By- Shailendra Shukla Sir

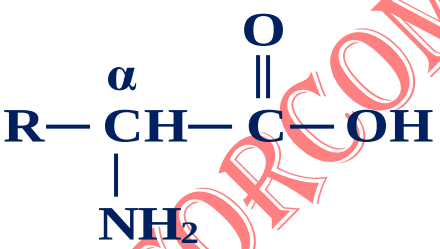
Proteins

Proteins are the most abundant biomolecules of the living system. Chief sources of proteins are milk, cheese, pulses, peanuts, fish, meat, etc. They are found in every part of our body and form the fundamental basis of structure and functions of life. They are also required for growth and maintenance of body.

The word protein is derived from Greek word, "**proteios**" which means primary or of prime importance. All proteins are polymers of α-amino acids.

Amino Acids

Amino acids are the compounds containing both amino ($-NH_2$) and carboxyl (–COOH) functional groups in same molecule. Depending upon the relative position of amino group with respect to carboxyl group, the amino acids are classified as α, β, γ, δ and so on amino acids. However, proteins are polymers of α-amino acids and therefore, they give only α-amino acids on hydrolysis.



α-Amino acids

Amino acids may also contain other functional groups along with amino and carboxylic acid groups.

All α-amino acids have trivial names, based either on their property or on their source. For example, Glycine is named because of its sweet taste (Greek, *glykos* means sweet). Similarly, tyrosine is named on the basis of its source i.e. cheese (Greek, *tyros* means cheese).

Amino acids are generally represented by a three letter symbol, where three letter of their common names (First in upper case and rest two in lower case) are used as their symbol. For example, glycine is symbolysed as "Gly" and alanine is symbolysed as "Ala". Sometimes, one letter symbol is also used for amino acids, where only one letter in upper case is used as their symbol. For example, glycine is symbolysed as "G" and alanine is symbolysed as "A".

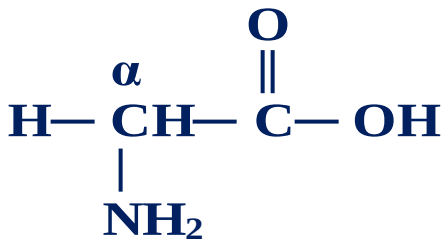
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Classification of Amino Acids

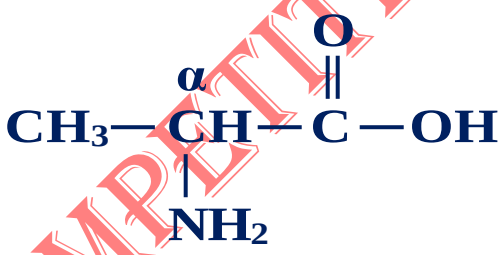
Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule. If an amino acid contains equal number of amino and carboxyl groups then it is neutral; if it contains more number of amino than carboxyl groups then it is basic and if it contains more carboxyl groups as compared to amino groups then it is acidic.

Essential and Non-essential amino acids

Those amino acids which can be synthesized in our body and therefore, they need not to be taken from outside are called **non-essential amino acids. For example, glycine, alanine, tyrosine, glutamine etc.**

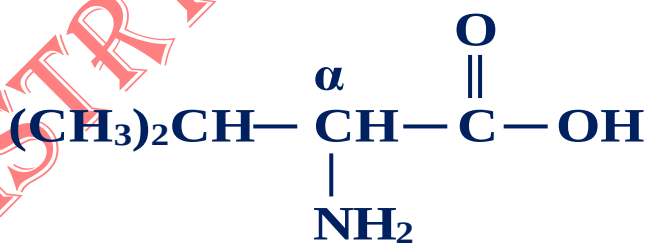


Glycine

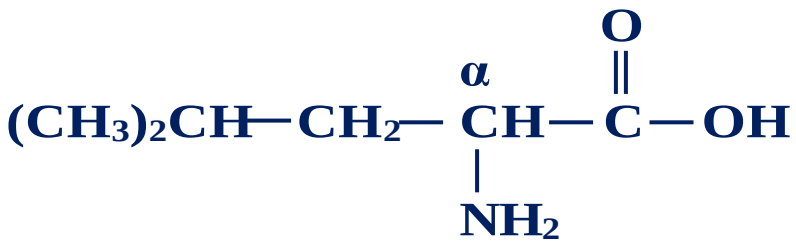


Alanine

On the other hand, those amino acids which cannot be synthesized in our body and therefore, they required to be taken from outside through diet, are known as **essential amino acids. For example, valine, leucine, isoleucine etc.**



Valine

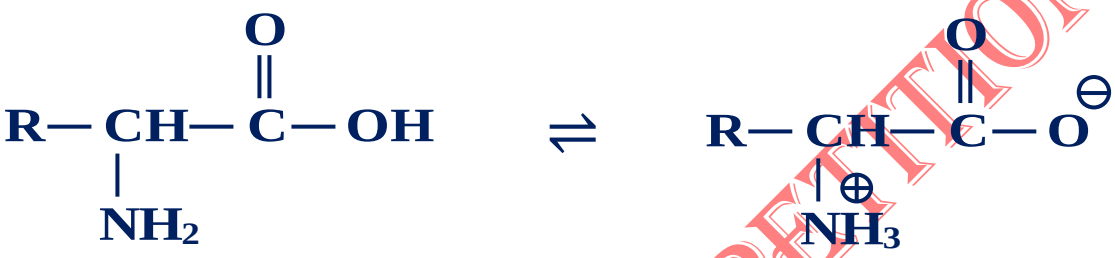


Leucine

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Zwitter Ion

Amino acids are usually colourless, crystalline solids. These are water-soluble, high melting solids and behave like salts rather than simple amines or carboxylic acids. This behaviour of amino acids is due to the presence of both acidic (carboxyl group) and basic (amino group) groups in the same molecule. In fact, in aqueous solution, the carboxyl group of amino acids loses a proton and amino group of same molecule accepts it to form a dipolar ion called *zwitter ion*. Zwitter ion contains both positive and negative poles, but it is over all neutral in nature.



Amino acid **Zwitter ion**

In zwitter ion form, amino acids show amphoteric behaviour as they react both with acids and bases.

Except glycine, the α-carbon atom of naturally occurring amino acids is asymmetric. Hence, all the naturally occurring α-amino acids except glycine are optically active and exist in d and l forms.

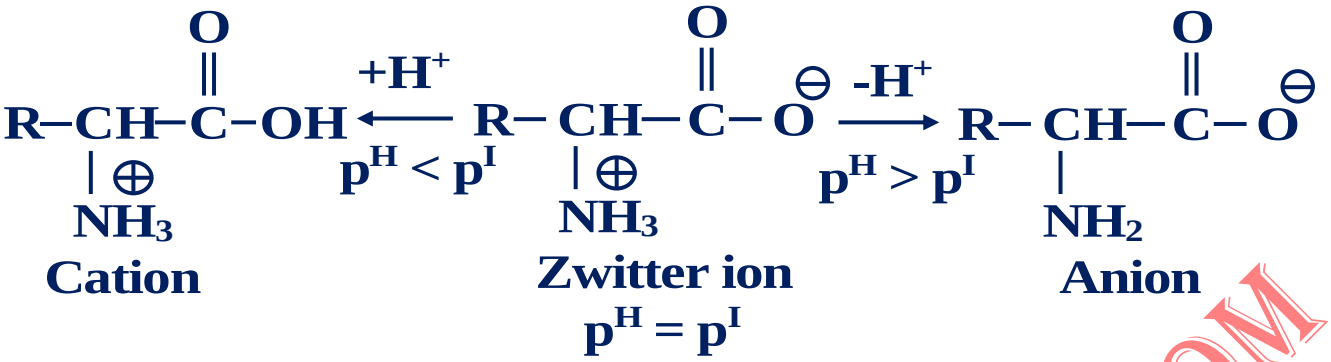
Amino acids exist both in D and L forms. Most naturally occurring amino acids have L-configuration. L-Amino acids are represented by writing the $-NH_2$ group on left hand side.

Isoelectric Point (p^I)

There is a p^H at which an amino acid exists in neutral zwitter ion form and therefore, it does not move towards any electrode in electric field. This p^H is called isoelectric point (p^I) of the respective amino acid.

In fact, in a solution having p^H below isoelectric point, zwitter ion takes a proton from solution and gets converted into cation and therefore, moves towards negatively charged electrode (cathode) in electric field. On the other hand, in a solution having p^H above isoelectric point, zwitter ion loses a proton and gets converted into anion and therefore, moves towards positively charged electrode (anode) in electric field.

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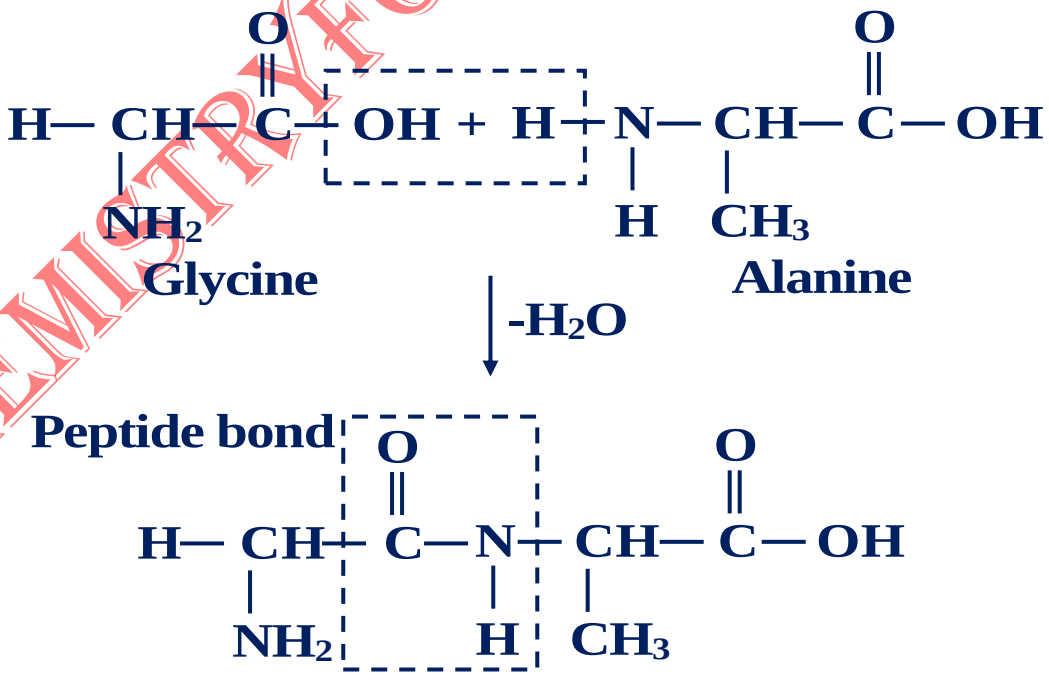
Isoelectric point is the characteristic of an amino acid and is different for different amino acids. For example, isoelectric point of glycine is 5.97.

At isoelectric point, the solubility of an amino acid in water is the least.

Peptide Bond or Peptide Linkage

All proteins are polymers of α-amino acids where different amino acids remain connected to each other by **peptide bond** or **peptide linkage.** Chemically, peptide linkage is an amide bond (-CO-NH-) formed between -COOH group of one molecule and -NH_2 group of another molecule of same or different amino acid with elimination of a water molecule.

For example, when carboxyl group of glycine combines with the amino group of alanine, a **dipeptide**, glycylalanine is obtained.



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If a third amino acid molecule combines to a dipeptide, the product is called a **tripeptide**. A tripeptide contains three amino acids linked by two peptide linkages.

Similarly when four, five or six amino acids are linked, the respective products are known as **tetrapeptide, pentapeptide or hexapeptide** respectively.

When the number of such amino acids is more than ten, then the products are called **polypeptides**.

A polypeptide with more than hundred amino acid residues and having molecular mass higher than 10,000u is called a protein. However, the distinction between a polypeptide and a protein is not very sharp. Polypeptides with fewer amino acids are also called proteins, if they have a well defined conformation of a protein. For example, insulin contains only 51 amino acids, but it is a protein.

Classification of Proteins

On the basis of molecular shape, **proteins** may be of following two types-

(1) Fibrous Proteins

In these proteins, the polypeptide chains run parallel to one another and are held together by hydrogen and disulphide bonds. It results in the formation of the fibre like structures. These proteins are generally insoluble in water. For examples, keratin (present in hair, wool, silk), myosin (present in muscles), etc.

(2) Globular Proteins

In these proteins, the polypeptide chains coil around to give a spherical shape. These are usually soluble in water. Insulin and albumins are the common examples of globular proteins.

Structure of Proteins

Structure and shape of proteins can be studied at four different levels, i.e., primary, secondary, tertiary and quaternary levels. Here, each level is more complex than the previous one.

(1) Primary structure of proteins

Proteins consist of one or more polypeptide chains. In each polypeptide chain, different amino acids remain linked together in a

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specific sequence. This sequence of amino acids in a polypeptide chain is called the primary structure of respective protein.

Any change in primary structure i.e., the sequence of amino acids in polypeptide chain results in a different protein.

(2) Secondary structure of proteins

The secondary structure of protein represents the shape in which a long polypeptide chain can exist. In fact, a polypeptide chain can have two different types of structures namely α-helix and β-pleated sheet structure. These structures arise due to the regular folding of the backbone of the polypeptide chain due to hydrogen bonding between >C=O and -NH- groups of the peptide bond.

α-Helix is one of the most common way in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right handed screw (helix) with the –NH- group of each amino acid residue hydrogen bonded to the >C=O group of an adjacent turn of the helix.

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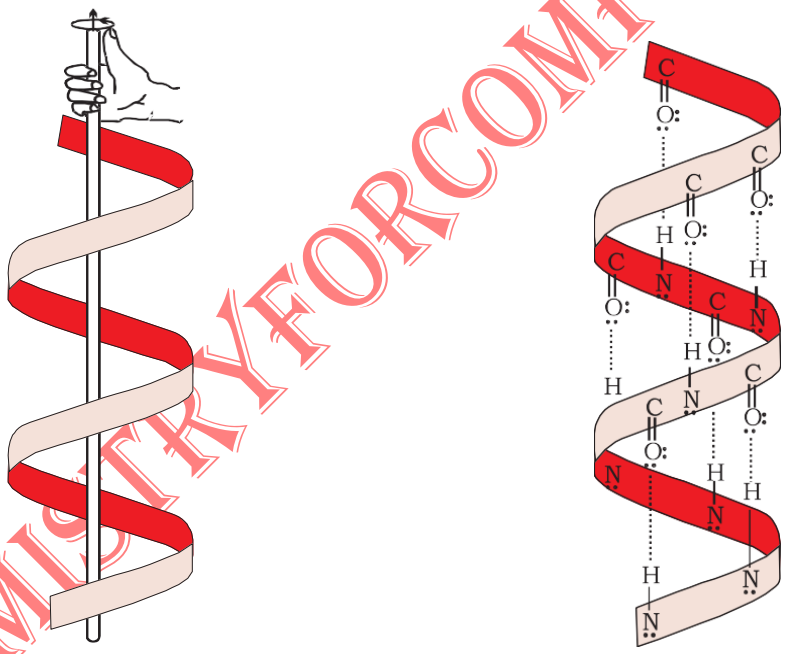


Fig.- α-Helix Structure of Proteins

In β-pleated sheet structure, all the peptide chains are stretched out to nearly maximum extension and then laid side by side which are held together by intermolecular hydrogen bonds. The structure resembles the pleated folds of drapery and therefore, it is known as β-pleated sheet.

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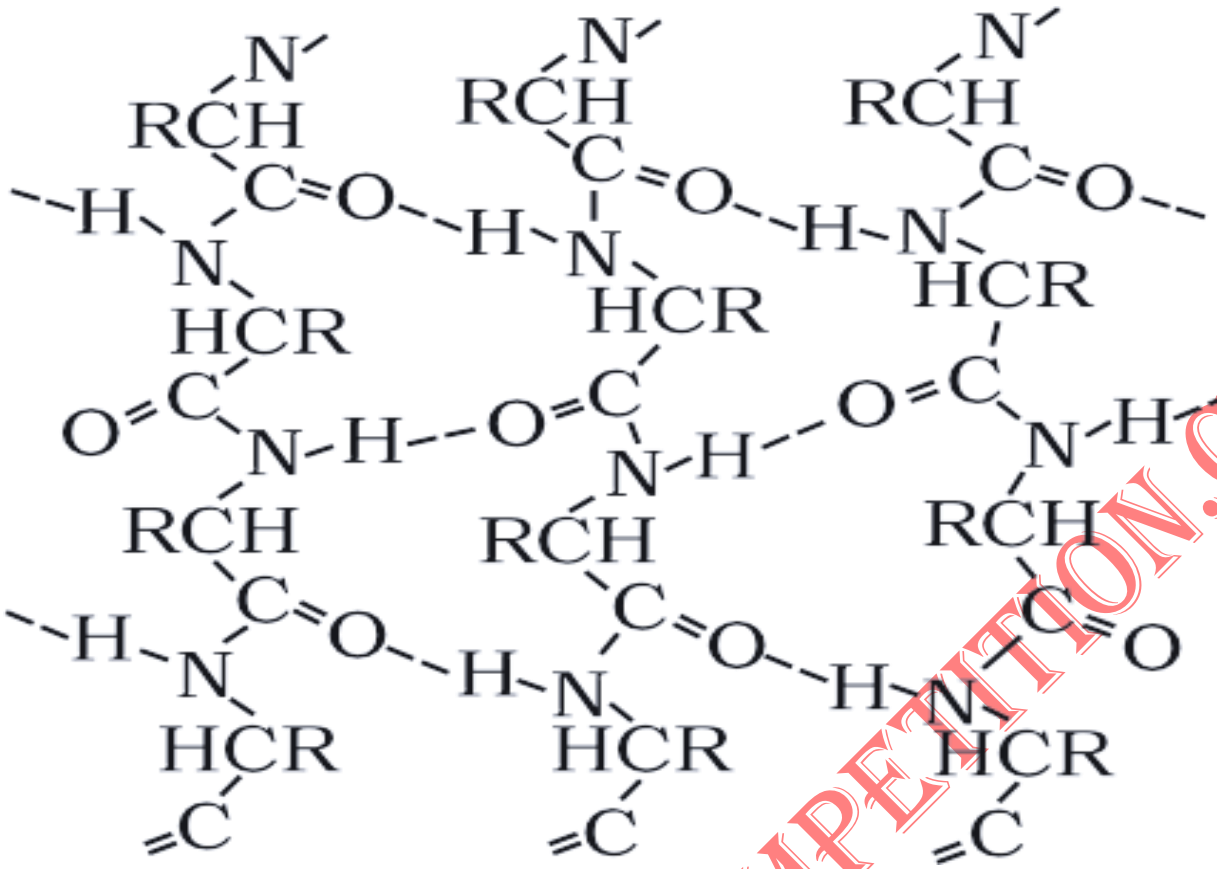


Fig.- β-Pleated Sheet Structure of Proteins

(3) Tertiary structure of proteins

The tertiary structure of proteins represents the overall folding of the polypeptide chains i.e., further folding of the secondary structure. It gives rise to two major molecular shapes namely fibrous and globular. The main forces which stabilize the 2° and 3° structures of proteins are hydrogen bonds, disulphide linkages, vander Waal's and electrostatic forces of attraction.

(4) Quaternary structure of proteins

Some of the proteins are composed of two or more polypeptide chains referred to as sub-units. The spatial arrangement of these subunits with respect to each other is known as quaternary structure.

A diagrammatic representation of all the four structures of proteins (where each coloured ball represents an amino acid) is as follows-

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Primary Secondary Tertiary Quaternary

Fig.- Diagrammatic representation of Protein Structure

Denaturation of Proteins

Proteins found in the biological system have a unique three-dimensional structure and biological activity. They are called as native proteins. When a protein in its native form, is subjected to a physical change like change in temperature or a chemical change like change in pH, the hydrogen bonds get disturbed. Thus, the globules get unfolded and the helix get uncoiled so that, the proteins lose their biological activity. This is called **denaturation** of proteins. During denaturation, secondary and tertiary structures are destroyed, but primary structure remains intact.

The coagulation of egg white on boiling is a common example of denaturation. Another example is curdling of milk which is caused by the formation of lactic acid due to the bacteria present in milk.

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