

ENDOCRINE CONTROL OF SEAWATER ADAPTATION IN Anguilla rostrata

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Adaptation to seawater by freshwater eels involves an increase in the specific activity of Na-K-ATPase in gill filaments and intestinal mucosa. An influence of the endocrine glands on this process may be suspected from the fact that hypophysectomy or adrenalectomy performed on saltwater eels results in a high serum sodium and a reduced sodium outflux across the gills, restored to normal by cortisol.

In the present experiments, specimens of yellow Anguilla rostrata trapped in a freshwater pond were gradually adapted to seawater for one to three weeks. Daily injections of hydrocortisone as the hemisuccinate were given to other eels maintained in freshwater. Two dose levels were used: 50  $\mu\text{g}/100\text{ gm/day}$  for 7-10 days, and 400  $\mu\text{g}/100\text{ gm/day}$  for 7-14 days. The specific activity of Na-K-ATPase and Mg-ATPase was measured in gill filaments and intestinal mucosa (Jampol and Epstein, Bull. MDIBL 8:32, 1968). The results are summarized in Table 1.

Table 1

EFFECT OF SALTWATER ADAPTATION AND HYDROCORTISONE ON ATPase LEVELS IN GILL AND INTESTINE OF Anguilla anguilla

	N	Na-K-ATPase	Mg-ATPase
		Pi $\mu\text{M}/\text{mg protein/hour}$	
Freshwater gill	16	$4.6 \pm 1.2$	$9.4 \pm 5.6$
Saltwater gill	17	$6.8 \pm 1.4$	$8.5 \pm 2.6$
Low-dose cortisol gill	5	$7.7 \pm 2.3$	$7.6 \pm 2.1$
High-dose cortisol gill	11	$12.2 \pm 2.8$	$8.3 \pm 1.2$
Freshwater gut	5	$9.6 \pm 1.9$	$11.4 \pm 3.6$
Low-dose cortisol gut	5	$12.1 \pm 3.9$	$14.0 \pm 2.1$
High-dose cortisol gut	5	$17.9 \pm 6.6$	$21.7 \pm 3.5$

Values are mean  $\pm$  standard deviations.

Adaptation to salt water produced a 50% increase in Na-K-ATPase in gill filaments, from 4.6 to 6.8  $\text{M Pi}/\text{mg protein/hr}$  ( $p < 0.001$ ). The lower dose of hydrocortisone induced a rise in Na-K-ATPase in freshwater eels similar to that elicited by transfer to salt water. The high dose of hydrocortisone raised the enzyme level in freshwater gills even higher, to 12.2. Mg-ATPase in the gill was unchanged by transfer to saltwater or hydrocortisone injections. The activity of Na-K-ATPase and Mg-ATPase in intestinal mucosa, as well as the capacity of the isolated gut to transport water and salt (see W. MacKay, report #17 this issue), was increased by 400  $\mu\text{g}/100\text{ gm/day}$  of hydrocortisone. A striking and unexpected finding was that the ventral surface of freshwater eels injected with hydrocortisone for more than 7-10 days lost its yellow

coloration and turned silver, resembling the silver hue of eels spontaneously migrating to the sea. Freshwater eels prepared by 10 days of hydrocortisone injections ( $400 \mu\text{g}/100 \text{ gm/day}$ ) withstood sudden transfer to full strength seawater without preliminary residence in 50% seawater, and their plasma chloride did not rise as high as that of control eels transferred abruptly to full strength seawater (W. MacKay, report #17 this issue).

The data indicate that hydrocortisone induces a series of changes in freshwater eels, including a rise in Na-K-ATPase of gill and intestine, that successfully prepares these euryhaline teleosts to combat the osmotic stress of migration to seawater.

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RELATION OF SALT AND WATER TRANSPORT TO FINE STRUCTURE OF THE INTESTINE AND GILLS OF THE EEL, Anguilla rostrata AND THE DOGFISH, Squalus acanthias

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(1) The spiral valve of the dogfish was isolated and the lumen and artery perfused with saline to establish conditions of maximal and minimal rates of water transport across the mucosa. Under such conditions the morphological configuration of the intercellular space in the epithelia should show correlative change. An additional factor is the intraluminal hydrostatic pressure and the experimental procedure was designed to determine the effects of changes in this parameter. Specimens of these preparations were fixed and embedded for electron microscopy. They are currently being studied.

(2) The transfer of eels from fresh to salt water is accompanied by increased salt and water transport in the gills and gut. In collaboration with Franklin Epstein, Ralph Janicki, and William MacKay samples were obtained for electron microscopy of the gills and the proximal gut to provide morphological correlates of the functional states observed by them. The existence of elevated Na-KATPase levels in gills of fresh water eels treated with hydrocortisone (see Epstein this bulletin) should provide interesting comparisons with corresponding levels of enzyme activity and the morphological changes usually associated with animals adapted to sea water.

(3) Preliminary observations on the fine structure of mesothelia found on dogfish mesentery indicate the presence of junctional complexes of the kind found in gill epithelia (close junction, zonula adherens and maculae densa). Other aspects of the fine structure may provide clues to the low rates of absorption of drugs and metabolites from the peritoneal cavity in this animal.

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THE TRANSPORT OF VARIOUS ORGANIC MATERIALS FROM BLOOD TO TISSUE IN Squalus acanthias

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Studies of the blood to tissue transport of eight organic compounds have been undertaken in