25.4: The Urea Cycle

Learning Objectives

- Describe the urea cycle reactions.

Deamination of amino acids results in the production of **ammonia** (as well as the ammonium ion, NH_4^+). Ammonia is an extremely toxic base and its accumulation in the body would quickly be fatal. Animals that live in aquatic environments tend to release ammonia into the water. Terrestrial organisms have evolved other mechanisms to excrete nitrogenous wastes. These animals must detoxify ammonia by converting it into a relatively nontoxic form such as urea or uric acid. Mammals, including humans, produce urea through the **urea cycle**, whereas reptiles and many terrestrial invertebrates produce uric acid. Animals that secrete urea as the primary nitrogenous waste material are called ureotelic animals.

The Urea Cycle

The urea cycle is the primary mechanism by which mammals convert ammonia to urea. Urea is made in the liver and excreted in urine. The overall chemical reaction by which ammonia is converted to urea is 2 NH_3 (ammonia) + CO_2 + 3 ATP + H_2O → H_2N-CO-NH_2 (urea) + 2 ADP + 4 P_i + AMP.

The urea cycle utilizes five intermediate steps, catalyzed by five different enzymes, to convert ammonia to urea, as shown in Figure 25.4.1. The amino acid L-ornithine gets converted into different intermediates before being regenerated at the end of the urea cycle. Hence, the urea cycle is also referred to as the ornithine cycle. The enzyme ornithine transcarbamylase catalyzes a key step in the urea cycle and its deficiency can lead to accumulation of toxic levels of ammonia in the body. The first two reactions occur in the mitochondria and the last three reactions occur in the cytosol. Urea concentration in the blood, called blood urea nitrogen or BUN, is used as an indicator of kidney function.

Figure 25.4.1: The urea cycle converts ammonia to urea.

Note Everyday Connection: Gout

Mammals use uric acid crystals as an antioxidant in their cells. However, too much uric acid tends to form kidney stones and may also cause a painful condition called gout, where uric acid crystals accumulate in the joints, as illustrated in Figure 25.4.2 Food choices that reduce the amount of nitrogenous bases in the diet help reduce the risk of gout. For example, tea, coffee, and chocolate have purine-like compounds, called xanthines, and should be avoided by people with gout and kidney stones.

Figure 25.4.2 Gout causes the inflammation visible in this person's left big toe joint. (credit: "Gonzosft"/Wikimedia Commons)

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