beetles

Science and Teaching for Field Instructors

Student Activity Guide

Tracking

Animals are sometimes hard to see, but with observation skills we can use evidence to figure out where they've been and what they've been doing. Students love to look for evidence of animals, and teaching them basic tracking skills can open up a world of intrigue and mystery. In this Focused Exploration activity, students use observation skills to notice evidence of animals living in the area. With a few basic tracking tools, students look for animal signs, and follow animal paths to new discoveries. Students also engage in key science practices as they share explanations for the animal signs they find, compare and evaluate explanations based on the strength of evidence, and take part in scientific argumentation.

Students will...

- **Use evidence to make explanations about animals in the area.**
- **Critique and compare explanations through scientific argumentation.**
- **Learn and apply basic tracking skills.**

Grade Level:
Grades 3-8. Adaptable for younger or older students.

Timing:
60-80+ minutes (altogether) or three 20+-minute chunks

Related Activities:
I Notice, I Wonder, It Reminds Me Of; NSI: Nature Scene Investigators; What Lives Here?; Bark Beetle Exploration; Case of the Disappearing Log

Materials:
For instructor: Pictures of local animals from your area (you provide); Pictures of "Doors and Windows"(page 15); Optional: local field guides (for more information, see page 5)

Tips:
To ensure a successful experience, review the teaching tips found on page 2 and throughout this guide.

Setting:
Choose an area where you know there will be plenty of animal evidence to find: scat, tracks, openings in brush used by animals to pass through, burrows, nests, etc.

NEXT GENERATION SCIENCE STANDARDS

FEATURED PRACTICE

Constructing Explanations
Engaging in Argument from Evidence

FEATURED CROSSCUTTING CONCEPT

Cause & Effect

DISCIPLINARY CORE IDEAS

DCI's will vary, based on students' focus and the guidance of the instructor.

For additional information about NGSS, go to page 11 of this guide.

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Tracking

ACTIVITY OVERVIEW

Tracking	Learning Cycle Stages	Estimated Time
Introducing the Activity	Invitation	5 mins.
Cast of Characters	Invitation	5 mins.
Tracking Take 1: Practicing Observations	Exploration	10-20 mins.
Tracking Take 2: Practiving Explanations Order	Exploration, Concept Invention	20-30 mins.
Evaluating Explanations	Concept Invention, Application	15+ mins.
Wrapping Up	Application, Reflection	5 mins.
TOTAL		**60-80+ minutes**

TEACHING TIPS

Scout your site beforehand. Don't assume you'll find animal signs anywhere you want to do this activity. Keep an eye out in your site for areas that tend to collect tracks and animal sign. Good areas for finding footprints include: areas with snow, sandy shores, creek beds, mud around a meadow or lake, and bare soil a few days after a rain. Great places for animal paths, tunnels, and holes include: chaparral, riparian zones, grassland, desert, marsh, and coastal scrub. Once you've found a site that tends to have reliable tracks and sign, be sure to visit it ahead of time on the day you plan to teach the activity so you're sure there's enough available for students to check out.

Build students' observation skills first. Students' observations (and the explanations they make using those observations as evidence) will be richer if they practice making detailed observations first, through such routines as *I Notice, I Wonder, It Reminds Me Of* and *NSI: Nature Scene Investigators.*

Follow students' excitement. Looking for tracks can be fun and exciting! As much as possible, follow your students' interest and, if necessary, adjust the timing of the activity. For example, if your group is engrossed in looking for and observing animal tracks and signs in the first phase of the activity, let them keep at it. If they really get into making explanations for their discoveries later in the activity, encourage them to continue. Students will be more likely to continue to apply tracking skills in the future if they have the autonomy to follow their interests the first time they try it.

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Introducing the Activity

1. **Ask students to step into the circle if...** Gather students in a circle and ask them to step into the circle if the statement you say applies to them. Say each of the statements below, pausing to allow students to step into the circle, and then ask everyone to step back. Step into the circle if...
   - *you've ever put your hands through your hair and noticed a hair fall out.*
   - *you've ever been out in the rain, then walked inside and accidentally left muddy footprints on the floor.*
   - *you've ever followed the tracks of a person or animal.*
   - *you've ever eaten chicken or fish and left the bones on your plate.*
   - *you've ever had to go to the bathroom when you were outside so you dug a hole or picked a nice tree to step behind.*
2. **Explain: Hair, footprints, bones, and waste are all evidence that humans and other animals leave behind.** Explain that this evidence might let other people know we've been somewhere.
3. **Ask students to *Turn & Talk* to discuss: What evidence do different kinds of animals leave behind?** Give students about a minute or so (until you notice 1 or more pairs run out of things to say, or get off topic) to discuss types of evidence that animals might leave behind.
4. **Call on a few pairs to share out their ideas.**
5. **Get students pumped to look for evidence of animals in the area.**
   - *You're going to get to explore this area looking for tracks and signs animals have left behind, making discoveries and learning about what you find.*

Cast of Characters

1. **Show pictures of common animals in the environment.** Every community has its own cast of characters, and students might not have experience with the animals native to your site. You can print pictures, or bring local field guides and show pictures of common animals that leave behind tracks and sign in your area.
2. **Introduce the concept of "doors and windows": as animals pass through vegetation like grass, or move through things like dirt or snow, they can leave behind paths, tunnels, and holes that are evidence of their movement.**
3. **Hold up the photos of doors and windows, asking students to observe each one and use their hands to show the likely size of the animal that made the evidence.** Using the printed photos at the end of this activity, or your own photographs of doors and windows you've found, ask students to carefully observe each photo. Then, prompt them to show with their hands the likely size of the animal that made each door or window. Note: One of the included photos is of a wood rat nest.
   - *When we find a "door" or a "window" like paths through the grass or holes in the dirt, we can observe it and try to imagine how large the animal was that created it. This can help us to figure out what animal could have left behind this evidence.indow. Note: One of the included photos is of a wood rat nest.*

TEACHING NOTES

See BEETLES Discussion Routines for logistics of *Turn & Talk.*

Don't skip the pictures! Ahead of time, gather and print some photos of local animals who may have left behind evidence. Knowing the "cast of characters" will lead students to more accurate explanations about the tracks they find, and can clear up their misconceptions about the size or trophic level of the animals in the area (like thinking a coyote weighs 200 pounds and likely to eat humans!).

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TEACHING NOTES

Tracking Take 1: Practicing Observations

1. **Explain and model to students how they'll explore, looking for animal signs or tracks and then making observations about their discoveries.** Tell students they will focus on making observations as they explore. Model different examples of observations students might make ("I notice the tracks are facing uphill," "I notice the tracks have four toes," etc.). Remind students they might find animal signs that aren't footprints.

2. **Establish boundaries and go over safety protocols.** Describe the boundaries and agreements you have chosen, such as asking students to stay in view of leaders at all times. Tell students to only look in places that are safe. Make sure they know it's not safe to touch scat or the remains of a dead animal.

3. **Set students free (within boundaries!) to search for signs and tracks, then circulate and be a co-explorer.** Remind students they might find animal signs that aren't footprints. Leave enough time for some exhilarating discoveries—at least 10 minutes. Help focus students who aren't engaged by asking them what they notice about a certain track or sign, or asking them questions that will lead them to generate more observations, like:
   - *How would you describe the shape of the track?*
   - *Compare one track to another. What's similar and what's different?*
   - *Are the tracks close together? Far apart?*
   - *Do the tracks seem to be deep or shallow?*
   - *How big is the door/window?*
   - *How would you describe the shape and size of the scat? What do you see in it?*
   - *What other observations can we make?*

4. **Gather the group back together, and ask students to *Turn & Talk* to share their discoveries.** Give students a minute or so to talk about their discoveries with another student they were not exploring with.

5. **Gather the group around a student discovery of an animal sign, and ask for observations, using some questions from above.** Choose something a student discovered and circle the group around it. Make sure everyone can see well. If you're on soft ground, draw a circle or lines around the sign so no one steps on it. Ask students to share what they notice about the sign. If students make explanations instead of sharing observations, gently point this out, and ask for observations. Use the questions above to elicit more observations, but move on to the next step after a few students share.

Tracking Take 2: Practicing Explanations

1. **Introduce the crosscutting concept: Cause and Effect.** Explain:
   - *The animal tracks and signs that some of you just observed were all caused by animals that were in this area at some point. Sometimes scientists observe the world, then try to figure out the causes behind what they see.*

Boundaries. Set boundaries that make sense for your site and group of students. Some instructors let students explore and follow animal trails as far as they'll go, as long as they stay within earshot. Others require students to stay in sight of a leader. Figure out what's safe in your area and what you feel comfortable with before you let students explore.

More than big mammals. Students can get caught up in looking for tracks of big mammals, like coyotes, deer, or bobcats. While these larger tracks are fun to find and observe, remind students to look for evidence of smaller animals like birds, rodents, and even insects, which can all leave visible and interesting signs to check out.

Observations before explanations. When looking at exciting discoveries like tracks, students often skip straight to making explanations instead of observations. (For example, "I found coyote tracks," or "This animal was running away from something," as opposed to "I found tracks with four toes and claws," or "These tracks are spaced out from one another.") Tracking is all about making explanations—but more specifically, explanations based on evidence. Students' initial explanations about tracks sometimes aren't based on much evidence. Beginning with observations helps students gather evidence from which to make explanations.

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2. **Explain that when tracking, students are looking at effects, and trying to figure out the causes.**
   - *We can think of what we just saw and observed as "effects" and can think of the animals and behaviors that produced them as "causes."*
   - *Even though we can't always "catch animals in the act," we can study the effects to try to figure out what animals were here, how long ago, and what they were doing when they left these tracks and signs.*

3. **Tell students they will make explanations based on evidence about the tracks and signs they found.** Explain to students that they can't know for sure what behaviors or animals caused the tracks they observed, but they can make an explanation based on evidence.
   - *You're going to make explanations about the tracks and sign you saw.*
   - *Your explanations should be nonfiction stories of what could have caused the tracks or signs you saw.*
   - *Base your explanations on evidence. The evidence could be something you observed, or any information you might know about the animals in this area.*

4. **Give 1-2 examples of an explanation based on evidence.** For example: "I think these tracks might have been made by an animal that was moving at different speeds, because the tracks first are close together, then farther apart, and I have observed that animals make bigger strides when they're running than when they're moving slowly." Or: "I think this track was left here not long ago, because its edges are very crisp and fresh in the snow, and it just snowed this morning." Or: "I think this line of tracks that are a bunch of small dots all in a line could be from a mouse, because mice aren't big, so they would leave really small tracks behind."

5. **Tell students to *Turn & Talk* to share a few explanations about the tracks and signs they found, then ask a few of them to share their ideas.** After students make explanations in pairs, ask a couple of students to share their explanation based on evidence. Coach students to share evidence or to use a language of uncertainty.

6. **If the group seems excited to keep discussing explanations, hear more ideas from them for a few minutes, asking follow-up questions and listening carefully to student thinking.**

7. **Introduce tools for finding more evidence—analyze the "Found" and the "Surround."** Explain:
   - *When we find tracks or signs of an animal, there are a few things we can think about every time, to help us to find more evidence and make explanations about what might have happened. One tool is thinking about the "Found" and the "Surround":*
   - **What's been Found?:** We can ask questions like: What is it? Who left it? How long ago? What can we learn about the animal from it? (For example, from scat we can learn about diet; from tracks, the direction the animal was moving; from fur, the color of the animal.)
   - **What's the Surround?:** We can ask questions like: What's nearby? How could that have affected what the animal was doing? Where is the

TEACHING NOTES

Introducing the Crosscutting Concept. Introducing "Cause and Effect" as a big idea of science, then pointing out how students are using the concept, makes it more accessible to them as a "thinking tool" for learning about nature. See the Instructor Support section for more information about making connections between this activity and the *NGSS*.

The language of uncertainty. When making explanations, it's important to use "the language of uncertainty" to reflect the fact that we don't know exactly what happened. Encourage students to use phrases like: Maybe... I think... I wonder if... The evidence seems to show... I'm not sure, but I think...

More tools for tracking. For more questions to guide students' explanations while tracking, see the book *Animal Tracking Basics* by Jon Young and Tiffany Morgan.

Using local field guides. Field guides often include facts about common animal behaviors or habitat needs that can inform students' explanations of tracks and animal evidence. If you've brought local field guides along, consider offering them to students here as a tool to further their ideas and thinking.

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TEACHING NOTES

closest water or food source? What is the terrain like? Do you have any guesses about where the animal was going, and why?

8. **Introduce another tool—try getting into the animals' perspective.** Demonstrate an "animal perspective" by getting down low and imagining being the same size as the animal that left the sign. Ask students to look around and try to imagine what the animal was seeing when it was in this spot. Tell them that changing their perspective physically could lead them to notice evidence they hadn't picked up on before. It might also lead you to notice more "doors and windows," which can be followed to more discoveries!

What kinds of explanations? If students seem "stuck" in this phase of the activity and aren't sure what to make explanations about, remind them they can try to figure out the identity of the animal that left the track behind, how fast it was moving, why it might have been there, where it went next, where it came from, etc.

9. **Send students to explore with the goal of make explanations based on evidence, using the Found and the Surround, and getting into the animal's perspective to look for more evidence.** Let students return to former discoveries (or find new ones), with the goal of making explanations based on evidence. Depending on the area and your comfort level, set boundaries for students' explorations.

10. **Circulate, troubleshoot, and be a co-explorer with students, listening to their explanations and helping them assume animal perspectives to discover as much as possible.** Ask students to share their explanations and evidence, and always encourage them to use the language of uncertainty.

Evaluating Explanations

1. **Ask the group to share what they found and to visit some of their discoveries, then stop at one discovery to introduce tools for evaluating explanations.** Gather students to share out particularly cool discoveries and explanations they came up with. Take a tour of the most intriguing discoveries. Stop at one discovery to introduce tools for evaluating explanations.

2. **Tell students: Some explanations are more supported by evidence than others.** Explain that some explanations simply have stronger evidence, which makes them more trustworthy. For example: "If you see a mountain lion biting into a dead deer, then you have very strong evidence that the mountain lion is eating the deer. But if you see a broken stick and your explanation is that a mountain lion broke it while walking by, the connection between your evidence and your explanation is much weaker. There are many other possible explanations for the broken twig."

Scientific argumentation. It can be helpful to explain that "arguments" in science are different from everyday arguments that students are more familiar with. Scientific argumentation means respectful sharing and critiquing of ideas, based on evidence, with the goal of finding the best possible explanations. When students change their minds in light of a different explanation that is supported by stronger evidence than their own, point out they have not "lost the argument," but instead have demonstrated some of the most highly valued and celebrated scientific habits of mind—open-mindedness, intellectual honesty and integrity. Changing one's mind or adding to one's understanding in light of new and compelling evidence is a higher form of learning, and it's how our understanding of the world through science progresses.

3. **Introduce the science practice of argumentation.** Explain:

   ▶ *In order to figure out the best explanation possible, scientists engage in scientific argumentation with each other about their different explanations. This means they share why they think the evidence best supports their explanation, and also why they think the evidence for other explanations is weaker.*

4. **Point out the animal sign you are gathered around, then ask pairs of students to come up with a few possible explanations about it. Next, respectfully discuss which explanation seems stronger, based on the evidence they have.** Ask students to share and evaluate each other's

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explanations. Make sure they know they can disagree with each other's explanations or the strength of their evidence, but that they must do so respectfully, and must provide reasons for their thinking.

5. **Lead a short discussion by asking a few students to share their explanations for the animal sign, including how strong they think their evidence is; then encourage others to explain why they agree or disagree.** When students share explanations, ask them for their evidence and the strength of their evidence. Encourage others to share why they agree or disagree. Use the questions below to elicit student thinking:
   - *How strong is the evidence for that explanation?*
   - *What are the pros and cons of that explanation?*
   - *Do we have any evidence against that explanation?*
   - *What evidence do you wish you had to be more sure of this explanation?*

6. **[Optional] If the group is really "into it," ask students to engage in argument from evidence around a second animal sign, first in pairs, then with the whole group.** Gather students around a different animal sign and have them first share explanations in pairs and then in a group. Encourage them to compare and evaluate different explanations based on the strength of the evidence.

Wrapping Up

1. **Ask students to *Turn & Talk* or *Walk & Talk* about a few of these reflection questions:**
   - *What was a skill you felt like you got better at during this activity?*
   - *If you were going to teach a younger sibling or family member about tracking and looking for evidence of animals, what would you do?*
   - *What questions do you have about the tracks and signs you saw today?*

2. **Explain that this way of thinking—figuring out the causes of effects that can be observed—is an approach that scientists use in many different fields, and it can be a fun and interesting way of looking at the world.**

3. **Point out that students can make possible explanations for what they observe in nature and learn about their surroundings in all kinds of environments, including around their homes.** Encourage them to think about cause and effect in the future to learn about their surroundings.

4. **Encourage the group to continue looking for tracks and signs throughout the rest of their field experience, and to continue to practice making explanations based on what they find.**

TEACHING NOTES

Extending thinking by illustrating explanations. To continue students' thinking about possible explanations for a track or sign, consider having them make an illustration or a comic book panel in their journals to show their explorations, evidence, and findings.

See the BEETLES activity *Walk & Talk* for the logistics of this routine.

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TEACHING NOTES

Many ways to teach tracking. This activity focuses on an approach to tracking through making explanations based on evidence, and is designed to be taught in 1 to 1½ hours. If you have more time or are interested in more immersive and comprehensive techniques for teaching tracking, you can check out the excellent exercises and background in Jon Young's *Coyote's Guide to Connecting with Nature* or Tom Brown's *Field Guide to Nature Observation and Tracking.*

Instructor Support

Teaching Knowledge

Spirit of Inquiry and Investigation. Everyone loves a mystery, and tracking taps into that interest. The lens of tracking can transform fire roads, muddy trails, and snowy schoolyards into scenes of inquiry and debate. Instructors can give students skills to make detailed observations, and can challenge students to support their explanations with observation-based evidence.

Scaffolding and Introducing Tracking Skills. Showing students a few types of evidence that they might find will help them to be successful at noticing more signs of wildlife than just tracks. Encourage students to move "slow and low," taking their time and staying close to the ground. This will help them be more successful at finding evidence of animals. Show students how easy it is to trample animal signs accidentally, and encourage them to tread lightly and look before they step in order to preserve tracks throughout the exploration.

Tracking, Science Practices, and Scientific Language. Science is about coming up with the best explanation for all the available evidence. It's also about being open-minded to other explanations that could be better. In science, nothing is ever proven! That's why scientists tend to use language of uncertainty when discussing ideas and explanations. Try to use sentence starters like "Maybe…" "I wonder if…" "That evidence makes me think…" "The evidence seems to show…" Encourage students to phrase their statements in similar language.

Conceptual Knowledge

Tracking Skills. Different skills and strategies are useful for identifying different evidence of animals. Here are some useful tracking skills for common animal signs:

Footprints: When looking at tracks, keep the tracks between you and the sun. This positioning makes shadows more visible and tracks easier to see, and keeps your group's shadows from blocking the tracks. When possible, draw a circle or two lines around the tracks to keep students from accidentally stepping on them.

Note the size, shape, number of toes, presence of claws, and spacing between tracks. All of these traits can tell you about the animal that left the footprints. For example, canine tracks have four toes, tend to be oval in shape, and have visible toenail marks. Feline tracks also have four toes, but tend to be more circular, and do not often have toenail marks because felines' claws retract into their paws when they take a step.

Assume the animal's perspective. Get down on all fours and put your head low to the ground, at the approximate height of the animal. When you glance down the set of tracks from this direction, new patterns may emerge. You may be able to see a center line, and then can recognize which tracks correspond to left or right feet. Noting the impact depth of the tracks may help you infer the weight or speed of an animal.

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Think about the environment in which the track was found to get a sense of how old a track is. For example, if a track was found in the mud, ask yourself: "When was the last rain?" "How long has this ground been wet?" "Are there raindrops visible on top of the track?" If you find a track on wet sand at the beach, ask yourself: "When was the last high tide?" By thinking about the substrate and how fresh and crisp the track is, you can make an educated guess about when the animal was there.

Scat: Note the shape, size, and contents of scat to help identify who left a "little gift" on the trail. Scat location and surroundings can also be informative. For example, certain animals, like foxes, mark their territory by scatting on prominent locations such as rocks. Bobcat scat, by contrast, tends to be surrounded by scratch marks that the bobcat makes with its hind legs. SAFETY NOTE: While scat is exciting to explore, it is also the disease vector of choice for many pathogens. Touching, tasting, and smelling are not appropriate modes for scat investigations.

Kill sites: Investigate the carcass and the surrounding area for clues. Look around for fur, feathers, blood, or drag marks. Investigate bones, teeth marks, remaining flesh, sun bleaching, and the extent to which a skeleton is intact to make inferences about how long ago an animal died. SAFETY NOTE: Animal carcasses can also be sources of disease. Touching, tasting, and smelling are not appropriate modes for explorations of kill sites.

"Doors" and "Windows": Pay attention to the size of the door or window to help identify the animal that made it. These signs of animals are often less familiar to students, but in certain habitats they can be extremely abundant. Animals leave behind trails of pressed down vegetation, broken twigs, holes, or compacted paths. The size of these trails is a useful identification trait.

Useful Criteria for Evaluating the Strength of Evidence in Making an Explanation

Learning to evaluate the strength of evidence is an important skill in science as well as life. Tracking can be a great opportunity to coach students to start thinking about the strength of evidence used to support their explanations by looking at the quantity of evidence, the size of the assumption, and the quality of the source.

Quantity of Evidence. Something that has been observed one time by one person is not as strong evidence as something observed multiple times by one person, or multiple times by many different people. Increasing the amount of data often makes patterns and important details more clear. The more evidence collected through reliable sources, the more certain we can be about an explanation. For example, if you see a patch of grass that's been flattened and your explanation is that a bobcat had been lying on the grass, you don't have much evidence for your explanation. But if you also find bobcat tracks leading toward and away from the flattened grass, you have more and stronger evidence for your explanation.

TEACHING NOTES

"It's a powerful thing to show kids that scientists review one another's work in a supportive and respectful way, and that makes science stronger!" –Molly Honea, field instructor at YMCA Point Bonita

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TEACHING NOTES

Size of Assumption. This refers to the conceptual leap needed to connect the evidence with the explanation or conclusion. For example, to see a mountain lion with a deer in its mouth and use that as evidence to make an explanation that mountain lion eat deer, you're making a small assumption (you're assuming that the mountain lion will actually eat the deer, and that other mountain lions also eat deer). But it's a large assumption if you see a broken twig, and you say a mountain lion had walked by and your evidence is the broken twig. There could be lots of other reasons the twig was broken. Evidence tends to be stronger when the assumption is smaller. With students, you might want to call the following terms instances of "size of assumption"—"explanations that have stronger connections to evidence than others," "explanations that are closer to the evidence," "stronger evidence," or "evidence that leaves the least doubt."

Quality of Source. During tracking or other outdoor learning, students often share prior knowledge as evidence in their explanations. For example, a student might say, "I think this rabbit was killed by a coyote, because I know that coyotes eat rabbits." The student is using their prior knowledge that coyotes eat rabbits as evidence in their explanation. Coach students to include the source of the information they share during discussions (e.g. "I know this about coyotes in rabbits because I read it in a book, or heard my friend who is a hunter talk about it, or saw it on a nature show), and remind them to think about the quality of the source of that information. The higher the quality and reliability of the source, the stronger the evidence to support the explanation. If you have a lot of evidence from a lower-quality source, it doesn't necessarily outweigh a smaller set of evidence from a higher-quality source. Encourage students to start asking each other for their sources of information. This can become a part of the culture of a group, with students pausing to ask, "What's your source for that information? Do you think it is a reliable source? Why or why not?" Having these types of discussions about sources for information has connections to both the *Common Core* and the *NGSS*.

Scientists think about all three of these criteria for evaluating evidence in order to decide how strong an explanation is. As you get students familiar with evaluating evidence, encourage them to start thinking about the strength of the evidence in different ways. Do they have a small size of an assumption, but a low quality of source? Then the evidence isn't as strong as if the source were more reliable.

Two BEETLES Classroom activities, *Evaluating Sources* and *Evaluating Evidence*, teach students how to think about how reliable sources of information are, and how to think about the size of the assumption within the evidence they are using. The BEETLES field activity *What Lives Here*? also engages students in evaluating the quality of evidence.

Questions that encourage explanations from evidence and arguing from evidence

Asking students questions can guide them and scaffold skills of making explanations and arguing from evidence. Use these questions to engage students in discussion with each other:

- What do you notice? What's happening here?

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- Do you agree with that observation?
- What questions do you have about it?
- What might have happened here?
- What is an explanation for that? What's a different explanation for it?
- What are some pros and cons for those explanations?
- What's the evidence for that explanation?
- Do we have evidence against that explanation?
- What evidence would you like to have to be more certain of that explanation?
- What's your source for that? Does it seem like a trustworthy source for science information?

Common Relevant Misconceptions

Misconception. Tracking simply means looking for footprints and scat of large mammals.

More accurate information. Tracking involves using evidence of large and small animals (even insects) to attempt to make as many explanations as possible about what has been left behind. This can include the identity of an animal, how fast it was moving, why it might have been there, where it was going, where it came from, etc.

Misconception. Carnivores are always hunting, and all dead animals were hunted and killed.

More-accurate information. Carnivores have lots of behaviors beyond hunting, and there are many causes of death beyond death by carnivore. Students are often exposed to wildlife in the context of food chain lessons, so they tend to think of animals as only operating within their food chain roles. Encourage students to come up with other explanations for what carnivores might be doing or what might have caused the death of an animal you find, and then to support their explanations with evidence.

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to provide opportunities for the "three-dimensional" learning that is called for in the Next Generation Science Standards (NGSS). Three-dimensional learning weaves together Science Practices (what scientists do), Crosscutting Concepts (the thinking tools that scientists use), and Disciplinary Core Ideas (what scientists know). Students should be exploring and investigating rich phenomena, and figuring out how the natural world works. The abilities involved in using Science Practices and Crosscutting Concepts—looking at nature and figuring things out, using lenses or big ideas to guide thinking, and understanding ecosystems and natural processes more deeply—are mindsets and tools that students can take with them and apply anywhere to deepen their understanding of nature. And, they're interesting and fun to do!

In *Tracking*, students engage in the science practices of *Constructing Explanations and Engaging in Argument from Evidence* as they use the

TEACHING NOTES

About the Next Generation Science Standards (NGSS). The development of the Next Generation Science Standards followed closely on the movement to adopt nationwide English language arts and mathematics Common Core standards. In the case of the science standards, the National Research Council (NRC) first wrote a Framework for K-12 Science Education that beautifully describes an updated and comprehensive vision for proficiency in science across our nation. The Framework–validated by science researchers, educators and cognitive scientists–was then the basis for the development of the NGSS. As our understanding of how children learn has grown dramatically since the last science standards were published, the NGSS has pushed the science education community further towards engaging students in the practices used by scientists and engineers, and using the "big ideas" of science to actively learn about the natural world. Research shows that teaching science as a process of inquiry and explanation helps students to form a deeper understanding of science concepts and better recognize how science applies to everyday life. In order to emphasize these important aspects of science, the NGSS are organized into three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas (DCI's). The DCI's are divided into four disciplines: Life Science (LS), Physical Science (PS), Earth and Space Science (ESS) and Engineering, Technology and Applied Science (ETS).

Read more About the Next Generation Science Standards at:

- www.nextgenscience.org/
- ngss.nsta.org/

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Importance of teaching science practices. "Engaging in the practices of science helps students understand how scientific knowledge develops...It can also pique students' curiosity, capture their interest, and motivate their continued study..." –National Research Council, A Framework for K-12 Science Education. Focus on these science practices will help to ensure a more scientifically literate public who will be better able to make thoughtful decisions.

About Crosscutting Concepts in the NGSS. Crosscutting concepts are considered powerful thinking tools for how scientists make sense of the natural world. The seven "big ideas" listed as crosscutting concepts are: Patterns; Cause & Effect; Scale, Proportion & Quantity; Systems and System Models; Energy & Matter: Flows, Cycles and Conservation; Structure & Function; and Stability & Change. These concepts may sound familiar, as they are quite similar to the themes referred to in science literacy documents as being important ideas that unify all disciplines of science and engineering.

crosscutting concept of Cause and Effect to investigate their surroundings. Depending on the tracks and signs they find, there may be opportunities for students to build understanding of disciplinary core ideas in Interdependent Relationships in *Ecosystems or in Cycles of Matter and Energy in Ecosystems.*

Featured Science and Engineering Practices

Engaging students in Constructing Explanations. According to the NRC's *Framework for K-12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about it, and students should develop their understanding of science concepts through making their own explanations about natural phenomena.

- The process of tracking is rooted in making explanations. When a student encounters a track or sign, then makes a guess at which animal left it, when it was left, or what the animal might have been doing at the time, that student is making a possible explanation about that track or sign.
- Students also discuss their explanations with peers, coming up with multiple possible explanations for what they have observed, both in pairs and in the large group where the instructor can act as a coach.
- Students practice gathering evidence through observation, then they evaluate the strength of evidence used to support their explanations. This helps students refine their understanding of the practice.
- Without that phase of the activity, students may not realize that the strength of the evidence is correlated to the strength of their explanation.
- Listen to students' statements as they evaluate their explanations in pairs, and use what you learn to think about how you can continue to deepen students' engagement with this practice.

Engaging students in Arguing from Evidence. The Framework for K-12 Science Education highlights reasoning and argumentation skills as key for finding the best explanation for a natural phenomenon. They are also important life skills. Engaging in argumentation from evidence is critical to students learning to understand science as a process, and also understanding how scientific knowledge is developed.

- As students support explanations of signs and tracks with evidence, evaluate each other's evidence, and critique each other's explanations, they gain practice with scientific argumentation.
- Support students' deepening their abilities with this practice by asking them to critique each other's explanations based on the available evidence, and to share why they agree or disagree. As you coach students to do this, they can learn to recognize and apply these skills on their own.

Featured Crosscutting Concepts

Learning science through the lens of Cause and Effect. When scientists make explanations for how or why something might have happened, they are thinking about the "big idea" of cause and effect. What we can observe in the

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natural world are "effects" of one or more causes.

- In Tracking, students observe evidence left behind by animals and make possible explanations about the specific animals and environmental circumstances that could have caused what they observe.
- Students continue to think about cause and effect throughout the activity.
- The instructor points out cause and effect as a thinking tool when students offer explanations, making a connection to how scientists think.
- At the end of the activity, students reflect on how thinking about cause and effect helped them to learn, and they think about other places they could explore nature through this lens.
- This practice can help students realize that the way they're thinking is useful when they're exploring other parts of the world, or even trying to explain aspects of other mysteries.

Connections to Disciplinary Core Ideas

Building a foundation for understanding Disciplinary Core Ideas. The NGSS make it clear that students need multiple learning experiences to build their understanding of Disciplinary Core Ideas. Depending on what students discover and the kinds of explanations they focus on making, Tracking gives students the opportunity to develop understanding of some Disciplinary Core Ideas related to Interdependent Relationships in Ecosystems (LS2.A) and Cycles of Matter and Energy Transfer in Ecosystems (LS2.B).

As students make possible explanations for the tracks and signs they find (like the "Surround" of what the animal was doing, or where it was going), they build some understanding of the ways in which organisms get what they need from their environment in order to survive (LS2.A). If students see signs that include evidence of animals' eating plants or other animals, they also build some basic understanding of the ways in which matter gets transferred through various parts of the ecosystem (LS2.B).

Performance Expectations to Work Toward

The NGSS represent complex knowledge and multifaceted thinking abilities for students. No single activity can adequately prepare someone for an NGSS performance expectation. Performance expectations are examples of things students should be able to do, after engaging in multiple learning experiences or long-term instructional units, to demonstrate their understanding of important Disciplinary Core Ideas and Science Practices, as will as to show their ability to apply crosscutting concepts. Performance expectations are not a "curriculum" to be taught to students. Some of the performance expectations this activity can help students work toward are:

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS1-4. Use an argument based on empirical evidence and scientific reasoning to support an explanation of characteristic animal behaviors

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Translating the codes used in the NGSS. Each standard in the NGSS is organized as a collection of performance expectations (PE) for a particular science topic. Each PE has a specific code, provided here so that they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K - kindergarten, 1 - first, 2 - second,etc...MS - middle school, and HS - high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that is addressed by the PE, and the last digit identifies the number of the PE itself.

So 3-LS4-4 means it's part of a third grade standard (3) for life science (LS), addressing the fourth core idea (4), Biological Evolution: Unity and Diversity, within the life science standards, that deals with Biodiversity and Humans. It's also the fourth performance expectation (4) that makes up the complete LS4 standard at this grade level.

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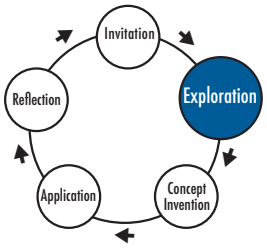

This activity completes a full learning cycle. Within a series of experiences focused on studying organisms' structures and functions, this activity falls in the *Exploration* phase.

and specialized plant structures that affect the probability of the success of animals and plants, respectively.

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Activity Connections and Additional Ideas

I Notice, I Wonder, It Reminds Me Of and *Nature Scene Investigators* are good activities to do before Tracking, to build student skills of observation, questioning, and explanation. Students could also participate in the BEETLES Classroom Activities Evaluating Sources and Evaluating Evidence before they get to your site, to practice thinking about the strength of evidence. *Bark Beetle Exploration* and *The Case of the Disappearing Log* are activities in which students "track" evidence of animals. During *What Lives Here?* students practice evaluating evidence, and look for evidence of animals in an area.

Other possible follow-up activities could include tracking in other ecosystems and comparing signs left by organisms in different ecosystems. For example, students could note how the environment (e.g. whether the ground is covered in leaf litter or is muddy) affects the types of tracks you can observe, and then could construct explanations for why tracks from different organisms may exist in different places. You can use this as an opportunity to highlight disciplinary core ideas relating to LS2.A Interdependent Relationships in Ecosystems. Alternatively, you could focus on what tracks and signs—scat in particular—indicate about the food web and how matter is cycling through the ecosystem. *Food, Build, Do, Waste* could be used as a follow-up activity to further highlight LS2.B Cycles of Matter and Energy Transfer in Ecosystems.

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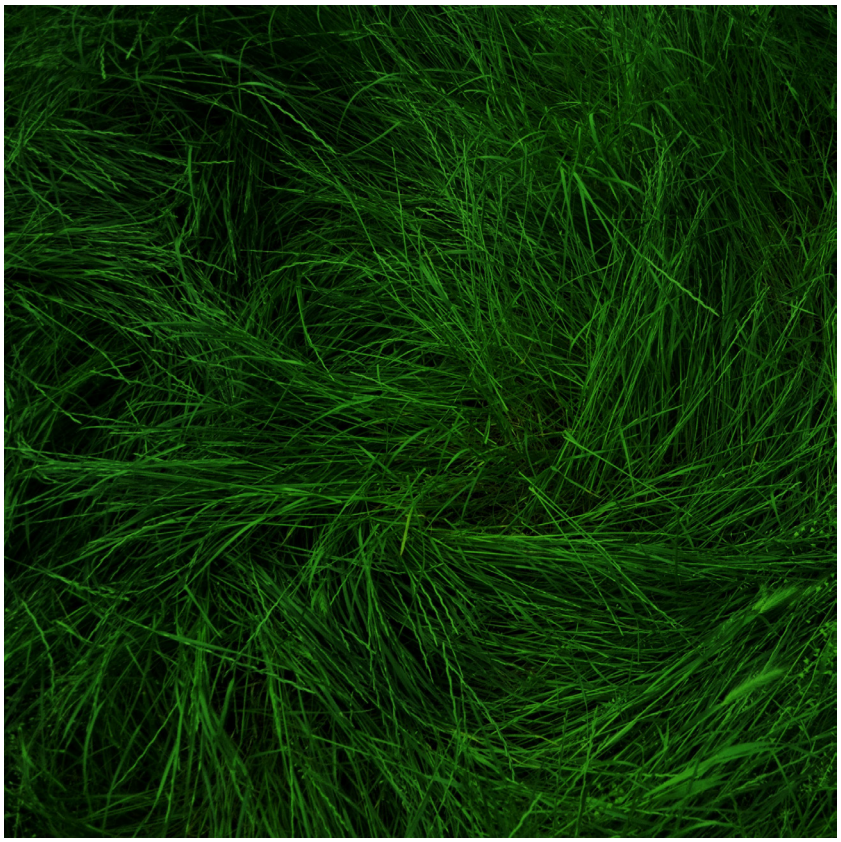
Doors and Windows (pg. 1)



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Tracking

Introducing the Activity

1. Ask students to step into the circle if... Gather students in a circle and ask them to step into it if the statement you say applies to them:
   - *you've ever put your hands through your hair and noticed a hair fall out.*
   - *you've ever been out in the rain, then walked inside and accidentally left muddy footprints on the floor.*
   - *you've ever followed the tracks of a person or animal.*
   - *you've ever eaten chicken or fish and left the bones on your plate.*
   - *you've ever had to go to the bathroom when you were outside so you dug a hole or picked a nice tree to step behind.*
2. Explain: Hair, footprints, bones, and waste are all evidence that humans and other animals leave behind.
3. Ask students to Turn & Talk to discuss: What evidence do different kinds of animals leave behind?
4. Call on a few pairs to share out their ideas.
5. Get students pumped to look for evidence of animals in the area.
   - *You're going to get to explore this area, looking for tracks and signs animals have left behind, making discoveries and learning about what you find.*

Cast of Characters

1. Show pictures of common animals in the environment.
2. Introduce the idea of "doors and windows" (openings in vegetation or land through which animals may have passed).
3. Show pictures of "doors and windows" (paths, tunnels, holes) and other evidence of animals, asking students to observe each photo and use their hands to show the likely size of the animal that made the evidence.

Tracking Take 1: Practicing Observations

1. Explain and model to students how they'll explore, looking at animal signs or tracks and making observations about their discoveries.
2. Establish boundaries and go over safety protocols.
3. Set students free (within boundaries) to search for signs and tracks, then circulate, and be a co-explorer, asking questions like:
   - *How would you describe the shape of the track?*
   - *Compare one track to another. What's similar and what's different?*
   - *Are the tracks close together? Far apart?*
   - *Do the tracks seem to be deep or shallow?*
   - *How big is the door/window?*
   - *How would you describe the shape and size of the scat? What do you see in it?*
   - *What other observations can we make?*
4. Gather the group back together, and ask students to Turn & Talk to share their discoveries.
5. Gather the group around a student discovery of an animal sign, and ask for observations, using some questions from above.

Tracking Take 2: Practicing Explanations

1. Introduce the crosscutting concept of Cause and Effect. Explain:
   - *The animal tracks and signs you just observed were all caused by animals that were in the area at some point. Sometimes scientists observe the world, then try to figure out the causes behind what they see.*
2. Explain that when tracking, students are looking at effects, and trying to figure out the causes.
   - *We can think of what we just saw and observed as "effects" and can think of the animals and behaviors that produced them as "causes."*
   - *Even though we can't always "catch animals in the act,"' we can study the effects to try to figure out what animals were here, how long ago, and what they were doing when they left these tracks and signs.*
3. Tell students they will make explanations based on evidence about the tracks and signs they found.
   - *You're going to make explanations about the tracks and signs you saw.*
   - *Your explanations should be nonfiction stories of what could have caused the tracks or signs you saw.*
   - *Base your explanations on evidence. The evidence could be something you observed, or any information you might know about the animals in this area.*
4. Give 1-2 examples of an explanation based on evidence.
5. Tell students to Turn & Talk to share a few explanations about the tracks and signs they found, then ask a few students to share their ideas.
6. If the group seems excited to keep discussing explanations, hear more ideas from the group for a few minutes, asking follow-up questions and listening to student thinking.

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7. Introduce tools for finding more evidence—analyze the "Found" and the "Surround." Explain:

   ▶ *When we find tracks or signs of an animal, there are a few things we can think about every time to help us to find more evidence and make explanations about what might have happened. One tool is thinking about the "Found" and the "Surround":*

   - **What's been Found?:** We can ask questions like: What is it? Who left it? How long ago? What can we learn about the animal from it? (For example, from scat we can learn about diet; from track, the direction the animal was moving; from fur, the color of the animal.)
   - **What's the Surround?:** We can ask questions like: What's nearby? How could that have affected what the animal was doing? Where is the closest water or food source? What is the terrain like? Do you have any guesses about where the animal was going and why?
8. Introduce another tool—try getting into the animals' perspective.
9. Send students to explore with the goal of making explanations based on evidence, using the "Found" and the "Surround" and getting into the animal's perspective to look for more evidence.
10. Circulate, troubleshoot, and be a co-explorer with students, listening to their explanations and helping them assume animal perspectives to discover as much as possible about the "Found" and the "Surround."

Evaluating Explanations

1. Ask the group to share what they found and visit some discoveries, stopping at at least one discovery to introduce tools for evaluating explanations.
2. Tell students: Some explanations are more supported by evidence than other explanations, and offer an example if necessary: "If you see a mountain lion biting into a dead deer, then you have very strong evidence that the mountain lion is eating the deer. But if you see a broken stick and your explanation is that a mountain lion broke it while walking by, the connection between your evidence and your explanation is much weaker. There are many other possible explanations for the broken twig."
3. Introduce the science practice of argumentation. Explain:

   ▶ *In order to figure out the best explanation possible, scientists engage in scientific argumentation with each other about their different explanations. This means they share why they think the evidence best supports their explanation, and why they think the evidence for other explanations is weaker.*
4. Point out the animal sign you're gathered around, then ask student pairs to come up with a few possible explanations about it and to respectfully discuss which explanation is stronger, based on the available evidence.
5. Lead a short discussion by asking a few students to share their explanations for the animal sign, including how strong they think their evidence is; then encourage others to explain why they agree or disagree. Use the questions below to elicit student thinking:

   ▶ *How strong is the evidence for that explanation?*

   ▶ *What are the pros and cons of that explanation?*

   ▶ *Do we have any evidence against that explanation?*

   ▶ *What evidence do you wish you had to be more sure of this explanation?*
6. [Optional] If the group is really "into it," ask students to engage in argument from evidence around a second animal sign in pairs, then with the whole group.

Wrapping Up

1. Ask students to Turn & Talk or Walk & Talk about a few of these reflection questions:

   ▶ *What was a skill you felt like you got better at during this activity?*

   ▶ *If you were going to teach a younger sibling or family member about tracking and looking for evidence of animals, what would you do?*

   ▶ *What questions do you have about the tracks and signs you saw today?*
2. Explain that this way of thinking—figuring out the causes of effects that can be observed—is an approach that scientists use in many different fields, and can be a fun and interesting way of looking at the world.
3. Point out that students can observe nature and make possible explanations for what might have caused what they observe, so they can learn about their surroundings in all kinds of environments, including around their homes.
4. Encourage the group to continue looking for tracks and signs throughout the rest of your field experience, and to continue to practice making explanations based on what they find.

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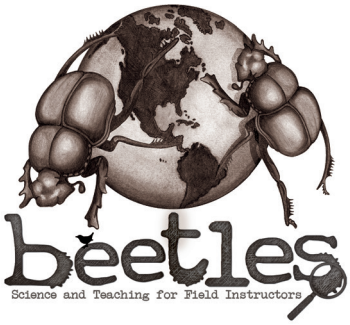

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The following programs contributed to the development of these materials by field testing and providing invaluable feedback. For a complete list of contributors and additional partners, please see beetlesproject.org/about/partners/

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Photos: Pages 1 and 2 by Kevin Beals. *Icons*: Backpack by Rémy Médard; Growth by Arthur Shlain; Cut by Nathan Thomson; Outside by Petr Holusa; Park by Antar Walker; &Time by Wayne Middleton all from The Noun Project.

Funding from 2012-2019 for BEETLES publications such as this one has been generously provided by the S.D. Bechtel, Jr. Foundation, The Dean Witter Foundation, Pisces Foundation, the Mary A. Crocker Trust, and the National Science Foundation under Grant No. 1612512. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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