Salt control: A fish story

Maintaining a proper balance between intracellular and extracellular salt concentrations is a problem faced by both fish living in tidal areas and people suffering from congestive heart failure.

Looking at the dilemma from a fish's point of view, Karl Karnaky of the University of Texas in Houston has found a reliance on a particular kind of cell. He has used these cells, called chloride cells, to evaluate new diuretic drugs for heart failure. And since two human diseases, cholera and cystic fibrosis, are marked by abnormal chloride movement, learning more about how fish chloride cells operate may suggest ways to treat those diseases, Karnaky said at last week's American Heart Association Science Writers Forum in Sarasota, Fla.

Fish blood, like ours, is about one-third as salty as seawater. Saltwater fish consequently have to contend with the force of osmosis sucking water from their bodies and a counter-rush of salts coming in. Their strategy, says Karnaky, is to "drink like a fish and try like heck to hold onto the water and get rid of the salt."

Freshwater fish have the opposite problem. The higher salinity in their bodies pulls water in; they in turn constantly excrete dilute urine.

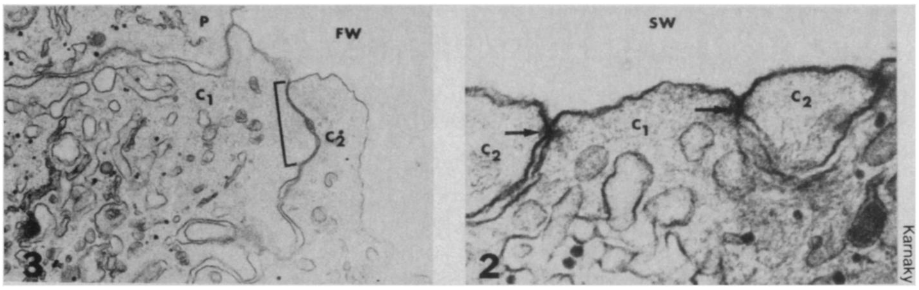
As many novice aquarists learn, most fish have a narrow tolerance for salinity. But some fish, like the killifish Karnaky is studying, are able to adapt to the daily freshwater-saltwater changes in tidal waters.

The chloride cells that allow them to survive the change use much the same mechanism as do cells in the human gut — cellular pumps and carriers that transport chloride and sodium.

For years scientists suspected that chloride cells used their sodium pumps to rid the body of excess sodium ions. But if this were so, the sodium pumps would be clustered on the sides of the cell that face either the external environment or the gut; instead, researchers found them primarily facing the blood, positioned to move sodium from the cell *into* the bloodstream.

Pairs of chloride cells apparently are the actual salt controllers, Karnaky has found. When the fish need to get rid of salt, the chloride cells absorb sodium and chloride from the internal milieu and send the chloride to the outside world via a channel at the "top" of the cell. The sodium is moved into the extracellular fluid by the sodium pump and diffuses out through the junction between the two chloride cells.

To adapt to different salinities, the junction between the two chloride cells narrows to let less sodium leak out, or widens to allow more sodium to escape.



Karnaky

Chloride cells (C_1, C_2) on a freshwater-adapted fish (left, × 19,500) have longer junctions than those on saltwater-adapted fish (right, × 52,000), so less sodium leaks out.

On the human level, Karnaky is using a chloride-cell-containing membrane from a killifish to measure the abilities of different diuretics to inhibit the movement of chloride, and thus encourage the excretion of water.

The cholera and cystic fibrosis connections come in because both conditions are marked by abnormal chloride transport. In cholera, the toxin released by the cholera bacterium triggers sodium and chloride secretion. The high salt concentration in the gut sucks water out of cells, and diarrhea ensues. While massive fluid infusions can reverse the potentially deadly diarrhea, if an agent that blocks the chloride channel can be found it might provide an effective therapy, says Karnaky.

One of the markers of cystic fibrosis is salty sweat. While for many years the problem was thought to be the body's failure to reabsorb sodium from sweat before it is released, in the past two years researchers have begun to view it as a chloride transport failure. Figuring out how the chloride reabsorption pathway is disturbed may suggest ways to intervene in cystic fibrosis, Karnaky says.

— J. Silberner

Deep-sea 'test-tube babies'

By mixing eggs and sperm of sea urchins that live deep in the sea, marine biologists have produced embryonic sea urchins and have obtained a new glimpse into the life cycle of animals that inhabit the ocean depths.

The lives of these animals have been well hidden from scientific scrutiny, because specimens caught in dredges or nets generally arrive at the sea surface dead or severely damaged. But researchers from the Harbor Branch Foundation in Ft. Pierce, Fla., recently used a submersible vessel with a collecting device that resembles a vacuum cleaner to bring healthy animals to the surface, to a shipboard laboratory.

Eggs and sperm removed from specimens of two sea urchin species and one starfish species successfully developed into embryos. Embryos of solely deep-dwelling echinoderms (the phylum including starfish and sea urchins) had never previously been observed by scientists, says Craig Young of Harbor Branch.

In the fertilization experiment, the scientists removed gonads from the adult animals they had collected. They used a hormonelike chemical, 1-methyladenine, to make the eggs mature before mixing them with the sperm. In an expedition planned for this spring, the researchers hope to produce embryos of more species.

An unexpected lifestyle for deep-sea echinoderm larvae has been postulated from the observation of the eggs of 21 species recovered by Young and his colleagues Lane Cameron of Harbor Branch and Larry McEdward of the University of Alberta in Edmonton. In shallow-water-dwelling echinoderms, the size of the egg correlates with larval behavior: In species with small eggs, larvae begin swimming and feeding on plankton early in life; in species with large eggs, larvae survive for long periods on the yolk. Marine biologists had predicted that, because plankton is scarce at great depths, animals there would be found to have large, yolky eggs. But Young and Cameron report that most of the echinoderms they collected have small, transparent eggs, only 90 to 150 microns in diameter. They speculate that the newly hatched larvae undertake an epic journey. To find food they must swim more than 2,000 feet upward, propelled only by their minute, hairlike cilia.

— J.A. Miller

John Miller/Harbor Branch

A proud parent: Sea urchin, Linopneustes longispinus.