beetles

Science and Teaching for Field Instructors

Student Activity Guide

Decomposition Mission

In this activity, students investigate the fascinating and complex process of decomposition and lay the foundation for deeper understanding of concepts related to matter and energy transfer in ecosystems. Through exploration and discussion, students go beyond simple definitions. Instead, students discover key characteristics of decomposition as they struggle with creating a sequence for decomposing wood and leaves. They learn the difference between physical decomposition and chemical decomposition and that many things contribute to decomposition, but certain organisms are classified as decomposers. They also search for and discuss evidence of decomposers, make model diagrams to further develop their ideas about the process of decomposition, and discuss decomposition and its role in the cycling of matter. Finally, students are challenged to recognize the evidence and impact of decomposition in the ecosystems they explore.

Students will:

- **Explore, observe, and compare samples of decomposing materials and use reasoning to determine the level of decomposition among them.**
- **Search for and classify decomposers (or evidence of them) as fungi, bacteria or invertebrates.**
- **Investigate and discuss decomposition as the process of breaking down dead organisms and their waste materials into smaller and simpler forms of matter.**
- **Create a model diagram for the process of decomposition**
- **Discuss the role decomposers play in making matter available to living plants**

Grade Level:
Grades 5-8. Adaptable for younger or older students.

Timing:
About 90 minutes altogether or split into three 30-minute chunks

Setting:
1) A leafy forest floor with many examples of approximately 4 species of decaying leaves and logs.
2) Area with rotting logs to turn over.
3) Area to sit in circle for discussion.

Materials:
For instructor: portable white board with markers; 1-2 sets of FBI images (page 20); (optional) Decomposition statements (page 23). *For each student:* journal and pencil; (optional) 1 hand lens

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

Related Activities:
- *Matter & Energy Diagram*
- *The Case of the Disappearing Log*
- *Bark Beetle Exploration*
- *Eat, Build, Do, Waste*

NEXT GENERATION SCIENCE STANDARDS

For additional information about *NGSS*, go to page 16 of this guide.

FEATURED PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Developing and Using Models	Energy and Matter	Cycles of Matter and Energy Transfer in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Decomposition Mission

ACTIVITY OVERVIEW

Decomposition Mission	Learning Cycle Stages	Estimated Time
Introducing the Activity	Invitation	5 minutes
Decomposition Displays	Exploration, Concept Invention	25 minutes
Search for Decomposers	Exploration, Concept Invention	25 minutes
Making Decomposition Diagrams Models	Concept Invention, Application	10 minutes
Decomposition Discussion		15 minutes
Wrapping Up: Reflection on Decomposition	Reflection	10 minutes
TOTAL		**~90 minutes**

TEACHING TIPS

Field Notes. On page 24 of this guide, is a pocket-sized version of this lesson that you can use in the field.

Read the Instructor Support Section. Beginning on page 10, you'll find more information about pedagogy, student misconceptions, science background, and connections to standards.

Discussion is an important part of learning. If a student knows how to state a definition of decomposition or "the FBI!" they don't necessarily understand the concepts of decomposition and decomposers. Allowing students to talk to each other, examine evidence, voice questions and ideas, apply concepts, and make connections is what will build deeper understanding and make the learning stick.

Pay attention to group needs. Consider moving to a new location between sections of this activity so students don't lose focus or interest. Or, split the activity into three main chunks and teach them at different times throughout the day/week.

More info on decomposition & common misconceptions. See the Instructor Support section for more information about misconceptions and to read accurate information about decomposition.

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

Introducing the Activity

1. **Ask students what they think happens to the matter from living things when they die.**

   ▶ *If plants and animals have been living and dying here on Earth for millions of years, why aren't we hiking through all their dead matter right now? Where has all that stuff gone?*

   - Allow a few students to share out their ideas. If they say "decomposition," or, "they decomposed," ask them to describe what they mean by that word.

2. **Use a fresh leaf and soil to introduce first and last stages of decomposition.** In one hand, hold up a "fresh" green leaf, and in the other hold some soil.

   ▶ *How could a leaf become part of the soil like this?*

   - Listen to their ideas, then introduce this definition:

   ▶ *Decomposition is when dead organisms and their wastes are broken down into smaller and simpler forms of matter–such as nutrients, carbon dioxide, water and organic matter that all become part of soil.*

3. **Tell students that by looking closely at different stages of decomposition, they can find evidence of how it happens.**

   ▶ *Today we're going to explore and study decomposition in action to try to figure out how it happens.*

Decomposition Displays

1. **Groups of ~4 find & lay out stages of leaf or wood decomposition.** Divide students into groups of ~4. Assign each group to a different type of abundant leaf or wood (e.g. oak leaves, birch bark, pine wood, etc.) that has already fallen. Tell them to begin making displays organizing samples from "fresh" (i.e., the least decomposed) to part of the soil (i.e., the most decomposed).

   ▶ *Your mission is to make a display that shows the stages of decomposition of the leaves or wood you were assigned, going from "fresh" to being part of the soil. Try to include as many stages as you can.*

2. **Circulate, ask questions, & troubleshoot.** Circulate as students work. Ask questions and encourage them to explain their reasoning behind putting pieces in a particular order. Encourage them to make comparisons between stages of decomposition. Support groups with issues about working together, and help any students confused with the task. Ask questions such as:

   ▶ *What characteristics are you using to decide which things are more decomposed than others? (e.g.,: dry, brittle, soft, with holes, more grayish etc.)*

TEACHING NOTES

What's the matter? If your students aren't sure what is meant by "matter," you may need to help them with an accessible definition and examples. Definition examples: "stuff," "a physical substance," "something that has mass and takes up space." Examples of examples of matter: "this tree is made of matter, the water is, *you* are, and air is. All the 'stuff' in the universe is matter. But energy, like heat or light, is not matter."

Defining decomposition with younger students. With younger students, consider stating the definition in simpler form, such as: "Decomposition is when dead things and their wastes are broken down into smaller pieces and into different stuff, like tiny pieces of poop, water, and air."

Provide more structure for groups that need it. If certain groups are struggling with this task, provide more structure as they build their decomposition displays. You can assign roles to students: some are in charge of looking for more samples; others are in charge of putting the samples in order; others are asking why it should go in that order.

TEACHING NOTES

Make sure to emphasize how student displays are scientific models. All scientific models are used to make explanations and predictions. Models can be diagrams, physical structures and/or computer simulations. It can be helpful to discuss in what ways the displays are accurate and inaccurate models of what happens during decomposition. Examples of inaccuracies: all the pieces represent what happens to one piece over time, it happens over a long period of time, it doesn't show all the steps.

3. **Groups present displays to each other & describe characteristics they used to generate the order of decomposing materials.** Allow each group to present their work to the whole group, or give groups time to check out each others' displays. Ask students to explain to others what characteristics led them to classify objects as more or less decomposed.

4. **Students &/or instructor share characteristics the decomposing leaves and sticks from different displays have in common.** Ask students - or summarize for them yourself - characteristics for decomposition that the decomposing leaves and wood from different group displays share in common. For example, "the decomposing leaves and sticks tend to be more dull in color," or, "many of the decomposing leaves and sticks had holes in them."

5. **Point out evidence in displays, like holes or sponginess of wood, of something missing, & ask where it may be now.** For example:

   - *See the holes in this wood? There used to be wood there, but now it's not there anymore. Where could it have gone?*
   - *Feel how spongy this wood feels. That's evidence that stuff that used to make it feel hard is missing. Where could that stuff be now?*

6. **Connect displays to models used in science.** Explain that when scientists try to understand a process like decomposition, they often create models similar to these, to make predictions about what they might see in nature over a long period of time. Then they might check to see if their model is accurate by leaving the material outdoors to decompose more while carefully recording what happens.

Search for Decomposers

Continue reminding students of the definition of decomposition. There is a lot in the definition to absorb to understand decomposition. Throughout the activity, use variations of the definition to help direct their thinking. E.g.,: So you think that's a decomposer? How do you think it breaks dead stuff down into simpler forms of matter, like the stuff in soil, and in the air?

1. **Ask students to describe evidence of what causes things to decompose that they have seen in their displays or elsewhere.** Ask students to think back on the leaves and wood in their displays, and remember anything they saw that might be evidence of what is causing things to decompose [e.g.,: We saw tiny holes that could be evidence of an insect eating it]. They can also bring up evidence they've seen during other parts of the field experience, or any other time from their lives. If it's helpful, you might tell them to return to their displays for a moment to look.

2. **Gather the group around a display that has clear evidence of things breaking down into both *smaller* & *simpler* parts.** For example, for smaller, you might have leaves or wood broken up into smaller pieces. For simpler, you might have termite frass or soil with lots of organic matter in it (leaves/wood that have been changed into a different substance).

Learn more about chemical vs. physical decomposition in the Instructor Support section.

3. **Introduce part of decomposition as breaking things down into *smaller* parts, & ask for examples.** Tell students there are two parts to decomposition. When you break up a leaf or piece of wood, you're breaking things down into *smaller* parts, but not necessarily simpler parts. Point out an example of this in the display.

4. **Demonstrate breaking something into smaller parts with a dead leaf or piece of wood. Say:**

   ▶ *Each smaller piece of wood (or leaf) I'm breaking off is smaller, but it's still made of the same stuff. It's just smaller pieces of wood (or leaf).*

5. **Ask students for examples of other things that might break leaves or wood down into smaller parts [chewing, stomping, grinding etc.]. Listen to their ideas.**

6. **Introduce another part of decomposition as breaking things down into *simpler* parts - different stuff - like poop, CO_2 & H_2O, & point out examples in the display.** Tell students that decomposition isn't complete until dead things are broken down into *simpler* parts that are made of a different substance than what they were. When a deer chews grass, it's just becoming smaller pieces of grass. When it *digests* grass, the grass is changed into poop, carbon dioxide, and water, which are all different substances than grass.

7. **Ask students for other decomposition examples they can think of in which things are broken down into simpler parts (there are many!).**

8. **Explain that scientists put organisms in categories that describe what they mostly do for an ecosystem & how they get their food in an ecosystem.**

9. **Explain that "decomposer" is a group of organisms that break down things that used to be alive, & their wastes, into simpler parts that can be used by plants.** Tell students that some organisms have a special role in the ecosystem because they make decomposition happen–they're called decomposers.

   ▶ *Decomposers are organisms that break down dead plants, animals, and other organic matter into simpler forms of matter, like nutrients that become part of soil, and carbon dioxide and water that become a part of air. They break them down into forms of matter plants can use to build and grow.*

10. **Introduce FBI (fungi, bacteria & invertebrates), show students the "FBI Cards" & ask what they might look like in the environment.** Let students know they will have a chance to search for decomposers in the area, and that learning what they could look like will help them track these decomposers down.

    - **Show images of fungi & ask students to describe what they see –** Round spots on leaves, and white thread-like stuff in dirt and decomposing logs may be fungi, or evidence of fungi.
    - **Show images of bacterial decomposition & ask students to describe what they see –** Bacteria itself is too small to see. But spots on leaves that aren't round may be *evidence* of bacteria.
    - **Show images of invertebrates & ask students to describe what they see**

11. **Explain that decomposers, though often tiny, leave evidence behind**

TEACHING NOTES

"Decomposer" describes the role within an ecosystem; it is not a strict definition. Read more about defining decomposers in the Instructor Support section. Remember to avoid perpetuating this misconception–tell students that invertebrate decomposers don't always eat dead things and emphasize that they can and often do eat things that are still alive, and that organisms don't care or know what category we've put them in, and are focused on their own survival, not what they can do for the ecosystem. Let students know that finding an invertebrate under a log does not necessarily mean it's a decomposer. When discussing what they found, encourage students to use language of uncertainty. For example: "I found an insect that looks like a beetle which might be a decomposer".

Fungus or bacteria? Spots on leaves are evidence of bacteria and fungi. Round spots are more likely from fungi, because fungi tend to grow outwards in circular patterns.

TEACHING NOTES

Model how to look for decomposers. Model digging in the duff and decaying wood, or peeling bark away from logs to get students exploring actively. Refer to BEETLES *Habitat Literacy and Exploration Protocols* for more on *Under Log* exploration.

Using diagrams as scientific models. Models are used by scientists to represent a system that's being studied, to help develop questions, predictions and explanations, and to communicate ideas to others. A model diagram makes the underlying processes more visible and accessible when they are difficult to observe directly. By developing a model diagram that represents their understanding of decomposition, students are actively building on their own explanations and communicating ideas with others. For more on models, see Featured Science and Engineering Practices in the Instructor Support section.

like spots on leaves, holes, tunnels, poop etc. Tell students that although many decomposers, like microscopic bacteria and fungi, are hard to see, there are ways to see decomposers at work. Describe fallen logs where they can find small invertebrates, and tunnels or droppings as evidence of invertebrates. Point out that holes or bites in leaves are sometimes evidence of invertebrates or even vertebrates (i.e., deer grazing).

12. **Give safety talk about finding decomposers.** Tell students not to touch any organisms without an instructor (except plants, if you know they're safe to touch).
    - Roll logs toward your body (demonstrate this).
    - Don't put fingers where you can't see to avoid accidentally touching harmful organisms, such as scorpions or spiders.
    - Gently return logs or rocks to their original position to preserve moist habitat.
    - [Provide warnings about any harmful organisms you are aware of in the area.]
13. **Students search for decomposers while instructor circulates.** Tell students they'll spend ~10 minutes searching for decomposers and evidence of decomposers. As you're searching with them, ask broad questions to encourage exploration and thinking:
    - What evidence have you found? What might have caused it?
    - What organism could've made this happen to the wood or leaf?
    - What about this place might make it possible for the organism to live here?
    - What do you think it eats? Where might it get the matter it consumes?
    - Where did you find the most evidence of decomposers? The least amount of evidence?
14. **Gather the whole group, & ask a few students to share what they found.** Listen as students share explorations and take the group to directly observe any evidence that seems particularly interesting.
15. **Ask about where they found the most & least decomposers, & what about those areas made them good or bad for decomposers.** Ask where they found the most decomposers/evidence of decomposers, and what made it possible for the decomposers to live there. Ask where they found the least decomposers/evidence of decomposers, and ask what made it less hospitable for them to live there.

Making Decomposition Diagram Models

1. **Explain that the decomposition displays they made were one type of model for decomposition, & now they'll make a different type of model.** Explain that now they'll make another type of model for decomposition - a diagram. What makes their diagram a model is that it uses drawings, lines, arrows and words to explain what is happening during decomposition.
2. **Write the following on a paper or white board, & tell them to include all**

these things in their diagram models:

- Show an example of decomposition
- Explain how decomposition happens
- Include decomposers
- Show results of decomposition

3. **Post this list where it can be seen while they work on their diagrams.**
4. **Demonstrate quick examples, using their suggestions.** On a whiteboard, show how to make a diagram model, including drawing, writing, lines, and arrows. Ask what they might write or draw to show an example of decomposition, and quickly sketch and write what they suggest. Do the same for the other points they need to include (how it happens, examples of decomposers and the results). Use arrows to show when something changes into something else, and lines to show connections. Erase, and quickly model another example suggested by students.
5. **Describe the value in using drawings, labels, writing, arrows & lines in a model.** Point out that diagrams like this are good for showing things that are hard to describe or see. Lines are good for showing specific connections between things. Labels can be used to describe something that's hard to draw (like air), to say what something is, to say what an arrow represents, etc. Writing can also be used to explain ideas or observations. Point out that arrows are useful for showing when something changes into something else.
6. **Encourage students to include examples they've seen today, & from other parts of their lives.** Tell them: *You've seen examples of decomposition and of decomposers today. You've also seen examples in other parts of your life. Describe what it is and how it happens. Include examples from today and/or include examples that you know about from before.*
7. **Students create a diagram model, while discussing with partner for ~5-10 minutes.** Tell students to each find a partner to discuss and complete their diagrams together. As they're working, circulate, and ask questions to help you understand their thinking. Also ask questions that might help them improve their diagram model, such as, "how do growing plants fit into all of this?" or, "how might you add arrows to show how things are changing?"
8. **When it's time, tell each pair to join another pair to share & compare.** They discuss what's similar and what's different. Tell them they can feel free to change or add to their diagram after sharing and discussing with others.

Decomposition Discussion

1. **Encourage a free-flowing discussion about decomposition.** After pairs have completed their model diagrams, ask students if they have any questions or ideas about decomposition for the group to discuss. Use some or all of the following questions to lead a discussion:

TEACHING NOTES

Assessment opportunity. As you circulate, pay attention to what students have included or not included in their diagrams. Ask questions, and use this opportunity to find out as much as you can about what they do and don't understand. Use this information to build upon later, to inform any clarifications to bring up later, or what follow-up activities to do. If possible, collect their journals at the end of the experience, so you can more carefully read what they've written and drawn to understand their thinking.

Avoid commenting on "prettiness." As you comment on student work, avoid commenting on the "prettiness" of their drawings and diagrams. If you tell students "you don't have to make a pretty picture" and then the first thing you say when you see their work is "What a pretty picture!" you'll lose credibility, especially with students who are not confident in their artistic abilities. The key is to give feedback on what you've asked students to do, which is to make a diagram that shows their understandings about decomposition. It's natural to comment a pretty drawing, but it sends the message that it's artistic ability, not making observations, that is valued.

Connections to Matter & Energy activity diagram. If you have used the *Matter & Energy Diagram* BEETLES activity with your students, pull it out and point out any matter cycles they just observed evidence of. If their ideas have grown, add to the diagram.

TEACHING NOTES

Consider using these additional discussion questions for more advanced groups.

- How long might it take different materials, like wood, glass, or plastic to decompose? How could you find out?
- Do you think scavengers, like vultures, should be grouped as decomposers? Why or why not?
- How do you think decomposition might happen in the ocean?

Read more about discussing humans as decomposers in the Instructor Support section.

Opportunity to contrast producers. If students bring up plants during this discussion, let them know that they are actually, producers ("composers?"), not decomposers, because they take in carbon dioxide and water, and make more complex matter out of it.

Concluding the discussion. As part of concluding the decomposition discussion, consider telling students that some scientists consider only bacteria and fungi to be true decomposers. From this point of view, worms would not be considered decomposers, but the bacteria in their guts that help them to break down matter would be the decomposers.

See the BEETLES *Walk & Talk* activity and *Discussion Routines* handout for logistics of these discussion-based activities.

Be sure to take time for reflection! Don't skip this part of the activity. Providing opportunities for students to reflect on their own learning is important for cementing their understanding. As they talk to each other during the *Walk & Talk*, you can listen in on their conversations to hear their ideas about decomposition.

- *Where is the stuff that used to part of the wood now?*
- *Why is decomposition important for ecosystems?*
- *What other things can you think of that might help make decomposition happen?*
- *Can humans be considered decomposers? Why or why not?*

2. ***Optional:* Incorporate decomposition statements from cards when appropriate.** As needed, ask students to read the decomposition statements aloud to spark more discussion or "un-stick" a group that is struggling to move forward in their thinking. Select a card based on whether the idea might add to learners thinking and/or help them build on their ideas. Try to avoid derailing a discussion if learners are actively engaged in discussing their own ideas, or don't seem quite ready for new information.

3. **Use a student model or a nearby example to explain importance of decomposers to ecosystems: breaking dead things down into CO_2, H_2O, & minerals that plants can use to grow.** At some point, select a student model that includes a plant, and point out that it takes decomposers to break dead things down into carbon dioxide gas (as well as water and nutrients) that can be used by plants.

   - *Decomposers are important for ecosystems, because they make matter available for plants.*

4. **Explain that once matter becomes carbon dioxide gas, it takes a lot for it to change into matter that living things can consume again - it takes photosynthesizers (plants).** Through photosynthesis, plants, algae, phytoplankton, etc., make carbohydrates from carbon dioxide and water gas, using energy from the Sun. If no student diagram includes a plant (which would tell you something about their understanding!), explain this using the living plants around you.

   - *Plants are important to ecosystems, because they make matter available as food for living things.*

5. **Tell students that if their ideas have changed during the discussion, they have a few minutes to add to or change their diagrams/models to show this.**

Wrapping Up: Reflecting on Decomposition

1. **Lead students in a *Turn & Talk* or *Walk & Talk* pair discussion.** Ask the following questions to encourage students to reflect on their learning process:

   - *Describe something new that you learned about decomposition.*
   - *How would you describe decomposition to someone who didn't know anything about it?*

- *How does a leaf become part of the soil? Part of the air?*
- *How might this area look different without decomposition?*

2. **Share out their ideas & review the definition of decomposition.** Ask students to share any interesting ideas they heard from their discussion partners. Try to summarize the ideas that are shared. Review the definition for decomposition:

   - *Decomposition is when things that used to be alive are broken down into smaller, simpler forms of matter, such as carbon dioxide and water, as well as nutrients and organic matter that become part of the soil.*

3. **Challenge students to find more decomposers and evidence of decomposition as they continue on the field experience.**

4. **Encourage students to keep looking at nature through the lens of matter cycling.** Ask students to look at all the plants, dead plants, soil and air around them, and to think about how matter is cycling through them. Bring this perspective back now and then, as appropriate. For example:

   - *The stuff around us in nature is changing. Some of the stuff seems to be disappearing. What is changing it, and what is it changing into?*
   - *Where do you think that lizard gets the matter it's made of? Where do you think the matter in the lizard will go after the lizard dies?*
   - *Breathe in some air that used to be part of plants, animals, and soil. What you breathe out will eventually cycle back into those.*
   - *Look at all the trees, other plants, wood, soil and air around you. Imagine all the matter that is moving through them as they change. Think about how long this has been happening with the same matter changing from one thing to another, cycling round and round on Earth.*
   - *How might the water in that stream become part of living or non-living things? What other living or non-living things do you think the matter in the water has cycled through?*

5. **[Optional journal activity].** If students had interesting responses to the question "Are humans decomposers?," then tell them to write about this in their journal, using evidence to explain why or why not. This journal prompt can be used as an assessment to learn what they took away from their decomposition explorations and discussions.

TEACHING NOTES

Telling the "story" of matter cycling through an ecosystem. If you think your group may be into it, you might narrate a "story" describing how matter might move through an ecosystem, while your students run around pointing out examples of each part of the narrative. Alternatively, you could ask them to act it all out with their bodies as you describe each step as matter is being transferred. For example: "There's air around us that it matter. Some of that matter, carbon dioxide, is being sucked into leaves of trees and other plants, and combined with water using energy from the Sun to make sugars for the plant. Some animals eat parts of the plants, and the matter goes into their bodies. Some gets used to build and repair their bodies, and some goes out as poop and carbon dioxide. When the plants die, other critters eat them up, taking the matter into their bodies. Some gets used to build, some ends up as poop, and some ends up being breathed out into the air as carbon dioxide. Then that carbon dioxide gets sucked into other plants. The matter keeps cycling around...

Instructor Support

Teaching Knowledge

Introducing Concepts. Avoid delivering names and content at the beginning of the activity, which might squelch student curiosity and thinking. After students have explored the area and created their stages of decomposition displays, it's a good time to introduce them to more specific details about decomposers.

Spirit of Inquiry and Investigation. Students often get caught up in wanting to see the "charismatic mega-fauna" in a forest, but often the coolest finds are those we more easily see and can fit inside a cup. Keep in mind that smaller creatures can be observed more closely and usually for a longer amount of time. Looking in and under rotting wood is often a rich place to find a variety of organisms, as students do during the Search for Decomposers.

Science Language. Science is about coming up with the best explanation for all the available evidence. It's also about being open-minded about hearing another explanation that could be better. In science, nothing is ever "proven." That's why scientists tend to use language of appropriate levels of uncertainty when discussing ideas and explanations. Try to use sentence starters like, "Maybe..." "I wonder if..." "That evidence makes me think..." "The evidence seems to show..." and encourage students to phrase their statements in similar language of uncertainty.

Conceptual Knowledge

The following information is meant as background information for the instructors, not as talking points for a lecture, or as a list of concepts students should understand.

Decomposition is a complex process that many students may struggle to fully understand. The main ideas regarding decomposition that most 4-8th gradestudents can begin to develop through this activity are:

- Decomposition is the process of dead plants and animals breaking down into smaller and simpler parts.
- When dead plants and animals decompose, they eventually become part of the soil, water, and air.
- Decomposers help break down (or decay) dead plants and animals.
- Plants use the nutrients from soil, not as food, but as vitamins that help run their body systems.
- Decomposers are important to ecosystems, because they make matter available to plants, which 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, 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 plants, animals, animal wastes, and other organic matter into simpler forms of matter–chemically different substances–like nutrients that become part of soil, and carbon dioxide

and water that become a part of air.

What exactly are decomposers? 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's always gray area, and you can end up with organisms that could potentially fit in different categories. More categories get invented to clarify and describe subtle distinctions, but these categories can also be confusing to students.

It can be frustrating for kids to try to categorize organisms, if the categories are portrayed as absolute and clearcut. It is more satisfying (and interesting) if they can understand that categorizations are useful, but there is also gray area and that can be discussed. 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, but most of these organisms are placed in other 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 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* are animals, such as vultures and hyenas, that also feed on dead animals and plants. Confusing, huh? Because this can be a little confusing, with students, these ideas are often simplified. Earthworms, sow bugs and other invertebrates are often accepted as decomposers along with fungi and bacteria (the FBI). But fungi and bacteria are the true stars of decomposition. Bacteria live all over the place, including in the digestive systems of other organisms, like worms, and decompose organic matter inside of them. And fungi is generally considered to be the most important decomposer in ecosystems. Fungi are the only decomposers able to break down the lignin in wood, and there's a lot of wood to break down in many ecosystems. So, what to do with kids? In this session, we have chosen to go with the good ole FBI, partly because invertebrates are often easier to observe. But 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 things down into "smaller parts" we're referring to the physical changes in decomposition. Breaking things down 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

"Decomposer" describes the role within an ecosystem. When students learn that invertebrates are decomposers, they often mistakenly assume that these organisms only eat dead things, or that they can't eat anything but dead material because "it's not their job."

Not all invertebrates are decomposers. Students often carry the misconception that every invertebrate is a decomposer. Let students know that finding an invertebrate under a log does not necessarily mean it's a decomposer.

TEACHING NOTES

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 a child could come up with this explanation after watching fruit rot, if they don't see or recognize fungi and bacteria as organisms. Later students may recognize that organisms are involved in decomposition, but they see it mostly as a mechanical process that occurs through chewing, and stomping.

Most students grow to recognize macro-organisms as decomposers, such as worms, sow bugs, mushrooms, and slugs. They may still not acknowledge 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. The remaining soil is made up of the undigested and inorganic (i.e., pebbles, sand, mineral) 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 the purpose of 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. 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 are like vitamins for plant cells, and are crucial ingredients for certain processes to occur.

Carbon Cycle. As environmental educators, we often say, "everything is connected." Sharing parts of the carbon cycle with students really offers 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're part of the carbon cycle!

Matter. Matter is the "stuff" things are made of. Wood is matter, bones are matter, water is matter, and even air is matter. Matter takes up space, but it's hard to feel that with air unless you capture some in a balloon or bag. Matter also has mass (weight), but that's also hard to feel with air, because it has so little mass. We live in a "sea of air." It's difficult to feel the weight of air when we're surrounded by it on all sides.

Energy. Energy is much harder to define than matter, and has different

definitions depending on the branch of science. In this context, energy can be defined simply as what organisms get from food that allows them to do things. If you are introducing students to the term "matter," energy can be partially defined as "not matter." Unlike matter, energy doesn't take up space or have mass. Energy has no physical form; it is not a substance. When energy is transferred from one organism to another, no physical thing is passed from place to place. What's transferred is the capacity to do things, e.g. to live and to grow. Sounds weird, but it's accurate.

Matter cycles & Energy flows. If you tackle this topic with students, or a part of it, it's important to make the distinction that matter cycles and energy flows. In ecological science, that's an important distinction. The matter in Earth's system is pretty much fixed: it's the same matter that's been here for ages. We may lose a little bit of matter in the form of air molecules and space craft we send out into outer space, and we gain some matter from meteorites etc., but otherwise it's the same stuff cycling round and round since the Earth was formed. The matter around us and that we are made up of has been cycling through countless different forms throughout Earth's history. Energy, on the other hand, flows through Earth's systems. Every day energy from the Sun enters Earth's atmosphere, while an (almost) equal amount is released from the atmosphere and travels into outer space. If that wasn't the case, Earth would become an extremely hot planet. Sometimes in environmental education, matter and energy are treated as interchangeable, which is inaccurate and confusing to students. The concept of energy is complex and harder for students to understand, and matter is a much more concrete concept to grasp. That's why in this activity we've chosen to focus in on the cycling of matter through the process of decomposition. If you have more advanced students, you may choose to help them to think about how decomposition is also involved in the flow of energy through ecosystems.

Importance of photosynthesis. Plants take matter from air (CO_2 and H_2O) and use energy from the Sun to "package" it as carbohydrates ($C_6H_{12}O_6$), giving off the waste product of O_2. This is an amazing thing, and it converts stuff that life forms couldn't otherwise use into carbohydrates that they can use. This stuff is food to organisms when it's in a form they can consume and take matter from the food to use to build and repair body parts, fluids etc., and energy to use to do things, like run, fly, grow, etc.

Understanding the Nutrient Cycle. Plants need nutrients from the soil to grow, just like people need vitamins and other substances from their food. Soil nutrients come from gases in the air, from the breakdown of mineral-bearing rocks, and from organic matter, which comes from the decomposition of plants and animals. The nutrients that plants get from the soil are stored in all plant tissues, for example in leaves, stems, and flowers. When these tissues fall to the ground, they start to break down, and, together with decomposing dead insects, dead animals and animal feces, they are eventually re-incorporated 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.

Living things interact with soil by creating tunnels for water and air, recycling nutrients, and mixing mineral particles throughout the soil. Organisms such

TEACHING NOTES

as earthworms, isopods, bacteria, and fungi help decompose dead plants and 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.

Understanding Soil & Climate Change. Plants remove CO_2 from the air, and the carbon becomes part of plant bodies. Decomposers break down organic material, like dead plants, 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. But some organic material breaks down much more slowly, thus "storing" some carbon in the soil. The Earth's soils contain about three times more carbon than vegetation does, and twice as much as is in the atmosphere. 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 increases the soil's health and carbon storage.

Human as Decomposers. If you discuss this question with students, make sure to let them know that humans do contribute to decomposition, but scientsists do not usually consider humans to be decomposers. There is lots of gray area within these ecological categories, but the "decomposer" label is used for organisms that primarily break matter down into substances that can be used by plants to grow. Of course the bacteria in our guts, (which is kind of part of us) are considered decomposers, so we carry our own little private posses of decomposers that help us survive. See the Instructor Support section for more on this.

Common Relevant Misconceptions

Misconception. Dead organisms spontaneously break down.

More accurate information. Dead things don't spontaneously break down. Organisms referred to as decomposers, such as bacteria, fungi and invertebrates, consume the dead tissue, releasing some of the matter as carbon dioxide and water into the air, and undigested waste products that become part of soil.

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

More accurate information. All the matter in dead organisms eventually continues cycling through the soil, the atmosphere and the bodies of other organisms.

Misconception. Energy from the Sun is captured by the Earth and keeps cycling round and round in ecosystems.

More accurate information. Eek! If that were true, Earth would be a sweltering planet! Matter cycles through ecosystems here on Earth, and does not usually leave the planet. A large amount of energy flows to Earth

from the Sun in the form of light energy, and it is captured by plants and "packaged" with matter in the form of food. But at every link in a food chain or web, ~90% of the energy is released from the organism and eventually drifts into outer space as heat. Only ~10% of the energy is passed on to the next organism. There is a constant flow of energy from sunlight into an ecosystem (during the day), and a constant flow out of the ecosystem into space.

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

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

Misconception. The matter that plants use to make sugar mostly comes from soil.

More accurate information. Many students (and adults) think that plants make food from soil, probably because carbon dioxide seems so insubstantial, and because the nutrient cycle tends to get a lot of focus in environmental education. Plants make sugar/food from carbon dioxide and water, in the presence of sunlight. The soil provides important nutrients (not food!) for plants, and are kind of like what vitamins provide for people. This is an oversimplification of the role that nutrients like phosphates and nitrogen compounds play in plants' metabolic processes. However, it's important not to reinforce this misconception that may have originated from references to "feeding" plants with fertilizers. It's funny, because even people who have studied photosynthesis, and are familiar with the equation (which doesn't include soil) often list soil as where the mass of plants mostly comes from, perhaps because they haven't been asked to apply what they've learned about photosynthesis to food webs and food chains.

Misconception. Plants build their mass from minerals they get from the soil.

More accurate information. Minerals are important to plants to function, like vitamins are important to us, but they are not food. The bulk of the matter of plants comes from CO2 from the air and H2O, that are used to build sugars in the presence of sunlight.

Misconception. Organisms convert matter into energy.

More accurate information. This is a very common misconception, even among adults. Matter is not converted into energy in life systems on Earth. Almost all of our energy comes from the Sun. Through photosynthesis, plants make use of a tiny portion (less than 10%) of the incoming Sun energy. Plants bind this energy and matter together into a package that animals can digest as food. At each stage of the food chain, an organism is able to make use of some of that energy, as it is tranformed from chemical energy to other useable forms.Most of the energy consumed by organisms is released in the form of heat and eventually drifts off into space. The matter in food never becomes energy. When organisms eat, some of the matter becomes part of their bodies (they gain weight, gain muscles, grow taller,

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 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 (DCIs). The DCIs 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

etc). The rest of the matter gets released when organisms breathe, sweat, pee or poop.

Misconception. All invertebrates are decomposers.

More accurate information. Some invertebrates are not decomposers. Invertebrates are included in the FBI, because many of them serve that function in an ecosystem. Examples of common invertebrates that are not decomposers include: bees, ladybugs, and spiders.

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 it 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 or decaying 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 the decomposers, but 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 non-scientific language can perpetuate the people-centric idea that nature and its systems exist primarily for our benefit or or 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, and air and water. Life depends on soil. It provides substrate, nutrients and homes for many organisms and can be considered the living skin of our planet. In this sense, soil plays a vital role in sustaining human welfare and assuring future agricultural productivity, textile production, and environmental sustainability.

Misconception. Decomposers turn dead things into soil.

More Accurate information. As they consume dead organisms and deposit the resulting "poop" into the soil, decomposers do contribute to the organic constituents found in soil. However, soil also contains inorganic materials from rocks and often some broken down man-made materials. 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.

Connections to Next Generation Science Standards (NGSS)

BEETLES student activities are designed to provide opportunities for the "three-dimensional" learning that is called for in the NGSS. To experience

three-dimensional learning, students need to engage in scientific practices to learn important science concepts (Disciplinary Core Ideas) and make connections to the big ideas in science (Crosscutting Concepts). In short, students should be using the tools of science to explore and investigate rich phenomena, trying to figure out how the natural world works.

Decomposition Mission engages students in the science practice of *Developing and Using Models* to build a foundation for understanding disciplinary core ideas related to *Cycles of Matter and Energy Transfer in Ecosystems* and connect those ideas to the crosscutting concept of *Energy and Matter: Flows, Cycles, and Conservation.*

Featured Science and Engineering Practices

Engaging students in Developing and Using Models. According to NRC's *A Framework for K-12 Science Education,* scientists use conceptual models to investigate parts of a system not visible to the naked eye to better visualize and understand phenomena. Students should be developing models that represent their current understanding of a system or process under study, in order to help develop explanations and communicate ideas to others. In *Decomposition Mission,* the displays students create serve as their initial models for the process of decomposition, as they discuss how increasingly decomposed matter may look over time. While they are not asked to revise or articulate how the model is accurate or inaccurate, the displays do represent students' current understanding of the process of decomposition. Throughout the activity they build understanding of the factors involved, and may revise their own internal model of decomposition. Later, students make a diagram model that allows them to use their thinking from the display models, along with their observations of decomposers, to create a more complete conceptual framework for the process of decomposition. By referring to concrete examples in their discussion of the diagram with a partner, students are able to deepen their understanding of decomposition and adjust their own mental models accordingly.

Featured Crosscutting Concepts

Learning science through the lens of Energy and Matter. Tracking the transfer of matter and energy in and out of, as well as within, a system enables scientists to learn about the relationship between the various elements that make up and drive all kinds of systems. The *Framework* states that a significant part of helping students see the value in this crosscutting concept is discussing how thinking about matter and energy transfer in ANY system helps you to understand more about how that system works. *Decomposition Mission* focuses on describing how matter cycles through ecosystems, specifically through the role of decomposers and the decomposition process. We suggest encouraging students to apply this lens to other contexts, such as water in a stream, to help students better understand and "own" this thinking tool. As students discuss how matter in decomposing organisms is broken down into smaller bits of matter that can be used by plants, they are beginning to identify important connections within the ecosystem, as well as realizing that matter is always conserved (i.e., neither created nor destroyed). Though this lesson focuses less on energy, it provides a solid foundation for how matter cycles and energy flows in ecosystems. It's important to frame the activity

TEACHING NOTES

Importance of teaching science practices. "Engaging in the practices of science helps students understand how scientific knowledge develops...It can also pique students' curiosity, capture their interest, and motivate their continued study..." -National Research Council, *A Framework for K-12 Science Education.* Focus on these science practices will help to ensure a more scientifically literate public who will be better able to make thoughtful decisions.

About Crosscutting Concepts in the NGSS. Crosscutting concepts are considered powerful thinking tools for how scientists make sense of the natural world. The seven "big ideas" listed as crosscutting concepts are: Patterns; Cause & Effect; Scale, Proportion & Quantity; Systems and System Models; Energy & Matter: Flows, Cycles and Conservation; Structure & Function; and Stability & Change. These concepts may sound familiar, as they are quite similar to the themes referred to in science literacy documents as being important ideas that unify all disciplines of science and engineering.

Applying the crosscutting concept of matter and energy to different contexts. Crosscutting concepts are thinking tools used in all disciplines of science, to help scientists think about and understand the natural world through different lenses. In order for students to more fully understand and "own" this thinking tool for tracking matter and energy flow, they need to apply it to different contexts. Applying the crosscutting concept of Energy and Matter to the water in an ecosystem is a way for student to extend their thinking to a different context.

TEACHING NOTES

Translating the codes for the *NGSS* performance expectations. Each standard in the *NGSS* is organized as a collection of performance expectations (PEs) for a particular science topic. Each PE has a specific code, provided here so they can be easily referenced in the *NGSS* documents. The first number or initial refers to the grade level: K - kindergarten, 1 - first, 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...MS-LS2-2 means it's part of a middle school standard (MS) for life science (LS), addressing the second core idea (2) *Ecosystems: Interactions, Energy & Dynamics*, within the life science standards, that deals with Interdependent Relationships in Ecosystems. It's also the second performance expectation (2) that makes up the complete LS2 standard at this grade level.

by pointing out how following matter through an ecosystem and thinking about how it changes form, helps us to learn more about the process of decomposition.

Featured Disciplinary Core Ideas

Building a foundation for understanding Disciplinary Core Ideas. The *NGSS* make it clear that students need multiple learning experiences to build their understanding of disciplinary core ideas. *Decomposition Mission* provides students with an opportunity to develop some understanding of the disciplinary core ideas related to LS2.B *Cycles of Matter and Energy Transfer in Ecosystems.*

When students create their decomposition displays and discuss the characteristics that led them to organize those displays, they are introduced to the idea that dead plant matter becomes part of the soil (LS2.B). In searching for decomposers and engaging in a discussion about different aspects of decomposition, students build understanding of the idea that matter is transferred between living and non-living things in an ecosystem. Throughout the activity, students build understanding of the idea that matter cycles between air and soil and among plants, animals, and microbes (LS2.B).

Through a series of discussion prompts and particularly by making their diagram models, *Decomposition Mission* provides students with several opportunities to use concrete observations in making sense of the process of decomposition and how it relates to the cycling of matter in ecosystems. Though this may seem like a simple model, it enables students to more fully work out their own understanding of the definition, characteristics, and examples of decomposition and decomposers–and this is how significant learning can happen. You can also use the diagram models to assess students' understanding and inform your decisions about what to focus on during discussions. Based on what is shown in their models, you might choose to reinforce concepts your group is struggling with, or to go deeper into a concept or idea that students are intrigued with and have still more to learn about.

Performance Expectations to Work Towards

When examined closely, it is clear that the NGSS represent complex knowledge and multi-faceted thinking abilities for students. No single activity can adequately prepare someone for an NGSS performance expectation. Performance expectations are examples of things students should be able to do, after engaging in multiple learning experiences or long-term instructional units, to demonstrate their understanding of important core ideas and science practices, as well as their ability to apply the crosscutting concepts. As such, they do not represent a "curriculum" to be taught to students. Below are some of the performance expectations that this activity can help students work towards.

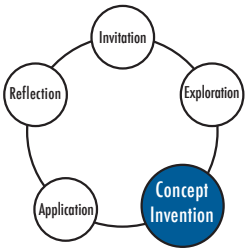
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.

Activity Connections

For an exploration activity that focuses on decomposition try *Bark Beetle Exploration* or *The Case of the Disappearing Log*. For older students, present or return to the *Matter Energy Diagram* to provide students with a deeper understanding of matter cycles and energy flow. *Eat, Build, Do, Waste* is another activity that tackles matter and energy.

TEACHING NOTES



Learning Cycle Stage for This Entire Activity as Part of an Extended Trail Experience

Student FBI Cards

Cut out along dotted line and fold over.

Photo credit (clockwise from top-left): Kirill Ignatyev, Boobook48, Scot Nelson, Don McCullough, Bart Everson, Scot Nelson Monteregina (Nicole).

Photo credit (clockwise from top-left): Scot Nelson, International Institute of Tropical Agriculture, Venenivibrio, Anthony D'Onofrio, Bart Everson, Scot Nelson Monteregina (Nicole).

Photo credit (clockwise from top-left): Arthur Chapman, Kai Wei, Starwatcher307, Andreas Kay, Ian Morton

Decomposition Statements to Aid Discussion:

Cut out the cards before you teach this lesson. Don't introduce these cards randomly. If you feel the information on a card will further the discussion, pass it to a student to read aloud. Help students integrate this new information into their discussion by asking questions or bringing students back to the main topic.

All the stuff around us that takes up space is matter. All the leaves and wood we've looked at, all the fungi and invertebrates are made of matter. Even air, though it's hard to see and feel, is matter.	**Decomposition is when things that used to be alive are broken down into smaller, simpler forms of matter, such as carbon dioxide, water, nutrients and organic matter.**
Just by breathing you lose about 2 pounds of weight everyday from the carbon dioxide molecules you breathe out. That's about the same weight as a full water bottle.	**Drink some water from your water bottle. The same molecules in the water you just drank have been cycling for millennia through plants, clouds, oceans, dinosaurs, ice, even saliva! MATTER CYCLES.**

FIELD CARD

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

DECOMPOSITION MISSION

Introducing the Activity

1. Ask students what they think happens to the matter from livings things when they die.
   - ▶ *If plants and animals have been living and dying here on Earth for millions of years, why aren't we hiking through all their dead matter right now? Where has all that stuff gone?*
2. Use a fresh leaf & soil to introduce first & last stages of decomposition.
   - ▶ *How could a leaf become part of the soil like this?*
   - ▶ *Decomposition is when dead organisms and their wastes are broken down into smaller & simpler forms of matter, such as nutrients and organic matter that become part of soil, and carbon dioxide and water.*
3. Tell students that by looking closely at different stages of decomposition, they can find evidence of how it happens.
   - ▶ *Today we're going to explore and study decomposition in action.*

Decomposition Displays

1. Groups of ~4 find & lay out stages of leaf or wood decomposition.
   - ▶ *Your mission is to make a display that shows the stages of decomposition of the leaves or wood you were assigned, going from "fresh" to part of the soil. Try to include as many stages as you can.*
2. Circulate, ask questions & troubleshoot. Ask:
   - ▶ *What characteristics are you using to decide which things are more decomposed than others?*
3. Groups present displays to each other, & describe characteristics they used to make their order.
4. Point out evidence in displays, like holes or sponginess of wood, of something missing, and ask where it may be now.
5. Connect displays to models used in science.

Search for Decomposers

1. Ask students to describe evidence of what causes things to decompose that they have seen in their displays or elsewhere.
2. Gather the group around a display that has clear evidence of things breaking down into both smaller & simpler parts.
3. Introduce part of decomposition as breaking things down into *smaller* parts, & ask for examples.
4. Demo breaking something into smaller parts with a dead leaf or piece of wood. Say:
   - ▶ *Each smaller piece of wood (or leaf) I'm breaking off is smaller, but it's still made of the same stuff. It's just smaller.*
5. Ask students for examples of other things that might break leaves or wood down into smaller parts
6. Introduce another part of decomposition as breaking things down into *simpler* parts - different stuff-like poop, CO2 & H2O, & point out examples in the display.
7. Ask students for other decomposition examples they can think of in which things are broken down into simpler parts.
8. Explain that scientists put organisms in categories to describe what they mostly do for an ecosystem, & how they get their food in an ecosystem.
9. Explain that "decomposer" is a group of organisms that break down things that used to be alive, & their wastes into simpler parts that can be used by plants.
   - ▶ *Decomposers are organisms that break down dead plants, animals, and other organic matter into simpler forms of matter–like nutrients that become a part of soil, and carbon dioxide and water that become a part of air. They break them down into forms of matter plants can use to build and grow.*
10. Introduce FBI (fungi, bacteria & invertebrates), show students "FBI Cards" & ask what they might look like in the environment.
    - – Show images of fungi, & ask students to describe what they see. (round spots on leaves, white thread-like stuff)
    - – Show images of bacterial decomposition, & ask students to describe what they see. (Too small to see but non-round spots may be evidence of bacteria)
    - – Show images of invertebrates, & ask students to describe what they see.
11. Explain that decomposers, though often tiny, leave evidence, like spots on leaves, holes, tunnels, poop, etc..
12. Give safety talk about finding decomposers.
13. Students search for decomposers while instructor circulates. Ask questions like:
    - ▶ *What evidence have you found? What might have caused it?*
    - ▶ *What organism could've made this happen to the wood or leaf?*
    - ▶ *What about this place might make it possible for the organism to live here?*
    - ▶ *What do you think it eats? Where might it get the matter it consumes?*
    - ▶ *Where did you find the most evidence of decomposers? The least?*
14. Gather the whole group, & ask a few students what they found.
15. Ask where they found the most & least decomposers, & what about

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FIELD CARD

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

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those areas made them good or bad for decomposers

Making Decomposition Diagram Models

1. Explain that the decomposition displays were a type of model of decomposition, & now they'll make a different type of model: a diagram.
2. Tell students they're each going to make a diagram/model-including drawing, writing, lines & arrows-showing what they understand about decomposition.
3. Write the following on a paper/white board, and tell them to include them all in their diagrams/models:
   - _ show an example of decomposition
   - _ explain how decomposition happens
   - _ include decomposers
   - _ show results of decomposition
4. Demo quick examples, using their suggestions.
5. Describe the value in using drawings, labels, writing, arrows & lines in a model.
6. Encourage students to include examples they've seen today, & from other parts of their lives.
7. Students each create own diagram/model, while discussing with partner for ~5-10 min.
8. When it's time, tell each pair to join another pair to share & compare.

Decomposition Discussion

1. Encourage a free-flowing discussion about decomposition. Use some or all these Q's:
   - *Where is the stuff that used to be part of the wood now?*
   - *Why is decomposition important for ecosystems?*
   - *What other things can you think of that might help make decomposition happen?*
   - *Can humans be considered decomposers? Why or why not?*
2. Optional: Incorporate decomposition statements from cards when appropriate.
3. Use a student diagram/model or the real world to explain importance of decomposers to ecosystems by breaking dead things down into CO2, H2O, & minerals that plants can use to grow.
   - *Decomposers are important for ecosystems, because they make matter available for plants.*
   - *Explain that once matter becomes carbon dioxide gas, it takes a lot for it to change into matter that living things can consume again - it takes photosynthesizers (plants).*
   - *Plants are important to ecosystems, because they make matter available as food for living things.*
4. Tell students that if their ideas have changed during the discussion, they have a few minutes to add to or change their diagrams models to show this.
5. Wrapping Up: Reflecting on Decomposition
6. Lead students in *Turn & Talk* or lead *Walk & Talk* pair discussion:
   - *Describe something new that you learned about decomposition.*
   - *How would you describe decomposition to someone who didn't know anything about it?*
   - *How does a leaf become part of the soil? part of the air?*
   - *How might this area look different without decomposition?*
7. Share out their ideas & review definition of decomposition.
8. Students look for more decomposers & evidence of decomposition as they hike.
9. Encourage students to keep looking at nature through lens of matter cycling. E.g.,:
   - *The stuff around us in nature is changing. Some of the stuff seems to be disappearing. What is changing it, & what is it changing into?*
   - *Where do you think that lizard gets the matter it's made of? Where do you think the matter in the lizard will go after the lizard dies?*
   - *Breathe in some air that used to be part of plants, animals & soil. What you breathe out will eventually cycle back into those.*
   - *Look at all the trees, other plants, wood, soil & air around you. Imagine all the matter that is moving through them as they change. Think about how long this has been happening with the same matter changing from one thing to another, cycling round & round on Earth.*
   - *How might the water in that stream become part of living or non-living things? What other living or non-living things do you think the matter in the water has cycled through?*
10. [Optional journal activity]. Students write a response to "Are humans decomposers? Why or why not?

ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) is a program of The Lawrence Hall of Science at the University of California, Berkeley, that provides professional learning sessions, student activities, and supporting resources for outdoor science program leaders and their staff. The goal is to infuse outdoor science programs everywhere with research-based approaches and tools to science teaching and learning that help them continually improve their programs.

www.beetlesproject.org

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