Amino Acids

Amino acids are organic compounds that contain amine ($–NH_2$) and carboxyl (–COOH) functional groups, along with a side chain (R group) specific to each amino acid.

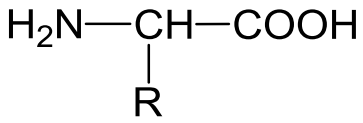
The key elements of an amino acid are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), although other elements are found in the side chains of certain amino acids.

Amino acids can be classified according to the core structural functional groups' locations as alpha- (α-), beta- (β-), gamma- (γ-) or delta- (δ-) amino acids; other categories relate to polarity, pH level, and side chain group type (aliphatic, acyclic, aromatic, containing hydroxyl or sulfur, etc.). In the form of proteins, amino acid residues form the second-largest component (water is the largest) of human muscles and other tissues. Beyond their role as residues in proteins, amino acids participate in a number of processes such as neurotransmitter transport and biosynthesis.

In biochemistry, amino acids which have the amine group attached to the (alpha-) carbon atom next to the carboxyl group have particular importance. They are known as α-amino acids (generic formula $H_2NCHRCOOH$ in most cases, where R is an organic substituent known as a "side chain").

General Structure

In the structure shown at the top of the page, R represents a side chain specific to each amino acid. The carbon atom next to the carboxyl group is called the α–carbon. Amino acids containing an amino group bonded directly to the alpha carbon are referred to as alpha amino acids. These include amino acids such as proline which contain secondary amines, which used to be often referred to as "imino acids".



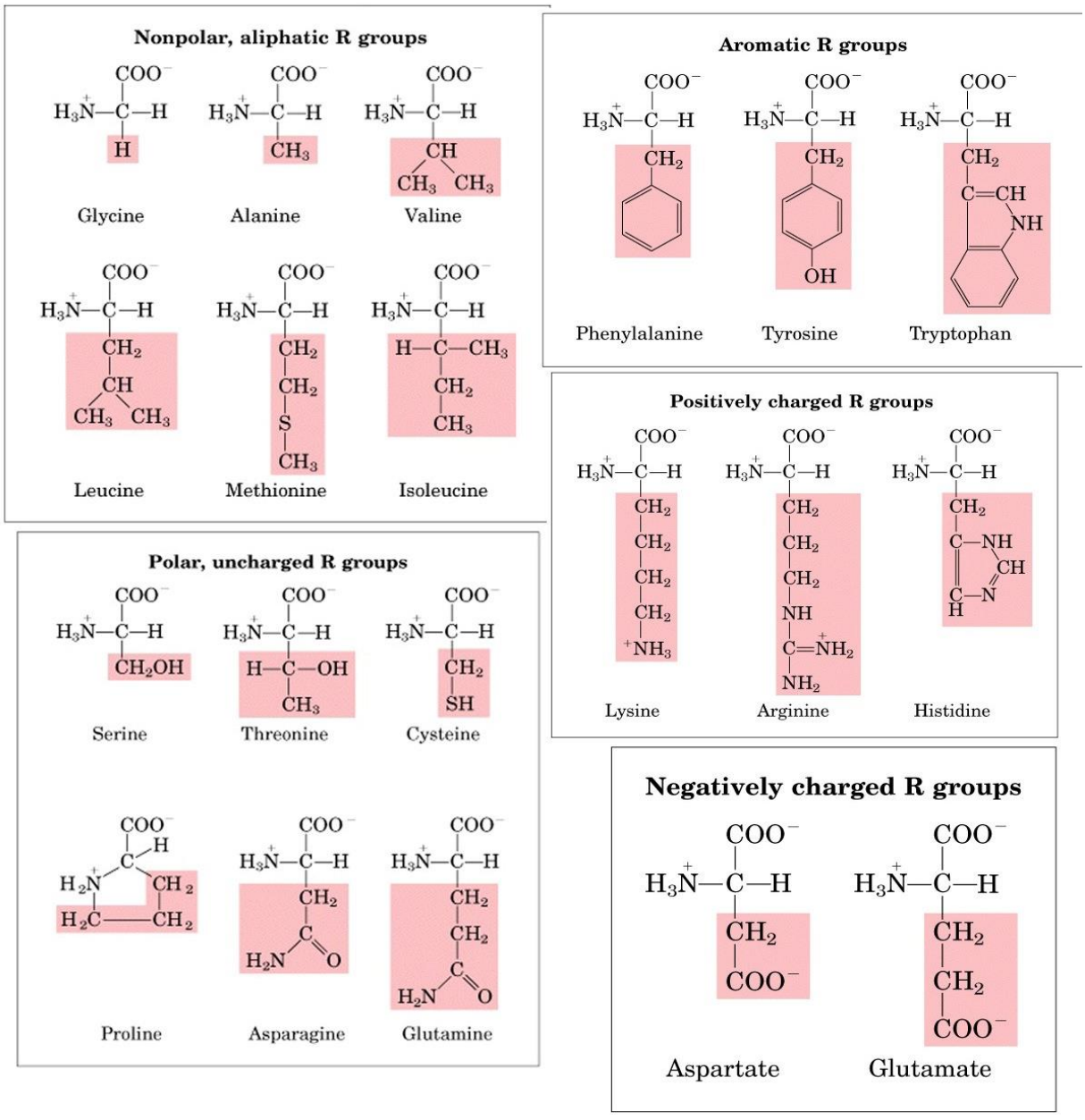
General structure of α-Amino acid

Isomerism

Alpha-amino acids are the common natural forms of amino acids. With the exception of glycine, other natural amino acids adopt the L configuration. While L-amino acids represent all of the amino acids found in proteins during translation in the ribosome.

Side chains

Amino acids are usually classified by the properties of their side chain twenty of the proteinogenic amino acids are encoded directly by triplet codons in the genetic code and are known as "standard" amino acids. Their structures have shown in the scheme below



Occurrence and functions in biochemistry

1-Proteinogenic amino acids

Amino acids are the structural units (monomers) that make up proteins. They join together to form short polymer chains called peptides or longer chains called either polypeptides or proteins. These chains are linear and unbranched, with each amino acid residue within the chain attached to two neighboring amino acids. The process of making proteins encoded by DNA/RNA genetic material is called translation and involves the step-by-step addition of amino acids to a growing protein chain by a ribozyme that is called a ribosome. The order in which the amino acids are added is read through the genetic code from an mRNA template, which is an RNA copy of one of the organism's genes.

Twenty-two amino acids are naturally incorporated into polypeptides and are called proteinogenic or natural amino acids. Of these, 20 are encoded by the universal genetic code. The remaining 2, **Selenocysteine** and **Pyrrolysine**, are incorporated into proteins by unique synthetic mechanisms.

2-Non-proteinogenic amino acids

A side from the 22 proteinogenic amino acids, many non-proteinogenic amino acids are known. Those either are not found in proteins (for example **Carnitine**, **GABA**, **Levothyroxine**) or are not produced directly and in isolation by standard cellular machinery (**i.e.**, **4-hydroxyproline**, **5-hydroxylysin** and **Selenomethionine**).

The 20 amino acids that are encoded directly by the codons of the universal genetic code are called **standard** or **canonical amino acids**. A modified form of methionine (N-formylmethionine) is often incorporated in place of methionine as the initial amino acid of proteins in bacteria, mitochondria and chloroplasts. Other amino acids are called nonstandard or non-canonical, like **L-Ornithene** and **Citrulline,** which appear as compounds in the urea cycle that occurs in the body.

ESSENTIAL AMINO ACIDS

Essential amino acids cannot be made by the body. As a result, they must come from food.

NONESSENTIAL AMINO ACIDS

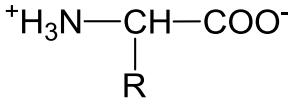
Nonessential means that our bodies produce an amino acid, even if we do not get it from the food we eat.

S. no	Essential amino acids	S. no	Nonessential amino acids
01	Arginine	01	Alanine
02	Histidine	02	Asparagine
03	Isoleucine	03	Aspartate
04	Leucine	04	Cysteine
05	Lysine	05	Glutamate
06	Methionine	06	Glutamine
07	Phenylalanine	07	Glycine
08	Threonine	08	Proline
09	Tryptophan	09	Serine
10	Valine	10	Tyrosine

Zwitterions

In aqueous solution amino acids exist in two forms (as illustrated at the right), the molecular form and the zwitterion form in equilibrium with each other.

Because all amino acids contain amine and carboxylic acid functional groups, they are amphiprotic. The amino acid in the acidic medium carries a positive charge, while in the basic medium it carries a negative charge, while in the neutral medium it carries two charges, and that also depends on the nature of the amino acid.



Zwitterion

Isoelectric point(pI)

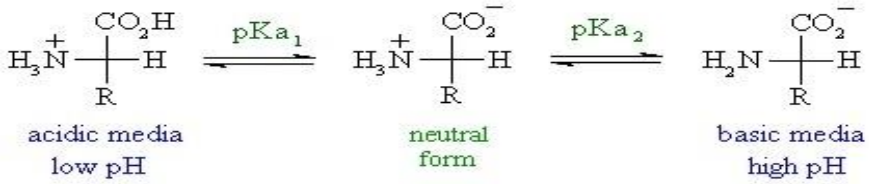
The isoelectric point (pI) is the pH at which a particular molecule carries no net electrical charge. The net charge on the molecule is affected by the pH of its surrounding environment and can become more positive or negative due to the gain or loss of protons, respectively. A net charge of 0 may result in protein Aggregation. It is important to note

that the calculation of the pI for a protein purely based on its amino acid sequence is often imprecise, since protein folding, modification and also labeling can influence the pI.

Calculating pI values

For an amino acid with only one amine and one carboxyl group, the pI can be calculated from the mean of the pK_as of this molecule.

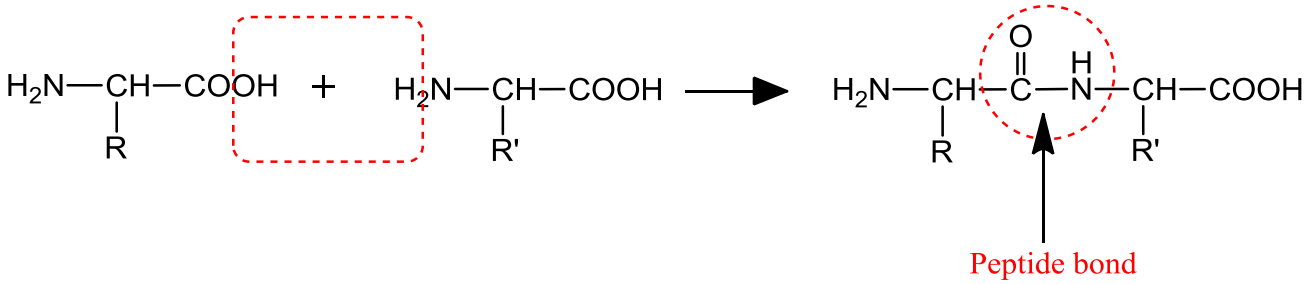
$$pI = \frac{PK_{a1} + PK_{a2}}{2}$$



Peptides

Peptides: are short chains of between two and fifty amino acids, linked by peptide bonds.

Peptide bond: A bonding force formed between two amino acids (between the carboxyl group of the first amino acid and the amine group of the second amino acid) after drawing a water molecule between them



The peptide is written from the free amine terminal (left side) and ending with the free carboxylate (right side).

Polypeptide: is a longer, continuous, unbranched peptide chain of up to approximately fifty amino acids.

A polypeptide that contains more than approximately fifty amino acids is known as a protein.

Example families

The peptide families in this section are ribosomal peptides, usually with hormonal activity. All of these peptides are synthesized by cells as longer "propeptides" or "proproteins" and truncated prior to exiting the cell. They are released into the bloodstream where they perform their signaling functions.

Antimicrobial peptides, like

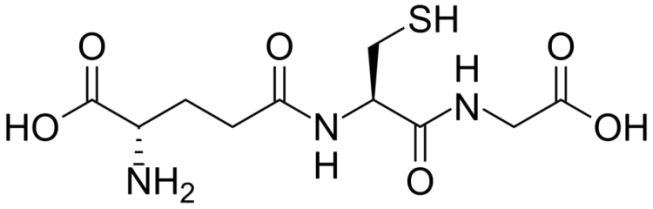
- Magainin family
- Defensin family

Vasoactive intestinal peptides

- VIP (Vasoactive Intestinal Peptide)
- GHRH (Growth Hormone Releasing Hormone)
- Glucagon
- Secretin

Other peptides

Glutathione (GSH): is an antioxidant in plants, animals, fungi, and some bacteria and archaea. 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. It is a tripeptide with a gamma peptide linkage between the carboxyl group of the glutamate side chain and cysteine. The carboxyl group of the cysteine residue is attached by normal peptide linkage to glycine.

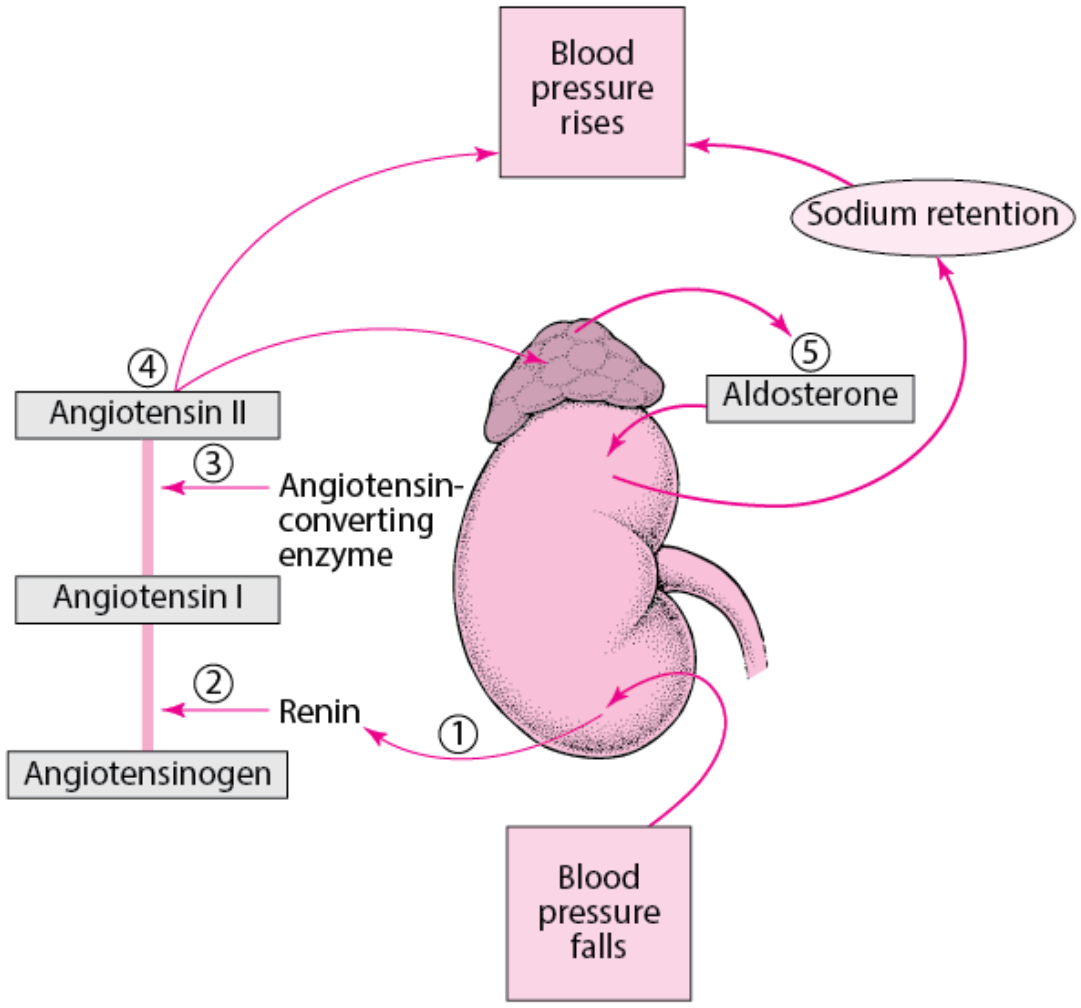


Oxytocin (Oxt): is a peptide hormone and neuropeptide. It is normally produced in the hypothalamus and released by the posterior pituitary. It plays a role in social bonding, reproduction, childbirth, and the period after childbirth.

The deduced structure of the active nonapeptide is:

Cys – Tyr – Ile – Gln – Asn – Cys – Pro – Leu – Gly

Angiotensin: is a peptide hormone, that causes vasoconstriction and an increase in blood pressure. It is part of the **renin–angiotensin-aldosteron system**, which regulates blood pressure. Angiotensin also stimulates the release of aldosterone from the adrenal cortex to promote sodium retention by the kidneys.

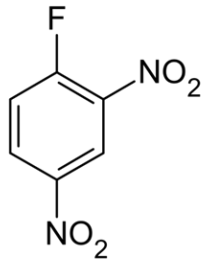


Regulating Blood Pressure: The Renin-Angiotensin-Aldosterone System

The sequence of peptide

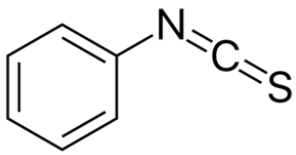
To detect the amino acid sequence in peptides, it is used for this assignment. Some of them reveal the amino side and others reveal the carboxylate side.

Sanger's reagent (DNB): 1-Fluoro-2,4-dinitrobenzene is a chemical that reacts with the N-terminal amino acid of peptides.



1-Fluoro-2,4-dinitrobenzene

Edman reagent (Phenyl isothiocyanate): is a method of sequencing amino acids in a peptide. In this method, the amino-terminal residue is labeled and cleaved from the peptide without disrupting the peptide bonds between other amino acid residues.



Phenyl isothiocyanate

Carboxypeptidase: It reveals the amino acid sequence of the carboxylic terminal.

EX: Penta peptide contain the following amino acids (Ala., Leu., Gly., Tyr., Ser), treated with sanger reagent gave DNB-Ser. Gly was isolated when treated with carboxypeptidase, and the partial hydrolysis of the peptide gave the following fragment(Ser.-Leu.),(Tyr.-Gly.) and (Ala.). Write the sequence of the peptide.

Solve:

Ser-Leu-Ala-Tyr-Gly