Chem 30B

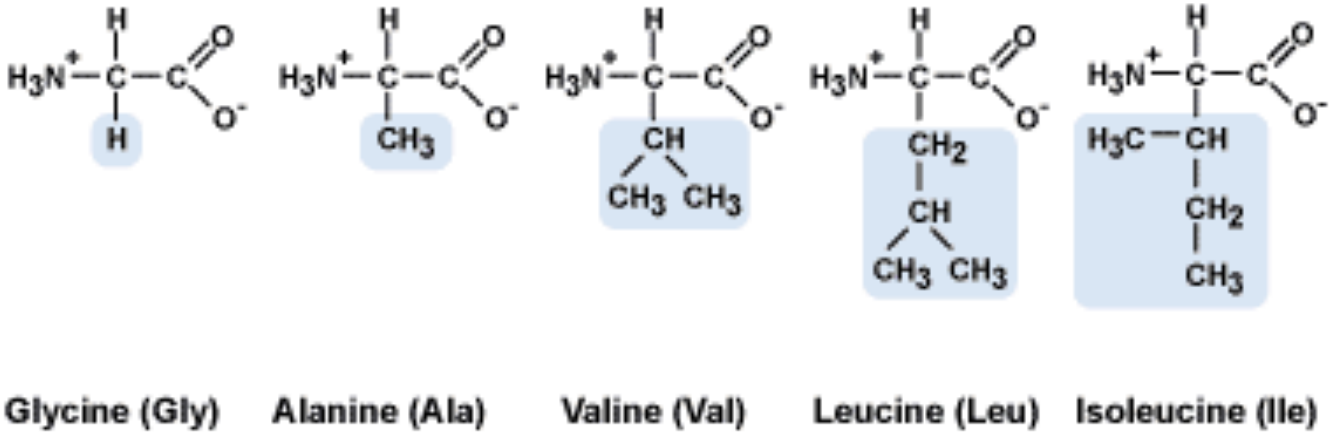
# Ch18: Amino Acids and Proteins

# Protein Functions

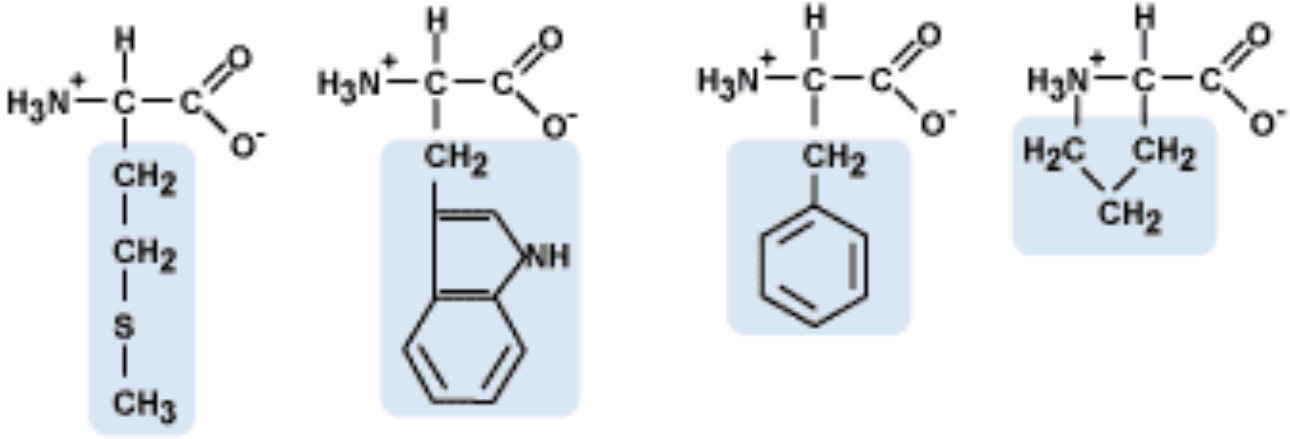
**TABLE 18.2 Classification of Proteins by Function**

| Type | Function | Example |
|---|---|---|
| Enzymes | Catalyze biochemical reactions | *Amylase*—begins digestion of carbohydrates by hydrolysis |
| Hormones | Regulate body functions by carrying messages to receptors | *Insulin*—facilitates use of glucose for energy generation |
| Storage proteins | Make essential substances available when needed | *Myoglobin*—stores oxygen in muscles |
| Transport proteins | Carry substances through body fluids | *Serum albumin*—carries fatty acids in blood |
| Structural proteins | Provide mechanical shape and support | *Collagen*—provides structure to tendons and cartilage |
| Protective proteins | Defend the body against foreign matter | *Immunoglobulin*—aids in destruction of invading bacteria |
| Contractile proteins | Do mechanical work | *Myosin and actin*—govern muscle movement |

# Amino Acids: Neutral Nonpolar Side Chains

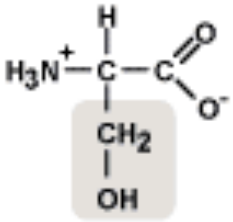


Glycine (Gly) Alanine (Ala) Valine (Val) Leucine (Leu) Isoleucine (Ile)

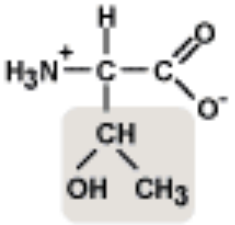


Methionine (Met) Tryptophan (Trp) Phenylalanine (Phe) Proline (Pro)

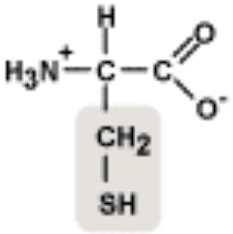
# Amino Acids: Neutral Polar Side Chains



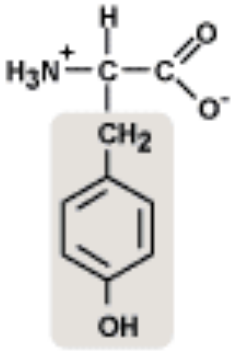

Serine (Ser)



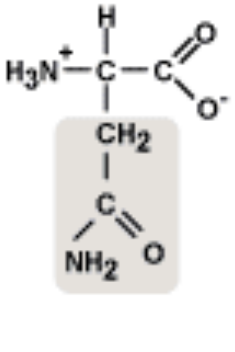

Threonine (Thr)



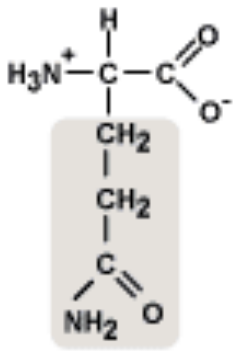

Cysteine (Cys)




Tyrosine (Tyr)

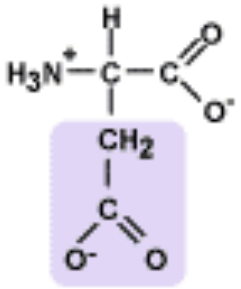


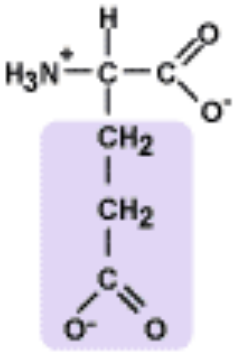

Asparagine (Asn)




Glutamine (Gln)

# Amino Acids: Ionizable Side Chains

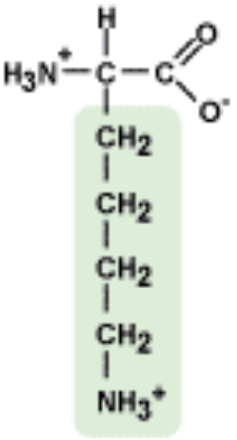




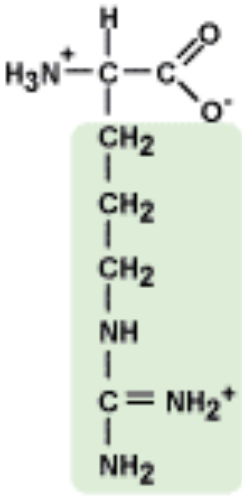
**Acidic**

Aspartic Acid (Asp)

Glutamic Acid (Glu)

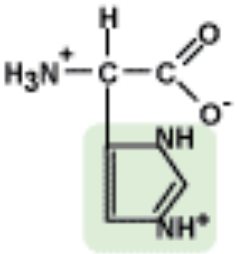


Lysine (Lys)

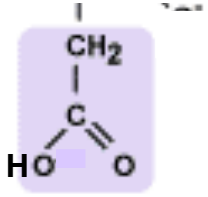


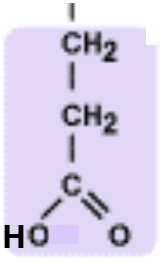
**Basic**

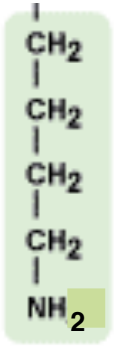
Arginine (Arg)

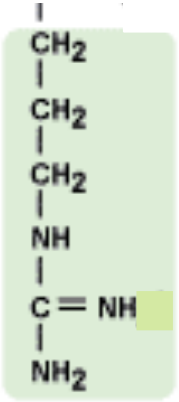


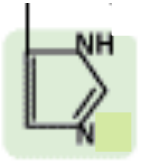
Histidine (His)



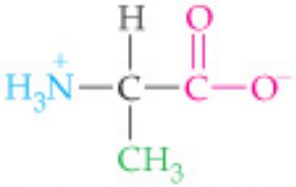




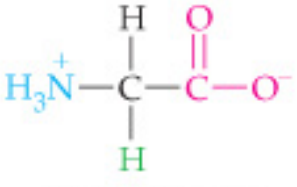




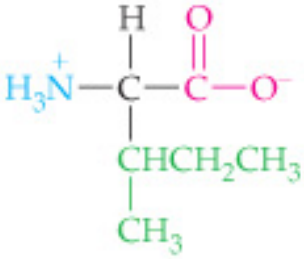
# Amino Acids: Neutral Nonpolar Side Chains



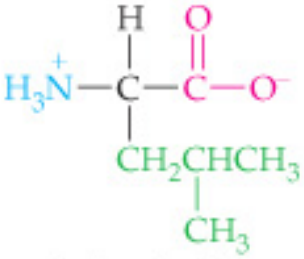
Alanine, Ala (6.0)



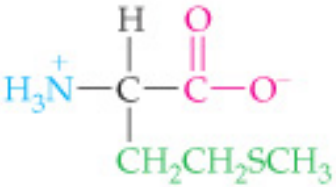
Glycine, Gly (6.0)



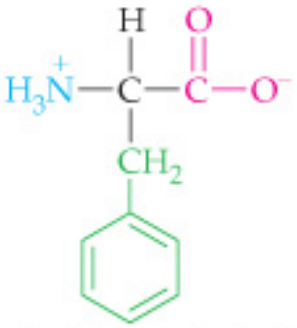
Isoleucine, Ile (6.0)



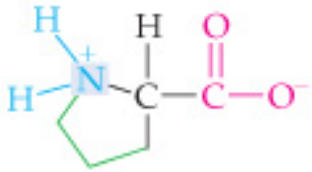
Leucine, Leu (6.0)



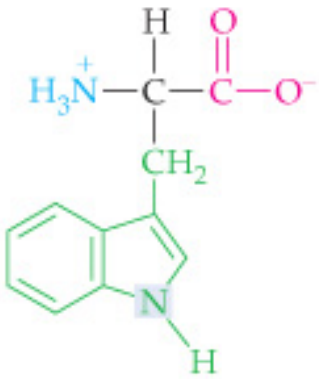
Methionine, Met (5.7)



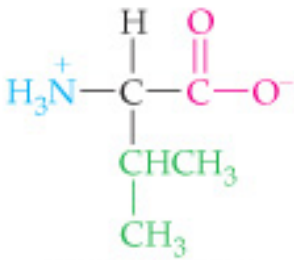
Phenylalanine, Phe (5.5)



Proline, Pro (6.3)

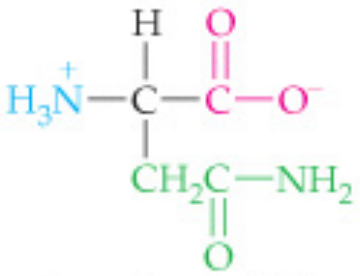


Tryptophan, Trp (5.9)

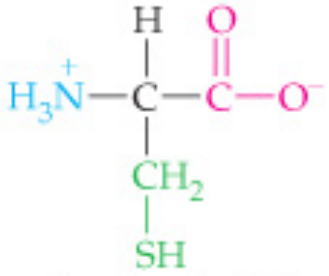


Valine, Val (6.0)

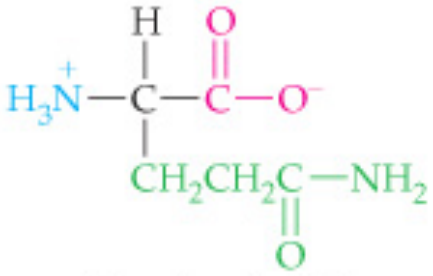
# Amino Acids: Neutral Polar Side Chains



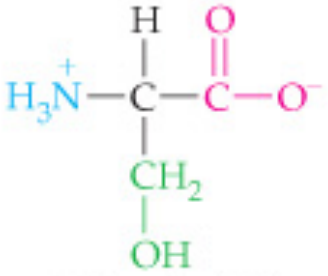
Asparagine, Asn (5.4)



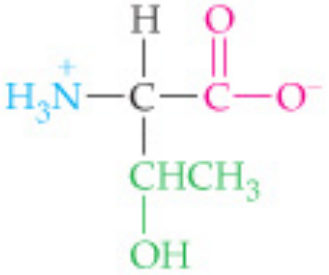
Cysteine, Cys (5.0)



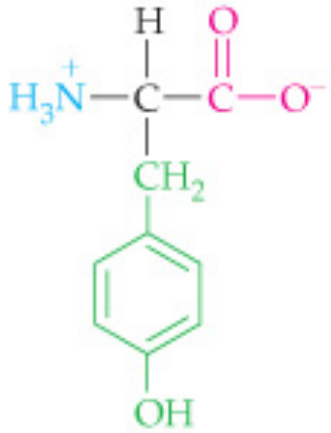
Glutamine, Gln (5.7)



Serine, Ser (5.7)

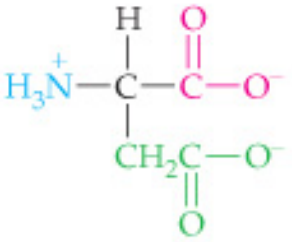


Threonine, Thr (5.6)

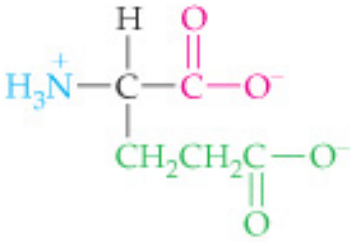


Tyrosine, Tyr (5.7)

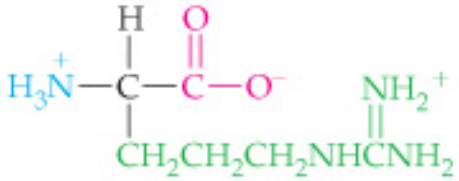
# Amino Acids: Ionizable Side Chains



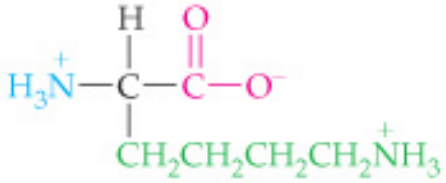
Aspartic acid, Asp (3.0)
(Aspartate)



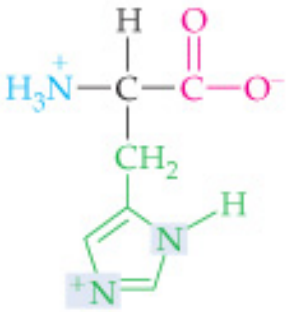
Glutamic acid, Glu (3.2)
(Glutamate)



Arginine, Arg (10.8)

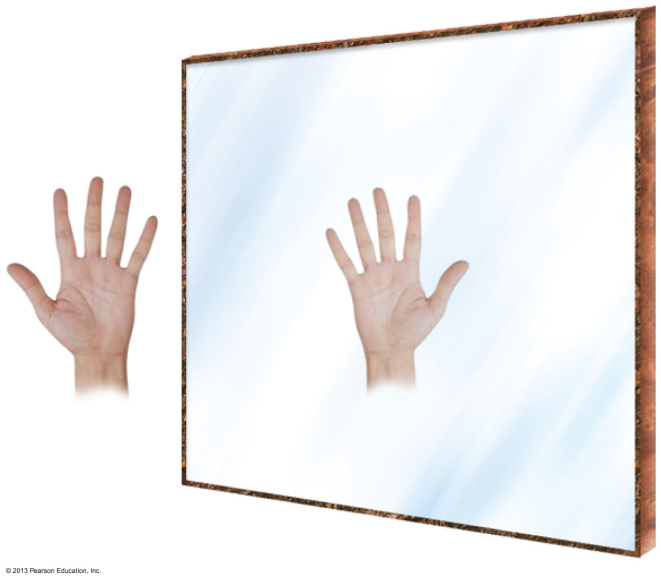


Lysine, Lys (9.7)



Histidine, His (7.6)

# Handedness (Chirality)

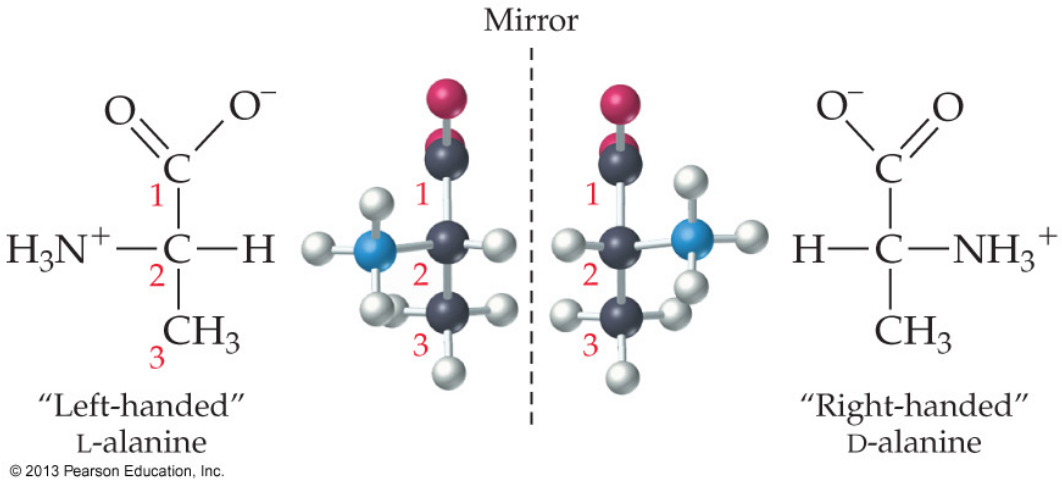



Hand is not superimposable on its mirror image → CHIRAL


Chair is superimposable on its mirror image → ACHIRAL

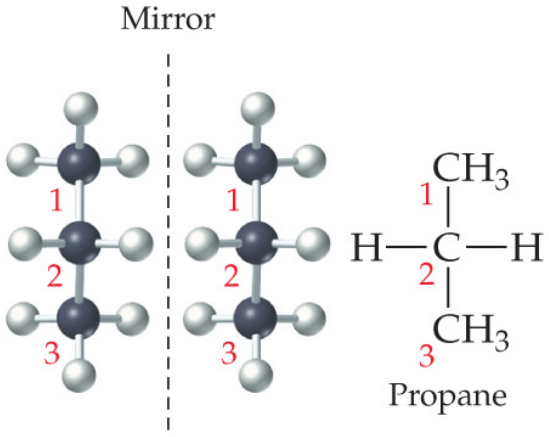
# Chirality

## Alanine: Chiral

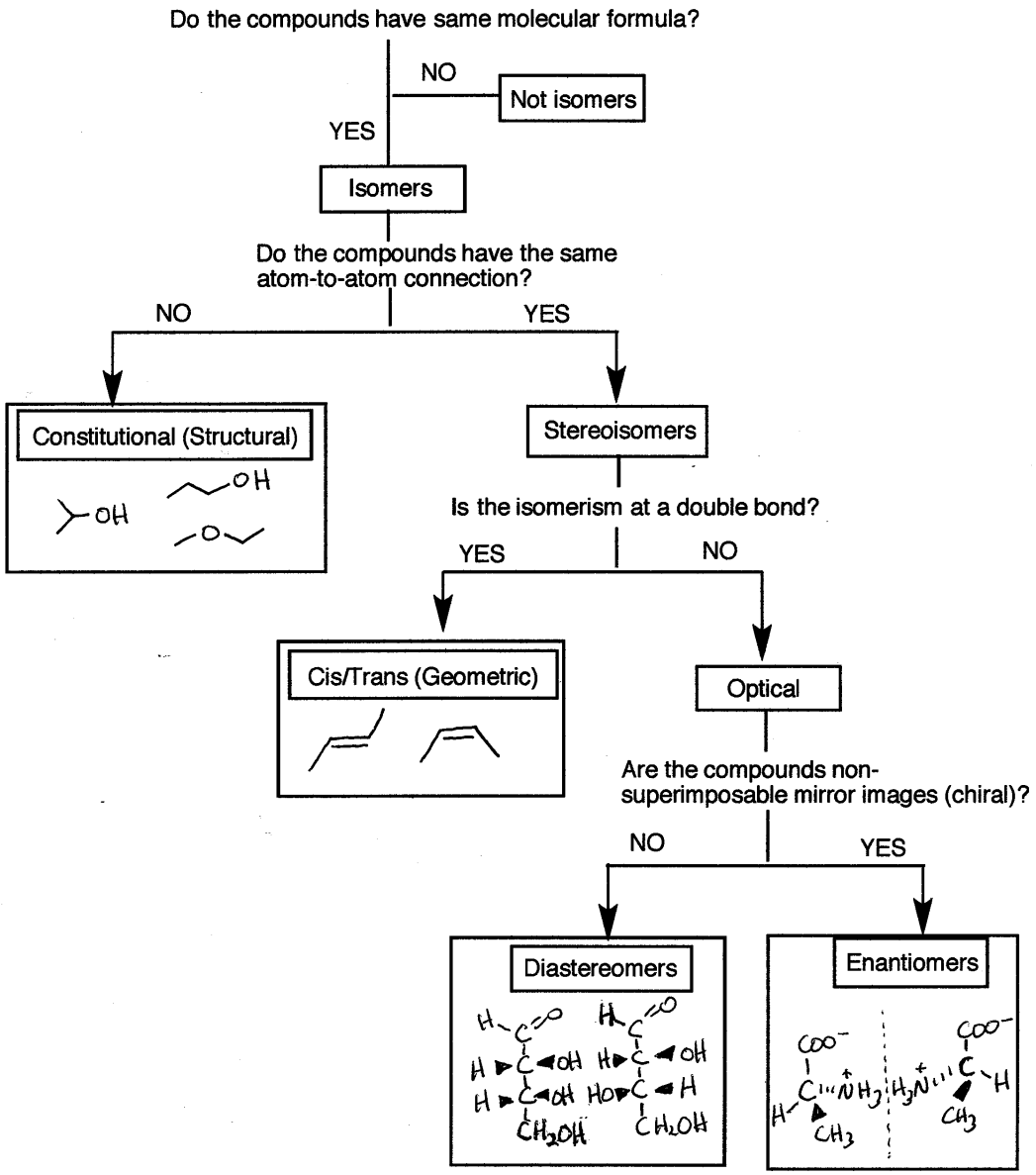




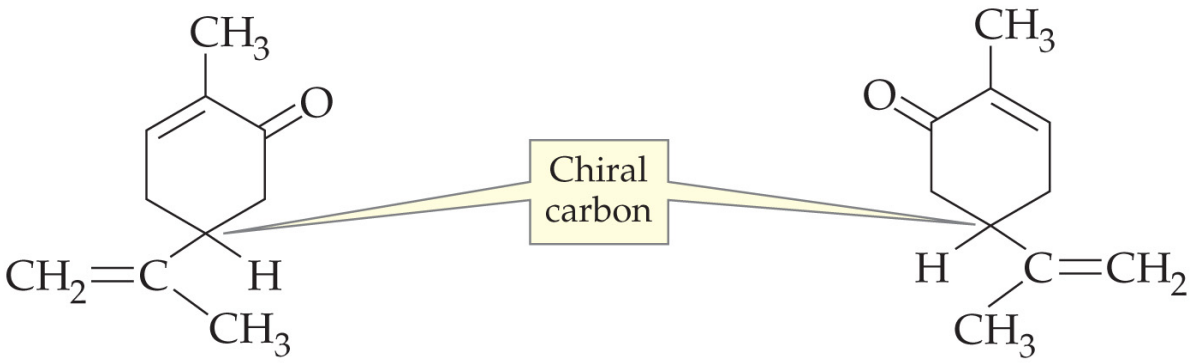
## Propane: Achiral



# Isomer Types



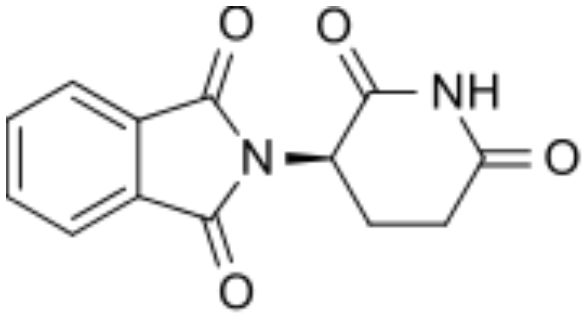
# Enantiomers of Carvone



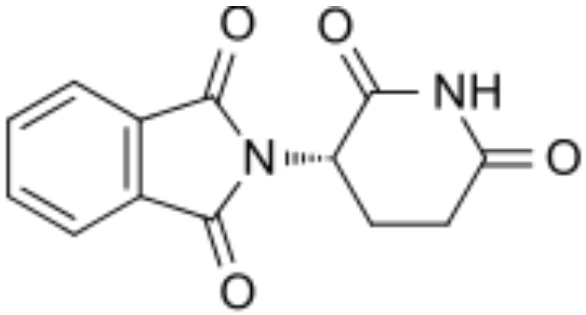

L-carvone
(in spearmint)

D-carvone
(in caraway)

# Case of Thalidomide




(R)-thalidomide




(S)-thalidomide

1957- Sold as sedative, nausea-reliever for pregnant women.
Racemic mix resulted in infants born with limb deformation

# Levels of Protein Structure

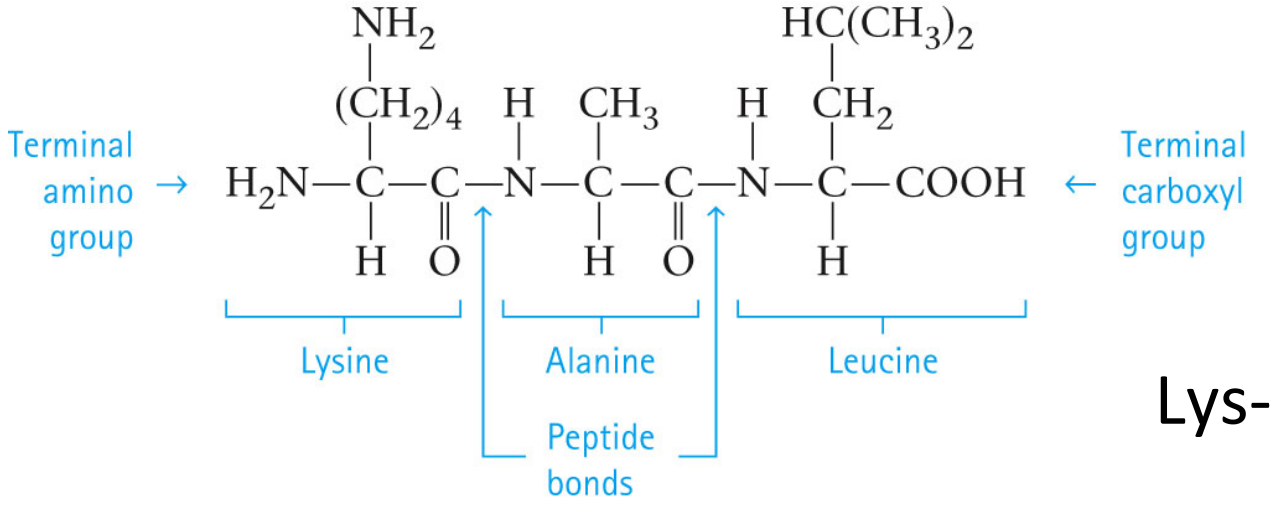
1. Primary
2. Secondary
3. Tertiary
4. Quaternary

Protein structure and function are intimately linked!

# Primary Structure of Proteins

Primary structure: the sequence of the amino acids (residues) in the chain.


- Read sequence from amino end → carboxyl end.




Lys-Ala-Leu

# Primary Structures of Two Peptides

Oxytocin: Hormone that triggers contraction of uterus and milk secretion

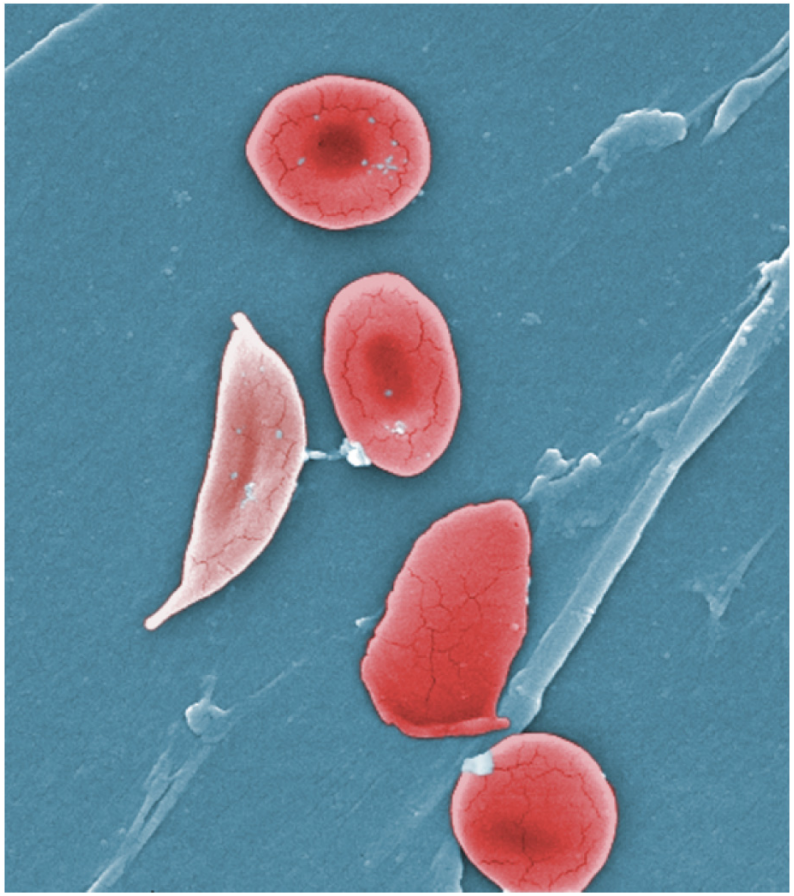
cys-tyr-ile-gin-asn-cys-pro-leu-gly

Vasopressin: Hormone that raises blood pressure and regulates kidney function

cys-tyr-phe-gin-asn-cys-pro-arg-gly

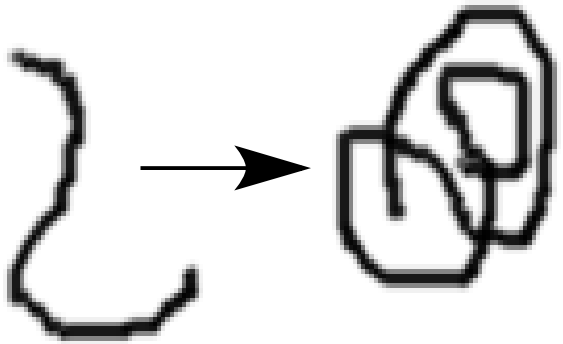
# Sickle Cell Anemia

Result of a single Glu → Val mutation in hemoglobin



# Higher-Level Structures in Proteins

- Secondary, Tertiary, and Quaternary structures have to do with how peptides "fold" into 3-dimensional structure.
- Protein chains fold into very specific 3D structures that are finely tuned to their functions.



# Interactions that Stabilize 3D Protein Structure

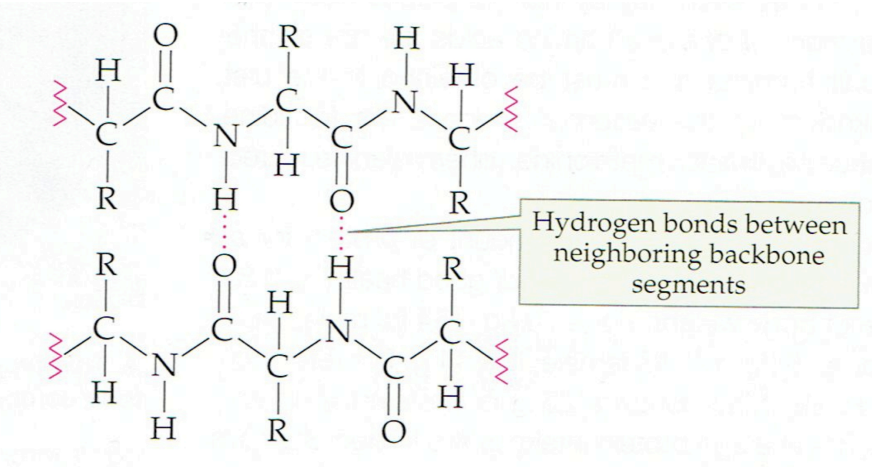
## Noncovalent

- Hydrogen bonding
- Ionic interactions
- Hydrophobic interactions

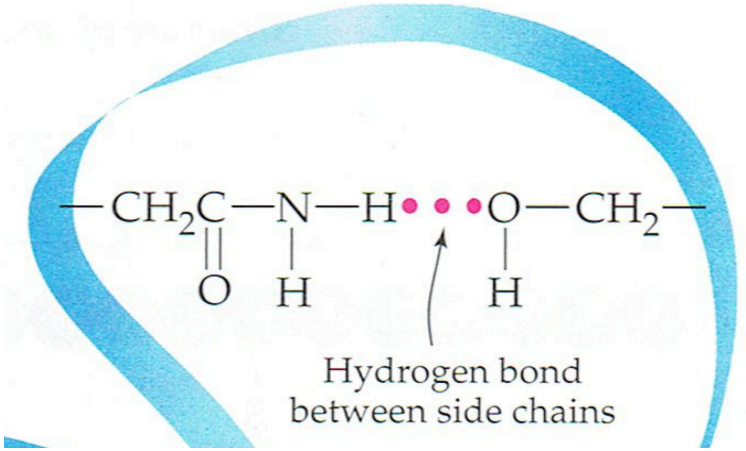
## Covalent

- Disulfide bonds

# Hydrogen Bonding

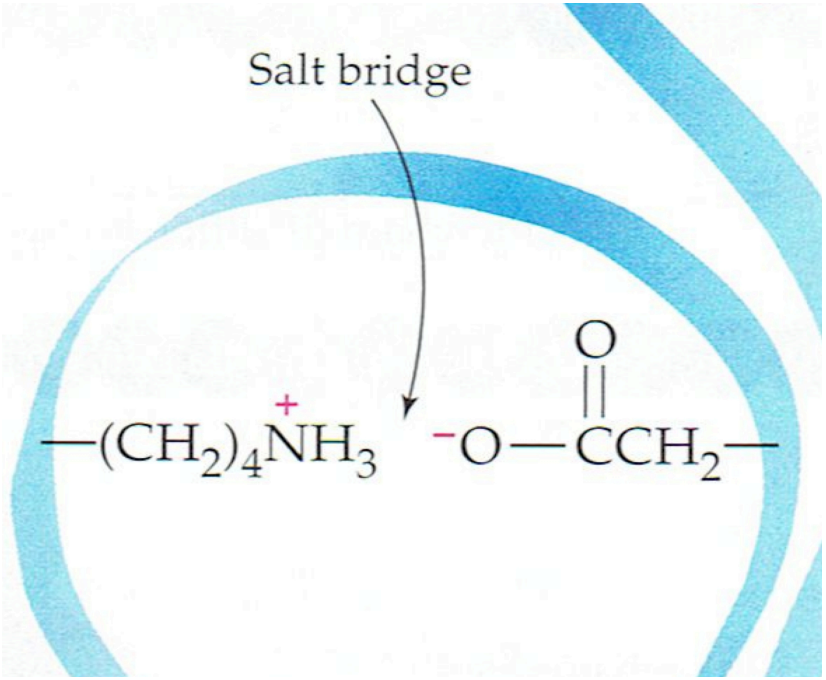



Along backbone



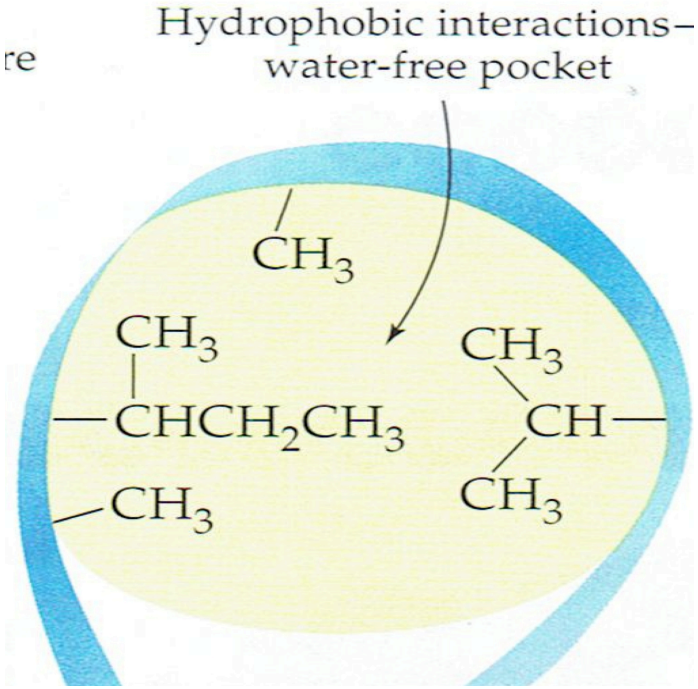

Between side chains

# Ionic Interactions (salt bridge)




Between ionized acidic and basic side chains

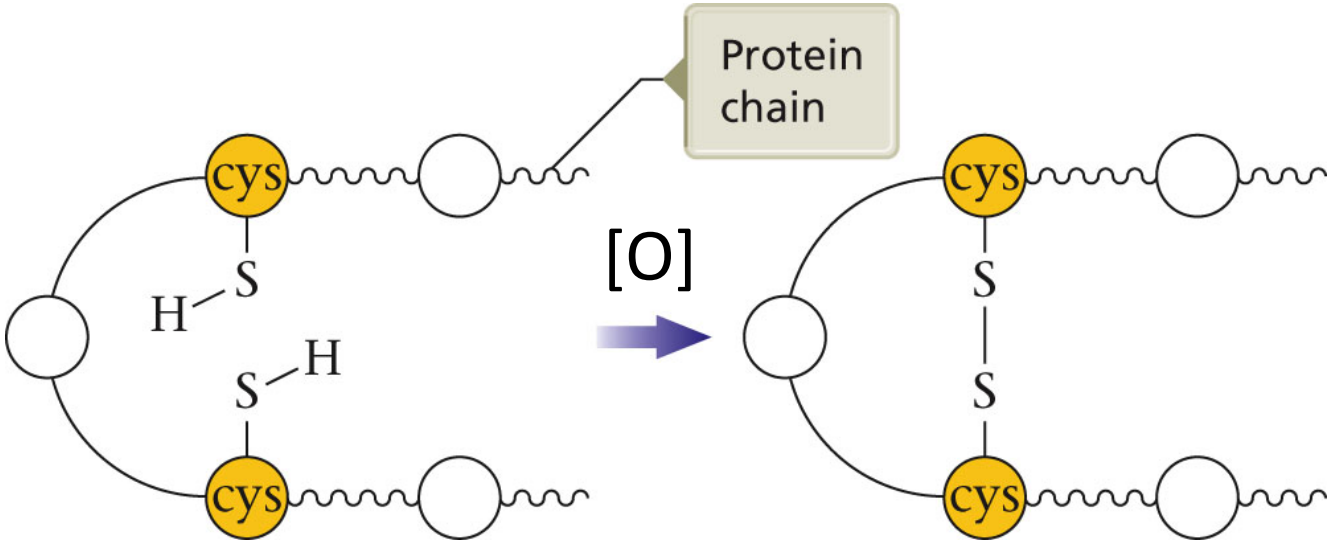
# Hydrophobic Interactions




Between nonpolar side chains

# Disulfide Bond (S-S bond)

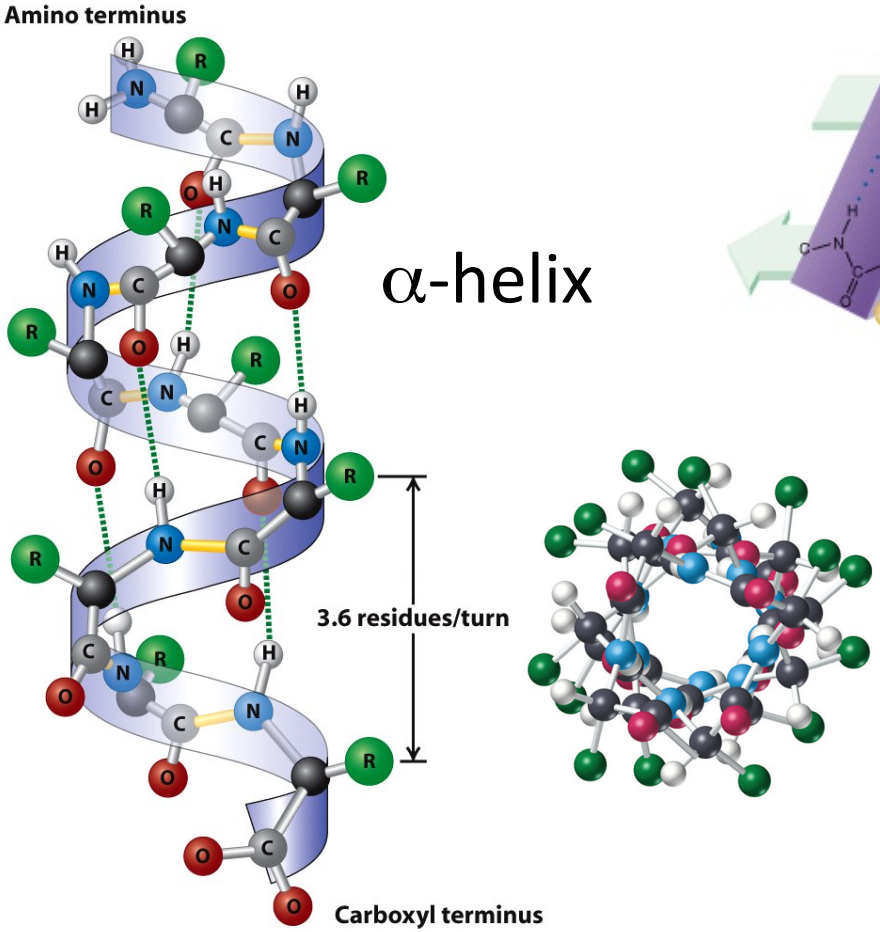
- Disulfide Bond: Covalent linkage between two cysteine side chains




Ex prob

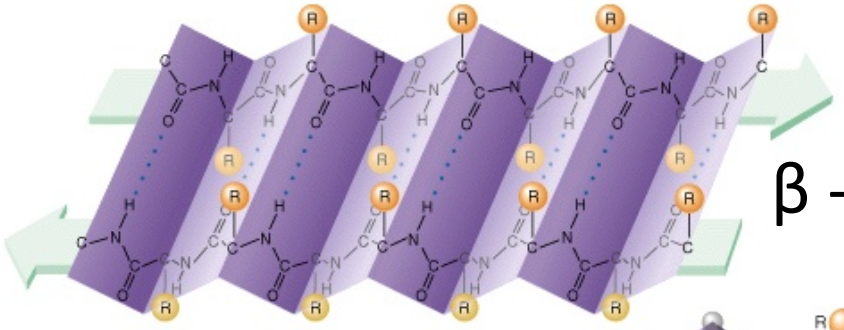
# Secondary Structure

Secondary structure: regular 3D arrangement of polypeptide backbone held together by hydrogen bonding between backbone atoms, plus loops or coils

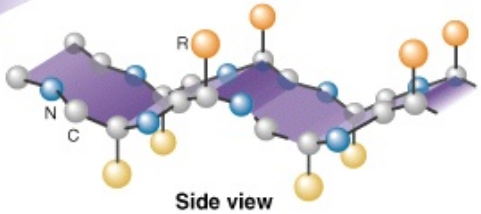


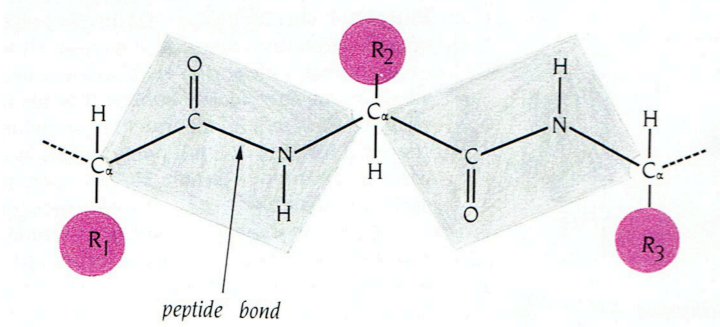

α-helix





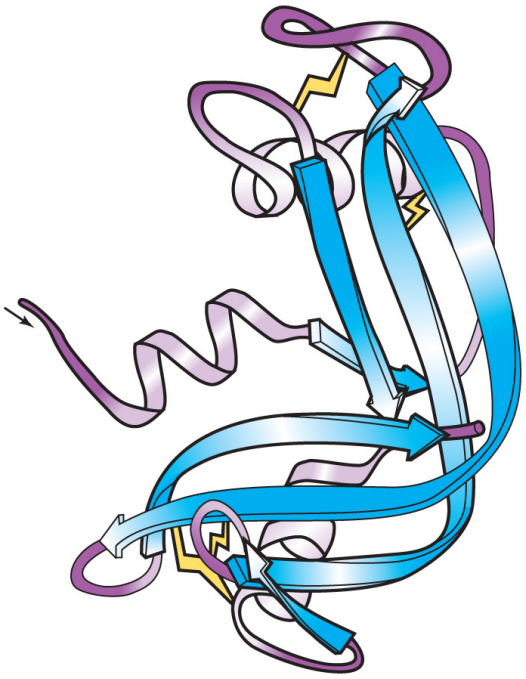

β -sheet



# Tertiary Structure of Proteins

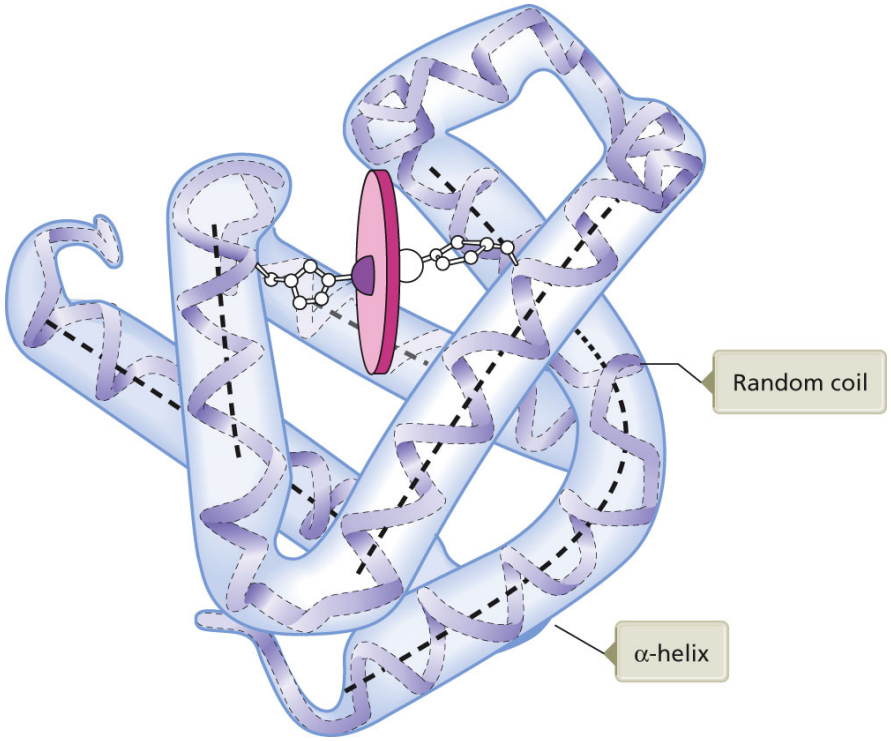
- Tertiary structure: the overall 3-dimensional shape that results from folding of the protein; mainly dependent on side chain interactions, often far apart on polypeptide chain

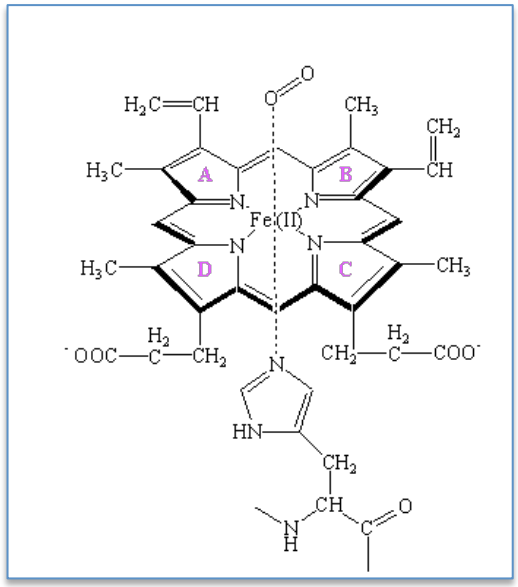


Ribonuclease

Ribonuclease

# Tertiary Structure




heme

Myoglobin (a conjugated protein)

# Simple vs. Conjugated Proteins

- Simple proteins: Contain only amino acids
  - Eg. Ribonuclease

- Conjugated proteins: Have non-amino acid component(s)
  - Eg. myoglobin

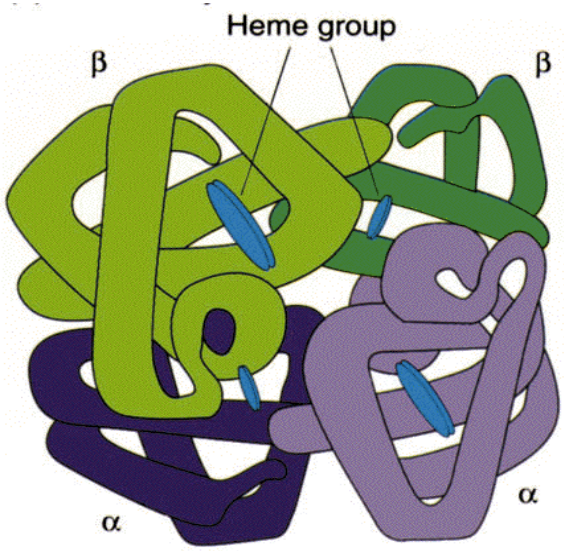
# Examples of Conjugated Proteins

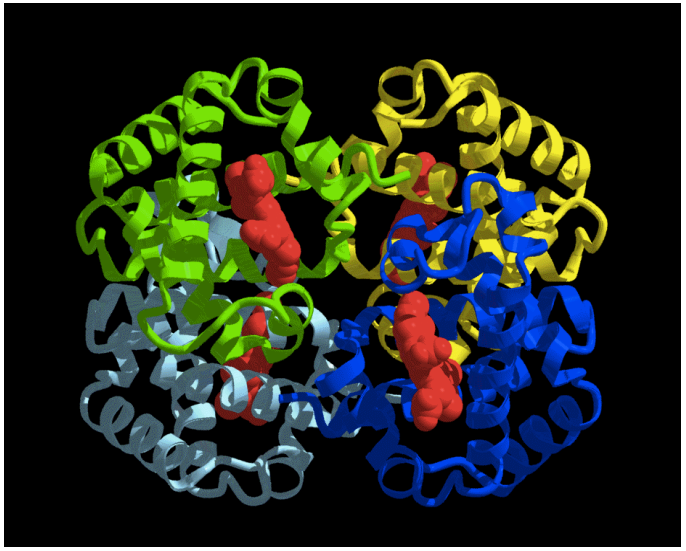
**TABLE 18.5 Some Examples of Conjugated Proteins**

| Class of Protein | Nonprotein Part | Examples |
|---|---|---|
| Glycoproteins | Carbohydrates | Glycoproteins in cell membranes (Section 21.9) |
| Lipoproteins | Lipids | High- and low-density lipoproteins that transport cholesterol and other lipids through the body (Section 24.2) |
| Metalloproteins | Metal ions | The enzyme cytochrome oxidase, necessary for biological energy production, and many other enzymes |
| Phosphoproteins | Phosphate groups | Milk casein, which provides essential nutrients to infants |
| Hemoproteins | Heme | Hemoglobin (transports oxygen) and myoglobin (stores oxygen) |
| Nucleoproteins | RNA (ribonucleic acid) | Found in cell ribosomes, where they take part in protein synthesis |

# Quaternary Structure

- Quaternary structure: two or more folded protein chains (subunits) held together by noncovalent interactions



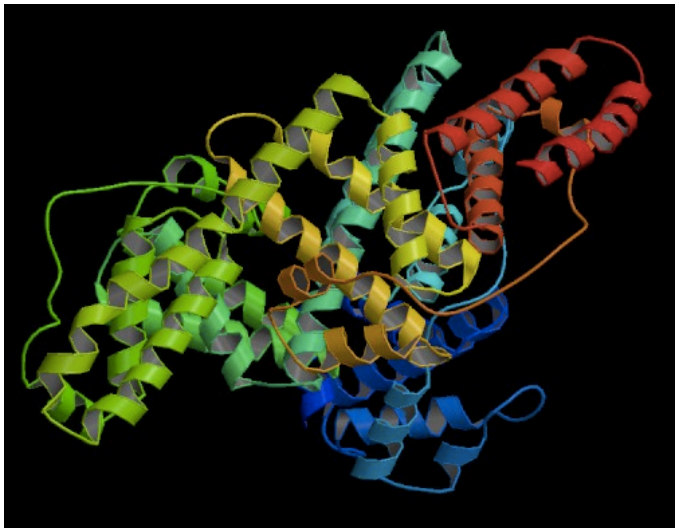
Hemoglobin: $O_2$ carrier in red blood cells

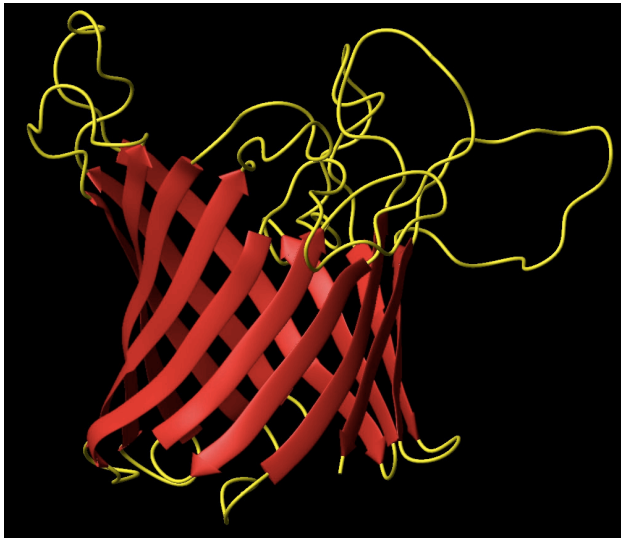
# Broad Categories of Protein Shapes

- Globular – roughly spherical; "worker" molecules with many different functions; typically water-soluble

- Fibrous – tough, water-insoluble, composed of fibers and sheets; give structural integrity and strength; main components of muscle, hair, cartilage, etc.

# Structures of Globular Proteins

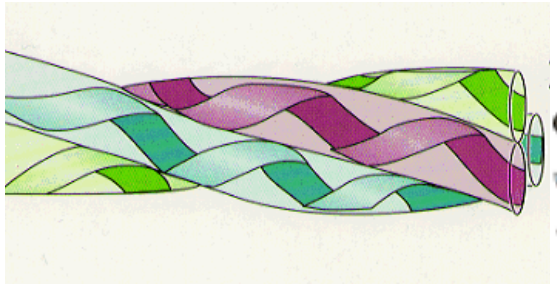


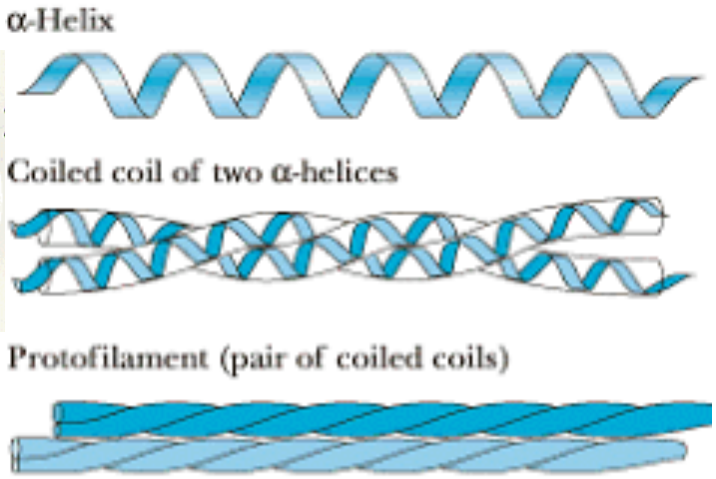



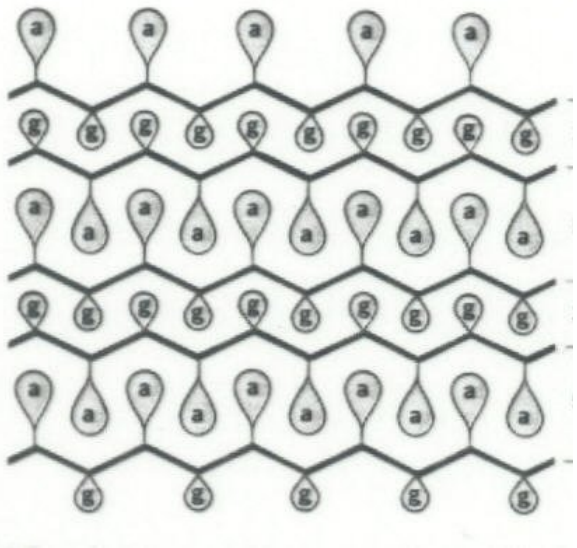
Protein structure is optimized for protein function:

- Solubility (polar and nonpolar side chains)
- Binding sites

# Structures of Fibrous Proteins






## Collagen

-Connective tissues like cartilage, ligament, tendons, skin

-Triple helix cable

## Keratin

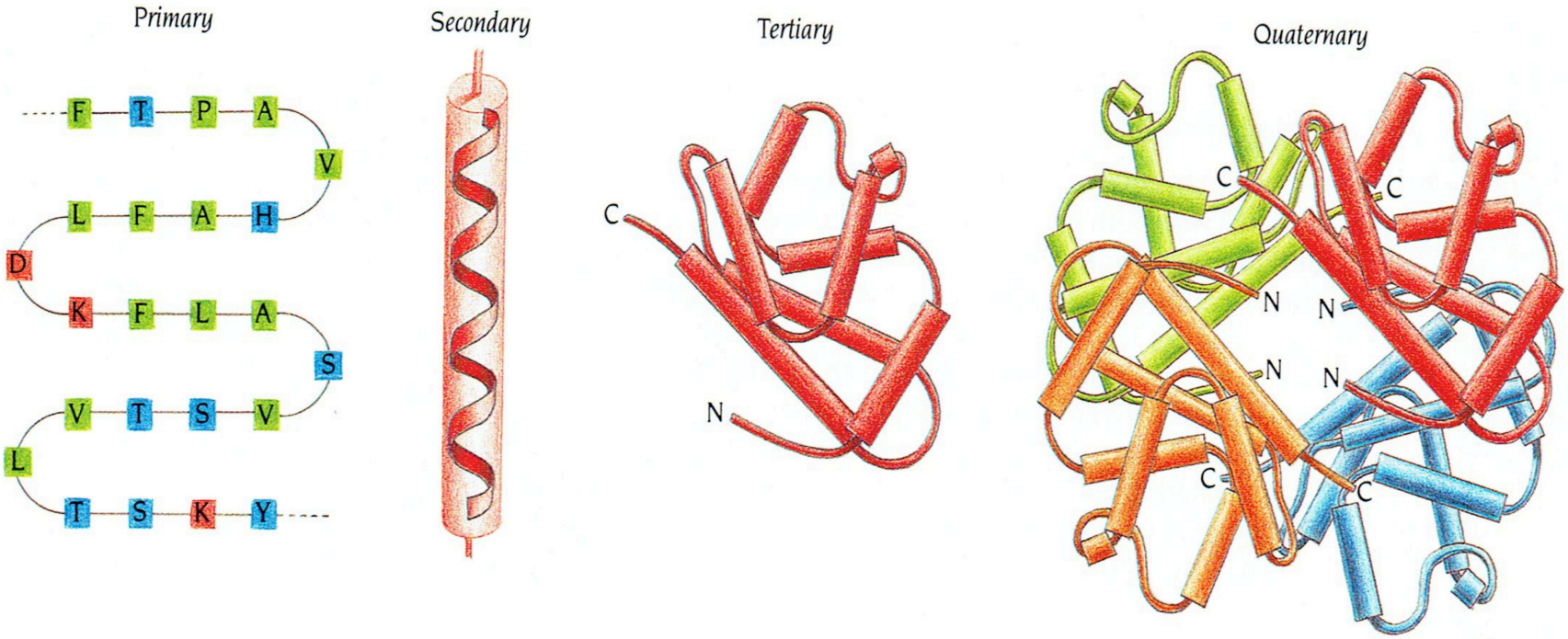
-Hair, horn, nail

- Helix of helices

## Silk

-Stacked layers of pleated sheets

# Levels of Protein Structure



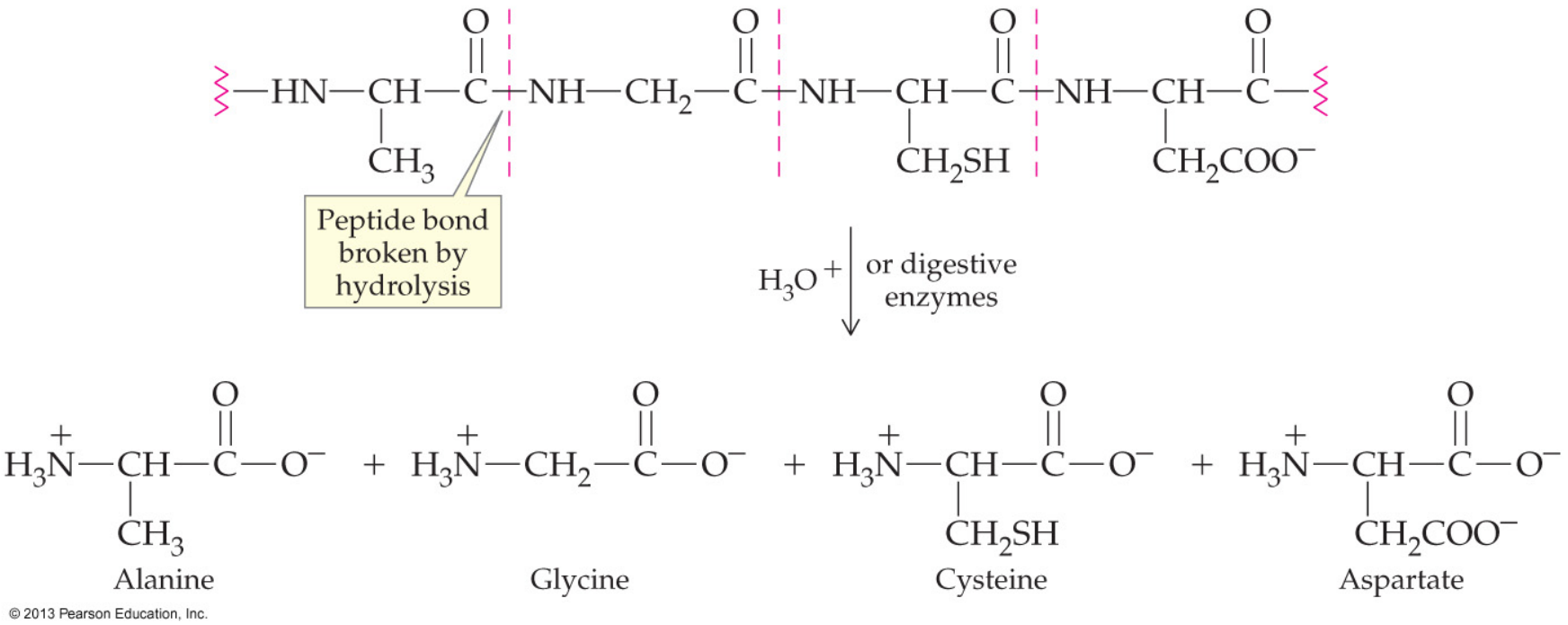

Primary Secondary Tertiary Quaternary

# Example Problem: Identify level of structure

Q: Identify as secondary, tertiary, or quaternary structure.

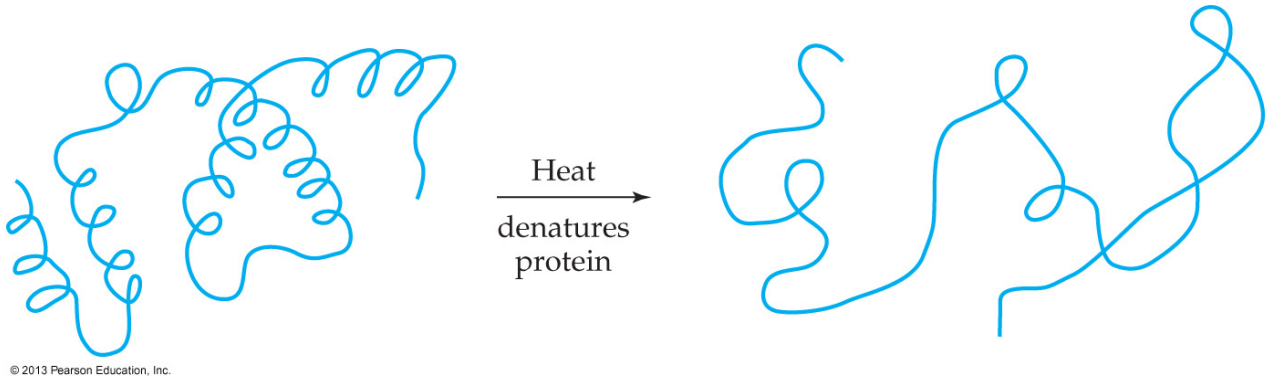
1. The protein α-hemolysin is made of 7 subunits associated together.
2. Polypeptide backbone hydrogen-bond to make a β-sheet.
3. In the protein albumin, α-helices pack together with all the nonpolar residues in the interior.

# Protein Hydrolysis



# Protein Denaturation

- **Denaturation**: loss of secondary, tertiary, and quaternary protein structure (protein "unfolding")
  - Primary structure is intact.
  - Protein function lost.



# Protein Denaturing Agents

- **Heat—**Disrupts side-chain interactions (eg. frying egg, cooking collagen into gelatin)
- **Mechanical agitation—(**eg. beating egg whites)
- **Detergents—**Disrupt hydrophobic interactions.
- **Organic compounds—**Polar solvents interfere with hydrogen bonding; nonpolar solvents disrupt hydrophobic interactions.
- **pH change—**Disrupt salt bridges
- **Inorganic salts—**High concentrations can disturb salt bridges.

Most denaturation is irreversible.