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DO NOT CROAK! A STORY OF SURVIVING YELLOWSTONE'S FRIGID WINTERS

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YOUNG REVIEWERS:


EVAN
AGE: 16


LUCY
AGE: 16


PACIFIC CREST MIDDLE SCHOOL
AGES: 11–13

Have you ever wondered how "cold-blooded" animals like amphibians (frogs, toads, and salamanders) survive the winter without fur or feathers to keep them warm? Yellowstone National Park's amphibians have found ways to stay alive during the cold winter months. These animals have evolved various coping strategies, from burrowing underground, to living in ponds, to tolerating the freezing of much of the water in their bodies. This article will explore the strategies used by several amphibians to survive the winter, including strategies used by the boreal chorus frog, Columbia spotted frog, western toad, and western tiger salamander. Understanding the diverse ways that amphibians survive in their winter habitats helps scientists to recommend ways to protect those habitats, to ensure that amphibians have healthy places to live and reproduce.

SURVIVING YELLOWSTONE'S LONG WINTERS

Despite being known for its warm geysers like Old Faithful, Yellowstone National Park (United States of America) is a relatively cold, dry place (Figure 1). Winter in Yellowstone is the harshest season of the year, but it can be cold and snowy at any time. To survive, animals living there must deal with long, cold winters. Yellowstone's animals have a variety of strategies to deal with freezing winter temperatures. Some animals, like most songbirds and pronghorn antelope, migrate to warmer, less snowy places. Other animals, like weasels and wolves, stay put and must search for food year-round above the snowy surface. Pikas prepare for winter by stockpiling food and staying active beneath the snow. Finally, animals like the grizzly bear **overwinter** in their dens. All these animals are "warm-blooded" and have feathers or fur to trap the heat generated by their bodies' chemical reactions (called their **metabolism**).

OVERWINTERING

In animals, a state of inactivity and slowing of metabolism, used to save energy in difficult conditions.

METABOLISM

Chemical reactions in the cells of a living organisms that keep the body alive, such as digesting food, repairing damage, and growing.

Figure 1

Bison in Hayden Valley, Yellowstone National Park (United States of America) in December 2010 (Photograph credit: Dr. Charles R. Peterson).

Other animals must deal with winter in a naked state. Fish and **amphibians** (frogs, toads, and amphibians) are "cold-blooded," or **ectothermic**, animals. Winter is a problem for ectotherms because their body temperatures are limited by the environment. Fish in Yellowstone's frigid waters live in ice-free areas of streams, rivers, or lakes. For Yellowstone's amphibians, no single solution has proven to be the best. Instead, Yellowstone's amphibians show diverse coping strategies. Some burrow into holes created by rodents. Some live in ponds under the ice. Others tolerate the freezing of much of the water in their bodies. These amphibians are so good at surviving that they have persisted in the park for thousands of years! Here we share the fascinating strategies that boreal chorus frogs, western toads, western tiger salamanders, and Columbia spotted frogs [1] use to survive the winter (Figure 2). We describe how various overwintering strategies allow species to coexist and survive in the harsh, winter-dominated landscape of Yellowstone National Park (Figure 3).

AMPHIBIANS

Animals with an aquatic phase of life, spent living in the water and breathing with gills; and a terrestrial phase of life, living on land and breathing with lungs.

ECTOTHERM

A "cold-blooded" animal whose body temperature depends primarily on external heat sources, such as sunlight. Ectotherms include most fishes, amphibians, reptiles, and invertebrates.

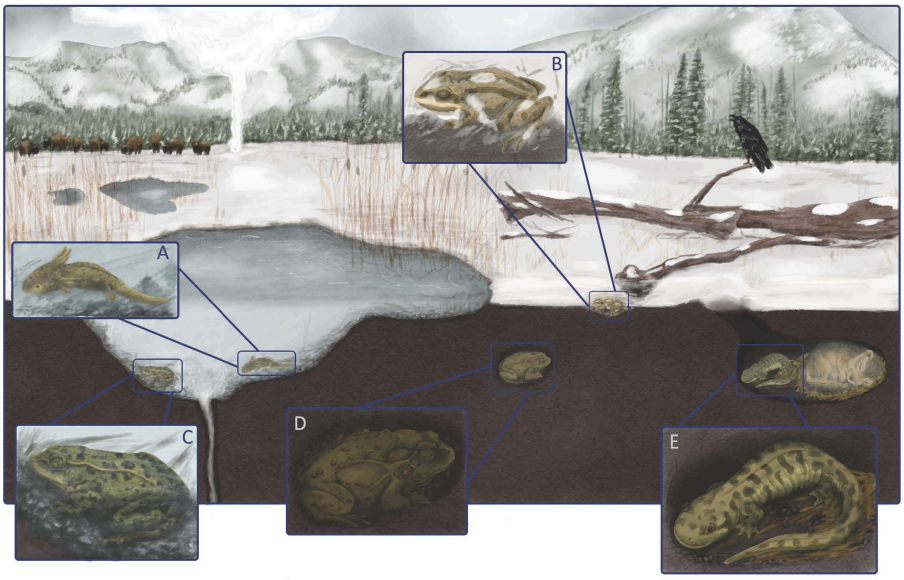

Figure 2

A Yellowstone National Park winter landscape, showing four amphibian species in their winter habitats. **(A)** A larval western tiger salamander in unfrozen water with enough oxygen; **(B)** a boreal chorus frog burrowed underneath a log; **(C)** a Columbia spotted frog on the bottom of an unfrozen pond; **(D)** a western toad in a burrow under the frostline; and **(E)** an adult western tiger salamander sharing a burrow under the frostline with other animals (Image credit: Ashelee Rasmussen).

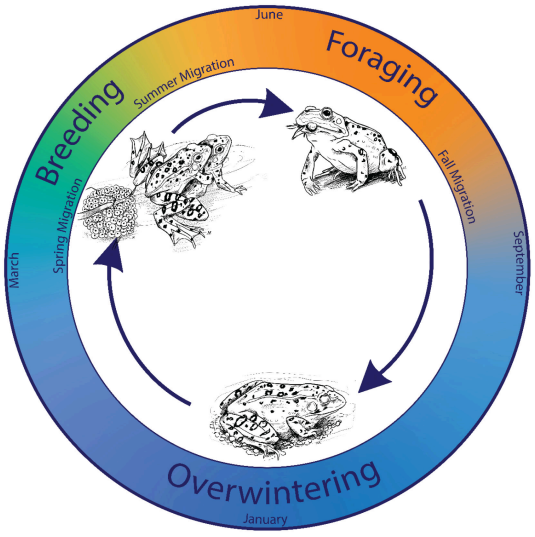

Figure 3

Figure 3

Seasonal variation in the activity periods of Yellowstone's amphibians. The colors in the outer circle show activity and reflect the approximate time of year spent in these activities. Note that over half of the time is spent relatively inactive, and under cold conditions (Image credit: Ashelee Rasmussen).

COLUMBIA SPOTTED FROGS STAY WET

Columbia spotted frogs overwinter in water. They need unfrozen water with enough oxygen for them to survive all winter. For some spotted frogs, that can be just a few hops into a nearby pond. Others have longer journeys to find water bodies that would make good winter homes. These water bodies could be a spring from an underground water source, a deep lake, a pond fed by springs, or the right kind of flowing stream or river. Sometimes these suitable places can be far away and difficult to reach.

Some young spotted frogs in Yellowstone have been found to travel about 460 meters (500 yards) on their first trek to find a suitable winter

spot, much of it over dry ground. Some adult spotted frogs go much farther on their journeys from their summer to winter habitats, over rough and rocky terrain. How frogs do this— especially the youngest ones—is still something of a mystery. We think they use vision, smell, an inner compass, and (for adult frogs) memory from previous years. Once in their winter homes, spotted frogs adapt to the cold by slowing their metabolism. They do not eat or grow, but they do not take a long winter nap, either. In winter streams, spotted frogs rest on the bottom of the stream, facing upstream, or they slowly move around under the surface ice of lakes. Frogs with radio transmitters attached to their backs revealed much about their winter activity, showing scientists that they move around in ponds and streams to find the best places to survive. These places could be spots where the water is warmer or has more oxygen that they can absorb through their skin. The frogs sometimes crawl up into cavities next to the water, where they can breathe air and keep their temperatures above freezing. Spotted frogs are early risers in spring. Adult frogs often arrive at breeding ponds with ice and snow still on them from the long Yellowstone winter.

WESTERN TOADS BORROW WINTER HOMES

FROSTLINE

The maximum depth at which soil is frozen.

Like the spotted frog, western toads do not let their bodies freeze. However, they spend the winter on land instead of in the water. Toads find habitats below the **frostline**, which is the maximum depth at which the soil is frozen. They dig under the ground or use existing tree roots, peat hummocks, or decayed root tunnels. Toads also use underground habitats created by other animals, such as abandoned beaver dams or burrows and tunnels made by gophers, muskrats, and squirrels [2]. The toads slow down their breathing, heart rate, and metabolism to save energy. In this inactive state, they are vulnerable to predators who might eat them!

Adult toads can travel almost 2 kilometers (1.25 miles) and burrow over 100 centimeters (40 inches) underground to find good places to overwinter [3]. When the ground around them begins to warm, the toads make their way toward the surface. They emerge from the ground in the spring when the soil thaws and the frostline disappears. Then they find their way to ponds to breed.

WESTERN TIGER SALAMANDERS HAVE SEVERAL OPTIONS

METAMORPHOSIS

A change in the form and habits of some animals during transformation from an immature stage (such as a tadpole or larva) to an adult stage (such as a frog or toad).

Western tiger salamanders spend winters in areas also used by other Yellowstone amphibians and mammals. Tiger salamanders are part of a group of amphibians known as mole salamanders. This name comes from the fact that they spend much of the day underground in burrows. **Metamorphosed** (animals who undergo changes in their form and habits when they transform from an immature stage, such

as a tadpole or larva, into their adult form, such as a frog or toad) tiger salamanders probably overwinter in burrows beneath the frostline. Tiger salamanders are strong diggers [4]. In sandy soil, they can dig burrows large enough to hide themselves in just 10–20 min. Some dig with such strength that they throw dirt into the air during the excavation process. In studies done in the Rocky Mountains, tiger salamanders were the second most common animals found in the burrows of pocket gophers, ground squirrels, and even badgers. That is right, salamanders appear to share the burrows of other animals!

Salamanders have another interesting twist to their overwintering strategy. Some will metamorphose and leave the ponds where they were born. Others will stay in their ponds long enough to develop into adults [5]. These pond dwellers keep their external gills and other larval characteristics. In this form, salamanders can become sexually mature without ever leaving the pond, and they spend their winters underwater. Their greatest danger is the pond freezing solid. This interesting ability to maintain an aquatic form as a reproductive adult happens more in males than in females. Maybe this ability has allowed these salamanders to adjust to the wetter and drier periods over the course of Yellowstone's history.

BOREAL CHORUS FROGS TOLERATE FREEZING

Like the western toad, boreal chorus frogs do not overwinter underwater. Instead, they rely on leaves, logs, tree roots, rocks, and even layers of snow to help protect them from cold weather near the surface of the ground [6]. Sometimes these frogs will use burrows made by other animals, like rodents. Then, when temperatures drop below freezing, chorus frogs freeze, too!

When boreal chorus frogs freeze, their hearts stop beating, their blood stops flowing, and they even stop breathing. If you were to see a chorus frog in the winter, you might think that it was dead! But the bodies of chorus frogs make a chemical called **glucose** [7]. Glucose is a form of sugar that acts like antifreeze, preventing ice from forming inside the frogs' cells. At the same time, the water in the spaces outside of their cells is allowed to freeze. As long as their cells do not freeze, the rest of their bodies can freeze and they can stay alive for months. As Yellowstone begins to melt in the spring, the bodies of chorus frogs begin to thaw. Soon they are breathing, moving, and making their way back into the wetlands to begin a new year.

GLUCOSE

A sugar found in blood that is the main source of energy for animals.

WHY IS THIS IMPORTANT?

Yellowstone National Park does not have many amphibian species. The four widespread species in the park use diverse strategies to stay alive during the long, cold winter months. Recent studies

have shown that ectotherms who commonly live in places with extended cold environments will live longer than their counterparts in warmer areas [8]. Each amphibian species has developed its own successful strategy that has allowed it to live for centuries in these harsh conditions. By occupying different winter habitats, these species can coexist and endure Yellowstone's frigid climate. Studying these behaviors and identifying the essential overwintering habitats of Yellowstone's amphibians is also important for protecting the interconnected water and land habitats necessary for the survival of these incredible animals.

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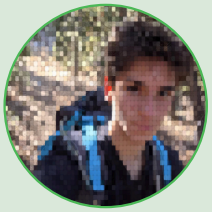
YOUNG REVIEWERS



EVAN, AGE: 16
My name is Evan and I am a science student at a stem charter school. Because of this, science is a very present part in my life and so I take a lot of interest in things like chemistry, biology, and genetics. Outside of school however, I enjoy skiing, handing out with my friends, and most importantly, rock climbing. I also love traveling and a good book.

LUCY, AGE: 16
A junior in high school who is super interested in science and math, climbing, and learning!

PACIFIC CREST MIDDLE SCHOOL, AGES: 11–13
This awesome group of students took their science literacy classes seriously and provided great feedback for authors!

AUTHORS

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Ashelee Rasmussen is a doctoral student engaging in research that explores how illustration can facilitate science education and research. She is designing and enacting methods for using drawing as a learning tool for biology education and making this information available to educators. In biological illustration courses and workshops, she engages students and researchers in using illustration to observe, record, and communicate science and nature. Ashelee has an M.S. in biology and a B.S. in ecology. She is an educator for informal and formal life-science education, participates in ecological research, and works as a biological illustrator.

DEBRA PATLA

Debra Patla has been engaged with the Yellowstone/Grand Teton cooperative amphibian monitoring program since its earliest days (2000). Her work on amphibians began in 1992 with her M.S. research of a Columbia spotted frog population near Lake Lodge in Yellowstone, with Charles Peterson (Idaho State University). Since then, she has continued annual amphibian survey and monitoring projects in the Greater Yellowstone Ecosystem, witnessing many local changes. Deb is a research associate of the Northern Rockies Conservation Cooperative.

ANDREW RAY

Andrew Ray is an ecologist with the National Park Service's Greater Yellowstone Network in Bozeman, Montana. Andrew received his B.S. from Purdue University, an M.S. from Northern Michigan University, and a Ph.D. from Idaho State University. He previously worked as the science coordinator with the Crater Lake Science and Learning Center, where he helped document the distinguishing characters of a population of rough-skinned newts in Crater Lake. He now coordinates long-term monitoring of wetlands and amphibians for the National Park Service in Yellowstone and Grand Teton national parks.

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Charles Peterson is an Emeritus Professor in the Department of Biological Sciences at Idaho State University. His teaching responsibilities include herpetology and nature photography. Much of his research has focused on reptile populations on Idaho's Snake River plain and on amphibian populations in the Greater Yellowstone area. He is currently working on citizen science projects, documenting amphibian and reptile distribution and activity in Idaho and the Greater Yellowstone Area. Peterson is an avid nature photographer and seeks to use photography to conserve and restore amphibian and reptile species and habitats.