FUNDAMENTALS OF BIOCHEMISTRY

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AMINO ACIDS AND PROTEINS

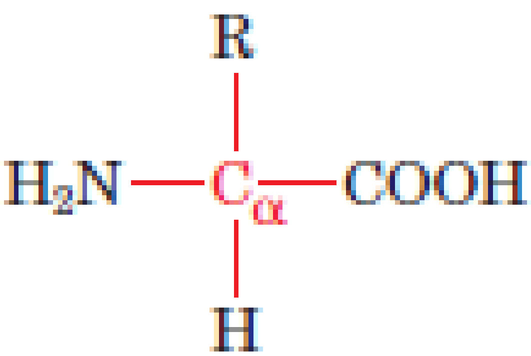
Concept Covered

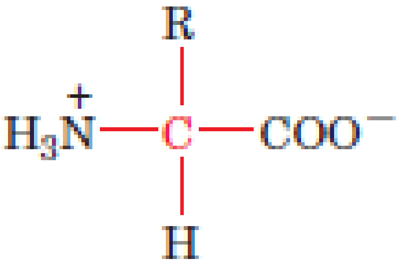
- Amino Acids
- D-/ L- Isomerism
- Classification of Amino Acids
- Properties of Amino Acids
- Peptide/Protein
- Structure of Peptide/ Protein

Amino Acids

The building blocks of peptides and proteins

- ❖ Amino acids are monomers of proteins Each amino acid contains
- ❖ a central carbon atom referred to as the Cα(C-alpha) atom
- ❖ an amino group (-NH2)
- ❖ a carboxyl group (-COOH)
- ❖ a side chain (-R)
- ❖ a single hydrogen atom



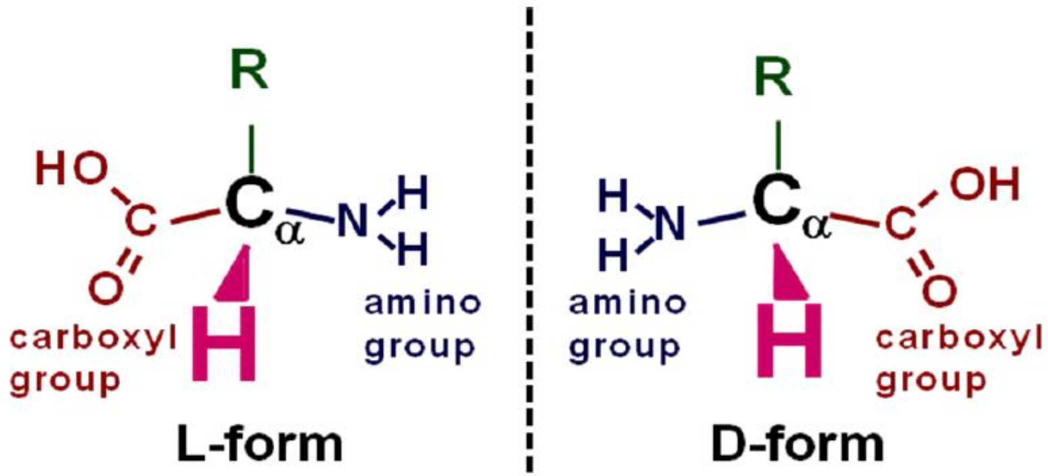


In the physiological pH range, both the carboxylic acid and the amino groups of -amino acids are completely ionized

Zwitterionic form of the α -amino acids

- All Amino Acids are Chiral Compound
- A chiral molecule is a type of molecule that has a non-superposable mirror image. The presence of an asymmetric carbon atom is normally the reason a molecule is chiral and this property is also referred to as asymmetry.
- only one amino acid Gly is achiral – meaning that the four atoms attached to the central Cα are not all different
- The R-group represents what is called a side chain which varies from one amino acid to another.
- This R-group is what makes each amino acid unique in nature.
- This group of atoms may have just carbon and hydrogen or in addition to these atoms may contain heteroatoms such as nitrogen, oxygen and/or sulfur.
- This specific combination of atoms will give rise to a particular side chain with specific properties that will define the characteristics of the amino acid.

- An important feature of amino acid structure is the stereochemistry.
- Each amino acid have two enantiomers of the , L- amino acid and D- amino acid e.g., L-alanine and D-alanine. They are also called optical isomers.
- Each of these molecules are mirror images of one another.
- The L-form is the isomer mostly seen in organisms.
- D-amino acids are not found in proteins naturally
- D- amino acids are found in bacterial cell walls



- The normal practice by chemists is to use what is called an R, S system to distinguish between enatiomers of molecules. However, many biochemical systems – mostly amino acids and sugars – use the D and L system based on the earliest method for identifying enantiomers from glyceraldehyde.
- The glyceraldehyde molecule contains three carbon atoms with one form referred to as D and the other as L based on their ability to rotate polarized light either to the right (dexter) or left (laevus).
- The enantiomers of the amino acids are designated on the basis of their similarity to the D and L forms of glyceraldehyde.

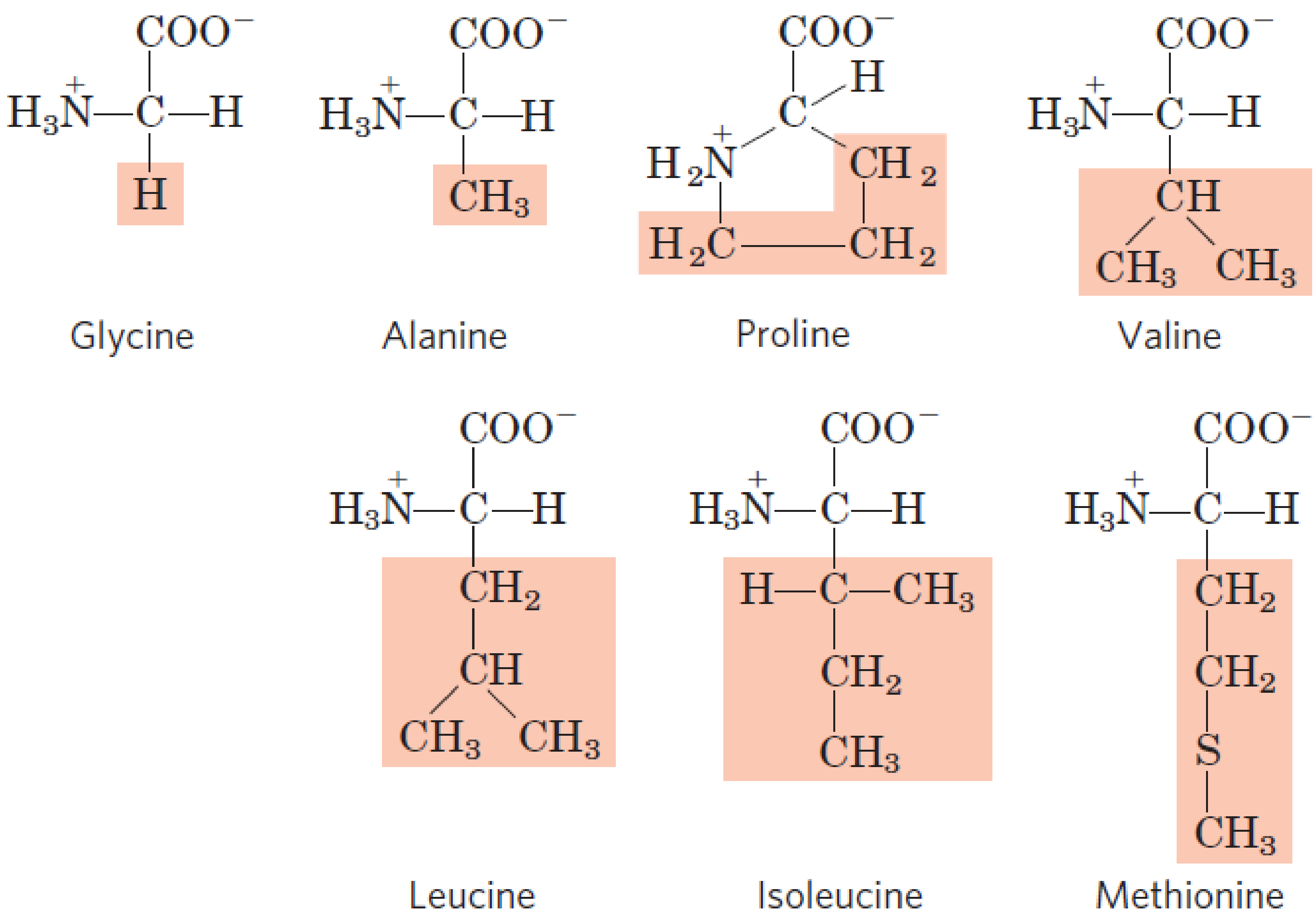
Amino Acids Can Be Classified by R Group

- **Nonpolar, Aliphatic R Groups**

  e.g. alanine, **valine**, **leucine**, **isoleucine, Glycine, Methionine, Proline**

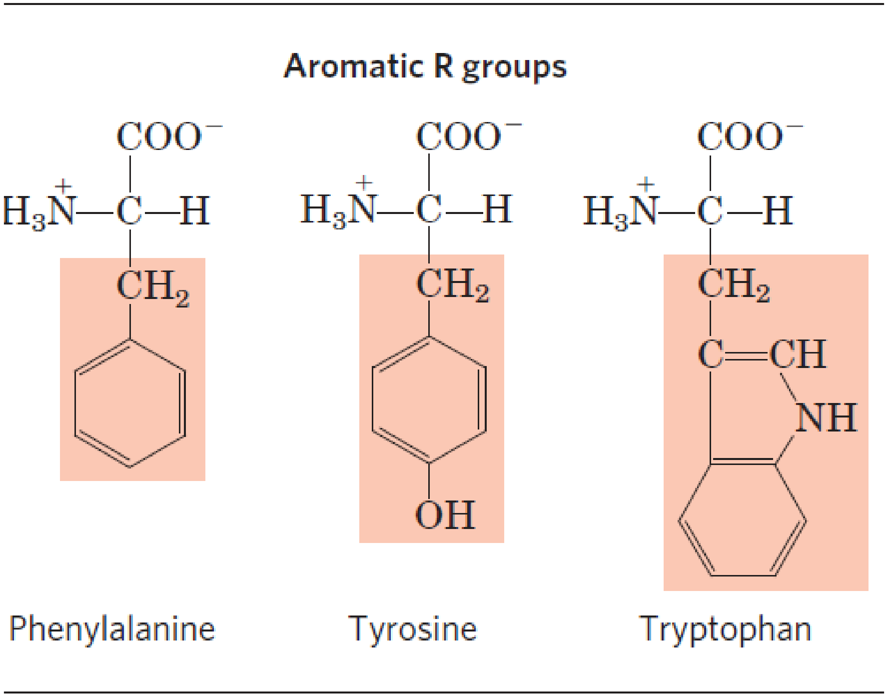
- **Methionine**, one of the two sulfurcontaining amino acids, has a slightly nonpolar thioether group in its side chain.
- **Proline** has an aliphatic side chain with a distinctive cyclic structure. The secondary amino (imino) group of proline residues is held in a rigid conformation that reduces the structural flexibility of polypeptide regions containing proline

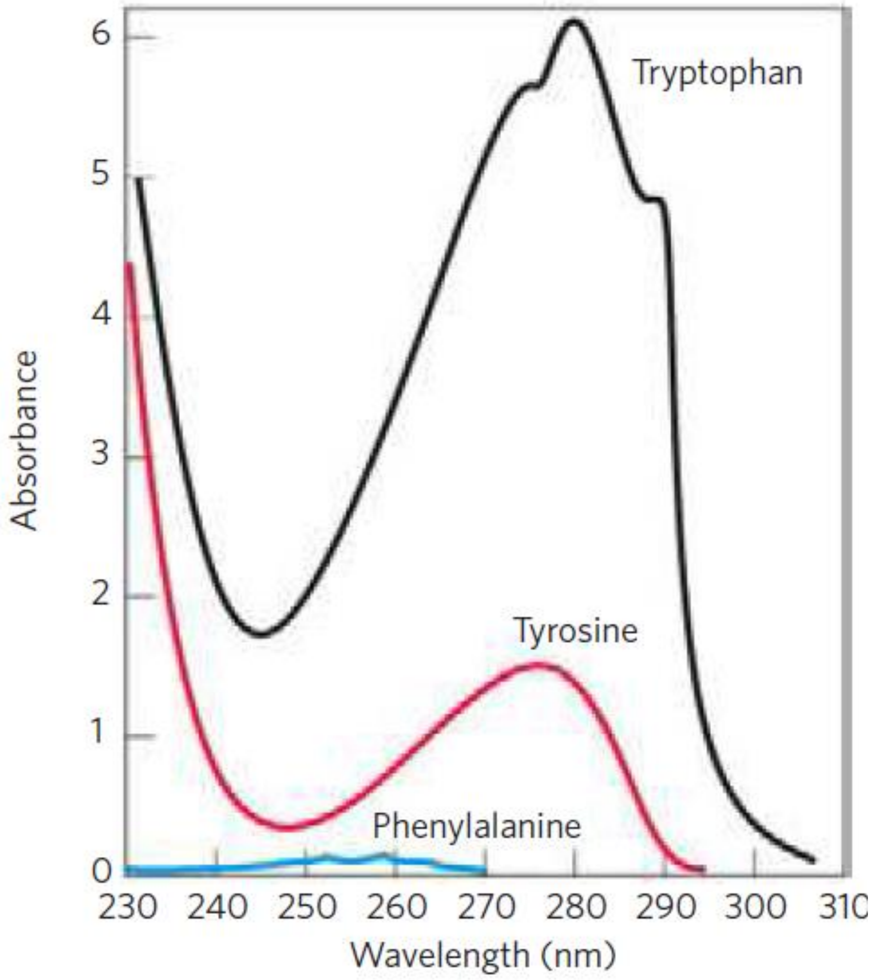
Nonpolar, aliphatic R groups



Aromatic R Groups

- **Phenylalanine**, **tyrosine**, and **tryptophan**, are relatively nonpolar (hydrophobic).
- All can participate in hydrophobic interactions.
- The hydroxyl group of tyrosine can form hydrogen bonds, and it is an important functional group in some enzymes.
- Tyrosine and tryptophan are significantly more polar than phenylalanine, because of the tyrosine hydroxyl group and the nitrogen of the tryptophan indole ring.
- Tryptophan and tyrosine, and to a much lesser extent phenylalanine, absorb ultraviolet light



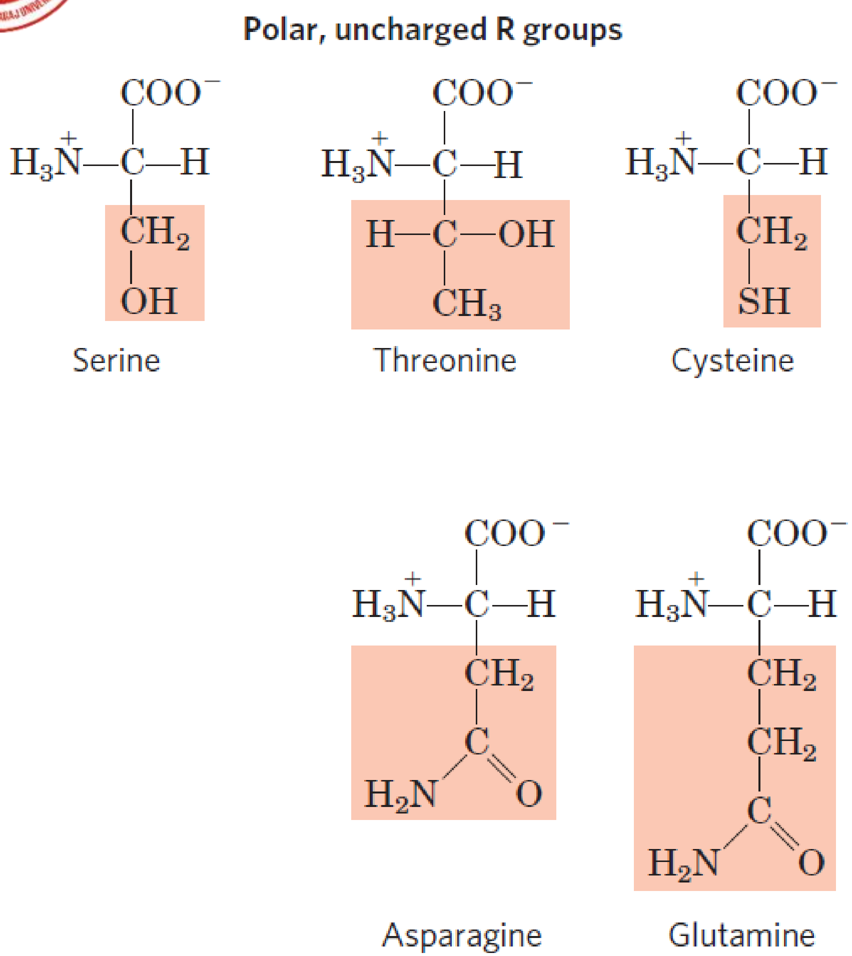

Tryptophan
Tyrosine
Phenylalanine
Absorbance
Wavelength (nm)
0
1
2
3
4
5
6
230
240
250
260
270
280
290
300
310

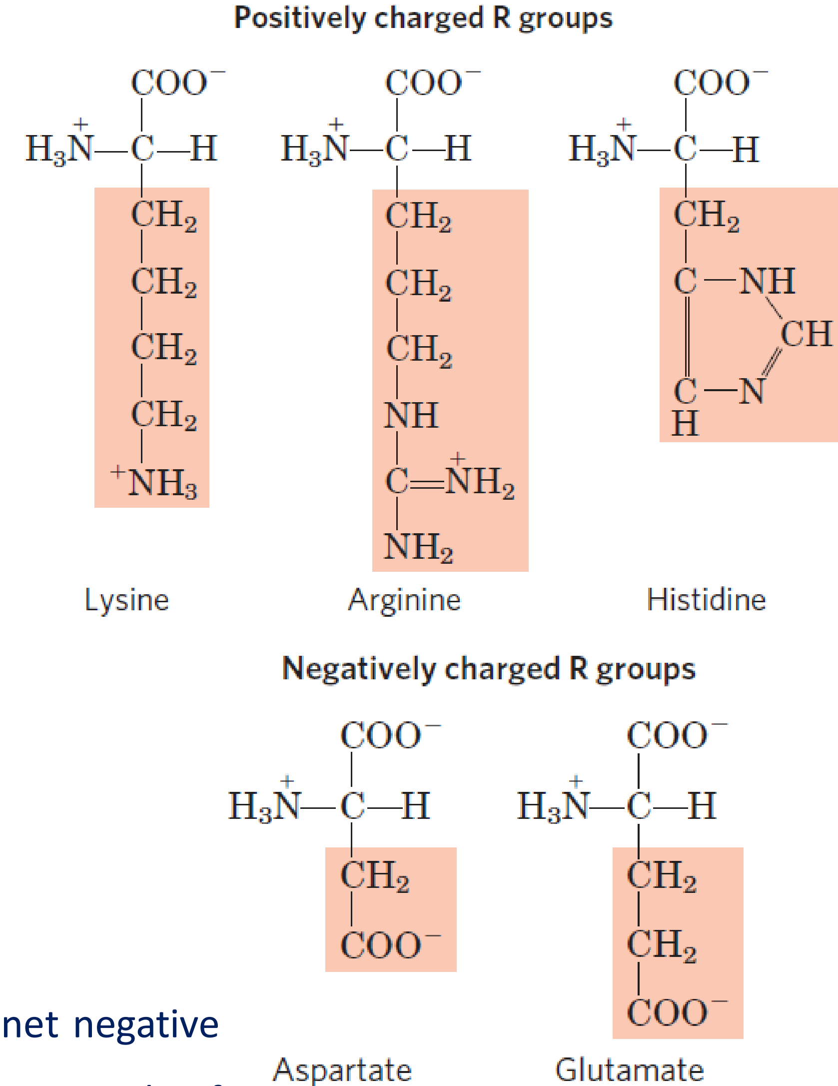
Polar, Uncharged R Groups

- The R groups of these amino acids are more soluble in water, or more hydrophilic, than those of the nonpolar amino acids, because they contain functional groups that form hydrogen bonds with water. This class of amino acids includes **serine**, **threonine**, **cysteine**, **asparagine**, and **glutamine**.
- The polarity of serine and threonine is contributed by their hydroxyl groups, and that of asparagine and glutamine by their amide groups.
- Cysteine is readily oxidized to form a covalently linked dimeric amino acid called **cystine**, in which two cysteine molecules or residues are joined by a disulfide

Positively Charged (Basic) R Groups

- The amino acids in which the R groups have significant positive charge at pH 7.0 are **lysine**, which has a second primary amino group at the ε position on its aliphatic chain; **arginine**, which has a positively charged guanidinium group; and **histidine**, which has an aromatic imidazole group.



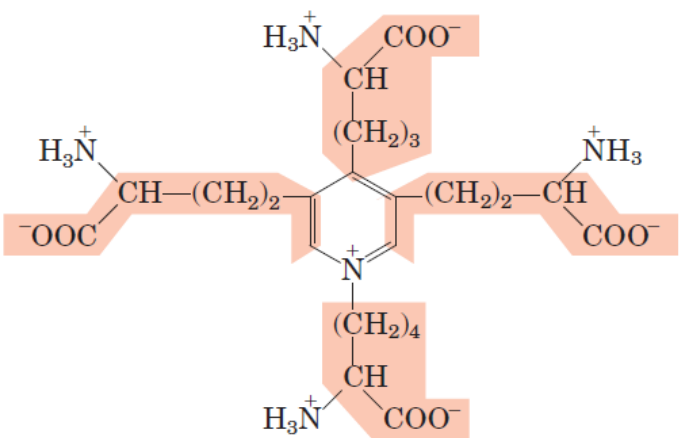


Negatively Charged (Acidic) R Groups

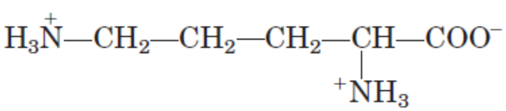
❖ The two amino acids having R groups with a net negative charge at pH 7.0 are **aspartate** and **glutamate**, each of which has a secondcarboxyl group.

Uncommon amino acids.

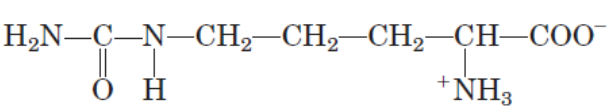
- Some uncommon amino acids found in proteins. All are derived from common amino acids.
- Desmosine is formed from four Lys residues
- Ornithine and citrulline, which are not found in proteins, are intermediates in the biosynthesis of arginine and in the urea cycle.



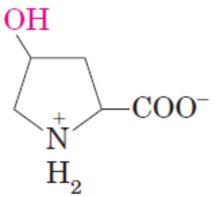
Desmosine



Ornithine



Citrulline

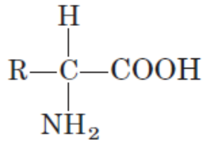


4-Hydroxyproline

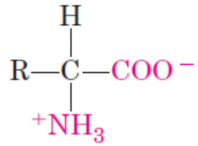
4-Hydroxyproline found in plant cell wall proteins, and collagen, a fibrous protein of connective tissues.

Amino Acids Have Characteristic Titration Curves

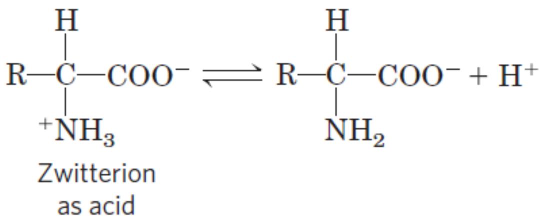
- Acid-base titration involves the gradual addition or removal of protons
- The two ionizable groups of glycine, the carboxyl group and the amino group, are titrated with a strong base such as NaOH.
- The plot has two distinct stages, corresponding to deprotonation of two different groups on glycine.
- Each of the two stages resembles in shape the titration

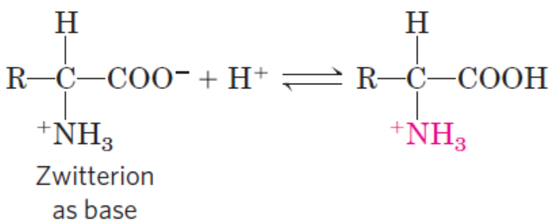


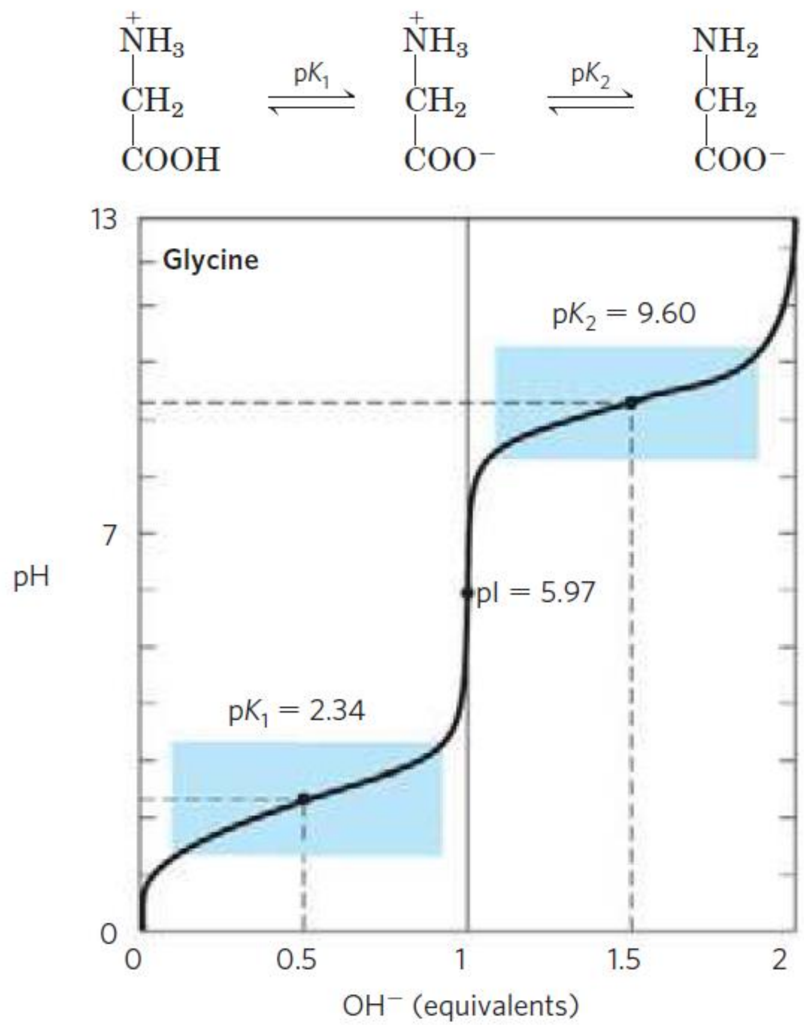
Nonionic form



Zwitterionic form







- Titration of an amino acid. Shown here is the titration curve of 0.1 M glycine at 25^0C. The ionic species predominating at key points in the titration are shown above the graph.
- The shaded boxes, centered at about p*K*1 5 2.34 and p*K*2 5 9.60, indicate the regions of greatest buffering power. Note that 1 equivalent of OH 5 0.1 M NaOH added.