

Figure 4

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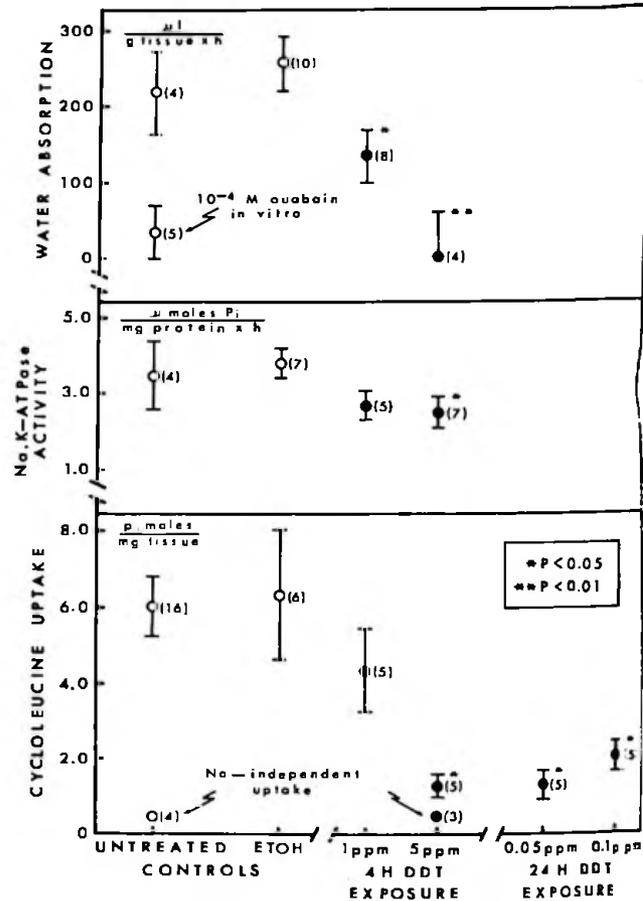
DDT Inhibits Nutrient Absorption and Osmoregulatory Function in *Fundulus heteroclitus* Intestine

D.S. Miller, A.S. Seymour, Jr., D.G. Shoemaker and W.B. Kinter. Mount Desert Island Biological Laboratory, Salsbury Cove, Maine 04672.

Previous studies have suggested that DDT-induced osmoregulatory failure in marine teleosts is accompanied by inhibition of intestinal Na,K-ATPase, an enzyme associated with the Na pump of the epithelial cell (*Science*, 173:1146-1148, 1971; *Environ. Health Perspectives*, 1:169-173, 1972). Since intestinal osmoregulatory (salt and water) nutrient (sugar and amino acid) transport is Na-dependent, (*Physiol. Rev.*, 50:637-718, 1970), pump inhibition by DDT could affect a wide range of essential intestinal functions. To determine if Na-coupled processes were affected by DDT *in vivo*, sea water (SW)-adapted Killifish (*Fundulus heteroclitus*) were exposed to 0.05-ppm DDT in SW as previously described (*Environ. Health Perspectives*, 1:169-173, 1972). After 4 h of exposure to 1 or 5 ppm, fish exhibited elevated plasma Na levels as reduced (30-35%) intestinal Na, K-ATPase activities; intestinal absorption of water and cycloleucine (a non-metabolized leucine analog) was substantially inhibited (Fig. 1). Significantly, only the Na-dependent component of cycloleucine transport was affected by DDT. Comparable inhibition of cycloleucine transport was also observed in fish exposed to 0.05 or 0.1 ppm for 24 h (Fig. 1). DDT levels in the intestinal mucosae of fish exposed to 5 ppm for 4 h and 0.05 ppm for 24 h averaged 5 and 1 ppm, respectively.

The data reported here suggest a cause and effect relationship with regard to impaired fluid transport and osmoregulatory disruption. Since there are no definitive data available which indicate whether DDT retrads growth or protein synthesis in fish, the environmental significance of the observed impairment of amino acid transport has yet to be determined.

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Regeneration in Spinal Cord of Hagfish, *Myxine glutinosus*

Marion Murray. Medical College of Pennsylvania Philadelphia, Pennsylvania

Lower vertebrates retain a remarkable capacity for functional regeneration of their central nervous systems. This phenomenon has been most thoroughly characterized in the goldfish visual system. When the retinal axon is cut, the goldfish retinal ganglion cell makes a vigorous regenerative response which includes cellular hypertrophy, increased synthesis of RNA and protein, formation of a large number of sprouts at the cut end and formation of these sprouts into the optic tectum through glial channels. The most significant points of departure from the response of mammalian central neurons to axotomy which does not lead to regeneration, seem to be in (a) the quantitatively greater synthetic response by the cell body and (b) the apparently active participation by the glial cells in the guidance of the regenerating neurons. The hagfish spinal cord was examined in order to

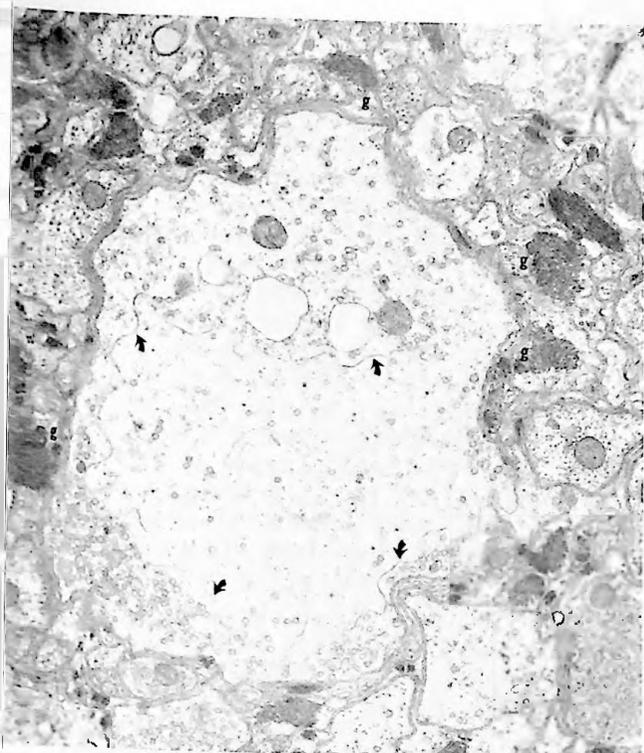


Figure 1

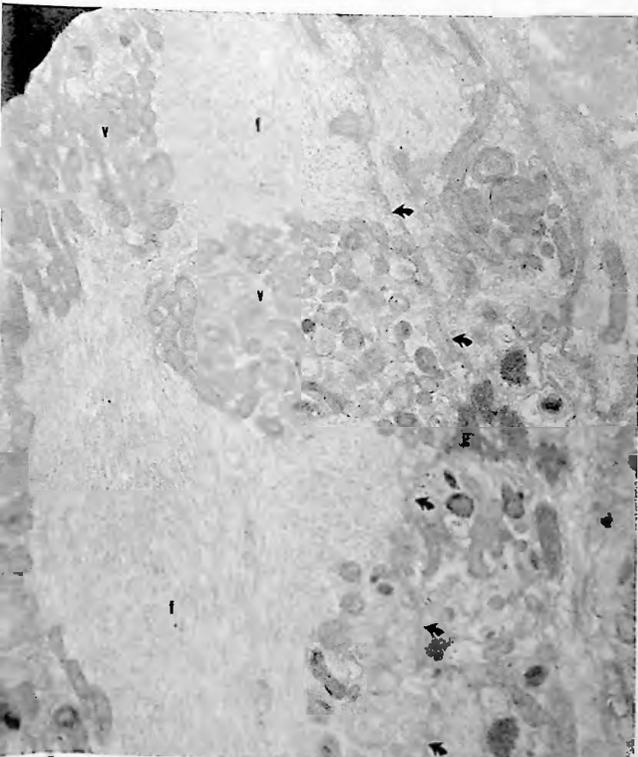


Figure 2

...etermine whether these factors are of general im-
 ...ance in the mechanism of central nervous system
 ...eneration in lower vertebrates.

Hagfish spinal cord resembles lamprey spinal cord in
 ...ny respects. It is a thin dorso-ventrally flattened

structure. The gray matter is reduced and there are no recognizable dorsal horns. A few large neurons are present laterally. Hagfish neurons are distinguished from other vertebrate neurons primarily in the frequent occurrence of dense and crystalline material within their perikarya. The white matter contains axons of various sizes, although none reach the diameters of the giant axons in lamprey cord. In other respects, hagfish axons resemble lamprey axons. Large amounts of fibrillar glial cytoplasm seems to be associated with most or all axons. Unlike the larval lamprey, capillaries are present within the spinal cord of hagfish.

The spinal cord was transected in 9 hagfish. The animals were anesthetized with Tricaine and perfused through the mouth and gills with sea water. A midline ventral incision in the midthoracic region exposed the vertebral column. The cartilage was removed and the spinal cord transected. The muscle was then sutured and the cut edges of the skin were approximated with wound clips. Seven hagfish survived. These animals were killed from 4 to 21 days postoperatively by decapitation or by intracardiac perfusion with Karnovsky's fixative.

The site of the transection was marked by an intense vascular reaction. The density of capillaries within the spinal cord was apparent.

At 4 and 7 days postoperatively, degenerating boutons and axons could be seen in the spinal cord both rostral and caudal to the lesion. Synaptic vesicles were often swollen. At 14 and 21 days, chromatolytic neurons could be identified in the gray matter. Large axons rostral to the transection commonly contained accumulations of vesicular material dense-cored vesicles and mitochondria. The axonal contents were often compartmentalized, usually by smooth endoplasmic reticulum membrane (Figure 1). At 21 days large axons contained densely packed neurofibrils with peripheral accumulations of mitochondria and vesicular material. These axons, which were presumably regenerating, were surrounded by fibrillar glial cytoplasm (Figure 2).

Preliminary evidence therefore suggests that hagfish spinal neurons are capable of regeneration and that this process may be characterized by both a neuronal synthetic reaction (chromatolysis) and by close glial association with the regenerating axon.

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Renal and Endocrine Response of the Dogfish to Change in Sea Water Concentration

Myers, Jack D.; Rea, Vifran; Kraus, Kathy; Murdaugh, Anne W.; Siegel, Abraham L. and Murdaugh, H.V. University of Pittsburgh, Pittsburgh, Pennsylvania, Duke University, Durham, North Carolina And University of Alabama, Birmingham, Alabama.

Homer Smith stressed the role of urea in osmoregulatory adaptation by elasmobranchs (*Biol. Rev.* 11:49, 1936). Forster further summarized these osmoregulatory