beetles
Science and Teaching for Field Instructors

Student Activity Guide

Tree Exploration

Trees can be intriguing! This interest can deepen if children (and adults) have the opportunity to spend time with one individual tree to which they feel drawn. In *Tree Exploration*, pairs of students choose a tree to study and then get to know it through recording observations, questions, and explanations in a nature journal. Students expand their understanding about trees through discussion and through interpreting a diagram showing interactions between trees and the environment. Students also learn to use a field guide/key for identifying local trees and then return to their original tree to identify it as well as to apply what they've learned about trees. Students leave the experience knowing how to identify a few local trees, with a deeper understanding about how trees interact within ecosystems in general and with a relationship with a particular tree.

Students will:

- **Sharpen and practice observation skills.**
- **Record their observations, questions, and connections through field journaling.**
- **Learn how to identify trees, using a key or field guide.**
- **Learn about relationships between trees and other organisms.**
- **Build a relationship with one specific tree.**

Grade Level:
Grades 4–8. Adaptable for younger or older grades, depending mainly on the grade-level suitability of your field guide/key resources and choice of Tree Interactions diagram.

Related Activities:
BEETLES: *I Notice, I Wonder, It Reminds Me Of, Thought Swap; Fungi Exploration; Lichen Exploration; Bark Beetle Exploration; What Lives Here?; Decomposition Mission.* Non-BEETLES: From the book *How to Teach Nature Journaling,* the *Poetry of Place and Moment* activity and the *Biodiversity Inventory* activity.

Timing:
Approximately 60 minutes

Materials:
See the Materials and Preparation section on pages 3–5 for details.

Setting:
A forest with at least three kinds of trees that students can observe closely.

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

Acknowledgment: This activity was inspired by and adapted from activities submitted by BEETLES partners: Westminster Woods, Guadalupe River Park Conservancy, and Descanso Gardens.

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, beginning on page 19.

NEXT GENERATION SCIENCE STANDARDS

For additional information about NGSS, go to page 22 of this guide.

FEATURED SCIENCE AND ENGINEERING PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Obtaining, Evaluating, and Communicating Information	Systems and System Models	Interdependent Relationships in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Tree Exploration

ACTIVITY OVERVIEW

Tree Exploration	Learning Cycle Stage	Estimated Time
Part 1: Thought Swap	Invitation	**5–10 minutes**
Exploring a Tree	Exploration	**30 minutes**
Making Sense of Trees	Concept Invention	**5–15 minutes**
Part 2: Identifying Trees	Application	**10 minutes**
Reflecting on Trees	Reflection	**10 minutes**
Optional Extension: Writing Tree Poems	Application, Reflection	**15 minutes**
TOTAL:		**60–90 minutes**

TEACHING TIPS

Read the Instructor Support section. Beginning on page 14, you'll find more information about pedagogy, student misconceptions, science background, equity and inclusion, and standards.

Choosing a location. Choose an area with at least three different kinds of trees that students can access fairly easily without hazards. The area should have enough space between trees for students to move around and circle up, but the trees should be close enough together so you can circulate and keep an eye on students as they work. If it's winter, depending on your location, you may need to focus on evergreen trees.

Reading and facilitating the group. Much of the success of an activity like this depends on reading the group and adjusting the timing and content of each section as needed. Give directions that are thorough, so students know what to do, but efficient so the directions don't take too long. Give pairs enough time to get in depth with exploring their trees but not enough to become bored. If you sense the group is losing interest during a discussion, ask students to briefly *Turn & Share* about a question and then come back to the whole group, or just move on to a new topic. Read the group in the moment to decide when to shift to the next section of the activity. If students are really into their exploration, let them continue. If a section is dragging, go to the next section, play a quick high-energy game as a break, or move students somewhere else.

Adjustments for younger students. If you're working with 3rd-grade students or younger, consider skipping the journaling and the tree diagram and keeping the discussion short during the "Making Sense of Trees" activity.

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

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 instructor

- 1 model field journal (Tree Study Example, page 25)
- portable whiteboard
- whiteboard marker
- optional: a local field guide or tree-finder book

For each pair of students

- 1 copy of the Tree Interactions diagram (Version A: page 27 or Version B and Explanations for Tree Interactions: pages 28–29)
- 1 copy of a simple tree identification field guide/key (you will create)
- optional: 1 hand lens

For each student

- 1 copy of the Tree Journal (page 26) or a blank sheet of paper
- clipboard
- pencil
- optional: 1 sheet of paper (for the poetry extension)

PREPARATION

1. **Create a tree identification field guide/key.** *Note: You will need to do this before the day you plan to lead the activity.* A simple field guide/key to trees is an essential part of this activity, and you will need to make it in advance. Most published field guides are more complex than is needed in this context when students may be learning to use this kind of resource for the first time. To ensure the most success for your students, you will need to make your own simple local guide to trees where you plan to do the activity (unless you or your organization already has one). It can be fairly quick to make an accessible guide that students can use to identify trees. Follow these steps to create a field guide/key for your students:
   - **Find between 5–10 common trees to include in the field guide/key.** Choose the most common trees that students will find in the area where you're planning to do the activity.
   - **Photograph a leaf from each tree that you plan to include in the field guide/key.** Also, if there is room on the page, consider taking close-up photos of bark and fruits/nuts/flowers/cones or the overall growth form of the tree so you can include those in the guide.
   - **Consider what structure of tree field guide or key will be most accessible to your students.** On pages 30–32, we offer two examples of field guides/keys: a one-page picture-based field

TEACHING NOTES

TEACHING NOTES

MATERIALS AND PREPARATION (continued)

guide with a small amount of text and a multipage picture-based field guide with additional text.

- **To make a one-page picture-based field guide/key (see example on page 30):** Put all images on one page. For each tree species, include a leaf photo, the name of the tree, and a small amount of text describing field marks useful for identification. This kind of field guide/key is the simplest to make and use and is a good choice for younger students.
- **To make a multipage picture- and text-based field guide/key (see example on pages 31–32):** Make a document with one tree species per page or half page. For each tree species, include the tree name, photographs of the bark, leaves, fruits/nuts/flowers/cones, and a few sentences of text. The text could include descriptions of tree parts such as leaves, bark, or fruits; information about interactions the tree has with other living and nonliving things; information about the kinds of ecosystems in which the tree tends to be found; and/or other information.

- **Also consider bringing a published local field guide or tree-finder guide, just in case students run into a tree that's not in your field guide/key.** You can offer these kinds of guides as a resource that students can use to look up and read more information about trees after they've identified their tree with your picture-based key.

2. **Choose the version of the Tree Interactions diagram you will use and make enough copies so each pair of students can share a diagram.** There are two different versions to choose from, depending on what will best meet your learning goals and your students' needs

- **Version A (page 27):** This version is intended for use with 4th- and 5th-grade students. It focuses on tree interactions with common, observable organisms (such as caterpillars eating leaves, squirrels, birds, moss, spiders, bees, lichen, and lizards) and de-emphasizes nonobservable underground tree interactions with fungi, as well as interactions with nonliving things such as air, water, and minerals. This diagram is single-sided and does not include a page of written explanations.
- **Version B (pages 28–29):** This more complex version is intended for use with some groups of older students (5th grade and above). It includes a variety of different interacting organisms, including underground interactions with fungi as well as interactions with nonliving things such as minerals, water, and air (photosynthesis). To go along with Version B, we've provided the Explanations for Tree Interactions, which includes lettered explanations that students can match to the

MATERIALS AND PREPARATION (continued)

letters on the diagram. (You can print Version B double-sided, or you can print two separate pages and staple them together.)

3. **Decide whether you want students to use the provided Tree Journal (page 26) or a blank sheet of paper.** The Tree Journal offers guidance that invites students to observe their trees in a variety of ways and a structure to organize their writings and drawings. Sometimes, the structure of a worksheet can discourage students from making deep observations. A blank sheet of paper gives students the opportunity to organize the information as they see fit and encourages more agency in what students write and draw. Choose what you think will work best for your students or give them the choice.
   - **Make copies of the Tree Journal.** If you decided to have students use this page, make enough copies so each student can have their own Tree Journal.
   - **Optional (and recommended): Prepare a model Tree Journal.** A model tree journal page is included with this activity write-up (page 25: Note that the title on the example is Tree Study, and the page is *slightly* different than the provided Tree Journal page). It is meant as a visual aid to offer students an example of what their Tree Journal might look like. It is best to have a sample journal page that you made yourself to use as a model for students. Why? Because showing that you did the activity yourself and are willing to share your own work models engagement with the process. When students know that their instructor values the activity enough to do it on their own, it helps make the activity seem like a legitimate task rather than busy work, especially if you describe how you enjoyed making it and things you noticed and learned from the process.
4. **Decide if you will conduct Optional Extension: Writing Tree Poems (page 13).** If you decide to have students write tree poems, each student will need a sheet of paper.
5. **Plan where and when you will do Parts 1 and 2 of this activity.** This activity is best taught in two parts—with a change of location, a physically active activity, or some other kind of break to be done after Part 1. Plan where you will lead each part of the activity and how you might give students time to decompress and move their bodies between the two parts. Be prepared to adjust your plan to be responsive to students' needs in the moment. In cold, snowy, or rainy weather, some instructors have found success doing the journaling part of the "Exploring a Tree" and "Making Sense of Trees" sections in a nearby shelter.
   - **Part 1:** Thought Swap, Exploring a Tree, Making Sense of Trees
   - **Part 2:** Identifying Trees, Reflecting on Trees, Optional Extension: Writing Tree Poems

TEACHING NOTES

TEACHING NOTES

Discussion Routines. See the BEETLES activity *Thought Swap* (formerly known as *Walk & Talk*) or the BEETLES resource Discussion Routines for logistics on these discussion formats. Wondering why we changed the name from *Walk & Talk*? We received some feedback from our community partners on how we can use more inclusive language, and we 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.

Additional questions. For more examples of improvised questions about tree interactions, see the Instructor Support section (beginning on page 14).

Giving instructions. Some instructors find it easier to give the instructions for exploring, observing, and journaling all at once at the beginning of the activity in order to avoid interrupting the momentum students build while exploring. Other instructors choose to bring students back together after each stage of the activity to give the next set of instructions so they don't have to share so much information all at once. Do what feels right for your instructional style and your group of students.

Part 1

Thought Swap

1. **Invite students to *Thought Swap* (formerly known as *Walk & Talk*) about the following questions while you move toward the location of the activity.** After each question, pause the group and debrief with the whole group. *Thought Swap* questions:

   - *Describe a tree you know well or have seen before—at your home, in your neighborhood, at your school, or anywhere. Describe the leaves, bark, fruit, nuts, seeds, how tall it is, the shape of the branches, and anything you can think of.*
   - *What do trees need to survive and grow?*

   Include an improvised question about something students can observe that shows interactions between trees and other living and nonliving things. For example:

   - *Everyone pick up a leaf like this with spots on it and, with your partner, make observations and try to explain what the spots might be.*
   - *Check out that weird growth on the tree. With your partner, make observations and try to explain what it might be.*
   - *What other things live in, around, and on trees? What kinds of things interact with trees? Which do you think might help, harm, or be neutral for the tree?* [Ask for or share a few examples so students understand what is meant by *interacting* with a tree.]

Exploring a Tree

1. **Share that pairs will have the opportunity to choose a nearby tree to observe and study.**
   - *Trees are cool and interesting! And they're important to our lives, to ecosystems, and to other organisms. You'll have the opportunity to choose a tree to observe and learn about.*
2. **Request that students treat the tree respectfully as they make observations. Invite students to share examples of what that might look like.**
3. **Share that students will begin with an opportunity to observe their tree. Then, model how to observe a tree in different ways.** Share that students will first explore their tree, using their senses such as sight, touch, smell, and hearing. If they are familiar with the *I Notice, I Wonder, It Reminds Me Of* routine, invite them to use it during their observations. With a sample tree, model a few examples of tree observations from the following list. For each item on the list, model making one observation yourself and then ask a few students to share observations, questions, and connections out loud. (Keep this brief.)
   - touching the tree's bark and describing how it feels

- smelling a leaf and noticing the shape of the leaf
- observing and describing leaves, bark, shapes, and roots
- observing and describing the overall shape of the tree
- describing what is living on, in, and around the tree and thinking about if those things might be helpful, harmful, or neutral for the tree
- observing closely with a hand lens (e.g., *Xiomara and Emily, can you get in there with your hand lens, and tell us what you see? What does it make you wonder? What does it remind you of?*)
- searching for evidence that animals use the tree and the area around the tree (such as holes in leaves, husks of seeds that have been eaten, animal poop, etc.)
- treating the tree respectfully and not harming it

4. **Let students know that after they observe their trees, they will have an opportunity to record their discoveries in their Tree Journals.**

5. **Share that the goal is to make observations and record them in the Tree Journal as you begin to model adding drawings to your journal page.**

   ▶ *It's not about making a pretty picture of your tree. The goal is to record your observations and ideas.*

   ▶ *Use both drawings and writing to show your observations. If you're more comfortable drawing, draw more. If you're more comfortable writing, write more.*

6. **Model how students could record tree observations as you do a Think-Aloud.** Use the Tree Journal (or a blank journal page, if you feel this will be better for your students) to model drawing, labeling, and writing notes about a tree while explaining your thinking. The goal at this time is not to make a perfect or complete journal page. Briefly model drawing and adding notes to the page as you give the instructions below. Model making a quick drawing of a leaf; the bark; or a fruit, nut, cone, or flower.

   a. Model adding a couple of labels to your drawing, doing a Think-Aloud as you decide what words to record.

   ▶ *On your journal page, make life-size or close-up drawings of a leaf; the bark; and a fruit, nut, cone, or flower. (You may choose to model making a leaf rubbing with the side of a pencil, too.)*

   ▶ *Add labels to describe colors and things such as holes or textures.*

   ▶ *For example: This part of the leaf is very smooth, so I could write "smooth." This part of the leaf is more rough and is yellow, so I could write "rough and yellow."*

   ▶ *If you need more room to draw a large leaf or to write other notes, use the back side of your Tree Journal (or a blank sheet of paper).*

   b. Do a Think-Aloud as you model adding writing to the page.

   ▶ *Use words to show your tree observations in the labeled boxes: Observations (I notice . . .), Questions (I wonder . . .), and Connections ("It reminds me of . . ."). Connections are things that the tree or part of it*

TEACHING NOTES

Scaffolding for younger students. With 3rd-grade students and younger, do not give all the instructions up front. Instead, we recommend inviting students to choose trees that are close enough together so students can all see and hear you while at their trees. Then, offer each step of the instructions and pause to give time for students to follow those instructions. For example: "We're going to start by using our sense of touch to learn about the tree. Touch the bark and then the leaves. How do they feel? Smooth or rough? Bumpy or spiny? Smooth in some places and bumpy in others? Take a moment to explore the tree, using your sense of touch, and share what you find with your partner."

Needles are leaves. If trees in your area have needles (such as those on pine trees or fir trees), point out some needles to your group and share that they are leaves, too. Leaves are plant organs that are mostly used for photosynthesis and for exchanging gases, including needles on pines and scales on junipers. Needles are often flat, to absorb sunlight, and thin, so light and carbon dioxide can reach the cells in the leaf.

Leaf-drawing tips. Drawing a leaf accurately can be challenging. Offer the following techniques and practice each technique yourself before you model them.

- **Tracing.** Place the leaf on the page and trace around the edge of the leaf (best for leaves with a simple shape).
- **Connecting the dots.** Hold the leaf against the paper but instead of tracing it, make dots around the edges. Then, lift up the leaf and connect the dots to get the general shape of the leaf.
- **Making leaf rubbings.** Place the paper on top of the leaf and use a crayon or side of a pencil to draw over the leaf. Then, draw on top to add detail.
- **Drawing a part.** For leaves with many small parts, such as a Douglas fir or Redwood, draw the overall shape. Then, draw just a few parts in detail.

TEACHING NOTES

reminds you of, such as something you have seen or experienced before, something it looks like, or something you know about trees. Record anything you wonder about your tree. For example: Earlier, I wondered what eats the fruits we see on this tree, so I will write "I wonder what eats the fruits."

c. Model looking for tree interactions and adding them to the page.

▶ *Look for and record interactions between the tree and living and nonliving things around it. This could be something you see, such as an ant on the tree, or it could be evidence that makes you think an interaction happened in the past—such as a hole in a leaf.*

d. Model writing a descriptive name for the tree.

▶ *Write a descriptive name for the tree that you come up with—for example: "Big Hand-Shaped Leaf Tree."*

7. **Share that students will begin observing their trees without journaling and that you will bring students a pencil and a journal page when it is time to start journaling.**

8. **Share a premade example of a Tree Journal page, modeling these features.** Use the Tree Journal Example on page 25, unless you have a model page that you created or a previous example from a student. The more enthusiasm you share for trees and journaling—and the more you are able to characterize it as important, interesting, and enjoyable—the more likely students will engage with the task.

9. **Assign partners or invite students to find their own partners.** Either assign partners if this is best for your group, or offer an invitation for students to choose a partner with whom they think they will work well.

10. **Warn students of any hazards, share the boundaries, and demonstrate the attention-getting signal you will use when it's time to regroup.** Give warnings about avoiding any hazards in your area, such as poison oak or poison ivy. Demonstrate the attention-getting signal you'll use (e.g., a whistle or a word or phrase you'll call out to the group) when it's time for the whole group to gather again. Clearly show students the boundaries, ideally by going to each boundary and saying a description of the boundary loudly enough for students to hear you. For example: "See this creek right here? The tree you choose has to be on this side of the creek."

11. **Send pairs to choose a tree to explore and observe (without journaling for now).** Encourage students to quickly find a tree that is interesting to them. Then, have students observe and study it as the group did with the demonstration tree. You may choose to keep students' Tree Journals (or blank sheets of paper) with you and then hand them out after students have explored for a while. Alternatively, you may choose to have students take their Tree Journals with them and set them aside until you invite them to journal.

12. **After pairs have observed their trees for at least 5 minutes (but before students lose interest), ask them to begin journaling.** Either distribute

Support, scaffolding, and student engagement. *Tree Exploration* includes scaffolding throughout the activity to support students' participation. When the instructor breaks down scientific drawing into steps, uses visual aids while explaining directions, 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, as does inviting students to unpack vocabulary or clarify definitions. This write-up activity also offers a range of options for tree journal pages, tree identification keys, tree diagrams, questions to ask, and structuring of the activity. This allows instructors to consciously choose the approaches that are engaging for their specific groups of students.

Why no journaling at first? Although journaling helps increase observations through focus, it can be beneficial for students to make some observations at first, without their journals. Observing the tree first allows students to focus on observing the tree in detail and using one skill (observation). Later, they can focus on recording details in their Tree Journals, which involves a different set of skills.

one Tree Journal (or blank sheet) to each student or ask students to pick up their Tree Journals and begin recording.

13. **Circulate as students work, supporting student participation and engagement, modeling observation strategies, and troubleshooting.** Encourage students to use writing and drawing to show their observations. Guide any students who seem less engaged. This could include inviting students to choose a fallen leaf, encouraging them to make observations about it verbally (perhaps joining in as a co-investigator), and then encouraging students to record those observations. Encourage any chaperones present to help out with this, too. Following are examples of prompts you might use as you circulate:
    - *What are you noticing about the tree?*
    - *What do you notice about the bark? The leaves? How about the shape of the whole tree?*
    - *What evidence/clues/signs of animals living here do you notice?*
    - *What makes this tree a good place for the animal to be?*
    - *How could you observe in a different way—like looking up close or far away—to notice more?*
    - *Oh, that's a really interesting question (observation, connection, etc.). Be sure to record that in your Tree Journal!*

Making Sense of Trees

1. **After students have had time to explore their trees and journal, but before they lose interest, call the group back together.** Pay attention to your group's energy and focus to decide when to invite them to regroup.

2. **Ask pairs to connect with another pair to share and compare their trees.** Ask each pair to connect with another pair who observed a different kind of tree. Ask each group of four to share their journal observations about bark, leaves, roots, shape; where their tree is living; and what is living on, in, and around their tree. Encourage students to share their questions, connections, and what they found most interesting about their trees.

3. **Distribute one copy of the Tree Interactions diagram to each pair of students and share: There's a lot going on with trees!**

    ▶ *There's a lot going on with just the tree itself—roots, branches, bark, etc.*

    ▶ *Beyond that, it's not just a tree! There are a lot of things interacting with a tree. This is a diagram of a tree that has information about how trees interact with other things in the environment.*

4. **Offer a definition for the term *interaction*, share some examples, and ask students to brainstorm types of interactions between different organisms and nonliving parts of the ecosystem.** Share that an interaction is when something affects another thing. Give examples of interactions and lead a brainstorm of interactions:

    ▶ *When an animal eats something, it's interacting with the thing it is eating; when a bird flies, or when a plant takes in gases and releases gases, they're*

TEACHING NOTES

Engaging directly with nature. Centering learning on students' in-the-moment observations of trees 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 in which participation requires prior knowledge about science ideas; students who have had more exposure to science tend to have an advantage.

More modifications for younger students. Younger students may benefit from a shortened version of the activity, without the diagram. If it makes sense for your group, skip the diagram and make the "Making Sense of Trees" discussion focused and brief.

Reading the group. Before introducing the diagram, read the group. If needed, take a short break. If students seem tired or disengaged, consider skipping the diagram at this stage of the activity and revisiting it later.

TEACHING NOTES

More about interactions. If your students are confused about interactions, try using these *Pair-Share* questions:

- **I once saw an interesting interaction between two animals.** [Describe an interesting interaction you've seen, ideally at your site.] *What was a time you saw animals interact (do something with each other) in nature? It could be from a video.*
- **I once saw an interesting interaction between an animal and a plant.** [Describe an interesting interaction you've seen, ideally at your site.] *What are some ways that animals and plants might interact?*
- **I once saw an interesting interaction between a living thing and a nonliving thing.** [Describe an interesting interaction you've seen, ideally at your site.] *What are some ways that organisms interact with nonliving things in their ecosystem?*

Meaning-making discussions. Discussion is a key part of learning. It's also an important part of creating an equitable, inclusive learning environment. Meaning-making discussions like this one offer opportunities for students to make connections to prior knowledge, share their lived experiences, and create an environment in which they get to see themselves and one another as sources of expertise. Participating in meaning-making discussions also helps students grow their capacity to take on more challenging learning tasks in the future. To learn more about creating an inclusive learning experience, see page 19 of the Instructor Support section.

interacting with air; and even when an animal stands on something else, it's interacting with it.

- *What are different ways living and nonliving things might interact with a tree?*

5. **Model discussing one interaction shown on the Tree Interactions diagram.** To support students in understanding the instructions, model having both sides of a discussion about one interaction shown on the diagram. For example:

   - *I notice that there is a drawing of a caterpillar on the tree. It is making holes in the leaves. I wonder how those holes affect the leaf? Do the holes make it so the leaf doesn't work as well?*

   OR

   - *Look, there are roots under the ground, and they are connected to fungi! It says that there are nutrients and water going in that help the tree grow. Cool! I wonder, how do the fungi and roots find each other underground?*

6. **Ask students to study and discuss the Tree Interactions diagram with their partners and to use it to figure out as much as they can about how trees interact with other parts of their environment.** Invite students to look at the diagram and talk about it with their partners. If you're using Version A of the diagram, ask students to figure out ways that trees interact with other living things. If you're using Version B, ask students to use the tree diagram, along with their observations, to see what they can figure out about how trees work and how trees interact with other things and creatures. Ask students to share questions they're wondering about and to come up with possible explanations, too. If you're using Version B, point out that the letters on the diagram correspond with deeper explanations that can be found on the Explanations for Tree Interactions.

7. **As students look at the Tree Interactions diagram, circulate and engage them in conversation about their ideas.**

8. **After students have had some time with the diagram (but before they become disengaged), gather the group around the same tree you used in your introduction and lead a discussion in which students share a few things they figured out about trees and things that interact with trees from the diagram.** Invite students to share what they were able to figure out from the diagram.

9. **Throughout the discussion, connect statements to the tree you are next to, ask follow-up questions, encourage students to share ideas, and share and add some information yourself about the topics in which students are most interested.** Share a little information from the Explanations for Tree Interactions (for Version B)—but not the whole list! Apply everything to the tree you're near. For example, if you bring up information about leaves and photosynthesis, use leaves from the tree to illustrate what you're saying and point out how the leaves are positioned to collect sunlight.

10. **Conclude the discussion by sharing that trees are deeply interconnected with living and nonliving things in their ecosystems, but many of these connections are hard to see.** The underground interconnections between

trees with fungi and trees with trees have only recently begun to be understood, and they are complex. Connections with fungi, other trees, sunlight, carbon dioxide, oxygen, minerals, etc. are difficult for us to see, but they are extremely important.

11. **Make a connection between the thinking that students have done while exploring trees and the NGSS Crosscutting Concept of *Systems and System Models*.**

    - *You all have been observing a tree, looking at the parts of a tree, and thinking about how the parts of a tree interact or are connected to things around it—such as animals, other plants, and things such as water and soil.*
    - *This approach—thinking about the parts of a system and thinking about how the parts affect one other—is something that scientists and thinkers who study many things use in order to learn.*

Take a break. Offer students time to have a break before launching into the next stage of the activity. This might involve moving the group to another area, leading a physically active activity, or giving them some unstructured time.

Part 2

Identifying Trees

1. **Share that students will have the opportunity to use a tool to identify their trees, distribute a copy of the simple tree identification field guide/key you made to each pair of students, and offer guidance on how to use it.** Use a sample leaf and piece of bark (or use a whole tree) to model how to use the field guide to identify a tree, preferably using a different kind of tree than any of the trees your students focused on for their study. Use the term *evidence* as you do this. For example: *I think this is a bay laurel tree, and my evidence is that the shape is kind of feather-like, and it has a strong smell.*

    - *This is a tool we will use to identify, or learn the names of, trees. When we know the names of trees or plants, it can be like recognizing friends wherever we go!*
    - *Let's practice. To use this tree field guide, we can look at the pictures of leaves, bark, fruits, nuts, and seeds and try to see which one matches our tree.*
    - [If your guide also has words on it] *We can also read the words to get more information that the pictures can't show us, such as: Bay Laurel trees have a strong smell.*
    - *Let's look at this tree* [point to an example tree, preferably a tree species that none of your students observed]. *With your partner, look through the tree field guide and try to figure out what tree it is.*
    - *Share your evidence, such as: I think this is a Bay Laurel because the leaf has a strong smell, and it says that on the page, and because the leaf on the tree and in the picture are both the same shape as a feather."*

TEACHING NOTES

Offering content and correcting inaccurate ideas. How much content should you introduce in this discussion and how should you respond if students share inaccurate ideas? There is no need for students to understand everything on the diagram. Focus on a few things that interest students. Begin by listening to their ideas, asking follow-up questions, giving accepting and neutral responses (e.g., *Interesting. Say more about that.*), and asking students to respond to one another. After students share some ideas, you might choose to gently share a few accurate ideas about concepts that seem particularly important. Do so by using phrasing such as *What scientists have found through many observations is . . . .*

So many systems! You might want to lead students to the understanding that a tree and all its interactions is a system (an ecosystem) that is part of the greater ecosystem, which is the forest. A tree has systems within it for photosynthesizing, transferring food throughout its system, etc. A bird nesting in the tree has a digestive system, respiratory system, etc. There are systems everywhere!

You may want to explain that Traditional Ecological Knowledge (TEK) has long understood that trees communicate, and science is recently exploring this idea. Often, TEK has described trees as able to communicate with one other. Until recently, this idea was not considered scientific, as scientists have often not acknowledged indigenous knowledge as a valid source of scientific information. "There is now compelling evidence that our elders were right—the trees are talking to one another. They communicate via pheromones, hormonelike compounds that are wafted on the breeze, laden with meaning." —Robin Wall Kimmerer

TEACHING NOTES

Biodiversity Inventory. For a follow-up activity, go to a different area with a variety of trees that includes some trees students have already seen. Challenge students to use their field guides/keys to identify as many trees as they can within the boundaries. Then, ask students to look for patterns in tree growth: *Where do certain kinds live and not live? Are there more kinds of one tree or another in certain areas?* For a full activity on taking notes about organisms in an area (or two) and interpreting the data, see the *Biodiversity Inventory* activity from *How to Teach Nature Journaling* by John Muir Laws and Emilie Lygren (https://howtoteachnaturejournaling.com/activities/biodiversity-inventory/).

2. **Invite pairs to return to their trees with the tree identification field guide/key, use evidence to identify their trees, and use what they learned in the discussion or from the Tree Interactions diagram to understand their trees better.** Let students know that their goal is to identify their trees and try to use what they learned from the Tree Interactions diagram to understand or wonder even more about their trees. If pairs identify their trees, tell them to write the name after "Tree identification" in their Tree Journals. Offer support with tree identification as needed. Students can also use what they learned from the Tree Interactions diagram to think about their trees in different ways. For example, they might focus on lichen or other aspects they hadn't noticed before, such as fruits, nuts, seeds, flowers, dead branches, etc. As they do this, circulate and help out as needed.

3. **As students use the field guide/key to identify and think about their trees, circulate and engage them in discussion about their ideas.**

4. **Guide the group to review the kinds of trees they've identified and share their evidence.** Gather the group and review the trees they've figured out how to identify by taking the group to one kind of tree and asking the pair(s) who identified it what characteristics they used as evidence to help them identify it. Repeat with each type of tree.

Reflecting on Trees

1. **Lead a *Thought Swap* (formerly known as *Walk & Talk*) to facilitate students reflecting on the experience and what they have learned.** Possible *Thought Swap* questions:

   - *What are some meaningful or exciting things you learned about the tree you observed?*
   - *What are some things you learned about trees that surprised you?*
   - *What are some thoughts, ideas, and questions you have about trees?*
   - *What are some skills you used to learn about trees? How might you share about these skills with a family member or friend who wanted to learn about trees?*
   - *Discuss the trees you learned to identify and the characteristics that helped you identify them.*
   - *How could you use what you learned about identifying plants when you go home?*
   - *What did you learn about how to record observations and ideas in a nature journal?*

2. **Throughout the rest of your field experience, encourage students to notice and identify trees, using evidence.** Occasionally, as you come across trees that students know, invite one or more students to share how they are able to identify a certain kind of tree, ideally with the field guide/key. If you come across a tree your group hasn't identified yet, use the field guide/key to identify it together, citing evidence from the field guide/key and student observations.

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

Optional Extension: Writing Tree Poems

1. **Invite students to find a place to sit near a tree.** Ideally, encourage students to find the same tree as the one they focused on earlier in the activity.
2. **Share that students will have the opportunity to write a poem about a tree.**
3. **Offer some scaffolding to guide students' writing.**
   - *You will have an opportunity to write a poem inspired by your tree, what's around it, and your response to it.*
   - *Begin by using "I notice, I wonder, it reminds me of . . ." to describe the tree. You could observe things such as the branches, what is near or around the tree, or focus on shapes and colors. Add questions or things the tree reminds you of—either the whole tree or a specific part of the tree such as a leaf or the trunk.*
   - *Then, turn the prompts "I notice, I wonder, it reminds me of . . ." inward to describe your internal experience, emotions, and thoughts in this place and as you are observing this tree.*
   - *Alternate back and forth between looking out and describing what you see or notice and looking within and writing about what you notice about how you feel and what you are reminded of.*
   - *You can add to the poem the observations, questions, and connections you made while studying your trees earlier.*
   - *If you're ever not sure what to write, you can always come back to noticing and making observations of the tree.*
4. **Give students 10–15 minutes to write their poems.** As students write, model engagement by writing a poem yourself and then circulate to support student engagement as needed.
5. **Bring students back together and offer individuals the opportunity to share their poems or a part of their poems if they would like to.**
6. **Consider writing an example poem to share with students or offer this one as an example:**

I notice dry leaves flutter and spin in the wind,
and bark that curls and falls to the ground.
I wonder who else has sat beneath this tree.
The leaves remind me of clouds
just before a rain,
heavy and full.
I wonder if the tree misses the leaves
after they fall.
I wonder if after I leave, the tree will miss me, too.

TEACHING NOTES

"The roots of many poems can begin with the same fundamental tools of scientific thinking—noticing, wondering, and making creative connections." –John Muir Laws and Emilie Lygren, from *How to Teach Nature Journaling*

Poet-tree activity. This poet-tree activity is adapted from the *Poetry of Place and Moment* activity from the book *How to Teach Nature Journaling* by John Muir Laws and Emilie Lygren (https://howtoteachnaturejournaling.com/activities/poetry-of-place-and-moment-2/). For a more thorough write-up of this activity as well as many other activities and ideas to teach students how to nature journal, check out the book.

Using the arts to communicate about trees. The botanist, researcher, and science communicator Dr. Nalini Nadkarni brought a group of artists to the rain forest to study trees with her. Dr. Nadkarni is a scientist and science communicator who sees value in sharing about science ideas through multiple modes and disciplines. The group of artists included painters, dancers, hip-hop artists, poets, and songwriters. For another optional extension, share this story with students and invite them to choose a way of using art to communicate about their tree that feels authentic to them. This could be a poem, a rap, a song, a dance, or a skit about their tree, and/or trees in general, based on their notes and observations.

TEACHING NOTES

Instructor Support

Teaching Knowledge

Sharing content and correcting inaccurate ideas. How much content should you share during discussions and how should you respond if students share inaccurate ideas? For starters, *don't* share everything you know about trees! An overwhelming delivery of information can get in the way of student curiosity, learning, and engagement. There is no need for students to understand everything on the Tree Interactions diagram. Work with a few things that interest students and let these guide the discussions. Throughout the activity, primarily focus on students' observations and ideas and add in *just enough* new content to increase their understanding while keeping them curious to learn more. Approach inaccurate ideas with thoughtfulness. Don't start correcting every inaccurate idea as this can make students feel less encouraged to share their thinking. Begin by listening to students' ideas, asking follow-up questions, giving accepting and neutral responses (e.g., *Interesting. Say more about that.*), and asking others in the group what they think about each idea. Eventually, after students share some ideas, you *might* choose to gently share a few accurate ideas about concepts that seem particularly important. Do so by using phrasing such as *What scientists have found through many observations is . . .* or *What indigenous people have learned through their observations, today and in the past, is . . . .* You can also take note of students' current understandings and introduce ideas later in the learning experience that could shift their thinking.

Connecting content with unanticipated experiences in nature. It's impossible to script all the interactions students could have during a nature exploration activity because nature is so delightfully complex, and so are student minds; you never know what you're going to come across during a field experience or how students might respond to it. The more you're able to take what your students find interesting in nature and connect it to what you're hoping they learn, the more interesting and productive the experience will be. The following is an example of how one instructor did this with watermelon leaf fungi:

> During the introductory *Thought Swap*, the group began walking through freshly fallen maple leaves, and one person noticed interesting spots on them. The instructor paused the group and asked them to each pick up at least one leaf, make observations of the spots, and try to explain what they might be to their partner. The energy and discussion in the group surged as they excitedly explored and talked about their findings. Questions, observations, and connections popped up. *Is it a fungus? How come this one is brown, but the spots have green around them? Does the fungus somehow keep that part of the leaf from turning brown? It reminds me of watermelon seeds! Let's call it watermelon fungus!* As a gust of warm wind hit, leaves began falling from high above. The instructor exclaimed, "See if you can catch one!" and students started running around catching leaves. Eventually, the instructor challenged students to line up the leaves on the ground in order of decomposition, which stirred up more discussion. *Does it grow on the leaves before they fall or after? Oh look, the ones still up in the trees. You can see the spots on them up there, so*

TEACHING NOTES

they get them before they fall! After the discussion had calmed down a bit, the instructor gathered the group of students in their lines again and asked them to describe to their partners observations, questions, and connections they'd made. The students had a lot to say in pairs. Next, some shared out with the whole group. Finally, the instructor shared, "This is something I only learned about last year, and it blew my mind. I learned that leaves often have fungus that lives in them all the time, and it actually protects them in some ways. But then when they die, the fungus consumes them. First it protects, then it consumes. Weird, huh? That's just one of many interactions trees have with living and nonliving things around them. What are others you can think of?"

Including improvised questions. During your *Thought Swap* (formerly known as *Walk & Talk*), include an improvised question about trees around you at the time. Look for some intriguing phenomena students can observe that shows interactions/relationships between trees and other living and nonliving things such as spotted leaves, holes in leaves, fungi on trees, lichen, fire-charred bark, very exposed roots, a tree with many pollinators or nests, etc. Then, share *a little bit* of related information about relationships between trees and living and nonliving things around them. For example:

The instructor picks up a leaf with dark spots on it.

- *Everyone, pick up a leaf like this with spots on it and, with your partner, make observations and try to explain what the spots might be.*

Listen to their observations and ideas and then share:

- *Many healthy leaves have fungi living in them, helping protect them. But when they die, the fungi consumes them. Trees have a lot of different kinds of relationships with fungi. Some fungi harm trees, but many fungi are helpful to trees. If we could see underground, we'd see white threadlike fungi all over the place, taking in minerals, connecting with tree roots, and exchanging minerals for sugars from tree roots.*

OR

The instructor points to a fungus on a tree.

- *Check out that weird growth on the tree. With your partner, make observations, and try to explain what it might be.*

Listen to their observations and ideas and then share:

- *I've actually looked that up in a key (name the key) and identified it as a _____ fungus. But what we are seeing is only the fruit of the fungus. Most of the fungus is white threads inside the tree, consuming it. Trees have different kinds of relationships with fungi. This one is harmful to the tree. But if we could see underground, we'd see white threadlike fungi all over the place, taking in minerals, connecting with tree roots, and even exchanging minerals for sugars from tree roots. Those are helpful relationships.*

- *What other things live in, around, and on trees? What kinds of things interact with trees? Which do you think might help, harm, or be neutral for the tree?* [Ask for a few examples so students understand what is meant by *interacting* with a tree.]

TEACHING NOTES

Content Knowledge

There is a lot to know and learn about trees and their relationships with other living organisms and the environment! Following is some content knowledge that can help you understand more about trees and that you can use to help students understand more about trees—but you shouldn't share all the facts and information in this section with students. Choose to share a couple of pieces of information about a topic related to trees that students are interested in and that they are unlikely to figure out through their own observations.

Interspecies Relationships

There are some scientists who use the term *symbiosis* only to describe relationships in which both species benefit from the relationship. However, it's now more common in science to use the term for any type of close, ongoing relationship between different species. Below are the scientifically accepted definitions of the most commonly used terms describing various types of communal relationships between different species of organisms.

- **symbiosis:** a close and often long-term interaction between two or more separate biological species
- **mutualism:** a symbiotic relationship in which each individual benefits (e.g., lichen, clownfish/anemone, rhizobia bacteria/legumes, plant roots/fungi, pollinator/flower, ant/aphid, and humans/gut flora)
- **commensalism:** a symbiotic relationship in which one organism benefits without adversely affecting the other (e.g., remora/shark, whale/barnacles, and orchids/trees)
- **parasitism:** a symbiotic relationship in which one organism benefits at the expense of the other (e.g., athlete's foot; vertebrates/tapeworms or fleas; mistletoe/trees; cuckoos/cowbirds; and viruses, bacteria, protozoa/other organisms)

Relationships Between Fungi and Plants

The partnership between fungi and plants—*mycorrhizal symbiosis*—is one of the most important symbioses on Earth. The term is a combination of the Greek words for fungus (*mykós*) and root (*riza*). Mycorrhizal symbiosis has been around for a long time, at least 400 million years, and around 80 percent of plant species depend on it. In this symbiosis, the mycelium grows around actual plant roots underground. The mycelium takes up nutrients and water from the soil and passes them to the plant. Since the mycelium covers a much larger area than the plant's roots and has more surface area, this allows the plant to get a lot more nutrients than it would without the fungus. Some plants get almost all their nutrients through mycorrhizal fungi. Mycorrhizae can also connect plants to one another underground, enabling different plants to share resources. Fungi can help protect plants from predators and diseases and increase their resistance to pollution and other environmental stresses, such as droughts. This vast underground network of roots and fungi is sometimes called the Wood Wide Web. Trees can communicate with one another by sending chemicals through this network. For example, a tree being invaded by aphids can send signals to other trees to prepare their defenses

against an aphid attack before the aphids arrive. In return for providing plants with benefits, the fungi get sugars that the plant makes through photosynthesis. Most mycorrhizal relationships are mutualistic (they benefit the plant and the fungus), but sometimes they're parasitic, such as when the plant relies on the fungus without providing anything in return or when the fungus is mildly harmful to the plant.

Tree Communication, Traditional Ecological Knowledge (TEK), and Science

In her book *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants*, Dr. Robin Wall Kimmerer refers to indigenous stories about trees talking to one another and how that idea has long been dismissed by scientists. Yet she points out, "There is now compelling evidence that our elders were right—the trees *are* talking to one another. They communicate via pheromones, hormone-like compounds that are wafted on the breeze, laden with meaning." (pages 19–20). She goes on to describe how scientists are learning about how fungal networks connect trees and "redistribute the wealth of carbohydrates from tree to tree." (page 20). The idea of communication between trees was understood by Indigenous peoples long before science managed to "discover" it. Integrating Traditional Ecological Knowledge (TEK) with scientific knowledge allows for an overall holistic understanding of the environment that improves existing processes and management. TEK can also add to the understandings built through science, validating the information known about the natural world in a different way. It's a lovely example of the complementarity between science and TEK and how we can see the world more fully when we use both.

Fungi Living in Leaves

In addition to symbiosis with plants' roots, fungi have another major, though less understood role, as endophytes (from the Greek words for *in plants*)—virtually all living leaves have fungi inside them! Some research suggests that these endophytic fungi live within the plant cells and cause the plant to alter its chemical composition to deter herbivores (plant eaters) and decrease other stresses. Another explanation is that these fungi set themselves up to digest the leaves as soon as they die, getting there before fungi that live on the ground can.

Fungi as Decomposers of Wood

Fungi are some of the only organisms that can digest wood. As fungi break down dead wood, they turn it into simpler forms of matter that other organisms can more easily digest. If it weren't for fungi (and bacteria) breaking down wood into simpler forms of matter, other organisms would not have access to these nutrients that help to sustain them, and there would be piles of dead material covering the forest floor. (Yes, we may see logs and leaves on the forest floor, but they decompose eventually. Without fungi, most of the wood and tree matter would stay on the ground for a very long time!) Some kinds of fungi grow on living trees and are harmful to trees. Bark helps protect trees from harmful fungi, but fungi may invade a tree through wounds in bark.

TEACHING NOTES

Trees and Lichen

Lichen can grow on just about any stable surface that is well lit, including trees. The leaves on deciduous trees can shade and help keep lichen from drying out during summer; when the leaves drop in winter, this allows lichen more access to sunlight. Lichen do not harm the trees on which they grow. More lichen growth is often found on dead trees or dead branches of trees, but the lichen is not the cause of the branches dying. Dead bark is a more stable surface for lichen to grow on, and dead branches don't have leaves, so lichen can access more sunlight on dead branches.

Trees Need Oxygen

In addition to producing oxygen as a waste product through photosynthesis, plants, like all living things, need to be able to consume the food they've made. This is called cellular respiration, and plants need oxygen to do it. The green leaves and stems on a tree can simply use the oxygen they produce, but all cells in the plant need oxygen for cellular respiration, including roots. Tree roots tend to depend on getting oxygen from the environment, through air from small spaces in soil. This is why a tree can "drown" if the ground gets too soggy for them. Mangroves have solved this issue with snorkel-like structures on their roots that stick up out of the water to get air.

Flowers, Seeds, Nuts, Fruits, and Cones

It can sometimes come as a big *Aha!* when students recognize that flowers, seeds, nuts, fruits, and cones that are so common in our lives are actually plant organs for sexual reproduction and that they are connected. Sexual reproduction happens in plants when the male and female cells of plants join to form genetically distinct offspring. Flowers have male (stamen) and female (ovary) parts. The stamen makes pollen, and a bee or other pollinator may move the male pollen to the female ovary of another flower, and the ovary may become fertilized. The flower then loses its petals and grows seeds and may form fruit. The seeds can then get spread by wind, water, or animals and, if the conditions are right, can grow into new, genetically distinct plants. In conifers it's similar, but instead of having flowers with male and female reproductive parts, they have cones. Tiny male cones, similar to the stamens of flowers, produce pollen, which needs to be moved to larger female cones for fertilization to take place. Seeds grow within the female cones, tucked into the scales of the cone, and then get released to form new plants when the scales open up.

Dead Lower Branches

You can't shake hands with a redwood is a saying that represents how at the lower trunks of tall redwood trees there are often no branches because the lower branches have died and broken off. What causes some trees to have dead lower branches and others to have thick, hefty, and healthy lower branches? If a tree is part of a dense forest, there's a good chance that as it grows, the lower branches will eventually die from lack of light. The tree doesn't need them anymore and just gets its light by using branches that are higher up where there's more light. Trees that grow more out in the open with

more light will often keep their lower branches because they get plenty of light, and they may grow large. Sometimes, lower limbs on trees can die from a disease or from a lack of water.

Photosynthesis

Like all plants, trees are producers and make their own food through photosynthesis. They take in carbon dioxide (CO_2) through tiny openings in their leaves (stomata), and they take in water (H_2O) through many surfaces on leaves, stems, and roots. Using light energy, they make sugar ($C_6H_{12}O_6$) by combining carbon dioxide from the air with water. The oxygen that is released through the stomata in leaves during photosynthesis comes from water. So the mass of plants is built almost completely from carbon dioxide in the air and the hydrogen in water. It's strange to think that the mass of plants comes from something so seemingly insubstantial as a gas, but it does. A lot of people think that the mass of trees comes from soil, perhaps because curricula may often focus on the nutrient cycle and because soil seems more substantial than air. Trees need minerals, kind of like people need vitamins, but the bulk of the mass of what a tree makes through photosynthesis comes from carbon dioxide and water (NOT from soil).

Common Relevant Misconceptions

Misconception. Fungi are always harmful to plants, animals, and insects.

More accurate information. Though some fungal diseases harm plants—such as Dutch elm disease that has devastated populations of elms—many plants rely on fungi to survive. The mycelium of fungi surround and grow on plant roots underground and reach out into the area around the roots. The mycelium absorbs nutrients and water from the soil and passes them to plants, playing an important role in helping plants get what they need to survive. There's also the crucial role fungi play as decomposers in the forest, which directly and indirectly benefits other living things in the ecosystem.

Misconception. Lichens are parasites on trees.

More accurate information. Lichens can grow on almost any stable and reasonably well-lit surface. They can absorb minerals from the soil, rock, or trees on which they grow but aren't parasitic to these living surfaces. Lichens growing on trees don't harm the trees; they are simply using them as a surface on which to grow. More lichen is often found on dead trees and branches because the dead bark is more stable than living bark. Dead branches without leaves also allow more light to reach lichen.

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

TEACHING NOTES

community of learners. BEETLES design principles [http://beetlesproject.org/about/how-do-we-approach-teaching/] ensure that each 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 and offers 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 just 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* (formerly known as *Walk & Talk*) that are part of every BEETLES student activity can help ensure that students have these kinds of opportunities for discussion.

Specifically, *Tree Exploration* promotes an equitable, inclusive, and culturally relevant learning experience by:

- giving students multiple opportunities to connect to and share their lived experiences, and for students and the instructor to listen to and learn from these experiences and perspectives.
- scaffolding skills of scientific observation, illustration, and communication to support students' visual literacy, language acquisition, and engagement with the activity.
- using broad questions to invite students to share their observations, prior knowledge, and experiences with one another and the instructor.
- engaging students with commonly found parts of nature such as trees—contrasting the exclusionary idea that nature only exists in pristine wilderness areas—requires a panoramic view or unique geographic feature to be engaging, or is otherwise a place students need to go to as opposed to something they are always surrounded by.
- providing space for students to come up with connections between what they are observing and learning and prior experiences and knowledge.
- contradicting the exclusionary idea that science is merely a set of facts to memorize by offering a science learning experience that is centered around student observation, discussion, ideas, and perspectives and framing science as a process and way of thinking about and increasing understanding of the world.
- 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.

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*, 2014). 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 in which all students feel capable of success and have the tools to carry that success into other domains.

Resources on unconscious bias. There are many great resources on understanding and shifting unconscious bias. Here are a few books and organizations 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 : Why It's So Hard for White People to Talk About Racism* by Robin DiAngelo
- *Culturally Responsive Teaching & 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/]

TEACHING NOTES

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/

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.

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the three-dimensional learning that is called for in the 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 *Tree Exploration*, 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 *Systems and System Models*. Students will build understanding of Disciplinary Core Ideas related to *Interdependent Relationships in Ecosystems.*

Featured Science and Engineering Practice

Engaging students in *Obtaining, Evaluating, and Communicating Information.* According to the National Research Council's *A Framework for K–12 Science Education*, a major goal of science is to deepen human understanding of the world through making explanations about how things work. Students should develop their understanding of science concepts through obtaining, evaluating, and communicating information about natural phenomena. It's important for scientists and, according to the NGSS, for students to get 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. Students are exposed to different sources of information during every step of *Tree Exploration*.

- Students' initial source of information is their own observations as they explore their chosen trees.
- When students record their observations and ideas in drawing and writing in their journals, they generate scientific text that prepares them to engage in conversation with their peers.
- Students communicate information verbally as they work with partners and then as partners share their findings with another pair.
- Students also obtain more information from the Tree Interactions diagram and the identification field guide/key.

- Students communicate with others in the group about evidence they used to identify their trees.

Featured Crosscutting Concept

Learning science through the lens of *Systems and System Models*. The world is complicated! Isolating systems for study—such as focusing on one body system or, in this case, focusing just on the interactions between a tree and other parts of an ecosystem—helps scientists and engineers understand parts of how the world works. Investigating the parts of a system can help students recognize that each organism and object does not exist in isolation, but rather in relation to the other parts of the system of which it's a part.

- In *Tree Exploration,* students identify a tree as a system and focus on the many interactions between trees and other living and nonliving things, with a particular focus on interactions with fungi.
- Throughout your students' field experience, keep asking them to point out and think about interactions between trees and other parts of the ecosystem.
- A further step could be to have students begin to notice smaller systems within the ecosystem. For example, to recognize a tree as a system with its own internal parts or to notice the greater ecosystem of which the trees are part.
- The more systems that students identify, the more students will come to recognize the usefulness of a systems lens to understand the natural world. To help your students understand and use this "thinking tool," explain that scientists use models to isolate one system, or parts of it, to learn about the larger systems that make up the world. Scientists decide which parts of the system to focus on and which to leave out. They pay attention to interactions between parts of a system. They also notice things outside the system that affect it. It's important that students interpret the model tree in the Tree Interactions diagram and use it to answer questions in a scientific manner.

Featured Disciplinary Core Idea

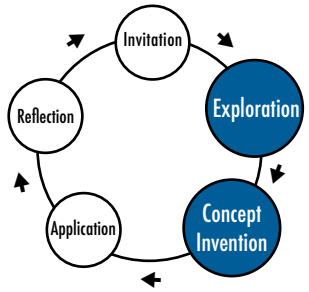
Building a foundation for understanding Disciplinary Core Ideas. The NGSS make it clear that students need multiple learning experiences to build their understanding of Disciplinary Core Ideas. *Tree Exploration* gives students an opportunity to develop understanding of some life science core ideas related to *Interdependent Relationships in Ecosystems* (LS2.A).

- As students observe tree interactions with living and nonliving things in their surroundings by observing their trees, and also through studying and discussing the Tree Interactions diagram, they build some understanding of the ways in which organisms get what they need from their environment in order to survive and are dependent on environmental interactions with other living things and nonliving factors. (LS2.A)

You can informally assess students' understanding of these concepts during different stages of the activity in individual interactions with students and by listening carefully during the group discussions. This information can help

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-LS4-4 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 Biodiversity and Humans. It's also the fourth Performance Expectation (4) that makes up the complete LS4 standard at this grade level.



Learning cycle. As a separate activity, *Tree Exploration* completes a full learning cycle. Within a sequence of other activities focused on developing student understanding of ecosystems, this activity could serve as Exploration or Concept Invention.

you decide which ideas to focus on in future lessons so follow-up activities or discussions can be used to further student understanding.

Performance Expectations to Work Toward

No single activity can adequately prepare students for an NGSS Performance Expectation. Performance Expectations are designed as examples of things that students should be able to do to demonstrate their understanding of content and big ideas in science after engaging in multiple learning experiences and instruction over a long period of time. They are *not* the curriculum to be taught to students. Following are a few Performance Expectations this activity can help students work toward:

- **5-LS2-1.** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- **MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

Activity Connections

Leading *I Notice, I Wonder, It Reminds Me Of* before *Tree Exploration* will offer students skills of observations, curiosity, and connection they can call on while learning about their trees. The *Thought Swap* discussion routine is used twice during the activity. *Fungi Exploration*, *Lichen Exploration*, and *Bark Beetle Exploration* each delve into organisms that interact intimately with trees. As part of a sequence on ecosystems, *Tree Exploration* could work well for introducing interactions that could be fleshed out more during *What Lives Here?* in which students make food webs based on their observations. *Decomposition Mission* also would be an excellent connection as it focuses on how things such as wood decompose, how matter moves through ecosystems, and how trees and other living and nonliving things are connected in ecosystems. Non-BEETLES activities that connect well with *Tree Exploration* include two activities from the book *How to Teach Nature Journaling* by John Muir Laws and Emilie Lygren: *Poetry of Place and Moment* is an activity that scaffolds moving from observations and questions into poems; during *Biodiversity Inventory*, students can focus on patterns of where trees do and don't grow in an area.

Acknowledgments

This activity was inspired by and adapted from the following activities submitted by BEETLES partners: *Plant Diversity* by Rebecah Jones at Westminster Woods, *Similari-trees* by Mel Sarmento at Guadalupe River Park Conservancy, and *Tree Habitat Exploration* by Samantha Spina at Descanso Gardens. We are very grateful for their generous offering of these activities.

Tree Journal Example

TREE STUDY

Name: Janet

My name for my tree: SMELLY LEAF TREE

Date: 11/1/19 Location: my schoolyard

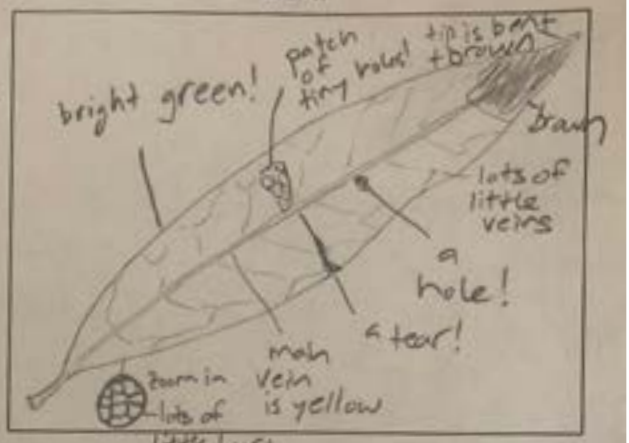
Tree identification:

Observations (I notice...)

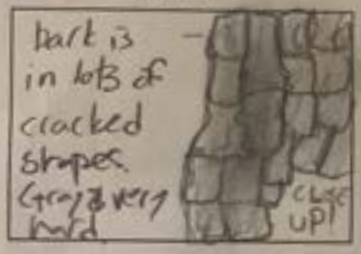
The tree has 6 long bendy trunks coming from one base.

There are some holes (big!) on the trunk.

LEAF



BARK



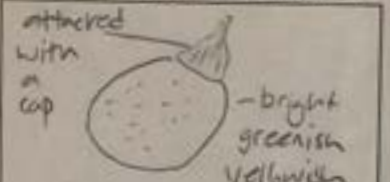
Questions (I wonder...)

How does the fruit know when to fall?
Do animals eat the seeds? How?
Do all these kinds of trees have similar shapes of trunks?
Does moss hurt the tree?

My tree reminds me of....

- Cooking soup (the smell.)
- looking at leaves with my big brother
- surfboards (the leaves.)

FRUIT/NUT/CONE/FLOWER



Notes on tree interactions *(things I notice on the tree, around the tree, or evidence)*

Moss on trunks. Ant on branch. Do things live in big holes on the trunk?
Are the holes or brown spots on leaves evidence of something eating it?

Name: _____ Date: _____

Tree Journal

Name for my tree:

Location:

Tree identification:

Observations (I notice . . .)

LEAF (includes needles)

Questions (I wonder . . .)

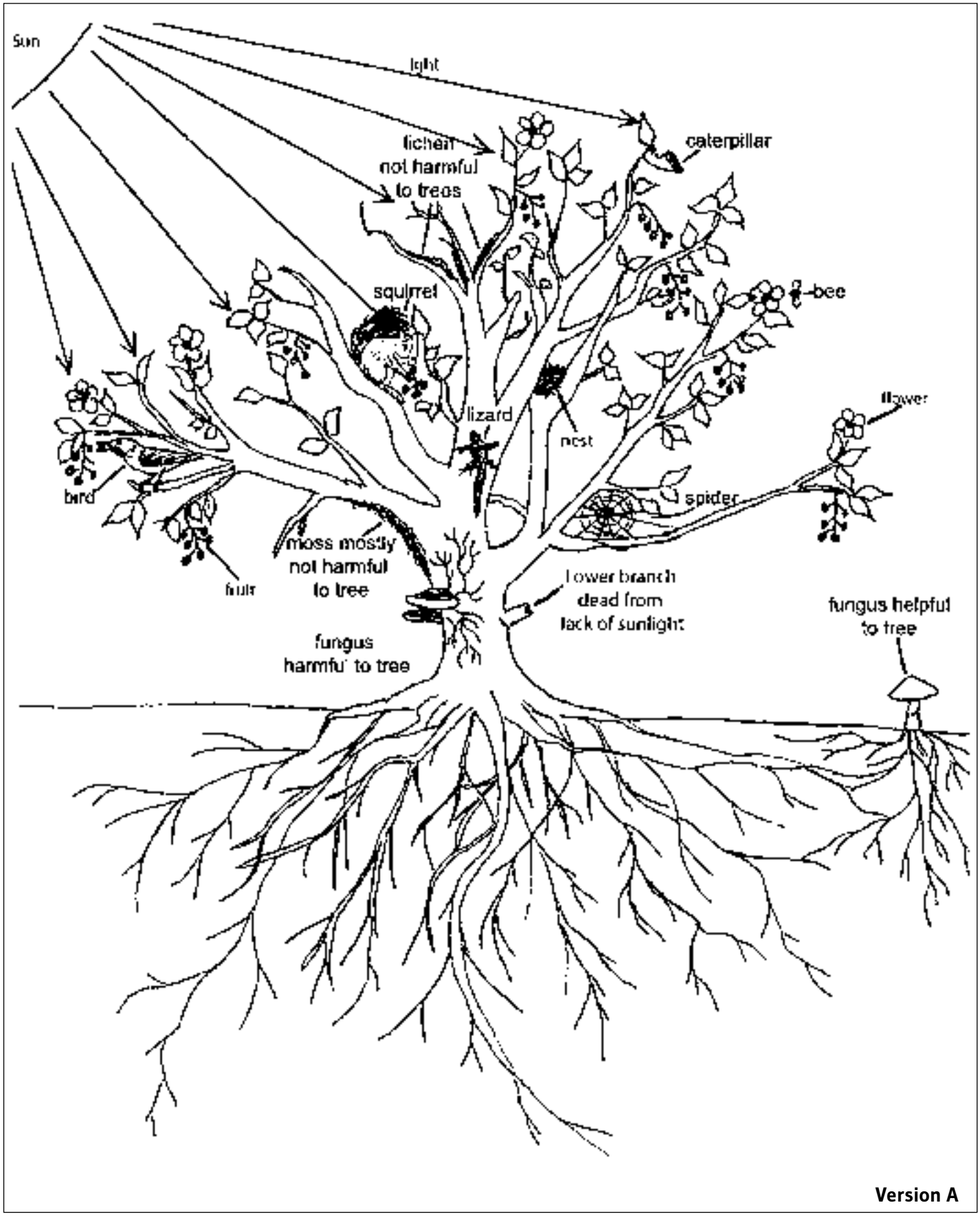
BARK

Connections (It reminds me of . . .)

FRUIT/NUT/CONE/FLOWER

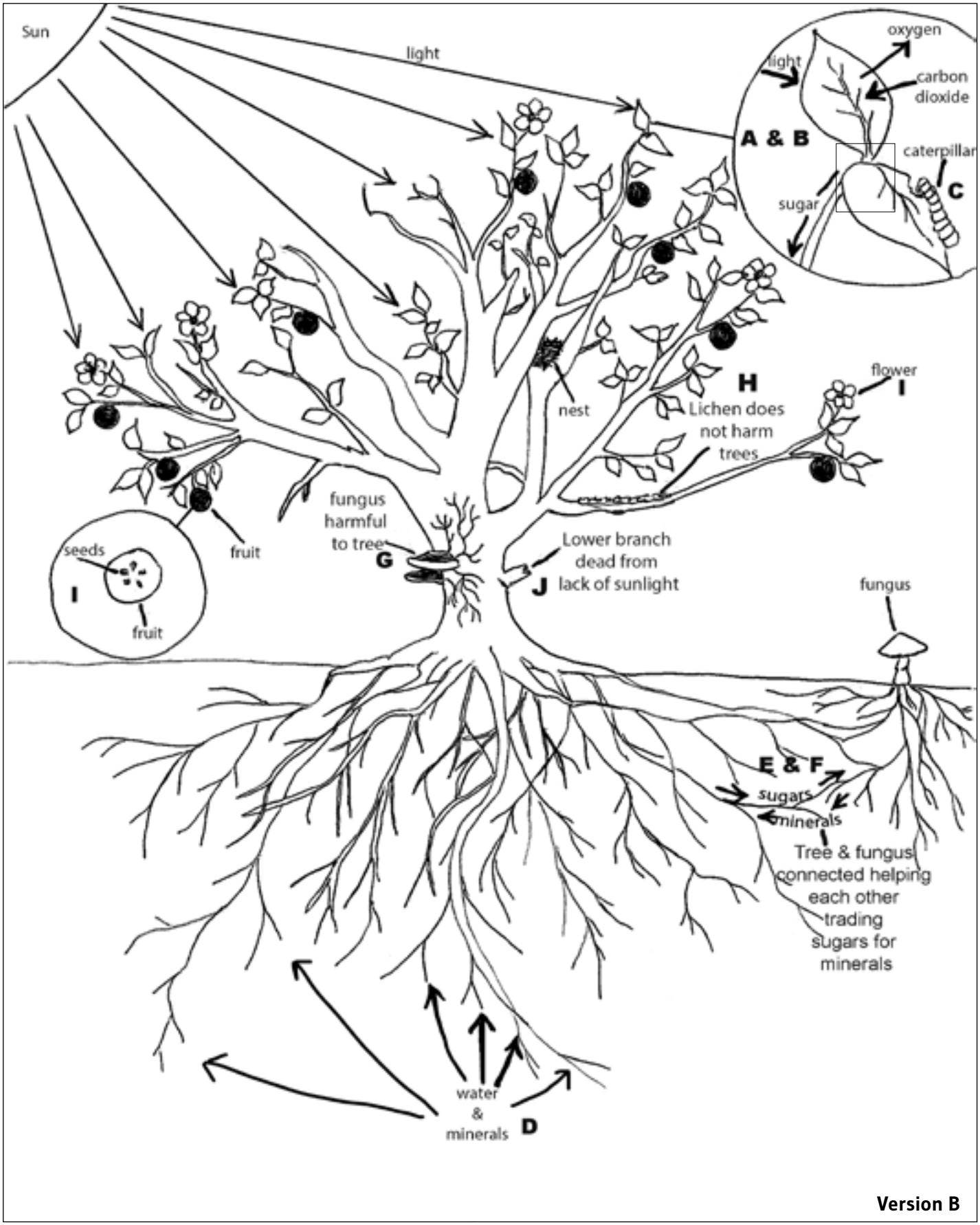
Notes on tree interactions (Look for plants, animals, and fungi or mushrooms on the tree or around the tree. Look for signs or evidence that animals have left behind on the tree such as holes in leaves, poop, nests, etc.)

Tree Interactions



Version A

Tree Interactions



Explanations for Tree Interactions

The letters and explanations below match letters on the Tree Interactions diagram and explain parts of the diagram.

A. Trees need light, water, carbon dioxide, and minerals to grow and survive.

B. Leaves make food for the plant, using carbon dioxide and water in the presence of light (photosynthesis). When they do this, they release oxygen into the air.

C. Many animals get their food by eating plant matter the tree has made through photosynthesis.

D. Trees need minerals, kind of like how people need vitamins. Most of what a tree is made of comes from carbon dioxide and water (NOT from soil).

E. Tree roots often connect with underground threadlike fungi parts. The fungi get sugars from the tree, and the tree gets minerals from the fungi.

F. Trees can communicate with one another (such as warning that insects are attacking). They can also share resources through these connections.

G. Some kinds of fungi grow on trees and are harmful to trees. Bark helps protect trees from harmful fungi. Fungi may invade a tree through wounds in bark.

H. Lichen often grows on trees, but it is NOT harmful to them. Lichen often grows on dead or dying branches where the bark isn't growing.

I. Flowers are for reproducing through pollination. Fruits and nuts come from flowers and include seeds to make new "baby' trees.

J. Lower branches on a tree often die as the tree grows because they no longer get much sunlight and aren't needed anymore.

Tree Identification Field Guide: One-Page Example

Trees at Westminster Woods

Young trees might look like bushes, but there are older trees nearby with the same kinds of leaves.

Bay

The leaf has a strong smell when broken.

Canyon Oak

The leaf edges can be smooth or spiky.

Coast Live Oak

The leaves are humped up in the middle like an umbrella.

Tan Oak

The leaf is still and hairy.

Oregon Ash

The leaves usually grow in sets of 7.

Oregon Oak

Madrone

The bark is red and peely. The leaf edges can be smooth or like a saw.

Hazelnut

The leaves feel soft, like felt.

White Alder

The tree is usually near a stream.

Buckeye

The leaves grow in sets of 5 or 7.

Big Leaf Maple

Douglas Fir

The needles grow around the branch.

Redwood

The needles grow around the branch.

Nutmeg

The needles lay flat. They have hard, sharp spines at the ends.

Credits: tree/shrub image from http://www.lacasamorett.com/foxgallery/classification-of-plants-herbs-shrubs-trees.html; all photos taken by "Redwood" Jones

Tree Identification Field Guide: Two-Page Example

Credit for all photos: Westminster Woods

Redwood

Sequoia sempervirens

Other common names: coast redwood, California redwood

Description: flat needles, conical crown, reddish-brown soft fibrous bark, egg-shaped cones are 2–3 cm

Where it's found: Central and Northern California coastal fog belt

Other facts: Redwoods are the tallest trees in the world. They are often more than 200 feet tall. The tallest known redwood, discovered in 2006, is 379.7 feet tall. The trees can live more than 2,000 years. Tannins make the bark red and resistant to bugs and rot. "Goose pens" are caused by recurring fires and decay that happens once the protection of the bark is gone. Redwoods reproduce from seed and sprouting.

Credit for all photos: Westminster Woods

Douglas Fir

Pseudotsuga menziesii

Other common names: ——

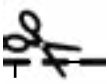
Description: leaves are arranged in a spiral; cones have little paper-thin 3-pointed "tails" coming out of the scales; cones are 3 ½ inches; bark is reddish-brown and deeply furrowed

Where it's found: western North America; in California—north to central coast and below 7,000 feet in the central Sierras

Other facts: Douglas firs are the second tallest conifers in the world. The seeds are an extremely important food source for birds and small mammals.

FIELD CARD

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



Tree Exploration

Part 1

Thought Swap

1. Invite students to *Thought Swap* (formerly known as *Walk & Talk*) about the following questions while you move toward the location of the activity.
   - *Describe a tree you know well or have seen before—at your home, in your neighborhood, at your school, or anywhere. Describe the leaves, bark, fruit, nuts, seeds, how tall it is, the shape of the branches, and anything you can think of.*
   - *What do trees need to survive and grow?*

   Include an improvised question about something students can observe that shows interactions between trees and other living and nonliving things. This could be a question about a specific leaf or tree feature or a question about the kinds of things students think might live in, around, or on trees in the area.

Exploring a Tree

1. Share that pairs will have the opportunity to choose a nearby tree to observe and study.
   - *Trees are cool and interesting! And they're important to our lives, to ecosystems, and to other organisms. You'll have the opportunity to choose a tree to observe and learn about.*
2. Request that students treat the tree respectfully as they make observations. Invite students to share examples of what that might look like.
3. Share that students will begin with an opportunity to observe their tree. Then, model how to observe a tree in different ways.
   - touching the tree's bark and describing how it feels
   - smelling a leaf and noticing the shape of the leaf
   - observing and describing leaves, bark, shapes, and roots
   - observing and describing the overall shape of the tree
   - describing what is living on, in, and around the tree and thinking about if those things might be helpful, harmful, or neutral for the tree
   - observing closely with a hand lens
   - searching for evidence that animals use the tree and the area around the tree (such as holes in leaves, husks of seeds that have been eaten, animal poop, etc.)
   - treating the tree respectfully and not harming it
4. Let students know that after they observe their trees, they will have an opportunity to record their discoveries in their Tree Journals.
5. Share that the goal is to make observations and record them in the Tree Journal as you begin to model adding drawings to your journal page.
   - *It's not about making a pretty picture of your tree. The goal is to record your observations and ideas.*
   - *Use both drawings and writing to show your observations. If you're more comfortable drawing, draw more. If you're more comfortable writing, write more.*
6. Model how students could record tree observations as you do a Think-Aloud.
   a. Model adding a couple of labels to your drawing, doing a Think-Aloud as you decide what words to record.
   b. Do a Think-Aloud as you model adding writing to the page.
   c. Model looking for tree interactions and adding them to the page.
   d. Model writing a descriptive name for the tree.
7. Share that students will begin observing their trees without journaling and that you will bring students a pencil and a journal page when it is time to start journaling.
8. Share a premade example of a Tree Journal page, modeling these features.
9. Assign partners or invite students to find their own partners.
10. Warn students of any hazards, share the boundaries, and demonstrate the attention-getting signal you will use when it's time to regroup.
11. Send pairs to choose a tree to explore and observe (without journaling for now).
12. After pairs have observed their trees for at least 5 minutes (but before students lose interest), ask them to begin journaling.

FIELD CARD

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

13. Circulate as students work, supporting student participation and engagement, modeling observation strategies, and troubleshooting.
    - *What are you noticing about the tree?*
    - *What do you notice about the bark? The leaves? How about the shape of the whole tree?*
    - *What evidence/clues/signs of animals living here do you notice?*
    - *What makes this tree a good place for the animal to be?*
    - *How could you observe in a different way—like looking up close or far away—to notice more?*
    - *Oh, that's a really interesting question (observation, connection, etc.). Be sure to record that in your Tree Journal!*

Making Sense of Trees

1. After students have had time to explore their trees and journal, but before they lose interest, call the group back together.
2. Ask pairs to connect with another pair to share and compare their trees.
3. Distribute one copy of the Tree Interactions diagram to each pair of students and share: There's a lot going on with trees!
   - *There's a lot going on with just the tree itself—roots, branches, bark, etc.*
   - *Beyond that, it's not just a tree! There are a lot of things interacting with a tree. This is a diagram of a tree that has information about how trees interact with other things in the environment.*
4. Offer a definition for the term *interaction*, share some examples, and ask students to brainstorm types of interactions between different organisms and nonliving parts of the ecosystem.
   - *When an animal eats something, it's interacting with the thing it is eating; when a bird flies, or when a plant takes in gases and releases gases, they're interacting with air; and even when an animal stands on something else, it's interacting with it.*
   - *What are different ways living and nonliving things might interact with a tree?*
5. Model discussing one interaction shown on the Tree Interactions diagram. For example:
   - *I notice that there is a drawing of a caterpillar on the tree. It is making holes in the leaves. I wonder how those holes affect the leaf? Do the holes make it so the leaf doesn't work as well?*
6. Ask students to study and discuss the Tree Interactions diagram with their partners and to use it to figure out as much as they can about how trees interact with other parts of their environment.
7. As students look at the Tree Interactions diagram, circulate and engage them in conversation about their ideas.
8. After students have had some time with the diagram (but before they become disengaged), gather the group around the same tree you used in your introduction and lead a discussion in which students share a few things they figured out about trees and things that interact with trees from the diagram.
9. Throughout the discussion, connect statements to the tree you are next to, ask follow-up questions, encourage students to share ideas, and share and add some information yourself about the topics in which students are most interested.
10. Conclude the discussion by sharing that trees are deeply interconnected with living and nonliving things in their ecosystems, but many of these connections are hard to see.
11. Make a connection between the thinking that students have done while exploring trees and the NGSS Crosscutting Concept of *Systems and System Models*.
    - *You all have been observing a tree, looking at the parts of a tree, and thinking about how the parts of a tree interact or are connected to things around it—such as animals, other plants, and things such as water and soil.*
    - *This approach—thinking about the parts of a system and thinking about how the parts affect one other—is something that scientists and thinkers who study many things use in order to learn.*

Part 2

Identifying Trees

1. Share that students will have the opportunity to use a tool to identify their trees, distribute a copy of the simple tree identification field guide/key you made to each pair of students, and offer guidance on how to use it.

FIELD CARD

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

- *This is a tool we will use to identify, or learn the names of, trees. When we know the names of trees or plants, it can be like recognizing friends wherever we go!*
- *Let's practice. To use this tree field guide, we can look at the pictures of leaves, bark, fruits, nuts, and seeds and try to see which one matches our tree.*
- [If your guide also has words on it] *We can also read the words to get more information that the pictures can't show us, such as: Bay Laurel trees have a strong smell.*
- *Let's look at this tree* [point to an example tree, preferably a tree species that none of your students observed]. *With your partner, look through the tree field guide and try to figure out what tree it is.*
- *Share your evidence, such as: I think this is a Bay Laurel because the leaf has a strong smell, and it says that on the page, and because the leaf on the tree and in the picture are both the same shape as a feather."*

2. Invite pairs to return to their trees with the tree identification field guide/key, use evidence to identify their trees, and use what they learned in the discussion or from the Tree Interactions diagram to understand their trees better.
3. As students use the field guide/key to identify and think about their trees, circulate and engage them in discussion about their ideas.
4. Guide the group to review the kinds of trees they've identified and share their evidence.

Reflecting on Trees

1. Lead a *Thought Swap* (formerly known as *Walk & Talk*) to facilitate students reflecting on the experience and what they have learned.
   - *What are some meaningful or exciting things you learned about the tree you observed?*
   - *What are some things you learned about trees that surprised you?*
   - *What are some thoughts, ideas, and questions you have about trees?*
   - *What are some skills you used to learn about trees? How might you share about these skills with a family member or friend who wanted to learn about trees?*
   - *Discuss the trees you learned to identify and the characteristics that helped you identify them.*
   - *How could you use what you learned about identifying plants when you go home?*
   - *What did you learn about how to record observations and ideas in a nature journal?*
2. Throughout the rest of your field experience, encourage students to notice and identify trees, using evidence.

Optional Extension: Writing Tree Poems

1. Invite students to find a place to sit near a tree.
2. Share that students will have the opportunity to write a poem about a tree.
3. Offer some scaffolding to guide students' writing.
   - *You will have an opportunity to write a poem inspired by your tree, what's around it, and your response to it.*
   - *Begin by using "I notice, I wonder, it reminds me of . . ." to describe the tree. You could observe things such as the branches, what is near or around the tree, or focus on shapes and colors. Add questions or things the tree reminds you of—either the whole tree or a specific part of the tree such as a leaf or the trunk.*
   - *Then, turn the prompts "I notice, I wonder, it reminds me of . . ." inward to describe your internal experience, emotions, and thoughts in this place and as you are observing this tree.*
   - *Alternate back and forth between looking out and describing what you see or notice and looking within and writing about what you notice about how you feel and what you are reminded of.*
   - *You can add to the poem the observations, questions, and connections you made while studying your trees earlier.*
   - *If you're ever not sure what to write, you can always come back to noticing and making observations of the tree.*
4. Give students 10–15 minutes to write their poems.
5. Bring students back together and offer individuals the opportunity to share their poems or a part of their poems if they would like to.
6. Consider writing an example poem to share with students or offer the example poem in the activity script.

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 Acknowledgements:

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/*.

Tree Exploration was inspired by and adapted from the following activities submitted by BEETLES partners: *Plant Diversity* by Rebecah Jones at Westminster Woods, *Similari-trees* by Mel Sarmento at Guadalupe River Park Conservancy, and *Tree Habitat Exploration* by Samantha Spina at Descanso Gardens. We are very grateful for their generous offering of these activities.

BEETLES Team: **Craig Strang**, **Kevin Beals**, **Jedda Foreman**, and **Emilie Lygren**
Additional Contributors: **Emily Arnold**, **Lynn Barakos**, **José González**, **Catherine Halversen**, **Valeria Romero**, and **Emily Weiss**
Research Team: **Mathew Cannady**, **Melissa Collins**, **Rena Dorph**, **Aparajita Pande**, **Valeria Romero**, and **Aujanee Young**. 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 2012-2020 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.