41.2B: Nitrogenous Waste in Birds and Reptiles: Uric Acid

Birds and reptiles have evolved the ability to convert toxic ammonia into uric acid or guanine rather than urea.

Learning Objectives

• Compare the major byproduct of ammonia metabolism in mammals to that of birds and reptiles

Key Points

• Nitrogenous wastes in the body tend to form toxic ammonia, which must be excreted.
• Mammals such as humans excrete urea, while birds, reptiles, and some terrestrial invertebrates produce uric acid as waste.
• Uricothelic organisms tend to excrete uric acid waste in the form of a white paste or powder.
• Conversion of ammonia into uric acid is more energy intensive than the conversion of ammonia into urea.
• Producing uric acid instead of urea is advantageous because it is less toxic and reduces water loss and the subsequent need for water.

Key Terms

• urea: a water-soluble organic compound, CO(NH2)2, formed by the metabolism of proteins and excreted in the urine
• guano: the excrement of seabirds, cave-dwelling bats, pinnipeds, or birds more generally
• purine: any of a class of organic heterocyclic base containing fused pyrimidine and imidazole rings; they are components of nucleic acids
• **xanthine**: a precursor of uric acid found in many organs of the body
• **hypoxanthine**: an intermediate in the biosynthesis of uric acid
• **uric acid**: a bicyclic heterocyclic phenolic compound, formed in the body by the metabolism of protein and excreted in the urine

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**Nitrogenous Waste in Birds and Reptiles: Uric Acid**

Of the four major macromolecules in biological systems, both proteins and nucleic acids contain nitrogen. During the catabolism, or breakdown, of nitrogen-containing macromolecules, carbon, hydrogen, and oxygen are extracted and stored in the form of carbohydrates and fats. Excess nitrogen is excreted from the body. Nitrogenous wastes tend to form toxic ammonia, which raises the pH of body fluids. The formation of ammonia itself requires energy in the form of ATP and large quantities of water to dilute it out of a biological system.

While aquatic animals can easily excrete ammonia into their watery surroundings, terrestrial animals have evolved special mechanisms to eliminate the toxic ammonia from their systems. The animals must detoxify ammonia by converting it into a relatively-nontoxic form such as urea or uric acid.

**Figure 

Figure 

Birds, reptiles, and most terrestrial arthropods, such as insects, are called uricothelic organisms because they convert toxic ammonia to uric acid or the closely-related compound guanine (guano), rather than urea. In contrast, mammals (including humans) produce urea from ammonia; however, they also form some uric acid during the breakdown of nucleic acids. In this case, uric acid is excreted in urine instead of in feces, as is done in birds and reptiles.

Uric acid is a compound similar to purines found in nucleic acids. It is water insoluble and tends to form a white paste or powder. The production of uric acid involves a complex metabolic pathway that is energetically costly in comparison to processing of other nitrogenous wastes such as urea (from the urea cycle) or ammonia; however, it has the advantages of reducing water loss and, hence, reducing the need for water.

Uric acid is also less toxic than ammonia or urea. It contains four nitrogen atoms; only a small amount of water is needed for its excretion. Out of solute, it precipitates and forms crystals. The enzyme xanthine oxidase makes uric acid from xanthine and hypoxanthine, which in turn are produced from other purines. Xanthine oxidase is a large enzyme whose active site consists of the metal, molybdenum, bound to sulfur and oxygen. Uric acid is released in hypoxic conditions.

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