Research team heads to Antarctic to get icy insight into how brain adapts to temperature change

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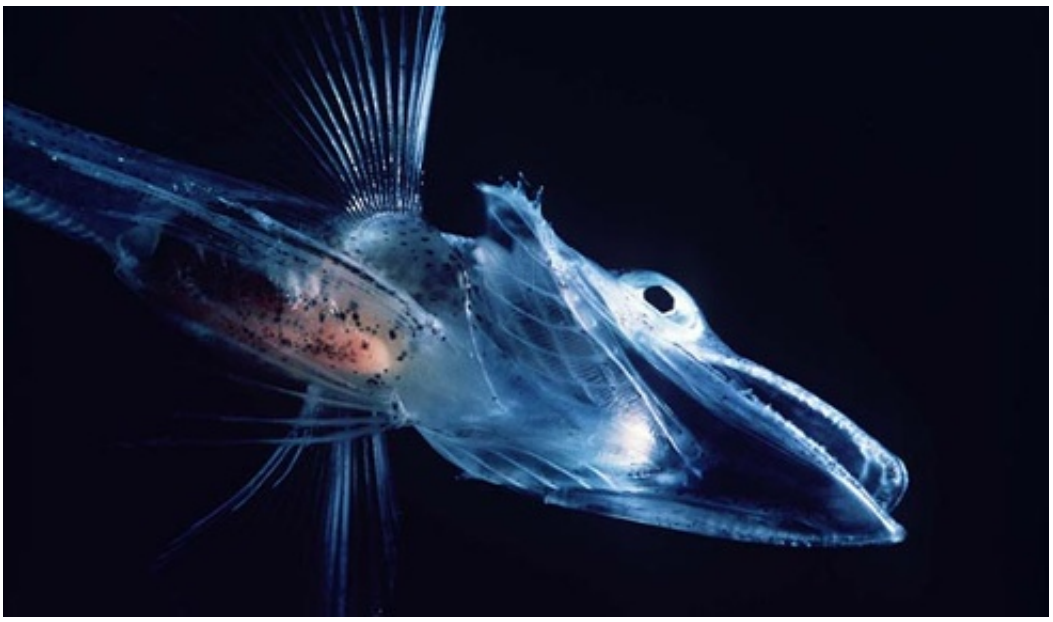

Michael Friedlander and his team will study how rising temperatures affect the brain of the icefish. Credit: Dr. Uwe Kils, Rutgers University

At the southernmost extremes of the planet lives a fish different from all other vertebrates on Earth.

Aptly nicknamed the icefish, the notothenioid lives in such cold temperatures that antifreeze runs through its veins – literally. But the Antarctic Ocean is warming, and icefishes are in danger.

Now, a team of scientists with the Virginia Tech Carilion Research Institute will travel to Antarctica to find out, for the first time, how rising temperatures affect the brains and hearts of the icefish – and what it means for the rest of the world.

"Icefishes are adapted to survive and thrive in water that's colder than ice," said Michael Friedlander, the executive director of the Virginia Tech Carilion Research Institute, whose laboratory will oversee brain research during the expedition. "The temperature is warming, though, and even the subtle elevations seem to be having a profound effect on life in the Southern Ocean."

Friedlander's team will study how temperature change affects electrical activity of neurons in the icefish brain, an endeavor for which Friedlander has unique experience.

Forty years ago, Friedlander and Bruce Sidell, who went on to become a professor of marine sciences at the University of Maine, were graduate students in the laboratory of C. Ladd Prosser, a professor of physiology at the University of Illinois at Urbana–Champaign. Considered by many to be the father of comparative physiology, Prosser worked with Friedlander and Sidell to advance an experimental approach to examine how temperature change affects the entirety of a living organism, in this case the common goldfish.

The results of their work were published in a paper recently named a classic by the *Journal of Experimental Biology*. They had found that molecular, cellular, and behavioral processes in the goldfish brain could acclimate to a wide range of temperatures.

Icefishes, however, are more genetically constrained than goldfish. A slight temperature increase – just a degree or two – can catastrophically shift the balance of biological systems in icefishes.

"The icefishes go into something akin to heat shock, but at a temperature a human would still find to be very cold," Friedlander said. "The elevation in temperature might subtly manipulate the electrochemical activity in the brain, including the cerebellum, and that can have profound consequences on how the animal navigates its world, affecting the coordination of essential behaviors such as predation, reproduction, and predator avoidance."

According to Friedlander, the icefishes are at risk of dying out and, since they account for 70 percent of the biomass of the Antarctic Ocean, the consequences would be tremendous.

"Until we run the actual experiment of changing temperatures – the experiment nature is currently running for us – we're not going to know the exact final outcome," Friedlander said. "We can see where the rising temperature is taking the ocean, and it's disruptive. We want to determine the consequences on a complex system – the vertebrate brain in a series of well-controlled experiments with well-defined endpoints."

Friedlander's team is working in collaboration with scientists from the University of Alaska at Fairbanks and Ohio University, who will study the icefishes' cardiovascular systems. Elizabeth Crockett, an associate professor of biological sciences at Ohio University and the lead investigator on the National Science Foundation grant funding the expedition, was a graduate student mentored by Sidell. She considers Friedlander an academic uncle, and his continued research made him a logical choice when building the research collaboration.

"Mike's experimental approach and design with goldfish seemed the perfect experimental strategy to explore the physiological and biochemical underpinnings of thermal tolerance in Antarctica fishes," Crockett said. "It's a timely challenge for scientists to learn how individual species, populations, and ecosystems will respond to climate

change."

In addition to ecological implications, Friedlander's team will gain insights from icefishes into the impact of low temperatures on synaptic function in the brain during extreme conditions – an area of importance in human health, especially in critical situations involving stroke, drowning, and traumatic brain injury.

"Medically, these fish are peculiar," Friedlander said. "They make an antifreeze molecule, and they're the only vertebrate on Earth whose blood cells don't have hemoglobin, the essential molecule that carries oxygen to all of the tissues in our body, including the brain. We expect to learn some of the secrets of this fish that allow the brain and the heart to function in extreme cold as well as why small rises in temperature can be so devastating."

That's the hope of Los Angeles, California, native Jordan Scharping, a second-year Virginia Tech Carilion School of Medicine student who will be flying down in several weeks.

"Going to Antarctica is not an opportunity many people come by," Scharping said. "But I'm even more excited about the experiments. Much of the science involved in this research is still uncharted. No one has studied the functional properties of the neuronal circuits in the brain of living icefishes before."

Antarctica: Iskander Ismailov, an assistant research professor at the Virginia Tech Carilion Research Institute, fishes with other members of an international research collaboration. The scientists will study the icefishes they collect from the water surrounding Antarctica.

The researchers will collect continuous digital records of the ongoing electrical activity of individual neurons in the cerebellum, while listening to the neural activity of the brain in real time with an electronic system tailored for the project by Jorge Cadena, an undergraduate in Virginia Tech's Bradley Department of Electrical and Computer Engineering, who is from Manta, Ecuador.

The Virginia Tech collaboration also includes Thomas Wertalik, a glassblower in Virginia Tech's College of Science, who created unique glass instrumentation for the scientists to locally modulate the temperature of only the cerebellum within the brain.

"It's a big collaboration," said Iskander Ismailov, a research assistant professor at the Virginia Tech Carilion Research Institute, "not only between Virginia Tech, Ohio University, and the University of Alaska, but within Virginia Tech itself."

Ismailov will be on site at Palmer Station, a U.S. research facility in Antarctica, for three months. Ismailov, who is already in Antarctica, said he was prepared for the cold.

"I grew up in Russia and Uzbekistan, where we had winter temperatures of minus 20 degrees Fahrenheit, and summers above 100 degrees Fahrenheit," Ismailov said. "I'm adapted to climate change, perhaps better than the icefishes."

The scientists must go to Antarctica because the icefishes are sensitive to the stress of relocation. The fish wouldn't survive being moved from the Southern Ocean to Virginia, without risk of significant damage.

"Sometimes you just have to go where the action is," Friedlander said. "So we're going to the fish."

Provided by Virginia Tech