

Shelter

Because they find shelter from the severe winds and cold, many living things remain on the tundra year-round.

The small mammals, insects, and plants living in the tundra cannot migrate to distant places to avoid the severe winter conditions. Their adaptive strategy is to remain beneath the snow, near the ground. Lemmings, for example, tend to live together in areas where the snowpack is deepest and least dense. This type of snow shelters them from the wind and offers some protection from the cold of winter. In contrast, dense, wind-packed snow is a poor insulator and provides only limited protection from the cold.

Some animals, such as the arctic ground squirrel, move underground for winter. Soil, like snow, provides insulation against the cold and wind. Many plants have a similar adaptation: their above-ground parts die back each winter, while their main growth and energy storage is in their underground roots, sheltered by soil and snow.

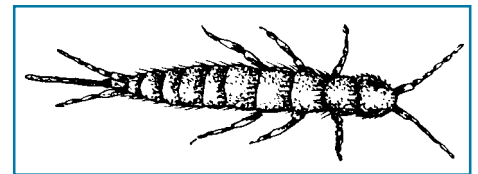
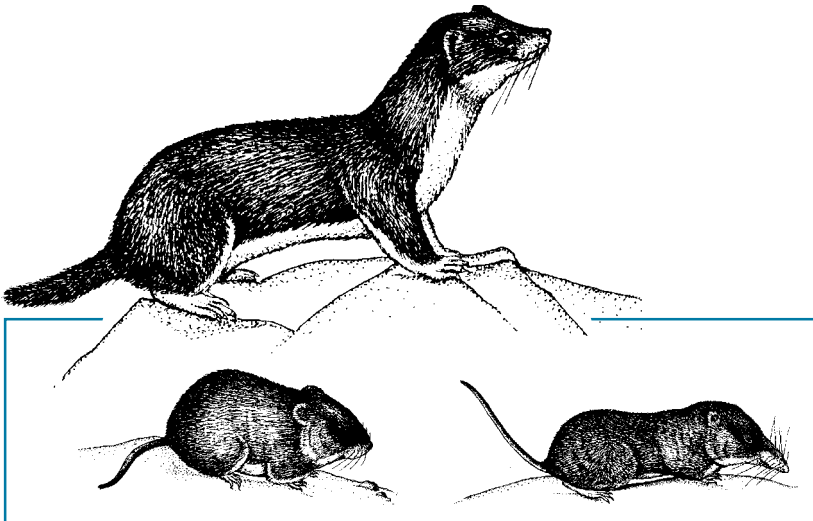
The cool temperatures and strong winds of tundra summers also call for special adaptations. The answer for many is to live close to the ground. Just place your hand on the ground to feel the advantage – it's WARM! Due to friction, the wind speed within 2 inches (5 centimeter) above the ground is slower. The

air is also warmer near the ground than higher above it because soil absorbs and radiates heat from the sun into the air.

Tundra plants typically are small and grow in flattened, cushionlike forms. Many tundra insects live their entire lives in the shelter of ground plants, thus avoiding the most severe cold and wind. Wingless forms of many insect groups are the most common in tundra environments. Arctic ground squirrels and brown bears dig their underground dens on south-facing slopes that will be the first to warm in spring.



Air temperatures are warmer and winds are slower near the ground's surface. Many tundra plants, such as moss campion, grow in low, flat mats or cushions to take advantage of these milder conditions.



Wingless insects are common in tundra environments. They spend their entire lives in the shelter of soil, mosses, or other plants.

Lemmings, voles, shrews, weasels, arctic ground squirrels, insects, and most plants survive the winter winds and cold by living beneath the snow. Temperatures under a blanket of deep, soft snow are usually 20°F (7°C) warmer than the air temperature above the snow.



Scarcity of food in winter prompts a range of adaptations from dormancy and hibernation to stocking up.

Sheltering near or under the ground is only half the survival mechanism for some tundra life that stays year-round. Plants, insects, and microscopic organisms simply cease functioning during the tundra winter. They stop moving, growing, and breathing during the winter, so they have no need for food. Birds, mammals, and fish, however, cannot survive unless they continue to breathe, thus they cannot become **dormant**.

Some animals survive by reducing their functions to the minimum needed for survival. Arctic ground squirrels and marmots **hibernate**. During winter, an arctic ground squirrel's heart beat slows from 200-400 beats per minute to 7-10 beats per minute; its body temperature lowers from 97° to 62°F (36° to 17°C); and it breathes only three times each minute instead of 60 times. While hibernating, a ground squirrel uses 98 percent less energy than while awake.

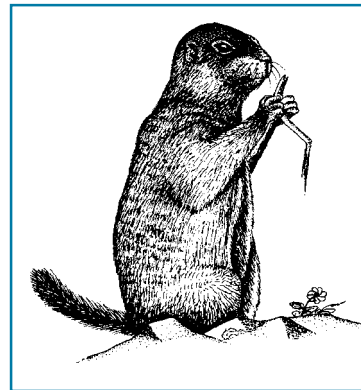
Brown bears survive winter in a modified hibernation. Their heart rate slows from 50 or 60 beats per minute to 20 beats, but their body temperature is not reduced.



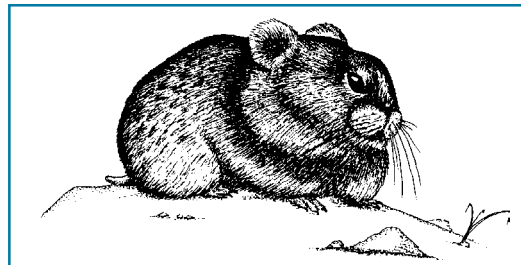
Brown bears eat only during four to five months of the year. Some lose up to 60 percent of their body weight during winter when they must live off the energy stored in their fat.

Arctic ground squirrels, marmots, and brown bears must eat enough food in four months of summer to maintain their body functions during eight months of sleep. They store this needed energy as layers of fat. In tundra habitat, a brown bear weighing 300 pounds (136 kilograms) in fall emerges from its den in spring weighing less than 200 pounds (91 kilograms) because it used its fat – energy reserves – while in its den.

Other tundra animals, lemmings for example, remain active and even raise young during winter. They survive by feeding on the energy-rich buds, stem bases, and **rhizomes** of dormant plants. Pikas and singing voles remain active during winter and survive by eating food they cached for winter use. During summer, pikas busily gather and dry grasses in the sun, then store the hay near their nests. Singing voles build large piles of grasses and other plants for winter food.



Humans may die if their body temperature drops below 90°F (32°C) for even a short time; arctic ground squirrels, however, lower their normal 97°F (36°C) body temperature to only 62°F (17°C) during hibernation. This greatly reduces their need for energy.



Pikas cut grasses and other plants, dry them in the sun during summer, and store the dried hay underground as a winter food supply.

TUNDRA ADAPTATIONS

Size and Shape

Large size and short appendages are adaptations that help tundra animals keep warm. “Small” works best for plants.

Many tundra birds and mammals are larger and have smaller appendages than do similar species living in warmer environments. Tundra hares, for example, are among the largest hares and have shorter ears and legs than do desert hares (called jackrabbits).

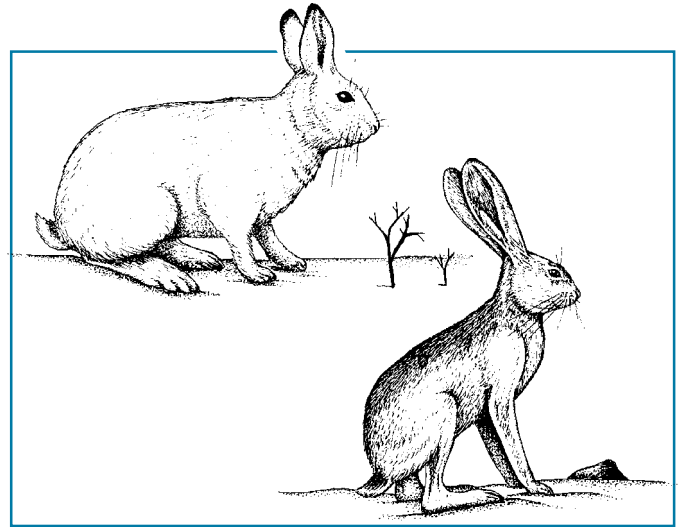
Similarly, arctic foxes have shorter ears than do desert kit foxes. Even lemmings are larger and have smaller ears and tails than do most other mouselike animals. Large body size and short appendages are adaptations that reduce heat loss and resist the cold.

The amount of heat loss increases as the ratio of exposed surface area to body weight increases. Because small animals have more surface relative to their weight than do large animals, they lose heat more quickly. An animal with long legs, ears, or a tail has more surface area than does an animal of the same size that has shorter appendages.

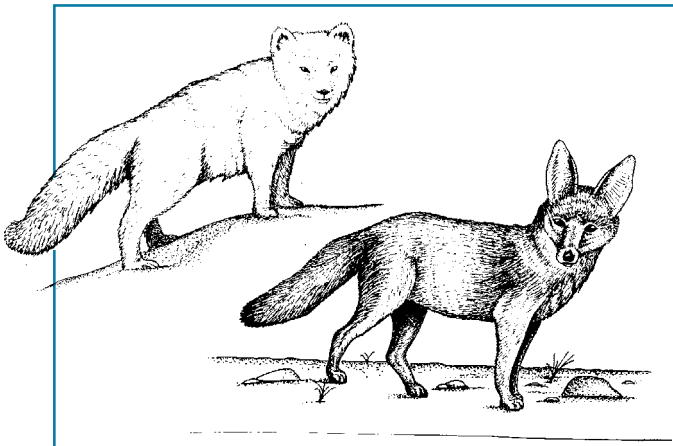
Small size, however, can also be an adaptation for survival on the tundra. Why? A small organism can survive on less food than can a large organism of the same species. Very small organisms can live under the

snow and avoid the most severe conditions of winter. Shrews, the smallest of all mammals, thrive in the tundra.

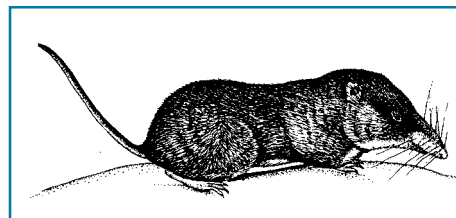
Tundra plants are often dwarf relatives of similar plants from milder climates. Short plants can better avoid drying and abrasive winds and stay warmer in the near-ground microclimate. Their small flowers save energy.



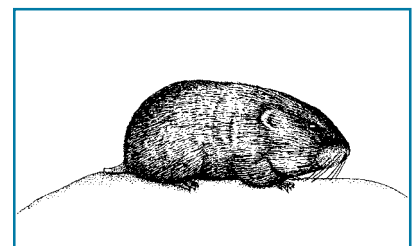
Tundra hares are larger and have shorter ears than hares that live in hot environments.



Arctic foxes have shorter ears than desert kit foxes.



Small animals such as shrews are able to keep warm on the tundra despite their small size, in part because they can live under the snow.



Lemmings are large and have smaller ears and tails than most other mouselike animals.

TUNDRA ADAPTATIONS

Fur, Feathers, and Movement

Most tundra organisms have insulation to help them stay warm.

Feathers and fur are the most obvious adaptations for life in a cold environment. Most tundra birds and mammals actually wear two coats. Their outer coats are made of tough, coarse, water-repellent feathers or guard hairs. Their inner coats are soft, fluffy feathers or hairs that trap air. Even at temperatures of -29°F (-34°C), ptarmigan can keep their body temperatures at 104°F (40°C) without increasing their respiration rate. Caribou and muskoxen have hollow hairs that are fatter at the tip than at the base. This shape helps trap a layer of air next to the body. Trapped air provides excellent insulation.

Even tundra bumblebees wear an insulating coat of dense body hairs that slows heat loss. They “shiver” their flight muscles to generate heat, which is temporarily trapped within their velvet coats. They can keep their body temperatures $68 - 86^{\circ}\text{F}$ ($37 - 47^{\circ}\text{C}$) above air temperatures, allowing them to be active at colder temperatures when the other cold-blooded insects are grounded. The chemical reactions necessary for movement need heat.

Many tundra plants also wear adaptive coats – furry and waxy coatings on their leaves and stems. Fine hair or fuzz slows the wind, thus reducing drying and preserving heat. Dense hairs around the flowers of the woolly lousewort also act like the glass of a greenhouse – trapping solar energy. This surrounds the flowers with relatively warm air, sometimes 34°F (18°C) warmer than the environment. This is important because cell division, necessary for seeds to form, cannot occur at cold temperatures.

The waxy coating of many plants also reduces water loss and evaporative cooling by the wind. Many tundra plants retain, rather than shed, their dead

leaves each year. The dead leaves insulate fragile new buds from the wind and cold. Grass tussocks provide a good example of this.

Woolly lousewort, a tundra plant, is covered with hairs that help block the wind and trap warm air around its leaves and flowers.



Ptarmigan, whose feathery coats cover even their feet, have the best insulation of any tundra bird.



Tundra bumblebees have dense, velvet-like hair that helps them keep the heat they generate when they move their wing muscles.



A double coat of dense hair helps muskoxen stay warm even when the air temperature is -40°F (-40°C).



Tundra organisms use color to increase heat absorption or to hide from predators.

Dark colors absorb solar energy, and light colors reflect it. One would expect that, to take advantage of summer sunlight, organisms living in cold tundra environments would be darker than organisms living in warmer environments. However, dark objects also radiate and lose heat more rapidly than do light objects, therefore during winter, some organisms reduce heat loss with white coloration.

Many of the tundra's summer flowers are purple or blue because these colors absorb more heat than do white or light yellow. Indeed, the percentage of dark-colored flowers is greater in the tundra than in warmer environments. Certain tundra insects, active in the summer, are darker than related species occurring in warmer habitats.

The value of a dark color can be increased by an organism's behavior. For example, many butterflies bask in the sun with their dark wings spread wide to absorb heat.

Surprisingly, the light coloration of yellow arctic poppies and other flowers is also an adaptation to the cold environment. The flowers of these plants are **heliotropic**; they turn to face the sun. The shapes of the light-colored petals reflect sunlight toward the flower center where the seeds are produced. Several kinds of insects bask in the centers of these heliotrophic flowers and benefit from the focused solar heat.

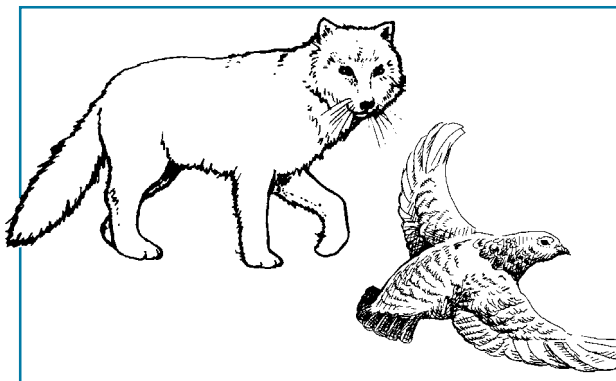
For survival, sometime protection or hunting success is more important than heat absorption. Many arctic animals change colors seasonally to use the advantage of camouflage throughout the year. White fur and feathers hide animals in the snow. White coloration helps collared lemmings, ptarmigan, and snow buntings escape their predators.

Some predators also use color to their advantage. Weasels and arctic foxes change color seasonally, and that helps them sneak up on their prey. Polar bears that den in winter in the coastal areas of the arctic tundra are white year-round because they rely on camouflage for surprise as they hunt on the sea ice.

More tundra plants have blue or purple flowers than do plants in warmer environments because these colors absorb more solar energy.



Most tundra insects are darker than related insects in warmer environments.



Many warm-blooded animals that live in tundra have white fur or feathers during winter for camouflage and to reduce heat loss.



Some tundra organisms make antifreeze.

Humans add antifreeze to water in vehicles to prevent the water from freezing in winter. This antifreeze is ethylene glycol, a fluid that freezes at a temperature lower than the freezing point of water.

Most living things are 70 percent water. When water freezes, it expands as it forms ice crystals. If this occurs in a living organism, cells burst or are damaged. Repeated freezing and thawing are particularly hazardous for living tissue, yet these fluctuations are characteristic of summer temperatures in tundra environments. How do living things survive these conditions?

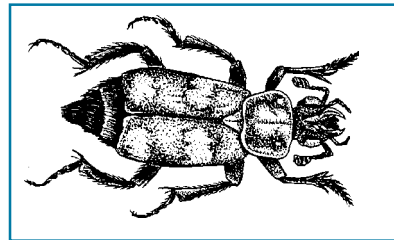
Some organisms overcome this problem by producing chemicals that lower the freezing temperature of cell fluids. These antifreezes prevent the formation of large ice crystals within the cells, even at very low temperatures.

Because of the antifreeze in their blood, wood frogs can survive temperatures of 21°F (-6°C). Most arctic insects produce glycerol, which is an effective antifreeze. If cooled slowly, certain arctic insects can withstand temperatures of -76°F (-60°C). Mosquitoes can survive temperatures down to about -25°F.

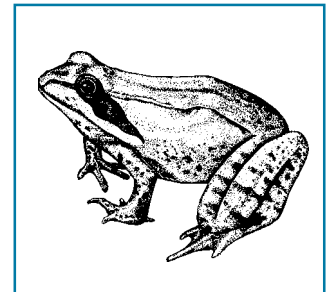
Some tundra fishes also have antifreeze. The Alaska blackfish is able to breathe air through its esophagus in addition to getting oxygen from water through its gills. It can survive temperatures as low as 4°F (-16°C), and some have survived being partially frozen for 45 minutes. Some parts of the fish must remain unfrozen, however, for it to survive.

Plants need antifreeze not only to prevent freezing, but also so that they can make enough food to survive. Because the process of photosynthesis

requires water, many plants cannot function if the temperature is less than 32°F (0°C), the freezing point of water. But air temperatures in tundra environments frequently drop below freezing in spring, fall, and even summer. Many tundra plants, such as the tundra grass, are able to photosynthesize at temperatures of 25°F (-4°C) because they produce antifreeze that keeps their cell fluids liquid even at this low temperature.



Some tundra insects can withstand temperatures of -76°F (-60°C).



Wood frogs can withstand temperatures of 21°F (-6°C).



Many tundra plants, such as the tundra grass, can photosynthesize sugars at temperatures below the freezing point of water because they produce antifreeze.

Growth and Reproduction

Most tundra animals grow slowly and raise young only when conditions are favorable.

Growth and reproduction require food – energy and minerals. Any organism growing faster than it is able to obtain food starves to death. Similarly, an animal that produces young when food or other conditions are unfavorable reduces its own chances for survival as well as the chances for survival of its offspring.

Food availability and weather are variable in tundra environments. Thus, opportunism, or the ability to adjust growth and reproduction according to environmental conditions, is a survival adaptation in tundra environments.

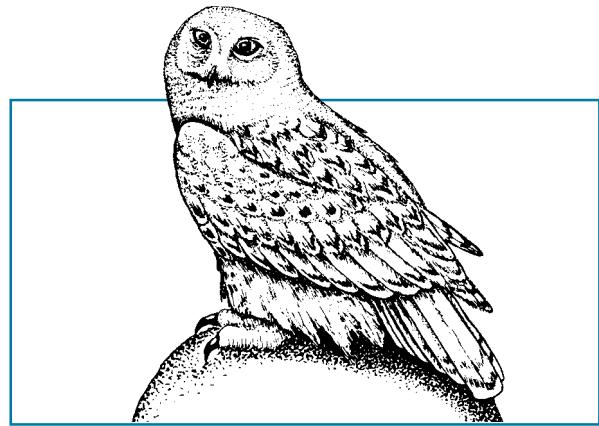
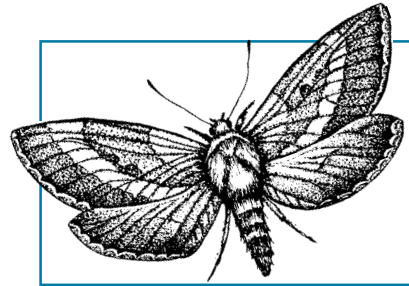
Most cold-blooded tundra organisms grow slowly or not at all when temperatures are too cold. They do not reproduce until they reach a certain size and conditions are favorable. For example, certain arctic moths may require up to 10 years to develop into adults. In milder environments, the same species can reach adult size within two years. Similarly, lake trout in the tundra need 10 years to grow to adulthood, compared with five or six years needed by a lake trout living in nontundra lakes.

Brown bears living in northern tundra of Alaska do not begin breeding until they are eight years old; they give birth to only two young every four years. Compare this to brown bears of southeast and southcentral Alaska – they begin breeding when three or four years old, and give birth to two or three young every three years.

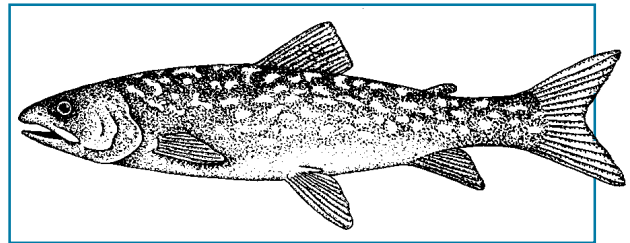
Some migratory birds, including geese, swans, and shorebirds, lay fewer eggs or none at all when winter snows melt late. They save their energy for another year when food will be more plentiful.

Predatory animals such as jaegers, snowy and short-eared owls, rough-legged hawks, arctic foxes, and weasels produce more young in years when lemmings (their main prey) are abundant. When lemmings are scarce, some of their avian predators do not nest.

Most tundra insects grow very slowly. Certain moths live 5 to 10 years before becoming adults.



Predatory birds such as snowy owls do not nest when lemmings (their main prey) are scarce.



Lake trout living in tundra lakes do not reach adult size for about 10 years because of short growing seasons, low temperatures, and scarcity of food.



Tundra producers beat the short growing season with long life cycles.

As with an iceberg, there is more to tundra plants than what you see on the surface. Aerial parts are reduced in favor of root mass in the protective soil. This is also an adaptation used by many desert plants. Tundra plants tend to form clumps or cushions, which create milder microclimates (as much as 20 degrees warmer) to insulate growing tissues and preserve moisture. Keeping their dead leaves is such an adaptation.

Arctic tundra plants can grow at lower temperatures than can similar plants in milder environments. The energy and minerals stored in their large roots allow the plants to start to grow instantly in the spring – even under the snow.

Tundra plants further make up for the short growing season by adopting long life cycles to accomplish reproduction. Many tundra plants grow for 10 years or more before saving enough energy to form flower buds. Even then a plant might form flower buds one year, bloom the next, and make seed a year later.

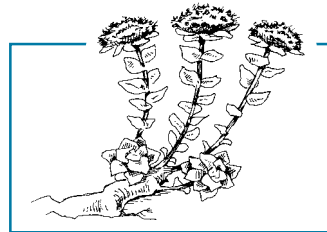
The fragile flower buds develop underground or encased by dead leaves so they are well insulated. When spring comes, the tundra can literally burst into bloom because the flower buds were formed in previous years.

Many plants reproduce by rootstocks or runners instead of, or in addition to, seeds. The tiny plants that sprout from rootstocks are identical to their parent plant. The parent plant nourishes the clone plants until the clones have many leaves of their own.

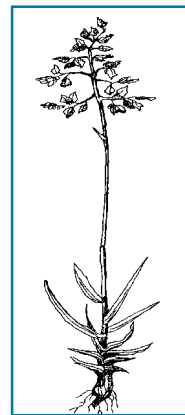
Some plants, such as the alpine poa, produce seeds that germinate and begin to develop while still attached to the parent. This is an advantage, because when the young plants drop from the parent, they

already have tiny leaves and can begin photosynthesis immediately.

Alpine tundra plants can photosynthesize under widely fluctuating temperatures, in brilliant light, and in short periods of daylight. Arctic tundra plants can photosynthesize at low temperatures, at low light intensities, and for long periods of daylight.



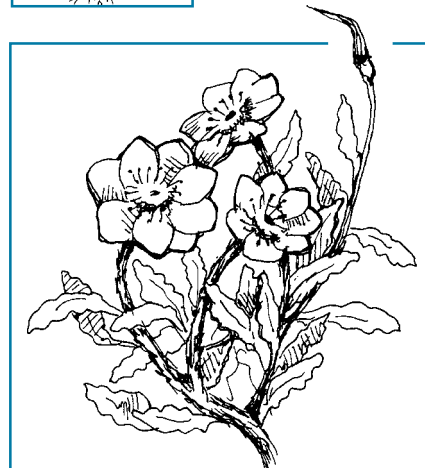
Many tundra plants reproduce by rootstocks or runners.



The seeds of alpine poa germinate and grow while still nourished by the parent plant.



Tundra flowers bloom from buds that are one to two years old.



Most tundra plants are several years or decades old. The age of some woody tundra plants has been estimated at 200 to 300 years, based on counts of their annual rings.

“Cold-blooded” organisms find ways to keep warm, use less energy, and ensure reproductive success.

Cold, short growing seasons, relatively little plant life, and variable day lengths have led to extraordinary adaptations in life span, reproduction, and behavior for tundra invertebrates (earthworms, mites, **springtails**, and flies are the most common).

Unlike invertebrate animals in warmer climates, tundra invertebrates live much longer (except for many mosquito species). Tundra invertebrate species tend to have long **larval stages** (sometimes years) and very short adult stages. This life-cycle adaptation is a means of taking advantage of the stage in which the animals live and grow in the protection of the warmer soil layer.

For example, woolly bear caterpillars spend much of their long lives in the larval caterpillar stage before their brief lives as moths. This reduces their energy consumption and their exposure to risks. These big, active caterpillars are clothed in long, rusty orange

“hairs” for added warmth. The caterpillars can live as long as five years. Like most invertebrates, they are **dormant** in winter and develop only during the short summer.

Many tundra invertebrates have flexible life cycles. Some arctic blackflies develop eggs while they are still **pupae**. When they finally emerge from a stream as flies, their eggs are mature and they need only to mate and lay eggs during the few days of their adult life.

Tundra insects also have behavioral adaptations for surviving on the tundra where just keeping warm requires the majority of their energy. Instead of flying, many tundra insects crawl because the energy cost of flying is so great.

