Cold Feet, Frogsicles, and Time Travelling Trees
by Sally Cheung

Over the holidays, I had some free time to do some winter birding. Though unlike summer birding where you can grab a pair of binoculars and jump outside in a t-shirt and shorts, winter birding requires some, or rather lots, of layering up. The order goes short-sleeve, long-sleeve, long johns, pants, socks, sweater, jacket, another jacket, toque, mitts, until I look like this:

![Photo by Franica Pulis from nisse.cafe.se](image)

The birding begins, and on the river is a mallard standing in -10°C weather, looking as content as a duck can be, with two webbed feet in full contact with the sheet of ice frozen over the river. And I look down at all the layers I’ve drowned myself in and look back at the duck. How is that duck’s feet not frozen? How do other animals survive the winter without putting on 5 layers of clothing? What do plants and trees do to withstand the cold temperatures?

Ducks and many other species of birds have a countercurrent heat exchange system in their feet, since their feet are not covered in feathers nor have a layer of fat for insulation. The warm arterial blood that flows towards the feet come into close contact with branches of the vein carrying cold blood from the feet back to the body. As a result of this, the heat from the arteries warms up the blood in the veins so that blood reaching the feet is already cold to conserve heat and blood flowing back the body is warm to help maintain core temperatures. Since birds’ feet are not up of much soft tissue, there is less of a need for warm blood and this reduction in temperature differences between the feet the ice allows for less heat to be lost. heat exchange system is so effective that 5% of their body heat is lost through feet. The feet just need enough blood to receive food and oxygen, without getting frostbite and damaging any tissue.

![Drawing by Tom Pelletier from askanaturalist.com](image)
Now when it comes to other animals we know that some eat a lot and then sleep a lot, some migrate south to warmer destinations, and humans will use both those strategies when they can. However, one unique example comes to mind when I think about surviving the winter: the wood frog.

Many humans think we’re the smartest species on this planet, but the wood frog has figured out how to time travel! Over the winter months, these frogs will completely freeze into frogsicles and when the weather gets warmer, they thaw out and continue on with their lives. Once the weather starts to drop, the frog’s liver produces large amounts of glucose and replaces the water in their cells with all this thick sugary substance. This process pushes all the water into the space outside the cells, which eventually freeze, but the cell itself avoids freezing and thereby being destroyed. The frog’s heart will stop, brain activity stops, and the frog is frozen. Once the frog thaws in warmer temperatures, the ice outside the cells melt and the water flows back into the cells resuming normal functions.

Photo by J.M. Storey from ariannesociety.org

For the longest time, I thought that process was unique in the natural world, until I found out that trees are just as smart! Some plant cells within the tree will change their membranes so that more water can easily move out of the cell into the intercellular space. Then the trees will also use sugar as an antifreeze, turning starch into sugar and replacing the water inside the cell with high concentrations of sugar. This prevents the cells from freezing and dying, just like in the wood frog. Trees also will go through a dormant state over the winter months, lowering their metabolism, using less energy by dropping leaves in the fall, and slowing down growth.

Now only if humans can figure out how to time travel. But in the meantime… shirt, shirt, sweater, jacket, long johns, pants, and mittens will do!


This article was written for our January 2019 e-newsletter.
To subscribe or see the complete newsletter and other newsletters please visit our website at: http://www.uoguelph.ca/arboretum/educationandevents/enewsletter.shtml