Nitrogen Balance in Fishes

Nitrogen Balance

Nitrogen balance means dietary intake of Nitrogen equals to the daily loss of Nitrogen through Gills (G), Urine(U) and Faeces (F)

Nitrogen balance= Daily N2 Intake= Daily N2 Loss via G+U+F

- As heterotrophic organism, there is usually an imbalance in the proportion of the major components (e.g. Carbohydrates, lipids, proteins) of foodstuff taken in vs. the proportions of these component required for growth, maintenance and reproduction.
- Excess intake of protein rich diets, leads to the accumulation of nitrogen in the body as ammonia or urea through deamination and oxidation of amino acids (building blocks of protein).
- Although, ammonia is useful for rebuilding amino acid, but this form of nitrogen is most toxic. Other less toxic form is urea but are costly to synthesize (in ATP equivalents).
- So, to maintain the cellular or body equilibrium in term of nitrogen, the waste nitrogen either in the form of ammonia or urea must be excreted from the body.
- The entire mechanism of nitrogen balance involve the several process by which waste nitrogen is produced and excreted in fishes.

Why ammonia Toxic ?

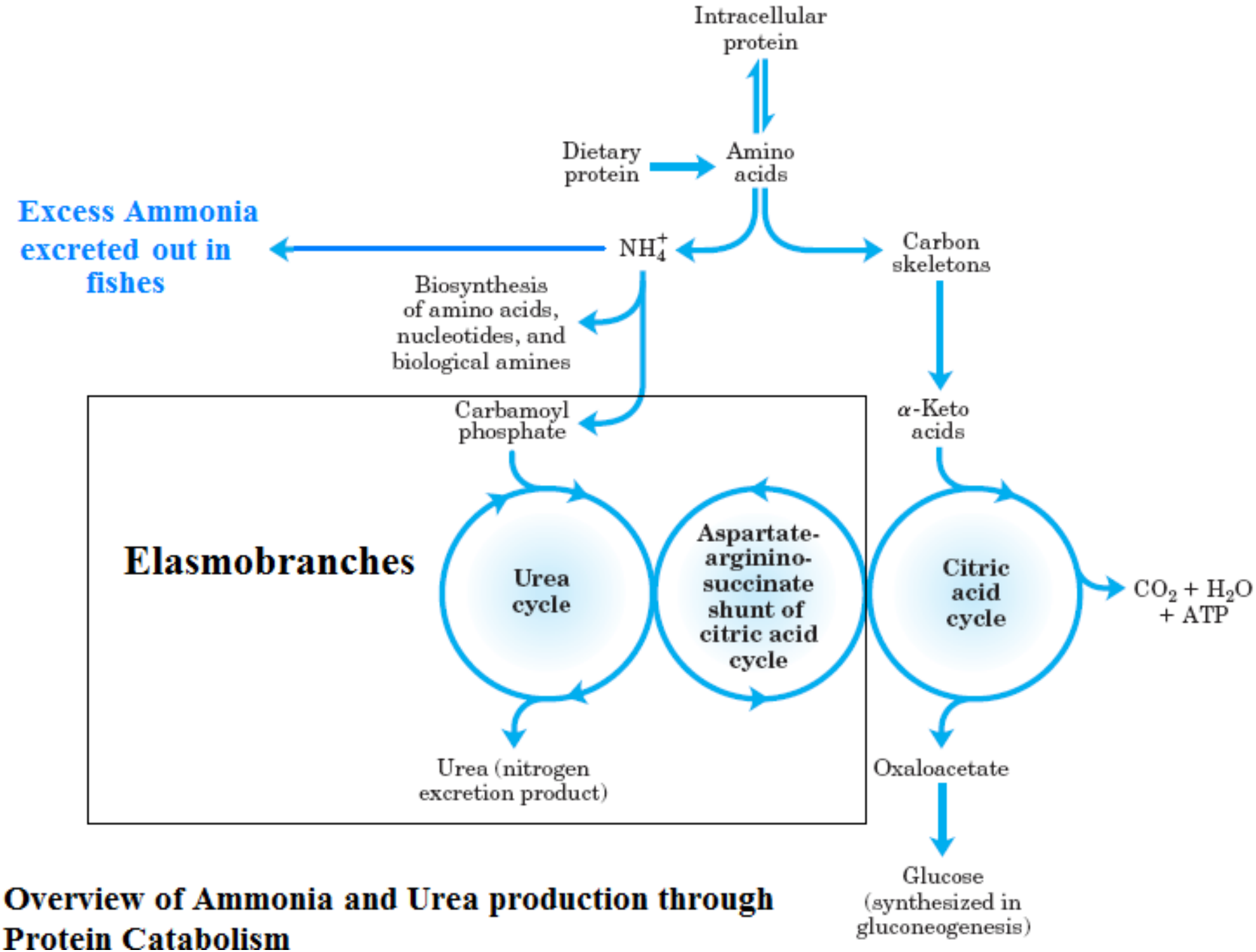
- NH3 accumulation could push or pull bio-chemicals by single mass action effects. For example, NH3 could potentially drive the glutamate dehydrogenase reaction far towards glutamate, potentially depleting the Krebs cycle intermediates (via =ketoglutarate).
- If NH3 were produced in large quantities metabolically, as a strong base it could combine with protons to elevate blood and intracellular pH, perhaps to level incompatible with macromolecular function.
- If NH_4^+ were accumulated to high level, it could disrupt the normal trans-membrane movements of other ions, for example, by its substitution for Na+ and K+ in ion transport pathways.

Why Urea is toxic ?

- It is less toxic than ammonia because it exist in single form, a non charged molecule and does not exert direct electrochemical, acid-base or gaseous effect.

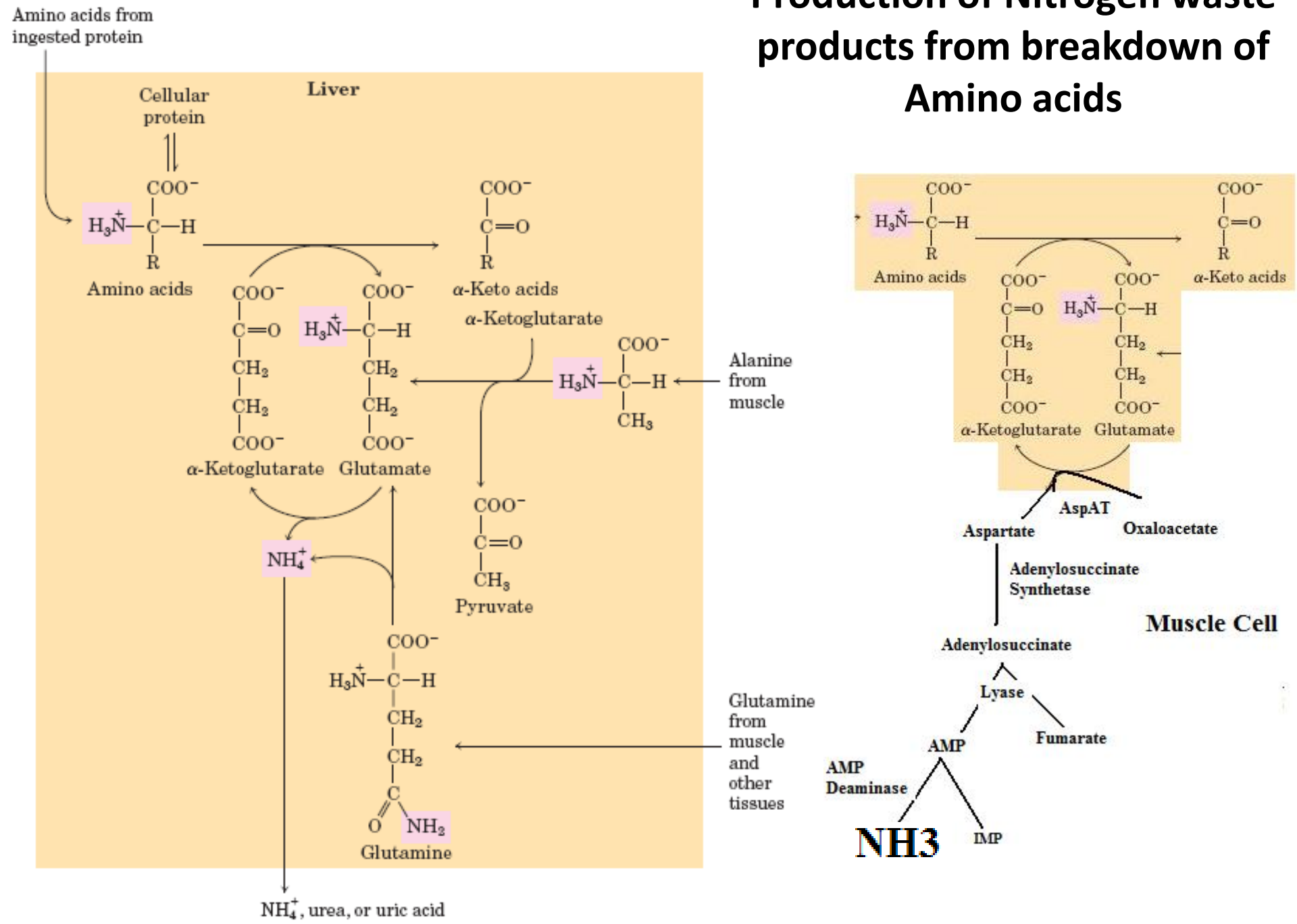
- But the high concentration of urea cause destablizing effects on the cell macromolecules (eg. Proteins).

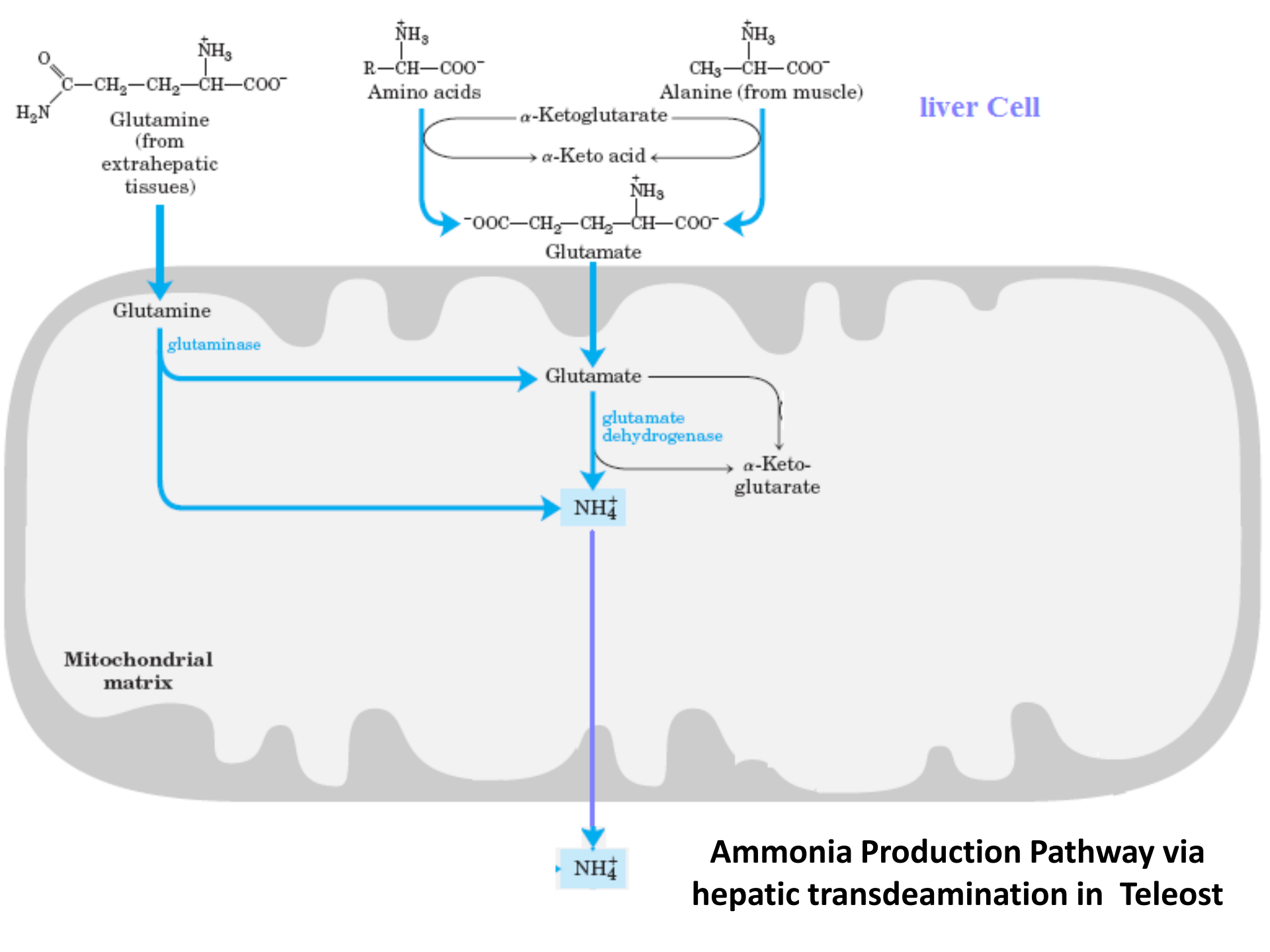
- Organism which accumulate urea to high levels for osmo-regulation have adopted a “counteracting solute strategy” in which high concentration of TMAO, with opposing (stabilizing) effects on macromolecules are accumulated in tandem.



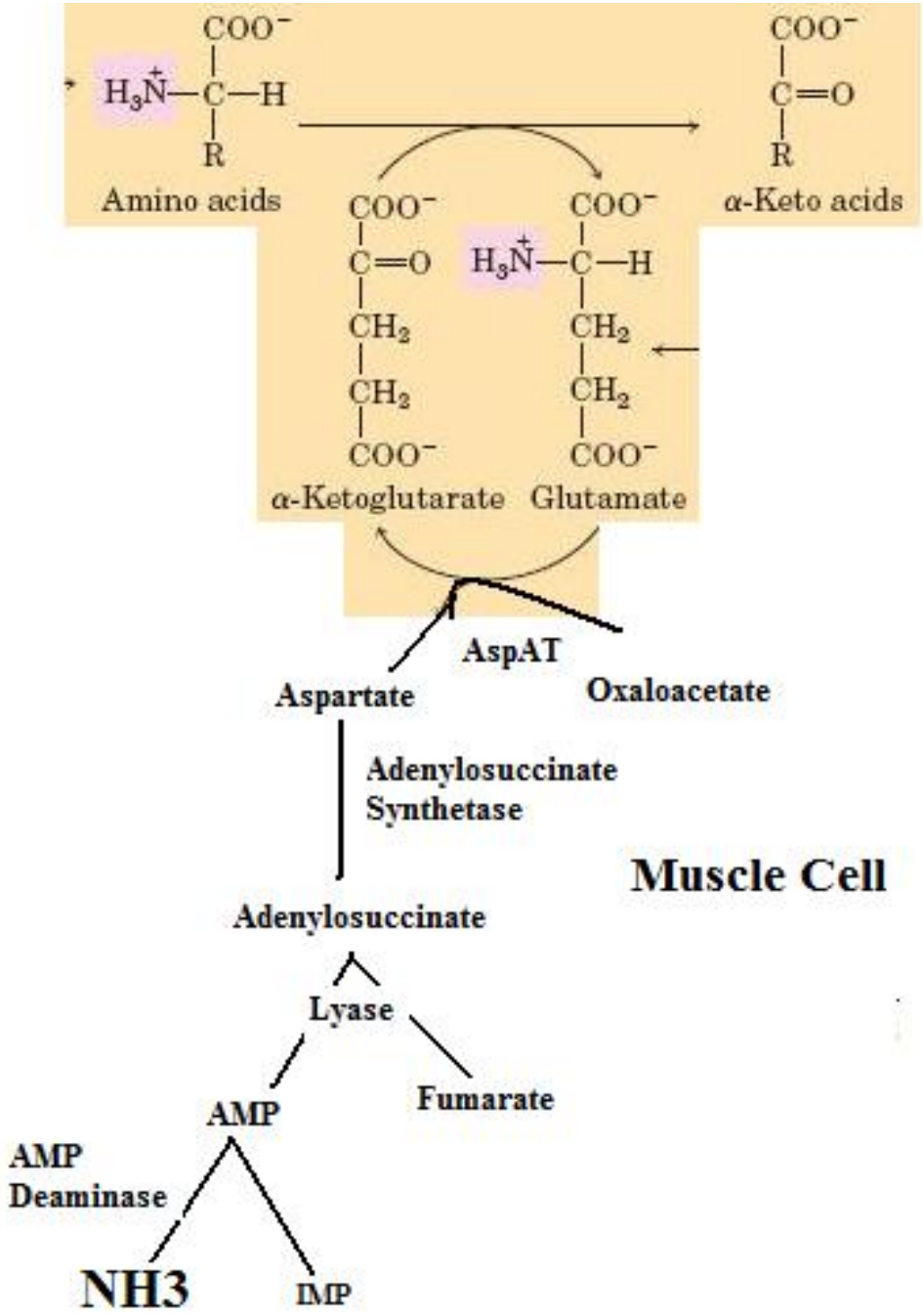
Overview of Ammonia and Urea production through Protein Catabolism

Production of Nitrogen waste products from breakdown of Amino acids



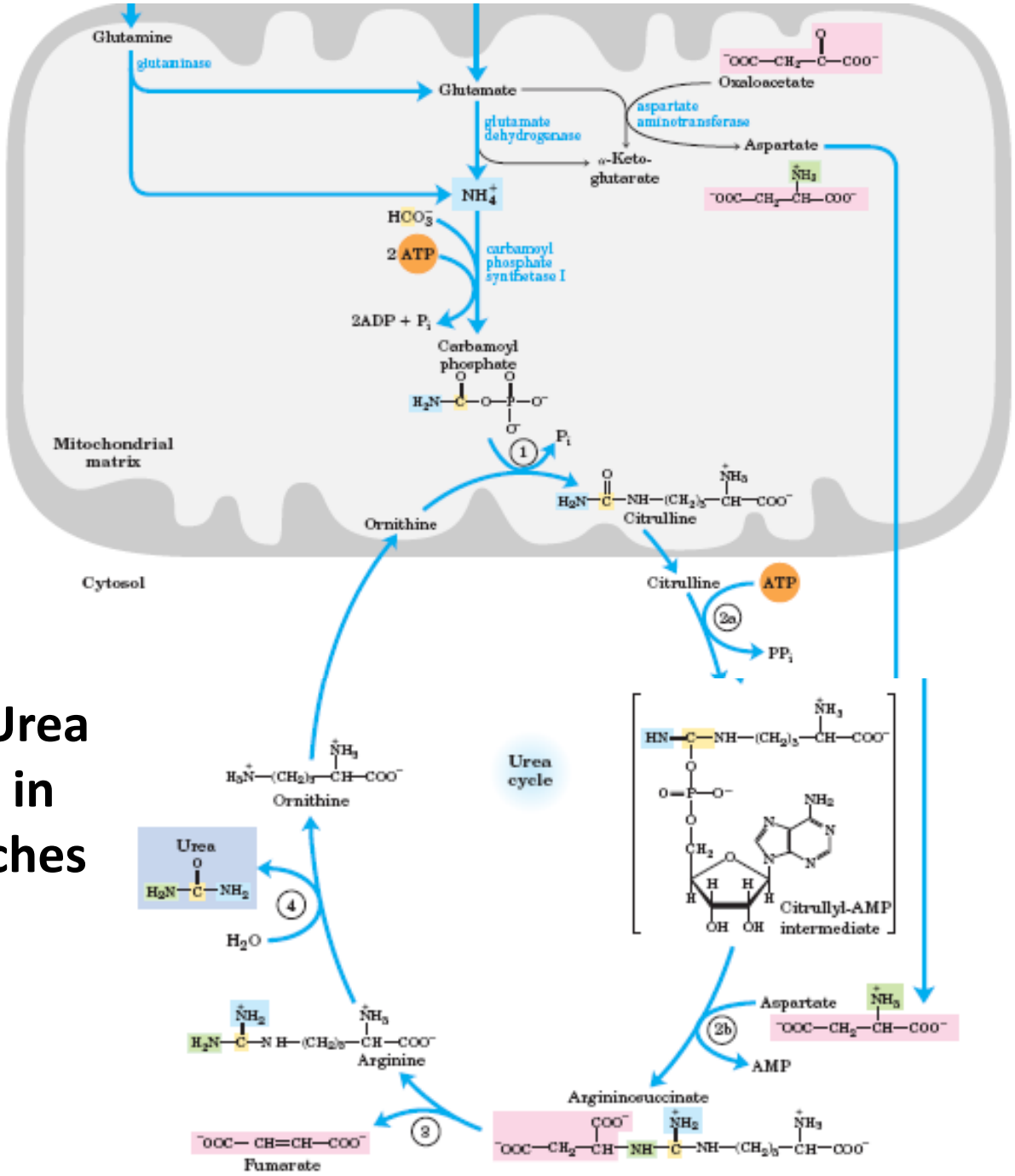


Ammonia Production Pathway via hepatic transdeamination in Teleost



Ammonia Production via Purine nucleotide cycle in Fish Muscle

Pathway of Urea Production in Elasmobranches



Transport of Ammonia from Plasma to water

From liver or muscle cells it diffuse into the blood vessels along the concentration gradient and get dissolved into the blood plasma from where it goes to gills and excreted out by following three mechanism:

- **Direct Diffusion of NH_3 from blood to water**
- **Direct Diffusion of NH_4^+ from blood to water**
- **Functional Na^+/NH_4^+ exchange channel located at the apical membrane of gill cells**

Transportation of Urea

- Urea can diffuse through the lipid bilayer of the plasma membrane, so some amount of urea excreted by simple diffusion through plasma membrane of haepatocyte and gill cells

- Most of the urea transported and excreted out from body by the help of **urea transporter** (transporter protein) which are present on the membrane of haepatocytes, RBCs and Gill cells.