beetles
Science and Teaching for Field Instructors

Student Activity Guide

Matter and Energy Diagram

Understanding how matter and energy move through ecosystems is the foundation for understanding the carbon cycle, which, in turn, is key to understanding climate change—one of the most pressing challenges of our time. Concepts of matter and energy are also key to understanding food chains and pyramids, decomposition, photosynthesis, and many other common outdoor science topics.

In *Matter and Energy Diagram*, the instructor and students collaboratively draw a diagram based on prior knowledge about matter and energy relationships between plants, animals, air, and soil. Using a diagram to represent students' understanding of predator–prey interactions, plant and animal interactions with air, decomposition, etc. offers students an opportunity to make sense of connections between parts of an ecosystem while also offering the instructor a window into student thinking. This activity can begin a series of activities focused on matter and energy; revisiting the diagram after other activities at the end of an ecosystems, matter, and energy–themed experience offers an opportunity for students to apply and reflect on their new knowledge.

Students will:

- **Describe pathways of energy and matter in an ecosystem.**
- **Share ideas and create a model in collaboration with one another and with the instructor.**
- **Begin to understand how matter cycles and how energy flows within an ecosystem.**

Grade Level:
Grades 6–8. This activity is most appropriate for students with some prior knowledge about matter and energy. Boxed features offer instructions for adapting the activity for younger students.

Related Activities:
You Are What You Eat Name Game; Decomposition Mission; Card Hike; Food, Build, Do, Waste; Case of the Disappearing Log; What Lives Here?; Ecosystems Theme Field Experience

Timing:
Approximately 25–34 minutes

Materials:
For details, see the Materials and Preparation section on page 3.

Setting:
Choose an area where students can sit comfortably in a circle.

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

Equity, Inclusion, and Cultural Relevance (informed by Youth Outside)**:**
This activity has been designed to demonstrate how to create an equitable, inclusive, and culturally relevant teaching and learning experience. Read more on page 12.

NEXT GENERATION SCIENCE STANDARDS

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

FEATURED SCIENCE AND ENGINEERING PRACTICE	FEATURED CROSSCUTTING CONCEPT	DISCIPLINARY CORE IDEAS
Developing and Using Models	Matter and Energy	Cycles of Matter and Energy Transfer in Ecosystems, Interdependent Relationships in Ecosystems

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Matter and Energy Diagram

ACTIVITY OVERVIEW

Matter and Energy Diagram	Learning Cycle Stage	Estimated Time
Introducing the Activity	Invitation	5 minutes
Discussing Matter	Exploration, Concept Invention	5–7 minutes
Discussing Energy	Exploration, Concept Invention	5–7 minutes
Revisiting the Diagram	Concept Invention, Application	5–10 minutes
Reflecting and Wrapping Up	Reflection	5 minutes
TOTAL:		~25–34 minutes

TEACHING TIPS

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

Engage as many students as possible. In a complex discussion like this, support student engagement by using different approaches to encourage participation from everyone: *Think-Pair-Share*, *Turn & Share*, *Dominoes*, etc. For more information on these discussion routines, see: http://beetlesproject.org/cms/wp-content/uploads/2016/02/Discussion-Routines.pdf

Accessing prior knowledge. In the first part of the activity, focus on listening to students' prior knowledge, not on teaching new content. If a group doesn't bring up a particular connection or idea, that's okay! The goal at the beginning is to make a diagram of students' current understanding. You may need to offer some simple working definitions of *matter* and *energy*; other than that, focus on finding out what students know, putting it in the model, and supporting students to make connections. Later in the day or program, after doing more matter and energy activities, you can offer the opportunity for students to add to the diagram and synthesize what they've learned.

Other matter and energy activities. This activity is intended to be used at the beginning and end of a series of activities that engage students in thinking about matter and energy (and not to be used by itself). Do the first part of the activity and then do some ecosystems, matter, and energy–related activities such as *What Lives Here?*; *Decomposition Mission*; *Card Hike*; *Case of the Disappearing Log*; or *Food, Build, Do, Waste*. Then, go back to the diagram and finish the activity.

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

Adjusting the activity for younger students. As written, this activity is intended for older students with more prior knowledge about matter and energy: 7th–8th graders and older as well as some 6th-grade groups. For 4th–5th graders, and some younger 6th-grade groups, we recommend the following adjustments:

- Gather students around an easy-to-observe animal. Choose something slow moving and easy to observe, such as a newt or a large slug. If there are none nearby, remind students of one you observed earlier or show a photo of an animal that might be found in the area.
- Follow the script as written, but instead of only discussing general categories, focus students' discussion and thinking on the one interesting organism you've chosen and its interactions with its surrounding environment.
- Record students' ideas on large paper, but focus everything on the animal. For example, ask: "What connections can you think of between this newt and the stream we just saw, or with that log?" "How might the newt be connected to the objects you collected?"
- When making the diagram, write "Air," "Soil," "Plants," and "Animals" on a blank sheet of paper. Write the name of the animal you're observing next to "Animals."
- During the discussion, invite students to *Turn & Share* about questions. For example, ask: "How is the newt connected to air?" "How is the newt connected to plants?" "To other animals?"
- Introduce a simple definition of *matter* (Matter is the stuff things are made of) and invite students to *Turn & Share* about questions. For example, ask: "Is the newt made of matter?" "What happens to the newt when it dies?" "Where does its matter go?"
- With younger students, just stick with matter and don't include energy in your diagram. Energy is more abstract of a concept than matter, and it is more appropriate for older students.

MATERIALS AND PREPARATION

MATERIALS

For the instructor:

- ❏ 1 sheet of paper or cardboard, approximately 25" x 30" (large enough to record the whole diagram) (Don't use a whiteboard, as it will be difficult to save the image to revisit later on in the field experience.)
- ❏ markers: black, blue, and red

PREPARATION

1. **Gather materials.** This activity uses blue and red lines to distinguish between parts of the Matter and Energy Diagram. To support students who are color blind in participating, make all the red energy arrows with dashed lines to offer a further distinguishing feature.
2. **Study the Example Matter and Energy Diagram handout (pages 18–19).** Use this example to get a sense of what the diagram you co-construct with your students might look like. If you have questions yourself, check out the Instructor Support section (beginning on page 9) for content knowledge.

TEACHING NOTES

Adjusting the activity for younger students. For grades 4–5 (and some 6th-grade groups), this activity works, but only if you make adjustments. See the outline in the blue box on page 3 for more guidance.

Picking the right time. If students are too energetic at the beginning of a field experience to focus on *Matter and Energy Diagram*, consider skipping it as a pre-assessment and only using it later as a post-assessment and reflection to review what students have learned after several activities.

***Producers* and *consumers*.** If students are already familiar with the terms, use *producers* and *consumers* instead of *plants* and *animals*. If students are unfamiliar with the terms *producers* and *consumers*, stick to the terms students already know for now. The main purpose of the activity is not to offer new content, but instead, to find out what students already know and to support them to make connections in preparation for future learning experiences.

***Pair-Share* vs *Think-Pair-Share*.** In a *Pair-Share*, students discuss a topic or question in pairs and then share out in the whole group. In a *Think-Pair-Share*, students start out by thinking quietly about the topic before discussing in pairs and sharing out in the whole group. Adding the "Think" step leads to more thoughtful answers and supports emerging multilingual learners. It also provides more opportunities for all students to participate successfully. Think time also takes a bit longer and can sometimes halt the momentum of an exciting discussion if every student is already excited and ready to share their ideas. Switch between *Pair-Share* and *Think-Pair-Share* to meet the needs of your group, making sure to keep the discussion from dragging on too long.

Introducing the Activity

1. **Invite students to choose two objects nearby that used to be alive (or part of something alive), find a partner, and discuss: *How are your objects connected? How might they interact with each other?*** Invite students to compare the two objects, noticing as many connections as possible. For example, if a pair has gathered an acorn, a stick, a leaf, and a bone, they might share:

   ▶ *I think the acorn came from a tree and was growing off of a stick like this one. I think stuff the plant needs flowed through the stick and the acorn when it was alive, like stuff the acorn needed to grow. The leaf uses sunlight and makes food that moves through the plant, like through the stick. The bone is from some animal that maybe would eat the acorn. Or maybe it would eat the stick or leaf.*

2. **Prepare for the diagram and discussion: Write "Air," "Soil," "Plants," and "Animals" with a black marker on the large sheet of paper and invite students to sit or stand in a circle around it.** Write these words: "Air" (in a drawing of a cloud a little below the top of the paper), "Soil" (at the bottom of the paper), "Plants" (on the left side of the paper), and "Animals" (on the right side of the paper).

Discussing Matter

1. **Invite students to *Turn & Share* or *Think-Pair-Share* about the following questions and then add their responses to the diagram, using a blue marker to draw matter arrows. Keep it moving so students stay engaged.** Don't get bogged down in the discussion or spend so much time that students lose interest. To keep things moving, change up the way you invite students to respond to questions (e.g., occasionally skip the pair talk and just invite students to share in the whole group; intersperse quiet thinking time, etc.). Take note of any misconceptions and later see if you can address these through the activities you choose to do as a follow up.

   a. Focus on air. Ask:

   ▶ *What are some interactions between animals, plants, and air?*

   - Give ~30 seconds for students to share ideas with a partner next to them (Pair) and then invite students to share out in the whole group (Share).
   - As students share ideas in the larger group, draw arrows (with the blue marker) on the diagram to represent what they say. For example, if they say, "Animals breathe air," draw an arrow from the word *air* to the word *animals*.
   - Encourage students to be as specific as possible. If they say, "Animals breathe air," ask them if they know what part of the air the animals need. If students say "oxygen," then add an "oxygen" label to the arrow. If they don't know, move on.

   b. Focus on matter. Ask students if they've heard of matter and then introduce the concept (Matter is stuff! Even air!), explaining that

you're drawing arrows on the diagram to show the movement of matter. Come up with a definition of *matter* based on students' ideas and, if necessary, add the idea: Matter is the stuff things are made of! Show students that you're drawing arrows on the diagram to indicate the movement of matter. Make sure to point out that air is made of matter as well.

c. Focus on organisms. Ask:

▶ *How does matter move between organisms (living things)?*

- Again, use arrows to represent students' answers and, as much as possible, try to draw out specific statements from students to further describe what is moving with the arrow. Students may say things such as, "Plants breathe out oxygen, and we breathe out CO_2; we breathe in oxygen, while plants breathe in CO_2." Or, "Some animals eat plants, and some animals eat other animals."
- Nose-ring arrows (arrows that go from one thing and back to itself) can be used to show that animals can eat each other or that plants create their own food.

d. Focus on soil. Ask:

▶ *How does matter move between organisms (living things) and soil?*

- Listen to students' answers and draw arrows to represent their answers. As much as possible, ask for details about what in particular is moving between the soil and animals, plants, or decomposers. Students may say things such as, "Plants grow out of soil." Or, "Dead organisms decompose into soil."

Discussing Energy

1. **Introduce energy. On the diagram, use the black marker to write "Sun" (at the top left) and "Outer Space" (above "Air").**

   ▶ *So far, we've just been thinking about how matter moves in ecosystems, but what about energy? Almost all Earth's energy is from the sun, which is in outer space. What are some energy interactions between the sun and plants, air, animals, and soil?*

2. **Listen to students' answers and draw red arrows to represent the movement of energy.** Make the red arrows with dashed lines to offer a further distinguishing feature for color-blind students.

3. **Offer some ideas about how matter and energy connect to the ecosystem you are in and encourage students to think about this perspective throughout the rest of your field experience..**

   ▶ *All around us, matter and energy are moving. This diagram shows some ways that this happens. Keep thinking about other ways that energy and matter move around in an ecosystem as our time together goes on. Later, we'll come back to the diagram and see what we might want to add or change as we learn more.*

TEACHING NOTES

Don't skip the partner discussions. Discussion gives students authentic opportunities to process content, formulate and share ideas, and make meaning. Partnered discussions give every student in the group the chance to share and process their ideas and to listen to those of their peers. Partner discussions also help create an equitable and inclusive learning space. The opportunity to think through ideas and "rehearse" what to share with the whole group in a low-stakes situation is particularly beneficial for emerging multilingual learners and provides increased opportunities for all students to participate successfully.

What are matter and energy? As appropriate, you can explain that matter is the "stuff" that things are made of, and energy is the ability to do things. You might also choose to share that matter has mass (which can be measured as weight), and energy doesn't have mass/weight. Energy can be complicated to understand. If your students are still building their understanding of matter, consider focusing on tracing the cycling of matter and not on the flow of energy. See more on the definitions of *matter* and *energy* in the Instructor Support section (beginning on page 9).

Example Matter and Energy Diagram. Check out the sequence of images on pages 18–19 for an example of how your diagram might progress. All diagrams will look different; let your group's diagram evolve in its own way. It is not the time to correct inaccuracies in student thinking, but be sure to note them for yourself so you can address them in follow-up activities throughout the learning experience.

Keep it moving. At this point, the goal isn't to have an exhaustive discussion about matter or to offer concepts as the instructor; rather, the point is to get a sense of students' current thinking and ideas. Keep the activity moving so students stay engaged.

TEACHING NOTES

Energy flows, matter cycles, and life webs from Dr. Art. "Energy flows, matter cycles, and life webs" is from *Dr. Art's Guide to Planet Earth: For Earthlings Ages 12 to 120* by Art Sussman, Ph.D.

Gradually adding arrows. If your students are excited about thinking about matter and energy, or if it works better for your schedule, you could add a few arrows at a time throughout your field experience, whenever students see evidence or become aware of matter cycling or of energy being used.

Including types of energy. If (and only if) students have prior knowledge about types of energy, ask them to name which type of energy it is as they describe how energy is transferred (heat, light, chemical, motion) and write it on the arrow. For example, light energy from the sun moves toward plants. This can help students begin to develop a deeper understanding of how energy works and will help you understand if they are able to distinguish energy from matter. (Note: In the NGSS, this content is in the 6th–8th grade band.)

Different examples. Adjust the examples of what matter cycles through, based on your students' interests and prior knowledge.

4. **Continue with the rest of your field experience, doing activities that focus on ecosystems, matter, and energy, such as *Decomposition Mission*; *Food, Build, Do, Waste*; *What Lives Here?*; *Card Hike*; or *Case of the Disappearing Log*.** See the Instructor Support section, beginning on page 9, for more information on sequencing activities.

Revisiting the Diagram

(After Other Matter and Energy–Focused Activities)

1. **After doing activities focused on ecosystems, matter, and energy, gather students and invite them to add new arrows or ideas to the diagram or to change any arrows drawn earlier based on what they have learned since then.** After activities on matter and energy, such as *Decomposition Mission*; *Food, Build, Do, Waste*; *What Lives Here?*; *Card Hike*; or *Case of the Disappearing Log*, revisit the diagram and invite students to make additions or changes. If there are particular inaccuracies you noticed when first making the diagram, and students have had experiences since then that offered them the opportunity to develop more accurate understandings, bring students' attention to these.

2. **Share that the matter in Earth's systems is changing form but that there is no new matter being made.** Share that there is the same matter on Earth all the time, it's just changing its form, and no new matter is actually being made. For example, in a chemical reaction, a new substance is created from the interaction of other substances, but this is matter changing form, not new matter being created. When an animal (a deer, for example) breathes out, some carbon that was part of the deer becomes part of carbon dioxide. If a plant takes in that carbon dioxide, it converts it into carbohydrates. If an animal eats a leaf, it takes in carbohydrates, which may become part of its body. And so on.

3. **Offer the idea that matter that has been part of organisms and things in Earth's systems throughout history—such as dinosaurs, people who lived long ago, and wooly mammoths—is also in students and in their surroundings.**
   - *Matter is constantly cycling, changing form as it moves between parts of this ecosystem and all other ecosystems on Earth.*
   - *That same matter might have been a part of people who lived very long ago, dinosaurs, or really old rocks. Throughout history, matter is constantly being recycled in Earth's systems and is a part of you and your surroundings.*

4. **Invite pairs to spend a few minutes looking around for examples of matter cycling among the natural materials they see.** Share some examples of what this might look like:
   - *You might see a hole in a leaf, which would be evidence of matter cycling from the leaf to whatever ate it.*

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

- *Or the wood in that stick is decomposing into other things, such as soil and carbon dioxide in air.*
- (If students made connections between air and plants): *Or, when you breathe out, you are releasing carbon dioxide into the air. That carbon dioxide could become part of a nearby plant!*

5. **Share: Energy flows from the sun through an ecosystem and then flows to outer space.**
   - *Eventually, all energy flows to outer space, but we get new energy from the sun every day.*
   - *If energy cycled like matter and didn't have a way to flow out, Earth would get unbearably hot!*
6. **Using red arrows, show how energy flows from Earth to outer space.**
7. **Invite students to point out examples of energy flowing in their surroundings. (For example, anything alive has energy in it, anything moving has energy in it, anything warm has energy in it, etc.)**
8. **Share that energy is in matter such as food, so it cycles through organisms temporarily but is constantly flowing from Earth to outer space.**
   - *Since there is some energy in all matter, energy also moves in cycles temporarily, but it's constantly being lost, such as when we release heat from our bodies as we do things.*
   - *For example, there's energy in a leaf. When a snail eats a leaf, it gets energy from the leaf to do things the snail needs to do, such as move or grow more of its shell. That energy is moving in a temporary cycle from leaf to snail. A small amount of energy stays in the snail. When the snail uses the energy to do a "snail-y" thing, such as moving around, the energy used is released to the atmosphere.*
   - *That energy eventually flows to outer space.*
9. **Share that plants "package" energy from the sun with matter and make food, adding energy to an ecosystem.**
   - *Although energy is constantly lost from the ecosystem, more energy is entering the ecosystem.*
   - *Through photosynthesis, plants capture and "package" energy from the sun, along with matter, and make food. Food is matter that an organism can use to grow and get energy. Plants are the ultimate source of food for the ecosystem, including for themselves. By capturing energy from the sun and making it into food, plants make energy available in the ecosystem.*
10. **Change food arrows to show that food = matter + energy. Then, invite students to take 1 minute to search for an example of something that**

TEACHING NOTES

***Decomposition* definition in related activities.** When you do decomposition activities or other relevant activities, be sure to include a definition of *decomposition* that includes that the process breaks down matter into smaller parts *and* into simpler parts, such as carbon dioxide and water. This will increase the chances that students' future explanations and understanding of concepts are more accurate and can contradict the common misconception that decomposition is just breaking things into smaller pieces.

Does energy ever move in cycles? When a snail eats leaves, most of the energy (~90%) is lost into the atmosphere as the snail uses the energy to do the things snails do. Eventually, this energy flows from the atmosphere out into space. However, there's some energy (~10%) that remains in the snail from the leaves. When a bird eats snails, once again, ~90% of the energy is used to do bird things and is lost to space, but ~10% remains in the bird. In this sense, some energy does move through food chains and cycles along with matter. It all eventually leaves planet Earth, but some energy gets caught up in cycles for a while before it leaves Earth. On the other hand, matter always cycles (except for relatively miniscule amounts of matter in the form of air, artificial satellites, etc. that are lost in space).

Does matter ever leave ecosystems? Yes. Carbon dioxide in the air can leave an ecosystem before a local plant captures it. An animal can move to a distant ecosystem. However, matter essentially does not leave planet Earth.

might be food for an organism in the ecosystem and then share this with a partner. Go back and combine the red and blue arrows to represent food (add blue to the red arrows and red to the blue arrows) to show that food is a special package of matter and energy. Then, ask students to search for something nearby that could be food (providing matter and energy) for another organism.

Reflecting and Wrapping Up

1. **Highlight how students have been tracing the cycling of matter and flow of energy through an ecosystem and connect this to the work of scientists.**
   - *We've been thinking about how matter and energy move through this ecosystem in order to better understand the ecosystem, how the parts of this ecosystem interact, and how we're connected with it.*
   - *That's something scientists in lots of different disciplines do, too.*
2. **Encourage students to think about matter and energy at other times during your program or in different ecosystems they visit in the future.**
   - *It can be interesting to think about matter and energy when you are in other places or ecosystems in both urban and rural areas, looking for evidence of matter cycling, or thinking about how energy flows through the system.*
3. **Ask students to *Turn & Share* or *Thought Swap* about one or more of the following questions:**
   - *What are some things you learned about matter and what helped you learn them?*
   - *What are some things you learned about energy and what helped you learn them?*
   - *Choose something around you in nature and try to explain how it relates to matter cycling and energy flowing.*
   - *What questions do you still have about matter, energy, or ecosystems?*
   - *What was one thing that made your thinking change today?*
   - *If you were to show a younger relative or any family member evidence of how matter cycles, what might you show them?*

TEACHING NOTES

Students struggling with ideas? Understanding how matter and energy work is difficult and takes time! These are big concepts that are challenging for adults as well as students. This should be one of many learning experiences students have throughout their education that focuses on building understanding of matter and energy, and it's okay if students find some parts confusing. This is one step on a longer journey of learning, and the "productive struggle" students might experience while engaging in this activity is an important part of that process.

Highlighting learning behaviors. Calling attention to how students' existing skills and learning behaviors mirror those of scientists can build students' positive identities as learners and 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. Highlighting these skills and learning behaviors can also offer students a more accurate understanding of science as a discipline.

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

Instructor Support

Teaching Knowledge

Engaging students in discussion. In order for students to be able to engage in discussion, it's important to set up a culture of discourse in your group and to give students opportunities to discuss in pairs and in small groups before participating in a whole-group discussion. To establish a culture of discourse, create and nurture an atmosphere of respect and intellectual curiosity by responding equitably to students' ideas as a facilitator and facilitating—not dominating—the discussion. When you respond to students, do so in a neutral, accepting manner and then probe their thinking with follow-up questions. Encourage agreement and disagreement that builds toward a deeper understanding and establish that when there is disagreement about ideas, students will not be ridiculed for having the "wrong" answer. Emphasize that sharing ideas as a group is an important part of the learning process.

Sharing ideas in pairs first. Offering time for students to share ideas in pairs before sharing them with the whole group is an important way to support participation in this activity. *Pair-Shares* interspersed with whole-group talk tends to lead to more participation in the whole-group discussion and also to more thoughtful responses.

A place to begin. This activity is meant to bring forth students' current ideas about matter and energy transfer in ecosystems at the beginning of a sequence of activities focused on these concepts. These are complex topics, and students will need to participate in multiple learning experiences in order to build their understanding of these concepts. In this activity, focus on inviting students to share their ideas and putting those ideas onto the diagram. Avoid lecturing or introducing more content on matter and energy than is outlined in the activity write-up. After *Matter and Energy Diagram*, involve students in other activities that will engage them more deeply in building understanding of these concepts, such as *Decomposition Mission*; *Card Hike*; *Food, Build, Do, Waste*; *Case of the Disappearing Log*; and *What Lives Here?* Then, return to the diagram to offer students the opportunity to share what they've learned and to offer you, as the instructor, an opportunity to see how their understanding has developed.

Conceptual Knowledge

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

Carbon cycle. Sharing parts of the carbon cycle with students offers concrete ways in which we are connected to living and nonliving things in our environment and how they are connected with one another. Plants and other photosynthesizing (mostly) or chemosynthesizing (rarely) organisms take in carbon dioxide, water, and energy and convert them into food. Through food chains, all organisms feed off this food. As each organism eats and uses some of the food, it gives off carbon dioxide and water into the air and loses energy

TEACHING NOTES

Listening and responding to students. How you respond to students' observations and comments matters. Create a culture in which students feel safe sharing ideas by frequently asking broad questions that have multiple acceptable responses and by giving all students neutral, accepting responses to your questions. When we ask students broad questions and then we react to their responses by showing a preference for some responses over others (e.g., *Yes, that's right.* Or *No, but keep thinking.*), we're sending the message that only some student thinking is acceptable. When we give neutral, accepting responses (e.g., *Hmm . . . interesting. Can you say more?* Or *Thank you for sharing. What do others have to say about that idea?*), we encourage a group culture of participation and sharing.

Who is speaking, who isn't? In a discussion, it's important for each voice to have the opportunity to be heard. However, research summarized in the book *Failing at Fairness: How Our Schools Cheat Girls* by Myra and David Sadker shows that girls are called on significantly less than boys. Promote equitable participation by using wait time (pausing 3+ seconds before calling on students), including time for pair discussion, and intentionally calling on a range of different students. Toward the end of a discussion, try pausing and saying, "I'm going to wait for a moment in case anyone who hasn't spoken up yet has something they'd like to share." Use the activity *Group Agreements for Science Discussions* to offer your group skills for paying attention to how their participation might be affecting the group and to enlist them in working together to create an environment in which everyone feels supported to share their ideas.

TEACHING NOTES

that flows from Earth to outer space. When dead organisms decompose, they are mostly converted into carbon dioxide and water in the air and lose energy that flows from Earth to outer 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 difficult to feel that with air unless you capture some in a balloon or a bag. Matter also has mass (weight), but that's also difficult 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 more difficult 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*, the term *energy* can be partially defined as simply not matter. Unlike matter, energy doesn't take up space or have mass. Energy has no physical form; it isn't a substance. When energy is transferred from one organism to another, no physical thing is passed from thing to thing. What's transferred is the *capacity* to do things—to live and to grow. A little confusing, huh? That's why when working with students, we recommend starting with matter and working up to energy.

Common Relevant Misconceptions

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

More accurate information. Eek! If that were true, Earth would be a hot planet. Matter cycles through ecosystems here on Earth and does not usually leave the planet (some air molecules are lost into space, and sometimes a spacecraft flies away). A large amount of energy flows to Earth from the sun in the form of light energy and is captured by plants and "packaged" with matter in the form of food. However, at every link in a food chain or food web, ~90% of the energy is lost from the ecosystem when it is released into the atmosphere as heat and eventually drifts into outer space. About 10% of the energy is passed on to the next organism that eats it. So there is a constant flow of energy from sunlight into Earth's systems (during the day) and a constant flow out of the systems into space. This is why it's important to keep these ideas separate and not combine energy and matter into one driving force that cycles through all the systems on Earth. For example, by including the sun in food webs (sometimes done to try to simplify energy flow and matter cycles), it can reinforce the inaccurate idea that energy is constantly cycling through Earth systems. By teaching students that food is energy *and* matter and that *matter cycles* and *energy flows*, we can give students a more accurate picture. Sometimes, it can be less confusing to focus first on matter and then introduce the more abstract concept of energy later.

TEACHING NOTES

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

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

Misconception. The matter that plants use to build their structures mostly comes from soil.

More accurate information. Plants make sugar/food from carbon dioxide and water in the presence of sunlight. The soil provides tiny amounts of important nutrients (not food!) for plants that are kind of like what vitamins are for people. Many students (and adults) think that most of the mass of plants comes from soil, probably because carbon dioxide seems so insubstantial and because the nutrient cycle tends to get a lot of focus in environmental education. 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. People can also be confused because nutrients to be added to garden plants are often labeled as "plant food," while "plant nutrients" or "plant vitamins" might be a more accurate label.

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 our energy comes from the sun. Through photosynthesis, plants and other photosynthesizing organisms make use of a tiny portion (less than 10%) of the incoming sun energy. Through photosynthesis, they bind this energy and matter together into packages that they and animals can use as food. At each stage of the food chain, an organism is able to make use of some of that energy, but most of the energy at each stage leaves the ecosystem and eventually flows into outer 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, repair body damage, grow taller, etc.). The rest of the matter gets released when organisms breathe, sweat, pee, poop, etc.

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

More accurate information. It's important for educators to offer opportunities for students to share ideas and to pay attention to what students say. At any given time, students have many ideas and interpretations in their heads about the world—some accurate and some inaccurate (but based on experience and logical thinking). Whether or not you provide opportunities for students to share these ideas out loud, these ideas are there; if these ideas are not brought out into the open,

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they will likely remain unchallenged. Without opportunities to discuss their ideas, students may be able to memorize more accurate ideas (and even pass tests), but they still may privately hold onto their original inaccurate beliefs unless they encounter convincing reasons to let them go. When students share ideas out loud, it draws attention to potentially conflicting ideas and inconsistencies. It also provides students with the opportunity to evaluate their ideas against other's thinking and to compare their ideas with the available evidence. For instructors, student-centered discussion can provide insights into students' ideas, which can then be used to guide instruction. For example, it can help an instructor to think of particular evidence that may benefit student thinking and help student ideas evolve.

Supporting Equitable, Inclusive, and Culturally Relevant Learning Experiences

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

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

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

When learners think like a scientist and practice academic language, they develop critical thinking skills that support them to become more independent learners—learners who have skills and thinking tools they use to learn, regardless of the level of support available from a teacher or instructor. Giving students the opportunity to think like a scientist by making observations, asking questions, and constructing explanations supports students' growth as learners, offering them the opportunity to build critical thinking skills and learning behaviors they can apply in any context. Many students in schools that have historically been under-resourced due to racist school-funding policies, redlining, income inequality, and police profiling have fewer opportunities to develop as independent learners. Specifically ensuring that students in these kinds of schools have opportunities to develop as independent learners is an issue of equity. Learning and practicing critical thinking skills in an engaging outdoor context supports students to succeed back in their classrooms, in science, and in other academic disciplines. Offering opportunities for students to discuss ideas with their peers and

knowledgeable adults makes science more accessible by connecting it to students' own actions and discoveries in the moment—not to knowledge they may not have or experiences they may not have had.

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

- using broad questions to invite students to share their observations, prior knowledge, and experiences with one another and with the instructor.
- providing space for students to come up with connections between what they are observing and prior experiences and knowledge, which supports their learning and retention.
- engaging students in meaning-making discussions that prepare them to take on increasingly rigorous learning tasks in the future.
- providing a lesson structure for the instructor to act as a "guide on the side" and build 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.
- surfacing students' prior knowledge about concepts they will work with in subsequent activities, which offers windows into student thinking that support the instructor to be more responsive to students.
- offering strategies such as pair talk and intentionally making room for students who haven't shared yet that the instructor can use to support equitable student participation in discussions.

Overall, these factors contribute to creating a student-centered approach in which "the ultimate goal . . . is to help students take over the reins of their learning." (Zaretta Hammond, *Culturally Responsive Teaching & the Brain*, 2014). This approach to teaching supports students in becoming independent

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

- *White Fragility: Why It's So Hard for White People to Talk About Racism* by Robin DiAngelo
- *Culturally Responsive Teaching & the Brain* by Zaretta Hammond
- Youth Outside [http://www.youthoutside.org/]
- The Avarna Group [https://theavarnagroup.com/]
- Center for Diversity & the Environment [https://www.cdeinspires.org/]

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

Read more about the Next Generation Science Standards at http://www.nextgenscience.org/ and http://ngss.nsta.org/

learners who are able to succeed, regardless of any individual teacher or learning context. BEETLES has intentionally designed the sequence and structure of this activity to support learning experiences in which all students feel capable of success and have the tools to carry that success into other domains.

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

Connections to Next Generation Science Standards (NGSS)

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

In *Matter and Energy Diagram*, students engage in the Science and Engineering Practice of *Developing and Using Models* and have the opportunity to relate what they learn to the Crosscutting Concept of *Matter and Energy: Cycles, Flows, and Conservation*. Students will build understanding of Disciplinary Core Ideas related to *Cycles of Matter and Energy Transfer in Ecosystems* and *Interdependent Relationships in Ecosystems*.

Featured Science and Engineering Practice

Engaging students in *Developing and Using Models*. As described in the National Research Council'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. The scientist decides what to include and what not to include in their model, which affects what they can see or can't see through their model. 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 *Matter and Energy Diagram*, the instructor guides students as they co-create a model that shows how matter cycles and energy flows through ecosystems.

- Students use the model to make explanations about connections between organisms and other parts of the ecosystem.
- Later, students revise their model as a group, using new knowledge about matter and energy and examples of observations from their field experience to add new arrows or to change arrows representing connections in the ecosystem.
- As students revise their co-created model, it's a chance to point out that scientists continually update, revise, and refine their models as new evidence comes to light.

Featured Crosscutting Concept

Learning science through the lens of *Matter and Energy*. According to the National Research Council's *A Framework for Secondary Science Education*, students should be thinking about questions such as *How is energy flowing through this system/organism?* and *How is matter cycling through this system/organism?* Looking at matter and energy in an ecosystem can lead to a deeper understanding of the interactions and impacts of parts of the ecosystem.

- In *Matter and Energy Diagram*, students discuss interactions of organisms with the environment. As students tell the instructor to add arrows to the diagram to show the movement of matter and flow of energy, they describe organisms and interactions they have directly observed, tying these concepts to real-world examples.
- Since so much of the activity takes place in group discussion, it's a chance for the instructor to listen to students' ideas and get a sense of their level of understanding of matter cycling and energy flow.
- The instructor can use this information about students' understanding to decide what other learning experiences might take their learning to the next level.
- Adding in the sun and outer space to the diagram and discussing how food is matter and energy packaged together can help nudge students' understanding of the complex concept of energy and distinguish energy flow from matter cycling.

To help your students understand and use this thinking tool of *Matter and Energy*, explain that scientists also think about and trace matter as it cycles and energy as it flows. Scientists use this way of thinking in many different disciplines to better understand interactions and effects on things such as ecosystems, the built environment, global climate and weather patterns, and space. Point out to students how they can think about matter and energy anywhere, looking for evidence of matter cycling or thinking about how energy flows.

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. *Matter and Energy Diagram*

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gives students a chance to develop an understanding of the life science core ideas related to *Organization for Matter and Energy Flow in Organisms* (LS1.C), *Interdependent Relationships in Ecosystems* (LS2.A), *Cycles of Matter and Energy Transfer in Ecosystems* (LS2.B), and *Energy in Chemical Processes and Everyday Life* (PS3.D).

- As students co-construct the diagram based on their observations of organisms and the ecosystem, they will build understanding of the idea that matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. (LS2.A)
- As students discuss plants in the context of the diagram, tracking how air and water are what make plant matter, students will build understanding of the idea that plants acquire their material for growth chiefly from air and water. (LS1.C)
- If students include a specific organism in their diagram, they'll build understanding of the idea that food provides animals with the materials they need for body repair and growth and the energy needed to do things, maintain body warmth, and be in motion. (LS1.C)
- During the focus on energy flows through ecosystems, students build understanding of the idea that energy released from food was once energy from the sun that was captured by plants to form plant matter from air and water. (PS3.D)

Translating the codes for the NGSS Performance Expectations. Each standard in the NGSS is organized as a collection of Performance Expectations (PE's) for a particular science topic. Each PE has a specific code, which is provided here so they can be easily referenced in the NGSS documents. The first number or initial refers to the grade level: K = kindergarten, 1 = first grade, 2 = second grade, MS = middle school, and HS = high school. The next letters in the code refer to the science discipline for the standard: LS, PS, ESS, ETS. The number following the discipline denotes the specific core idea within the discipline that is addressed by the PE, and the last digit identifies the number of the PE itself. So, 3-LS4-3 means the Performance Expectation is part of a third-grade standard (3) for life science (LS), addressing the fourth core idea (4), Biological Evolution: Unity and Diversity, within the life science standards, which deals with Adaptation. It's also the third Performance Expectation (3) that makes up the complete LS4 standard at this grade level.

Performance Expectations to Work Toward

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

- **5-LS2-1.** Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- **5-PS3-1.** Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. [Clarification Statement: Examples of models could include diagrams and flowcharts.]
- **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- **5-LS1-1.** Support an argument that plants get the materials they need for growth chiefly from air and water.

Activity Connections

Matter and Energy Diagram is meant to begin and finish a series of activities focused on ecosystems, matter, and energy. The *You Are What You Eat* name game is a good starting point for thinking about matter and energy before leading the *Matter and Energy Diagram* activity. We recommend following those activities with others, such as *Decomposition Mission*; *Card Hike*; and *Food, Build, Do, Waste*—all of which provide the hands-on experiences students need to flesh out the concepts. *Case of the Disappearing Log* and *What Lives Here?* are also activities that will lead students to think about matter cycling in ecosystems.

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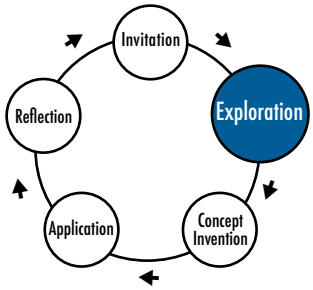
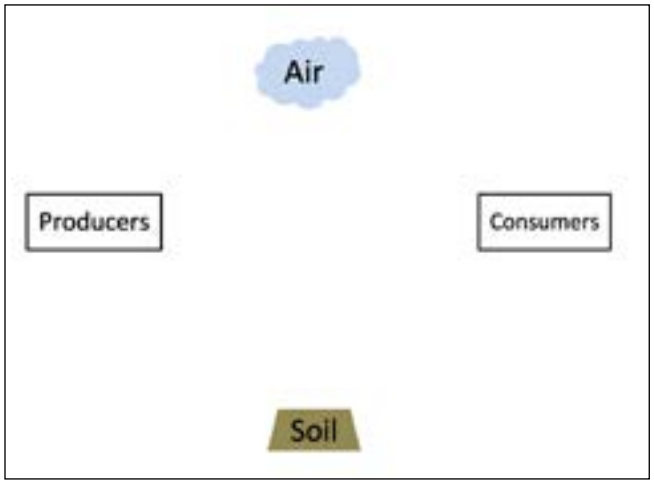


Learning cycle. In a sequence of activities focused on matter, energy, and ecosystems, the beginning part of this activity serves as an Invitation and Exploration, and the last part of this activity functions as a Concept Invention, Application, and Reflection.

EXAMPLE MATTER AND ENERGY DIAGRAM

This is intended as an example of a diagram an instructor might draw and add to during the activity. Base your own diagram on what your students share. (Note: The diagrams below use the terms *producers* and *consumers* instead of *plants* and *animals*. If your students are unfamiliar with the terms *producers* and *consumers*, stick to the terms *plants* and *animals*.)



Draw and label "Air," "Soil," "Producers," and "Consumers."

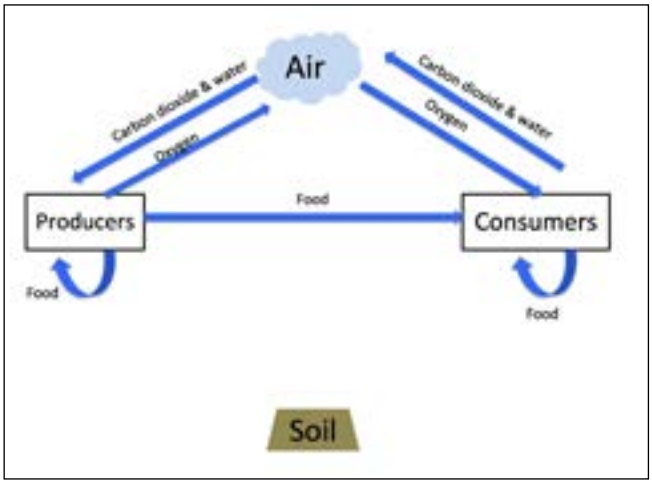
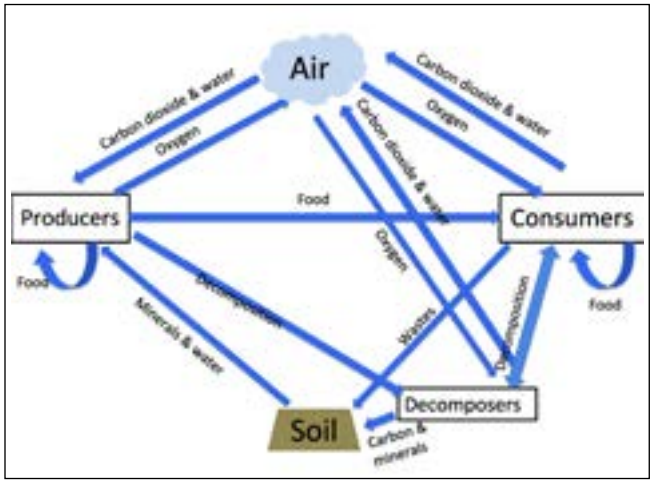
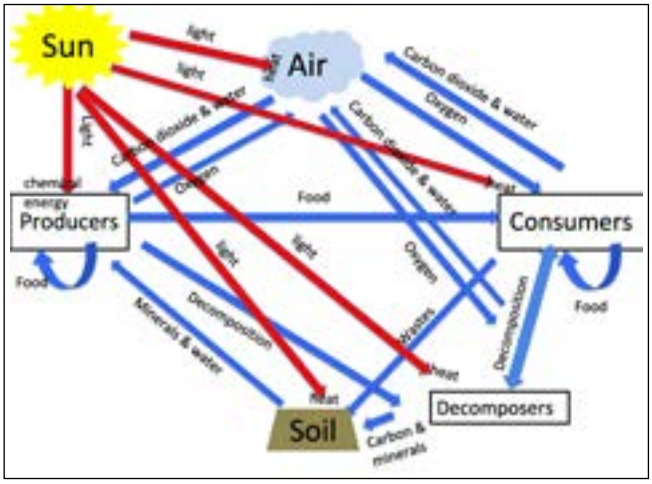


Diagram the transfer of matter between organisms and air.

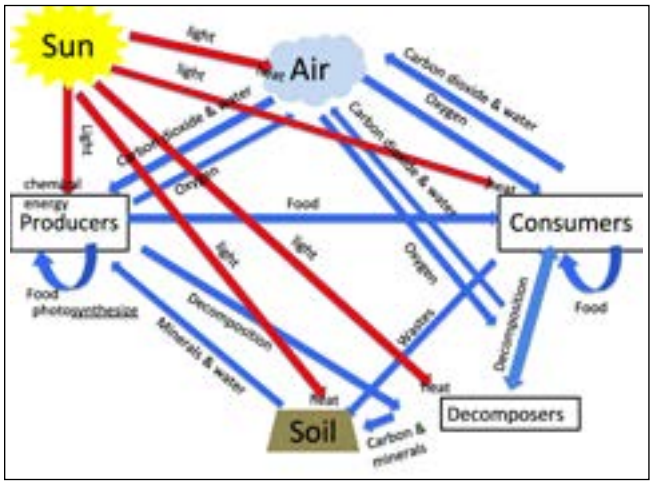


Add blue arrows to represent matter interactions between soil and organisms.

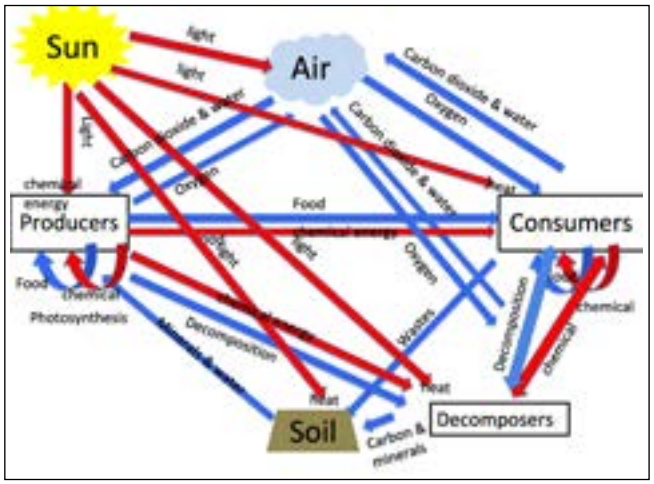


Add the sun and red energy arrows from the sun.

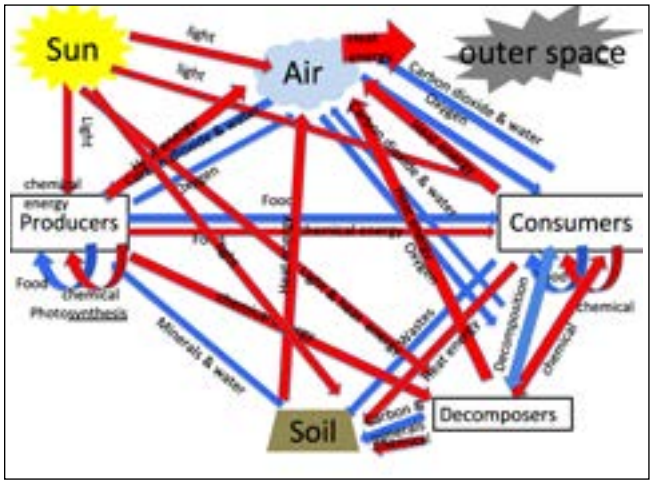
EXAMPLE MATTER AND ENERGY DIAGRAM (continued)



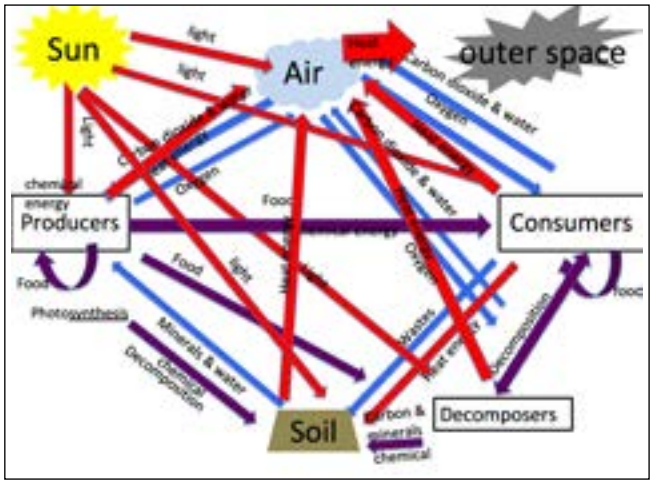
Focus on flow of energy from the sun to producers: photosynthesis



Producers use some energy from photosynthesis for their own life processes, but they also provide energy to other parts of the ecosystem.



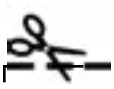
Add burst for outer space. Add red arrows for ideas about heat energy flowing away from organisms and Earth and radiating out into outer space.



Change the food and chemical energy arrows to purple to show that the matter (blue) and energy (red) are combined in food.

FIELD CARD

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



Matter and Energy Diagram

Introducing the Activity

1. Invite students to choose two objects nearby that used to be alive (or part of something alive), find a partner, and discuss: *How are your objects connected? How might they interact with each other?*
2. Prepare for the diagram and discussion: Write "Air," "Soil," "Plants," and "Animals" with a black marker on the large sheet of paper and invite students to sit or stand in a circle around it.

Discussing Matter

1. Invite students to *Turn & Share* or *Think-Pair-Share* about the following questions and then add their responses to the diagram, using a blue marker to draw matter arrows. Keep it moving so students stay engaged.

   a. Focus on air. Ask:

   ▶ *What are some interactions between animals, plants, and air?*

   - Give ~30 seconds for students to share ideas with a partner next to them (Pair) and then invite students to share out in the whole group (Share).
   - As students share ideas in the larger group, draw arrows (with the blue marker) on the diagram to represent what they say. For example, if they say, "Animals breathe air," draw an arrow from the word *air* to the word *animals*.
   - Encourage students to be as specific as possible. If they say, "Animals breathe air," ask them if they know what part of the air the animals need. If students say "oxygen," then add an "oxygen" label to the arrow. If they don't know, move on.

   b. Focus on matter: Ask students if they've heard of matter and then introduce the concept (Matter is stuff! Even air!), explaining that you're drawing arrows on the diagram to show the movement of matter.

   c. Focus on organisms. Ask:

   ▶ *How does matter move between organisms (living things)?*

   - Again, use arrows to represent students' answers and, as much as possible, try to draw out specific statements from students to further describe what is moving with the arrow.
   - Nose-ring arrows (arrows that go from one thing and back to itself) can be used to show that animals can eat each other or that plants create their own food.

   d. Focus on soil. Ask:

   ▶ *How does matter move between organisms (living things) and soil?*

   - Listen to students' answers and draw arrows to represent their answers. As much as possible, ask for details about what in particular is moving between the soil and animals, plants, or decomposers.

Discussing Energy

1. Introduce energy. On the diagram, use the black marker to write "Sun" (at the top left) and "Outer Space" (above "Air").

   ▶ *So far, we've just been thinking about how matter moves in ecosystems, but what about energy? Almost all Earth's energy is from the sun, which is in outer space. What are some energy interactions between the sun and plants, air, animals, and soil?*

2. Listen to students' answers and draw red arrows to represent the movement of energy.
3. Offer some ideas about how matter and energy connect to the ecosystem you are in and encourage students to think about this perspective throughout the rest of your field experience.

   ▶ *All around us, matter and energy are moving. This diagram shows some ways that this happens. Keep thinking about other ways that energy and matter move around in an ecosystem as our time together goes on. Later, we'll come back to the diagram and see what we might want to add or change as we learn more.*

4. Continue with the rest of your field experience, doing activities that focus on ecosystems, matter, and energy, such as *Decomposition Mission*; *Food, Build, Do, Waste*; *What Lives Here?*; *Card Hike*; or *Case of the Disappearing Log*.

Revisiting the Diagram

(After Other Matter and Energy–Focused Ativities)

1. After doing activities focused on ecosystems, matter, and energy, gather students and invite them to add new arrows or ideas to the diagram or to change any arrows drawn earlier based on what they have learned since then.
2. Share that the matter in Earth's systems is changing form but that there is no new matter being made.
3. Offer the idea that matter that has been part of organisms and things in Earth's systems throughout history—like

FIELD CARD

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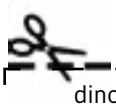

dinosaurs, people who lived long ago, and wooly mammoths—is also in students and in their surroundings.

- *Matter is constantly cycling, changing form as it moves between parts of this ecosystem and all other ecosystems on Earth.*
- *That same matter might have been a part of people who lived very long ago, dinosaurs, or really old rocks. Throughout history, matter is constantly being recycled in Earth's systems and is a part of you and your surroundings.*

4. Invite pairs to spend a few minutes looking around for examples of matter cycling among the natural materials they see.
   - *You might see a hole in a leaf, which would be evidence of matter cycling from the leaf to whatever ate it.*
   - *Or the wood in that stick is decomposing into other things, such as soil and carbon dioxide in air.*
   - (If students made connections between air and plants): *Or, when you breathe out, you are releasing carbon dioxide into the air. That carbon dioxide could become part of a nearby plant!*
5. Share: Energy flows from the sun through an ecosystem and then flows to outer space.
   - *Eventually, all energy flows to outer space, but we get new energy from the sun every day.*
   - *If energy cycled like matter and didn't have a way to flow out, Earth would get unbearably hot!*
6. Using red arrows, show how energy flows from Earth to outer space.
7. Invite students to point out examples of energy flowing in their surroundings. (For example, anything alive has energy in it, anything moving has energy in it, anything warm has energy in it, etc.)
8. Share that energy is in matter such as food, so it cycles through organisms temporarily but is constantly flowing from Earth to outer space.
   - *Since there is some energy in all matter, energy also moves in cycles temporarily, but it's constantly being lost, such as when we release heat from our bodies as we do things.*
   - *For example, there's energy in a leaf. When a snail eats a leaf, it gets energy from the leaf to do things the snail needs to do, such as move or grow more of its shell. That energy is moving in a temporary cycle from leaf to snail. A small amount of energy stays in the snail. When the snail uses the energy to do a "snaily" thing, such as moving around, the energy used is released to the atmosphere.*
   - *That energy eventually flows to outer space.*
9. Share that plants "package" energy from the sun with matter and make food, adding energy to an ecosystem.
   - *Although energy is constantly lost from the ecosystem, more energy is entering the ecosystem.*
   - *Through photosynthesis, plants capture and "package" energy from the sun, along with matter, and make food. Food is matter that an organism can use to grow and get energy. Plants are the ultimate source of food for the ecosystem, including for themselves. By capturing energy from the sun and making it into food, plants make energy available in the ecosystem.*
10. Change food arrows to show that food = matter + energy. Then, invite students to take 1 minute to search for an example of something that might be food for an organism in the ecosystem and then share this with a partner.

Reflecting and Wrapping Up

1. Highlight how students have been tracing the cycling of matter and flow of energy through an ecosystem and connect this to the work of scientists.
   - *We've been thinking about how matter and energy move through this ecosystem in order to better understand the ecosystem, how the parts of this ecosystem interact, and how we're connected with it.*
   - *That's something scientists in lots of different disciplines do, too.*
2. Encourage students to think about matter and energy at other times during your program or in different ecosystems they visit in the future.
   - *It can be interesting to think about matter and energy when you are in other places or ecosystems in both urban and rural areas, looking for evidence of matter cycling, or thinking about how energy flows through the system.*
3. Ask students to *Turn & Share* or *Thought Swap* about one or more of the following questions:
   - *What are some things you learned about matter and what helped you learn them?*
   - *What are some things you learned about energy and what helped you learn them?*
   - *Choose something around you in nature and try to explain how it relates to matter cycling and energy flowing.*
   - *What questions do you still have about matter, energy, or ecosystems?*
   - *What was one thing that made your thinking change today?*
   - *If you were to show a younger relative or any family member evidence of how matter cycles, what might you show them?*

ABOUT BEETLES™

BEETLES™ (Better Environmental Education Teaching, Learning, and Expertise Sharing) provides environmental education programs nationally with research based approaches and tools to continually improve their programs.

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