beetles

Science and Teaching for Field Instructors

Student Activity Guide

Evaluating Evidence

Every day we're faced with competing explanations. The ability to evaluate the strength of evidence is an important part of constructing and critiquing scientific explanations (as well as an important life skill). Yet it's not just a matter of which explanation has more evidence. In this activity, students learn a criterion for evaluating the quality of evidence based on how connected the evidence is to a claim. Next, they apply this criterion by sorting various possible pieces of evidence for a claim and discussing the strength of that evidence. Then, students apply this criterion in a discussion about the evidence of animals they may see during their time at an outdoor science experience. This activity is designed to prepare students for an outdoor science experience (but can also be done after such an experience.)

Students will...

- **Learn a criterion for evaluating the strength of evidence: how connected the evidence is to the claim it is meant to support.**
- **Based on this criterion, rate the strength of evidence cards that could support the claim: *Cheetahs are predators of wildebeest*.**
- **Apply this criterion in a discussion about the strength of different pieces of evidence for the presence of animals.**

Grade Level:
Grades 5–12. This activity can also be used with adults.

Timing:
40–60 minutes

Related Activities:
Classroom: *Evaluating Sources*, Field: *NSI: Nature Scene Investigators*, *What Lives Here?*, *Argumentation Routine*

Materials:
See Materials and Preparation on page 3 for details.

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

NEXT GENERATION SCIENCE STANDARDS (NGSS)

This activity supports students in deepening their capacity to engage in the Science and Engineering Practices of *Constructing Explanations*; *Engaging in Argument from Evidence*; and *Obtaining, Evaluating, and Communicating Information*. For more information, see Instructor Support on page 11 of this guide.

For additional information about NGSS, go to page 13 of this guide.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Evaluating Evidence

ACTIVITY OVERVIEW

Evaluating Evidence	Learning Cycle Stages	Estimated Time
Introducing Claims, Evidence, and Explanations	Invitation, Exploration	15 minutes
Sorting Cards	Exploration, Concept Invention	10–15 minutes
Discussing the Strength of Evidence	Concept Invention, Application	5–15 minutes
Discussing Evidence of Animals	Application	5–10 minutes
Reflecting and Wrapping Up	Reflection	5 minutes
TOTAL:		**40–60 minutes**

TEACHING TIPS

Read the Instructor Support section. Beginning on page 11, you'll find more information about pedagogy, student misconceptions, science background, and standards.

Describing the criterion for evaluating the strength of evidence. During this activity, students evaluate the strength of evidence based on how connected it is to the claim it's meant to support. For example, a student who sees a hole in the ground may make a claim that the hole was dug by a bear, based on the evidence that bears have claws. Another student may make a competing claim that the hole was dug by a gopher, based on the evidence that they actually saw the gopher digging the hole. The evidence of seeing the gopher digging the hole is very closely connected to the claim. The evidence of bears having claws is less connected to the claim. The more connected the evidence is to the claim, the more likely the explanation is true. The less connected the evidence is to the claim, the less likely the explanation.

More on evidence. *Evaluating Sources* is a companion BEETLES activity for this activity that gets students thinking about and discussing the varying quality of different sources of evidence. Both these sessions are good building blocks before experiences in which students make explanations based on evidence or engage in argument. Consider doing *Evaluating Sources* with your students after this activity.

All materials created by BEETLES™ at The Lawrence Hall of Science.
Find the latest activities and information at http://beetlesproject.org.

MATERIALS AND PREPARATION

MATERIALS

For the class

- 1 copy of the Tracks photo (See page 18.)
- 1 set of Evidence Cards (See page 19.)
- whiteboard
- whiteboard markers
- magnets or tape

For each group of 3–4 students

- 1 set of Evidence Cards (See page 19.)

PREPARATION

1. **Prepare sets of Evidence Cards.** Print and make enough copies of the Evidence Cards (on page 19) for each group of 3–4 students to have one set. Print cards in color, single-sided, and cut apart cards.
   - Also make an additional set that you can attach to the whiteboard for the entire class to see. Plan how you will attach these to the whiteboard (e.g., with magnets or tape).
2. **Set up a projector or other system to show the Tracks photo so the whole class can see it together.**
3. **Consult a species list for the outdoor science school that students will attend.** If your students are going to attend an outdoor science program, get a species list, if possible, from the outdoor science program (sometimes these are on the organization's website). This will help you center students' discussion of animal evidence around an accurate list of the animals that are living near the outdoor science school.
4. **Review the Teaching Tips on page 2 and Instructor Support section on page 11.**

TEACHING NOTES

TEACHING NOTES

The goal is not identification, but rather to get students excited about nature mysteries. The goal of looking at the Tracks photo is not for students to accurately identify what made the tracks and what it was doing, but to get them excited about making observations and trying to figure it out. Get students interested about the more general idea that there are mysteries everywhere in nature, and it's fun to try to figure them out. There's no need to spend too much time on it—just enough to get the group revved up about nature mysteries. If students want to know more about this specific set of tracks, you might want to give them more time later to discuss and try to figure it out. Afterward, you might choose to share that a lizard dragging its tail may leave tracks like those in the photo, or that fringe-toed lizards leave tracks like those in the photo.

About claims, evidence, reasoning, and explanations. A scientific explanation is more than simply an answer to a question. By itself, an answer to a question is just a claim. An explanation must include a claim, and it also needs to include evidence and clear reasoning about how that evidence supports the claim. If your students are unfamiliar with *claims*, *evidence*, and *reasoning*, you might want to review these terms with them. See the Instructor Support section for more on scientific explanations.

Introducing Claims, Evidence, and Explanations

1. **Show the Tracks photo and get students excited about trying to explain what they see, using language of uncertainty.**
   - **a.** Show the photo of animal tracks.
   - **b.** Ask students to describe what they notice in the photo.
   - **c.** Ask students for their explanations about what might have caused what they're seeing.
   - **d.** Listen to some responses and ask follow-up questions to get students looking more closely, thinking more deeply, and considering different possible explanations.
   - **e.** Encourage students to use the scientific language of uncertainty, such as *Maybe…*, *I wonder if…*, or *It looks like it might be…* .

2. **Explain that this activity will help students develop skills to figure out nature mysteries:**
   - **a.** When you're in nature (like at an outdoor science program), you're surrounded by interesting nature mysteries.
   - **b.** This activity will help you develop skills for figuring out nature mysteries.

3. **Point out some of the evidence students brought up when discussing the photo. Explain:**
   - **a.** When you were trying to figure out what was going on in the photo, you brought up different evidence, such as the line in the sand, the marks on either side of the line, the little lines that some thought looked like toe marks, and so on.

4. **Explain that this activity will help students learn how to evaluate evidence, which is a skill they can use in outdoor science (and many other places):**
   - **a.** People often use evidence to argue points.
   - **b.** Scientific explanations depend on evidence and on understanding the quality of the evidence.
   - **c.** Being able to evaluate the strength of evidence is key to these discussions.
   - **d.** This activity will help you think about how to know if evidence is strong, weak, or somewhere in between.

5. **Write "Dinosaurs used to live on Earth." on the whiteboard and ask students how we know this.**

6. **Listen to students' ideas and then explain:**
   - **a.** We know there were dinosaurs on Earth because scientists have found their bones, fossils, footprints, fossilized poo, and so on.

7. **Explain that you just shared a claim that, when supported by evidence and reasoning, is a scientific explanation:**
   - **a.** *Dinosaurs used to live on Earth.* is an example of what in science is called a claim.
   - **b.** If you had never heard of dinosaurs and someone told you there used to be giant reptiles roaming Earth, that claim might sound ridiculous.

c. When the claim is supported by evidence (fossils, bones, poo, etc.), the claim seems more likely.
d. Then you have an explanation—an evidence-based, nonfiction story that dinosaurs actually once lived on Earth.

8. **Explain that one goal of science is to figure out the best possible explanations for things, based on all the available evidence:**
   a. An important part of science is trying to figure out and explain how things in the natural world work.
   b. Scientists do this by making claims about the natural world and figuring out which claims are best supported by all the available evidence.
   c. In this way, they try to figure out which explanation is most accurate.
9. **Explain that some evidence is stronger than other evidence:**
   a. Some evidence is weaker, while some evidence is stronger.
   b. Stronger evidence supports a claim better than weaker evidence.
   c. Stronger evidence makes it more likely that an explanation is accurate.
10. **Brainstorm: If a mountain lion walked past a house, what kinds of evidence might it leave behind?**
    a. Listen to students' ideas.
11. **Explain that some evidence students mentioned is weaker, while some is stronger:**
    a. Some of that evidence is more convincing than other evidence.
    b. In other words, some of that evidence is weaker, and some is stronger.
12. **Explain: Imagine that someone is making a claim that a mountain lion walked past a house, based on evidence.**
13. **Ask students to *Turn & Talk* to discuss the strength of a few pieces of evidence in support of this claim: *A mountain lion walked past the house*. Read the first piece of evidence, give students about 30 seconds to discuss it, then read the second piece of evidence, and then read the third piece of evidence.**
    a. Which of the following evidence do you think is stronger? Which is weaker?
       - A mountain lion walked past the house, and the evidence is a broken stick the mountain lion could have broken while it walked past.
       - A mountain lion walked past the house, and the evidence is tracks that looked like the tracks of a large cat of some kind next to the house.
       - A mountain lion walked past the house, and the evidence is actually seeing a mountain lion walking away from the house.
14. **Ask students to share ideas and then explain why the broken stick is the weakest evidence, prints on the ground is stronger evidence, and seeing the mountain lion is the strongest evidence.**
    a. The broken stick is the weakest piece of evidence because it is not strongly connected to the claim.
    b. Many other things could have caused the stick to break.

TEACHING NOTES

All *available* evidence, not *selected* evidence. We are bombarded by claims and explanations in life, some of which are scientific, and others that are not. In an attempt to arrive at the most accurate explanations as possible, accurate science requires that claims and explanations need to be supported by ALL the available evidence. Any good scientific discussion of a claim will not just include how evidence supports it; it will also include any evidence that doesn't seem to support it, details on how the evidence was gathered, possible faulty reasoning, etc.

Another way to frame it. If students are struggling to understand what makes evidence stronger, consider sharing the idea that stronger evidence leaves less doubt about what happened.

TEACHING NOTES

Group Agreements for Science Discussions. Having specific group agreements for science discussions scaffolds important skills while it supports student participation. If you have group agreements for discussions, review them here and remind students to put them into practice. If you don't already have agreements in place, see the BEETLES activity *Group Agreements for Science Discussions*. This includes the following Group Agreements, plus a protocol for introducing them to students: *Listen actively and share ideas*; *Share and ask for evidence*; *Take space, make space*; *Keep an open, curious mind*; *Build on others' ideas*.

Showing photos. Start by showing photos of a cheetah and a wildebeest so students who haven't heard of or seen images of these animals can understand this claim.

Definition of *predator*. Sometimes during this activity, students discuss whether the evidence shows that cheetahs are predators of wildebeest as opposed to simply scavengers. In that situation, share this definition: A predator is an animal that lives by capturing and eating other animals (American Heritage Science Dictionary).

Supporting productive discussions. If students are having trouble working together or are not discussing their reasoning for card placement, consider providing sentence starters to help them engage in respectful, productive discussion. Some useful sentence starters include: *I agree because...*; *I wonder if...*; *I disagree because...*; and *I'm not sure, but I think...* For more tips on supporting discussions, see BEETLES resources for "Encouraging Student Discussion and Productive Talk" on the BEETLES website.

- **c.** It's a big jump to say that a broken stick tells you that a mountain lion walked by.
- **d.** It's a smaller jump to say that large cat prints are evidence that a mountain lion walked by.
- **e.** It's a *much* smaller jump to say that seeing a mountain lion walking away is evidence that a mountain lion walked by.

15. **Explain: The more closely the evidence is connected to the claim, the stronger the evidence is.**

Sorting Cards

1. **Write "Cheetahs are predators of wildebeest." on the whiteboard and show photos of a cheetah and a wildebeest.** Explain:
   - **a.** Is this a complete scientific explanation? [No.]
   - **b.** What's missing?
   - **c.** To create a scientific explanation, you need evidence that supports the claim.
2. **Show cards and introduce the card sort activity. Explain:**
   - **a.** You will break into groups of 3–4.
   - **b.** Each group will get a set of cards.
   - **c.** The cards show photos of cheetahs along with other animals.
   - **d.** Each photo could be used as evidence to support the claim: *Cheetahs are predators of wildebeest*.
   - **e.** Your task is to work together to organize the cards from the weakest evidence to the strongest, based on how connected the evidence is to the claim.
3. **Divide the class into groups, distribute sets of Evidence Cards, and let students start sorting cards. Explain:**
   - **a.** Work together to sort the cards.
   - **b.** Discuss your reasoning for the placement of the cards as you sort them.
   - **c.** It's not a race! It's fine if you don't agree on the card order.
   - **d.** Discussing your reasoning is the most important part of this activity!
   - **e.** Respectfully disagree with your groupmates if you have different ideas from one another.
4. **Circulate, troubleshoot, encourage discussion, and listen to reasoning.**
   - **a.** Mingle among groups, paying attention to discussions.
   - **b.** Encourage discussion among groups that need support.
5. **Choose one group that has (thoughtfully) sorted their cards and arrived at a place of agreement quickly. Have them put their sorted cards on the whiteboard (using magnets or tape).**
   - **a.** Write "Weakest Evidence" on one side of the whiteboard and "Strongest Evidence" on the other side, Draw a horizontal line between them with arrows on both ends.
   - **b.** Ask members from one group to make a copy of their card sort on the whiteboard, using the class set of the cards attached to the whiteboard.

c. They can do this while other students are participating in the gallery walk (next step).

Weakest Evidence ⟵⟶ Strongest Evidence

6. **Ask students to do a gallery walk to see other groups' card sorts. Explain:**
   a. Walk around to notice how other groups sorted the cards.
   b. Discuss differences in how other groups sorted the cards.
   c. Notice and discuss patterns in how groups sorted the cards.

Discussing the Strength of Evidence

1. **Give the class a moment to observe how the group arranged their cards on the whiteboard.**
   a. Look at how members of this group organized their cards.
   b. Notice any differences from your own group's card placements.
2. **Have students ask the group about the reasoning behind the placement of any of their cards.**
   a. Tell students that if there's one or more cards about which they disagree with the placement, or wonder why it was put where it is, to ask this group for their reasoning behind the placement. For example, "What's your reasoning behind why you put the picture of the cheetah eating the antelope under strong evidence?"
   b. Ask follow-up questions to get and keep the discussion rolling and interesting.
   c. Ask the chosen group to explain what they think makes the evidence they've categorized as weakest so weak and the strongest evidence so strong.
3. **Ask students from other groups if they organized their cards differently. If they did, have them discuss any controversies.**
   a. If other groups placed cards differently, ask them to share their reasoning. Encourage students to agree or disagree politely with one another's placements.
   b. Move the cards around during the discussion to illustrate students' ideas.
4. **Point to the strongest and weakest evidence on the whiteboard and reiterate that stronger evidence is more connected to the claim, while weaker evidence is less connected. Explain:**
   a. The strongest evidence (e.g., a cheetah actually taking down a wildebeest) is more connected to the claim that cheetahs are predators of wildebeest.
   b. The weakest evidence (e.g., cheetah's sharp teeth) is less connected to the claim.

   Different orders of evidence. Students often order the cards in the following order (on next page):

TEACHING NOTES

Behavior management for gallery walk. Model appropriate and engaged behavior for a gallery walk, set clear expectations for moving from one group's card sort to the next, and emphasize the focus of the gallery walk (to notice differences in groups' sorts). You could also focus students by asking them to record differences they noticed between different groups or questions that came up as they did the gallery walk. This gallery walk is a great opportunity for students to get up and move around and to spur further discussion about the strength of evidence. However, you can skip this step if it doesn't make sense to do it for your class or context.

Encourage students to engage in meaningful dialogue. Encourage your students to thoroughly discuss each card like scientists by challenging one another's ideas. For example, a student might say that the card showing a cheetah chasing some wildebeest is strong evidence, while another student may say that just because an animal is chasing another doesn't necessarily mean it's going to eat that animal. Even the card with a dying wildebeest hanging out of the cheetah's mouth could be challenged by someone saying that cheetahs might be scavengers that eat wildebeest that they did not actually hunt and kill. This could lead to a discussion about whether an animal is a predator if it doesn't kill its own food. This kind of meaning-making, in which students wrestle with and apply concepts to real-world examples, is valuable for learning.

TEACHING NOTES

Other ways of applying and describing this idea. Providing examples of strong and weak evidence, and giving students a chance to apply the idea of stronger and weaker evidence, helps them make sense of what we mean when we conclude that an item is *more connected to the claim.* Other ways you might describe this hard-to-describe concept include:

- The amount of doubt the evidence leaves, as to whether or not the claim is true.
- How big a jump or leap it is from the evidence to the claim.
- How big the size of the assumption is, judging from the evidence to the claim.

Not going to an outdoor science program? If students aren't expected to have a planned outdoor science experience in the future, ask them about animals that might live in a local park or in their neighborhood.

Get a species list from the outdoor science program. Some outdoor science programs have species lists of animals found at their site. Ask if it's possible to get this list ahead of time so students can reference an accurate list of animals.

Examples of evidence. Some examples of evidence of animals might include: tracks, scat, munch marks on leaves, tunnels in the ground, bones, scratch marks, fur, feathers, webs, nests, etc.

Don't skip this conversation! It's important for students to have the chance to apply the idea of strong/weak evidence *and* to think about how that might serve them in a different context. This will also get students excited about an upcoming outdoor science experience or curious about the kinds of animals they might encounter in their local area.

Example Evidence Sort (Weaker to Stronger):
Cheetah's mouth/teeth
Cheetah running
Cheetah chasing an impala
Cheetah eating an impala
Cheetah stalking wildebeest
Cheetah chasing wildebeest
Cheetah taking down a wildebeest
Cheetah eating a wildebeest

Depending on their reasoning, there are different ways that students might sort the cards. As long as they offer sound reasoning for why they think the weakest evidence is the weakest, and the strongest evidence is the strongest, that's okay. If they did not share clear reasoning for their sorting, push for them to do so before wrapping up the discussion.

Discussing Evidence of Animals

1. **Explain that students will now focus on evidence that animals might leave behind at an outdoor science school (or in any other outdoor experience that students might be prepping for):**
   a. We're going to brainstorm about any animals that may live near the outdoor science school we're going to.
   b. We'll also think about evidence those animals might leave behind.
2. **Ask students to list which animals might live near where they will attend an outdoor science school.**
   a. Record students' ideas on the whiteboard.
   b. If possible, consult a species list from the area beforehand so you can add to students' ideas.
   c. Be sure to include insects and other small animals that students are likely to see.
3. **Ask students to *Turn & Talk* to discuss evidence of one animal on the list.**
   a. Choose one of the animals on the list to focus on as a class.
   b. Explain: Talk with a partner about what might be strong evidence and weaker evidence of this animal's presence.
4. **Listen to students' ideas and encourage discussion about the strength of evidence.**
   a. Ask several students to share strong or weak evidence of the animal's presence.
   b. Ask other students to agree or disagree with students' reasoning and encourage discussion

5. **Encourage excitement about the animals (and evidence of them) that students might see during their outdoor science experience (or around their neighborhood).**
   - **a.** You'll definitely see some animals.
   - **b.** You'll probably see more small animals, such as insects, than large ones.
   - **c.** If you're paying attention, you'll probably see a lot more evidence of animals than animals themselves!
   - **d.** When you see evidence of animals, it means it's kind of a mystery. It can be fun to try to figure out and explain what left the evidence and what the animal was doing at the time.
   - **e.** When you do this, remember to think about how strong or weak the evidence is.

Reflecting and Wrapping Up

1. **Explain that the stronger the evidence is, the stronger the explanation:**
   - **a.** Thinking about the strength of the evidence that supports an explanation is a way to evaluate the strength of the explanation itself.
   - **b.** Generally, the more closely connected the evidence is to the claim, the stronger it is.
2. **Explain that when scientists evaluate the strength of different explanations, they also think about the quantity of evidence that supports each explanation:**
   - **a.** Scientists also take into account how much evidence supports the explanation.
   - **b.** Usually, multiple observations are stronger evidence than just one observation.
3. **Explain that sometimes you can have a large quantity of less accurate evidence, which is actually not strong support for a claim:**
   - **a.** On the other hand, the quantity of evidence alone is not enough. It's possible that many people could make a similar, though inaccurate, observation.
   - **b.** Sometimes you could have a lot of inaccurate evidence.
4. **Explain that it's important to balance the amount of evidence with how closely connected it is to the claim:**
   - **a.** Some people make the mistake of choosing an explanation simply because it has more evidence, even if that evidence is less strong.
   - **b.** You need to think about both *how much* evidence supports an explanation and *how well connected* the evidence is to the explanation.
5. **Encourage students to critique both the strength of their own evidence when they make an explanation and also the strength of their peers' explanations and evidence. Explain:**
   - **a.** When you are thinking about a claim, whether it's yours or someone else's, think about how connected the evidence is to the claim and also think about the quantity of the evidence.
   - **b.** This is not only useful in science, it's useful in everyday life!

TEACHING NOTES

A true example of evidence closer to a claim trumping the quantity of evidence. Say that an outdoor science group of students leaves their gear for a bit and returns to find that the snack food containers have been ransacked. Students argue that raccoons are responsible, citing the evidence that they saw a raccoon the previous night, they noticed raccoon prints nearby, and they have actually seen raccoons rummaging for human food before on outdoor trips. The field instructor argues that she actually saw ravens tearing into the bags and eating the food. Judging just by the quantity of evidence (three kinds), students might decide that raccoons did the deed. However, judging by the closeness of the evidence to the claim, the one piece of evidence supporting that ravens were responsible—a reliable witness directly observing ravens in the act with their beaks in the bags—is stronger. In this case, the quantity of evidence loses to one piece of evidence that is closer to the claim.

TEACHING NOTES

Connect to *Evaluating Sources*. If you have already done the *Evaluating Sources* card sort with your class, remind students of the reliability of the source as another of the criteria that can be used to evaluate the strength of evidence.

Engaging in argument. Critiquing the strengths and weaknesses of various possible explanations for events and phenomena in the natural world (i.e., engaging in argument) is an important part of how scientific knowledge is constructed. By encouraging your students to critique their own and their peers' explanations, you're giving them a chance to engage in an authentic and important science practice. For more on this, see the Instructor Support section.

   c. We make and hear explanations every day, and it's important that we evaluate the evidence well to know which explanations are the strongest.

6. **Optional: If you are also going to do the *Evaluating Sources* activity with your students, tell them that the quality of the source of evidence also affects the strength of an explanation.**
   a. There is another factor to keep in mind when evaluating evidence.
   b. It's important to pay attention to the *quality of the source* of the evidence.
   c. We'll take a look into that during our next lesson.

7. **Ask students to *Turn & Talk* and/or write about the following questions:**
   - *Have your ideas changed during the course of this activity?*
   - *How or why did your ideas change?*
   - *How might you explain to someone else how to tell if evidence is stronger or weaker?*

8. **If you asked your students to focus on a particular science discussion group agreement, ask them to discuss with their small group how they did with it**

Instructor Support

Teaching Knowledge

About explanations and arguments in science. A strong scientific explanation goes beyond just answering a question; it needs to make clear how different pieces of evidence support the answer to a question. The process that scientists use to decide which is the best possible explanation about something in the natural world is called argumentation. In this process, scientists propose possible explanations for something in the natural world and then identify the weaknesses and limitations of the various explanations in order to determine which explanation is best supported by all the available evidence. Argumentation is based on the idea that since science is a collaborative endeavor, argumentation is a crucial part of how science knowledge is generated.

Key Vocabulary

- **claim:** A proposed answer to a question.
- **data:** Factual information, such as observations, measurements, or test results.
- **evidence:** Data that help answer a question, form an explanation, or disprove an explanation.
- **explanation:** A nonfiction, evidence-based story about how or why something in the natural world appears or happens. A scientific explanation must connect data or phenomena with accepted scientific knowledge.
- **reasoning:** The process of showing how evidence supports a particular claim.

Useful criteria for evaluating the strength of evidence in making an explanation. This activity focuses on the first of the following three criteria for evaluating the strength of evidence in making an explanation or engaging in argument:

- **Size of the assumption.** *How connected it is to the claim* is a more student-friendly term for a concept that is also sometimes referred to as *inferential distance*. For example, a student who sees a piece of scat and says it's coyote scat is making an assumption because they didn't actually see the scat emerge from a coyote. The smaller the assumption, the more likely the explanation. The bigger the assumption, the less likely the explanation.
- **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 clearer. The more evidence we can collect through *reliable* sources, the more certain we can be about an explanation.
- **Quality of source.** A scientific paper is a higher-quality source for scientific information than an advertisement. Although that may seem obvious in this context, when people aren't thinking deliberately about the quality of the source of the information, they may place a higher value on evidence from the lower-quality source. The higher the quality and reliability of the

source, the more sound the evidence, which results in a higher level of certainty. If you have a lot of evidence from a lower-quality source, it may not compare favorably with having less evidence from a higher-quality source. If you have evidence that is closely connected to the claim but a low quality of source, it may not be convincing. **Note:** The BEETLES *Evaluating Sources* classroom activity supports students in evaluating the reliability of different sources of science information and works well as a follow-up to this activity.

Scientists use reasoning to weigh all three of these criteria to evaluate the strength of an explanation.

Providing skills students can use at an outdoor science program. Teaching this activity *before* students go to an outdoor science school or any kind of outdoor science experience helps them develop skills they can use as they explore the natural world, setting them up for a more meaningful learning experience. In nature, you're surrounded by nature mysteries: *What caused the spots on this leaf? What left the line of silk on a branch or a rock? What made the hole in the acorn?* Outdoor science experiences are a great way for students to engage authentically in science practices as they try to understand the things that surround them in nature. With this activity's introduction to one important criterion for evaluating evidence—*thinking about how connected the evidence is to a claim*—students will be better prepared to construct strong arguments and explanations about the natural phenomena they see at outdoor science school. They'll also be more likely to pay attention to evidence of animals in the area, to question explanations that peers make (i.e., engage in scientific argument), and to come to a deeper understanding of the natural world by doing so!

Resources for teaching evidence-based explanation and argumentation. This activity is merely the tip of the iceberg for supporting students in constructing explanations and engaging in argument from evidence. Skills in evaluating evidence are a crucial foundation for making strong explanations, yet students will need much more support to actually engage deeply in argument and construct strong explanations. Here are some great resources to learn more about these practices and to support your students in using them:

- **The Argumentation Toolkit.** This free collection of online resources was developed to support middle school teachers in engaging their students in argumentation. The videos and other tools are also useful for a broader range of instructors. The argumentation toolkit can be found at: http://www.argumentationtoolkit.org/
- **Middle School Strategy Guides.** These free strategy guides introduce various approaches for engaging students in meaningful science learning opportunities. These guides were developed for middle school teachers but include approaches that could be adapted and used by a broader range of instructors. Several strategy guides particularly useful for engaging students in constructing evidence-based explanations or in practicing argumentation are listed below. All the strategy guides can be found at: http://learningdesigngroup.org/resources-strategy-guides

TEACHING NOTES

Connecting to your students' outdoor science program. Experiences in outdoor science schools tend to be very memorable and can even be life changing for students. The more opportunities that students have to connect what they are learning in the classroom to what they experience at outdoor science school, the more meaningful their outdoor experience will be and the more lasting the impacts are likely to be academically. This activity presents one way to connect classroom and outdoor learning through engaging in science practices. Think of other ways you can connect what students are learning at school to what they might experience in outdoor science school. Let instructors at the outdoor science school know the activities you've done with your students so you can better prepare the instructors for the experience.

- Engaging in Argumentation with a Science Seminar: Regional Climate in the Atacama Desert
- Reteaching Loop: Identifying Basic Components of Strong Argumentation Writing by Analyzing Student Work
- Reteaching Loop: Practicing Oral Discourse Skills
- Reteaching Loop: Understanding the Role of Relevant Evidence in Supporting a Claim
- Supporting Claims with Evidence by Using an Argumentation Card Sort: Fossils

- ***Seeds of Science/Roots of Reading*® Strategy Guides.** These free strategy guides were developed to highlight important instructional strategies that are embedded in the grades 2–5 *Seeds of Science/Roots of Reading*® integrated science–literacy curriculum. Since these strategy guides are connected to the curriculum, they reference books from that curriculum (which can be purchased separately). They also provide useful teaching tips and activities that can be employed more broadly. Some strategy guides that are particularly helpful for engaging students in constructing evidence-based explanations or in argumentation are listed below. All the strategy guides can be found at: http://scienceandliteracy.org/teachersupport/strategyguides
  - Teaching Scientific Explanations with *Gary's Sand Journal*
  - Teaching Scientific Explanation Writing with *Chemical Reactions Everywhere*
  - Using Discourse Circles with *What About Pluto?*
  - Using Roundtable Discussions with *Dragonfly Explanations*
  - Teaching About How Scientists Make Inferences with *Science You Can't See*
  - Teaching about the Nature and Practices of Science with *Why Do Scientists Disagree?*

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the three-dimensional learning that is called for in the Next Generation Science Standards (NGSS). Three-dimensional learning weaves together Science and Engineering Practices (what scientists do), Crosscutting Concepts (thinking tools 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 and Engineering Practices and Crosscutting Concepts—looking at nature and figuring things out, using certain lenses to guide thinking, and understanding ecosystems more deeply—are mindsets and tools students can take with them and apply anywhere to deepen their understanding of nature, and they're interesting and fun to do!

The primary purpose of this classroom activity is to give students some foundational skills in the Science and Engineering Practice of *Obtaining,*

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About the Next Generation Science Standards (NGSS). The development of the NGSS 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 toward 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 http://www.nextgenscience.org/ and http://ngss.nsta.org/

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Evaluating, and Communicating Information that will help them engage in *Constructing Explanations* and *Engaging in Argument from Evidence* when they go to outdoor science school.

Engaging students in Obtaining, Evaluating, and Communicating Information. It's important for scientists and, according to the National Research Council's *A Framework for K–12 Science Education*, for students to encounter scientific information from many sources, to try to interpret this information, to communicate their own ideas in written and spoken form, and to discuss their observations and explanations with their peers. *Evaluating Evidence* allows students to think through what constitutes strong evidence, which is an essential part of evaluating science information.

Constructing Explanations and Engaging in Argument from Evidence. The *Framework* also states that (1) a major goal of science is to deepen human understanding of the world through making explanations about how things work, and (2) reasoning and argument are important processes that help scientists determine the best explanation for a natural phenomenon. Scientific knowledge evolves as scientists uncover new evidence and engage in argument about competing claims. Additionally, according to the *Framework*, engaging in argument is critical to students' understanding of the nature of science and how scientific information is gathered.

In order to construct a strong evidence-based explanation, or to support an argument from evidence, students must be able to evaluate evidence effectively. In *Evaluating Evidence*, while students do not construct explanations or consider competing claims, they do learn a useful criterion for evaluating evidence, which they can then apply when given the opportunity to construct an argument or assess the strengths and weaknesses of an argument in the future.

The table on the next page, from the NGSS, describes the aspects of argumentation in which students should become proficient as they progress from kindergarten to grade 12. Looking at the bullet points for each grade band makes it clear how developing the ability to evaluate evidence is a significant component of the Science and Engineering Practice of *Engaging in Argument from Evidence*.

Engaging in Argument from Evidence			
Grades K–2	**Grades 3–5**	**Grades 6–8**	**Grades 9–12**
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations. • Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim. • Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully

(continued on next page)

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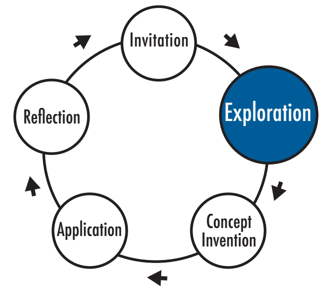
Engaging in Argument from Evidence (continued)			
Grades K–2	**Grades 3–5**	**Grades 6–8**	**Grades 9–12**
	• Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	• Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	to diverse perspectives, and determining additional information required to resolve contradictions. • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

Activity Connections

Evaluating Sources, another classroom activity, would complement students' developing understanding of what strong evidence is and would further prepare students well for outdoor science. Almost all BEETLES activities engage students either in constructing explanations from evidence or engaging in argument, or both. So nearly any BEETLES field activity would be a good follow-up to this activity. In particular, *NSI: Nature Scene Investigators*, *Group Agreements for Science Discussions*, *What Lives Here?*, and *Argumentation Routine* would provide great opportunities for students to deepen and apply the foundational skills that these classroom activities support.

Learning Cycle: *Evaluating Evidence* includes a complete learning cycle as a discrete activity. However, further application of it is needed to help students apply ideas learned here during their future science discussions. Within the sequence of many activities, *Evaluating Evidence* is considered to be primarily an Exploration activity.

TEACHING NOTES

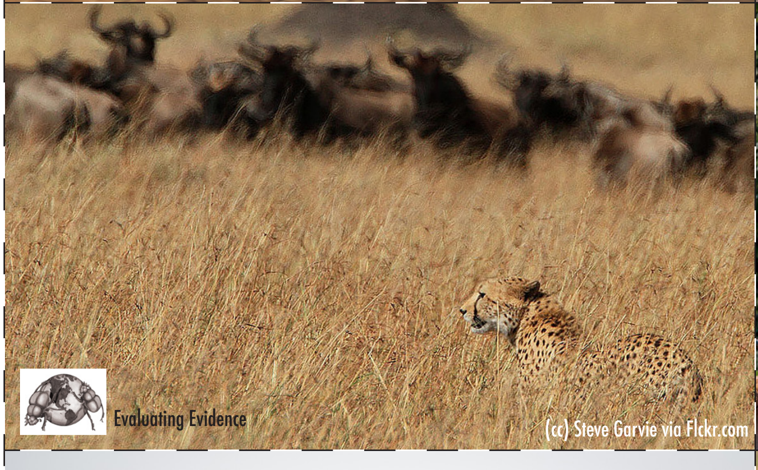


Within a longer sequence of activities, *Evaluating Evidence* functions as an Exploration activity.

TRACKS

Photo Credit: Kevin Beals

EVIDENCE CARDS



ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) provides environmental education programs nationally with research-based approaches and tools to continually improve their programs.

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California: YMCA Camp Campbell, Rancho El Chorro Outdoor School, Blue Sky Meadow of Los Angeles County Outdoor Science School, YMCA Point Bonita, Walker Creek Ranch, Santa Cruz County Outdoor Science School, Foothill Horizons Outdoor School, Exploring New Horizons Outdoor Schools, Sierra Nevada Journeys, San Joaquin Outdoor Education, YMCA Camp Arroyo, Shady Creek Outdoor School, San Mateo Outdoor Education, Walden West Outdoor School, Westminster Woods.

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