



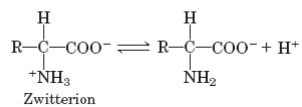
AMINO ACIDS, PEPTIDES, AND PROTEINS

Presented by Dr. A.H.Mahdavi

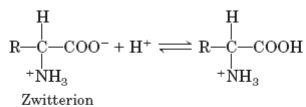
Amino Acids Can Act as Acids and Bases



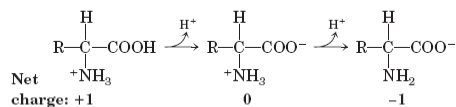
as either an acid (proton donor):



or a base (proton acceptor):



Substances having this dual nature are **amphoteric** and are often called **ampholytes** (from "amphoteric electrolytes"). A simple monoamino monocarboxylic α -amino acid, such as alanine, is a diprotic acid when fully protonated—it has two groups, the $-\text{COOH}$ group and the $-\text{NH}_3^+$ group, that can yield protons:



Amino Acids Have Characteristic Titration Curves

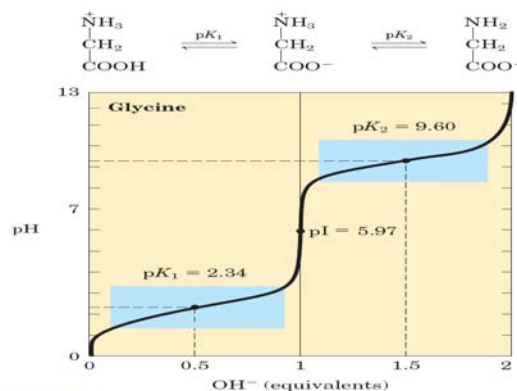


FIGURE 3-10 Titration of an amino acid. Shown here is the titration curve of 0.1 M glycine at 25 °C. The ionic species predominating at key points in the titration are shown above the graph. The shaded boxes, centered at about pK₁ = 2.34 and pK₂ = 9.60, indicate the regions of greatest buffering power.

$$pI = \frac{1}{2} (pK_1 + pK_2) = \frac{1}{2} (2.34 + 9.60) = 5.97$$



Amino Acids Differ in Their Acid-Base Properties

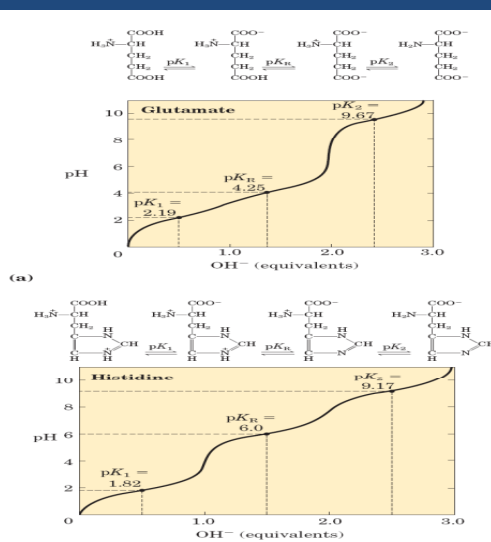


FIGURE 3-12 Titration curves for (a) glutamate and (b) histidine. The pK_a of the R group is designated here as pK_R.



Peptides and Proteins

- Two amino acid molecules can be **covalently** joined through a substituted amide linkage, termed a **peptide bond**, to yield a **dipeptide**. Such a linkage is formed by removal of the elements of water (dehydration) from the alpha-carboxyl group of one amino acid and the alpha-amino group of another.
- When a few amino acids are joined in this fashion, the structure is called an **oligopeptide**.
- When many amino acids are joined, the product is called a **polypeptide**.
- Proteins may have thousands of amino acid residues. Although the terms “protein” and “polypeptide” are sometimes used interchangeably, molecules referred to as polypeptides generally have molecular weights below 10,000, and those called proteins have higher molecular weights.

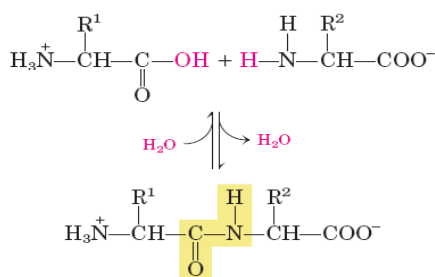


FIGURE 3-13 Formation of a peptide bond by condensation. The α -amino group of one amino acid (with R^2 group) acts as a nucleophile to displace the hydroxyl group of another amino acid (with R^1 group), forming a peptide bond (shaded in yellow). Amino groups are good nucleophiles, but the hydroxyl group is a poor leaving group and is not readily displaced. At physiological pH, the reaction shown does not occur to any appreciable extent.

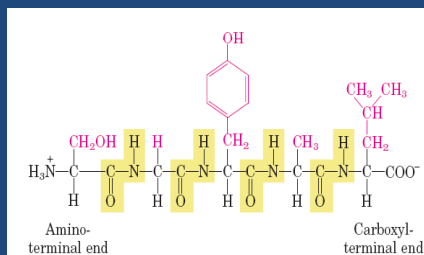
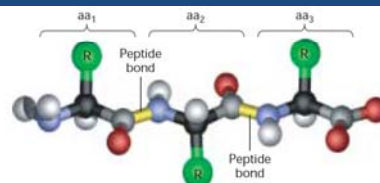


FIGURE 3-14 The pentapeptide serylglycyltyrosylalanyl-leucine, or Ser-Gly-Tyr-Ala-Leu. Peptides are named beginning with the amino-terminal residue, which by convention is placed at the left. The peptide bonds are shaded in yellow; the R groups are in red.



▲ FIGURE 3-2 Structure of a tripeptide. Peptide bonds (yellow) link the amide nitrogen atom (blue) of one amino acid (aa) with the carbonyl carbon atom (gray) of an adjacent one in the linear polymers known as peptides or polypeptides, depending on their length. Proteins are polypeptides that have folded into a defined three-dimensional structure (conformation). The side chains, or R groups (green), extending from the α carbon atoms (black) of the amino acids composing a protein largely determine its properties. At physiological pH values, the terminal amino and carboxyl groups are ionized.



TABLE 3-2 Molecular Data on Some Proteins

	<i>Molecular weight</i>	<i>Number of residues</i>	<i>Number of polypeptide chains</i>
Cytochrome c (human)	13,000	104	1
Ribonuclease A (bovine pancreas)	13,700	124	1
Lysozyme (chicken egg white)	13,930	129	1
Myoglobin (equine heart)	16,890	153	1
Chymotrypsin (bovine pancreas)	21,600	241	3
Chymotrypsinogen (bovine)	22,000	245	1
Hemoglobin (human)	64,500	574	4
Serum albumin (human)	68,500	609	1
Hexokinase (yeast)	102,000	972	2
RNA polymerase (<i>E. coli</i>)	450,000	4,158	5
Apolipoprotein B (human)	513,000	4,536	1
Glutamine synthetase (<i>E. coli</i>)	619,000	5,628	12
Titin (human)	2,993,000	26,926	1

Polypeptides Have Characteristic Amino Acid Compositions

TABLE 3-3 Amino Acid Composition of Two Proteins

Amino acid	Number of residues per molecule or protein*	
	Bovine cytochrome c	Bovine chymotrypsinogen
Ala	6	22
Arg	2	4
Asn	5	15
Asp	3	8
Cys	2	10
Gln	3	10
Glu	9	5
Gly	14	23
His	3	2
Ile	6	10
Leu	6	19
Lys	18	14
Met	2	2
Phe	4	6
Pro	4	9
Ser	1	28
Thr	8	23
Trp	1	8
Tyr	4	4
Val	3	23
Total	104	245

*In some common analyses, such as acid hydrolysis, Asp and Asn are not readily distinguished from each other and are together designated Asx (or B). Similarly, when Glu and Gln cannot be distinguished, they are together designated Glx (or Z). In addition, Trp is destroyed. Additional procedures must be employed to obtain an accurate assessment of complete amino acid content.

Some Proteins Contain Chemical Groups Other Than Amino Acids

TABLE 3-4 Conjugated Proteins

Class	Prosthetic group	Example
Lipoproteins	Lipids	β_1 -Lipoprotein of blood
Glycoproteins	Carbohydrates	Immunoglobulin G
Phosphoproteins	Phosphate groups	Casein of milk
Hemoproteins	Heme (iron porphyrin)	Hemoglobin
Flavoproteins	Flavin nucleotides	Succinate dehydrogenase
Metalloproteins	Iron	Ferritin
	Zinc	Alcohol dehydrogenase
	Calcium	Calmodulin
	Molybdenum	Dinitrogenase
	Copper	Plastocyanin

There Are Several Levels of Protein Structure

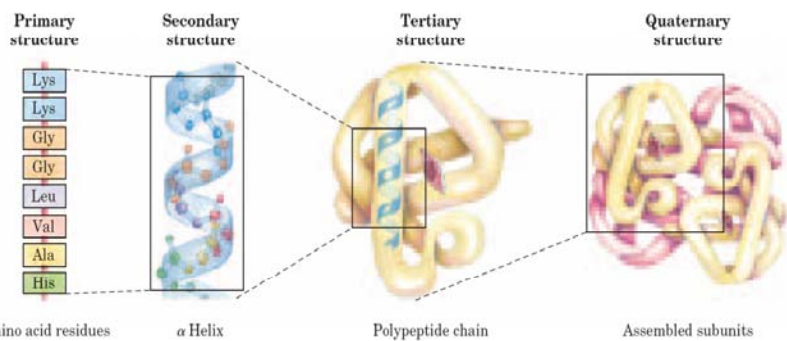


FIGURE 3-16 Levels of structure in proteins. The *primary structure* consists of a sequence of amino acids linked together by peptide bonds and includes any disulfide bonds. The resulting polypeptide can be coiled into units of *secondary structure*, such as an α helix. The he-

lix is a part of the *tertiary structure* of the folded polypeptide, which is itself one of the subunits that make up the *quaternary structure* of the multisubunit protein, in this case hemoglobin.