

## **WEEK THREE**

### **PROTEINS AND AMINO ACIDS**

The word protein is a term from Greek word “PROTEIOS” meaning prime or primary. Proteins are essential organic constituent of living organism and are in the class of nutrient with highest concentration in muscle tissue of animals.

Like carbohydrate and fat, they contain carbon, hydrogen and oxygen but in addition, they all contain nitrogen and generally Sulphur. Without protein synthesis, life will not exist. Each specie has its own specific protein. A large number of protein occur in nature.

### **AMINO ACID**

The monomer yield of protein are amino acid, they are produced when protein are hydrolysed by enzymes, acid or by alkali. Over 200 amino acids have been isolated from biological materials since protein are large molecules which cannot form the intestinal walls, so they are hydrolysed to amino acids.

**Note:** Carbohydrate digestion starts from the mouth.

Digestion of protein starts from the stomach.

### **CLASSIFICATION OF PROTEIN**

1. Simple Protein
  - a. Globular Protein
  - b. Fibrous Protein
2. Conjugate Protein
  - a. Glyco Protein
  - b. Lipo Protein
  - c. Chromo Protein
3. Phospho Protein

## PROTEIN DIGESTION AND ABSORPTION IN NON RUMINANT

The digestion of protein takes place in the stomach and upper small intestine by enzyme from 3 sources:

1. Mucosa of the stomach
2. The Mucosa of the intestine
3. The Pancreas

The proteolytic enzymes, their production sites and specificity of action.

Enzymes	Site of Production		pH of optimal activity
Pepsin	Mucosa of stomach	Tryptopphan, Phenyl-amine, Tryoxine, Methionine	1.3-2.0
Trypsin	Pancreas	Arginine, lysine	8 - 9
Chymo-trypsin	Pancreas	Aromatic amino acid	8 - 9
Elastase	Pancreas	Aliphatic amino acid	8 - 9
Carboxyl Peptase "A"	Pancreas	Aromatic amino acid	7.2
Carboxyl Peptase "B"	Pancreas	Arginine	8.0
Amino peptidase	Mucosa of stomach	Amino acid with free NH <sub>2</sub> groups	7.4

All this protein dis-integrating enzymes are called **ZYMOGENS**, converging of zymogens into Aliphatic amino acids are amino acid formed in form of ring active form takes place in the GIT, the main products of protein digestion is amino acid which are absorbed from the small intestine to the portal blood and then to the liver.

## **PROTEIN DIGESTION AND METABOLISM**

The major difference between ruminant and non-ruminant is the fermentation on microbial digestion in the reticulo-rumen where feed or food stays for a longer time in the alimentary tract (Digestive tract i.e GIT).

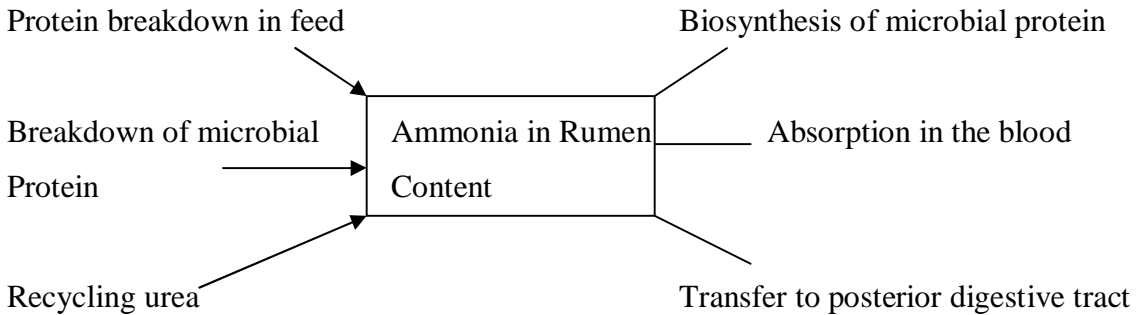
The rumen micro-organism produce proteolytic enzymes which hydrolyse, the dietary protein to peptide and amino acid which are further fermented by de-amination to carbon IV oxide, ammonia and short chain fatty acid. The proteolytic activity of the micro-organism in the rumen is responsible for the liberation of amino acid from the dietary protein taken by the farm animal which may further be de-aminated. Ruminants are almost independent of the quality of ingested protein. Apart from the nitrogen in the ruminant feed supply in form of simple nitrogen compound such as ammonium or urea.

Protein ingested by ruminant takes the following pathways:

1. During passage of the food through the rumen, much of the protein is degraded to peptide by action of proteases, the peptides are further catabolised to free amino acid and later to ammonia, fatty acid and carbon IV oxide.
2. The de-gradation product formed in the rumen particularly ammonia are used by micro-organisms in the presence of adequate energy sources for the synthesis of protein and other microbial cell constituents such as nitrogen containing cell wall components and nucleic acids.
3. Part of the ammonia liberated in the rumen cannot be fixed by the micro-organism. It is absorbed into the animal blood and transformed in the liver to urea (urea cycle) the greater part of which is not utilized by the animal, it is excreted in the urine.
4. Bacterial cell (Bacterial protozoa) containing protein as their main component pass together with unaltered dietary protein from the reticulo-rumen through the omasum and the abomasums into the intestine. The digestion and absorption of microbial dietary protein occur in the small intestine of ruminant animals in a similar way to that with a monogastric species. The microbial protein and non-degraded food protein are digested in the small intestine by proteins. Amino acid originating from microbial protein from feed and

endogenous protein contribute to the failure of amino acid absorption from the gut into the intestinal tissue and blood.

**Note:** Ruminant animals depend on microbial protein plus dietary protein that escape through digestion in the rumen for its supply of essential amino acids. Proteins are degraded by rumen microbes according to the schematic diagram below leading finally to the production of ammonia, volatile fatty acid and CO<sub>2</sub>

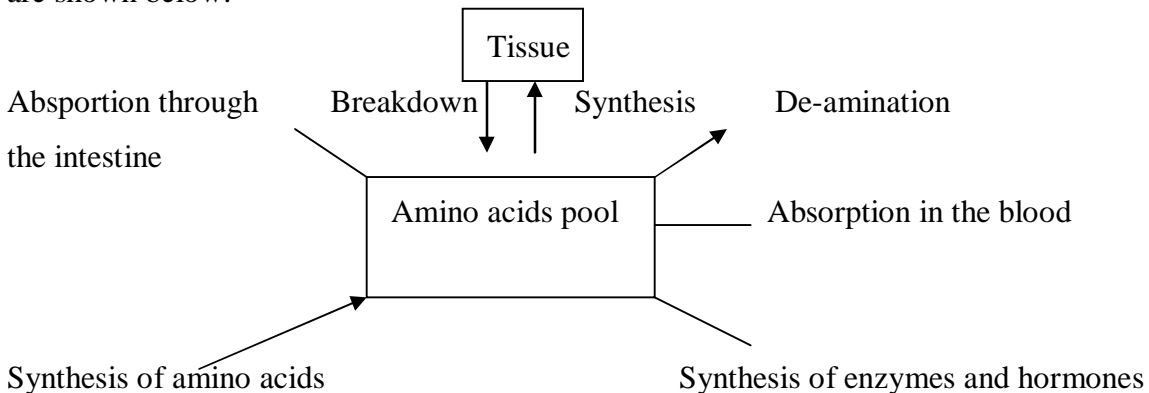


### **METABOLIC PATHWAY OF AMMONIA**

The amino acids are absorbed from the small intestine by active transport mechanism which is sodium dependent. Vitamin B<sub>6</sub> (pyridoxine) also enhances normal amino acid transport across the cell. The main objective of protein digestion is achieved by protein and peptide degrading enzymes which are specific for certain linkages acting in a definite sequence. Ruminant animals are practically independent of the supply of essential amino acids in the diet since ruminant micro-organisms synthesize the amino acid required by the host animal.

### **PROTEIN METABOLISM**

The process of tissue protein synthesis of amino acid and breakdown of tissue protein into amino acid takes place simultaneously. The various reactions involving amino acids are shown below:



**Note:** Amino acids act in the body as a common pool irrespective of their origin and source.

## PROTEIN SYNTHESIS

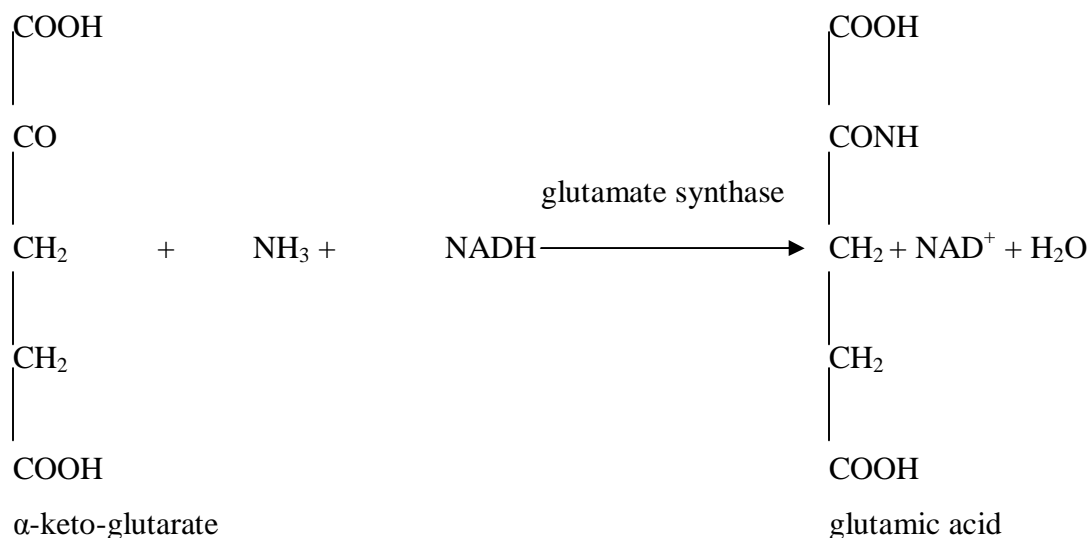
Biosynthesis of protein comprises a series of processes involving DNA, which carries the genetic information, determines the exact structure of the protein to be synthesized. DNA controls the formation of the 3 types of RNA which determine the sequence of the amino acid and the molecular size of the protein been formed.

## BIOSYNTHESIS OF AMINO ACID

Of the 19 amino acids found in animal body, about 9 can be synthesized in animal body particularly the liver cell. The carbon skeleton of the non-essential amino acid can be formed from carbohydrate, fats or essential amino acid. The  $\alpha$ -amino acid originates either from ammonium ion or from the amino group of the amino acid according to the following 2 pathways.

1. Formation of amino acid by fixation of ammonia.

Glutamic acid is formed by reductive amination of  $\alpha$ -keto-glutarate on intermediate product of sugar breakdown.



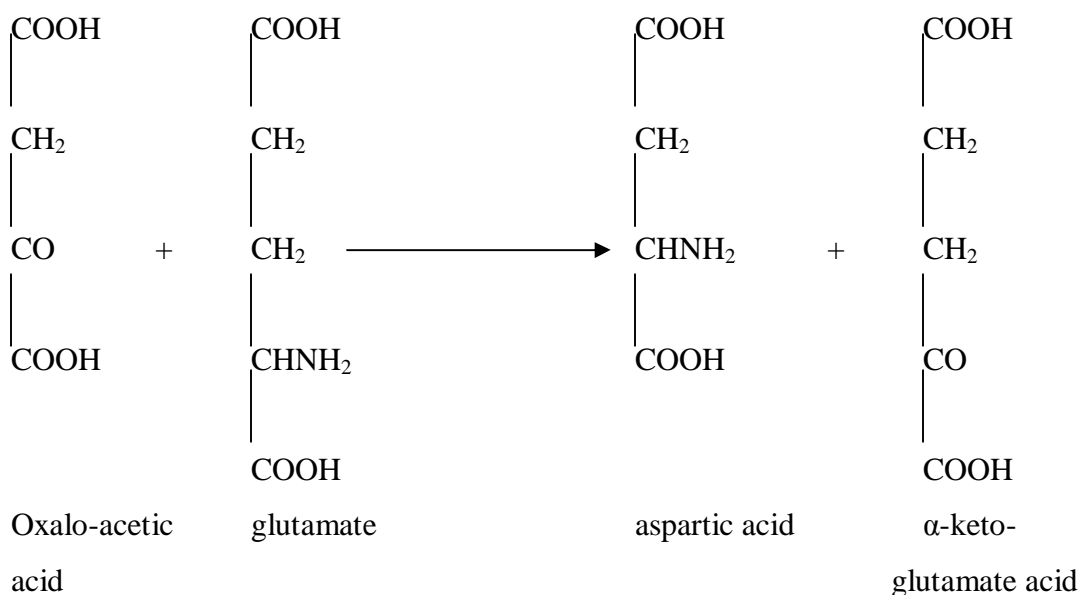
Glutamate can be easily converted by trans-amination into other non-essential amino acids. Hence glutamate (glutamic acid) formation is important for the synthesis of non-essential amino acid and amino acid catabolism. Since the ammonia incorporated into the glutamate can be transformed into urea.

2. Trans-amination: It is a reversible reaction between amino acid and  $\alpha$ -oxo acid leading to an exchange of the amino acid and a ketone group. Pyridoxal

phosphate, the co-enzyme formed or vitamin B<sub>6</sub> catalyze such reaction e.g oxaloacetic acid and glutamate leading to aspartic acid and keto-glutanic acid.

**Note:** that trans-amination is catalysed by enzymes formed.

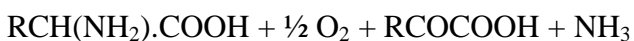
Transaminases occur in most animal tissues particularly liver and it enables transformation of one amino acid into another. In trans-amination, pyridoxal phosphate acts as an acceptor of amino group. The resulting pyridoxamine transform the amino group to a new  $\alpha$ -keto-acid resulting in the regeneration of pyridoxal phosphate and the formation of a new amino acid. Other amino acids formed by trans-amination from the breakdown of carbohydrate metabolism are alanine from pyruvic acid, serine from 3-phospho-glyceric acid and glycine.



## AMINO ACID DEGRADATION

Amino acids that are not used for synthesis undergo catabolic reaction such as de-amination or de-carboxylation.

Oxidation de-amination of amino acids in tissues results in the liberation of ammonia and the conversion of amino acid to the corresponding keto acid.



De-amination is a process whereby amino acids are converted to the corresponding  $\alpha$ -keto acid with the liberation of ammonia.

De-amination is therefore a process in which the amino group of amino acids are removed and keto acids are formed with the liberation of ammonia. Keto acids formed

from amino acids can be oxidized for energy supply or used for glucose synthesis or converted to fat.

Free ammonia becomes harmful to the cell when its concentration exceed certain limits and thus it is ultimately excreted as urea in mammals or uric acid in birds and reptiles.

$\alpha$ -ketoglutaric acid + alanine -----glutamic acid +  $\alpha$ -keto acid

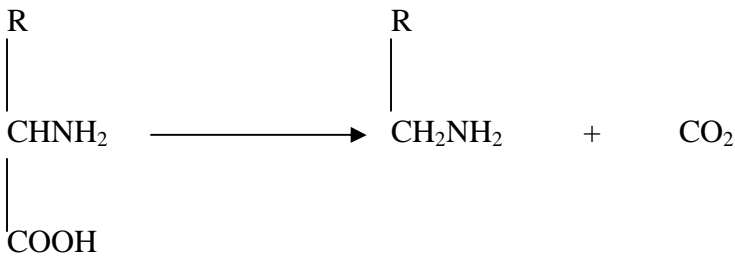
Glutamic acid +  $\text{NAD}^+$  +  $\text{H}_2\text{O}$ -----  $\alpha$ -keto acid +  $\text{NADH} + \text{H}^+ + \text{NH}_3$

Amino acid +  $\text{NAD}^+$  +  $\text{H}_2\text{O}$ -----  $\alpha$ -keto acid +  $\text{NADH} + \text{H}^+ + \text{NH}_3$

De-amination of amino acid is effected by  $\text{NAD}^+$  or  $\text{NADP}^+$  linked dehydrogenases in tissues is glutamic acid dehydrogenase. In conjunction with trans-aminase, glutamic acid dehydrogenase is taken to be responsible for the liberation of ammonia from other amino acids. All the amino nitrogen from amino acids which undergo trans-amination can be transferred to glutamate which is easily deaminated.

**DECARBOXYLATION**

The breakdown of amino acid by decarboxylation occurs in animal tissues of many micro-organisms particularly intestinal ones.



**Read about the following**

- a. Amino acid antagonism
- b. Metabolic Nitrogen
- c. Endogenous Nitrogen
- d. Nitrogen balance