Amino acid metabolism

Amino acids are important as they are precursors of proteins. In plants, they are synthesized from organic acids (produced during glycolysis and Kreb's cycle) and inorganic nitrogen (NH_3). The inorganic nitrogen enters into plants either in the form of nitrate or ammonium. The nitrate is first reduced to ammonium and then is incorporated into amino acids. The leguminous plants possess symbiotic nitrogen fixing bacteria in their root nodules and they use atmospheric nitrogen to synthesize amino acids. The micro-organisms differ in their capacity to synthesize amino acids. The following are the mechanisms of amino acid metabolism.

1. Reductive amination :-

The conversion of inorganic nitrogen (NH_3) into organic nitrogen (amino acid) through organic acids, where amination and reduction at keto group of the organic acid takes place is called reductive amination. It is the primary pathway of amino acid biosynthesis. For example, the amino acid glutamic acid is synthesized from α-ketoglutaric acid in presence of enzyme glutamic dehydrogenase and $NADPH_2$

$$\alpha\text{-Ketoglutaric acid} + NH_3 + NADPH \underset{\text{Glutamic dehydrogenase}}{\rightleftharpoons} \text{glutamic acid} + NADP^+ + H_2O$$

The amino acid glutamic acid serves as a precursor for several other amino acids like proline, arginine etc. These amino acids are formed by transamination reaction of glutamic acid.

The glutamic acid can also be synthesized by an alternate pathway called glutamine synthetase / glutamate synthase (GS/GOGAT) pathway. Here glutamic acid is synthesized through the amide glutamine, which itself is synthesized from glutamic acid and ammonia.

$$\text{Glutamic acid} + NH_3 \xrightarrow[ATP]{\text{Glutamine synthetase (GS)}} \text{Glutamine}$$

α-Ketoglutaric acid combines with glutamine and undergoes amination reaction to produce two molecules of glutamic acid in presence of enzyme glutamic acid synthetase.

$$\alpha\text{-Ketoglutaric acid} + \text{glutamine} \xrightarrow[NADH]{\text{Glutamate synthase (GOGAT)}} \text{Glutamic acid (two molecules)}$$

Thus, one molecule of glutamic acid synthesizes two glutamic acid molecules showing net production of one glutamic acid molecule.

The aspartic acid and alanine can also be synthesized directly by the incorporation of ammonia into oxaloacetic acid

and pyruvic acid respectively as follows

Oxaloacetic acid + NH_3 ⇌ Aspartic acid

Pyruvic acid + NH_3 ⇌ Alanine

2. Transamination :-

The transfer of amino group ($-NH_2$) of an amino acid to carbonyl group of a keto acid is called transamination. About 17 amino acids are synthesized from glutamic acid by transamination. For the synthesis of various amino acids, first glutamic acid is produced by reductive amination and then the other amino acids are synthesized by the transfer of its amino group to various keto ~~group~~ acids. The transamination reaction is catalysed in presence of enzyme transaminase. Each amino acid synthesis requires a separate transaminase enzyme. The coenzyme pyridoxal phosphate is also required for this reaction.

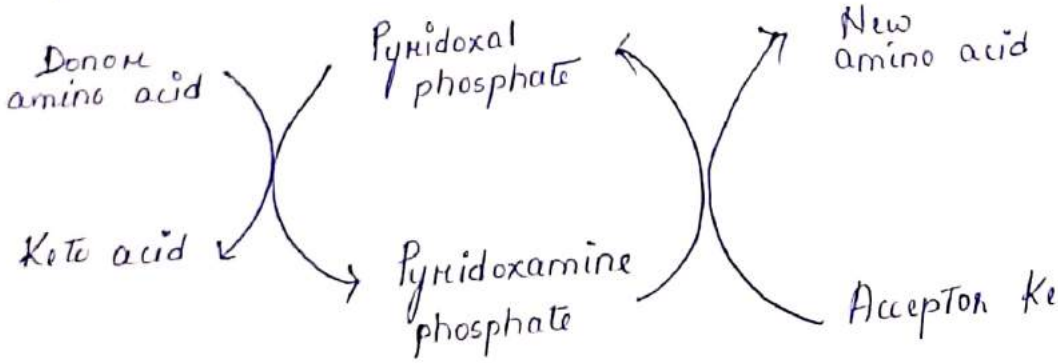
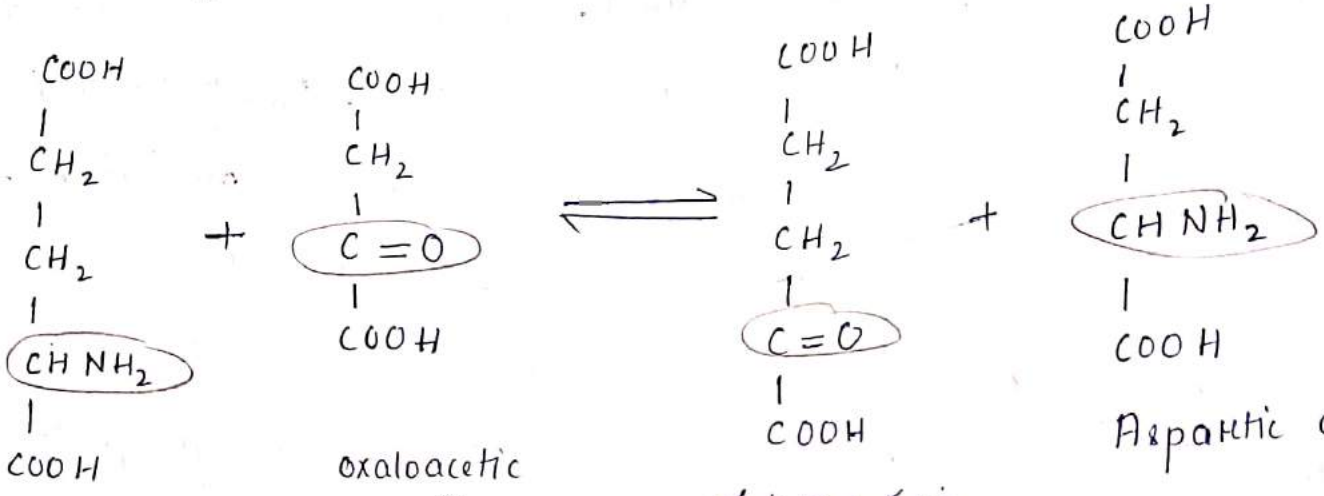


Fig: Transamination reaction.

In the above reaction the co-enzyme pyridoxal phosphate acts as a carrier of amino group, picks up amino group

from the donor amino acid and is converted into pyridoxamine phosphate which ultimately transfers the amino acid to acceptor keto acid to form new amino acid and to regenerate pyridoxal phosphate. The formation of aspartic acid by transamination is as follows.



Transamination reactions are also involved in the synthesis of glucine, leucine, isoleucine, alanine etc.