Old Man Winter's grip is finally relaxing, as the days are getting noticeably longer and the air holds the promise of spring. Many woodland animals have begun their vernal rituals. Birds are migrating from tropical areas and claiming nesting territories and many mammals are seeking out the dens and burrows they will use to birth their young.

Amphibians are also gearing up for spring after the long winter. You might think their first priority would be to find food, but what really tops their priority list is mating. Amphibians need water to lay their eggs, so springtime for frogs, toads, and salamanders means heading to water to court mates and breed. Some species that have overwintered in pools or ponds, like the green frog, will have much shorter voyages than others. The spotted salamander, for example, will undergo amazing migrations in droves to reach breeding waters. At times, the forest floor can be so full of salamanders migrating on a mission, it will appear to be moving – quite a sight to see!

There are 15 species of frogs and toads in Ohio, and 24 species of salamanders. While most of us are familiar with the hopping, croaking, peeping frogs and toads, salamanders remain Ohio's secretive and silent amphibians. Most salamanders spend their lives under logs or rocks, burrowed in the soil, or within caves or rocky outcroppings. The best times to catch a glimpse of salamanders venturing out of their shelters are on warm, rainy days or in the early spring while they are traveling to breeding waters.

Before we further explore the intrigues of spring-time amphibian activity, we must first learn how amphibians cope with seasonal cold. Not many weeks ago, times were tough as winter was in full force. The ability of amphibians to withstand the cold is a critical, fascinating aspect of their natural histories, and an undisputable woodland wonder!

Frozen frogs: science fiction... or fact?

Avoidance is always an animal's first means of protection from harsh conditions. In autumn, many birds and even some insects migrate to warmer climates. Many small mammals, such as bats and ground squirrels, escape winter's fury by taking shelter in a protected site that helps them conserve energy. But amphibians, like all cold-blooded, or ectothermic species, face special challenges during winter because they cannot warm their bodies with metabolic heat. The temperature of their body essentially mirrors that of their surroundings, meaning that, when it's cold outside, it's also cold inside.

To escape the big chill, many amphibians retire to frost-free sites where they pass the winter without risk of freezing. The ideal refuge, known as a hibernaculum, also keeps its occupant hydrated and safe from predators. For instance, bullfrogs, like other highly aquatic amphibians, overwinter on the bottom of a pond or stream where they evade the much colder air that would freeze and kill them.

Freeze avoidance is a popular strategy of terrestrial species as well. Some, such as toads and mole salamanders, descend below the frost line by digging into the soil or by following abandoned rodent burrows or rotted root channels to an underground lair. But others, notably woodland frogs, take only modest precautions: they brave severe cold on the forest floor, insulated only by a thin layer of leaf litter, bark, and other debris. Overwintering in such exposed sites allows these frogs to emerge at the earliest signs of spring. But on the downside, it virtually guarantees that they will experience temperatures low enough to turn their bodies into ice.

For any amphibian, even brief exposure to subfreezing temperatures threatens serious injury or death. Severe cold disrupts bodily functions in many ways, for example, by slowing the blood's circulation and the delivery of oxygen and nutrients to cells. Cold
can alter the molecular structure and functions of enzymes and other proteins, disrupting metabolic processes. And, of course, it can cause animals to freeze, which creates some additional problems. Notably, when a portion of the body water changes from a liquid to a solid (ice), the fluid that remains unfrozen becomes laden with extra salts and other perturbing substances. The process also causes cells to shrink, which, if taken to an extreme, can cause their membranes to buckle and fail. Ice itself can rupture delicate vessels and shear apart the cells within tissues. For the vast majority of amphibians, and other animals, too, these conditions are overwhelmingly damaging.

Remarkably, though, a handful of woodland frogs are specially adapted to survive the repeated freezing and thawing of their bodies. This phenomenon, known as freeze tolerance, also occurs in several other vertebrates, including salamanders, turtles, snakes, and lizards. Among Ohio’s amphibians, freeze tolerance is known in the spring peeper, chorus frog, gray tree frog, Cope’s gray tree frog, and wood frog. Of these, the wood frog is by far the best studied with regards to understanding this fascinating adaptation.

Unlike its aquatic cousins, the wood frog is highly terrestrial and prefers cool, moist woodlands, often far from permanent water. In early autumn, they suspend feeding and retire to a simple depression in the soil, where they will spend the next four or five months beneath a modest blanket of leaf litter. A snowfall will add insulation, but the frogs nevertheless can cool enough that their bodies freeze. They may remain continuously frozen for hours or weeks, and can experience several bouts of freezing and thawing over the course of a typical winter.

It is fitting that the wood frog’s ability to survive freezing peaks in midwinter, when it counts the most. The tolerance begins to develop in autumn as the frogs undergo physiological changes that prepare them for the cold weather ahead. One of these changes is a limited breakdown of muscle tissue to form the waste product urea, which, although usually lost in the urine, now accumulates to high levels. They also amass huge amounts of glycogen, which is the storage form of glucose, the blood sugar in frogs and humans alike. With this extra glucose safely stored in the liver, the hefty frogs can avoid the complications of diabetes while also remaining poised to unleash a flood of glucose the instant freezing begins. The sugar enters the bloodstream and circulates to cells throughout the body where it, along with urea, helps reduce freezing damage. These compounds, called cryoprotectants, work by lowering the solution’s freezing point, just as automotive antifreeze does. They effectively limit the

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amount of ice that can form as the frog continues to cool. This is a critical function because even freeze-tolerant frogs can not withstand the freezing of more than 65 percent of their water. Cryoprotectants such as glucose and urea (and glycerol in tree frogs) play other important roles, such as reducing cell shrinkage, fueling and regulating metabolism, and stabilizing membranes, proteins, and other cellular components.

Regulation of the freezing process is another key to the freeze tolerance adaptation. Usually, freezing is triggered when frost in the surrounding soil permeates the frog’s moist skin, causing a wave of ice to spread uniformly throughout its body. However, as a back-up, specialized ice-nucleating bacteria within the frog’s gut can initiate freezing. Controlled freezing ensures that ice accumulates slowly, which helps the cells cope with the many stresses that develop within frozen tissues.

A frozen frog’s skin is frosty and its eyes are filled with ice crystals.

How Low Can They Go?
The wood frog’s capacity to survive freezing is well matched to the temperatures it experiences throughout the winter. Frogs indigenous to Ohio can recover from freezing at temperatures as low as 21°F, but what about their brethren living near the northern reach of their geographic range, which extends to the Arctic Circle? Those northern frogs, which have adapted to their harsh climate over thousands of years, can easily tolerate temperatures near 0°F. If that seems unimaginable, consider that some species of Siberian salamanders can survive being frozen to below minus 31°F! Artwork courtesy of Michael F. Wright.

It has no heartbeat or blood circulation, does not breathe, and is unresponsive to the touch. Inside, pockets of ice fill the spaces among organs, and the organs themselves are shrunkken. Narrow plates of ice appear within and around muscles, which are unable to contract.

By any reasonable standard the frog would be considered dead, but, amazingly, it is very much alive. In fact, just a bit of warming brings on a swift recovery. The heart resumes its rhythmic contractions even before the frog has fully melted. Breathing and blood circulation return next, followed by muscle contractions and, eventually, locomotion. Most bodily functions are restored within a day or two of thawing, although a longer recuperation is needed if the freezing was especially severe. So, are frozen frogs science fiction? Most definitely not— they are science fact!

Summing it up

From frozen frogs to great migrations to nightly serenades, Ohio amphibians are an intriguing group of animals. Perhaps this spring, as the unbelievably loud chorus of peepers causes you to close your bedroom window, or when that first warm spring rain hits, you’ll pause to marvel over what these animals go through from year to year. We hope you agree with us when we exclaim, “Woodland wonders never cease,” especially when it comes to Ohio’s amphibians.

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He’s ALIVE!
The long, cold winter has ended...now what?

After the thaw, literally for some of Ohio's woodland frogs, amphibians' first priorities are to seek out a mate and begin breeding. For frogs and toads, this is marked by the chorus of croaks, peeps, trills, and quacks coming from ponds, pools, and other bodies of water.

The wood frog is one of the first of the frogs and toads to begin calling, sometimes as early as February. Its unique 'quacking' call can be heard from vernal pools surrounded by woodlands. A vernal pool is a shallow pool that holds water through spring, and sometimes into the summer if the pool is larger, and does not contain fish. These seasonal water bodies are some of the most diverse and dynamic of ecosystems. For breeding amphibians, they are a critical breeding site lacking the fish that would prey on tadpoles and larvae. Vernal pools that are surrounded by woodlands provide an ideal breeding site for woodland-living amphibians.

The wood frog's chorus is followed by the spring peeper's serenade, which typically begins in March. Spring peepers are perhaps the loudest frog given their size in Ohio. An adult spring peeper is only \( \frac{3}{4} \) inch to 1¼ inches long, but encounter a body of water full of these tiny peepers and it can be deafening. Many woodland owners are very familiar with the peeper's easily recognized, repetitive ‘peeping'.

As spring progresses into summer, all 15 species of Ohio's frogs and toads will be out and about serenading the opposite sex. The green frog is one of the last species to begin calling in May and continues to call into August when most other species have fallen silent. The green frog call sounds like a plucked banjo string. Green frogs are also the species that when startled, will leap from the banks of a pool back into water with a surprised, if not indignant, "Meep!"

One of the best strategies to determine what frog and toad species you have on your property is to conduct an acoustic survey. As each frog or toad has their own unique call, species can be determined just by listening. The best time to go out and listen is at night—better yet, a rainy night. Head out to a vernal pool or pond and don't forget a flashlight. Spring peepers, gray tree frogs, and western chorus frogs like to call from vegetation on or close to the shore, while wood frogs, bullfrogs, and green frogs like to call from the water. Shining your light over the surface of the water can reveal many sets of eyes peeking just above the water level. Visit the Ohio Frog and Toad Webpage (www.ohioamphibians.com/frogs/frogspecies.html) to learn each species call.

Searching for salamanders

As the silent amphibians, salamanders can be a bit more challenging to find. Knowing when and where to look is the best strategy. Mole salamanders, named because they spend much of their lives underground as moles do, are the largest terrestrial salamanders in Ohio. The largest salamander in the state is the endangered aquatic hellbender.

The spotted salamander, a common mole salamander, can reach up to 8 inches in length. The best time and place to spot a spotted salamander is late winter into early spring, when many of the mole salamanders emerge and migrate to vernal pools. The great migration sometimes occurs in late February, sometimes in March, but is marked by the first thawing spring rain. Put on a raincoat, grab a flashlight, and head out to a vernal pool that night (travels are safer at night for salamanders), and if you don't encounter migrators on the way, perhaps you will find the pool swarming with mating salamanders. If you miss this nighttime activity, head out to the pool during the day to look for egg masses, or maybe around May with a dip net to look for larvae.

Other great places to search for salamanders are within and along the shores of streams, creeks, or seeps. Check under large, flat rocks or logs along the banks. Salamanders typically found in these environments are small, delicate, and brightly colored. For example, the longtail salamander has a bright yellow to orange body speckled with dark brown or black spots. The redback salamander has a dark brown to black body with a red-orange stripe down its back.

Be cautious when searching for salamanders. Chemicals on our skin can irritate the permeable skin of amphibians, so if handling is necessary, for example to safely reposition the salamander before you place the rock back over it, make sure your hands are wet and free of soaps or lotions.

For more information on salamanders, check out OSU Extension's bulletin "Getting to Know Salamanders in Ohio: Life History and Management," available at www.woodlandstewards.osu.edu under the 'Publications' tab. ♦

Interested in attending a class to learn more about vernal pools and amphibians?

Check out the Ohio Woodland Stewards Program for woodland wildlife classes at www.woodlandstewards.osu.edu

For more information of all of Ohio's frogs, toads, and salamanders, visit The Ohio Frog and Toad Webpage http://www.ohioamphibians.com/index.html.