

## Desert Tortoise *Gopherus agassizii*: Cutaneous Water Loss

**Abstract.** *Evaporative water loss from the integument of the desert tortoise Gopherus agassizii constitutes a major proportion of the water loss, but is far less than in tortoises from wetter regions. Respiratory water loss also is less.*

We have shown that, contrary to previous assumptions, the skin of reptiles is a major avenue for water loss (1). We also found that evaporation from the skin was less in certain species that live in dry rather than in wetter areas. Thus the lizard *Iguana iguana*, a dweller in tropical forests, loses water about five times as rapidly as the lizard *Sauromalus obesus*, which lives in hot desert regions. This finding suggests that in lizards there may be adaptation of the integument, associated with aridity of the habitat. Lizards and tortoises have evolved separately for a very long period, and so it was of interest to learn whether water losses differ similarly in tortoises. We shall show that comparison of the desert tortoise *Gopherus agassizii* with the box turtle, *Terapene carolina*, suggests that such differences do indeed exist in the Chelonia.

Total water loss was determined (1) from changes in weight, after correction for metabolic loss of carbon. Water loss from the respiratory tract (head) was determined separately by enclosing the trunk and limbs in a thick plastic bag containing anhydrous  $\text{CaSO}_4$  (Drierite) to absorb water lost from the skin. The surface area was calculated according to the formula of Benedict (2); oxygen consumption was determined with a Beckman paramagnetic oxygen analyzer.

Evaporative water losses from the desert tortoise were measured at 23° and 35°C, the latter temperature probably being more "normal" (Table 1). Evaporation from the desert tortoise was far less than from the two other chelonians previously examined (1). Thus the cutaneous water loss at 23°C was 12.2 mg cm<sup>-2</sup> day<sup>-1</sup> in the aquatic species *Pseudemys scripta*, 5.3 mg in the forest dweller *T. carolina*, and only 1.5 mg in *Gopherus*. The respiratory water losses in *Gopherus* were also less. The integument, however, remained a major avenue of water loss at both 23° and 35°C.

In previous tests the lizard *S. obesus*

Table 1. Evaporative water loss from the desert tortoise *Gopherus agassizii* in dry air at 23°C (6 animals) and 35°C (5 animals); means  $\pm$  S.E. Animals weighed 725 to 2600 g; mean, 1770 g. BW, body weight.

T (°C)	Oxygen consump- tion (ml g <sup>-1</sup> BW day <sup>-1</sup> )	Water loss					
		Total		Respiratory		Cutaneous	
		Per- centage BW (per day)	Weight (mg cm <sup>-2</sup> day <sup>-1</sup> )	Weight (mg g <sup>-1</sup> BW day <sup>-1</sup> )	Relation (mg H <sub>2</sub> O: ml O <sub>2</sub> )	Weight (mg cm <sup>-2</sup> day <sup>-1</sup> )	Percent- age of total loss
23°C	0.26 $\pm$ 0.04	0.17 $\pm$ 0.03	2.0 $\pm$ 0.22	0.4 $\pm$ 0.12	1.5 $\pm$ 0.42	1.5 $\pm$ 0.21	76 $\pm$ 3.8
35°C	.47 $\pm$ .05	.34 $\pm$ .05	3.8 $\pm$ .54	1.6 $\pm$ .15	4.0 $\pm$ .65	2.1 $\pm$ .36	52 $\pm$ 4.5

lost water less rapidly than the other reptiles, but it was the only representative from a desert. It is interesting that water losses from the integument and respiratory tract of *Gopherus* are similar to those in *Sauromalus*; the former has a far lower rate of oxygen consumption than *Sauromalus* but loses more water relative to the amount of oxygen consumed, and the similarity in respiratory loss of water is therefore fortuitous. The difference is probably caused by a greater extraction of oxygen by *Sauromalus* from the inspired air. We have shown (3) that *Sauromalus* may have periodic or discontinuous breathing and may extract oxygen

from the inspired air at levels as low as 5 percent; such a mechanism may contribute to the above differences.

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### References and Notes

1. P. J. Bentley and K. Schmidt-Nielsen, *Science* **151**, 1547 (1966).
2. F. G. Benedict, *Carnegie Inst. Washington Publ. No. 425* (1932).
3. K. Schmidt-Nielsen, E. C. Crawford, P. J. Bentley, *Federation Proc.* **25**, 1787 (1966).
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## Nucleotide Formation as a Determinant of 5-Fluorouracil Response in Mouse Leukemias

**Abstract.** *Survival of mice bearing different transplantable leukemias and treated with 5-fluorouracil was compared with accumulation of drug nucleotides in vitro. There was significant correlation, suggesting that cellular capacity for conversion of the drug to nucleotides is a major determinant of inherent drug sensitivity of these leukemias.*

Transplantable mouse leukemias show various responses to the drug, 5-fluorouracil, ranging from almost complete resistance to "cures" (1). We incubated suspensions of 15 lines of murine leukemia with radioactive 5-fluorouracil and examined the intracellular disposition of the drug in order to find a basis for the variation in response observed. The rate of uptake of radioactive 5-fluorouracil in vitro was roughly similar in all cells regardless of tumor line, and the uptake occurred by passive, temperature-insensitive diffusion (2). Some of the radioactivity which had accumulated failed to diffuse from the cells during their subsequent washing at 37°C in drug-free medium. The relative amount of this nondiffusible fraction varied considerably among the groups tested.

A correlation (Fig. 1) was found between the extent of drug conversion into nondiffusible metabolites in vitro and drug response in vivo. These metabolites were identified as a mixture of 5-fluorouracil nucleotides and RNA that contained 5-fluorouracil.

The methods we used for collection of ascitic fluid from tumor-bearing mice, isolation of cells, and incubations have been described (3). The uptake of the drug was measured by incubating portions of cell suspensions containing 7.5 mg of cells (wet weight) in 150  $\mu$ l of buffer (4) with 5-fluorouracil-2-C<sup>14</sup> (10  $\mu$ g/ml) (5) for 30 minutes at 37°C, then collecting cells by centrifugation. To measure drug conversion to nucleotides, the centrifuged cells were suspended in 300  $\mu$ l of buffer and incubated for 15 minutes at