Urea Cycle

The urea cycle is a process for excess nitrogen to be broken down and excreted by the kidneys. This biochemical pathway converts ammonia to urea, and takes place in both the liver and the kidneys.



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Mitochondria

N-Acetylglutamate
Seagull-glue-tomato
The urea cycle begins in the mitochondrial matrix. Here, N-acetylglutamate serves as an activator for this process, working to allosterically activate carbamoyl phosphate synthetase I.

Carbamoyl Phosphate Synthetase I
Cardboard-mole Synthesizer
Carbamoyl phosphate synthetase is the first enzyme involved in the urea cycle. It takes ammonia (NH3), bicarbonate (HCO3), and two molecules of ATP, using them to eventually form carbamoyl phosphate. Of note, during this reaction, the bicarbonate is converted to CO2 and H2O, so other interpretations of this first step can also show NH3 + CO2 being converted by this enzyme.

NH3 + CO2
Ammo and CO2 Molecule
Carbamoyl phosphate synthetase I takes NH3 and CO2 (Converted to CO2 and H2O from HCO3), as well as two ATP molecules to produce carbamoyl phosphate.

Carbamoyl Phosphate
Cardboard-mole
Carbamoyl phosphate enters the urea cycle as a substrate for ornithine transcarbamylase, which converts this substrate and ornithine into citrulline.

Ornithine Transcarbamylase
Hornet-Train made of cardboard
Ornithine transcarbamylase synthesizes citrulline with the help of ornithine which accepts the substrate carbamoyl phosphate in this reaction.

Citrulline
Citrus-Crystals
Citrulline is synthesized from carbamoyl phosphate and ornithine. Citrulline can then react with aspartate in an ATP-dependent step.

Cytosol

Aspartate
Ass-potato
The amine group in aspartate attacks the carbonyl carbon group on citrulline, working to form argininosuccinate, but can only do so with ATP and the enzyme argininosuccinate synthetase. Of note, this portion of the reaction occurs after transportation out of the mitochondrial matrix to the cytosol of liver cells.

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Argininosuccinate

Orange-suckers

Argininosuccinate is formed by citrulline and aspartate in a reaction requiring ATP. The enzyme arginosuccinase promotes the breakdown of argininosuccinate into arginine and fumarate.

Fumarate

Fuming

Argininosuccinate is cleaved into arginine and fumarate. Fumarate is then used in the citric acid cycle, helping to form malate and later, oxaloacetate.

Arginine

Orange-in-jeans

The arginine produced in the earlier step is then broken down by arginase to produce urea and ornithine, with the addition of water.

H2O to Urea

Water changing into U-rainbow colors

The enzyme arginase combines H20 and arginine, synthesizing urea and ornithine. This urea is excreted out of the body in urine via the kidney.

Ornithine

Hornets

The ornithine produced in the previous step is recycled back to the mitochondria to be used in the next urea cycle.

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