LESSON PLANS
INTRODUCTION

Lesson A. Soil Composition Overview

Lesson B. What's the Soil Type?
- Texture and Feel Activity
- Soil Triangle Activity
- Soil In a Jar Activity
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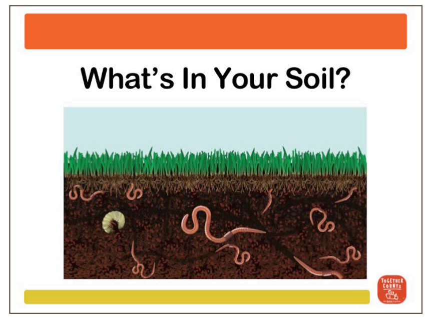
Lesson C. Ecosystems Under Our Feet



PPT Slide Examples

Time Frame: Five or six 45-minute sessions

Learning Objectives:

- Develop a basic understanding of soil composition.
- Understand that soil is made up of minerals, water, air and organic matter.
- Identify six different types of soil by sight and feel.
- Know characteristics of the different types of soil and which are best for cultivation of certain crops.
- Learn more about the organisms that live in soil and their role in keeping soil healthy.
- Understand how soil sustains life in an ecosystem and why soil is essential to life.

Materials for Lesson Plan: (Per Group)

- PowerPoint deck
- Computer with Internet access and projector
- Copies of Soils: Student Reference Sheet
- Samples of different types of soil — all 6 types if possible (sandy, silty, clay, loamy, peaty, chalky)*
- Blindfolds (optional)
- Copies of the "Feel Test" worksheet
- Copies of "By the Numbers" worksheet
- Copies of "Soil In a Jar" worksheet
- Large glass jar with a lid
- Measuring cup
- Laundry detergent (optional — to help with separation)
- Long spoon
- Ruler
- Soil Triangle

- Calculator (optional)
- Hand spades
- One-quart zip-top bags or similar to collect soil samples
- Masking tape and marker for label
- Berlese Funnel
  - Large funnel (2-quart)
  - Clear 2-quart jar or beaker (wide enough for funnel to rest in securely)
  - 2- to 3-inch piece of coarse screen
  - Wet paper towel
  - NOTE: Funnel and container can also be made from a 2-liter clear soda bottle (or gallon milk jug)
- Light source (preferably a clamp light on a ring stand)
- Hand lenses or microscope plus slides
- Soil Nutrient Testing Kit (See *example here*.)
- Copies of Experiment Worksheet
- Copies of Organism I.D. Sheet
- Clipboard and pencil

*Soil samples available online at the *AgClassroomStore*: *agclassroomstore.com/soil-samples-soil-texture/*

Standards Alignment:

This project meets the following Next Generation Science Standards:
- MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- LS2.B: Food webs are models that describe how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plants or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.

Overview:

Learn all about soil composition — from the big picture breakdown (water, air, mineral and organic matter) to the main soil groups (sand, silt and clay) and the six soil types and their characteristics. Discover the differences in soil type through touch and feel, and by checking the component percentages against a soil triangle. Do an experiment to uncover some of the creatures that make up rich soil ecosystems and zoom in on the microscopic life under our feet.

Prior Knowledge:

Students should know that plants need water, and nutrients from soil, gathered trough their roots in order to live and grow. They should also know about food webs and life cycles.

LESSON PLAN A

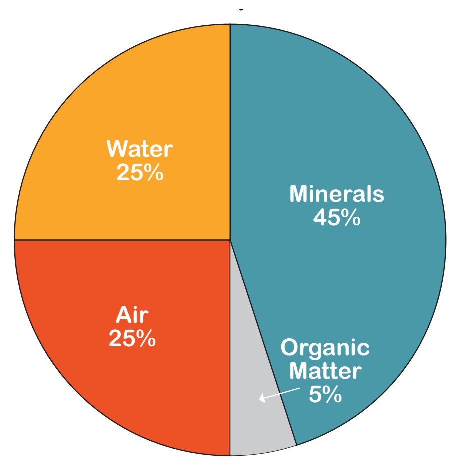
SOIL COMPOSITION OVERVIEW: WHAT IS SOIL?

Materials for Lesson Plan:

- PowerPoint deck
- Copies of Soils: Student Reference Sheet

What Is Soil?

Soils are made up of minerals, water, air, organic matter and countless organisms. Soils are dynamic and always changing!



Soil Composition

Soil is vital to life on earth.

- Soils provide the medium for growing all kinds of plants.
- Soils provide a habitat for animals and organisms that live in the soil – which accounts for most of the living things on Earth!
- Soils emit and absorb gases (such as carbon dioxide, methane, water vapor) and dust.
- Soils absorb, hold, release, alter and purify most of the water in terrestrial systems.
- Soils process recycled nutrients, including carbon, so that living things can use them over and over again. This is often done in partnership with living organisms.
- Soils act as a living filter to clean water before it moves into an aquifer.
- Soils serve as engineering support for construction of foundations, roadbeds, dams and buildings, and serve as support against erosion.

Further Resources: "What's In Your Soil?" Lesson Plan

Student Activities:

Start a Worm Bin!
http://archive.fieldmuseum.org/undergroundadventure/teachers/worm_bins.shtml
The Field Museum in Chicago tells you how.

Dig It! The Secrets of Soils (Smithsonian Environmental Education Center)
http://forces.si.edu/soils/
Features include the Soil Minerals Interactive and the "Explore the 12 Soil Orders" around-the-world journey.

Chef's Challenge (Smithsonian Environmental Education Center) – for grades 5–6
http://forces.si.edu/soils/video/chefs_challenge.html
Two top chefs compete to create the best soil recipe from the same secret ingredient.

Related Videos

Video: Soil | PBS
A good summary of all the information covered in this lesson plan, and more.

Video: SOS Save Our Soil | PBS
The top six inches of soil are the most precious, yet least understood ecosystem on earth — yet we continue to treat soil like dirt. Get down and dirty with large-scale Midwestern composters, California carbon farmers reversing climate change and a West Virginia poultry farmer creating 'biochar' from chicken poop. Explore new frontiers beneath our feet that just might save our soil.

Video: The Science of Soil Health: Compaction | USDA NRCS
Watch this video that explores alternatives to tilling. Then discuss how tilling and fertilizers can adversely affect the organic matter and microorganisms found in the soil. Can students think of any other creative solutions?

Teacher Reference

Soil Education | Natural Resources Conservation Service USDA
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/7thru12/?cid=nrcs142p2_054330

K–12 Soil Science Teacher Resources | Soil Science Society of America
https://www.soils4teachers.org/home

Dig Deeper: Soils for Kids | Soil Science Society of America
https://www.soils4kids.org/
Experiments and games divided by grade level.

4-H Exploring Your Environment Curriculum
https://4-h.org/parents/curriculum/exploring-your-environment/
Explores environmental questions or issues and allows youth in grades 6-8 to jump right into activities that focus on real-world issues.

Soil Health

Soil Health Overview | Natural Resources Conservation Service, USDA
As world population and food production demands rise, keeping our soil healthy and productive is of paramount importance. By farming using soil health principles and systems that include no-till, cover cropping and diverse rotations, more and more farmers are actually increasing their soil's organic matter and improving microbial activity. As a result, farmers are sequestering more carbon, increasing water infiltration, improving wildlife and pollinator habitat—all while harvesting better profits and often better yields.

Soil Health Fact Sheets | Natural Resources Conservation Service, USDA
Six fact sheets, including Checklist for Growers:
Managing for soil health is one of the best ways farmers can increase crop productivity while improving the environment. Results are often realized immediately and last well into the future. Following are four basic principles to improving the health of your soil.

1. Minimize disturbance
2. Maximize soil cover
3. Maximize biodiversity
4. Maximize presence of living roots

It is important to note that not all practices are applicable to all crops. Some operations will benefit from just one soil health practice while others may require additional practices for maximum benefit. These core practices form the basis of a Soil Health Management System that can help you optimize your inputs, protect against drought, and increase production.

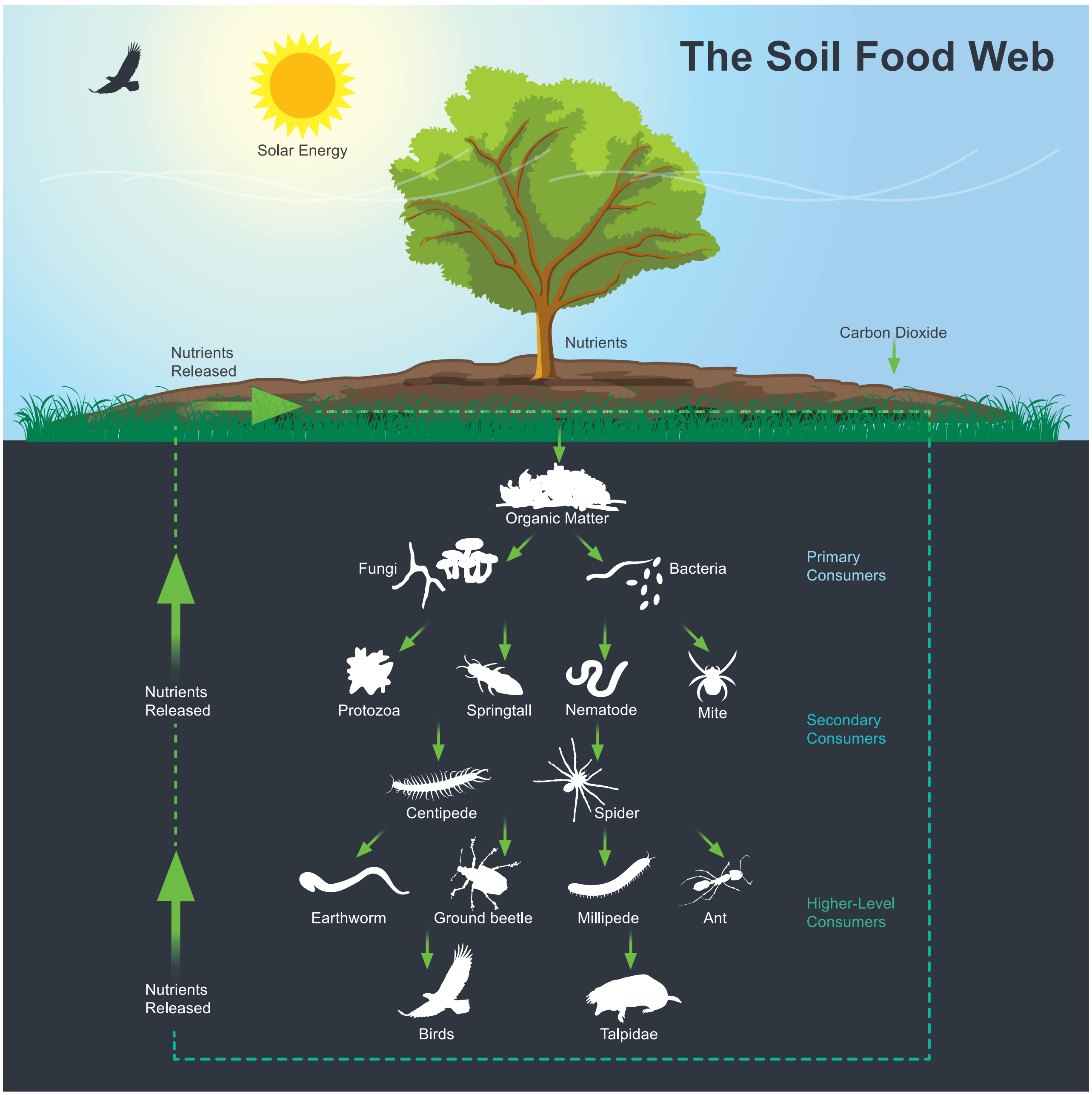
About Fertilizers and Pesticides l USDA
https://www.ers.usda.gov/topics/farm-practices-management/fertilizers-pesticides/

Biotechnology and Genetically Engineered Seeds l USDA
https://www.ers.usda.gov/topics/farm-practices-management/biotechnology/

Worksheets & Downloads:

Soils: Student Reference Sheet

Soil is so much more than just dirt; it houses an entire **ecosystem**. Healthy soil is full of life — from microbes to bugs to burrowing rodents. Just one gram of fertile soil can contain up to one billion bacteria! Different **organisms** all serve a purpose in the ecosystem, converting different organic matter into specific **nutrients** that can be used by the plant. In return, the plant gives back nutrients to the organisms and provides shelter for them. It also prevents the **erosion** of the soil with its root structures.



The organisms living in the soil range from those we can easily see, like earthworms and spiders, all the way down to single-celled **bacteria** and **protozoa**. Many of these organisms form **symbiotic**, or mutually beneficial, relationships with each other. For example, certain fungi will grow on the roots of a plant and be given sugar molecules by the plant in exchange for helping it take up nutrients like **phosphate**. This relationship is called **mycorrhiza**. Fungal networks have also been found to help plants support each other and communicate. Other members of the ecosystem, like pill bugs and beetles, work to keep pests away. When you put all of these organisms' relationships together you get a whole ecosystem.

Nutrients and Nutrient Cycles

One of the main functions of this ecosystem is to recycle nutrients such as **nitrogen**, **potassium** and **phosphorous**. These nutrients are very important to a plant's growth, but are not always as easily available as other elements. When a plant or animal dies, those nutrients are still part of their matter. Organisms help decompose the dead matter and recycle those nutrients back into the soil. The larger organisms start breaking down organic matter by eating it and breaking it down in their digestive tract. This matter if further broken down as it passes through many other organisms, including microorganisms, like bacteria. The plant then uses the nutrients, and when it dies, the process starts all over again!

Example: If a fox eats a rabbit or a rabbit eats a leaf, they have taken something live and consumed it. Then it goes through their digestive tract and comes out as waste for smaller organisms to consume. All of it eventually gets to the microscopic organisms.

Nutrients can find their way into the soil through other ways as well — for instance, from fertilizers, water run-off or volcanic ash.

Soil in Agriculture

Farmers must pay close attention to the health of their **soil** in order to manage crop productivity. Most farmers use fertilizers to improve soil quality and till their land to loosen up the soil. However, some scientists and farmers believe that non-tilling practices better protect the health of the organisms within the soil. Organic farmers work to ensure the organisms have enough space to move freely and not suffocate.

Sometimes farmers will plant particular crops and allow them to die in the field rather than harvest them — just so they continue the cycle of organic matter breakdown in the soil food web. In a process called **crop rotation**, farmers "recycle" by rotating plants with different nutrient needs so that one particular nutrient isn't exhausted. For example, due to the nitrogen-fixing ability of legumes (beans and peas), it is a good idea to plant vegetables that benefit from nitrogen — such as cabbage, kale and cauliflower — in the same soil in the following year. Crop rotation also protects plants from disease and pests and lessens the need for pesticides and herbicides, both of which negatively affect the soil's organisms.

The planting of cover crops is another form of these practices. Cover crops — such as rye, clover, and oats — can be planted between other crop cycles and help promote soil health, as well as prevent erosion, disease and pests. Farmers also test levels of **nutrients**, and, if needed, will supplement with fertilizers to bolster the nutrients in the soil.

Soil Health Defined

"Soil health is the continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals and humans. Only living things can have 'health,' so viewing soil as a living, breathing ecosystem reflects a shift in the way we view and manage our nation's soils. Soil isn't an inert growing medium, but rather is the home of billions of bacteria, fungi and other organisms that together create an intricate symbiotic ecosystem. This ecosystem can be managed to support plants and animals, by cycling nutrients, absorbing, draining and retaining rainwater and snowmelt for use during dry periods, filtering and buffering water to remove potential pollutants, and providing habitat for the soil biological population to flourish and diversify to keep the ecosystem functioning well." – Natural Resources Conservation Service (NRCS / USDA)

LESSON PLAN B

WHAT'S THE SOIL TYPE?

Time Frame: Three 45-minute sessions (or one 60-minute lab followed by shorter sessions)

Learning Objectives:

- Learn how to identify the soil type by two different methods:
  - By "texture and feel"
  - By the numbers, using the Soil Texture Triangle tool
- Learn about the composition of each type of soil.
- Observe how the different types of soil settle in a water solution.
- Determine percentages of soil types within a soil sample and apply that to the Soil Triangle.

Materials for Lesson Plan:

Texture and Feel Activity
- Samples of different types of soil — all 6 types if possible (sandy, silty, clay, loamy, peaty, chalky)*
- Blindfolds (optional)
- Copies of the "Feel Test" worksheet

Soil Triangle Activity
- Copies of "By the Numbers" worksheet

"Soil In a Jar" Activity
- Large glass jar with a lid
- Different soil samples (collected prior to lesson)*
- Measuring cup
- Water
- Laundry detergent (optional — to help with separation)
- Long spoon
- Ruler
- Soil Triangle
- Calculator (optional)

*Soil samples available online at the AgClassroomStore: agclassroomstore.com/soil-samples-soil-texture/

Introduction (Day One, 5 minutes)

1. Ask students if they know what the three basic types of soil are. After they give their answers, briefly describe them.
   a. There are three basic categories of soil: sand, silt and clay. But, most soils are composed of a combination of the different types.
   b. Clay particles are the smallest, while sand particles are the largest.
   c. Sand doesn't hold water. Clay holds the most. Silt is somewhere in the middle.
   d. The Gold Standard! – Loam is the ideal type of soil for most farming. It provides all the necessary elements to grow many crops. It contains a balance of all three soil materials—silt, sand and clay—plus humus (dark, organic material that forms from decayed plant and animal matter). It has a higher pH and calcium levels due to its rich organic matter.

2. Referring to the information on the "Feel Test" Worksheet and Reference Sheet, give a brief introduction to the six soil types:
   - Sandy
   - Silty
   - Clay
   - Loamy
   - Peaty
   - Chalky

Soil I.D. Method #1: "Texture and Feel" (Day One, 20-25 minutes)

In this activity, students rely on touch and feel to guess the soil type. You may add an extra challenge by requiring that students wear a blindfold while doing this.

Materials for Activity:

- Samples of different types of soil — all 6 types if possible (sandy, silty, clay, loamy, peaty, chalky)*
- Blindfolds (optional)
- Copies of the "Feel Test" worksheet

Teacher Preparation:

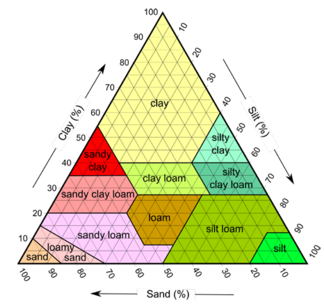
Create stations with each type of soil. Each sample should be broken up into smaller amounts so that multiple students can make observations at the same time.

Familiarize yourself with the appearance and characteristics of each soil type. Watch this video to see a demonstration: *Soil Texture By Feel*

Instructions:

1. Review the six soil types and tell students that they are now going to use their own sense of touch to try and identify different soil samples. You may need to go over some of the descriptors to make sure they understand what they are looking for.
2. Divide students into six groups so that they can rotate around the different stations.
3. Give each student the "Feel Test" worksheet and instruct them on how to fill it out.
4. Each group will then go to a different table and begin making their observations. This should take only 2-3 minutes per table. Rotate groups until they have tested every soil sample.
5. Bring groups together to share guesses.
6. Reveal the soil types and allow students to compare their guesses.

Soil I.D. Method #2: By the Numbers! (Day One or Two, 15-20 minutes)
Students learn how the Soil Triangle works and then complete a worksheet to practice the method themselves. In addition (or as an alternative to the worksheet), they conduct the "Soil in a Jar" test to apply the Soil Triangle method for a relevant purpose.



Materials for Activity:

- Copies of "By the Numbers" worksheet
- Computer with Internet access (optional)
- Projector (optional)

Teacher Preparation:

View this video in advance: Soil Texture Triangle Tutorial. You may wish to show it to your students as well (see step #5 below).

Instructions:

1. Tell students that the "Feel Test" is a good way to make a rough hypothesis about soil type. However, scientists have developed a mathematical tool to form a more precise identification.
2. Show them an image of the Soil Triangle.
3. First, point out that the three sides are made up of the three main types of soil: sand, silt and clay.
4. Next, point out the numbers that run along each side. These numbers represent the percentage of each soil type found in a soil sample.
5. To demonstrate how to use the triangle, you may do so yourself or with the following video: Soil Texture Triangle Tutorial. You may need to show a few examples and have students try it. There is another example in the "By the Numbers" worksheet.
   a. Explain that the Soil Triangle is like a coordinate grid.
   b. There are three pieces of data that must add up to 100%.
   c. For example, one soil sample might have the coordinates of 70% sand, 22% clay and 18% silt.
   d. Even if one of these pieces of data was missing, you can figure out the missing piece of data by subtracting the total of the other two from 100.
   e. To find the soil texture, you find out where all three coordinates meet.
      i. The sand coordinate lines move upward and diagonally to the left.
      ii. The clay coordinate lines move horizontally to the right.
      iii. The silt coordinate lines move downward and diagonally to the left.
   Following the coordinates of 70% sand, 22% clay and 8% silt will land you in the area made up of Sandy Clay Loam.
6. Hand out the "By the Numbers" worksheet and go over the directions. Students are to work on these individually or in pairs.
7. When students have completed all parts of the worksheet, bring them together to discuss their answers.

Soil I.D. Method #2 "Soil in a Jar" Test (Day One, 10-15 minutes; Day Two, 15-20 minutes)
Students see the three main soil types (sand, silt and clay) settle into layers within a water solution. In addition, they will be able to use measurement and percentages of those layers, in conjunction with the Soil Triangle, to identify the specific texture of the soil.

Materials for activity:

- Copies of "Soil in a Jar" worksheet
- Large glass jar with a lid
- Different soil samples (collected prior to lesson)*
- Measuring cup
- Water
- Laundry detergent (optional — to help with separation)
- Long spoon
- Ruler
- Copies of Soil Triangle handout
- Calculator (optional)

* Number the samples and note where they came from. Students can guess where they came from after identification.

Teacher Preparation:

Collect 5-6 soil samples from different locations. Number the samples and note where they came from. You may also want to practice preparing the jars and determining percentages and specific soil textures.

Watch this video for reference: *DIY Soil Texture Test*

Day One Instructions:

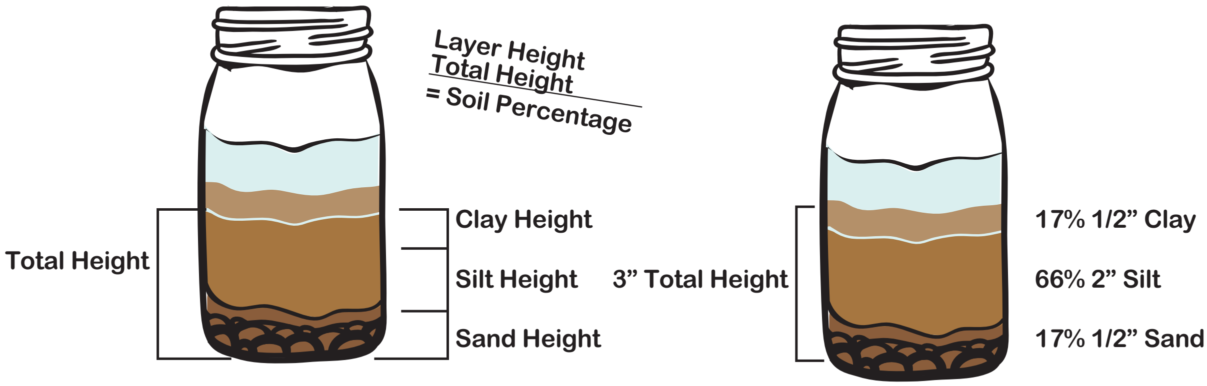
1. Review the three main types of soil (sand, silt, clay) with students, as well as the types identified in the Soil Triangle.
2. Ask students how they think the percentages in the Soil Triangle activity were determined. Let them briefly discuss.
3. Introduce the "Soil in a Jar" test and explain how it will separate out a soil sample into the three main types of soil. Demonstrate how to set up the experiment with a classroom example. (This will be used later to demonstrate how to figure out percentages as well.)
4. As a whole group, have students hypothesize out loud about the order of layers, from bottom to top. They should explain their reasoning. Do not reveal the correct answer, but rather let them discover answers themselves as they perform the experiment.
5. Then tell them that, based on the amount in each layer, they will be able to determine a more specific soil texture by using the Soil Triangle. (This part of the activity will be reviewed later.)
6. Divide the class into 4-5 small groups.
7. Give each group a numbered soil sample and have them follow the instructions on the Soil in a Jar worksheet.
8. When the groups have completed the setup, they should hypothesize about the specific texture of soil they think their sample will be.
9. Leave the mixture to settle overnight.

Day Two Instructions:

1. Have students examine their soil sample in the jar and reflect on their hypotheses, using the Soil in a Jar worksheet.
2. Using the example jar, show students how they can measure the different layers of soil and divide that by the overall measurement of all three layers to get percentages. See example in illustration. Depending on math experience, some students may need additional instruction and/or a calculator.

A 3-inch soil sample divided into layers of ½ an inch of clay, 2 inches of silt and ½ an inch of sand would also be equal to 17% clay, 66% silt and 17% sand.

Measure total height and layer heights **For Example:**



1. Using the calculations from the sample jar and the Soil Triangle, determine the specific texture of the soil. In the case of the illustrated example, the specific type would be ***Silt Loam***.
2. Students will now figure out the percentages within their jars and determine the specific soil texture. They will record these on the table on their worksheets.
3. When done, they should do the same with the other jars. This will enable them to further practice the procedures.
4. Once all of the specific soil textures have been identified, have groups compare their outcomes. There might be slight variations based on measurement and calculations, but the specific textures should be very similar.
5. Finally, based on the soil texture type, have students hypothesize where each soil sample was taken from. Discuss these hypotheses and then reveal the locations. Ask them if these locations fit with what they know about soil types.

Teacher Reference:
Here are the results students should expect to see. Three main layers of soil:
- **Sandy** soil sinks and forms a layer on the bottom. The water will look clear.
- **Silty** soil leaves a thin layer of particles on the bottom. The water will be cloudy.
- **Clay** will look almost the same as silty, but the water is cloudier.

Video for reference: *DIY Soil Texture Test*

Other Soil I.D. Methods:

Super-Fast Soil I.D.
Student Instructions: Water a section of soil with a watering can. Does the water on the surface disappear quickly? Then it's probably sandy. Does the water stay on the surface longer? Then it's likely clay.

Now pick up a handful of soil and squeeze it lightly. Does it form a ball? Does it stay in a ball or crumble? Or does it not form a ball at all? Read the clues above and make your best educated guess.

USDA's Soil Texture Calculator
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054167
This is the easiest way of all — but make sure students try the harder methods first!

Worksheets & Downloads:

"Feel Test" Worksheet

Instructions:

1. Record your observations for each soil sample. Focus your observation mostly on texture.
2. Then, using the attached reference sheet, make a guess at what type of soil each sample is.
3. After the soil types are revealed, record and compare to your guess.

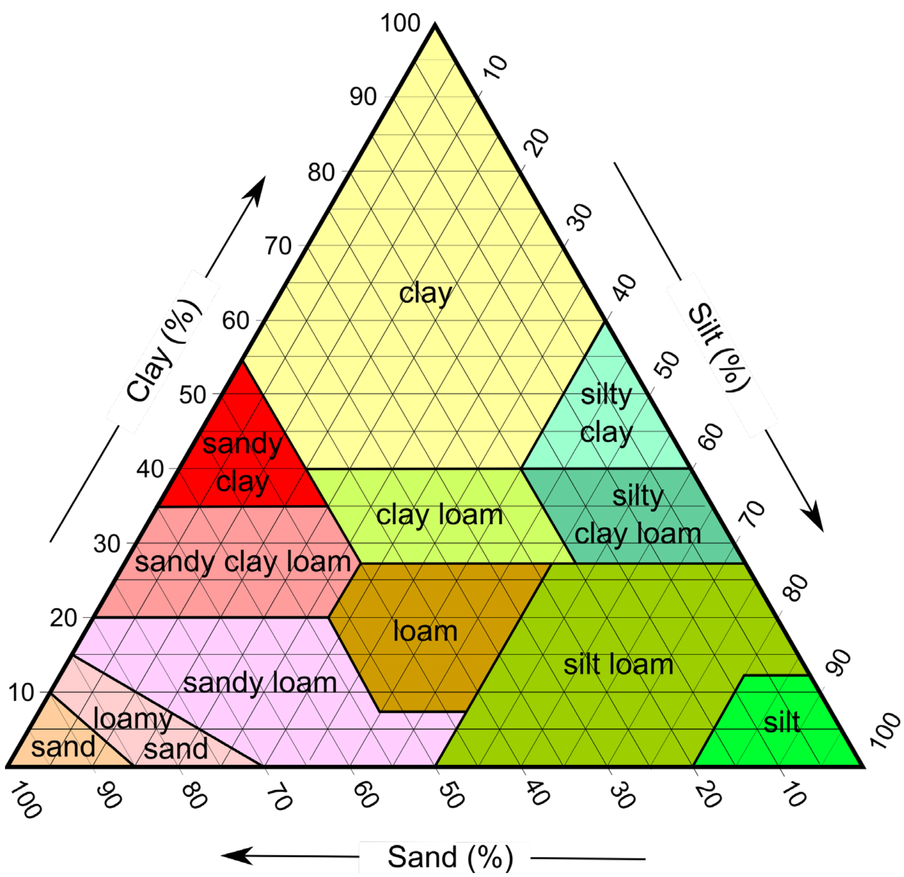
	Observations	Soil Type Guess	Actual Soil Type
Sample #1			
Sample #2			
Sample #3			
Sample #4			
Sample #5			
Sample #6			

"Feel Test" Reference Sheet – Soil Types & Characteristics

Clay	Peaty
Feels slightly sticky Rolls up into a ball when moist Feels slimy when wet, smooth when dry Lumpy and dense (heavy) Hard as a rock when dry Pros: Holds more nutrients than many soils (if properly irrigated) Cons: Few air spaces, drains poorly	Feels spongy Does not form a ball when moist Dark brown or black color Rich in organic matter Pros: Protects roots during very wet months, holds water during dry months Cons: Can get very dry in summer
Sandy	**Chalky**
Feels gritty Does not form a ball when moist Crumbly when moist Drains freely Pros: Easy to cultivate, warms quickly in spring Cons: Dries out quickly, nutrients easily washed out of soil	Usually stony Solid, soft rock, breaks down easily Alkaline, with a pH of 7.5 or more Pros: Fertile and drains freely Cons: Lacking in some minerals, holds little water and dries out easily
Silty	**Loamy**
Feels smooth and soapy Forms a ball when moist but crumbles Heavier than sand Retains moisture Richer in nutrients (more fertile) than sandy soil Easier to cultivate than clay Pros: A very good soil if well managed Cons: Soil structure is weak and easily compacted	Feels smooth but slightly gritty Forms a slightly sticky ball when moist but crumbles easily Good structure Drains well but retains moisture Pros: Full of nutrients, easy to cultivate Cons: Prone to erosion

"By the Numbers" Reference Sheet

Soil Type ID Method #3: By the Numbers!
The soil texture triangle categorizes soil types according to their clay, silt and sand composition. It is one of the tools that soil scientists use to visualize and understand the meaning of soil texture names.



How to read a Soil Texture Triangle:
Follow any two component percentages to find the soil type. Try using one or two rulers the first time to demonstrate.

For example, to find the soil type for 30% sand / 30% clay / 40% silt: Locate 30% along the sand line at the bottom and place your ruler diagonally to follow the slanted line up and to the left. Stop at the horizontal line for 30% clay, and you'll find the soil type: Clay Loam.

Here's another example. Do this one together as a class:
75% Sand
15% Silt
10% Clay
Question: What type of soil is this? Answer: Sandy Loam

Source: Natural Resources Conservation Service (NRCS) | USDA)

Soil in a Jar Worksheet

Experiment Setup (Day 1)

Materials for activity:

- Large glass jar with a lid
- Soil sample
- Measuring cup
- Water
- Long spoon
- Ruler
- Soil Triangle
- Calculator (optional)

Three Main Layers of Soil
Sandy soil sinks and forms a layer on the bottom. The water will look clear.
Silty soil leaves a thin layer of particles on the bottom. The water will be cloudy.
Clay will look almost the same as silty, but the water is cloudier.

Instructions:
1. Add 1/2 cup of soil to your jar.
2. Now fill the jar with tap water. But leave a small amount of air at the top to enable you to shake the mixture.
3. Stir the mixture well with a spoon; or put on the lid and shake it vigorously.
4. Leave the mixture to settle overnight.
5. Record a hypothesis for the following questions.

Hypothesis #1: What order of layers will the three main soil types settle into, from bottom to top? Explain.

____

Hypothesis #2: What specific texture type do you think your soil sample will be? Explain.

____

Determining Soil Types (Day 2)
Observe the layers that have formed in your jar and answer the following questions.

Was your first hypothesis correct? Explain.

____

Was your second hypothesis correct? Explain.

____

Instructions:
1. Using a ruler, measure the total height of all three soil layers in your jar and record in Table 1.
2. Then measure each individual layer and record in Table 1.
3. Find the percentage of each layer and record in Table 2.
4. Using the Soil Triangle, determine the specific soil texture of your soil sample and record in Table 2.
5. Based on what you know about soil, record where you think this soil originated from.
6. Repeat these steps for the other groups' samples.

Table 1 - Layer Measurements

	Total Measurement	Sand Measurement	Silt Measurement	Clay Measurement
Sample #1				
Sample #2				
Sample #3				
Sample #4				
Sample #5				
Sample #6				

Table 2 - Layer Percentages and Texture Type

	% Sand	% Silt	% Clay	Texture	Origin
Sample #1					
Sample #2					
Sample #3					
Sample #4					
Sample #5					
Sample #6					

Soil Triangle Worksheet

Learn how to use the Soil Triangle (formal name "Soil Textural Triangle") to determine the specific soil texture.

1. Using the Soil Texture Triangle, determine the soil textural class for each problem below.

Sample 1: 40% Sand, 50% Silt, 10% Clay____

Sample 2: 70% Sand, 15% Silt, 15% Clay ____

Sample 3: 35% Sand, 15% Silt, 50% Clay____

Sample 4: 20% Sand, 60% Silt, 20% Clay ____

Sample 5: 30% Sand, 40% Silt, 30% Clay ____

2. Complete the chart using the Soil Textural Triangle.

% Sand	% Silt	% Clay	Texture
5		50	
27	35		
	31	33	
22	23		
10		7	
	21	27	

3. Which soil textural class do you believe is best for growing plants? Why?

____

____

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Soil Triangle Worksheet – Answer Key

1. Determine the soil textural class using the Soil Texture Triangle for each problem below.

Sample A: 40% Sand, 50% Silt, 10% Clay **Silt Loam**

Sample B: 70% Sand, 15% Silt, 15% Clay **Sandy Loam**

Sample C: 35% Sand, 15% Silt, 50% Clay **Clay**

Sample D: 20% Sand, 60% Silt, 20% Clay **Silt Loam**

Sample E: 30% Sand, 40% Silt, 30% Clay **Clay Loam**

2. Complete the chart using the Soil Textural Triangle.

% Sand	% Silt	% Clay	Texture
5	**45**	50	**Silty Clay**
27	35	**38**	**Clay Loam**
36	31	33	**Clay Loam**
22	23	**55**	**Clay**
10	**83**	7	**Silt**
52	21	27	**Sandy Clay Loam**

3. Which soil textural class do you believe is best for growing plants? Why?

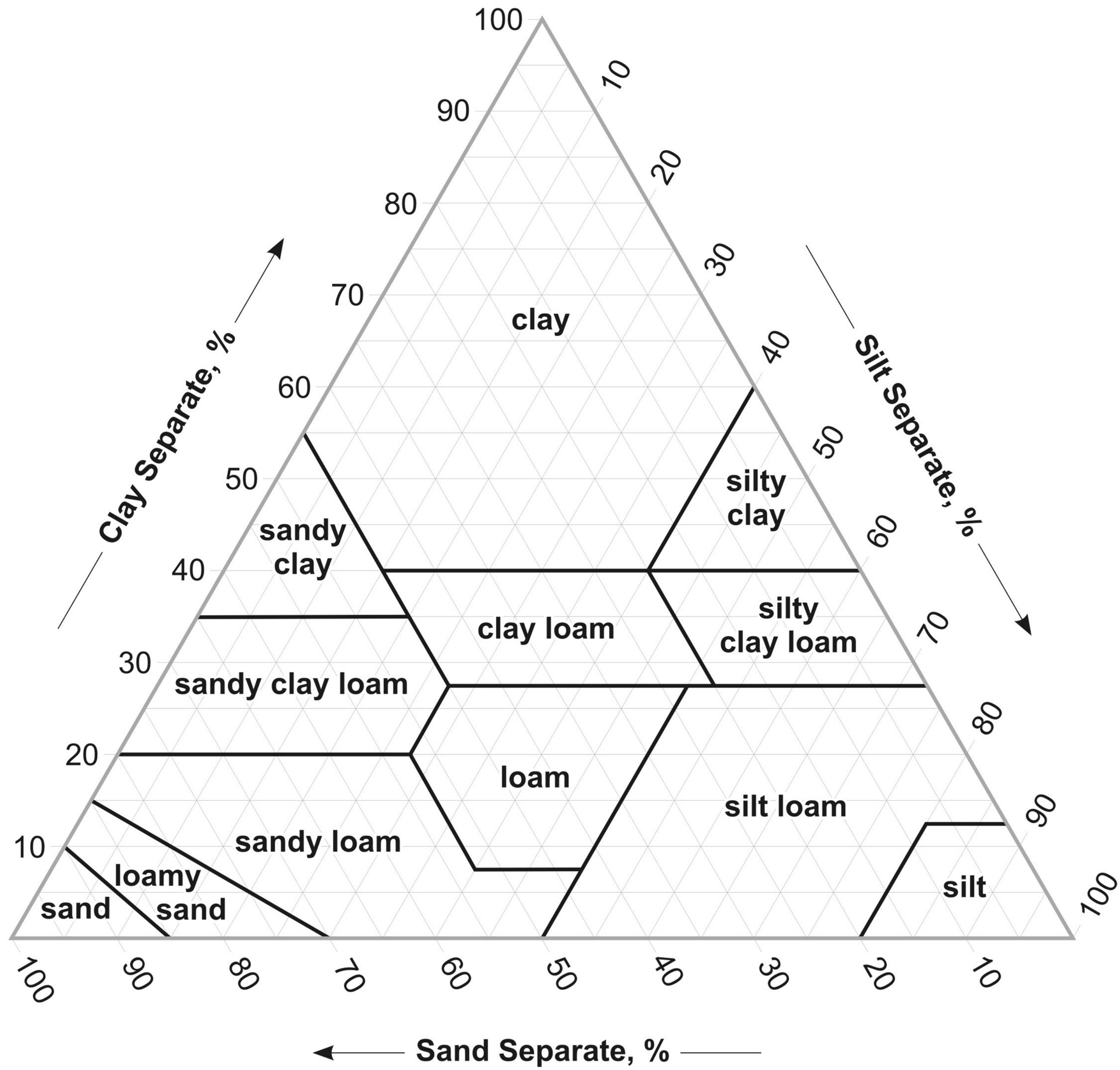
Answers will vary. Consider there are three general categories of soil texture: coarse texture (sandy soil); medium texture (loamy soil); and fine texture (clay soils).

Coarse soil texture soils warm up faster in the spring. Sandy soils usually have good aeration, but can't hold water well. So, both water and nutrients can easily leach through the soils.

Soils with finer textures hold water and nutrients better than coarse textures. Clay soils retain more water and nutrients than sand, but there is little filtration of the water and less oxygen for the plant due to less pore space than those of coarser textures.

Loam is the ideal soil, holding water, nutrients and oxygen in a balance of sand, clay and organic matter.
Note that answers will also vary because different plants grow better in different soils.

Soil Textural Triangle



LESSON PLAN C

SOIL EXPERIMENT: "ECOSYSTEMS UNDER OUR FEET"

Discover some of the many organisms that live in soil and learn about their role in making the soil healthy and able to sustain crops and other plant life.

Time Frame: 90 minutes (over two consecutive days)

Materials for Lesson Plan:

- Hand spades
- One-quart zip-top bags or similar to collect soil samples
- Masking tape and marker for label
- Berlese Funnel
  - Large funnel (2-quart)
  - Clear 2-quart jar or beaker (wide enough for funnel to rest in securely)
  - 2- to 3-inch piece of coarse screen
  - Wet paper towel
  - NOTE: Funnel and container can also be made from a 2-liter clear soda bottle (or gallon milk jug) cut in half with the top inverted and placed snugly into the bottom half with at least an inch of space between the opening and bottom.
  - WARNING: If using plastic funnels and containers, light source should be kept at a safe distance. Or use an LED bulb.
- Light source (preferably a clamp light on a ring stand)
- Hand lenses or microscope plus slides
- Soil Nutrient Testing Kit (See *example here*.)
- Copies of Experiment Worksheet
- Copies of Organism I.D. Sheet
- Clipboard and pencil

Teacher Preparation:

Step 1 can be done by the class as part of the activity, or by the teacher in advance to save time. However, if done ahead of time, students will not be able to observe the area in which the sample was collected. It is a good idea, though, for the teacher to identify different areas for sample collection prior to activity and pre-observe.

Note that the experiment will be much more informative and exciting if soil samples are from active ecosystems, such as compost piles, forest floors, under rotting logs or other lush environments. Abandoned lots, urban gardens and other such areas will provide good samples as well. If possible, have each group get a sample from a different area so that their results can be compared at the end of the lesson.

Introduction (Day One, 5-10 minutes)

1. Tell students they will be going outside to collect samples of soil, probably from different areas. (Identify the different areas.) Have students verbally hypothesize about what they think they'll find in these soil samples and what roles, if any, these items would play in soil and plant health.
2. Record the different hypotheses on the board or screen.
3. Review what they are about to do and what they will be looking for. Prior to going outside, they should review the Experiment Worksheet and the Organism I.D. Sheet and ask any questions.

Instructions – Sample Collection (Day One, 15-20 minutes)
[Divide the class into 4–5 groups.]

1. Before going outside, let students know of any predetermined collection sites they can choose from. Also, explain to students that to get a good sample, they need to dig down to at least the depth of their fingers and to fill the collection bag. (Maybe have a sample to show them.)
2. Tell students that they must label their bag with the location and date of the sample collection. They must also complete the first part of the Experiment Worksheet, describing their initial observations and reflections.
3. Bring students outside with necessary materials (collection bags, spades, labels, markers, clipboards, pencils and Experiment Worksheets). Give them 10-15 minutes to collect samples and make observations.
4. Back in the classroom, have students briefly share their observations and reflections.

Instructions – Experiment Setup (Day One, 10 minutes)

1. Go over the instructions on how to assemble the Berlese funnel (also in Experiment Worksheet), as well as the next set of questions in the worksheet (Experiment Procedure Questions).
2. Have students set up the Berlese funnel.
3. Once the device has been set up, have students place the soil sample into the funnel on top of the mesh. This should be done gradually.
4. Finally, the students should turn on the lamp and place it over the funnel. The light should be as close to the soil sample as is safe. This will depend on the type of materials being used.
5. The light should be kept on overnight. This will force the organisms to move away from the light and down into the collection container. Choose a safe place to keep the experiments overnight.
6. Have students complete the next section of the worksheet (Experiment Procedure Questions).

Instructions – Next-Day Observations (Day Two, 15-20 minutes)

1. On the next day, have each group turn off the light source to their experiment.
2. Students will then remove the funnel and wet paper towel.
3. Students will observe the wet paper towel and try to identify the different organisms that have been driven down into the container. Have students refer to the Organism I.D. Sheet. All observations should be recorded on the Experiment Worksheet.
4. After initial observations, students can use magnifying lenses to identify smaller organisms.
5. If students have microscopes and time, they can also take a small soil sample and place it on a slide to see if there are other microorganisms.
6. Following these observations, students should take a small piece of each sample and use the soil testing kit to identify the levels of different nutrients. Each nutrient level should be recorded on the Experiment Worksheet. You may need to go over the kit directions and show them how to do this.

[After everyone has completed their observations, or as groups finish, have the class share their data (number of organisms, nutrient levels) with the group. Post this information on the board so that students can answer the final section of questions.]

Instructions – Using the Data (Day Two, 20-25 minutes)

1. When done collecting data, students should complete the Using the Data section of the Experiment Worksheet.
2. Follow up with a whole-group discussion.
3. Testing Your Understanding questions may be completed during this session, answered in the whole-group discussion, or as a homework assignment. The questions also connect well to the Follow-Up Videos.
4. At the end of the class, don't forget to return all soil and organisms to their environments!

Teacher Reference:

The Berlese Funnel – Instructions | Soil Science Society of America
A Berlese funnel is a device that is used to extract insects from soil samples. It uses a heat source (in this case a light bulb) to dry the sample, forcing the insects through a screen
(optional) and into a jar of preserving fluid.

The Berlese Funnel | Dr. Dirt – K-12 Teaching Resources

Constructing Berlese Funnels to Study Invertebrate Density and Biodiversity
Here are sample directions and history of the experiment.

Follow-Up Videos:

The following videos provide students with a deeper understanding of how different organisms play a role in soil and plant health. Discussions and/or extension activities may accompany these videos.

Video: Soils Are Living! | Soil Science Society of America (3:01 mins)
Soil is a living, dynamic natural resource. It helps us sustain life — our food, clothing and shelter come from soil. But soil doesn't do its job alone. Animals large and small — including microscopic — live in soil. This biodiversity is critical to a healthy world.

Video: The Living Soil Beneath Our Feet | California Academy of Sciences (2:50 mins)
Travel underground for an up-close look at the ants, amoebas and bacteria that maintain healthy soil. Glimpse this microscopic world and learn about the symbiotic relationship between fungi and tree roots.

Video: How Trees Secretly Talk to Each Other | BBC News (1:47 mins)
Trees talk and share resources right under our feet, using a fungal network nicknamed the Wood Wide Web. Some plants use the system to support their offspring, while others hijack it to sabotage their rivals.

Worksheets & Downloads:

Experiment Worksheet – "Ecosystems Under Our Feet"

Refer to the Organisms I.D. Sheet and then record your observations below. Draw pictures and rough sketches in addition to writing notes.

Initial Observations:

1. Describe where you found your soil sample. Use words and pictures.

What kinds of plants were around it? Was there water close by? Did you see any animals or insects in the area?

2. Describe the sample itself. Is it: compact or loose, moist or dry, one color or many? Do you see any animals, plants or insects in the sample? Are there any roots? Is there any trash or plastic? Are there any unidentifiable organisms or materials? Use words and pictures.

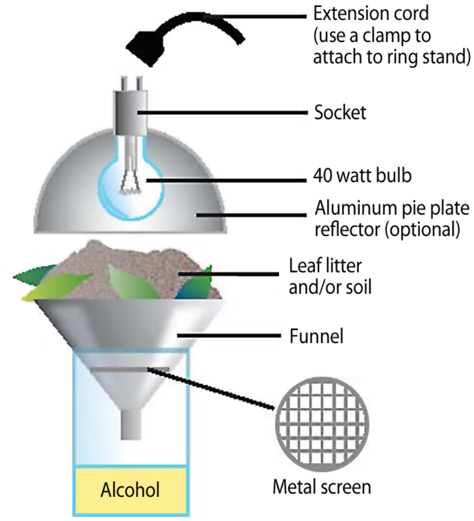
3. Hypothesis Reflection: Was your initial hypothesis correct? Describe the similarities and differences. What were you surprised about?

Setup for "Ecosystems Under Our Feet" Experiment

1. Place a wet paper towel at bottom of the jar.
2. Place the funnel's spout in the mouth of the jar.
3. Bend the mesh screen so that it fits securely into the bottom of the funnel, above the spout.
4. Gradually place the soil sample into the funnel.
5. Adjust the lamp to direct the light onto the top of the sample from about 20 cm away, or as is determined to be most safe.

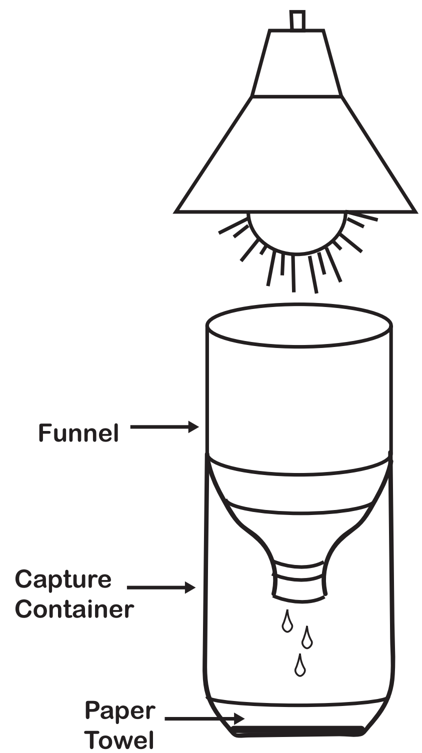
Berlese Apparatus illustration found at:
https://www.soils4teachers.org/lessons-and-activities#PlantGrowth5

BERLESE APPARATUS



Alternative Setup for Experiment

1. Using scissors, cut the bottom off the bottle/jug. This will be the collection jar.
2. Place a wet paper towel at the bottom of the bottle/jug.
3. Secure the funnel (top of the bottle/jug) by taping two rulers to either side of the funnel. Make sure there are a couple of inches between the spout and the end of the ruler.
4. Insert the funnel, spout first, into the collection chamber. The rulers will keep the spout from touching the bottom.
5. Bend the mesh screen so that it fits securely into the funnel, above the spout.
6. Gradually place the soil sample into the funnel.
7. Adjust the lamp to direct the light onto the top of the sample from about 20 cm away, or as is determined to be most safe.



Invertebrate Migration Apparatus

Experiment Procedure Questions:

1. Develop a hypothesis before you begin: What do you think is the purpose of the light in this experiment? Explain.

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2. Why do we use mesh to stop the soil from falling through, rather than a coffee filter? Explain.

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Next Day Observations:

1. Was your hypothesis correct? Explain.
2. How many organisms do you see in your sample?
   a. Ants ______
   b. Earthworms ______
   c. Pill Bugs ______
   d. Millipedes ______
   e. Spiders ______
   f. Beetles ______
   g. Nematoda ______
   h. Mites ______
   i. Bacteria ______
   j. Fungi ______
   k. Protozoa ___

Soil Testing Data:

1. What are the levels of the following nutrients in your soil?
   a. K (Potassium) _______
   b. N (Nitrogen) ______
   c. P (Phosphorous) _______

Using the Data:

Organize the data from each group's soil samples into two sets of bar graphs (types of organisms and nutrient levels). Color code each group's data.

Compare the number of organisms to the nutrient levels in the pair of graphs. What do you notice? Is there a correlation between the amounts of nutrients in the soil and the number of organisms in the soil sample?

1. Does one nutrient seem like a better indicator than the others? Explain.

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2. What are some of the ways that these nutrients end up in the soil?

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Testing Your Understanding:

1. Why would farmers be interested in the organisms living in their soil?

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2. We focused on organisms in the soil that we could see — but what about the ones we can't see? Why are bacteria and fungi important to this process as well?

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Optional Extension:
Use what you've learned from this experience to design a new experiment.

Experiment Worksheet – "Ecosystems Under Our Feet" Answer Key

Experiment Procedure Questions:

1. What is the purpose of the light in this experiment? To drive the organisms from the soil down into the container in the bottom. As the soil begins to dry from the light/heat source, small invertebrates in the sample move downward to the moister soil.
2. Why do we use mesh to stop the soil from falling through, rather than a coffee filter? If we used a filter, larger organisms would not be able to pass through it.

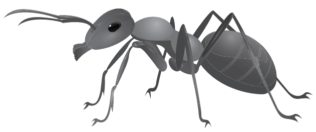
Using the Data:

1. 2. Look at the rest of the class's data. Is there a correlation between the amount of nutrients in the soil and the number of organisms in the soil sample? There should be a general correlation between the levels of nutrients and the number of organisms in the sample. However, that is not always the case. The outcome also depends on the types of organisms and other factors.
2. 4. What are some of the ways that these nutrients end up in the soil? How do the organisms in the soil help that cycle? Nutrients get reintroduced into the soil mainly through the decomposition of living things that have died, such as plants and animals. As those dead organisms decompose, insects, bacteria and fungi all help to break down that organism's cells into their basic elements. Other plants then use these nutrients to live and grow — until they die, and the cycle continues. Nutrients find their way into the soil through other means as well — for example, when applied as fertilizers or carried by water or volcanic ash.

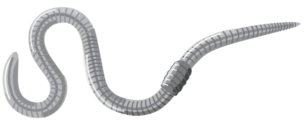
Testing Your Understanding:

1. Why would farmers be interested in the organisms living in their soil? Farmers would want them to be healthy and have lots of them because they help recycle nutrients that their crops use to grow. They use many practices to encourage the health of these organisms. Some of these practices include tilling/non-tilling, crop rotation, cover crops, fertilizers, and allowing plants to die and become organic matter. (See Teacher Resources in Lesson A for reference.)
2. We focused on the organisms in the soil that we could see — but what about the ones we can't see? Why are bacteria and fungi important to this process as well? Bacteria and fungi keep breaking down organic matter into smaller and smaller pieces after they are partially broken down by larger organisms, to a point where they are able to be used by plants. For example, fungi form a symbiotic relationship with plants by connecting to their root systems and providing the plants with nutrients (such as phosphate and nitrogen) in return for sugar. Fungal networks have also been found to help plants communicate with and support each other.

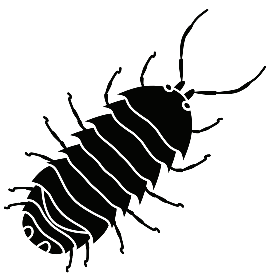
Organisms I.D. Sheet



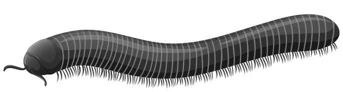
Ants are small insects that live in complex social colonies. They create underground structures to live and work in, while helping to aerate and improve soil for plants. Tunneling ants turn over soil like tiny rototillers, redistributing nutrients and allowing air and water to get down to the plant roots. Those tunnels also help with soil drainage. And the ant mounds you see on the surface? Those help with water retention in the soil underneath.



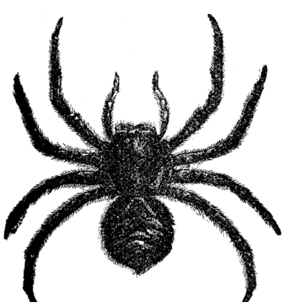
Earth Worms actively break down organic matter like leaves and grass into nutrient-rich waste, which provides nutrients for plants. Their tunnels also increase the amount of air and water that gets into the soil. When they eat, they leave behind castings that are a very valuable type of fertilizer.



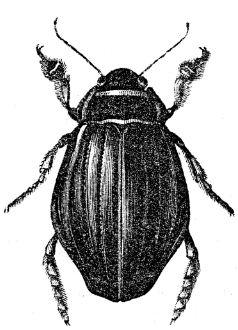
Pill Bugs help recycle nutrients by eating decaying matter in the soil environment. These "bugs" are actually crustaceans and related to crabs and lobsters. They feed mainly on decaying plant leaves and other decomposing materials and are often found under mulch, leaves and rocks. Pill bugs have also been found feeding on seedlings and some plant roots, leading to occasional status as a "minor pest." How do you tell a pill bug from a sow bug? Pill bugs roll into a ball when disturbed, whereas sow bugs do not.



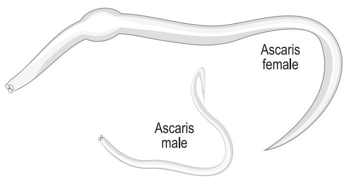
Millipedes work hard to decompose decaying leaves and other dead plant matter. These insects have more than 20 body segments and 40 legs! Millipedes are detritivores, earth's natural recyclers. They feed on plants and animals that have died, which recycles nutrients back into the soil much faster than waiting for the plant or animal to decompose naturally.



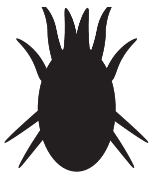
Spiders come in different shapes and sizes, but all have eight legs. Spiders help control pests including aphids, caterpillars, leafhoppers and spider mites in the soil environment.



Beetles are insects with wings and a hard exoskeleton. Different species serve different roles in the ecosystem. Predatory species, such as lady beetles, control aphids and scale insects. Scavengers and wood-boring beetles are useful as decomposers and recyclers of organic nutrients. Most ground beetles are considered beneficial organisms, as they prey on invertebrates, including many pests. They also reduce the amount of weed seeds in the soil, which is beneficial to farmers. However, many other beetles are seen as major pests of agricultural plants and stored products like grains.



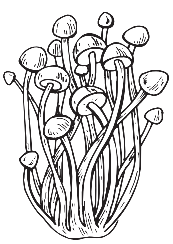
Nematoda, known as roundworms, manage the bacteria and fungi population in an environment. They also recycle nitrogen. While nematodes can be helpful, they can also be pests. When they eat bacteria and fungi, they release some of those good nutrients into the soil. However, when there are too many nematodes in one environment, they can over-eat and throw off the natural balance of the bacteria and fungi population.



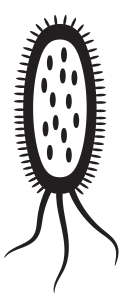
Mites are tiny (less than 1 mm long) but play a big role in the decomposition of organic matter in soil.

We can't see them, but they're still there!

Bacteria are one-celled organisms that do important work in the decomposition process. Bacteria are able to perform a range of beneficial processes in soil, including decomposing organic matter, releasing nutrients from organic matter for plant uptake, forming soil aggregates, degrading toxic substances, fixing atmospheric nitrogen, and preventing plant disease.



Fungi are spore-producing organisms. Molds, mushrooms and yeasts are all examples of fungi. Their microscopic cells usually grow as long threads or strands called hyphae, which force their way between particles of soil, rocks and roots.



Protozoa are one-celled organisms that live in water or as parasites in plants or animals, including amoebas. They are larger than bacteria but still microscopic. Protozoa play an important role in nutrient cycling by feeding on bacteria. As they eat bacteria, they release excess nitrogen back into the soil in a usable form for plants and other members of the food web. They unlock the nutrients so that plants can use them.