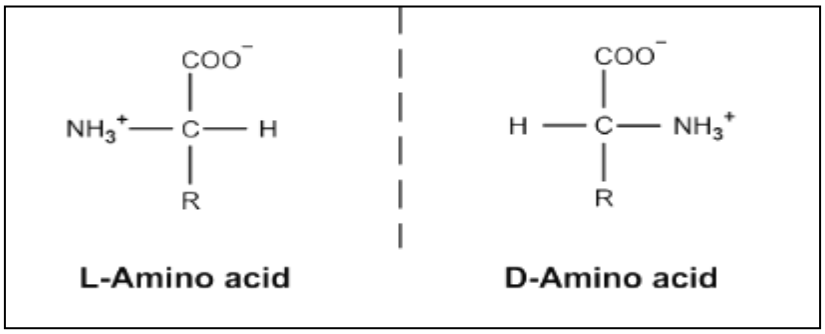
Amino acids

Amino acids are biologically important organic compounds composed with a side-chain specific to each amino acid. In addition providing monomer units of amino acid to polypeptide chains of proteins are synthesized, the L-amino acids and their derivatives participate in cellular functions and nerve transmission, the biosynthesis of porphyrins and purines, pyrimidines. Short polymers of amino acids called peptides perform prominent roles in the system as hormones. While peptides contain both D- and L-amino acids are therapeutic value, including the antibiotics gramicidin and antitumor agent. Consequently, the human diet must contain adequate quantities of these nutritionally essential amino acids.



Properties of amino acids

1-There are approximately 300 amino acids present in various animal, plant and microbial systems, but only 20 amino acids are involved in the formation of proteins.

2- All the 20 amino acids found in proteins have a carboxyl group (-COOH) and an amino acid group (-NH2) • Amino acids differ from each other in their side chains or R-groups, attached to the α-carbon.

3- The standard amino acids have been assigned three letters abbreviations and one letter symbol, e.g. amino acid glycine has abbreviated name Gly and symbol letter G.

4-All the amino acids found in proteins are exclusively of the L configuration.

In Table showed R-groups of all amino acids, amino acids differ from each other in their side chains or R groups, attached to the α-carbon, Exception of glycine, the carbon of amino acids is chiral that the R group was H. Although some protein amino acids are dextrorotatory and some levorotatory. Essential amino acids cannot be synthesized by the body, therefore, be essentially supplied through the diet. Ten amino acids, essential for humans include: Phenylalanine, Methionine, Valine, Histidine, Threonine, Arginine, Tryptophan ,Lysine, Isoleucine, Leucine.

Classification of amino acids

There are five ways of classifying amino acids depending on the:

1. Chemical nature of the amino acid in the solution
2. Structure of the side chain of the amino acids
3. Nutritional requirement of amino acids
4. Metabolic product of amino acids
5. Nature or polarity of the side chain of the amino acids.

Classification Based on Chemical Nature of the Amino Acid in Solution

According to this type of classification, amino acids are classified as follows:

i. Neutral amino acids
ii. Acidic amino acids
iii. Basic amino acids.

Classification Based on Chemical Structure of Side Chain of the Amino Acid

According to this type of classification, amino acids are classified as:

1. Aliphatic amino acids
2. Hydroxy amino acids
3. Sulfur containing amino acids
4. Dicarboxylic acid and their amides
5. Diamino acids
6. Aromatic amino acids
7. Imino acids or heterocyclic amino acids.

Nutritional Classification of Amino Acids

On the basis of nutritional requirement, amino acids are classified into two groups:

1- Essential or indispensable amino acids

2- Nonessential or dispensable amino acids.

Metabolic Classification of Amino Acids

On the basis of their catabolic end products, the twenty standard amino acids are divided in three groups

1-**Glucogenic amino acids:** Those which can be converted into glucose. Fourteen out of the twenty
standard amino acids are glucogenic amino acids

2- **Ketogenic amino acids:** Those which can be converted to ketone bodies. Two amino acids leucine and lysine are exclusively ketogenic.

3- **Both glucogenic and ketogenic:** Those which can be converted to both glucose and ketone bodies. Four amino acids isoleucine, phenylalanine, tryptophan and tyrosine are glucogenic and ketogenic.

Classification Based on Nature or Polarity of Side Chain of Amino Acid:

According to this type of classification, amino acids are classified into two major classes **:**

1- Hydrophilic or polar amino acids

2- Hydrophobic or nonpolar amino acids.

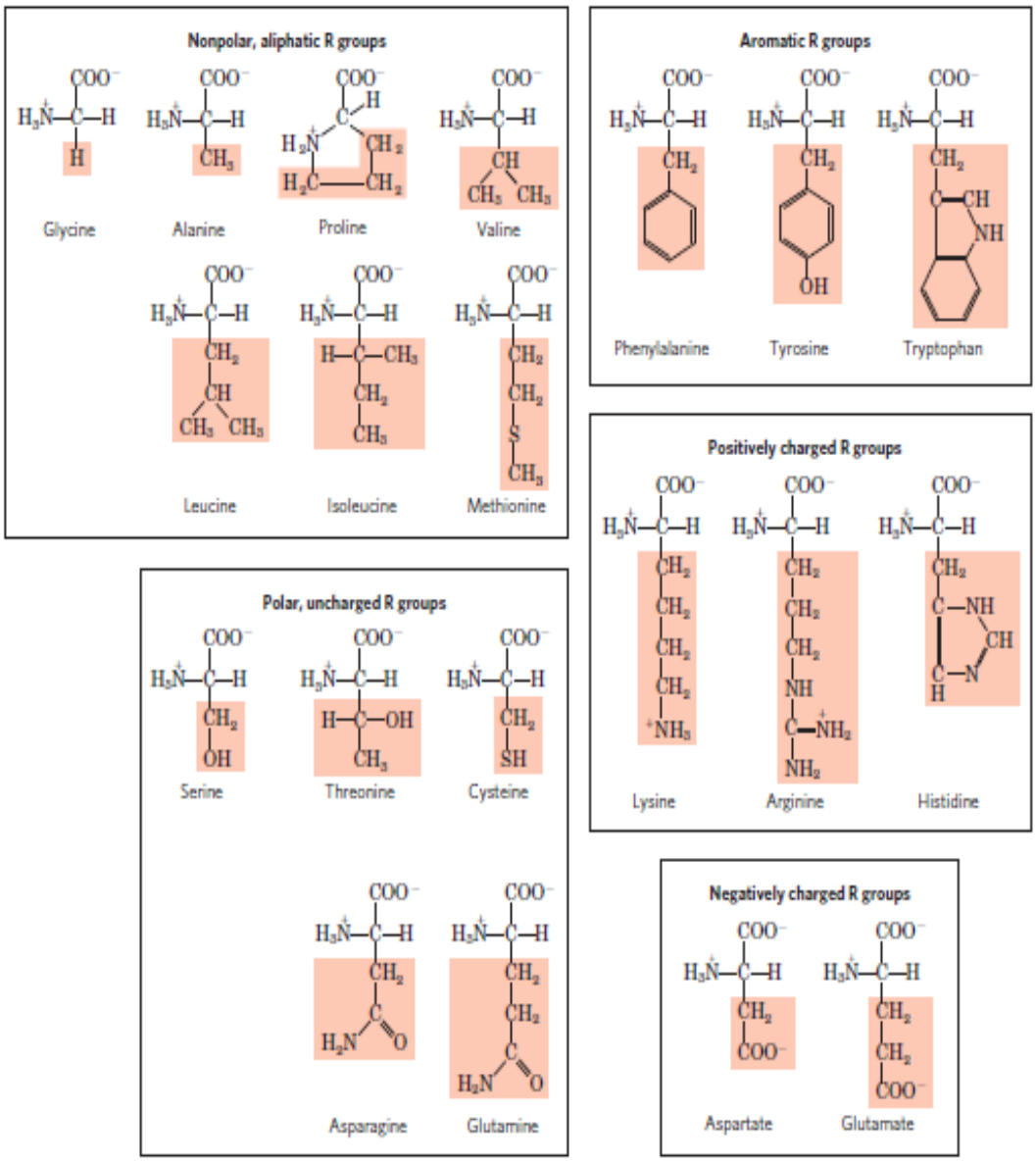


Table: Structures of amino acids

Amphoteric properties of amino acids

Substances having a two-way property are called amphoteric or ampholytes. As amino acids have both acidic and basic groups, they can donate a proton or accept a proton, hence amino acids are regarded as amphoteric. Monoamino monocarboxylic acids exist in aqueous solution as dipolar molecule or zwitter ions, which means that they have both positive and negative charges on the same amino acids.

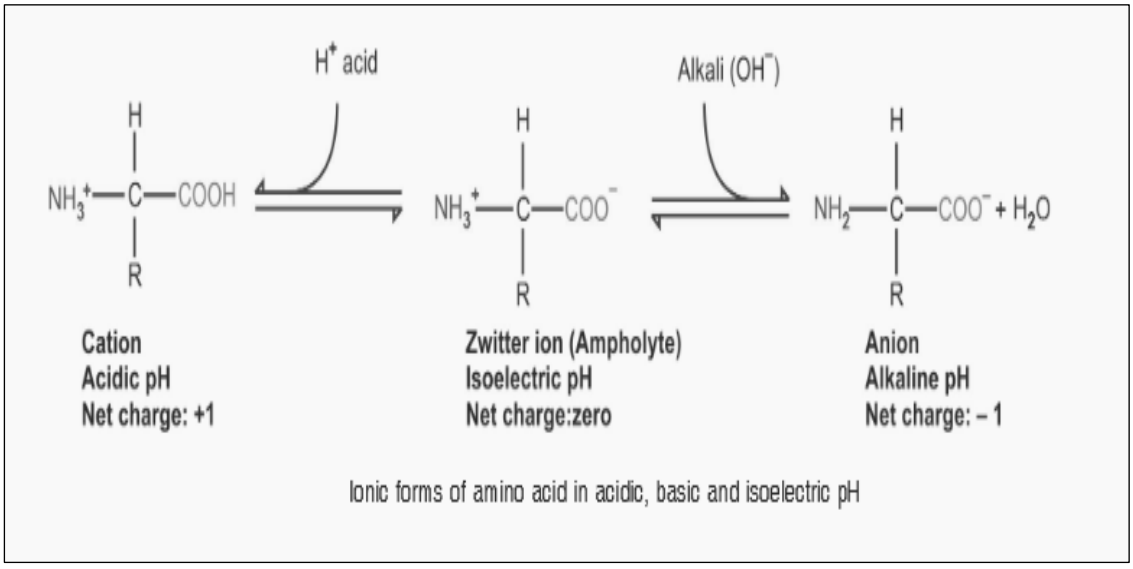
– The α-COOH group is ionized and becomes negatively charged anion (COO–) and

– The α-NH2 group is protonated to form a positively charged cation (NH3 +).

Thus, the overall molecule is electrically neutral. Thus, the molecular species which contain an equal number of ionizable group of opposite charge and as a result bear no net charge, are called **zwitter ions.** The net charge of an amino acid depends upon the pH of the medium.

– At acidic pH, amino acid is positively charged because ionized COO– group accepts a proton and becomes uncharged (COOH), so that the overall charge on the molecule is positive.

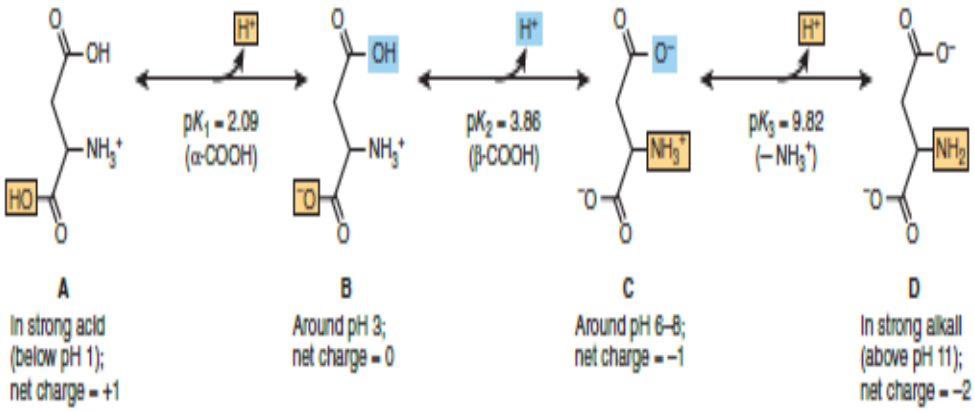
–at alkaline pH it is negatively charged as the NH3 + group loses its proton and becomes uncharged; thus the overall charge on the molecule is negative **.**



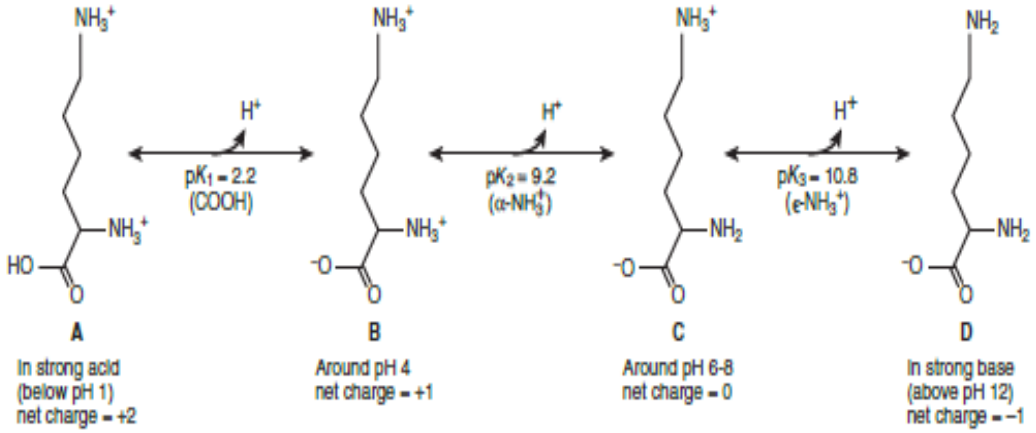
Ionic forms of amino acid in acidic, basic and isoelectric pH

Isoelectric pH (PI)

Zwitterions are one example of an **isoelectric** species—the form of a molecule that has an equal number of positive and negative charges and thus is electrically neutral. The isoelectric pH, also called the pI, Isoelectric pH (PI): The pH at which amino acid bears no net charge (zwitter ion) and therefore does not move in an electric field .



Protonic equilibria of aspartic acid.



Protonic equilibria of lysine.

Importance of Amino Acids

• **Formation of proteins:** Amino acids are joined to each other by peptide bonds to form proteins and peptides.

• **Formation of glucose:** amino acids are converted to glucose in the body.

• **Enzyme activity:** The thiol (-SH) group of cysteine has an important role in certain enzyme activity.

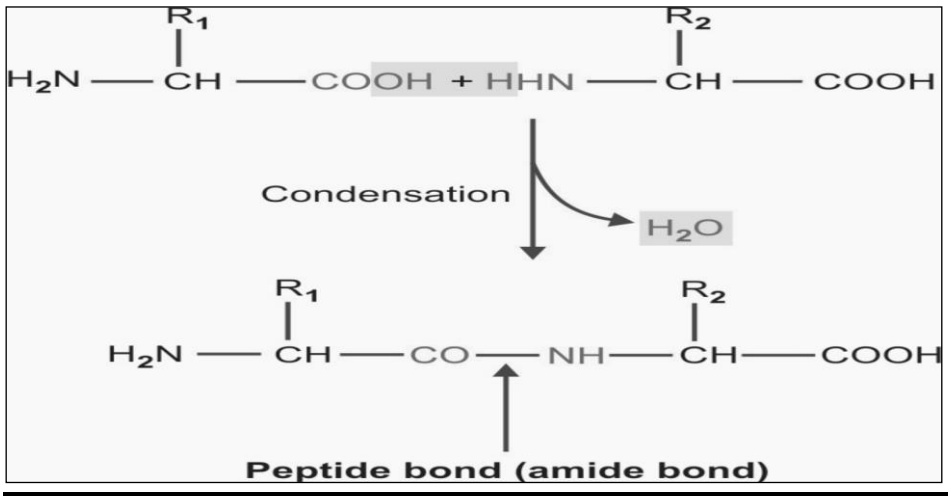
• **As a buffer**: amino acids present in protein can potentially act as buffer, e.g. histidine can serve as the best buffer at physiological pH.

• **Detoxification reactions:** Glycine, cysteine and methionine are involved in the detoxification of
toxic substances.

Biological important of peptide

• Peptides are chains (polymer) of amino acids. Two amino acid molecules can be covalently joined through a **peptide bond,** to yield **dipeptide.** Peptide linkage is formed by the removal of water from the α-carboxyl group of one amino acid and the α-amino group of another **.**

• When many amino acids are joined, the product is called **polypeptide.** Proteins are polypeptides with thousands of amino acids.

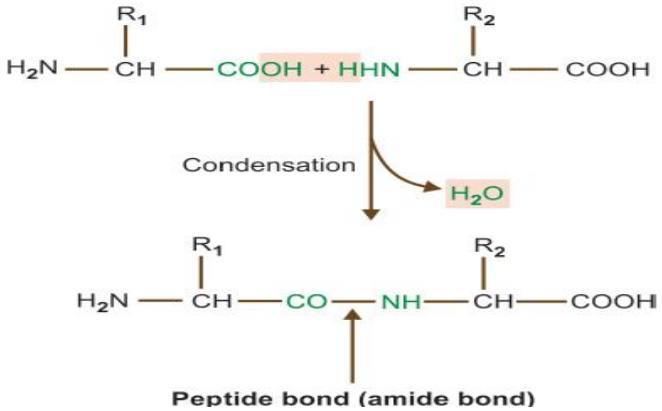


Buffering action of amino acid

Amino acid can act as weak acid or weak base. In addition, each of the acidic and basic amino acids contains an ionizable group in its side chain. Thus, both free amino acids and some amino acids present in proteins can potentially act as buffers. Among the 20 standard amino acids, histidine serves as the best buffer at physiological pH. Because the side chain of histidine has a pKa of 6.0 and can serve as the best buffer at physiological pH. All other amino acids have pKa value, too far away from pH 7 to be an effective physiological buffer. Maximum buffer capacity occurs at pH equal to the pKa.

Biological importance of peptide:

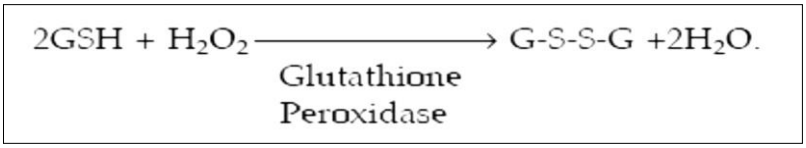
Peptides are chains (polymer) of amino acids. Two amino acid molecules can be covalently joined through a peptide bond, to yield dipeptide. Peptide linkage is formed by the removal of a molecule of water from the α-carboxyl group of one amino acid and the α-amino group of another . When many amino acids are joined, the product is called polypeptide. Proteins are polypeptides with thousands of amino acids. There are many naturally occurring small polypeptides some of which have important biological activities and are called biologically important peptides like:

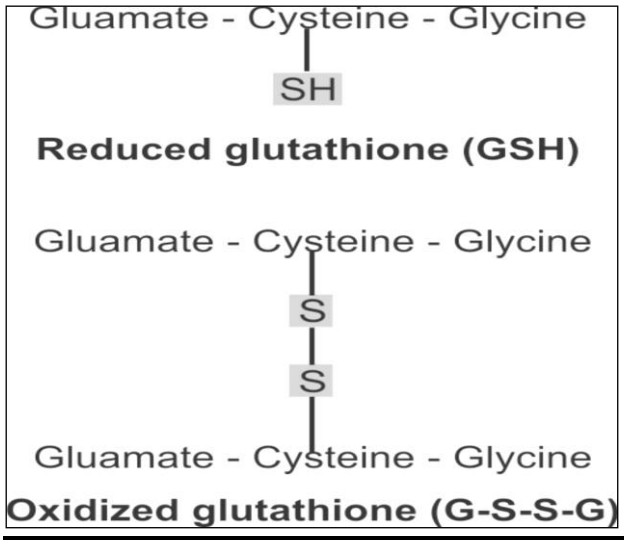


1-Glutathione

GSH is a tripeptide (γ glutamyl – cysteinyl – glycine) containing glutamate, cysteine and glycine. Glutathione is found in all mammalian cells except the neurons.

Glutathione may exist as the reduced (GSH) or oxidized (G-S-S-G) form and can thus play a role in some oxidation–reduction reactions. In oxidized form, two molecules of glutathione are linked by disulfide bond. The sulfhydryl (-SH-) is the functional group primarily responsible for the properties of glutathione. Glutathione plays a key role in detoxification by reducing H2O2 the harmful byproduct of metabolism. Glutathione is capable of preventing damage to important cellular components caused by reactive oxygen species such as free radicals, peroxides, lipid peroxides and heavy metals.





2-Oxytocin

This is a 9-amino acid residue hormone secreted by posterior pituitary and stimulates uterine contractions. Oxytocin is normally produced by the paraventricular nucleus of the hypothalamus and released by the posterior pituitary. Oxytocin is released into the bloodstream as a hormone in response to stretching of the cervixand uterus during labor and with stimulation of the breastfeeding.This helps with birth, bonding with the baby, and milk production

3-Vasopressin

Named antidiuretic hormone (ADH), arginine vasopressin (AVP) . This is a 9-amino acid residue hormone secreted by posterior pituitary and it increases blood pressure and has an antidiuretic action, a hormone synthesized as a peptide prohormone in neurons in the hypothalamus, and is converted to AVP. It then travels down the axon of that cell, which terminates in the posterior pituitary, and is released from vesicles into the circulation in response to extracellular fluid hypertonicity (hyperosmolality). AVP has two primary functions. First, it increases the amount of solute-free water reabsorbed back into the circulationfrom the filtrate in the kidney tubules of the nephrons. Second, AVP constricts arterioles, which increases peripheral vascular resistanceand raises arterial blood pressure. It has a very short half-life, between 16–24 minutes

4-Gastrin

Gastrin is a peptide hormone that stimulates secretion of gastric acid (HCl) by the parietal cells of the stomach and aids in gastric motility. It is released by G cells in the pyloric antrum of the stomach, duodenum, and the pancreas. Gastrin stimulate the release of histamines , and it induces the insertion of K^+/H^+ ATPase pumps into the apical membrane of parietal cells (which in turn increases H^+ release into the stomach cavity). Its release is stimulated by peptides in the lumen of the stomach.

5-Angiotensin

Angiotensin II is a vasoconstrictor and elevates the arterial pressure and also promotes the synthesis of a steroid hormone called aldosterone that promotes sodium retention.

6-Insulin

A pancreatic hormone contains two polypeptide chains: one having 30-amino acid residues and the other 21. Insulin regulates the glucose concentration in blood.

7-Glucagon

This is a pancreatic hormone of 29-residues that opposes the action of insulin.

8-Thyrotropin Releasing Hormone (TRH)

TRH is a hypothalamic hormone of three amino acid residues. It stimulates the release of hormone thyrotropin, from the anterior pituitary gland.