Biochemistry

Amino acids and proteins

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- **Amino Acids are the building units of proteins. Proteins are polymers of amino acids linked together by what is called " Peptide bond" .**

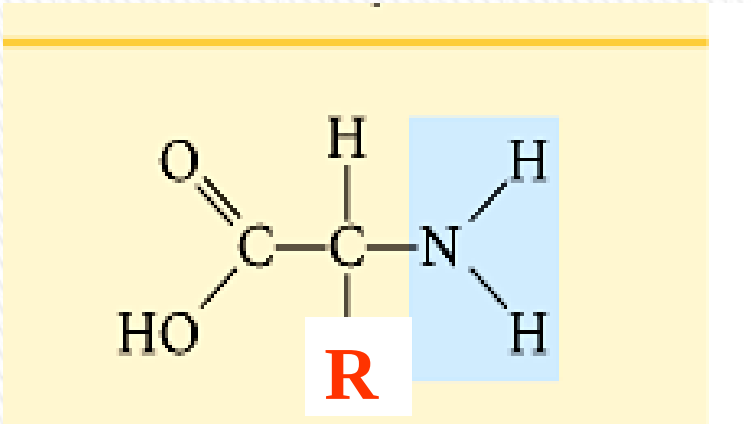
- **There are about 300 amino acids occur in nature. Only 20 of them occur in proteins.**

Structure of amino acids:

Each amino acid has 4 different groups attached to α- carbon (which is C-atom next to COOH). These 4 groups are : amino group, COOH gp,

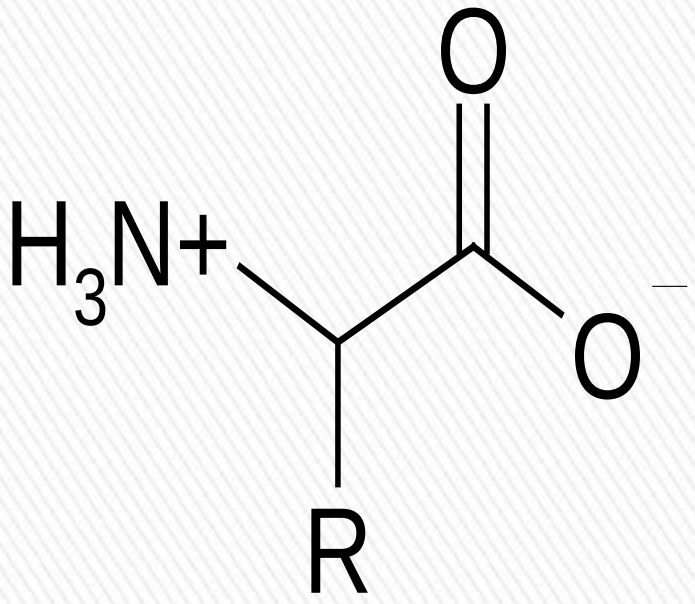
Hydrogen atom and side

Chain (R)



Amino Acids:properties

- Same general structure
- Called alpha amino acids
- L- isomer is physiologically active
- Side chain or R group determines other properties
- Acid-base properties

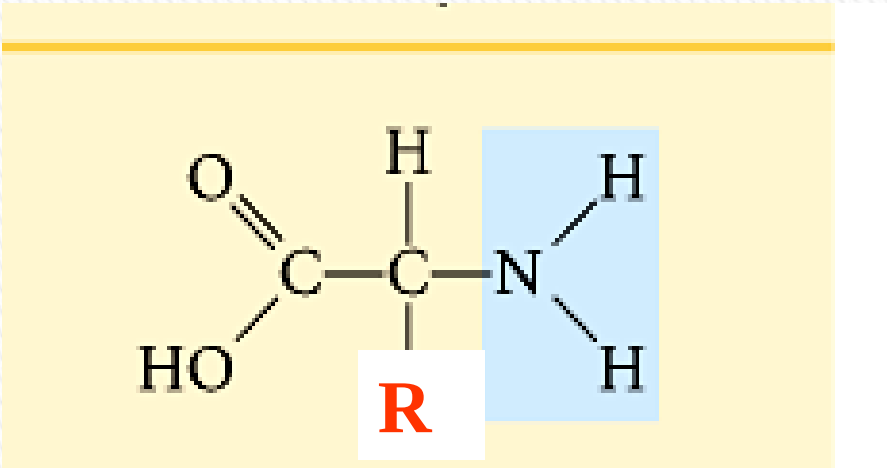


- **At physiological PH (7.4), -COOH gp is dissociated forming a negatively charged carboxylate ion (COO^-) and amino gp is protonated forming positively charged ion (NH_3^+) forming Zwitter ion**

Classification of amino acids

I- Chemical classification: According to number of COOH and NH_2 groups i.e. according to net charge on amino acid.

A- **Monobasic, monocarboxylic amino acids i.e. neutral or uncharged:**



Subclassification of neutral amino acids:

All structures are required

1- **Glycine** R= H

2- **Alanine** R= CH_3

3- **Branched chain amino acids:** R is branched such as in:

a - **Valine** R= isopropyl gp

b- **Leucine** R= isobutyl gp

c- **Isoleucine** R = is isobutyl

R is isobutyl in both leucine and isoleucine but branching is different: in leucine → branching occurs on γ carbon

in isoleucine→ branching occurs on β- carbon

4- Neutral Sulfur containing amino acids:

e.g. Cysteine and Methionine.

5- Neutral, hydroxy amino acids:

e.g. Serine and Threonine

6- Neutral aromatic amino acids:

a- Phenyl alanine : It's alanine in which one hydrogen of CH_3 is substituted with phenyl group. So it's called phenyl alanine

b- Tyrosine: - it is P- hydroxy phenyl alanine

- it is classified as **phenolic amino acid**

c- Tryptophan: as it contains indole ring so it is classified as **heterocyclic amino acid**

7- Neutral heterocyclic amino acids:

a- Tryptophan: contains indole ring

b- Proline: In proline, amino group enters in the ring formation being α-imino gp so proline is an α-imino acid rather than α-amino acid

B- Basic amino acids: Contain two or more NH_2 groups or nitrogen atoms that act as base i.e. can bind proton.

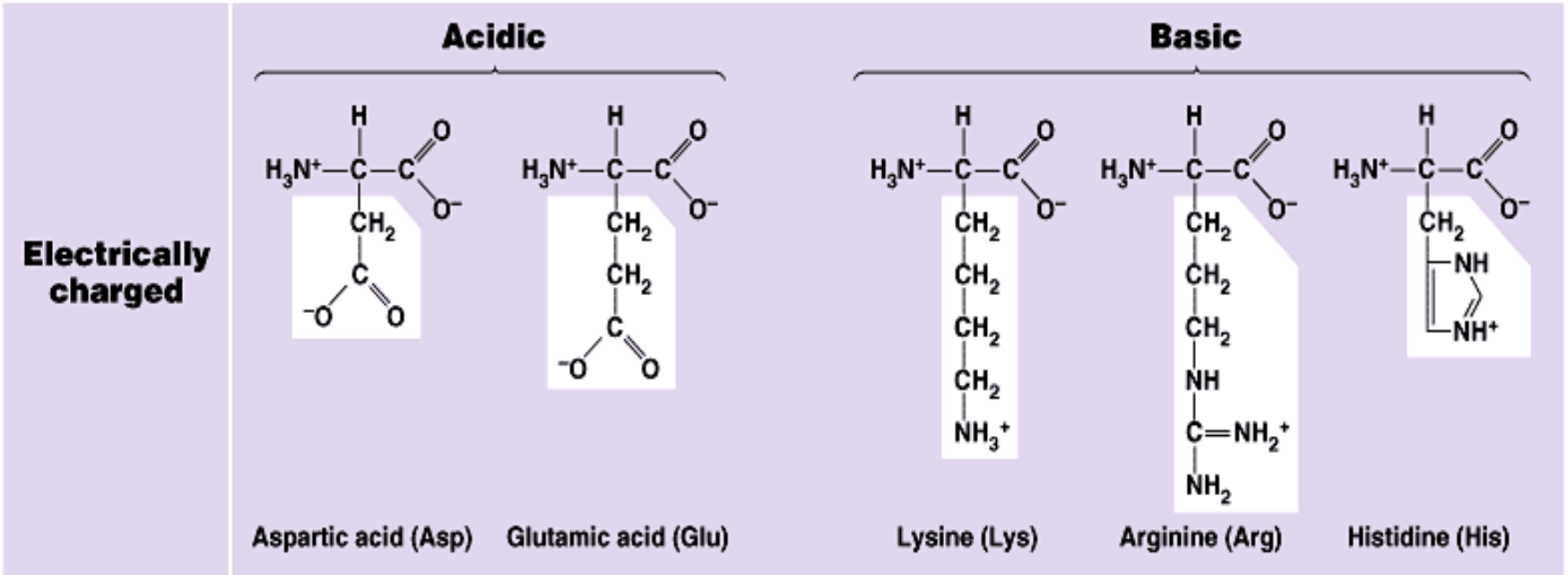
At physiological pH, basic amino acids will be **positively charged**.

e.g.

a- Lysine

b- Arginine: contains guanido group

c- Histidine: is an example on basic heterocyclic amino acids



C- Acidic Amino acids: at physiological pH will carry negative charge.

e.g. Aspartic acid (aspartate) and Glutamic acid .

Aspargine and Glutamine: They are amide forms of aspartate and glutamate in which side chain COOH groups are amidated.
They are classified as neutral amino acids.

II- Classification according to polarity of side chain (R):

A- Polar amino acids: in which R contains polar hydrophilic group so can forms hydrogen bond with H_2O. In those amino acids, R may contain:

1- OH group : as in serine, threonine and tyrosine

2- SH group : as in cysteine

3- amide group: as in glutamine and aspargine

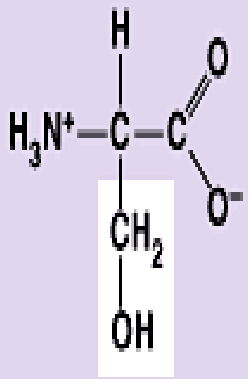
4- NH_2 group or nitrogen act as a base (basic amino acids): as lysine, arginine and histidine

5- COOH group (acidic amino acids): as aspartic and glutamic .

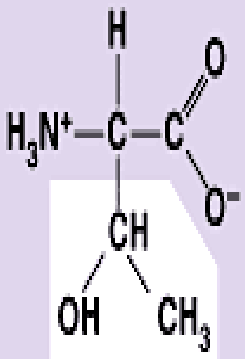
B- Non polar amino acids:

R is alkyl hydrophobic group which can't enter in hydrogen bond formation. 9 amino acids are non polar (glycine, alanine, valine, leucine, isoleucine, phenyl alanine, tryptophan, proline and methionine)

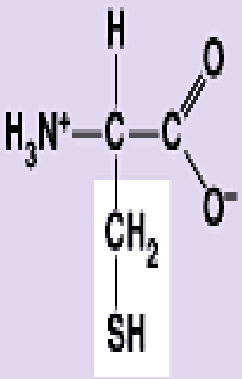
Polar



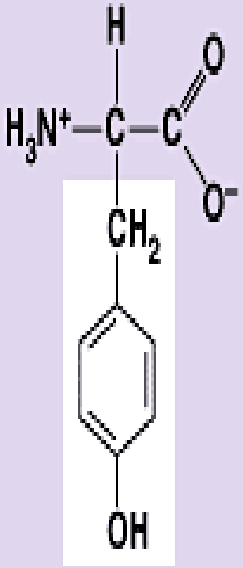
Serine (Ser)



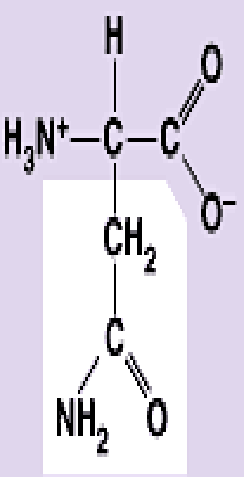
Threonine (Thr)



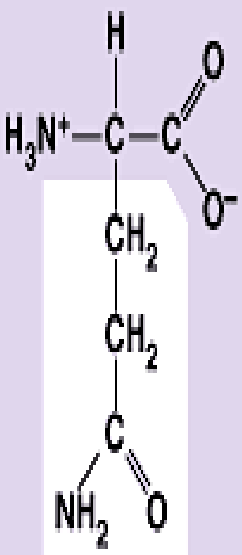
Cysteine (Cys)



Tyrosine (Tyr)

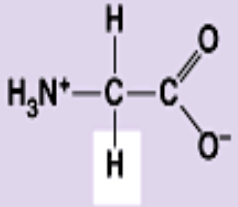


Asparagine (Asn)

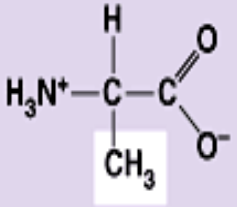


Glutamine (Gln)

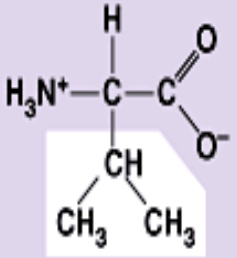
Nonpolar



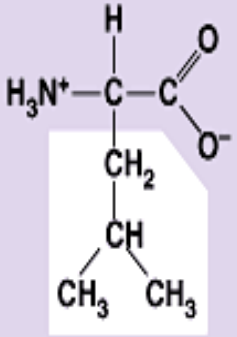
Glycine (Gly)



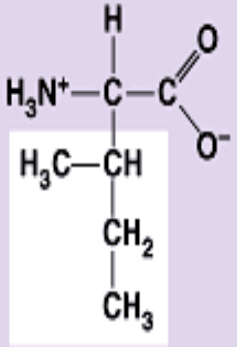
Alanine (Ala)



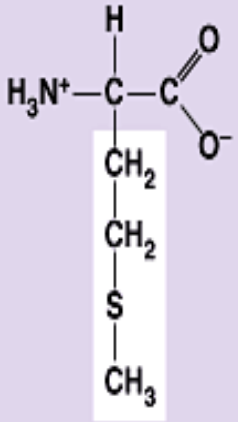
Valine (Val)



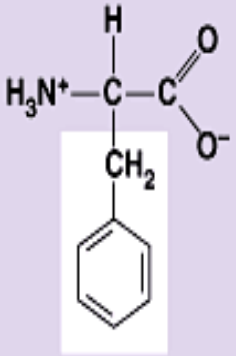
Leucine (Leu)



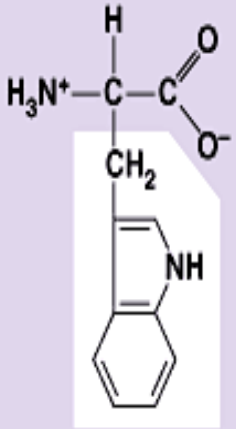
Isoleucine (Ile)



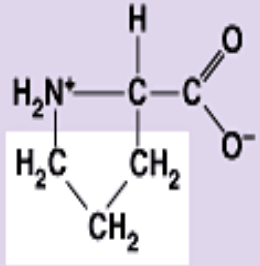
Methionine (Met)



Phenylalanine (Phe)



Tryptophan (Trp)



Proline (Pro)

III- Nutritional classification:

1- Essential amino acids: These amino acids can't be formed in the body and so, it is essential to be taken in diet. Their deficiency affects growth, health and protein synthesis.

2- Semiessential amino acids: These are formed in the body but not in sufficient amount for body requirements especially in children.

Summary of essential and semiessential amino acids:

V= valine i= isoleucine l= lysine l= leucine

A = arginine* H= histidine* M= methionine

T= tryptophan Th= threonine P= phenyl alanine

*= arginine and histidine are semiessential

3- Non essential amino acids: These are the rest of amino acids that are formed in the body in amount enough for adults and children. They are the remaining 10 amino acids.

IV- Metabolic classification: according to metabolic or degradation products of amino acids they may be:

1- Ketogenic amino acids: which give ketone bodies . **Lysine** and **Leucine** are the only pure ketogenic amino acids.

2- Mixed ketogenic and glucogenic amino acids: which give both ketonbodies and glucose.These are: isoleucine, phenyl alanine, tyrosine and tryptophan.

3- Glucogenic amino acids: Which give glucose. They include the rest of amino acids. These amino acids by catabolism yields products that enter in glycogen and glucose formation.

Amphoteric properties of amino acids: that is they have both basic and acidic groups and so can act as base or acid.

Neutral amino acids (monobasic, monocarboxylic) exist in aqueous solution as " Zwitter ion" i.e. contain both positive and negative charge. Zwitter ion is electrically neutral and can't migrate into electric field.

Isoelectric point (IEP) = is the pH at which the zwitter ion is formed. e.g IEP of alanine is 6

Chemical properties of amino acids:

1- Reactions due to COOH group:

-Salt formation with alkalis, ester formation with alcohols, amide formation with amines and decarboxylation

2- Reactions due to NH2 group: deamination and reaction with ninhydrin reagent.

-Ninhydrin reagent reacts with amino group of amino acid yielding blue colored product. The intensity of blue color indicates quantity of amino acids present.

Ninhydrine can react with imino acids as proline and hydroxy proline but gives **yellow color.**

3- Reactions due to side chain (R):

1- Millon reaction: for tyrosine gives red colored mass

2- Rosenheim reaction: for trptophan and gives violet ring.

3- Pauly reaction: for imidazole ring of histidine: gives yellow to reddish product

4- **Sakagushi test:** for guanido group of arginine and gives red color.

5- Lead sulfide test (sulfur test): for sulfur containing amino acids as cysteine give brown color.