Aminoacids and Proteins

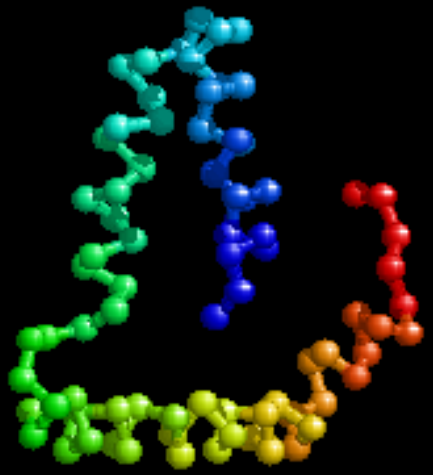
Dr Hadi Ansarihadipour

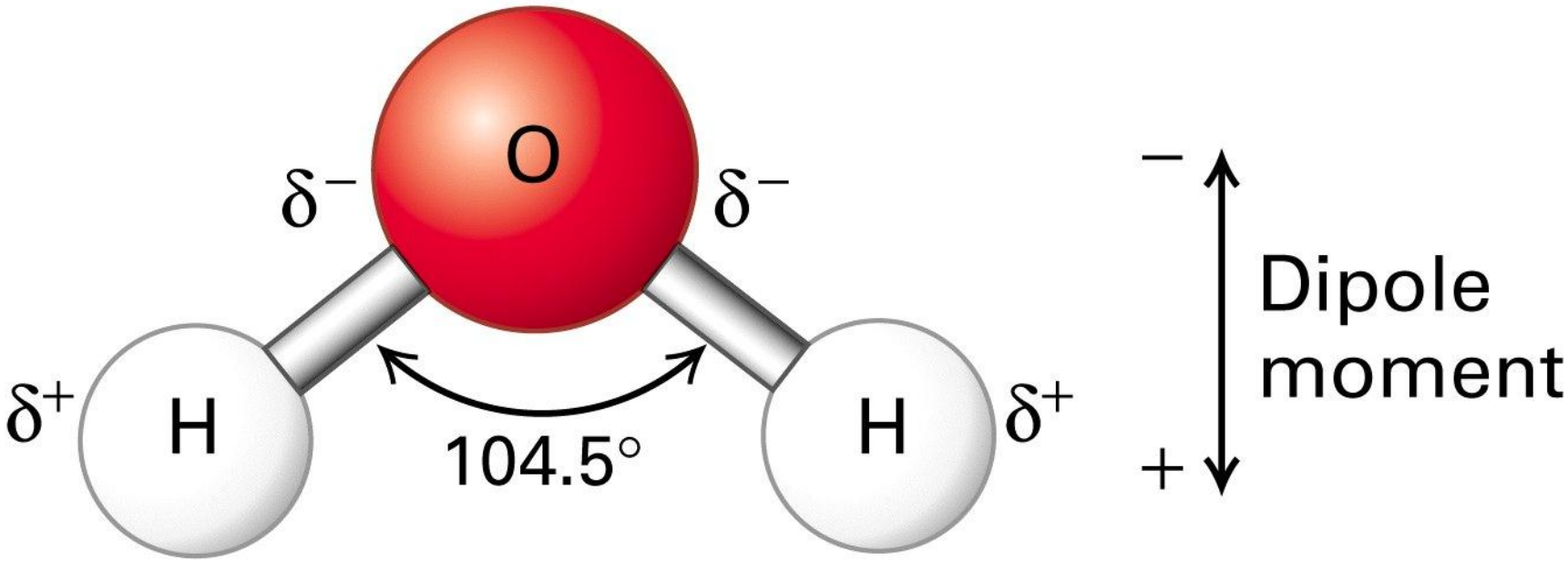
References:

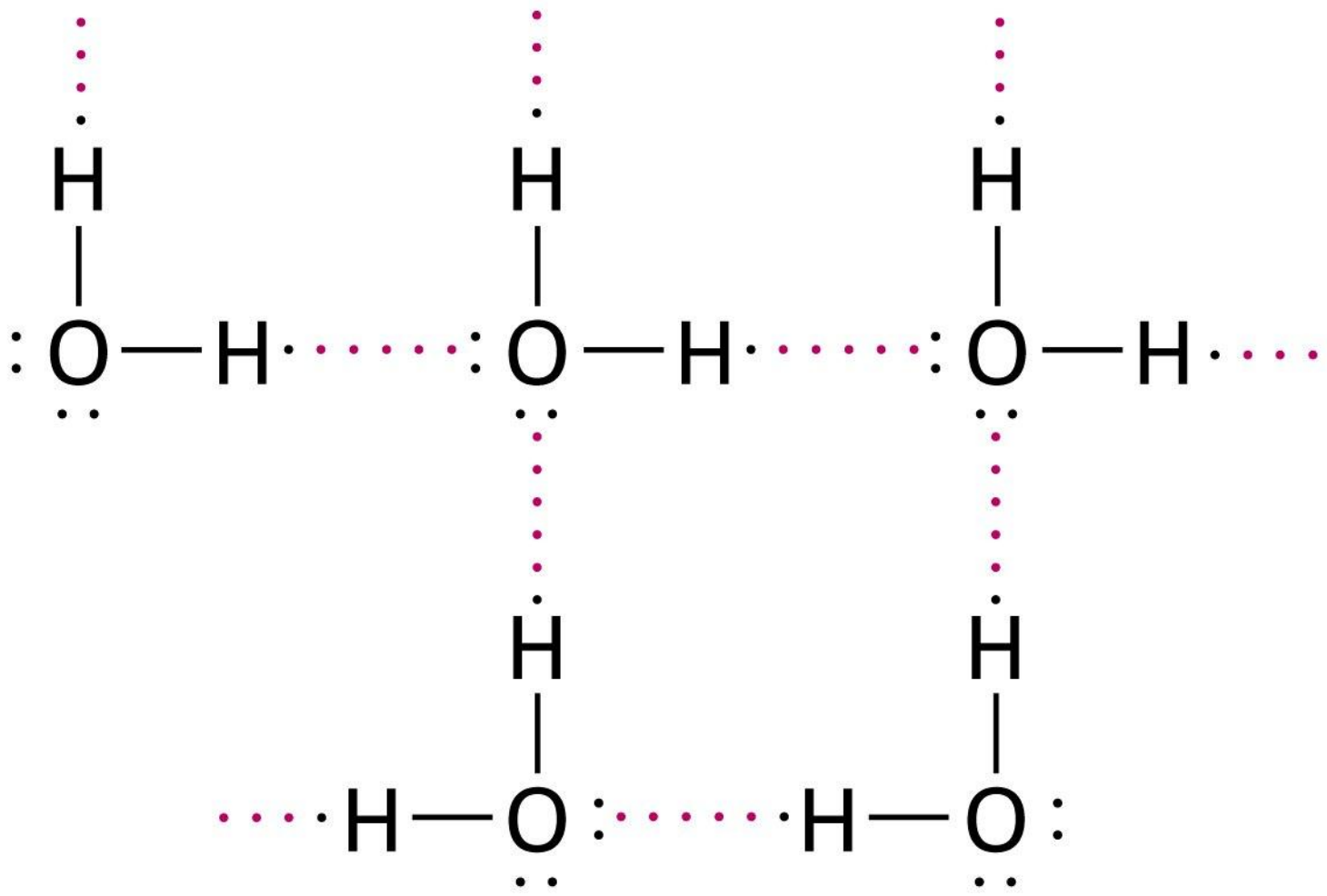
1. **Molecular Cell Biology. Fifth Edition. Harvey Lodish. Copyright © 2004 by W. H. Freeman & Company**

2. **Biochemistry. Lehninger. 4th Edition, 2005.**

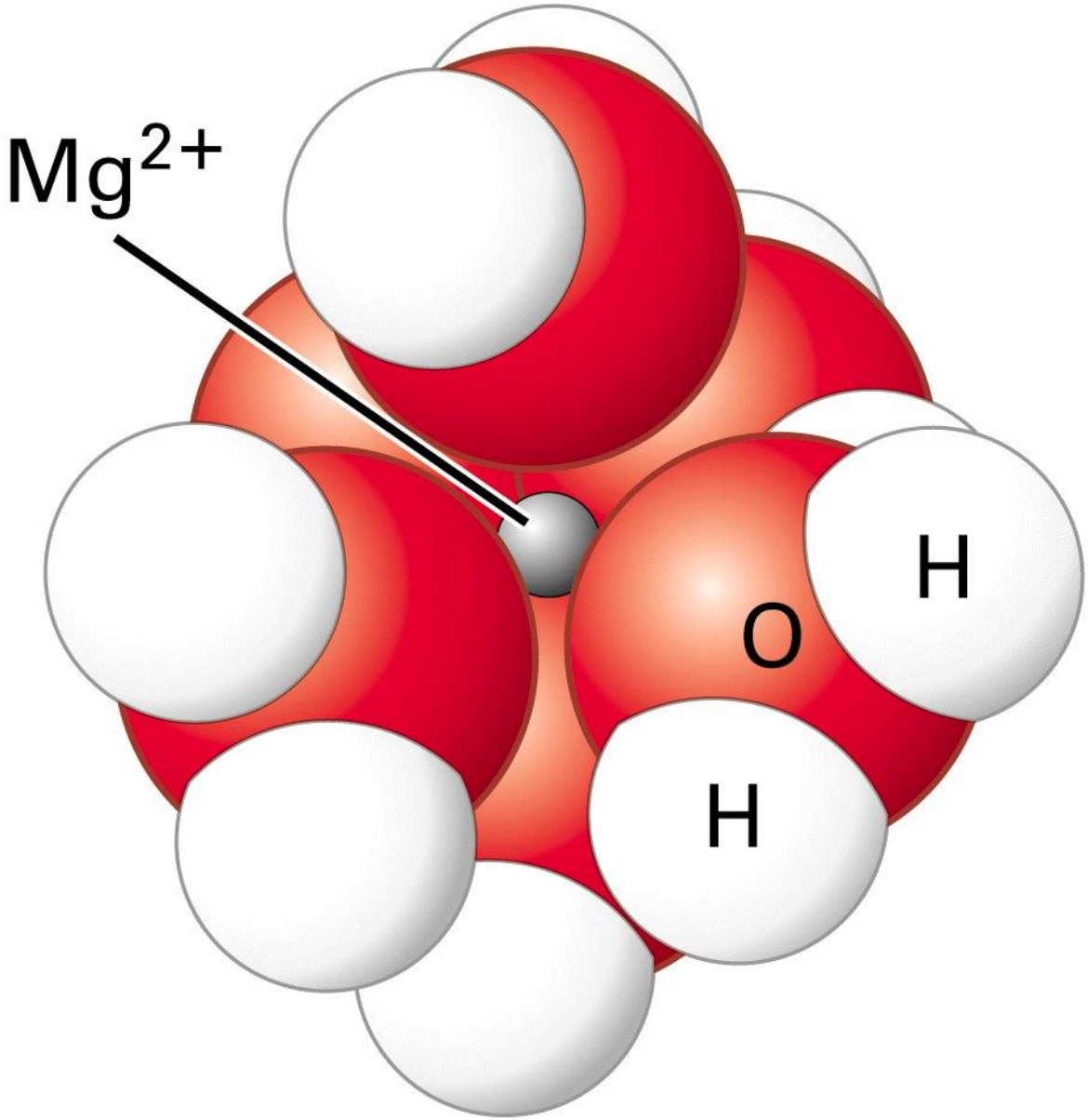
3. **Wikipedia**



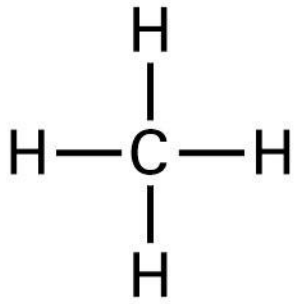


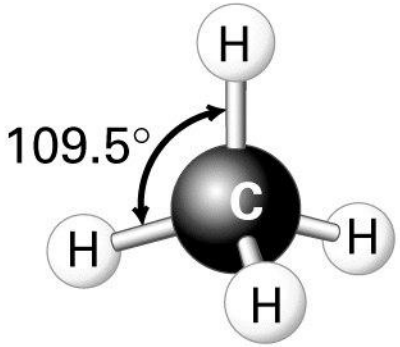


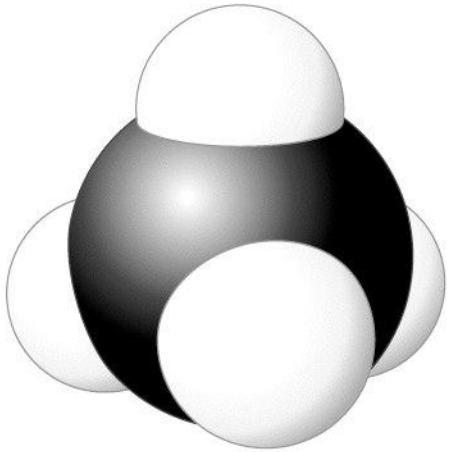
Water-water



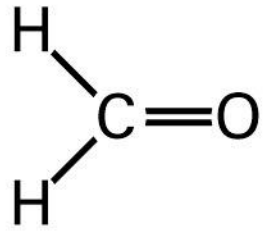
(a) Methane

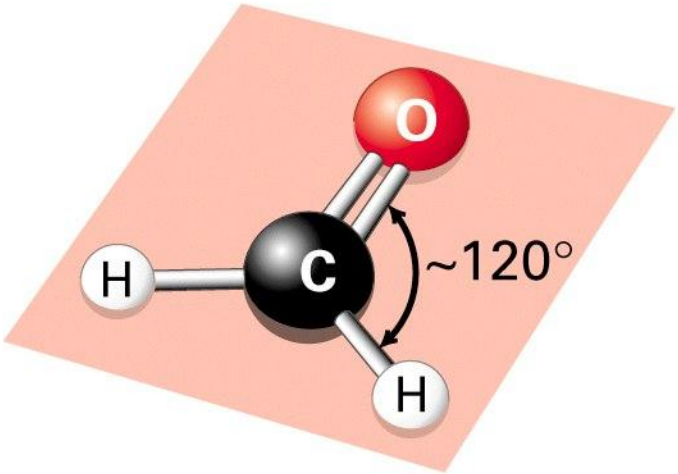


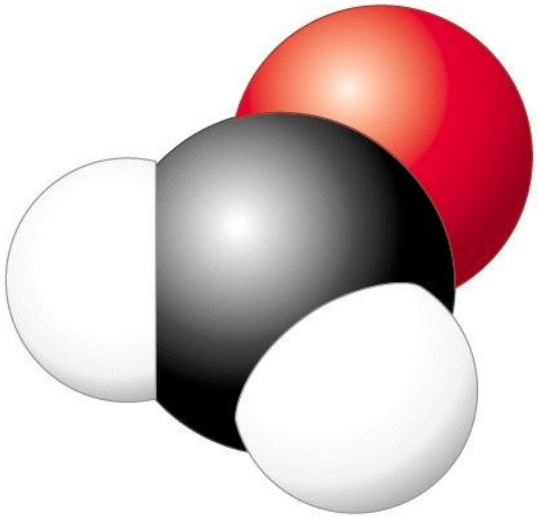




(b) Formaldehyde





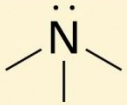
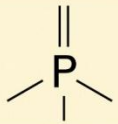
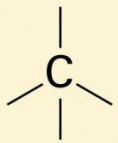


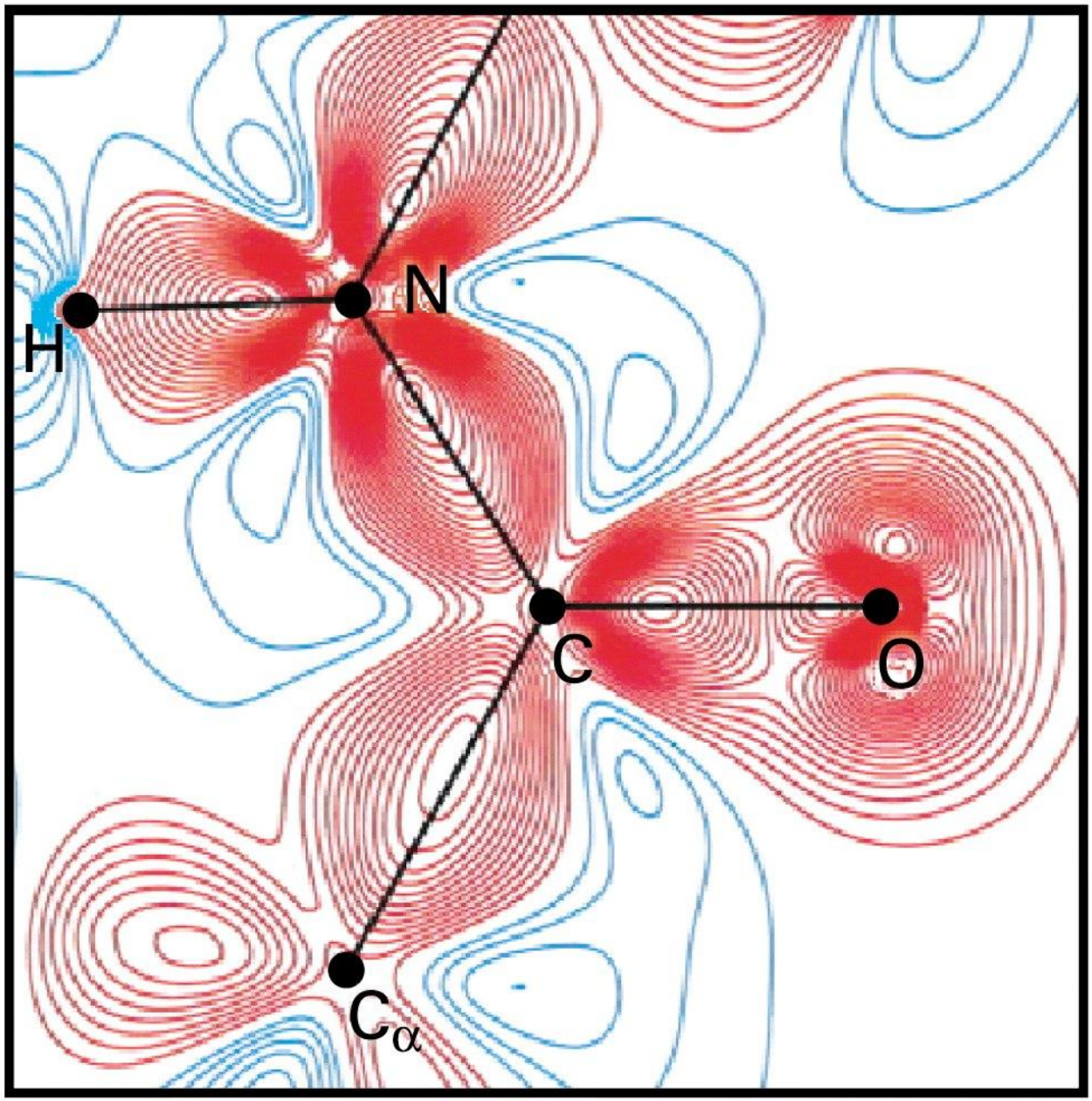
Chemical structure

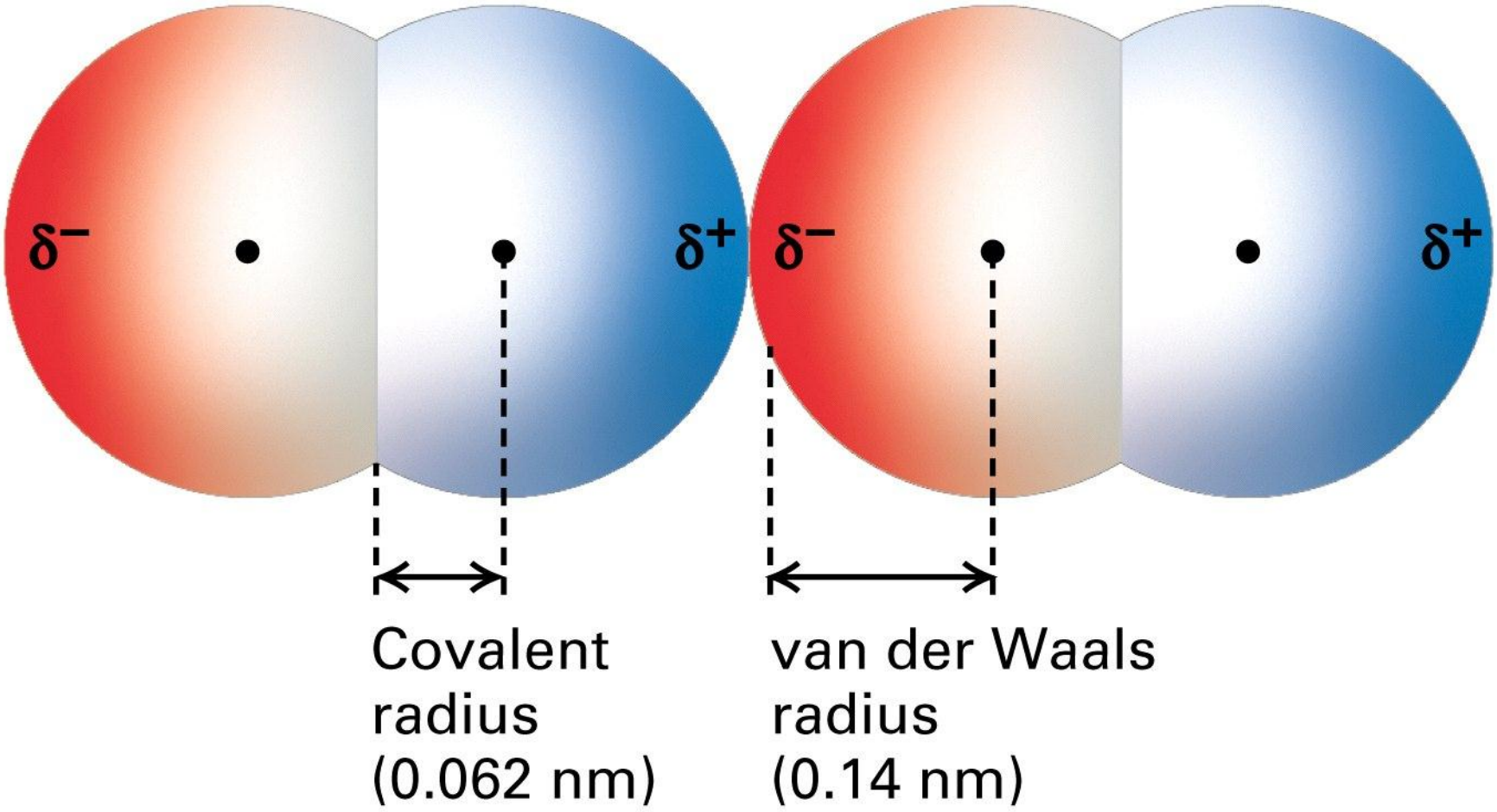
Ball-and-stick model

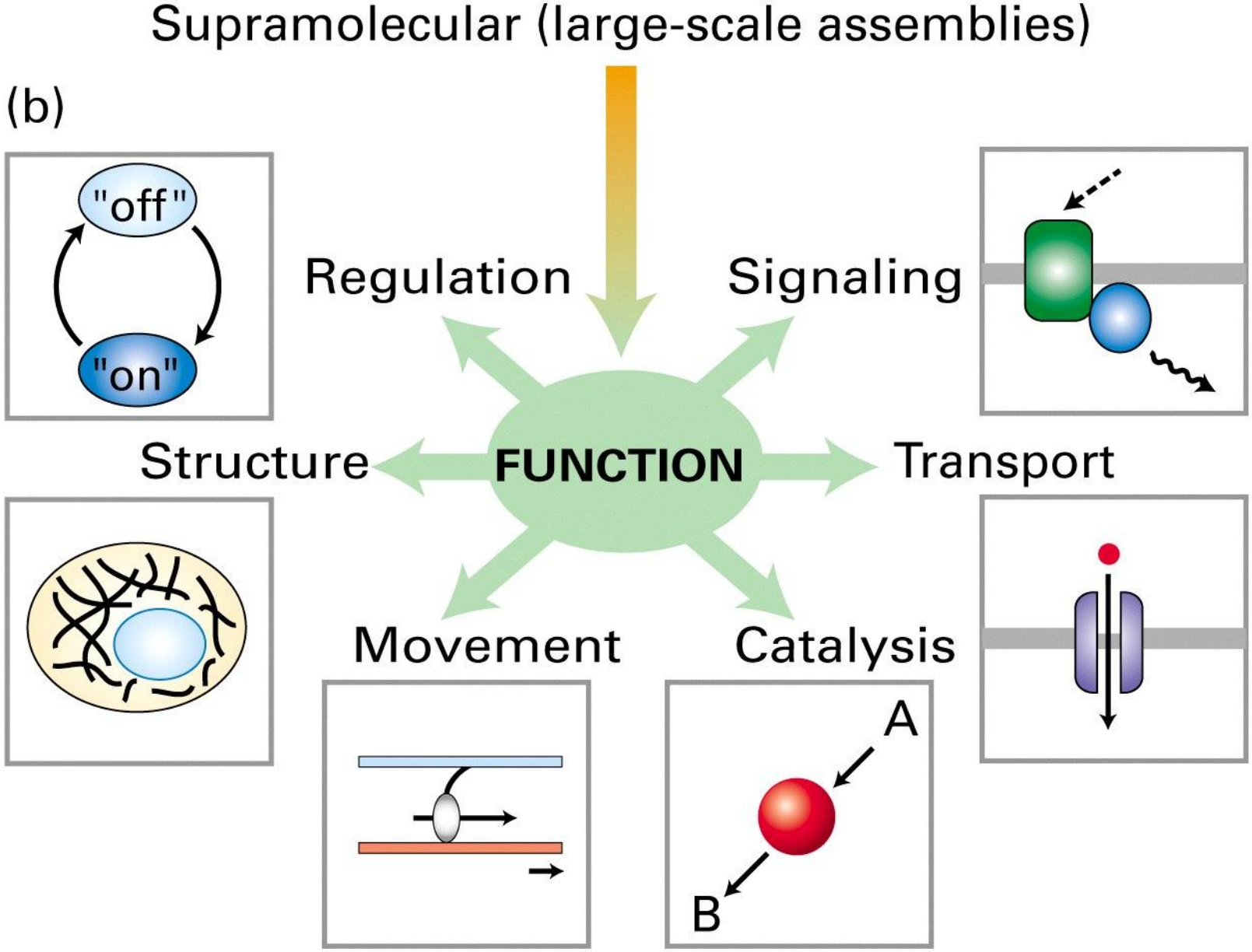
Space-filling model

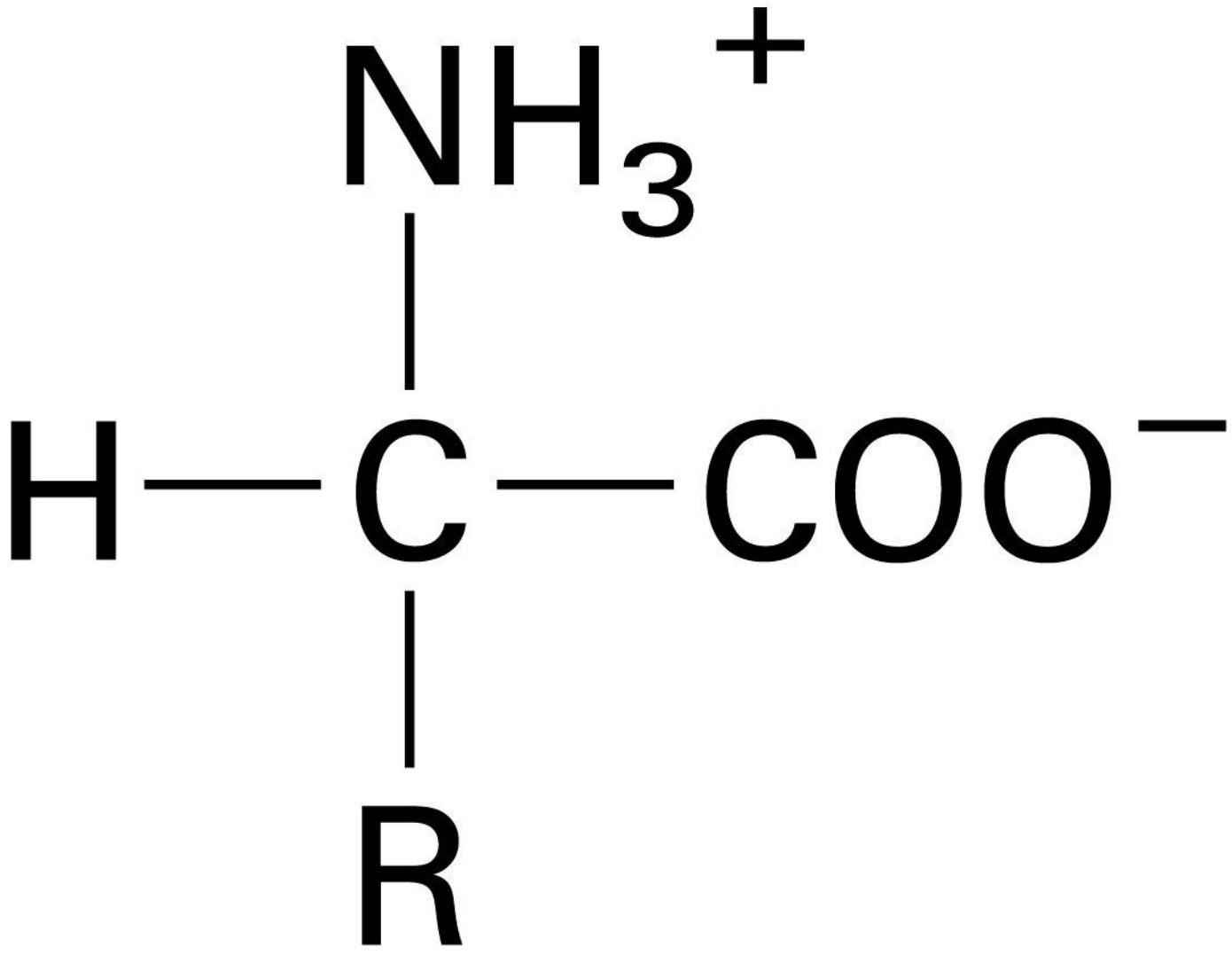
TABLE 2-1 Bonding Properties of Atoms Most Abundant in Biomolecules

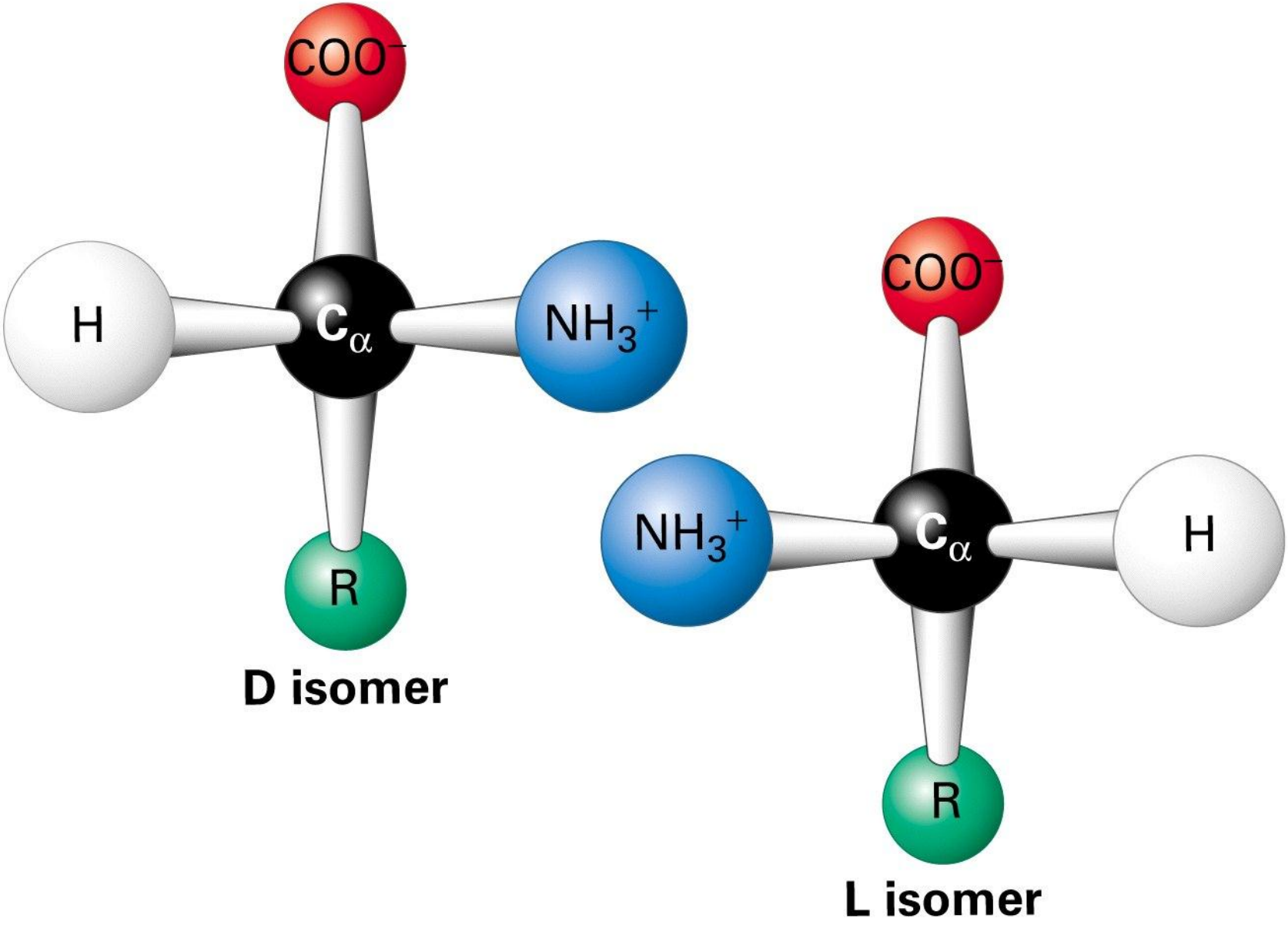
Atom and Outer Electrons	Usual Number of Covalent Bonds	Bond Geometry
H	1	
O	2	
S	2, 4, or 6	
N	3 or 4	
P	5	
C	4	



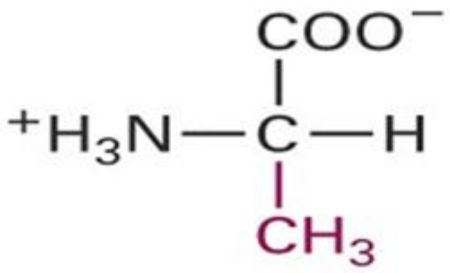



Supramolecular (large-scale assemblies)
(b)
"off"
"on"
Regulation
Signaling
Structure
FUNCTION
Transport
Movement
Catalysis
A
B

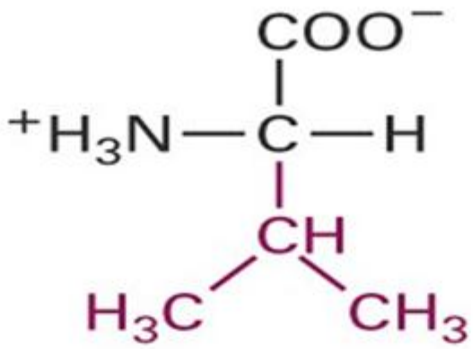




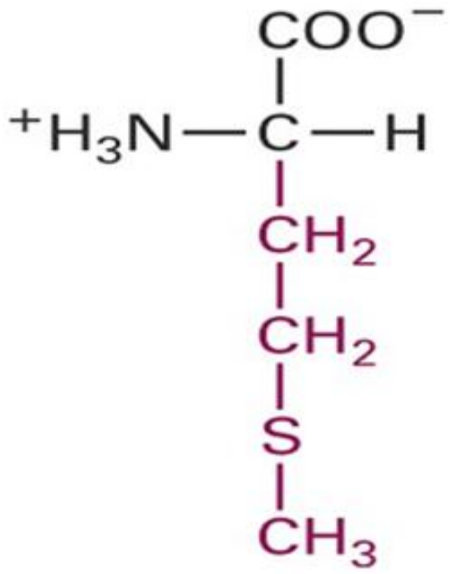
HYDROPHOBIC AMINO ACIDS



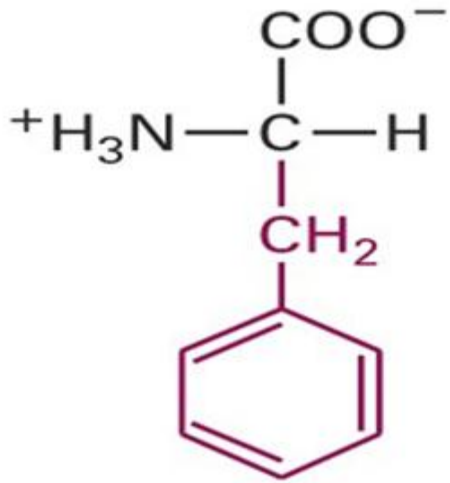
Alanine



Valine



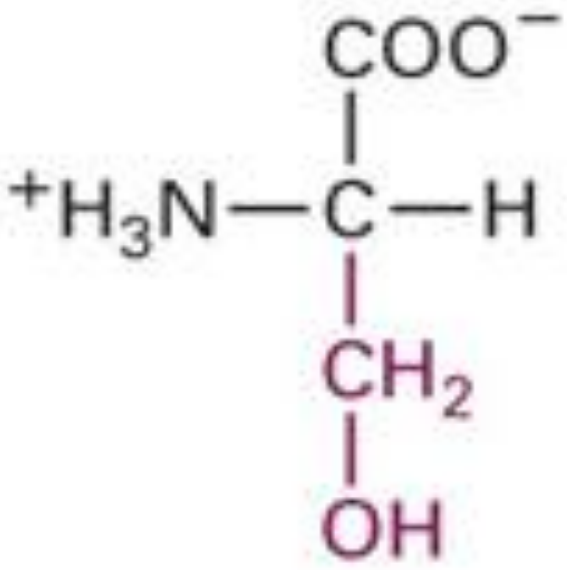
Methionine



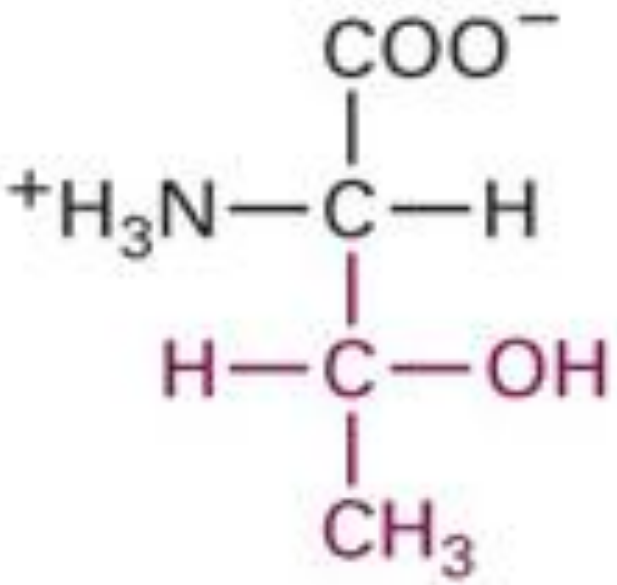
Phenylalanine

HYDROPHILIC AMINO ACIDS

Polar amino acids with uncharged R groups



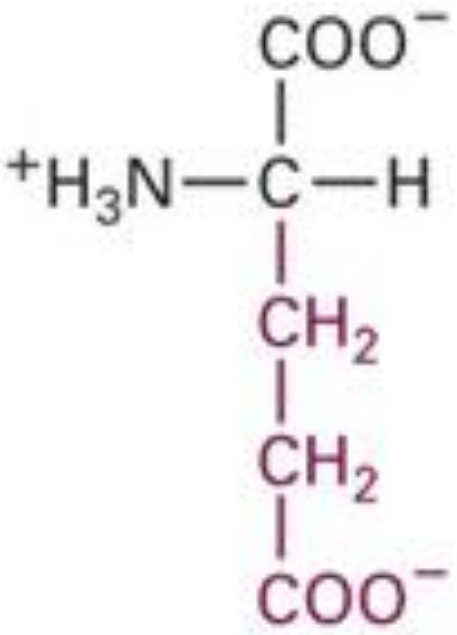
Serine (Ser or S)



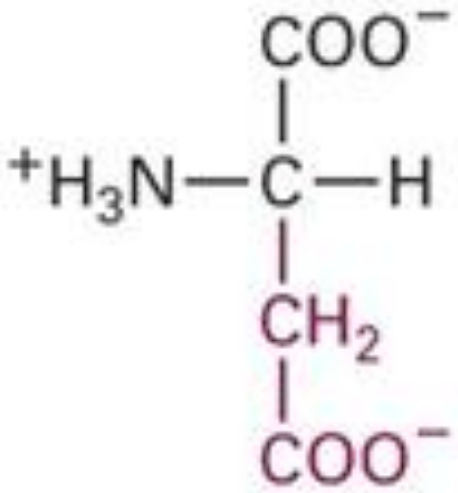
Threonine (Thr or T)

HYDROPHILIC AMINO ACIDS

Acidic amino acids



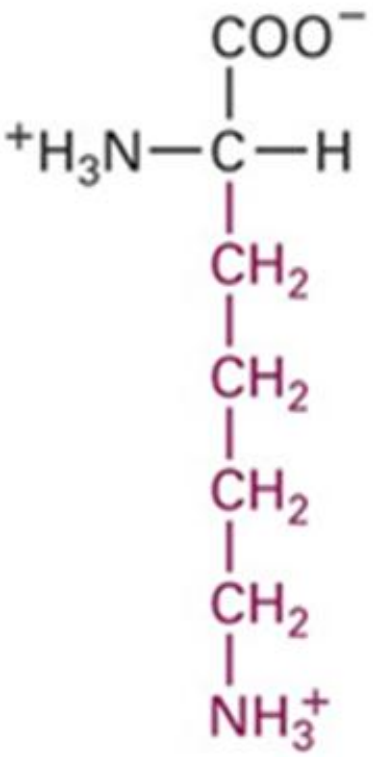
Glutamate (Glu or E)



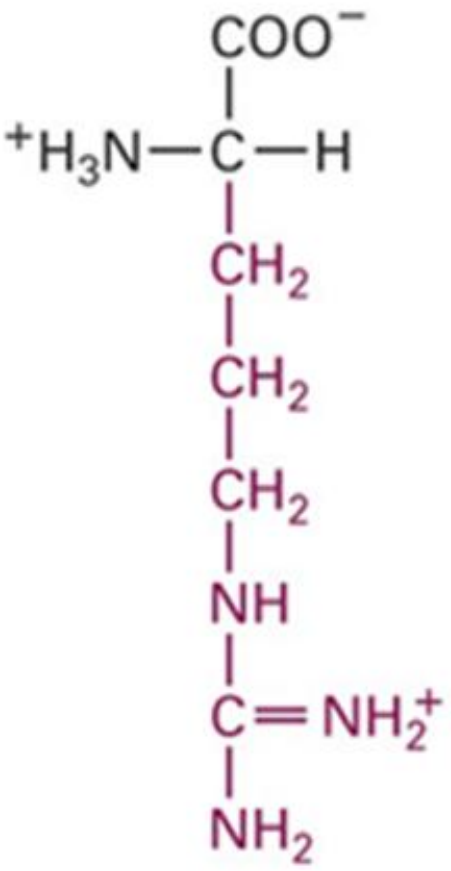
Aspartate (Asp or D)

HYDROPHILIC AMINO ACIDS

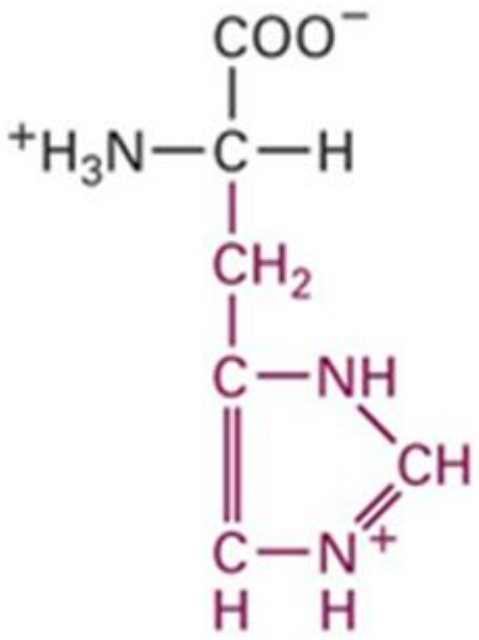
Basic amino acids



Lysine
(Lys or K)



Arginine
(Arg or R)

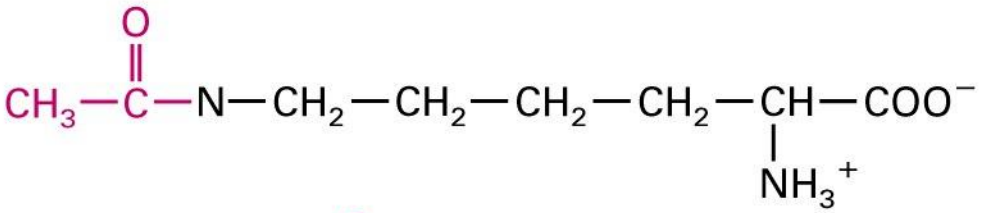


Histidine
(His or H)

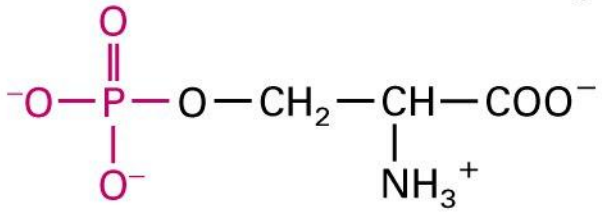
Abbreviations and Codes

Alanine **A, Ala**
Arginine **R, Arg**
Asparagine **N, Asn**
Aspartic acid **D, Asp**
Cysteine **C, Cys**
Glutamine **Q, Gln**
Glutamic Acid **E, Glu**
Glycine **G, Gly**
Histidine **H, His**
Isoleucine **I, Ile**
Leucine **L, Leu**
Lysine **K, Lys**
Methionine **M, Met**
Phenylalanine **F, Phe**
Proline **P, Pro**
Serine **S, Ser**
Threonine **T, Thr**
Tryptophan **W, Trp**
Tyrosine **Y, Tyr**
Valine **V, Val**

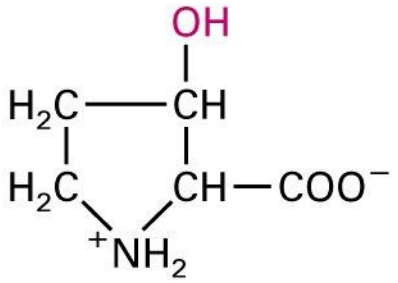
Acetyl lysine



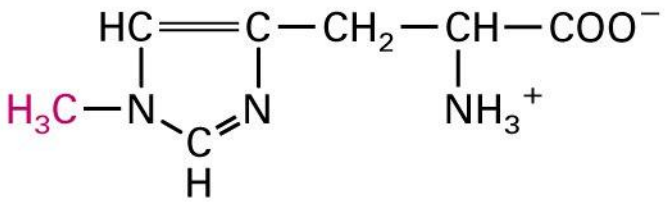
Phosphoserine



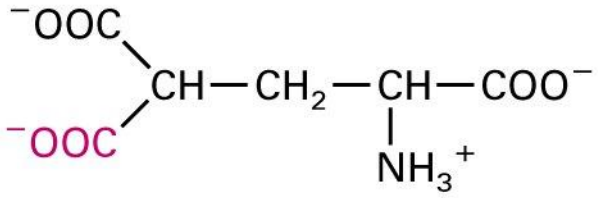
3-Hydroxyproline



3-Methylhistidine

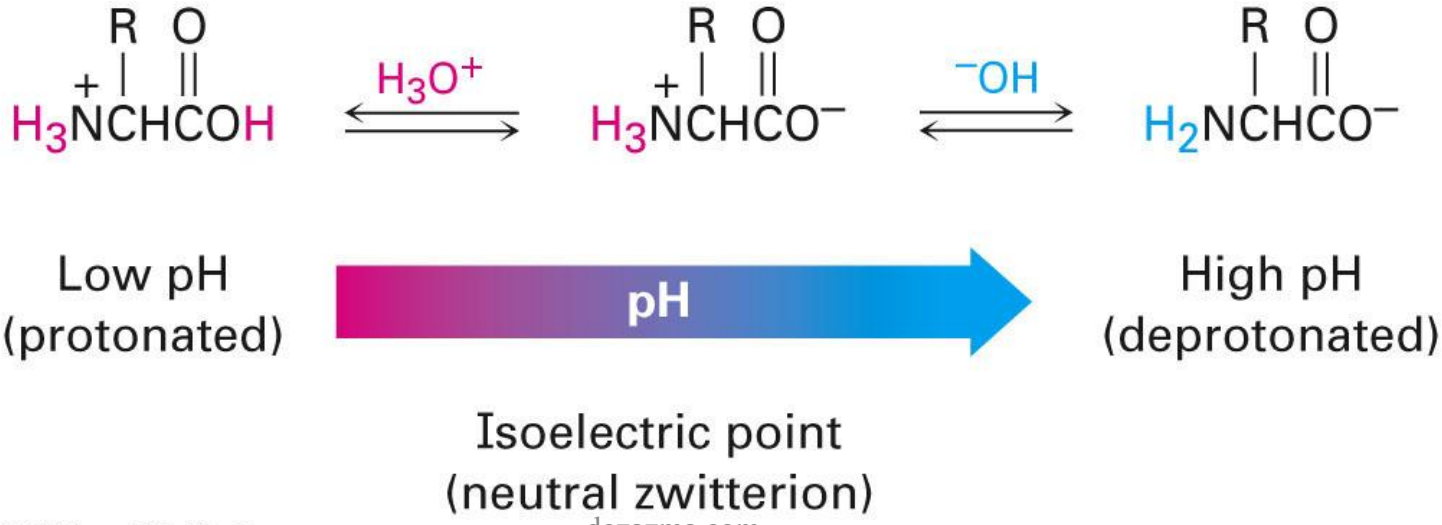


γ-Carboxyglutamate



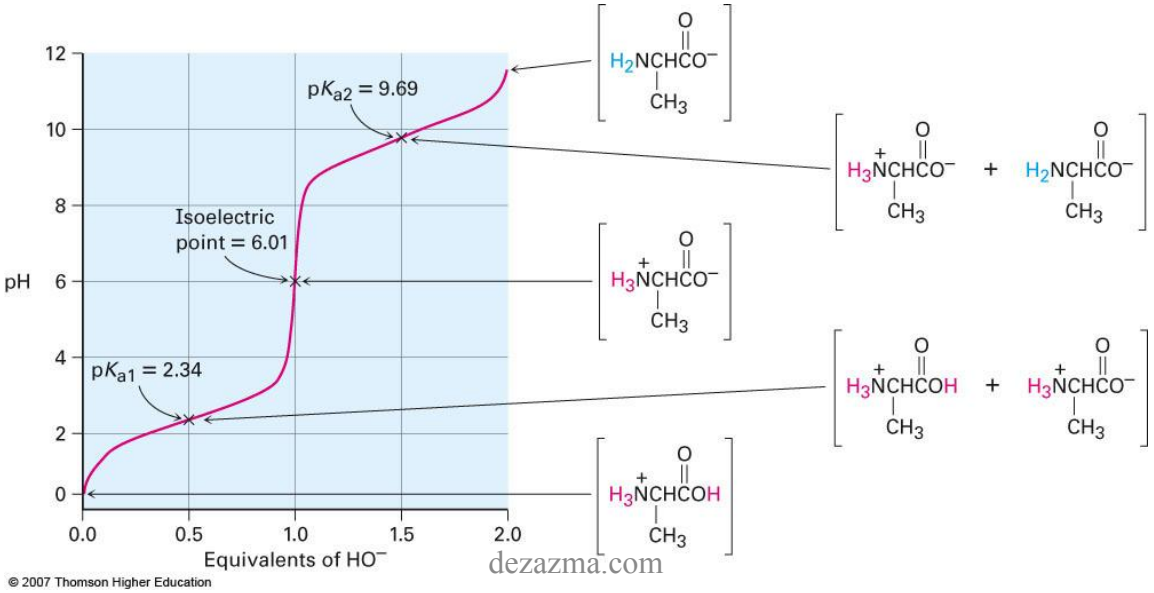
26.2 Amino Acids, the Henderson Hasselbalch Equation, and Isoelectric Points

- In acidic solution, the carboxylate and amine are in their conjugate acid forms, an overall cation
- In basic solution, the groups are in their base forms, an overall anion
- In neutral solution cation and anion forms are present
- This pH where the overall charge is 0 is the isoelectric point, pI



Titration Curves of Amino Acids

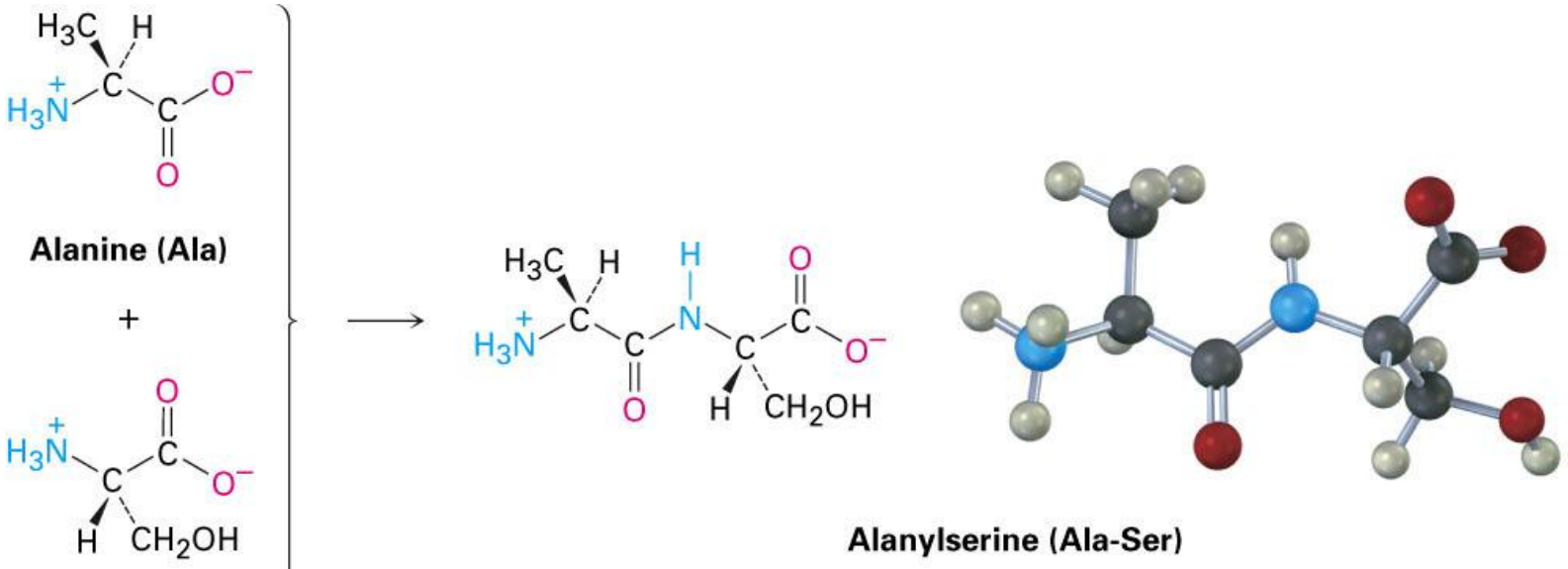
- If pKa values for an amino acid are known the fractions of each protonation state can be calculated (Henderson-Hasselbach Equation)
- $pH = pK_a - \log [A^-]/[HA]$
- This permits a titration curve to be calculated or pK_a to be determined from a titration curve



$$\mathrm{pH} = \mathrm{p}K_\mathrm{a} + \log_{10}\left(\frac{[\mathrm{A}^-]}{[\mathrm{HA}]}\right)$$

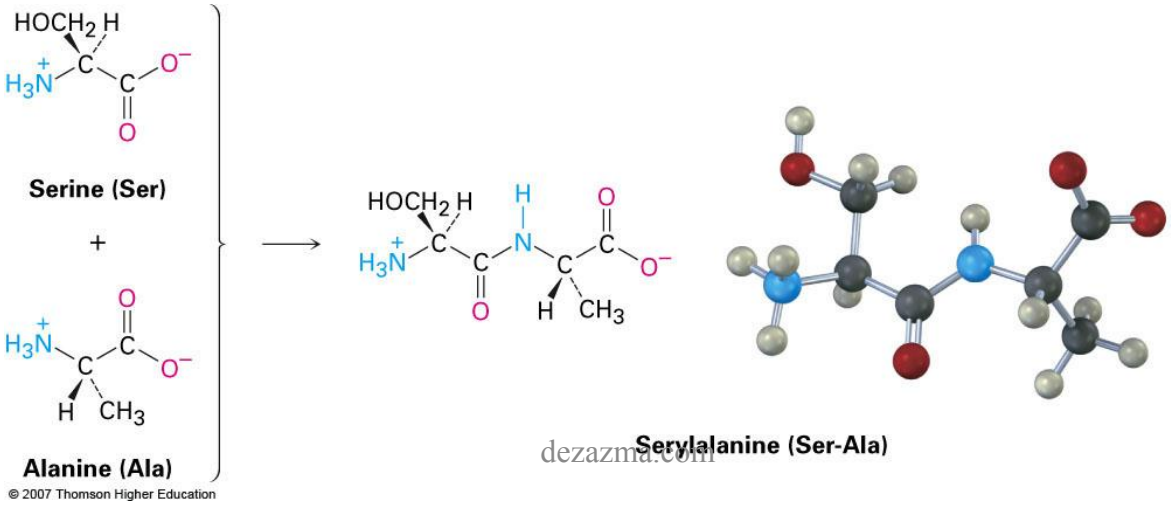
26.4 Peptides and Proteins

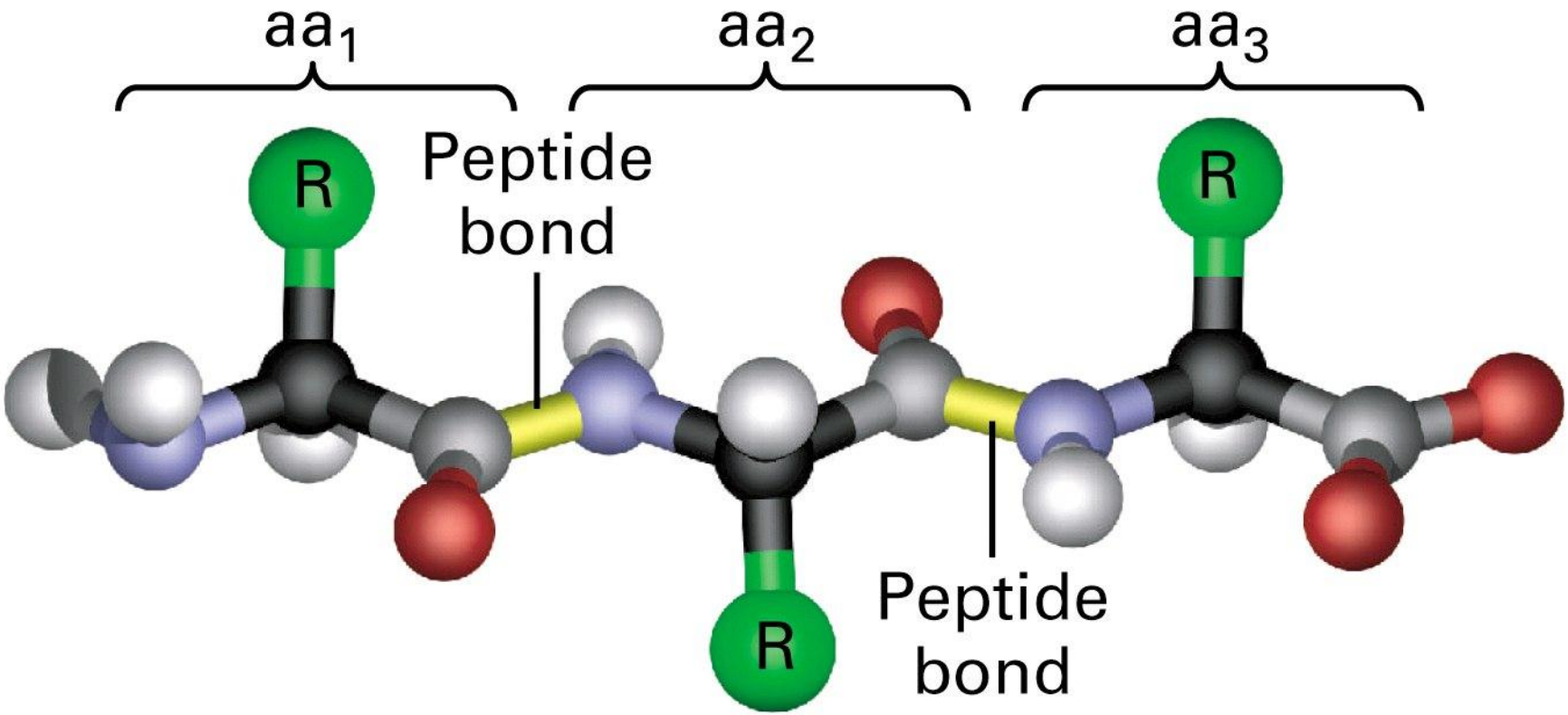
- Proteins and peptides are amino acid polymers in which the individual amino acid units, called residues, are linked together by amide bonds, or peptide bonds
- An amino group from one residue forms an amide bond with the carboxyl of a second residue

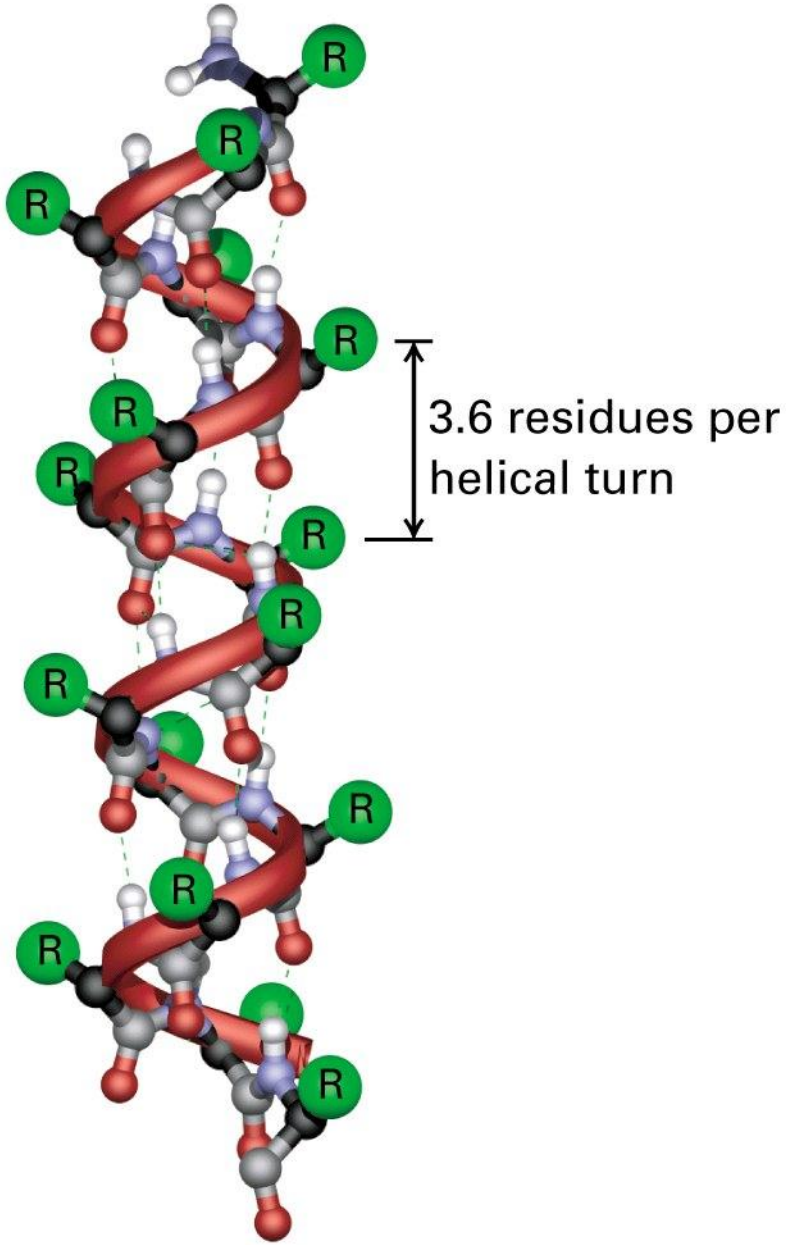


Peptide Linkages

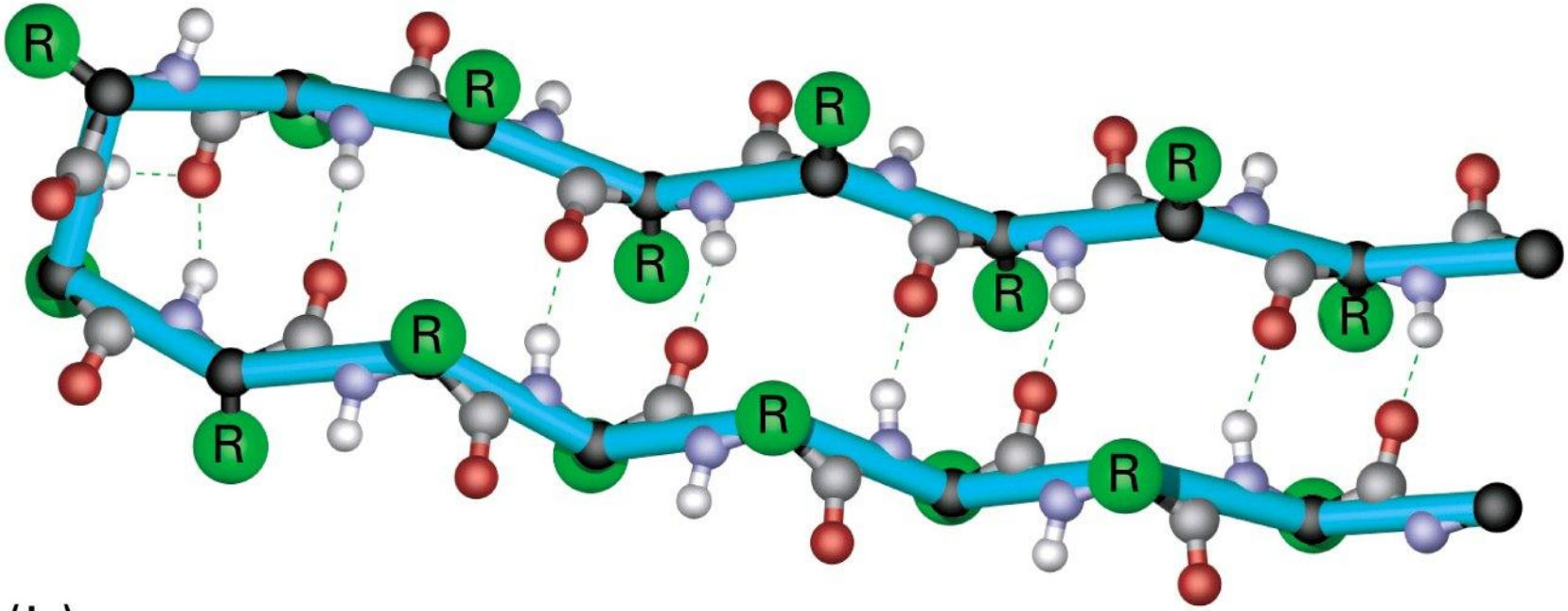
- Two dipeptides can result from reaction between **A** and **S**, depending on which COOH reacts with which NH_2 we get AS or SA
- The long, repetitive sequence of —N—CH—CO— atoms that make up a continuous chain is called the protein's backbone
- Peptides are always written with the N-terminal amino acid (the one with the free —NH_2 group) on the left and the C-terminal amino acid (the one with the free —CO_2H group) on the right
- Alanylserine is abbreviated Ala-Ser (or A-S), and serylalanine is abbreviated Ser-Ala (or S-A)



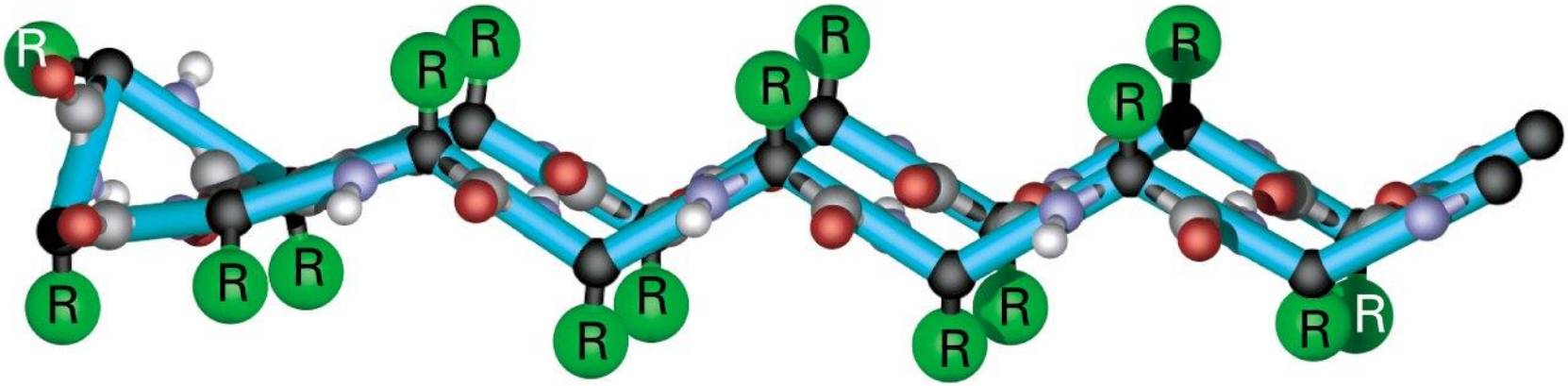




(a)

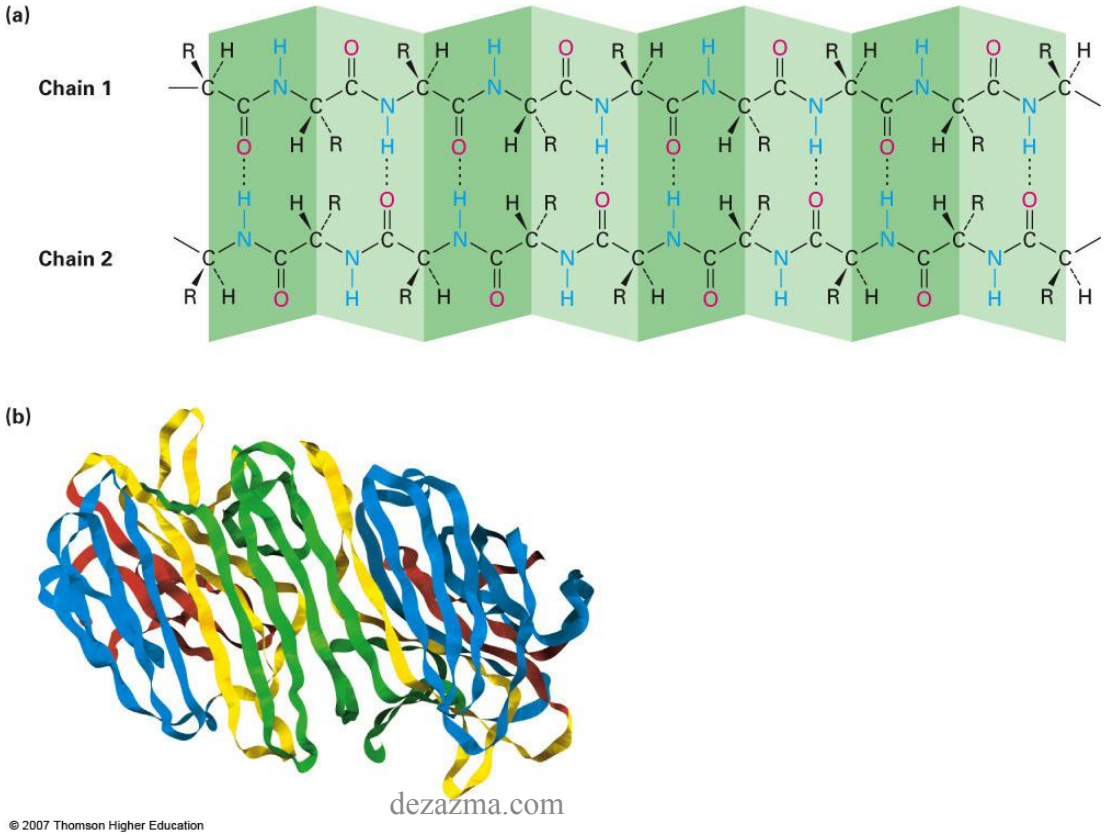


(b)

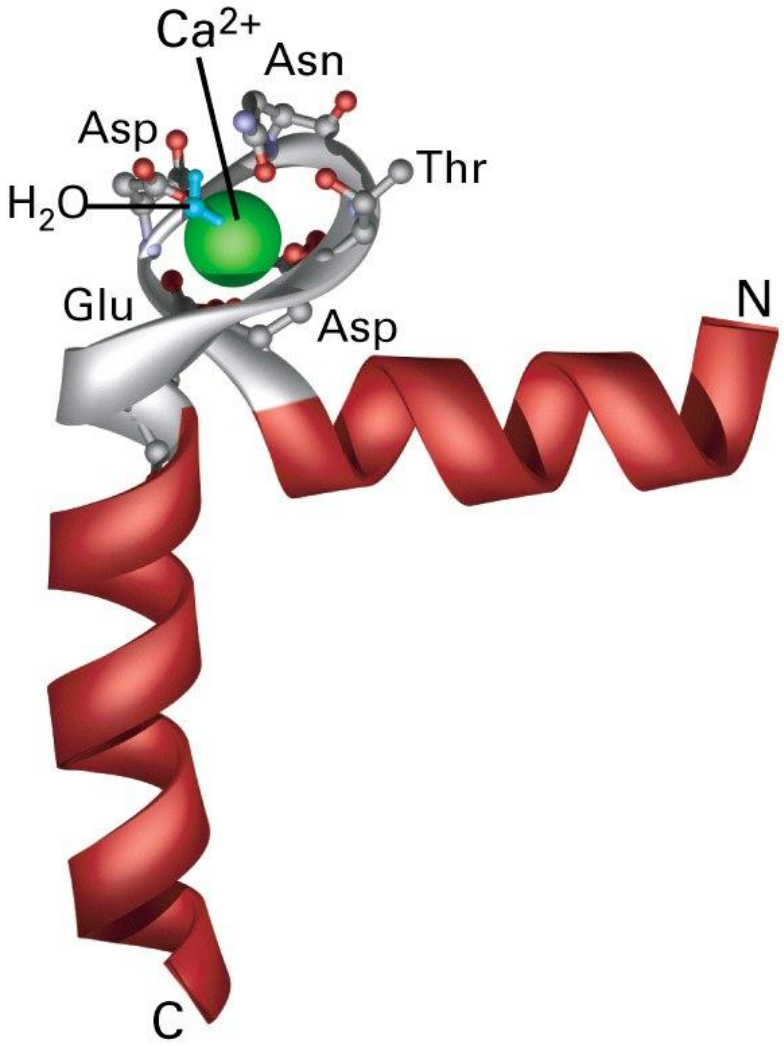


β-Pleated Sheet

- β-pleated sheet secondary structure is exhibited by polypeptide chains lined up in a parallel arrangement, and held together by hydrogen bonds between chains

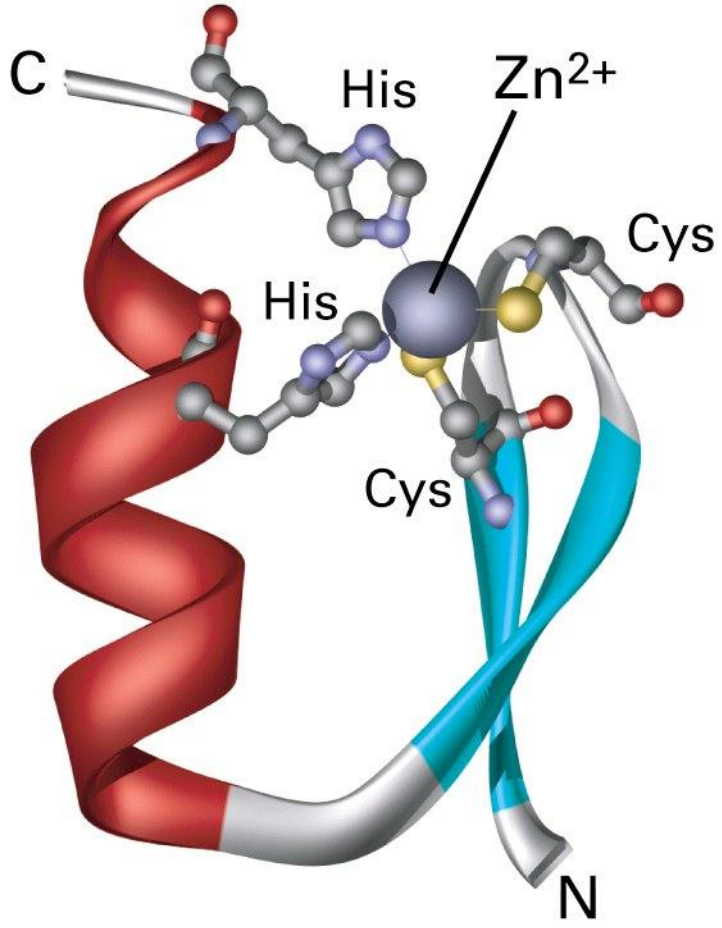


(a) Helix-loop-helix motif



Consensus sequence:
D/N - D/N - D/N/S - [backbone O] - - - - E/D

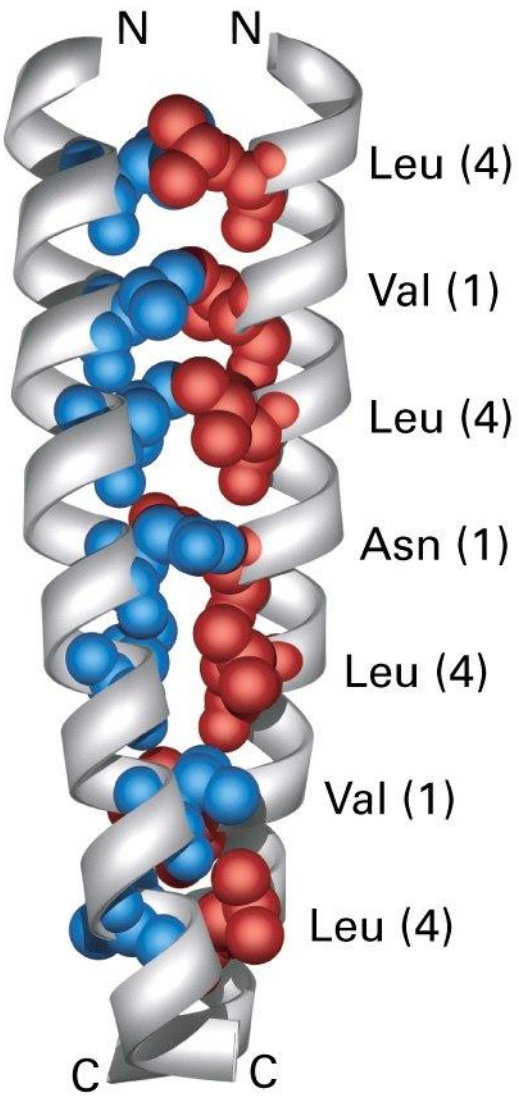
(b) Zinc-finger motif



Consensus sequence:

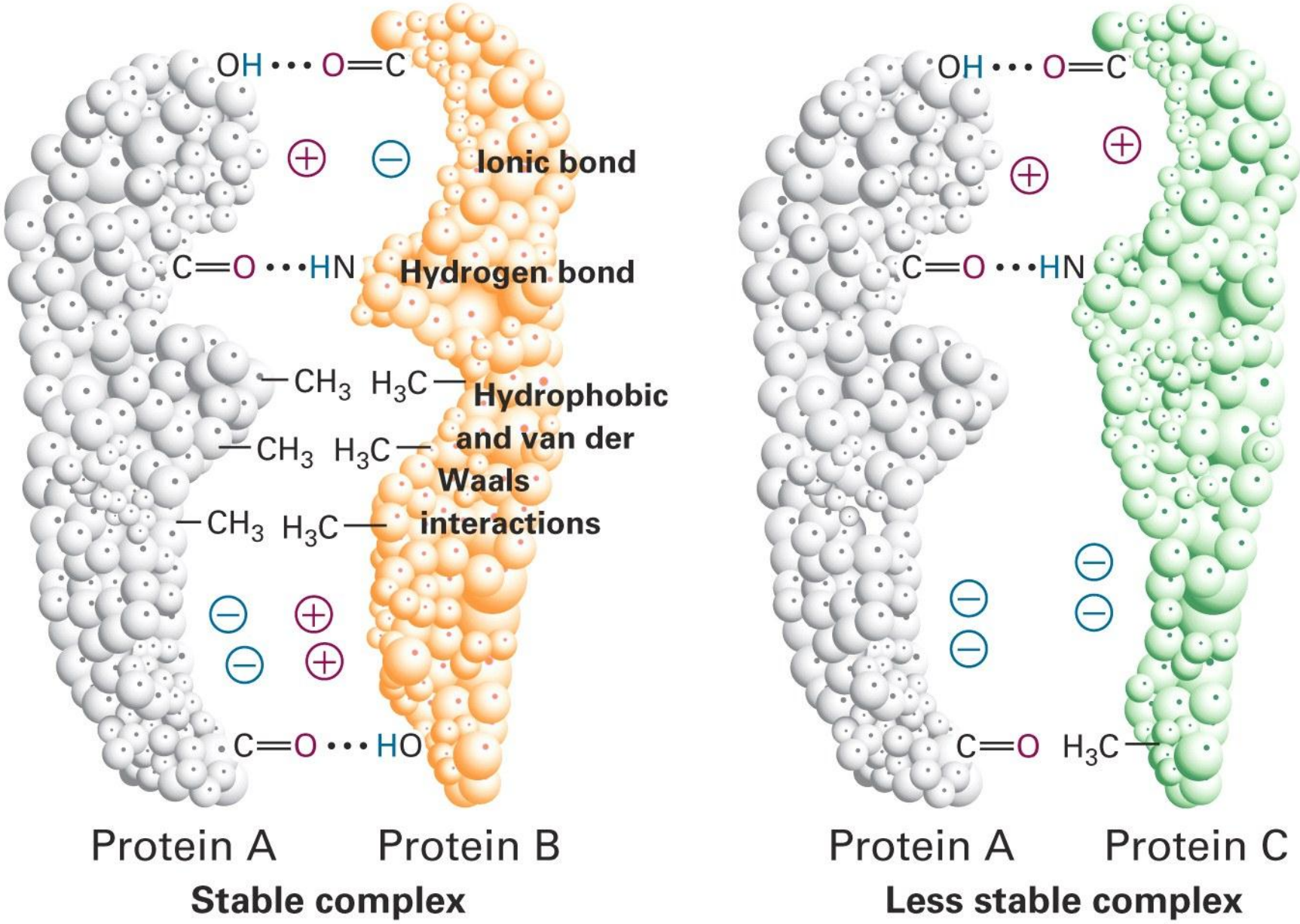
F/Y - C - - C - - - - F/Y - - - - - - - - H - - - H -

(c) Coiled coil motif

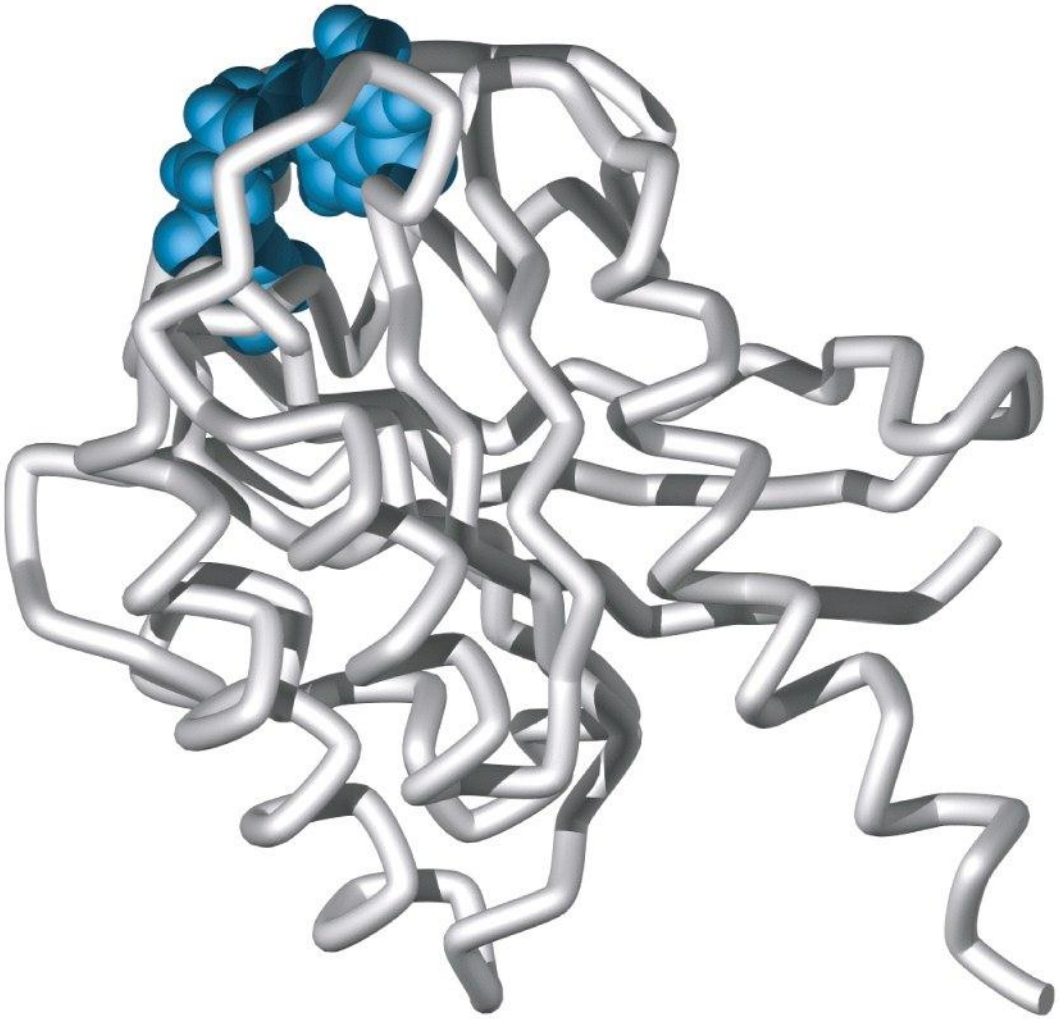


Heptad repeat:
[V/N/M] - - L - - -

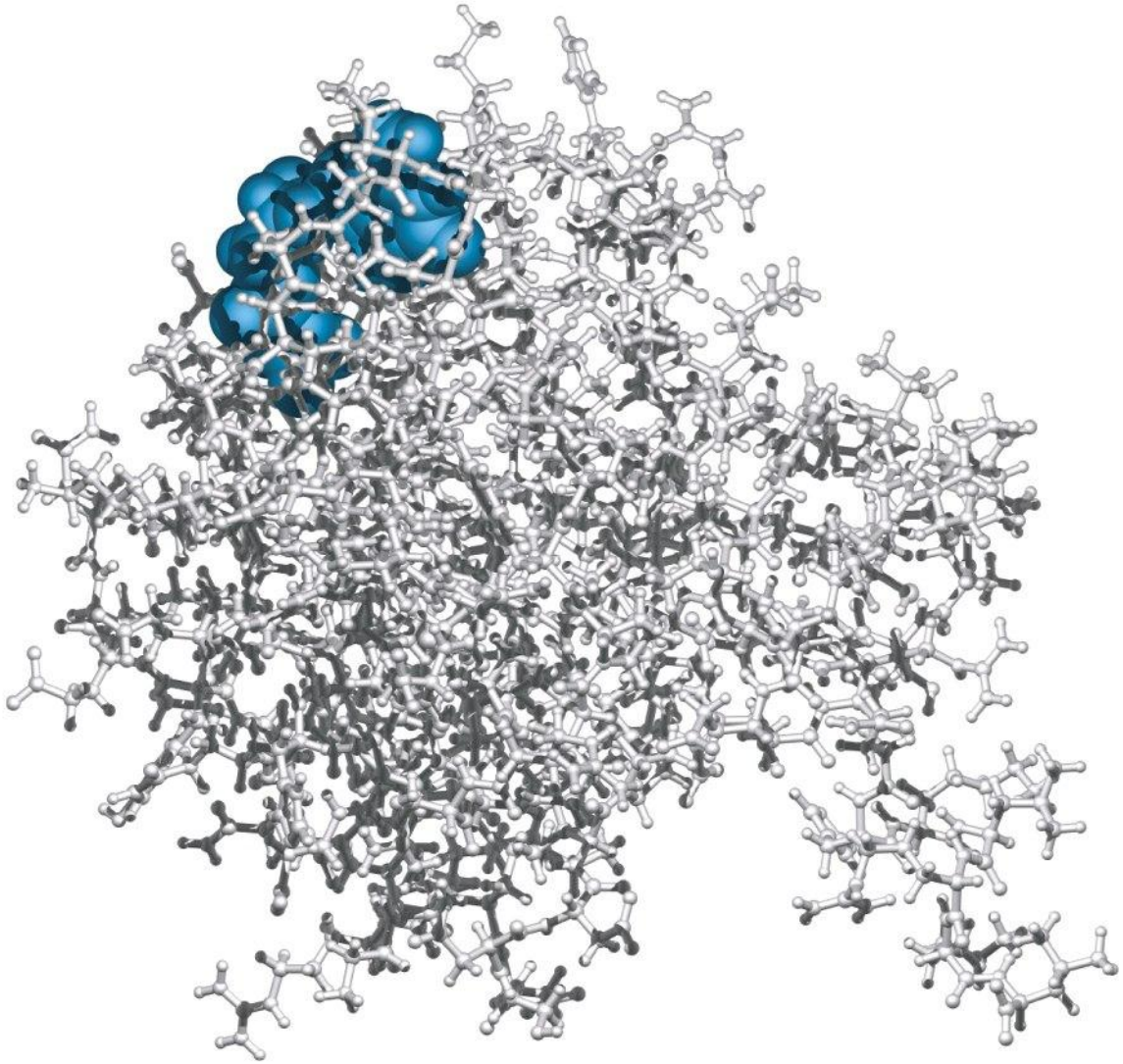
(c) Ribbons


OH ••• O=C
Ionic bond
C=O •••HN
Hydrogen bond
—CH3 H3C—
—CH3 H3C—
—CH3 H3C—
Hydrophobic and van der Waals interactions
C=O ••• HO
Protein A
Protein B
Stable complex
OH ••• O=C
C=O •••HN
C=O
H3C—
Protein A
Protein C
Less stable complex

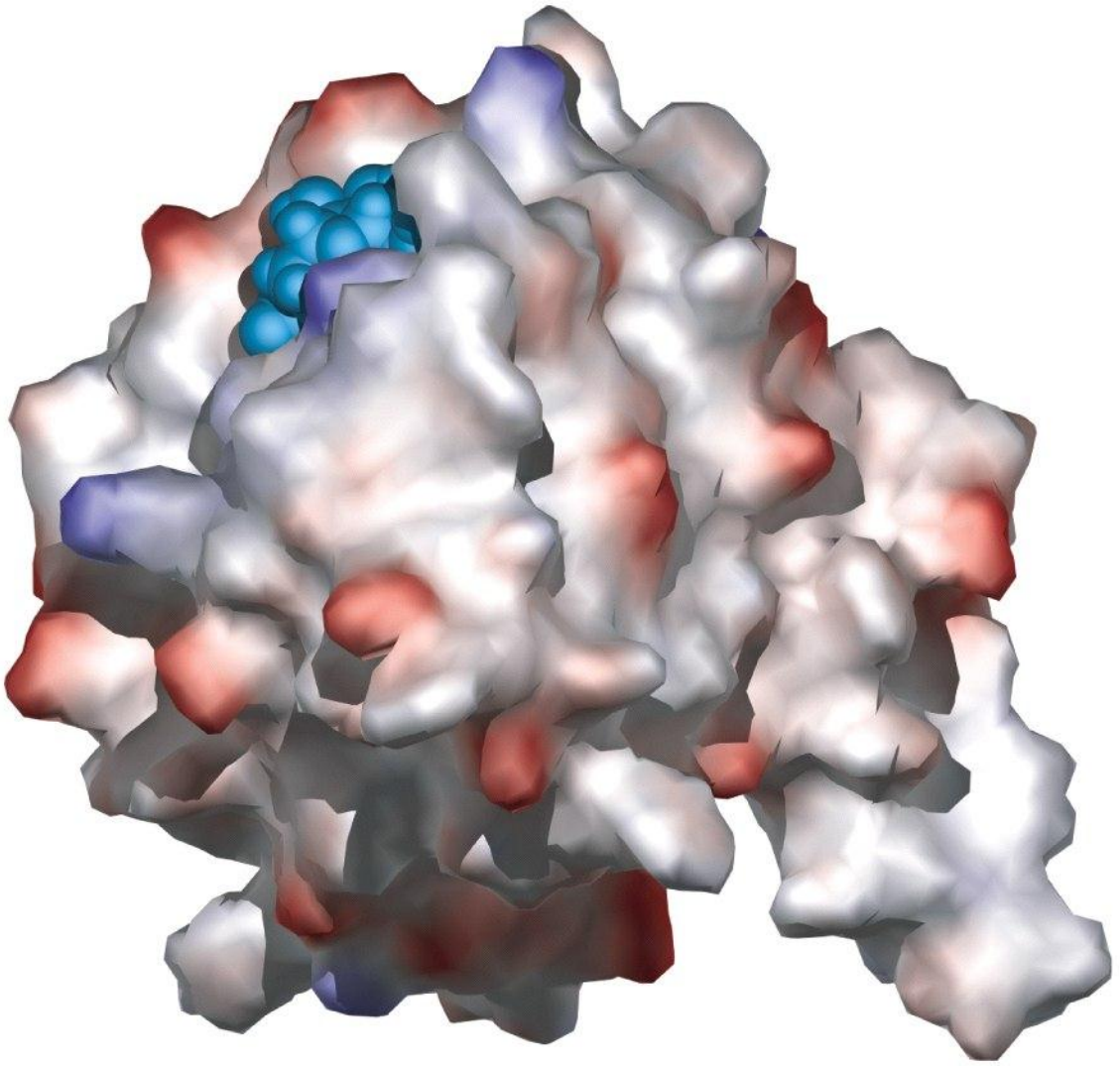
(a) C_α backbone trace

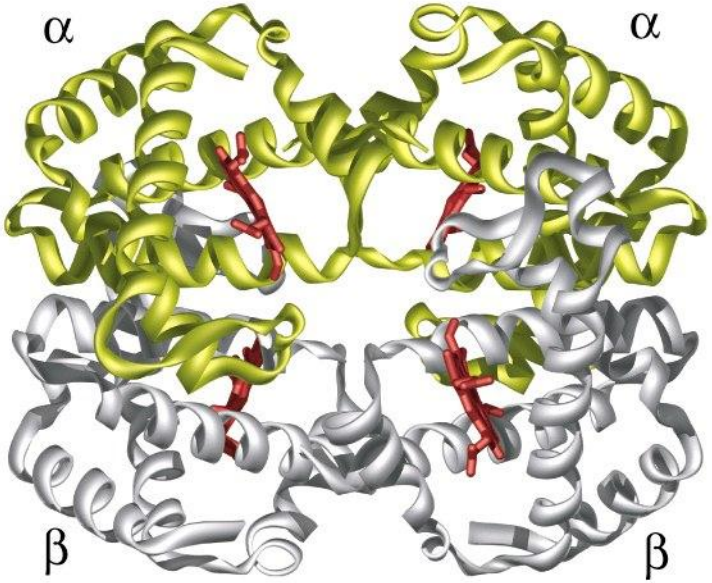


(b) Ball and stick

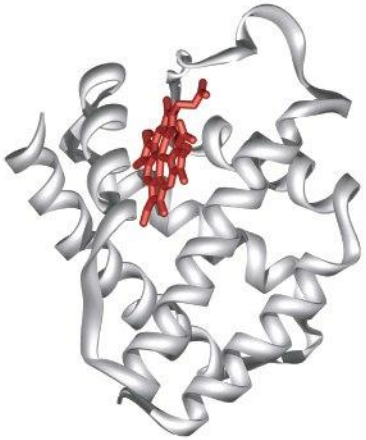


(d) Solvent-accessible surface

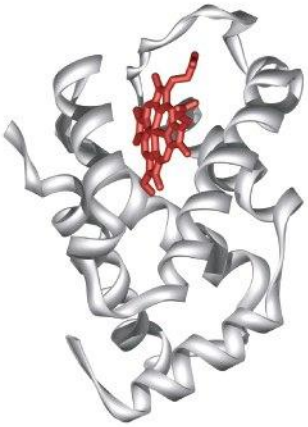




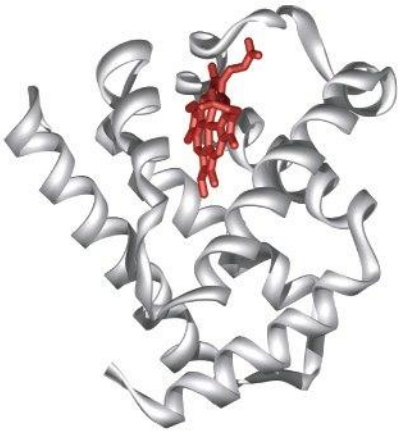
Hemoglobin



Leghemoglobin

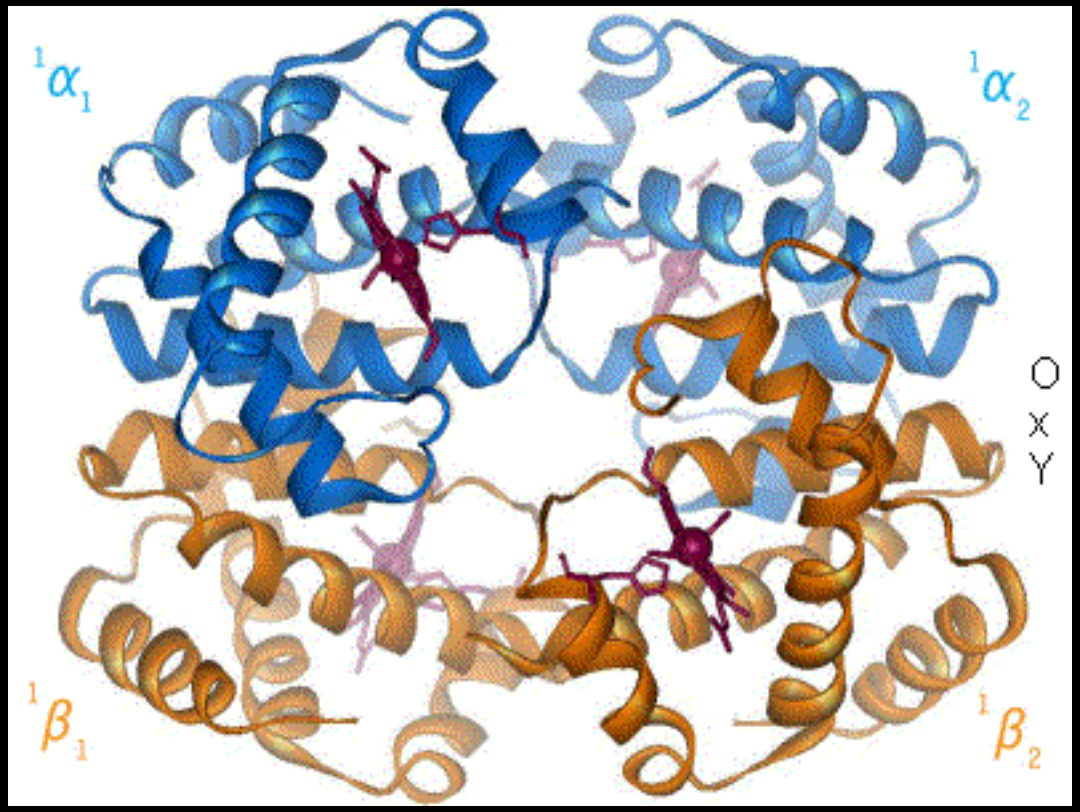


β subunit
of hemoglobin

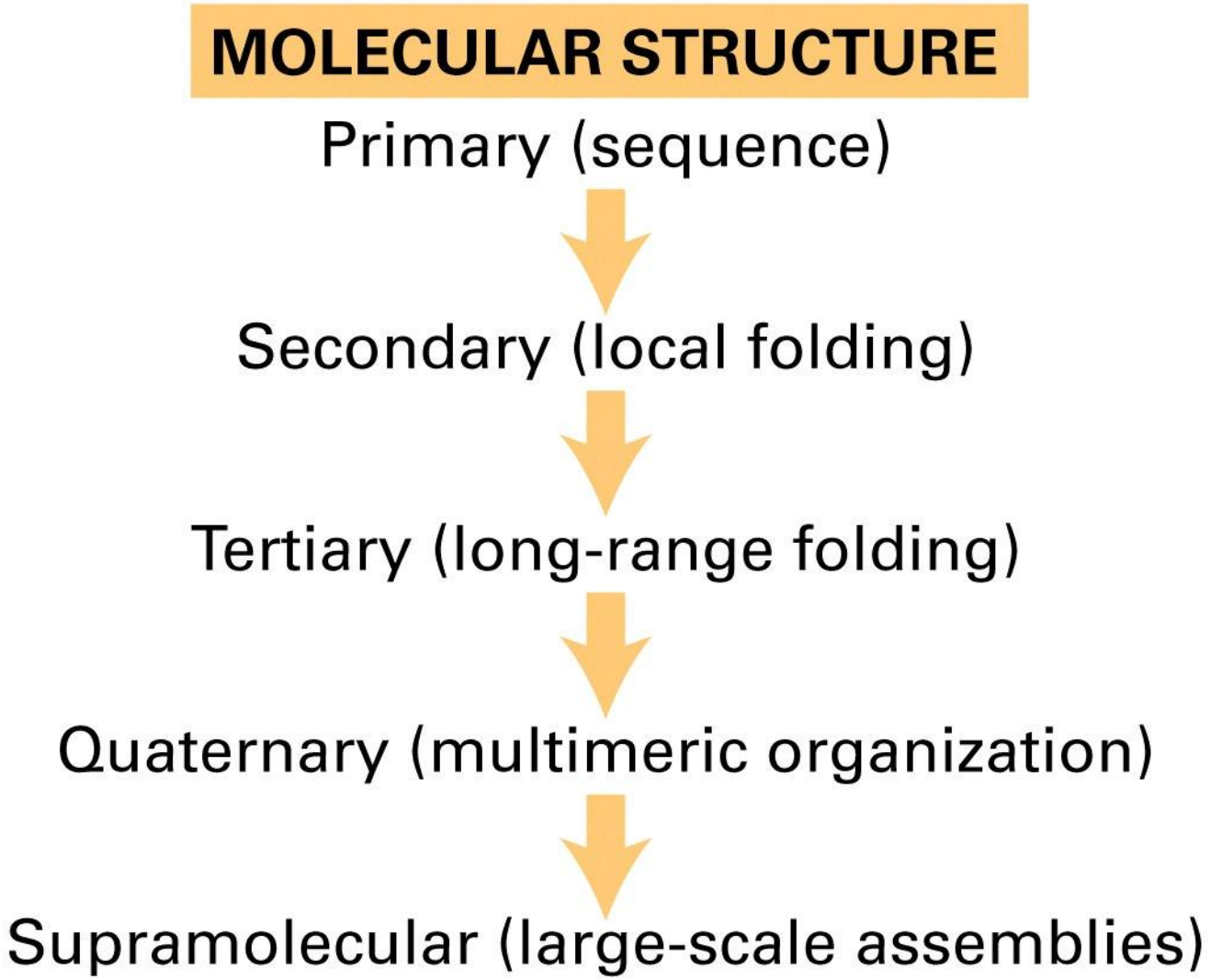


Myoglobin

- Hb A (α2β2) is the major adult Hb and Hb A_2 (α2δ2) is the minor one.



(a)



Denaturation of Proteins

- The tertiary structure of a globular protein is the result of many intramolecular attractions that can be disrupted by a change of the environment, causing the protein to become denatured
- Solubility is drastically decreased as in heating egg white, where the albumins unfold and coagulate
- Enzymes also lose all catalytic activity when denatured