BIOCHEMISTRY 1

2ND CLASS

UNIVERSITY OF ANBAR
COLLOGE OF SCIENCE
BIOLOGY DEPARTMENT

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Amino Acids

Lecture one(1)

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References:

Harper's Illustrated Biochemistry

Lippincott Biochemistry

Lehninger Principles of Biochemistry

Stryer Biochemistry

SYLABUSE

1- Carbohydrates
2- Amino Acids, Peptides and Proteins.
3- Lipids.
4- Enzymes.
5- Vitamins and Coenzymes.
6- Nucleotides and Nucleic acids.
7- Biological Oxidation.

Amino Acids, Peptides, and Proteins

Major Concepts

A. To know what are proteins and their biomedical importance.

B. To learn what are amino acids, their classification and properties.

C. To learn the classification and properties of proteins.

D. Learn the structure of protein

Specific Objective

A. 1. Define protein.

2. Describe the biomedical importance of protein and learn composition of proteins.

B. Basic monomeric unit of protein is amino acid.

1. What are amino acids? Learn the basic structure of amino acid.

2. Classify amino acids.

3. Learn the nonstandard amino acids.

4. Learn the occurrence of amino acids.

5. List essential amino acids, semiessential amino acids and non-essential amino acids and why they are called so.

6. Learn the general functions of amino acids.

7. Learn the physical and chemical properties of amino acids.

C. 1. Classify proteins.

• Based on size and shape, • Based on functions, • Based on solubility, structure and physical properties—Most commonly employed classification. According to this, proteins are classified as simple, conjugated and derived proteins.

2. • Learn the physical and chemical properties of proteins.

• Learn precipitation reaction of proteins and its application.

• Learn various colour reactions of protein due to specific amino acid.

• Learn the peptide linkage in a protein molecule and learn few biologically important peptides.

D. • **Study the primary structure of protein.**

• **Study the secondary structure of protein, linkages and types such as α-helix, β-pleated sheet structure, Triple helix, and Random coil.**

• **Learn the tertiary structure, bonds involved in tertiary structure formation.**

• **Learn the quaternary structure, bonds that make it and examples.**

• **What is denaturation of protein? Learn various factors that cause denaturation, its application and the changes a protein molecule undergoes after denaturation.**

• **Study the criteria of purity of protein.**

Amino Acids

Proteins are polymers of amino acids, with each amino acid residue joined to its neighbor by a specific type of covalent bond. (The term "residue" reflects the loss of the elements of water when one amino acid is joined to another.) Proteins can be broken down (hydrolyzed) to their constituent amino acids by a variety of methods, and the earliest studies of proteins naturally focused on the free amino acids derived from them. Twenty different amino acids are commonly found in proteins. The first to be discovered was asparagine, in 1806. The last of the 20 to be found, threonine, was not identified until 1938. All the amino acids have trivial or common names, in some cases derived from the source from which they were first isolated. Asparagine was first found in asparagus, and glutamate in wheat gluten; tyrosine was first isolated from cheese
its name is derived from the Greek tyros,"cheese"); and glycine (Greek glykos, "sweet") was so named because of its sweet taste.

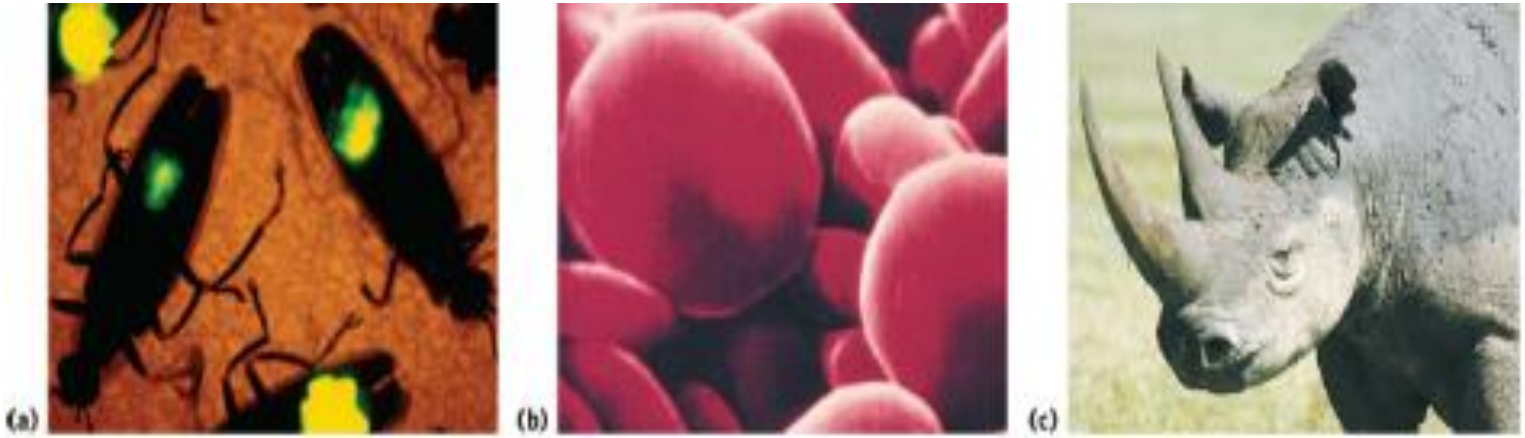


FIGURE 3-1 Some functions of proteins. (a) The light produced by fireflies is the result of a reaction involving the protein luciferin and ATP, catalyzed by the enzyme luciferase (see Box 13-1). (b) Erythrocytes contain large amounts of the oxygen-transporting protein hemoglobin. (c) The protein keratin, formed by all vertebrates, is the chief structural component of hair, scales, horn, wool, nails, and feathers. The black rhinoceros is extinct in the wild because of the belief prevalent in some parts of the world that a powder derived from its horn has aphrodisiac properties. In reality, the chemical properties of powdered rhinoceros horn are no different from those of powdered bovine hooves or human fingernails.

Amino Acids Share Common Structural Features

All 20 of the common amino acids are α-amino acids. They have a carboxyl group and an amino group bonded to the same carbon atom (the α carbon) (Fig. 1). They differ from each other in their side chains, or R groups, which vary in structure, size, and electric charge, and which influence the solubility of the amino acids in water. In addition to these 20 amino acids there are many less common ones. Some are residues modified after a protein has been synthesized, others are amino acids present in living organisms but not as constituents of proteins, and two are special cases found in just a few proteins. The common amino acids of proteins have been assigned three-letter abbreviations and one-letter symbols ,which are used as

shorthand to indicate the composition and sequence of amino acids polymerized in proteins.

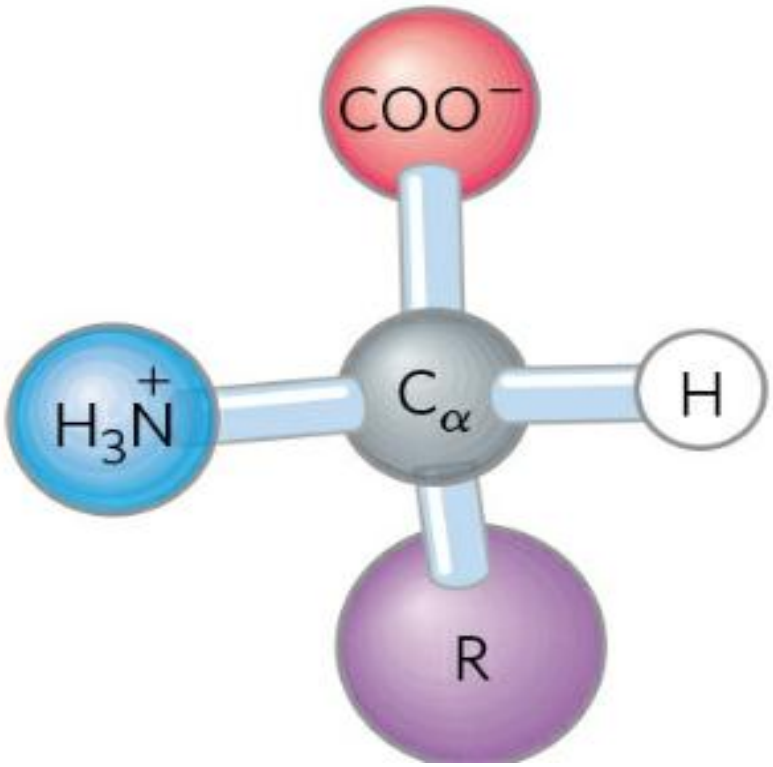


FIGURE 1 **General structure of an amino acid. This structure is common to all but one of the α-amino acids. (Proline, a cyclic amino acid, is the exception.) The R group, or side chain (purple), attached to the α carbon (gray) is different in each amino acid.**

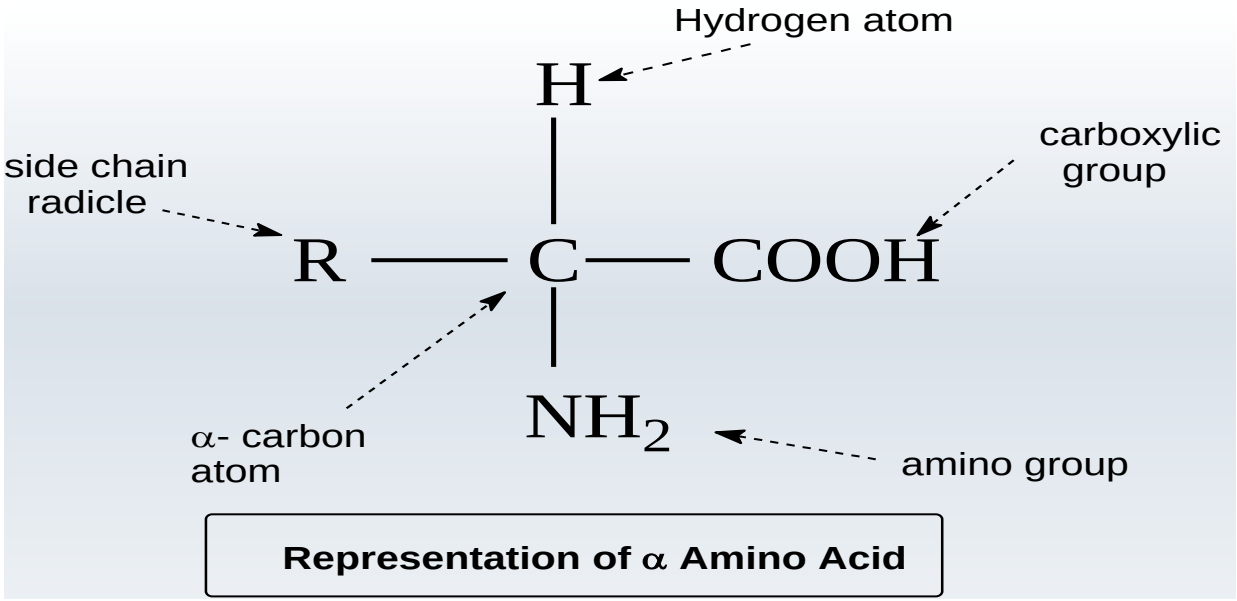
For all the common amino acids except glycine, the α carbon is bonded to four different groups:

a carboxyl group,

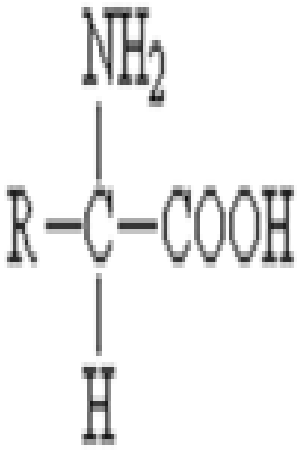
an amino group,

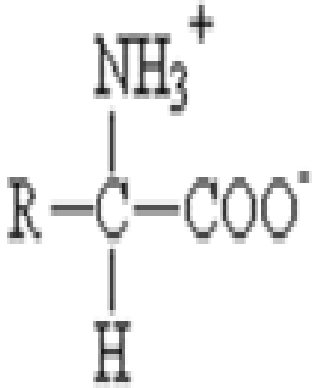
an R group,

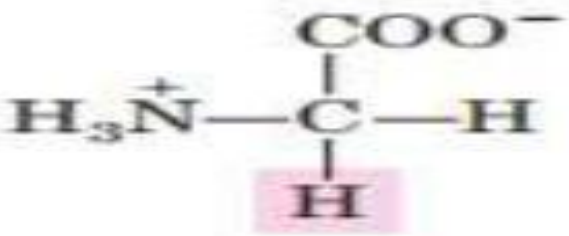
and a hydrogen atom (Fig. 1; in glycine, the R group is another hydrogen atom). The α-carbon atom is thus a chiral center.



Representation of α Amino Acid

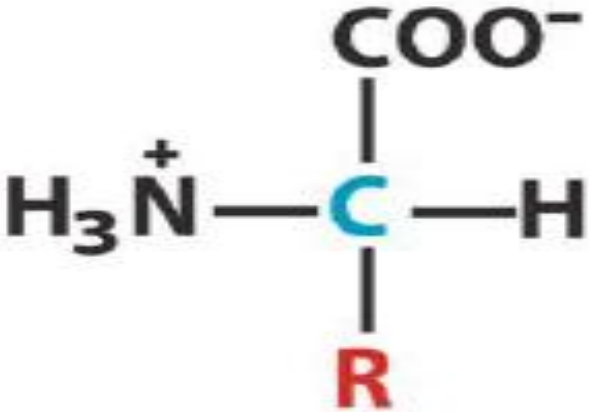






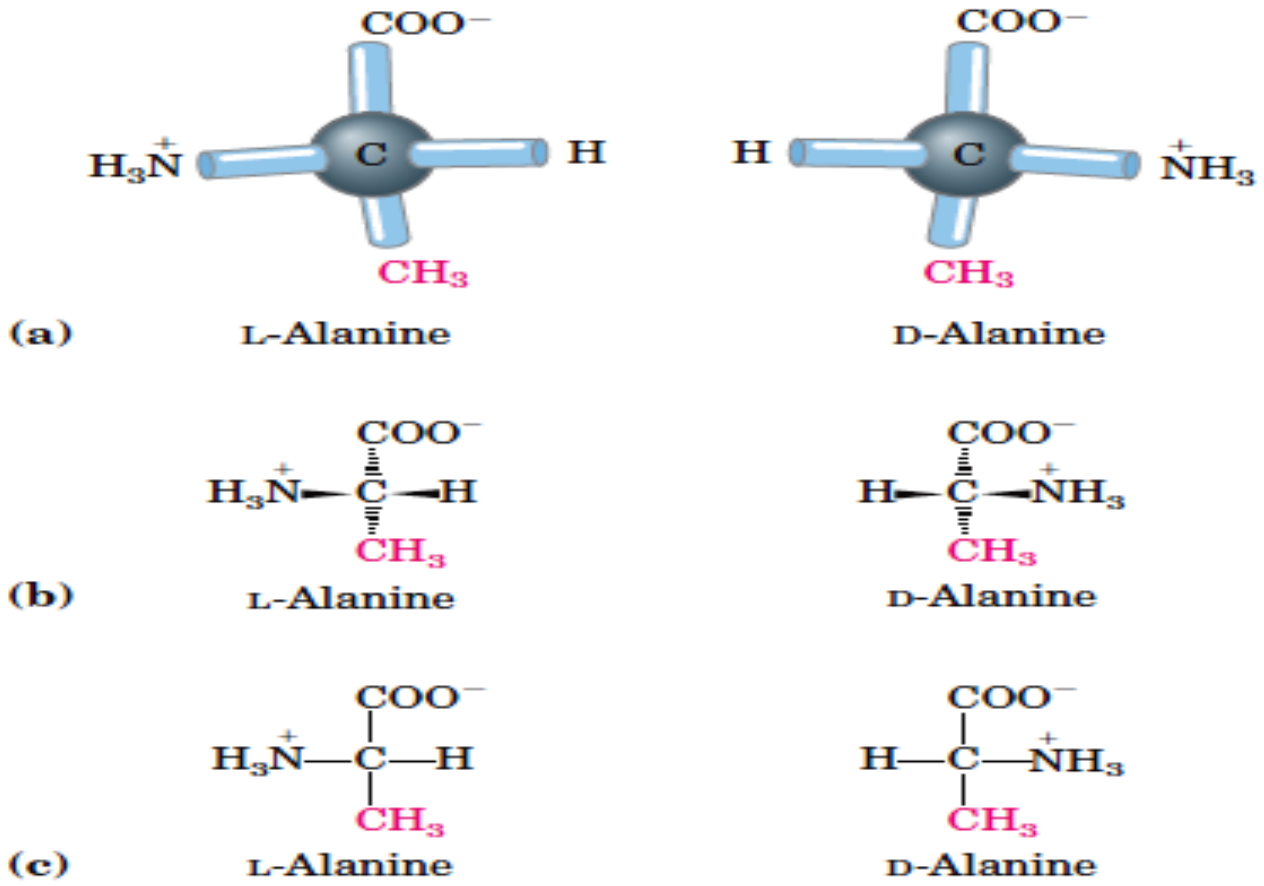
Glycine

Gly G



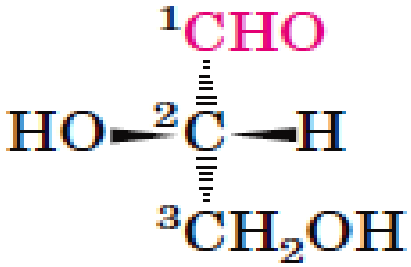
Amino acids are the building units of protein.

the four different groups can occupy two unique spatial arrangements, and thus amino acids have two possible stereoisomers. Since they are nonsuperposable mirror images of each other, the two forms represent a class of stereoisomers called enantiomers.

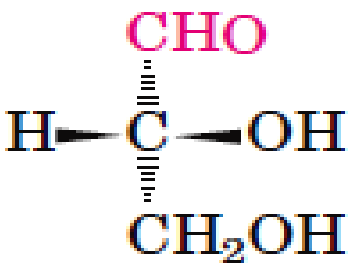


All molecules with a chiral center are also optically active—that is, they rotate the plane of plane-polarized light

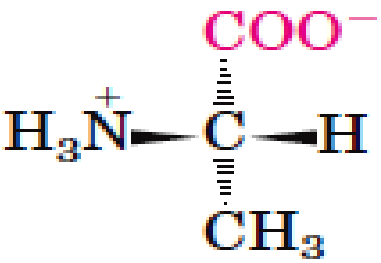
★Steric relationship of the stereoisomers of alanine to the absolute configuration of L- and D-glyceraldehyde



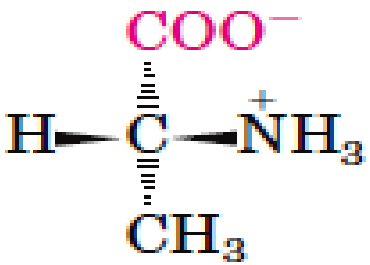
L-Glyceraldehyde



D-Glyceraldehyde



L-Alanine



D-Alanine

★ L-Amino acids are those with the -amino group on the left, and D-amino acids have the -amino group on the right.

Nearly all biological compounds with a chiral center occur naturally in s in protein molecules are exclusively L stereoisomers. D-Amino aonly one stereoisomeric form, either D or L. The amino acid residuecid residues have been found in only a few, generally small peptides, including some peptides of bacterial cell walls and certain peptide antibiotics.

Functions of amino acids

- ✯ Synthesis of structural and functional proteins.
- ✯ L-amino acid and their derivatives play a role in intracellular functions as nerve impulse transmission and regulation of cell growth.
- ✯ Precursors of other biological molecules (Nitrogen-containing Compounds)

(purines, pyrimidines, Heme, Glutathione, urea, Nucleotides and porphyrins.)

- ✯ L-and D-amino acids are present in polypeptide antibiotics secreted by microorganisms.
- ✯Energy source.

Classifications of Amino Acids

Amino acids can be classified by different classification:

1- **Reaction(polar and Nonpolar) classification (Charge properties).**

2- **Chemical classification.**

3- **Nutritional classification.**

4- **Metabolic classification.**

1-Reaction(polar and Nonpolar) classification (Charge properties).

- Amino acids can be grouped into two main classes based on polarity of the "R" groups , or their tendency to interact with water at biological pH (near pH 7.0)

- polar amino acids: polar and hydrophilic (water-soluble)
- Nonpolar amino acids: nonpolar and hydrophobic (water-insoluble)

POLAR AMINO ACIDS

1- Polar, Uncharged R Groups: The R groups of these amino acids are more soluble in water, or more hydrophilic. contain functional groups that form hydrogen bonds with water. includes

-Serine (hydroxyl group)

-Threonine (hydroxyl group)

- Cysteine (sulfhydryl group)

- Asparagine (Amide group)

-Glutamine. (Amide group)

2- Positively Charged (Basic) R Groups: The most hydrophilic R groups are those that are either .positively or negatively charged The amino acids in which the R groups have significant positive charge at pH 7.0

-Lysine a second primary amino group .

- Arginine guanidinium group.

-Histidine an aromatic imidazole group.

3- Negatively Charged (Acidic) R Groups: The two amino acids having R groups with a net negative charge at pH 7.0 are aspartate and glutamate, each of which has a second carboxyl group.

Nonpolar Amino Acids

-Nonpolar, Aliphatic R Groups: The R groups in this class of amino acids are nonpolar and hydrophobic. The side chains of alanine, valine, leucine, and isoleucine tend to cluster together within proteins stabilizing protein structure by means of hydrophobic interactions. Glycine has the simplest structure.

- Methionine, one of the two sulfur-containing amino acids, has a nonpolar thioether group in its side chain. -Proline has an aliphatic side chain with a distinctive cyclic structure.

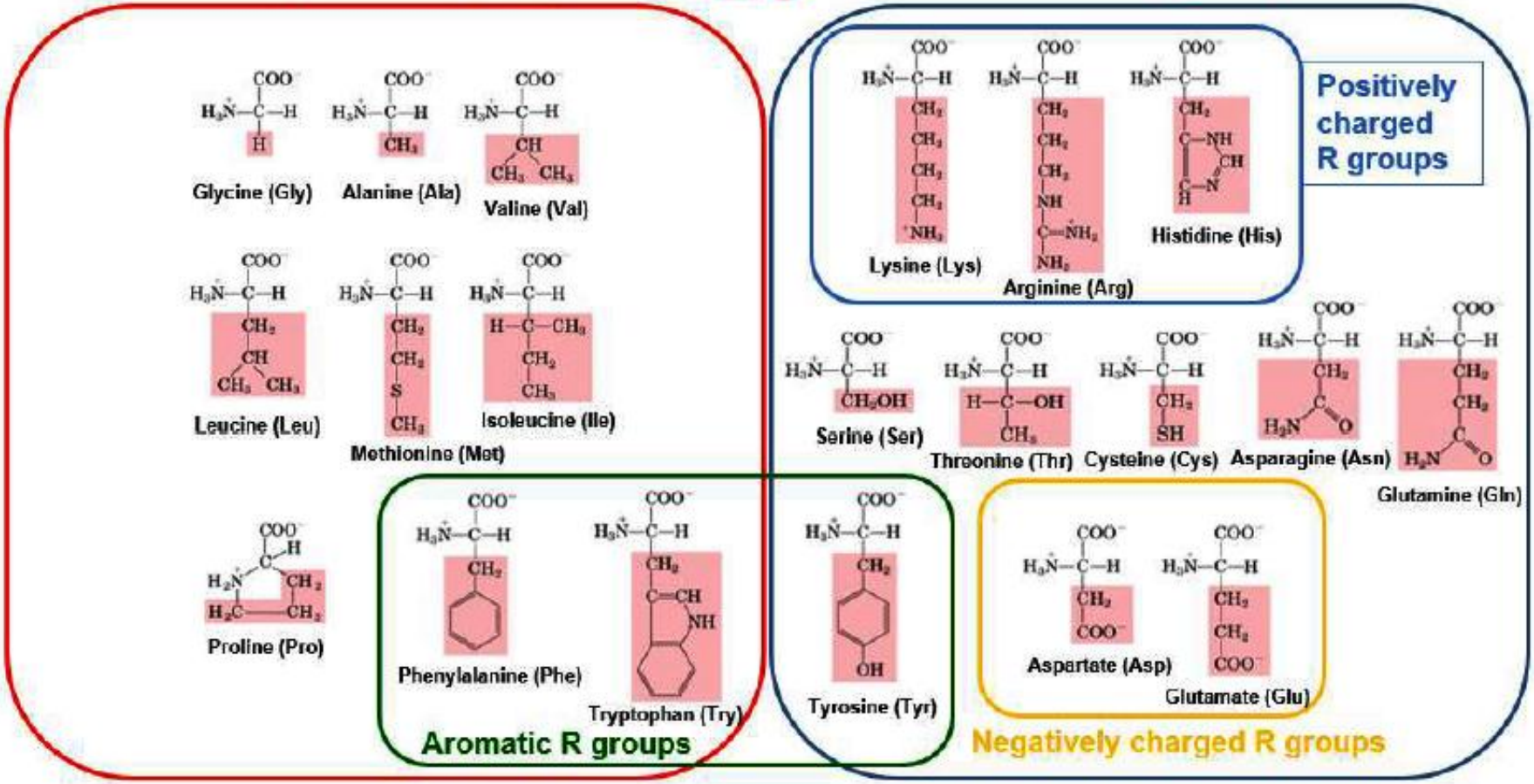
-Aromatic R Groups Phenylalanine, tyrosine, and tryptophan, with their aromatic side chains, are relatively nonpolar (hydrophobic). All can participate in hydrophobic interactions. The hydroxyl group of tyrosine can form hydrogen bonds (polar), and it is an important functional group in some enzymes.

Polar and Non-polar Amino Acids

Nonpolar R groups

20

Polar R groups



2- Chemical classification.

- **20 amino acids found in proteins are also divided into 7 distinct groups:**

1- Amino acids with Aliphatic side chains:

- Glycine (Gly)
- Alanine (Ala)
- Valine (Val)
- Leucine (Leu)
- Isoleucine (Ile)

2- Amino acids with side chains containing Hydroxylic (OH) groups:

- Serine (Ser)
- Threonine (Thr)
- Tyrosine (Tyr)

3- Amino acids with side chains containing Sulfur atoms:

- Cysteine (Cys)
- Methionine (Met)

4- Amino acids with side chains containing Acidic groups:

- Aspartic acid (Asp)
- Asparagine (Asn)
- Glutamic acid (Glu)
- Glutamine (Gln)

5- Amino acids with side chains containing Basic groups:

- Arginine (Arg)
- Lysine (Lys)
- Histidine (His)

6- Amino acids with side chains containing Aromatic rings:

- Phenylalanine (Phe)
- Tyrosine (Tyr)
- Tryptophan (Trp)

7- Imino Acid:

- Proline (Pro)

3- **Nutritional classification.**

They are classified into three groups:

1-Essential amino acids: They are amino acids which cannot be synthesized in the body and must be taken in diet; phenylalanine, methionine, isoleucine, leucine, lysine, valine, threonine and tryptophan.

2-Semi essential amino acids: They are amino acids required in the food of growing children not in the food of adult as histidine and arginine.

3-Non essential amino acids: can be synthesized inside the body as glycine, alanine, serine, cysteine, cystine, aspartic, tyrosine, glutamic, proline and hydroxyproline

4- Metabolic classification.

According to their fate in the body they are classified into three groups:

1. **Glucogenic amino acids:** give glucose inside the body as glycine, alanine, aspartic and glutamic.
2. **Ketogenic amino acid:** gives ketone bodies as leucine.
3. **Glucogenic and ketogenic amino acids**: They give both glucose and ketone bodies as lysine, tryptophan, tyrosine, phenylalanine and isoleucine.

Clinical importance of amino acids and their derivatives

- L-tyrosine is sometimes recommended by practitioners as helpful for weight loss, clinical depression.
- Dopamine derived from tyrosine is a neurotransmitter.
- Thyroxin is an important thyroid hormone from tyrosine.
- Gamma amino butyric acid (GABA) derived from glutamic acid; which is a neurotransmitter.
- Cycloserine derived from serine is an anti-tuberculous drug.
- Arginine stimulates the healing of burning wound and other wounds.
- Arginine together with lysine can limit herpes attacks (bladders in the mouth) for people that carry this virus.
- Cysteine can help to recover the damage by smoking and alcohol.
- Glutamine can give the mind new energy and can help to prevent and treat inflammations of the large intestine.

- **Which of the following amino acid is an acidic amino acid.**
  - Arginine
  - Aspartic acid
  - Lysine
  - Leucine

- **Which of the following amino acid is both neutral and aromatic in nature?**
  - Alanine
  - Histidine
  - Plyenylalanine
  - Proline

- **All amino acids which both glucogenic and ketogenic are essential amino acids EXCEPT**
  - Phenylalanine
  - Tyrosine
  - Glycine
  - Alanine

Amino acid not found in proteins:

Few amino acids are not found in proteins (non-protein amino acids)

- L-Ornithine is an intermediate of urea cycle . It is formed from arginine
- L- citrulline is intermediate of urea cycle . It is formed from ornithine
- Homoserine is an intermediate in methionine metabolism. It is formed from serine.
- GABA: γ amino butyric acid :is an inhibitor neurotransmitter
- DOPA: Dihydroxyphenylalanine : Is formed from tyrosine and precursor for biosynthesis of epinephrine and norepinephrine
- β alanine : occurs in coenzyme A , Pantothenic acid and it is also formed during degeneration pyrimidine nucleotides

- Selenocysteine is an amino acid containing selenium (trace element). It is considered as the 21st amino acid since it is coded by the stop codon UGA. Examples of proteins containing selenocysteine are glutathione peroxidase enzyme and 5'deiodinase .

References:

Harper's Illustrated Biochemistry

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