Feed the World
Soil and Sustainability Overview

These lessons are focused on soil as an ecosystem with abiotic and biotic components. The Science and Engineering Practices used in these lessons include **Constructing Explanations and Designing Solutions**, **Developing and Using Models and Analyzing and Interpreting Data.**

Lesson 1 describes The Dust Bowl as a phenomena and asks "Since very little of the Earth is untouched, will there be another Dust Bowl?" The evidence of human intervention is all around us. Humans have built and developed areas for housing and businesses, mined areas for precious metals and farmed areas to increase food production. The impacts of these activities are many and varied. Throughout the remaining lessons: *Lesson 2 Soil Texture*, *Lesson 3 Soil Nutrients*, *Lesson 4 Soil Your Undies* (life in the soil) and *Lesson 5 Soil Stability* students see the impact not only of geologic/climatic events (these primarily affect soil texture), but also human activities, which more often affect nutrients, microbes and structure.
What we do to the soil and what we put on it can have far-reaching consequences as is illustrated by the Dust Bowl, the drought in the 1930's when tons of topsoil were blown away from Texas, Oklahoma, Colorado, New Mexico and Kansas all the way to the east coast.

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FTW Soil storyline

Lesson/ Focus Question ***What is soil? How have humans impacted soil?***	**Overview**	**What should students be able to explain?**	**How does this add to their explanatory model?**
Lesson 1 Phenomena: The Dust Bowl *How do humans impact soils?*	Students watch a powerpoint, or watch a video, or listen to a podcast that describes The Dust Bowl. What have humans done to soil sustainability?	Humans can have an impact on soils. Soil conservation practices help to maintain soils; amendments can be made to soils to help add nutrients.	The differing sizes of particles, amounts of minerals, the composition, the amount of compaction, the moisture content and the variety of living microbes and small organisms in soil will affect what if anything, can grow.
Lesson 2 Soil Texture *What is soil texture? How is it determined? What geologic history contributed to soil texture?*	Students measure soil texture qualitatively and quantitatively.	Differences in soils are due to organic matter content and particle size. Particle sizes can be felt and quantified. Geologic events led to the development of soil textures in different parts of the earth.	Soil particles are determined by geology. Different regions have different soil textures because of these different events.
Lesson 3 Nutrient Testing of Soils *Which nutrients are primary soil nutrients? How can soil nutrients be added to soil that needs them?*	Students test soil samples for nutrient and pH levels. Students determine what amendments may need to be added and in what form.	Nutrients can be found in soil that help plants to stay healthy and productive. Nutrients come from organic material that has decomposed (manure, compost) or synthetic fertilizer.	NPK play a role in soil health and farmers/gardeners/homeowners all play a part in adding nutrients back to the soil.
Lesson 4 Soil Your Undies *How healthy is your soil? What evidence can be used to support the claim of soil health?*	Students bury cotton briefs in soil at some point in the school year, then dig them up to see the effect of microbes in the soil.	Microbes used the cotton as a food source.	Soil microbes are present and active in soil.

Lesson 5 Soil Stability Test *How do soils differ in stability?* *What helps soil to be stable?*	**Stability Test** Place 2 (or more) soil samples (same texture/different land use) into separate graduated cylinders containing water and hardware cloth for suspension. Observe the interaction between the soil samples and water.	Something in the soils is different. One sample should hold together and not crumble or fall apart, while the other sample will.	There must be something added to one of the soils to help it stick together. Students may be able to explain that a microorganism is helping to maintain the soil structure.

Soil and Sustainability
Pre-/Post Test

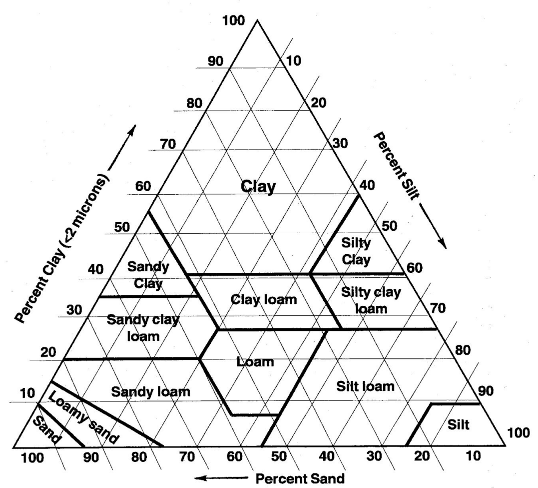
1. What are two practices that help to conserve soil?

2. What are the three major soil nutrients?

3. List the three soil particles.

4. Microbes in soil will:
    a. Feed on organic material
    b. Help nutrients to stay in the soil
    c. Create a food web where prey eat predators
    d. Help aerate the soil so no air can circulate

5. Use the soil triangle to identify this soil type:
    a. Sand 40%
    b. Silt 35%
    c. Clay 25%



6. A soil with a pH of 5.5 is considered:
    a. Basic
    b. Acidic
    c. Neutral

7. Which soil nutrient helps root development?
    a. Nitrogen
    b. Phosphorus
    c. Potassium
    d. pH

8. Which soil nutrient helps leaves to stay green?
    a. Nitrogen
    b. Phosphorus
    c. Potassium
    d. pH

9. What geologic event may lead to large deposits of silt to be found in soils?
    a. Volcanic eruption
    b. Flooding
    c. Crater formation
    d. Glacier formation

10. Organic material provides the basis for which level of the soil food web?
    a. Producers
    b. Primary consumers
    c. Secondary consumers
    d. Tertiary consumers

Soil and Sustainability
Pre-/Post Test

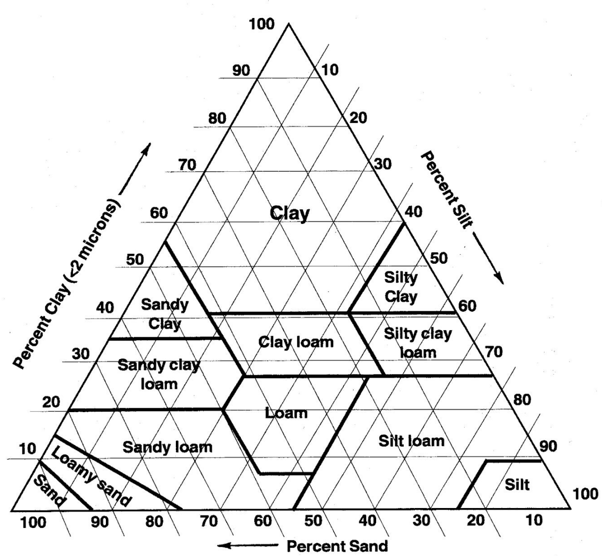
1. What are two practices that help to conserve soil?
- *Contour plowing*
- *Wind breaks*
- *Shelter belts*
- *Crop rotation*
- *Conservation tillage or no-till*

2. What are the three major soil nutrients?
- *Nitrogen*
- *Phosphorus*
- *Potassium*

3. List the three soil particles.
- Sand
- Silt
- Clay

4. Microbes in soil will:
   a. Feed on organic material
   b. Help nutrients to stay in the soil
   c. Create a food web where prey eat predators
   d. Help aerate the soil so no air can circulate

5. Use the soil triangle to identify this soil type:
   a. Sand 40%
   b. Silt 35%
   c. Clay 25% Loam



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    b. Primary consumers
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    d. Tertiary consumers

Lesson 1
Phenomena
The Dust Bowl

Focus Question: *What is soil? How have humans impacted soil?*
Learning Target: (Phenomena) *Students see the effects of the Dust Bowl and determine if there might be another event like it in the future.*

MS-ESS3. Earth and Human Activity

Performance Expectation	**Classroom Connection**
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Students are introduced to The Dust Bowl as an historic event and begin an investigation of how have humans impacted soils to determine if the same thing might happen again.
Science and Engineering Practice	
Constructing Explanations and Designing Solutions ● Apply scientific principles to design an object, tool, process or system.	Throughout this unit students will be looking for best management practices for soil conservation.
Disciplinary Core Idea	
ESS3.C: Human Impacts on Earth Systems ● Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	More than 95% of the Earth's soils have been affected by human activities. In what ways can soils be protected, yet continue to be productive?
Cross Cutting Concept	
Cause and Effect ● Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.	

*Student handout information is indicated in light gray print. Answer keys are embedded in the student handout section.

Teacher Background
Soil is made up of three different particle sizes in varying amounts: sand, silt and clay. Clay are the smallest particles, yet they hold the most water and nutrients. Clay particles are charged

particles and can hold onto the ions in nutrient compounds allowing for roots to easily absorb and use them. The disadvantage of clay soil is that it can become water-logged and when it dries, the soil surface may become hard as rock. Clay soils also may become easily compacted, since the spaces between the particles are so small. Water does not easily move through clay soils, so it is said to be less permeable than other soils

Sand is the largest soil particle. Sandy soil does not hold nutrients, nor water. Generally, sandy soils do not have a lot of organic material, nor many microbes. Without the organic material to feed on, there isn't much for microorganisms to eat. Sandy soils are the most permeable and porous, with large spaces between the particles.

Silt is third soil particle and is between clay and sand in terms of size. Silty soils result from wind, water, ice and snow carrying dust particles. River sediments are usually classified as silt. Silt is found everywhere and most soils are a combination of all three soil particles.

Other materials found in soil include organic matter, once living material, commonly referred to as humus (not to be confused with hummus that you can eat!), along with nutrients (forms of nitrogen, phosphate, and potassium) and minerals (such as sulfur, calcium, boron, etc).

The objective of this lesson is to introduce students to the Dust Bowl and pose the question: Could there be another Dust Bowl event?

Materials
Video presentation History Brief: The Dust Bowl
https://www.youtube.com/watch?v=n-rBhbkvtm0
Slide presentation The Dust Bowl
Student observations

Teacher preparation
Watch the video at https://www.youtube.com/watch?v=n-rBhbkvtm0
Watch the slide presentation to introduce weather factors that played a role
Listen to this podcast at
https://www.pri.org/stories/2018-02-03/trees-helped-save-americas-farms-during-dust-bowl-are-now-under-threat
Potentially allow students to watch/listen to one of the presentations and discuss what they learned with members of their lab group.

Student Handout

1. Describe what happened during the Dust Bowl.

2. What questions do you still have about the Dust Bowl.

3. What other aspects beyond cultivation affect soil?

4. What are humans doing now that impact soils? (Think of a wider group than farmers.)

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the soil types for their local community by visiting https://websoilsurvey.nrcs.usda.gov/app/

ii. **Students with special needs (language/reading/auditory/visual)**: allow students to choose how they want to learn more about the Dust Bowl

iii. **Extra support**: Check out Classzone.com for information about human impacts on soils (https://www.classzone.com/science_book/mls_grade7_FL/248_252.pdf)

iv. **Extensions**: Students could be divided into groups to research the effects of different land uses on soil (Construction/Development, Mining, Farming).

Lesson 1
Dust Bowl

Focus Question: *What is soil? How have humans impacted soil?*

1. Describe what happened during the Dust Bowl.

2. What questions do you still have about the Dust Bowl.

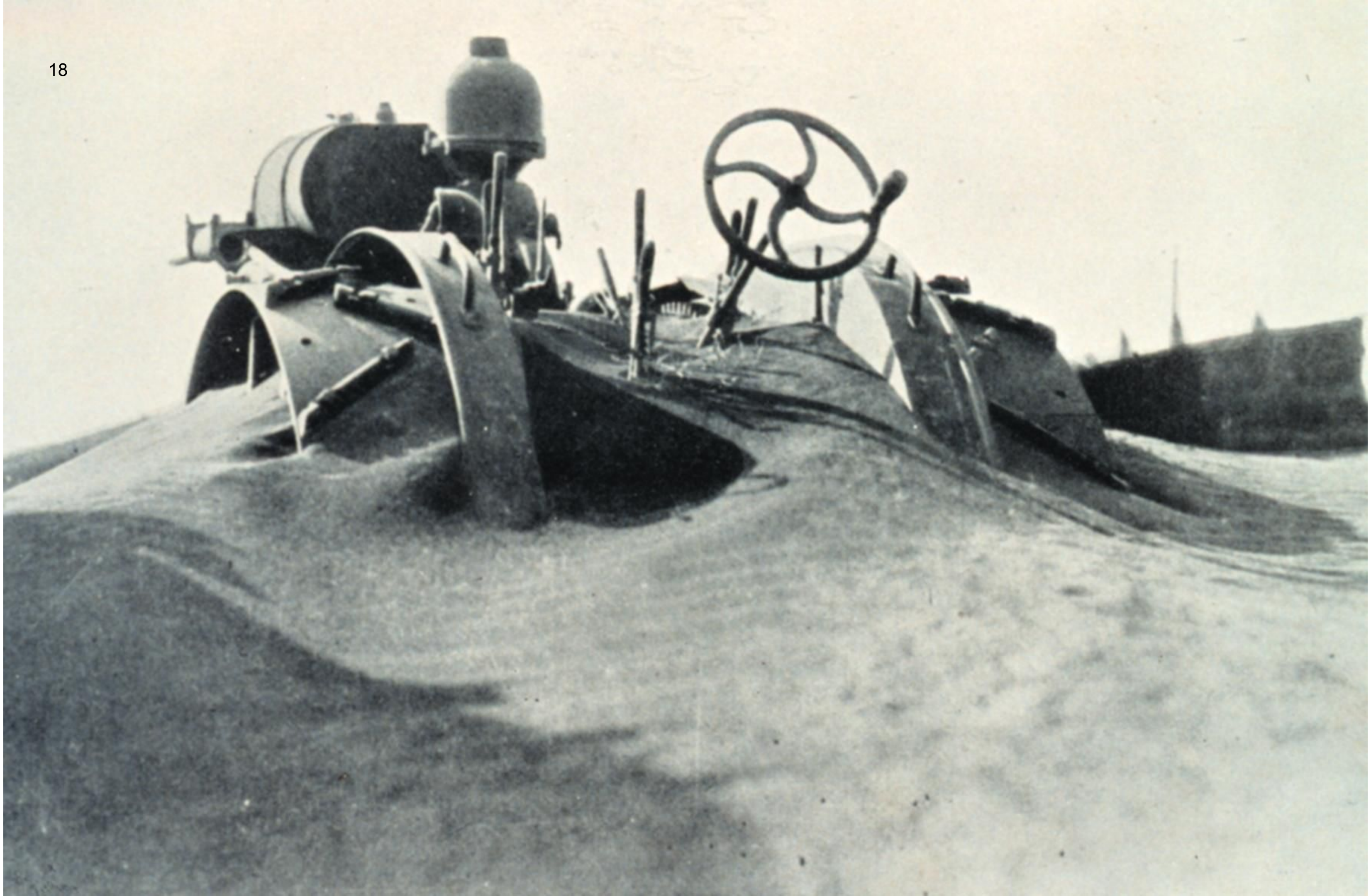
3. What other aspects beyond cultivation affect soil?

4. What are humans doing now that impact soils? (Think of a wider group than farmers.)

The Dust Bowl

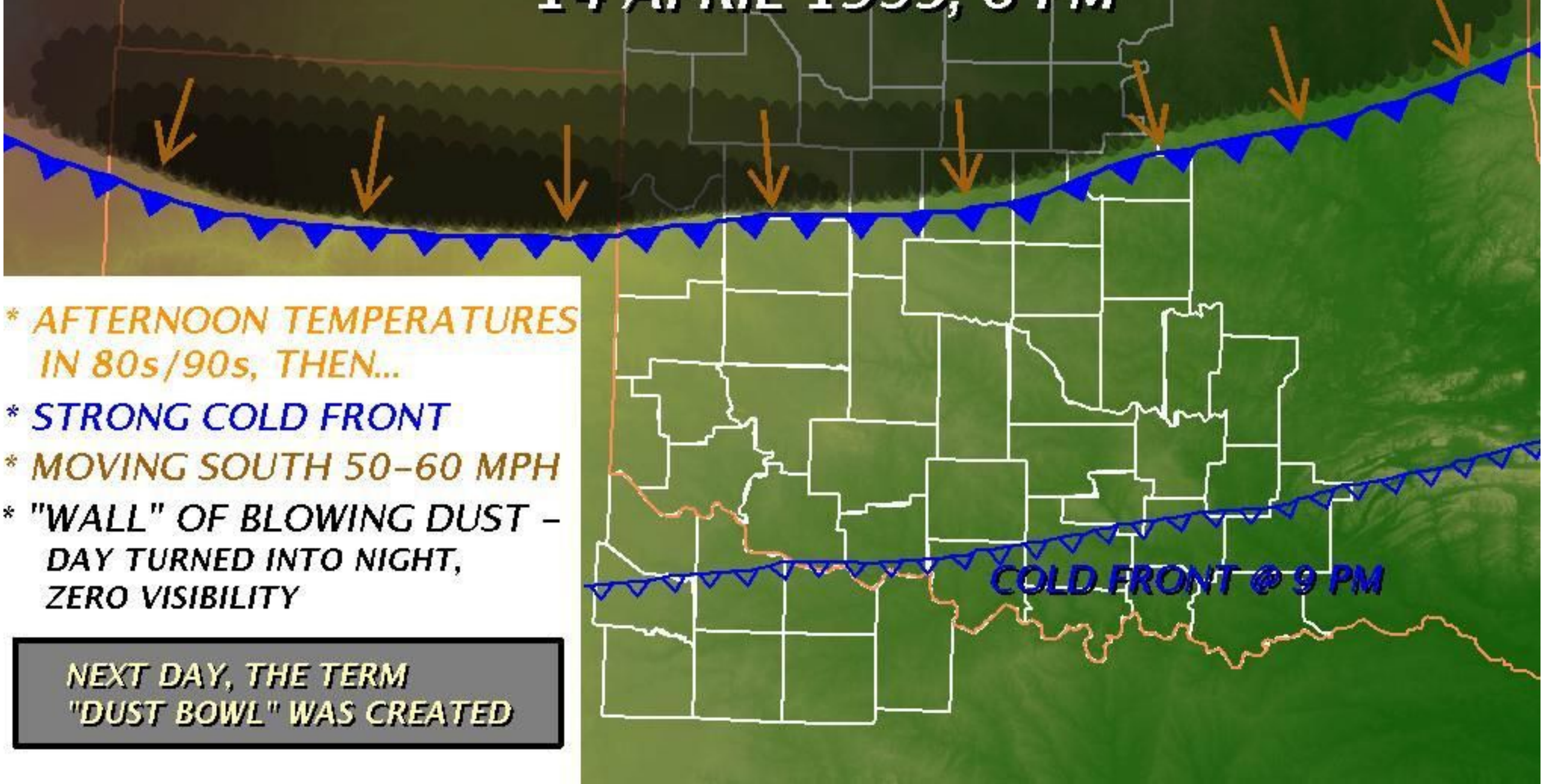
Feed the World: Soil and Sustainability
Lesson 1

https://commons.wikimedia.org/wiki/File:Dust_Storm_Texas_1935.jpg



BLACK SUNDAY

14 APRIL 1935, 6 PM



* AFTERNOON TEMPERATURES IN 80s/90s, THEN...
* STRONG COLD FRONT
* MOVING SOUTH 50-60 MPH
* "WALL" OF BLOWING DUST – DAY TURNED INTO NIGHT, ZERO VISIBILITY

NEXT DAY, THE TERM "DUST BOWL" WAS CREATED

Conditions that led to Dust Bowl

In the 1920s people were prosperous; using farming practices that were not sustainable.

In the 1930s, there were drought conditions

Tillage/Cultivation practices over time led to removal of much of the vegetative cover so topsoil was blown away.

“So long as worn-out farms could be abandoned for new, untouched lands to the west, there was little incentive for conservation of soil resources. As in the case of other natural resources, the land was subjected to reckless and wasteful exploitation.” https://library.cqpress.com/cqresearcher/document.php?id=cqresrre1936012700

Other factors that affect what grows in soils

How might these factors have been changed due to these practices?

- pH
- Organic matter
- Microbes
- Nutrients

Are there truly any wild places where soil is still untouched?

Worldwide, only 17 percent of land is still virtually untouched — mostly because it is inhospitable to humans.

Only 2 percent of the total in areas capable of growing basic crops.

How do humans affect soils?

Land uses

- Construction and development
- Mining
- Farming

What do humans do to make soil sustainable (reduce erosion, make it viable to grow crops, etc)?

- Create drainage ponds and landscapes to protect soil and waterways
- Reclaim mined areas by turning them into parklands, etc.
- Add nutrients (compost, manure, fertilizer) to maintain soil health
- Conserve soil by covering it; reducing tillage

Is it enough?

Might there be another Dust Bowl event?

Learn about soils…and what farmers are doing to conserve it.

Make a prediction...

Lesson 2
Soil Texture - Teacher

Focus Questions: *What is soil texture? How is it determined? What geologic history contributed to soil texture?*
Learning Target: *Students will follow a flow chart to determine soil texture then measure the amount of each soil particle to determine soil texture and compare their results using the two methods.*
Vocabulary: *sand, silt, clay*

MS-ESS3 Earth and Human Activity

Performance Expectation	Classroom Connection
MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.	Students test soil texture to determine the relative percentage of sediment types in each.
Science and Engineering Practice	
Constructing Explanations and Designing Solutions ● Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	Students compare the results from two different testing methods on the same sample of soil.
Disciplinary Core Idea	
ESS3.A: Natural Resources ● Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.	Defined by the location of the soil sample, students *construct an explanation* for the amount of sand, silt and/or clay that they find in their sample based on geologic history of the area.
Cross Cutting Concept	
Cause and Effect ● Cause and effect relationships may be used to predict phenomena in natural or designed systems.	The geologic history had an effect on the amount of each soil sediment found in the sample.

*Student handout information is indicated in light gray print. Answer keys are embedded in the student handout section.

Teacher background

Soil is composed of particles that are categorized into groups according to their size, as shown in the table below.

Clay	*< 0.002 mm (2 microns)*
Silt	*0.002 mm – 0.06 mm (2-60 microns)*
Sand	*0.06 mm – 2.0 mm (60-2000 microns)*
Gravel	*> 2.0 mm (2000 microns)*

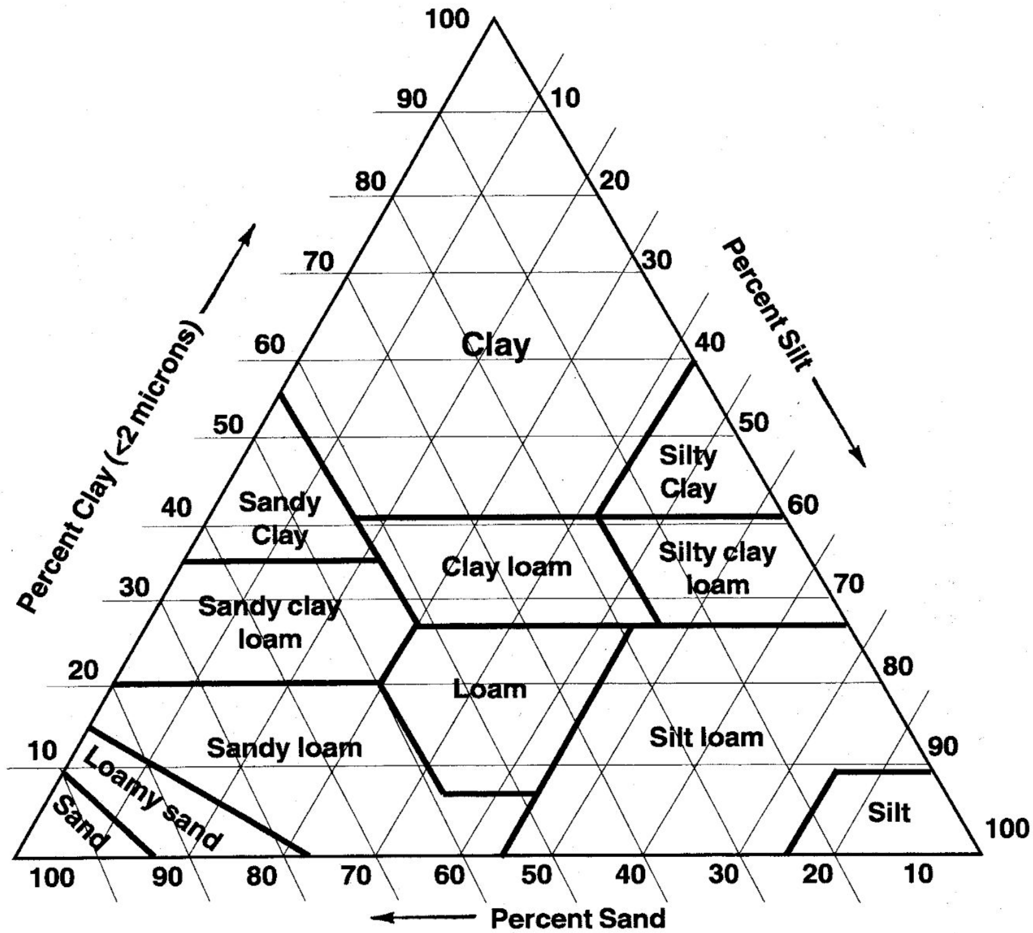
The sediment sizes and percentages of each in a sample are determined by the history of geologic and climatic events in an area.

One method of classifying soils is to measure the relative amounts of sand, silt, and clay in a soil sample, then use a soil triangle to determine the soil type. In this lab, the textural classification of a soil sample will be determined by measuring the relative amounts of sand, silt, and clay particles, then using a soil triangle to determine the soil type. The comparative volumes of sand, silt, and clay will be determined since the different sized particles will settle out of the soil/water mixture at different rates.

This can be accomplished in two different ways, one by feel and the other by volume. It is best to have students attempt both methods on the same soil then compare their results. Texture by feel is subjective or qualitative following steps in a flow chart (see flow chart).

Students will begin with a fistful sized sample of soil, that has had organic material and foreign debris removed. Wet the soil by pouring 3-5 ml of water on top in the cupped palm. The soil should be kneaded to work in the water; add more water as kneading to make a ball. It should feel like putty. Answer the questions as posed on the flow chart. (see https://www.youtube.com/watch?v=2FjxKnJURBI for a demonstration of a soil ribbon).

Texture by volume is quantitative and can be accomplished by creating a soil column in a flat bottomed container with a lid or graduated cylinder in which a quantity of water is added to soil, along with a small amount of borax or non-foaming dish soap, shaken vigorously for at least two minutes, then allowed to settle for 24-48 hours*. See: https://www.youtube.com/watch?v=7pIpyBDNPJE for a step-by-step demonstration. The layers of soil will settle out with sand on the bottom, silt in the middle, and clay on the top. Students then measure the height of each level, add the heights together to get a total soil column height. Divide each layer by the total to determine the percentage of each soil particle in the column. Use the soil texture triangle to find out what soil type you have.



The lines that divide the sand, silt, and clay columns will be visible.

Materials

500 ml of soil (a flower bed will work: dig under the mulch layer)

100 ml graduated cylinder or flat bottomed clear jar with a lid.

Borax

Parafilm (or plastic wrap)

Ruler

Trowels, or shovels for collecting soil (soil core samplers are not necessary, since the goal is to determine texture, not test for nutrient levels).

Bucket or gallon bags for soil

Prior knowledge

Students should know the three different sediments in soil: sand, silt and clay. They need to be able to calculate percentages. Students are expected to construct an explanation for the texture that they find, so they need to have studied geologic history to help them understand how soil texture is a result of a geologic event (i.e. if a shallow ocean once covered the region, a soil may be expected to have a large amount of sand, etc).

Teacher preparation

-Determine where students can collect soil samples or ask students to bring in samples from home.

-Have students dig below the root zone of a flower bed or grassy area to collect soil. They will not need more than a gallon bag full.

-Once samples have been collected, find a space in the room for soil samples to be spread out so organic material, roots and debris may be removed.

-Provide clear, flat bottomed containers (spice jars work) or large graduated cylinders for soil columns. (I recommend the jars, because it is difficult to get soil out of graduated cylinders after settling occurs.)

-During one class, students can prep the soil columns, then complete the soil texture by feel flow chart. The following day, students can measure the height of each layer in the column, complete the calculation to determine the percentage of each to the total, then use the soil texture triangle to identify the soil texture.

-Keep soil samples so students can use for nutrient testing and soil stability.

Student Handout

Materials

500 ml of soil (a flower bed will work: dig under the mulch layer)
100 ml graduated cylinder or clear, flat bottomed jar with a lid.
Borax
Parafilm (or plastic wrap)
Ruler

Instructions

Day 1: Collect soil and prepare soil columns

1. Follow teacher instructions to collect soil samples.
2. Lay soil out on a table top. Remove any mulch, roots, debris from the soil.
3. Add 50 ml of soil and a pinch of Borax to a 100 ml graduated cylinder or jar.
4. Add water up to 100 ml in the cylinder or over half full in the jar.
5. Cover the top of the cylinder with parafilm or cap the jar and shake vigorously to mix the water throughout the soil, then let sit overnight.

6. Follow the directions on the soil texture flowchart (on the following page) to determine the soil texture of your sample by feel.

Record your soil texture by feel:

Day 2

1. Examine the graduated cylinder or jar you prepared day 1.
2. Measure the height of each layer of soil sediment in the column. (The largest particles are sand and should be on the bottom; the middle sized particles are silt and should be in the middle; the smallest particles are clay and should be on the top.)
3. Add the three measures together, then divide each by the total to find the percentage. (The total may not equal 50, due to settling, floating humus or organic material that will not be included.)
4. Use the percentages to determine soil texture using the USDA soil texture triangle.

Follow-up

Research the recent geologic history of the region where your soil sample was collected. Using the geologic history, construct an explanation for the soil texture you found.

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the soil types for their local community by visiting https://websoilsurvey.nrcs.usda.gov/app/

ii. **Students with special needs (language/reading/auditory/visual)**: watching the videos listed: https://www.youtube.com/watch?v=2FjxKnJURBI for a demonstration of a soil ribbon; https://www.youtube.com/watch?v=7plpyBDNPJE to see a demonstration of setting up a soil column; https://www.youtube.com/watch?v=4hW59WZ0EQI for a soil texture triangle tutorial.

iii. **Extra support**: see above videos.

iv. **Extensions**: Students might compare soils from different areas to see how the texture differs.

Rubric for Assessment

Skill	Developing	Satisfactory	Exemplary
Texture by feel flow chart	Student did not complete all aspects of the chart.	Student completed all the portions of the chart and identified a soil texture.	Student identified multiple soil samples to determine texture using the flow chart.
Texture by volume and soil texture triangle.	Student determined percentages of each soil particle, but did not	Student completed the texture by volume and successfully used the	Student was able to accurately identify the soil texture and

	successfully identify the texture of the soil using the triangle	soil texture triangle.	matched them using both methods.
Construct an explanation for soil textures	Student was unable to construct an explanation connecting a geologic event(s) and soil texture.	Student constructed an explanation using one past geologic event to support the soil texture results.	Student constructed an explanation using more than one past geologic event to support the soil texture results.

Rubric for Self-Assessment

Skill	Yes	No
I was able to complete the texture by feel flow chart and determine the texture of my soil sample.		
I was able to determine the texture by volume, read the soil texture triangle and compare it to the texture by feel.		
I researched the recent geologic history of the area to construct an explanation of why my soil sample had the texture it does.		

Lesson 2
Soil Texture

Focus Questions: *What is soil texture? How is it determined?*
Vocabulary: *sand, silt, clay*

Materials
500 ml of soil (a flower bed will work: dig under the mulch layer)
100 ml graduated cylinder or clear, flat bottomed jar with a lid.
Borax
Parafilm (or plastic wrap)
Ruler

Instructions
Day 1: Collect soil and prepare soil columns

1. Follow teacher instructions to collect soil samples.
2. Lay soil out on a table top. Remove any mulch, roots, debris from the soil.
3. Add 50 ml of soil and a pinch of Borax to a 100 ml graduated cylinder or jar.
4. Add water up to 100 ml in the cylinder or over half full in the jar.
5. Cover the top of the cylinder with parafilm or cap the jar and shake vigorously to mix the water throughout the soil, then let sit overnight.
6. Follow the directions on the soil texture flowchart (on the following page) to determine the soil texture of your sample by feel.

Record your soil texture by feel:

Day 2

1. Examine the graduated cylinder or jar you prepared day 1.
2. Measure the height of each layer of soil sediment in the column. (The largest particles are sand and should be on the bottom; the middle sized particles are silt and should be in the middle; the smallest particles are clay and should be on the top.)
3. Add the three measures together, then divide each by the total to find the percentage. (The total may not equal 50, due to settling, floating humus or organic material that will not be included.)
4. Use the percentages to determine soil texture using the USDA soil texture triangle.

Follow-up

Research the recent geologic history of the region where your soil sample was collected. Using the geologic history, construct an explanation for the soil texture you found.

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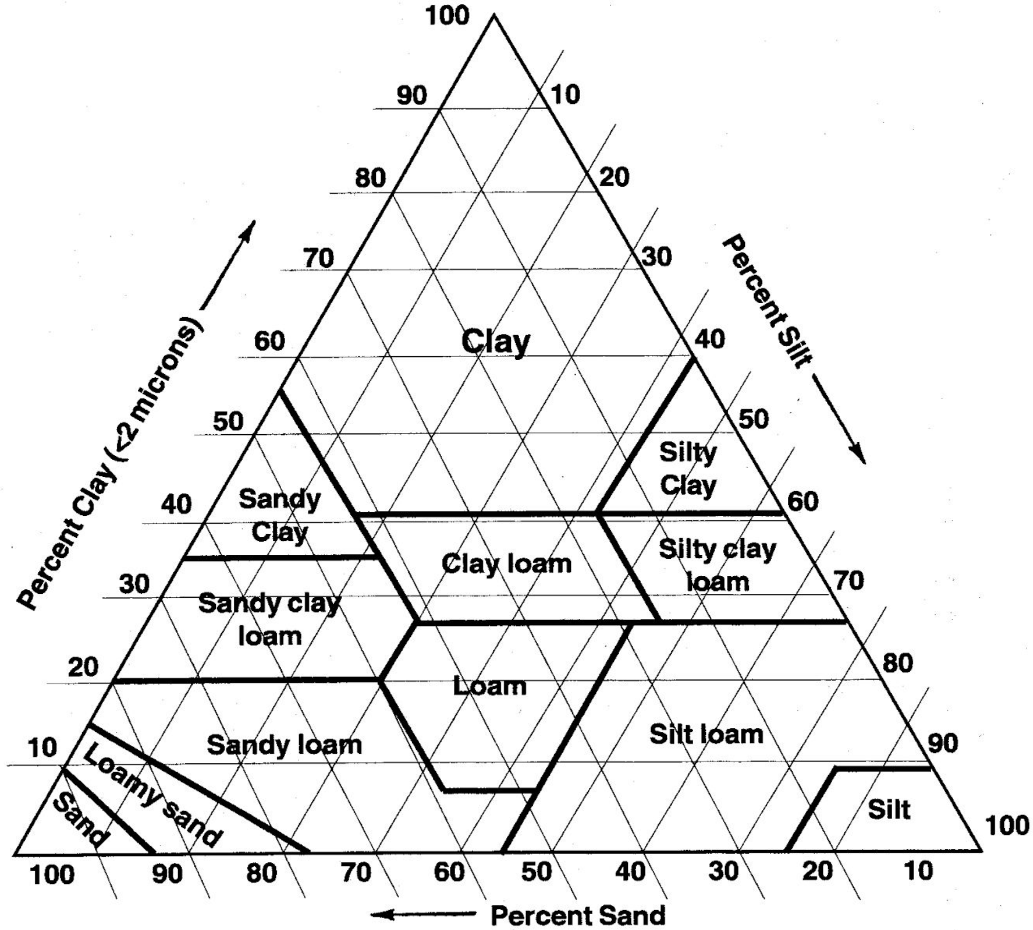
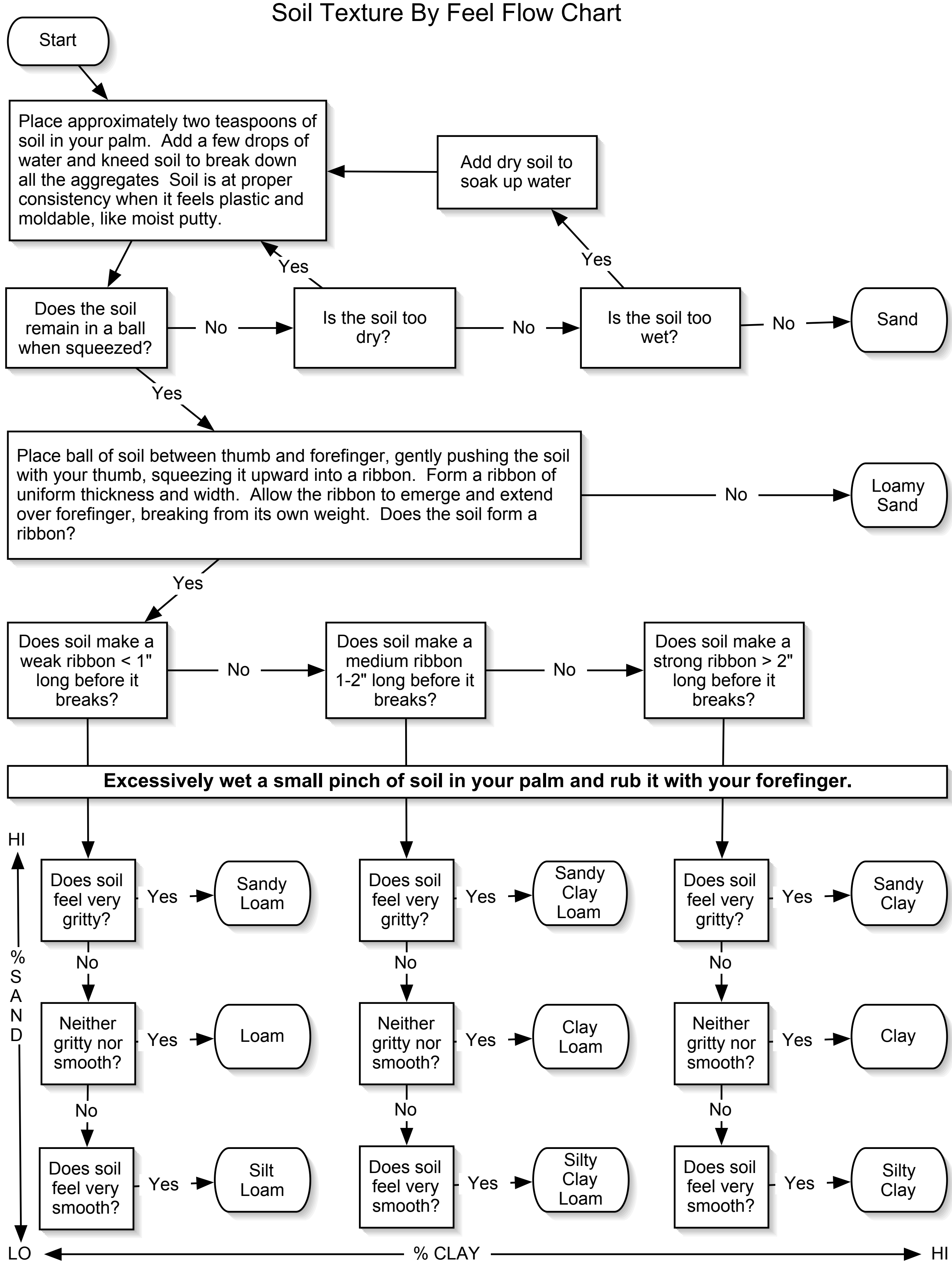


Rubric for Self-Assessment

Skill	Yes	No
I was able to complete the texture by feel flow chart and determine the texture of my soil sample.		
I was able to determine the texture by volume, read the soil texture triangle and compare the results to the texture by feel.		
I researched the recent geologic history of the area to construct an explanation of why my soil sample had the texture it does.		

Soil Texture By Feel Flow Chart



Source: Oregon State University Extension Service

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Lesson 3

Soil Nutrient Testing - Teacher

Focus Question: *What nutrients are found in soil? What effects do the nutrients in soil have on plants?*

Learning Target: *Students will test soil samples for nutrients and pH. Students will connect soil nutrients to plant health.*

Vocabulary: *pH, phosphorus, nitrogen, potassium*

MS-ESS3 Earth and Human Activity

Performance Expectation	Classroom Connection
MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.	This lesson works in tandem with Lesson 2, however, the explanation for soil nutrients is not solely determined by a geologic event, but more likely by human intervention.
Science and Engineering Practice	
Constructing Explanations and Designing Solutions ● Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Analyzing and Interpreting Data** ● Analyze and interpret data to determine similarities and differences in findings.	Students test soil samples for pH, nitrogen (N), phosphorus (P) and potassium (K). Students research the effects of pH, nitrogen, phosphorus and potassium on plants in soil. Students determine ways that pH, N, P, and K can be adjusted in soil.
Disciplinary Core Idea	
ESS3.A: Natural Resources ● Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. **ESS3.C: Human Impacts on Earth Systems** ● Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing	Humans have used soil resources to increase production of food. Through that use, there have been advances that allow nutrient levels in soils to be manipulated to meet the need for higher yields. Human activities have impacted soils. The amount of nutrients are affected by the crops/plants that grow in them, the soil structure is affected by tillage or cultivation, the soil micro biome is

the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.	affected by the amount of disturbance to the soil as well.
Cross Cutting Concept	
Cause and Effect ● Cause and effect relationships may be used to predict phenomena in natural or designed systems.	Students can attempt to amend soils to see the effects of the changes.

*Student handout information is indicated in light gray print. Answer keys are embedded in the student handout section.

Teacher background

The three major nutrients found in soil are nitrogen (N), phosphorus (P) and potassium (K). N and P usually occur in the form of compounds (Nitrate and Phosphate) while K is generally available in soil solution only. pH can play an important role in soils as it controls nutrient uptake by roots. If the soil is too acidic, other ions can leach out of the soil, and create additional problems with run off.

Soil is best conserved when covered or anchored with plant roots. Loose soil can be easily eroded by wind, rain, ice and snow. When soil erodes, it may enter into waterways, carrying nutrients with it, that can impact the health of streams.

Organic matter in soils can vary greatly. Generally, the darker the soil, the more organic matter found in the soil. "Properties influenced by organic matter include: soil structure; moisture holding capacity; diversity and activity of soil organisms, both those that are beneficial and harmful to crop production; and nutrient availability. It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides." (FAO) Large amounts of organic matter may indicate that there are naturally occurring decomposers that will cycle nutrients through the soil.

Humans have made use of soils in order to efficiently plant and raise crops for food, not just for people, but animals as well. In the hundreds of years humans have farmed, there have been many developments in technology. Most farmers have soils on their farms soil tested following a grid pattern, every 2.5 to 5 acres, and based on the results, they will apply only the inputs of fertilizer that the soils need.

Prior knowledge

Students need to know the three major nutrients found in soil are nitrogen (N), phosphorus (P) and potassium (K). Students may compare organic matter (colors) in their soil samples.

Materials

100 ml of soil
Soil sieve or wire mesh colander
LaMotte complete soil test kit

Teacher preparation
This lesson will take place over two days if you ask students to prepare the samples. The samples collected for the soil texture activity (Lesson 2) are appropriate to use for this activity. If the soils were left to dry after the texture activity, Day 1 should be spent having students move their samples through a wire screen sieve or mesh colander, being sure to break up the soil particles for testing in the small test tubes that come with the Lamotte kits. Re-mix all soil particles from the samples, not just the smallest particles.

If samples are collected specifically for this activity, it will take at least overnight for soils to be dry enough to use for testing nutrients. Do not bake samples to accelerate drying. This will remove the organic matter and potentially change the nutrient levels in the samples.

Students will test their soil sample and make recommendations on how to amend and in what form to grow a specific crop.

Provide information on reading a fertilizer label; the differences between compost, manure, and synthetic fertilizer for students to compare each source. See:
-https://ag.umass.edu/crops-dairy-livestock-equine/fact-sheets/plant-nutrients-from-manure
-https://www.thespruce.com/how-to-make-sense-of-a-fertilizer-label-1402466
-https://www.youtube.com/watch?v=EWPNm2DNdSw

Ask students to research how to adjust soil pH for ideas on how to change the pH of soil.

Student Handout
Reflection
1. Choose a crop or plant that you would like to plant. Research the best growing conditions for that crop/plant. What soil amendments may need to be added to make your soil fit for that crop/plant?
- *Answers will vary depending on their soil tests.*

2. What form of nutrients would you add? (compost, manure, synthetic fertilizer) Which is better? Use evidence to support your answer.
- *Again, answers will vary depending on their soil tests.*

3. How might you change the pH of your soil, if needed?
- *Adding lime or calcium carbonate will increase the pH and make soil more basic; adding sphagnum peat or peat moss, will make the soil more acidic.*

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the soil types for their local community by visiting https://websoilsurvey.nrcs.usda.gov/app/ and compare the nutrient levels in various locations. Determine if there is a pattern when comparing soil textures and amounts of nutrients.

ii. **Students with special needs (language/reading/auditory/visual)**: Students can be paired for the activity to allow for team choice of plant to investigate and methods to be followed for amending soil.

iii. **Extra support**: Watch this video on how farmers can adjust nutrient use efficiency: https://www.youtube.com/watch?v=BFBVdOoJh8g

iv. **Extensions**: Watch this video on 4R Nutrient Stewardship (https://www.youtube.com/watch?v=IftF5eBYA7k) that helps explain choices for nutrient management.

Rubric for Assessment

Skill	Developing	Satisfactory	Exemplary
Construct an explanation for the differences in soil nutrients found in different locations.	Student can construct an explanation for the difference in soil nutrients only related to location.	Student can construct an explanation for the difference in soil nutrients related to past geologic events, and human impact.	Student can construct an explanation for the difference in soil nutrients related to past geologic events, and human impacts specific to the locations of the samples.
Research for specific plant/crop	Student chose a crop/plant, but did not determine what soil amendments would be necessary to his/her sample to grow it.	Student chose a crop/plant, researched the needs of the plant and was able to make recommendations about soil amendments needed for it to grow.	Student chose a crop/plant, researched the needs of the plant and was able to make recommendations about soil amendments needed for it to grow in amounts specific to an area where it might grow (amount in lbs/acre).

Rubric for Self-Assessment

Skill	Yes	No
I measured the amounts of all soil nutrients.		
I understand the function of each of the nutrients I measured in aiding plant growth and health.		

Lesson 3
Soil Nutrient Testing

Focus Question: *What nutrients are found in soil? What effects do the nutrients in soil have on plants?*
Vocabulary: *pH, phosphorus, nitrogen, potassium*

Materials
100 ml of soil
Soil sieve or wire mesh colander
LaMotte complete soil test kit

Procedure
1. For day 1, spread out 100 ml of soil on a clean sheet of paper or plastic to dry (from amount collected for texture activity). Spread out the soil, break apart any soil clumps and remove organic matter such as leaves, etc. Allow the soil to dry for several hours or overnight.
2. Push the dry soil through a soil sieve or colander to break up soil particles. Mix the dry soil to be used for testing.
3. For day 2, use the LaMotte complete soil test kits to determine the pH and level of N, P and K in your soil samples. Create a data table to record your results.

pH test
1. Fill the test tube to line 4 with pH Indicator. Squeeze bottle gently to control the amount dispensed.
2. Use 0.5g spoon to add 3 measures of soil sample.
3. Cap and mix gently for 1 minute.
4. Allow tube to stand for 10 minutes to allow soil to settle.
5. Match color reaction with pH color chart and record result.

Nitrogen test
1. Fill test tube to line 7 with Nitrogen extracting solution.
2. Use 0.5g spoon to add 2 measures of soil sample.
3. Cap and mix gently for 1 minute.
4. Remove cap and allow soil to settle.
5. Use a clean pipette to transfer the clear liquid to a second test tube. Be careful not to pull up any soil into pipette.
6. Fill second test tube to line 3 with liquid.
7. Use 0.25g spoon to add 2 measures of Nitrogen Indicator powder to soil extract in second tube.
8. Cap and gently mix. Wait for 5 minutes for pink color to develop above the powder.
9. Match test color with Nitrogen color chart and record result.

Phosphorus test

1. Fill test tube to line 6 with Phosphorus extracting solution
2. Use 0.5g spoon to add 3 measures of soil sample.
3. Cap and mix gently for 1 minute.
4. Remove cap. Allow to stand, and soil to settle, until liquid above soil is clear.
5. Use 1 pipette to transfer the clear liquid to a second clean test tube. To avoid agitation of soil, squeeze bulb of pipette before inserting tip into liquid. Release bulb slowly to draw clear liquid into pipette. Do not pull up any soil.
6. Fill second tube to line 3 with clear liquid.
7. Add 6 drops of Phosphorus Indicator reagent to soil extract in second tube.
8. Cap and mix.
9. Add one Phosphorus test tablet.
10. Cap and mix until tablet dissolves. A blue color will develop.
11. Match color reaction with Phosphorus color chart and record result.

Potassium test

1. Fill test tube to line 7 with Potassium extracting solution
2. Use 0.5g spoon to add 4 measures of soil sample to test tube.
3. Cap and shake vigorously for 1 minute.
4. Remove cap and allow soil to settle.
5. Use a clean pipette to transfer the clear liquid to a second test tube. Be careful not to pull up any soil into pipette.
6. Fill second test tube to line 5 with liquid.

Note: If additional extract is needed to fill the tube to line 5, repeat steps 1 through 4.

7. Add 1 Potassium indicator tablet to soil extract in second solution.
8. Cap and mix until tablet dissolves. A purplish color will appear.
9. Add Potassium test solution, 2 drops at a time, keeping count. Mix contents after each addition. Stop adding drops when the color changes from purplish to blue.
10. Use Potassium end point color chart as a guide in reading this color change. Keep an accurate count of the number of drops added. Read test result from the table and record.

Reflection

1. Choose a crop or plant that you would like to plant. Research the best growing conditions for that crop/plant. What soil amendments may need to be added to make your soil fit for that crop/plant?

2. What form of nutrients would you add? (compost, manure, synthetic fertilizer) Which is better? Use evidence to support your answer.

3. How might you change the pH of your soil, if needed?

Data Table

Sample Location:

Component	**Level (units)**
pH	
N	
P	
K	

Rubric for Self-Assessment

Skill	**Yes**	**No**
I measured the amounts of all soil nutrients.		
I understand the function of each of the nutrients I measured in aiding plant growth and health.		

Content designed by EducationProjects.org on behalf of the farmer boards at Ohio Corn & Wheat and the Nebraska Corn Board.

Lesson 4
Soil Your Undies - Teacher

Focus Question: *How healthy is your soil? What evidence can be used to support the claim of soil health?*
Learning target: *Students will observe the result of microbial activity on cotton briefs.*
Vocabulary: *microbe, abiotic, biotic, macroinvertebrate*

Performance Expectation	Classroom Connection
MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	Students bury a pair of cotton briefs to determine the amount of microbial activity in the soil.
Science and Engineering Practice	
Developing and Using Models ● Develop a model to describe phenomena.	Cotton briefs will act as a food source for microbes.
Disciplinary Core Idea	
LS2.B: Cycle of Matter and Energy Transfer in Ecosystems ● Food webs are models that demonstrate 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 plant 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.	Microbes (living organisms) will “eat” the material of the briefs. Based on the number of microbes and macro organisms in the soil, the briefs will show more or less degradation.
Cross Cutting Concept	
Energy and Matter ● The transfer of energy can be tracked as energy flows through a natural system. *Connections to the Nature of Science* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ● Science assumes that objects and events in natural systems occur in consistent	The cotton briefs act as an energy source that is transferred to the microbes to help them do their “work” in the soil.

patterns that are understandable through measurement and observation.	

*Student handout information is indicated in light gray print. Answer keys are embedded in the student handout section.

Teacher background

The soil ecosystem includes a diverse and large microbiome as well as many macroinvertebrates. These organisms cycle energy through a soil ecosystem that is impacted by many abiotic and biotic inputs: rain, snow, roots, dead organisms, nutrients, additional soil from wind erosion, etc.

There are many variations in microbial activity determined by depth and season. This overview by the USDA explains some of these variations. Soil Food Web (https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053868)

Collecting soil samples and allowing it to warm in the classroom will give students a chance to observe some of the macro organisms in the soil. See: https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg for a soil food web diagram. Students can identify producers and consumers then look through samples to see if they find examples of each.

Streaking agar plates with sterile swabs that have been immersed in soil or soil solution can be helpful for discovering the amount of bacteria and fungi found in soils.

Prior knowledge

- Students should be aware that there are living things in soil that will feed on organic material (cotton).

Materials

1 (or more) new pair of white 100% cotton undies (no dyes or polyester blends)
1 marker flag
Shovel
Gallon storage bag
Lamotte soil test kit
Hand lens
Plastic tub or bucket for soil sample
Soil Food Web diagram
(https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg)
Optional:

Agar plates

Sterile swabs

Teacher preparation

The drawback of this lesson is that it takes 2-3 months to see the results. It is the teacher's choice whether to have pre-planted the briefs or if the students will begin this lesson 2-3 months prior to finishing it.

Choose your planting location carefully. If it is in an area that will be disturbed, the briefs may not be there when you go to find it again. If it is planted over the winter, there may be little activity if the ground is frozen. This can be a great problem-solving activity to share with students. Each student group may choose a different location for their briefs with a reason for choosing it. After collecting the briefs they can compare and determine which area had the most microbial activity with a supportive statement as to why.

When the briefs are planted, consider having students collect samples that they can examine with hand lenses to look for soil life. They can make a chart that counts the numbers of each of the different organisms they found and they can identify them on the soil food web. When the briefs are collected, they can take another sample to compare to the first soil count.

Use white trays or white dish tubs for soil sample observations. Students can use plastic spoons to move soil around in the tray or tub while looking for macro organisms. Students must be patient. The soil critters can be elusive and hide well in the soil. If the weather is cold when the soil is collected, it can take a couple of days for soils to warm enough for the critters to become active. If the soil is in an area without many plants, there may be few visible organisms.

Have sterile swabs and petri dishes with agar available for students to use. (Plates can be purchased with ready made agar or you can prepare your own agar.) Have them stick the swab in the soil or a solution of soil and distilled water mixed, then streak on an agar plate. Incubate the plate on the tabletop overnight and colonies will be visible the next day.

Student Handout

Procedure

1. Draw an accurate representation of your undies before soil exposure.
2. Record the soil type, date buried and dry mass of the cotton undies to be tested.
3. Dig a trench 15 cm deep in the test soil so that it is large enough to lay the test undies in the trench with the waistband sticking out.
4. Place the test undies into the trench and bury them with the displaced topsoil so that the waistband is exposed.
5. Mark the burial site with a flag so you'll be able to find it again in 2 months.
6. Collect a soil sample from the area where you buried the undies.

7. Back in the classroom, test the soil for pH, N, P, K and record in the data chart below (using Lesson 3 Soil Nutrients procedure).
8. Look for macroinvertebrates in the soil using a hand lens. Record observations on soil food web diagram.
9. Streak an agar plate with a sterile swab that has been dipped in the soil or soil solution.
10. Leave the undies buried for 2 months.

2 months later

11. Dig up the undies carefully and place in a plastic bag for transport.
12. Collect a soil sample again from the area to test for nutrients and soil life.
13. Rinse any attached dirt from the undies, dry and record the final mass.
14. Draw an accurate representation of your undies after soil exposure.

Data

Sample location (GPS)	
Date buried	**Date harvested**
Initial mass	**Final mass**
Soil type	
pH	**pH**
Nitrogen	**Nitrogen**
Phosphorus	**Phosphorus**
Potassium	**Potassium**
Tillage pattern/Disturbance	
Crop rotation	
Initial drawing/description of undies before burial:	**Final drawing/description of undies after burial:**

Reflection

1. What did the undies reveal about the health of the soil? Explain.
- *The healthier the soil, the more microbial activity there should be. If the briefs are full of holes or barely holding together, the material was found to be a good food source to many microbes and macroinvertebrates.*
2. How does the data in the chart above compare before and after burial of the undies?
- *Answers will vary. There may be more nutrients in the soil, illustrating that there was active decomposition of the organic material that returned nutrients to the soil. There may be more critters visible in the soil since there was a food source (briefs) to draw more organisms.*
3. What can a farmer do to improve the overall health of the soil?
- *Add organic material in the form of crop stubble or ground cover during the winter to give microbes a food source. There are other possible answers, such as rotate crops, reduce tillage, limit the use of broad spectrum insecticides.*

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may plant the briefs in various locations around the school in a garden area, or in a farm field if available.

ii. **Students with special needs (language/reading/auditory/visual)**: Students may watch this video through a VR viewer https://www.youtube.com/watch?v=-dhdUoK7s2s

iii. **Extra support**: Watch this video to see what the results should be: https://www.youtube.com/watch?v=nyVf3tQAGX4

iv. **Extensions**: Students compare soils from different areas to see how the activity differs.

Rubric for Assessment

Skill	Developing	Satisfactory	Exemplary
Explain the briefs as a model to illustrate soil health.	Student collects data but does not see that the briefs were a food source that helped to measure microbial activity in soil.	Student can explain how the briefs act as a model food source to collect information about microbial life in soil.	Student explains that briefs are a model to measure microbial activity and soil health by describing the energy transfer among organisms in the soil ecosystem.

Rubric for Self-Assessment

Skill	Yes	No
I collected data on: soil nutrients,		
...soil activity by macroinvertebrates		
...by streaking soil solution on an agar plate		
...and am able to make a conclusion about microbial and macroinvertebrate activity in the soil.		

Lesson 4
Soil Your Undies

Focus Question: *How healthy is your soil? What evidence can be used to support the claim of soil health?*
Vocabulary: *microbe, macroinvertebrate, abiotic, biotic*

A healthy soil is teeming with hungry microbial and macroinvertebrate life. The ground beneath your feet contains millions of bacteria, fungi, protozoa, nematodes, arthropods, annelids and more. These organisms are busy transferring key nutrients, eating and decomposing organic material, and stabilizing the soil. Healthy soils keep key nutrients in place for crops and help to decrease soil runoff. Farmers are improving soil health by incorporating diverse cover crops and decreasing tillage patterns for less soil disturbance. Healthy soils mean less soil inputs and more money in a farmer's pocket.

This activity measures the biological activity of your soil by exposing a pair of 100% cotton undies as a microbial buffet. Place your undies in similar soil types with different crop rotations or different tillage management and compare nutrient profiles, rainfall, and microbial activity. Sterile, lifeless soil will stain your undies and keep them intact, whereas soil with a thriving biology will eat away at your white undies, leaving nothing but an elastic strap! The greater the biological diversity, the less of the undies there will be.

Materials

1 (or more) new pair of white 100% cotton undies (no dyes or polyester blends)
1 marker flag
Shovel
Gallon storage bag
Lamotte soil test kit
Hand lens
Plastic tub or bucket for soil sample
Soil Food Web diagram
(https://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049822.jpg)
Optional:
- Agar plates
- Sterile swabs

Procedure

1. Draw an accurate representation of your undies before soil exposure.
2. Record the soil type, date buried and dry mass of the cotton undies to be tested.
3. Dig a trench 15 cm deep in the test soil so that it is large enough to lay the test undies in the trench with the waistband sticking out.

4. Place the test undies into the trench and bury them with the displaced topsoil so that the waistband is exposed.
5. Mark the burial site with a flag so you'll be able to find it again in 2 months.
6. Collect a soil sample from the area where you buried the undies.
7. Back in the classroom, test the soil for pH, N, P, K and record in the data chart below (using Lesson 3 Soil Nutrients procedure).
8. Look for macroinvertebrates in the soil using a hand lens. Record observations on soil food web diagram.
9. Streak an agar plate with a sterile swab that has been dipped in the soil or soil solution.
10. Leave the undies buried for 2 months.

2 months later

11. Dig up the undies carefully and place in a plastic bag for transport.
12. Collect a soil sample again from the area to test for nutrients and soil life.
13. Rinse any attached dirt from the undies, dry and record the final mass.
14. Draw an accurate representation of your undies after soil exposure.

Data

Sample location (GPS)	
Date buried	**Date harvested**
Initial mass	**Final mass**
Soil type	
pH	**pH**
Nitrogen	**Nitrogen**
Phosphorus	**Phosphorus**
Potassium	**Potassium**
Tillage pattern/Disturbance	
Crop rotation	
Initial drawing/description of undies before burial:	**Final drawing/description of undies after burial:**

Reflection

1. What did the undies reveal about the health of the soil? Explain.

2. How does the data in the chart above compare to the final state of the undies?

3. What can a farmer do to improve the overall health of the soil?

Rubric for Self-Assessment

Skill	Yes	No
I collected data on: soil nutrients,		
...soil activity by macroinvertebrates		
...by streaking soil solution on an agar plate		
...and am able to make a conclusion about microbial and macroinvertebrate activity in the soil.		

Lesson 5
Soil Stability Test

Focus Questions: *How do soils differ in stability? What helps soil to be stable?*
Learning Target: *Students compare different soils to see which has better structure.*
Vocabulary: *slake, glomalin, fungi*

MS-LS2-3 Ecosystems: Interactions, Energy, and Dynamics

<table>
<tr><th>Performance Expectation</th><th>Classroom Connection</th></tr>
<tr><td>MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.</td><td>This activity helps students to see how critical microorganisms are to a soil system.</td></tr>
<tr><th colspan="2">Science and Engineering Practice</th></tr>
<tr><td>Developing and Using Models
● Develop a model to describe phenomena.</td><td>Students compare soils to see the effect of immersive wetting.</td></tr>
<tr><th colspan="2">Disciplinary Core Idea</th></tr>
<tr><td>LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
● Food webs are models that demonstrate 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 plant 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.</td><td>The difference between soils of the same type that hold together vs fall apart when immersed in water is due to a microorganism and a protein that it secretes.</td></tr>
<tr><th colspan="2">Cross Cutting Concept</th></tr>
<tr><td>Energy and Matter
● The transfer of energy can be tracked as energy flows through a natural system.

Connections to Nature of Science
Scientific Knowledge Assumes an Order and Consistency in Natural Systems
● Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.</td><td>The transfer of energy from fungi to the roots of plants may be lacking when the soil is tilled or cultivated. This affects water infiltration, run off, and the health of plants growing in the soil.</td></tr>
</table>

*Student handout information is indicated in light gray print. Answer keys are imbedded in the student handout section.

Teacher Background
Throughout this unit, different aspects of soil have been highlighted. This aspect is often left out. The soil stability or structure is a result of healthy microbes, plant cover and adequate nutrient flow in soil. Humans can improve the stability of a soil by rotating crops, having plants in soil all year round and reducing the amount of cultivation or tillage.

Teacher preparation
Using the same soils for all of these lessons allows students to create a baseline of data, then compare for soil organisms, texture and nutrients to determine if there is a pattern to location and numbers of organisms and nutrients found.

Watch *Soil Health Lessons in a Minute: Soil Stability Test* (https://www.youtube.com/watch?v=9_ItEhCrLoQ&t=7s) for a demonstration for how to set up this activity.

This pdf helps to explain the role of glomalin, a protein secreted by fungi, in soil formation and health.
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1144429.pdf

Student Handout

A soil's stability demonstrates its capacity to resist disruption when outside forces such as rain, wind or compaction are applied. The stability is important for a variety of reasons: the rate of water infiltration, root growth, and resistance to water and wind erosion. This activity measures the stability of soil when exposed to rapid wetting.

Materials
• 1000 mL beaker
• Soil samples
• Water
• Wire mesh (Hardware cloth)

Procedure
1. Collect several samples of topsoil about the size of a small apple. (It will need to be able to fit inside the top of your beaker without touching the sides of the container). Try to find samples from different land uses {i.e. from a flower bed, from a yard (remove grass and roots), from an area near a sidewalk that has no vegetation, etc.}

Note: It is best to collect samples from the same soil type for comparison purposes. These samples should be removed with a small spade or hand shovel from 3–5 inches below the surface and be collected in their entirety to prevent loss of soil stability.

2. Position wire mesh over the rim of the beaker to make a “shelf” that will extend down into the beaker and will be able to hold the soil sample while it is submerged in the water. Remove wire mesh from beakers.
3. Fill the beakers with water until they are almost full (1/2 to 1 inch from the top) and will cover the soil samples.
4. Place the soil samples onto the wire mesh and gently submerge the soil samples into the beakers of water at the same time.
5. Observe each soil’s stability (its capacity to resist disruption) over 1 minute intervals, record data in the table below.

Sample location	**Time (minutes)**	**Soil stability**	**Water clarity**	**Notes *(loose sediment, action of water on soil, etc.)***
	1			
	2			
	3			
	1			
	2			
	3			
	1			
	2			
	3			

What makes the difference between soil samples?

The more stable a soil is, the greater the biological activity, energy flow, and nutrient cycling found within it. Soil particles are bound together by *glomalin*, a protein produced by fungi that helps to hold nutrients, create pores and channels for water, plant roots and macroinvertebrates as they move within the soil.

Reflection

1. What is the difference between good and poor soil stability? How is this demonstrated in the soil slake test?

- *Good stability is demonstrated by the soil holding together when immersed in the water. Bubbles may be visible to show that water is infiltrating the soil and displacing air in the soil. Sediments do not drop off to dissolve or become suspended in the water. Poor stability will be shown by a soil that seems to fall apart of disintegrate when exposed to the water.*

2. What happens to soil with poor stability when intense rain comes in contact with it? Why does this happen?

- *Soils with poor stability will be washed away with hard rain. Whatever nutrients are on the soil sediments will be washed away with the sediments. There is no “glue’ to hold the sediments/aggregates together.*

3. How does soil stability impact a soil’s ability to produce crops?

- *A stable soil will be able to hold roots, more water and protect plants from drought conditions longer. The microbial community will be intact and help to deliver nutrients from the soil to the plants.*

4. How might a farmer improve soil stability?

- *Reducing tillage will help improve soil stability, as well as rotating crops and incorporating fertilizers when added.*

Differentiation

Other ways to connect with students with various needs:

i. **Local community**: students may investigate the soil types for their local community by visiting https://websoilsurvey.nrcs.usda.gov/app/ and compare the nutrient levels in various locations. Determine if there is a pattern when comparing soil stability and the other aspects tested in this unit: texture, nutrients, and microbial activity.

ii. **Students with special needs (language/reading/auditory/visual)**: Students can be paired for the activity to allow for team collaboration in determining if there is a pattern.

iii. **Extra support**: Watch this video Watch *Soil Health Lessons in a Minute: Soil Stability Test* (https://www.youtube.com/watch?v=9_ItEhCrLoQ&t=7s)

iv. **Extensions**: Students may present a full soil write up about their samples and use the evidence from each of the tests to support their reasoning that soil health includes all of these aspects.

Rubric for Assessment

Skill	Developing	Satisfactory	Exemplary
The model determines soil stability	Students can explain the demo as a model, but do not connect to soil stability or structure	Students can explain the demo as a model, and connect the model to soil stability by using one example of how structure keeps soil intact during rain or other similar example.	Students can explain the demo as a model, use an example of how soil stability is helpful and can generalize to different soil samples and different aspects of soil working together as a system.
Develop a model			Student can model soil stability in a different way.

Rubric for Self Assessment

Skill	Yes	No
I can determine which soils have higher stability.		
I can determine the advantages of soils with higher stability when compared to soils with less stability.		
I can explain how soil stability is related to soil microbes, soil texture and soil nutrients.		

Lesson 2
Soil Stability Test

Focus Question: *How do soils differ in stability? What helps soil to be stable?*
Vocabulary: *slake, glomalin, fungi*

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