

what water can buy you: ammonia, urea or uric acid, and the kidney that concentrates the last drop



Excretion, Defined Against Digestion

- metabolism (catabolic + anabolic) produces by-products that must leave the body: metabolic waste products
- unlike digestive waste (unabsorbed food, never entered a cell), metabolic waste forms inside body cells
- excretory products in humans: water, CO₂, nitrogenous wastes (ammonia, urea, uric acid), creatinine
- also excess mineral salts, and bile pigments: bilirubin via faeces, urochrome via urine
- also excess vitamins, hormones and drugs, and volatile spice compounds via the lungs
- excess amino acids cannot be stored, so they undergo deamination: the amino group is removed
- deamination forms toxic ammonia, excreted as-is or converted to a less toxic form first

One Deamination Product, Three Exits *

how much water can the animal afford to spend diluting ammonia?

plenty of water

Ammonotelism

excrete ammonia directly, ~300-500 ml water per gram; energy-cheap but water-expensive

some water, must conserve

Ureotelism

convert to urea first, ~50 ml water per gram; less toxic, moderately soluble

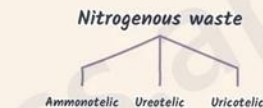
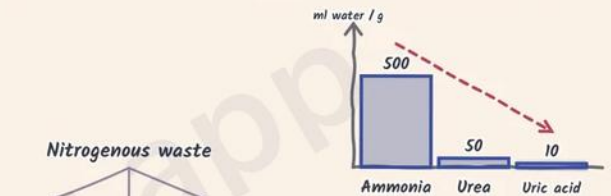
very little water

Uricotelism

convert to uric acid, ~5-10 ml water per gram or none; energy-expensive but almost water-free

toxicity runs the opposite way to water cost: ammonia is most toxic and cheapest to make, uric acid is least toxic and costliest to make

Three Routes for One Waste Molecule



one deamination product, ammonia, splits three ways depending on how much water the animal can spend diluting it

approximate water spent per gram of waste excreted (upper end of each range): ammonia costs the most water, uric acid the least

Who Uses Which Route *

Ammonotelic

aquatic invertebrates, bony fishes, aquatic/larval amphibians, protozoa (contractile vacuole only, no organ)

Ureotelic

mammals, cartilaginous fishes (sharks, rays), many aquatic reptiles, most adult amphibians. liver's ornithine/urea cycle, 3 ATP per urea

Uricotelic

birds, many reptiles, land snails, some insects, via the inosinic acid pathway in the liver

habitat, not phylogeny, predicts the waste type: a tadpole is ammonotelic in water, the adult frog turns ureotelic on land. spiders, scorpions and penguins excrete guanine instead: guanotelism

