OSMOREGULATION IN THE SEA IN TELEOST FISHES

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Annotation: *The development of the marine environment by vertebrates began at the end of the Silurian - the beginning of the Devonian and proceeded on the basis of the glomerular anlage characteristic of their ancestors. The tasks of osmoregulation in sea water are directly opposite to those in fresh water: in sea water, the osmotic pressure of the internal environment of the body is slightly lower than in sea water, and because of this, the body is constantly dehydrated. As a result, the filtration function of the kidneys, aimed at increasing water excretion, is weakened in marine bony fish. A significant part of the glomeruli does not participate in filtration at all.*

Experiments on trout showed that although the filtration capacity of individual nephrons in seawater is higher (3.74 nl/min versus 1.31 nl/min in fresh water), overall glomerular filtration is due to a decrease in the number of functioning nephrons in fresh water. in sea water is lower than in fresh water - 20.1 and 142.6 nl/min, respectively.

In many marine fish, the size of the glomeruli decreases, and often their number. As an extreme example, we note the existence in the sea of fish species with an aglomerular (devoid of glomeruli) kidney: the nephron tubules in such a kidney end blindly, their walls have a secretory function. Such a kidney is characteristic, in particular, of fish of the family Syngnathidae, and is also found in a number of Antarctic species. In the latter case, the loss of glomeruli appears to promote a more stable retention of antifreeze glycoproteins in the blood.

A decrease in the level of renal filtration does not yet compensate for the loss of water. Therefore, marine fish regularly drink water, while receiving excess amounts of salts. It has been experimentally established that eel and goby in sea water absorb up to 50-200 cm3 of water. If you block the possibility of its entry through the intestines, the body becomes dehydrated and, having lost 2-20% of its original mass, dies. In experiments with salmon, fish kept in fresh water did not drink, but in 32-, 50- and 100% seawater they absorbed 42, 95 and 129 ml of water per 1 kg of body weight in 1 day, respectively; 80% of the water drunk was absorbed in the intestines.

In accordance with the changed tasks of osmoregulation, the reabsorption of ions in the renal tubules of marine teleost fishes sharply decreases, but at the same time intensive reabsorption of water from primary urine occurs. Marine fish excrete a relatively small amount of urine (on average 0.13-0.96 cm3 kg-1 h-1), the concentration of which is almost equal to (only slightly lower than) blood plasma. Water is also intensively absorbed in the bladder of bony fish, the walls of which have high osmotic permeability.

In addition to the kidneys, excess salts are eliminated through the intestines: intense absorption of water occurs here, while the salts are concentrated and excreted in the feces. This mainly concerns divalent ions, while sodium chloride is actively absorbed, creating a concentration gradient in the mucous membrane, due to which water is transferred through the intestinal wall.

Gills play an important role in removing excess salts. If divalent ions are excreted in significant quantities through the kidneys and digestive tract, then monovalent ions (mainly Na + and Cl-) are excreted almost exclusively through the gills, which perform a dual function in fish - respiration and excretion. The gill epithelium contains special large goblet cells containing a large number of mitochondria and a well-developed endoplasmic reticulum. These “chloride” (or “salt”) cells are located in the primary gill filaments and, unlike respiratory cells, are associated with the vessels of the venous system. The transfer of ions through the gill epithelium is of the nature of active

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transport and is associated with energy expenditure. The stimulus for the excretory activity of chloride cells is an increase in blood osmolarity.

The participation of gills in the active transport of monovalent ions is typical not only for teleost fish. Such cells are found in lampreys, shark fish, cartilaginous and bony ganoids. As indicated, active transport of ions is also characteristic of freshwater fish, but in them it occurs in the opposite direction. According to the latest data, these multidirectional functions are performed by the same cells, which, depending on the osmotic state of the body, change the direction of the active function of ion transport.

In general, the osmoregulation scheme of marine bony fishes can be represented as follows. Hypertonicity of the external environment causes constant osmotic losses of water (mainly through the gills), which are replenished by drinking. The resulting excess salts are excreted through the kidneys and feces (mainly divalent ions), and are also actively excreted by special cells of the gill epithelium (mainly Na+ and Cl-). The functioning of osmoregulation mechanisms makes it possible to maintain the osmotic pressure of the internal environment at a relatively constant level, hypotonic in relation to the external environment.

Some invertebrates find themselves in a similar situation, for which living in the seas is an evolutionarily secondary phenomenon. Like teleost fish, they perform hypotonic osmoregulation. These are, for example, some marine crustaceans, in particular Cladocera, which developed primarily as freshwater animals.

The preservation of the glomerular system in most marine fish gives the entire complex of osmoregulatory reactions greater mobility: depending on the salinity of the environment, the ratio of functioning and “reserve” nephrons changes, which ultimately significantly expands the range of accessible bodies of water. for life. A remarkable example of broad adaptability to the salt regime is the so-called anadromous forms of some cyclostomes (lamrai) and fish. When migrating from the sea to rivers, the mechanism of their osmoregulation undergoes a polar transformation (change in the hypo- and hypertonic state of the body), which is based on the freshwater type of kidney structure in all aquatic vertebrates. Figure 5.1 shows the change in indicators of water-salt metabolism in the eel, a fish that regularly changes its marine habitat to freshwater, and vice versa. In this table, Δt° refers to the decrease in freezing point as a function of solute concentration; this is one way of expressing salinity.

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