Fifth Through Tenth Grade:
Physical Science, Earth Science, and Biology

The Great Garden Dilemma

Warning! Green Gardener Ready To Sling Dirt! For the first time in ten years, Mimi Best did not win the Grand Prize at this year's County Fair Flower Show. Her flowers were only good enough for second place. Mimi Best was outdone in every category she entered this year, and what made it worse was that she lost to a pair of youngsters—a brother and sister team from a nearby neighborhood. Mimi Best said she would get to the bottom of this before slinging dirt at the siblings.

Unable to come up with any answers, Mimi Best has turned to you to help her investigate why she lost the competition. She has promised an all-expense paid trip to the local amusement park for you and your friends as payment. This sounds like a real challenge, but it definitely has its rewards. You accept the challenge.

Investigation

To solve this mystery, you will have to find out what causes plants to grow differently. You have been given two soil samples, one from Mimi Best's garden, and one from the siblings' garden. They have been exposed to the same climate, but one grew champion plants, and one only grew second place plants. A trip to the local university greenhouse and botany department has provided you with a soil sample that is high in nutrients and used for growing new seedlings. The botany professor you spoke with indicated that your investigation should focus on the different physical characteristics and chemical differences of the two soils from the two pots. In general, soil may vary in its color, composition, and possibly in its acidic and conductive nature. By using a pH Sensor and a Conductivity Probe, you can quickly determine the values of each soil sample to help figure out the differences. In addition, you can investigate the physical nature of soil using a ProScope to see if there are any differences in the organic and inorganic materials in the soil.

Objectives

In this experiment, you will:

- Compare the physical and chemical characteristics of three different soils
- Examine the inorganic and organic composition of soil using a ProScope digital USB microscope
- Learn to use Vernier science sensors, including a pH Sensor and a Conductivity Probe with a computer
- Determine which soil is best for growing plants
- Report your findings in a presentation format using iPhoto software

Materials

- Macintosh computer with Mac OS X
- iPhoto software
- Bodelin ProScope with 50X lens
- Bodelin USB Shot software
- Vernier pH Sensor
- Vernier Conductivity Probe
- Vernier Go! Link interface
- Vernier Logger Lite software
- Inkjet or laser printer (optional)
- Soil samples
- Distilled water
- Coffee filters
- 350 mL beakers
- 250 mL graduated cylinder
- Rubber bands

Procedure

1. Based on your preliminary examination of the soil and your fact-finding trip to the university, why do you think Mimi Best's flowers were only second best? Write your hypothesis in your science journal.
2. Obtain and wear goggles.
3. Using four 350 mL beakers, label the beakers "Mrs. Best's Soil," "University Sample," "Winning Sample," and "Waste." Obtain the proper soil for each sample and place it in the appropriate beaker.
4. Set up the ProScope to examine each of the three soil samples:
   - **a** Connect the ProScope to a USB port on the computer.
   - **b** Open the USB Shot application. You should see an image on your computer screen.
   - **c** For each soil sample, touch the tip of the ProScope with the 50X lens to the soil to view an image. Press the button on the ProScope to snap a still image. Look for both organic and inorganic materials present in the sample.
   - **d** Repeat the procedure for each of your soil samples.
   - **e** If possible, print your images and place them in your science journal and on the data sheet.
   - **f** Based on what you observe, modify your hypothesis if necessary.

5 Prepare the computer to collect pH data:

- **a** Connect the pH Sensor to the Go! Link.
- **b** Connect the Go! Link to the computer.
- **c** Open the Logger Lite software.
- **d** Choose Data Collection from the Experiment menu and set the experiment length to 30 seconds.
- **e** Click Done.

6 Prepare your first data run:

- **a** Drape a coffee filter over a beaker and secure it with a rubber band.
- **b** Place 50 grams of soil on top of the filter.
- **c** Pour 200 mL of water over the soil, allowing it to drain into the beaker.
- **d** Label the beaker with the appropriate name of the soil sample.

7 Repeat step 6 for the other two soil samples.

8 Collect your first data run:

- **a** Rinse the pH Sensor with distilled water and then place it into the beaker labeled "University Sample." Click the Collect button to begin data collection. Data collection will last for 30 seconds.
- **b** Store this run by clicking the Store button . Click the Statistics button to display the statistics box on the graph. Record the mean pH data on your sheet or in your journal.

9 Rinse the pH Sensor with distilled water, allowing the water to spill into the beaker labeled "Waste," and proceed to collect your second and third data runs. Record your findings in the data table or in your science journal. Repeat step 8 for each of the two remaining samples. Store your second and third runs and save the file.

10 Prepare the computer to collect conductivity data:

- **a** Rinse the pH Sensor in distilled water.
- **b** Disconnect the pH Sensor from the Go! Link and place it in the storage solution.
- **c** Set the conductivity setting switch to the 0 to 2000 range.
- **d** Connect the Conductivity Probe to Go! Link.
- **e** Make sure the Go! Link is connected to the computer.
- **f** Click the NEW button on the toolbar.
- **g** Choose Data Collection from the Experiment menu and set the experiment length to 30 seconds.
- **h** Click Done.

11 Collect your conductivity data:

- **a** Using the first beaker labeled "University Sample," place the Conductivity Probe into the liquid. Click the Collect button  to begin data collection. Data collection will last for 30 seconds.
- **b** Store this run by clicking the Store button . Record the data on your sheet or in your journal.

12 Rinse the Conductivity Probe with distilled water, allowing the water to spill into the waste cup, and proceed to collect your second data run. Record your data on your data sheet or in your science journal.

13 Repeat steps 11 and 12 for the two remaining soil samples.

14 You should now have enough data to compare the soil samples from the two flower pots to the university sample.

15 Within your Applications folder, find the Snap folder created by USB Shot. Import this folder or specific images into iPhoto for captioning, organization, and presentation.

16 Prepare an iPhoto slideshow of the microscopic examination to support an oral presentation of your findings.

Processing the data

	ProScope Image	Description of Image	pH	Conductivity
Soil From University Sample				
Soil From Mimi Best's Flower Pot				
Soil From the Winning Flower Pot				

Analyzing your data

1 What differences can you observe in the appearance of the three soil samples? What differences in the three soil samples are highlighted by the ProScope examination?

2 What does pH measure?

3 Which sample most closely matches the pH of the university sample? What can you infer about the pH of the soil based on the pH of the runoff?

4 What does conductivity measure?

5 Which of your samples had the highest conductivity reading? How do the two samples from the contest compare to the university sample?

6 Why did Mimi Best lose the flower show contest this year?

7 What do you think Mimi Best could have done to make her soil more productive?

Teacher Information

Hypothesis

This experiment is designed to promote student observation, questioning, and presenting possible explanations. The focus of the activity is on the composition of the soil used in the contest versus the soil of known composition from the university. These differences of composition are then related to the growth of the plants. The identification of the problems or variables in this experiment can be challenging for students to identify because they are not clearly visible. In this scenario, we are looking for a cause from the effect, which is the change in plant growth. Because of this, students are given the type of tests that can help differentiate between the types of soils. Students should be encouraged to form their own questions as part of the investigation and develop possible explanations or a hypothesis. Here is an example of a question and hypothesis:

Question: Which soil supports the best plant growth?

Hypothesis: The soil with the most nutrients will be best for plant growth. The soil that matches the data from tests of the known university soil high in nutrients will grow better flowers.

Science concepts

This experiment has several key concepts that interact. The first is the composition of soil. Soil has two basic components. The first component is inorganic material, which includes the small rock chips, minerals, and other materials that are not from living organisms. Some of these minerals are used by plants and are soluble in water. The dissolved minerals are absorbed and used by plants. The second component of soil is organic material. This material is mainly composed of decaying plant and animal remains. The decay of this material adds key elements to the soil such as nitrates and phosphorous. When these materials are missing, plant growth and productivity are usually reduced. To compensate for the lack of organic material, fertilizers are used to restore the nutrients that plants need. As in ecological situations, there is always a balance of benefits and complications that arise from these actions. The addition of the fertilizers helps the plant grow; however, the same fertilizer contaminates water resources with runoffs containing chemicals not normally found in water. These changes in water can dramatically affect all aquatic organisms.

The changes in soil characteristics can be seen in two basic tests. The first is in the degree of acidity or alkalinity. This degree is a function of the concentration of hydrogen ions present in the substance. The pH level is a measure of the concentration of hydrogen on a logarithmic scale from 1 to 14, with 1 being the most acidic and 14 the most basic or alkaline. Pure water generally has a pH of 7. In this experiment, fertilizer will noticeably change the pH of the soil. The pH level can have profound effects on the growth of plants. Many plants have a very specific pH range for optimal growth. The second way we measure change in the soil is to measure the level of dissolved salts and minerals in runoff water. In water, these substances form ions. The ions change the rate of flow of electrons in water, or the conductivity of the water. This conductivity can be measured using a Conductivity Probe. This experiment is designed to demonstrate the effects of fertilizer on soil conditions, water runoff, and plant growth using probes to measure the changes.

Facilitation tips

In this experiment, proper conditions are the key to success. You will have to provide appropriate conditions to demonstrate the effects. To emphasize the effects on plant growth, make sure the differences between the two soils in the pots are very noticeable. If possible, make sure one pot has soil that is lacking in humus or the organic portion of the soil. Sandy or clay soil types will fit this need very well. If you want dramatic differences, transplant several plants of the same species in pots containing this soil type and allow them to grow for several weeks before presenting them to the class. Another controlled condition that can be present for students to test is to vary the pH of the soil of the two pots by a marked degree. Choose a plant from the list provided below that will grow well in one pot, but not the other.

Ideal pH Levels for Flower Growth

Ageratum 6.0–7.5	Columbine 6.0–7.0	Forget-Me-Not 6.0–7.0	Lilac 6.0–7.5	Primrose 5.5
Alyssum 6.0–7.5	Coreopsis 5.0–6.0	Forsythia 6.0–8.0	Marigold 5.5–7.0	Roses 5.5
Aster 5.5–7.5	Cosmos 5.0–8.0	Foxglove 6.0–7.5	Morning Glory 6.0–7.5	Salvia 6.0
Azalea 4.5–6.0	Crocus 6.0–8.0	Gladiola 6.0–7.0	Nasturtium 5.5–7.5	Snapdragon 5.5
Calendula 5.5–7.0	Daffodil 6.0–6.5	Gypsophilia 6.0–7.5	Pansy 5.5–7.0	Sunflower 5.0
Candytuft 6.0–7.5	Dahlia 6.0–7.5	Holly 5.0–6.5	Petunia 6.0–7.5	Sweet Pea 6.0
Carnation 6.0–7.5	Day Lily 6.0–8.0	Hyacinth 6.5–7.5	Pinks 6.0–7.5	Sweet William 6.0
Celosia 6.0–7.0	Delphinium 6.0–7.5	Iris 5.0–6.5	Poppy 6.0–7.5	Tulip 6.0
Chrysan-themum 6.0–7.0	Dianthus 6.0–7.5	Lavender 6.5–7.5	Portulaca 5.5–7.5	Viola 5.5

Extensions

1 Science. Have students grow plants in varying soil conditions and determine which factor seems to be the most critical.

2 Earth science. Have students create a ProScope image analysis of different soil types. Make sure to include sandy soil, clay, rocky soil, and some local soils.

3 Internet research. How are soils analyzed for farms? Once the analysis is complete, how are soils modified?

4 Science. Have students fertilize the soil and repeat the experiment. Use various amounts and different brands of fertilizer.

5 Science and Internet. What are the measuring units for fertilizer?

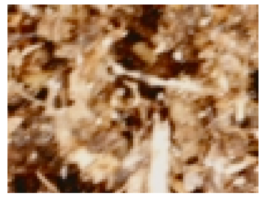
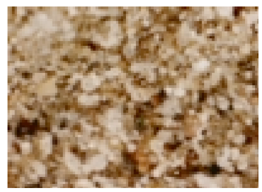
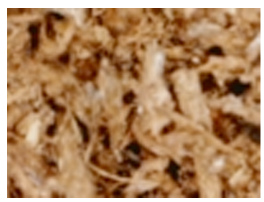
Expected outcomes

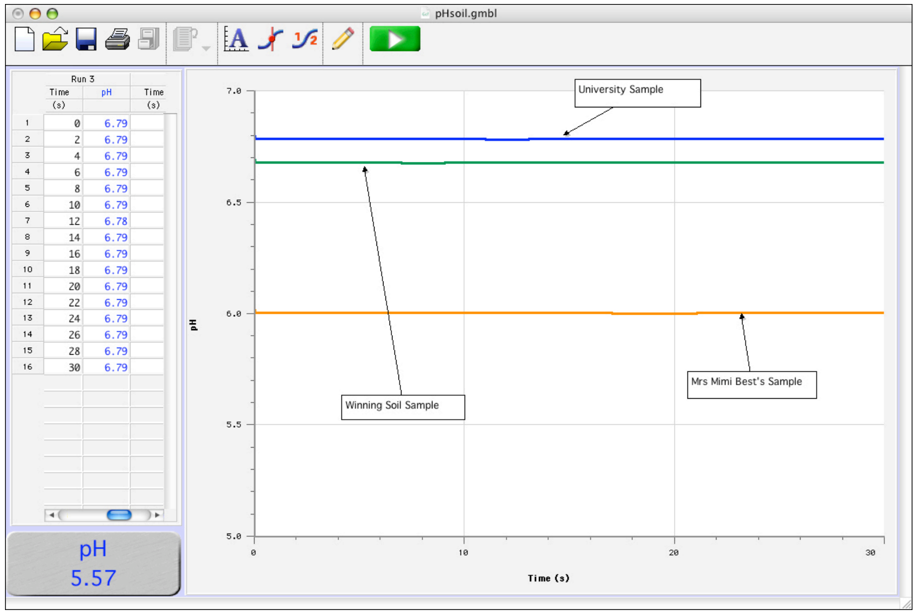
The outcomes for this experiment should be very clear to students. The university soil, which has added nutrients and the correct physical conditions of the soil to promote plant growth, acts as a control to which the students can compare the unknown soil sample conditions. From the comparison of results, students should be able to decide which soil promoted the best growth. The focus of this experiment is the basic biological concept that plants have specific needs and ranges of conditions that will support optimal growth. The addition of nutrients changes the conditions of the soil and is used to promote growth. These changes in soil can be measured using the pH Sensor and Conductivity Probe.

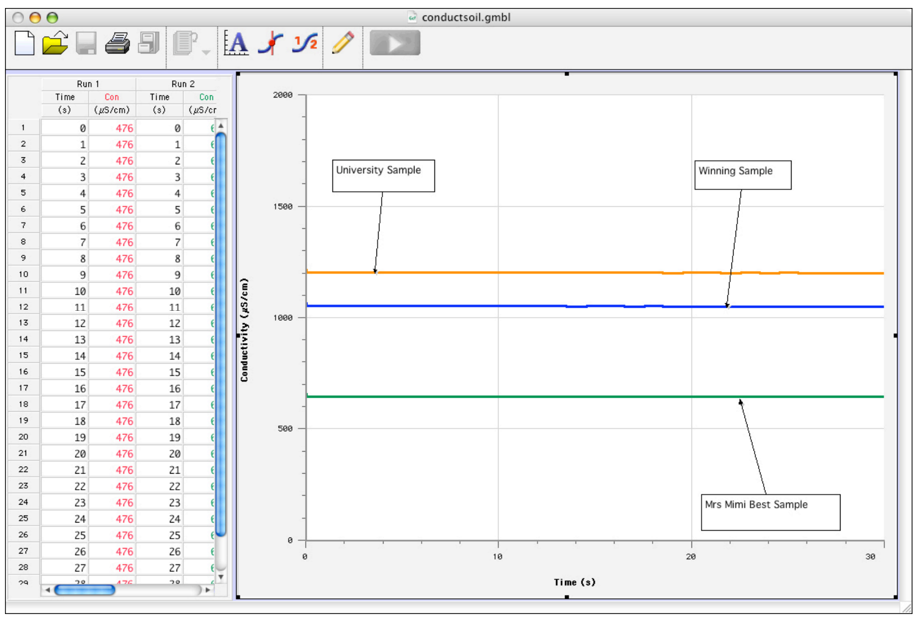
Data

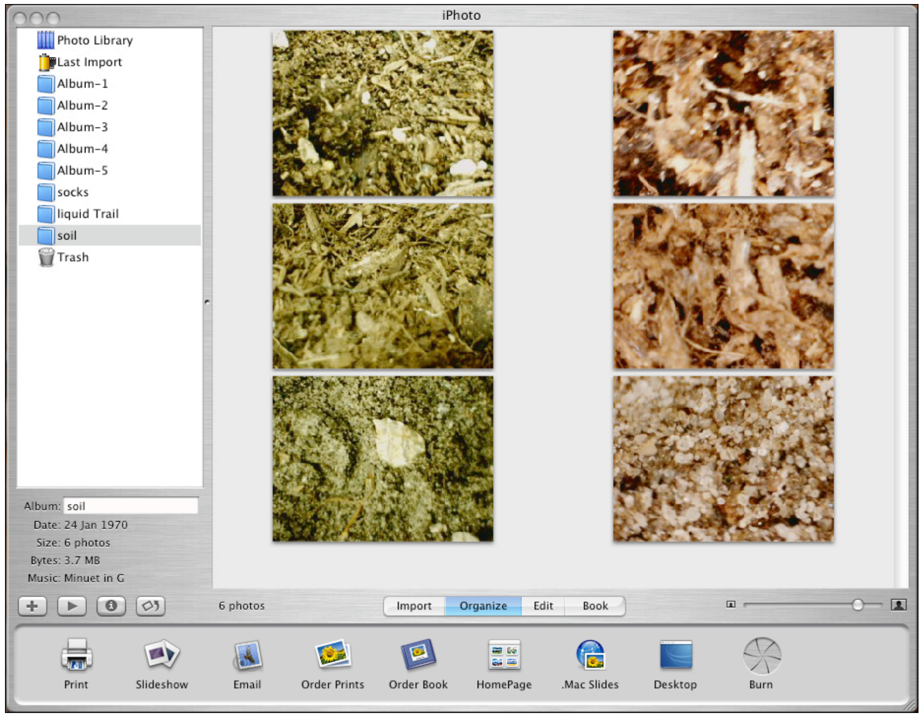
- ProScope images of all soil samples
- pH data for all soil samples
- Conductivity data for all soil samples

Sample results

	ProScope Image	Description of Image	pH	Conductivity
Soil From University Sample		Examination of the university sample shows mostly organic material with little inorganic sand or rocks present. The soil appears dark and rich.	6.8	1205 µS
Soil From Mimi Best's Flower Pot		Mrs. Best's soil has very little organic material and consists of mostly fine grains of sand and brown appearing dirt.	6.0	646 µS
Soil From the Winning Flower Pot		The winning soil sample appears to be very similar to the university sample. There are few inorganic materials present in the sample with only an occasional small crystal or sand particle present.	6.6	1055 µS


pHsoil.gmbl
Run 3
pH
5.57
University Sample
Winning Soil Sample
Mrs Mimi Best's Sample
Time (s)


conductsoil.gmbl
Run 1
Run 2
University Sample
Winning Sample
Mrs Mimi Best Sample
Conductivity (µS/cm)
Time (s)


iPhoto
Photo Library
Last Import
Album-1
Album-2
Album-3
Album-4
Album-5
socks
liquid Trail
soil
Trash
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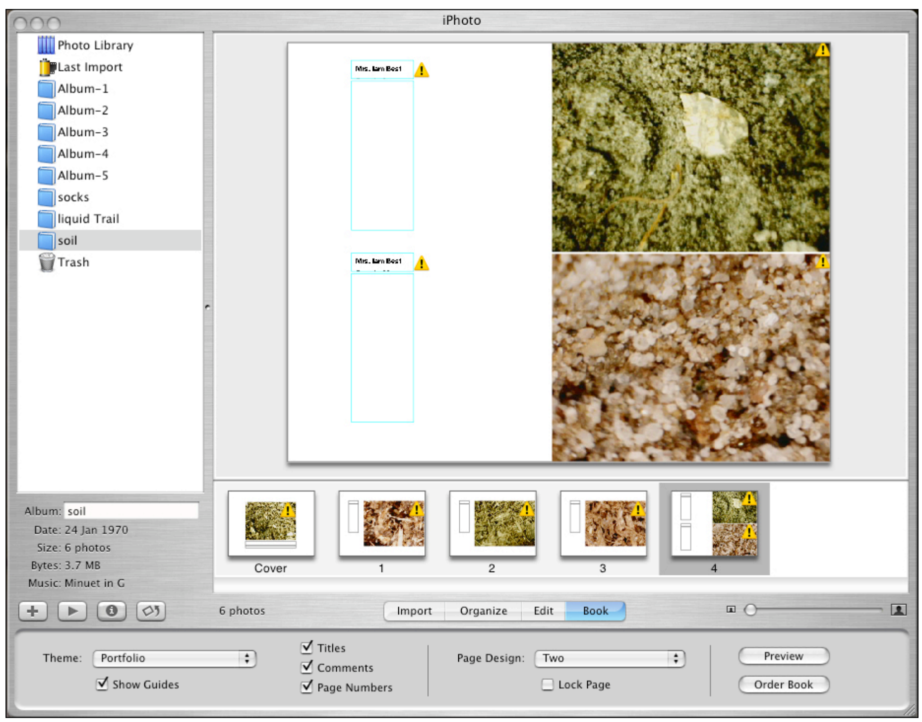
Date: 24 Jan 1970
Size: 6 photos
Bytes: 3.7 MB
Music: Minuet in G
6 photos
Import
Organize
Edit
Book
Print
Slideshow
Email
Order Prints
Order Book
HomePage
.Mac Slides
Desktop
Burn


iPhoto
Photo Library
Last Import
Album-1
Album-2
Album-3
Album-4
Album-5
socks
liquid Trail
soil
Trash
Album: soil
Date: 24 Jan 1970
Size: 6 photos
Bytes: 3.7 MB
Music: Minuet in G
Cover
1
2
3
4
6 photos
Import
Organize
Edit
Book
Theme: Portfolio
Show Guides
Titles
Comments
Page Numbers
Page Design: Two
Lock Page
Preview
Order Book

Answers to analyzing your data questions

1 Students should realize that properties such as size, shape, color, and texture are all physical properties of the soil. Descriptions of the soil will vary depending on the sample used. Generally, soils that support good plant growth have both inorganic and organic materials. Soils composed of only one type of component will have limited nutrients. In this experiment, the university sample is high in organic materials with little or no inorganic components. The soil from Mrs. Best's flowers has little organic material and is high in inorganic materials. The winning soil has about equal amounts of each.

2 pH is a chemical property of matter that measures the relative acidity or alkalinity of a substance.

3 The winning soil sample has similar data to the university soil. Since the water began as near neutral (7.0) and the runoff is acidic, it can be inferred that this soil sample is acidic. Answers will vary depending on the soil sample you use.

4 Conductivity is a measure of the ability of a substance to conduct an electric current. In this experiment, we are measuring the conductivity of the water. Changes in the conductivity are due to the dissolved salts and minerals and the resulting ions present in the water.

5 The university soil had the highest conductivity levels. We also know that this soil was modified to contain a high level of nutrients. The next highest was the winning soil sample. From the data and the observations from the ProScope, Mrs. Best's soil has the least organic material present. The conductivity readings of her soil are the lowest.

6 Mimi Best lost this year's contest because her soil was lacking in nutrients due to the low amount of organic material in her soil.

7 Mimi Best could add fertilizer, compost soil, or even liquid plant nutrients to improve the plant growth. Increasing the organic components of the soil would improve the conditions for a longer period of time.

Science standards alignment

This experiment provides direct alignment to national standards by allowing students to actually see and measure the differences in soil composition. In addition, the nature of the soil is then applied to growth of plant organisms. The varying composition of soil is studied for the effects on growing plants. The experiment also allows students to understand how this knowledge is applied in real-world settings. The design of the experiment also emphasizes alignment with measurement, inquiry, and investigative standards by having students use technology to practice and gain insight to these skills.

National Science Standards

Unifying Concepts and Processes

1 Evidence, models, and explanation.

2 Change, constancy, and measurement.

Science as Inquiry

Content Standard A

As a result of activities, students should develop

1 Abilities necessary to do scientific inquiry.

2 Understandings about scientific inquiry.

National Content Standards

Level 5-8. Physical Science Standards

Content Standard B. Properties and changes of Properties in matter.

A substance has characteristic properties, such as density, a boiling point and solubility, all of which are independent of the size of the sample.

Content Standard C. Structure and function in Living Systems.

All organisms must be able to obtain and use resources, grow, reproduce and maintain stable internal conditions while living in a constantly changing external environment.

Content Standard D. Structure of the Earth System

Soil consists of weathered rocks and decomposed organic material from dead plants, animals and bacteria. Soils are often found in layers with each having a different chemical composition and texture.

National Educational Technology Standards (ISTE)

Standards Categories:

1 Basic operations and concepts

3 Technology productivity tools

4 Technology communication tools

5 Technology research tools

6 Technology problem-solving and decision-making tools

Performance Indicators.

1 Use content-specific tools, software, and simulations (e.g., environmental probes, graphing calculators, exploratory environments, Web tools) to support learning and research.

2 Apply productivity/multimedia tools and peripherals to support personal productivity, group collaboration, and learning throughout the curriculum.

3 Design, develop, publish, and present products (e.g. Web pages, videotapes) using technology resources that demonstrate and communicate curriculum concepts to audiences inside and outside the classroom.

4 Collaborate with peers, experts and others using telecommunications and collaborative tools to investigate curriculum-related problems, issues and information, and to develop solutions or products for audiences inside and outside the classroom.

5 Select and use appropriate tools and technology resources to accomplish a variety of tasks to solve problems.

Learn more

If you enjoyed this hands-on science experiment, learn more about the Science CSI Kit and additional other curriculum lessons that can be used for concentrated science investigations at: http://www.apple.com/education/sciencecsikit.

Special thanks

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