Amino Acids and Proteins

By

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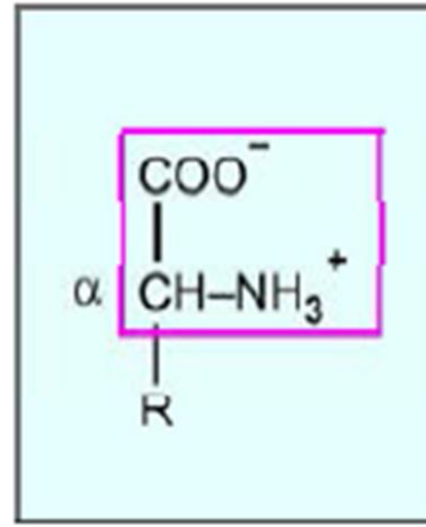
The word protein is derived from Greek word, **"proteios"** which means primary. As the name shows, the proteins are of paramount importance for biological systems. Out of the total dry body weight, 3/4ths are made up of proteins. Proteins are used for body building ; all the major structural and functional aspects of the body are carried out by protein molecules. Abnormality in protein structure will lead to molecular diseases with profound alterations in metabolic functions.

Proteins contain Carbon, Hydrogen, Oxygen and Nitrogen as the major components while Sulphur and Phosphorus are minor constituents. Nitrogen is characteristic of proteins. On an average, the nitrogen content of ordinary proteins is 16% by weight. All proteins are polymers of amino acids. Commonly occurring amino acids are 20 in number. Most of the amino acids (except proline) are alpha amino acids, which means that the amino group is

attached to the same carbon atom to which the carboxyl group is attached.



CLASSIFICATION OF AMINO ACIDS

A. Aliphatic Amino Acids

a. **Mono amino mono carboxylic acids:**

- Simple amino acids:

1. Glycine
2. Alanine

- Branched chain amino acids:

3. Valine, 4. Leucine, 5. Isoleucine (Fig. 2.3)

- Hydroxy amino acids:

6. Serine, 7. Threonine (Fig. 2.4)

- Sulfur containing:

8. Cysteine, 9. Methionine (Fig. 2.5)

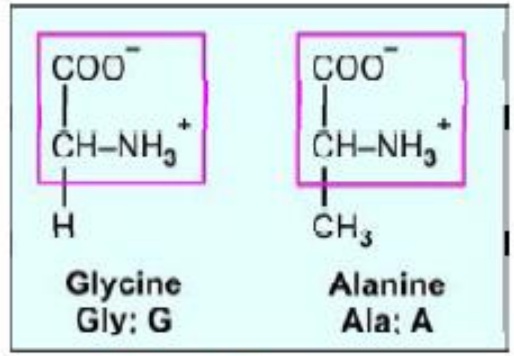


Fig. 2.2: Simple amino acids

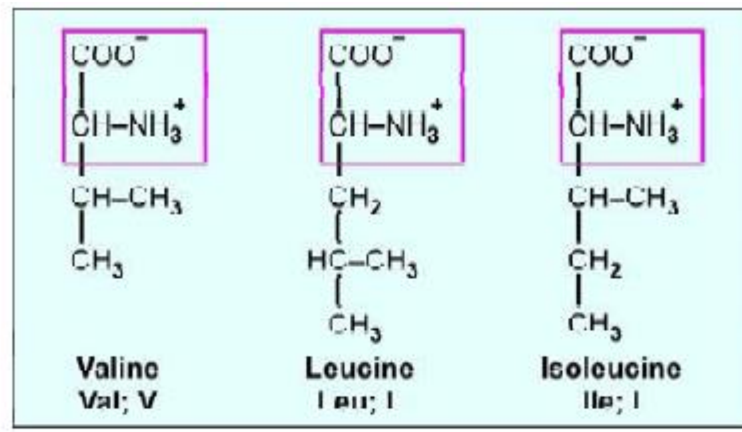


Fig. 2.3: Branched chain amino acids

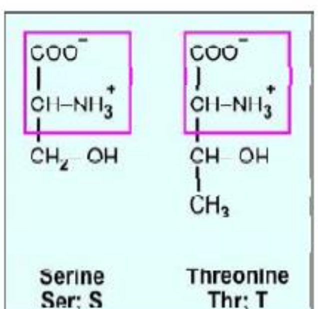


Fig. 2.4: Hydroxy amino acids

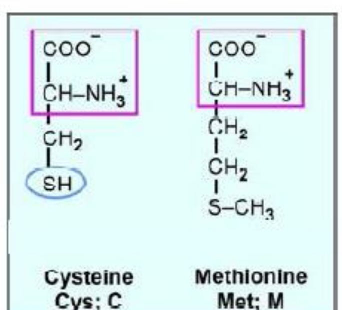


Fig. 2.5: Sulfur containing amino acids

- Having amide group:

10. Asparagine, 11. Glutamine (Fig. 2.6)

b. **Mono amino dicarboxylic acids** (Fig. 2.7):

12. Aspartic acid, 13. Glutamic acid

c. **Dibasic mono carboxylic acids:**

14. Lysine, 15. Arginine (Fig. 2.8)

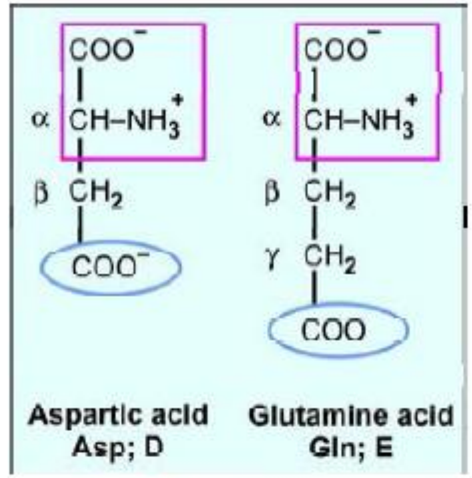


Fig. 2.7: Dicarboxylic amino acids

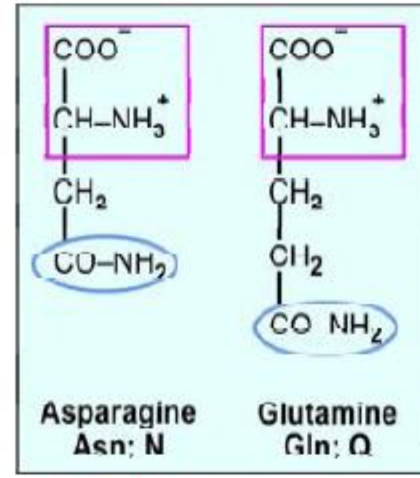


Fig. 2.6: Amino acids with amide groups

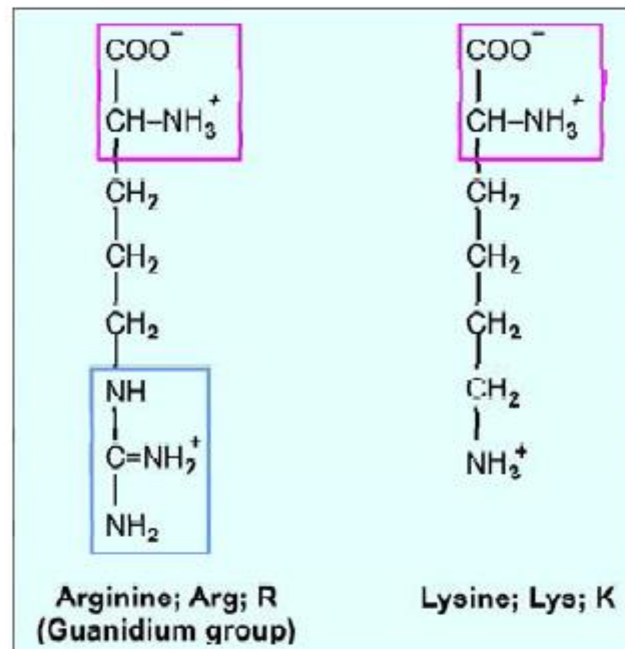


Fig. 2.8: Dibasic amino acids

- ***B. Aromatic Amino Acids***
- 16. Phenylalanine, 17. Tyrosine (Fig. 2.9)
- ***C. Heterocyclic Amino Acids***
- 18. Tryptophan
- (Fig. 2.10),
- 19. Histidine
- (Fig. 2.11)

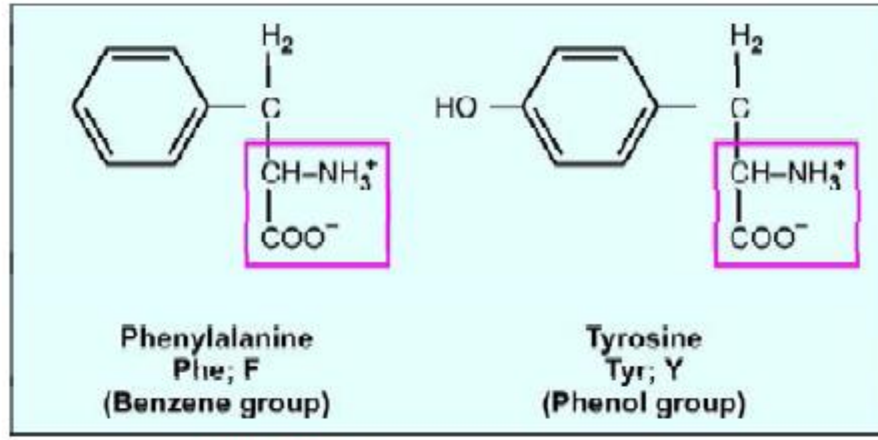


Fig. 2.9: Aromatic amino acids

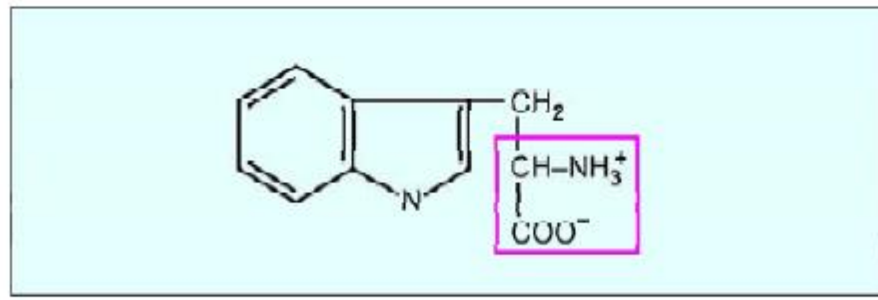


Fig. 2.10: Tryptophan (Trp) (W) with indole group

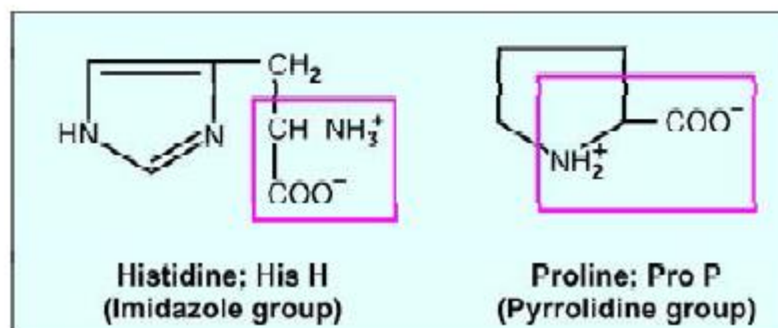


Fig. 2.11: Histidine and Proline

- ***D. Imino Acid***
- 20. Proline (Fig. 2.11)
- ***E. Derived Amino Acids***

a. **Derived amino acids found in proteins:**

After the synthesis of proteins, some of the amino acids are modified, e.g. hydroxy proline (Fig. 2.12) and hydroxy lysine are important components of collagen. Gamma carboxylation of glutamic acid residues of proteins is important for clotting process

(Fig. 2.12).

b. **Derived amino acids not seen in proteins:**

(Non-protein amino acids): Some derived amino acids are seen free in cells, e.g. Ornithine ,Citrulline, Homocysteine. These are produced during the metabolism of amino acids. Each amino acid will have three-letter and one letter abbreviations which are shown in Figures 2.2 to 2.11

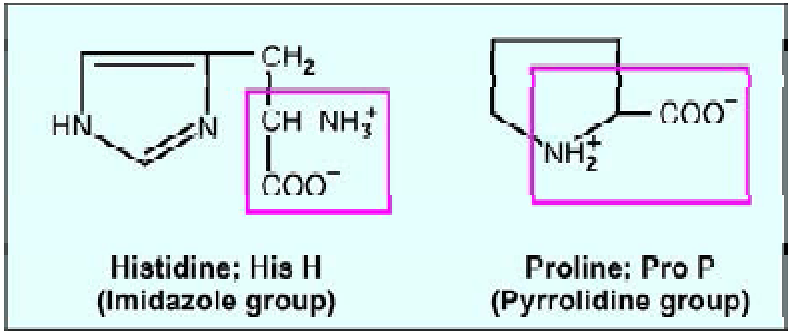


Fig. 2.11: Histidine and Proline

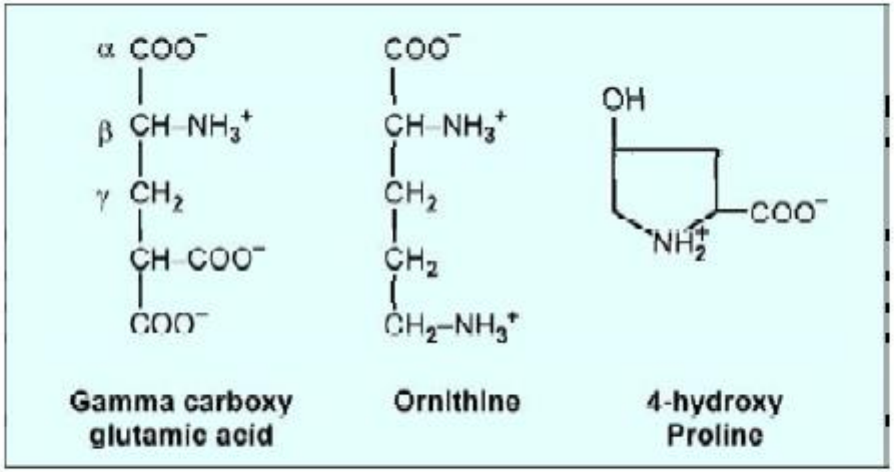


Fig. 2.12: Some derived amino acids

2. Classification Based on Side Chain

A. Amino Acids having Nonpolar Side Chains

These include Alanine, Valine, Leucine, Isoleucine ,Methionine, Proline, Phenylalanine and Tryptophan.These groups are **hydrophobic** (water repellant)

and lipophilic.

B. Amino Acids having Uncharged orNonionic Polar Side Chains

Glycine, Serine, Threonine, Cysteine, Tyrosine,Glutamine and Asparagine belong to this group.These amino acids are **hydrophilic** in nature.

C. Amino Acids having Charged or Ionic Polar Side Chains

They are hydrophilic in nature.

a. **Acidic amino acids:** They have a negative charge on the R group: Aspartic acid and Glutamic acid. (Tyrosine is mildly acidic).

b. **Basic amino acids:** They have a positive charge on the R group: Lysine, Arginine and Histidine.

3. Classification Based on Metabolic Fate

A. Purely Ketogenic

Leucine is purely ketogenic because it will enter into the metabolic pathway of ketogenesis.

B. Ketogenic and Glucogenic

Lysine, Isoleucine, Phenylalanine, Tyrosine and Tryptophan are partially ketogenic and partially glucogenic. During metabolism, part of the carbon skeleton of these amino acids will enter the fatty acid metabolic pathway and the other part into glucose pathway

C. Purely Glucogenic

All the remaining 14 amino acids are purely glucogenic as they enter only into the glucogenic pathway.

4. Classification Based on Nutritional Requirement

A. Essential or Indispensable

The amino acids may further be classified according to their essentiality for growth. Thus, **Isoleucine, Leucine, Threonine, Lysine, Methionine, Phenylalanine, Tryptophan, and Valine** are essential amino acids. Their carbon skeleton cannot be synthesized by human beings and so preformed amino acids are to be taken in food for normal growth.

B. Partially Essential or Semi-essential

Histidine and Arginine are semi-indispensable amino acids. Growing children require them in food. But they are not essential for the adult individual.

C. Nonessential or Dispensable

The remaining 10 amino acids are nonessential. However, they are also required for the normal protein synthesis. All body proteins do contain all

the nonessential amino acids. But their carbon skeleton **can be synthesized** by metabolic pathways and therefore their absence in the food will not adversely affect the growth.

PROPERTIES OF AMINO ACIDS

1. Isoelectric Point

i. Amino acids can exist as **ampholytes** or **zwitterions** (German word "zwitter" = hybrid) in solution, depending on the pH of the medium. The pH at which the molecule carries no net charge is known as *isoelectric point or isoelectric pH* (pI)*.* In acidic solution, they are cationic in form and in alkaline solution they behave as anions (Fig. 2.13).

ii. At isoelectric point, the amino acid will **carry no net charge;** all the groups are ionized but the charges will cancel each other. Therefore at iso-electric point, there is *no mobility in an electrical field*. Solubility and buffering capacity will be minimum at isoelectric pH.

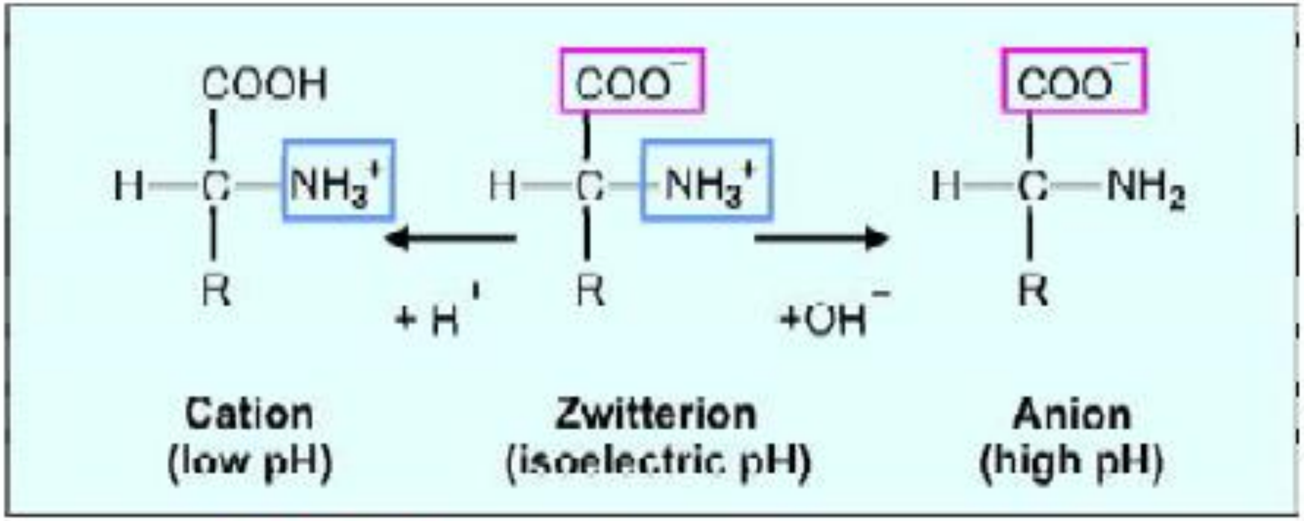


Fig. 2.13: Ionic forms of amino acids

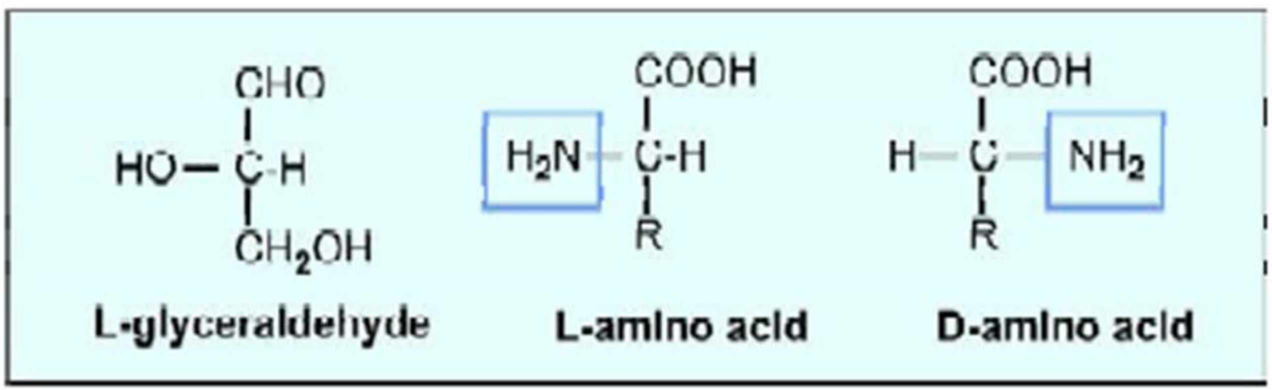


Fig. 2.14: L and D amino acids

2. Optical Activity

i. Amino acids having an asymmetric carbon atom exhibit optical activity. **Asymmetry** arises *when 4 different groups are attached to the same carbon atom* (Fig. 2.14).

ii. Glycine is the simplest amino acid and has no asymmetric carbon atom and therefore shows no optical activity. All others are optically active.

iii. These mirror image forms produced with reference to the alpha carbon atom, are called D and L isomers (Fig. 2.14).

iv. The L-amino acids occur in nature and are therefore called **natural amino acids.** D-amino acids are seen in small amounts in microorganisms and as constituents of certain antibiotics such as Gramicidin and bacterial cell walls.

3. Reactions due to Carboxyl Group

A. Decarboxylation

The amino acids will undergo alpha decarboxylation to form the corresponding amine (Fig. 2.15). Thus, some important amines are produced from amino acids. For example:

i. Histidine ----- Histamine + CO_2

ii. Tyrosine ----- Tyramine + CO_2

iii. Tryptophan ------ Tryptamine + CO_2

iv. Glutamic acid ----- Gamma aminobutyric acid (GABA) + CO_2

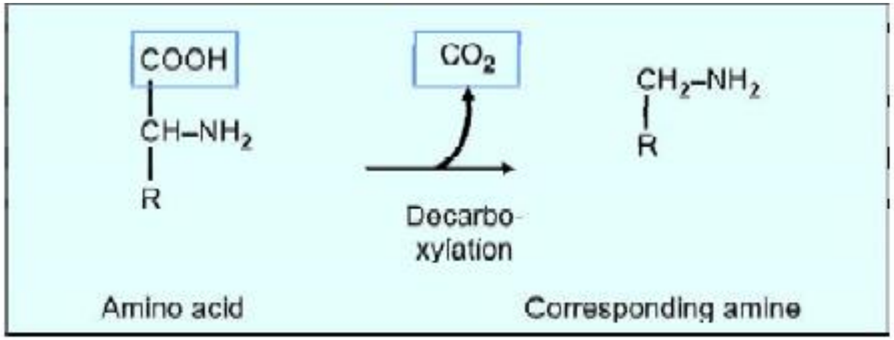


Fig. 2.15: Decarboxylation of amino acid

B. Amide Formation

The -COOH group of dicarboxylic amino acids (other than alpha carboxyl) can combine with ammonia to form the corresponding amide (Fig. 2.16). For example:

Aspartic acid +NH_3-------- Asparagine

Glutamic acid+NH_3-------- Glutamine

These amides are also components of protein structure. The amide group of glutamine serves as the source of nitrogen for nucleic acid synthesis.

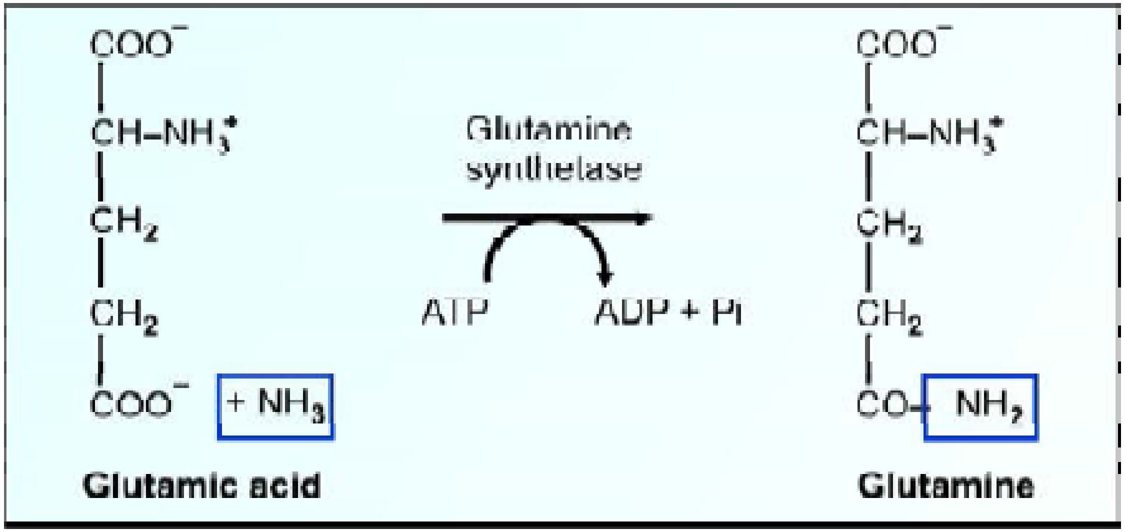


Fig. 2.16: Formation of glutamine