

and the second one week before sampling, showed transport rates comparable to sea water adapted fish (Figure 2).

The present studies demonstrate that all water transport observed in vitro in the eel intestine was due to active metabolic processes and that the increase in water transport during sea water adaptation was due to an increase in sodium transport across the gut. However, a large component of water transport is not ouabain sensitive and may be due to the transport of other solutes. Gut water transport in the eel increases sharply during the first few days of sea water adaptation and then decreases to a level approximately twice as high as in freshwater eels. Similar increases in water transport can be obtained in guts from freshwater eels which have received injections of hydrocortisone or Depo Medrol.

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OSMOTIC AND DIFFUSIONAL WATER PERMEABILITY IN TADPOLES AND FROGS, Rana clamitans

William C. Mackay and Bodil Schmidt-Nielsen, Department of Biology, Case Western Reserve University, Cleveland, Ohio 44106

In one of the earliest biological experiments using isotopic tracers (Hevesy, Hofer and Krogh, *Skand. Arch. Physiol.* 72:199-214, 1935) it was found that the permeability of frog skin to water as measured by the unidirectional diffusion of heavy water, differed from the permeability as measured by net flux of water under an osmotic gradient (osmotic flux). The osmotic permeability of frog skin or (P_f) was found to be greater than the diffusional water permeability (P_d) by a factor of about 5. Later (Koefoed-Johnson and Ussing, *Acta Physiol. Scand.* 28:60-76, 1953), the conclusion was reached that water flux due to an osmotic gradient takes place as bulk flow through pores.

In the adult frog antidiuretic hormone (arginine vasotocin) greatly enhances the osmotic permeability with little effect on the diffusional permeability (Maetz, in Perspectives in Endocrinology. Barrington and Jorgensen, eds. New York: Acad. Press, 1969). Such a feature is advantageous for the amphibians as it allows them to rapidly take up water through the skin when they return to the pond. In the tadpole arginine vasotocin has only a very small effect on water balance (Alvarado and Johnson, *Comp. Biochem. Physiol.* 18:549-61, 1966). Furthermore, it has been found that the morphology of the tadpole skin differs from that of the frog and that the structure of the skin changes during metamorphosis (R. E. Taylor, personal communication). For these reasons we expected that the relationship between P_d and P_f in tadpoles might differ from that of the frog. We therefore set out to measure P_d and P_f in tadpoles and recently metamorphosed frogs of comparable size. Diffusional water flux was measured by using tritiated water. The method used was described for the leech (Schmidt-Nielsen and Pagel, *Bull. MDIBL* 8:61-62, 1968). The urine flow from animals placed in tap water was measured. Since the animals maintain a constant body weight and do not feed or drink during the experiments, the urine flow must equal the osmotic net water influx across the body surface (gills and skin). Diffusional water flux expressed as milliliters of net influx per kg body weight per hour (under the osmotic gradient existing between tap water and body fluid osmolalities) was significantly greater in 7 tadpoles

(1804 ± 1.11 SEM) than in 6 newly metamorphosed frogs (6.39 ± 0.45 SEM), but osmotic water influx was not significantly different in 6 tadpoles (23.1 ± 5.0 SEM) and 10 frogs (21.1 ± 2.1 SEM). Thus, osmotic flux was over 3 times greater than diffusional flux in the frog, but the two fluxes were not significantly different in tadpoles (Figure 1).

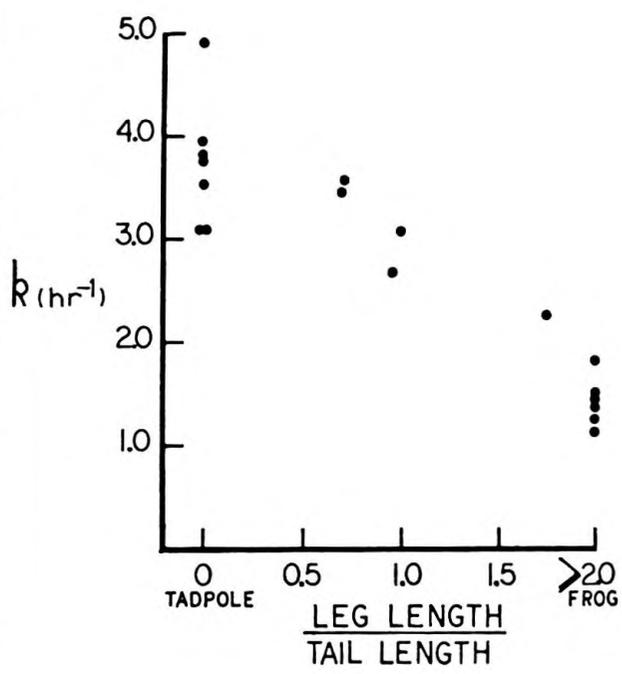
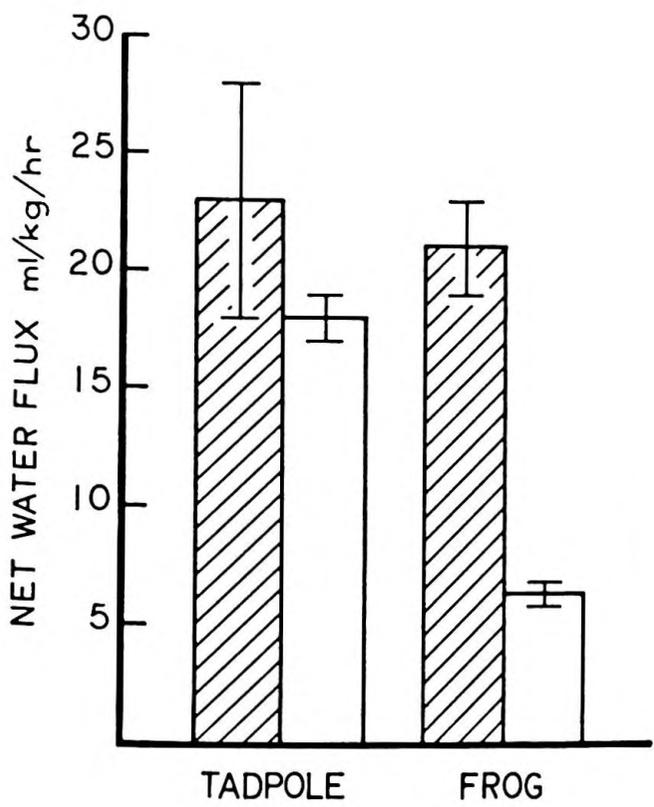


Figure 1. Net influx of water in tadpoles and frogs. Hatched bars show net osmotic influx determined by urine collection. Open bars show theoretical net water influx calculated from efflux of THO. Vertical lines indicate one standard error of the mean.

Figure 2. Changes in the rate constant, k, for tritiated water efflux during metamorphosis of *Rana clamitans* tadpoles. Each point represents a determination in a single animal.

Maetz et al (personal communication), have found that in fish no difference could be measured between diffusional and osmotic fluxes across the gills. Thus, pores permitting bulk flow of water might not necessarily be present in the skin or gills of fully aquatic forms such as fish and tadpole. In our studies we found a gradual decrease in diffusional flux in the integuments of the tadpole during the process of metamorphosis (Figure 2). This decrease in diffusional flux occurs at the same time as the skin undergoes morphological changes (Taylor, personal communication). However, more data are needed to confirm this observation. At this time we cannot distinguish between the changes that occur in the permeability of the skin and the change coming about as the gills disappear and the animal starts breathing by lungs. Further studies on animals in the process of metamorphosing should elucidate these problems.

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