subpod® For Schools.

Compost Guide for Educators

About the Project Partners

Subpod's mission is to make composting a part of everyday life. We believe that passionate educators who teach their students to grow food and divert waste will change the way future generations treat waste. Our goal with KidsGardening is to create valuable tools for educators that will help them make lasting sustainable change.

KidsGardening has been helping youth garden programs across the United States thrive since 1982. We offer inspiration and support to educators and families by way of grants, original educational resources, and by cultivating a community of practice. Our mission is to create opportunities for kids to play, learn, and grow through gardening, engaging their natural curiosity and wonder.

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Introduction

Did you know?

The Food and Agriculture Organization of the United Nations currently classifies 33% of the earth's soils as degraded and is predicting that number could rise to 90% by 2050. Ninety-five percent of all food production is dependent on the health and viability of these soils. (Food and Agriculture Organization of the United Nations, 2020).

An estimated 17% of food produced in the world is wasted by consumers. When this is added to food that is lost as it moves through the food system from farm to table, up to 1/3 of all food grown is never consumed by humans. (United Nations Environment Programme, 2021)

Approximately 44% of solid waste globally is comprised of food and other organic materials. (World Bank, 2018)

Degraded soils. Wasted food. Landfills overflowing. These alarming statistics highlight the inefficiency and unsustainability of our current food production systems. They highlight the critical need for all countries to re-evaluate their current food production and distribution practices. And they're a call to action to find ways that individuals, producers, and communities can best use and preserve our natural resources.

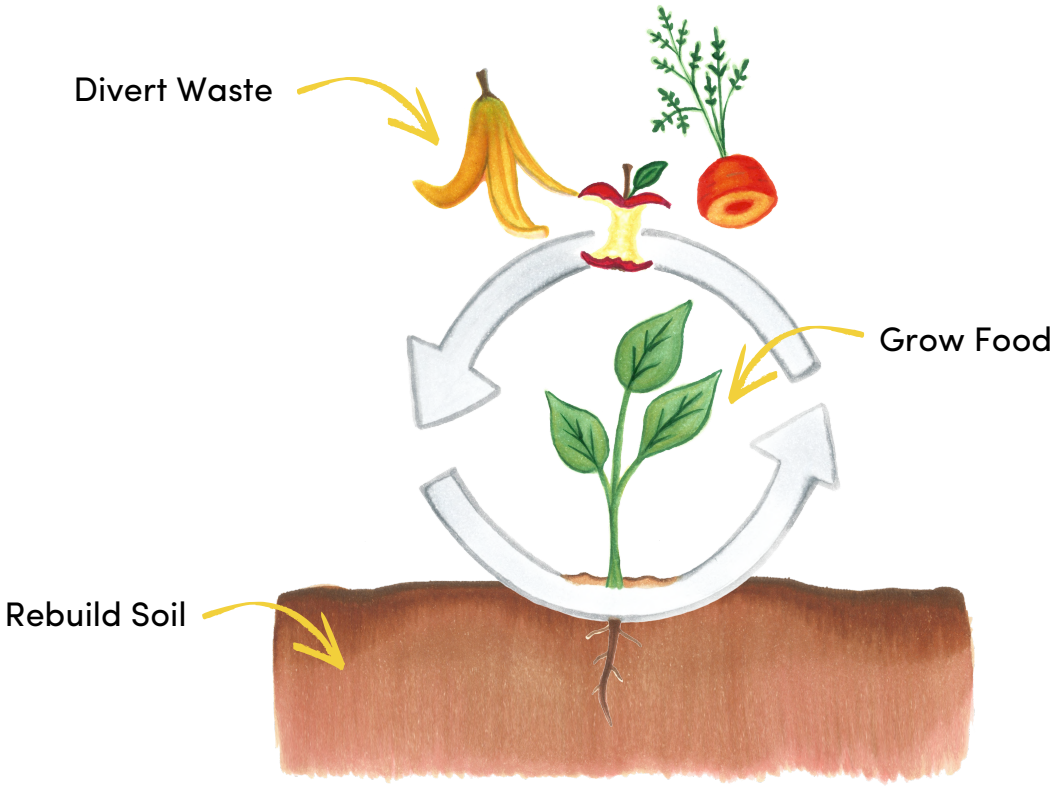
About This Guide

The information, lessons, and activities in this guide are designed to support and enhance the use of the Subpod (or another composting method) in formal and informal education settings.

Our goal is to inspire educators, students, and families to:

- Dig deeper into the critical environmental concerns we face related to our food and waste management systems.
- Reflect on how each of us can be part of the solution.
- Create a generation of informed and inspired global citizens to address and solve these challenges.

The Guide is divided into three topic areas based on vision statements of the Subpod Community: Divert Waste, Rebuild Soil, Grow Food



All three objectives build to Subpod's ultimate mission to "Feed the Soil. Feed the world." The target audience is youth in primary (K-8) grade levels; however, each activity concludes with suggestions for extending the lesson through more advanced learning experiences for secondary students (9-12 grades) and ideas for introducing related themes to early childhood students (preschool).

A Global Challenge

Food and other organic materials make up an estimated 44% of the solid waste entering landfills around the world. As these materials readily decompose in natural settings, this statistic may not seem like a call for concern. Unfortunately, when placed in landfill environments lacking the necessary airflow, moisture, and organisms for efficient decomposition, organic materials decompose at a much slower rate. During excavations conducted through The Garbage Project at the University of Arizona, researchers uncovered 25-year-old lettuce completely intact!

Additionally, decomposition of organic matter in landfills results in the production of methane gas, a flammable greenhouse gas that contributes to climate change. Every year, approximately 1.6 billion tons of greenhouse gas emissions are generated by solid waste treatment, primarily from open dumps and landfills without landfill gas collection systems. Decomposing food waste accounts for about 50% of these emissions.

All indicators predict a continued increase in human population and a decrease in viable land and water availability, which will only deepen the environmental strain caused by current food and waste systems. This complex and multi-faceted environmental crisis cannot be solved with a single solution.

People across the globe will need to make many significant lifestyle changes to alleviate the human impact on our environment. Collectively, we must learn to:

- use fewer resources.
- use the resources we do consume more efficiently.
- find beneficial ways to use waste products to more closely mimic the cycles found in nature.

Where to begin? Try composting!

Composting is a technique for transforming food waste and other organic matter into a nutrient-rich material. Once it's fully composted, the material resembles the humus found in soil that is created naturally as organic matter decomposes.

Benefits of Composting

People have long recognized the many benefits of composting, including:

- It decreases the amount of food and organic waste entering landfills.
- When compost is incorporated into soil, it increases nutrient availability, improves soil structure, decreases soil erosion, increases water retention, and promotes plant growth.
- Composting is a sustainable gardening practice that turns organic matter into a valuable soil amendment.
- When implemented on a large scale, composting has the potential to make a significant impact on the amount of waste generated by a community.

Traditional compost piles rely on a careful balance of the right quantity and quality of fresh and dried materials in order to promote safe and effective decomposition. Creating these ideal conditions can be challenging. Many gardeners struggle to maintain the proper moisture and aeration of their pile — yet these are critical for the pile to reach the temperatures needed for decomposing organisms to thrive and optimum decomposition to occur. Despite the best of intentions, many homeowners, schools, and community gardens end up with smelly "rot piles" rather than true compost piles.

Worm Composting

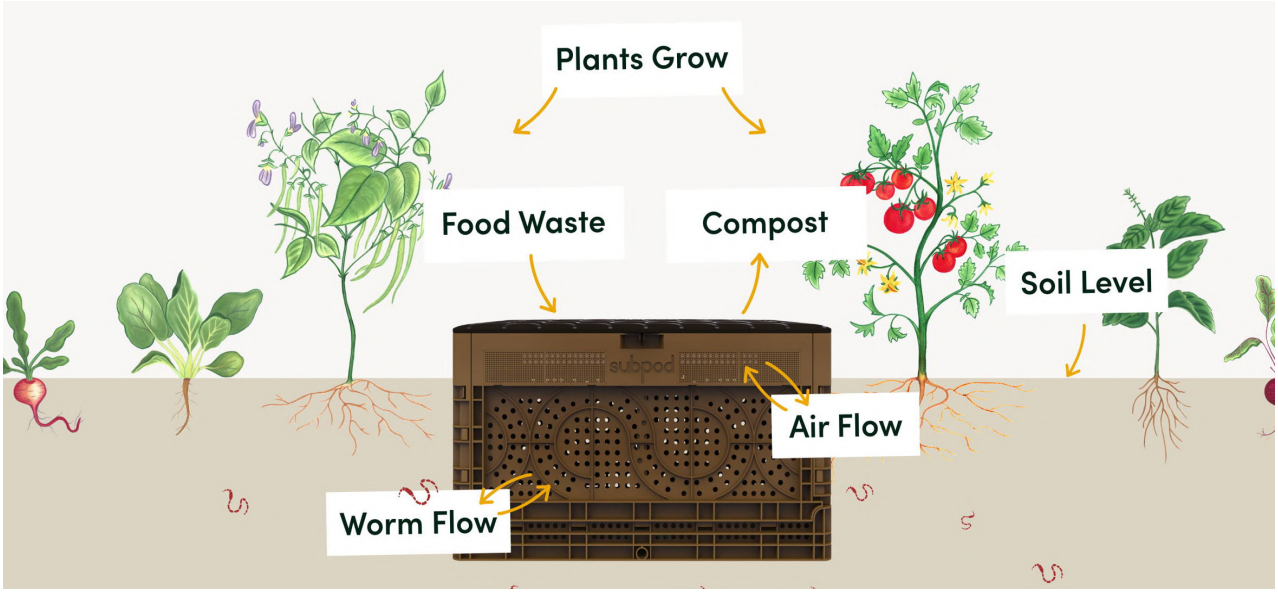
Vermicomposting, also called worm composting, enlists the help of worms to break down food and organic matter into castings (worm "poop"). Most vermicompost systems rely on special red worms that are well-suited to the task. However, these worms are sensitive to temperature and humidity extremes, and in many climates, worm bins must be placed indoors or in protected locations. Unfortunately, indoor worm bins pose their own challenges — the earthy odor and potential to attract annoying fruit flies, to name a few — with the result that many people are reluctant to install them in their indoor spaces.

The Subpod Solution

The Subpod Composting System addresses the challenges posed by traditional compost piles and worm bins, allowing more people to adopt composting practices. The Subpod is a specially crafted worm bin suitable for installing outdoors, either in-ground or in raised beds. The soil surrounding the bin helps buffer the environment for the worms, and the outdoor placement is a welcome alternative for people resistant to an indoor worm bin.

The Subpod is an excellent tool for educators and families who want to introduce composting to young children. Students are fascinated by worms, and the worms' large size allows them to better visualize the decomposition process. (Many of the other stars of the decomposition process are mighty but microscopic organisms that cannot be viewed without magnification.) The Subpod also provides opportunities for exploring foundational science topics including habitats, soil, and the nutrient cycle. Subpod composting sparks conversations about waste management and allows students to participate in an impactful sustainable practice with practical, everyday applications. The Subpod is the perfect size for a family or classroom to compost snack and meal scraps.

Explore "How Subpod Works" here.



Dig In

Regardless of the type of composting system you use, or the size and shape of garden space available to you, getting students composting and gardening early and often is an important step to growing the next generation of environmental caretakers. We hope you will use the following lessons and activities to engage students of all ages in learning about our current food system while also inspiring them to envision a better, more sustainable food system of the future.

Divert Waste

Through the following activities, students will learn about

- Current issues surrounding food and organic waste.
- Landfills and their environmental impact.
- Composting and its role in diverting waste.

Introduction

Without a doubt, Plant Earth has a trash problem.

In a recent publication titled What a Waste 2.0, The World Bank conducted an extensive study investigating solid waste management around the globe. Some of the highlights from their final report include:

Across the globe, humans generate an estimated 2.01 billion tons of solid waste each year. This equates to about 0.74 kilograms/1.6 pounds per person per day.
By conservative estimates, at least a third of all solid waste is not managed in an environmentally safe manner.

- Approximately 36.6 percent of waste is disposed of in some form of a landfill (7.7 percent are classified as sanitary landfills with landfill gas collection systems).
- Open dumping accounts for an estimated 33 percent of waste.
- About 13.5 percent of waste is recovered through recycling and another 5.5 percent through composting.
- Another 11.1 percent of waste is incinerated for final disposal. The final 0.3 falls into the category of other.

What is being thrown away? The estimated break down of the materials disposed of is:

44% Food and green matter

17% Paper and cardboard

14% Other

12% Plastic

5% Glass

4% Metal

2% Wood

2% Rubber and leather

Every year, approximately 1.6 billion tons of greenhouse gas emissions are generated by solid waste treatment, primarily from open dumps and landfills without landfill gas collection systems. Decomposing food waste accounts for about 50% of these emissions. Overall, greenhouse gases generated from solid waste disposal account for about 5 percent of total global emissions.

For more information, the complete report can be downloaded from:
What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050
https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

Kaza, Silpa; Yao, Lisa C.; Bhada-Tata, Perinaz; Van Woerden, Frank. 2018. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development;. Washington, DC: World Bank. © World Bank. (https://openknowledge.world License: CC BY 3.0 IGO)

The Landfill Dilemma

Without significant changes to our existing consumption patterns, the amount of waste humans generate is predicted to grow to 3.40 billion tons a year by 2050. Decreasing the amount of waste we produce is of the highest priority.

In addition, we must find better solutions for managing the waste that is inevitable. Our current reliance on landfills is not a sustainable option for many reasons, including:

- Clearing property for landfills disrupts the existing landscape and all of the plants and animals that call it home.
- Even with the latest technology for landfill construction, landfills have the potential to leak hazardous chemicals into the soil, water, and air.
- Environmental impacts affect not only the immediate location of the landfill, but can spread beyond its boundaries.

Thus, decreasing the amount of waste we produce must be paired with increasing efforts to divert waste from landfills.

Diverting Waste Through Composting

Almost half of the waste we generate is composed of organic matter (food and green organic matter along with wood). This means that composting systems — both small-scale and large-scale — have the potential to divert much of this waste from ending up in landfills.

In addition to decreasing the quantity of materials entering landfills, composting can also significantly reduce harmful chemicals that landfills release into the air. That's because organic matter breaks down differently in landfills compared to the way it decomposes in nature or in an efficient compost system. Lacking the necessary airflow, moisture, and organisms for efficient composting, the organic matter in landfills releases methane gas as it breaks down. Methane is a flammable greenhouse gas that contributes to climate change.

Also, the materials in landfills break down very slowly, so they occupy space for a longer period of time. During a landfill excavation called The Garbage Project, researchers at the University of Arizona uncovered 25-year-old lettuce completely intact!

Out of Sight, Out of Mind

An important first step to teaching youth about the issues related to waste is to increase awareness about what is getting thrown away, where it goes, and what happens to it once it's there. Ironically, the efficiency of waste collection in many communities, such as weekly trash pick-up, shields people from seeing the enormity of the situation and the importance of committing to finding new solutions. Additionally, recycling programs give consumers a false sense of being environmentally friendly and may keep people from feeling the pressure to decrease their waste. The attitude of “out of sight, out of mind” is a major challenge to overcome as we work to solve this environmental crisis.

The following activities are designed to introduce youth to our waste system, to build awareness of the issues related to waste and its impact on our environment, and to explore sustainable solutions as we work together to take care of our planet.

Activity 1:
What is left on my plate?

Summary

Leftover food is a significant component of solid waste across the globe. The first step to decreasing the food waste problem is to understand the size and scope of the issue. In this activity students will help set up a food waste audit at home or school to measure how much food waste is being produced. They will then use that information to explore why so much food is wasted and brainstorm ideas for decreasing the amount of waste.

Materials

- Food Waste Audit Worksheet
- Buckets or containers for collecting and separating uneaten food
- Gloves
- Trash bags
- Collection table
- Measuring tools to fit collection size (food scales, people scales, luggage scales, measuring cups)

Instructions

1. Make plans to conduct a food waste audit at home or at school. Use the following questions to help design your procedures:

- Do you want to conduct your audit at school or ask students to measure waste at home?

- Who do you need to involve in your audit? Contact administrators, cafeteria staff, teachers, parents, volunteers and others as needed.

- If you want to measure at school, do you want to have the whole school participate or just a couple of classrooms?

- How many meals do you want to include in the audit? Measuring multiple meals is more time consuming, but may help you determine average waste more accurately.

- Do you want to measure all waste together or do you want to separate it out into different categories or more specifically by individual item? Do you want to measure liquids also?

Make copies of the food waste audit worksheet, or make your own recording tool.

2. Gather the supplies you will need. At minimum you will need a bucket or other type of container to sort food waste from other types of waste (such as paper napkins or disposable cutlery). You'll also need a way to measure the quantity (volume or weight) of the waste collected. Gloves for sorting and trash bags for disposal after measuring are also helpful.

3. Designate one or two tables for the sorting process. If you're measuring the waste at school lunches, when students finish eating ask them to sort their waste into buckets or containers. You can sort very specifically by having one bucket for each type of item (for example carrots or bananas) or group more broadly (for example have a fruit bucket). If you want to keep it really simple, just measure all leftover food together.

4. As you are sorting, if time and space allow, you could also ask students to share why they did not eat particular items. Remember the goal is simply to collect data and is not meant to make a judgment on their choices. If you are able to collect this kind of feedback, it could be useful when coming up with ideas for decreasing waste at the end of the audit.

5. Measure your waste. If you are working with large quantities at a school, you may want to use a shipping scale, bathroom scale, or luggage scale. If you know the size of the buckets or containers you are using, you could also base it on how many buckets/containers are filled. If you are collecting data at home, smaller measuring tools such as food scales or even measuring cups may be appropriate depending on the volume of waste.

6. Compile your data and ask students, Did the amount of food being disposed of surprise you? Was it more or less than you were expecting? Did you notice any trends in what was left over?

7. Based on your audit, brainstorm ideas for decreasing the amount of waste being placed into the trash. Could we decrease the food portions being served? Could we get students more excited about eating what is on their plate? Do students need more time to eat? Are we able to share food that is uneaten with others? Could we compost food scraps in outdoor compost bins like a Subpod Composting System or indoor worm bins? Identify one or two practices you are able to implement to help decrease the amount of food from your school or home going to landfills.

Want to watch a cafeteria food sorting station in action? Check out the NYC School Food Waste Compost Program Instructional Video at:
https://www.youtube.com/watch?v=ZEqDl3_RWZY

Extension for Secondary Students

Invite older students to explore Understanding Food and Climate Change, a digital guide from The Center for Ecoliteracy available at: https://www.ecoliteracy.org/download/understanding-food-and-climate-change-interactive-guide.
This guide uses video, photography, text, and interactive experiences to show how food and climate systems interact and how personal choices can make a difference. Ideal for grades 6–12 (and adults too), it provides materials needed for students to dig deeper into the issues surrounding food waste within our current food system along with resources for further investigation.

Ideas for Early Childhood Students

Even young children can participate in a food waste audit. To adapt the audit for a younger audience, it is best to conduct it on a smaller scale such as with one classroom or at home.

Obtain 3 clear plastic bins with lids to accumulate your food scraps in. Label one bin "Compost Bin," one "Recycle Bin" and a third "Trash Bin." After snack or lunch, have students bring their leftovers up to a table and have the teachers or adult volunteers sort into each of the 3 bins explaining what goes where and why while they work. After sorting leftovers, talk about which bin is the most full and the least full and place them in that order. Record results with a picture. Try this activity over multiple days and compare your findings.

Food Waste Audit Worksheet

Date: .....

Location: .....

TYPE OF FOOD	AMOUNT COLLECTED	FEEDBACK ON WHY FOOD WAS NOT EATEN

Activity 2: Follow that Garbage Truck

Summary

Do your students know where their garbage goes after it's picked up? Most people don't. This activity will increase awareness about local waste disposal by asking students to discover how their trash is collected and where it goes after being picked up.

Materials

- A regional map or access to Google Maps

Instructions

1. Begin by locating the bin or dumpster used for trash collection at your home or school. Find out when garbage is collected. If possible and safe, allow students to watch the collection process.

2. Tell students you'll be contacting your waste management company (or the environmental services department of your municipality) and have them brainstorm a list of questions for them. (Note: Some companies/departments have outreach coordinators on staff whose job it is to educate the public.)

Sample questions include: Where does the garbage truck take the waste? How it is processed once it is there? What is the total capacity of our local landfill and how much space is still available? How did you pick that location to serve as a landfill? Are there measures in place to protect the environment? When do you expect this landfill to be full? What will happen when the landfill is full?

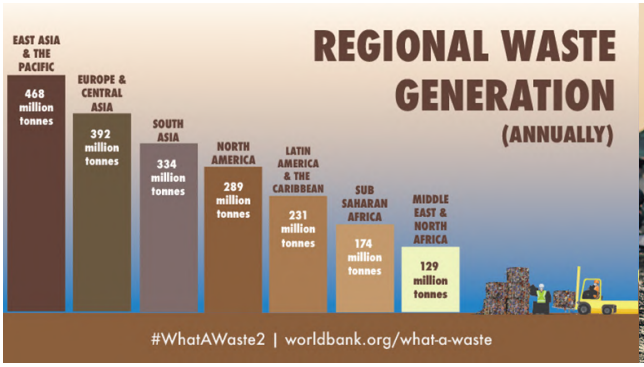
In the United States, The Environmental Protection Agency maintains a list of landfills at: https://www.epa.gov/lmop/project-and-landfill-data-state.

3. On a hard copy map or using Google Maps online, trace the journey between your school/home to the landfill. How many miles/kilometers did the waste have to travel?

4. You can follow this activity by exploring the path of your community's recycled materials, including how they are processed and returned to use.

Extension for Secondary Students

The World Bank conducted an extensive study of waste management around the globe which was published in 2018. Have secondary students read and discuss the summary article:



What a Waste: An Updated Look into the Future of Solid Waste Management from The World Bank (September 20, 2018): https://www.worldbank.org/en/news/immersive-story/2018/09/20/what-a-waste-an-updated-look-into-the-future-of-solid-waste-management.

More advanced students could also read the full report available for download at: https://openknowledge.worldbank.org/handle/10986/30317.

Follow up their exploration with an assignment that allows them to share the knowledge they learned with other student and/or community members. Options include writing a newsletter, newspaper article, or blog post, creating posters or an educational display in a public space, or making public service announcement video.

Ideas for Early Childhood Students

Young children love trucks! Contact your local waste facility to see if they offer any opportunities for students to see how their trucks work up close (safely). Many communities in the United States offer "Touch-a-Truck" events to explore common working vehicles.

If a guest speaker visit or field trip is not possible, there are many fun truck videos available for young children on YouTube such as:

Garbage Truck from The Twenty Trucks Channel: https://www.youtube.com/watch?v=HWLuXiA-Lsw

Landfill Compactor from The Twenty Trucks Channel: https://www.youtube.com/watch?v=4yj5XT0FTcg

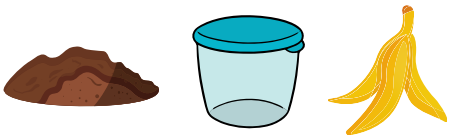
Activity 3: What happens to food waste in landfills?

Summary

In nature, organic matter like food waste will decompose, a process that is aided by decomposing soil organisms and favorable conditions that include airflow and moisture. Manmade landfills do not provide the optimum conditions for decomposition. In this activity, students provide different conditions for food waste to observe differences in the decomposition process.

Materials

- Clear plastic containers or plastic storage bags
- Food waste (fruit, vegetables and/or bread)
- Soil



Instructions

1. Explain to students that they are going to create mini decomposition observation chambers. Begin by placing food waste, such as fruit and vegetable scraps and bread, into multiple clear plastic containers or plastic storage bags. Fill each with approximately the same quantity and type of materials. In half of your bags, also add a scoop of soil.

2. You can stop there, close up the decomposition chambers, and have students begin their observations by comparing the decomposition process with soil present and without soil present. Alternatively, if space and resources allow, you can test out additional variables such as:

- Add additional water to some to see the impact of different moisture levels.
- Choose multiple locations for placement to test the impact of sunlight availability (offering a variety of light exposures) and temperature (perhaps put some in a refrigerator).
- Punch holes in some of the containers to introduce different amounts of air.

3. Have students record observations making note of the date relative to the starting date; they'll likely see some mold and other fungal growth within a week, however the rate of change will depending on what you placed in the bag and the conditions of your space (temperature, sunlight, etc) so how frequently you need to make

observations in order for students to document change accurately can vary. You can use the Decomposition Observation Worksheet to track your findings.

4. Continue the observations until the contents of some of the bags begin to resemble soil. Compile the results and discuss, prompting students with questions, such as, Did some of the bags decompose faster than others? What factors seemed to influence the timing? What do you think was different in the bags that also contained soil? Based on this experiment, how do you think the conditions provided by landfills impact the decomposition of organic materials?

A fun way to incorporate your Subpod Composting System into this lesson is to place the exact same ingredients in your Subpod bin at the same time you start your decomposition chambers and also track the rate and process of decomposition of the materials in your Subpod for comparison. You could also place the materials in a regular compost bin and even try burying them under ground (although this is not quite as easy to observe as you will disturb the contents when you dig it up).

Extension for Secondary Students

Dr. W.J. Rathje was an archeology professor at the University of Arizona who had a field of interest that he called "garbology." He and his students excavated and then sorted and cataloged materials found in landfills. In addition to exploring the waste disposal behaviors of people and communities, he also made some interesting discoveries related to the decomposition of organic materials.

Encourage students to learn more about his work by reading:

Seeking the Truth in Refuse by William Grimes August 13, 1992
New York Times
https://www.nytimes.com/1992/08/13/nyregion/seeking-the-truth-in-refuse.html

The Garbage Project by W.J. Rathje
http://web.stanford.edu/group/archaeolog/GarbologyOnline/files/63674.pdf

They may also be interested in watching the video clip featuring Dr. Rathje from Garbologist- Talkin' Trash available at: https://www.youtube.com/watch?v=ObYwvpDKWIo&t=94s.

Ask students to write reflection paper about The Garbage Project and its findings.

Ideas for Early Childhood Students

Young children can also begin to explore decomposition of living things through observation on a simpler scale by watching one fruit or vegetable decompose. This is a fun activity to explore using a fall pumpkin.

Mark off a portion of your outdoor garden or playground for your decomposition experiment or alternatively, create a raised bed for your experiment by putting soil in a shallow, but wide container like an old kiddie swimming pool that is no longer able to be used because it has cracks in it (if there are not already holes in the container, drill a few holes to help with drainage). You want the children to be able to see the pumpkin as it changes, but it will grow mold and fungus, so you do not want them to play with it. Provide clear instruction that this will be an experiment we observe with our eyes.

Place a carved or uncarved pumpkin (if you have carved the pumpkin, it is fun to leave a few seeds inside for this experiment) in your marked off spot and then let nature work its magic. Over time, weather and decomposers will help break down your pumpkin. By late spring, your pumpkin will be mostly decomposed and you may even have seeds sprout and begin the cycle again with a new pumpkin plant. You can have students draw pictures for observation throughout the year and also take dated digital photos for comparison. At the end of the spring, reflect on how your pumpkin has changed over time and what has contributed to that change.

You can try this experiment with other fruits or vegetables, however hard-shelled pumpkins meant for decoration (the kind generally purchased at Halloween) are more likely to not be disturbed and consumed by larger animals than some other items.

Pumpkin Circle by George Levenson is an excellent companion book for this activity for young children.

Decomposition Observation Worksheet

Chamber #	Contains Soil (yes or no)	Additional Treatment of Chamber	Day # _____	Day # _____	Day # _____	Day # _____	Day # _____

Activity 4: Composting 101

Summary

Composting is the process of facilitating the decomposition of organic matter in a controlled setting. It is a technique used by gardeners and farmers to recycle organic matter into a nutrient-rich material similar to the humus that is naturally created in the soil as organic matter decomposes. In this activity students will explore how composting works and research the benefits of compost.

Materials

- Composting 101 Worksheet

Instructions

1. Plan a walk in a wooded natural area such as park or state forest. If this is not possible, ask students to reflect on past experiences in wooded areas. Ask, What happens to the leaves each fall? Do they stay on the ground forever? What would it look like if it did? What do you think happens to them?

2. Explain to students that in nature, when leaves and other organic matter fall to the ground, the materials decompose or break down into smaller and smaller pieces, eventually getting incorporated into the soil. This decomposed organic matter is called humus, and it's nature's way of returning nutrients to the soil for new living things to use.

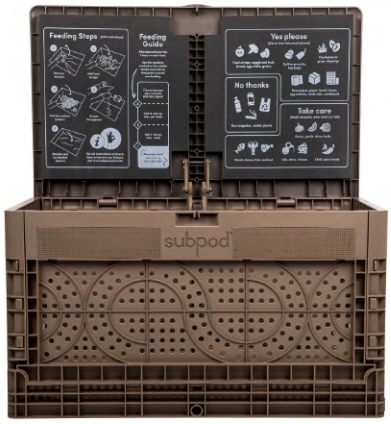
3. Describe how composting mimics this natural process, and that it's a method of nutrient recycling that has been used by farmers and gardeners across the globe for millennia. Use the Composting 101 worksheet to help you explain how the composting process works.

4. Brainstorm a class list of the benefits of composting at school or at home. If your city offers a composting program, learn more about how it works and how much waste it keeps out of the landfill each year. Invite a local composting expert to speak to your class. If a guest speaker is not convenient, try watching one or more of the informative Subpod videos available on their You Tube Channel at: https://www.youtube.com/channel/UCM6hkx6KrAU25KDMbqZx2aA.

Extension for Secondary Students

Although composting can be done in free-standing piles, numerous types of bins and other containment systems have been devised to help gardeners compost organic material. Ask students to find an example of a composter to share with the class. Ask them to report back on the following information and also share a picture (or sketch if a picture is not available):

- Name of Composter
- Materials made from
- Size
- Summary of how it works
- How much organic material does it hold
- Ability to compost food waste
- Rate of decomposition
- Ease of use
- Cost



Compile your results and, as a class, discuss the benefits and challenges of different systems.

At minimum, make sure to compare the Subpod composting system, an above ground worm bin, a traditional free standing bin, and one kind of compost tumbler.

If they need help beginning their search, Gardener's Supply Company offers a wide variety of compost systems for viewing at: https://www.gardeners.com/buy/composting/composters/.

If resources allow, an ideal follow up to this research project, is to have the opportunity to set up an experiment using two or more kinds of composting systems and compare your results to your researched cost/benefit analysis.

Ideas for Early Childhood Students

Gather and read some fun children's books about composting at school or home. Although many are available, here are a few suggestions to help you get started on your search:

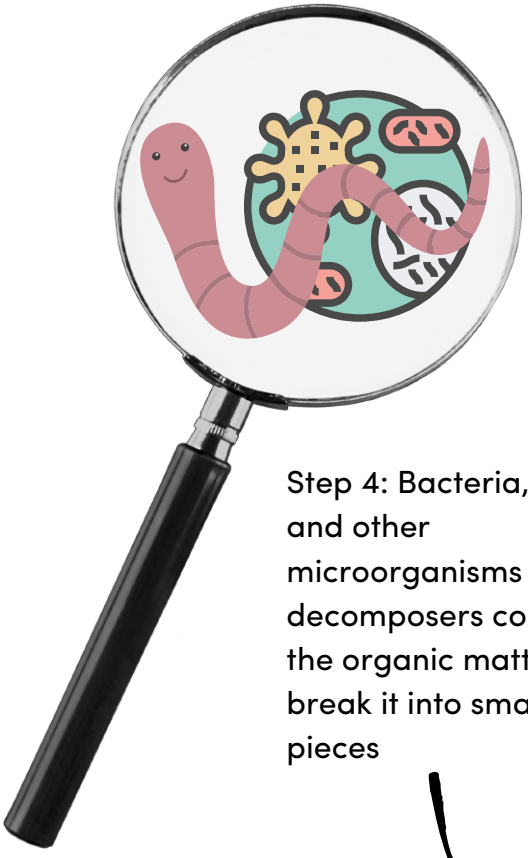
- Compost Stew by Mary McKenna Siddals
- Composting: Nature's Recyclers by Robin Koontz
- Save the Scraps by Bethany Stahl

Composting 101

Step 1: Create a pile with layers of green organic material, brown organic material and soil

Step 2: Add water and keep moist

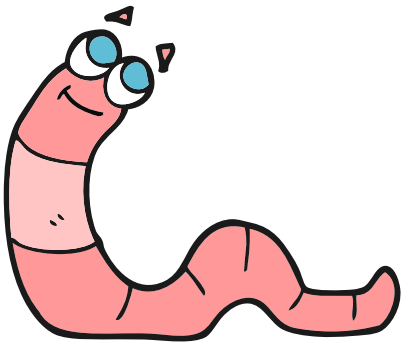
Step 3: Turn pile regularly to add air



Step 4: Bacteria, fungi, and other microorganisms called decomposers consume the organic matter to break it into smaller pieces

Final Result: Organic matter is so small it becomes compost that can be added to the soil

Activity 5: Vermicomposting



Summary

Vermicomposting, which uses worms to break down food and organic matter, was developed as an alternative to traditional compost systems. As the worms eat the food scraps, they create compost from their castings (worm “poop”) that can be added to gardens. In nature, worms are important soil-dwelling decomposers. People can harness the power of the worm to conveniently decompose kitchen scraps indoors. In this activity, your class will make an indoor worm bin for close observation to pair with your outdoor Subpod Composting System.

Materials

- Plastic storage container with a lid
- drill
- piece of fine screen
- newspaper
- spray bottle of water
- food scraps
- red wiggler worms (The earthworms you find naturally in the ground outside do not like to live inside. For indoor bins, red wigglers are best. These slender worms eat just about everything and are happy with indoor temperatures. If you do not already have worms in a Subpod system, search out other vermicomposters in your area who may be willing to donate some worms. If you cannot find a local supplier, there are many options available online.)

Instructions

1. Find a plastic storage container with a lid. Drill 10 or so small (1/4") holes on the sides and bottom. The holes on the sides provide airflow, and the holes on the bottom allow excess liquid to drain. Cover the holes with pieces of screen to ensure your worms don't try to explore outside the bin.

2. Fill 1/2 to 3/4 of the bin with strips of newspaper, which will serve as a bed for your worms (and they will eat it too).

3. Use a spray bottle to moisten the newspaper — worms don't like to dry out.
Add red wriggler worms.

4. Bury some food scraps in the newspaper. Your worms will eat a variety of foods, including fruit and vegetable peels, pasta, rice, bread, coffee grounds, tea bags, and trimmings from the garden. Don't add dairy products, oils, or meats.

5. Place the bin in a warm spot out of direct sunlight (remember, these worms are comfortable in the same temperatures as you). Set the container on a tray or pan to collect any liquid that might drain out — this liquid, called "compost tea," is a nutrient-rich fertilizer!

6. Add food and check on the bin regularly. If the bin becomes overly wet, decrease the amount of food you are adding and mix in additional newspaper for bedding. If dry, increase the amount of food and add moisture with a spray bottle.

7. Watch for castings to build up; timing will vary depending on the size of your bin and the number of worms you added (you may begin to see results in just a few weeks). When your bin has a lot of castings, use a spoon to scoop them out (leaving the worms in the bin) and add the castings to the soil around your plants.

With the right balance of worms, food, and moisture, your worm bin should not give off any foul odors. However, if you're hesitant about an indoor worm bin, alternatively you could create mini composting bottles to bring in worms from your Subpod Bin for occasional observation indoors. Just make sure to have the air and drainage holes as noted in Step 1 above, even if it is for temporary observation.

Extension for Secondary Students

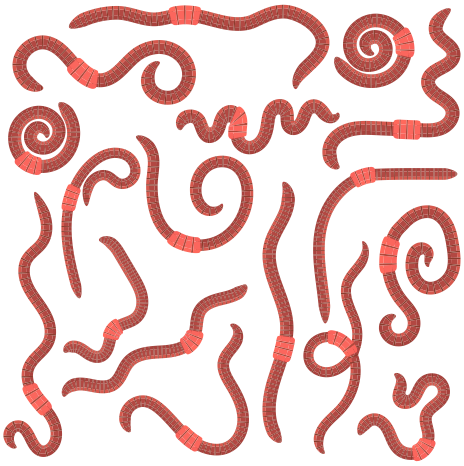
Traditional composting requires outdoor space and a balance of materials that may not be readily available for all. Once a bin is set up, vermicomposting requires only kitchen scraps and shredded paper, which are generally accessible.

Drawing on their firsthand experience, ask students to create educational materials designed to inspire friends, family, and neighbors to try vermicomposting as a way to divert waste going to landfills. As the worms in your Subpod or indoor worm bin multiply, you may also be able to share worms to help others get bins started — or perhaps even use them as a fundraiser for your school garden program.

Ideas for Early Childhood Students

Young children are fascinated with worms. Creating a worm bin for your classroom or adding a Subpod system to your playground as described above will be a wonderful addition to your early childhood education facility. Adapt as needed to make sure young children are safely able to add food scraps to your bin and watch the compost process happening. Since it may be a challenge for them to carefully sort through a worm bin for observation, you may want to place some worms on a plate or shallow bin to allow closer inspection by young children for short periods of time, however remind students that your worms are animals and you need to be very gentle with them. Make sure not to leave the worms out for too long as they may dry out.

Activity 6: Waste Warriors: Red Wiggler Worms



Summary

Red wiggler worms are eating machines. At some points in their life cycle, they can eat their weight in food scraps in a day! Learning about the natural habitat of red wiggler worms, along with their basic needs and anatomy, helps students further engage in your classroom vermicomposting efforts.

Materials

- Anatomy of a Worm Worksheet
- Plates
- Red wiggler worms
- Hand lenses
- Paper and pencil

Instructions

1. There are many different kinds of worms in the animal kingdom, but not all of them are well-adapted to life in a worm bin. One type that thrives in worm bins is the "red wiggler," a common name that usually refers to worms of the scientific classification Eisenia fetida. They are native to warm and humid climates in Europe. These worms feed on organic matter on or near the very top of the soil surface and generally do not survive cold winters.

As a class, research the habitat of red wiggler worms. Ask kids to make a list of all the things they need to survive.

2. Worms' bodies are very different than the bodies of humans. Share the Anatomy of a Worm Worksheet with your students and explore how their bodies work. Make sure to highlight:

Receptor Cells – Worms do not have eyes; however, they do have special cells that are sensitive to light so they can move away from it.

Skin – Worms do not have lungs. They breathe through their skin which must stay moist.

Mouth – Worms have a mouth at one end of their bodies. They do not have teeth but instead have muscles that can push soft, small pieces of food down through their bodies.

Crop and Gizzard – Instead of a stomach, worms have a crop and gizzard. The crop is where the food is stored until it can move into the gizzard. Like birds, worms rely on small rock particles in their gizzards to help grind up their food, and the contracting of their muscles to digest it.

Intestines – After moving out of the gizzard, food continues to move through their bodies into their intestines. Nutrients pass into the bloodstream through the walls of their intestines.

Anus – Any waste not absorbed moves out through their anus and becomes a worm casting – a valuable, nutrient-rich soil amendment for plants.

Setae – Worms do not have legs. Their bodies are covered in bristles called setae that help them move.

For more information about worm anatomy, check out Worms Eat My Garbage by Mary Appelhof and Joanne Olszewski or Wormy Facts and Interesting Tidbits by Rhonda Sherman of NC State Extension at: https://composting.ces.ncsu.edu/vermicomposting-2/wormy-facts-and-interesting-tidbits/

3. After learning about the parts of the worm, give your students a chance to observe red wigglers up close by placing them on a plate and providing hand lenses. It is very important to keep observation time short so that the worms do not dry out and perish. Observation is best conducted indoors or in the shade. Provide water spray bottles if needed to maintain moisture.

As they make their observations, have students draw a picture of the worms on a piece of paper or in their garden journals. They can use the Anatomy of a Worm Worksheet to help add labels to their drawings.

Extension for Secondary Students

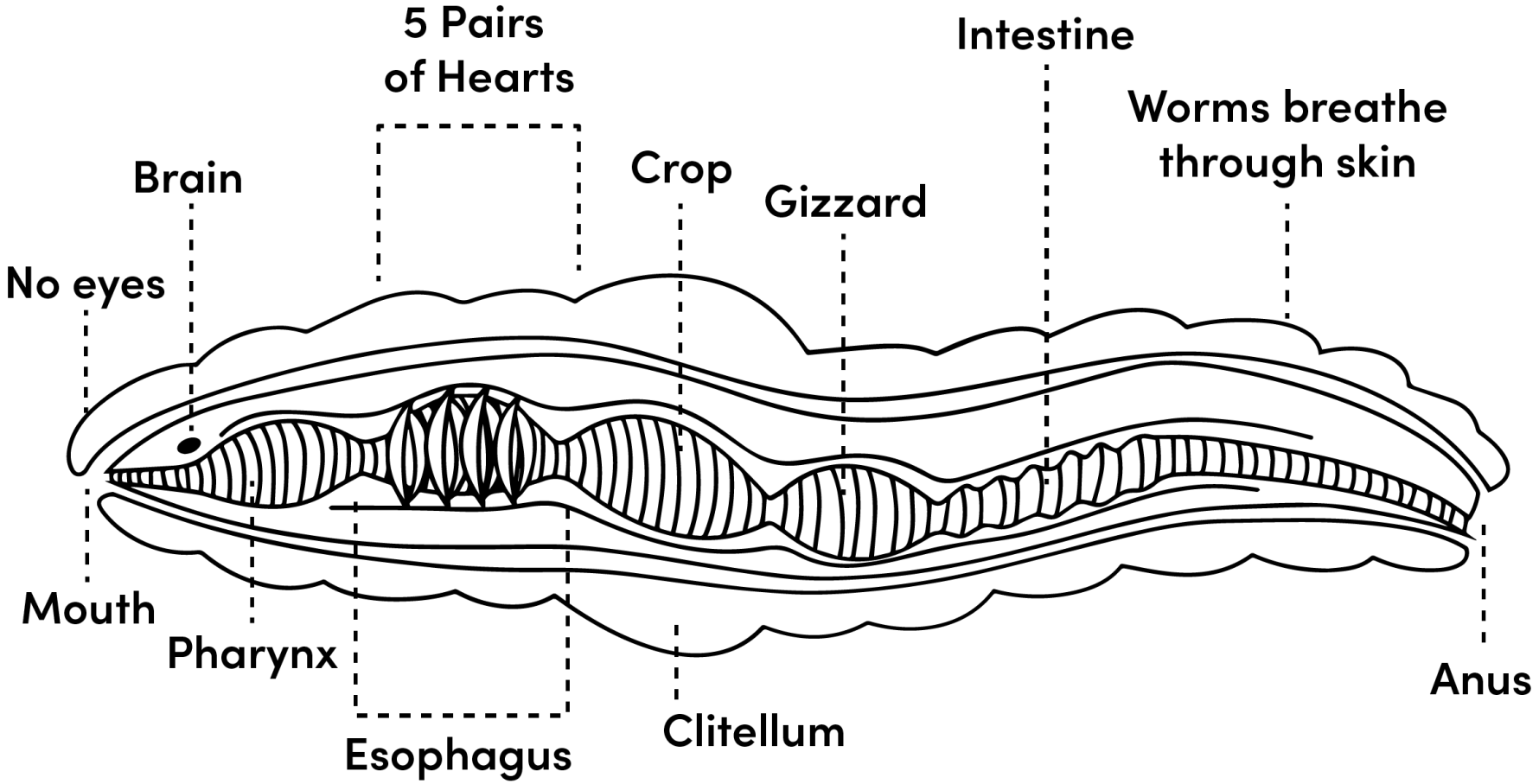
Native worm species do not exist in land once covered by glaciers, so the introduction of any type of worm in natural environments in these areas can be invasive and detrimental to other wildlife as they compete with native species for food and territory.

Although researchers have not noted issues with the presence of red wiggler worms (Eisenia fetida) in the southern United States, they have raised concerns about the introduction of invasive worm species in northern forests. Task students with investigating the discussion surrounding vermicomposting and the introduction of non-native worm species. Ask them to research and compile best practices for using worm bins in your area.

Ideas for Early Childhood Students

Read the book a Diary of a Worm by Doreen Cronin. Make a list of all the things that you can feed red wiggler worms in a worm bin and talk about the other things red wigglers need to live, such as water and air.

Anatomy of worm worksheet



Rebuild Soil

Through the following activities, students will learn about

- Soil and why it is so important to life on Earth.
- The soil web of life and how all its organic and inorganic components work together under our feet.
- The benefits of compost in restoring our soils.

Introduction

Soil is the top layer of the Earth's surface that is comprised of both inorganic and organic matter. The inorganic matter is derived from rock broken down over thousands of years by climatic and environmental conditions (rain, glaciers, wind, rivers, animals, etc.). The organic matter of the soil is derived from decaying and decayed remains of once-living plants and animals.

Soil is also teeming with life, including microorganisms such as bacteria and fungi (in healthy soils you can find billions in a single teaspoon!) and larger animals such as worms and pill bugs. Many of these underground inhabitants feed on remains of plants and animals, breaking down their tissues and releasing nutrients back into the soil in the form of humus.

Just like the living organisms above the ground, life under the ground also comprises a very intricate food web. Plant roots give off substances called exudates that consist of carbohydrates produced by the plant through the process of photosynthesis. These exudates become food for bacteria and fungi in the soil. These microscopic organisms are consumed by slightly larger life forms (although in most cases still too small to see with the naked eye), such as nematodes, protozoa, and some arthropods. These organisms are eaten in turn by larger creatures that can be seen without a microscope, such as larger arthropods (like millipedes and pill bugs) and earthworms. Finally, near the top of the web, small soil creatures become a buffet for even larger animals, such as moles.

In addition to eating each other, many of these underground dwellers also consume dead and decaying organic matter (both plant and animal) that has made its way down to the soil. Closing the loop, as the organic matter is consumed and decomposed, nutrients that plants need to survive are released back into the soil in the form they need for healthy growth.

The Role of Soil

Soil plays many important roles in our global ecosystem. To name just a few, soil:

- holds nutrients and water needed by most plants. Plants then provide the foundation for all animal life on our planet as both a food source and source of oxygen.
- serves as a home for many organisms, from tiny bacteria to larger burrowing animals.
- catches and filters groundwater. It also impacts surface water collection and distribution.
- stores carbon and helps regulate the balance of chemicals in our atmosphere that ultimately impacts our climate.

Threats to Soil Health

Unfortunately, modern day cultivation and urbanization is threatening this very essential resource. In a recent report, the Food and Agriculture Organization of the United Nations ("Status of the World's Soil Resources available at: http://www.fao.org/3/i5199e/i5199e.pdf) published a list of threats to soil, including nutrient imbalance, acidification, loss of biodiversity, compaction, contamination, erosion, carbon loss, salinization, sealing, and waterlogging.

Many of these problems can be solved by proper planting/land cover, and the incorporation of more organic matter into the soil. Compost to the rescue!

Compare the threats to soil listed above with the benefits of compost offered by the US Composting Council at https://www.compostingcouncil.org/page/CompostBenefits. They provide research evidence linking the incorporation of compost into soil to benefits including:

- Preventing soil erosion
- Assisting in stormwater management
- Improving soil health
- Promoting healthier plant growth
- Conserving water
- Reducing waste
- Combating climate change
- Assisting in wetland reclamation

Not only does composting efficiently process waste, decreasing the land needed for landfills, it also produces a product that can improve soil and soil life, making the lands we have available healthier and more productive. Composting is powerful tool to rebuild and restore our soils.

Activity 1: What is Soil?

Summary

Through this activity, students will discover soil is made up of minerals including sand, silt, and clay along with organic matter. They will conduct a simple experiment to separate each of the soil components.

Materials

- Soil samples
- Water
- Clear, straight-sided bottle or jar with lid
- Landry detergent (optional)

Instructions

The mineral components of soil are categorized by particle size — sand, silt and clay. These mineral particles are derived from rocks broken down over thousands of years by climatic and environmental conditions (rain, glaciers, wind, rivers, animals, etc.).

Sand - The largest, coarsest mineral particles are sand. These particles are 2.00–0.05 mm in diameter and feel gritty when rubbed between your fingers.

Silt - Silt particles are 0.05–0.002 mm and feel similar to flour when dry.

Clay - Clay particles are extremely fine — smaller than 0.002 mm. They feel sticky in your fingers when wet and clump to the point that you can't see an individual particle without a microscope. The proportion of these three mineral particle sizes in a soil determines its texture.

Soil also contains organic material which ranges from living creatures to decaying matter.

In this experiment students are going to make a mudshake to separate the different components of soil for observation.

1. Fill a clear container with straight sides about two-thirds full of water, then add enough soil to nearly fill the jar. You can also add a pinch of laundry detergent to help the soil components separate well.

2. Shake the jar vigorously and then set it in a place where it won't be disturbed.

3. Have students observe the jar over the next couple of days as the particles settle into layers. The larger sand particles are heaviest and settle at the bottom, followed by a layer of silt, then topped by a layer of clay. The clay may stay suspended and cloud the water for a couple of days, which is why the sample needs to sit undisturbed. Organic matter will float on or just below the water surface.

4. Once the soil in the jar has settled, measure the height of each layer, as well as the overall height of the soil (including all layers). Then translate these measurements into percentages for each component by dividing the height of each component by height of the sample. Record the results.

5. If you would like to provide an additional sensory activity, you can also conduct a ribbon test with any left over soil sample. To conduct a ribbon test:

- Take a small clump of soil and add water until it makes a moist ball.

- Roll the ball of soil between your hands. If the soil makes a nice, long ribbon, then it has a lot of clay in it (sticks together well). If it crumbles in your hand, then it contains a lot of sand. If it is somewhere in between, then the soil is probably a mix of sand, silt, and clay. (A soil with a balance of all three components is called a loam.)

6. Compare your observations to your findings from the mudshake test. Explain that the ribbon test may not be exact, but that scientists often use it as a convenient tool in the field to create a general description of a soil because it is very easy to implement — all you need is a little water.

Extension for Secondary Students

The United States Department of Agriculture Natural Resource Conservation Service uses information about the sand, silt, and clay composition of soil to define the texture of soil which would predict how the soil would "behave."

The smaller the soil particles, the more they bind together when wet. Thus, clay soils can be sticky and difficult to work. They drain poorly and have less pore space for air, so roots may suffer from a lack of oxygen. However, clay soils are often rich in plant nutrients. In contrast, sandy soils can drain water too quickly for healthy plant growth and tend to be low in nutrients, but they are easier to work.

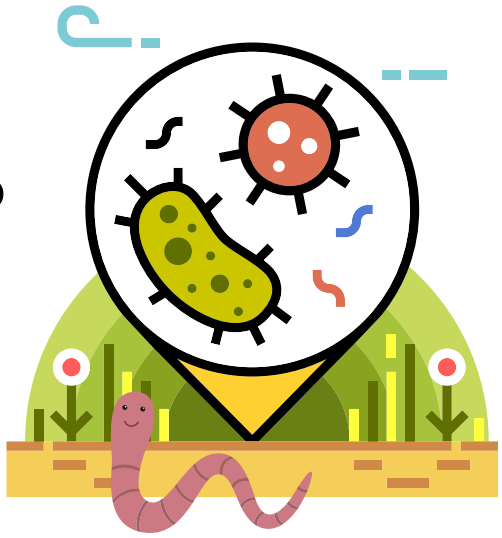
Generally, most gardeners and farmers would like to have a mix of sand, silt, and clay which is called a loam. Adding organic material can also offset many of the problems associated with either extreme.

With percentages in hand from the mudshake test above, students can then use the U.S.D.A. Natural Resources Conservation Service's Soil Texture Triangle and Calculator to determine their soil's classification based on texture. The calculator is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054167.

Ideas for Early Childhood Students

Create a Dig Bed in your garden. Set aside an area in the garden to leave unplanted and give young children the opportunity to dig and observe the soil through unstructured exploration. You can provide a variety of digging tools, however a sturdy plastic trowel is all that is needed. You can bury objects for them to find or simply encourage them to search for things naturally found in the soil. They can use found items like rocks, twigs, acorns and flowers to create small playscapes or simply enjoy the therapeutic benefits of digging. A Dig Bed is an excellent feature for a children's garden especially for young children who may lose interest in more formal gardening activities.

Activity 2:
Who Lives in the Soil?



Summary

Soil (and compost) is alive! Millions of creatures from microscopic organisms to worms to larger reptiles and mammals call the soil home. They are part of the web of life that keeps the soil healthy and full of nutrients to support plants. In this activity, students will explore who lives in the soil.

Materials

- Soil and/or compost samples
- Small trowels
- 32 ounce drinking cup (at least 2)
- Water
- Dish soap
- Clear plastic container
- Hand lens

Instructions

1. Have students begin their investigations by digging through soil samples with small trowels or spoons to look for gastropods (slugs and snails) and large arthropods (invertebrates such as insects, mites, and centipedes). Students can work individually or in small teams. Have students keep an inventory of what they find.

If you have a Subpod composting system, you can also also scoop out a sample of compost to explore and inventory. Because the Subpod is installed in an outdoor garden, it will be home to many more decomposers than just the red wiggler worms you placed in the bins when setting it up.

2. Since your collected soil sample is just a small measure of your space, expand your exploration by setting up some pitfall traps around your schoolyard or garden. To make a pitfall trap, dig a 32-ounce plastic cup into the soil so that its rim is flush with ground level. Take a second cup, add 1 to 2 inches of water and a few drops of dish soap. The soapy water will kill some insects and prevent others from being able to escape. Place your new cup within the buried cup.

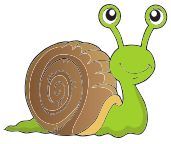
3. Leave the cup in the ground overnight and return the next day to see what might have made its way into your trap.

4. Pour contents of the cup into a larger clear plastic container so you can better examine your collection. If you have hand lens available, you can let your students take a closer look.

5. After examining your samples, ask students how many organisms they think live in soil? From these observations, they are likely to say just a few. However, let them know that there is much more there than we can see without the help of a microscope. One cup of soil could have as many as 200 billion bacteria, 20 million protozoa, 100,000 nematodes, and 100,000 meters of fungal hyphae (threadlike strands)!

6. As a class, create a list of all the living things that call soil home. Possible inhabitants to add to your list include (but are not limited to):

- bacteria (including actinomycetes)
- archaea (single-celled organisms similar to bacteria)
- fungi
- algae and slime molds
- protozoa (amoebae, ciliates, flagellates)
- nematodes
- arthropods (mites, spiders, centipedes, millipedes, springtails, roaches, beetles, termites, ants, sow bugs)
- earthworms
- gastropods (slugs and snails)
- reptiles and mammals (snakes, moles, voles)



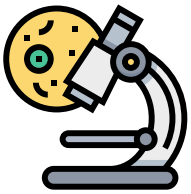
Extension for Secondary Students

Secondary students can use more advanced techniques to look for smaller inhabitants in your soil or compost sample from your Subpod. They can use Berlese Funnels to force out smaller organisms. Instructions for creating a funnel can be found at the following resources.

"The Berlese Funnel" by the Soil Science Society of America:
https://www.soils4teachers.org/files/s4t/lessons/berlese-funnel.pdf

"Constructing Berlese Funnels to Study Invertebrate Density and Biodiversity" by Carolina Biological:
https://www.carolina.com/teacher-resources/Interactive/constructing-berlese-funnels-study-invertebrate-density-biodiversity/tr19101.tr

Or, if you have microscopes available, students can look for microorganisms present in their samples. Dr. Elaine Ingram from the Soil Food Web Inc. has a series of YouTube videos that demonstrate the process of investigating soil organisms under a microscope: https://www.youtube.com/watch?v=H8CClDH7jW0.



Have students complete an inventory of their findings and use the information to create a graph or chart to share with others.

If you want to extend the learning, you can increase the number of soil and/or compost samples from different areas around your community or from different kinds of compost systems and compare differences in your findings. Try to collect samples from diverse locations where you might expect to find different soil life populations. For example, collect some samples from areas where plants are thriving (and thus you would expect to find healthy soil life populations) and some from areas where the soil is bare or has poor plant growth (where you would expect to find little to no soil life). Collect soil from land that is intensely maintained and land that has minimal human impact. Compare samples from compost piles that maintain high temperatures and those do not.

Ideas for Early Childhood Students

Explore an outdoor space with your students, looking for some common soil organisms by turning over rocks and digging through mulch or leaf debris. You can also bring in soil samples that you know contain examples of larger decomposers like earthworms and pill bugs and place in a discovery bin for children to explore.

Activity 3:
Why is Soil Important?

Summary

Soil is so important to our planet that the United Nations has designated December 5th each year as World Soil Day. We rely on it for the food we eat, the water we drink, and the air we breathe. In this activity, students will explore all the reasons soil is critical for life.

Materials

- Internet Access
- Dry erase board or chart paper
- Dry erase markers or markers(at least 2 colors)

Instructions

1. Ask students to brainstorm all the reasons that soil is important to us and our world. Write answers on a dry erase board or chart paper.

2. Next, explore the resources put together by the United Nations for World Soil Day. There is a video available at:
Keep Soil Alive, Protect Soil Biodiversity - https://www.un.org/en/observances/world-soil-day
Or
https://www.youtube.com/watch?v=hbdsHOnd_gw

and there is also an extensive collection of online children's books for download available at:
http://www.fao.org/world-soil-day/bookcontest/en/

3. After reading and/or watching more about soils, use another color of marker to add to your list of why soil is important. Did your list grow? Ask students if they learned anything new about soil.

4. Extend your learning by watching The Soil Story Video from Kiss the Ground:
https://kisstheground.com/thesoilstory/

Extension for Secondary Students

Plan your own World Soil Day Event! Each year the Food and Agriculture Organization of the United Nations creates a diverse array of educational materials, from posters to videos to social media messages, to help you spread the word about the importance of soil.

Have students check out the World Soil Day website and resources at http://www.fao.org/world-soil-day/en/ and plan an outreach event for peers, family members, and neighbors. Ask them to come up with a list of recommended sustainable gardening practices, such as creating worm bins, to show others how they can help protect and rebuild the soil in your community. You can even register you event with the UN be part of the global campaign to save our soils!

Ideas for Early Childhood Students

Make a mini root viewer. Punch holes in the bottom of a clear plastic drinking cup and then plant bean seeds around the edges of the cup in potting soil. As the seeds grow and roots spread through the soil, talk about all the things that happen under the soil and all the organisms that call it home. Introduce students to the importance of soil in our world.

Up in the Garden and Down in the Dirt by Kate Messner is a good companion book for this activity for young children.

Activity 4: Compost in Action

Summary

Adding compost to soil can help improve its structure and pore space, in addition to increasing the nutrients available to plants. Growing plants with and without compost mixed into the soil gives students the chance to explore the impact of compost on plant health and growth.

Materials

- Planting containers or raised beds
- Compost (from your Subpod or indoor worm bin, compost pile, or purchased from a garden center)
- Garden soil or potting soil without added nutrients
- Assorted seeds and/or plants

Instructions

1. Set up an experiment to compare the growth of plants in compost-enriched vs. plain soil. Depending on the space and time available, you can design this experiment in various ways:

Indoor Plants – Use smaller (4"-6") pots, a potting soil mix without added nutrients and compost. Try different ratios of potting soil to compost, taking care to label the containers and record the mixture to help with analysis at the end.

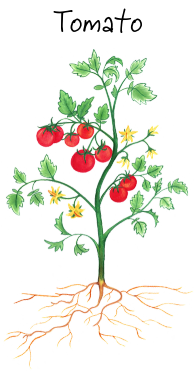
Outdoor Plants – Small Space Available – Use 6" to 8" (or larger) containers filled with potting soil mix without added nutrients, along with various amounts of compost. As above, try different ratios of potting soil to compost.

Raised Beds (or in-ground beds) – Raised beds and in-ground beds allow you to grow plants in natural soil rather than potting mix. Raised beds give you more control over the ratio of soil to compost. If you decide to use an in-ground bed, your treatment will be defined by the amount of compost added.

2. Choose seeds or plants. If time is limited, choose fast-growing plants, such as beans (plant from seed), tomatoes (plant from seeds or transplants) or marigolds (use transplants). To ensure the most meaningful results, limit the variables in the experiment by planting seeds at the same time, or selecting plants that are approximately the same size, age, and health.

3. Track growth and make regular observations. You can use the Plant Growth Observation Worksheet for your notes.

4. Continue your experiment for at least 6 weeks to allow students to observe any differences in growth that might occur.



Extension for Secondary Students

Soil nutrient testing kits are available at garden centers and educational supply stores. Although they may not be as accurate as professional soil tests, they can provide an approximation of the levels of nitrogen, phosphorus, and potassium (the 3 nutrients plants need in the highest quantities) in soil and in most cases also the pH.

Collect samples of garden soil and compost and use home nutrient testing kits to compare nutrient availability. Discuss your findings.

Ideas for Early Childhood Students

Collect samples of compost from a compost bin (a Subpod, an indoor worm bin, or a traditional compost pile). Although it is best if children can help and or watch the compost being harvested, if you do not have your own composting system, you can also bring in a sample obtained from a local gardener or purchased at a garden center.

Fill one discovery bin with soil from outside and one with your compost sample and give students time to compare the two. Engage students in using all their senses to explore the differences. Help them create a Venn diagram using descriptive words about how the soil and compost samples are the same and how they are different.

Plant Growth Observation Worksheet

Container #	Soil / Compost Ratio	Observation after 1 week	Observation after 2 weeks	Observation after 3 weeks	Observation after 4 weeks	Observation after 5 weeks	Observation after 6 weeks

Activity 5: Like a Sponge

Summary

Adding compost to soil can help improve its water-holding capacity. This can benefit plant health, decrease runoff, and prevent soil erosion. Students explore this benefit by comparing the ability of different soils to absorb water

Demonstrating the differences of soil with and without compost to absorb water gives students the chance to explore this benefit.

Materials

- Soil
- Compost (obtained from your Subpod or other composting system if possible)
- 6" inch pots with drainage holes (any size pot will work but all should be identical in size and shape)
- Trays or bowls (same as number as pots)
- Measuring cup
- Bin or container for mixing soil and compost
- Water

Instructions

Set up an experiment to investigate how the addition of compost impacts the water-holding capacity of soil. You can use compost harvested from your school's Subpod or from an alternate composting system. Compost can also be purchased in most locations where soil is available too if needed. If you have the time and space, you can expand your experiment to also compare the impact of different sources of compost and kinds of soil.

Use your measuring cup to fill one pot with all soil and note how many cups it holds. Fill a second pot with all compost. In the other pots, vary the ratio of soil to compost using the cup to measure the amounts. For example, if your pot holds 4 cups, then a blend of 3 cups of soil to 1 cup of compost gives you a ratio of 3:1. Measure the soil and compost into a bin or other container and blend it thoroughly before placing the mixture in a pot. Label the pots so you can keep track of the different mixtures.

For example, you might have these five options:

- All soil
- All compost
- Half soil/half compost
- 3/4 soil and 1/4 compost
- 3/4 compost and 1/4 soil

2. Water all of your pots until saturated; that is, until water is coming out of the drainage holes. Allow the water to drain and let the pots sit overnight.

3. Place each pot inside its own tray or bowl. Measure out a small amount of water and slowly apply the same amount of water to each pot. Make sure your trays/bowls are catching all the drainage.

4. Keep applying a measured amount of water until all pots have water draining out the bottom. Keep track of how much water was applied.

5. After the pots have finished draining, measure how much water drained out of each pot.

6. Compile data in a chart. Did you notice any difference in the drainage from the pots with/without compost added? Why do you think additional water-holding capacity might be a benefit for soil? What do you think that would mean to the plants that grow in the soil? How might water-holding capacity impact the land when it rains?

Extension for Secondary Students

Extend this experiment to also test how the water-holding capacity of soil is influenced by plant roots by repeating this experiment with some samples planted with grass (make sure roots have had time to become established). Instead of using pots, it may be interesting to use repurposed clear, 2-liter bottles with the tops cut off and drainage holes added so you can see the roots and watch the water draining.

Help students fully appreciate this benefit of improved water-holding capacity by discussing how this quality can help prevent erosion, increase the absorption of rainfall, decrease flooding, and potentially clean toxins out of water runoff. The United States Geological Survey offers a wealth of educational material through their Water Science School at: https://www.usgs.gov/special-topic/water-science-school. They also offer
a resource called “Science in Your Watershed” at https://water.usgs.gov/wsc with additional experiment ideas.

Ideas for Early Childhood Students

Put on some old clothes or smocks and let young children engage in some classic mud pie creation. Provide an assortment of different kinds of soil and compost samples with different mixtures of sand, silt, clay and compost/organic matter in plastic bins. Allow students to add water using small cups and then try rolling the mixtures into balls and ribbons. Although they may not be already to understand this topic in great detail, as they work, they will begin to understand that different kinds of soils absorb different amounts of water and act differently when wet.

Grow Food

Through the following activities, students will learn about

- The interdependent relationships of plants and animals above and below ground.
- The value of growing food.
- The importance of adopting sustainable agriculture practices for food production.

Background Information

The natural world is based on a series of cycles, including the carbon cycle, the nutrient cycle, and the water cycle, that collectively create and support an awe-inspiring circle of life. We need oxygen and breathe out extra carbon dioxide. Plants need carbon dioxide and release extra oxygen. Plants absorb nutrients from the soil and use the sun's energy to manufacture food. Animals eat plants. Decomposers break down animal waste and the bodies of deceased animals and release the nutrients they contain back into the soil for plants to use again. Together, these processes and relationships maintain a balance of resources and create an ecosystem that supports an intricate and interconnected web of life.

The garden is a place where youth can observe these relationships and cycles firsthand. They learn how below-ground organisms and the soil ecosystem support thriving plants above the ground. They experience the joy of harvest and the importance of eating healthy fruits and vegetables. They can share harvest with others and feel pride in feeding their community. They can close the loop by maintaining a compost system (traditional, Subpod, or an indoor worm bin) and return the nutrients to the soil to begin the cycle again.

Through gardening and composting, not only do students learn how to increase the food available to them, they also gain a greater appreciation for the work necessary for producing food and a better understanding of the relationship between animals, plants, and the soil. Students who garden and compost come to know the effort and energy required to produce food and begin to comprehend the true cost and value of food. As they gain a deep understanding of our current food system, these youth — the next generation of leaders — will be prepared to tackle the task of reimagining our food system to adopt more sustainable practices that better protect our environment and achieve the goal of increasing access to healthy foods for all.

Gardens for Food Security

Access to adequate calories and nutrient-rich foods is a critical need for all people. According to the United Nation's State of Food Security and Nutrition in the World 2020 (available for download at: http://www.fao.org/documents/card/en/c/ca9692en), 690 million people (8.9% of the world's population) are chronically undernourished and suffer severe food insecurity. Another 2 billion people are moderately food insecure and face regular uncertainty related to the quantity and quality of available food. Decreasing the prevalence of food insecurity — with the ultimate goal of ending it entirely — is going to require a multipronged strategy, including a food system that is more efficient and produces less waste. One solution being investigated involves increasing the number and capacity of local, small-scale producers. Home, school, and community gardeners, along with local farmers, have the potential to make a significant impact on the amount of high quality, nutrient-rich food available in communities.

Learning about Sustainability

However, simply growing enough food to feed the world is not enough. The environmental impact of an inefficient food system is staggering. Removal of forests, erosion caused by excessive tillage, damage to soil life caused by over-use of fertilizers, a decrease in pollinator populations due to pesticide applications — these are just a handful of the agricultural practices that result in severe environmental consequences. Previous generations have boosted food production through methods that were not always kind to the land. When soil was degraded through poor management, production would merely shift to new lands still rich with resources. However, as the amount of arable land decreases and populations rise, this is no longer an option.

Scientists and food producers around the world are researching best practices to create a more sustainable food system. Many of these techniques are inspired by nature and the relationships found in nature. Here are a few techniques that young gardeners can explore and implement to learn more about growing food sustainably and in harmony with their environment:

Test your soil.
Teach students about plant nutrients and the importance of only applying extra nutrients when they are needed. Learn about the texture of your soil and discover ways to use compost to improve its food-growing capacity.

Use organic fertilizers.
When nutrients are needed, use those derived from organic sources. As students learn about the millions of amazing organisms that live in the soil, they'll gain a deeper understanding of how soil health depends on this vibrant underground ecosystem. They'll learn that organic fertilizers support this ecosystem — as opposed to synthetic fertilizers, which can be detrimental to soil life.

Start composting.
Set up and monitor a compost pile or start your own Subpod worm bin. The practice of composting is an essential component of our food system. When we discard our food and yard waste off to landfills, we are effectively taking the resources used to produce them out of the natural circulation on our planet. The nutrients and energy are locked away and no longer available to help produce more food. Instead of a cycle, our current consumption patterns are linear, concluding in a dead end.

Control pests wisely.
Monitor for pests and use mechanical or biological pest control when needed. Teach students the difference between beneficial and pest insects. Explain how in nature they keep each other in balance. Demonstrate how growing diverse crops and rotating crops each season can decrease pest problems.

Use no-till practices.
Tilling ravages the intricate soil ecosystem and should be minimized or avoided. Also, use mulch and cover crops to promote soil health.

Select plants that grow well in your area.
They are more likely to thrive and need fewer inputs (water, fertilizer, etc.) than poorly adapted plants. Grow a diversity of crops to teach students the benefits of growing plants that complement each other. Avoid monocropping (growing large swaths of one type of plant), a practice that creates a feast for pests and lead to an explosion in pest populations that can wipe out entire plantings.

Use water wisely.
Apply water only when needed and try water-saving techniques like drip irrigation.

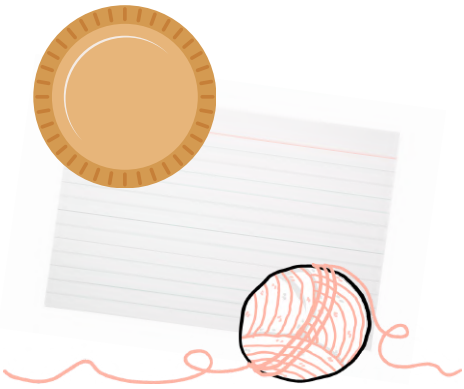
Grow food to consume and to share.
Teach students about the many benefits of eating local foods.

Implementing sustainable practices in home and school gardens provides young gardeners with a foundation for better understanding both the challenges and potential solutions of the agriculture industry on a broader scale. It will spark their curiosity and interest in making lifestyle changes to help support a more sustainable food system.

Activity 1: The Web of Life

Summary

Who lives in the garden? In this lesson, students will explore the intricate relationships of garden residents.



Materials

- Index cards (one for each student)
- A crafted sun (paper plate and construction paper)
- A ball of string

Instructions

1. Begin by explaining to students that a food web is a combination of all the food chains in an ecosystem and that all food chains must include producers (organisms that make their own food) and consumers (organisms that eat other organisms).

2. Pass out an index card to each student. Go around the room and ask each student to name a different organism that lives in the garden and then have them write that name down on the front of their index card. On the back of the card, ask them to say if their organism is a producer or a consumer. Then have them write down a list of what that organism needs to fulfill its energy needs. (Students may or may not need to use resource materials to discover the answer.) You can adapt this activity for younger students (or if you have limited time) by having the names and information already written down for students. Since students are likely to list larger animals, try to encourage a few students to choose smaller animals (including insects) and plants in your area (producers) — or you may need to add those yourself.

Depending on what your students choose, you may also need to provide some additional background about the soil food web since students may or may not have learned much about the soil web of life. Additional details about the soil food web can be found in the introduction of the Rebuild Soil section of this guide.

3. Have students sit in a circle with their cards in front of them with the name of the organism facing out and, using a ball of string, begin to connect your food web. Start by giving students with apex predators (a consumer that is not eaten by any other organism, such as people, hawks, or owls) a ball of string. Have them hold the end of

the string, and then ask them to look for another student that represents one of their foods sources and throw their ball of string to them. Continue on until everyone is connected and until each food 'chain' has landed on a plant/producer species.

4. Next, stand in the middle of the circle and have the students that ended up with the balls of string hand them to you. Ask students to guess what you represent. The answer is the sun. Hang your crafted sun around your neck. Share that plants make their own food through photosynthesis, a process that uses the energy from the sun to manufacture the food (carbohydrates) needed by the plant — food that, in turn, is also used by all other living things.

5. Pull on the strings and ask if anyone who feels the tug to then pull on their string. Continue on until every student can feel the tug. The message: we all depend on the sun's energy and plants' ability to convert the sun's energy into food to live.

Extension for Secondary Students

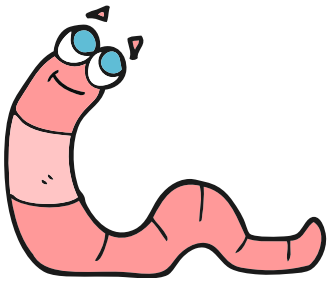
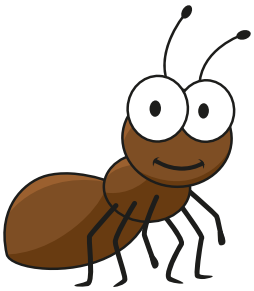
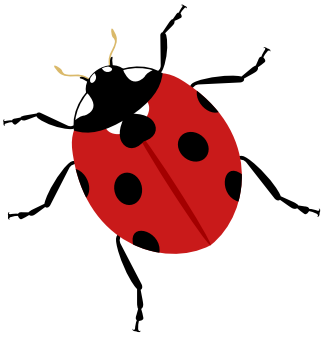
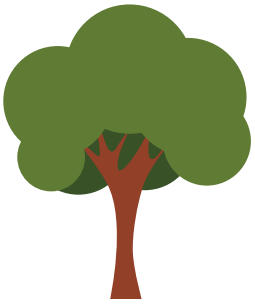
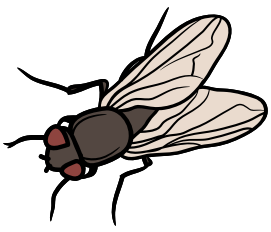
Connect this lesson to your Subpod composting efforts by asking older students to research "Superstars" of the composting world. Ask students to identify a common decomposer important in the composting process and write a short research paper about it. At minimum, they need to find a picture of their organism, a description of its life cycle, learn about what it eats and the conditions it needs to survive, and finally the role it plays in compost production. Have them share their reports with their classmates and, as a class, choose a creative way to share their findings with others, such as by making a Compost Inhabitant Yearbook or recording a class video to post on the school's webpage. Possible inhabitants to choose from include (but are not limited to):

- bacteria
- actinomycetes
- fungi
- protozoans
- nematodes
- arthropods (mites, centipedes, millipedes, springtails, roaches, beetles, termites, ants, sow bugs)
- earthworms

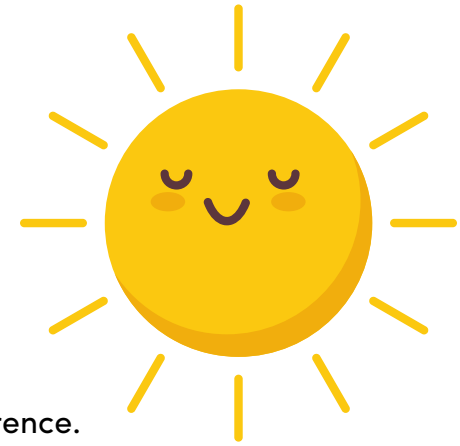
Ideas for Early Childhood Students

Go on a scavenger hunt in your garden or another natural area and look different kinds of garden residents. You can use the Subpod Garden Scavenger Hunt page provided, or create your own. Bring a crayon so you can mark off items as you find them.

Nature Scavenger Hunt

 Earthworm	 Butterfly	 Ant
 Lady Bug	 Plant	 Tree
 Bird	 Bee	 Fly

Activity 2: What do We Need?



Summary

All living things have similar needs with one major difference. Plants have the ability to make their own food using energy from the sun. Animals and other organisms must obtain their energy by consuming plants or other organisms.

Materials

- Chalkboard, dry erase board, or chart paper
- Marker or dry erase marker

Instructions

1. Draw an empty a Venn diagram (two large, slightly overlapping circles) on a chalkboard, dry erase board or piece of chart paper. Label one circle “Plant Needs,” label the second circle “Animal Needs,” and label the overlap area “Plant and Animal Needs.”

2. Ask a class, fill in the diagram. Your answers may include:

Plant Needs:
Sunlight
A place to grow

Animal Needs:
Shelter
Food

Plant and Animal Needs:
Air
Water
Nutrients

3. Ask students, Can we meet all of these needs in a garden? How does a garden provide for plants’ needs? How does a garden provide for animal needs?

Extension for Secondary Students

Use your Subpod Composting System or an indoor worm bin to dig deeper into the lives and needs of red wiggler worms. Ask students to research their unique anatomy, their native environment, what they eat and how they meet their needs in nature and in a composting system. The book Worms Eat My Garbage by Mary Appelhof and Joane Olszewski is a helpful resource.

After completing their initial research, ask students to design an experiment to determine worm food preferences. If you have a two-bin Subpod system, this can be done by placing two different kinds of foods on each side of the bin and checking for migration from one side to the other. Create a list of foods to test, and then test two at a time to create your own Worm Food Tournament Bracket. Before you get started, students can create their own hypothesis about which food will end up on top and treat the experiment as part science and part competition.

Ideas for Early Childhood Students

Teach students to eat a rainbow! The colors in fruits and vegetables represent different nutrients we need to grow healthy and strong. Explain to students we should try to eat a rainbow of fruits and vegetables every day so that we get all the nutrients we need.

Cut out pictures of different kinds of fruits and vegetables in all different colors from a seed catalog or cooking magazine (or print from a website). Have students sort the pictures by color and organize them into a rainbow. If you want to take it a step further, create a chart where students can add a sticker or check mark when they eat different colors of fruits and vegetables.

Activity 3: Plant an Edible Container Garden

Summary

Container gardens are an easy way for young gardeners to give edible gardening a try. By growing their own fruits and vegetables, students experience the joys and challenges of producing food and become part of their local food system.

Materials

- 5 gallon bucket or alternate planting container (anything that will hold soil and has drainage holes will work)
- Potting soil
- Compost (from your Subpod if available)
- Vegetable seeds or transplants

Instructions

Container gardens are a great first garden project for gardeners of all ages. The following instructions are for planting a container garden in a 5 gallon bucket, but you can make a container garden from any vessel that holds soil that you can drill drainage holes in – even an old shoe or boot.

1. Start by finding a location that receives 6 to 8 hours of sunlight each day. Most fruit and vegetable plants need at least that much sunlight to thrive. Container gardens can be moved throughout the day to maximize sunlight exposure if needed.

2. Let students decide what they want to plant. The more input they have on the selection, the more ownership they will feel over the garden. KidsGardening offers a guide for choosing vegetable varieties for small-space gardens at: https://kidsgardening.org/growing-guide-compact-vegetables/. You can also consult with local gardeners to find out what grows well in your area.

3. Drill 5 to 7 holes in the bottom of your bucket. The holes should be about ¼ to ½" in diameter. Since you are growing edible plants, make sure to obtain buckets that are

food-safe. If you're purchasing buckets, look for those labeled as a “Food Grade Container.” You may also want to check with local restaurants or grocery stores to see if they might have buckets they can donate to you. Many bulk food items are delivered in buckets and so they may have some on hand.

4. Fill your bucket with moist potting soil that has been mixed with compost. The compost will provide a slow-release source of nutrients (fertilizer) for your plants. You will want to use a quality potting mix that absorbs water but also drains well. Don't use soil from the yard or garden, because it likely drains poorly. If you are planning on planting seeds, add soil to about 1 inch below the rim then follow the directions listed on the seed packet. If you are planting seedlings, add soil until reaching the size of the seedling pot plus about 1 inch. For example, if you are planting seedlings that are currently in a 4-inch-tall pot, add soil up to about 5" from the rim. Then take the seedlings out of the pots, arrange them in the container, and carefully add soil around the roots. You want to end up with the soil about an inch or so below the rim. If your soil level is too high, it will be difficult to water your containers. However, also avoid having your soil level too low, because this will impede air movement around stems and you may end up having problems with rot and disease.

5. Plant your seeds or transplants.

6. Gently water your new garden until water begins to drain from the bottom. Place your containers in a spot to match your plants’ sunlight needs.

7. Enjoy! Check on your container garden daily and look for changes and growth. Monitor soil moisture. The best way to determine when your new container garden needs water is to put your finger in the soil to see if it is dry. Also keep an eye out for pest problems and nip them in the bud early. Add nutrients using harvested vermicompost or compost tea from your Subpod as needed.

Extension for Secondary Students

More advanced students can build on this activity by planning their dream edible garden. They will need to take into account mature plant size, plant spacing and light needs. Suggest that they also incorporate a Subpod or alternate compost system into their design.

KidsGardening.org offers a wealth of information to help them get started.

Once complete, set up an exhibit for them to share their designs with family and friends. If possible, incorporate some of the ideas into a school or community garden project.

Ideas for Early Childhood Students

There are many delightful stories about children planting their own gardens. Here are a few you may want to share with young children:

- Lola Plants a Garden by Anna McQuinn
- Oliver's Vegetables by Vivian French
- Errol's Garden by Gillian Hibbs
- Growing Vegetable Soup by Lois Ehlert

Activity 4: Follow Nature's Lead

Summary

Students will discover how scientists, farmers and gardeners are exploring growing techniques that mimic nature to keep the planet healthy.

Materials

- Subpod Compost System or alternate composting system to observe

Instructions

1. Ask students, "As gardeners, we provide nutrients (fertilizer) to the plants in our garden, but does anyone add nutrients in a forest? What about other natural areas?" Share that in most cases, people do not add nutrients though fertilizer to natural areas because nature provides a cycle of releasing nutrients through the decomposition of organic matter after it dies. Introduce students to the nutrient cycle. Create a class diagram depicting the nutrient cycle.

2. The nutrient cycle is the inspiration for composting. The practice of composting was inspired by observations by farmers and scientists of how things grow in nature. Humans have been practicing composting for tens of thousands of years. You may want to share some of the history of composting, which can be found in the article "The Green, Brown, and Beautiful Story of Compost" by Aaron Sidder on National Geographic available at: https://www.nationalgeographic.com/culture/article/compost--a-history-in-green-and-brown.

3. Ask students to observe a compost system, either a Subpod or an alternate type of composting system, and discuss how it mimics nature. When composting, just like in nature, you must provide for the needs of decomposers, which includes plenty of food and consistent moisture.

4. You can conclude your discussion by watching the Supbod video of Geoff Lawton talking about composting with Subpod at https://www.youtube.com/watch?v=nuaPJQpKnLA.

Extension for Secondary Students

Vermicomposting is not just for home gardeners. Larger scale operations that produce vermicompost — not only to help manage waste, but also to sell as a product on its own — exist and are expanding. Learn more about research into the use of vermicompost in commercial horticulture from Cornell University: http://cwmi.css.cornell.edu/vermicompost.htm

Have students (individually, in teams, or as a class) create a formal business plan for their own vericomposting business. Ask them to include:

- A business name
- Summary
- Plan for the organization structure
- Marketing plan
- Operating plan
- Financial plan

Give them the chance to pitch their ideas to potential supporters like school administrators and parents.

Ideas for Early Childhood Students

If you have access to a Subpod or indoor worm bin, harvest some vermicompost or compost tea and teach students about how it provides nutrients that our garden plants need. Avoid calling it plant "food," because plants make their own food through photosynthesis. Explain that the plant nutrients in compost and fertilizers can be considered similar to vitamins for people.

Demonstrate adding vermicompost or compost tea to a container plant or your school garden. This can become a regular activity or even a student job if supply is available. If possible, also provide them with a small bag of vermicompost to take for their home garden.

Activity 5: Grow a Salad

Summary

There is no better way to get students excited about growing food than by having opportunities for them to harvest, prepare, and eat fresh fruits and vegetables from the garden. Growing salad greens is a practical and fun way for new and young gardeners to get started growing their own food.

Materials

- variety of salad green seeds
- containers, raised beds, or in-ground garden beds
- soil and compost

Instructions

Salad greens like lettuce, spinach, arugula, and kale are some of the fastest crops to grow to harvest and they can be grown indoors or outdoors.

Indoor Garden

1. If planting indoors, purchase soilless potting mix and plastic growing containers. Rather than buying pots, you can also be creative and grow salad greens in recycled household containers. For example, the clear plastic containers that store-bought lettuce mixes come in make excellent growing trays. The key with any homemade container is to poke drainage holes in the bottom and put a saucer underneath to protect surfaces.

2. Locate the window in your indoor space that provides the most sunlight possible. Optimally, choose a location with eight more hours of sunlight, which will usually be a south- or west-facing window. Note that light coming through a window will not be as intense as outdoor light, thus making it important for plants to receive as long a duration of sunlight as possible. If you do not have enough natural sunlight available, you can supplement with artificial light, such as grow lights.

3. Moisten the potting soil in a bucket or bowl before placing it in your container. You want the soil to feel like a damp sponge — evenly moist but not so wet that water can be squeezed out of it. You can also add some vermicompost to the soil to serve as a slow-release fertilizer. Fill your containers with the moist soil. Next, sprinkle the seeds

about 1" apart on the soil surface and barely cover them with soil. Because the seeds of greens are so small, you may want to help young children with this step.

4. Place the planted containers in your window or under lights and keep the seeds and soil moist. If using lights, keep the bulbs on for 14 hours a day. Once the seeds germinate, keep the lights positioned just a few inches above the seedlings. Adjust the lights daily as the plants grow. If your plants are placed in a windowsill, rotate the pots a quarter turn every couple of days so all sides of the plants receive light.

5. Water as needed. If the leaves turn pale green or yellow, this can indicate a nutrient deficiency. Give the plants some liquid fertilizer like compost tea from an indoor worm bin or vermicompost from your Subpod.

Outdoor Garden

1. Choose a site for growing. Full sun is best; however, most salad greens will also grow well with just 4-6 hours of direct sun per day, especially as daytime temperatures heat up. Plant in well-drained, fertile soil that has been amended with compost or other organic matter. Most salad greens have fairly shallow roots, so they grow well in containers if you do not have raised bed or in-ground garden space available to you.

2. Most salad greens are cool-season crops. They can be planted earlier in the spring and later in the fall than many other vegetables. If you want to start seeds indoors and then plant in your outdoor garden, sow seeds about 4 weeks before you want to plant. If you want to sow your seeds directly outdoors, you can do that in the spring as soon as your soil has thawed. Select varieties that mature quickly so plants are ready to harvest before the weather turns hot. In the fall, you will need to wait until the weather cools to plant.

3. Scatter lettuce seeds in wide rows or plant in rows, spacing seeds about 1" apart. Barely cover the seeds with fine soil (1/4 inch deep), as light helps lettuce seeds

germinate. Thin seeds as recommended for the variety you are growing, adding the thinnings to salads.

4. Water regularly and make sure your plants have consistently moist soil, especially when the weather is hot.

5. Watch for pests. Just like you, there are a host of insects and animals that enjoy eating greens, from small aphids to caterpillars to larger mammals like rabbits.

Harvest (Indoor or Outdoor)
6. Once the leaves on the greens are a few inches tall, you can begin harvesting. Remind your gardeners that you won't be growing full heads of lettuce like the ones you buy at the store. The idea is to harvest a few leaves at a time from each plant and then let them grow again. That way, the plants won't take up too much space and you'll get multiple harvests.

7. Harvesting is easy. Using scissors, simply cut the greens 1 inch above the soil line, leaving a few larger leaves in the center to keep plants healthy. Lettuce, spinach, and mesclun greens will grow back to yield another harvest in a couple of weeks. After a few harvests the plant stems may get thick and the leaves may remain small. This indicates it's time to compost the potting mix and roots, and start over.

8. Depending on the size and number of plants you are growing, your harvest may continue for many weeks.

Extension for Secondary Students

Engage older students in comparing homegrown/garden-grown salad greens with store-bought salad greens. Chart the path from soil to table. Some data to gather:

- Time and inputs to grow
- Packaging required
- Transportation
- Cost
- Preparation
- Taste comparison

Use the information collected to engage in a conversation about the environmental impact of our food system and the benefits and challenges of growing local foods.

Ideas for Early Childhood Students

Make eating fruits and vegetables (including salad) fun! Turn a plate of vegetables into a work of art!

Cut fresh fruits and vegetables in a variety of colors into bite-sized pieces and place in a bowl. With clean hands, encourage students to use the samples to create a 3-D picture. Toothpicks and dips can be used to enhance their creations. When they are finished, snap a picture and then enjoy!