AP Classroom Topic 4.3 (Video 1=particle size, soil triangle; Video 2=how to test soil)

What are similarities and differences of the physical properties among various soil types?

Pre-lab (and the *)

Researchers were interested in comparing the water-holding capacity of soils collected from various biomes. Samples were collected from five biomes (tropical rainforest, taiga, temperate grassland, desert, and temperate deciduous forest). 50-gram samples were collected at a depth of 6 inches in each of the various locations, and the percentage of water by mass was calculated and is shown in Table 1.

TABLE 1: WATER-HOLDING CAPACITY OF VARIOUS BIOME SOILS

Biome	Soil Type	Water-holding Capacity
Tropical rainforest	Oxisol	17%
Taiga	Spodosol	11%
Temperate grassland	Mollisol	19%
Desert	Aridisol	10%
Temperate deciduous forest	Alfisol	21%

1. Identify the independent and dependent variables in the investigation.
2. Identify one variable that the researchers should hold constant that was not mentioned in the description of their experimental design setup.
3. A researcher claims that Aridisols have the highest clay content of these five soil types. Provide reasoning to *support* or *refute* the researcher's claim.
4. Propose which type of soil might be most appropriate for growing crops that require large amounts of water, such as corn.

Test 1: Soil Porosity (density) and Percolation/Permeability *(use class soil)*
Activity One – Drainage Rate of Packed vs. Loose Soil

1. Obtain two clear tubes with open ends.
2. Rubber-band two pieces of cheesecloth to one end of each tube.
3. Place each tube upright, with cheesecloth end down, in a plastic cup.
4. Measure 40mL of soil using a graduated cylinder
5. Place the 40mL of loosely packed soil in tube #1
6. Place the same amount of soil (40mL) in tube #2. Pack the soil down, using a pencil
7. Hold tube #1 above the plastic cup and pour 40mL of water into the tube. Use a stopwatch to time the drainage of the water. *Start* timing as soon as all of the water has been poured into the tube. *Stop* timing when the water stops dripping from the bottom of tube #1. Record time under: *Time of Drainage for the Loose Soil in Data Table 1.*
8. Repeat step 7 for tube #2. Record the time of drainage of the water for tube #2 in:

    Seconds under Time of Drainage for Packed Soil in Data Table 1.

9. Using the amount of water placed into each tube and the time required for drainage, determine the drainage rate of the loosely and tightly packed soil in **mL per second** in *Data Table 1*.
10. Pour the water from each cup into the waste bucket. Save the tubes with the soil and the cups for activity 2.

***State Hypothesis-Label IV, DV**

Test 1: Soil Porosity (density) and Percolation/Permeability cont'd *(use class soil)*
Activity Two-Drainage Rate of Wet vs. Dry

11. Place each of the tubes with the wet soil in the cups once again

12. Hold tube #1 above the cup and once again fill the tube with 40mL of water. Start timing as soon as all the water has been poured into the tube. Stop timing when the water stops dripping from the tube. Record drainage time from the first tube in seconds under:

Time of drainage of wet soil in Data Table 2.

13. Repeat step 12 for tube #2. Record the time for the second tube under:

Wet Soil in the Data Table 2.

14. Calculate the drainage rate for tubes #1 and #2 using the procedure from in step 9.

15. Dispose of the soil and clean the tubes according to the instructor.

***State Hypothesis** *(with regards to drainage of wet vs dry soils)*-**Label IV, DV**

Data Table 1 (test 1) - Dry Soil Drainage

	Time of Drainage	***Drainage Rate (vol/time) (mL/s)***	***Hypothesis reflection***
Loose soil			
Packed Soil			

Data Table 2 (test 1)– Wet Soil Drainage

	Time of Drainage	**Drainage Rate (vol/time) (mL/s)**	***Hypothesis reflection***
Loose soil			
Packed Soil			

Test 2: Soil Percolation/Permeability *(use sample, sand, gravel)(closed tube)*

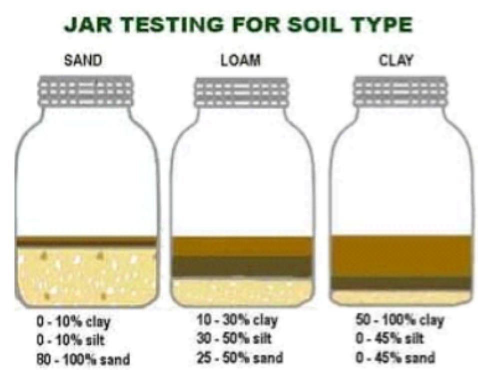
1. Fill each tube with 100 mL of each sediment/soil.
2. Measure out 100mL of water and pour it into one of the tubes. Begin the stopwatch when the first drop of water hits the soil.
3. Carefully watch the bottom of the tube. Stop the watch when the first drop of water hits the bottom. Record the time. Repeat for the other tubes.

***State hypothesis-Label IV, DV**

Sediment/soil type	Time of Drainage in 100 mL	*Hypothesis reflection*
Sample		
Sand		
Gravel		

Test 3: Day 1 (use sample)

1. Fill the jar with about 40 mL of soil.
2. Fill the jar nearly to the top with water. Leave room for shaking.
3. Tighten the lid and shake the jar for several minutes so that all the particles are in suspension.
4. Set the jar of soil test aside for several hours, so the particles have a chance to settle.



Test 3: Day 2

1. Using a ruler, measure the total height of soil layers.

Particle	Height of layer (mm)	Percentage (height/total) *100%
Total		

2. Identify the three individual sedimentation layers; measure the height of each layer.

3. Calculate the percentage represented by each layer by dividing the height of the layer by the total height and multiplying the result by 100.

4. Using the soil triangle, find the soil's texture. The clay line is drawn horizontally from left to right, the silt line is drawn on a diagonal from the percentage on the right toward the bottom left of the triangle, and the sand line is drawn diagonally from the percentage on the bottom toward the top left of the triangle. The point or section where all three lines meet is the soil texture for the sample.

Conclusion

1. Describe why percolation rates differ between different soil textures.

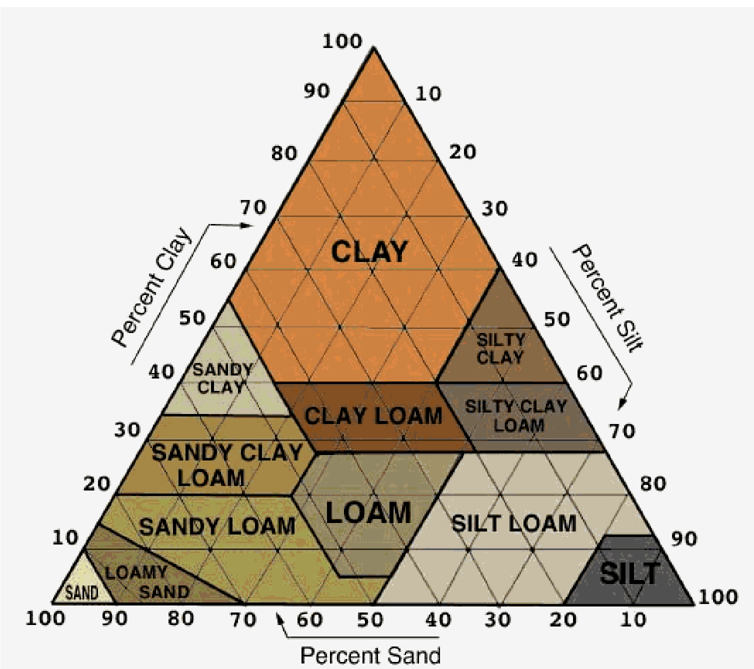
2. Which soil would be most subject to erosion from Test 2? Why?

3. If there are two sloping fields, one of sandy soil and one of clay soil, which would likely experience more flooding at the bottom? Why?

4. If there are two fields of crops, both of the soils in number 3, which would you water most often? Why?

5. How does climate influence soil formation?

6. Soil texture analysis:



Using the triangle, identify the type of soil for the given percentages:

a. 70% silt, 20% sand, 10% clay=

b. 20% silt, 10% sand, 70% clay=

c. What is the soil texture from test 3 with the percentages listed here?

------------------------------------end of lab--

AP Classroom Topic 4.3 (Video 1=particle size, soil triangle; Video 2=how to test soil)

Data Table 1 (test 1) - Dry Soil Drainage

	Time of Drainage	*Drainage Rate (vol/time) (mL/s)*	*Hypothesis reflection*
Loose soil			
Packed Soil			

Data Table 2 (test 1)– Wet Soil Drainage

	Time of Drainage	Drainage Rate (vol/time) (mL/s)	*Hypothesis reflection*
Loose soil			
Packed Soil			

Data Table (test 2)-Soil Permeability

Sediment/soil type	Time of Drainage in 100 mL	*Hypothesis reflection*
Sample		
Sand		
Gravel		

Data Table (test 3)- Soil Composition

Particle	Height of layer (mm)	Percentage (height/total) *100%
Total		

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2020

8. Most agricultural fields receive inputs of phosphorus, calcium, and magnesium, which are usually obtained by mining rocks containing those elements, grinding them up, and adding them to fertilizers. Assess the likely impact of this practice on the demand for certain rocks and on soil dynamics with regards to **both a)** a nutrient cycle **and b)** a feedback loop.

Test 1: Soil Chemistry (of sample) (see backside for directions)

1. Using the pH sensors and additional handout with Logger pro to test the soil sample.

PROCEDURE

Test 1:

1. Prepare the water-soil mixture.

   a. Place 50 g of soil into a 250 mL beaker.

   b. Stir once every three minutes for 15 minutes.

   c. After the final stirring, let the mixture settle for about five minutes. This allows the soil to settle out, leaving a layer of water on top for you to take your pH measurement. Proceed with Step 2 while you are waiting.

2. Connect the GoLink to the laptop. Important: For this experiment, your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.

3. Rinse the pH Sensor with distilled water.

4. Prepare the computer for data collection by opening Logger Pro on Desktop.

See extra handout if the pH sensor needs calibration.

5. Measure the pH.

   a. Carefully place the tip of the pH Sensor into the liquid part of the beaker contents. Make sure the glass bulb at the tip of the sensor is covered by the water. Stir gently.

   b. Continue gentle stirring. Note and record the pH value when the reading stabilizes.

5. Rinse the pH Sensor while still plugged in with distilled water and return it to its storage container.

Extra info: (for test 1)

Soil pH Vernier Software and Technology

When you think of pH, you probably think of acidic and basic solutions. But soil can be acidic or basic, too. Soil pH, sometimes referred to as soil acidity, can be expressed using the pH scale. The pH scale ranges from 0 to 14. Soils with pH above 7 are basic or sweet.

Plant Nutrients	
Macronutrients	**Micronutrients**
Nitrogen	Iron
Phosphorus	Manganese
Potassium	Zinc
Sulfur	Copper
Calcium	Molybdenum

AP Classroom Topic 4.3 (Video 1=particle size, soil triangle; Video 2=how to test soil)

Soils with pH below 7 are acidic or sour. A soil with a pH of 7 is neither acidic nor basic, but is neutral.

The pH of soil is an important factor in determining which plants will grow because it controls which nutrients are available for the plants to use. Three primary plant nutrients – nitrogen, phosphorus, and potassium – are required for healthy plant growth. Because plants need them in large quantities, they are called macronutrients. They are the main ingredients of most fertilizers that farmers and gardeners add to their soil. Other nutrients such as iron and manganese are also needed by plants, but only in very small amounts. These nutrients are called micronutrients.

The availability of these nutrients depends not only on the amount but also on the form that is present, on the rate they are released from the soil, and on the pH of the soil. In general, macronutrients are more available in soil with high pH and micronutrients are more available in soil with low pH. Figure 1 shows the effect of pH on the availability of nutrients in the soil.

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Extension (not 2021)

In the landmark 1997 report “Livestock Production: Energy Inputs and the Environment,”Cornell University ecologist David Pimentel wrote that feeding grain to cattle consumes more resources than it yields, accelerates soil erosion, and reduces the supply of food for the world's people. Some highlights of the report include the following:

• Each year an estimated 41 million tons of plant protein is fed to U.S. livestock to produce an estimated 7 million tons of animal protein for human consumption. About 26 million tons of the livestock feed comes from grains and 15 million tons from forage crops. For every kilogram of high-quality animal protein produced, livestock are fed nearly 6 kg of plant protein. The 7 billion animals consume five times as much grain as the entire U.S. population.

• Every kilogram of beef produced takes 100,000 liters of water. Some 900 liters of water go into producing a kilogram of wheat. Potatoes are even less "thirsty," at 500 liters per kilogram.

• About 90 percent of U.S. cropland is losing soil because of erosion at 13 times the rate of soil formation. Soil loss is most severe in some of the richest farming areas; Iowa, for example, loses topsoil at 30 times the rate of soil formation. Iowa has lost one-half of its topsoil in 150 years of farming. This soil took thousands of years to form.

A. Reflect on your diet for a day, or a week. How much animal protein is consumed? Therefore, how much plant protein and water was used to “raise” that much animal protein?

B. Compare your diet to that of a person in a developing country with regards to their diet footprint.

C. Most agricultural fields receive inputs of phosphorus, calcium, and magnesium, which are usually obtained by mining rocks containing those elements, grinding them up, and adding them to fertilizers. Assess the likely impact of this practice on the demand for certain rocks and on soil dynamics with regards to **both** a nutrient cycle **and a** feedback loop.

AP Classroom Topic 4.3 (Video 1=particle size, soil triangle; Video 2=how to test soil)

If time:

	Nitrogen results	Phosphorus results	Potassium results
Soil sample			
Reasons and Implications			

2. Connect the pH Sensor and the data-collection interface. Important: For this experiment, your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.

3. Rinse the pH Sensor with distilled water.

4. Prepare the computer for data collection by opening file "08 Soil pH" from the *Agricultural Science with Vernier* folder.

See extra handout if the pH sensor needs calibration.

5. Measure the pH.

a. Carefully place the tip of the pH Sensor into the liquid part of the beaker contents. Make sure the glass bulb at the tip of the sensor is covered by the water. Stir gently.

b. Continue gentle stirring. Note and record the pH value when the reading stabilizes.

5. Rinse the pH Sensor with distilled water and return it to its storage container.

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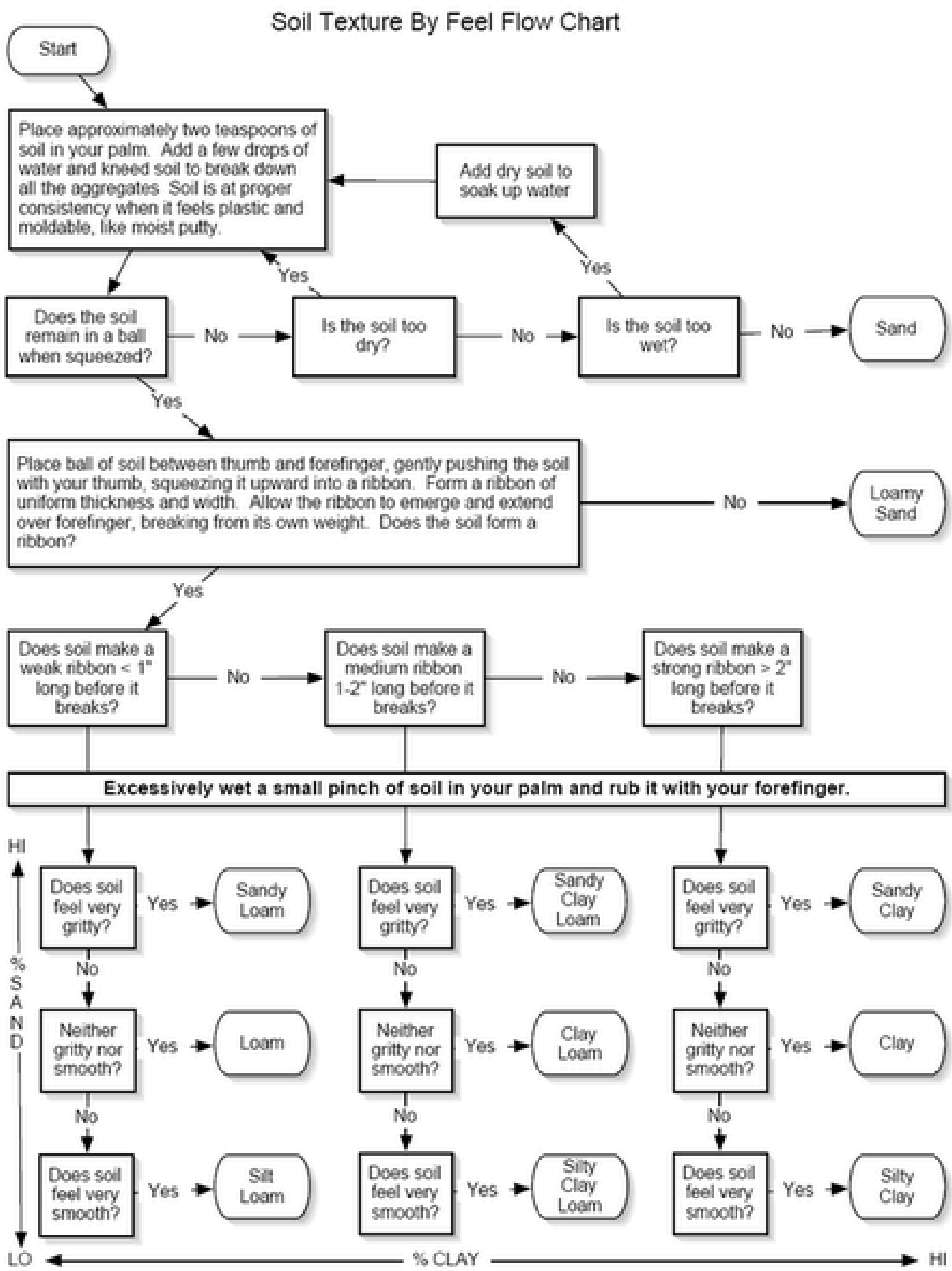

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