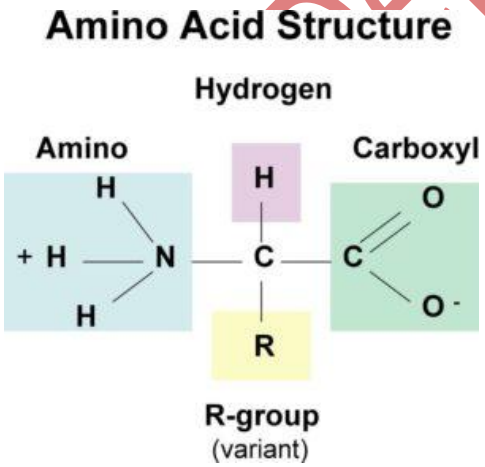
Properties and classification of Amino acids

Amino acids constitute a group of neutral products clearly distinguished from other natural compounds chemically, mainly because of their ampholytic properties, and biochemically, mainly because of their role as protein constituents. An amino acid is a carboxylic acid-containing an aliphatic primary amino group in the α position to the carboxyl group and with a characteristic stereochemistry. Proteins are biosynthesized from 20 amino acids in a system involving strict genetic control. Thus, amino acids are the basic unit of proteins. More than 300 amino acids are found in nature but only 20 amino acids are standard and present in protein because they are coded by genes. Other amino acids are modified amino acids and called non-protein amino acids. Some are residues modified after a protein has been synthesized by posttranslational modifications; others are amino acids present in living organisms but not as constituents of proteins.

All 20 of the common amino acids are alpha-amino acids. They contain a carboxyl group, an amino group, and a side chain (R group), all attached to the α-carbon.



Exceptions are:

- **Glycine**, which does not have a side chain. Its α-carbon contains two hydrogens.

- **Proline**, in which the nitrogen is part of a ring.
- Thus, each amino acid has an amine group at one end and an acid group at the other and a distinctive side chain. The backbone is the same for all amino acids while the side chain differs from one amino acid to the next.
- All of the 20 amino acids except glycine are of the L-configuration, as for all but one amino acid the α-carbon is an asymmetric carbon. Because glycine does not contain an asymmetric carbon atom, it is not optically active and, thus, it is neither D nor L.

❖ Properties of the Amino acids

♣ Physical Properties:

1. Amino acids are colorless, crystalline solid.
2. All amino acids have a high melting point greater than 200^{o}C
3. **Solubility:** They are soluble in water, slightly soluble in alcohol and dissolve with difficulty in methanol, ethanol, and propanol. R-group of amino acids and pH of the solvent play important role in solubility.
4. On heating to high temperatures, they decompose.
5. All amino acids (except glycine) are optically active.
6. Peptide bond formation: Amino acids can connect with a peptide bond involving their amino and carboxylate groups. A covalent bond formed between the alpha-amino group of one amino acid and an alpha-carboxyl group of other forming -CO-NH-linkage. Peptide bonds are planar and partially ionic.

♣ Chemical Properties:

1. **Zwitterionic property:** A zwitterion is a molecule with functional groups, of which at least one has a positive and one has a negative electrical charge. The net charge of the entire molecule is zero. Amino

acids are the best-known examples of zwitterions. They contain an amine group (basic) and a carboxylic group (acidic). The -NH2 group is the stronger base, and so it picks up H+ from the -COOH group to leave a zwitterion. The (neutral) zwitterion is the usual form amino acids exist in solution.

2. **Amphoteric property:** Amino acids are amphoteric in nature that is they act as both acids and base since due to the two amine and carboxylic group present.
3. **Ninhydrin test:** When 1 ml of Ninhydrin solution is added to a 1 ml protein solution and heated, the formation of a violet color indicates the presence of α-amino acids.
4. **Xanthoproteic test:** The xanthoproteic test is performed for the detection of aromatic amino acids (tyrosine, tryptophan, and phenylalanine) in a protein solution. The nitration of benzoid radicals present in the amino acid chain occurs due to reaction with nitric acid, giving the solution yellow coloration.
5. **Reaction with Sanger's reagent:** Sanger's reagent (1-fluoro-2, 4-dinitrobenzene) reacts with a free amino group in the peptide chain in a mild alkaline medium under cold conditions.
6. **Reaction with nitrous acid:** Nitrous acid reacts with the amino group to liberate nitrogen and form the corresponding hydroxyl.

♣ **Biological Properties:**

1) **Alanine (A/Ala):** Important source of energy for muscle. One of the three most important glycogenic amino acids. The primary amino acid in sugar metabolism. Boosts immune system by producing antibodies.
2) **Valine (V/Val):** Essential for muscle development.
3) **Leucine(L/Leu):** Beneficial for skin, bone and tissue wound healing.

4) **Isoleucine (I/Ile):** Necessary for the synthesis of hemoglobin.
5) **Phenylalanine (F/Phe):** Beneficial for healthy nervous system. It boosts memory and learning.
6) **Threonine (T/Thr):** Required for formation of collagen. Helps prevent fatty deposits in liver. Aids in antibodies' production.
7) **Lysine (L/Lys):** Component of muscle protein, and is needed in the synthesis of enzymes and hormones which is essential for healthy nervous system function.
8) **Aspartate (D/Asp):** Increases stamina and helps protect the liver; DNA and RNA metabolism; immune system function.
9) **Glutamate (E/Glu):** Neurotransmitter that is involved in DNA synthesis.

❖ Classification of anino acids

Classification of anino acids on the basis of of R-group

1. **Nonpolar amino acids**: These are also known as Hydrophobic. The R group can be either of Alkyl groups (with an alkyl chain) or Aromatic groups.
   a) **Aliphatic amino acids**: The R groups in this class of amino acids are nonpolar and hydrophobic. Glycine (H), Alanine (CH_3), Valine ($CH(CH_3)_2$), leucine ($CH_2CH(CH_3)_2$), Isoleucine ($-CH(CH_3)CH_2CH_3$), Methionine, Proline.
   b) **Aromatic amino acids:** Phenylalanine, tyrosine, and tryptophan, with their aromatic side chains, are relatively nonpolar (hydrophobic). All can participate in hydrophobic interactions.
2. **Polar amino acids:** If the side chains of amino acid contain different polar groups like amines, alcohols or acids they are polar in nature. These are also known as Hydrophilic Acids. These are further divided into three further categories.

a) **Uncharged amino acids (Neutral):** These are neither acidic nor basic. They have an equal number of amino and carboxyl 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 (CH_2OH), threonine ($CH(OH)CH_3$), cysteine (CH_2SH), asparagine (CH_2OHNH_2), Tyrosine and glutamine ($CH_2CH_2CONH_2$).

b) **Acidic amino acids:** Amino acids in which R-group is acidic or negatively charged. They tend to donate their hydrogen atom. These are Glutamic acid (CH_2CH_2COOH) and Aspartic acid (CH_2COOH).

c) **Basic amino acids:** Amino acids in which R-group is basic or positively charged. These have an extra nitrogen group that tend to attract a hydrogen atom. These are Lysine ($CH_2(CH_2)_2NH_2$), Arginine, Histidine

- **Classification of anino acids on the basis of of Nutrition**

1. **Essential amino acids (Nine):** Nine amino acids cannot be synthesized in our bodies. We must rely on food sources to obtain these amino acids. They are histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.
2. **Non-essential amino acids (Eleven):** These amino acids can be synthesized in the body itself and hence we need not rely on outside sources for them. They are either produced in our bodies or obtained from protein breakdowns.

These are Arginine, glutamine, tyrosine, cysteine, glycine, proline, serine, ornithine, alanine, asparagine, and aspartate.

- **Classification of anino acids on the basis of metabolic fat**

1. **Glucogenic amino acids**: These amino acids serve as precursors gluconeogenesis for glucose formation. Glycine, alanine, serine, aspartic

acid, asparagine, glutamic acid, glutamine, proline, valine, methionine, cysteine, histidine, and arginine.

2. **Ketogenic amino acids:** These amino acids breakdown to form ketone bodies. Leucine and Lysine.
3. **Both glucogenic and ketogenic amino acids:** These amino acids breakdown to form precursors for both ketone bodies and glucose. Isoleucine, Phenylalanine, Tryptophan, and tyrosine.

❖ Functions of anino acids

1) In particular, 20 very important amino acids are crucial for life as they contain peptides and proteins and are known to be the building blocks for all living things.
2) The linear sequence of amino acid residues in a polypeptide chain determines the three-dimensional configuration of a protein, and the structure of a protein determines its function.
3) Amino acids are imperative for sustaining the health of the human body. They largely promote the:

   Production of hormones
   - Structure of muscles
   - Human nervous system's healthy functioning
   - The health of vital organs
   - Normal cellular structure
4) The amino acids are used by various tissues to synthesize proteins and to produce nitrogen-containing compounds (e.g., purines, heme, creatine, epinephrine), or they are oxidized to produce energy.
5) The breakdown of both dietary and tissue proteins yields nitrogen-containing substrates and carbon skeletons.

6) The nitrogen-containing substrates are used in the biosynthesis of purines, pyrimidines, neurotransmitters, hormones, porphyrins, and nonessential amino acids.
7) The carbon skeletons are used as a fuel source in the citric acid cycle, used for gluconeogenesis, or used in fatty acid synthesis.