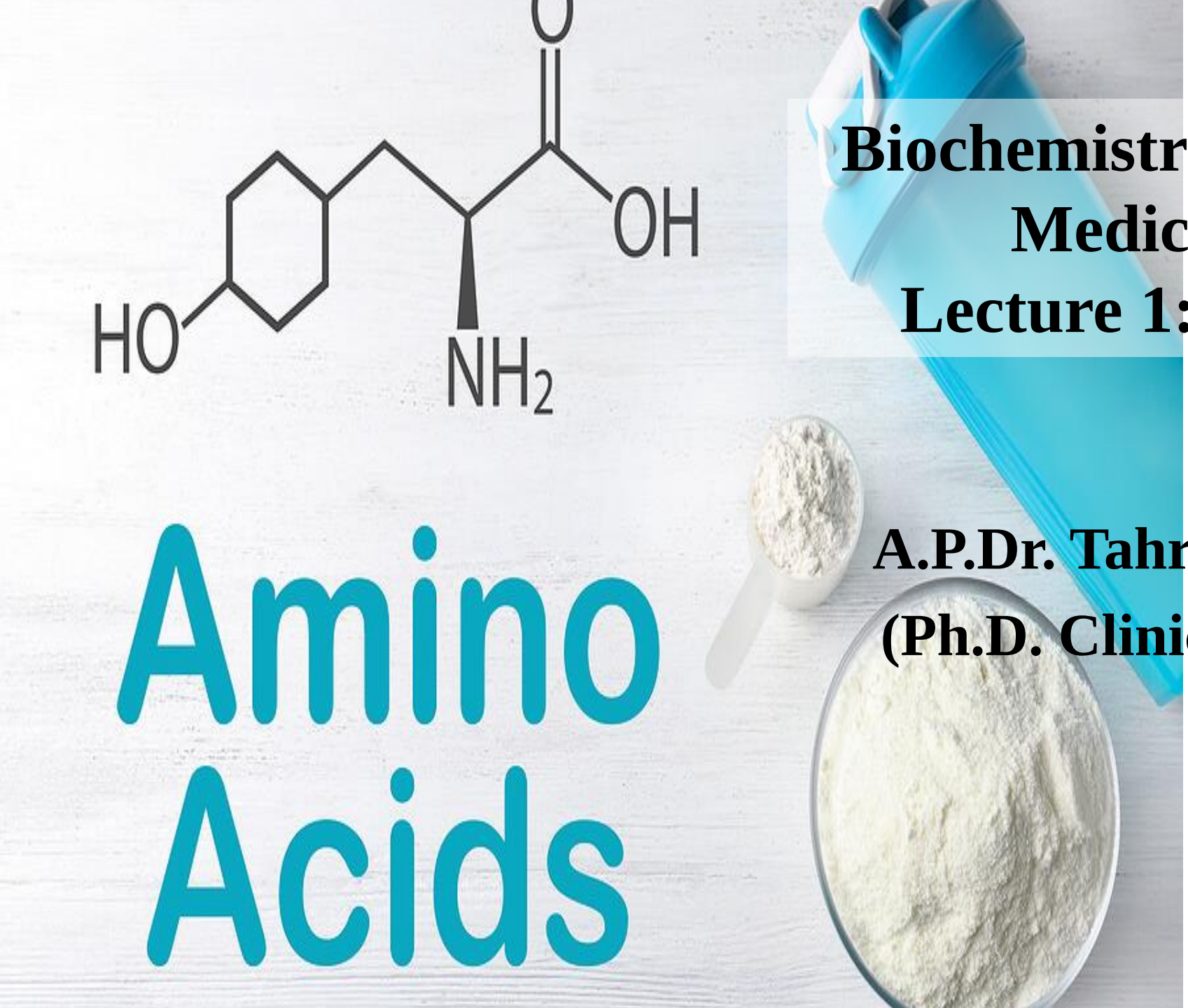

Biochemistry1 For First Year Medical Students
Lecture 1: Amino Acids I

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At the end of the lecture students will be able to :

- **State the composition & structure of amino acids .**
- **Classify amino acids.**
- **Identify Essential, Semi-essential and Nonessential amino acid.**

Amino Acids and Proteins

Overview:

- **Proteins are the most abundant and functionally molecules in living systems.**
- **Enzymes and polypeptide hormones direct and regulate metabolism in the body.**
- **Contractile proteins in muscle permit movement.**
- **In the bloodstream, proteins, such as hemoglobin and plasma albumin, shuttle molecules essential to life.**
- **Immunoglobulins fight infectious bacteria and viruses.**
- **Proteins share a common structural feature of being polymers of amino acids.**

Structure of the Amino Acids:

- **More than 300 different amino acids have been described in nature.**
- **Only twenty are commonly found as constituents of mammalian proteins.**

[Note: These are the only amino acids that are coded for by DNA, the genetic material in the cell].

- **New Amino Acids:**

In addition to 20 L-amino two more new amino acids described. They are:

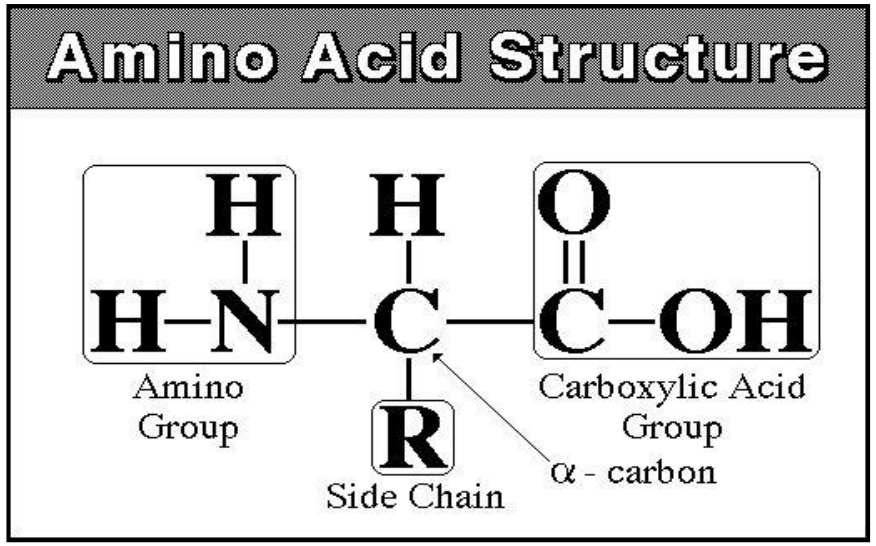
A. Selenocysteine

Selenocysteine is introduced as 21st amino acid. Selenocysteine occurs at the "active site" of several enzymes.

B. Pyrrolysine :the 22nd Amino Acid

It has been claimed as 22nd amino acid by some scientists.

Structure of the Amino Acids:



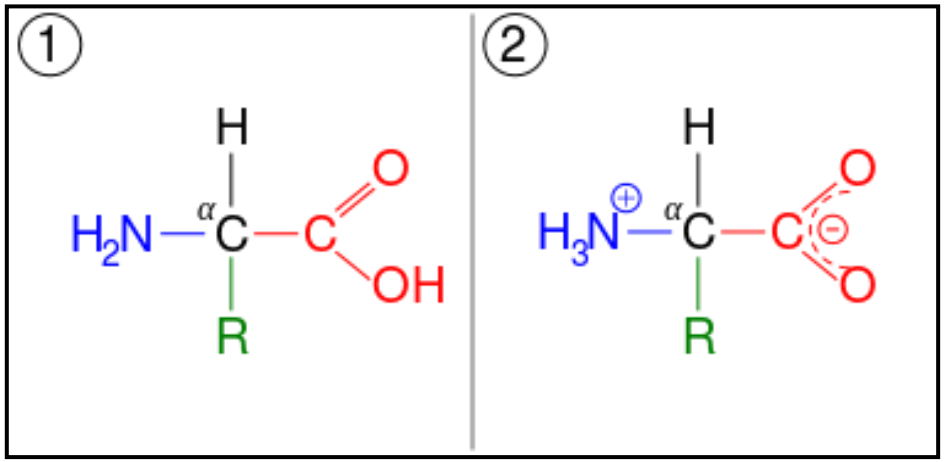
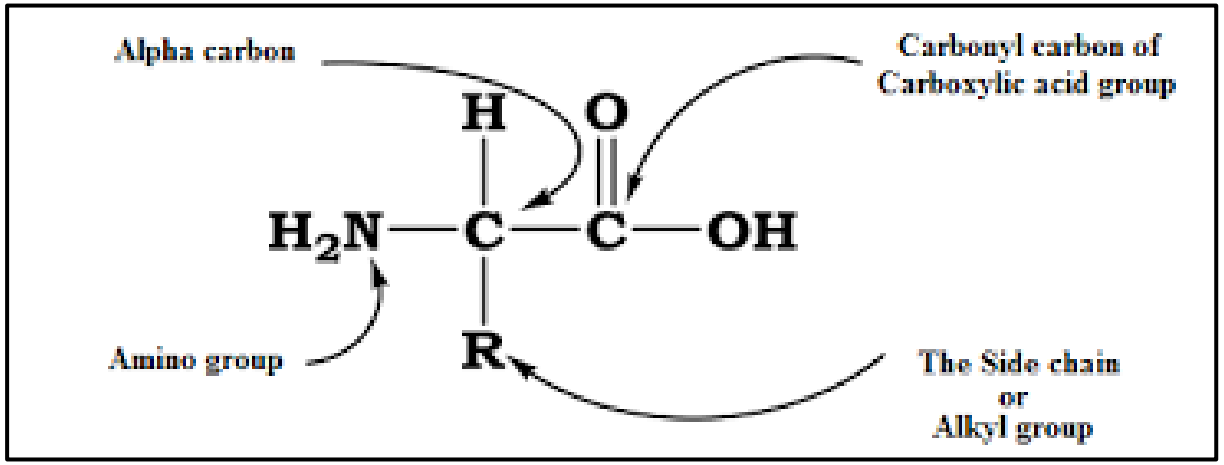


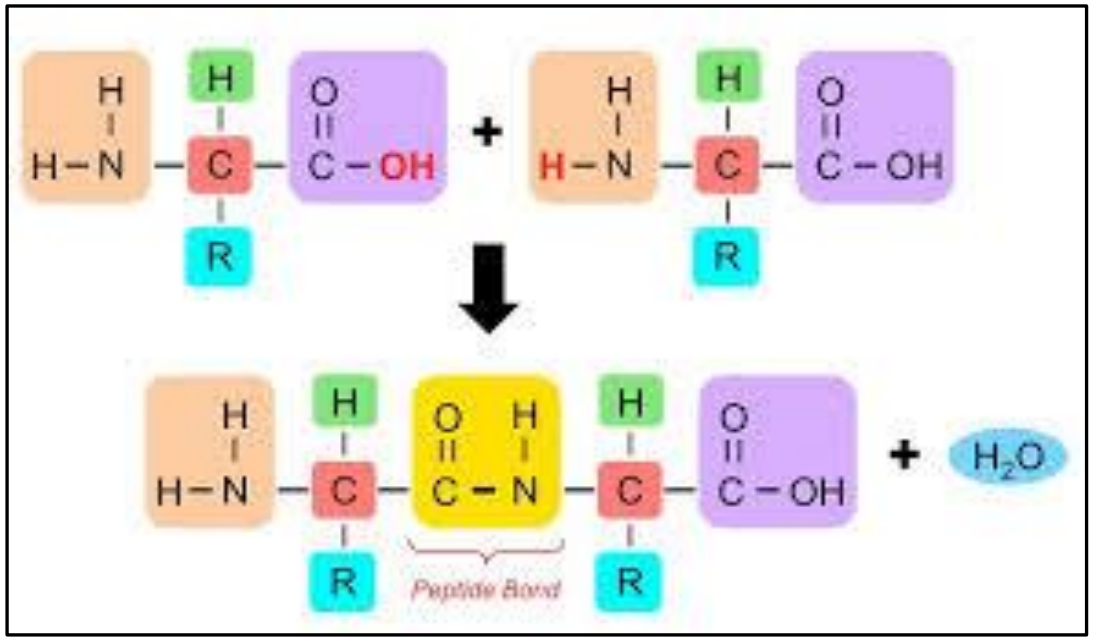
Figure 1: Amino acid in its (1-unionized form, 2-zwitterion form).

•**Each amino acid (except for proline) has :**
A carboxyl group, a primary amino group, and a distinctive side chain (“R-group”) bonded to the α-carbon atom (Figure1).

•**At physiologic pH (approximately pH 7.4), the carboxyl group is dissociated, forming the negatively charged carboxylate ion ($–COO^-$), and the amino group is protonated ($–NH_3^+$).**



In proteins, almost all of these carboxyl and amino groups are combined in <u>peptide linkage (peptide bond)</u> and, in general, are not available for chemical reaction except for hydrogen bond formation. Thus, <u>the nature of the side chains that dictates</u> the role an amino acid plays in a protein. Therefore, it is useful to classify the amino acids <u>according to the properties of their side chains.</u>



Classification of amino acids based on side chain:

A.Amino acids with nonpolar side chains.

Each of these amino acids has a nonpolar side chain that does not bind or give off protons or participate in hydrogen or ionic bonds (Figure 2).

The side chains of these amino acids can be thought of as “oily” or lipid-like, a property that promotes hydrophobic interactions.

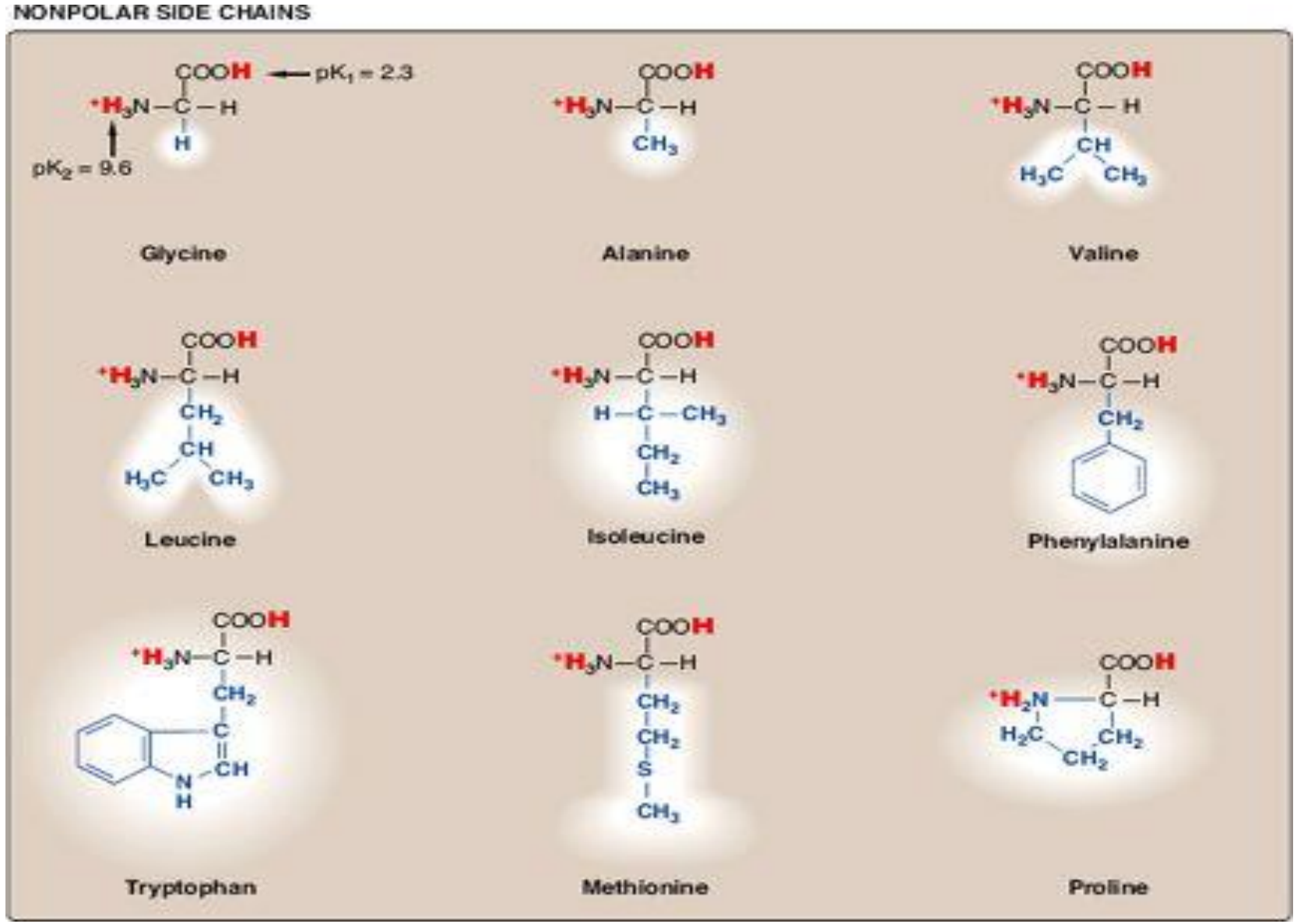


Figure 2: Amino acids with nonpolar side chain.

Location of nonpolar amino acids in proteins:

In proteins found in aqueous solutions (a polar environment), the side chains of the nonpolar amino acids tend to cluster together in the interior of the protein .

This phenomenon, known as the hydrophobic effect, is the result of the hydrophobicity of the nonpolar R groups, which act much like droplets of oil that coalesce (merge) in an aqueous environment. The nonpolar R groups, thus, fill up the interior of the folded protein and help give it its three-dimensional shape. However, for proteins that are located in a hydrophobic environment, such as a membrane, the nonpolar R groups are found on the outside surface of the protein, interacting with the lipid environment Figure 3. The importance of these hydrophobic interactions is stabilizing protein structure.

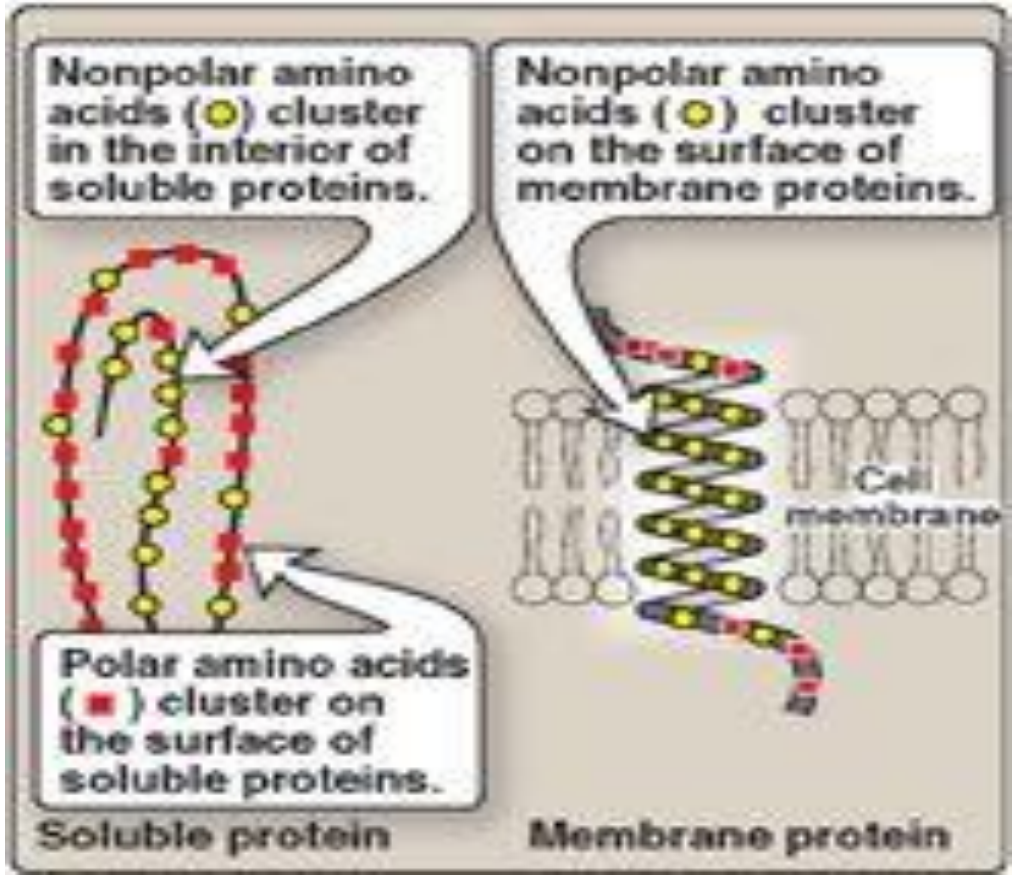


Figure 3: Location of nonpolar amino acids in soluble and membrane proteins.

- **Proline: Proline differs from other amino acids in that proline's side chain and α-amino N form a rigid, five-membered ring structure (Figure 4). Proline, then, has a secondary (rather than a primary) amino group. It is frequently referred to as an imino acid. The unique geometry of proline contributes to the formation of the fibrous structure of collagen.**

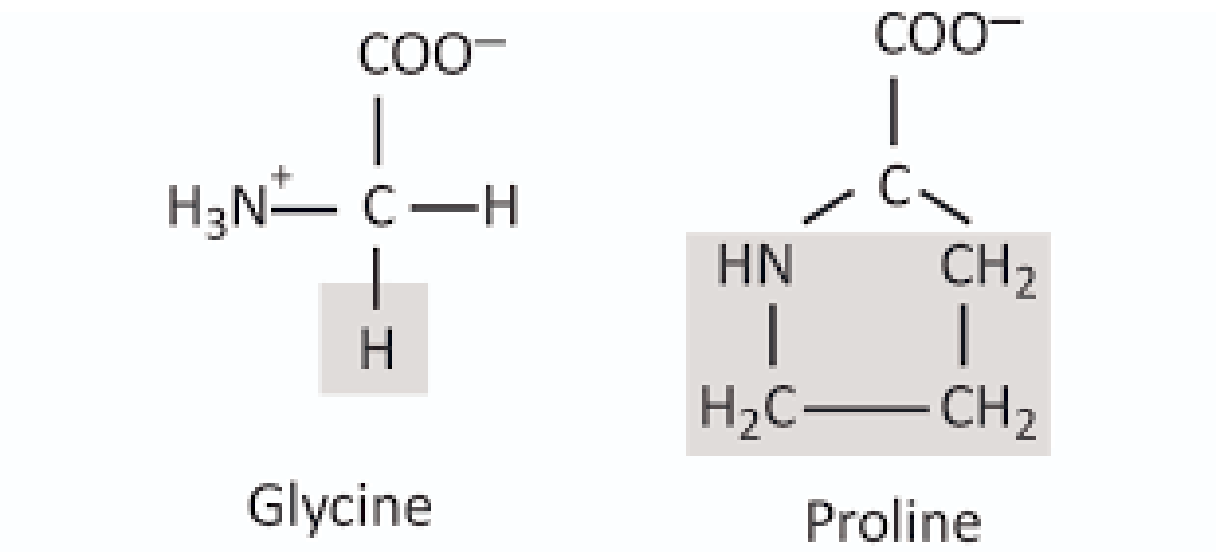


Fig. : structure of glycine and proline amino acid

B. Amino acids with uncharged polar side chains: -

These amino acids have zero net charge at neutral pH, (Figure 5).

Disulfide bond: The side chain of cysteine contains a sulfhydryl group(–SH), which is an important component of the active site of many enzymes. In proteins, the –SH groups of two cysteines can become oxidized to form a dimer, cystine, which contains covalent cross-link called a disulfide bond (–S–S–).

Note:

Many extracellular proteins are stabilized by disulfide bonds. Albumin, a blood plasma protein that functions as a transporter for a variety of molecules, is an example.

C. Amino acids with acidic side chains (negatively charged):-

The amino acids aspartic and glutamic acid are proton donors. At physiologic pH, the side chains of these amino acids are fully ionized, containing a negatively charged carboxylate group ($–COO^-$). (Figure 5).

D. Amino acids with basic side chains (positively charged):-

The side chains of the basic amino acids accept protons (Figure5).

At physiologic pH the side chains of lysine and arginine are fully ionized and positively charged. In contrast, histidine is weakly basic and the free amino acid is largely uncharged at physiologic pH.

When histidine is incorporated into a protein, its side chain can be either positively charged or neutral, depending on the ionic environment provided by the polypeptide chains of the protein. This is an important property of histidine that contributes to the role it plays in the functioning of proteins such as hemoglobin.

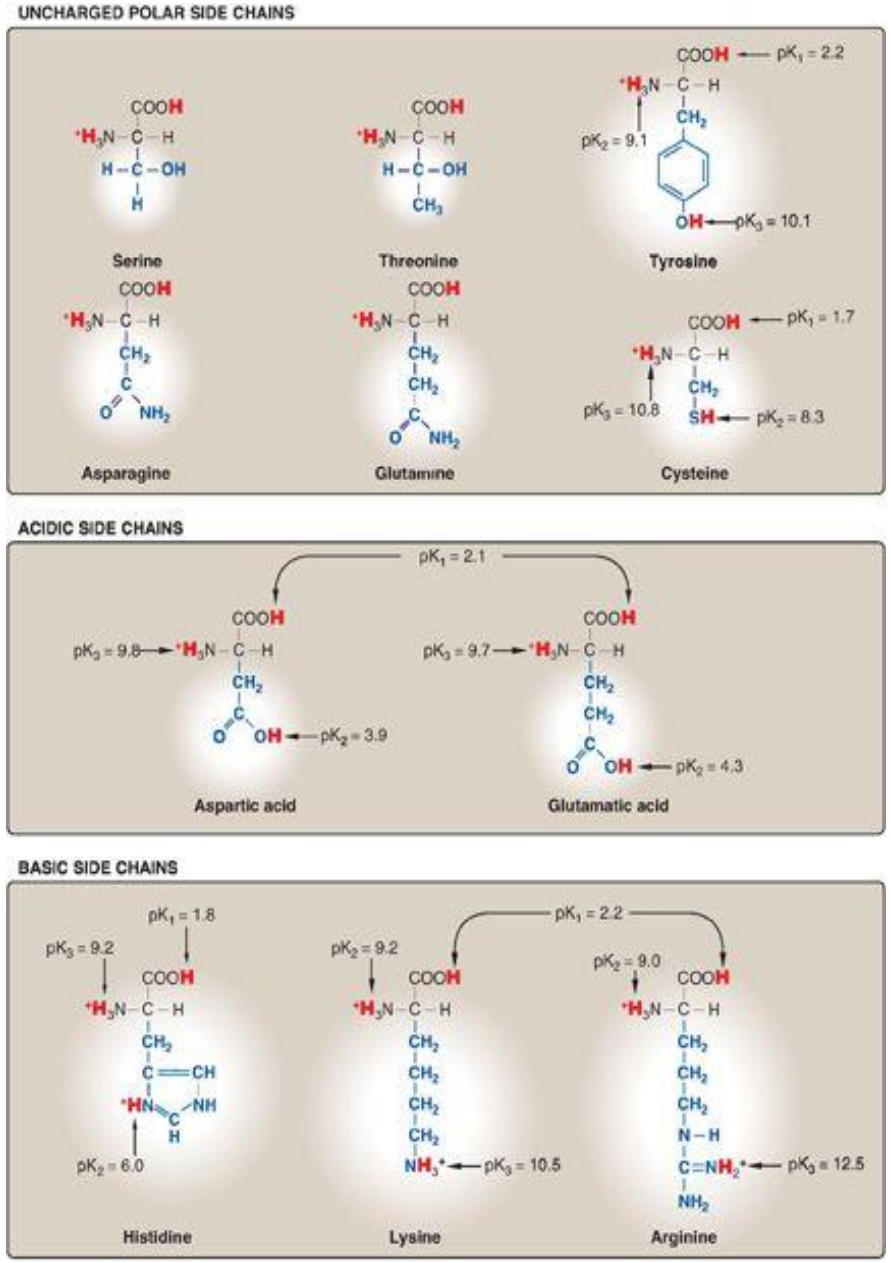


Figure 5: amino acids with polar uncharged, acidic and basic side chains.

Abbreviations and symbols for common amino acids:

Each amino acid name has an associated three-letter abbreviation and a one-letter symbol (Figure 7).

Three letters and one letter abbreviation for 20 primary amino acids in the Genetic Code					
Amino acid	Three letter abbreviation	One letter abbreviation	Amino acid	Three letter abbreviation	One letter abbreviation
Alanine	Ala	A	Leucine	Leu	L
Arginine	Arg	R	Lysine	Lys	K
Asparagine	Asn	N	Methionine	Met	M
Aspartic Acid	Asp	D	Phenylalanine	Phe	F
Cysteine	Cys	C	Proline	Pro	P
Glutamic Acid	Glu	E	Serine	Ser	S
Glutamine	Gln	Q	Threonine	Thr	T
Glycine	Gly	G	Tryptophan	Trp	W
Histidine	His	H	Tyrosine	Tyr	Y
Isoleucine	Ile	I	Valine	Val	V

Classification of amino acids based on nutritional requirements:

Essential , Nonessential and Semi essential Amino Acids:

Nutritionally, amino acids are of **three types:**

(a) Essential amino acids: These are the ones which are not synthesized by the body and must be taken in diet. They include **valine, leucine, isoleucine, phenylalanine, threonine, tryptophan, methionine, histidine and lysine.**

- **For remembering the following formula is used – PVT TIM HALL.**

(b) Non-essential amino acids: They can be synthesized by the body and may not be the requisite components of the diet.

(c) Semi-essential amino acids (conditionally essential): These are **growth promoting factors** since they are not synthesized in sufficient quantity during growth. For example **arginine**. They **become essential in growing children, pregnancy and lactating women.**

ESSENTIAL AMINO ACIDS

Essential Amino Acid Mnemonic

Private Tim Hall => PVT TIM HALL

P.V.T.

- P = Phenylalanine
- V - Valine
- T - Threonine

T.I.M.

- T - Tryptophan
- I - Isoleucine
- M - Methionine

H.A.L.L.

- H - Histidine
- A - Arginine*
- L - Leucine
- L - Lysine

* Only essential during (+)Nitrogen Balance

Essential & Non-Essential Amino Acids

Essential Amino Acids:

- Arginine
- Isoleucine
- Histidine
- Leucine
- Methionine
- Lysine
- Phenylalanine
- Tryptophan
- Threonine
- Valine

Non-Essential Amino Acids:

- Alanine
- Arginine
- Asparagine
- Aspartic Acid
- Cysteine
- Glutamic Acid
- Glutamine
- Glycine
- Proline
- Serine
- Tyrosine

Assessments and evaluation:

Try to answer these Questions?

1. **Classify amino acids according to their side chain?**
2. **What are essential and non-essential amino acids?**
3. **Why proline is called imino acids?**