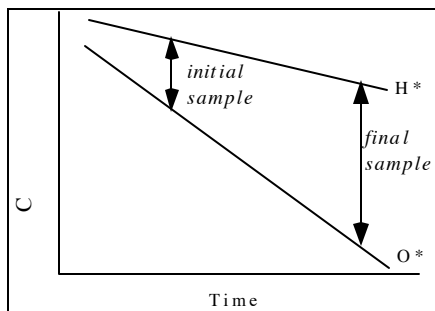


USING DOUBLY-LABELED WATER TO ESTIMATE FIELD METABOLIC RATES

Appendix to Metabolism II

Doubly-labeled water is used to estimate CO₂ production and thus the metabolic rate in free ranging animals. The technique works well on most free-living, unrestrained, terrestrial animals in nature. The technique measures the washout rates of isotopes of H* and O* [such as ¹⁸O and ³H, hence "doubly labeled"], which are injected as water into animals in nature. The hydrogen isotope is lost as body water (urine, sweat, breathing) and is replaced as new, unlabeled water is added from water in food and drink. The oxygen isotope (O*) is lost not only in water, but also in CO₂ as a byproduct of metabolism. Consequently the loss rate for O* is steeper than that for H*. Thus the greater the CO₂ production and hence metabolic rate, the greater the **difference** between the slopes of H* and O* washout. The method works well with most animals, except aquatic ones, where turnover rates of water are too high.



Method -- A known quantity of doubly labeled water is injected into an animal, allowed to equilibrate with bodily fluids, and then a baseline blood sample (H*:O*) is taken. At a future time (1 day in a small bird, 1 week in a small lizard), a second sample is taken and the new isotope concentrations are measured. Using calibrations from lab studies, one can convert these ratios into estimates of CO₂ production, which are easily converted to metabolic rates. Note that doubly labeled water can also be used to

estimate the rate of water turnover (flux) in the animal as well as feeding rate (see Nagy 1989).

Accuracy -- Predicts CO₂ production (under laboratory conditions) to within 3% -8%. Recall, however, that CO₂ is inherently less reliable than is O₂ consumption. Why?

Limitations -- Cost has been the major limitation, especially for large animals that require a large dose of doubly labeled water. New methods have reduced the cost of dosages, but the costs on analyses are still high.

➔ Homework – Draw a graph like the one above, but for an animal with a higher metabolic rate.

References:

Nagy, K.A. 1989. Doubly-labeled water studies in vertebrate physiological ecology, pp. 270-287. In P. W. Rundel, et al., eds., 1989, Stable Isotopes in Ecological Research.