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In Alaska, wood frogs freeze for seven months, thaw and hop away

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Each September, the wood frogs of Alaska do a very strange thing: They freeze.

They do not freeze totally solid, but they do freeze mostly solid. Two-thirds of their body water turns to ice. If you picked them up, they would not move. If you bent one of their legs, it would break.

Inside these frozen frogs other weird physiological things are going on. Their hearts stop beating, their blood no longer flows and their glucose levels sky rocket.

"On an organismal level they are essentially dead," said Don Larson, a graduate student at the University of Alaska, Fairbanks who studies frogs. "The individual cells are still functioning, but they have no way to communicate with each other."

The craziest thing of all may be that in this frozen state, they can withstand temperatures as low as zero degrees Fahrenheit for as long as seven months, and then, when spring arrives, thaw out and hop away.

Biologists have known for decades that some frogs freeze in the winter and thaw in the spring, but a [paper](#) published in the *Journal of Experimental Biology* reports that they can freeze longer and tolerate cooler temperatures than previously thought.

"There have been some studies, largely in the lab, that show frogs can stay frozen for a couple of weeks at temperatures of about 20 degrees Fahrenheit," said Brian Barnes, director of the Institute of Arctic Biology at the University



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The wood frog of Alaska spends nearly seven months a year in a frozen state, according to a new study.

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of Alaska, Fairbanks. "But up here in Alaska, we know these frogs are common all the way into the Arctic circle where it gets a lot colder than that. That's what kicked off our interest."

Adult wood frogs are about the size of the palm of your hand. A juvenile is the size of your thumbnail. According to Barnes, their lifespan is four to six years.

To see how these frogs were surviving the winter in the extreme Alaskan environment, the researchers used super glue to attach small radio transmitters about the size of a nickel to the backs of 16 frogs over two years.

The radio transmitters allowed the researchers to see where the frogs made their hibernacula -- divots in the leaf litter near a lake or pond, where they planned to spend the winter. Once the frogs were settled, the researchers placed little cages over the divots and stuck a wire thermometer in there to record the temperature at regular intervals.

"The snow provides a nice insulated layer for them, but we knew from previous studies that it still gets very cold beneath the snow," said Larson, the lead author of the study. "It was the survival that was surprising. We didn't see any die off, and that was the big shock."

Over the course of two years, none of the frogs in the study died.

The researchers also discovered that the frogs don't freeze once and stay frozen. Instead they spend a week or two freezing at night and thawing during the day, until the temperature drops permanently below freezing.

Larson thinks this thawing and freezing patterns helps the frogs convert more of the glycogen stored in their liver into glucose. This is essential because it is the high levels of glucose in the frogs' cells that keep them alive throughout the long, cold winter.

The glucose's main function is to keep water inside the cells. Frostbite in humans is caused when the water in our blood outside turns to ice. That hyperconcentrates the fluid around the cells and tissues, which in turn draws water out of the cells. Eventually the cells get so dehydrated that they die.

Larson offers this analogy: "If you put a potato in salty water, the whole potato kind of shrivels up because all the water from the potato goes to the higher concentration of salinity, but if you add a bunch of salt to a potato, it would retain its water," he said.

By making the cells super sweet with glucose, the frogs keep the water from leaving their cells.

When spring comes and the frogs thaw, they turn as much of the glucose as they can back into glycogen, and they pee out the rest. Then they hurry to the nearest pond or lake to start mating. After all, they only have five months to make babies and gather all the food that they can before the freezing process starts again.

And now, there are more questions to answer.

"So we have these amazing frogs that survive seven months frozen," Larson said. "I'm asking, what about the parasites and all the cool things that live in its mouth and its butt? Is freeze tolerance its own protection against disease? Can it rid animals of parasites?"

There's still a lot to learn.