beetles
Science and Teaching for Field Instructors

Student Activity Guide

What's in Compost?

Guiding Question: *What is in compost, and why is it there?*

Many students love finding and observing live organisms, and compost is often rich with organisms. Even students whose first reaction is that compost is icky or stinky tend to become engaged as they find cool organisms and begin to figure out how things decompose into soil. Compost is a key part of many gardens, and giving students the opportunity to directly observe what is in compost is offering an opportunity for them to build their understanding of how composting and decomposition works.

In *What's in Compost?*, students discuss or think about the Guiding Question: *What is in compost, and why is it there?* Then, pairs search through trays of compost, use the key to identify what they find, and record their discoveries on a journal page. Students also discuss interactions between parts of compost, think about the effects of adding different things to compost, and continue to build understanding of how compost works. In optional extensions, students search for evidence of decomposers or read about the types of organisms they found in a book. Finally, students return to the Guiding Question and reflect on what they've learned.

Students will...

- Search through compost and categorize what they find, using a picture-based key.
- Record on a journal page what they find.
- Make possible explanations to figure out why what they found might be in compost.
- Consider the effects of putting different things in compost.
- Optional: Read Handbook of Forest Floor Animals; Search for evidence of decomposers in the garden

Grade Level:
Grades 3-8

Timing:
Approximately 35–75 minutes

Related Activities:
Decomposition Mission; Case of the Disappearing Log; What Lives Here?; Food, Build, Do, Waste; Worm Explorations; I Notice, I Wonder, It Reminds Me Of

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

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

Setting:
In a garden, classroom, or outdoor learning area where students are able to observe compost trays on tables or on the ground.

Equity, Inclusion, and Cultural Relevance (informed by Youth Outside):
This activity has been designed to demonstrate how to create an equitable, inclusive, and culturally relevant teaching and learning experience. Read more on page 18.

NEXT GENERATION SCIENCE STANDARDS
For additional information about NGSS, go to page 20 of this guide.

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Constructing Explanations	Cause and Effect	Cycles of Matter and Energy transfer in Ecosystems, Interdependent Relationships in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

What's in Compost?

ACTIVITY OVERVIEW

What's in Compost?	Learning Cycle Stages	Estimated Time
Introducing the Activity	Invitation	5-10 minutes
Exploring Compost	Exploration, Concept Invention	15-20 minutes
Discussing Compost	Exploration, Concept Invention	10-20 minutes
Option 1: Reading *Handbook of Forest Floor Animals*	Concept Invention	10+ minutes
Option 2: Searching for Decomposers in the Garden	Application	10+ minutes
Reflecting and Wrapping Up	Reflection	5 minutes
TOTAL		~35-75 min

TEACHING TIPS

Read the Instructor Support Section. Beginning on page 12, you'll find more information about pedagogy, equity and inclusion, student misconceptions, science background, and standards.

You need rich compost. This activity is exciting when students can find and identify a variety of organisms. ***Check weeks in advance*** to make sure your compost is rich with organisms. If it's not, add food scraps and make sure it's moist enough for critters to thrive, but not so wet that it will be messy to handle.

Deciding how to use the key. The key is two pages. The first page of the key shows pictures of things students might find in compost. The second page shows the same pictures and also includes written information alongside each picture. It's ideal to print this key as one double-sided sheet so students can identify what's in compost and then read or learn a bit about each thing they find. For younger students, you might choose to just distribute the page of the key with pictures. This would reduce the amount of time you'd need to introduce the activity.

Selecting optional extensions. After students find things in compost, they are often curious and want to know more. This is a great opportunity for students to access some content or think more deeply about compost through one of the optional extensions, explained further in the Materials and Preparation section (on page 3).

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

PREPARATION

1. **Check weeks in advance to make sure your compost is rich with organisms.** Some hard chunks of compost can be fun, too, as students can crack them open to find isopods curled up inside. If you don't have ideal compost, look to community gardens that do have compost rich in organisms and ask if they'll let you use some samples. Or, alter your own compost to try to support organisms by adding food scraps, water, or making other alterations.

   > **Finding the right compost.** Mature or "finished" compost (very decomposed, mostly soil) isn't very rich with organisms to find. New compost with mostly very fresh food scraps is less interesting for students to investigate because there are likely fewer organisms living in it and less evidence of decomposition. Compost that is too dry or too wet can also be hard to handle or lack organisms. Compost that has lots of decomposing scraps will tend to have lots of organisms. The compost you want is not too fresh, not too decomposed, not too dry, or too wet, but just right.

2. **Make copies of print materials.** Make copies of the following print materials:
   - Compost Key: 1 double-sided copy for each pair of students
   - Compost Key Example photos: 1 set of 3 photos
   - Procedural signs: 1 set of 5 signs
   - Things Found in Compost journal page: 1 copy for each student
3. **Gather materials.** Gather containers of compost samples, craft sticks, pencils, and clipboards.
   - **optional: write or print text of discussion questions on paper or a manila folder.**
4. **Decide whether to do optional extensions.** The core of this activity is designed to be completed in approximately 35 minutes. If you have more time and think your students will be up for it, choose one of the two optional extensions: Option 1: Reading *Handbook of Forest Floor Animals* or Option 2: Searching for Decomposers in the Garden. Reading *Handbook of Forest Floor Animals* is a great way for students to learn more about things they might have found within compost and to practice accessing information from text. Searching for decomposers is a fun application opportunity for students to connect their learning about decomposers in the compost pile to the garden environment.
5. **Optional: If you choose Option 1: Reading *Handbook of Forest Floor Animals*, obtain one or more copies of the book.** This is a nonfiction informational text about forest floor organisms, many of which are found in compost. Although the book is written for 2nd–3rd graders, the content and illustrations make it appealing to older students as well. (Note: You might need to look for a secondhand copy of the book. If you can't find one, look for an age-appropriate informational text about organisms that could be found in compost.) Following are three suggestions for how to read the book with students:
   - **Obtain 1 copy per pair (ideal!).** Pairs can follow their own interest by engaging directly with the book.
   - **Obtain 1 copy for the class.** Familiarize yourself with the book so you're prepared to summarize information in the chapters for students. Show the book to students, read the names of the chapters out loud, and ask students which chapter(s) they're interested in. Then, summarize the content of the chapter while showing students the pictures.
     - Chapters include: Beetles, Centipedes and Millipedes, Crickets, Earthworms, Pill Bugs and Sow Bugs, Snails and Slugs.
   - **Loan 1 copy or a classroom set.** If you are not students' classroom teacher, loan a single copy or a classroom set to students' classroom

MATERIALS

For the instructor:

- ❏ compost sample (to show students at beginning of lesson)
- ❏ 5 signs (pages 23-27): 1 Guiding Question, 3 procedural signs, *Decomposer* definition
- ❏ 1 copy of Compost Key Examples (slug, rotting fruit, centipede), page 29 (or actual rotting food scraps)
- ❏ optional: 1 copy of the *Handbook of Forest Floor Animals* book
- ❏ optional: additional discussion question signs

For each group of four students:

- ❏ compost sample in container (e.g., a tray or bowl)
- ❏ 1 craft stick
- ❏ optional: small containers (e.g., plastic cups) to isolate organisms for observing
- ❏ optional: 1 hand lens (or 1 per student)

For each pair of students:

- ❏ 1 copy of Compost Key, pages 30-31 (printed two-sided, in color)
- ❏ optional: 1 copy of the *Handbook of Forest Floor Animals* book

For each student:

- ❏ 1 copy of Things Found in Compost (journal page) page 28
- ❏ pencil
- ❏ clipboard

TEACHING NOTES

Using the book supports students in accessing content. At the end of the lesson when students are curious about what they've found in compost, it can be a great opportunity for them to learn some content. Accessing content through reading a book or through following along as an instructor guides them through the text of a book, is an opportunity for learning more about compost and decomposition. This also builds students' academic literacy skills, supporting them to access information on their own in the future through text.

Collaborating with classroom teachers. If you are an informal educator or garden education specialist, consider how you might collaborate with classroom teachers. It can be difficult for garden specialists to fit everything into their allotted teaching time. Knowing that collaborating classroom teachers will follow up the lesson with a reading on the topic and build on students' learning in the garden can relieve some of that pressure, and it is an opportunity for students to make connections between the garden and their learning in the classroom.

PREPARATION

teacher. (Note: You might need to look for a secondhand copy of the book. If you can't find one, look for an age-appropriate informational text about organisms that could be found in compost.)

- **Book information:** *Handbook of Forest Floor Animals* by Marco Bravo and Kimi Hosoume. Illustrated by Jeff Grader. © 2007 The Regents of the University of California [http://store.lawrencehallofscience.org/index.php?app=ecom&ns=prodshow&ref=501092&LHS_SRC=ajax]

6. **Optional: If you choose Option 2: Searching for Decomposers in the Garden, check if decomposer evidence can be easily found in your outdoor areas.** Do a search before class and poke around to make sure there are decomposers or evidence of them for students to find. Look in your compost bins, under logs, stumps, sticks, or stepping stones, etc.

Introducing the Activity

1. **Show a sample of compost to students and share:**
   - ▶ *This is compost. We put it in the soil when we grow plants, and it's very important for gardening because it's rich in nutrients that help garden plants grow.*
   - ▶ *It can be very interesting to explore, because lots of things live in compost.*

2. **Hold up the sign showing the Guiding Question, read it out loud, and then invite students to *Thought Swap* (formerly known as *Walk & Talk*) or *Turn & Share* about the question.** Share:
   - ▶ *This is our Guiding Question for today. We'll be thinking about this question for all of class: What is in compost, and why is it there?*
   - ▶ *Please (*Turn & Share, Thought Swap*) about the question. Since we haven't explored compost yet, discuss what you think might be in compost, what you've heard about compost, or what you notice about this compost I'm holding.*

3. **Share that students will get to find out what is in compost by exploring it and looking for decomposers:**
   - ▶ *You're going to get to do some science and find out what lives in compost by making your own observations! You'll be looking for decomposers and anything else you find.*
   - ▶ *We'll also be observing what gardeners put into compost and thinking about why they add those things to compost.*

4. **Offer a definition for *decomposers* while holding up a sign showing the definition and showing students a food scrap and finished compost.** (Or, if your students are already familiar with decomposers, remind them of the definition here).
   a. ***Decomposer* definition:** Decomposers are living things that break down things that used to be alive into parts of soil.
   - ▶ *Decomposers are living things that break down things that used to be alive into parts of soil. Decomposers eat things such as this (*show a piece of food scrap*) and turn it into this (*show rich soil*). The rich soil is great for gardening.*

5. **Share that when a gardener sets up a compost pile, they're trying to make a place where decomposers can survive, so decomposers will live in the compost and turn wastes into soil:**
   - ▶ *Compost piles are homes that gardeners build for decomposers to live in so the decomposers will decompose food wastes into soil. It's a cool deal—the gardener puts food waste in, and soil comes out!*

6. **Share that students will get to search through compost to find decomposers and whatever else is in compost.**

7. **Distribute one copy of the Compost Key to every pair of students and one copy of the Things Found in Compost journal page to each student.**

8. **Share that students will practice using a tool to identify things in compost and then guide students through the process of using the key.** After pairs receive a key, share that it is a tool to identify things in compost.

TEACHING NOTES

Logistics of the *Thought Swap* (formerly known as *Walk & Talk*) routine. See the BEETLES activity *Thought Swap* for the logistics of this discussion routine. Wondering why we changed the name from *Walk & Talk*? As a part of an effort to use more inclusive language in our resources, we changed the name so we were not normalizing walking as the only way of moving, and talking as the only way of communicating.

Learning new words. It takes about seven exposures to learn new vocabulary words. It's worth being intentional about the vocabulary you choose to share with students and taking the time to define a complex concept such as decomposers, even if students have already engaged with the concept before.

Definition for older students. If you're working with older students (middle school and up), you might choose to use this more nuanced definition of *decomposers*: Decomposers are organisms that break down dead plants, algae, animals, and other organic matter into simpler forms of matter such as nutrients that become part of soil, the air, or large bodies of water. Decomposers break down things into forms of matter that plants and algae can use to build and grow.

TEACHING NOTES

Learning how to access information. Guidance and modeling can support students in navigating different types of informational text, including pictorial identification keys like the one in this activity. Scaffolding the process of engaging with the key can set up students for success, particularly if interacting with informational text is a newer skill for them.

Support, scaffolding, and student engagement. *What's in Compost?* includes scaffolding throughout the activity to support students' participation. When the instructor models accessing information from a field guide or 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 to clarify definitions. This activity write-up also offers a range of options for how students might respond to a question, including writing time, thinking time, or *Pair-Shares*; this encourages instructors to consciously choose the approaches that are engaging for their specific group of students.

a. **Hold up and post Procedural Sign 1: *Look through compost and find things on the key.***

b. **Offer guidance on how to use the key to look up things students find:**

- ▶ *This key is a tool for identifying things in compost. When you find something in your compost, look at the pictures and words on the key and try to find a match for what you see in the compost.*
- ▶ *Then, read about why it might be there.*

(Note: If you haven't included the second page of the key that includes text, just have students try to find a match with one of the pictures.)

c. **Hold up slug photo and share:**

- ▶ *Let's practice how this will go. What if you found this in your compost? Look for it on your key to try to identify it. Give a* [thumbs up or other signal you share] *when you and your partner have found it or ask for help finding it if you need to.*

d. **Offer framing on how to use the key to identify the part of compost and look up information:**

- ▶ *Look at the title of the group the slug is in. What group is it in?"* [Decomposers.]
- ▶ (If you are using both pages of the key*) Now, find the slug on the back of the key. What's one piece of information about slugs that's in the key? What's another one?* [They eat plants that have died and also eat plants that are still living. They live in moist areas.]

9. **Repeat the same process as in Step 8, using the example photos to introduce each of the other sections of the key (Evidence of Decomposers, Not Decomposers):**

   a. **Use examples of spider and rotting fruit.** Use the photo of the spider for Not Decomposers and the photo for rotting fruit (or actual food scraps, if you prefer) for Evidence of Decomposers.

   b. **Each time, guide students to find the example object on the key, practice looking at what group it's in, and access written information from the key.**

   c. **Offer context that will support students in using the key, including addressing common misconceptions.** For example, when you introduce the "Not Decomposers" category, share that not all invertebrates are decomposers. Use the spider photo as an example. (This contradicts the common misconception that all invertebrates are decomposers.) When you introduce the "Evidence of Decomposers" category, share that rot or rotting smell, big brown blotches, dots, or watery spots are evidence of decomposers and that some decomposers, such as bacteria, are too small to see but leave behind this evidence.

10. **Set expectations by sharing that students' samples of compost might not include everything on the key.**

11. **Hold up and post Procedural Sign 2: *Record what you find.* Share that after students find and identify something in compost, they can write**

what it is in the appropriate box on their Things in Compost journal page:

- ▶ *After you find something in compost, use the key to identify it. Then, read a little about it and write its name on your Things in Compost journal page—in the box with the same title as is on the key: the "Decomposers and Evidence or Decomposers" box or the Not Decomposers" box.*
- ▶ (Show slug photo again) *Which category on the journal page should you put it in?* [Decomposers.] *Now, point to where you would add it on the journal page.*

12. **Share: Students will look through compost in groups of four, discuss what they find, and use the key to learn more.** However, each student will write on their own journal page. Share that students can use craft sticks to search through compost if they don't want to touch it and can put organisms in plastic cups if they want to observe the organisms more closely.

Exploring Compost

1. **Divide students into groups of four, distribute materials, and invite students to begin exploring compost.** Encourage students to work together as a team. Offer any reminders for following your specific garden rules and protocols.

2. **Circulate, troubleshoot, and engage with students as they work.** As students work, circulate and support any groups that are struggling with working together and guide students to stay focused and engaged in the activity:
   - **Encourage the use of the Compost Key.** Remind students to use the key to look up what they find in compost and to read the key to learn more information about what they find.
   - **It's okay for students to focus on different aspects of the task.** Don't worry if groups are at different stages with their journal pages or if different members of the same group are also at different stages of the activity. Some students might be more excited about finding things in compost, while others might engage more through writing. Encourage students to do more of what they are excited about, as long as they're engaged in some part of the activity.
   - Ask broad questions to encourage curiosity. Offer questions such as:
     - ▶ *What have you found so far?*
     - ▶ *What makes you say that's evidence of a decomposer?*
     - ▶ *What else can you find? What about this? What category does this go in?*
   - Encourage students to look at ALL parts of the compost. Encourage students to look at food scraps, grass, hay, inside dirt clods, and the soil itself—and not just at the organisms. To engage a group of students, pick up a part of the compost on which the group isn't focused and ask, "What do you think this is? What makes you think that?"

TEACHING NOTES

Using journaling to focus students. In field tests of this activity, some instructors left the journal pages out of the activity and then wished they hadn't. Field testers noted that the journaling supported students in focusing and organizing their thinking.

Engaging and managing students. Decide whether it's best to pre-assign your students into groups of four or for students to form their own groups. Recruit extra energetic students to come get supplies for their groups.

Group size. This activity was designed for groups of four. However, if you think your students will be more successful working in pairs, adjust the activity accordingly.

Students who think it's icky. If any of your students are grossed out by exploring the compost, take some time to find organisms with them, modeling excitement about your finds. Remind students that they don't need to touch anything; they can use the craft stick to poke around. If a student is really struggling, encourage them to focus on asking other group members questions about what they're finding and on writing information on the journal page. See more about why compost smells in the Instructor Support Section.

Distinguishing roly-polies and sow bugs. Sow bugs and roly-polies are very similar, so it's easy to misidentify them. If you notice students misidentifying these two organisms, challenge them to compare the two photos on the key carefully. (Some notable differences are: roly-polies can roll into a ball, while sow bugs cannot. Sow bugs have antennae-like structures sticking out of the rear part of their bodies). Learning how to tell these two organisms apart is often an exciting "aha" moment for students. (If students are unsure how to pronounce *sow*, share that It rhymes with *ow*.)

3. **After 10–20 minutes, but BEFORE students lose interest, get their attention and call them back to your meeting area.**

Discussing Compost

1. **Using some of the questions below, facilitate a discussion about compost.** Choose a discussion strategy that you think will work well for your group of students. (This could be *Turn & Share*, writing/thinking time leading into a pair discussion, a group discussion, or some other discussion strategy). Use the following approaches to support the discussion:
    a. **Optional: Hold up the large question signs.** If you've made signs showing the discussion questions, hold up a sign for each question as you pose the question to the group.
    b. **Pairing students.** If you're only doing a paired discussion with no large-group discussion, it's ideal to pair up students with members from a different group so they hear about what others found in compost.
    c. **Ask some of the following questions, prioritizing the questions in bold.**
        - ***What did you find? How do you think it got there?***
        - Example of related follow-up questions:
            - *If you found something, do you think the gardener put it there? If so, why do you think they would think it's a good thing to include in compost?*
            - *If the gardener didn't put it there (such as some kinds of organisms), why is it in the compost? How does it benefit from being in the compost? How could it have gotten there?*
        - ***As a gardener, what would you need to put in compost so decomposers can live there?***
        - ***What are some ways to finish this sentence: Gardeners want decomposers in compost because . . .***
        - ***What are some things decomposers eat? Think back to the key or make an explanation based on what you already know about decomposers.***
        - *What might be harmful to decomposers if you put it in your compost?*
        - *What should you do to take care of your compost throughout the year so decomposers can live/survive there?*
        - *Where might we find decomposers in the garden? What makes you think that?*

2. **Share that scientists use cause and effect to think about how the world works.** Then, offer an example of cause-and-effect thinking.
    ▶ *Scientists sometimes try to think about causes and effects to figure out how something works or what might happen in the future.*
    ▶ *For example, I might want to make decomposition happen faster in the compost. So, I'd think about some things I could do—or causes that would lead to that effect.*

TEACHING NOTES

Pair or group discussion? This section provides important opportunities for students to think about the observations they made and to begin to take their learning deeper as they make explanations about worm structures and behaviors. If your students are newer to participating in group discussions, you can offer each question and then give students time to *Turn & Share* about it in their pairs.

Modeling answers to a question. To support students in participating in discussions, it can be helpful to offer an example of what the discussion you're asking them to have might look like. For example, after reading the first two questions to the group (*What did you find in the compost? How do you think it got there?*), you might model one person saying, "Well, we found mostly things that were decomposers, and we thought they were there because there was food there for them to eat." Then, model another person responding, "Oh yeah, we found lots of evidence of decomposers on food scraps, etc." These "Think-Alouds" support emerging multilingual learners and all learners to participate more successfully.

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

- ▶ *If I cut up a banana peel before I put it in the compost, then, maybe it would decompose faster, because then there would be more surfaces that organisms could get to and eat more easily.*
- ▶ *The effect is decomposers getting to it more easily and decomposing it faster.*

3. **Invite students to brainstorm possible effects of putting different things in compost.** Share about how gardeners use cause-and-effect thinking. Then, ask students to think about the effects of putting a few different things in compost.
   - ▶ *When gardeners make compost, they think about cause and effect, too. They want the compost to be a place with the right conditions for decomposers to live in and turn food scraps into soil.*
   - ▶ *They try to figure out how putting different things in compost might cause or make certain effects happen, and they use this to decide what to put in (or not put in) compost.*
   - ▶ *What might be effects of putting the following in compost:*
     - *food scraps*
     - *straw*
     - *meat*
     - *plastic*
     - *sticks*
     - *pesticides*

   [Students might say: Food scraps will be eaten by decomposers and would turn into soil over time. Straw could make more air pockets in the compost and make it more possible for decomposers to live there. Plastic won't break down because decomposers can't eat it. Pesticides could cause harm to decomposers or other living things in the compost, so maybe they would die.]

4. **Invite students to discuss what might have caused certain effects or conditions to happen in compost.** Ask:
   - ▶ *Scientists also try to figure out what might be causing the compost to be a certain way, such as too wet or dry. What might be possible causes of the following effects:*
     - *The compost is too wet.*
     - *The compost is too dry.*
     - *There aren't very many decomposers in the compost.*
     - *Things are decomposing very slowly in the compost.*

   [Students might say: Rain or lots of food; the compost is too packed and there isn't enough air circulating for decomposers; there aren't enough decomposers; weather conditions, etc.]

Optional Additions (5-15 minutes)

If you have time and think it will work well for your group, include one of these optional additions to give your students the opportunity to apply their learning and to go deeper with the topic.

TEACHING NOTES

Trash in your compost. Compost often includes bits of trash, such as plastic labels from produce. When students find these in their compost samples, it can lead to discussions about how long it takes for the trash to decompose, why there shouldn't be trash in compost, where "away" is when you throw things in trash cans, etc.

Understanding decomposition. It's a common misconception that decomposers break down dead things into soil for the sake of other organisms and the benefit of the ecosystem. A well-developed understanding of decomposition is that a variety of organisms, primarily microscopic bacteria and fungi, consume the matter of dead organisms, not because they feel like helping out the ecosystem, but for their own survival. This nuanced understanding of decomposition takes time to develop, and this activity is one opportunity for students to deepen their understanding. For more on common misconceptions and more accurate information about decomposition, see pages 16-18 of the Instructor Support section.

TEACHING NOTES

One book per pair is ideal. If you have enough copies, distribute one book to each pair and then invite students to look at the names of chapters, follow their interests, and look up and read about different organisms. Ask students for ideas on how they can share the book and task successfully.

Some decomposers eat both living and nonliving things. Organisms often don't strictly follow rules of categories in which we humans put them. If your students observe an organism that usually functions as a decomposer—such as a sow bug eating something alive, such as a living plant—you can offer the idea that many organisms will eat what is available and that humans have come up with categories of organisms such as "Decomposer" based on what organisms eat most of the time.

Engaging directly with nature. Centering learning on students' in-the-moment observations of worms 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, and students who have had more exposure to science tend to have an advantage.

Option 1: Reading *Handbook of Forest Floor Animals*

1. **Gather students and show them the book *Handbook of Forest Floor Animals.*** Show students the book and share that it has information in it about some of the animals they observed in their compost.

2. **(If you only have one copy of the book) Read the names of the chapters out loud and then ask students to pick one or two chapters about which they are most interested in learning.** After you share the titles from the Contents page, ask students to vote (or decide in some other quick way) which one or two chapters they want to learn from.

3. **Summarize the chapters chosen by students out loud to the group.** If you won't have time to read an entire chapter out loud, show students some illustrations as you summarize some of the main points from the one or two chapters that students chose.

4. **Connect information in the book to things students observed in compost.** Where possible, make connections between what students observed and information in the book. For example, if students found sow bugs, you might say:
   - ▶ *Remember how we saw sow bugs and noticed a yellowish thing on some of their bellies? This book says that females carry eggs in a pouch on their bellies. Raise your hand if you saw something like that on one of the sow bugs you found. Check it out! You can see baby sow bugs in this picture!*

5. **Encourage student questions.** If you have time and students are excited about the topics, encourage them to ask questions about compost, things that might be in the book, or anything else related to the Guiding Question.

Option 2: Searching for Decomposers in the Garden

1. **Share that students will have a chance to search for decomposers and evidence of decomposers in the garden (or other outdoor area).**

2. **Invite students to discuss or think briefly about the following questions before you send them to explore:**
   - ▶ *Think about this question for a minute: What might be evidence of a decomposer?" (Invite a few students to share examples.)*
   - ▶ *Where might you find decomposers or evidence of decomposers in the garden? (Invite a few students to share examples.)*

3. **Remind students of any garden exploration protocols you have, encourage them to share what they find with each other, and then give students 5–10 minutes to explore.**

4. **Circulate and engage students in conversation about what they found.**
   - As you circulate, ask students to share what they found and what made them think that what they're looking at is a decomposer or evidence of a decomposer.
   - Consider asking questions or gently offering a correction if students miscategorize what they find. If students find something eating a living

leaf in the garden and identify it as a decomposer, ask students about their evidence and reasoning. Or, point out that it's eating a living plant and share that decomposers generally eat things that *used* to be alive.

5. **Optional: After students come back, ask additional discussion question:**
   - ▶ *Do you think compost or the garden is a better environment for decomposers to survive in? What is your evidence?*

Reflecting and Wrapping Up

1. **Ask students to look at the Guiding Question again and think about what they know now about the question.** Also have students reflect on the learning experience.
   - ▶ *Take a look at our Guiding Question again: What's in compost, and why is it there?*
   - ▶ *Think for a minute, what do you know about the Guiding Question now? What have you learned since the beginning of class?*
   - ▶ *What did you do today that helped you to learn about compost?*
2. **Ask students to return their materials by using whatever system you have for your garden.**

Additional possible follow-up activities:

- Pairs choose one organism from the compost and journals about it, using words, pictures, and numbers to describe what they see. (Each student makes their own journal entry.)
- Invite students to help you make additions or adjustments to the compost pile, including adding and chopping up food scraps, watering the compost, adding green plants, etc. As you work, engage informal discussion about the possible effects of the additions and adjustments.
- Students do more in-depth research on an organism they found in the book *Handbook of Forest Floor Animals* or in other sources.
- Students apply what they learned by actually planning and making their own compost or helping the gardener plan what to put in the compost next.
- Students put together a food web showing what eats what in the compost. Students can use information from the "Things Found in Compost" key, along with *Handbook of Forest Floor Animals* to make their food webs.

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Broad questions and science learning. Science is often viewed or taught as a collection of facts; this is reinforced by science learning experiences that focus on memorization or recall of facts and narrow questions posed to students that invite only one correct answer. However, science is a way of knowing and a process for thinking and learning, not just a body of knowledge. Including broad questions in science learning (questions that have multiple possible responses, such as "What might be the effect of putting pesticides in compost?") engages students in scientific sense-making, encourages critical thinking, and makes space for divergent perspectives and differing ideas to be shared. Weaving broad questions throughout science lessons also sends the message that students' ideas and creative thinking are an essential part of science learning, contradicting the exclusionary idea that memorizing facts is what it means to be good at science.

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Instructor Support

Teaching Knowledge

Adapting this activity. The overall structure of this lesson is: a short introduction focused on posing the Guiding Question and scaffolding the activity instructions; giving students time to explore compost and learning from their own observations, the Compost Key, and one another; discussing what students found and thinking about how compost works; and returning to the Guiding Question.

The Learning Cycle. The structure of this activity is learning cycle–based (see Activity Overview on page 2). Keep this general structure to support student learning. The activity is designed intentionally so most of students' time is spent actually looking at compost. Include at least one optional section in order to make the experience a full learning cycle and to give students the opportunity to apply their learning. Skip the optional activities if you don't have the time or if it's not possible, given your setting or the needs of your students.

Options for discussion. This activity suggests different options for discussion, including pair discussions and group discussions. Offering time for students to share ideas in pairs before sharing with the whole group is an important way to support participation in this activity. Pair-Shares interspersed with whole-group talk tend to lead to more participation in the whole-group discussion, student engagement, and also to more thoughtful responses.

Supporting authentic engagement. Students might be more engaged or less engaged with different aspects of the activity. For example, one student might be really excited to find things in compost—so excited that they don't focus much on the journal page. Another student might not be as enthusiastic about touching things in compost, but is totally hooked on looking at the Compost Key. It's a goal of the activity, of course, for students to learn a bit about what's in compost and why it's there; there are many ways for students to engage in this kind of learning successfully. It's also a goal to get students excited about being in the garden, interested in compost, and engaged in actively exploring something while they are there. Offering autonomy in what students focus on is one way to support their excitement and engagement.

Conceptual Knowledge

The following information is meant as background information for instructors and not as talking points for a lecture or as a list of concepts that students should understand. The content presented here goes much deeper than the activity does, and it is meant to give instructors background knowledge to be able to address student questions, effectively plan a sequence of age-appropriate activities to develop student understanding of the concepts, and avoid perpetuating common misconceptions about the topic.

Some goals of this activity are for students to get a sense of what's in compost; build some understanding of what decomposers are by observing them; and separate compost into parts, including decomposers, not decomposers, and evidence of decomposers. This can help students develop an understanding of what decomposition actually is and what the process looks like. Other (equally important) goals are for students to practice skills such as making observations, constructing explanations, engaging with resources (e.g., a field guide), and working together in teams. It's also a goal for students to have fun finding organisms and getting to check out compost!

Decomposition is a complex process, and it takes time to build an understanding of it. The main ideas about decomposition that most elementary/middle school students can begin to develop through this and other activities are:

- Decomposers help break down (or decay) dead organisms.
- Decomposition is the process of dead organisms breaking down into smaller and simpler parts.
- When dead organisms decompose, they eventually become part of the soil, water, and air. Most decomposition takes place in the ocean where there is no "soil."
- Plants use the nutrients from soil, and algae use nutrients from ocean water—not as food, but as vitamins that help keep their body systems healthy.
- Decomposers are important to ecosystems because they make matter available to photosynthesizing organisms such as plants, algae, phytoplankton, and microbes. Decomposition is an important part of matter cycling through ecosystems.

***Producers, consumers*, and *decomposers* are three terms used to categorize organisms in an ecosystem.** Producers—such as plants, microbes, and algae—are able to produce their own food from inorganic substances such as carbon dioxide and water. Consumers get their energy and matter by consuming other organisms. Decomposers are organisms that break down dead organisms and their wastes into simpler forms of matter—chemically different substances—such as nutrients that become part of soil or ocean water and carbon dioxide that becomes a part of air.

It can be frustrating for students to try to categorize organisms, if the categories are portrayed as absolute and clearcut. To try to understand matter cycling and energy flowing through ecosystems, ecologists have given names to categories of organisms to describe their roles in ecosystems. Of course, whenever you try to categorize something as wonderfully complex as an ecosystem, there are always gray areas, and you can end up with organisms that fit in multiple categories. More categories get invented to clarify and describe subtle distinctions, but these categories can also be confusing to students.

It is more satisfying (and interesting) if students understand that categorizations are useful but that there are gray areas to discuss. The term *decomposer* can itself be confusing because there are many things (including animals and plants) that contribute to decomposition but are not considered decomposers. For example, fire contributes greatly to decomposition, but it's not an organism, so it's not called a decomposer. Anything that eats contributes to decomposition in some way, but most of these organisms

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Why does compost smell? If students ask this question, point out the section "Evidence of fungi and bacteria" on their keys and encourage them to read the information. The smell is evidence of the most important decomposer of them all! Bacteria are too small to see without magnification, but they are there. Bacteria also live in the guts of animals, including humans. About 4 pounds of a human's weight is from the bacteria living in and on them, most of which is beneficial bacteria.

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are placed in other categories. When students are younger or newer to these terms/categories, it can be easier to focus on offering definitions without delving into the gray area. As students become more familiar with the concepts, they will be better prepared to entertain and understand the complexity of different categories.

Fungi and bacteria are considered by some to be the only decomposers. This is because these organisms can break down cells of dead organic matter without internal digestion. Organisms that do this by using internal digestion, such as sow bugs or earthworms, are called detritivores. Some people use the terms *decomposer* and *detritivore* interchangeably. Saprotroph is another related term that refers to any organism, especially fungi and bacteria, that lives and feeds on dead organic matter. Scavengers, such as vultures and hyenas, are animals that also feed on dead animals and plants. Confusing, huh? Since this can be a bit confusing, these ideas are often simplified when they are first taught to students. Earthworms, sow bugs, and other invertebrates are often accepted as decomposers along with fungi and bacteria. However, fungi and bacteria are the true stars of decomposition. Bacteria live all over the place, including in the digestive systems of other organisms, such as worms, and decompose organic matter inside of them. Fungi is generally considered to be the most important decomposer in forest ecosystems. Fungi are the only decomposers able to break down the lignin in wood (the compound in the cell walls of wood that makes wood rigid and, well, woody), and there's a lot of wood to break down in many ecosystems.

So, what to do with kids? In this activity, we have chosen to keep it pretty simple by including fungi, bacteria, and invertebrates as decomposers—partly because invertebrates are often easier to observe. However, with older students, you might want to highlight fungi and bacteria more. Discussions about what other factors/organisms contribute to decomposition can also be interesting with students.

Decomposition involves chemical and physical changes. When we discuss breaking down things into *smaller* parts, we're referring to the physical changes in decomposition. Breaking down things into simpler parts is an introductory way of describing how chemical bonds are being broken, and new ones are formed. By middle school, students should begin to understand that organic matter is changed into different, simpler substances through the process of decomposition.

Ideas about decomposition develop over time. Early ideas about decomposition tend to be that things break down spontaneously because they get old. Young students often don't understand that organisms are involved in decomposing. It's easy to see how this explanation could emerge after watching fruit rot before students are aware of fungi and bacteria. As students learn more, they may recognize that organisms are involved in decomposition, but they can sometimes see this mostly as a mechanical process that occurs through chewing and stomping.

Over time, students recognize macroorganisms—such as worms, sow bugs, mushrooms, and slugs—as decomposers, and, in time, students will also start to recognize that microorganisms—such as bacteria and microscopic fungi—are primarily responsible for decomposition. In fact, it's the bacteria in the worm's gut that are really doing the decomposing. At this stage, students often see decomposition as decomposers turning dead organisms into soil, without understanding that the organic matter in dead organisms is eventually converted into carbon dioxide and water by a decomposer and that most decomposition takes place in the ocean-—and so does not result in soil. Decomposition in the ocean puts nutrients into suspension in the water. On land, soil is also made up of undigested and inorganic (i.e., pebbles, sand, minerals) matter.

Students also commonly think that decomposers break down dead things into soil for the sake of other organisms and the benefit of the ecosystem. A well-developed understanding of decomposition is that a variety of organisms, primarily microscopic bacteria and fungi, consume the matter of dead organisms not because they feel like helping out the ecosystem, but for their own survival. As these decomposers consume food and nutrients from the dead organisms, some of the matter from the dead organisms is converted into carbon dioxide and water and released into the atmosphere. The nutrient rich waste matter from decomposers then becomes part of soil or water. Plants use nutrients from the soil for growth. Although plant mass is built primarily from carbon dioxide in air and water, nutrients in the soil or water are like vitamins for the cells of plants and other photosynthesizing organisms and are crucial ingredients for certain growth processes to occur.

The carbon cycle. Some environmental educators say that everything is connected. Sharing parts of the carbon cycle with students illustrates concrete ways in which we are connected to our environment. Plants take in carbon dioxide, water, and energy and convert them into food. Through food chains, all organisms get matter and energy from this food. As each organism eats and uses some of the food, it gives off carbon dioxide and water into the air and releases energy that flows into space. When dead organisms decompose, they are mostly converted into carbon dioxide and water in the air and release energy that flows into space. When you breathe out carbon dioxide, you are concretely connected to that ecosystem—you are part of the carbon cycle!

Understanding the nutrient cycle. Plants need nutrients from soil to grow, and algae need nutrients from ocean water to grow, just like people need vitamins and other substances from their food. Soil nutrients come from gases in the air; the breakdown of mineral-bearing rocks; and organic matter, which comes from the decomposition of organisms. The nutrients that plants get from soil are stored in all plant tissues—for example, in leaves, stems, and flowers. When these tissues fall to the ground or are put in compost, they start to break down, and together with decomposing dead insects, dead animals, and animal feces, they are eventually reincorporated into the soil by rainfall and soil organisms. In the soil, the organic matter is further broken down and slowly transformed to become nutrients that are available to growing plants, and the cycle continues. The nutrient cycle also takes place in bodies of water, such as the ocean, but with nutrients suspended in the water rather than in soil.

Living things interact with soil by creating tunnels for water and air, recycling nutrients, and mixing mineral particles throughout the soil. Organisms such as earthworms, isopods, bacteria, and fungi help decompose dead plants and

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animals. Nutrients from the decomposing materials are left in the soil where they can be used by plants. The plants, in turn, provide food for the animals, and the cycle continues.

Two carbon reservoirs: soil and the ocean. Plants, microbes, and algae remove CO_2 from the air, and the carbon becomes part of their bodies. Decomposers break down organic material, such as dead plants and algae, and release the carbon back into the atmosphere as CO_2. Most of the organic matter moves through the cycle pretty quickly, and the carbon cycles back into the atmosphere. However, some organic material breaks down much more slowly, thus "storing" some carbon in the soil or the ocean. Earth's soils contain about three times more carbon than vegetation does and twice as much as is in the atmosphere. The largest carbon reservoir on Earth is the ocean. Many dry land soils have become depleted and are very low in organic materials and carbon storage. Currently, the idea of restoring these soils is seen as a hopeful way to lower CO_2 levels in the atmosphere to reduce the impacts of climate change, until carbon released through fossil fuels can be reduced. Manure from grazing animals is considered the most efficient way to get carbon into soils. Studies have shown that dense herds of grazing animals moving through an area dramatically increase the soil's health and carbon storage.

Common Relevant Misconceptions

Misconception. Decomposition is just breaking things into smaller parts—so breaking up clods of dirt or smashing eggshells is decomposition.

More accurate information. Decomposition is actually way more complex than that, and the significant aspect of decomposition is a chemical change. A more accurate definition of decomposition is the process of breaking down organic material into simpler and smaller parts. Breaking things into smaller parts is one aspect of decomposition, but the simpler part of the definition is significant. Fungi and bacteria are responsible for much of the decomposition that happens, and they have the ability to digest wood, and, through the digestion process, break down wood (which is a chemically complex material) into component parts such as carbon, etc., that are either released as carbon dioxide (through breathing or some other similar process) or through excreting. If you break a leaf into smaller pieces, each piece is still made of the same leaf material. However, if an organism digests the leaf, the stuff it "poops" out is clearly made of a different, simpler material.

Misconception. All invertebrates are decomposers.

More accurate information. When students learn that decomposers are fungi, bacteria, and invertebrates, they often assume that any invertebrate they encounter after that is a decomposer. There are millions of invertebrates, and lots of them are decomposers, but many are not. If you have defined decomposers as fungi, bacteria, and invertebrates, be sure to regularly point out whenever students encounter an invertebrate that isn't a decomposer and discuss invertebrates that aren't decomposers. There are many invertebrates that are not decomposers. Some examples of common invertebrates that are not decomposers include bees, ladybugs, centipedes, dragonflies, butterflies, and spiders.

Misconception. Plants grow by taking in soil in order to get bigger.

More accurate information. This is a very common misconception, even among adults. The matter plants use to grow chiefly comes from carbon dioxide and water. Plants acquire nutrients from the soil, which help them to grow larger than they would without it, but mostly they are built from water and carbon dioxide. The Next Generation Science Standards (NGSS) emphasize this distinction and make sure students understand that most plant matter comes from carbon dioxide and water.

Misconception. When things decompose, they are used up, and there is nothing useful left.

More accurate information. All the matter in dead organisms eventually cycles through the soil, water (the ocean), atmosphere, and the bodies of other organisms.

Misconception. Dead organisms are decomposed into nutrients that plants use.

More accurate information. This is not totally a misconception—it's just vastly incomplete. Most of the matter that's decomposed eventually is converted into CO_2 and water, which becomes part of air. A tiny bit becomes nutrients that plants can use.

Misconception. All decomposers only eat dead stuff.

More accurate information. Decomposer is a definition of a role within an ecosystem. Decomposers are named as such because they help to decompose matter, thus making that matter accessible for plants. However, some decomposers may also eat living material or whatever else is needed to survive (e.g., banana slugs can eat living leaves or decaying/dead leaves). There are some scientists who consider only bacteria and fungi to be true decomposers. From this point of view, worms would not be considered decomposers; rather, the bacteria in their digestive tract that further break down matter are the actual decomposers.

Misconception. Decomposers break down matter from dead things in order to provide soil for other organisms in the ecosystem.

More accurate information. Decomposers consume dead organisms to get the matter and energy they need to survive. They are not concerned with supporting the ecosystem, except in the sense that these interconnections support their survival. This kind of nonscientific language can perpetuate the people-centric idea that nature and its systems exist primarily for our benefit or for the benefit of the charismatic creatures we care about.

Misconception. Soil is no big deal. Soil is just dirt.

More accurate information. Soil is much more than dirt! It's a mixture of mineral particles, living and dead organisms, air, and water. Soil also contains inorganic materials from rocks and often some broken down human-made materials. Life on land depends on soil. It provides

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substrate, nutrients, and homes for many organisms and can be considered the living skin of the land on our planet. In this sense, soil plays a vital role in sustaining human welfare and assuring future agricultural productivity, textile production, and environmental sustainability. In the ocean, seawater is the equivalent of soil on land. Seawater carries the nutrients and gases that photosynthesizers need to survive.

Misconception. The only product of decomposition is soil.

More accurate information. As decomposers consume dead organisms and deposit the resulting "poop" into the soil, they do contribute to the organic constituents found in soil. During the chemical process of decomposition, gases such as CO_2 and water vapor are also released into the surrounding air, thus contributing to the atmosphere as well as the soil. Most decomposition takes place in the ocean where there is no soil. In the ocean, decayed material becomes dissolved and/or suspended in the water, resulting in nutrient-rich seawater.

Supporting Equitable, Inclusive, and Culturally Relevant Learning Experiences

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

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

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

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

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

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

- Scaffolding skills of scientific observation, including accessing information from a key, supports students' visual literacy and language acquisition and supports students to be independent learners; visual literacy and language acquisition are also critical pieces of the Common Core State Standards.
- Providing students with autonomy to explore what interests them, which increases engagement with the activity and further supports development of scientific habits of mind and general thinking skills.
- Connecting students' in-the-moment learning behaviors to practices of working scientists, contradicting the exclusionary ideas that science is a list of facts to memorize or that only people who are good at memorizing facts can be good at science.
- Using broad questions to invite students to share their observations, prior knowledge, expertise, and experiences with one another and with the instructor.
- Engaging students with compost, something that is commonly found in gardens, 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 may have access to in their own community.
- Focusing the group's learning on a common experience everyone has access to, so that learning is accessible regardless of prior experiences or comfort level outdoors.

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

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

- 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*). This approach to teaching supports students in becoming independent learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences where all students feel capable of success and have the tools to carry that success into other domains.

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

Connections to the Next Generation Science Standards (NGSS)

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

The NGSS are designed to have fewer concepts for students to learn than the standards that preceded them and for students to go into more depth with each of those concepts. That means students need to have multiple learning experiences focused on developing understanding of Disciplinary Core Ideas and many opportunities to engage in Science and Engineering Practices. *What's in Compost?* should be one of many activities in which students explore ideas of decomposition and matter cycling.

In *What's in Compost?*, students engage in the practice of *Constructing Explanations* and apply the Crosscutting Concept of *Cause and Effect*. Students have the opportunity to build understanding of Disciplinary Core Ideas related to *Ecosystems: Interactions, Energy, and Dynamics*.

Featured Science and Engineering Practices

Engaging students in *Constructing Explanations.* 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 it. Students should develop their understanding of science concepts through making their own explanations about natural phenomena.

- Students have some opportunity to engage in the Science and Engineering Practice of *Constructing Explanations* (when they discuss questions such as "Why is that in compost?" or "What would a gardener need to put in compost for decomposers to survive there?") .
- In order for students to be fully engaged in the Science and Engineering Practice of *Constructing Explanations*, they need to go beyond just saying an explanation. They also need to consciously base their explanations on evidence and consider alternate explanations based on that evidence. The large-group discussion in which students share their ideas about possible effects of putting different things in compost and what might have caused certain effects or conditions to occur in the compost is a critical step in this activity because it's an opportunity to encourage students to include their evidence and reasoning when they give an explanation, to use the language of uncertainty, and to consider alternate explanations.
- Students have some opportunity to engage in the Science and Engineering Practice of *Obtaining, Evaluating, and Communicating Information* as they identify organisms using the Compost Key, record information on their journal pages, and discuss what they find with their peers.

Featured Crosscutting Concepts

Learning science through the lens of *Cause and Effect.* Students make some use of the ideas of *Cause and Effect* and *Systems and Systems Models* while thinking about why certain things are in compost and what kind of environment a gardener would make in order for decomposers to survive there. To fully align with NGSS, it's important for students to realize they're using a "big idea" Crosscutting Concept such as *Cause and Effect* and to connect this to the process of science. In this activity, telling students, "You're observing something and then trying to explain what might have caused what you observed—that's something scientists do, not only in gardens but in all other disciplines of science," you are helping students realize that the way they're thinking is actually a tool that can be applied to other settings.

Featured Disciplinary Core Ideas

Building a foundation for understanding Disciplinary Core Ideas. The goal of NGSS is not for students to be able to recite the statements below as definitions. Students need to understand these concepts, be able to speak about examples of these concepts in nature, and apply the ideas in other settings. Students need multiple learning experiences to build their understanding of Disciplinary Core Ideas. *What's in Compost?* provides students with an opportunity to develop understanding of some life science core ideas related to Interdependent Relationships in Ecosystems (LS2.A) and Cycles of

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

Matter and Energy Transfer in Ecosystems (LS2.B).

- Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms survive only in environments in which their particular needs are met. (LS2.A).
- Organisms obtain gases and water, from the environment, and release waste (gas, liquid, or solid) back into the environment. (LS2.B).

You can informally assess student understanding of these concepts during different stages of the activity through individual interactions with students and by listening carefully during the group discussions. This information can help 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 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. Below are some of the Performance Expectations that this activity could help students work toward:

- **3-LS4-3.** Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
- **4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
- **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Activity Connections

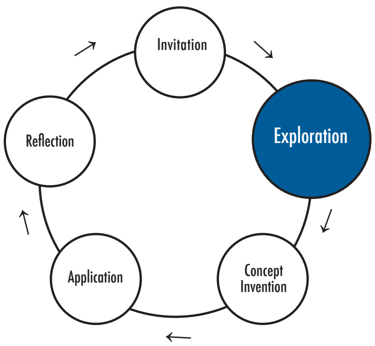
For an Exploration activity that focuses on decomposition, try *Decomposition Mission* or *The Case of the Disappearing Log*. Another related garden activity is *Worm Explorations*. Two classroom activities related to making explanations from evidence are *Evaluating Evidence* and *Size of Assumption*. For older students, present or return to the *Matter Energy Diagram* to give students a deeper understanding of matter cycles and energy flow. *Food, Build, Do, Waste* is another activity that tackles matter and energy follow-up to *What's In Compost?*

Learning cycle. The main parts of this lesson on their own—including Introducing the Activity, Exploring Compost, Discussing Compost, and Reflecting and Wrapping Up—are opportunities for Invitation, Exploration, Concept Invention, and Reflection. The optional extensions offer opportunities for Application and Concept Invention. In a series of lessons and activities focused on decomposition, this serves primarily as an Exploration.

TEACHING NOTES

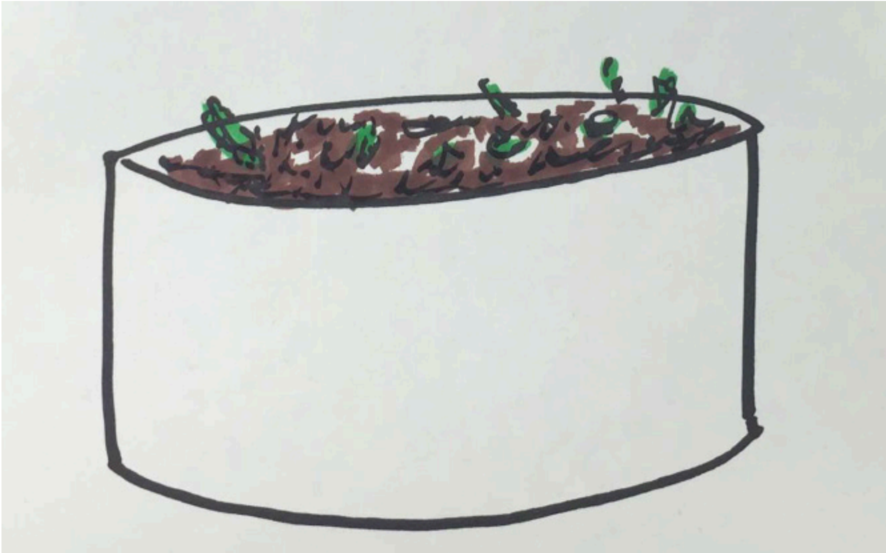
Translating the codes used in the NGSS. Each standard in the NGSS is organized as a collection of performance expectations (PE) for a particular science topic. Each PE has a specific code, provided here so that they can be easily referenced in the NGSS documents. The first number or initial refers to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

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

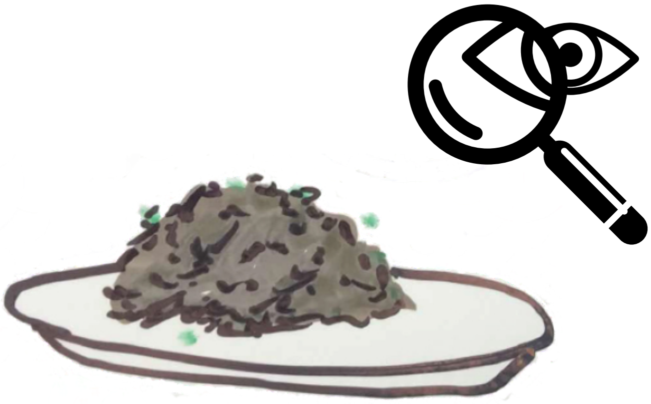


GUIDING QUESTION:

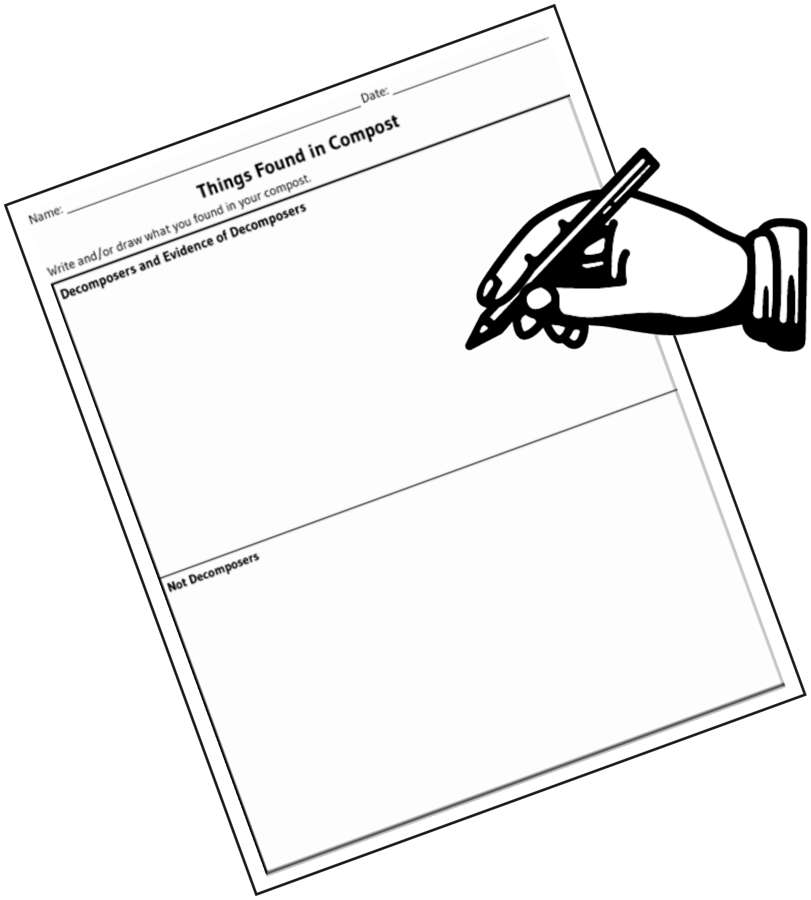
What is in compost, and why is it there?



1. Look through compost and find things on the key.

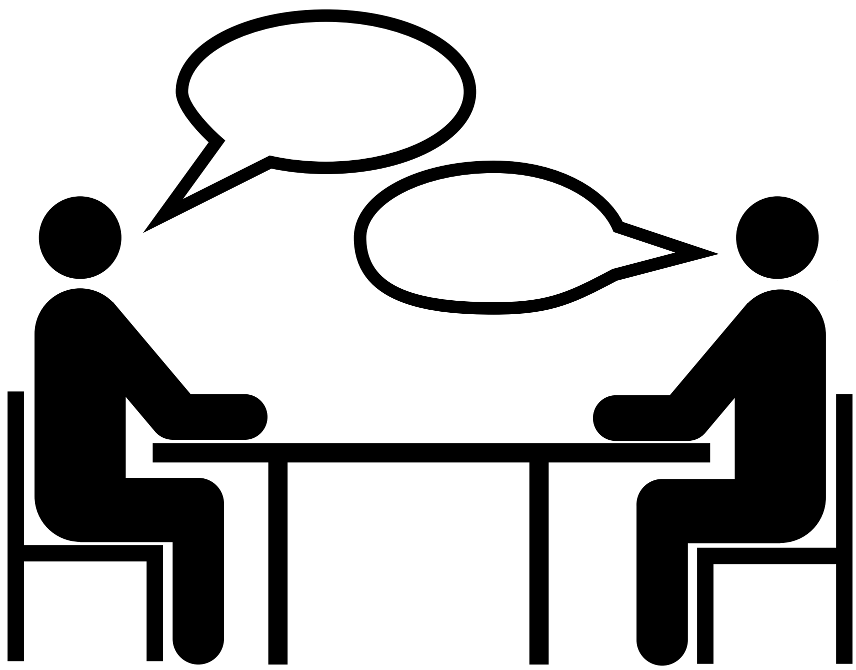


2. Record what you find.



Discuss:

- **What did you find?**
- **Why is it there?**



Decomposer Definition:

living things that break down things that used to be alive into parts of soil.

Things Found in Compost

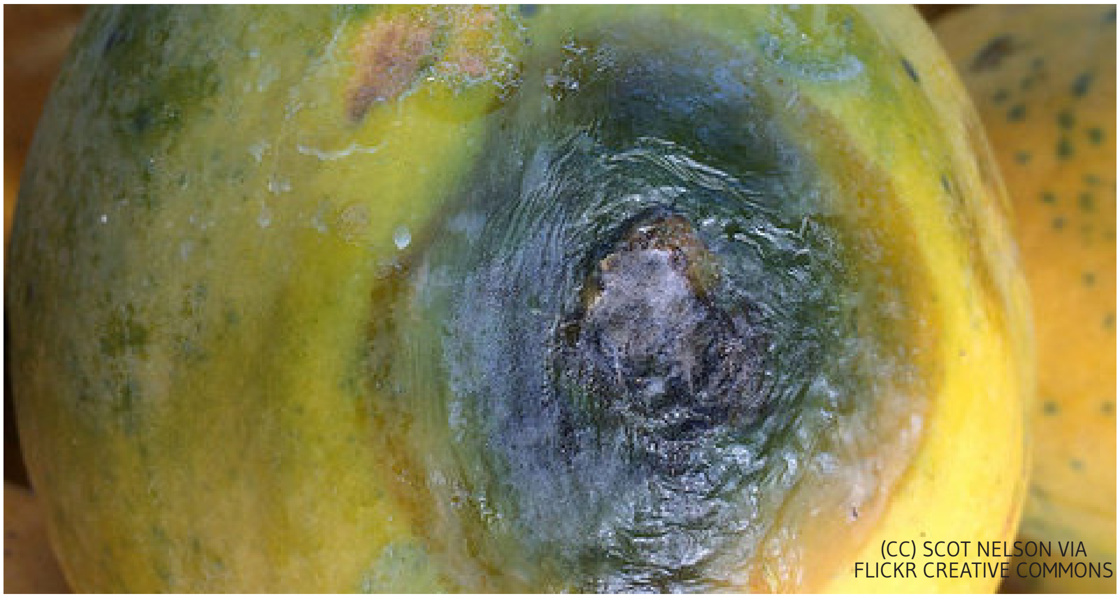
Name: ______________________________ Date: ____________________

Write and/or draw what you found in your compost.

Decomposers and Evidence of Decomposers
Not Decomposers

COMPOST KEY EXAMPLES


(CC) DISTANT HILL GARDENS VIA FLICKR CREATIVE COMMONS


(CC) SCOT NELSON VIA FLICKR CREATIVE COMMONS


(CC) LENNART TANGE VIA FLICKR CREATIVE COMMONS

COMPOST KEY

Decomposers

roly-poly (pill bug)

sow bug

fungi

look for thin white threads or fuzzy mold

worm

ant

slug

snail

millipede

larva

springtail

beetle

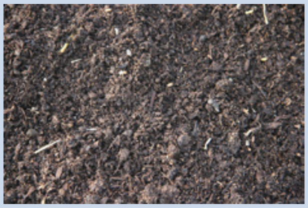
mite

Evidence of Decomposers

Evidence of fungi or bacteria:

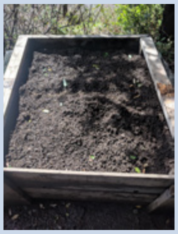
rot; round spots; or liquidy, watery look; rotting smell

worm castings (poop)



little brown clumps

soil (or "finished compost")



dark brown soft dirt

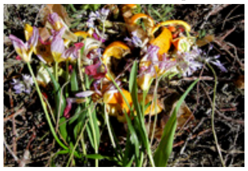
Not Decomposers

centipede

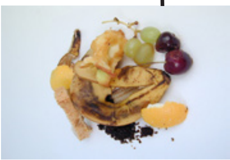
spider

rove beetle

weeds or other plants



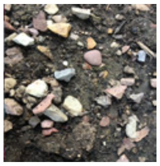
food scraps



plastic and other trash

straw

rocks



Mystery

If you find something that doesn't seem like it belongs in any of these groups, talk to your classmates and instructor to try to figure out what it might be.

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Find the latest activities and information at http://beetlesproject.org.

COMPOST KEY (pg. 2)

Decomposers

roly-poly (pill bug)

Can roll into a ball. Mostly eats dead plants. Active during the day. Needs calcium for body covering.

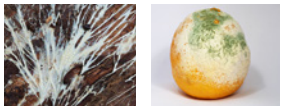
sow bug

Can't roll into a ball. Faster than roly-polies. Mostly eats dead plants. Needs calcium for body covering.

worm

Lives in moist areas. Eats living and dead things in soil. Their poop is called warm castings and becomes part of soil.

fungi



Digests wood, dead plants, and animals. Look for long white threads or fuzzy mold.

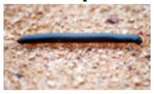
slug

Lives in moist or wet areas. Mostly eats dead or living plants.

snail

Mostly eats living and dead plants. Needs calcium to build shell.

millipede

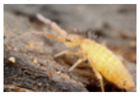


Slow. Lives in moist areas. Eats mostly dead plants in soil. Needs calcium to make body covering.

ant

Eats living or dead plants, animals, or human food.

springtail



Can jump. Eats dead and living plants and dead animals.

mite

Very small! Smaller than this picture!! Eats living and dead things in soil.

larva

Young insects. Eat living or dead plants or dead animals.

beetle

May eat fungi, living or dead plants, or dead animals.

Evidence of Decomposers

Evidence of fungi or bacteria:

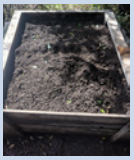
rotting smell, big brown blotches, dots, watery spots

Bacteria are too small to see, but are some of the most important decomposers! Heat is evidence of bacteria digesting compost. Bacteria also live in humans' stomachs and the stomachs of other animals and break down food in their stomachs. **Fungi** are the main decomposers of leaves and wood.

worm castings (poop)

These little blobs are worm poop. Worms eat things such as dead plants and food scraps and poop out nutrient-rich worm castings.

soil (or "finished compost")



After food scraps, dead plants, and other organic matter are eaten by decomposers and pooped out, it is dirt or soil ready to be used for planting.

Not Decomposers

centipede

Fast predators that eat worms, small millipedes, beetles, and other small invertebrates.

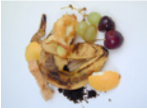
spider

Predators. Eat insects and other small invertebrates.

rove beetle

Predators. Eat insects, slugs, and other small invertebrates.

food scraps



Gardeners put food scraps in compost for decomposers to eat and break down into soil. Eggshells add calcium.

straw

Adding straw helps more air get into compost for decomposers to breathe.

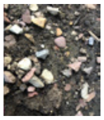
weeds or other plants

Gardeners add green plants to compost because decomposed green plants make compost more nutritious.

plastic and other trash

Plastic and many other kinds of trash won't break down into soil in compost because decomposers can't eat them.

rocks



Rock won't break down into soil in compost because decomposers can't eat them.

ABOUT BEETLES™

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