COMPOST (2 DAYS)

Summary: In this two-day lesson, students will explore the agricultural practice of composting, and the role of decomposition in a garden ecosystem. The first day focuses on exploring the process of decomposition using observations of a series of compost piles at different stages of decomposition. The second day asks students to apply their learning by building a compost pile of their own. Then students reflect on how their new understandings of decomposition may support them in developing a planting plan.

This is the twelfth of a 13-lesson series in which students will explore the basic ecological principle of interdependence through the lens of common organic farming practices.

Time: 45 minutes each day

Teacher Notes:

- For sections that instruct students to READ, you can record yourself reading aloud and send it to students. Invite them to read along with the recording. This is a helpful strategy for differentiating learning that supports all students.
- Preparation: Before this lesson, sort your composting system into 3-5 piles based on age. The exact ages of your piles will vary based on the rate of decomposition of your pile. Aim to have the oldest pile represent fully-decomposed and ready-to-use compost, while the newest pile should include fresh kitchen scraps. The piles in between are up to you, but ideally will represent observably different points in the process of decomposition.

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References and Resources:

Brown, M.; Miles. A. & Perez. J. (2015) *Teaching Organic Farming and Gardening*. Retrieved from https://casfs.ucsc.edu/about/publications/Teaching-Organic-Farming/PDF-downloads/1.2-tillage.pdf

Your Guide to Backyard Composting (2009). Santa Barbara County Public Works. Retrieved from http://www.lessismore.org/system/files/5/original/SB_Co_Backyard_Composting_Booklet_Complete.pdf

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Vocabulary

- **Nutrient:** a substance that provides nourishment for growth and survival.
- **Compost:** decayed organic material (such as dead plants and food scraps) often used as fertilizer for plants.
- **Fertilizer:** a natural or chemical substance often added to soil to increase its nutrient-content.
- **Matter:** a material substance—the "stuff" the universe is made of. Although matter may change forms, it cannot be created or destroyed.
- **Energy:** the capacity for doing work. Different forms of energy include potential, kinetic, thermal, electrical, chemical, nuclear, or other various forms. Although energy may change forms, it cannot be created or destroyed.
- **Conventional farming:** farming that uses chemicals to fight weeds or pests, and may use genetically-modified crops or other forms of biotechnology in order to grow food.

COMPOST

[READING]

READ: For the past two lessons, we've been digging deep into how energy and matter move through an ecosystem. In nature, this happens primarily through the *feeding relationships* between organisms—when a fox eats a rabbit for example, all the matter and much of the energy that the rabbit's body contains are transferred to the fox. The same is true of a rabbit eating a plant. (Remember, when one organism eats another, all of the matter transfers, but only some of the energy. The rest of the energy gets lost to the atmosphere as thermal energy. See L10: How Energy Moves Through an Ecosystem Reading to review).

Feeding relationships are also important to matter and energy transfer in garden ecosystems. You've likely observed this many times—a caterpillar eating a leaf, a bird eating a worm, or a squirrel eating an apple, for example. But even more so than in natural systems, the energy and matter in garden ecosystems tend to be highly impacted by human activity. Most notably, farmers regularly remove large quantities of matter and energy from the ecosystem by harvesting the fruits and vegetables that grow there. Therefore, unlike a "closed" ecosystem where the matter that starts there also ends there, most gardens are "open" ecosystems—there is a continuous flow of new matter in, and old matter out.

If matter and energy are always being removed from the garden, how can farmers make sure that their crops get the energy and matter they need to grow? Luckily, the energy a garden ecosystem needs to survive will never run out because the Sun is a consistent source of energy. (See L10:How Energy Moves Through an Ecosystem Reading to review). You also learned in the last lesson that the majority of a plants' mass comes from carbon dioxide in the air (See L11_Where Do Plants Get Their Matter? to review). Therefore, this is not in danger of running out either. However, this doesn't solve the question of how plants get the other nutrients they need in order to survive.

In today's lesson, we are going to dig further into where the nutrients in a garden ecosystem come from. Is it possible for the nutrients in a garden to run out? How have people who grow food learned to deal with these problems? Understanding how to ensure your garden ecosystem has an adequate supply of nutrients and matter will take you one step closer to developing a planting plan for the garden.

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ANSWER: What do you already know about how plants in the garden get their nutrients?

- Where do they come from and how do plants take them in? (Trace the nutrients back as far as you can)
- Do you know of any technique's farmers use to add nutrients into the garden ecosystem?

READ: Plants take in nutrients from the soil through their roots. The three main nutrients plants need are nitrogen (N), phosphorus (P) and potassium (K). (They also need smaller amounts of calcium, magnesium, sulfur, iron, manganese, zinc, copper, boron and molybdenum). Therefore, soil must contain all of these nutrients in order for plants to be able to grow.

To increase the nutrient-content of the soil, farmers often add nutrient-rich substances like **fertilizer** and **compost** to the soil. Fertilizer and compost both increase the nutrient-content of the soil, but they are created using very different processes and their nutrients come from very different sources. Today we are going to compare these techniques so that you can plan for how you'd like to ensure your crops get the nutrients they need for your project. We'll start with exploring how **composting** works.

OBSERVE: Take some time to observe these **compost** piles. On one end, you will see "completed" compost. This is compost that is ready to be spread on garden beds and worked into the soil. On the other end, you will see "fresh" compost. This compost pile was only very recently created. All the compost piles started like the "fresh" one, but they have been sitting here for different amounts of time. The only thing that has been done after building the initial piles, is to turn them over occasionally.

Spend some time observing the piles and answering the questions below.

- What do you observe about the different piles?
    - Use multiple senses: what do they look like? What ingredients do they contain? How do they feel? Describe the texture, temperature etc.. How do they smell?Can you hear anything? Do you notice any organisms in the piles?
- Sketch a close-up of each pile. Label your drawings with your observations.
- Soon, we will spread the "completed" compost onto garden beds. It is incredibly nutrient-rich.
    - Where do the nutrients in the "completed" compost come from? Explain your thinking.
    - Do you think that spreading "fresh" compost onto garden beds would provide the same benefits to the crops? Why or why not?
- What can you observe about these piles in terms of *matter* and *energy*?
    - What is happening to the *matter* in the piles over time?
    - Can you observe any evidence of *energy* playing a role in the differences between these piles? If so, where do you think this energy comes from?
    - (You might want to refer to the resource Matter and Energy to help with this question. See the reading in lesson ten: Flow of Energy in an Ecosystem)
- What do you think might be causing changes between piles to occur? Use evidence from your observations to support your hypothesis.
- *(Optional)* Do you think you would observe the same changes in a pile that was entirely composed of sticks? What about a pile entirely composed of food scraps? Explain your answer.

TEACHER NOTE: Students should be able to describe that particle sizes are decreasing, which has to do with matter, and that the compost is warm, which has to do with energy. They may even be able to suggest that there is an *exothermic reaction* occurring in order for heat energy to be released.

DISCUSS: As a class, discuss your answers to the question below. Remember, at this point you are still developing your hypotheses, so there are no wrong answers!

- What do you think might be causing changes between the compost piles to occur? Justify your hypothesis using evidence from your observations.

READ: Any time **matter** changes forms, **energy** is involved. In the case of a compost pile, you likely noticed that the matter dramatically transforms over time—what started out as kitchen scraps and dead plant material became a fine soil-like substance with hardly any human labor involved. Where did the energy come from to make this matter transform so dramatically? You may have noticed that the piles felt warm to the touch. This *thermal energy* is evidence of the process at the heart of composting: **decomposition**.

Decomposition is the process by which dead organic matter, such as plants and animals, get broken down into smaller parts. In a compost pile, decomposition is carried out by **decomposers**—organisms such as worms, centipedes, beetles, fungi, slugs, and other microorganisms that are too small to see without a microscope.

Examples of Decomposers

Images clockwise (starting top left), CC BY-SA 3.0 by Sanjay Acharya - Wikimedia // Public Domain Joe Bruce - National Park Service // CC BY 2.0 by allispossible.org.uk - Flickr // CC BY-SA 3.0 by JJ Harrison - Wikimedia

As the decomposers break down the organic material, some of the energy stored in the organic matter is released as **thermal energy**. At a particle level, this means energy is being released as bonds between molecules are broken. This causes the particles in the matter to move faster, therefore increasing the thermal energy of the matter. Though we can't *see* this process, we can observe evidence of it through the increase in temperature of a compost pile. The hotter the compost pile, the more energy we know is being released.

Meanwhile, all of the nutrients that were contained in the original organic materials remain in the resulting compost. They have just been broken down into smaller pieces, so the nutrients are easier for plants to take up through their roots. This makes compost extremely beneficial for plants. In addition to providing nutrients to plants, compost also helps soil to retain its moisture, and suppresses disease and pests. It encourages the production of beneficial bacteria and fungi, increasing the soil's capacity to break down organic matter. Finally, composting diverts waste that would have otherwise gone into landfills.

DISCUSS: With a partner or as a class, discuss your answers to the following questions:

- What causes the temperature of the compost pile to increase? What process is this evidence of?
- What does it mean for something to **decompose**?
- Why do you think that composting is such a common practice in organic farming? What benefits can you see it having for garden ecosystems?
- What questions do you still have about decomposition, or the flow of matter in a garden ecosystem.

DAY 2

READ: Yesterday we learned about the practice of composting and the process of decomposition. Today we are going to put into practice what we've learned by building a compost of our own. As you work, remember that compost piles are built specifically in order to help decomposition happen.

GATHER: There are a number of ways to compost. Today in the garden, we are going to make what is called a layered compost pile. Let's make sure we have all our materials gathered you will need:

- Garden tools; like a rake, garden fork
- Gloves (optional)
- A place to safely and effectively build a compost pile
- Elements of a compost pile; browns, greens, and water.

DO: Now it's time to build your compost pile. Make sure you have a good ratio of greens and browns and that you keep the pile moist.

- Alternate between layering browns and greens.
- Layers should be between 2 and 4 inches thick.
- Sprinkle water on brown layers before adding a green layer on top.
- Build your compost pile between knee and waist high. If it gets taller than that it will be difficult to turn!
- Once your compost pile is built, cover it with burlap, straw, or sheets of cardboard.
- Check back on your compost pile in a few days—use a *compost thermometer* to check the internal temperature. Between 130-160 F indicates very active compost!
- You may want to turn your compost every few weeks to introduce more oxygen to assist decomposition.

NOTICE: As your make your compost pile think about or discuss your answers to the following questions:

- What do you notice about the different elements of the compost pile? What differentiates "green" materials from "brown" ones?

- What could explain the specific steps you are taking to build this compost pile? *(Hint: consider what you know about the process of decomposition—how does it happen and what does it require?)*
    - Why do you think we add water to the "brown" layers?
    - In a couple weeks we will turn these piles to introduce more oxygen. Why do you think this is important? Be as specific as possible!
- How do you think early farmers developed the practice of composting? Where do you think this knowledge comes from?

DISCUSS: With a partner or as a class, discuss the following questions:

- How will the steps we took to build this compost pile help the process of decomposition?
    - What do you think would happen to all this material if we just left it on the ground?
    - What might happen if we built a compost pile with only sticks or only food scraps?

READ: Although decomposition happens everywhere, it happens more quickly and efficiently under certain conditions. When we build compost piles, we do it in a certain way to create ideal conditions for decomposers to thrive. All compost piles have 4 basic ingredients:

- **Browns:** materials such as dead leaves, branches, cardboard, and non-bleached or dyed paper products that are rich in **carbon**. Browns in compost piles provide a food source for organisms that work with microbes to break down the materials in your compost pile.
- **Greens:** Organic matter that is still "fresh"/recently growing. These include items such as vegetable and fruit scraps, grass clipping, etc.. These materials are rich in **nitrogen** and protein and support the microorganisms that break down the compost pile.
- **Water:** We add **water** to the compost in order to provide decomposers with the moisture they need to survive, and to help regulate the temperature of the compost, preventing it from getting too hot. The amount of water needed varies depending on the weather, temperature, ingredients in your pile, and other factors, but in general, if you squeeze healthy compost in your hand, it should feel like a wet sponge that has been wrung out.

- **Oxygen:** After we build the pile, we turn, or *aerate*, the compost in order to incorporate plenty of **oxygen**, which decomposers use to break down the organic matter through the process of cellular respiration. We add **water** to the compost in order to provide decomposers with the moisture they need to survive, and to help regulate the temperature of the compost.

DISCUSS: With a partner or as a class, discuss the question: **Is it possible for decomposition to occur outside of a compost pile?**

OBSERVE: Take some time to wander around the garden to look for evidence of decomposition. To answer the question below, you may want to get your hands dirty and dig in the soil.

- Do you see any decomposers, or evidence of decomposition occurring anywhere? Describe your observations.
- Are there any ways you can imagine speeding up the examples of decomposition that you observed? *(Hint: what do decomposers need to thrive? Consider the steps you took to build the compost pile, and how you might apply them in a garden bed).*
- What role does decomposition play in a garden ecosystem? What would happen to the nutrients and matter in the ecosystem if there were no decomposers?
- Do you think it is possible to successfully grow crops without adding compost to the soil? Why or why not?

MODEL: Add decomposers to the food web diagram that you made in the previous lesson. Use arrows to indicate how matter and energy are moving through the garden ecosystem. Write a short paragraph answering the question: What role does decomposition play in a garden ecosystem? Use the terms *energy* and *matter* in your response.

READ: Decomposition is happening all the time—anywhere you look in a garden, decomposition is already occurring. But the decomposition that occurs naturally in a garden bed generally doesn't happen fast enough to fully replace the nutrients that crops take from the soil. Therefore, if an area of land continuously has crops growing in it, the soil will eventually become depleted of nutrients. Almost all farmers amend their soil with some form of compost or fertilizer.

Fertilizer is the *conventional farming* alternative to compost. A **fertilizer** is any natural or chemical substance added to soil to increase its nutrient-content. Most fertilizers in

industrial agriculture contain high levels of nitrogen, phosphorus and/or potassium. While fertilizers are very efficient ways of adding large amounts of nutrients into soil, they can have a variety of harmful environmental impacts.

For example, it is common for leftover nutrients to stay on the surface of a field after fertilizer gets applied. The unabsorbed nutrients can then get dissolved in water from irrigation or rain and run into nearby streams and rivers. Over time, the nutrients build up in the water and can cause phenomena like *algae blooms*, where extremely large amounts of algae grow in a short period of time (fueled by the high concentration of nutrients), and lead to a depletion of oxygen in the water. This can have devastating impacts on the other organisms living in those aquatic ecosystems. The fabrication of fertilizers in factories can also be harmful to the environment by using large amounts of energy and emitting greenhouse gasses and other forms of pollution through the process.

DISCUSS:

- Compare and contrast compost vs. fertilizers. What are the similarities and what are the differences? How do each impact a garden ecosystem?
- How do you intend to provide your crops with the nutrients they need? Why?

REFLECT (OPTIONAL): If we take the idea of compost as a metaphor (a figure of speech that, for rhetorical effect, directly refers to one thing by mentioning another) what are some things that you want to compost in your life?

ANALYZE (OPTIONAL)*:* Imagine you were to pick 5 apples from a tree and leave them each in different places:

  - 1 sitting on the ground under the tree
  - 1 in a compost pile
  - 1 on a kitchen counter
  - 1 in a refrigerator
  - 1 in a warm, dry place like an oven or dehydrator
- Which one do you predict would break down the most quickly? The least quickly? Explain your thinking.
- For the apple that you predict would break down most quickly—what would happen to its *matter* and *energy*? Draw a diagram to illustrate your response.

What is Compost?

The word **compost** can be used in a few different ways, but it always relates to the process of allowing organic materials like kitchen scraps and garden waste to decompose. One common use of the word is to refer to the kitchen scraps and garden waste *before* they decompose as "compost." For example, "can you take the compost out and put it in the compost pile?" Technically however, *compost* is the substance leftover *after* these organic materials decompose. Fully decomposed compost still contains all the minerals and nutrients of the organic materials it's made from, so it can be added to the soil to help plants grow. Finally, *compost* can also refer to the *process* of creating compost. For example, the compost from the kitchen will be composted into usable compost that will be added to the soil.

To review, compost is a term used a few different ways:

- Compost refers to as kitchen scraps and garden waste *before* they decompose as "compost"
- Compost is the substance leftover *after* organic material decomposes.

Compost refers to the *process* of creating compost.

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