Tishk International University
Faculty of Applied Science
Nutrition and Dietetics Department

Nutritional Biochemistry I
2nd Grade

Protein Metabolism

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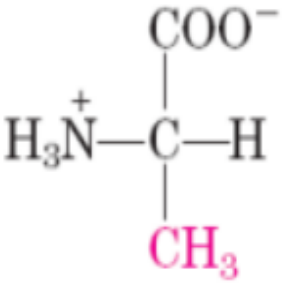
Outline

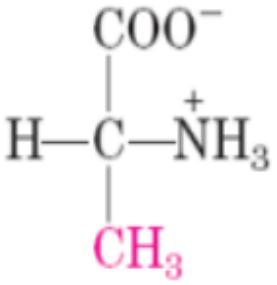
- Stereochemistry of amino acids
- Amino acid pool
- Dietary Proteins' digestion
- Protein metabolism
- Urea cycle
- Nitrogen Balance

Stereochemistry (Optical activity)

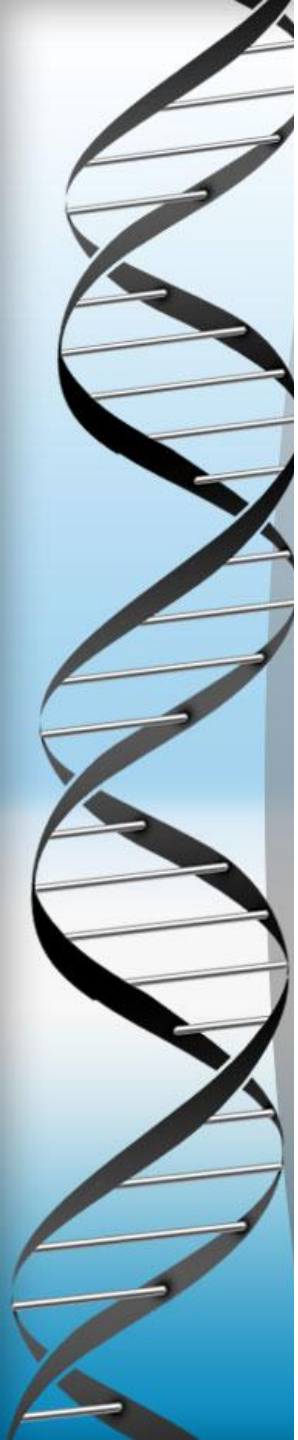
Stereochemistry mainly emphasizes the configuration of amino acids at the α-carbon atom, having either D or L-isomers.



L-Alanine



D-Alanine



Protein Turnover

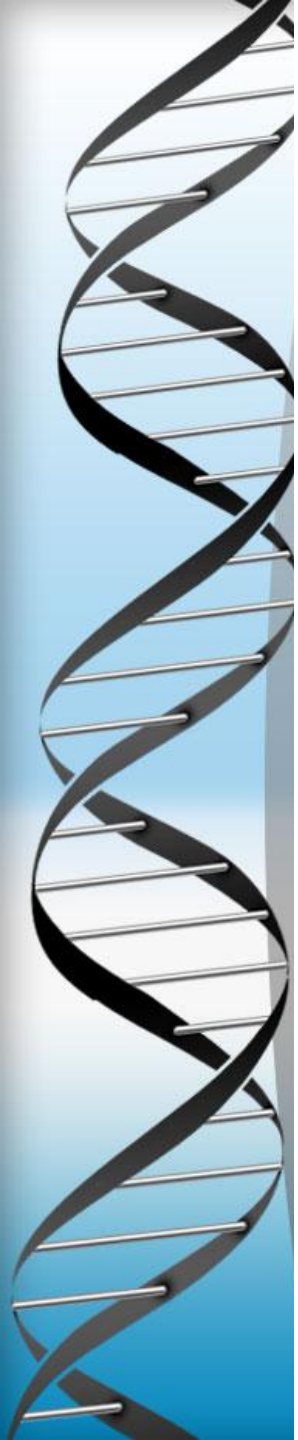
- The total amount of protein in the body remains constant(i.e. Rate of protein synthesis is constant).
- Is equal to protein degradation.
- This process is called as protein turnover.
- 300 to 400 g/day.

Amino acid Pool

- Amino acids released by *dietary* and *tissue protein*, mix with free amino acids of body which constitutes (100g).

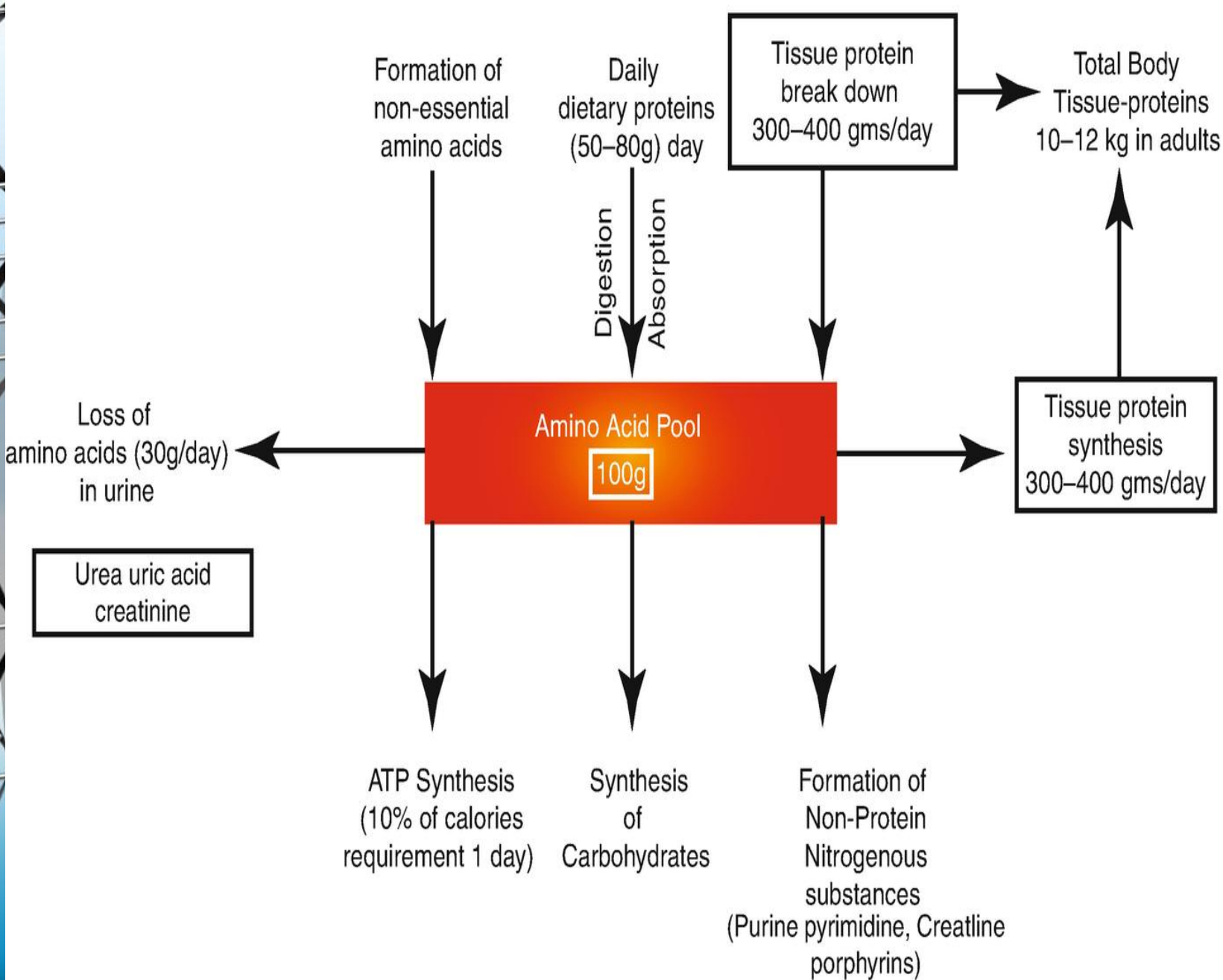
- Glutamate and Glutamine 50%
- Essential amino acids 10%
- Remanining -> Non-essential amino acids.

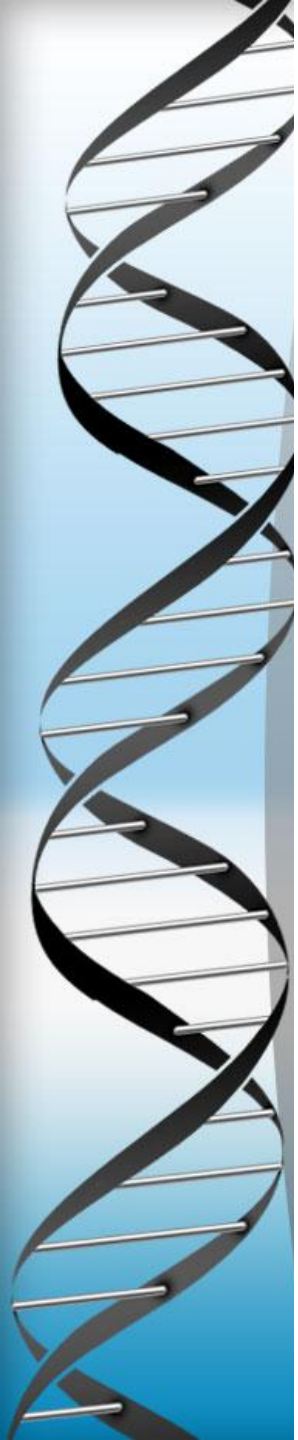
- Proteins rich in Proline, Glutamate, Serine and Threonine are rapidly degraded and have short half-lives.



- There is no storage form of amino acids like Glycogen and Triglycerides.
- Excess intake of proteins (A.as) are metabolized then oxidized to provide energy or converted to glucose or fat.
- Amino groups lost as Urea → Excreted

METABOLISM OF AMINO ACIDS





Digestion of Dietary Proteins

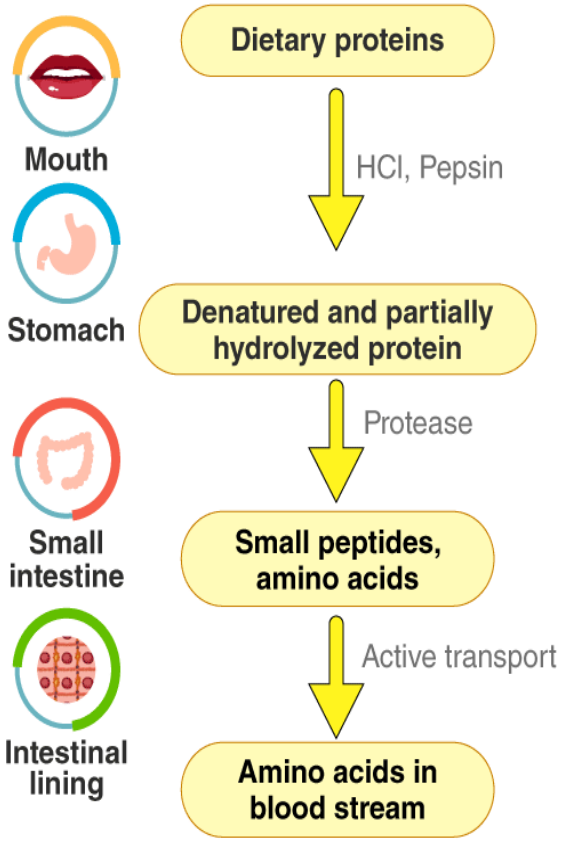
- Proteins are large polypeptide molecules coiled by weaker bonds in their tertiary structure.
- The digestion of proteins involves the gradual breakdown of the polypeptides by enzymatic hydrolysis into amino acid molecules which are absorbed in the blood stream.
- Proteolytic enzymes responsible for degrading proteins are produced by 3 different organs: Stomach, Pancreas and Small intestine.

The process of protein digestion can be divided depending on the sources of peptidases:

A. Gastric Digestion

B. Pancreatic Digestion

C. Intestinal Digestion



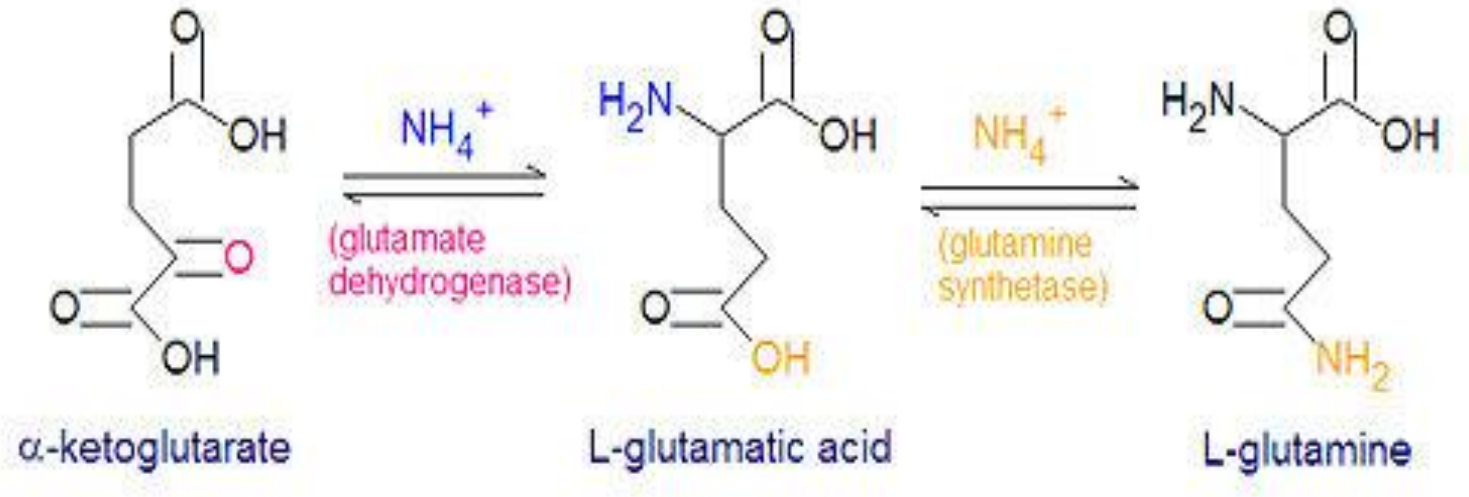
Metabolism of Protein

-Anabolism

-Catabolism

- Anabolism or (Biosynthesis):-

  Anabolism of non- essential amino acid (Amination) e.g Glutamic acid

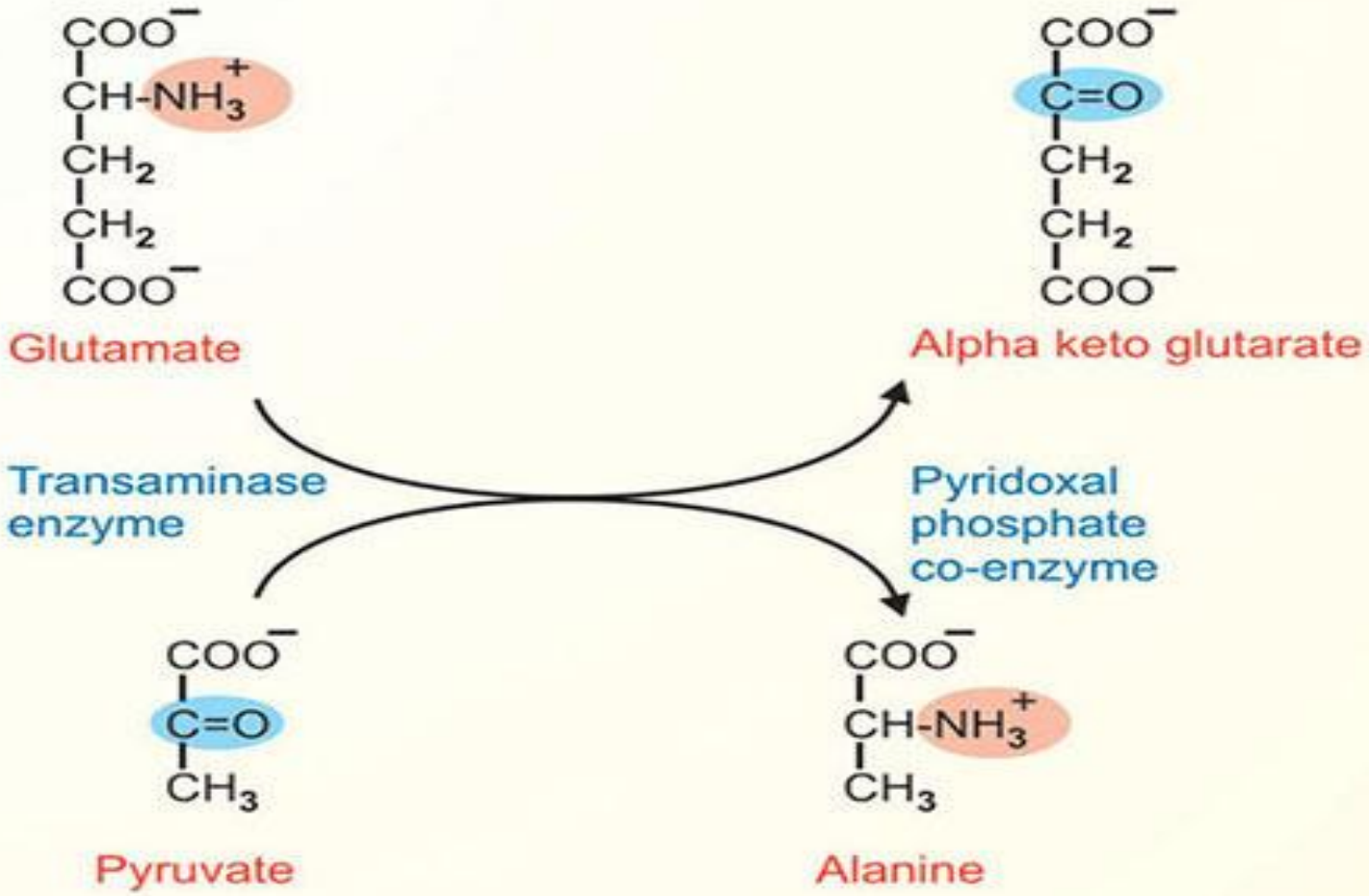


Amino acid Catabolism

A. Transamination: Is defined as a process in which amino group is transferred from an amino acid to ketoacid to form a corresponding amino acid that itself is forming Ketoacid without liberation of ammonia.

- All amino acids, except Lysine and Threonine participate in Transamination.

- Site: Liver



Summary

amino acid1 + keto acid 2 ⟶ amino acid 2 + keto acid 1

B. Deamination

Is the removal of an amine group from a molecule.

(Elimination of amino group from an amino acid with ammonia formation).

In the human body deamination takes place primarily in the liver , however glutamate is also de-aminated in the kidneys.

- Deamination is the process by which amino acids are broken down if there is an excess of protein intake.
  The amino group is removed from the amino acid and converted to ammonia.

There are 4 types of deamination:

1. Reduction deamination
2. Hydrolytic deamination
3. Intramolecular deamination
4. Oxidative deamination

Reduction deamination:

$$R\text{-}CH(NH_2)\text{-}COOH + 2H^+ \rightarrow R\text{-}CH_2\text{-}COOH + NH_3$$

amino acid *fatty acid*

Hydrolytic deamination:

$$R\text{-}CH(NH_2)\text{-}COOH + H_2O \rightarrow R\text{-}CH(OH)\text{-}COOH + NH_3$$

amino acid *hydroxyacid*

Intramolecular deamination:

$$R\text{-}CH(NH_2)\text{-}COOH \rightarrow R\text{-}CH\text{-}CH\text{-}COOH + NH_3$$

amino acid *unsaturated fatty acid*

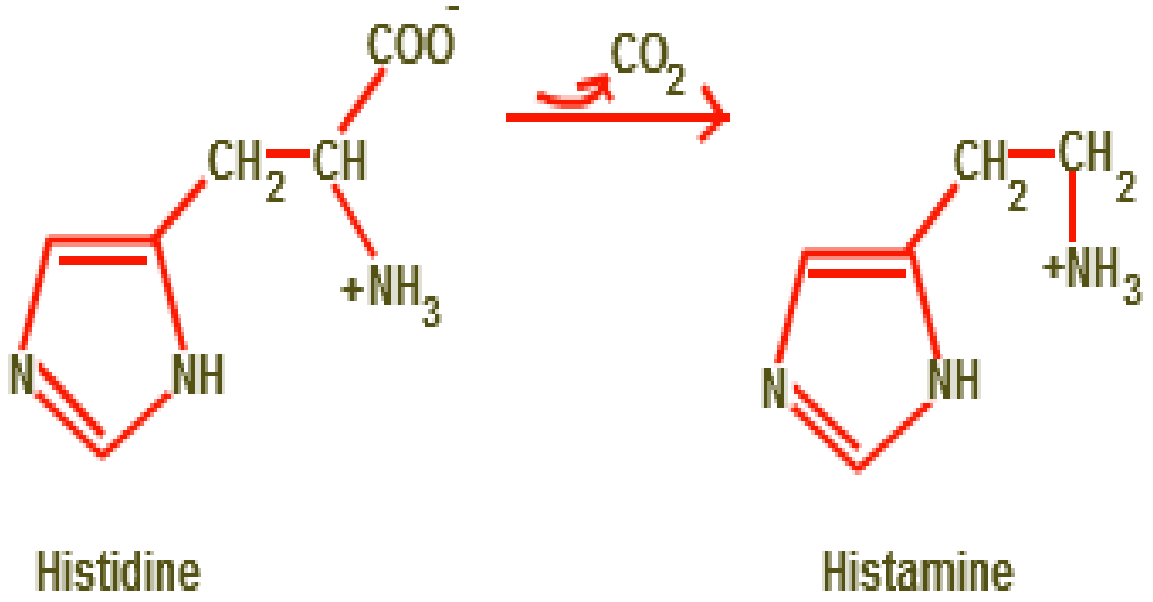
Oxidative Deamination

- Definition: Is liberation of free ammonia from the amino group of amino acid coupled with oxidation.
- Site: takes place mostly in mitochondria of liver and kidney
- Purpose oxidative deamination is to provide NH_3 for urea synthesis and α-Keto acids for a variety of reactions including energy generations.

C. Decarboxylation

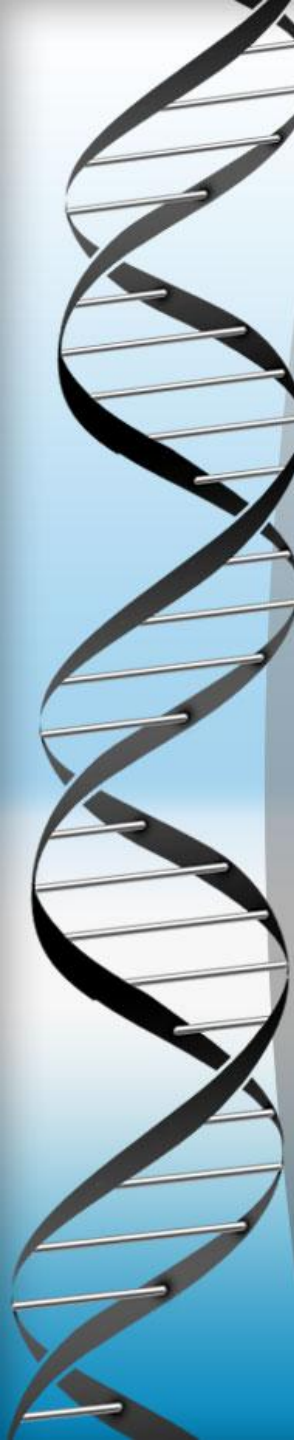
Few a.a undergo decarboxylation reaction in animal tissues to produce metabolically important primary amines.

e.g : A.A histidine is decarboxylation in the presence of histidine decarboxylase converted to histamine



Histidine

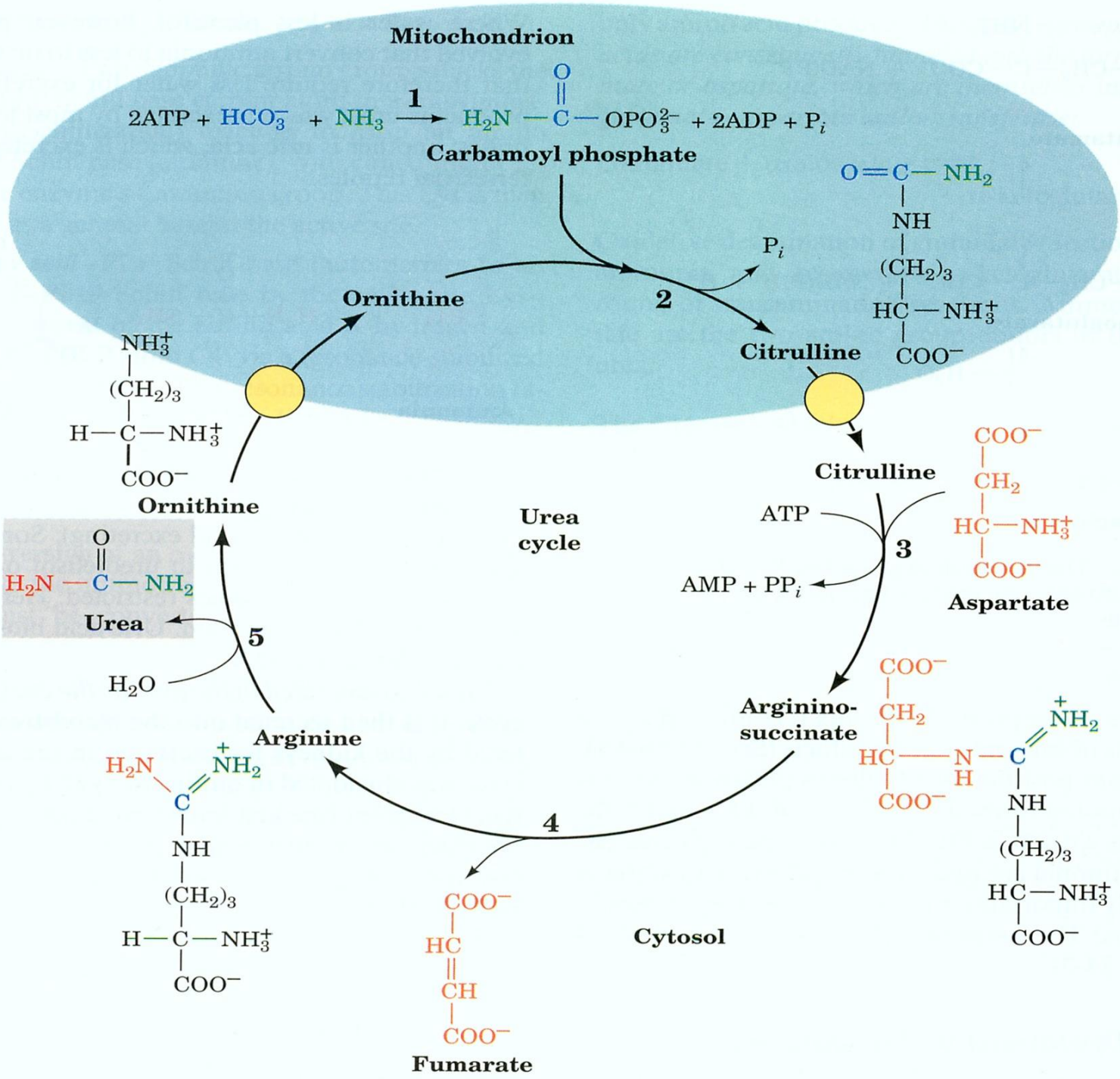
Histamine



Urea Cycle

A metabolic process by which ammonia derived from amino acids is converted into urea in the liver.

- Ammonia is formed as a result of deamination and transamination of a.a,
- The ammonia which is formed may be excreted such ammonia but only in very small amount,
- Certain amount of ammonia is reused in the biosynthesis of new a.a by amination α-keto acids .

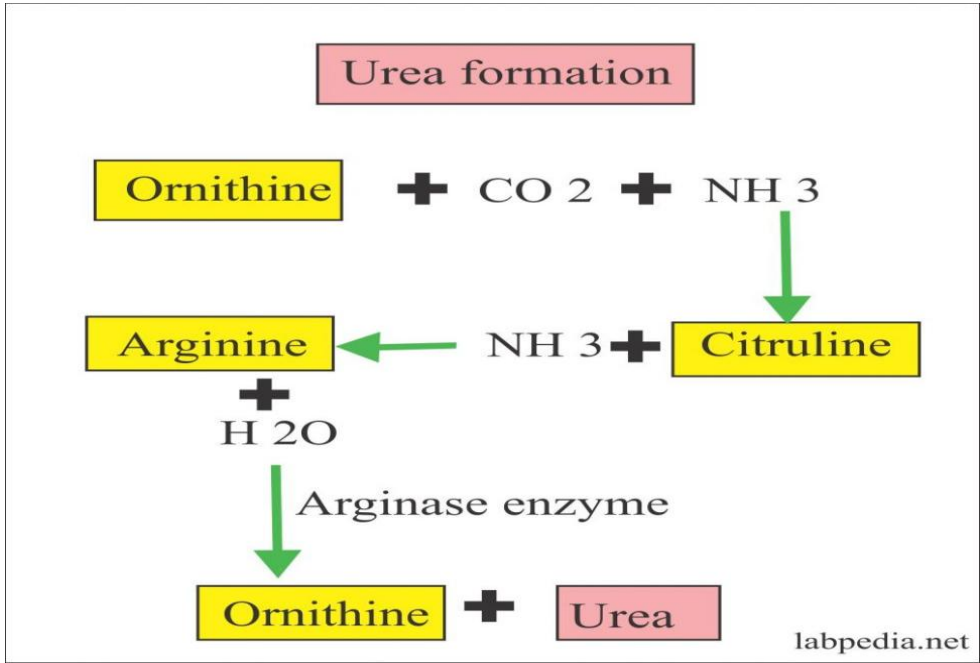

Mitochondrion
2ATP + HCO3− + NH3
1
H2N — C(=O) — OPO3 2− + 2ADP + Pi
Carbamoyl phosphate
Ornithine
2
Pi
Citrulline
Citrulline
ATP
3
AMP + PPi
Aspartate
Arginino-succinate
4
Arginine
5
H2O
Urea
Ornithine
Urea cycle
Fumarate
Cytosol

Urea formation

- Liver is the only organ which can form urea and all the enzymes involved have been isolated from the liver tissues.
- Kidney, can form up to arginine but cannot form urea as enzyme arginase is absent in kidney tissues.
- Brain, can synthesize urea if citrulline is available but lacks the enzyme ornithine transcarbamoylase which forms citrulline from ornithine.

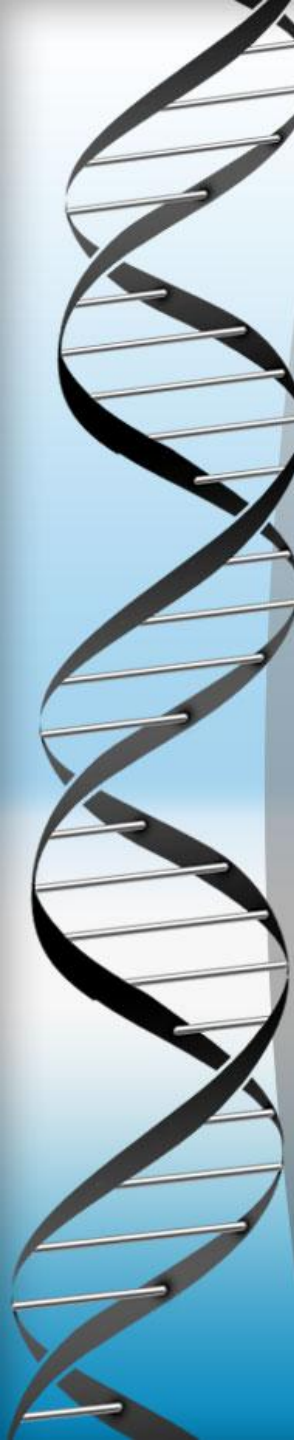
Sources of nitrogen (NH2 groups) in urea cycle:

- Urea contains two nitrogen (NH2 groups) one nitrogen of NH2 group is derived from the NH3 (NH4+ ion) (Reaction 1),
- Other nitrogen of NH2 group is provided by aspartic acid (Reaction 3).



Energetics of the Urea cycle

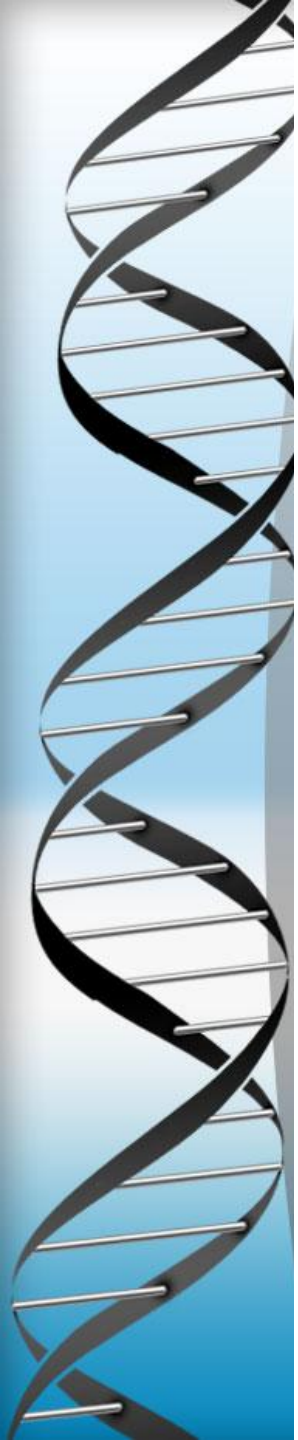
- Three (3) molecules of (ATP) are utilized for formation of one molecule of urea in urea cycle.
- 2 ATPs used to make up carbamoyl Phosphate.
- 1 ATP to make up Argininosuccinate.



Nitrogen Balance

Normal Nitrogen Balance is a state where the amount of N ingested each day is balanced by the amount excreted resulting no net change in the amount of the body Nitrogen.

1. Positive Nitrogen Balance
2. Negative Nitrogen Balance



Positive Nitrogen Balance

If the amount of N consumed exceeds the amount of N lost, the person is said to be in +N balance, which occur mainly during:

1. Pregnancy and during feeding after starvation.
2. Growing children who are increasing their body weight (incorporating more a.a into protein than they breakdown).

Negative Nitrogen Balance

Intake of N is less than the output of N is said to have a – N balance.

Occurs in;

1. Injury
2. Net destruction of tissue
3. Trauma
4. Illness
5. Old age