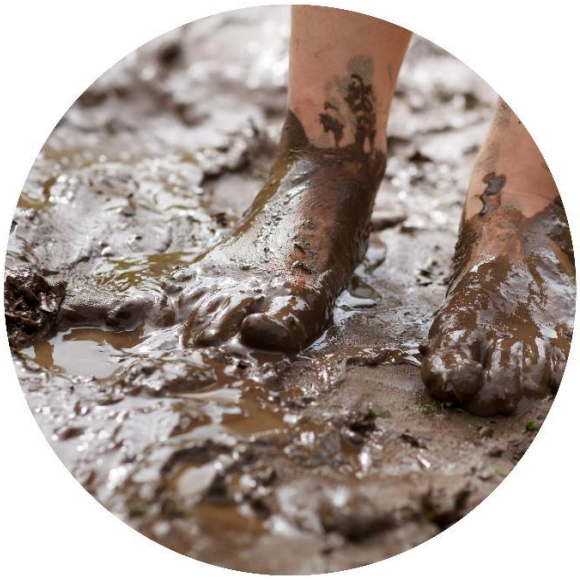
Soil is Alive!



*The following lesson is adapted from *Digging into Soil: A Garden Practicum*. Click here to download a digital copy of the full guide.

Overview: Healthy soils are teeming with life, from microscopic bacteria and fungi to large mammals like moles and voles. In this lesson, students will explore the many organisms that call soil home.

Grade Level/Range: 6th – 12th Grade

Objective: Students will learn:

- There are millions of microbes, soil insects, worms, and soil fungi living in healthy soil.
- Soil organisms help break down the organic and inorganic matter in the soil, providing nutrients for plants. In some cases, they also help with the delivery of the nutrients to the plants

Time: 2 hours

Materials:

- Chart paper
- Internet access
- Trowel or shovel
- Digital camera
- Soil samples
- Soil containers
- Small trowels or spoons
- Ring stand and funnel or clear soda bottle
- Empty jars
- ¼" hardware cloth or window screen
- Rubbing alcohol
- Lamp
- Scissors
- Tape
- Microscope
- Measuring device or medicine spoon
- Squirt bottle
- Eyedropper
- Slides and cover slips

Background Information:

Just like the living organisms above the ground, life under the ground also comprises a very intricate food web. The U.S.D.A. Natural Resources Conservation Service's *Soil Biology Primer* includes a Soil Food Web graphic; it is available at http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/.

In a simplified overview, plant roots give off 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 sow 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.

Just as they do for life above the ground, plants provide the base for the food chain in the soil. An interesting point to consider: Plants could probably survive without aboveground animals, but they are dependent on the food web below the ground to recycle the nutrients they need to live.

Plants rely on various bacteria and fungi to release nutrients from decaying plant and animal material, as well as from the breakdown of inorganic matter such as minerals. And in many cases these microorganisms also facilitate the availability of the nutrients to the plants. Nutrients as they naturally exist in the soil are not always in a form that plants can use. Plants depend on soil-dwelling microorganisms to convert certain nutrients into accessible forms that are available for uptake. Some microorganisms even play an active role in helping roots with the process of absorption. There is also evidence that plants form beneficial partnerships with organisms like mycorrhizal fungi to increase their access to water.

A lack of understanding about the complexities and importance of the soil food web results in problems for many gardeners. The application of insecticides, herbicides, and synthetic fertilizers, along with horticultural practices such as repeated soil tilling, can impact underground organisms and destroy the balance of life within the soil system. For example, a fungicide applied to a lawn will not only kill the fungus that is attacking the lawn, it may also kill off the fungus that is working beneficially with the grass's roots to make nutrients and water more available to them.

An excellent resource book for additional background information about life in soil is *Teaming with Microbes* by Jeff Lowenfels and Wayne Lewis (Timber Press, Portland,

OR, 2010). Although it's filled with detailed scientific information, it appeals to practical gardeners and is written in a style that is easy to read for both educators and students.

Advanced Preparation:

Collect five to 10 soil samples from different locations at your school or in your community. This can be a class activity, or the students and/or the instructor can collect them ahead of time. 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 each soil sample in a jar or other vessel with an open top, and then cover it securely with a piece of window screen to allow airflow and to keep any larger life from escaping before you can explore it. Plan to use the samples as soon as possible so the soil doesn't dry out, which may kill the organisms inside.

Label the samples and take careful notes about where each was collected, as well as the conditions of the surrounding area; for example, what type of plant life is present, is it close to water, does the area experience heavy foot traffic, etc. If possible, take photos of the sites to help with later discussions. You can use the Soil Sample Inventory Worksheet located in the Digging into Soil Guide to help with the data collection.

Laying the Groundwork:

Begin by asking students to list everything that lives in the soil. Record their responses on a sheet of chart paper so that you can compare it to what they learn about soil life in this lesson. Next, as an introduction to life underground, watch the video "The Science of Soil Health: Changing the Way We Think About Soil Microbes" from the U.S.D.A Natural Resources Conservation Service, available at https://www.youtube.com/watch?v=EyKfpOso8q8. This video offers amazing imagery of microscopic life in action and an overview of the importance of the soil food web. After watching the video, add to your list.

Exploration:

1. Explore your soil samples. Have students begin their investigations by digging through the 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.

2. Next, set up a Berlese funnel to look for smaller organisms. Instructions for creating a funnel can be found at the following resources.

   "The Berlese Funnel" by the Soil Science Society of America: http://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

A magnifying glass is helpful for close observation. Have students add this information to their inventory.

3. Finally, if you have microscopes available, students can look for any 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=H8CCIDH7jW0&t=656s. Record the findings.

4. With inventories in hand, ask students to develop a way to present and compare the data they have collected, such as through graphs or charts.

5. Discuss the results, asking students what they have discovered about the soil health at each sample's location. Based on the data, ask them, Can you draw any conclusions about how humans impact soil life? Are there any limitations of your findings? Complete the exploration by brainstorming a list of additional experiments students would like to conduct to further investigate this topic.

Making Connections:

Dig deeper into the background of the "Superstars" of the soil. Ask students to choose from a list of common soil inhabitants and write a short research paper. 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 soil life/health. Have them share their reports with their classmates and, as a class, choose to do one of two things to compile this information: create a Soil Inhabitant Yearbook or create a class play with their organisms as the main characters. Then have them present their project to other students and/or community members. Possible inhabitants to choose from include (but are not limited to):

- bacteria (actinomycetes)
- archaea
- 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)

Branching Out:

Dig deeper into the impact of the application of insecticides, herbicides, and synthetic fertilizers, along with horticultural practices such as repeated soil tilling, on underground organisms and how they alter the balance of life within the soil system. Repeat the exploration using two samples from soils under contrasting management. Collect one sample from an area that is highly maintained (such as a golf course) to consider the impact of regular fertilizer and pesticide applications, as well as a sample from a natural area where there is minimal human impact on the soil. (Make sure to get permission before collecting samples.)