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Name of the presenter: Marielou Ferrao,Ph.D.

Assistant Professor

St Xaviers College Mapusa-Goa

The amino nitrogen is excreted in 3 different forms in various types of life-forms

(a) as ammonia in most aquatic vertebrates, bony fishes and amphibian larvae

(b) as urea in many terrestrial vertebrates including man, (c) as uric acid in reptiles and birds

In the **urea cycle**, a mole of ornithine combines with one mole of ammonia and one of carbon dioxide to form citrulline. A second amino group is added to citrulline to form arginine. Arginine is then hydrolyzed to yield urea with concomitant regeneration of ornithine. Ureotelic animals have large amounts of the enzyme arginase in the liver. This enzyme catalyzes the irreversible hydrolysis of arginine to urea and ornithine. The ornithine is then ready for the next turn of the urea cycle. The urea is passed via the bloodstream to the kidneys and is excreted into the urine.

The ammonium ion generated in liver mitochondria is immediately used, together with carbonate produced by mitochondrial respiration, to form carbamoyl phosphate in the matrix. This ATP-dependent reaction is catalysed by carbamoyl phosphate synthetase I, a regulatory enzyme present in liver mitochondria. The formation of ammonium ion by glutamate dehydrogenase, its incorporation into carbamoyl phosphate, and the subsequent synthesis of citrulline occur in the mitochondrial matrix. In contrast, the next 3 reactions of the urea cycle, which lead to the formation of urea, takes place in the cytosol. Of the 6 amino acids involved in urea synthesis, one, N-acetylglutamate functions as an enzyme activator rather than as an intermediate. The remaining 5 amino acids — aspartate, arginine, ornithine, citrulline and argininosuccinate — all function as carriers of atoms which ultimately become urea. There is thus no net loss or gain of ornithine, citrulline, argininosuccinate or arginine during urea synthesis; however, ammonia, carbon dioxide, ATP and aspartate are consumed. The citric acid cycle and urea cycle both are linked to form "Krebs bicycle". The fumarate produced in the cytosol by argininosuccinate lyase reaction is also an intermediate of the citric acid cycle. Fumarate enters the citric acid cycle

in the the mitochondrion where it is first hydrated to malate by fumarase which, in turn, is oxidized to oxaloacetate by malate dehydrogenase. The oxaloacetate accepts an amino group from glutamate by transamination, and the aspartate thus formed leaves the mitochondrion and donates its amino group to the urea cycle in the argininosuccinate synthetase reaction; the other product of this transamination is α -ketoglutarate, another intermediate of the citric acid cycle.

Stickland fermentation or The **Stickland Reaction**, is the name for a chemical reaction that involves the coupled oxidation and reduction of amino acids to organic acids. The electron donor amino acid is oxidised to a volatile carboxylic acid one carbon atom shorter than the original amino acid. Alanine with a three carbon chain is converted to acetate with two carbons. The electron acceptor amino acid is reduced to a volatile carboxylic acid the same length as the original amino acid. Glycine with two carbons is converted to acetate. In this way, amino acid fermenting microbes can avoid using hydrogen ions as electron acceptors to produce hydrogen gas. Amino acids can be Stickland acceptors, Stickland donors, or act as both donor and acceptor. Only histidine cannot be fermented by Stickland reactions, and is oxidised. With a typical amino acid mix, there is a 10% shortfall in Stickland acceptors, which results in hydrogen production. Under very low hydrogen partial pressures, increased uncoupled anaerobic oxidation has also been observed. It occurs in proteolytic clostridiums such as: *C. perfringens*, *C. difficile*, *C. sporogenes*, and *C. botulinum*.

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