

## WINTER

(Narrator) Next on Quest – a guide to winter and some tips on surviving it.

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(Reeser Manley, Botanist) It's a tremendous physiological and biochemical change that occurs as the plant moves from the growing season through the fall and into winter that results in the really deep cold hardiness.

(Gerard Courtin, Center for Northern Studies) The only way that human beings have adapted to winter is through their intelligence. We're wearing our intelligence.

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### (Open)

(Linda Greenlaw, Segment Host) Hi, I'm Linda Greenlaw. Here in northern New England we consider all four of our seasons beautiful, but winters can be long and hard. A little more beauty than some of us can appreciate. But we all have to deal with winter, try as we may to avoid it. Even though some animal species can escape winter by migrating, most of our natural world has learned how to tough it out. Plants and animals have developed some pretty clever ways for doing just that. I've often wondered if there exists one best solution for coping with winter? If so, I wish someone would share it with me.

(Narrator) There is a stillness to winter that cannot be found in any other season. There's no doubt that life in northern New England shuts down in winter, and some of it dies. But in our natural world, there also are many incredible stories of survival. You can see it in the animals lowering their heads in a storm, determined to tough it out. In the scurrying of birds, feathers fluffed, in snow-caked evergreens. Even in the rattle of beech leaves on the coldest of winter days...somehow still hanging on months after turning brown and dry. The signs of perseverance are everywhere.

(Dick Smyth, Naturalist) I'm always looking for animal tracks. To me it's the gossip column in the snow. I can tell who's been out there and what they've been doing. Who's missing and who's just arrived. And I take great delight in sort of reading the tracks in the snow.

I think most people either play all winter or struggle all winter. But they don't really think about what winter really is. And it's obviously a time of very great stress on many organisms.

(Narrator) Many organisms have no choice but to stay, they're not designed for migrating. By necessity they've come up with effective ways to confront winter. In northern New England, that is the real story of winter.

(Gerard Courtin, Center for Northern Studies) It's the animals that sit there and face the music, that are the really interesting ones. The ones that stay winter-active all winter long and somehow manage to cope.

(Narrator) Both Courtin and Smyth teach at the Center for Northern Studies in Wolcott, Vermont. The school's campus is 350 acres of dense forest. It's just one small part of northern New England's boreal, or northern coniferous, forest.

(Dick Smyth, Naturalist) This is a wonderful spot for the Center for Northern Studies because it happens to be a little part of Vermont that is particularly cold...a true example of a boreal forest...a true northern forest that you might find in Scandinavia, or Canada, or Alaska. So we sort of have an outdoor laboratory that is ideally suited for what we are interested in.

(Narrator) The Center for Northern Studies is one of about 10 schools in all of North America that regularly offers winter ecology courses. This student is hoping to prove that photosynthesis continues through the winter in some northern trees, like the quaking aspen.

(Gerard Courtin, Center for Northern Studies)

It's part of the seasons that have been ignored. And it's been ignored because it is difficult to study. You're studying under cold, wet, often windy conditions. And you need a certain masochistic streak to be doing this sort of thing.

(Narrator) One of the first northern New Englanders to be engrossed by the science of winter was a Vermont farmer and self-taught meteorologist. Wilson “Snowflake” Bentley painstakingly took more than five-thousand stunning and detailed photos of snow. In 1885, he became the first person to photograph a single snow crystal by connecting a microscope to a bellows camera. He discovered that no two were alike - that each snow crystal had a unique design. Even though these photomicrographs are now a century old, they’ve had a lasting impression on many of us. But are snow crystals the same as snowflakes?

(Gerard Courtin, Center for Northern Studies) Our first misconception is what a snowflake is...and you can ask anybody and it’s that six-sided beautifully intricate structure. Everybody knows what a snowflake is and that’s not a snowflake. That’s a snow crystal. And it’s a stellar snow crystal, as opposed to being a plate or column. All of these fall out of the sky every time it snows. A snowflake is an aggregate of snow crystals. So when we see these doormats falling from the sky, those indeed are snowflakes. They’re made up of anything from two or three to many hundred snow crystals.

Most crystals come down broken, or having more grotesque shapes as that classic archetype six-sided figure. Having said that, that six-sided figure is based on the molecular structure of water...water looks very much like Mickey Mouse, a face with two ears...that is the blueprint for ice-forming crystals that are hexagonal, six-sided, in shape.

(Narrator) The shape and chemistry of snow crystals often change within a few hours of falling to the ground.

(Gerard Courtin, Center for Northern Studies) If we envisage a stellar crystal, the archetypic star, what happens is the water migrates from the sharp points at the end of the star to the hollows between two of the arms. And so it begins to get smaller and more rounded. If you take a look at a snowpack over a period of days, and it hasn’t snowed, you will find that it decreases in thickness. A lot of that decrease is that the crystals are becoming smaller and smaller.

(Narrator) If you’ve ever built a snowcave, as these students from the Center for Northern Studies are doing, you’d know how quickly snow compacts and becomes air tight. A few hours after being shoveled into a pile, it’s ready for being turned into a snow shelter. Under the snow at the surface of the ground, the snowpack also undergoes continual change - because of the movement of water vapor.

(Gerard Courtin, Center for Northern Studies)

The ground is unfrozen. Most people think it’s frozen. It’s not frozen unless there’s no snow. So what happens? Well, water moves up in the pack, and at the same time a very well known economic principle kicks into play and that is the poor get poorer, and the rich get richer. Small crystals disappear and the other become fat cats. Because there are larger spaces in between, the snowpack becomes quite brittle.

Right at the bottom of the pack, you get what is called in Eskimo language, pukak. Pukak is depth hoar. You get the greatest amount of change to the pack to crystals that don’t look anything like the ones that fell out of the sky. And which have magnificent intricate shapes. They look like square-cut diamonds, in fact, they have many many facets. And they form hexagonal logs which are as much as a quarter inch in length. Amazing, amazing things.

(Narrator) Ever noticed how snow crystals can be as dazzling as diamonds on some winter mornings? Those too are caused by the movement of water vapor. This scientist has literally gone to the ends of the Earth - Greenland and Antarctica - to study snow.

Surface hoar is a feathery type snow crystal that grows on top of snow. It would happen on a cold night where there might be liquid water in the snow. That water vapor again diffusing toward the atmosphere makes the feathery snow crystals on top of the snowpack. If the wind blows, they’ll blow away.

(Narrator) This scientist has literally gone to the ends of the Earth to study snow. Mary Albert’s snow and ice samples are kept for years in climate-controlled rooms at the Cold Regions Research and Engineering Laboratory, also known as CRREL, in Hanover, New Hampshire.

(Mary Albert) These are snow samples from Antarctica. This piece of snow here is about 40 years old.

(Narrator) There’s an array of military and civil engineering projects at CRREL devoted to winter-related problems. These are projects that help people deal with winter. Scientists here have made ice, as well as snow, their specialty. Leonard Zabilansky is a researcher for CRREL’s ice engineering facility.

(Leonard Zabilansky, Researcher for CRREL) Winter is usually, well, nothing happens in winter. Let’s forget about it. That’s when a lot of the changes are taking place.

(Narrator) Take frazil ice. It’s microscopic ice that collects near the bottom of streams and rivers – a common occurrence in northern New England because of the steep grades of waterways. Frazil ice grows very quickly – up to 12 feet deep. And once it starts forming, it progressively works its way downstream and overnight can change the flow and appearance of a river, blocking as much as

90% of a river's flow.

(Leonard Zabilansky, Researcher for CRREL)

In the wintertime that's not too much of a problem. It's when in the spring when you have break-up and water starts to move through the system, frazil collections impede the free movement of the water as it tries to move through the system. So now the water backs up and it needs routes to get back into the river. And if that happens to be Main St. USA, well that's where it goes.

(Narrator) Hardwick, Vermont - a typical northern New England town built along a river - had that problem. Main Street and the downtown area were flooded nearly every spring because of an ice jam at one of its bridges. The town turned to CRREL for a solution.

(Leonard Zabilansky, Researcher for CRREL) Through some work we've done downstairs in the research area, we built a model of various structures of geometry to come up with a design load to how big the structure would have to be, what's the geometry, what's the best shape, what's the spacing. As it turned out, it ended up being some very nice-looking granite blocks with a very large foundation so that a large collection of ice when it come down and hits these blocks, the blocks are not overturned. And it's been very effective in controlling the ice break-up process.

(Narrator) Think of it as four 42-ton blocks acting like a strainer upstream of town. And engineers at CRREL can keep an eye on the river with web cams that run 24 hours a day. It's a simple solution that few other facilities are equipped to perform.

(Leonard Zabilansky, Researcher for CRREL) This is a very well kept secret. As much as we try. This is a resource for the nation, tucked in the hills of New Hampshire and there's a lot of things that we do that have a very good benefit all across the nation. And most people in New England don't even know that we're here.

(Narrator) Although we humans are still learning to adapt to the stress of winter, the natural world has far experience to draw upon. For instance, the changes that naturally occur in the snowpack are taken advantage of by many of our smallest mammals. In winter, subnivean creatures – meaning those that live under the snow - move up from underground to the ground's surface under the snowpack. Subniveans include mice and shrews, as well as moles and voles. When covered with snow, the surface of the ground is a comfortable place to be because it stays within a degree or two of freezing, all winter long. It's even more inviting here because as shown in these electron microscopic images, water vapor from disintegrating snow crystals migrates upward to the top of the snow and re-condense onto the upper snow pack crystals, where it's colder. Before long, a "latticework" of ice pillars and columns create many spaces for sub-niveans to move around in. In the spring, when the snow melts, we often see the remains of their network of tunnels. But even though the subniveans are hidden under the snow, they're still heavily preyed upon. They may be out of sight, but they're not out of earshot.

(Bernd Heinrich, Biologist)...If you sat here every once in awhile you would hear a little gnawing. It's like a mouse gnawing on something. So if you're very very quiet you can hear things. And of course they have hearing much keener than ours. And it could be gnawing on an insect from quite some distance. And the gray owl for instance will locate precisely where that is and just pounce in with its feet and basically collapse the tunnels in that area. ...And coyotes and foxes do the same thing. They pounce with their front feet down into the snow where they hear something.

(Gerard Courtin, Center for Northern Studies)

There is a downside to winter for many animals. The animals that live beneath the snow, for instance, the sub-nivean creatures...work that a group of students have done recently have shown just how vulnerable those creatures are. Especially in the spring, when the whole snowpack changes its characteristics...when the pack alternately freezes from...day to night...and the meltwater at the top of the pack heated by the sun and rain runs down through that very very quickly. Once those nests are saturated, once the whole subnivean environment is underwater in many places...the mortality can be terrible. We've documented...total mortality. It is that they get wet and they have nowhere to go.

(Narrator) Many small mammals that are solitary during the summer become much more social in winter. They'll curl up together, huddle, and fluff their fur to maintain their body temperature. And small and large animals alike need to go into winter with some extra weight.

(Gerard Courtin, Center for Northern Studies) You can't be too small, and you can't be too big. You have to be just right. And being just right means you have to have a body that is big enough that you can lay down some groceries. And the groceries in this case are fat. And at the same time, you have to have a body that is not so large that when you need to arouse, you're not going to burn all that fat. If you do, then you're toast.

(Narrator) When it's bitterly cold, there comes a point when the animal must take other measures to generate more body heat. The temperature at which this becomes necessary is called the "lower critical temperature" or LCT. LCT varies from one species to another and is seasonally adjusted in many animals. And it may be more important to their overwintering success than anything else.

We often think of wildlife hibernating to deal with the rigors of winter. But hibernation is a very broad term, literally meaning “winter inactivity.” What many of us think as hibernation is actually torpor - when animals lower their body temperature to be more in line with the outside temperature. The “hibernating” black bear has been described as a biochemical marvel. Its winter temperature is only slightly lower than what it is normally - 90 degrees as opposed to 100 degrees Fahrenheit. By no means are bears in a deep sleep in winter – they can respond quickly when they feel threatened. What’s amazing is for four or five months, bears don’t have to drink or urinate. Instead of urine, bears create a non-toxic product which is turned into protein, helping to maintain their muscle mass. And water gets recycled because there are few toxic wastes to be flushed out.

(Craig McLaughlin, biologist) The Maine study is one of the longest running studies in North America. We’ve been working with bears for 27 years. We started it in 1975.

(Narrator) Craig McLaughlin is one of those biologists who thinks nothing about disturbing a sleeping bear to learn more about it.

(Craig McLaughlin, Biologist) They’re metabolizing body fat. They reduce their body temperature and therefore energy demands throughout the winter months, and they’re actually building lean muscle mass. They rebuild protein as they go through the winter. So they come out leaner and meaner than when they went in in the fall.

(Narrator) But just like there are different kinds of hibernation, there are various degrees of torpor.

(Bernd Heinrich, Biologist) We in fact lower our body temperature one or two degrees at night too. But we’re not torpid. We’re just a little hypothermic. There are all kinds of grades of that in different animals. In all durations. For example, some animals might go just overnight.

(Narrator) On cold nights, some of our smallest animals wouldn’t make it if they didn’t go into torpor.

(Wilson) Think of a bird spending 8 or 9 hours feeding. Then the sun goes down and it can’t feed, and the bird is so cold because it has to replace all that heat it’s losing over its surface area. And it sits there and shivers uncontrollably all night long. And overnight it may lose all of its fat stores that it built up over the day.

(Narrator) Chickadees can drop their body temperature 10 to 12 degrees at night – for a 20% energy savings.

(Gerard Courtin, Center for Northern Studies) They go into nighttime torpor. They drop their temperature down from very close to 40 degrees C to about 23. So roughly 100 down to about 80 – 75. The advantage of that... is you lose less heat. The downside of that is when you’re torpid, you can’t move very fast if there is a predator around. But it’s obviously an evolutionary strategy that has worked for chickadees.

(Narrator) But how do they sleep when they’re shivering all night long?

(Wilson) That would be something else to know. How much do you sleep when you sit there shivering uncontrollably all night? But they somehow manage.

(Narrator) Most of our smallest wildlife, including some bats, mice and insects, routinely go into partial torpor during the night. Just dropping their body temperature a few degrees makes a difference. Birdfeeders kept stocked with seed helps too.

(Wilson) We know from work with chickadees, winter birdfeed does increase their winter survival... We also know that birds do not become dependent on feeders. So that people should not feel any anxiety about feeding birds for part of the winter and not feeding them for several weeks. That’s perfectly fine. They do appreciate those handouts and their survivorship is enhanced by seeds in the wintertime.

(Narrator) Biologist Bernd Heinrich doesn’t mind trudging through the woods in winter, or even swinging high on slender saplings, to discover things that he missed in the summer.

(Heinrich) You can tell it’s a blue jay. But it’s two years old and pretty well falling apart.

(Narrator) Out with his winter ecology class from the University of Vermont, he’s retrieving bird nests for his students. The nesting habits of our native birds differ greatly, both in construction and location. And this diversity helps keep predators guessing. Heinrich’s gonzo-like methods are admired by students and colleagues alike.

(Heinrich) What is it a rose-breasted grosbeak? Yes. (Whistling).

(Narrator) Heinrich has done a lot of field research in the forests of western Maine, where he has a cabin in the woods. And from his

home office in northern Vermont, he can look out over another one of his favorite research topics - his flock of ravens. Several of his 10 books have won national prizes and are considered natural history classics. One of Heinrich's latest research projects is studying how insects make it through winter's cold. Most insects have little more than curled leaves or hollow plant stems for protection. Many spend the winter as pupae in cocoons; a few as eggs or larvae. But "winter moths" overwinter as adults and they can remain active year around. Not surprisingly, they are covered with a layer of insulating "fur".

(Bernd Heinrich, Biologist)

Their whole strategy is to be as cold as possible in the winter so as to conserve their energy supplies. There are winter moths here... which can shiver and warm up which allows them to be active in the winter. It allows them to be active in the winter, but only for short periods of time. They might have energy sources to shiver for an hour or so. But if they were to use up their energy reserves, they'd be dead.

(Narrator) These moths are unique because they can take immediate advantage of temporary thaws. But very few insects, even winter moths, are able to produce any significant quantity of heat in winter. Sooner or later it gets so cold that freezing is inevitable. In most animals, ice is lethal once it penetrates individual cells. Yet a number of insects, as well as garter snakes, intertidal mollusks and barnacles, and even hatchlings of the painted turtle, can tolerate slow and gradual freezing. It's the fluid between their cells that freezes, not the fluid inside the cells. The growth of ice in these extracellular areas is limited by special antifreeze proteins and alcohols. Essentially these creatures become "pickled" in antifreeze.

(Mark McCollough, Maine Department of Inland Fisheries & Wildlife) We have a number of species of frogs that hibernate, or overwinter, in the upland. So unlike the frogs that spend the winter in lakes, they have to evolve adaptations to be able to survive the winter in the forest floor. And our wood frog, our gray tree frog, and our spring peeper, and to the west of here, chorus frog, all hibernate in the upland. And they do that in an amazing way. They are underneath the forest floor, the litter, the leaves on the forest floor in the wintertime. And as things start to get cold, the wood frogs will pump their body full of glucose or sugar and this works as an anti-freeze to keep their body fluids from freezing. And as they get colder and colder, their body fluids actually start to freeze, and form ice crystals and draw water out of the tissues, the cells of the animal, which further concentrates the glucose inside the cells and acts as an anti-freeze.

So the wood frogs can actually withstand temperatures down to 21 degrees. They can freeze; up to half of their body freezes during the mid-winter time period and they can stay that way for several weeks.

Actually their heart stops, their breathing stops, they totally stop most of their bodily functions. And then in the springtime, when things start to thaw out, their heart starts to beat again, the animal thaw out, and they resume activity.

(Narrator) It's advantageous for these frogs to emerge from hibernation in early spring before their predators migrate back to northern New England.

One of the more ingenious strategies for winter survival is the heat exchange system used by various mammals and birds that have large tails or legs exposed to frigid water. Appendages like these are a detriment since they constantly drain heat away from the animal's body. To stay warm the animals essentially shut off heat to these extremities. When air temperatures drop, surface veins in the extremities constrict and more blood is sent through deeper veins. That blood is then warmed by arteries carrying warm blood from the core. This heat exchange works amazingly well in beavers and aquatic birds - allowing them to stay warm even when swimming in icy waters to find food.

In lakes and ponds, aquatic life shifts into winter mode often long before the onset of winter and before the thickening ice cover forms a lid over their world. For turtles, winter hibernation is a prolonged stay underwater - that lasts six months. From November to the end of March - in the mud, and with all breathing and presumably all heart activity stopped. Come spring, the turtles emerge, warm up, take a few breaths, and are ready to resume life. It's a strategy that has served them well for at least 140 million years. In the streams, aquatic insects dig in for winter too. Stoneflies, caddisflies and mayflies - move away from the banks where they spend most of the year and move into deeper water.

(Jim Kellogg, Stream Biologist)

They know what's coming through evolution and adaptation. They know there will be an ice-out which will scour the banks and cause considerable damage to those shoreline areas of streams. So they too move in, they move into the deeper water, they get under the rocks, more so than they do in the summer.

(Narrator) On close inspection, some of these insects look quite different this time of year.

(Jim Kellogg, Stream Biologist) It does surprise us that some of the mayflies and some of the stoneflies that we look at in the spring and summer and are so small, are actually at their largest size right about now.

(Narrator) In the bitterly cold waters off the northern New England coast, fish that don't migrate to warmer waters, also have to develop some kind of resistance to freezing. Here too antifreeze is the solution. A large number of this region's marine species, including Atlantic cod and winter flounder, produce anti-freeze proteins to lower the freezing point of their body fluids. That way

they're a step ahead when ocean temperatures dip below the usual freezing point of water.

It would seem that larger animals would have an easier time staying warm and dealing with winter. But is that really the case? It's true that both white-tailed deer and moose have a remarkable tolerance for cold. And because of their winter diet, they can usually find something to eat. But this winter browse has much less nutritional value than what they eat during other times of the year.

(Gerry Lavigne) If I were a deer today I would be struggling with the crust on...

(Narrator) Gerry Lavigne studies the health of white-tailed deer herds for the state of Maine.

(Gerry Lavigne)

14 to 15 inches of snow with a crust because it works away at the deer's shins and there's a lot of discomfort. They're very reluctant to walk in this.

When the snow hits the ground, the quality of deer diets changes for the worse. And that's just a fact of life. Woody browse, that is dormant shrubs, dormant tree seedlings, conifer foliage, that sort of thing, is fairly indigestible compared to their summer food. And they're fairly low in energy. It's hard to extract good quality out of winter browse...

Browse is important, but you have to realize as a sole diet, deer will lose weight on it.

(Narrator) Working in the deer's favor is an ability to adjust their lower critical temperature downward more effectively than just about any other animal.

(Gerry Lavigne) They decrease their activity levels, they also tend to slow down their metabolic rate, which is a very interesting adaptation. In essence, they turn down their thermostat on the rate in which they burn calories in their body. That too in January and February is an adaptation to survive the low quality and quantity of food.

(Narrator) Also working in their favor is a dense coat of fur that's hollow and glands next to the hair follicles that secrete oils that help "waterproof" the fur.

(Dave Erler, Squam Lakes Natural Science Center) You see a deer after a snowstorm that pretty much stays put, it will be covered with snow. It sits right on top of their body. An incredible amount of insulation there which is important for an animal like that because they're not seeking shelter underground or any other place. Their coat is the difference between life and death.

(Narrator) But during an especially cold winter, even this superior insulation is not enough.

(Gerry Lavigne) Below zero, deer have to move around a little bit more to stay warm. And you might observe deer shivering a little to burn more calories to stay warm. So the amount of time in winter where it's below zero critically affects the amount of calories a deer consumes.

(Narrator) Here in northern New England, white-tailed deer show a strong tendency to congregate in "deeryards", located in dense conifers where there's less snow and their collective trail system makes it easier to get around. In these yards they can find both protection from the wind and access to solar warmth.

(Gerry Lavigne) During the course of the day the sunlight filters down through the canopy and shines in little pools of light all around the forest. Deer take advantage of that. At times during the day, they'll bed in the sunlight gaining warmth from the sun just as you or I would at the beach. So another survival strategy of deer is to move around a little bit to positions that are out of the wind, but still in the sunlight to help them stay warm.

(Narrator) On the other hand, staying in a deeryard all winter puts considerable pressure on limited food supplies. And malnutrition is common at the end of a hard winter.

It's easy to see why scientists think winter is responsible for the evolutionary design of this somewhat odd looking, but very successful northern animal. Bill Silliker Junior is one of the best-known moose photographers in the field. He's spent enough time around moose to know them quite well and to earn the nickname, "The Mooseman."

(Bill Silliker, wildlife photographer) This is after the rutting season, the bull moose in particular has lost a lot of weight, and he'll start feeding heavily. He's got to put on weight; he's got to get back on if he's going to survive winter. They keep their antlers generally... they drop around December, mid-January. It comes off in two pieces; there's a right and left side. And they're on pedicles...and sometimes you'll see a moose with one walking around. For survival they don't need the antlers anymore, so by winter they have to drop those, they can weigh 60, 70 pounds. When it gets snow on it, it could weigh a lot.

(Narrator) With their exceptionally long legs, moose have little trouble getting around in deep snow.

(Bill Silliker, Wildlife Photographer) Moose will go higher to mountain tops often...they seem to like the mountains up here. There's less snow, it blows away, and they can get at more food. They're not impeded by snow, unless it's really deep.

(Narrator) Like deer, moose are inclined to stay in relatively small areas during winter, conserving energy, and fully taking advantage of good foraging habitat before moving on.

But animals don't have a monopoly on resourcefulness in surviving winter. Plants have no choice but to stay and face the rigors. Reeser Manley is a botanist with the University of Maine who specializes in winter stress.

(Reeser Manley, Botanist) Our northern hardwood trees, and our conifers, can withstand, easily withstand, temperatures that at their maximum hardiness, they can survive temperatures of minus 40 degrees. That same organism, that same tree, in the summer would be damaged or perhaps killed by a mild frost. It's a tremendous physiological and biochemical change that occurs as the plant moves from the growing season through the fall and into winter that results in this really deep cold hardiness that protects them through the winter.

(Gerard Courtin, Center for Northern Studies) If we were going to take a twig with buds at the beginning of August and freeze that. Bring it to just the freezing point, it would die. You do that a month later in September, it would probably be able to withstand down to minus 10 degrees C or somewhere around 12 F. Something's happened. It's the same twig, the same buds, and what has happened here...actual changes within each cell, and this is a very important change to take place.

(Narrator) So many plants, including deciduous or hardwood trees, have ways to avoid freezing.

(Gerard Courtin, Center for Northern Studies) The other thing that happens is as water is lost outside the membrane, is the concentration of sugars, and what are known as solutes, become all the more concentrated. And just as when you salt roads to melt snow, or in fact, to stop it from freezing, so that concentration of solutes in the cell lower the freezing point.

(Reeser Manley, Botanist) It's possible for water in the plant to go below what we consider the freezing point – 32 degrees F or 0 degrees C. And yet that water in these tissues will not freeze. It's amazing to me to realize that the water in some plant tissues can get down to minus 40 before it actually freezes. The freezing event at minus 40 is catastrophic. It's immediately lethal to the tissue. While the tree is successful avoiding freezing down to minus 40...if it encounters freezing, it's killed.

Conifers on the hand, which we find growing way up in northern latitudes where we find temperatures fall below minus 40 are using a different mechanism. They are actually tolerating the formation of ice in their tissues. But not in the living cells. That ice is growing in the space between cells. It's growing at the expense of water in the cells. In other words, water is moving through the cell membranes, and through the cell walls and it's feeding this ever-increasing ice mass.

Interestingly enough, some of the same anti-freeze proteins that are found in cold water fishes and insects, can be found in many plants.

(Narrator) Plants become cold-hardy very slowly - each frost enables them to tolerate lower temperatures. That's not the case at the end of winter though when there's an unseasonal series of freezes and thaws.

(Reeser Manley, Botanist) ...The loss of cold-hardiness seems to be a more abrupt event. This is why we often run into problems in late winter when our plants are fully dormant, fully cold hardy, but we have a warming spell and we often see buds start to break...and then a late winter or early spring freezing event can be very damaging because they've lost that ability to protect themselves.

(Narrator) Botanists are becoming increasingly concerned with the more extreme freezes and thaws we're experiencing in the middle of winter. Because when there's a loss of snow cover in winter, soil temperatures and root cells get much colder than they normally would.

(Gerard Courtin, Center for Northern Studies) The question really is just how cold can roots get before they are damaged.

(Narrator) Compared to plants and animals, humans seem to be the least tolerant of long winters and cold temperatures.

(Gerard Courtin, Center for Northern Studies) We're incredibly badly adapted. Incredibly badly adapted. We've got these long appendages. These tiny little feet and hands on the end. And these tiny little feet and hands have got long narrow fingers. We lose a tremendous amount of heat. The only way in which human beings have adapted to winter is with intelligence. We're wearing our intelligence...

(Narrator) The most effective natural mechanism we have for minimizing heat loss is constriction of the blood vessels close to the surface of our skin, which in turn reduces skin temperature. This mechanism is especially effective in our fingers and toes. It's a bit like the heat exchange mechanism in some animals, but the range of temperature reduction in our extremities rarely approaches that seen in the appendages of animals.

But we're a little better than most organisms at generating heat. Increased muscle activity, either voluntary or even by shivering, is our most effective way for us to warm ourselves up. Vigorous exercise can increase our heat production as much as 10 times. And shivering can raise the metabolic rate five times. Even before shivering, a measurable increase in muscle tone occurs, often felt as a tightening of the neck and shoulder muscles. This alone can double heat production. But when it's very cold, exercise has its own downsides.

(Gerard Courtin, Center for Northern Studies) ... there are still a lot of things that we don't do that are absolutely critical. Not to get cold, but not to get wet from our own perspiration. From the moment you begin to exercise then it's a matter of keeping whatever insulation you're wearing dry. The moment it gets wet, you're in trouble.

(Stephen Lunna, Army Mountain Warfare School) We're not an animal that is very well adapted to cold environments.

(Narrator) Here at the Army Mountain Warfare School in Jericho, Vermont, soldiers are learning how to conquer a wall of ice.

(Stephen Lunna, Army Mountain Warfare School) For these guys, this is still pretty much the crawl stage. We haven't even gotten to the walk phase yet. For a very large majority of these people this is their first ever experience on ice with crampons and ice picks.

This is one of a very few schools that the military provides. There's us and a school in California that the Marines run. And we're the only two schools that provide this type of training for the United States military. And we have soldiers coming from all over the country to experience what it takes to operate in mountainous and cold-weather environments so that they're better able to do their missions wherever they may be called for.

(Narrator) Because of our technological ingenuity we're able to withstand the worst winter has to offer. And given a little time to get acclimated, our bodies can actually increase our tolerance to cold. Perhaps there's a reason why many of us go to great lengths to avoid such exposure. Because biologically we're still tropical creatures.

(Erler) I think it's important if you live in northern New England to understand that the winter sure is a time of rest for a lot of creatures. But there's a lot going on out there. And the amazing thing is that they're so in tune with the environment.

(Bernd Heinrich, Biologist) The dominant theme in biology is diversity. And there are an incredible number of different ways to doing it. Slight pre-dispositions one way or another, that's how evolution works. It elaborates on what works.

(Linda Greenlaw, Segment Host) So is there one perfect solution to surviving winter? The answer is - there are many solutions. The natural world has come up with an impressive array of adaptations that we are just beginning to understand and appreciate. I'm Linda Greenlaw. Thanks for joining me on this quest.