## Membrane Structures of Red Salmon (*Oncorhynchus nerka*) Nephron Cells During Magnesium Secretion

The kidneys of salmonidae acquire an ability to secret magnesium in fresh water before migration of the fish to the sea. The transition from reabsorption to intense magnesium secretion is observed after magnesium chloride solution injection to red salmon fry in fresh water[1]. This experiment serves as a convenient model for studying alteration in the ultrastructure of nephron cells during magnesium secretion from blood into the tubule lumen.

Migrating fry of the red salmon *Oncorhynchus nerka* Walb. (Kamchatka, Dalneye Lake), weighing 20–30 g, received i.m. injection of a $MgCl_2$ solution after which the urinary papilla was tied with a Z-like suture. 2–3 h later urine was removed from the urinary bladder. Blood was collected by punctioning the caudal vessel. In urine and blood serum sodium was detected by flame photometry and magnesium – by atomic absorption spectrophoto-

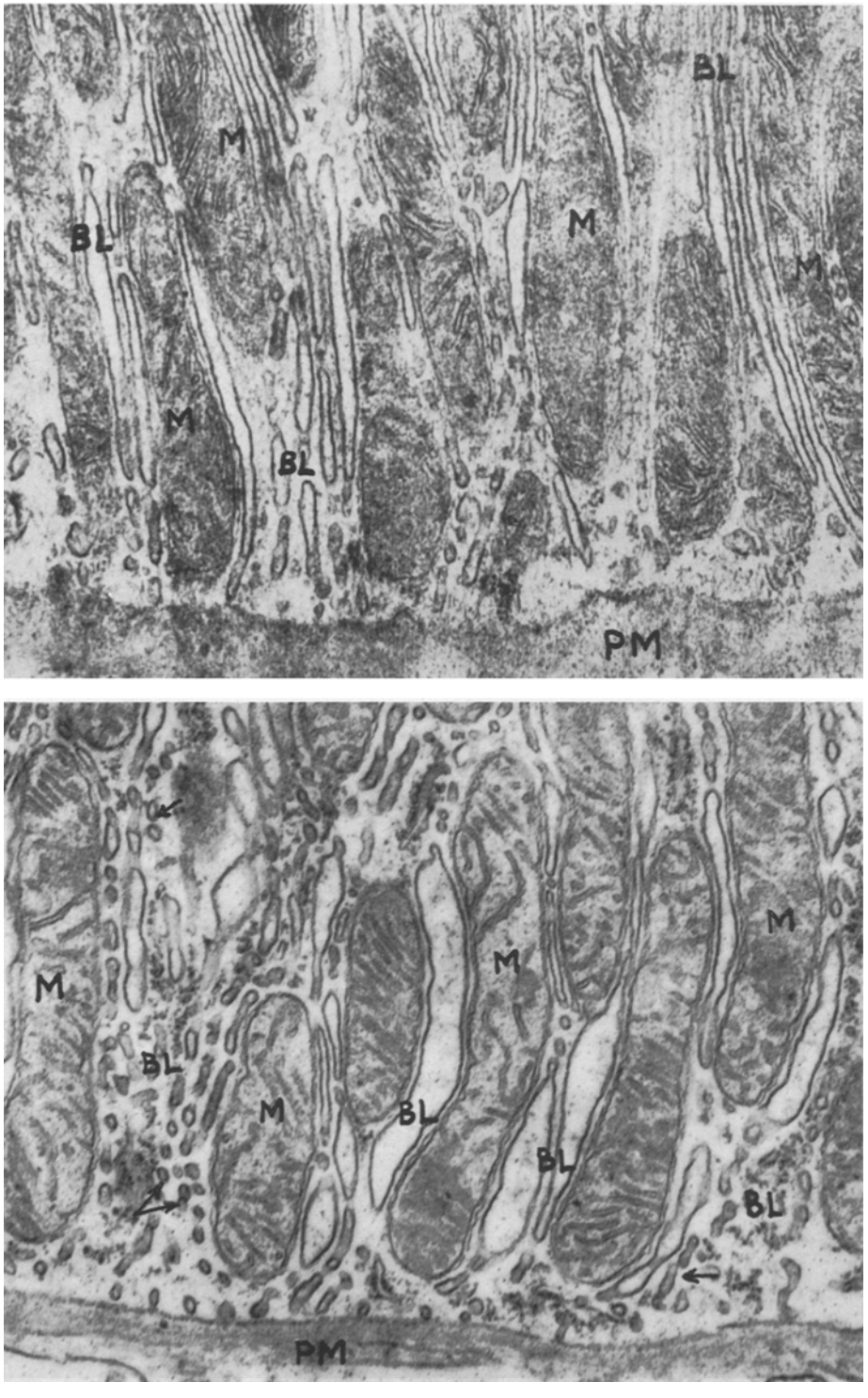


Fig. 1. Distal segment from the *Oncorhynchus nerka* showing the elongate mitochondria (M) which are perpendicular to the basement plasma membrane (PM) and parallel to the membrane structure of basal labyrinth (BL). A) control, B) injection of 0.1 ml 10% $MgCl_2$ solution. Spaces of the basal labyrinth are wider and there is fragmentation of the basal labyrinth canals (arrows). ×42,000.

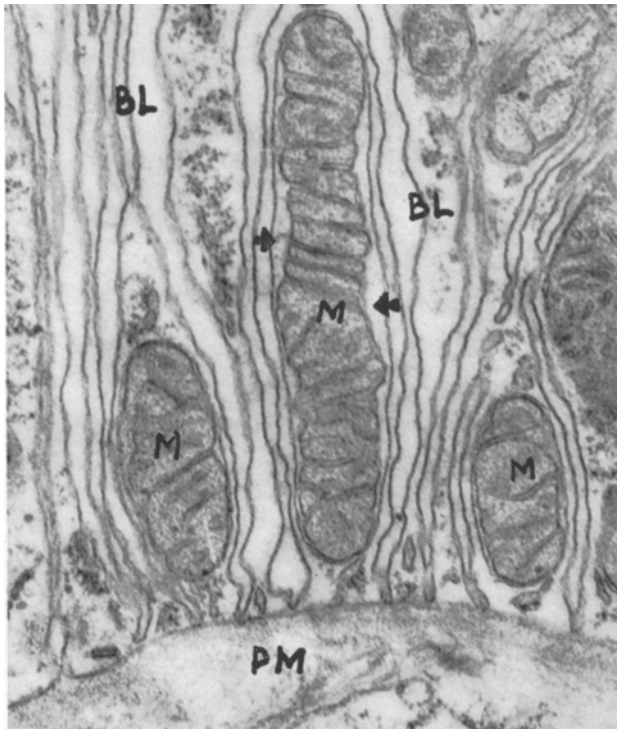


Fig. 2. Part of cell of distal segment from the *Oncorhynchus nerka* showing the swelling of mitochondria external chamber (arrows). Injection of 0.1 ml 40% $MgCl_2$ solution. ×42,000.

metry[2]. Pieces of the caudal part of kidney were fixed in 1% $OsO_4$ using phosphate or cacodilate buffer[3] with osmolarity of the medium about 310 mosm/l. After dehydration, the specimens were embedded in Araldite. Sections were obtained on a LKB–III microtome, contrasted with uranylacetate and lead citrate and examined in a JEM–7 electron microscope.

After injection of 0.1 ml of 10% $MgCl_2$ solution, the magnesium concentration in blood serum increased from 1.5 ± 0.32 m$M$/l to 5.3 ± 0.5 m$M$/l ($n = 16$), and the magnesium concentration in urine from 5.3 ± 1.05 m$M$/l to 75.5 ± 2.0 m$M$/l. As in both cases, the inulin concentration index was 2.5; this was an evidence of intense magnesium secretion after injection of $MgCl_2$ solution. After magnesium injection, sodium reabsorption by kidney was found to increase whereas the sodium content in urine decreased from 52.0 ± 2.3 m$M$/l to 8.7 ± 0.96 m$M$/l. Since such high sodium reabsorption against gradient is typical for distal segment cells of nephron, it seemed of interest to investigate their ultrastructure in conditions of increasing sodium reabsorption and magnesium secretion in the kidney.

In the control group of fishes, cells of the distal tubule are closely adjacent (Figure 1). There are smooth vesicles, single ribosomes or polysomes in the apical part of the cell. The nucleus as a rule lies in the central part of the cell. It is surrounded by rough endoplasmic reticulum. The basal part of the cell contains a great number of large elongated mitochondria lying parallel which are perpendicular to the basal plasma membrane. The matryx on mitochondria is of average density, crysts are tubular or lamellar. Spaces of the basal labyrinth are 300–400 Å width, mitochondria lie between membranes delimiting these spaces. In close vicinity to the plasma membrane, there are a small number of vesicles with the same diameter as the spaces of the basal labyrinth. Occasionally, one can trace their association with basal plasma membrane.

After injection of 10% $MgCl_2$ solution, the spaces of the basal labyrinth are widen up to 1000 Å and even more, and the electron density of their content decreases (Figure 1). In some parts of the cells, the widening of these spaces is less strongly pronounced and there is the fragmentation of the basal labyrinth canals without changes of their diameter and electron density. After injection of 0.1 ml of 40% $MgCl_2$ solution the alteration in the cells becomes more obvious, and the increase of the distance between the external and internal delimiting mitochondrial membranes is revealed. This is indicative of swelling of their external chamber (Figure 2). A similar reaction of membrane structures and mitochondria of the basal part of the cell can be also observed in cells of the nephron proximal tubule.

The correlation between magnesium secretion and total sodium reabsorption[1], sharp decrease of the sodium concentration in urine after magnesium injection allow the suggestion that this process occurs both in cells of the proximal and distal part of the nephron. The increase in sodium reabsorption enhances sodium flux into spaces of the basal labyrinth. Much like in other organs in which increase of sodium absorption results in widening of intercellular spaces[4], this effect may be observed in the distal tubule, but it is localized in spaces of the basal labyrinth. It is not inconceivable that stechiometry between sodium reabsorption and magnesium secretion is an indication that magnesium enters the cell in exchange with reabsorbed sodium. The increase of magnesium influx and content in the cytoplasm leads to intensification of transcellular transport (magnesium secretion) and accumulation of magnesium in mitochondria which is displayed as swelling of the external mitochondrial chamber. These changes in the structure of nephron cells are likely to reflect a transition from reabsorption to secretion of magnesium.

**ВЫВОДЫ.** После инъекции раствора $MgCl_2$ покатной молоди нерки увеличивается реабсорбция натрия клетками почечных канальцев и начинается интенсивная секреция магния. В клетках проксимального и дистального канальцев нефрона при секреции магния расширяются пространства базального лабиринта и набухает наружная камера митохондрий.

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[1] Yu. V. Natochin, M. M. Sokolova, G. P. Gusev, E. I. Schakhmatova, E. A. Lavrova, Proc. Acad. Sci. USSR *186*, 732 (1969).
[2] B. W. Grundbaum and N. Pace, Microchem. J. *15*, 666 (1970).
[3] J. B. Caulfield, J. biophys. biochem. Cytol. *3*, 827 (1957).
[4] J. M. Diamond and J. Tormey, Nature, Lond. *270*, 817 (1966).