What's Loam Got to Do with It?
High School Digital Lesson Educator Guide

Lesson Overview:
Maintaining soil health and reducing soil erosion are of utmost importance to farmers and ranchers. In this lesson, students will learn how to use a classification system to categorize soil into four major types: clay, sand, silt, and loam. Then, they will conduct investigations to determine pH and soil texture. Lastly, students will test their hypotheses related to soil erosion using a computer model and describe ways to combat soil erosion.

Duration: 90-120 minutes

Content Areas: Earth Science/Environmental Science

Grade Level: Grades 9-12

National Standards:

Next Generation Science Standards (NGSS)

- **HS-ESS2: Earth's Systems**
  - Students who demonstrate understanding can:
- **HS-ESS2-2:** Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
- **HS-ESS3: Earth and Human Activity**
  - Students who demonstrate understanding can:
- **HS-ESS3-4:** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Standards for Technological Literacy – International Technology and Engineering Educators Association (ITEAA)

- **Standard 5: Students will develop an understanding of the effects of technology on the environment.**
  - **G. Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.** For example, water treatment and filtering technologies can facilitate the reuse of water; wind and erosion can be reduced by no-till farming; and aluminum containers can be recycled.
  - **J. The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.** For example, building can be strategically oriented to the sun to maximize solar gain, and biodegradable materials can be used as compost to make the soil more productive.

Essential Questions:

1. How do we distinguish between the four major soil types?
2. What experimental methods are used to determine the pH and texture of soil?
3. What factors cause soil erosion and how can human activities prevent it?

Materials:

- Computers connected to the Internet
- Copies of the “Soil Textural Triangle” chart
- Copies of the Student Handout: "What Type of Soil is It?"
- Copies of the “Flow Diagram: Soil Texture by Feel Analysis”
- Copies of the “Experimental Data Sheet: Soil Texture and pH”
- Copies of "Water Erosion of Soil: Virtual Lab" sheet
- Copies of “4-Year Plant Rotation Plan” sheet as extension
- Copies of “Compare and Contrast Graphic Organizer” as extension
- Various local soil samples
- Hydrion pH paper (range 0-13) with color Chart
- Petri dishes
- Small cups of water
- Coffee stirrers
- Scale or tablespoons for measuring out soil samples
- Droppers or small disposable pipettes
- Metric or inch rulers (Note: 2.54 cm = 1 inch)
- Paper towels (for clean up)

Objectives:

- Distinguish between the four major soil types using a soil triangle
- Experimentally determine the pH and texture of soil samples
- Explore factors that contribute to soil erosion and ways that it can be prevented

Background Information:

Soil is a critical resource that is right under our feet. The importance of soil management and conservation cannot be overstated. Our food supply begins in the soil, which is the source of everything we eat. As such, we literally cannot live without it. To produce efficiently, farmers and ranchers need to maintain productive soil that can serve the country for many years to come.

During the first day of the lesson, students will use a soil triangle to classify soil types and to describe the composition of loam soil. In addition, students will perform experiments to determine the pH and texture of various soil samples using pH indicators and "texture by feel" charts. In the second day of the lesson, students will examine the causes of soil erosion using a web-based Virtual Lab and then describe agricultural methods that can be used to prevent soil erosion. As an extension, students will develop a plant rotation plan for a home garden using a table of plant families in order to maximize soil fertility and manage pests.

Procedure:

Day 1 (Slides 1-8)

Slide 1:

- Display the image of soil on this slide. Encourage students to look closely and try to observe as many details as possible.
- Give students time to jot down answers to the following questions:
    - What do you see? Remind students to only report on things they actually see in the image.
    - What do you think about that?
    - What does it make you wonder?
- Ask students to use the following stems when sharing: "I see...," "I think...," "I wonder...."
- Next, ask the class: In general, what do you think soil is made of? Equitably call on students and write down students' ideas on the board.
- Then, lead a class discussion to elicit the following key point: **Generally speaking, soil consists of air, water, weathered rock, decayed organic matter, and minerals.**

Slide 2:

- Review the lesson objectives and provide some background for the 2-day lesson.

Slide 3:

- Ask students; Why do you think loam, a type of soil, has been referred to as the “Holy Grail of Garden Soil”?
    - Clarify that loam is often a perfect combination of sand, silt, and clay particles that not only drains well but it also has the ability to hold in nutrients and moisture. Knowing the type of soil you have can provide gardeners and farmers with valuable information in terms of sustaining the optimal health of their plants/crops.
- Tell the class, *You're about to learn how to classify soils into different types*. Ask the class, *Why do you think it's important for farmers to know what type of soil they have?* Lead a class discussion to elicit the following key points:
    - Knowing the type of soil helps farmers decide what crop to plant and the most efficient way to apply fertilizer. Soil type/texture can play a role in determining the degree of erosion and runoff. Soils with higher percentage of sand are more prone to erosion and their particles tend to detach from each other in water transport. The opposite is true for soils with higher clay proportion whose smaller particles tend to be tightly bonded to one another.
- Have the class summarize these points in their own words at the top of the student handout: **"What Type of Soil Is It?"**

Slide 4:

- Next pass out: **“Soil Texture Triangle”.** This handout is a chart that is used to determine soil type based on percentage composition of clay, silt, and sand. Students will also use the previous handout: **“What Type of Soil Is It”.** This handout includes the questions students will be answering throughout this segment of the lesson.
- Explain to students that soil texture triangles help determine crop suitability and risk of erosion. Erosion can influence soil quality and crop productivity. Instruct the class in how to read the soil triangle. They should use the crisscrossing lines inside the triangle to match up the three percent compositions (clay, silt, and sand) to a single intersecting point.
- To make the process clearer, guide the class through the following example. Project the image so it's easier for students to visualize the markings as you go through the example.
  If a soil sample is composed of 35% clay, 30% sand, and 35% silt, we would classify it as clay loam since the three lines intersect at a point near the center of the soil triangle.

Slide 5:

- Next, have individual students complete the rest of the handout in which they classify the four soil samples using the soil triangle.
- Ask students to compare their answers with an elbow partner.

- Make sure to go over the correct answers provided on the answer key and to address any misconceptions before moving on to the next phase of the lesson.

Slide 6:

- During the next segment, students will be experimentally determining the pH and texture of a soil sample using two hands-on activities. Provide students with a number from 1-5 and have all the ones, twos, threes, fours, and fives get together in groups. Assign structured, cooperative-learning roles to each group member (by letter) to keep everyone productive and on task. Examples of structured cooperative learning roles include the following:
  - Role A: Group Supervisor: keeps group on task
  - Role B: Time Manager: serves as time keeper
  - Role C: Clean Up Manager: facilitates clean up
  - Role D: Lead Investigator: moderates discussion
- Then, pass out a different soil sample to each group, making sure to save about 25 grams (about two tablespoons) of each sample for the "texture by feel" part of the experiment. Ask the lead investigator of each group to come to the front of the class to pick up the remaining materials: experimental data sheets, pH paper with color chart, Petri dish, coffee stirrer, and small cup of water.
- Monitor the class as they go through the following steps of the experimental procedure:
  - The pH test is performed by initially placing the soil being tested into a Petri dish.
  - Add water to the soil to create a mixture of water and soil. Make sure the Petri dish does not overflow. Stir the mixture really well using the coffee stirrer.
  - Place the pH strip into the soil mixture and use the chart provided on the pH package to determine the pH of the soil.
  - Record your pH and acid-base properties (acidic pH is less than 7, neutral pH is equal to 7, and basic pH is greater than 7) in the first two columns of the data table for your assigned sample.

Slide 7:

- After students have recorded their data for pH and cleaned up, tell them that they will now use texture to classify their soil samples by type using a flow diagram in which they answer a series of yes/no questions. Assign new roles to the members of each group for the next part of the experiment. Each member of the group keeps the same assigned letter but their role switches as shown below:
  - Role A: Group Supervisor: keeps group on task
  - Role B: Time Manager: serves as time keeper
  - Role C: Clean Up Manager: facilitates clean up
  - Role D: Lead Investigator: moderates discussion
- Then pass out the remaining amount (about 25 grams = 2 tablespoons) of each soil sample to each group. Ask the lead investigator of each group to come to the front of the class to pick up the remaining materials: copies of the flow diagram, cup of water, metric ruler, and dropper/disposable pipette.
- Monitor the class as they go through the following steps of the experimental procedure:
  - In order to determine the composition of the soil, first place a handful of the soil that needs to be tested in the lead investigator's hand.
  - Next, moisten the soil by adding water dropwise using the pipette or dropper and kneading it to break down aggregates. Soil will be at the proper consistency when it is moldable, like moist putty.
  - Follow the rest of the flow diagram ("Soil texture by Feel Analysis") by answering the yes and no questions to determine the composition of your soil sample.
  - Record the texture description and type of soil in the final two columns of the experimental data sheet.
  - Clean up lab stations and wash hands

Slide 8:

- After students have recorded their individual group's data and cleaned up, ask the class to share data with other groups so everyone compiles a complete data sheet.
- Invite students to rate their soil samples.
- As closure, invite the class to compare and contrast the most important characteristics of different soil types using data to justify claims.

Day 2 (Slides 9-12)

Slide 9:

- Begin the lesson with a Think-Pair-Share warm-up activity. Ask students to write down a definition for "soil erosion" and then compare their definition with a partner. Call on several students to share definitions using equitable calling strategies. Provide an accurate definition of soil erosion, such as: **Soil erosion is the wearing away of the top layer of soil that contains the most organic and nutrient-rich materials.**
- Ask students, *Why do farmers, environmentalists, and others want to avoid erosion?* Lead a class discussion to elicit the following key points:
  - Soil erosion removes valuable top soil that results in lower yields of crops and plants. It also reduces the ability of soil to store water and nutrients, causing runoff and flooding. Soil erosion can lead to increased pollution and sedimentation in streams and rivers. This can clog waterways harming fish and other species.

Slide 10:

- Next, tell the class they will be examining the causes of soil erosion using a web-based Virtual Lab. Have students connect to the internet using a computer or other device and direct them to the following web-based Virtual Lab: http://bit.ly/1VjZN5R
  In this Virtual Lab, students will measure the amount of sediment collected from water runoff. This will allow them to compare the effects of three variables (Level 1) or four variables (Level 2) on water erosion.
- Ask students to write a hypothesis about how variables such as soil treatment (none, trench, plants), water flow (high, medium, low), and incline (steep, medium, low) affect the water erosion of soil for Level 1. For Level 2, students should write down a hypothesis about how variables such as soil treatment (none, trench, plants), water flow (high, medium, low), incline (steep, medium, low), and soil type (sand, silt, sand/silt mixture) affect the water erosion of soil. Invite students to write down their hypothesis statements on the "Water Erosion of Soil: Virtual Lab" sheet.
- Provide time for students to discuss/defend their hypotheses with the rest of the class.
- Then, direct students to test their hypotheses by completing the rest of the Virtual Lab following the step-by-step procedure on the main page. Students will click on different settings to test all possible combinations of the variables and record values in the data table.
- Direct students to complete the analysis/conclusions section of the virtual lab and explain their answers to the questions on the back of the virtual lab sheet.

Slide 11:

- At the end of the lesson, engage the class in a discussion of agricultural methods and conservation tactics that farmers and ranchers use to prevent soil erosion, such as:
  - No Till Farming
  - Contour/Terrace Farming
  - Cover Crops/Crop Rotation
  - Windbreaks
  - Buffer Strips
  - Maintaining pH Level of Soil
  - Irrigation methods and water conservation

  Information on these and other soil conservation methods can be found at:
  http://www.conserve-energy-future.com/methods-of-soil-conservation.php
  http://www.c3crop.com/products/sis-soil-mapping

Slide 12:

- As an extension, challenge students to research and develop a plant rotation plan for a home garden that maximizes soil fertility and manages pests using a table of plant families. Students should:
    - Compare and contrast large production agriculture crop rotation with a non-rotation method.
    - Provide a diagram illustrating how they will subdivide their garden into different areas.
    - Include a four-year plant rotation plan and describe their decision-making process using information from the table of plant families. A useful link to plant families for crop rotation can be found below:
    - http://extension.psu.edu/plants/gardening/fact-sheets/general-gardening/plant-rotation

  "Compare and Contrast Graphic Organizer" and "Four-year Plant Rotation" are included for students to capture their research.

Useful Resources:

- USDA Link: Soil Texture by Feel Chart
    - https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311
- Determining Soil Texture by the Feel Method:
    - http://www.ndhealth.gov/WQ/SW/Z1_NPS/PDF_Files/Soil_Texture_Feel_Test.pdf

SOIL TEXTURE TRIANGLE

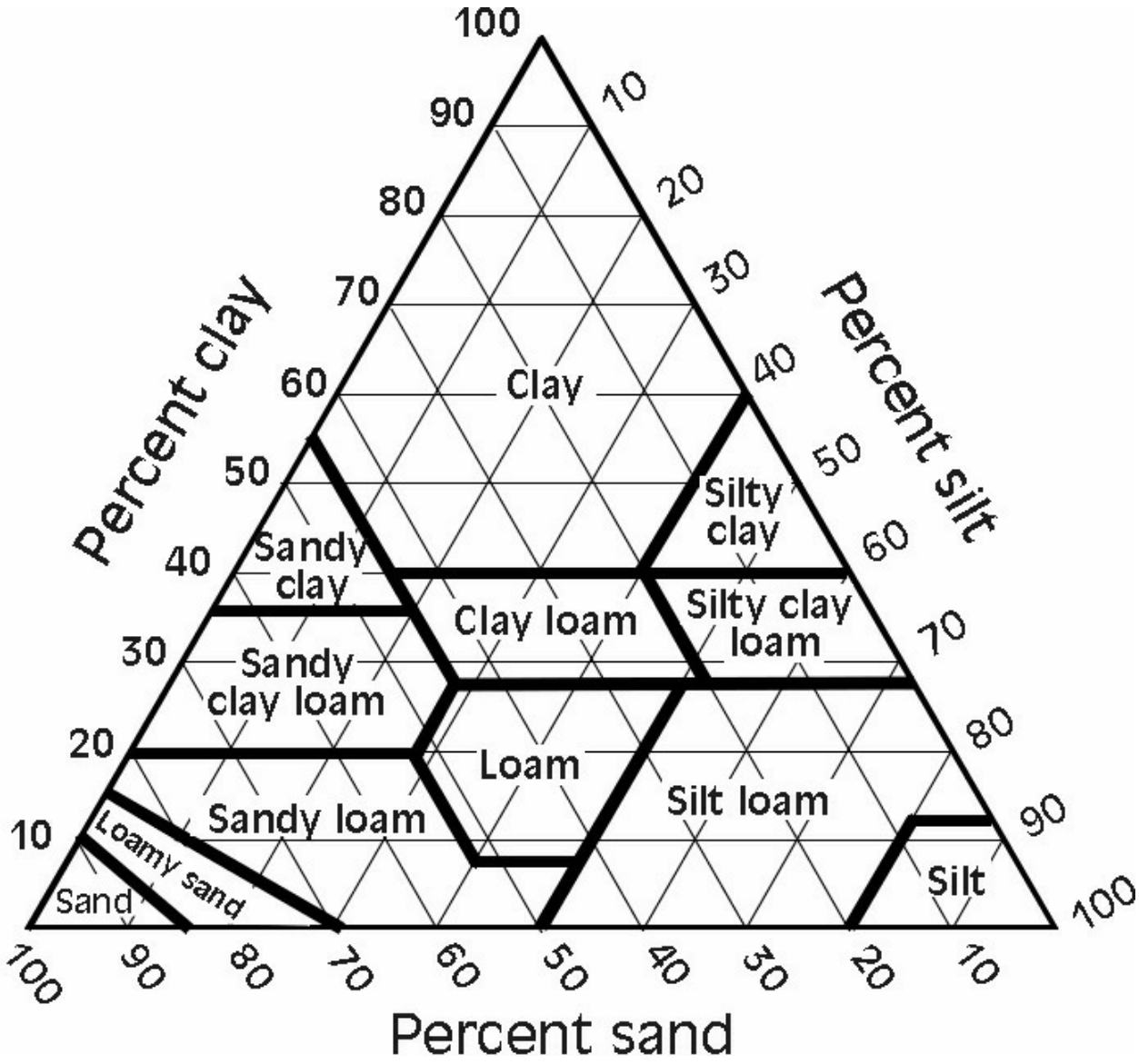


Image source:

https://tinyurl.com/kmuk4sj

Name: _____ Period: _____ Date: _____

WHAT TYPE OF SOIL IS IT?
STUDENT HANDOUT

Why is knowing the type of soil you have important?

_____

_____

Directions: Use the soil composition data shown below and the soil triangle to classify each of the following soil samples:

SOIL SAMPLE #1:
20% Clay, 40% Sand, and 40% Silt

What type of soil is it?

_____

SOIL SAMPLE #2:
60% Clay, 20% Sand, and 20% Silt

What type of soil is it?

_____

SOIL SAMPLE #3:
10% Clay, 60% Sand, and 30% Silt

What type of soil is it?

_____

SOIL SAMPLE #4:
20% Clay, 20% Sand, and 60% Silt

What type of soil is it?

_____

Name: _____ Period: _____ Date: _____

WHAT TYPE OF SOIL IS IT?
ANSWER KEY

Why is knowing the type of soil you have important?

Knowing the type of soil you have can provide gardener and farmers with valuable information in terms of sustaining the optimal health of their plants/crops. For example, loam has been referred to as the "Holy Grail of Garden Soil" since it not only drains well but it also has the ability to hold in nutrients and moisture. Soil type/texture can also play a role in determining the degree of erosion and runoff. Soils with higher percentage of sand are more prone to erosion and their particles tend to detach from each other in water transport. The opposite is true for soils with higher clay proportion whose smaller particles tend to be tightly bonded to one another.

Directions: Use the soil composition data shown below and the soil triangle to classify each of the following soil samples:

SOIL SAMPLE #1:
20% Clay, 40% Sand, and 40% Silt

What type of soil is it?
LOAM

SOIL SAMPLE #2:
60% Clay, 20% Sand, and 20% Silt

What type of soil is it?
CLAY

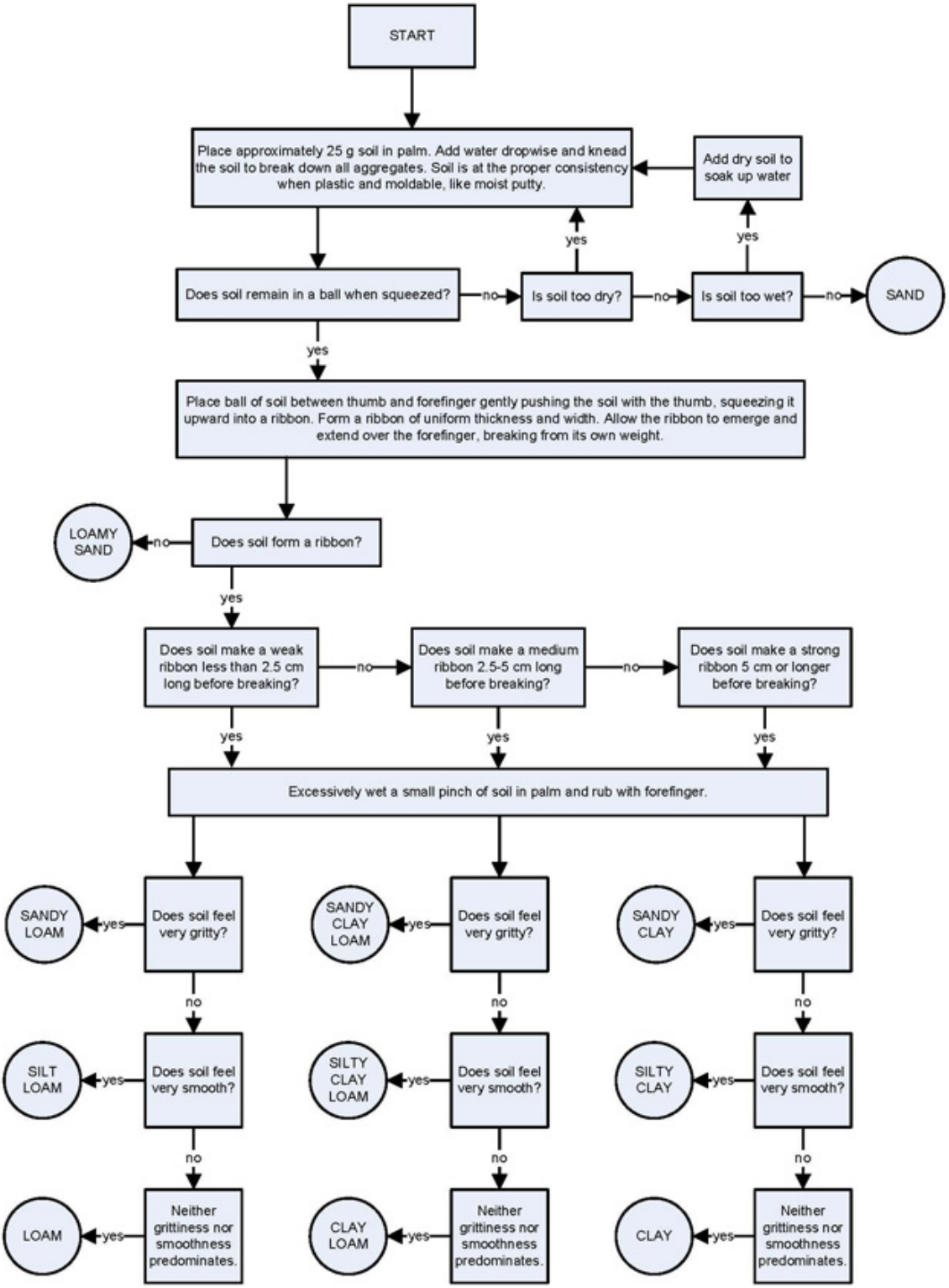
SOIL SAMPLE #3:
10% Clay, 60% Sand, and 30% Silt

What type of soil is it?
SANDY LOAM

SOIL SAMPLE #4:
20% Clay, 20% Sand, and 60% Silt

What type of soil is it?
SILT LOAM

FLOW DIAGRAM: SOIL TEXTURE BY FEEL ANALYSIS



Note: For a high-resolution version of this graphic, click on the following link:
https://www.nrcs.usda.gov/internet/fse_media/nrcs142p2_050352.jpg

Name: _____ Period: _____ Date: _____

EXPERIMENTAL DATA SHEET: SOIL TEXTURE & pH

Sample #	pH	Acidic, Basic or Neutral?	Texture Description	Type of Soil
1				
2				
3				
4				
5				

Name: _____ Period: _____ Date: _____

EROSION: VIRTUAL LAB

Virtual Lab:
https://www.as.uky.edu/sites/default/files/elearning/module07swf.swf

Hypothesis Statement Level 1:
_____
_____

Hypothesis Statement Level 2:
_____
_____

DATA TABLE: LEVEL 1

Conduct 8 trials and record your data below.

Trial	Soil Treatment	Amount of Water	Incline	Liters of Soil Erosion
1				
2				
3				
4				
5				
6				
7				
8				

DATA TABLE: LEVEL 2

Conduct 8 trials and record your data below.

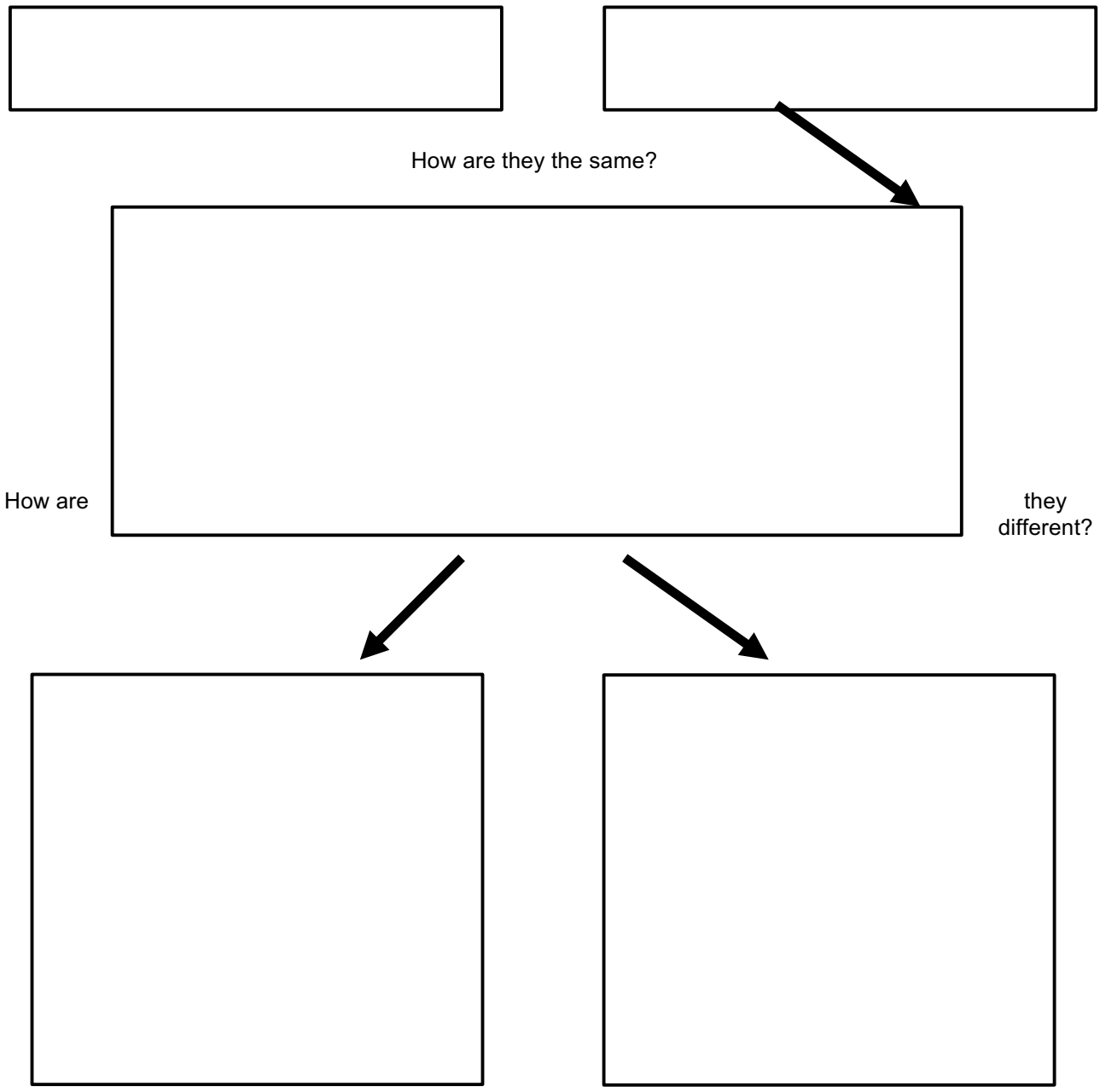
Trial	Soil Treatment	Amount of Water	Incline	Soil Type	Liters of Soil Erosion
1					
2					
3					
4					
5					
6					
7					
8					

Analysis and Conclusions:

Analyze the results of your experiment. Explain any patterns you observed. Do the results of your experiment support or refute your hypothesis? Which variable has the strongest influence on the amount of water erosion that occurs on a slope? What are some other factors that might influence erosion?

Compare and Contrast Graphic Organizer

Use the graphic organizer to compare and contrast large production agriculture crop rotation with a non-rotation method.



Four-Year Plant Rotation Plan

Outline your four-year plant rotation plan in the chart and include a justification with evidence for your selection.

Rotation Year	Crops	Justification for Selection
Year 1		
Year 2		
Year 3		
Year 4		