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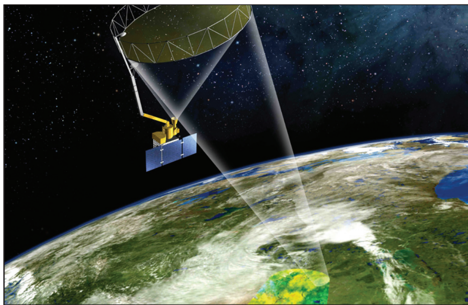


Dirt to Dinner

How does 0.001 percent of Earth's water keep you from going hungry? Soil moisture!

Grade Level
Middle School

Subject Areas
Science, Math, Agriculture

Duration
Preparation time: 45-60 minutes

Activity time:
Warm up: 10-20 minutes
Activity: One-two 50 minute classes
Wrap Up: 30-45 minutes

Setting
Classroom, gymnasium, schoolyard, park

Skills
Gathering (observing), Organizing (charting), Analyzing (identifying components and relationships, discussing), Interpreting (relating, identifying cause and effect, making models), Applying (predicting), Presenting (writing, demonstrating)

Vocabulary
Adhesion, capillary water, cohesion, combined water, decomposed, drought, elevation, evaporation, experimental control, free water, gravitational water, hydrologic, hygroscopic water, infiltration, mineral material, organic material, pore spaces, precipitation, runoff, saturation, slope, soil moisture, soil texture, soil-water balance, surface tension, topography, transpiration, water table

Summary
This activity gets students up and moving in a tag game format to learn about how water moves into, through and out of soil. Students use whole-body movement to model water, with soil, ground water, atmosphere and plants interactions.

Charting the Course

Prior to this activity you may want to review the water cycle with students. Project WET's *The Incredible Journey* ties in soil's role in the water cycle. Also visit www.DiscoverWater.org/water-cycle. Properties of water, including surface tension (cohesion) and adhesion are explored in Project WET's *H2Olympics*. In Project WET's *Get the Ground Water Picture* students model water movement through sand, silt and clay. All of these activities can be found in Project WET's *Curriculum and Activity Guide 2.0.*

Objectives

Students will:

- list the four components of soil—minerals, organics, water and air.
- model processes by which water moves into and out of soil due to gravity, evaporation and absorption by plants.
- compare gravitational (free) and capillary soil moisture.
- explore how different environmental factors (precipitation, soil texture, vegetation, topography and temperature) affect soil moisture.

Materials

Warm Up

- *Small plastic bag of soil*
- *Mixing bowl*
- *Sheet of paper (optional)*
- *Slice or loaf of bread*
- *Minerals—rocks and/or mineral samples*
- *Organics—twigs, leaves, grass*
- *Bottle of water*
- *Mixing spoon*
- *Magnifying glasses*

Part 1

- *Rope to mark boundaries*
- *Earth's Surface sign (**Soil Moisture Signs**)*
- ***Soil Particle nametags***
- *Water Table sign (**Soil Moisture Signs**)*
- *Copies of **Dirt to Dinner Student Copy Page** (one per student)*
- *Pens or pencils*
- *Copy of **Answer Key***

Part 2 and 3

- *All materials for Part 1*
- *Whiteboard and dry erase marker or large sheet of paper and marker*
- *Blue paper squares (or other objects, i.e. poker chips, total of sixty squares)*
- *Permanent marker*
- *Paper or plastic cup labeled "Atmosphere"*
- *Paper or plastic cup labeled "Surface Runoff"*

Part 4

- *All materials for Part 2*
- *Paper or plastic cups labeled "Soil Particle" (10)*
- *Paper or plastic cups labeled "Plant" (one per student)*

Soil is comprised of mineral material, organic material, air and water. PHOTO CREDIT: simplytheyu/iStockphoto

Demo Option

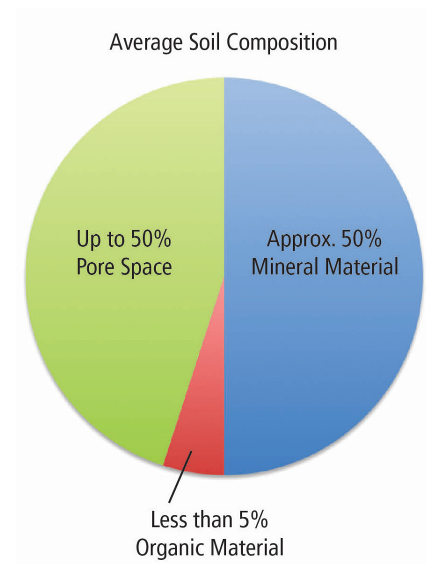
- *Copy of **Dirt to Dinner Demonstration***
- *Two egg cartons, one dozen each (optional)*
- *Markers*
- *Blue construction paper squares (at least thirty, approx. 0.5 inches square)*
- *Drinking straws (one per student)*

Making Connections

Do you ever think about soil when you are sitting at the dinner table? How about water? Perhaps you should start—you have soil moisture (the water in soil) to thank for all of the food on your plate! Soil moisture plays an important role in the food web. Soil moisture provides the water plants need to grow—plants which become ingredients in bread or feed the chicken or beef that end up feeding you. You may not realize it, but your life depends on soil moisture!

Background

We all know what soil is, but have you ever stopped to think about what soil is made out of and why it is so important? Soil is the top layer of Earth's surface and it contains four main components—mineral material, organic material, water and air. **Mineral material** in soil varies mainly depending on what types of rocks are found in the area. Rocks break down to form sand, silt and clay, which have different sized particles (sand particles are larger than silt particles, which are larger than clay particles). The composition of soil varies based on sand, silt and clay content and particle size. **Organic material** includes **decomposed** (broken down) twigs, leaves and other plant and animal matter from the surrounding plants and animals. An average soil contains about fifty percent mineral materials by volume. Less than five percent of soil is comprised of organic materials. Spaces between the soil particles called **pore spaces** contain air, which can account for up to half of the soil by volume. Water content in soil varies over time and space due to a variety of factors that will be explored in depth in this activity. Water in soil is called **soil moisture**. Soil moisture



accounts for about 0.001 percent of the total amount of water on Earth, yet without it, plants would not be able to grow.

Soils play a role in Earth's **hydrologic** or water cycle. Water enters soil from above as **precipitation** (rain or snow) or snow melt, and from below as ground water rises. The top surface of the ground water is called the **water table**. Soils store some water, and release most to ground water, plants, or the air. Water is absorbed through plant roots, moves through plants, and evaporates back into the atmosphere through a process called **transpiration**. Water in soil is subject to freezing, thawing or evaporating as temperatures fluctuate, which effects plant growth.

There are four types of soil moisture. **Gravitational water** or **free water** is water that stays in the soil a short time. It usually enters the soil as precipitation and filters through to ground water below due to gravity. At times, all of the pore spaces in the soil may fill with water before drainage and **evaporation** (the conversion of liquid water to vapor) cause it to dry out again. This condition when all the air in soil is replaced by water is called **saturation**. Gravitational water is only available to plants while it is in the soil, before it filters to the ground water below or evaporates. Gravitational water plays a role in moving finer particles downward through the soil creating coarser topsoil and denser subsoil.

Capillary water is leftover after gravitational water drains out. Capillary water is the relatively small amount of water that is held between the soil particles due to the forces of **cohesion** (**surface tension**—the attraction of water molecules to other water molecules) and **adhesion** (the attraction of water molecules to other surfaces) that are stronger than gravity. Capillary water is the primary source of water for plants, which makes it extremely important in relation to our food supply.

The other two types of soil moisture account for a very small amount of the total water in soil, and though important for other reasons, will not be addressed in this activity. **Hygroscopic water** forms a very thin film on soil particles due to adhesion. Plants are unable to access much hygroscopic water. **Combined water** is water that chemically bonds with soil particles. The chemical bonds are too tight for this water to be available to plants. It is only released through additional chemical reactions.

The amount of capillary water in soil greatly affects the soil's ability to support plant life. Data about soil moisture can help crop growers produce the most robust yields. Soil moisture data also helps us better understand and predict weather and climate changes, early **drought** (an extended period of below-average precipitation that affects crop production and water supplies) warning signs, the extent of flooding and even help to identify possible spread of diseases caused by insects that breed in standing water.

Soil moisture is affected by a variety of factors including **soil texture** (particle size), precipitation, vegetation (amount and type) and **topography** (landforms—hills, valleys, etc.). In general, soil particle size and soil moisture are inversely related. Soil layers made up of large particles retain less soil moisture. This is mainly due to gravitational water **infiltrating** (permeating through open spaces) easily through the larger pore spaces between larger particles. More

Many factors, such as precipitation and topography influence the soil moisture available to plants. PHOTO CREDIT: Joss/iStockphoto

Lack of soil moisture due to high temperatures can lead to loss of crops. PHOTO CREDIT: saints 4757/iStockphoto

precipitation potentially means more soil moisture, but the type and intensity of the precipitation affect the amount of soil moisture, too. Long, moderate rainfall has opportunity to soak into the soil, increasing soil moisture content in soil layers. Short intense periods of precipitation can cause flash floods because the soil cannot absorb the precipitation fast enough. Topography also influences soil moisture content. For example, soil moisture varies with **elevation** (height on a hill) and **slope** (degree to which a surface is tilted). Higher elevations generally have lower soil moisture, while lower elevations generally have higher soil moisture. This is because water flows downhill due to gravity. For the same reason steeper slopes generally hold less soil moisture than flatter areas. The amount of vegetation cover also plays a role in soil moisture content. More vegetation cover leads to more organic ground cover, which protects the surface soil from evaporation and retains soil moisture. Less vegetation cover leaves the soil exposed for soil moisture to evaporate.

On the ground, soil moisture for an approximately one square meter area can be measured using a probe like this one, but

PHOTO CREDIT:

with satellites we can measure soil moisture for much larger areas efficiently. NASA's new SMAP satellite will be able record soil moisture data for the first 5 cm depth of surface soil layer for areas between 3 to 36 square kilometers at a time, and will collect data for the entire planet once every two to three days.

Note to educators: The Warm Up for this activity reviews the composition of soil. Part 1 of this activity explores the types of soil moisture and the relationship between soil texture/particle size and soil moisture. Part 2 focuses on how precipitation and topography affect soil moisture. Part 3 adds temperature as a factor and Part 4 introduces the relationship between plants and soil moisture. The lesson builds upon itself, but the Warm Up and Parts 1-4 may also be used to teach each concept separately.

Procedure

▼ *Warm Up*

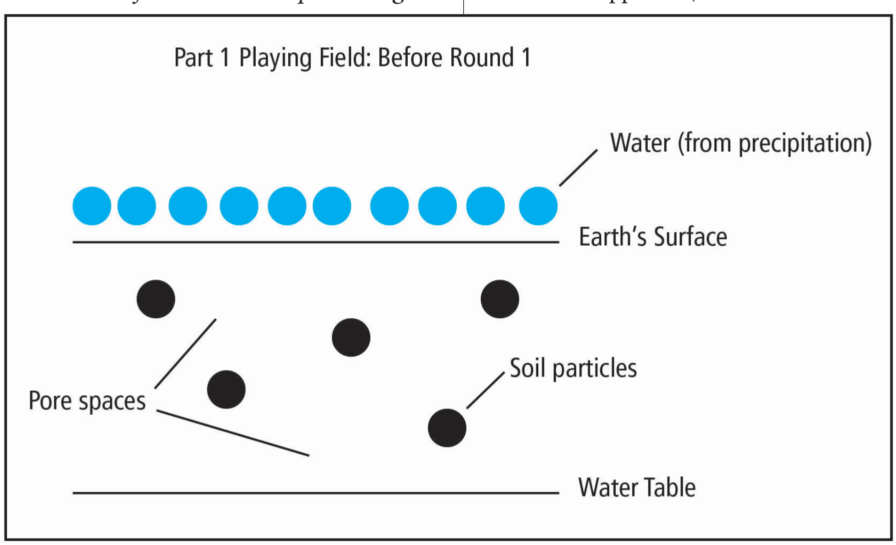
- Prior to the warm up, place a plastic bag of soil in the bottom of a mixing bowl. You may want to cover it with a piece of paper or other item to hide it from sight.

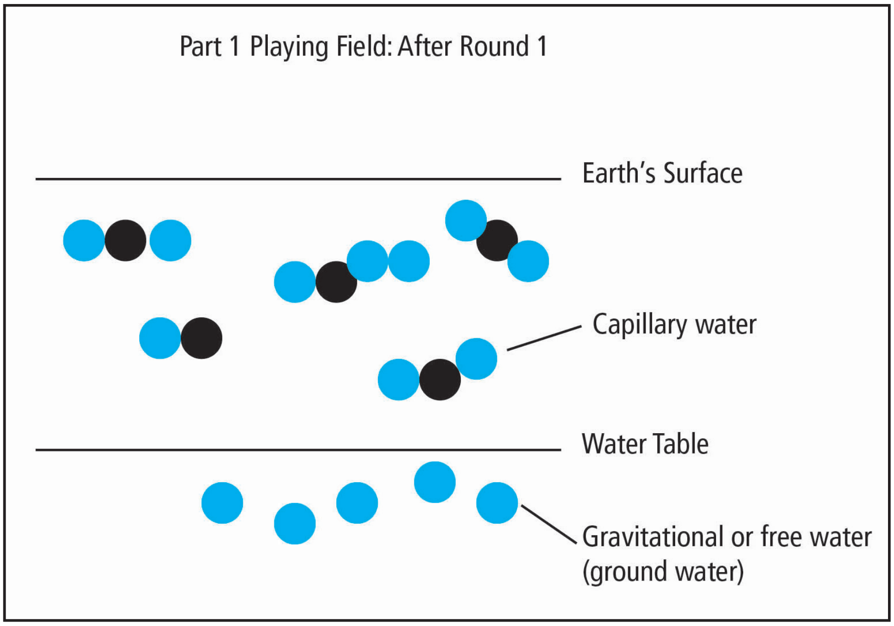
- Tell students they will be learning about soil in the following activity. Then show them the slice or loaf of bread and ask them if they can explain how it is connected to soil. They will likely discuss how soil is necessary for growing plants, but not elaborate on how soil and plants interact or soil moisture.
- Discuss how bread is made from various ingredients such as flour, sugar, water, etc. Discuss how water is necessary to grow the plants from which these ingredients are made (water is needed to grow wheat to make flour and sugarcane to make sugar). Discuss soil moisture's importance to plants and hence, students' food supply.
- Tell the class that instead of baking a loaf of bread you are going to explore the recipe for soil.
- Ask students what ingredients they think you need to make soil.
- Into the bowl add: minerals (rocks); organics (leaves and twigs); a bottle of water (just place the entire bottle in the bowl); and air (you can pretend to mix in air from around you)
- Stir—remove soil sample and pass around.
- Let kids touch the soil and look at it with magnifying glasses.
- Explain that soils vary depending on their "recipe"—amounts of minerals, organics, water and air.
- Ask students to discuss how the amounts of the "ingredients" might affect the soil "recipe".

The Activity

Part 1

1. **Explain to students that the group will now focus in on water in soils, or soil moisture.** The group will explore ways in which water moves into, through and out of soils, as well as environmental factors that affect the amount of soil moisture.
2. **First, students will play a game of tag to learn about how water moves through soil and important types of soil moisture.**
3. **Set up a playing field where one boundary represents the Earth's surface (mark with Earth's Surface sign), and the other parallel boundary represents the water table (don't mark with Water Table sign yet—the concept of the water table will be explained as the game progresses).**
4. **Choose five students to represent soil particles (both organic and mineral) and have them wear the soil particle nametags.** Students representing soil particles should stand between the Earth's surface and water table boundaries, facing the Earth's surface boundary. They should be scattered throughout the space so that they are near each other, but not touching. They will remain stationary but can lean and stretch to tag the other students. *(Note: it is critical that the five students representing soil particles fit into the defined playing field at such a density that some of the students representing water will be tagged. Be careful not to space the students representing soil particles out too far, or make the playing field too large. Adjust the size of the field accordingly.)*
5. **All of the other students represent water.** These students will demonstrate infiltration of water from precipitation through the pore spaces (area surrounding the soil particles) in the soil.
6. **On your mark, they will run from the Earth's surface boundary to the water table boundary.** This represents water raining onto the Earth's surface and then infiltrating (permeating through open spaces) through the soil. The role of each of the soil particles is to attempt to tag and capture one or two of the students representing water. If a student is tagged, he/she links arms with the soil particle. Each soil particle can catch two waters—one for each arm. Students who are caught by soil (adhesion) can attempt to catch other waters (cohesion). Water captured represents capillary water.
7. **Allow the students to run across once.** Several students should be caught as capillary water. Pause the game and ask students to explain what happened (some of the water





that came from precipitation was retained by soil particles due to the attraction of water to water (cohesion) and water to other surfaces (adhesion) as it filtered through the pore spaces in the soil). Explain to the students that the water caught by soil particles is called capillary water. The amount of capillary water is the soil moisture content. Count how many students became capillary water for this round. Explain that capillary water is the main source of water for plants. Explain that the rest of the water that filtered through as gravitational or free water has crossed the water table (top most surface of the ground water) and has become ground water—most plants' roots don't reach deep enough to tap into the ground water. Place the Water Table sign at the water table boundary.

8. **Explain that the size of pore spaces can affect how much water filters through the soil.** For the next round, have the five soil particles spread out further across the field to represent large pore spaces. Was more or less capillary water retained than when the pore spaces were smaller? Less water should be caught during this round and soil moisture content should be lower. Explain that this is an example of what might occur in a sandy soil where the particles are coarser or larger and so are the pore spaces which allows water to filter quickly through.
9. **For a third round, decrease the size of the field and have the soil particles stand closer together.** This time more water should be caught than in either of the previous rounds. Explain that this is an example of what might occur in a clay-rich soil where particles are finer or smaller and pore spaces are smaller and water filters more slowly.
10. **Hand out a copy of the Dirt to Dinner Student Copy Page to each student.** Have students label the diagram for Part 1 and make notes about how the soil moisture changed with changes in soil texture (you can discuss as a group—refer to **Answer Key** for explanations). Set **Dirt to Dinner Student Copy Pages** aside.
11. **Reset the game and play several rounds to allow students to try various roles.**

Part 2

1. **Now that students have a basic understanding about how water moves into and through soil, Part 2 will focus the effects of some environmental factors on soil moisture.**
2. **Explain to students that other environmental factors besides soil texture affect the soil moisture.** Part 2 will focus on two of these factors: precipitation and topography. Write precipitation on the board. Discuss what precipitation means and brainstorm ways in which precipitation could affect soil moisture.
3. **Explain to students that this first round will serve as an experimental control, or basis for comparison for additional rounds.** They will experiment in changing one factor affecting soil moisture in each additional round. The soil for the control round has the characteristics listed in the chart below (write them on the board—you can change each factor as it is addressed).
4. **Set up the game again, pointing out how the control factors are represented.**
5. **Choose five students to represent soil particles (both organic and mineral).** Students representing soil particles should stand between the Earth's surface and water table boundaries, facing the Earth's surface boundary. They should be scattered throughout the space so that they

Environmental Factor	Characteristics	Game Setup
Precipitation	Average	30 waters
Soil Texture	Silty	5 particles, moderately spaced
Topography	Flat	Boundaries are straight and parallel

are near each other, but not touching (same spacing as first round, Part 1). They should stand holding their hands out, palms upturned to collect water (blue paper squares) from the other students. Explain to everyone that for each round, you will secretly tell soil particles how many waters they may collect based on the environmental factors for that round. As soon as a soil particle gets that amount, they should put their hands down by their sides. All extra squares will be carried through to the ground water.

6. **The other students line up along the Earth's surface boundary.** They will be bringing the precipitation from the atmosphere into the soil. They should each gather blue squares that represent water from a cup labeled "atmosphere". For the first round the cup will contain thirty water squares (representing average precipitation). Divide the thirty squares by the number of students (minus the five soil particles) and instruct the students in how many squares each should take based on the class size—all thirty squares should be used (some students may have more than others).
7. **Explain to students that when the game starts, they will walk into the playing field.** Each soil particle will only be able to accept a certain number of water (in this case two squares each), but the other students won't know how many. (Secretly tell the soil particles that they can collect two squares each during this round.) As soon as a soil particle gets two squares, they should put their hands down by their sides. All extra squares will be carried through to the ground water.
8. Start the game. When all students have passed through to the ground water, pause the game and have the soil particles count the amount of water they retained. This number will be the value for soil moisture content for the control round. Each additional round will examine how different factors affect the amount of soil moisture in comparison to the control round.
9. **Collect all the blue squares from the students.**
10. **Ask students to retrieve their Dirt to Dinner Student Copy Page.** Have them record their observations and soil moisture value for the control round in Part 2. Explain that for each factor each student will make and record a prediction as to whether the environmental change will increase, decrease or not change the soil moisture compared to the control round, and the reasons behind why they made that prediction. Then ask them to write down a prediction for the next round—how will a long, slow rainstorm affect soil moisture and why? For each round the instructor will also need to make adjustments to the game according to the **Answer Key**. Don't explain the changes you make to the students—they will predict how changes affect soil moisture and collect data to test their predictions.
11. **Set up for the next round using the Answer Key to guide the setup.** Place the cup labeled "atmosphere" outside of the Earth's surface boundary. Explain to the students that in this round, everything else will stay the same, but there will be a long slow rainstorm. This time, put sixty blue squares into the atmosphere cup to represent more available moisture. Secretly tell the soil particles they can retain four squares this time. Play the game the same as before, but this time students must crabwalk to represent a slow rain. When all the students have reached the other boundary, have the soil particles count and report the new soil moisture content—it should be higher than the control round.
12. **Collect the blue squares from the students.**
13. **Have students record the soil moisture value for this round on their Dirt to Dinner Student Copy Page.** Then ask them to write down a prediction for the next round—will a short, intense rainstorm increase, decrease or not change the soil moisture as compared to the control?
14. **Set up for the next round. Explain to the students that in this round, everything else will stay the same, except precipitation.** There will be a short, intense rainstorm. Place the cup labeled "Surface runoff" near the Earth's surface boundary. Put sixty blue squares into the atmosphere cup to represent more available moisture. Explain that during an intense rainstorm there is not enough time for all the water to be absorbed by the soil and much ends up as **runoff** (precipitation that flows over the land surface)—even flash floods. To demonstrate and represent surface runoff take twenty squares out of the atmosphere cup and put them in the surface runoff cup where they are unavailable to students (there should be forty squares left for students in the atmosphere cup). Explain that the surface runoff cup represents water that cannot soak in to the soil fast enough during the intense storm. Secretly tell the soil particles that they can retain three squares each. Play the game the same as before. When all the students have reached the other boundary, have the soil particles count and report the new soil moisture content—it should be

higher than the control round, but lower than the long rainstorm round.

15. **Collect the blue squares from the students and remove the surface runoff cup.**
16. **Have students record the soil moisture value for this round.** Discuss the relationship between precipitation and soil moisture. Return to your notes on the board. Discuss ways this model might be used to test other hypotheses about precipitation and soil moisture (e.g. how does snowmelt affect soil moisture? A fast snow melt, a slow snowmelt?).
17. **Now write the word topography on the board.** Discuss what topography means and specifically discuss elevation (top and bottom of a hill) and slope (gradual vs. steep). Explain that the soil on the top of the hill has less available moisture because water flows downhill due to gravity.
18. **Now have students study the topography diagram on the Dirt to Dinner Student Copy Page page.** Ask them to write predictions relating to each area of the diagram as to whether each area has higher, lower or the same amount of soil moisture as the control soil (flat).
19. **Discuss student predictions and actual soil moisture for topography factors.** Use the **Answer Key** for explanation.

Part 3

1. **When students have finished the topography section of the Dirt to Dinner Student Copy Page, return to the playing field.** This time we will experiment with changing the temperature. Ask students to think about what happens to water as temperature increases (it evaporates) and decreases (it freezes). Explain that water in soil is subject to these same processes and that temperature has an effect on soil moisture. Explain that over time, soil loses capillary water through evaporation.
2. **Students will play a new control round to account for the addition of evaporation.**
3. **Set up the playing field as before with two boundaries, five soil particles spaced moderately.** Precipitation will be average so put thirty squares in the atmosphere cup. Play the game the same as before, students must walk and the soil particles can each collect two squares. When all the students have reached the other boundary, pause the game. Ask the soil particles to count their waters and give a soil moisture content value. This should be the same as the initial control from Part 2. Now introduce the idea of evaporation. Explain that to some degree, evaporation is occurring all the time. The instructor, who represents evaporation from the soil, enters from the surface and removes one water square from each soil particle and returns it to the atmosphere. Now have the soil particles count and report the new soil moisture content. This number will represent the new control factoring in evaporation at the moderate temperature of 65°F. Collect all water squares. Have students record this soil moisture content on the **Dirt to Dinner Student Copy Page**.
4. **Set up for the next round. Explain to the students that in this round, everything else will stay the same, but the temperature will be 90°F.** Ask students to predict whether soil moisture will increase, decrease or remain the same as in the control round they just played. Put thirty blue squares into the atmosphere cup to represent average precipitation. Secretly tell the soil particles that they can retain two squares each. Play the game the same as before with students walking. When all the students have reached the other boundary, pause the game. Explain that due to the high temperatures, there is increased evaporation from the soil. The instructor, who represents evaporation from the soil, enters from the surface and removes eight of the ten water squares from the soil particles and returns them to the atmosphere. Now have the soil particles count and report the new soil moisture content. It should be lower than the control. Ask students to discuss the concept of drought.
5. **Reset the game the same as above.** This time, explain that temperatures have dropped below 32°F for several days. The soil and water has frozen and no one can move. Discuss what the consequences of freezing temperatures might be for soil and for plants.

Part 4

1. **Explain to students that in Part 4 they are going to learn why soil moisture is vital to plants, and therefore to humans.** Review that along with water, humans need food

Environmental Factor	Characteristic	Game Setup
Precipitation	Average	30 waters
Soil Texture	Silty	5 particles, moderately spaced
Topography	Flat	Boundaries are straight and parallel
Temperature	Average	65°F

to survive. Humans depend on plants as part of the food web to sustain themselves (humans eat plants and animals that eat plants).

2. **Explain to students that for this part of the activity, they will now become plants.** The field remains the same, but soil particles are now represented by ten soil particle cups, and the capillary water the plants need is represented by blue paper squares inside the cups. These cups are scattered throughout the playing field. Each cup contains five squares of water.
3. **The students line up along the Earth's surface boundary.** Each student receives a cup labeled "plant". They should choose a location to place their plant cup along the Earth's surface boundary.
4. **Explain to students that when the game starts, they will represent their plant's roots.** They will run into the playing field, locate a soil particle with capillary water, take one piece of paper, and return to their cup to deposit it. They will then run into the field looking for more water, collecting it one piece at a time. As long as their plant cup contains water, the plant stays alive.
5. **Explain to the students that plants are also constantly losing water to the atmosphere through transpiration.** This will be represented by the instructor systematically, and continually removing water one square at a time from each of the plant cups, and placing them into the cup labeled "atmosphere".
6. **Tell the students they should continue to retrieve water from the soil and place it in their plant cup until they can't find any more.** At that point they should return to their plant cup. Transpiration will continue to occur. As the remaining water in their cups disappears, students should "wilt" (collapse on the ground) to represent the plant wilting.
7. **Ask the students to discuss how soil moisture affects plants, and how plants can affect soil moisture.** Assign students to write a paragraph on their **Dirt to Dinner Student Copy Page** addressing how soil moisture affects plants and plants affect soil moisture.

Wrap Up

- Students have now examined a variety of factors that influence the amount of water in soil, or soil moisture. The balance between the amount of moisture maintained and lost as water goes into, through and out of soil is called **soil-water balance**. Students should understand that soil moisture is complicated, but they should also have some idea about how various factors specifically affect it.
- Gather the group with their D**irt to Dinner Student Copy Pages** to discuss factors affecting soil moisture using the discussion prompts on the **Answer Key**. (Alternatively, you may choose to discuss each factor as you finish each part of the activity. It is not necessary to complete all activity parts for students to understand that many environmental factors influence soil moisture.)
- Discuss the importance of soil moisture in the food web. (Along with water, humans need food to survive. Plants are able to grow because of soil moisture. Humans depend on plants as part of the food web to sustain themselves. Humans eat plants and animals that eat plants).
- Discuss seasonal changes in soil moisture based on temperature.
- Discuss diurnal changes in soil moisture based on temperature.
- Discuss ways in which multiple environmental factors could affect soil moisture at the same time. For example, discuss soil moisture scenario outlined in the chart below.
- Discuss additional scenarios varying more than one environmental factor.

Demo Option

1. **Complete the Warm Up to help students understand of the components of soil.**
2. **Use the Dirt to Dinner Demonstration provided, or create a three-dimensional model of the demo using two egg cartons (the advantage to using egg cartons is the demo can be displayed vertically for context).**
3. **Show students the model of the atmosphere, plants, soil and groundwater.**
4. **Start the demo by placing three squares of paper in each atmosphere cell and two squares in each ground water cell.** Explain that there is always water in the atmosphere and underground as ground water.
5. **Ask students what happens when it rains (water soaks into the soil).** Have students help you move paper squares from the atmosphere into the soil (you may want to demonstrate a

Environmental Factors	Characteristics
Precipitation	Intense 30 minute thunderstorm
Soil Texture	Sandy
Vegetation	Some vegetation cover
Topography	Steep slope
Temperature	Average

little water running off the surface—talk about puddles, storm water, etc.).

6. **Once there are three squares in each soil cell, explain that some of the water that soaks into the soil filters through the pore spaces in the soil and becomes ground water.** Have students move one square from each soil cell down to the ground water. Explain that the ground water has been recharged (you could talk about the water table and how it moves up and down here, too).
7. **Explain that the leftover water in the soil is called capillary water and it is the water plants use to grow.**
8. **Now, assign each student a plant cell—they will represent a plant.** If using the **Dirt to Dinner Demonstration** sheet, you can have each student write their name in their cell. They will use their straw to represent plant roots and use it to remove capillary water from the soil and move it to the plant. The plant with the most water will grow the largest. Plants can only get water from the soil cells (not the ground water). Explain that plants also transpire meaning water evaporates from their leaves. The instructor will systematically remove one square at a time from each plant to represent transpiration.
9. **The game ends when there is no more capillary water to collect.** You can stop and see which plant grew larger (which plant had more water).
10. **Create additional scenarios demonstrating factors affecting soil moisture (precipitation events, soil texture, vegetation cover amount, topography and temperature).**

Assessment

Have students:

- list the four components of soil. (**Warm Up**)
- draw and label a diagram comparing capillary and gravitational or free soil moisture. (**Part 1**)
- draw and label a diagram describing how topography affects soil moisture. (**Part 2**)
- describe what happens to soil moisture at high, moderate and low temperatures. (**Part 3**)
- discuss and/or model how soil moisture impacts plants and how plants impact soil moisture (**Part 4**)
- predict how multiple environmental factors (precipitation, soil texture, vegetation, topography and temperature) might affect soil moisture. (**Wrap Up**)

Extensions

Have students randomly select environmental factors to describe a soil and have each student write a paragraph describing how these factors might affect the soil moisture for their unique soil sample.

Have students collect soil samples from one or more local sites and describe environmental factors that might affect soil moisture for each sample.

Teacher Resources

Videos

NASA SMAP eClips Videos:

Our World (elementary school level): http://bit.ly/1iXxQ4I

Real World (middle school level): http://bit.ly/18DrZux

Launchpad (high school level): http://bit.ly/IFYOU6Qb

Websites

https://smap.jpl.nasa.gov/

Earth's Surface

Water Table

Soil Particle

Soil Particle

Soil Particle

Soil Particle

Soil Particle

Dirt to Dinner Student Copy Page

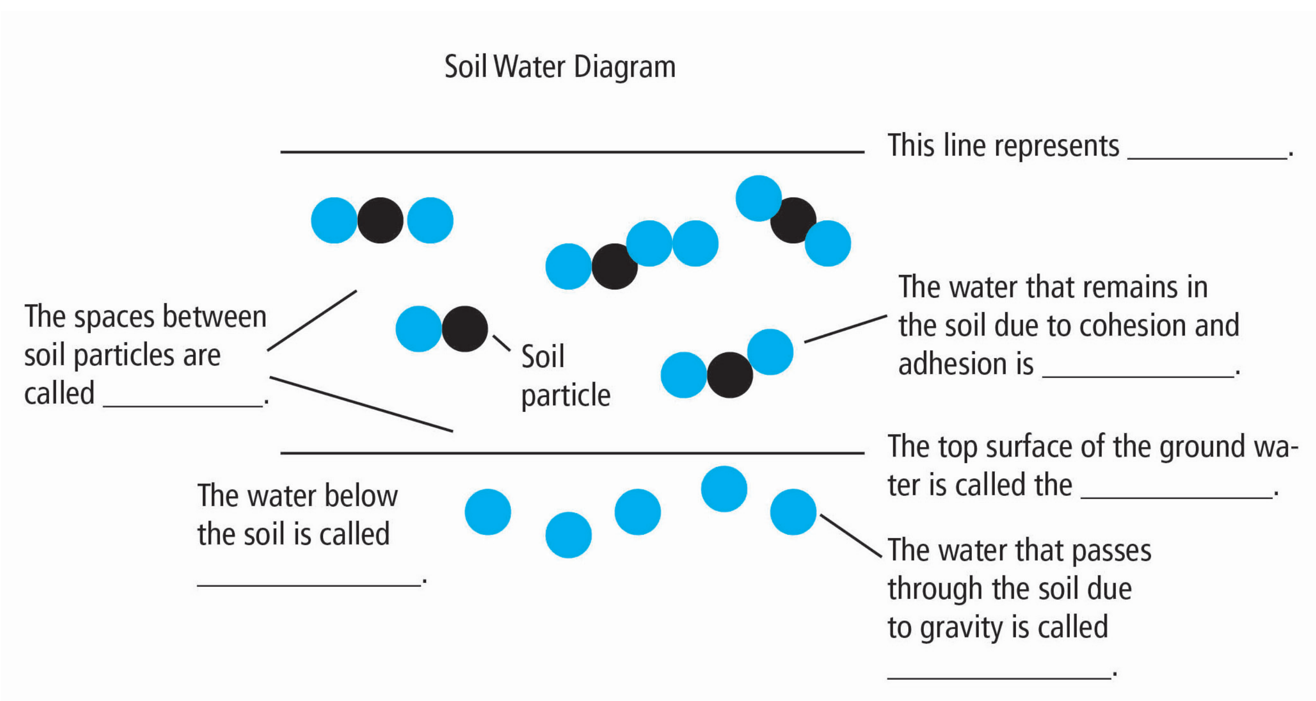
KIM Vocabulary Chart

As you encounter new vocabulary words throughout this activity, add them to this chart along with information including definition and a drawing or other memory cue to help you remember the word and its meaning.

Key (Vocabulary word, part of speech, synonyms, etc)	Information	Memory Cue

Part 1

Label the diagram.



Record observations about how different soil textures affect relative pore space and capillary water.

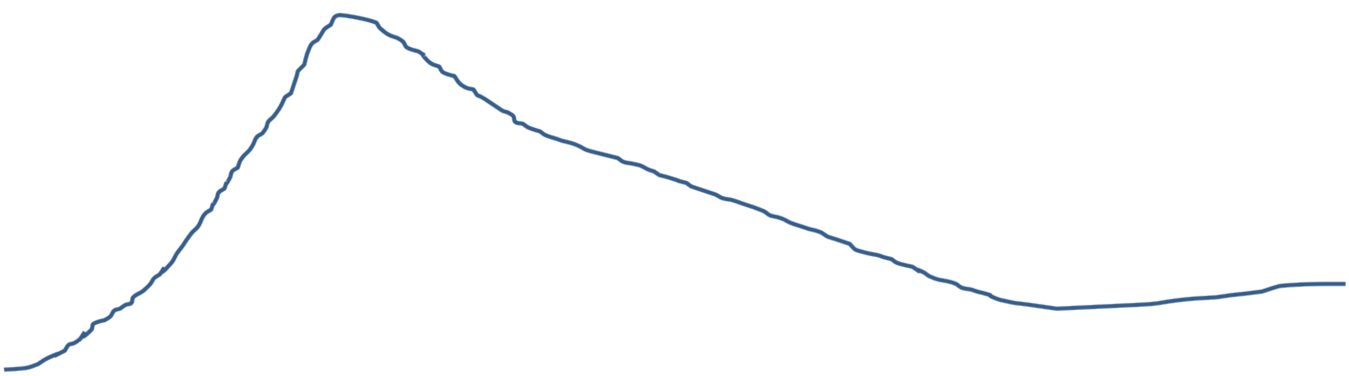
	Soil Texture	Pore spaces	Capillary water
Part 1	Silty		
	Sandy		
	Clay-rich		

Part 2

Precipitation

	Environmental Factor	Soil Moisture Prediction	Reason for Prediction	Actual Soil Moisture	Was your prediction correct? Explain.
Part 2	CONTROL: Precipitation—average	n/a	n/a		n/a
	Precipitation—long, gentle rainstorm				
	Precipitation—short, intense rainstorm				

Topography



	Environmental Factor	Soil Moisture Prediction	Reason for Prediction	Was your prediction correct? Explain.
Part 2	Topography—top of hill			
	Topography—bottom of hill			
	Topography—gradual slope			
	Topography—steep slope			

Part 3

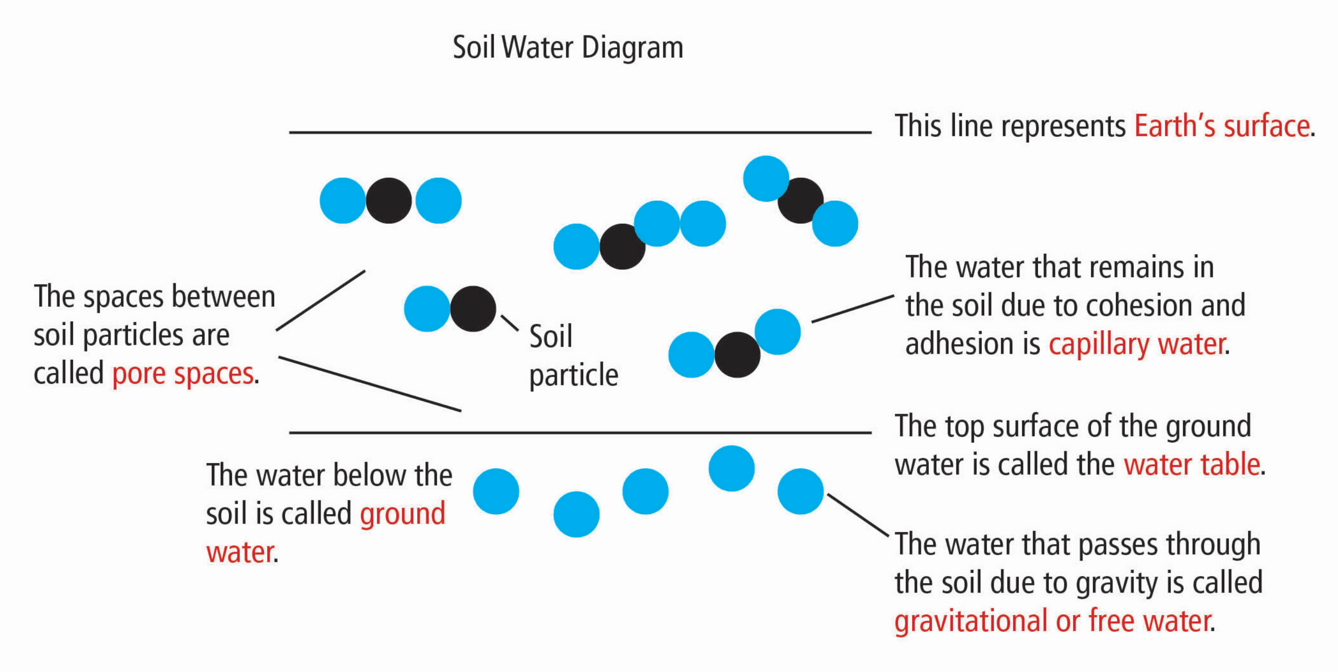
	Environmental Factor	Soil Moisture Prediction	Reason for Prediction	Actual Soil Moisture	Was your prediction correct? Explain.
Part 3	Temperature—moderate	n/a	n/a		n/a
	Temperature—high				
	Temperature—low, below freezing				

Part 4

Write a paragraph explaining how plants can affect soil moisture and how soil moisture can affect plants.

Dirt to Dinner Answer Key

Part 1



	Soil Texture	Pore spaces	Capillary water	What's going on here?
Part 1	Silty	Moderate	Moderate soil moisture	Silt particles are moderate in size compared to sand or clay.
	Sandy	Large	Less soil moisture	Because sandy soil contains larger soil particles and larger pore spaces (than silty soil), gravitational water filters more quickly through it, so less is retained as capillary water. Therefore, compared to the control soil a sandy soil will have lower soil moisture.
	Clay-rich	Small	More soil moisture	Because clay-rich soil contains smaller soil particles and smaller pore spaces (than silty soil), gravitational water filters more quickly through it, so more is retained as capillary water. Therefore, compared to the control soil a clay-rich soil will have higher soil moisture.

Part 2

Precipitation

Note to educator: Values below should hold true for any group size if five students play the role of soil particles and the number of paper squares to start with is divided evenly among the rest of the group.

	Environmental Factor	Atmosphere (start)	Soil Particles	Soil Moisture	What's going on here?
Part 2	CONTROL: Precipitation—average	30	2 squares each	10	Observed—Moderate
	Precipitation—long, gentle rainstorm	60	4 squares each	20	Long, slow precipitation event allows most of the water to soak into the soil. Some will filter through as gravitational water, but this will recharge capillary water. Control soil will have higher soil moisture content after this event than before.
	Precipitation—short, intense rainstorm	60	3 squares each	15	Short, intense precipitation event does not allow time for most of the water to soak into the soil. Some water will soak in, but most will remain on surface. Control soil will have a slightly higher soil moisture content after this event than before.

Topography

	Environmental Factor	Soil Moisture Prediction	Reason for Prediction
Part 2	Topography—top of hill	Less than control	Due to gravity, any precipitation that falls on a hill will flow downhill making less moisture available to soil at the top of a hill than would in a flat area. Therefore, less soil moisture is retained by a soil at the top of a hill than in a flat area.
	Topography—bottom of hill	More than control	Due to gravity, any precipitation that falls on a hill will flow downhill making more moisture available to soil at the bottom of a hill than would be in a flat area.
	Topography—gradual slope	Less than control	Due to gravity, any precipitation that falls on a gradual slope will flow downhill faster than precipitation that falls on a flat surface making less moisture available to soil on a gradual slope than on soil on a flat surface.
	Topography—steep slope	Less than control and less than gradual slope	Due to gravity, any precipitation that falls on a steep slope will flow downhill much faster than precipitation that falls on a flat surface making less moisture much less available to soil on a steep slope than on soil on a flat surface.

Part 3

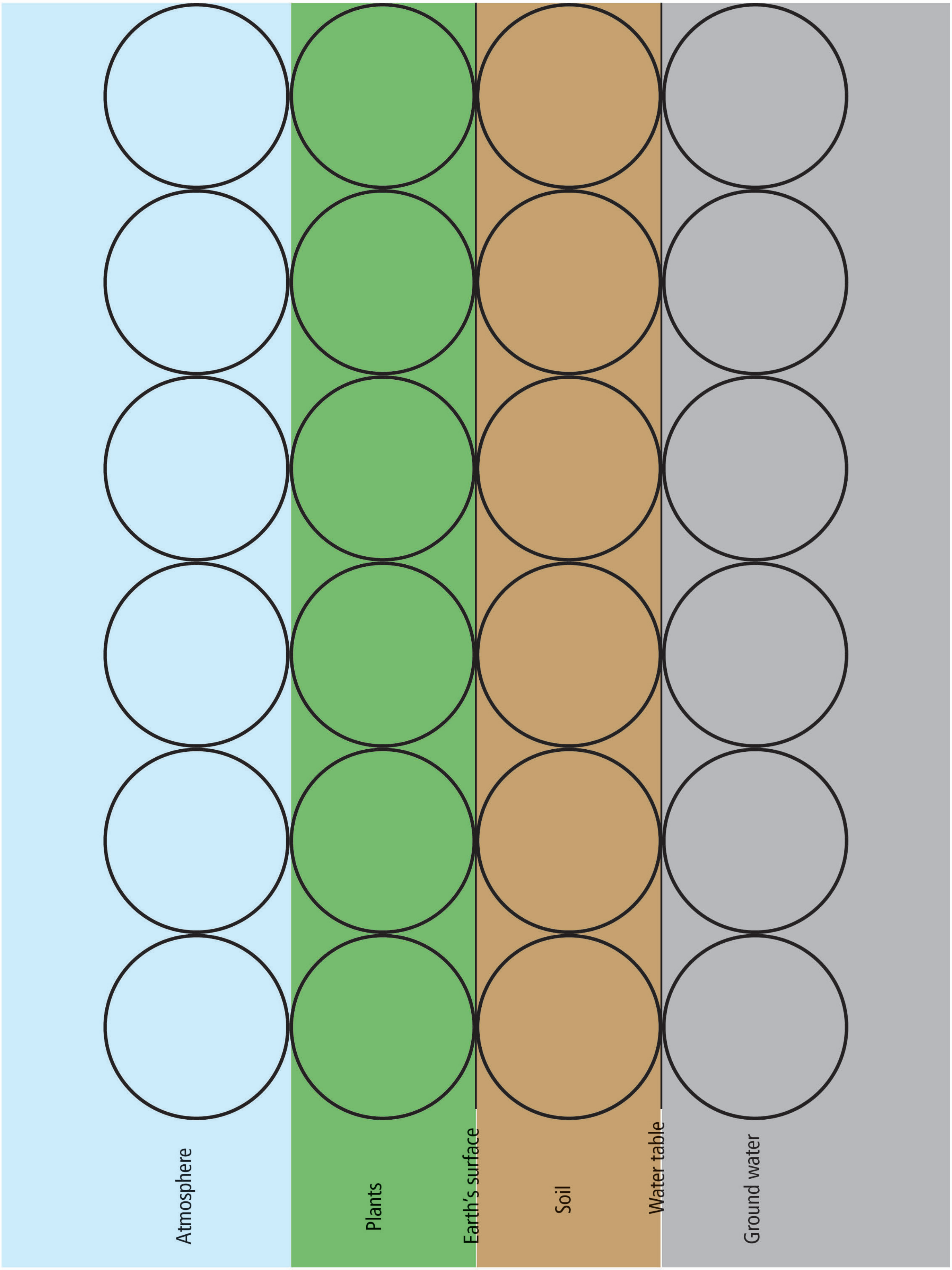
Note to educator: Values below should hold true for any group size if five students play the role of soil particles and the number of paper squares to start with is divided evenly among the rest of the group.

	Environmental Factor	Atmosphere (start)	Soil Particles	Lost to Evaporation	Soil Moisture	What is going on here?
Part 3	Control	30	2 squares each	5 squares	5	All other factors being the same as before, soil moisture decreases when evaporation increases.
	High Temperature	30	2 squares each	8 squares	2	High temperatures cause more water to evaporate from soil and transpire from plants. A soil subjected to high temperatures will have a lower soil moisture content than a soil in average temperatures.
	Low Temperature	30	2	0-freezing	10—but not available	Low temperatures cause less water to evaporate from soil and transpire from plants. A soil subjected to low temperatures will have a lower soil moisture content than a soil in average temperatures. However, the soil moisture in a soil subjected to freezing temperatures will freeze and all processes will stop until the soil thaws.

Wrap Up

Discussion Prompts

- Does soil texture affect soil moisture? (yes) How? (In general, water filters more quickly through larger particles, which means water moves more quickly through sand than silt or clay).
- Does precipitation affect soil moisture? (yes) How? (In general, more precipitation means more soil moisture and less means less soil moisture.)
- Does type of precipitation event affect soil moisture? (yes) How? (long slow storms increase soil moisture much more than short intense storms.)
- Does elevation (top or bottom of a hill) affect soil moisture? (yes) How? (Because water flows downhill due to gravity, the soils at the top of a hill are drier than those at the bottom).
- Does temperature affect soil moisture? (yes) How? (In general, higher temperatures increase evaporation and lower soil moisture content while lower temperatures and less evaporation help retain soil moisture. Freezing temperatures freeze water in the soil and in plants and slow or stop the movement of soil moisture to plants).
- Does precipitation affect plant growth? (Yes, in general more precipitation means more water available for plants, and less precipitation means less water available for plants).
- Does vegetation cover affect soil moisture? (yes) How? (More vegetation cover means more soil moisture because the organics protect the soil from evaporation.)


Atmosphere
Plants
Earth's surface
Soil
Water table
Ground water