Montana Natural History Center
Connecting People with Nature

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Animals in Winter

Nature Discovery Trunk Curriculum

Animals in Winter Trunk

Nature Discovery Trunk Contents List

Articles, Books & Pamphlets:
-Beaver Steals Fire
-Discover Nature in Winter
-Field Guide to Tracking Animals in Snow
-In the Snow: Who's Been Here?
-Over and Under the Snow
-Stokes Guide to Nature in Winter
-The Secret Language of Snow
-Tracking and the Art of Seeing
-Wild Tracks!
-Winter, an Ecological Handbook

Animal Track Molds:
-1 Red Fox
-1 Bobcat
-1 Mountain Lion
-2 Snowshoe Hare
-2 Otter
-2 Cottontail Rabbit
-1 Wolf
-2 Squirrel
-1 Deer

Animal Pelts:
-Pine Marten
-Red Fox
-Ermine
-Muskrat
-River Otter
-Beaver
-Bobcat

Additional Equipment:
-10 Rulers
-3 Fabric Samples (heavy fleece, cotton, flannel)
-9 Tin Cans (5 Large, 4 Small)
-10 Metal Thermometers in Tupperware
-3 Laminated Front/Hind track examples

Reverse Track Molds:
-2 Coyote
-2 Deer
-1 Water fowl
-2 Raccoon
-2 Red Fox
-2 Snowshoe hare
- 1 Raptor
-2 Muskrat

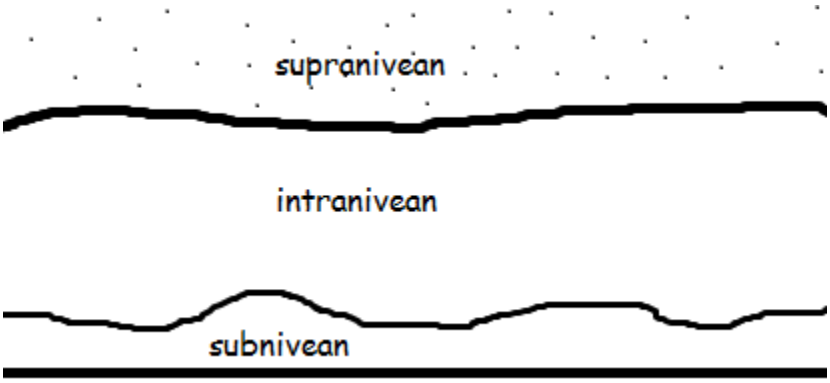
Scat Molds:
-1 Bobcat
-1 Red Fox
-1 Cottontail Rabbit
-1 Red Squirrel
-1 Beaver
-1 Elk
-1 White Tail Deer
-1 Mouse

Photographs: 8 sets of the following 14 pictures:

-Lynx	-Snowshoe hare
-Snowy owl	-Ermine
-Osprey	-Humming bird
-Black bear	-Ground squirrel
-Elk	-Whitetail deer
-Fox	-Wolf
-Coyote	-Bobcat

Background on Animals and Winter

The winter world is known as a nivean environment. Snow can either be the key to a particular organism's survival, or it may be the worst enemy. The nivean environment can be divided into three categories. The area which is at or above the snow surface is called the supranivean. The area within the snowpack is referred to as the intranivean. The subnivean is the interface between the ground and the snow.



Several forces or vectors of winter combine to create conditions that make survival more difficult. The sun is angled lower in the sky, causing less radiation to be received on the earth during winter. The five major vectors are snow, cold, radiation, energy, and wind, otherwise referred to as the SCREW factor. These forces shape the direction of evolutionary responses of life forms to winter.

Organisms must respond through expending energy in order to survive the challenging conditions of winter. Responses may be either short term or longer term. An organism may become *acclimated* to the SCREW factors over the course of a season. These are short term physiological or behavioral changes that ensure survival in the face of these conditions. The range of possible acclimation is fixed genetically within each individual. Acclimation occurs over days or months within the lifespan of an individual.

Adaptations are longer-term, genetic responses to environmental conditions. Adaptations occur over several generations, and affect populations by allowing better-adapted individuals to survive and reproduce.

An example of this is the lynx. All lynx have evolved large feet. These are adaptations. At various times during the winter, an individual lynx may alter its metabolism during cold spells in order to reduce heat loss. This is acclimatization.

Classification of Winter Animals

Background Information:
Plants and animals have learned to deal with the various forces of winter in different ways. Organisms are classified according to how they experience winter and how they have adapted to it over evolutionary time. The commonly used classification system was developed by Formozov and is based on the Greek word for snow, chion. This system is a simple means by which we can identify levels of adaptation to the winter environment which organisms have achieved.

Chionophobes-"snow fearers" are organisms which have been unable to adjust to life in the snow. Generally they are found in warmer regions. Examples are the black vulture, ocelot, and opossum. These animals have no specific adaptations to counter the rigors of winter. Although the opossum may be found in cooler areas due to its wide geographic range and successful reproductive strategies, individuals will often be found in spring with the tips of their ears or tails missing due to frostbite. An example of a plant chionophobe would be the palm tree.

Chioneuphores-"snow toleraters" are organisms which have adjusted their life to winter and can survive, but have no special adaptations. They are able to take advantage of the environment and may live under the snow or in favorable microclimates conducive to survival. Examples are the shrew, red fox, vole, and elk. During severe winters, many of these animals may not survive.

Chionophiles-"snow lovers" are organisms which possess definite adaptations for life in winter. Their geographic distribution is generally limited to winter-dominated regions. Examples are the snowshoe hare, lemming, ptarmigan, and weasel. Several of these animals become white in winter which is an obvious adaptation to the presence of snow. A chinophilic plant example is the spruce tree which has evolved specific adaptations to survive extreme snowfall.

Overview: Scientists have classified plants and animals according to evolutionary adaptations for dealing with winter. These classification systems allow us to categorize organisms in ways that make it easier to understand how they experience winter. In this lesson, students will sort and classify organisms in a variety of ways to understand how organisms have adapted to winter.

Procedure:
Part One:

1. Divide students into four groups.
2. Hand out the set of cards and ask students to generate as many ways of grouping the organisms as possible, with one person in each group recording their ideas.

3. After 20 minutes or so, have each group decide on their three best grouping or classification schemes and present them to the class, explaining why they were chosen.

4. Some of the following questions can be used to promote discussion:

- What are the pros and cons of classifying organisms?
- How/why do scientists classify things in the natural world?
- What categories were common between all of the groups? Why do you think this happened?
- What would have happened if you had more time to do this activity?
- What new things did you learn about these organisms from thinking of different ways to classify them?

5. Share with students the winter classification system of Chionophobes "snow fearers", Chioneuphores-"snow toleraters" and Chionophiles-"snow lovers." Did the students develop similar classification schemes?

6. Work as a class, or have students return to their teams, to assign all of the animals into one of the three groups. You can use the supplemental information to share notes on each of the species.

Extension Opportunity: Research one animal, plant, or insect that is well-adapted to winter, and one that is not. Develop a display which shows similarities and differences between the two organisms. Illustrate how each has evolved different strategies for their particular environment.

Exploring Winter Fur-Bearing Mammals

Background Information: Mammals have evolved different specializations in order to cope with wide variations in environmental conditions. It is remarkable to think about all of the places that mammals are found, from tropical jungles to the Arctic tundra, and to consider the dramatically different conditions under which they can survive. Mammals are homeothermic endotherms, that is, they produce their own internal heat and regulate their own body temperatures. This requires winter adaptations to help them stay warm.

Hair, more commonly referred to as fur, is unique to mammals and not found in any other group of living things. This evolutionary specialization provides several advantages. One of the primary advantages particularly with respect to mammals living in colder regions is insulation. There are two types of fur on a mammal's body. The underfur, like 'down', is very dense. The coarse over layer, act like guard hairs and can better handle abrasion, protecting the underfur from damage. These guard hairs are replaces often and animals spend time grooming to keep the underfur clean dry. All of these hairs trap air molecules, which get warmed from body heat, thereby providing insulative properties. Hairs can also protect the animal by providing a physical barrier, and also through coloration.

One simple explanation for light coloration patterns found in snow-covered areas is that it functions as a cryptic advantage, allowing these animals to be camouflaged by their environments. This makes intuitive sense: however several questions remain. What advantage is this to the arctic fox, which is a scavenger with little worry of predator avoidance? What is the advantage of turning white for weasels when they spend most of their time in winter hunting small mammals under the snow where visual cues are unimportant to predator or prey? Why does the arctic hare maintain its white coat in some northern areas throughout the summer where it becomes highly conspicuous?

Another a possible relationship between color and insulation is that whiteness is usually due to the absence of pigment melanin, which leaves hair very hollow. Such hollow spaces also result in better insulation for white animals.

Overview: In this lesson, students will explore different winter mammal furs to learn more about how these animals are adapted to live in a winter environment.

Procedure: In small groups or as a class, have students brainstorm ideas about the following.

- What are problems that animals face in winter?
- What are different ways that animals might deal with those problems?
- What is insulation? List as many forms of it that you can think of.

Students can present their ideas for discussion. Encourage them to explain their thinking about the ideas they've generated and challenge them to hypothesize about why things are as they understand them to be.

1. Set fur samples out on different tables and have students examine each one carefully. On their lab sheets, instruct them to sketch each fur and write down detailed observations (e.g. smell, magnified view, feel, etc.). Do not focus on guessing the name of each animal, encourage students instead to learn everything they can about the texture, feel, and look of each pelt.
2. When students have examined each fur carefully and finish recording their observations, have them put their lab sheets away and get into partners or trios. One student can volunteer to be first to be blindfolded. The partner will place the hands of the blindfolded person against one of the pelts and that student will try to guess which one it is. Each pair can take turns with 2 or 3 different pelts.
3. Either alone or in pairs, ask students to generate 2 or 3 inquiries about fur-bearing mammals in winter. Encourage students to formulate questions that they could investigate answers to through experimentation. Ask students to list at least 3 hypotheses which would answer the question they choose to focus on. Then, students can design an investigation to test their question. Be sure to discuss possible variables and ways that they can control these.
4. You can have students evaluate one another's plans for answering their inquiries. This can be done either informally through verbal discussion or by way of peer evaluation form.

Example
Inquiry: What is the advantage of having white fur in the winter?
Hypothesis

1. *It helps animals blend with the snowy environment so they won't be eaten by predators or seen by prey.*
2. *They don't have enough nutrition to keep their fur dark.*
3. *White fur coats are warmer than dark fur coats.*

Possible investigations:

- *Find a location where animal activity is likely. Place a white pelt and a dark pelt close together with bait under each fur. Wait to see which one a predator is more likely to take. (DO NOT TEST THIS WITH PELTS FROM THIS TRUNK!)*
- *Take two containers with boiling water in them and surround one with a white pelt and another with a dark pelt. Place both of them in similar locations that are cold, preferably on the snow. Check temperatures every 20 minutes to determine which has better insulative properties. (DO NOT TEST THIS WITH PELTS FROM THIS TRUNK!)*

Students can write more detailed procedures, and a list of variables and possible ways to control them.

Assessment

- Student-generated: in small groups, have students write in point form the various criteria that would define the quality of an investigation. Provide four possible headings such as excellent, good, satisfactory, and fair. Groups can share these ideas and, with teacher input, decide upon the criteria for evaluating all of their

investigations. Students can use these in their peer evaluations, and the teacher can use the same form when evaluating student work.

- Teacher-generated: you can formulate a rubric which outlines the criteria for excellent, good, satisfactory, and fair investigation designs and hand these out prior to the students starting work on part 4 of the above activity.
- Evaluate lab sheets for writing skills, observational detail, originality, and detail in sketching pelts.

Follow Up

- In small groups provide two pelts for students. On chart paper, ask students to generate a list of comparisons between the two pelts under the headings 'Similarities' and 'Differences'. This is another method of developing thinking skills and more in-depth knowledge of particular characteristics.
- Students can carry out their investigations by writing up the procedure, collecting the materials, recording and interpreting data, and drawing conclusions. They can then evaluate their own investigations and recommend changes to refine the procedures.

Lab Sheet: Exploring Mammal Fur

Explore the different animal furs available and write down your notes about each one. Pay attention to feel, how they look up close, how they smell, etc.

Fur Identification Number	Written Description	Detailed Sketch

Insulation Experiments

Overview: Students will design experiments to test how different types or combinations of insulation help keep hot water warm.

The main goal of this lesson is to reinforce and practice the process of conducting a full scientific experiment. Students will build off the knowledge and experience they gained in the Bergmann's Rule experiment to ask, and test, testable questions. In this investigation, students' questions will focus on which types of insulation layers work best to keep animals warm in winter.

Suggestion: Unless students have a lot of previous experience designing their own investigations, the teacher can lead the planning process as a whole class to design this next experiment. Then small groups of 4-5 students can each work to conduct repeated trials for this investigation.

Materials Needed
You will need to provide enough water to fill 5 soup cans and 5 smaller cans with hot water (120 degrees F or higher).

Procedure

1. Review the results from the Bergmann's Rule Experiment. Do bigger or smaller animals stay warm better in winter? Why?
2. In that experiment, what did we do to make sure it was a **Fair Test**? (We used **only 1 variable** and **many controls**).
3. What was the one variable in that experiment? (What changed or was different?) The *size* of the can. What were the controls? (What stayed the same?) Same type of can, same water *level* in can (not the water amount), insulated blue pads underneath both, same starting water temperature, same time sequence for measuring temperature, same unit of measurement (either all Fahrenheit or all Celsius readings).
4. In this next experiment we'll explore how insulation helps keep animals warm— by testing different materials to see which ones keep the water in the can warmest!
5. Review the steps of a scientific experiment (they can have their lab sheet in front of them for reference).
6. Show students the cans and the different types of insulation material.
7. Brainstorm a list of all the insulation variables the students can think of to test. Post for reference. Possibilities to compare: different types of insulation material, number of layers of insulation, different combinations of layers, closed or open area at top of can, with or without air pockets (using bubble wrap), etc.
8. Teacher leads discussion on which variable the class wants to test. Remember, for it to be a Fair Test, you can only test one variable at a time.
9. Have students work together to create a Testable Question. Record it on their lab sheet.
10. Together as a group or on their own, students should write down their hypothesis and fill out both the variable and controls sections of the lab sheet. Next, assist students in labeling the data table to record temperatures during the experiment.

11. Have students in small groups prepare the cans (assign teams responsible for each of the variable tests). Gather thermometers, hot water kettles, data sheets, and go outside to perform the experiment. Once the cans are set up with data recording teams ready, pour hot water into each can, keeping the amount of water in each can the same (control!).
12. Using the data table on the lab sheet, students should record the temperature at regular time intervals (designated by the group—1-2 minutes for each interval recommended).
13. Return to the classroom and use the data table to create a line graph. As a whole class, make a double line graph, with a key, to show compared variable sets of data. Review results. What is the conclusion? How do these variables compare to real adaptations for animals in winter?
14. Repeat this experiment if there is time and interest. Repeated trials help to validate the experiment. Or, students can revise their questions and investigate different insulation factors.

Lab Sheet: Insulation Experiment

What keeps animals warm during the winter?

Testable Question:_____

_____

Hypothesis:_____

_____

Variable:_____

Controls:_____

_____

_____

Data Table

Line Graph Title:

Conclusion:

_____

_____

_____

Size Matters!

Background Information: The body size of an animal is one of the most critical factors that plays a role in how an animal is able to survive a cold, winter climate. To maintain a stable body temperature, organisms must be able to produce heat by bulk of body tissue, muscles, and metabolic tissue. The larger the organism, the greater the heat production capacity. Heat production must not be exceeded by heat loss from the surface of the organism. Temperature stability is determined by the ratio between capacity for heat production, determined by volume, and the potential for heat loss, determined by surface area. Size ratio of surface area to volume is critical to heat retention. Smaller organisms have less potential for heat production and greater potential for heat loss. These animals, mice for example, have to eat a lot of food to continue to generate heat.

In 1847 German biologist Christian Bergmann first articulated the idea that within a particular species, body mass increases with an increase in latitude (and the correspondent colder climate). Bergmann's explanation of the phenomenon depended on the surface area to volume ratio – specifically, larger animals have a lower surface area to volume ratio than smaller animals so they radiate less body heat per unit of mass and thus stay warmer in cold climates. While there is some debate as to whether this ratio can fully explain the correlation between body size and latitude, the phenomenon itself it is pretty widely accepted within ecological circles as Bergmann's Rule.

The math underlying this principle is pretty straightforward: as an object (an animal in this case) increases in size, it surface area increases by a factor of 2 while its volume increases by a factor of 3. See example below:

	Small Cube 1 in x 1 in x 1 in	Large Cube 2 in x 2in x 2in cube
Surface Area	6	24
Volume	1	8
Surface Area to Volume Ratio	6:1	3:1

Overview: In this activity, students will use a science experiment to explore how the role of surface area and volume and the relation between the two play in an animal's ability to maintain body temperature. They will formulate and use an experimental design that tests their predictions about surface area and heat loss. The scientific process to follow includes:
1. Asking a testable question
2. Making a hypothesis
3. Doing the experiment
4. Graphing results
5. Making a conclusion

Materials not available in the trunk:
For this lesson you will need an electric tea kettle or another way to generate enough hot water (at 120 degrees F or higher) to fill all of the cans.

Procedure

1. Share with students the two different sized cans. In our experiment, we are going to determine which animal will stay warm better: larger bodied animals or smaller bodied animals. As you work through the experiment, emphasize each of the steps as a discrete step in the scientific method.

2. Step I. The question. Our question is a simple one: Do larger or smaller bodied animals stay warm better? We'll test this by filling different sized (but same shaped) metal cans with boiling water, taking them outside, and measuring their temperature change over a period of 7-10 minutes.

3. Step II. The hypothesis. Emphasize that this is a critical step in the scientific method. A hypothesis is a prediction you can test. After explaining the question, have kids write their own hypothesis (in a complete sentence with a" because" statement).

4. Step III. Do the experiment. Put students in groups of 2-4 to conduct the experiment. Each group will be measuring both a small can and a large can. Before heading outside, be sure to explain all the steps in the experiment. The steps:
   - The teacher will establish the appropriate area outside for conducting the experiment (where it is safe, away from the building, but on a flat surface) and arrange the cans for each group fairly close together in a line or circle so that you'll be able to add the hot water in a timely manner (and reduce the variability in time the water is exposed)
   - The teacher will set a thermometer in each can
   - The teacher will then quickly (but SAFELY) pour hot water into each can
   - Students need to record the temperature each minute, beginning at 1 minute, on the chart in their journal. It might work best to have pairs of students within the group focus on big or small can.
   - The teacher should determine exactly how long to conduct experiment (between 7 and 10 minutes) based on outside temp and how long it takes for a noticeable difference in cans to emerge. The teacher will need to rotate through the group of students, observing their data.
   - After the data are collected, gather the thermometers, pour out the water, and have students bring the cans back into the classroom.

5. Step IV. Graph Results. Back inside, you'll have students plot their temperature data from both cans as a line-graph. They will need to label the graph appropriately along the X and Y axis. Model how to do this the white board. They'll need to determine how differentiate between and identify the two lines as big and little can data. Give students several minutes to complete their graphs.

6. Once graphs are complete, collect data points from each of the groups to plot the on a line graph at the front of the room. Use the data from at least two big cans and two little cans. Color code each can size.

Assessment
Bring 2 students who are similar size and height to the front of the room. Ask the class, are they about the same size? Would they have similar surface areas? Is their weight about the same? Now, put them together back to back. The volume of the new shape has doubled but did the surface area double? Nope!

In their science journals, have students answer the following questions:

- How does surface area play a role in heat loss?
- What other factors affect heat loss in an organism?
- What adaptive behaviors do you think organisms might use to counter-act the loss of body heat through the surface of their skin?

Follow up ideas

- Students can generate a table and graph prior to carrying out the experiment to predict their results. These can be recorded in their science journals with explanations for their predictions.
- Students can evaluate their experimental design—what worked, what needed to be changed—and repeat the experiment with their revised procedures.
- Students can trade experimental designs and try to repeat the procedure of their classmates to see if they get matching results. The teacher can talk about the value of this step in the scientific method.

Lab Sheet: Size Matters!

How does size affect an animal's ability to stay warm?

Testable Question:_____

_____

Hypothesis:_____

_____

Variable:_____

_____

Controls:_____

_____

Data Table

Minute	Large Can Temperature	Small Can Temperature

Line Graph:

Conclusion: _____

_____

_____

Foot Force Math

(adapted from the Eagle Bluff lesson, Snowshoe Feet!)

Overview: Through math, students will explore how snowshoe hares are uniquely adapted for snow covered, winter landscapes.

Snow presents special challenges for animals that stay active during the winter. If you've ever walked in deep, fresh snow, you know how hard it can be to move around! What are the factors that determine if you sink or float on the snow when you are walking?

Animals who are active in winter often times have physical adaptations to help them thrive in snow covered environments. One of the most famous examples is the Snowshoe Hare, aptly named because its feet work like large snowshoes! When a hare moves through the landscape, it can hop and stay floating on the top of the snow, rather than sinking down deep. Hares can walk on top of the snow because their large back feet are very large compared to the weight of their body. In this lesson, students will examine the weight to foot size ratio and then use that information to predict how large their own feet should be if they were a snowshoe hare!

Procedure

15. Share images of the following animals: squirrel, mountain lion, whitetail deer, snowshoe hare, cotton tail rabbit, and fox. Have students predict, with reasoning, which animals will more easily walk and float on the snow and which animals might sink deeper in the snow.
16. Pull out the track casts for all of the animals.
17. Have students use rulers to measure and complete the foot area information for each animal on the Foot Force Worksheet. They should record measurements at the longest or widest point on the track impression.
18. To determine foot force, or how many pounds per square inch an animal carries, divide the average weight of each animal by the foot area on the worksheet.
19. Have a discussion guided by the questions in the student worksheet:
    a. Which animal will have the easiest time walking in the snow? Which will float the best? Why?
20. Have students make some predictions about how humans will compare to these animals.
21. Then have students use rulers to measure their own foot area and calculate foot force.
22. Lead a discussion guided by the questions in the student worksheet.
    a. How do you compare to the different animals?
    b. What could you do improve your ability to walk on top of the snow?
23. If you have access to a pair of snowshoes or cross country skis, the students could measure the foot area of these devices to see how the foot force would change if their weight was distributed differently.

Foot Force Math

Some animals are more equipped for snow travel. Let's find out why!

First, let's determine the Foot Area for each of the animal tracks:

Animal	Length of Track at longest point in inches	X	Width of Track at widest point in inches	=	Area
Squirrel*		X		=	
Mountain Lion/Cougar		X		=	
Whitetail Deer		X		=	
Snowshoe Hare*		X		=	
Cotton Tail Rabbit*		X		=	
Fox		X		=	

*(For the squirrel, rabbit and hare, add the measurements for both the back and front feet together to get 1 number for length and 1 number for width.)

Now figure out Foot Force of each animal. For each animal, divide the weight by 2 if they have different sized front and back feet (squirrel, hare, rabbit) or 4 if all of their feet are the same size. Then divide the average weight on each foot by the foot area calculated above to get the foot force.

Animal	Average Weight (pounds)	÷	Foot Area (square inches)	=	Foot Force (pounds/inch)
Squirrel	1 lb	÷		=	lbs/in
Mountain Lion/Cougar	110 lbs	÷		=	lbs/in
Whitetail Deer	145 lbs	÷		=	lbs/in
Snowshoe Hare	3.5 lbs	÷		=	lbs/in
Cotton Tail Rabbit	3 lbs	÷		=	lbs/in
Fox	18 lbs	÷		=	lbs/in

Next we will analyze our results:

1. Which animal has the easiest time walking on the snow? Why?

2. Which animals probably sink down into the snow when they walk? Explain why.

3. Which animal(s) will have the hardest time walking on snow? Which ones might sink deep into the snow when walking? Explain your predictions.

What is your foot force?

Determine your foot area:

	Length of your foot at longest point in inches	**X**	**Width of your foot at widest point in inches**	**=**	**Area (square inches)**
You		**X**		**=**	

Determine your foot force:

	Average Weight (pounds)	**÷**	**Foot Area (square inches)**	**=**	**Foot Force (pounds/inch)**
You	_____lb	÷		=	

How do you compare to the different animals?

What could you do to walk easier on the snow?