beetles
Science and Teaching for Field Instructors

Student Activity Guide

Discovery Swap

This flexible, student-centered Exploration Routine guides students to search for, observe, research, and share discoveries about organisms. *Discovery Swap* can be used to focus on any type of organism (or phenomenon) you choose, such as macroinvertebrates in streams or ponds, plants, under-log organisms, insects caught with nets, or seeds. First, students explore an ecosystem in pairs, collecting and examining many organisms. Then, each pair chooses one organism to study through drawing and recording observations and questions in writing. Students also use tools such as field guides or identification keys (if you have them) to identify and further research their organisms. Then, in a Cool Organism Convention, one member of each pair stays with their organism, while the other member circulates to check out the other organisms. Students discuss their discoveries, questions, and ideas with one another and then, after a few minutes, pairs swap roles so everyone has a chance to look at other organisms and to share about their own.

Students will…

- **Observe and compare organisms (or phenomena) in an ecosystem.**
- **Practice making and recording observations through drawing and writing.**
- **Identify and research organisms, using identification keys and/or field guides.**
- **Discuss their findings with their peers.**
- **Optional: Think about organisms in an ecosystem through the lens of structure and function.**

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

Timing:
Approximately 60 minutes

Related Activities:
I Notice, I Wonder, It Reminds Me Of; NSI: Nature Scene Investigators; Thought Swap (formerly *Walk & Talk*)

Materials:
See page 3 of the Materials and Preparation section for details.

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

Setting:
Any area where there are many organisms and space for students to explore and then gather in a group to share and discuss.

Equity, Inclusion, and Cultural Relevance (informed by Youth Outside)**:**
This activity has been designed to demonstrate how to create an equitable, inclusive, and culturally relevant teaching and learning experience. Read more on page 10.

NEXT GENERATION SCIENCE STANDARDS
For additional information about NGSS, go to page 12 of this guide.

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Obtaining, Evaluating, and Communicating Information	Structure and Function (if using optional steps)	Interdependent Relationships in Ecosystems; Structure and Function

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Discovery Swap

ACTIVITY OVERVIEW

Discovery Swap	Learning Cycle Stages	Estimated Time
Introducing the Activity	Invitation	5 minutes
Let's Go Exploring!	Exploration	15 minutes
Journaling About an Organism	Concept Invention	10 minutes
Identification and Further Research	Concept Invention	10 minutes
Cool Organism Convention	Application	15 minutes
Reflecting and Wrapping Up	Reflection	5 minutes
TOTAL		**60 minutes**

TEACHING TIPS

Read the Instructor Support Section. Beginning on page 9, you'll find more information about pedagogy, equity and inclusion, student misconceptions, science background, and standards.

Use this routine to support a theme or to build student literacy with an ecosystem, type of organism, or phenomenon. In this activity, students explore organisms in an ecosystem and gain knowledge through focused study and research. You can easily alter the instructions and materials to use it with different themes or to further student understanding of any ecosystem or type of organism. That's why instructions in this write-up are general and don't refer to specific organisms or ecosystems. Students' observations could focus on plants, invertebrates, leaves, pond organisms, other groups of organisms, or even nonliving things such as stones. Connect to a conceptual theme—such as adaptations, ecosystems, structure and function, interdependent relationships, food webs, biodiversity, etc.—by encouraging students to focus on those types of observations while they're studying and researching their organisms. You might repeat the routine in a different ecosystem or with different organisms to give students the chance to make comparisons. For more ideas on how to use this routine, see the Instructor Support section on page 9.

You don't need keys or field guides. If you don't have identification keys or field guides for students to use, this can still be a rich activity. Making observations, asking questions, making drawings, and sharing ideas with one another and with you are also valuable sources of information. To find a list of field guides that are easy to use with students, visit: http://beetlesproject.org/favorite-field-guides/

Field card. At the end of this activity write-up, you'll find a condensed, pocket-sized version to use in the field.

PREPARATION

1. **Gather the appropriate equipment for exploring a particular ecosystem and the organisms in that ecosystem.** Students will work in pairs during this activity. Have enough of the following items on hand: cups, bug boxes, nets, hand lenses, etc.
2. **Gather additional materials for sketching, identifying, and researching organisms.**
   - whiteboard and markers
   - journals and pens
   - Optional: field guides or keys to common organisms

MATERIALS

For the group:

- ❏ equipment for catching, containing, and observing organisms: cups or bug boxes, nets, hand lenses, etc. (Equipment needed depends on the organisms you're looking for and the ecosystem you're investigating.)
- ❏ optional: field guides or keys to common organisms

For the instructor:

- ❏ whiteboard and marker

For each student:

- ❏ journal (or sheet of paper)
- ❏ pencil
- ❏ optional: garbage bags or sit pads
- ❏ optional: clipboards or cardboard with binder clips

Introducing the Activity

1. **Invite students to get excited about exploring by sharing that there's cool stuff all around us!** Gather students at or near your exploration site. Point out that there's interesting stuff to explore all around them—places for organisms to hide, different plants, and intriguing landscape features.

2. **Share what students' focus of study will be (organisms in a stream, plants on a cliff etc.).**
   - ▶ *We're going to explore and study organisms—which means living things—kind of like scientists do.*
   - ▶ *To think like scientists and prepare to study organisms, we need to know a little background information about this ecosystem before we begin.*

3. **Use the *Think-Pair-Share* or *Thought Swap* (formerly known as *Walk & Talk*) questions below to engage students in a short discussion about the ecosystem they'll be exploring.** Ask students to share with a partner about the ecosystem they'll be studying. Pose questions to support students to develop some ecosystem literacy. Focus students' attention on environmental conditions that might be challenging for organisms found there. Ask follow-up questions to draw out student thinking. For example:
   - ▶ **General:** *What do you notice about our surroundings? How are the environmental conditions here (things such as temperature, sunlight levels, and how much water there is) different or similar to other places you've been? What might be potential dangers or difficulties for organisms living in this ecosystem? What are body structures (body parts) or behaviors (things they do) that organisms might have to help them survive here?*
   - ▶ **Stream:** *The organisms we find in this stream live underwater. How is living underwater different from living out of water? How do the organisms breathe? How do they deal with currents? How do they protect themselves from predators?*
   - ▶ **Intertidal:** *Let's think about what it means to be an intertidal creature. These organisms must survive under water for many hours at a time and out of water for many hours at a time. How do you think they might do that? How might they deal with being hit by ~8,000 waves per day? What structures (body parts) and behaviors (things they do) might these organisms have to help them survive here?*
   - ▶ **Cliff:** *All the plants we're checking out here are growing straight out of this cliff. How do you think their shape might be different from plants of the same kind that grow on flat ground? What are some situations that might cause these plants harm? How might they avoid harm?*

Let's Go Exploring!

1. **Share the first step of the procedure: Pairs of students find and/or catch as many of the type(s) of organisms you've chosen as they can.** Share that students' first goal will be to explore the area and find (e.g., plants, fungi, etc.) or catch as many organisms (e.g., animals, stream macroinvertebrates) as possible. If you want your students to focus on a particular kind of organism in the ecosystem, make that clear.
   - ▶ *In pairs, you'll have 12 minutes to explore this area and collect as many organisms (pond creatures, invertebrates, small plants, etc.) as you can.*

TEACHING NOTES

***Thought Swap* (formerly known as *Walk & Talk*).** See the BEETLES Activity *Thought Swap* for the logistics of this discussion routine. Wondering why we changed the name from *Walk & Talk*? We received feedback from community partners on how we can use more inclusive language and decided to change the name so we were not normalizing walking as the only way of moving and talking as the only way of communicating.

Build your own "ecosystem literacy." To be an effective co-explorer with your students, it's best to know a bit about the ecosystem and organisms you'll be investigating. Scouting ahead to make sure there are organisms to find helps, too.

More information about developing ecosystem literacy. For additional details and examples of these types of questions please see the *BEETLES Ecosystem Literacy and Ecosystem Exploration Strategies.*

Giving instructions. Some instructors find it easier to give the instructions for exploring, catching, sketching, identifying, and researching organisms all at once at the beginning of the activity to avoid interrupting the momentum and energy that students build while exploring. Other instructors choose to call students back in after each phase of the activity to give the next set of the instructions. Consider your context and student groups when figuring out what will work best for your group of students.

2. **Offer techniques for exploring and observing organisms and introduce safety considerations and boundaries.** If there are specific techniques that would be useful for students—such as kick-netting for streams or using other tools for catching small organisms—share those techniques. Describe any safety rules and boundaries that are necessary for your site.

3. **Share that students will get to pick a favorite organism to study.** Remind students not to let their organisms go, since they'll study them during the next step.
   - ▶ *Your goal during the exploration time is to be gentle with these organisms and to find as many different kinds as possible so you can pick a favorite to focus on.*
   - ▶ *Don't release organisms you collect because you'll need them later.*

4. **Optional—crosscutting concept: Invite students to pay attention to the structures of different organisms as they explore.** Invite students to look at organisms' structures (its parts) while they explore and to pay attention to the differences and similarities between the organisms' structures.

5. **Distribute equipment for catching organisms and invite students to go outside to explore and observe organisms.** As students work, circulate and troubleshoot. While students are exploring, engage them in observation and conversation about what they find. Remind them to catch as many different organisms as possible so they can then choose a favorite on which to focus. Support students who are struggling with finding organisms or with working together.

Journaling About An Organism

1. **When students have caught a few organisms, signal that it is time for each pair to choose one organism on which to focus.** When energy lags or when you think students are ready to move on, share that it is time for pairs to choose one organism to focus on and study. Share that each pair will become the group's "experts" on the individual organism they choose by studying it and recording in their journals what they find. If some pairs didn't catch any organisms, facilitate sharing organisms among groups (pairs that caught multiple organisms can share). Ask students to gently return the other organisms (that will not be observed) as close as possible to where those organisms came from.

2. **Offer techniques for sketching, journaling, and writing as a scientific tool.** As you speak, model what you're describing by writing a quick journal entry on a whiteboard:
   - ▶ *In your journal, you'll make a sketch of your organism and write as many observations, ideas, and questions as you can—just like a scientist would.*
   - ▶ *It's not about making a pretty picture. It's about noticing things and recording them in your journal, using words, pictures, and numbers.*
   - ▶ *Sometimes, a drawing will help show what you noticed; sometimes, words will communicate it better.*
   - ▶ *For example, it might take a long time to draw fuzzy hairs all over the organism, so you could just draw a couple of hairs as you observe them and then write a label that says "there are fuzzy hairs all over it."*

TEACHING NOTES

Use the *I Notice, I Wonder, It Reminds Me Of* routine beforehand. This powerful routine can be a great activity to lead before *Discovery Swap*. Whether or not your students have experienced *I Notice, I Wonder, It Reminds Me Of* before this experience, ask students these questions: "What do you notice about it?" "What do you wonder about it?" "What does it remind you of?"

Introducing the optional Next Generation Science Standard (NGSS) crosscutting concept. The optional steps included in this activity are for instructors who want to integrate the NGSS crosscutting concept of Structure and Function into Discovery Swap. For students to appreciate this big idea of science, they'll need to have multiple experiences using this lens to explore nature. See the Instructor Support section (beginning on page 9) for more information about making connections between this activity and the NGSS.

Support, scaffolding, and student engagement. *Discovery Swap* includes scaffolding throughout the activity to support students' participation and to promote literacy and language acquisition. When the instructor breaks down scientific drawing into steps, models how to access information from a field guide, and uses Think-Alouds to show how students might respond to a discussion question, they are modeling learning behaviors that students can apply during the activity. These strategies also support literacy and language development.

- ▶ *Use both drawing and writing in your study, but you can use more of whichever one is more comfortable for you.*
- ▶ *If your organism is very small, draw it larger than life so you can show interesting parts and details.*

3. **Encourage students to use words, pictures, and numbers to describe organism behaviors (what it's doing).** Share that students can use words, pictures, and numbers to describe what the organism is doing, such as *wiggled for 20 seconds* or *went to the bottom of the cup and didn't move.*

4. **Optional—crosscutting concept: Share that looking at structures and thinking about how they function is something scientists do, too.**
   - ▶ *When scientists study an organism (or anything else in the natural world), sometimes they focus on its structures (its parts) and how those structures might function (or work).*
   - ▶ *Thinking about the structures (or body parts) of living things in nature and trying to figure out how they might function (or work) is something many different kinds of scientists do.*
   - ▶ *As you record your observations in drawings and writing in your journal, pay attention to the structures your organism has and think about how those structures might help the organism survive in the ecosystem.*

5. **Distribute materials and invite students to begin journaling and recording observations through writing and drawing.** Hand out journals and pencils and support students as they focus on their chosen organisms. Engage students who are struggling to focus by asking questions about what they observe and encouraging them to write these observations in their journals.

Identification and Further Research

1. **Offer students resources for identification and further study and model how to use the key to identify organisms.** After students have had at least 10 minutes to record information in their journals and before they lose interest, gather the group and show them an identification key, field guide, or other resource they'll use for identification. Share that now that students have had a chance to observe and study their organisms a bit, this additional resource will help them identify their organisms and find out more about them. Model how to use the field guide or key to identify organisms and to find information. For example:
   - ▶ *The first question on this key is "Legs or no legs?" My organism here has no legs, so now I will go to the next question.*
   - ▶ *Based on our observations of the body parts of our organism and how its leg shape and tail matches the picture here, we think it is a dragonfly larva.*

2. **If students add information from a key or field guide to their journal entries, ask them to record the source of the information.** Share that students can record this information in their journals if they want to remember it. If they do so, they should also record the source(s) for the information (e.g., the name of the book the information came from).

TEACHING NOTES

Engaging directly with nature. Centering learning on students' in-the-moment observations of organisms helps create an inclusive learning experience by focusing it on a shared experience to which every student has access. This sets up a collaborative learning context in which students' ideas and observations drive the learning experience, and students recognize themselves and one another as sources of expertise. This is in contrast to science learning situations in which participation requires prior knowledge about science ideas, and students who have had more exposure to science tend to have an advantage.

The value of observing and drawing *before* identification. Often when students find organisms, they ask, "What is it?" If students learn the name of an organism right away, they can often move on to finding another organism and quickly forgetting the name of the first organism. On the other hand, when students get time to focus, observe, and draw an organism before they focus on identifying it, they tend to become more truly engaged with making observations of the individual organism. This approach also leads students to build some knowledge about the organism, which can support them in becoming more engaged when they do get to identify the organism.

No identification keys, field guides, or other resources? If you don't have identification keys or field guides for students to use, you can skip this section and instead invite students to come up with their own descriptive name for their organism and share some of their key observations. You can also encourage students to record questions and detailed observations and to consult resources, such as books or the Internet, later on.

3. **Encourage students to make careful identifications and to gather information to answer their questions.** If students have quickly identified (or misidentified) an organism, ask them to share evidence for why they made this identification (e.g., *It has spots on its sides*). If students came up with questions about their organisms, encourage them to look in the provided resources for possible explanations or related helpful information.

4. **As students are wrapping up their identifications, invite them to review and record any remaining observations, ideas, and questions.** If students haven't done so already, encourage them to record two or three compelling observations or ideas to share and possibly a question for future study.

Cool Organism Convention

1. **Share that students will get the opportunity to discuss their findings, questions, and ideas, just like scientists do.** Gather the group and remind them that an important part of science is sharing ideas. Scientists do research, ask questions, read and write papers, go to conferences and conventions, and discuss interesting ideas with one another. Share that students will participate in a Cool Organism Convention and will be discussing one another's research, like scientists do.

2. **Ask each pair to choose one person to be Student A and the other to be Student B.**

3. **Share the procedure: Students in the A group stay with their organism to share and discuss their findings; students in the B group circulate among the A group students.** Share that A group students will stay with their organisms to share their findings and discuss their organisms with B group students who come by. Share that after a bit, they'll switch roles. and the B group students will stay with the organisms while the A group students circulate.

4. **Encourage students to discuss their discoveries and questions with one another, (instead of just lecturing one another on what they found) and model what this might look/sound like.**
   - *This should be a discussion, not a one-way lecture.*
   - *Student A will share observations, questions, and ideas. For example, "We noticed that our organism kept going up to the surface of the cup, and we wondered if that was how it breathes."*
   - *Then, ask Student B what they think. For example, "What do you think of that idea?" "Do you have a different explanation or idea?"*
   - *Student B will share their own ideas in response and ask questions. For example, "What do you mean by that?" Or, "Did you notice anything about . . . ?"*

5. **Invite students to begin the Cool Organism Convention: B students circulate and discuss organisms with A students while you also participate.** Go around and visit the A students yourself and ask questions about what they've discovered.

TEACHING NOTES

Informal assessment check-in. Instructors should participate in the Cool Organism Convention by asking questions and engaging in discussion. You can also assess students' competency with science practices—such as making explanations from evidence—by looking at their drawings and notes, listening to what they are sharing, and asking them about their explorations and explanations.

Why not do a timed rotation? It is common to use timed rotations in situations where students move through stations so students will stay engaged. Try this write-up's more student-directed approach. The advantages of having free-choice rotation is that students get to pursue their own curiosity, which supports authentic engagement and deeper learning. The goal here is student-centered exploration, sharing, and discussion, which is more likely to occur when students have some choice about what they're observing, how long they observe, and who they're talking to. Students may cluster a bit around certain interesting organisms, but that's because they are interested, which is not a bad thing. If a student doesn't have anyone talking to them for a little bit, that usually doesn't last long, and they always have their organism buddy to study with. Disadvantages of timed rotations are that some student discussions are cut off before students are finished talking about an interesting idea, while other students who may be ready to move on may have to wait. Lack of choice can also lead to students becoming more passive, which is detrimental to cognitive engagement, motivation, and real learning. There are situations in which a timed rotation may be the better choice, but generally we've found that a more free-flowing, student-driven rotation format provides a greater opportunity for students to be active learners.

6. **After approximately 10 minutes, call for the group's attention and ask pairs to switch roles.** When you call time, B students will go to their organisms, and A students will circulate.

Reflecting and Wrapping Up

1. **Invite students to gently and carefully release organisms.** After the end of the convention, have students carefully return their organisms to the habitats, as close as possible to where students found them.

2. **Revisit questions about ecosystems.** Revisit some of the questions you originally asked about the environmental conditions and how those conditions might affect organisms found in this area. How have students' answers changed? You might want to record students' observations and reflections on a whiteboard to share and record their understanding of the ecosystem as a whole.

3. **Lead a *Thought Swap* in which students reflect on the science learning experience.**
   - *What was it like acting like a scientist, making discoveries, and doing research?*
   - *In what other ecosystems might you find your organism or similar organisms?*
   - *What questions do you still have about the organism you studied?*
   - *What are some skills you feel that you got better at today? (e.g., making observations, working with a partner, etc.)*
   - *How could you find more information about these organisms?*
   - *What other organisms would you like to study in this way?*
   - *What helped you to learn today?*

TEACHING NOTES

Student-centered science learning. Science is often viewed or taught as a collection of facts; this is reinforced by science learning experiences that focus on memorization or recall of facts and narrow questions posed to students that invite only one correct answer. However, science is a way of knowing and a process for thinking and learning, not just a body of knowledge. Student-centered science learning engages students in scientific sensemaking, encourages critical thinking, and makes space for divergent perspectives and differing ideas to be shared. Prioritizing time for students to share observations, ideas, and connections to prior knowledge is also a way of decentering expertise and sending a message that student thinking is an essential part of science learning, contradicting the exclusionary idea that memorizing facts is what it means to be good at science.

Highlighting learning behaviors. Recognizing how students' existing skills and learning behaviors mirror those of scientists can build students' positive identities as learners. This can also offer students a more accurate understanding of science as a discipline. Calling attention to how students' existing skills and in-the-moment learning behaviors are connected to what scientists do can highlight the fact that students are already doing science. This is one way to counteract exclusionary messages students may have received about what science is and who can do it.

Instructor Support

Teaching Knowledge

Timing for *Discovery Swap* is flexible. The overall timing for *Discovery Swap* can be fairly flexible. If students are actively engaged, let them keep exploring or discussing ideas. At the same time, be mindful of time constraints and be responsive to students' needs, shifting to the next phase of the activity just before energy and attention begin to wane.

Introducing content. In this activity, students construct their own understandings through making observations, asking questions, and peer discussion. It's helpful if instructors have a general knowledge of the ecosystem students are exploring and are familiar with the organisms students are likely to find. It's also important for instructors to strive to be a "guide on the side," encouraging students to make their own observations and gain new knowledge by using resources such as field guides instead of immediately telling students the names of organisms or information about them. Instructors can share content that they think will stimulate further student curiosity and hold off on introducing content until after students are well on their way to finding out and discussing information themselves.

Scientific language. Science is about coming up with the best explanation for all the available evidence. It's also about being open-minded about examining other explanations that might be better. In science, nothing is ever finally proven. This is why scientists tend to use language that demonstrates a healthy amount of uncertainty when discussing their ideas and explanations. To help students maintain this mindset, try to offer sentence starters, such as:

- Maybe . . .
- I wonder if . . .
- That evidence makes me think . . .
- The evidence seems to show . . .

Model this type of language yourself when discussing ideas and encourage students to phrase their statements in a like manner, particularly during the Cool Organism Convention.

Conceptual focus. The conceptual focus of *Discovery Swap* will vary based on the organisms or ecosystem you choose. Ideally, gather field guides, keys, or useful resources and do a bit of research yourself, before taking students outside to explore. For some ideas on questions that build students' ecosystem literacy when introducing this activity, refer to the *BEETLES Ecosystem Literacy and Exploration Strategies* [http://beetlesproject.org/ecosystemliteracies/].

Common Relevant Misconceptions

Misconception. If you let students share their ideas about science, they'll learn inaccurate information from one another. So, instead of student discussion, instructors should just tell students the accurate information.

TEACHING NOTES

An alternative to a *Professor Hike*. This activity was designed as an alternative to *Each One Teach One* (also known as a *Professor Hike*), a common environmental education activity in which students repeat information to other students that they've been told by an instructor or that they read off a card. *Discovery Swap* puts learning in students' hands by giving them the opportunity to choose what to focus on and to make their own discoveries. Students are also encouraged to discuss their organism with peers, as scientists would, which can be more engaging and productive for student learning than mini-lectures. This also supports students in developing a mindset and skills they can continue to use to investigate the natural world and to learn in other disciplines.

TEACHING NOTES

More accurate information. It's important for educators to offer opportunities for students to share ideas and to pay attention to what students say. At any given time, students have many ideas and interpretations of the world in their heads—some accurate, and some inaccurate (but often based on experience and logical thinking). Whether or not you provide opportunities for students to share these ideas out loud, they are there; if they are not brought out into the open, they will likely remain unchallenged. Without opportunities to discuss their ideas, students may be able to memorize more accurate ideas (and even pass tests), but they still may privately hold onto their original inaccurate beliefs unless they encounter convincing reasons to let them go. When students share ideas out loud, it draws attention to potentially conflicting ideas and inconsistencies. It also provides students with the opportunity to evaluate their ideas against other's thinking and compare them with the available evidence. For instructors, student-centered discussion can give insights into students' ideas, which can then be used to guide instruction. For example, it can help an instructor think of particular evidence that may benefit students' thinking and help their ideas evolve.

Supporting Equitable, Inclusive, and Culturally Relevant Learning Experiences

This BEETLES student activity has been intentionally designed to create an equitable, inclusive, and culturally relevant learning experience for a community of learners. BEETLES design principles [*http://beetlesproject.org/about/how-do-we-approach-teaching/*] ensure that each student activity is student-centered and nature-centered. This enables all learners to access, participate, and engage in the learning experience.

When learners engage directly with nature, they all have access to learning, regardless of their prior knowledge or experiences. Centering learning on students' in-the-moment observations of nature builds an inclusive learning experience by focusing the conversation on an experience shared by every student, as opposed to relying on students' prior knowledge or past experiences. As students engage with nature, instructors are in the role of the "guide on the side." This approach shifts power from the instructor to learners, challenges the typical learning situation in which the instructor is the only expert, encourages students to share their ideas and experiences, and makes learning a more decentralized and collaborative experience.

"Classroom studies document the fact that underserved English learners, poor students, and students of color routinely receive less instruction in higher order skills development than other students." (Allington and McGill-Franzen, 1989; Darling-Hammond, 2001; Oakes, 2005) –Zaretta Hammond, *Culturally Responsive Teaching & the Brain*

When learners think like a scientist and practice academic language, they develop critical thinking skills that support them to become more independent learners—learners who have skills and thinking tools they use to learn, regardless of the level of support available from a teacher or instructor. Giving students the opportunity to think like a scientist by making observations, asking questions, and constructing explanations supports students' growth as learners, offering them the opportunity to build critical thinking skills and learning behaviors they can apply in any context. Many students in schools that have historically been under-resourced due to racist school-funding policies, redlining, income inequality, and police profiling have fewer opportunities to develop as independent learners. Specifically ensuring that students in these kinds of schools have opportunities to develop as independent learners is an issue of equity. Learning and practicing critical thinking skills in an engaging outdoor context supports students to succeed back in their classrooms, in science, and in other academic disciplines. Offering opportunities for students to discuss ideas with their peers and knowledgeable adults makes science more accessible by connecting it to students' own actions and discoveries in the moment—not to knowledge they may not have or experiences they may not have had.

Through discussion, learners make connections to prior knowledge, share their lived experiences, listen to different perspectives, and have time to process the material. Productive discussions in which many voices are heard, and the group builds off one another's ideas, create an experience in which students see themselves and one another as sources of expertise. This ensures that instructors don't fall back on positioning themselves as the only source of accurate or important information. Participating in discussions also supports students to develop cognitive rigor and the ability to take on more advanced learning tasks. Discussions make student thinking and ideas visible to the instructor. When instructors value, appreciate, better understand, and connect to students' lived experiences, they create a more inclusive and culturally relevant learning space. Finally, multiple opportunities for discussion provide time and space for neurodiversity—allowing students to process information in different ways. Using discussion strategies such as *Turn & Share* or *Thought Swap* that are part of every BEETLES student activity can help ensure that students have these kinds of opportunities for discussion.

Specifically, this activity promotes an equitable, inclusive, and culturally relevant learning experience by:

- Connecting students' in-the-moment learning behaviors to practices of working scientists, contradicting the exclusionary ideas that science is a list of facts to memorize or that only people who are good at memorizing facts can be "good" at science.
- Using broad questions to invite students to share their observations, prior knowledge, and experiences with one another and with the instructor.
- Focusing the group's learning on a common experience to which everyone has access.
- Providing a lesson structure in which the instructor acts as a "guide on the side" and builds a collaborative learning environment in which students make observations, share ideas, and see themselves and one another (not just the instructor) as sources of expertise.
- Engaging students in meaning-making discussions, making observations, and other practices that prepare them to take on increasingly rigorous learning tasks in the future.
- Scaffolding skills of scientific observation, illustration, and communication to support students' visual literacy, language acquisition, and engagement with the activity.

Overall, these factors contribute to creating a student-centered approach in which "the ultimate goal . . . is to help students take over the reins of their learning." (Zaretta Hammond, *Culturally Responsive Teaching & the Brain*). This approach to teaching supports students in becoming independent learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences where all students feel capable of success and have the tools to carry that success into other domains.

Using student-centered and nature-centered learning approaches is just one piece of the work we can do to create equitable, inclusive, and culturally relevant learning experiences. Instructors must also work to become more aware of their own unconscious biases and triggers around culture, identity, and race that impact their interactions with students and affect their students' sense of inclusion.

TEACHING NOTES

Resources on unconscious bias. There are many great resources on understanding and shifting unconscious bias. Here are a few that we have looked to consistently to work on our own unconscious bias and to better understand how it can affect teaching and learning in the outdoors:

- *White Fragility* by Robin DiAngelo
- *Culturally Responsive Teaching and the Brain* by Zaretta Hammond
- Youth Outside [http://www.youthoutside.org/]
- The Avarna Group [https://theavarnagroup.com/]
- Center for Diversity & the Environment [https://www.cdeinspires.org/]

Connections to the 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!

In *Discovery Swap*, students engage in the Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information* and have the opportunity to relate what they learn to the Crosscutting Concept of *Structure and Function*. Depending on their observations, prior knowledge, and the instructor's focus, students can build a foundational understanding of Disciplinary Core Ideas related to *Structure and Function, Interdependent Relationships in Ecosystems*, or *Adaptations*. (Note: *Structure and Function* is a Crosscutting Concept and also a category of Disciplinary Core Ideas within the domain of life science.)

Featured Science and Engineering Practices

Engaging students in *Obtaining, Evaluating, and Communicating Information*. It's important for scientists and, according to the NGSS, 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.

- In *Discovery Swap*, students are exposed to different sources of information during every step of the activity. Their initial source of information is their own observations as they explore different organisms and then focus on a particular organism and generate questions about it.

- Students receive an outside resource such as a key or field guide to build upon their own observations and answer some of their questions.
- The order of the activity supports students in engaging in the Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information* when students build understanding through their own observations before they seek out information from field guides and other written sources. Then, when students do use the written sources, they have more context and prior knowledge under their belts.
- As an instructor, you can also act as a source during this activity by sharing relevant and interesting ideas or facts about organisms. A good rule of thumb is to share only information that students won't be able to learn from their own observations or through a resource such as a field guide and only information that will increase their curiosity. Students also communicate about information they learn in a variety of ways throughout *Discovery Swap*. When they record in their journals their observations and ideas in drawings and writing, they are generating scientific text that prepares them to engage in conversation with their peers.
- During the rest of the activity, students communicate observations and explanations with their peers. The Cool Organism Convention is a significant opportunity for students to fully engage in this practice because they have the chance to evaluate the many different ideas and explanations of their peers through open-ended discussion.
- Make sure to give students the opportunity to discuss one another's discoveries by giving them enough time for those conversations to really take off and by encouraging students to discuss their ideas instead of delivering mini-lectures to one another.
- The structure of the Cool Organism Convention also supports students in *Obtaining, Evaluating, and Communicating Information*. If instead, students are asked to present about their organisms to the entire group, one after the other, then they miss the chance to have the kinds of scientific discussions in which they can fully engage in this practice.

Featured Crosscutting Concepts

Learning science through the lens of *Structure and Function*. Crosscutting concepts are useful thinking tools in science that are applicable across disciplines. When scientists use the idea of *Structure and Function*, they think about how "the way in which an object or living thing is shaped . . . determine[s] many of its properties and functions." (NGSS)

- In the optional crosscutting concept steps in *Discovery Swap*, students begin to think about this concept when they gather many different organisms and compare their structures.
- Students aren't fully introduced to the term *structure and function* until they begin to draw their own diagrams in their journals of particular organisms and think about how their organism's structures help it survive in its habitat.

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 http://www.nextgenscience.org/ and http://ngss.nsta.org/

- If thinking about structure and function is a learning goal for your students, use this language at multiple points throughout the activity and remind students to think about their organisms using this lens, particularly before they discuss ideas with their peers during the Cool Organism Convention.
- Emphasize that a field scientist might also think in this way and that scientists in all disciplines use the idea of *Structure and Function* to better understand all parts of the world.

Learning science through the lens of other crosscutting concepts. Students may make particular kinds of observations and engage with different ideas if they focus on a different crosscutting concept during *Discovery Swap*. You may choose another crosscutting concept if there is one that matches a theme you have for your field experience or a big idea that will lead students to make observations and explanations related to content you wish for them to understand. The Crosscutting Concept of *Systems and System Models* relates well to helping understand the interactions in an ecosystem. To integrate the concept of *Systems and System Models*, ask students to focus on how their organism interacts with its surroundings when they're observing it. Point out that students are examining a system by exploring one of its components (individual organisms) and its interactions with other parts of the system. Emphasize that this is an approach that many types of scientists take to better understand how parts of the natural world are interconnected and how they affect one another.

Featured 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. *Discovery Swap* provides students with an opportunity to develop understanding of the life science core ideas of *Structure and Function* (LS1.A) and *Interdependent Relationships in Ecosystems* (LS2.A). The specific Disciplinary Core Ideas for which students might build understanding will vary depending on the organisms students explore and the Crosscutting Concept that guides their thinking.

Beginning the activity by discussing "ecosystem literacy" is an important step in students' conceptual development and understanding of these core ideas. The discussion about environmental conditions provides a context for students' observations of organisms' structures and their explanations about how those structures might function in the habitat in which the organisms live (LS1.A). Students have the opportunity to deepen their understanding of this Disciplinary Core Idea in multiple ways as they consult different resources (such as field guides) and engage in discussion about one another's observations and questions about the organisms. When students consider questions about how their organism deals with survival pressures, they also begin to build an understanding of how organisms depend on their interactions with living and nonliving parts of their ecosystems (LS2.A).

Performance Expectations to Work Toward

When examined closely, it's clear that 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 core ideas and science practices, as well as their ability to apply the crosscutting concepts. As such, they do not represent a curriculum to be taught to students. Below are some of the Performance Expectations that this activity can help students work toward:

- **4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- **MS-LS1-4.** Use an argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants, respectively.
- **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Activity Connections

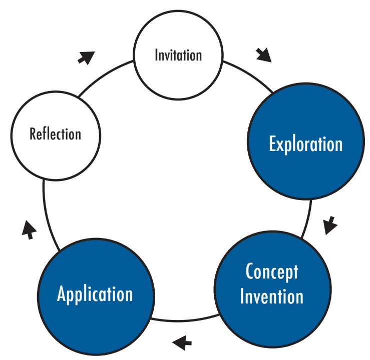
Leading the activity *I Notice, I Wonder, It Reminds Me Of* before *Discovery Swap* offers students observation strategies they can use to engage more deeply in the activity. *Discovery Swap* is a flexible routine that can be used to help students explore and deepen their understanding of almost any natural phenomenon, organism, or ecosystem and can be repeated in different places or with different organisms. Instructors might also choose one crosscutting concept to use as a recurring theme of a field experience. For example, in an adaptations-themed field experience, an instructor might choose to focus on the crosscutting concept of *Structure and Function*, weaving language and questions about structure and function throughout all activities, including *Discovery Swap*. Other BEETLES activities that could fit with this theme include *Adaptation Intro—Live!, Structures and Behaviors, Blending In and Standing Out, Related and Different*, and *Mating and Cloning*.

Learning cycle. On its own, this activity completes a full learning cycle. Within a longer sequence of learning cycle–based activities, the activity can work well as part of an Exploration, Concept Invention, or Application. For example:

- **Exploration.** During a field experience that focuses on various plant types and biodiversity, students could explore different kinds of plants in the area, using *Discovery Swap*, before moving on to developing a deeper understanding of those concepts.
- **Concept Invention.** *Discovery Swap* can work very well during a Concept Invention phase as students are identifying organisms and building connections between organisms and the ecosystem.
- **Application.** *Discovery Swap* can be used as an Application in the course of a field experience that's focused on a topic such as adaptations. After building some initial understanding of a definition for adaptations, students can observe organisms in *Discovery Swap* and develop explanations about possible adaptations.

TEACHING NOTES

Translating the codes for the NGSS Performance Expectations. Each standard in the NGSS is organized as a collection of Performance Expectations (PE's) for a particular science topic. Each PE has a specific code, which is provided here so they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K = kindergarten, 1 = first grade, 2 = second grade, 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-LS4-3 means the Performance Expectation is 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, which deals with Adaptation. It's also the third Performance Expectation (3) that makes up the complete LS4 standard at this grade level.



FIELD CARD

Cut out along outer lines and fold along the centerline. This makes a handy reference card that will fit in your pocket.

Discovery Swap

Introducing the Activity

1. Invite students to get excited about exploring by sharing that there's cool stuff all around us!
2. Share what students' focus of study will be (organisms in a stream, plants on a cliff etc.).

▶ *We're going to explore and study organisms—which means living things—kind of like scientists do.*

▶ *To think like scientists and prepare to study organisms, we need to know a little background information about this ecosystem before we begin.*

3. Use the *Think-Pair-Share* or *Thought Swap* (formerly known as *Walk & Talk*) questions below to engage students in a short discussion about the ecosystem they'll be exploring.

▶ **General:** *What do you notice about our surroundings? How are the environmental conditions here (things such as temperature, sunlight levels, and how much water there is) different or similar to other places you've been? What might be potential dangers or difficulties for organisms living in this ecosystem? What are body structures (body parts) or behaviors (things they do) that organisms might have to help them survive here?*

▶ **Stream:** *The organisms we find in this stream live underwater. How is living underwater different from living out of water? How do the organisms breathe? How do they deal with currents? How do they protect themselves from predators?*

▶ **Intertidal:** *Let's think about what it means to be an intertidal creature. These organisms must survive under water for many hours at a time and out of water for many hours at a time. How do you think they might do that? How might they deal with being hit by ~8,000 waves per day? What structures (body parts) and behaviors (things they do) might these organisms have to help them survive here?*

▶ **Cliff:** *All the plants we're checking out here are growing straight out of this cliff. How do you think their shape might be different from plants of the same kind that grow on flat ground? What are some situations that might cause these plants harm? How might they avoid harm?*

Let's Go Exploring!

1. Share the first step of the procedure: Pairs of students find and/or catch as many of the type(s) of organisms you've chosen as they can.

▶ *In pairs, you'll have 12 minutes to explore this area and collect as many organisms (pond creatures, invertebrates, small plants, etc.) as you can.*

2. Offer techniques for exploring and observing organisms and introduce safety considerations and boundaries.
3. Share that students will get to pick a favorite organism to study. Remind students not to let their organisms go, since they'll study them during the next step.

▶ *Your goal during the exploration time is to be gentle with these organisms and to find as many different kinds as possible so you can pick a favorite to focus on.*

▶ *Don't release organisms you collect because you'll need them later.*

4. Optional—crosscutting concept: Invite students to pay attention to the structures of different organisms as they explore.
5. Distribute equipment for catching organisms and invite students to go outside to explore and observe organisms. As students work, circulate and troubleshoot.

Journaling About An Organism

1. When students have caught a few organisms, signal that it is time for each pair to choose one organism on which to focus.
2. Offer techniques for sketching, journaling, and writing as a scientific tool. As you speak, model what you're describing by writing a quick journal entry on a whiteboard:

▶ *In your journal, you'll make a sketch of your organism and write as many observations, ideas, and questions as you can—just like a scientist would.*

▶ *It's not about making a pretty picture. It's about noticing things and recording them in your journal, using words, pictures, and numbers.*

▶ *Sometimes, a drawing will help show what you noticed; sometimes, words will communicate it better.*

▶ *For example, it might take a long time to draw fuzzy hairs all over the organism, so you could just draw a couple of hairs as you observe them and then write a label that says "there are fuzzy hairs all over it."*

▶ *Use both drawing and writing in your study, but you can use more of whichever one is more comfortable for you.*

▶ *If your organism is very small, draw it larger than life so you can show interesting parts and details.*

3. Encourage students to use words, pictures and numbers to describe organism behaviors (what it's doing).

www.beetlesproject.org

FIELD CARD

Cut out along outer lines and fold along the centerline. This makes a handy reference card that will fit in your pocket.

4. Optional—crosscutting concept: Share that looking at structures and thinking about how they function is something scientists do, too.

   ▶ *When scientists study an organism (or anything else in the natural world), sometimes they focus on its structures (its parts) and how those structures might function (or work).*

   ▶ *Thinking about the structures (or body parts) of living things in nature and trying to figure out how they might function (or work) is something many different kinds of scientists do.*

   ▶ *As you record your observations in drawings and writing in your journal, pay attention to the structures your organism has and think about how those structures might help the organism survive in the ecosystem.*
5. Distribute materials and invite students to begin journaling and recording observations through writing and drawing.

Identification and Further Research

1. Offer students resources for identification and further study and model how to use the key to identify organisms.

   ▶ *The first question on this key is "Legs or no legs?" My organism here has no legs, so now I will go to the next question.*

   ▶ *Based on our observations of the body parts of our organism and how its leg shape and tail matches the picture here, we think it is a dragonfly larva.*
2. If students add information from a key or field guide to their journal entries, ask them to record the source of the information.
3. Encourage students to make careful identifications and to gather information to answer their questions.
4. As students are wrapping up their identifications, invite them to review and record any remaining observations, ideas, and questions.

Cool Organism Convention

1. Share that students will get the opportunity to discuss their findings, questions, and ideas, just like scientists do.
2. Ask each pair to choose one person to be Student A and the other to be Student B.
3. Share the procedure: Students in the A group stay with their organism to share and discuss their findings; students in the B group circulate among the A group students.
4. Encourage students to discuss their discoveries and questions with one another, (instead of just lecturing one another on what they found) and model what this might look/sound like.

   ▶ *This should be a discussion, not a one-way lecture.*

   ▶ *Student A will share observations, questions, and ideas. For example, "We noticed that our organism kept going up to the surface of the cup, and we wondered if that was how it breathes."*

   ▶ *Then, ask Student B what they think. For example, "What do you think of that idea?" "Do you have a different explanation or idea?"*

   ▶ *Student B will share their own ideas in response and ask questions. For example, "What do you mean by that?" Or, "Did you notice anything about . . . ?"*
5. Invite students to begin the Cool Organism Convention: B students circulate and discuss organisms with A students while you also participate.
6. After approximately 10 minutes, call for the group's attention and ask pairs to switch roles.

Reflecting and Wrapping Up

1. Invite students to gently and carefully release organisms.
2. Revisit questions about ecosystems.
3. Lead a Thought Swap in which students reflect on the science learning experience.

   ▶ *What was it like acting like a scientist, making discoveries, and doing research?*

   ▶ *In what other ecosystems might you find your organism or similar organisms?*

   ▶ *What questions do you still have about the organism you studied?*

   ▶ *What are some skills you feel that you got better at today? (e.g., making observations, working with a partner, etc.)*

   ▶ *How could you find more information about these organisms?*

   ▶ *What other organisms would you like to study in this way?*

   ▶ *What helped you to learn today?*

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.

www.beetlesproject.org

Lawrence Hall of Science is the public science center of the University of California, Berkeley. *www.lawrencehallofscience.org*

Special Acknowledgments: We want to acknowledge Youth Outside (*youthoutside.org*) in supporting us to develop more equitable, inclusive, and culturally relevant instructional materials. To learn more about our collaboration with Youth Outside, see: *http://beetlesproject.org/beetles-collaboration-youth-outside/*.

beetles
Science and Teaching for Field Instructors

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

BEETLES Team: **Craig Strang**, **Kevin Beals**, **Jedda Foreman**, and **Emilie Lygren**
Additional Contributers: **Emily Arnold, Lynn Barakos, José González, Catherine Halversen**, *and* **Emily Weiss**
Research Team: **Mathew Cannady, Melissa Collins, Rena Dorph, Aparajita Pande,** and **Valeria Romero.** Emeritus: **Bernadette Chi, Juna Snow**
Project Consultants: **John (Jack) Muir Laws, Penny Sirota,** and **Mark Thomas**
Advisory Board: **Nicole Ardoin, Kevin Crowley, José González, Maggie Johnston, Celeste Royer, Bora Simmons,** and **Art Sussman.** Emeritus: **Kathy DiRanna, Kathryn Hayes, April Landale, John (Jack) Muir Laws, Jack Shea, Penny Sirota, Drew Talley,** and **Mark Thomas**
Editor: **Trudihope Schlomowitz**
Designer: **Barbara Clinton**

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/

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.

Other locations: Balarat Outdoor Education, CO; Barrier Island Environmental Education Center, SC; Chincoteague Bay Field Station, VA; Eagle Bluff Environmental Learning Center, MN; Great Smoky Mountains Institute at Tremont, TN; Wellfleet Bay Wildlife Sanctuary Mass Audubon, MA; Mountain Trail Outdoor School, NC; NatureBridge (CA, WA, VA); Nature's Classroom (CT, MA, ME, NH, NY, RI); North Cascades Institute Mountain School, WA; NorthBay, MD; Outdoor Education Center at Camp Olympia, TX; The Ecology School, ME; UWSP Treehaven, WI; Wolf Ridge Environmental Learning Center, MN; YMCA Camp Mason Outdoor Center, NJ; and YMCA Erdman, HI.

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; & Diversity by Cara Foster 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.

To contact BEETLES™, email beetles@berkeley.edu