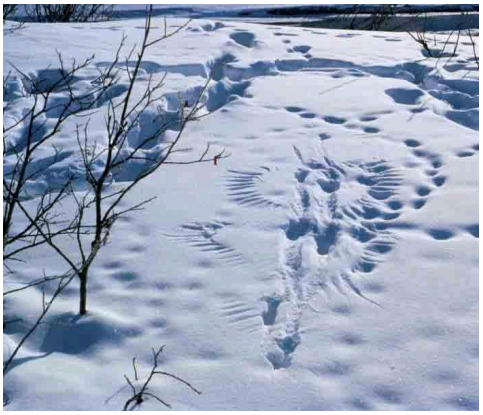
Animal Tracks Can Illuminate Many Things: A Detective Exercise

Setting the Stage

In science, as well as in life, we often face situations in which we have less than an optimal amount of data and must try and draw conclusions from that incomplete information. Following animal tracks (even just people, dogs, or squirrels) and investigating how tracks are made is a fun and exciting way to develop critical thinking, measurement and graphing skills.



Human footprints and wildlife tracks converge at Arctic National Wildlife Refuge in Alaska. Photo: Greg Weiler/USFWS

Lesson Overview

- *Activity 1 – Engage (20 minutes) Inferring from Evidence*
  Working like scientists do, students use the information available to fill in missing pieces of the puzzle.
- *Activity 2 – Explore (90 minutes) Unraveling the Mysteries Found in Tracks*
  Students collect data to answer questions with graphs and come up with evidence that describes motions recorded in tracks.
- *Activity 3 – Explain (20 minutes) Graphs as Models*
  Students analyze and interpret their data and two graphs to determine if the data collected on humans would be similar to animals.
- *Activity 4 – Elaborate (30 minutes) From Observations to Inferences*
  Students determine what an animal was doing based on evidence in the snow.
- *Activity 5 – Evaluate (10 minutes) What do Animal, Fossil, and Car Tracks all have in Common?*

Students consider how they could use the skills they learned to analyze other events.

Instructional Overview	
Grade Level	Middle School
Instructional Time	170 minutes *(total time needed)*
Standards Alignment	NGSS: DCIS: MS.LS4.A *(partial)* SEPs: Developing and Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data CCCs: Patterns; Scale, Proportion, and Quantity
Lesson Phenomenon	● Unraveling the mysteries found in animal tracks
Driving Question	● What can we learn from animal tracks?
Learning Goals	● Learn how measurements in combination with observation can reveal information about the speed, size and condition of the animal from its tracks. ● Learn how to use inferential skills along with data answer questions with limited information available.
Materials	● Tape measure or meter stick (1 per group of 2 students) ● Stopwatch (1 per group of 2 students) ● 30 cm rulers (1 per student) ● Graph paper or graphing program (2 per student) ● Optional: Print photos of animal tracks in the snow (1 per group of 2 students)
Material Preparation	○ Print photos of animal tracks from internet search (optional) ○ If data collection takes place outside, mark off a 20 meter length to be used for data collection. Note: Part of this lesson may occur outside in the snow (fresh snow is preferable) or at a location where animal footprints may be found (muddy location). Because of this, the students should be warned that they will be outside before the day of the lesson so that they can dress appropriately. In addition, students should be reminded to be careful because of the adverse conditions and all safety precautions associated with outdoor activities should be taken. If the weather or ground conditions are not safe, it is suggested that this lab be delayed or canceled.
Vocabulary	Track is an imprint left on the ground by a single foot. Track length is equal to foot length or shoe size. Stride length is the distance from a point of one foot to the corresponding

	point of the next track of the same foot. Speed is the rate of travel in units of distance over time. Correlation is the relationship or connection between two or more variables.
Instructional Strategies	Prerequisite Skills: Basic skills in conducting a research plan are necessary for this lab. Basic measurement and graphing skills are also important for this lab; the lab uses line graphs and may or may not use a bar graph.

	Lesson Resources
Activity 1: Websearch	After engaging students in Activity 1, consider Googling “Animal Tracks in Snow” to locate a number of pictures for students to ponder before moving into Activity 2.
Reference	American Museum of Natural History: Be a Trackway Detective https://www.amnh.org/learn-teach/curriculum-collections/dinosaurs-activities-and-lesson-plans/be-a-trackway-detective
Reference	Gibbons, Diane. 2003. Mammal tracks and signs of the Northeast. University Press of New England, Lebanon, New Hampshire.
Reference	Forrest, Louise. 1988. Field Guide to Tracking Animals in Snow. Stackpole Books, Harrisburg, Pennsylvania.
Reference	Halfpenny, James. 1986. A Field Guide to Animal Tracking in North America. Johnson Publishing Company, Boulder, Colorado

Activity 1 (Engage)
Inferring from Evidence (20 minutes)

Activity 1.1
Explain to the students that, frequently, scientists don't have all the necessary information about a situation to understand exactly what is occurring. Not knowing all the components to answer a question is common in many occupations; the students will likely associate putting different pieces of evidence together with detective work. Successful scientists are able to use observational skills in combination with different measurements to come up with a likely answer to their question. This is analogous to imagining the picture that a puzzle creates based only on the information of some, but not all, of the pieces. To see what this is like, have the students try to complete the picture of the puzzle in the handout by finishing the picture.

Student Handout: Often times in science we don't have all the pieces to the puzzle for the question we are trying to answer. Using the information that is available to fill in the rest of the picture below.

1. In what areas are you most confident about what you are drawing?
   Responses vary.

2. What areas are you least confident about what you are drawing?
   Responses vary.

Activity 1.2
An engaging way to practice the skills needed to answer scientific questions is by following, measuring and recording observations of animal tracks. For this part of Activity 1, students may share experiences with observing animal tracks, or you can print images of animal tracks in snow or mud. Ask small groups of students to describe a situation where they saw a set of tracks, animal or human, and could infer something about what that animal or person was doing. If photos are used, ask students what they can infer about the animal from the tracks. Then ask the groups of students to fill out the list in the handout of things that can usually be deduced from finding a set of animal tracks (e.g., species, approximate size, speed of the animal, if it was chasing another animal, if it was digging up food, etc.). Next, ask the students if

there is information that cannot be deduced from the tracks (e.g, a dog's fur color, if a person is wearing a hat or not, or what a squirrel's favorite food is). Tell students that in the next part of the lesson they will be creating and analyzing tracks to learn more about the behavior of those leaving tracks.

3. In science we often need to decide what information we we know and what information we don't know. If we were to find a set of dog tracks, what information would we know or could we discover through observation and measurement?

   Responses vary (e.g., approximate dog size, speed of the dog, if the dog had any injuries)

4. What don't we not know or can't find out?

   Responses vary (e.g., the dog's color, where the dog came from, what the dog looked like)

Activity 2 (Explore)
Unraveling the Mysteries Found in Tracks (90 minutes)

Activity 2

Tell the students that the goal of today's activity is to use measurements and create graphs to answer questions related to animal tracks and that we will be using data from their movements to see if the relationships are the same for both animals and humans. Students will be outside to collect data for this activity. If going outside is not an option, a long hallway or gymnasium could work as a replacement. To work around not have a soft surface to leave a track (footprint), students can trace their track on a piece of paper instead. For each question below, class data will need to be compiled. Consider creating a digital spreadsheet to be shared with all students, or a chart on the marker board that can be filled in by the students.

Can we estimate an animal's (or person's) height from a track or footprint left in snow or mud?

> Shoe size is related to a person's height, and therefore, show track length is correlated with height. Ask them how they might answer this question so it applies to all people. If the students are struggling to come up with a method to answer that question, remind them that because they don't have access to the general public and a million different tracks as would be ideal for this study, they will need to record their own height and their shoe track measurements, and then combine their data with their classmates. The students will record the data for their group in the field and graph it in the classroom once they have all the other students' data. Graphing: track size (centimeters) on the x-axis, and height (centimeters) on the y-axis.

Walking, trotting or running?

> Show students the track photos from Activity 1, and ask them how they may determine whether the animals are walking, trotting, or running, and follow this up if there is a way to figure this out for sure. They should recognize that they could possible measure the length of the stride of the animal, and that may help them to learn whether or not the animal is walking, trotting, or running. Tell them that they will be collecting data to determine the level of activity a person is exerting based on a few measurements including track (foot) length, hip height and stride length. *Stride length* is the distance from a point of one foot to the corresponding point of the next track of the same foot. Stride length is correlated with speed but is not the only determining factor. This can be determined by asking students work with a partner to measure the length of their stride

(SL), by counting and recording the number of steps they need to walk the 20 meter distance. They also need to gather the time it takes to walk this distance. To obtain their stride length for this distance, they divide the number of steps by two since there are two steps in a stride, and divide this into the distance of 20 meters. Ask them to repeat this for trotting and running. Next, they combine their data with the class data, and plot the relationship between speed (x-axis) and stride length (y-axis). This linear relationship is evident for most animals. To assist students with organizing their data, provide them with the following table:

Data Table:

Who? Walking, running, or trotting?	Column 1: # of steps in 20 meters	Column 2: # of strides (Column 1 divided by 2)	Column 3: Stride length (20 m divided by Column 2)	Column 4: Time (seconds)	Column 5: Speed (m/sec)

To help solve the mystery in a set of tracks as to whether or not the animal was walking, trotting or running, students work through this calculation to determine a ratio related to the speed at which the animal was moving. Remind them to convert all measurements to centimeters before performing the calculation.

Track length x 4 = hip height
Stride length / Hip height = ratio

If the ratio is less than 2.0, the animal was walking.
If the ratio is between 2.0 and 2.9 the animal was trotting
If the ratio is greater than 2.9, the animal was running.

Tell students that they will be analyzing all the data they collected, graphed and calculated to answer the questions.

Activity 3 (Explanation)
Graphs as Models (20 minutes)

Activity 3
The two graphs they created in the previous step using class data are scatter plots. Have them draw trendlines through the data, and for those students how are familiar with statistics, have them write the equations for the relationships in each graph. Lead a class discussion around the following ideas from their data:

- What relationships do you see in each graph?
- The data collected, graphed, and analyzed was from humans. Can the same methods be applied to animals? Why or why not?
- How are our graphs models of data? What information can they provide? Can we make predictions from them?

Pass out photos from Activity 1 and rulers, and ask students to apply the same procedure to the animal tracks in the photos. Follow this up with a correlation to the data from their strides, etc.

- Are the relationships the same for all animals? Why or why not?

Activity 4 (Elaboration and Extension)
From Observations to Inferences (30 minutes)

Activity 4
If there is time and it isn't too cold, you can do the next two tasks outside. If not, both can be done in small groups conceptualizing and sketching the following scenarios.

First, follow animal tracks (dog or squirrel will do) and try to determine what the animal is doing and what measurements could be useful in describing the animal's activities or comparing across a larger population of that species.

Second, break the class into small groups and have each group of students act out a human or an animal story leaving only tracks behind. Then have each group analyze each other group's tracks and try to decipher the story using the evidence that is available. Have the students list the evidence as well as measurements that may be important in supporting their ideas about what occurred and see how well it matches the story.

Activity 5 (Evaluation)
What do Animal, Fossil, and Car Tracks all have in Common? (10 minutes)

Activity 5
Have the students answer the final questions of the handout.

5. Imagine you are in the woods and find a set of animal tracks in some fresh snow. Write a list of characteristics you know about the animal that made the tracks. After following the tracks for a short distance, you notice that the stride length of the animal triples. What does this tell you about the approximate speed of the animal and what may be going on?

   This is a very open ended question and many answers are correct. The best answers are creative answers based on the environment and how the animal is interacting with the environment. You will likely know the species of the animal, what it was doing, it's approximate speed, and if it had any injuries. You also know what it is not doing if it isn't going near a nearby river to get water, it likely isn't thirsty. A tripling in stride length typically indicates a dramatic increase in speed and is likely because the animal is chasing prey or being chased.

6. Application: How could you use the skills you learned in this lab in analyzing other events, such as a car sliding on the snow? Or the interpretation of fossil tracks?
   Responses vary