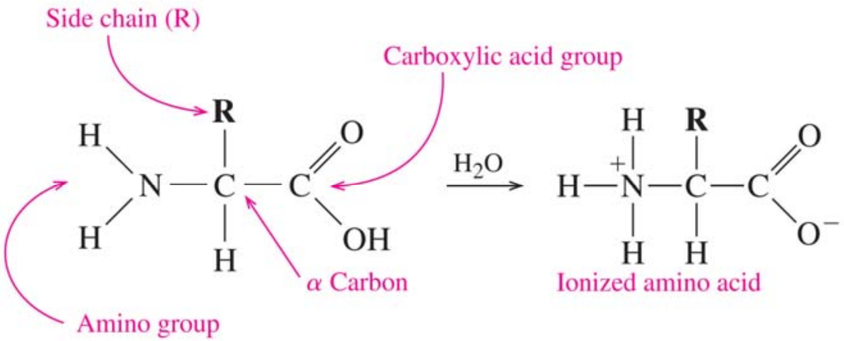
Chapter 19 Aminoacids and Proteins

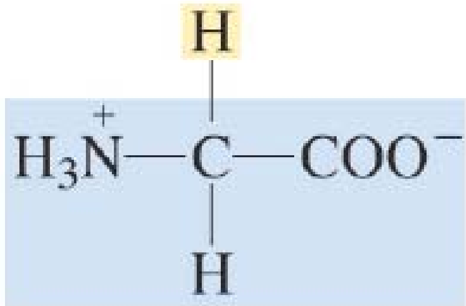
Amino acids are the building blocks of proteins;
they contain a carboxylic acid group and an amino group on the alpha (α) carbon, the carbon adjacent to the C=O;
because they have both a weak acid and weak base present, they actually exist as a salt;
each amino acid contains a different **side group (R)**

The structure of most amino acids



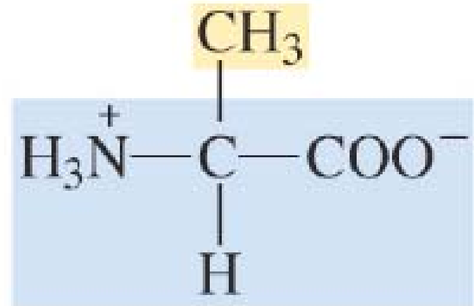
Unlike most organic compounds, amino acids are soluble in water, have either high melting points or decompose upon heating. They act more like inorganic materials than organic compounds.

When R = H, the molecule is called glycine; when R = CH_3, the molecule is called alanine



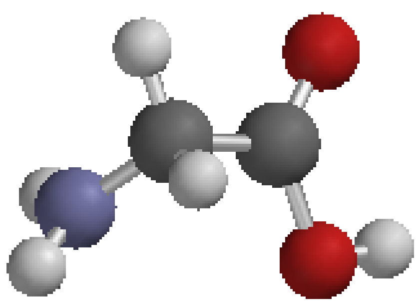
Glycine (Gly)

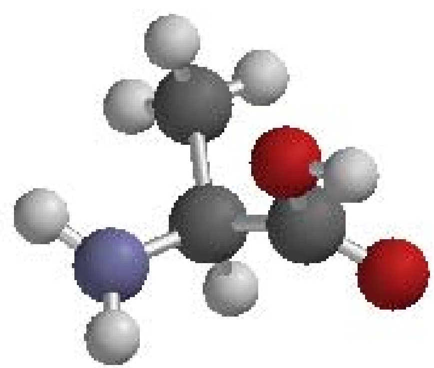
Aminoethanoic acid



Alanine (Ala)

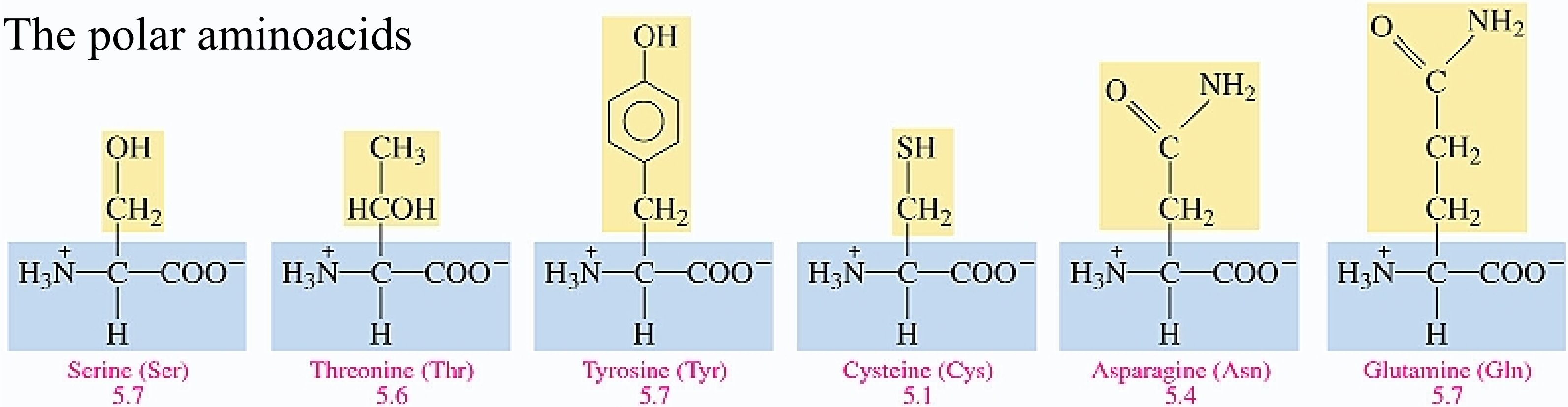
2-aminopropanoic acid



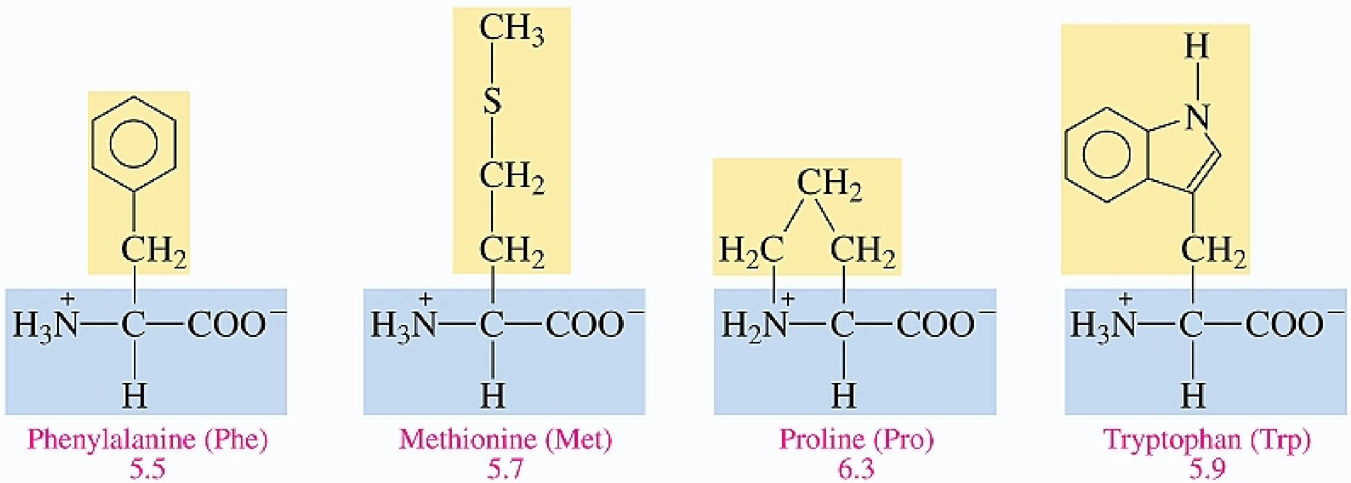


Some R groups are polar, others are less so and still others are non-polar; the polarity of these groups affects the properties of the amino acids when they are combined to form proteins

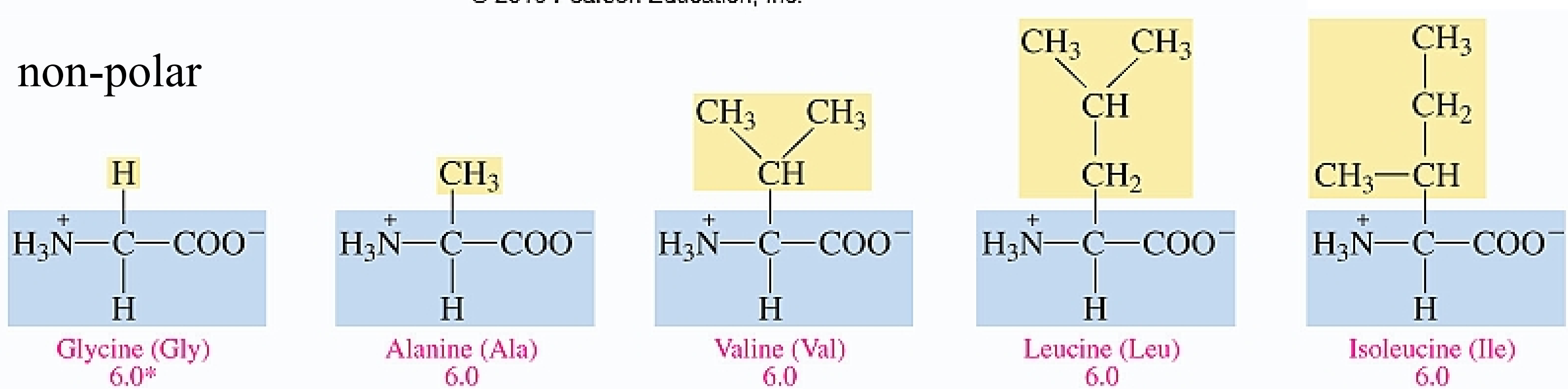
The polar aminoacids

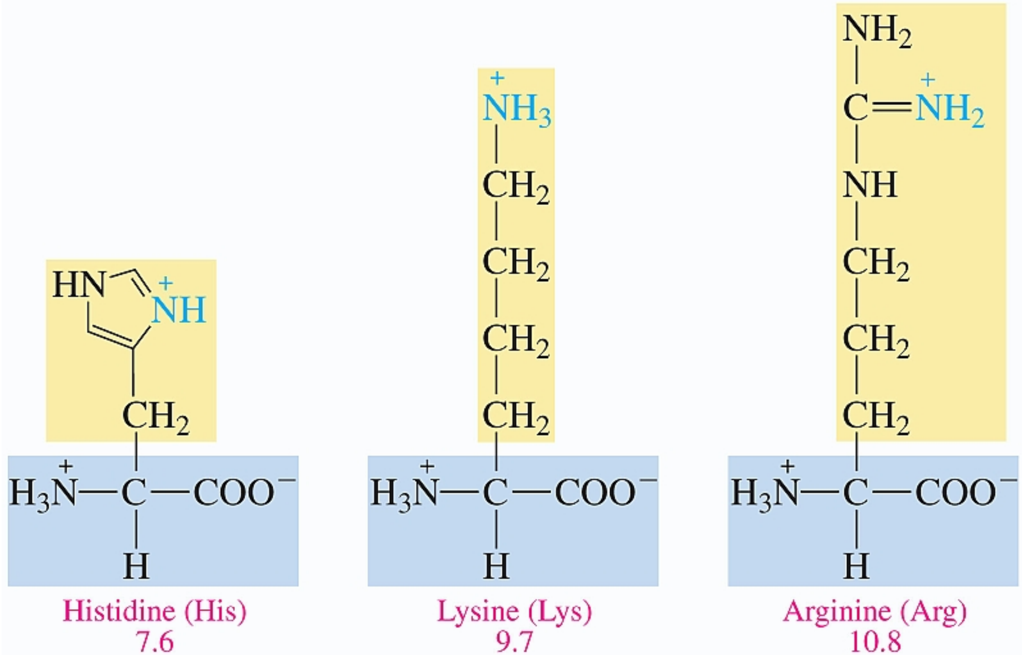


less polar

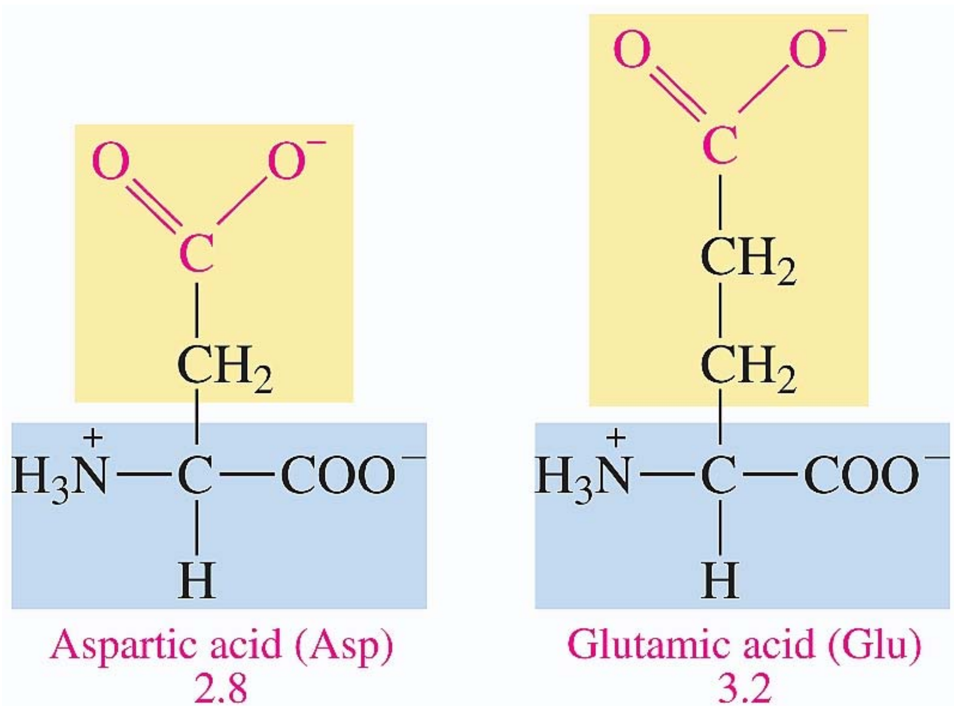


non-polar





polar basic amino acids

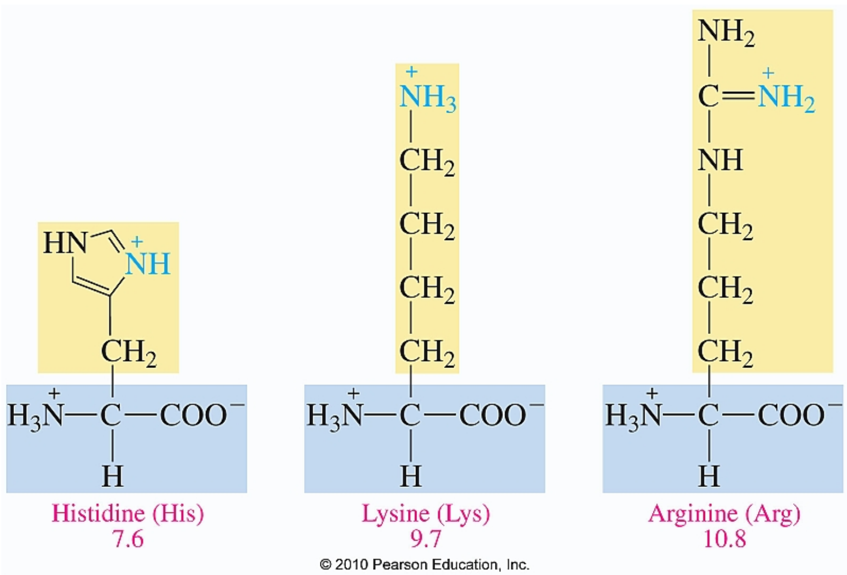


polar acidic aminoacids

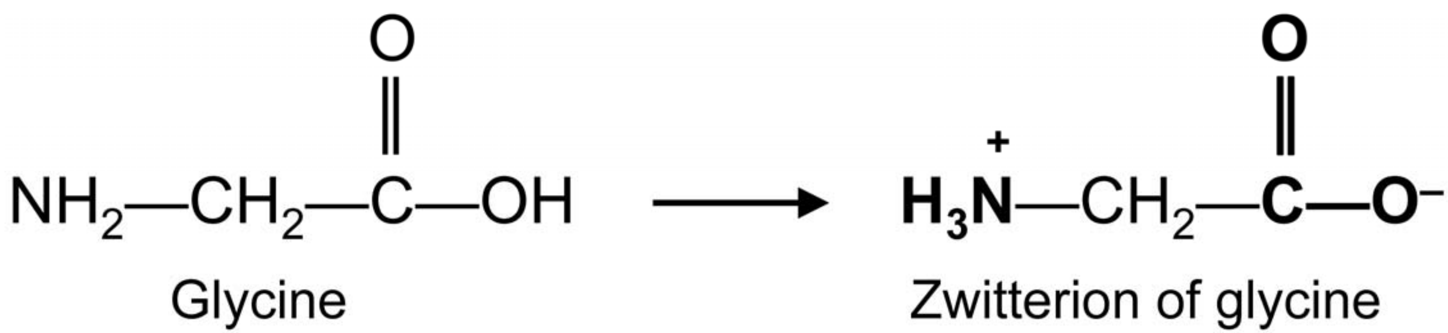
TABLE 19.3 Essential Amino Acids

Arginine (Arg)*	Methionine (Met)
Histidine (His)*	Phenylalanine (Phe)
Isoleucine (Ile)	Threonine (Thr)
Leucine (Leu)	Tryptophan (Trp)
Lysine (Lys)	Valine (Val)

*Required in diets of children, not adults



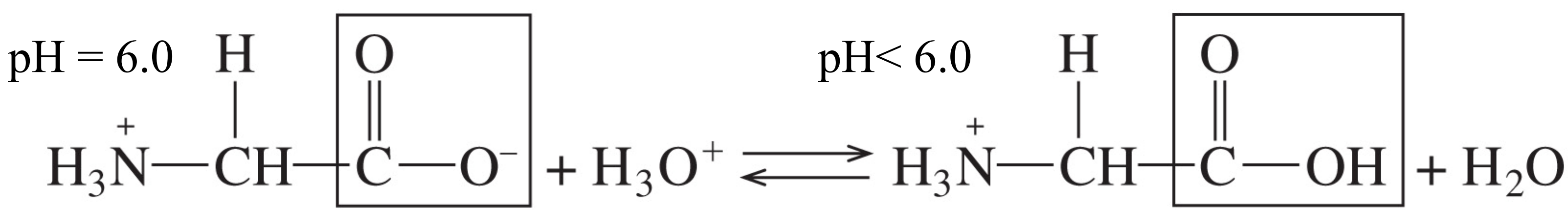
A **zwitterion** has an equal number of —NH_3^+ and COO^- groups
forms when the H from —COOH in an amino acid transfers to the —NH2



this form not present

The **isoelectric point (IP)** is the pH at which the amino acid has an overall zero charge
The isoelectric points (IP) of amino acids range from 2.8 to 10.8

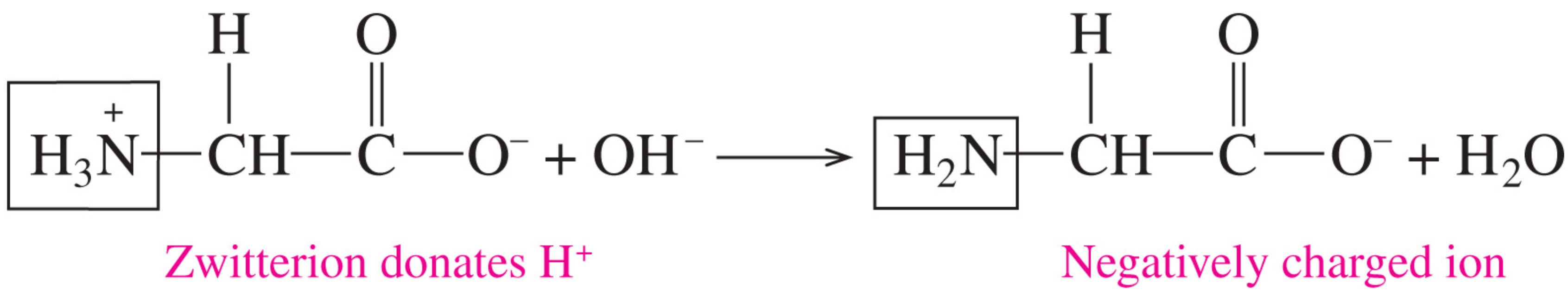
Glycine, with an IP of 6.0 exist as a positively charged species at a pH below 6.0



Zwitterion ion accepts H^+ Positively charged ion

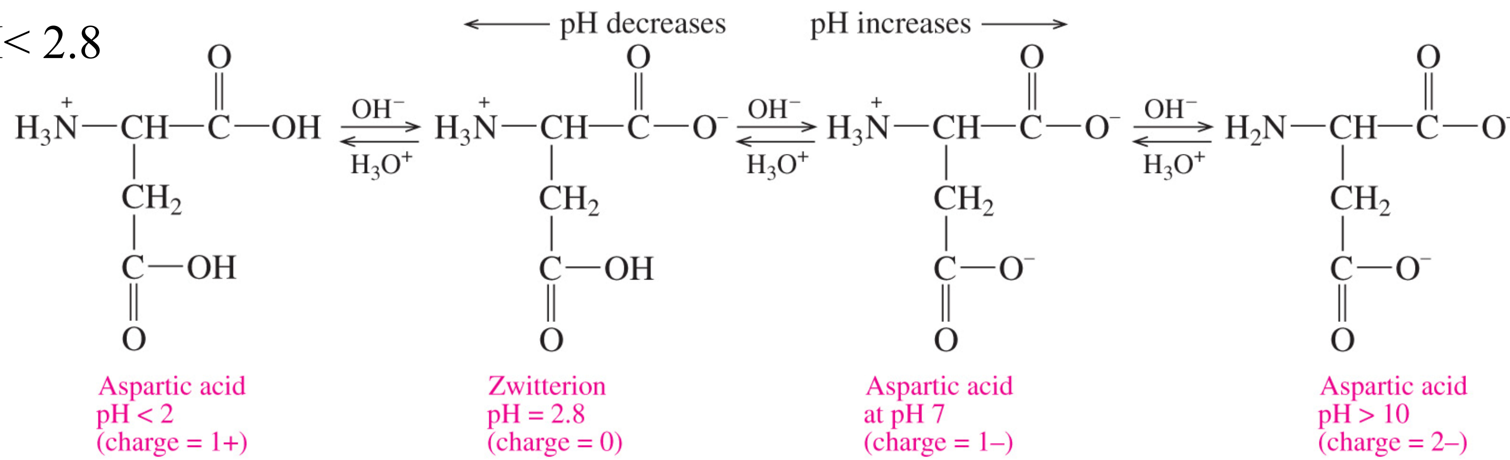
In solutions that are more basic than 6.0, solutions with a pH > 6.0 the NH_3^+ loses a proton and the amino acid has a negative charge

Glycine, with a IP of 6.0, has a 1– charge in solutions that have a pH above pH 6.0.



Aspartic acid, an acidic amino acid, has a IP of 2.8; it is a neutral salt at pH 2.8 forms negative ions with charges -1 and -2 at pH values greater than pH 2.8

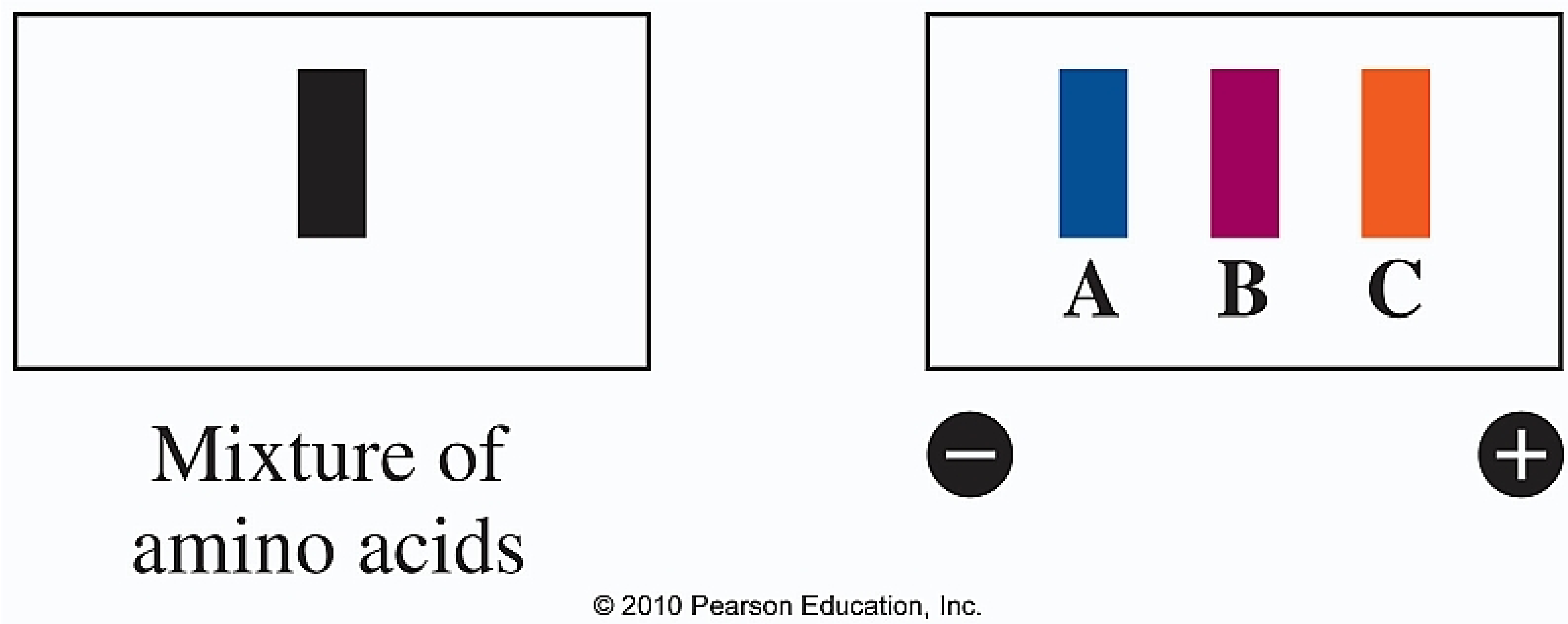
pH< 2.8



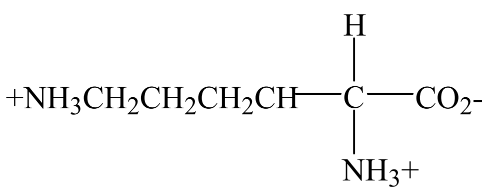
Why is the isolectric points of amino acids significant?

They provide a means of separating and identifying them

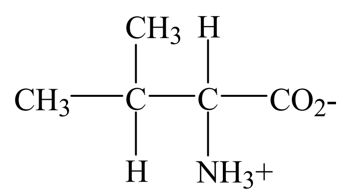
In **electrophoresis**, an electric current is used to separate a mixture of amino acids;
the positively charged amino acids move toward the negative electrode,
the negatively charged amino acids move toward the positive electrode
an amino acid at its pI does not migrate;
the amino acids are identified as separate bands on
the filter paper or thin layer plate



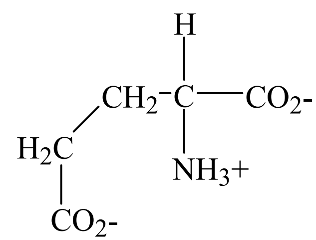
Consider a mixture of the amino acids lysine, valine, and aspartic acid at pH 6.0 that is subjected to an electric voltage. Which is which?



9.7

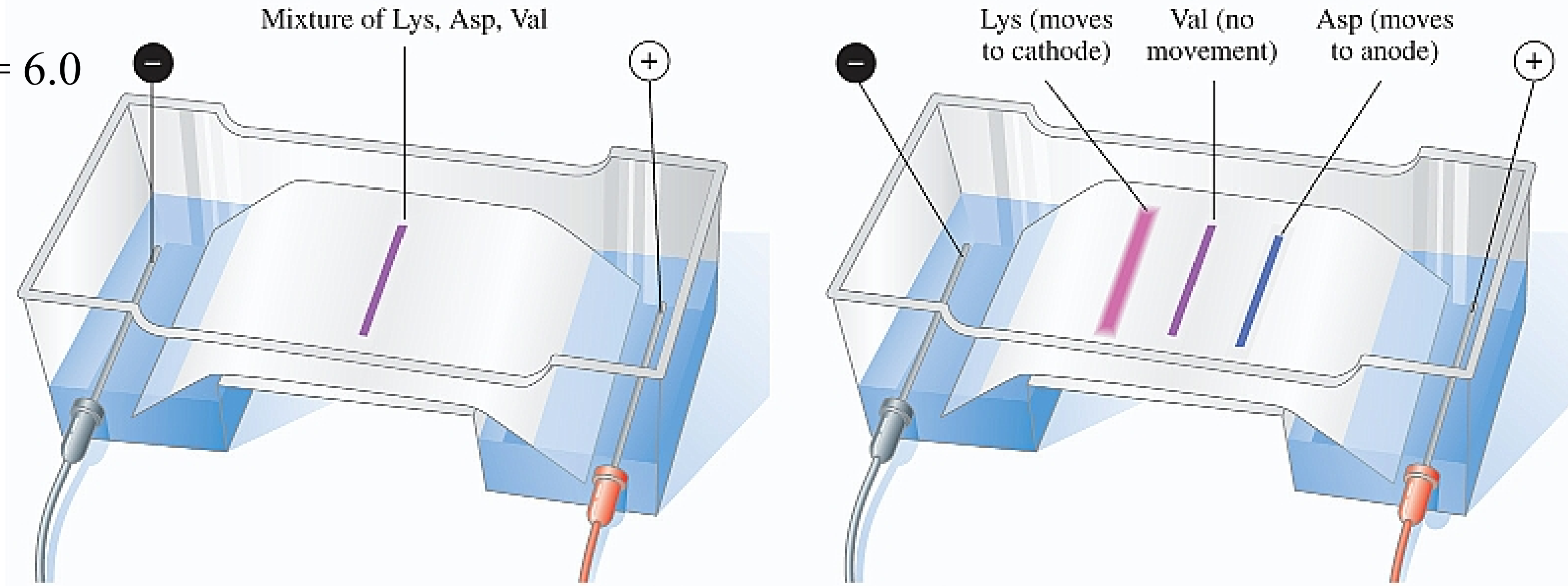


6.0



2.8

pH = 6.0



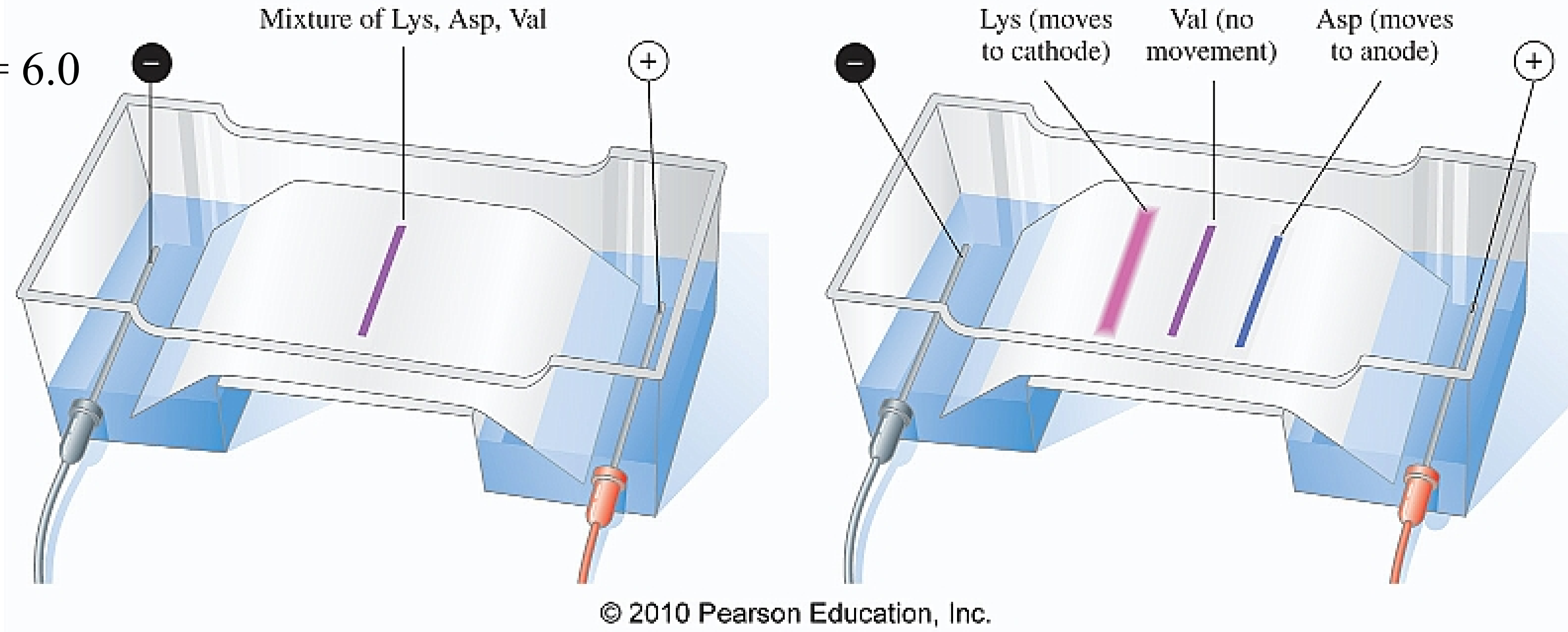
A positively species (pH < pI) moves toward the negative electrode; a negatively charged species (pH > pI) moves toward the positive electrode; a species with no net charge does not migrate.

lysine 9.7

aspartic acid 2.8

valine 6.0

pH = 6.0

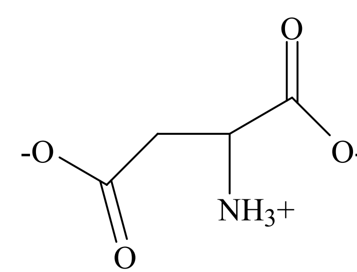


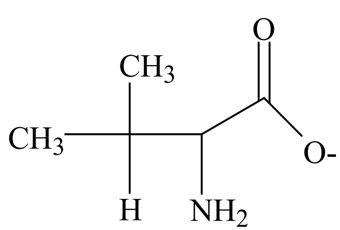
lysine 9.7

aspartic acid 2.8

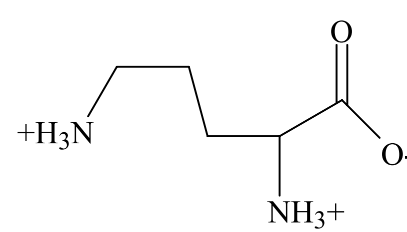
valine 6.0

At a pH of 6 aspartic acid exists as:

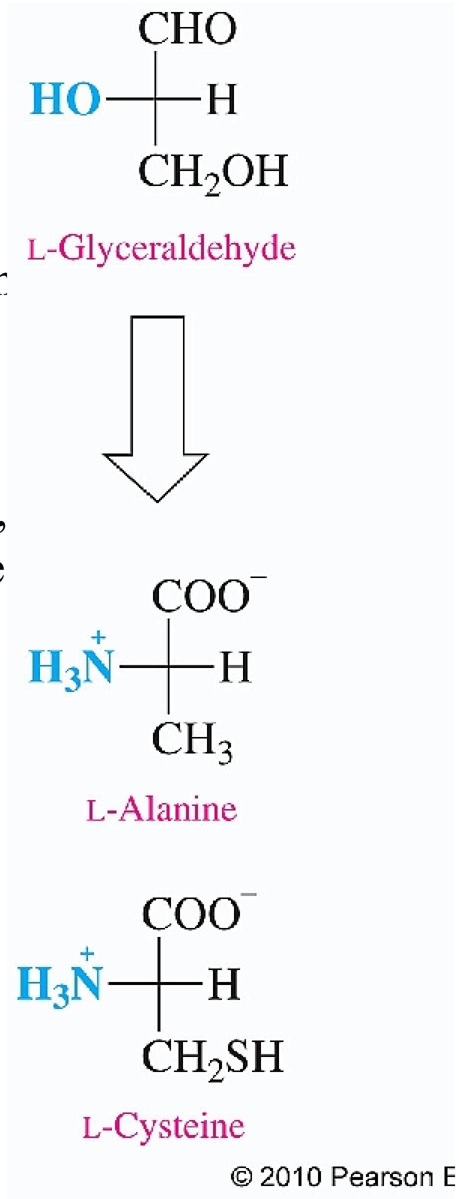




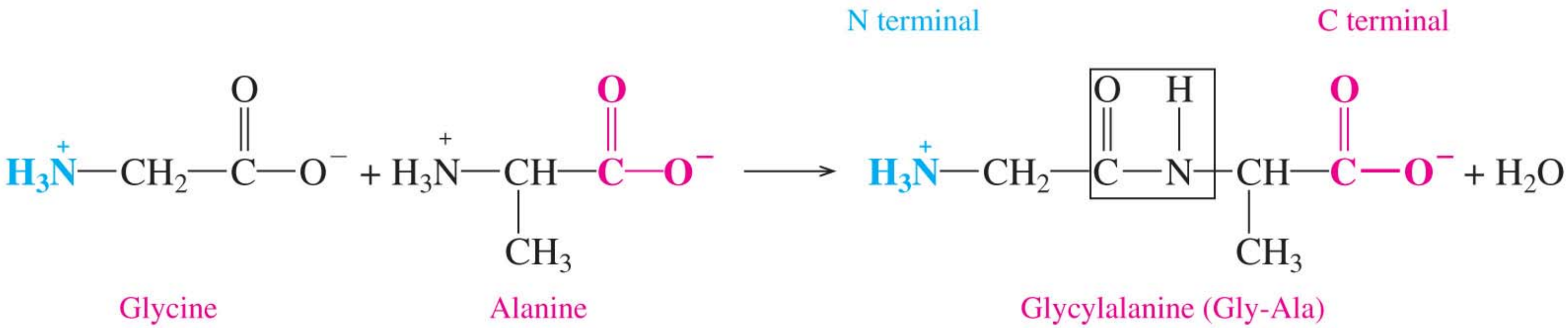
At a pH of 6 lysine exists as:

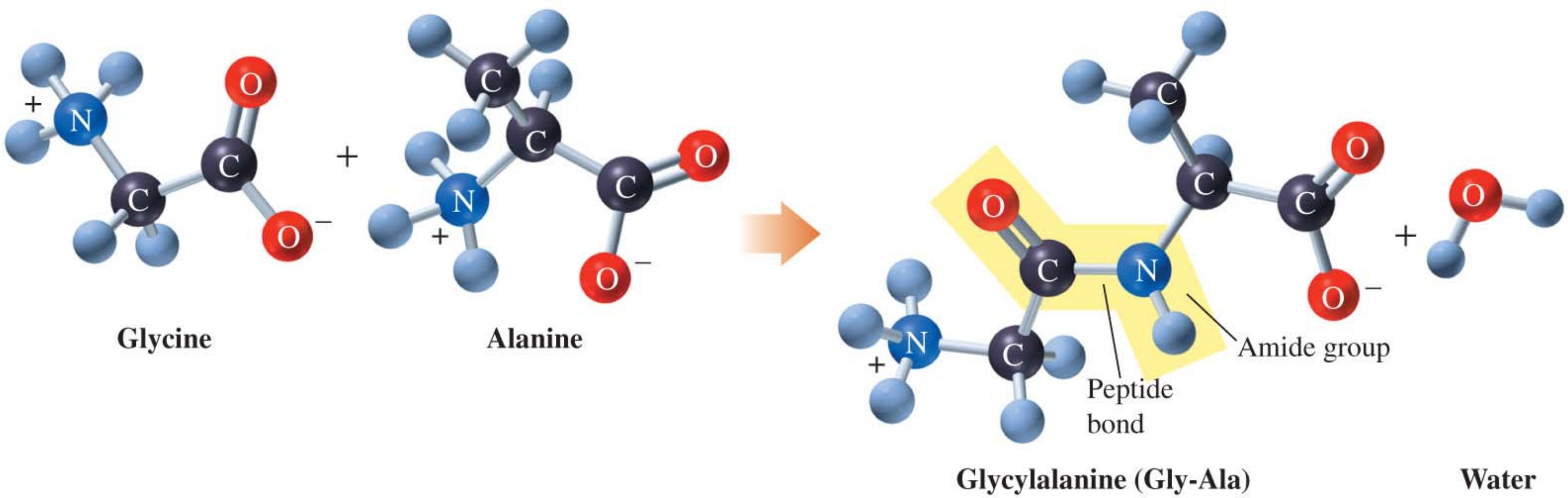


All amino acids are chiral except glycine, which has two H atoms attached to the alpha carbon atom;
All amino acids have the same relative orientation of groups in space;
the other orientation is essentially not present in living systems;
it is the L orientation that all amino acids possess, in contrast with sugars which have the D absolute orientation

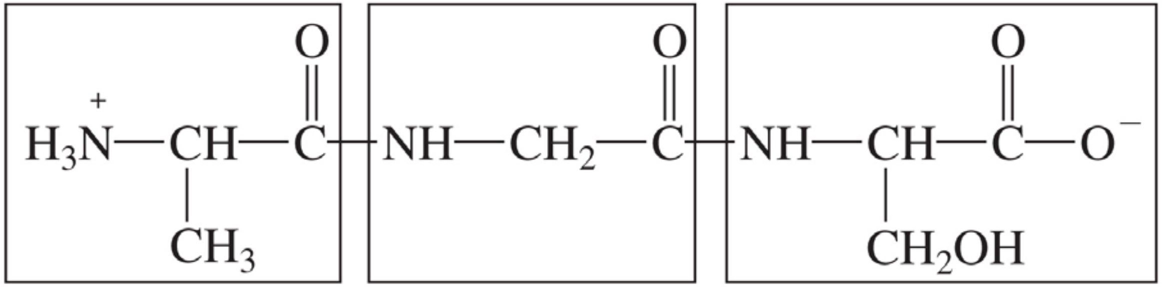


Formation of peptides (an amide linkange)





N -terminal



C-terminal

From alanine
alanyl

From glycine
glycyl

From serine
serine

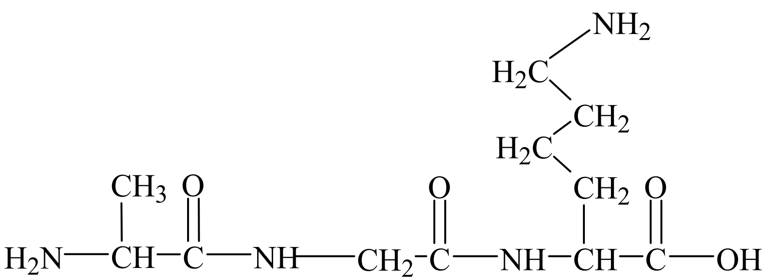
Alanylglycylserine
(Ala-Gly-Ser)

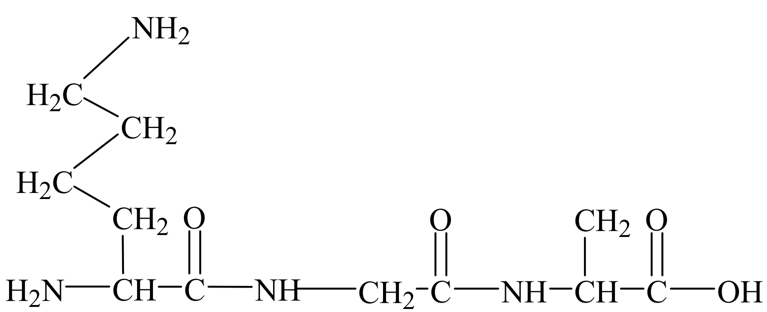
A **dipeptide** is named with a *yl* ending for the N-terminal (free H3N+) amino acid in sequence
the full amino acid name of the free carboxyl group (COO–) at the C-terminal end

What are the possible tripeptides formed from one each of leucine, glycine, and alanine?

Leu-Gly-Ala
Leu-Ala-Gly
Ala-Leu-Gly
Ala-Gly-Leu
Gly-Ala-Leu
Gly-Leu-Ala

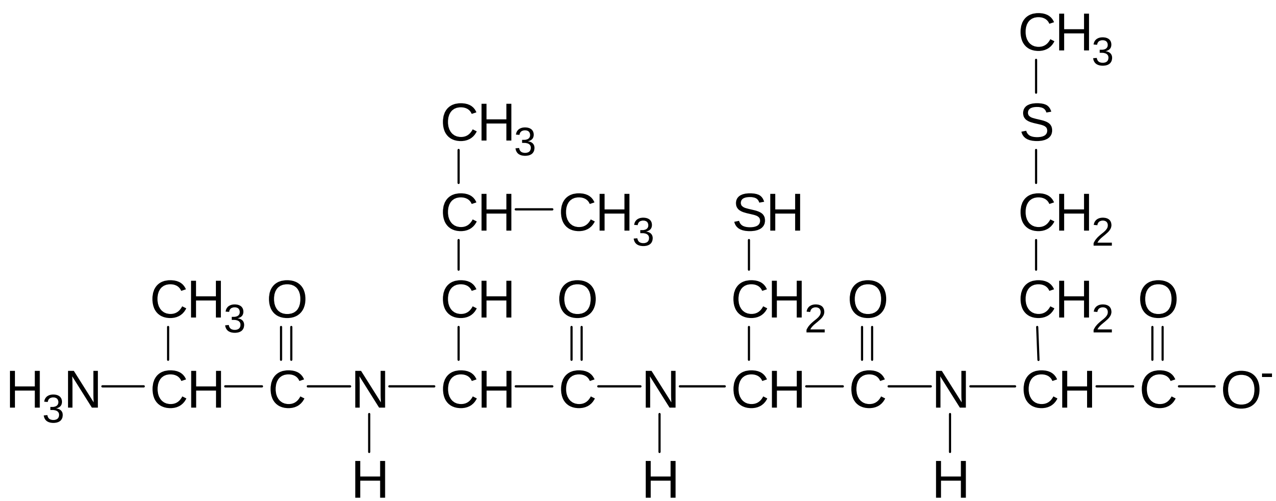
What is the difference between: Leu-Gly-Ala and Ala-Gly-Leu ?





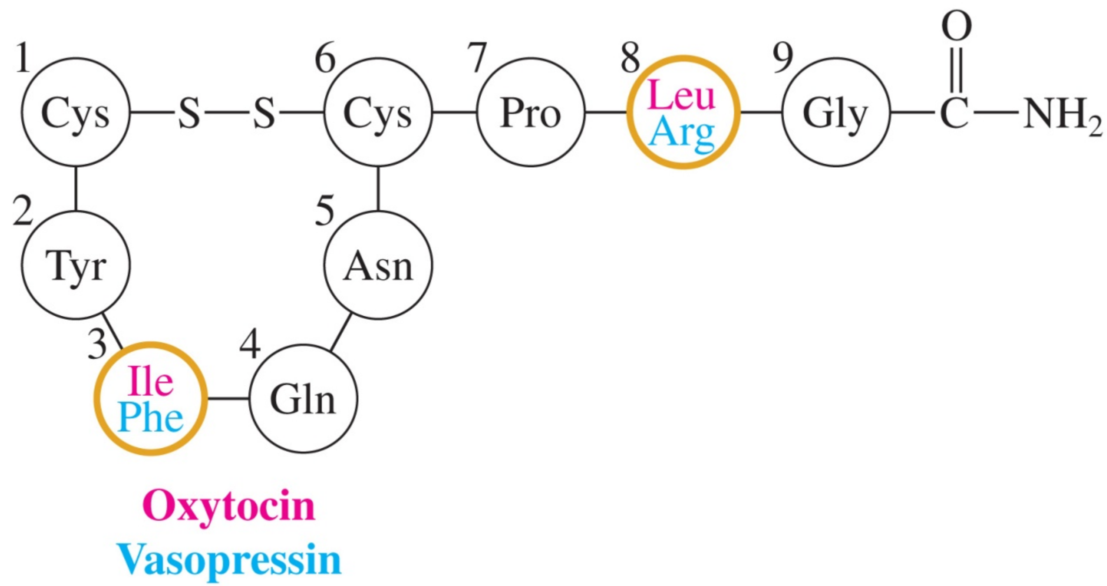
Structure of Proteins

The **primary structure** of a protein is the particular **sequence** of amino acids that form the backbone of a peptide chain or protein



Ala—Leu—Cys—Met

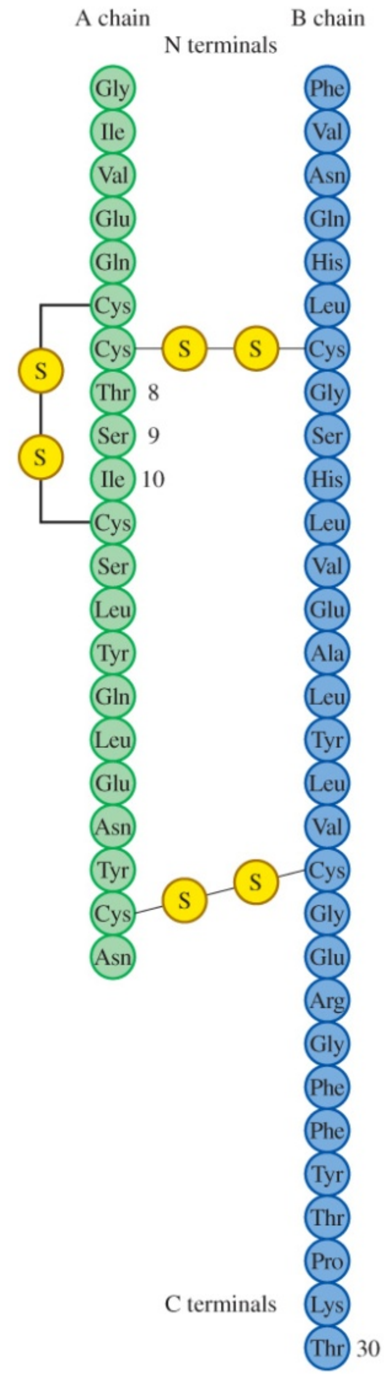
The nonapeptides oxytocin and vasopressin have similar primary structures differ only in the amino acids at positions 3 and 8



Insulin was the first protein to have its primary structure determined;

it has a primary structure of two polypeptide chains linked by disulfide bonds;

an A chain with 21 amino acids and a B chain with 30 amino acids



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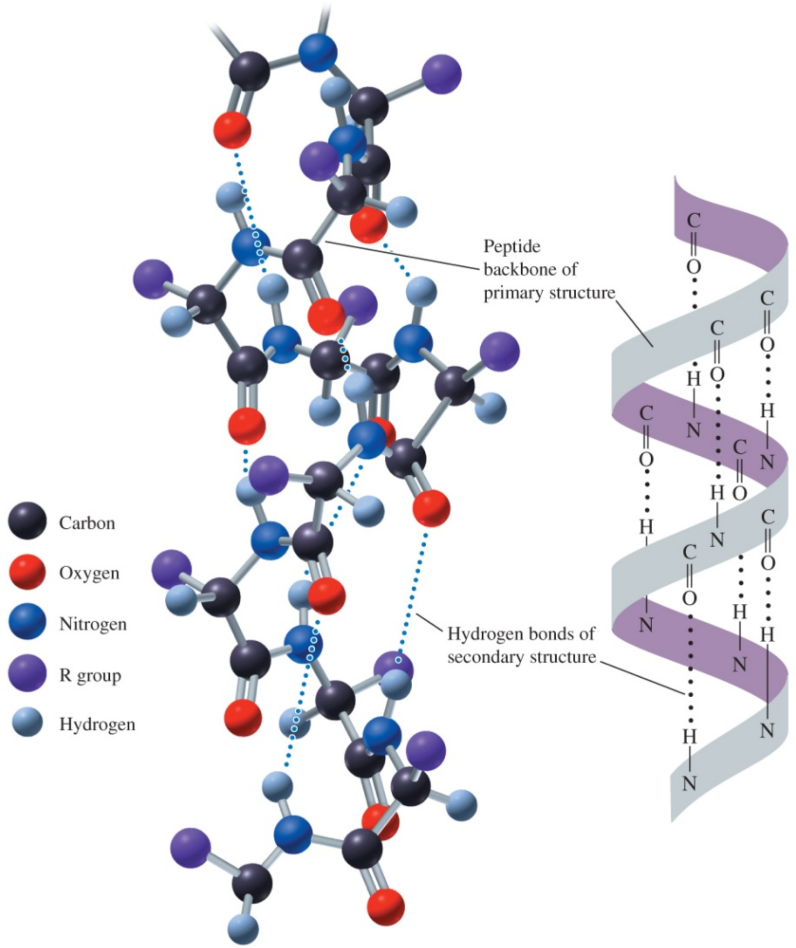
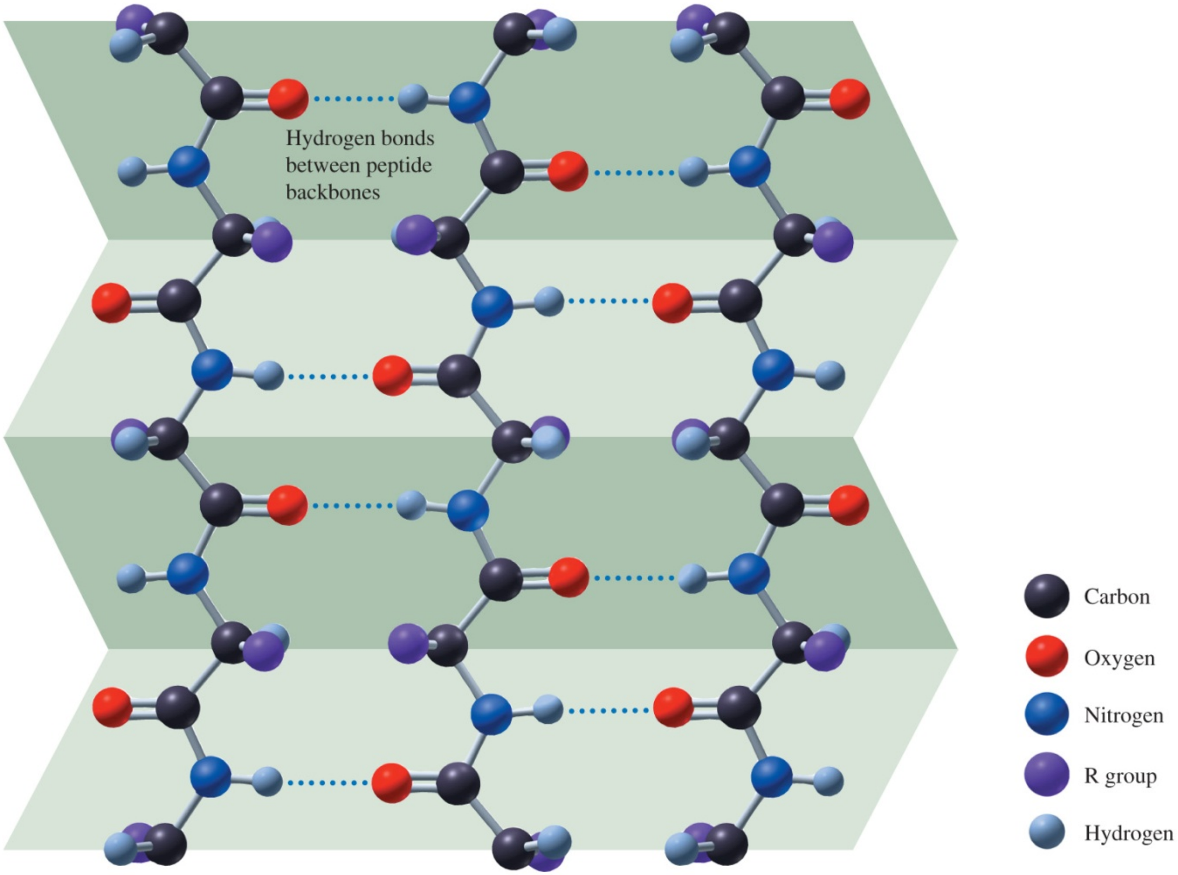
The **secondary structures** of proteins indicate the three-dimensional spatial arrangements of the polypeptide chains

Secondary structures

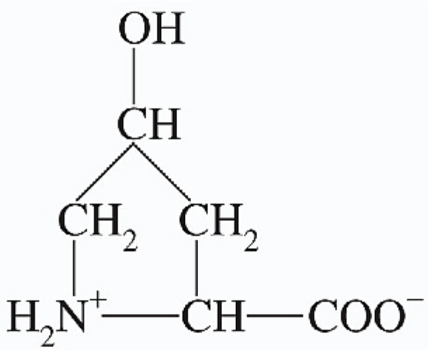
An **alpha helix (*α*-helix)** hasa coiled shape held in place by hydrogen bonds between the amide groups and the carbonyl groups of the amino acids along the chain hydrogen bonds between the H of an —NH group and the O of C═O of the fourth amino acid down the chain



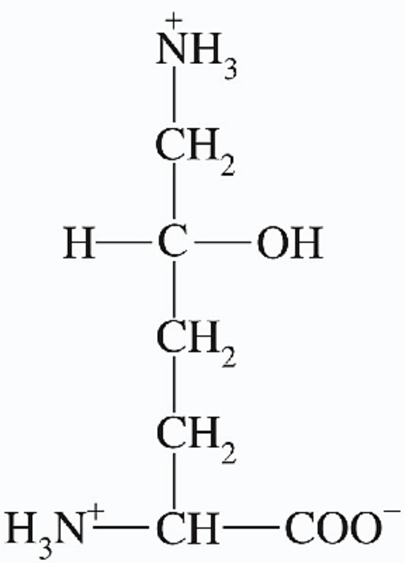
A **beta-pleated sheet (β-pleated sheet)** is a secondary structure that consists of polypeptide chains arranged side by side; it has hydrogen bonds between chains has R groups above and below the sheet is typical of fibrous proteins such as silk



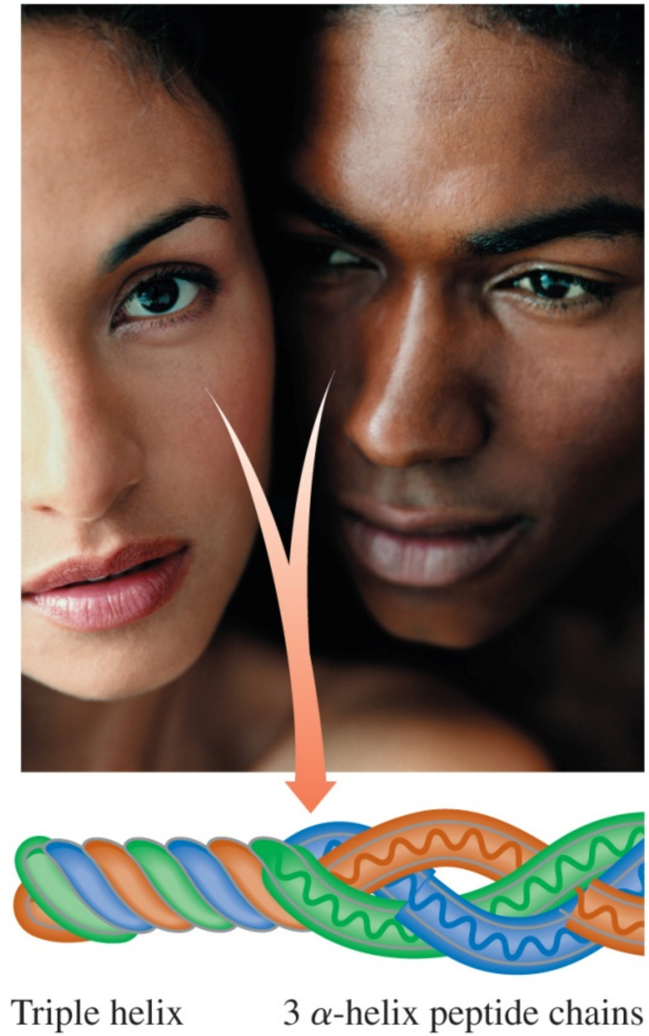
A **triple helix** consists of three alpha helix chains woven together contains large amounts of glycine, proline, hydroxyproline, and hydroxylysine that contain –OH groups for hydrogen bonding; it is found in collagen, connective tissue, skin, tendons, and cartilage



Hydroxyproline



Hydroxylysine

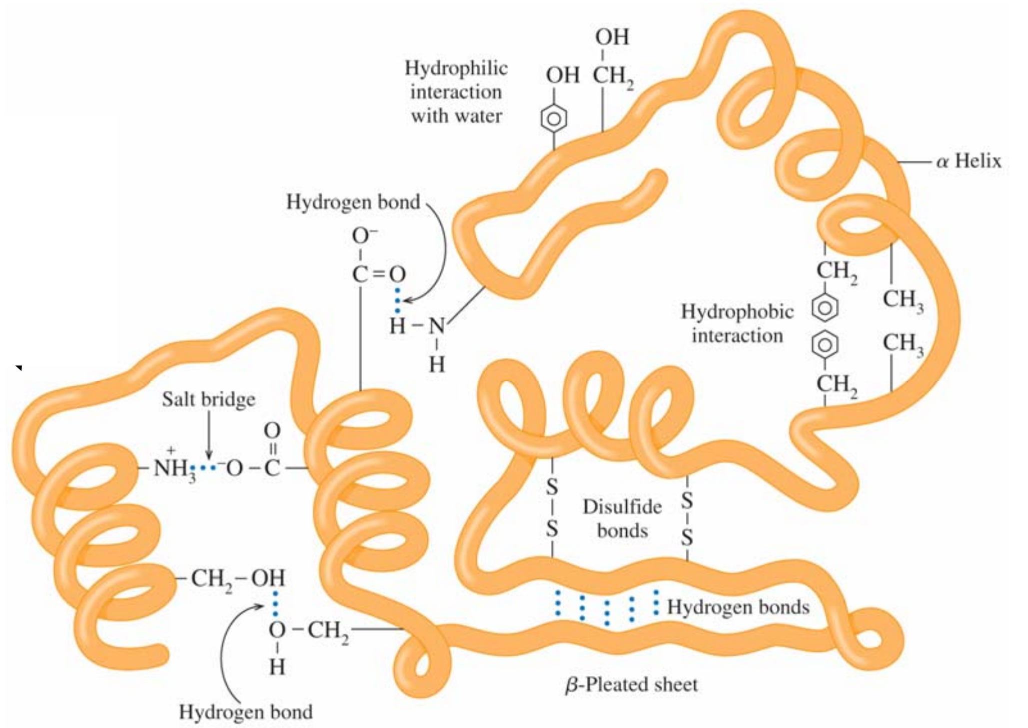


The **primary structure** of a protein is the particular **sequence** of amino acids that form the backbone of a peptide chain or protein

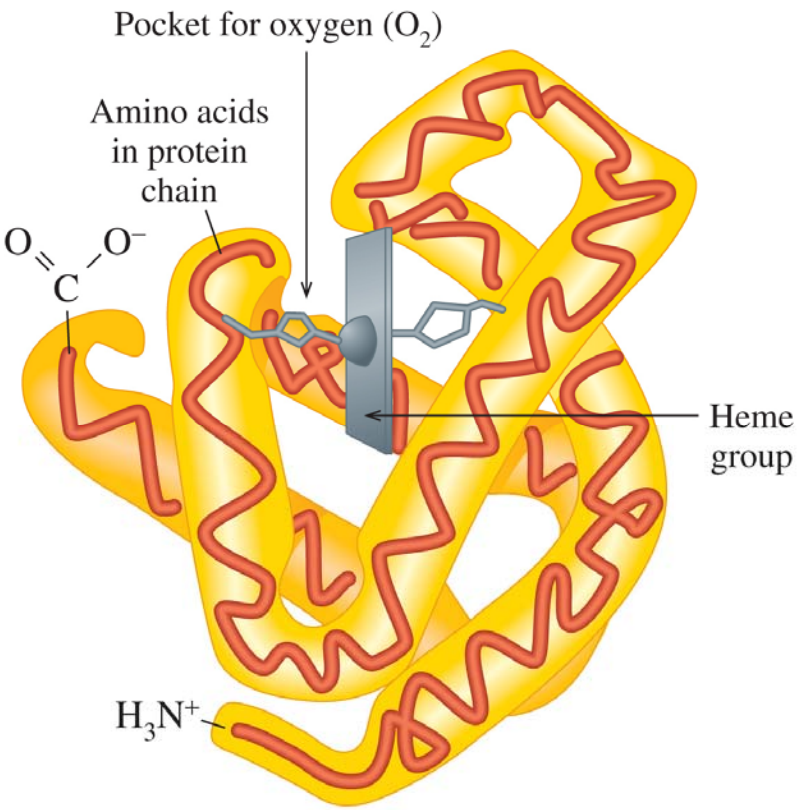
The **secondary structures** of proteins indicate the three-dimensional spatial arrangements of the polypeptide chains

The **tertiary structure** of a protein gives a specific three-dimensional shape to the polypeptide chain including interactions and cross-links between different parts of the peptide chain
The **tertiary structure** is stabilized by: hydrophobic and hydrophilic interactions, salt bridges hydrogen bonds and disulfide bonds

	Nature of Bonding
Hydrophobic interactions	Interactions between nonpolar groups
Hydrophilic interactions	Attractions between polar or ionized groups and water on the surface of the tertiary structure
Salt bridges	Ionic interactions between ionized acidic and basic amino acids
Hydrogen bonds	Occur between H and O or N
Disulfide bonds	Strong covalent links between sulfur atoms of two cysteine amino acids



Globular proteins have compact, spherical shapes
carry out synthesis, transport, and metabolism in the cells
A protein such as myoglobin stores and transports oxygen in muscle



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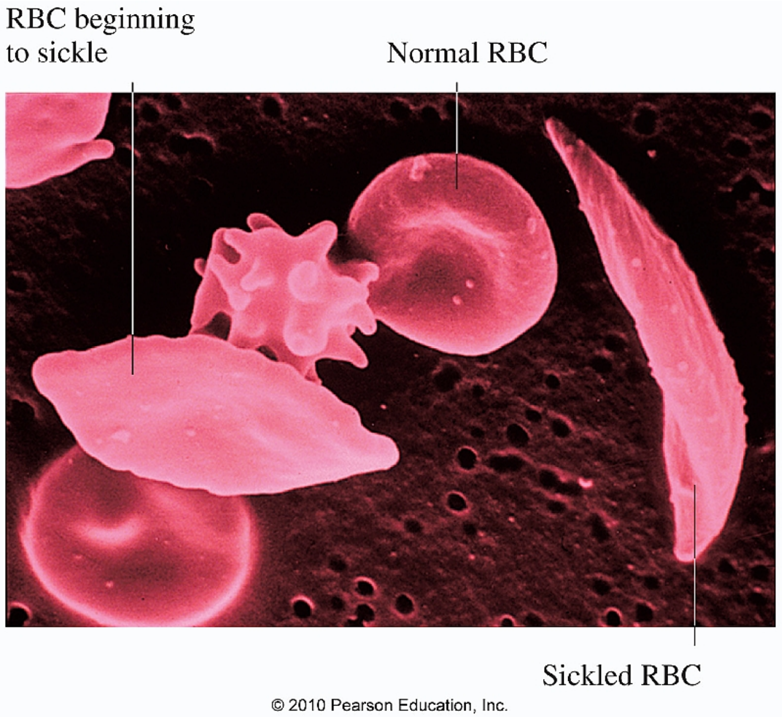
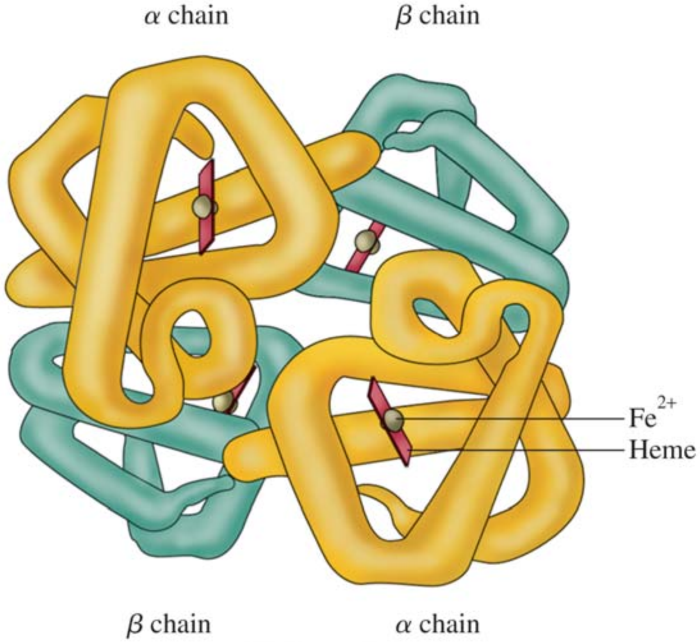
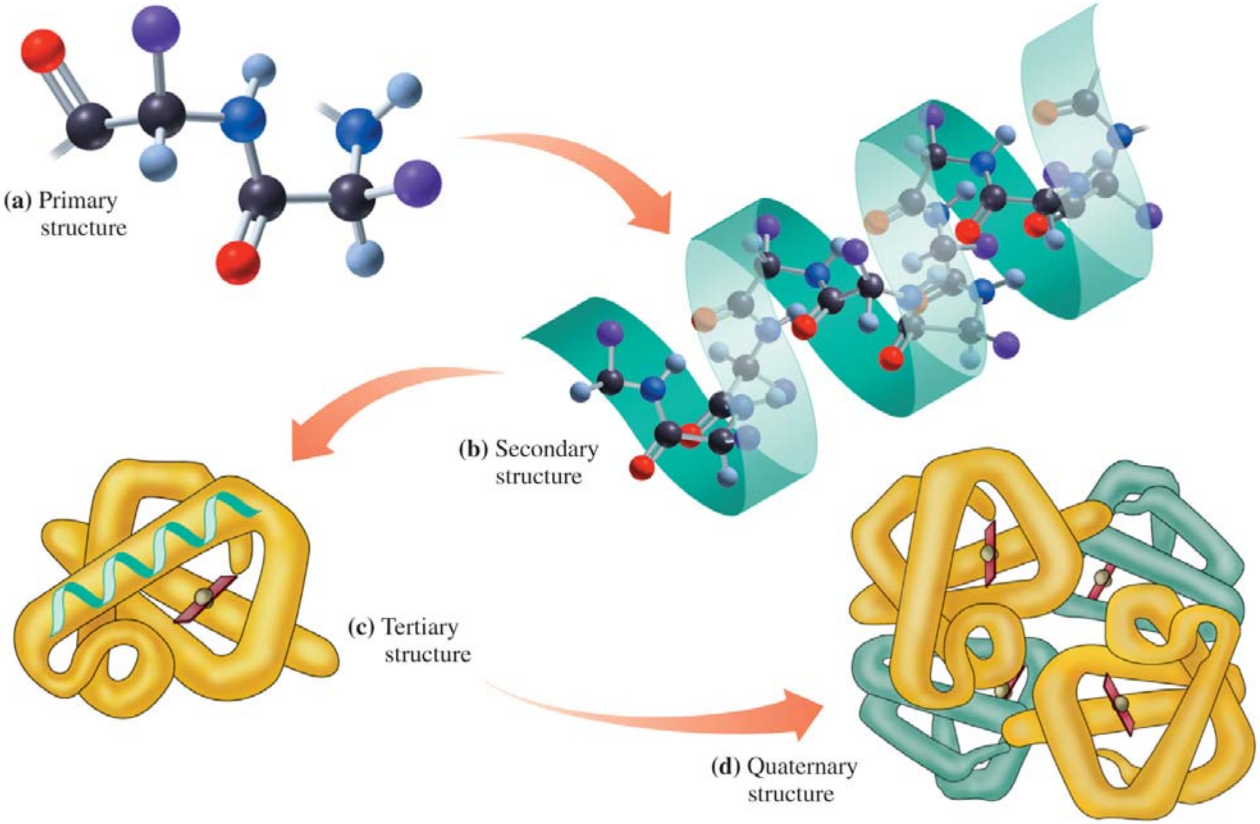
The **tertiary structure** of a protein gives a specific three-dimensional shape to the polypeptide chain including interactions and cross-links between different parts of the peptide chain

The **quaternary structure** is the combination of two or more tertiary units;
it is stabilized by the same interactions found in tertiary structures;
hemoglobin consists of two alpha chains and two beta chains with heme groups in each subunit that pick up oxygen for transport in the blood to the tissues





Summary of Protein Structure



Denaturation involves the disruption of bonds in the secondary, tertiary, and quaternary protein structures

heat and organic compounds that break apart H bonds and disrupt hydrophobic interactions

acids and bases that break H bonds between polar R groups and disrupt ionic bonds

heavy metal ions that react with S—S bonds to form heavy metal sulfides

agitation, such as whipping, that stretches peptide chains until bonds break

Denaturation of protein occurs when an egg is cooked

the skin is wiped with alcohol

heat is used to cauterize blood vessels

instruments are sterilized in an autoclave

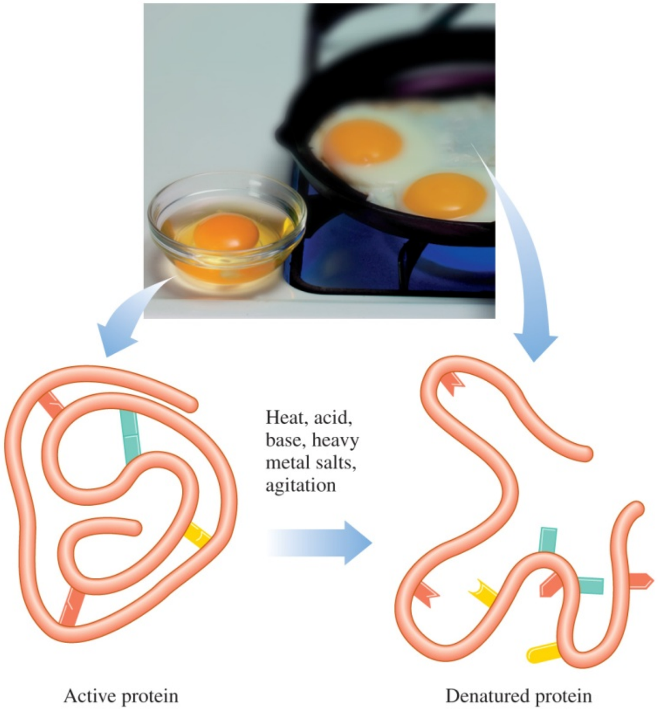
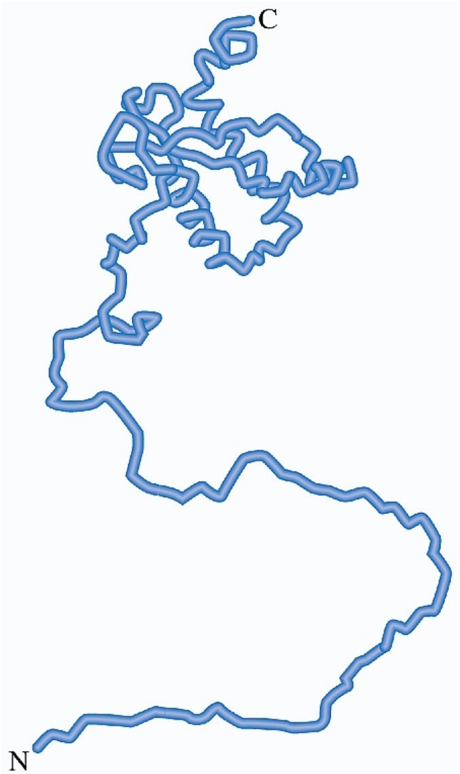


TABLE 19.1 Classification of Some Proteins and Their Functions

Class of Protein	Function in the Body	Examples
Structural	Provide structural components	*Collagen* is in tendons and cartilage. *Keratin* is in hair, skin, wool, and nails.
Contractile	Move muscles	*Myosin* and *actin* contract muscle fibers.
Transport	Carry essential substances throughout the body	*Hemoglobin* transports oxygen. *Lipoproteins* transport lipids.
Storage	Store nutrients	*Casein* stores protein in milk. *Ferritin* stores iron in the spleen and liver.
Hormone	Regulate body metabolism and nervous system	*Insulin* regulates blood glucose level. *Growth hormone* regulates body growth.
Enzyme	Catalyze biochemical reactions in the cells	*Sucrase* catalyzes the hydrolysis of sucrose. *Trypsin* catalyzes the hydrolysis of proteins.
Protection	Recognize and destroy foreign substances	*Immunoglobulins* stimulate immune responses.



A relatively new group of diseases are proteins called prions. In the non-infectious form the tail is a random coil (no regularity in its structure). Once injested, the tail can get folded into a beta pleated sheet. It now becomes an infectious agent and has devastating effects on the brain and spinal cord. Somehow some of it gets into the blood stran without getting metabolize (hydrolysed into smaller peptides). The protein appears to be found in brain spinal cord tissue.