beetles
Science and Teaching for Field Instructors

Student Activity Guide

Worm Explorations

Worms can be cool and interesting, especially when observed up close! Worms are also easy to contain, so observing worms is a great opportunity for students to learn about organism's structures and behaviors up close. In this lesson, students are invited to observe a worm and think about this Guiding Question: *What body parts and behaviors help a worm survive*? The instructor offers scaffolding for how students can observe and make scientific drawings of an organism and how to think about its structures and behaviors. Then, the group gets an opportunity to observe worms, discuss observations with peers, draw worms, and record observations of worm behaviors. Students will have the space and time to discuss what they noticed in pairs or as a group and make possible explanations for how worm structures and behaviors help worms to move, protect themselves, and survive. Optional extensions include reading a grade-level text about worms to the class, students searching for worms and evidence of worms in the garden, and singing a song about worms. *Worm Explorations* is designed to support an equitable and inclusive learning experience by using student-centered teaching practices, focusing the learning experience around a common part of nature to which every student has access, and scaffolding visual literacy and communication skills.

Students will...

- **Observe worm body parts and behaviors.**
- **Discuss observations with their peers.**
- **Practice scientific illustration skills as they draw and write behaviors of their worms.**
- **Discuss how worm structures and behaviors help worms survive in their habitats.**
- **OPTIONAL: Read a book to access additional concepts about worm structures and behaviors, search for and observe worms or evidence of worms in the garden, or sing a song and think about worms.**

Grade Level:
Suggested for grades 2–8

Timing:
~40–60 minutes

Related Activities:
Structures and Behaviors, Adaptation Intro Live!, Discovery Swap, What's in Compost?

Materials:
See the Materials and Preparation section on page 3 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 area—ideally in a place where students can set their worms on tables during observations.

Equity, Inclusion, and Cultural Relevance (reviewed 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 12.

NEXT GENERATION SCIENCE STANDARDS

For additional information about NGSS, go to page 14 of this guide.

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Constructing Explanations	Structure and Function	**LS1.A:** Structure and Function **LS2.B:** Cycles of Matter and Energy Transfer in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Garden Activity

Worm Explorations

ACTIVITY OVERVIEW

Worm Explorations	Learning Cycle Stages	Estimated Time
Introducing the Lesson	Invitation	5-10 minutes
Observing Worms	Exploration, Concept Invention	15-20 minutes
Discussing Worms	Concept Invention, Application	5-10 minutes
Optional Extensions: • Option 1: Reading *Earthworms Underground* • Option 2: Searching for Worms • Option 3: Singing "Gusano"	Concept Invention, Application	10-15 minutes
Reflecting and Wrapping Up	Reflection	5 minutes
TOTAL		~40-60 mins

TEACHING TIPS

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

Supporting language development and conceptual understanding. We recommend offering the Guiding Question in multiple languages and specifically in the home languages of your students. This supports language development, content acquisition, and student participation.

If you have students who you think might benefit from a Spanish version of the question, write "Cuáles estructuras (partes del cuerpo) y comportamientos (cosas que hace) ayudan al lombriz a sobrevivir? (en su medio ambiente)."

Choosing an optional activity. Once students observe worms, they're likely to be curious and have questions about worms. Offering observation time first and allowing students to follow their curiosity afterward is a great opportunity for them to learn content and engage with concepts. To keep this process student-centered, it is ideal if this content is not directly delivered by the instructor, but instead is content that students access through text or other media. This helps students learn about worms and is an opportunity to practice skills related to accessing information on their own. The optional activities offer different ways for students to engage in more content and thinking about worms. If you have time for an optional activity, choose the option most appropriate, accessible, and interesting for your students. See the Materials & Preparation section for more information about the optional activities.

PREPARATION

1. **Obtain worms.** You will need enough worms so each student can observe their own worm. This supports students to be engaged in the activity. If students share worms, it is more likely they will check out and not participate as fully in the activity as they would if they had their own worm to observe. Red wigglers are the worms you will mostly likely find in compost piles. (They prefer the warmer temperatures of compost.) Night crawlers and earthworms are best for observing structures. (They are much larger, but they prefer cooler garden soil temperatures and are harder to find in compost) Either can be purchased cheaply from bait shops. (Check with a bait shop in advance; some bait shops don't carry worms or only carry them if you request them in advance.) You can also dig out red worms from your worm bin or compost, if you have a compost, and it has worms.
2. **Prepare the worms for student observations.** Prep the worms for student observations by putting a worm and a damp piece of paper in a cup. Do this ahead of time; it won't work to do it during the lesson. If you purchase worms that come in a container filled with worms and castings (worm poop), consider rinsing the worm castings off the worms before giving them to students to make it easier to see worm structures. Just before class, put 1 worm per student in a clear plastic cup and place a small piece of paper towel (~1" x 1") over the worm. Then, give one spritz of water from the spray bottle to each piece of paper towel. Keep an eye on the worms or put lids on the cups because some worms will likely make a run (crawl?) for it and will need to be put back in their cups. Throughout the lesson, spritz the pieces of paper towels if they get dry.
3. **Prepare the Guiding Question.** On a whiteboard or a sheet of chart paper, write: "What body parts and behaviors help a worm survive?"

   Adjusting the Guiding Question. Use a version of the Guiding Question (listed below) that you think is most appropriate and accessible for your students. We recommend the first three questions for younger students (grades 2–4).

   - *What body parts and behaviors help a worm survive?*
   - *What body parts and behaviors (things it does) help a worm survive?*
   - *What structures (body parts) and behaviors (things it does) help a worm survive?*
   - *What structures (body parts) and behaviors (things it does) help a worm survive in its environment?*
4. **Make copies of the Worm Worksheet.** The Worm Worksheet can be found on page 17. Make enough copies so each student can get their own worksheet.
5. **Draw a giant model of a worm.** On a sheet of chart paper, draw a giant model of a worm. During Step 2 of the Observing Worms activity, you will post it and periodically draw samples from students' drawings on this giant worm model while commenting to the class as you draw.
6. **OPTIONAL:** If your students do not already have experience making scientific drawings that include labels, you can post the three provided signs as you model the process of making a scientific drawing (Introducing the Lesson, Steps 6–9).
7. **OPTIONAL: Reading *Earthworms Underground*.** Read the book to yourself so you are prepared to summarize chapters for students. *Earthworms Underground* is a nonfiction book about worms, written for elementary students. Although it's written for students in grades 2–3, the book, content, and illustrations are appealing to older students. If you have only one copy of the book, you can show the book to students, read the names of the chapters, ask students which chapter(s) they're interested in, and then read or summarize the content of the chapter while showing students pictures in the book. With one book per pair (ideal!), students can follow their own interest by engaging directly with the book. (*Earthworms Underground* by Kevin

MATERIALS

For the instructor:

- ❏ large photo of a worm (print one the size of a piece of paper)
- ❏ large photo of an elephant (or some other object to model scientific drawing)
- ❏ whiteboard or sheet of chart paper and marker
- ❏ Printed copies of 4 instructional signs (pages 18-21) :
  - ❏ Guiding Question
  - ❏ 1. Draw worm body parts—inside and out.
  - ❏ 2. Write worm behaviors.
  - ❏ Be gentle.
- ❏ 1 sheet of chart paper and marker (for large drawing of a worm)
- ❏ 1 spray bottle with water
- ❏ plate (for spreading out worms when picking them out of compost/castings)
- ❏ tape
- ❏ OPTIONAL: 1 copy of *Earthworms Underground* (*Seeds of Science/Roots of Reading* book)
- ❏ OPTIONAL: lyrics/recording of the song "Gusano" ("I Am a Worm"): moo-boing.com

For each student:

- ❏ 1 worm in a clear cup with a 1" x 1" piece of damp paper towel
- ❏ pencil
- ❏ Worm Worksheet (on page 17)
- ❏ OPTIONAL: 1 hand lens
- ❏ OPTIONAL: clipboard

TEACHING NOTES

PREPARATION

Beals. Illustrated by Debra Bandelin and Bob Dacey. © 2007 The Regents of the University of California. http://store.lawrencehallofscience.org/index.php?app=ecom&ns=prodshow&ref=501095&LHS_SRC=ajax)

8. **OPTIONAL: Searching for Worms.** Check if worms or worm evidence can be easily found in your outdoor areas. Dig around in your compost, look around in your garden, or explore outdoors where you'll be doing the activity. Are there worms there? Can you find worms or worm tunnels there by looking under stepping stones or logs or by digging into the soil? Are there tiny piles of worm castings on the ground in your garden area? If so, toward the end of the lesson you could include this optional activity in which students search for worms and evidence of worms.

9. **OPTIONAL: Singing "Gusano" ("I Am a Worm").** This is a song about worms, including the Spanish term for worm, gusano. (In many countries, lombriz is also the word for worm or earthworm). The recording and song lyrics can be found on the Bungee Jumpin' Cows website [moo-boing.com]. You can teach students the chorus and ask them to participate by clapping at the end of each line.

Introducing the Lesson

1. **Show a large photo of a worm to students and share:**
   - ▶ *We're going to be observing worms today. Take a moment to think quietly [or share with a partner]. What are some things you've observed or learned about worms?*
2. **Point out the Guiding Question (on the whiteboard or hold up the sign you made), ask for a volunteer to read it out loud, and then invite students to discuss or think about it in a way that will be successful for them.** (This could be a *Thought Swap*, *Turn & Share*, writing time, thinking time, or another strategy that works well for your group.)
   - ▶ *Can someone volunteer to read our Guiding Question out loud? We'll be thinking about this question during the entire lesson today. Please* [Turn & Share, Walk & Talk, *think, draw, etc.] about the question.*
3. **Unpack any vocabulary that students might be unfamiliar with, such as:**
   - **structures:** worm body parts
   - **behaviors:** what the worm does
   - **survive:** keep living, stay alive
4. **Invite students to share examples of human and worm body parts (or structures).**
   - ▶ *Arms are an example of a human body part. What are some other examples of human body parts you can think of?* [Accept a few answers.]
   - ▶ *Later, you'll have the opportunity to look for worm body parts. Do you think worms have arms or teeth? What are some examples of worm body parts that you think you might see on your worm?* [Accept a few answers.]
5. **Share that worm behaviors are things worms do and then invite students to share examples of human and worm behaviors:**
   - ▶ *Running and eating are examples of human behaviors. These are things humans do.*
   - ▶ *What are some other examples of human behaviors?*
   - ▶ *What are some examples of possible worm behaviors—some things you think worms might do?*

   Note: If your students already have experience doing scientific drawings that include labels, you may choose to skip Steps 6–9.
6. **Show a large photo of an elephant and then model drawing a scientific drawing, using it as an example.** Use the elephant photo and a whiteboard or piece of butcher paper to model drawing, labeling, and writing notes as you explain what you're doing. (**Note**: If you think it will be more engaging for your students, you could use a photograph of an animal local to your area, such as a kind of bird, a squirrel, a racoon, etc.)
   a. **Share that students will each have the opportunity to make a scientific drawing of a worm.**
      - ▶ *You're going to have the opportunity to do a scientific drawing of a worm.*
      - ▶ *Drawing is one tool that scientists use to learn and to figure out how things work.*

TEACHING NOTES

Indoor introduction. Some groups of students are more successful at focusing on listening to instructions when indoors. If that's the case with your students, consider doing the Introduction (or, if the weather is bad, the entire Observing Worms activity) inside.

Structures or body parts? If your students are familiar with the term structures, you can use it in place of body parts. If you think it will make more sense for your group to use the term body parts instead of introducing a new word at the time, stick with that.

Unpacking questions. To increase student engagement and participation in discussion, it helps to unpack a question—or break it into parts, offer examples of how students might respond to the question, or invite one or more students to rephrase the question in their own words. Unpacking questions can be particularly beneficial for emerging multilingual learners and provides increased opportunities for all students to participate successfully.

Keep it moving. Keep the introduction as efficient as you can, time-wise. Notice students' level of engagement and be responsive. The goal is to offer clear directions that will set up students to engage with the assignment with minimal teacher guidance and to do so efficiently and clearly. Keep it moving, without skipping important scaffolding.

TEACHING NOTES

Don't draw the whole thing. Don't drag out this process for too long. You don't need to draw the whole elephant or complete an entire scientific illustration. Move through the steps quickly, just providing enough of an idea of an example of what you're asking for, before moving on.

Support, scaffolding, and student engagement. *Worm Explorations* 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. The write-up activity also offers a range of options for how students might respond to a question, including writing time, thinking time, or pair shares; this allow instructors to consciously choose the approaches that are engaging for their specific groups of students.

Backlighting. It can sometimes be difficult to see the insides of worms' bodies. It helps to hold up the cup with the worm to the light so the backlighting makes the internal structures more visible.

b. **Model doing a scientific drawing by using an elephant.**
   - ▶ *I'm going to show an example of how we could do a scientific drawing by using this picture of an elephant.* (Optional joke: *I'm not going to give each of you your own elephant, but I will give each of you a worm.)*

c. **Share that the goal of a scientific drawing is to show what you observe.**
   - ▶ *In a scientific drawing, our goal is to observe carefully and draw what we actually notice, not what we think should be there. So, if I were making a drawing, I might notice that the elephant is holding its leg at an angle, and I would try to show that in my drawing.*
   - ▶ *The goal is not to make a pretty or perfect drawing but to show our ideas and observations. We can use labels and words to add information to the drawing.*

d. **Do a Think-Aloud as you draw.** Begin modeling how to make a scientific drawing while doing a short Think-Aloud about how you're trying to make observations and draw what you notice. For example:
   - ▶ *It looks like the leg goes down and curves like this, and then there's a line here . . . .*

e. **Do a Think-Aloud as you add labels and writing.** Model adding labels and writing to capture what you observe, including made-up behaviors (since the elephant in the photo will not be moving). For example:
   - ▶ *It looks like there's a little bit of yellow here, but I don't have a yellow pencil, so I'm going to write "yellow" with an arrow pointing to where it's yellow.*
   - ▶ *I notice his tail is wiggling, but it seems hard to draw the wiggling, so I'm going to make arrows that show how it's moving, and I'll add a label that says, "wiggling slowly."*

f. **Act out not following the directions by making a symbolic (not scientific) drawing and then invite students to redirect you.** Model starting to draw a symbolic and cartoonish version of an elephant, without looking at the picture. Share that this is not a scientific drawing because it is not based on observation and that this lesson is focused on the goal of making scientific drawings.

g. **Act out not following the directions by making a drawing that is very small and then ask students to redirect you.** Model drawing an elephant that is very small so there isn't enough space to show any details. Share that if you draw something too small, it's difficult to show the body structures.

7. **Post sign: 1. Draw worm body parts—inside and out.** Share:
   - ▶ *Please draw your worm, inside and out. A cool thing about worms is that they are see-through. You can actually see inside their bodies. Imagine if we had see-through skin! We'd be able to see one another's hearts and muscles! Draw the outside parts of your worm, but also see if you can draw the inside parts, too.*

8. **Post sign: 2. Write worm behaviors.** Share:
   - ▶ *Use words to describe what you see your worm doing.*

9. **Invite students to add questions and connections as they observe their worms.** Share:
   - *As you are observing your worm, you can also write questions you come up with or things your worm reminds you of—such as experiences, ideas, or something it looks like.*

10. **Post sign: Be gentle.** Share:
   - *We ask you to be gentle with your worm. This means moving the cup your worm is in slowly and carefully and trying not to hurt your worm. You do not have to touch your worm—it's actually better for the worm if you don't touch it!*

Observing Worms

1. **Distribute 1 cup with a worm and 1 copy of Worm Worksheet to each student, invite students to begin, then, circulate, engage students in discussion, and support those who might need additional support.** Once students begin observing their worms, circulate quickly to make sure all students know what to do and are engaged in the activity.

2. **As students work, post your drawing of a giant worm model and periodically draw samples from students' drawings on the giant worm model while commenting to the class.** As students work, look for examples of observations on their worksheets and add your own version of these to the giant worm model drawing. Announce these to the whole group. For example, say, *"Dante drew lines on his worm, so I'm going to draw lines up here," "Tanya wrote that the worms get shorter and longer." She also wrote, "Maybe that helps it move around." So I'm going to write that up here.*

3. **Ask students questions and offer bits of content as you circulate.** Continue to check in with students. Now and then, ask questions or offer content to the whole group. For example:
   - *Can you figure out which end is the head? What evidence can you use to figure that out?*
   - *Can you figure out how your worm moves around? How does it work its body to move?*
   - *If you see a red tube inside your worm, that's a blood vessel. You can label it if you see it.*
   - *If you see a brown tube inside your worm, that's the digestive system. You may label it if you see it.*

4. **Spritz drying worms.** If it looks like any of the worms are getting dried out, give them and the paper towel in each cup a squirt of water with the spray bottle.

Discussing Worms

1. **Prepare students for a whole-group discussion or set them up in pairs for discussion.**

2. **Using the questions below, facilitate a discussion about worms.** Refer to the giant worm drawing when it is appropriate. As appropriate, point to parts of your giant drawing as you explain the question or when you hear

TEACHING NOTES

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.

Modeling to encourage engagement. Calling attention to the work that students are doing as they observe worms can encourage students' participation and guide their observations, writing, and drawing.

Pairs 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 still building the skills to participate in group discussions, you can offer each question and then give students time to *Turn & Share* about it in their pairs.

students' observations and ideas. Keep the discussion moving so students stay engaged. The questions in bold italics are questions not to be skipped:

- How do you think the lines/segments on a worm help it survive?
- Which end do you think is the head? What is your evidence?
- ***Explain how you think earthworms move around. What is your evidence?*** [Clarify that this question is about trying to figure out the mechanics of how worms move, not just describing what it looks like when worms move.]
- What might earthworms eat?
- ***How might earthworms be good for compost, soil, and the garden?***
- How might earthworms protect themselves?
- ***What other questions do you have about earthworms?***

3. **After students have had time to talk through several questions, but before they become disinterested, wrap up the discussion.**

4. **Share that students used science practices and the thinking tool of structure and function to learn about their worms and connect this to the learning behaviors of scientists.**
   - ▶ *Today, we were observing worms, asking questions about them, and sharing ideas with our peers through drawing and discussion. By doing all those things, we were able to learn a lot about worms!*
   - ▶ *Scientists also use these same behaviors to learn about the world around them.*
   - ▶ *We were also thinking about worms' body parts, or structures, and trying to figure out how they work to help worms survive, or keep living.*
   - ▶ *This is something scientists do, too, when they are learning about all sorts of living things.*
   - ▶ *It can be fun and interesting to look at animals and plants and observe them and think about how their structures or body parts work.*

Optional Extensions

Option 1: Reading *Earthworms Underground*

1. **Gather students to sit close together and show them the book *Earthworms Underground*.** Show students the book and share that it has information in it about worms.

2. **Read the chapter names out loud and then invite students to pick the ones they're most interested in.** After you share the titles of the chapters, find a way for students to choose which chapters they want to hear you read (e.g., students could hold up the number of fingers that corresponds to the number of the chapter they want to hear, or you could use another quick consensus-building method).

3. **Summarize or read the chapters chosen by students and show pictures from the book.** If you don't have enough time to read all the text in the chapters out loud, summarize some of the main points from one or two chapters and show students the pictures as you share.

TEACHING NOTES

Information about worms. The Instructor Support section (beginning on page 11) includes some information about worms and some answers to the questions in Step 2. If students seem interested, offer some ideas and bits of content, but make sure to do this AFTER students have had the chance to come up with some ideas themselves.

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.

More copies of the book. If you have enough copies of *Earthworms Underground* so each pair of students can share a copy, you may choose to distribute the books and offer pairs time to read the chapters in which they are interested.

TEACHING NOTES

4. **Connect information in the book to things students observed and wondered about worms.** When possible, point out connections between what students observed and information in the book. For example, say, "Check out these illustrations showing how a worm moves. It looks a lot like what you were describing—the worm reaching and getting long and skinny and then pulling its body along and getting short and fat. But look at this close-up picture where you can see tiny hairs on the worm that you couldn't see when you observed your worms. Those tiny hairs are what the worm uses to hold onto soil and pull the rest of its body forward."

5. **Encourage students' questions.** If you have time and students are excited, encourage them to ask questions about worms, about things that might be in the book, or about anything else related to the Guiding Question. Ask students to include evidence in their explanations and offer an example.
   - ▶ *When we make explanations, we need to include evidence. Evidence can be observations we have made.*

   Share an example based on something you're actually observing:
   - ▶ *For example: I think this half of the tree is dead, and the other half is still alive. My evidence is that all the branches on that half are brown and very dry, while the branches on the other side are soft and have green leaves.*

Option 2: Searching For and Observing Worms in the Garden

1. **OPTIONAL: If you no longer need worms for other classes and can release them into the garden, offer this question to students:**
   - ▶ *What do you predict the worms might do when we put them in the compost/garden?*

2. **OPTIONAL: If you no longer need the worms for other classes, invite each student to put their worm in the compost or garden.** Invite students to put their worms in the compost or the garden and then observe what the worm does. (The compost is a better habitat for red wigglers.)

3. **If you know there are worms and/or evidence of worms that students can easily find in your outdoor area, share that students will get an opportunity to go look for worms and evidence of worms in the garden.**

4. **Offer some places where students could search for worms or worm evidence.** Offer ideas for places and things students could look for:
   - ▶ *You may find worm castings: tiny piles of worm poop left by worms near their burrows on the ground. It's also the stuff they leave in worm bins.*
   - ▶ *You might find worm tunnels under logs, rocks, or stepping stones. Some worm tunnels may have worms in them.*
   - ▶ *You might find worms in the compost pile.*
   - ▶ *Would anyone like to add an idea about where we might find worms or what evidence of worms we might notice?*
   - ▶ *Where have you seen worms in the past? What are some differences and similarities between the conditions in this place and where you've seen worms in the past?*

TEACHING NOTES

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. But science is a way of knowing and a process for thinking and learning, not just a body of knowledge. Including broad questions (questions that have multiple possible responses, such as "How might earthworms protect themselves?" or the question in Step 7) in science learning 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.

5. **Invite students to explore for 5–10 minutes, reminding them to follow garden rules and encouraging them to share what they found with one another.**

6. **Circulate and engage students in conversation about what they are finding.** As you circulate, ask students about what they are finding. If students share what they think is evidence of worms, ask them to share the reasoning and evidence behind their thinking.

7. **After students have had 5–10 minutes to explore, bring the group back together.** Then, offer a question comparing worms' experience in compost vs. in the garden:
   - ▶ *Do you think the compost or the garden is a better environment for worms to survive in? Why or why not? Support your answer with evidence.*

Option 3: Sing "Gusano" ("I Am a Worm")

1. **Sing the song "Gusano." After the song, ask students what they learned about worms through the lyrics.** Teach students the chorus and then sing the whole song together. Afterward, ask students if they learned anything else about worms by listening to the song's lyrics.

Reflecting and Wrapping Up

1. **Invite students to Turn & Share briefly about the Guiding Question and to notice if they feel they know more about worms now than they did at the beginning of the lesson.** Alternatively, you can have students discuss the question in pairs as they travel back to their classroom after Steps 2–4 of Discussing Worms.
   - ▶ *Take a look at our Guiding Question again. Discuss it with your partner. As you discuss the question, reflect. Do you feel that you know more now that would help you answer this question than you did at the beginning of class?*
   - ▶ *Share what you have learned about worms and what you did today that helped you to learn about worms.*

2. **Invite students to return their materials by using whatever system you have in place for your garden, classroom, or student group.**

3. **Ask students to wash their hands after class.**

Instructor Support

Some Answers to Frequently Asked Questions About Worms

How do worms move around? Worms have many clumps of bristles on each of their segments. Worms use these bristled segments to grip the ground and then pull themselves forward or backward.

How do worms breathe? Worms breathe through their skin. The mucus on worms' skin allows oxygen to pass into their circulatory system. This is why worms need to stay in moist environments to avoid drying out.

What do worms eat? Earthworms eat decaying leaves, decomposing bits of organisms, and other pieces of organic matter in the soil. Worms will also eat tiny organisms such as fungi, bacteria, and nematodes that live in soil.

How do worms affect their environments? Worms contribute to the decomposition process by eating dead organisms and their wastes and pooping out castings, which become a part of the soil. Worms also aerate the earth or their compost piles, allowing more air and water to come in and enter the soil.

Other cool stuff about worms. Worms were the first organisms to have a one-way digestive system in which food goes in one hole (mouth) and comes out another hole (anus). Before worms, it all entered and exited through the same hole. Digestion became more organized with worms.

Common Related Misconceptions

- **Misconception.** If you cut a worm in half, it will survive as two worms.

  More accurate information. If you cut a worm in half, you kill or damage the worm. If a worm loses its tail below its clitellum (the raised band encircling the middle of the worm), the head end will survive. The tail end may wiggle for a while, which works to distract a predator, but the tail end dies. If a worm is cut in two above the clitellum, both ends die.

- **Misconception.** Worms found in puddles during the day are drowning and must be rescued.

  More accurate information. When the ground is wet, worms often come to the surface at night. Scientists think this allows them to move around the area more quickly than they can with tunneling. It is also easier to find a mate aboveground than underground. However, worms can only emerge when it's damp enough so they won't dry out and when it's dark enough so birds don't feast on them. Worms found aboveground during the day are probably sick and dying, because worms don't have melanin in their skin to protect them from UV rays. Worms in puddles are more likely to be killed by drying out and by sunlight than by drowning. Worms can actually survive for days under water because worms' skin needs to be damp.

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.

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 experience, listen to different perspectives, and have time to process the material. Productive discussions, in which many voices are heard and the group builds off each other's ideas, create an experience where students see themselves and each other 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

TEACHING NOTES

"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* 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 like *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, *Worm Explorations* promotes an equitable, inclusive, and culturally relevant learning by:

- scaffolding skills of scientific observation, illustration, and communication to support students' visual literacy, language acquisition, and engagement with the activity.
- connecting students' in-the-moment learning behaviors to practices of working scientists, contradicting the exclusionary ideas that science is a list of facts to memorize or that only people who are good at memorizing facts can be good at science.
- using broad questions to invite students to share their observations, prior knowledge, and experiences with one another and the instructor.
- engaging students with commonly found parts of nature such as worms, 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.
- 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*). This approach to teaching supports students in becoming independent learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences where all students feel capable of success and have the tools to carry that success into other domains.

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

TEACHING NOTES

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

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

Connections to the Next Generation Science Standards (NGSS)

BEETLES student activities are designed to incorporate the three-dimensional learning that is called for in the 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 that students can take with them and apply anywhere to deepen their understanding of nature, and they're interesting and fun to do!

In *Worm Explorations*, students engage in the Science and Engineering Practice *Constructing Explanations* and apply the Crosscutting Concept *Structure and Function.* Students also have the opportunity to build understanding of Disciplinary Core Ideas related to *Structure and Function*. (Note: *Structure and Function* is a both a Crosscutting Concept and a category of Disciplinary Core Ideas within the domain of life science.)

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 how things work. Students should develop their understanding of science concepts through making their own explanations about natural phenomena.

- In *Worm Explorations*, students have some opportunity to engage in the Science and Engineering Practice *Constructing Explanations* as they observe their worms, make drawings, and discuss questions such as: *How do you think the lines/segments on a worm help it survive? Which end is the head? What is your evidence? Can you explain how earthworms move around?*

Featured Crosscutting Concepts

Learning science through the lens of Structure and Function. The idea that structure and function complement each other is a useful tool for explaining things in science. In the designed world and in any natural system, the shape and material of a structure is related to what it does, and vice versa. In *Worm Explorations*, students observe organisms' structures and make possible explanations for how each one helps the organism survive in a specific environment. In other words, students look at structures and think about how they might function. However, students aren't introduced to the specific language and scientific application of structure and function until they are asked to reflect on their own thinking processes toward the end of the activity.

- In *Worm Explorations*, students apply the Crosscutting Concept *Structure and Function* while thinking about how certain structures or behaviors work and help a worm survive.

TEACHING NOTES

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

- When the instructor points out to students how observing structures and thinking about how those structures function is something that scientists do, it helps students realize the way in which 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. Students need multiple learning experiences to build their understanding of NGSS disciplinary core ideas. *Worm Explorations* gives students an opportunity to develop understanding of some Disciplinary Core Ideas related to *Structure and Function* (LS1.A) and *Cycles of Matter and Energy Transfer in Ecosystems* (LS2.B).

- When students observe worm structures and behaviors and then think about how the structures and behaviors help worms to survive, they are building understanding that organisms have characteristic structures that serve functions in growth, survival, behavior, and reproduction. (LS1.A)
- Students can further their understanding of this content if they engage in the optional activity: *Reading Earthworms Underground*.
- As students observe earthworms' behaviors, thinking about how they breathe and interact with their surroundings, students build understanding of the idea that organisms obtain gases and water from the environment and release waste (gas, liquid, or solid) back into the environment. (LS2.B)
- Students can further their understanding of this content if they engage in the optional activity: Reading *Earthworms Underground*.

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

Performance Expectations to Work Toward

No single activity can fully 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 is one performance expectation that this activity can help students work toward:

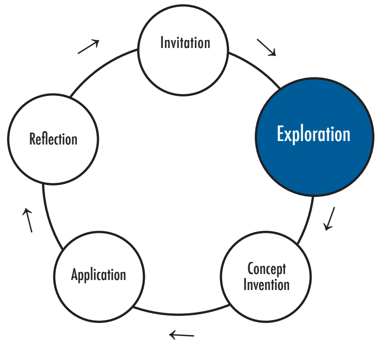
- **4-LS1-1.** Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Activity Connections

Other activities in which to engage students in applying the Crosscutting Concept *Structure and Function* include *Structures and Behaviors* and *Adaptation Intro– Live!* The activity *What's in Compost?* can be used to engage students in further learning in the garden.

TEACHING NOTES

Crosscutting Concept signs. The NGSS includes Crosscutting Concepts such as *Structure and Function*. These are big ideas that scientists use to come up with questions, make explanations, and understand science. John Muir Laws has free signs for educators to use. Hold them up when students are using a Crosscutting Concept in their thinking and point it out so they recognize Crosscutting Concepts as thinking tools. You can download the posters here: https://johnmuirlaws.com/product/crosscutting-concept-poster/



This activity takes students through a full Learning Cycle, but in the sequence of a larger learning experience, it falls mostly in the Exploration Phase.

Elephant Photo

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WORM STUDY

Name:

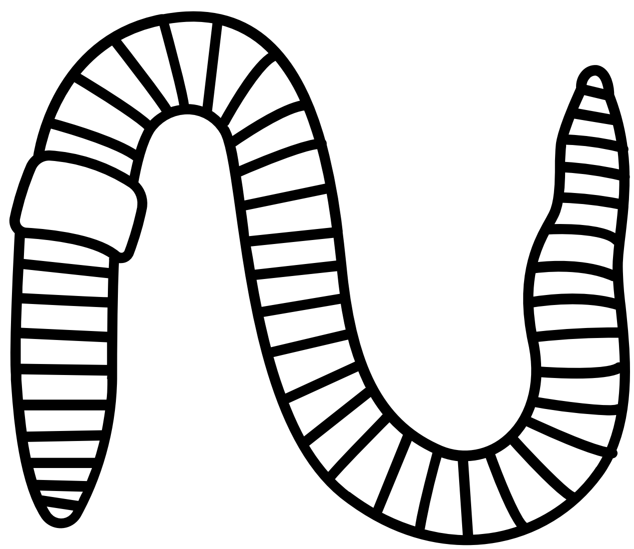
Date:

Draw your worm. Label its structures (body parts), inside and out

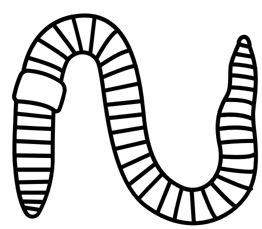
Write down your worm's behaviors (what it does)

GUIDING QUESTION:

What body parts and behaviors (things it does) help worms survive?

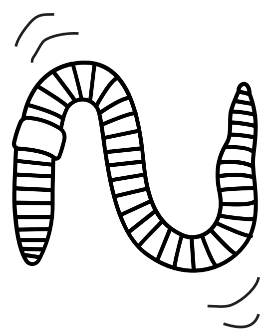


1. Observe and draw worm body parts
(inside and out)



2. Observe and write down worm behaviors

(things it does)



Be gentle

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