THE SCIENCE OF
Food

# What Is Soil Made Of?

Activity from *The Science of Food Teacher's Guide: From Ecosystems to Nutrition* and for *The Mysterious Marching Vegetables*

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BioEd[SM]
Teacher Resources from the
Center for Educational Outreach at
Baylor College of Medicine

Fourth edition. First edition published 1997.
Printed in the United States of America

ISBN: 978-1-888997-76-7

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This publication and educational unit were made possible by grant number R25 RR13454 from the National Center for Research Resources (NCRR) and by grant number R25 ES10698 from the National Institute of Environmental Health Sciences, (NIEHS). NCRR and NIEHS are components of the National Institutes of Health (NIH). The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the official views of Baylor College of Medicine, NCRR, NIEHS or NIH.

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**Acknowledgments**
The Science of Food educational materials, first developed as part of the My Health My World® project at Baylor College of Medicine, have benefited from the vision and expertise of scientists and educators from a wide range of specialties. Our heartfelt appreciation goes to Michael Lieberman, M.D., Ph.D., William A. Thomson, Ph.D., and Carlos Vallbona, M.D., who have lent their support and expertise to the project.

Special acknowledgment is due to our partners in this project, American Physiological Society (APS) and the Texas Medical Association. We especially thank Marsha Lakes Matyas, Ph.D., and Katie Frampton of APS for their invaluable direction of field testing and dissemination activities in the Washington, D.C. area.

We are indebted to the Science Education Partnership Award Program of the NCRR and to L. Tony Beck, Ph.D., for supporting the development and field testing of this unit. We also thank the National Institute of Environmental Health Sciences, Allen Dearry, Ph.D., Frederick Tyson, Ph.D., and Liam O'Fallon for their support of the My Health My World project and the related Environment as a Context for Opportunities in Schools (ECOS) project.

Many dedicated professionals helped assure the educational and scientific integrity of this publication. In particular, we are grateful to the following individuals who provided guidance: Joan Carter, R.D., Kimberly Chang, Ph.D., Marta Fiorotto, Ph.D., Katie Frampton, Michael Grusack, Ph.D., Kyle Roberts, Ph.D., Saundra Saunders, M.A., and Faye Sinnott.

We are especially grateful to the many classroom teachers in Washington, D.C., and Houston, Texas, who field tested these materials and provided invaluable feedback.

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# Building Blocks for Food

Physical Science Basics

### THERMIC REACTIONS

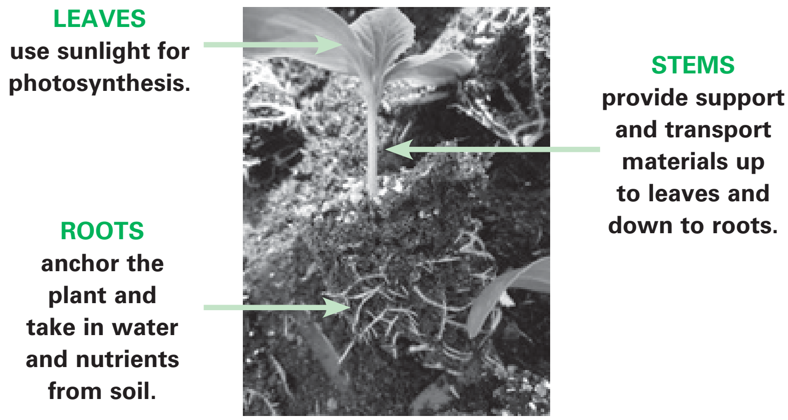
Endothermic reactions (endo = inside; thermic = heat) require energy to be added. During photosynthesis, for example, light energy is used to power the manufacturing of sugars. In fact, photosynthesis involves a series of endothermic reactions.

Reactions that release heat are known as exothermic (exo = outside; thermic = heat). The breakdown of sugars inside our bodies to release energy is an example of an exothermic reaction. Excess energy released as heat helps keep us warm.

A chemical reaction takes place any time substances come together and are transformed into new substances. The rising of a cake in the oven, the powering of an automobile by gasoline and digestion of food within our bodies all are examples of chemical reactions.

Did you know that heat energy is measured in calories? One calorie represents the amount of heat that it takes to raise the temperature of one cubic centimeter of water (10 milliliters) one degree. The Calories reported on food labels are kiloCalories (1,000 calories).

All the food on our planet depends on the sun and on nutrients in soil and water. You never may have thought about it in this way, but the food that we and all other animals eat ultimately comes from very simple raw materials put together by green plants and their relatives.




The healthy root system of this melon seedling shows it is ready for transplant into a larger container. Photo © Martyn Garrett, ossettweather.blogspot.com.

All living things need energy and nutrients to grow, move and stay warm. Some are able to capture energy directly from the sun through a process known as photosynthesis. Green plants, algae, “seaweeds” and some bacteria are examples of organisms that use energy directly from the sun to make their own food. The trapped energy is stored in food molecules, such as sugars and starches. Photosynthesis relies on carbon dioxide from air and water from soil. Soil also provides other essential minerals and nutrients for plants.

Soil consists of bits of mineral rock; pieces of animal and plant material; living things, such as bacteria, fungi, plant roots, insects and other animals; air spaces; and water. Soils develop slowly over time from weathered rock and sand.

The following activity introduces students to soil, which provides two of the three building blocks for photosynthesis. The role of light, another requirement for plant growth, is explored in Activity 3 of this guide. Additional activities on light and light energy can be found in The Science of Global Atmospheric Change unit. Activities on water are the focus of the The Science of Water unit.

# What is Soil Made Of?

Physical Science

Carbon, oxygen and hydrogen are the building blocks of the molecules that make up our bodies, our foods and even the fuels we burn. These elements are combined during photosynthesis to make energy-rich materials, such as sugars and other carbohydrates (starches). Plants obtain hydrogen from liquid water ($H_2O$). They obtain carbon from carbon dioxide ($CO_2$) gas in air. Oxygen is part of both water and carbon dioxide, and is present as oxygen gas ($O_2$) in air. However, all living things, including plants, require additional materials to carry out the chemical processes necessary for life.

**Unit Links**

***The Mysterious Marching Vegetables***
Story, p. 6–8;
Science box, p. 8

Where do these other materials come from? Most of them are released into water from soil. Plants and plant-like organisms, such as algae, absorb nutrients dissolved in water. Examples of these nutrients include nitrogen, phosphorous and potassium. Non-photosynthetic organisms obtain the minerals and more complex molecules that they need by consuming plants and other living things. Thus, the nutrients in soil are important not only for supporting plant growth, but also for assuring that other organisms are able to grow and survive.

Soil has both living and non-living components. It constantly changes through the action of weather, water and organisms. Soil formation takes a very long time—up to 20,000 years to make 2.5 cm of topsoil! This is only as deep as a quarter standing on its side!

The non-living parts of soil originated as rocks in the Earth's crust. Over time, wind, water, intense heat or cold, and chemicals gradually break rocks into smaller pieces, a process known as weathering. The size and mineral composition of the tiny rock particles determine many of the properties of soil.

Most soils are enriched by decomposed plant and animal material. Soil is home to many kinds of organisms: bacteria; fungi; algae (plant-like organisms that live in water or moist environments); earthworms; insect larvae; and plant roots, to name a few. Soil also contains many tiny air spaces. Typical garden soil is 25% water, 45% minerals, 5% material from living organisms and 25% air.

## SETUP

This activity works best with a recently dug sample of natural soil (from a field, yard, garden or the playground). About one large shovelful will be enough for the entire class. Collect the soil 24 hours or less before conducting the activity and store it in a large plastic bag (do not seal completely). Read "Safety," page 3.

Have students work in groups of 2–4 to conduct the activity.

## CONCEPTS

- Soil is a combination of many different living and non-living things.
- Soil provides raw materials needed by all living things.

## OVERVIEW

Students explore a sample of natural soil by identifying and separating its different components.

## SCIENCE, HEALTH & MATH SKILLS

- Observing
- Measuring
- Recording observations
- Drawing conclusions

## TIME

**Preparation:** 10 minutes for each session
**Class:** 30 minutes for each of 2 sessions

## MATERIALS

**Each group will need:**

- 2 cups of natural soil
- 2 paper plates
- 1/2 tsp of alum
- Clear soft drink bottle with screw-on cap, 2-liter size
- Measuring cup
- Metric ruler
- Newspapers to cover work area
- Copy of "Soil Observations" sheet

**Each student will need:**

- Craft stick, toothpick or coffee stirrer
- Hand lens (magnifier)

## SOIL LAYERS

Soils usually are layered. This layering can be observed along the sides of new roadways or in a recently dug hole. The top layer of soil consists of partially broken down plant and animal material, called humus. Immediately below is a layer of soil, enriched with tiny particles of dead plant and animal material. Below that is the first layer of mineral soil. It consists of 50–70% mineral particles, combined with plant and animal (organic) material. Even further down, there may be several more layers, made up of mineral soils with progressively less organic material. The deepest soil layers are similar to the original mineral rocks from which the soil was formed.



## SAFETY

You may want to sterilize soil by baking it at 375°C for 30–40 minutes. Or microwave loosely covered damp soil at full power for seven minutes. You also can create your own soil mix for students by combining packaged top soil and sand with a small amount of mulch.

## PROCEDURE

**Session 1: Looking at soil**

1. Direct students to cover their work areas with newspapers. Have the Materials Manager from each group measure about 2 cups of soil onto a paper plate and bring the soil back to their group.
2. Have students place about 1/2 of their group's soil in the center of their work area. Have them take turns describing the soil, using all of their senses, except taste. Ask, *What does the soil look like? How does it smell? How does it feel?*
3. Ask each student to write three words that describe some aspect of the soil sample on his or her student sheet.
4. Next, direct students to spread out the sample (using toothpicks, popsicle sticks, etc.) and to observe the different components of the soil sample. Ask, *What are some of the things that you can see in the soil?* Possibilities include twigs, pieces of leaves, plant roots, insects, worms, small rocks and particles of sand. Ask, *What are some things in soil that we can't see?* Answers may include air, water and microorganisms.
5. Have students list or draw the different things they find in their soil samples. Suggest that they think about and classify the different components of soil as coming from living or non-living sources.

**Session 2: Soil texture**

1. Each group will need a soft drink bottle (with cap) and the other half of its soil sample.
2. Ask students to describe the different components of the soil they investigated during the previous session. Tell them that now they are going to observe the make-up of soil in a different way.
3. Have each group add about 1/2 cup of soil and 1/2 teaspoon of alum to the soft drink bottle, then add water until the bottle is 3/4 full. If students have difficulty pouring soil into the bottle, have them make a paper funnel by rolling a sheet of paper into a cone shape.
4. Direct students to cap the bottles tightly and shake the bottles for about one minute.
5. Next, have students place the bottles in the centers of the groups' work areas and observe how quickly or slowly the different types of particles settle.
6. When layers are visible at the bottom of the bottle, have students measure and mark the layers and draw their observed

results on their student sheets. To facilitate accurate measuring, you may want to instruct students to fold a sheet of paper lengthwise, hold it against the side of the bottle, and mark the boundaries of each layer on the paper.

7. After students have completed their observations, invite the groups to share their observations. Ask, *How many different layers did you find? What was on the bottom? What was on the top?* The heaviest particles, such as sand and rocks, usually will make up the bottom layer, followed by fine sand and silt. Some clay particles are so tiny that they will remain suspended in the water. Plant and animal material also may remain floating at the top of the water. You also might ask, *Of what do you think soil is mostly made?*

## VARIATIONS

- Create unique soil samples for each group by mixing varying amounts of soil and sand from different sites. Have students compare their results and discuss which samples might be the best to use in a vegetable garden. Have them test their predictions by putting the different kinds of soils in pots or cups and planting flower or vegetable seeds in each one.
- Provide samples of pure sand and pure dry clay for students to examine with their magnifiers. Have them write about the difference between the samples.
- Try making your own pH paper to test soil acidity. Place about 1 cup of sliced purple cabbage into a sealable bag filled with warm distilled water. When the water is dark blue or purple, pour it into a container. Cut white coffee filters into 1-inch wide by 6-inch long strips. Dip the strips into the cabbage water and allow them to dry on a hard surface. Test the pH strips in vinegar (weak acid) and water with baking soda (weak base) to see how they change color. Measure 1/2 cup of soil into 2 cups of distilled water. Test the water using the pH strips. Compare several soils from different locations.

## QUESTIONS FOR STUDENTS TO THINK ABOUT

Nitrogen is very important for living organisms. It is found in proteins and in DNA (hereditary material in cells). Surprisingly, however, only a few organisms can use the abundant free nitrogen present in air. Most of these nitrogen-trapping organisms are bacteria that live in soil or in water. All other living things, including plants, depend on forms of nitrogen produced by nitrogen-trapping bacteria. Some nitrogen-trapping bacteria even work as partners with plants. They form special swellings or nodules in the roots of certain plants. This is especially common among members of the bean family (also known as legumes). See what you can find out about the partnership of these kinds of plants with bacteria OR have students create drawings of what they discover about the nitrogen cycle.

### CLASSIFYING SOIL

The non-living part of soil is made up of rocks and minerals, which are classified according to size. The classification names refer only to the size of the particle, not the composition of the sediment (e.g., a clay-sized particle might not be composed of a clay mineral).

- **SAND** (2–0.2 mm in diameter) is the largest size particle. Soil with a lot of sand feels gritty.
- **FINE SAND** (0.2–0.02 mm in diameter) feels less gritty than sand, but still can be seen without a magnifier.
- **SILT** (0.02–0.002 mm in diameter) feels powdery. You need a magnifier to see individual particles.
- **CLAY** (less than 0.002 mm in diameter) particles are so tiny that they cannot be observed, even with a low power microscope. A large percentage of clay in soil makes the soil feel sticky. Sometimes, you even can shape or mold it!

The best soils for growing plants have a mix of particle sizes and considerable amounts of dead plant and animal material. These soils have many nutrients and help hold water for plants.

Water in soil is present primarily as a film on the surfaces of soil particles.

# Soil Observations

Plants get water and nutrients from soil. Soil is important for people because we depend on plants that grow in soil.

Do you know what's in soil? To find out, you will need a clear soft drink bottle, soil, alum, water, a measuring cup, markers or crayons and a ruler.

## Looking at Soil

1. Put about 1 cup of soil in the middle of your table. Write three words to describe the soil.

   ____________________ ____________________ ____________________

2. Find as many different kinds of things as you can in your soil. Make a list or draw all of the different things you observe. Use the back of this page for your list.
3. Put a star by all of the things on your list that are living or came from something living.

## Soil Texture

1. Measure $\frac{1}{2}$ cup of soil and pour it into the bottle.
2. Measure one half teaspoon of alum and add it to the bottle.
3. Add water until the bottle is $\frac{3}{4}$ full.
4. Screw on the lid and shake the bottle.
5. What do you predict will happen to the soil? ______________________________

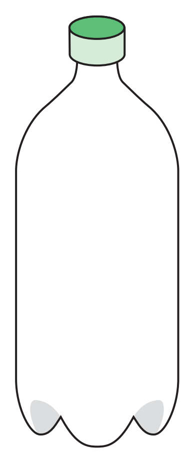
   ______________________________________________________________
6. Set the bottle down and let the soil settle. Watch what happens.
7. How many layers can you see in the soil? ______________________________
8. What does the bottom layer look like?

   ______________________________________________________________

   ______________________________________________________________
9. What does the top layer look like?

   ______________________________________________________________

   ______________________________________________________________
10. Draw lines on the bottle to the right to show each layer that formed in your bottle.
11. Measure each real layer in centimeters. Record your measurements below.



# Observaciones sobre el Suelo

Casi todas las plantas crecen en el suelo, de donde éstas obtienen agua y nutrientes. El suelo es importante para nosotros porque necesitamos las plantas que crecen ahí.

¿Sabes qué hay en el suelo? Para investigar esto, vas a necesitar una botella transparente de plástico, suelo, alumbre, agua, una taza de medir, marcadores o crayolas y una regla.

## Observando el Suelo

1. Vacía una taza de suelo en medio de la mesa. Escribe tres palabras descriptivas acerca del suelo.

   ____________ ____________ ____________

2. Busca tantas cosas diferentes como sea possible en el suelo. Haz una lista o dibuja las cosas que observas. Usa el otro lado de la página si necesitas más espacio.
3. Senãla con una estrella los objetos que observaste que provienen de algo viviente.

## Observando el Suelo

1. Mide una taza de suelo y viértelo en la botella
2. Mide $\frac{1}{2}$ cucharadita de alumbre y añádelo a la botella.
3. Añade agua para llenar $\frac{3}{4}$ partes de la botella.
4. Tapa la botella y agítala.
5. ¿Qué predices que pasará al suelo? ____________

   ____________
6. Pon la botella en la mesa y observa lo que pasa.
7. ¿Cuántas capas de suelo ves en el fondo de la botella? ____________
8. Describe la capa inferior.

   ____________

   ____________
9. Describe la capa superior.

   ____________

   ____________
10. En la botella que ves al lado, marca una línea para cada capa de suelo que observaste.
11. Mide cada capa que ves dentro de la botella. Escribe tus medidas en el espacio abajo.