Perc Through the Pores

LEVEL: Grades 3-6
SUBJECTS: Science, Language Arts
SKILLS: Analyzing, comparing similarities and differences, concluding, cooperating, demonstrating, describing, discussing, inferring, listening, observing, recording, role-playing

BRIEF DESCRIPTION
By pretending to become soil particles and water droplets, students simulate soil particle sizes and their pore space.

OBJECTIVES
The student will:
- describe the three main types of soil particles: sand, silt, and clay;
- simulate and compare the size and pore space of the three soil particles; and
- recognize that soil is generally made up of a combination of all three types of soil particles.

ESTIMATED TEACHING TIME
Two sessions: One hour each.

MATERIALS
Magnifying glasses or hand lenses; one (or more) empty, clear, plastic 1-liter soda bottle with lid; several different soil samples; water; 60 feet of string; photocopies of the attached ***Soil Settling*** and ***The Feel of Soil*** sheets.

VOCABULARY
absorption, clay, groundwater, particle, percolation, pore space, porosity, sand, saturated, silt

RELATED LESSONS
From Apple Cores to Healthy Soil
Root, Root for Life
Till We or Won't We?
In Harmony

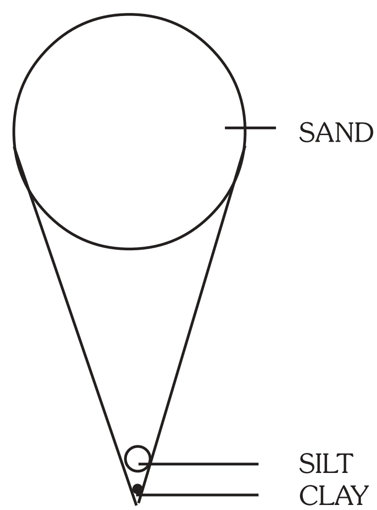
SUPPORTING INFORMATION
Soil is important to support life. We need it for building homes, planting vegetation, raising animals, and growing our food and fiber. Soil is made up of mineral particles, organic matter (once living plant and animal matter), and pore spaces (potential living spaces filled with air, water, or living organisms). Mineral particles, classified according to size, include:

- Sand: soil particle between .05 and 2.0 mm in diameter
- Silt: soil particle between .002 and .05 mm in diameter
- Clay: soil particle less than .002 mm in diameter

Sand is the largest mineral particle and it has more pore space between its particles than silt or clay. Silt particles are smaller than sand, but larger than clay particles. Likewise, there is less pore space between silt particles than between sand particles, but more than between clay particles. Clay, the smallest particle, has the least amount of pore space.

Since these particle sizes are difficult to visualize, an analogy helps clarify. If a sand particle is the size of a basketball, a silt particle would be the size of a golf ball, and a clay particle the size of a dot made by chalk. Rarely made up of only one type of particle, soils consist of varying combinations of the three. The percentage of sand, silt, and clay in a particular soil determines its texture.

THE RELATIVE SIZE OF SAND, SILT, AND CLAY



All soil particles have the ability to attract and hold water. Water moves quickly through a sandy soil because of the large pores, or empty spaces between the particles. A clay-type soil, however, will actually attract water and absorb it like a sponge. Clay particles, as a clump, swell as they get wet and shrink as they dry. These particles have the ability to pull and hold onto water with 2,500 pounds of force.

Water passes down or percolates through the soil at various rates. Over the years, some of this water may end up in the groundwater supply. The rate of water percolation, however, is reduced when all the pores are full of water, causing the soil to be saturated. Unfortunately, this can cause water to collect on top of the soil, increasing the possibility of soil erosion and flooding.

The porosity of the soil - the available pore space of a soil type - determines how quickly water will move through the soil. Some of the water is held by the soil particles. Gravity pulls the rest of the water, called free water, downward. The water held by soil particles is removed by plant roots for plant use.

Along with farmers, city and town planners are concerned with soil texture and porosity. A heavy clay soil can crack a building foundation because it shrinks and swells. Soil type is an important consideration in the location and size of septic systems and landfills.

Percolation and other soil tests help city and town planners and builders understand the soil types. From these tests, they can learn if there is too much clay in the soil, for example. If negative soil conditions exist, the builders will have to adjust their plans.

GETTING STARTED

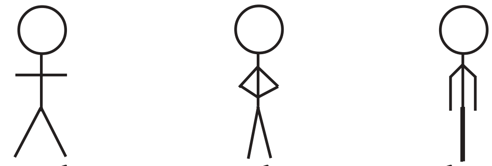
Have students bring in soil samples from home or a nearby area; gather one (or more) empty, clear, plastic 1-liter soda bottle with lid, water, string, and magnifying glasses or hand lenses. Make photocopies of the ***Soil Settling*** sheet for individual or pairs of students and ***The Feel of Soil*** sheet for pairs or small groups of students.

PROCEDURE

SESSION ONE

1. Ask the students what they know about soil and why it is important. List their comments in a visible place. Explain that they are going to learn about the different sizes of particles in soil.

2. Explain that students are going to pretend to become soil particles. They will simulate different soil particle sizes and pore spaces between the particles. Designate three or four students as "water droplets." The rest of the students will all simulate the "particles": sand, silt and clay. Explain that they will use arm actions to represent each soil particle. Draw these three stick people figures in a visible place.



sand	**silt**	**clay**
arms outstretched from shoulder	hands on hips, bent at the elbow	arms at your side

3. Have all the "particle" students represent "sand" particle size by getting in an imaginary flower pot with their arms outstretched. They should stand in a random arrangement and be able to rotate 360 degrees without hitting another student. (You may need to arrange some of the students.) Tell students their outstretched arms represent the largeness of a sand particle. The empty space between sand particles represents pore space. These "living" spaces in nature are filled with air, water or living organisms. Place the string on the floor around all the sand particles. Explain that this string defines our flower pot filled with sand. (Leave the string in the same position on the floor during the whole simulation.) Have students note the amount of space between particles.

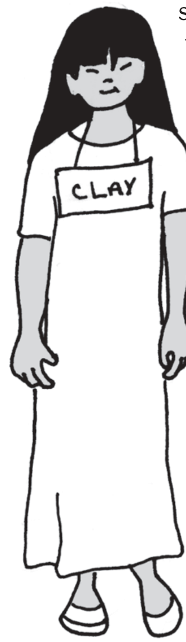
4. Add the "water droplet" students. Have them pass through the "sand" particles in the flower pot and out of the pot (circle). Throughout the simulations, the "water droplets" aren't allowed to go around the "particles," but they must pass through them in the easiest way possible by walking upright. (Students representing "sand" particles must allow "water droplets" to push their arms slightly to pass through the "sand" particles.)

5. Discuss briefly the relative ease with which the "water droplets" passed through the large pore spaces between the "sand" particles.

6. Next have all the "particle" students represent "silt" particles by placing hands on their hips with arms bent at the elbow. Have the students move next to each other with elbows just touching each other. They must stay within the flower pot. Add the "water droplet" students. Again, "water droplets" must pass through the particles in the easiest fashion and out of the pot. They may swing the arms of the particles.

7. Discuss the differences in water movement through the silt and the sand. Ask, "Did the sand or the silt particles take up the most space in the flower pot?"

8. Finally, have all the "particle" students represent "clay" particles by standing with their arms at their sides and touching the shoulder of another "clay" particle. The particles will be bunched in together. Add the "water droplet" students. The droplets pass through the particles by moving two particles "slightly apart" and moving through them. Have the "slightly apart" particles stay apart to represent the swelling action of clay. Water droplets cling to and surround clay particles. Excess water is pulled down into soil by gravity. Water that adheres to the clay particles is either removed by plant roots or evaporation.



9. Explain to students that when water percolates through a soil in nature each dry soil particle actually holds some water. Only the extra or "free" water that the soil particles cannot hold can be pulled further down by gravity. This water held by the soil particles is the water plants "drink" (suck up) with their roots.

10. Ask students to discuss the differences in:
    - particle size
    - pore space
    - total space occupied in the flower pot by the same number of different particles
    - ease of "water droplets" passing through the "sand" and "silt," versus the "clay" particles

    Make sure students understand that the <u>same</u> number of soil particles were in the flower pot each time. Ask:

    - Why do the same number of "clay" particles take up less room in the flower pot than the "silt" particles? *(The "clay" particle size and pore space between particles are smaller.)*

    - Why do the same number of "silt" particles take less room in the flower pot than the "sand" particles? *(The "silt" particle size and pore space between particles are smaller.)*

11. Have the "particle" students, still in the flower pot, demonstrate "clay," "silt," and then "sand" particles by adjusting their arm actions and the space between particles. Have the particles go from "sand" to "clay" to demonstrate the differences.

Have individual students be the particle of their choice so that the flower pot contains a combination of particles. (Be sure that the different particles are scattered in the pot.) Let students decide, based on the arm positions of the particles, if the flower pot's soil has a sandy, silty, or clayey texture. Is there an equal combination of particles, or is there more of one than the others? Have students repeat this process several times to help them draw the conclusion that the size of the pore space is directly related to the proportion of particle sizes in the soil. (More clay particles means smaller total pore space while more sand means larger total pore space. You can add the "water droplet" students to the mixtures to aid in the understanding of pore space.) Ask:

- Was it easier or harder for the "water droplets" to pass through the pore spaces in the pure samples of sand, silt and clay or in the mixtures you created?

- Which soil type does water move through the fastest? *(sand)* The slowest? *(clay)* Why?

- What are the three soil particles called? *(Sand, silt, and clay.)*

- Soils in nature are usually a mixture of the three soil particles. What might be the advantage of having a very sandy soil? A heavy clay soil? The disadvantages to one or the other? *(Sandy soil holds less water for plants and dries out more rapidly. Water moves through clay soils very slowly and may cause plants to suffocate by drowning the roots. Play areas in sandy soils would drain quickly and not be muddy. Play areas on clay soils would be wet a long time after a rain and be muddy. Clay soils shrink and swell and may break up things built on them.)*

- What kind of soil texture do you have at home or at school? How would you manage it to grow healthy plants? Why?

<u>SESSION TWO</u>

1. Distribute the ***Soil Settling*** sheet for individual or pairs of students to complete during the demonstration.

2. Add several handsful of one soil sample to the 1-liter soda bottle and fill it with water. (Break up any clumps of soil before adding the water. Adding a few drops of detergent may help to break the clay aggregates [clumps] so they perform like individual clay particles.) Cap and shake the bottle well. Set it on a table where students can observe the soil

particles settling. Ask:

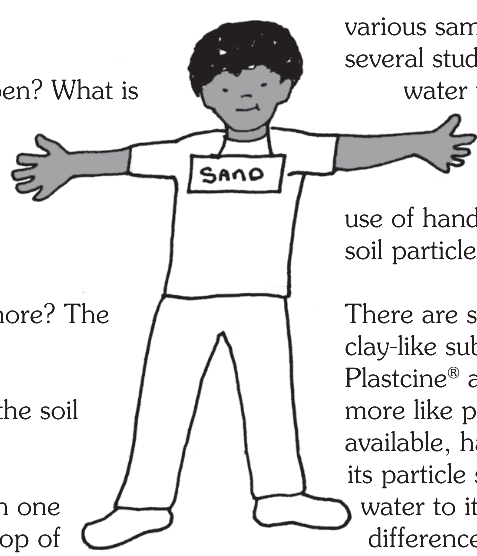
- What do you think will happen? What is happening?

- Why are some of the soil particles settling and some floating?

- Which soil particles weigh more? The ones settling or floating?

- How long will it take for all the soil particles to settle?

The sand will settle in less than one minute. The silt will settle on top of the sand, followed by the clay. This process can take all day or even as long as a week. Have students observe the differences in the soil particles' sizes, colors, and amounts. Have students record and draw their findings on the sheet.



3. Discuss with students the fact that a typical soil sample contains all three soil particles in varying amounts. Water allowed us to separate the particles. Use the diagram showing the relative size of the particles (see Supporting Information).

4. **Optional**: Repeat Step 2 using soils from different locations. Compare the differences. Ask:

   - Is the amount of sand, silt and clay the same in each sample?

   - How would you describe the colors of sand, silt and clay in each sample? Are they the same color in each sample?

   - Is there anything still floating after the bottles have been sitting for 24 hours? What is it? *(Organic matter [e.g., plant and animal material] will generally float.)*

5. Students can identify a soil's texture by experiencing the "feel" of different soil samples. Distribute ***The Feel of Soil*** sheet. Have several students place a small amount of soil from different soil samples in their hand, add water droplets slowly, and knead the soil to break up any clumps. Tell students the proper consistency for identification exists when the soil stays together. Have students identify its general texture using the information on ***The Feel of Soil*** sheet.

   Pass the soil samples around so all the students can feel the differences and similarities among the various samples. (The samples will dry quickly after several students have handled them. Add a little water to the samples after they have been handled by four to six students.) Ask if students agree with the assigned texture of each sample. Encourage the use of hand lenses or magnifying glasses to observe soil particle sizes.

   There are several commercially available types of clay-like substances used in schools, such as Plastcine® and Permoplast Molding Clay®, that are more like plastic than soil. If your school has any available, have students investigate its texture and its particle size with a hand lens. Have them add water to it. Ask, "What are some similarities and differences between these samples and real clay?"

6. To increase students' understanding of soil particle sizes, have them repeat the soil particle simulation from Session One.

EVALUATION OPTIONS

1. Evaluate students' ***Soil Settling*** and ***The Feel of Soil*** sheets for understanding and completeness.

2. Have students fold a piece of paper into thirds and draw lines between the sections. In the first section, have students draw "sand" particles, in the middle section, "silt" particles, and in the last section, "clay" particles. In all three sections, have students label the particle types and indicate the amount of pore space between the particles.

3. Give students a handful of soil. Have them identify the sample's general texture of sand, silt or clay, using the technique and characteristics described in the procedure on ***The Feel of Soil*** sheet.

4. Have students imagine they had three flower pots, one full of sand, one full of silt, and one full of clay. Which pot has the smallest pore space, the largest? Which soil type will hold more water?

EXTENSIONS AND VARIATIONS

1. Have students demonstrate porosity. Porosity, the available pore space in a soil, and water-holding capacity vary from one soil type to another. Porosity determines how fast water will move through the soil. It's important for water to move through soil, but not so quickly that plants don't get enough for their needs. Have students:

A. Assemble four clear plastic cups. Punch several drainage holes in the bottom of two cups. Line the bottom of the cup with a piece of thin cloth or paper towel so the soil is not washed out of the cup.

B. Put an equal amount of two different types of soil in the two cups with the holes in them. (Preferably a 'heavy' soil with clay content in one cup and a sandy soil in the other.) Which cup will have more soil particles in it?

C. Pour equal amounts of water onto the soil in each cup. Hold or place the cups over the other two cups, without holes, to catch the water draining out.

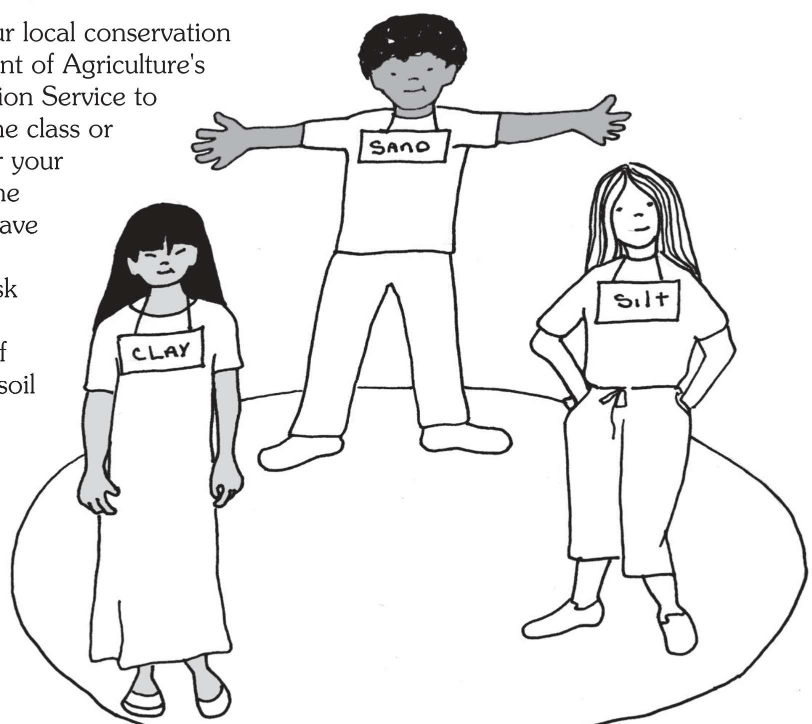
Ask:

- Which soil type drains more quickly?
- Did equal amounts of water drain out of both soil types?
- Which soil type is holding more water for plants to use? Why?

2. Have a student contact the office of the county commissioner and inquire about soil "perc tests" required before any new construction can be initiated.

3. Invite a soil scientist from your local conservation district or the U.S. Department of Agriculture's Natural Resources Conservation Service to discuss local soil types with the class or obtain a soil survey report for your area. Discuss or investigate the implications local soil types have for agriculture, construction, home owners, and others. Ask the soil scientist to bring soil profiles or pictures of them, if possible. Upon what type of soil is your school built?

4. Place different-size metal balls (or plastic beads) in glass jars filled with an equal amount of water. Explain that the various balls (or beads) are similar to the different types of soil. The space between the balls is similar to pore space. Have students compare the water height. What does this show about the different types of soil?



5. See the FLP lesson "Till We or Won't We?" to learn about soil formation, soil erosion, and soil conservation. See the FLP lesson "Root, Root for Life" to learn about the importance of roots to soil. See the FLP lesson "From Apple Cores to Healthy Soil" to learn about soil nutrients and composting.

CREDIT

Relative size of particles drawing from U.S. Department of Agriculture, Natural Resources Conservation Service.

ADDITIONAL RESOURCES

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Flanagan, Alice, Linda Labbo, Terrance Young. *Soil*. Compass Point Books. 2000. ISBN: 0756500354.

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Snedden, Robert. *The Super Science Book of Rocks and Soils*. Raintree Steck-Vaughn. 1994. ISBN: 1568472242.

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EDUCATOR'S NOTES

Name(s):______________________________

SOIL SETTLING

1. Your teacher will mix soil and water in a clear, plastic soda bottle by shaking the bottle and will then set it down for you to observe. What do you think will happen? Record your guess or prediction here.	Draw a picture of your prediction here.
2. What is happening to the soil particles and water in the bottle immediately after shaking? Record your observations here.	Draw a picture here.
3. What is happening in the bottle 30 minutes after shaking? Is anything floating? Record your observations here.	Draw a picture here.
4. Observe the plastic bottle the next day. What happened? Record your observations here. Why do you think it happened?	Draw a picture here. With your teacher's help, label the three types of soil particles in your drawing above.

THE FEEL OF SOIL

Name(s):____

You and your partner(s) are going to discover the general texture of a soil sample.

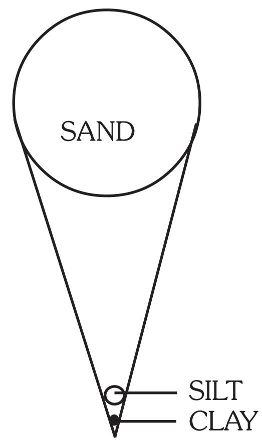
1. Place a small amount of soil from your soil sample in your hand, add drops of water slowly, and knead the soil to break up any clumps. When the soil is moist, not wet, it is ready to identify.

2. The soil texture is <u>mostly</u>
   Sand, if it:
   - feels gritty,
   - has grains (or particles) that can be seen, and
   - will not remain in a ball when squeezed.

   Silt, if it:
   - feels smooth like flour,
   - is not really sticky, and
   - forms a short snake and then breaks apart when rolled between hands.

   Clay, if it:
   - feels really sticky, and
   - forms a long snake when rolled between hands.

THE RELATIVE SIZE OF SAND, SILT AND CLAY



3. Our soil sample is mostly __________________. We know this because

   1.

   2.

   3.

4. Using a hand lens or magnifying glass, describe your sample (draw a picture too).

5. With another group, compare your samples. How are they the same? Different?