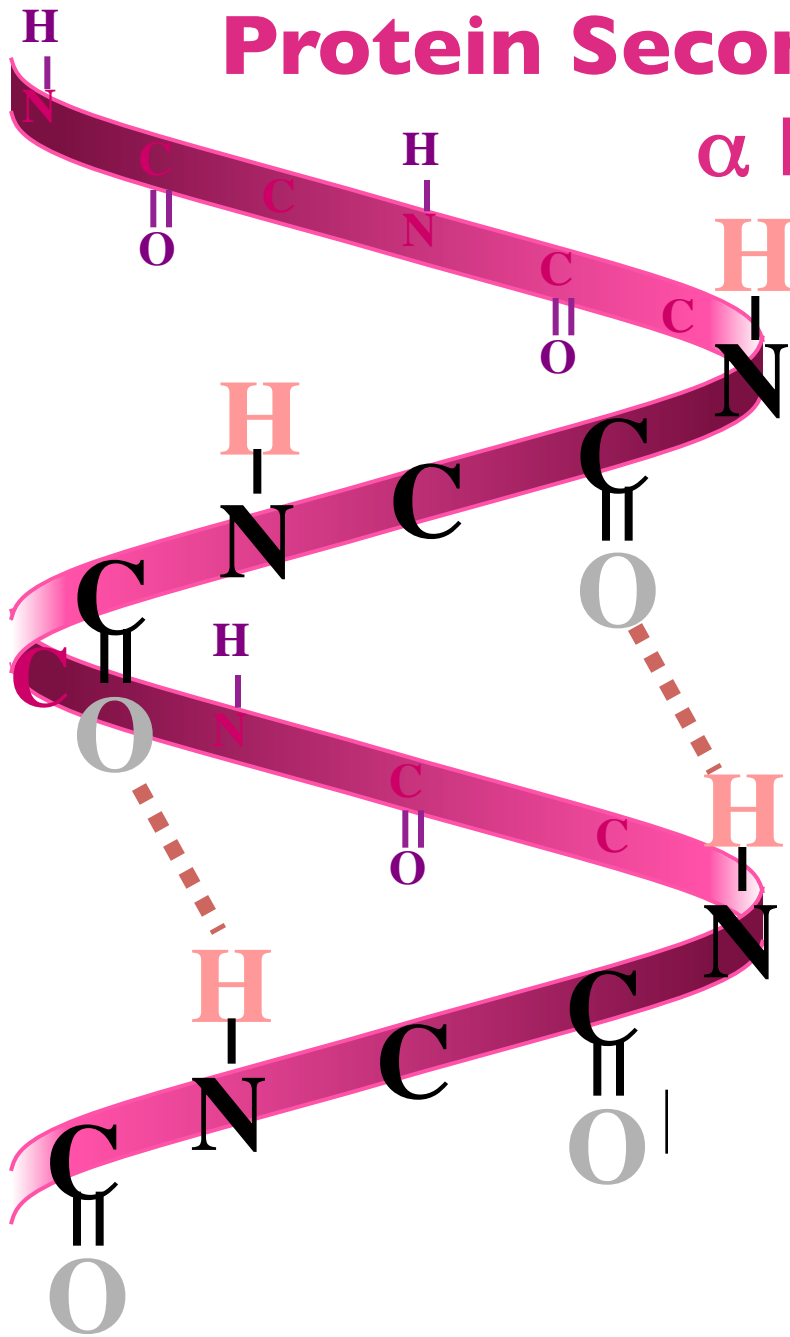


Secondary structure

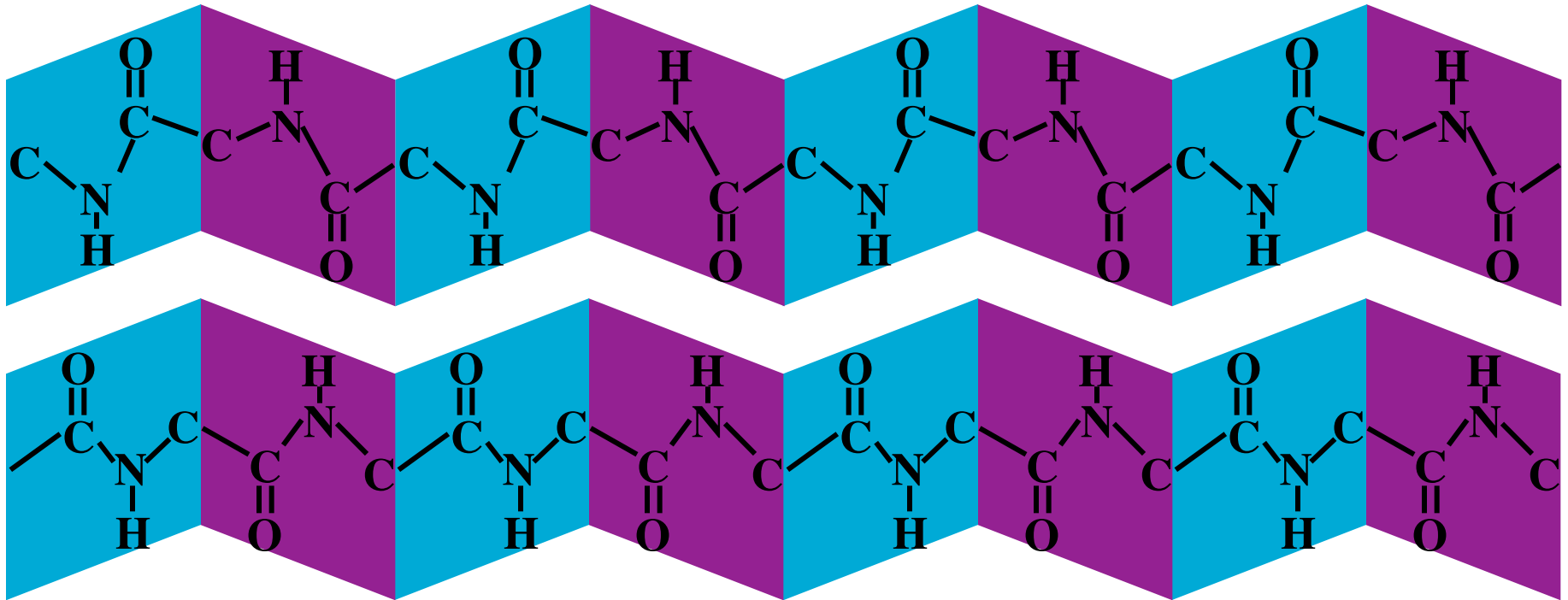
Protein Secondary Structure: α Helix



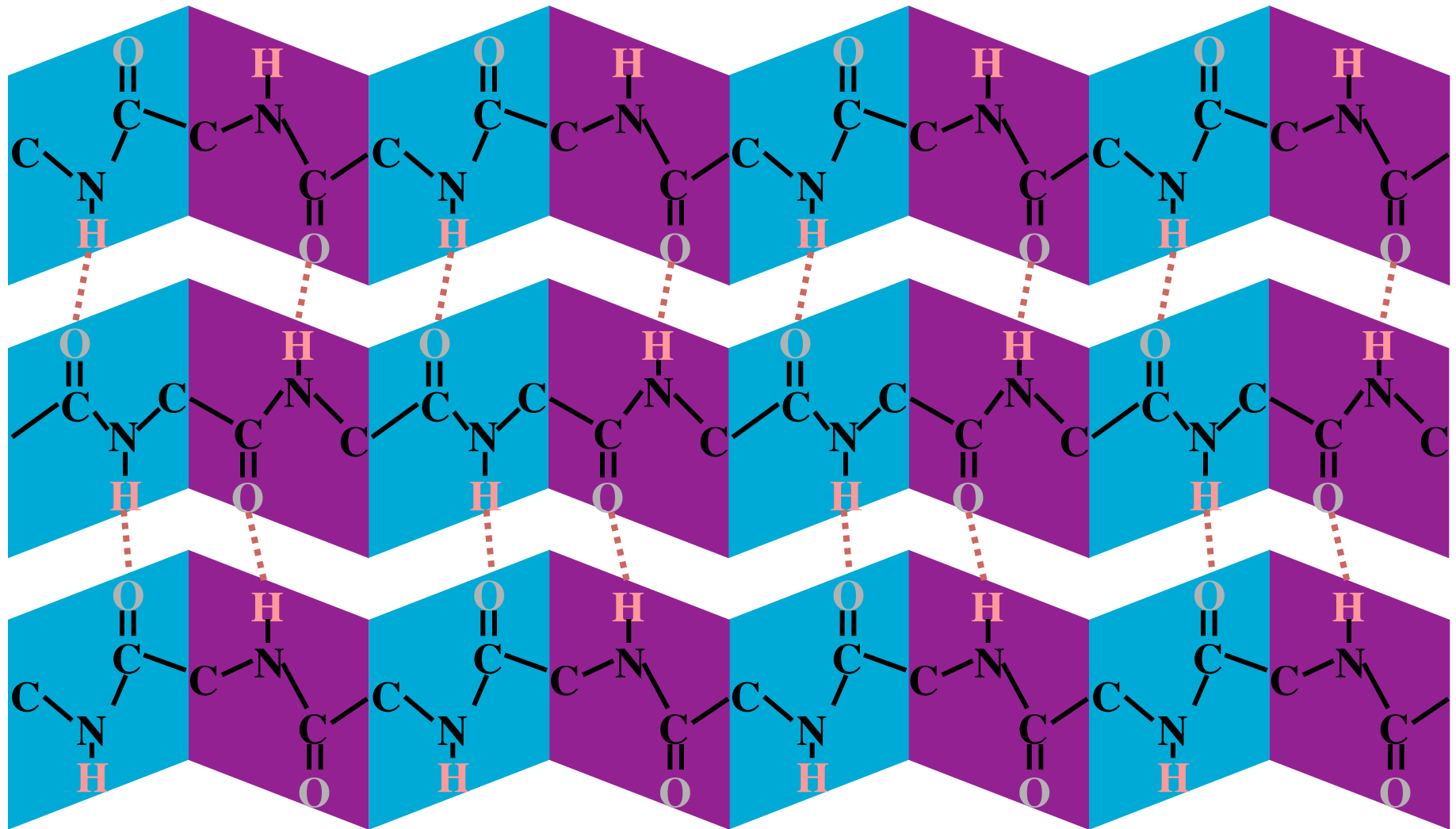
Protein Secondary Structure: α Helix

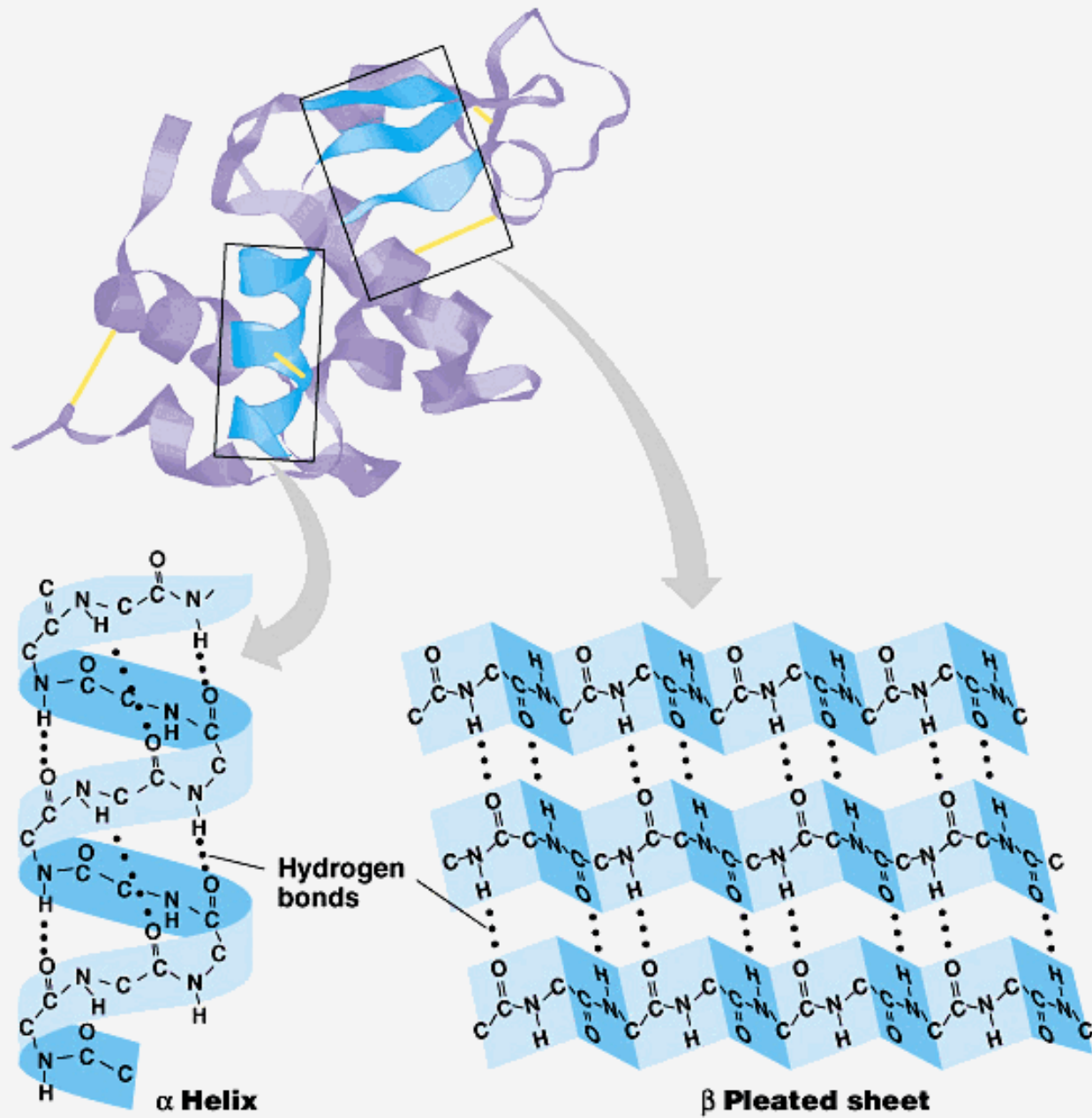


Protein Secondary Structure: β Pleated Sheet



Protein Secondary Structure: β Pleated Sheet



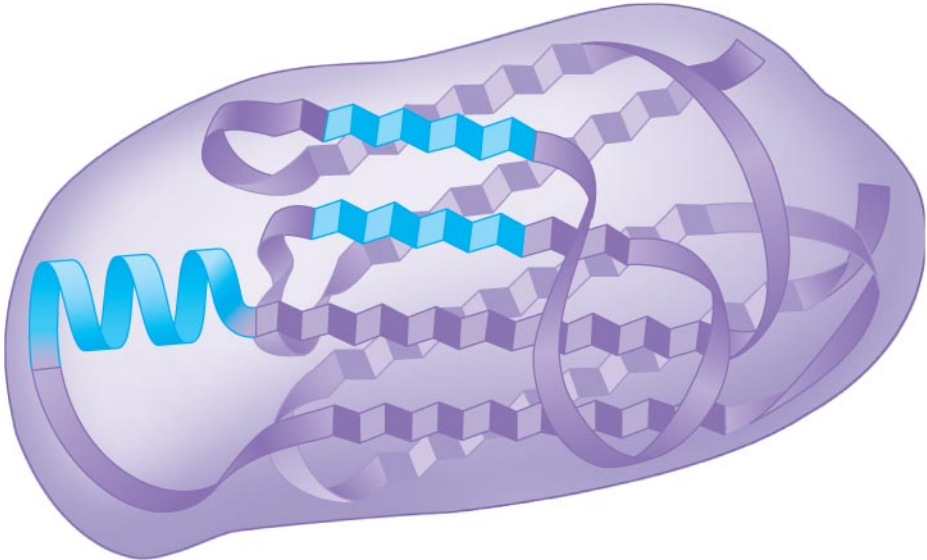


Levels of Protein Structure

- **Primary** - linear sequence of amino acids held together by peptide bonds.
- **Secondary** - The formation of alpha helices and beta pleated sheets due to hydrogen bonding between atoms of the peptide backbone (*not* R-group interactions)
- **Tertiary** - Folding of alpha helices and beta pleated sheets; influenced by R group interactions

Fig. 3-14ac

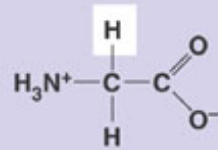
**Polypeptide
(single subunit
of transthyretin)**



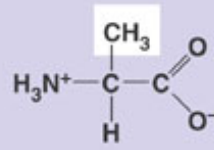
Tertiary structure

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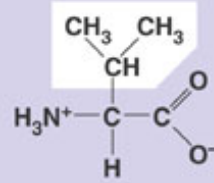
Nonpolar



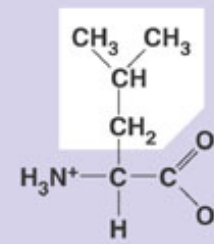
Glycine (Gly)



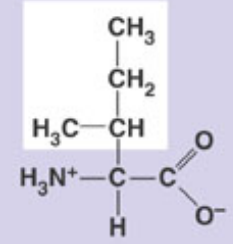
Alanine (Ala)



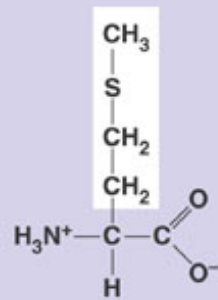
Valine (Val)



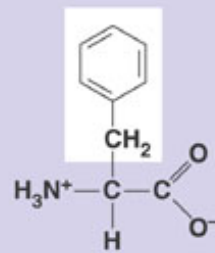
Leucine (Leu)



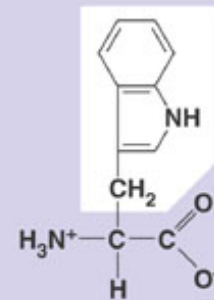
Isoleucine (Ile)



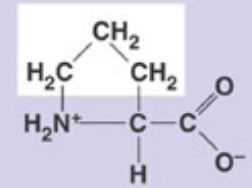
Methionine (Met)



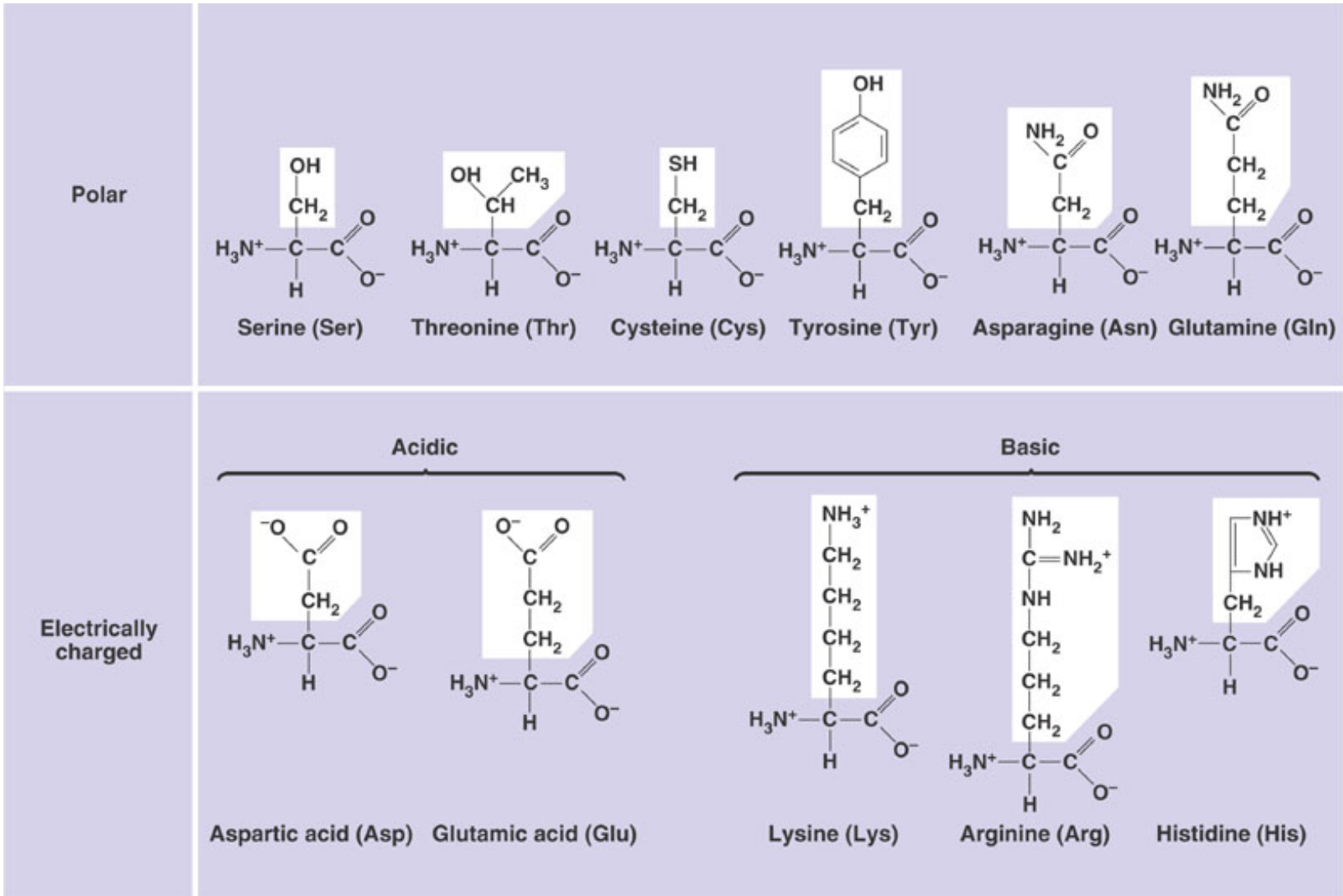
Phenylalanine (Phe)

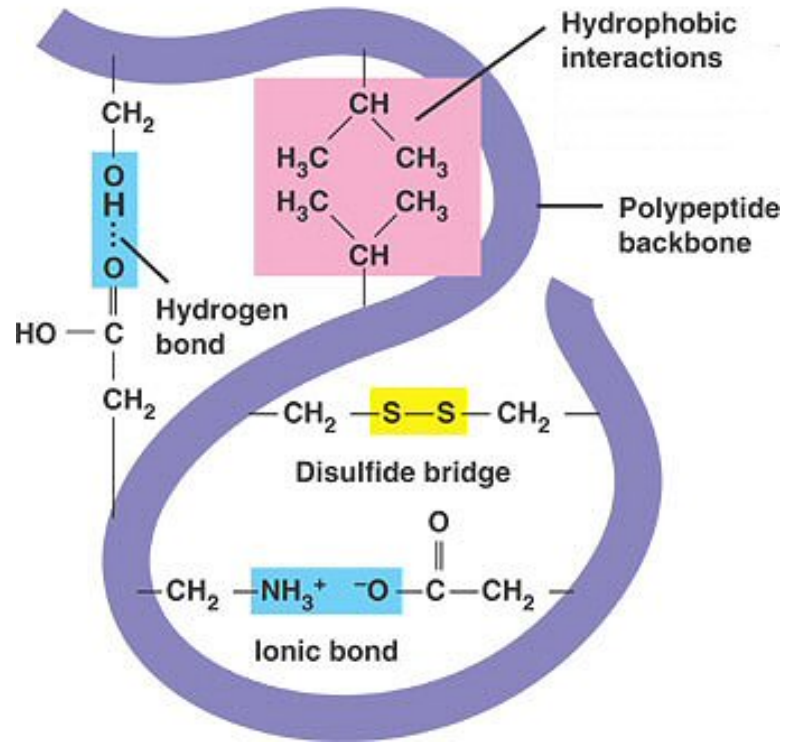
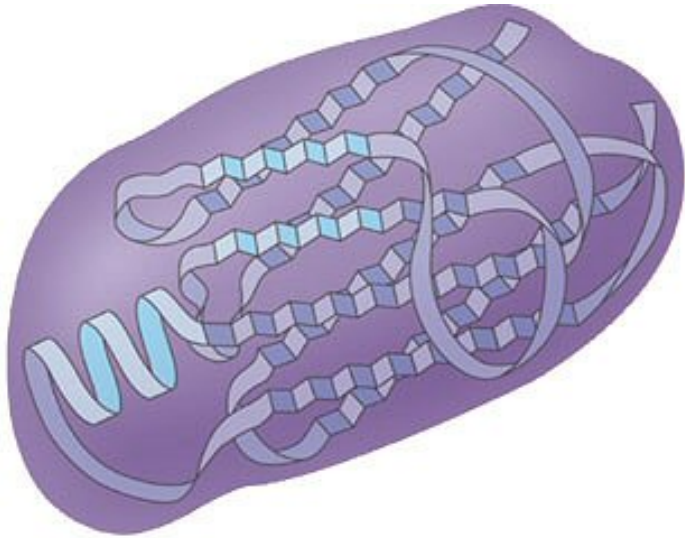


Tryptophan (Trp)



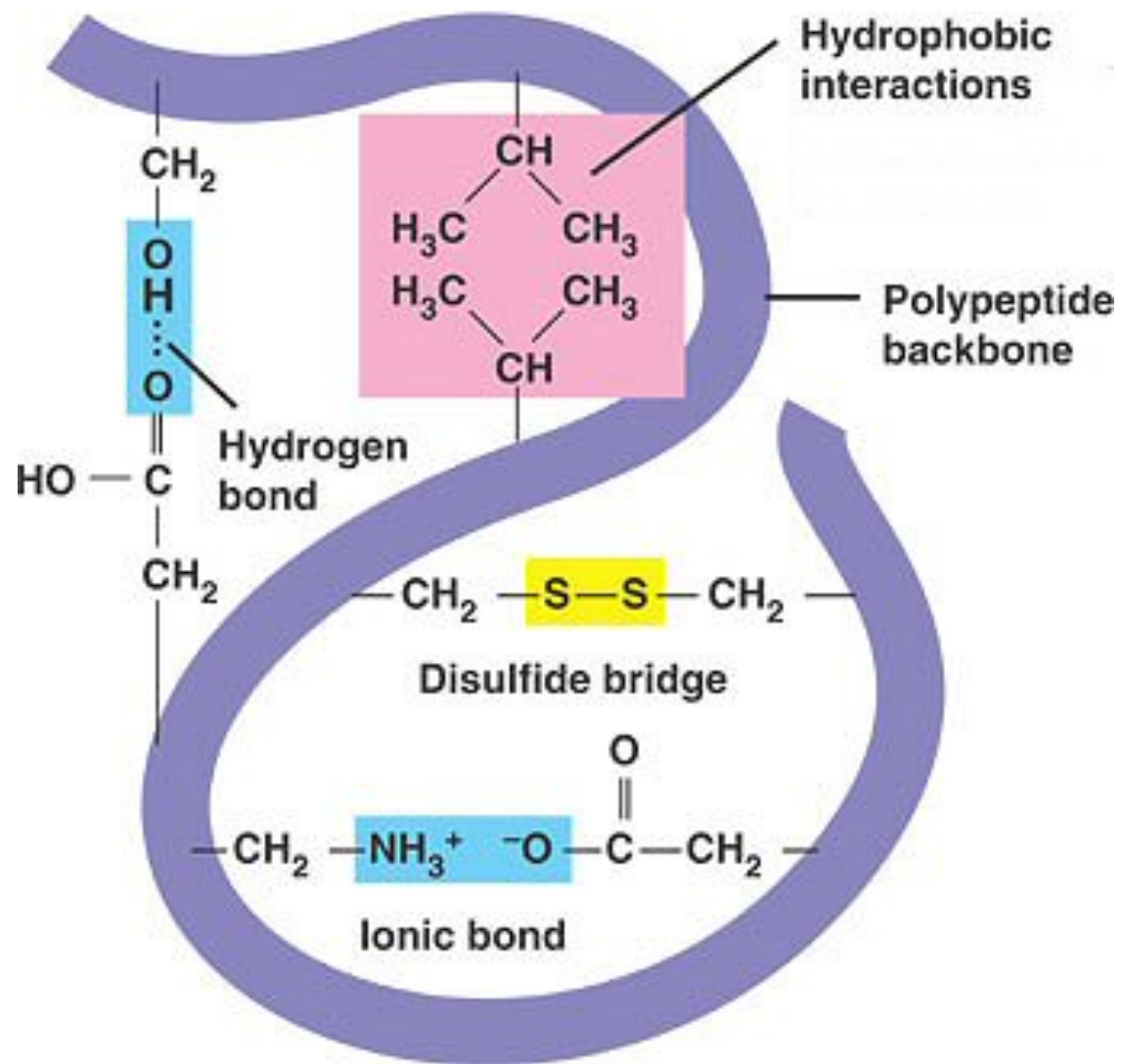
Proline (Pro)





More details on **tertiary protein structure**

- Three-dimensional folding caused by:
 - **Disulfide bridges** formed by covalent bond between two **cysteine** amino acids
 - **Salt bridges** formed by ionic bond between an **acidic** amino acid and a **basic** amino acid
 - **Hydrophobic (nonpolar)** amino acids move to middle of protein
 - **Hydrophilic (polar)** amino acids stay on outside



Levels of Protein Structure

- **Primary** - linear sequence of amino acids held together by peptide bonds.
- **Secondary** - The formation of alpha helices and beta pleated sheets due to hydrogen bonding between atoms of the peptide backbone (*not* R-group interactions)
- **Tertiary** - Folding of alpha helices and beta pleated sheets; influenced by R group interactions
- **Quaternary** - The association of more than one polypeptide into a protein complex; influenced by R group interactions

Fig. 3-14ad

**Transthyretin, with
four identical
polypeptide subunits**



Quaternary structure

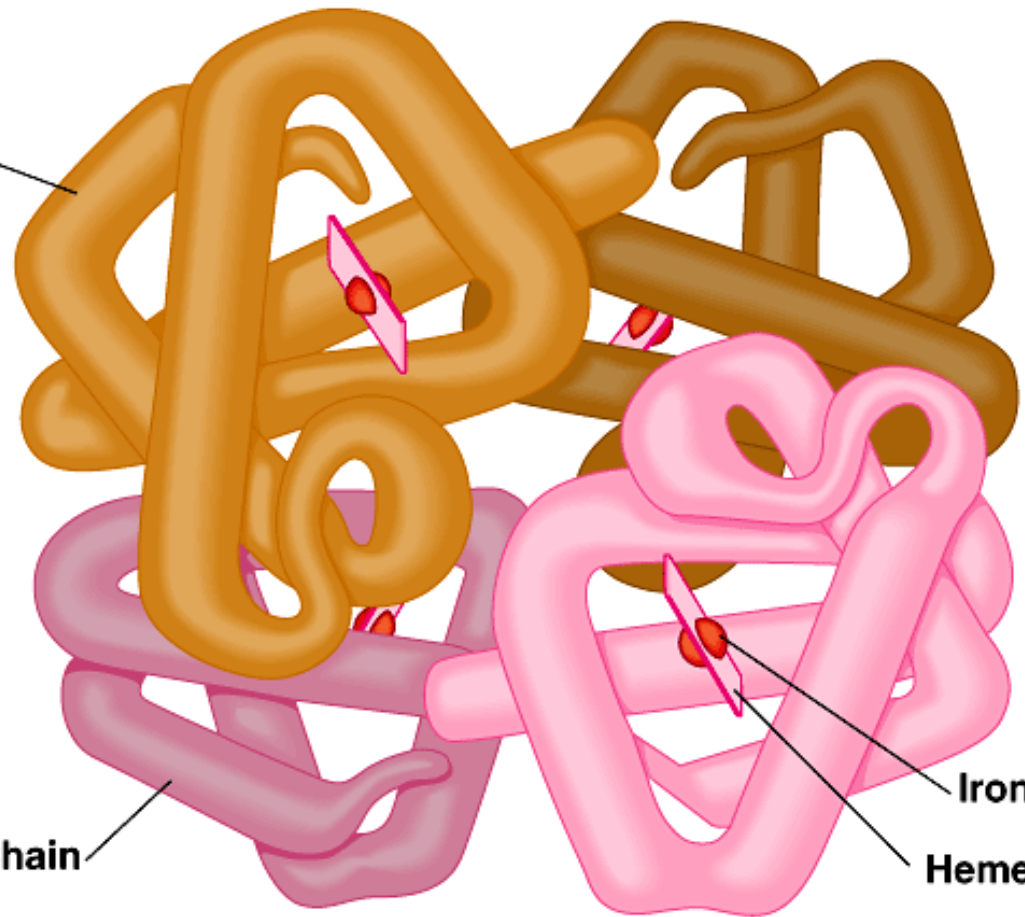


Polypeptide chain

(a) Collagen

β Chain

α Chain



Iron

Heme

(b) Hemoglobin

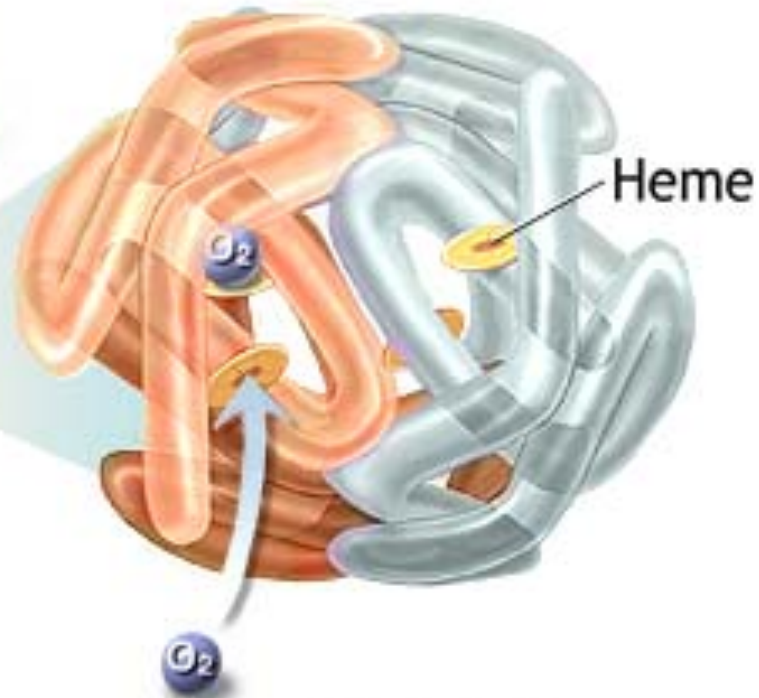


Red blood cell



Red blood cells contain several hundred hemoglobin molecules which transport oxygen

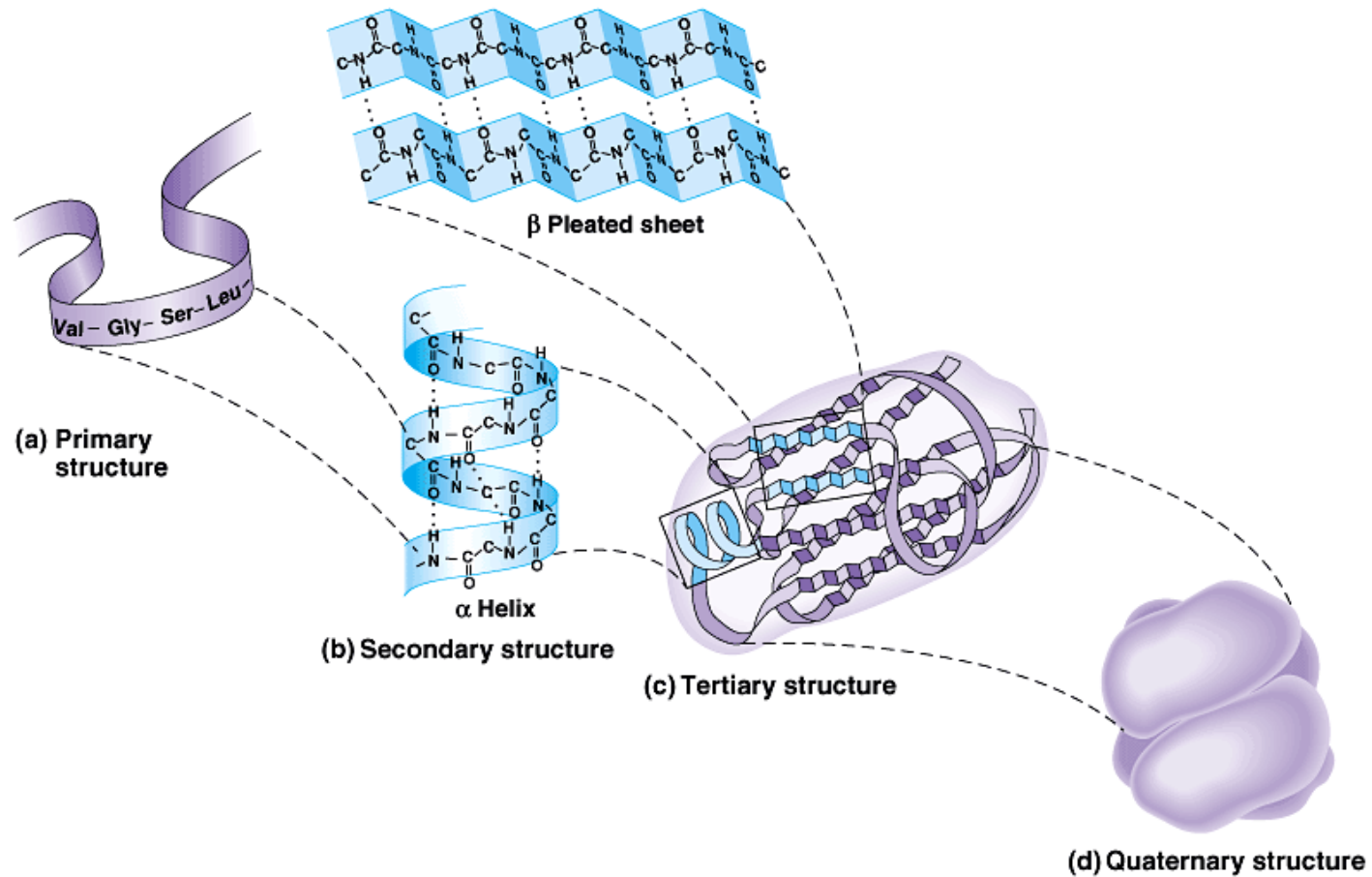
Hemoglobin molecule



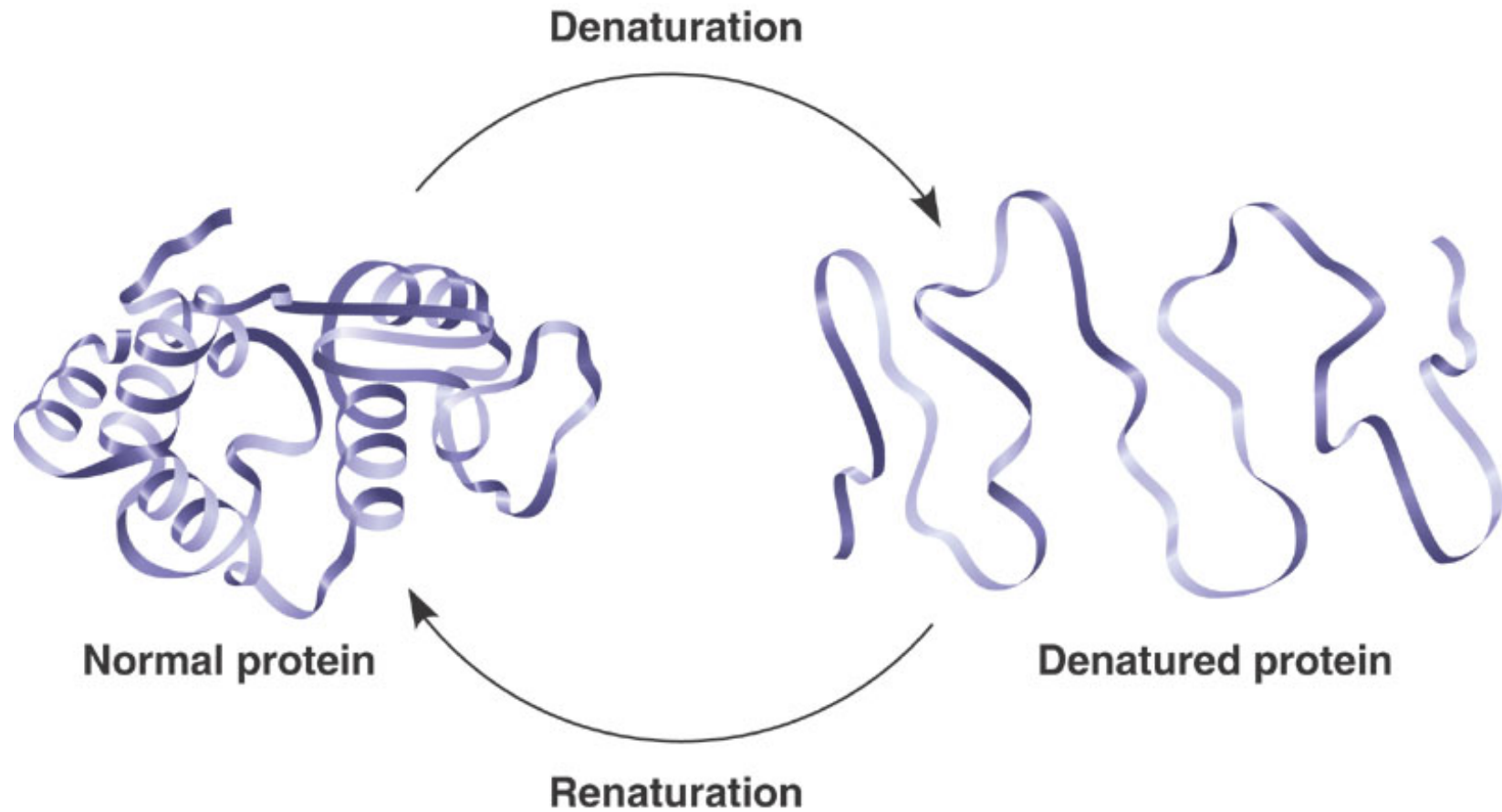
Heme

Oxygen binds to heme on the hemoglobin molecule

PROTEIN FOLDING RECAP



Protein Denaturation

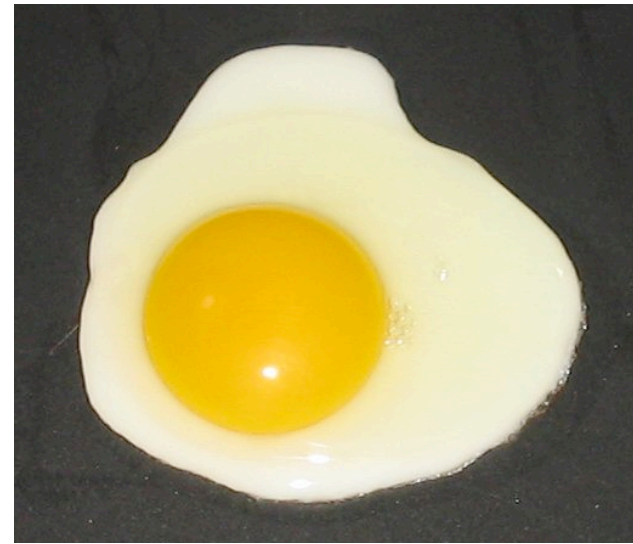


Protein Denaturation

- Loss of three-dimensional protein structure
- Can impact 4°, 3°, and/or 2° levels of structure

- Caused by:

- Heat
- Concentrated salts
- pH
- Organic solvents (e.g. alcohol, chloroform, acetone)
- Hydrophobic solutions



**PROTEIN
STRUCTURE**

=

**PROTEIN
FUNCTION**