Fifth Through Tenth Grade:
Middle School Science, Physical Science, and Chemistry

Solving the Liquid Trail

Family Warning! Irritated father on the loose! Before leaving for work and a really important meeting, Father sat in his favorite chair to enjoy a cup of coffee. Much to his surprise, his chair was very wet and his pants got soaked. This required a change of clothing and moods. With the possibility of being late weighing heavily on him, he quickly changed his suit and headed toward the door. Pausing only for a second, the question echoed through the house: Who spilled what in my chair?

Of course this question was answered by silence from your three younger siblings. You need to use the family car tonight, so you have to prove your innocence. You are determined to help your father in the investigation of "Solving the Liquid Trail."

Investigation

To unravel the mystery, you will have to find out what the spilled liquid is. You know the favorite drinks of each of your three siblings. You know that your brother Mark prefers orange juice, your sister Amy drinks orange soda, and your sister Sue likes orange Kool-Aid. Each drink has different physical characteristics. The drinks vary by color, composition, and possibly in their acidity. By using a pH Sensor, you can quickly determine the pH values of each drink to help figure out the identity of the spilled liquid. In addition, you can investigate the physical nature of the liquid using a ProScope. You will be able to see how each liquid reacts with fabric, how it changes the color of the fabrics when wet, or leaves a residue to determine which liquid was spilled. When you identify the liquid, Father will know which child spilled their drink, and you will have increased your chances of using the family car tonight.

Objectives

In this experiment, you will:

- Compare the pH values and physical characteristics of different types of liquids
- Learn to use a digital pH Sensor
- Learn to use a ProScope digital USB microscope
- Record, organize, and analyze your data
- Determine the type of liquid spilled on a chair
- Identify who spilled the liquid
- 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 Go! Link interface
- Vernier Logger Lite software
- Inkjet or laser printer (optional)
- Glass microscope slides and cover slips
- Variety of liquids (freshly-squeezed orange juice, orange soda, orange Kool-Aid)
- Sample of wet fabric with the unknown drink spill
- Small fabric samples to simulate the fabric of the chair cushion
- Distilled water
- Water bottles
- Paper cups
- Paper towels

Procedure

1 After examining the sample of wet fabric with the unknown drink spill, write down which liquid you think was spilled on the cushion.

2 Obtain and wear goggles.

3 Label three cups with the names of each of the children's favorite drink. Label a fourth cup "Waste." Fill each of the cups one-third full with a sample of the liquid that is marked on the cup. Label a fifth cup "Unknown" and set it aside.

4 Prepare the computer to collect temperature data:

a Connect the pH Sensor to the Go! Link.

b Connect 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.

5 Collect your first data run:

a Rinse the pH Sensor with distilled water into the waste cup.

b Using the first cup labeled "Freshly-Squeezed Orange Juice," place the pH Sensor into the juice. Click the Collect button  to begin data collection. Data collection will last for 30 seconds.

c Store this run by clicking the Store button  . Record the data on your sheet or in your science journal.

6 Rinse the pH Sensor with distilled water into the Waste cup and proceed to collect your second data run. Record your data on your sheet or in your science journal.

7 Repeat Steps 5 and 6 using the Kool-Aid.

8 Repeat Steps 5 and 6 using the orange soda.

9 Rinse the pH Sensor with distilled water and return it to the storage bottle containing storage solution.

10 Using a small amount of water, wash a small area of the stain, catching the water in the paper cup labeled "Unknown." Measure the pH of the unknown liquid. Compare your findings to those in your data sheet.

11 Obtain a small fabric sample that simulates the fabric of the chair cushion. Place a couple of drops of each drink on a separate area of the fabric. Allow the drops to dry. Make sure you label each area of the fabric with the name of the drink. In addition to the fabric, place a couple of drops of each drink on separate glass microscope slides. Allow these to dry.

12 Set up the ProScope to examine each of the fabric spots and the dried slides.

a Connect the ProScope to a USB port.

b Open the USB Shot application. You should now see an image on your computer screen.

c For each fabric sample, touch the tip of the ProScope with the 50X lens to each fabric sample to view an image. Press the button on the ProScope to snap a still image. Look for residue, crystals, or some material from each sample on the cloth.

d Repeat the procedure for each of your fabric stains.

e Compare your findings on the fabric to your slides. In your science journal, describe what you see for each fabric and slide. If possible, print your images and place them in your journal and on the data sheet.

13 On the fabric with the unknown spill, use the ProScope to examine the area with the spill. Press the button on the ProScope to snap a still image. Compare these findings with your findings from each of the known drinks. Record your findings.

14 Identify the most likely liquid and who spilled it.

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 Based on your findings, which liquid do you think was spilled? Prepare an iPhoto slideshow of the microscopic examination to support an oral presentation of your findings.

Processing the data

Child	Mark	Amy	Sue
Favorite Drink	Orange Juice	Orange Soda	Orange Kool-Aid

	Sample 1 Orange Juice	**Sample 2 Orange Soda**	**Sample 3 Orange Kool-Aid**	**Sample 4 Unknown Liquid**
pH Value				
ProScope Image Slide				
ProScope Image Fabric				

Analyze your data

1 Make sure the entire data table is complete. Decide which one matches the closest to your findings. Decide who spilled what.

2 Discuss the differences in pH. Why are there differences in the pH readings of each drink?

3 What do you think the debris in the orange juice is?

4 Why is it important to run the same test on all the samples?

5 What is pH?

Teacher Information

Hypothesis

This experiment is designed to promote student observation, questioning, and presenting possible explanations. The problem of identifying a liquid provides students with the opportunity to perform experiments that utilize technology to examine the physical characteristics of different liquids. Using the data collected during their examination allows the students to solve the mystery. It is recommended that students be allowed to form their own questions and possible explanations or hypothesis based on the introduction information. A sample question and hypothesis are provided here.

Question: Which liquid was spilled on the chair?

Hypothesis: The freshly-squeezed orange juice is what was spilled on the chair because of the physical characteristics of the orange stain that can be seen.

Science concepts

In this experiment, students explore several different concepts of both physical science and chemistry. The first major concept is that all substances are endowed with certain physical characteristics. These include boiling point, density, and solubility. Included in these physical characteristics is the degree of acidity or alkalinity. This degree is a function of the concentration of hydrogen ions present in the substance. The concentration of the hydrogen ions is measured as pH. The pH level is 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, you can enforce this concept of physical characteristics, one of which is pH, by allowing students to use technology—the pH Sensor—to explore a relatively complex concept.

In addition, students also are exposed to the basic concept of solution and suspensions. In the orange soda and orange Kool-Aid drink, the components are completely dissolved. The most common of the components in these drinks is common table sugar. The sugar molecules that are usually seen as white crystals are now broken down to their basic molecular structures. These sugar molecules are actually in between the water molecules. You no longer can see them, but you are sure able to detect them with taste and even other science experiments. Each substance that goes into solution in the liquid changes the physical characteristics of the liquid. In the freshly-squeezed orange juice samples, there is the presence of the cellular pulp from the oranges. These small particles of the orange will not go into solution, but remain suspended in the liquid. Upon examination of the orange juice under magnification, the cellular debris will be visible. Many times, when solutions dry, the material in solution will re-crystallize or form a solid that can be seen.

Facilitation tips

This experiment can be done in one class period if students work in teams. The first part of the experiment should be the preparation of the slides and fabric. This will take some time to dry. The setup of the computers and the Go! Link can be completed quickly as can the measurement of the pH. Prior to class, stain the fabrics with the unknown sample. It is most fun to use freshly-squeezed orange juice for the unknown samples as it leaves the cellular debris that students can find with the ProScope.

Extensions

- Science. As stated before, adding substances that go into solution with water will change the physical characteristics of water. A simple experiment is to measure the change in boiling point or freezing point of water after adding different amounts of sugar or salt.
- Mathematics and science. When materials go into solutions, there is no loss of mass. Have students start with 10 mL of water, which will have 10 grams of mass. Add 1 gram of sugar at a time. When the sugar is dissolved completely, have students measure the mass of the water and measure volume. Have students construct a bar graph comparing each sample you try.

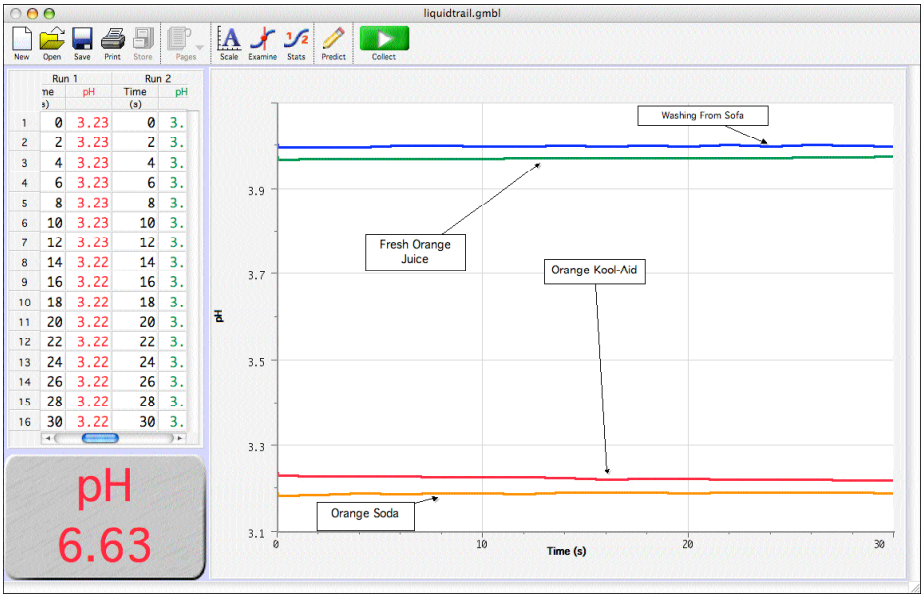
Expected outcomes

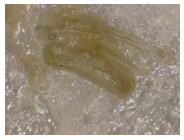
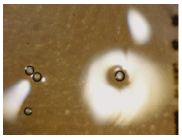
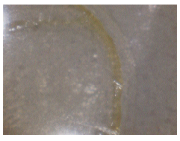
The physical differences of each of the liquids are enough that students should be able to easily separate the three. The orange juice should have the lowest pH and be the only one of the substances with cellular pulp. The dried slides should also provide contrast with the orange soda, Kool-Aid, and the orange juice. If the sugar concentration is high enough, sugar crystals may be able to be seen under ProScope examination. The examination of the fibers of the fabric will probably show only the cellular debris as the liquid soda and Kool-Aid will be absorbed by the fabric.

Data

- pH of each drink
- ProScope images of dried slides of each drink
- ProScope images of fabric with spilled drink sample

Sample results



	Sample 1 Orange Juice	Sample 2 Orange Soda	Sample 3 Orange Kool-Aid	Sample 4 Unknown Liquid
pH Value	3.97	3.19	3.22	3.99
ProScope Image Slide				
ProScope Image Fabric				

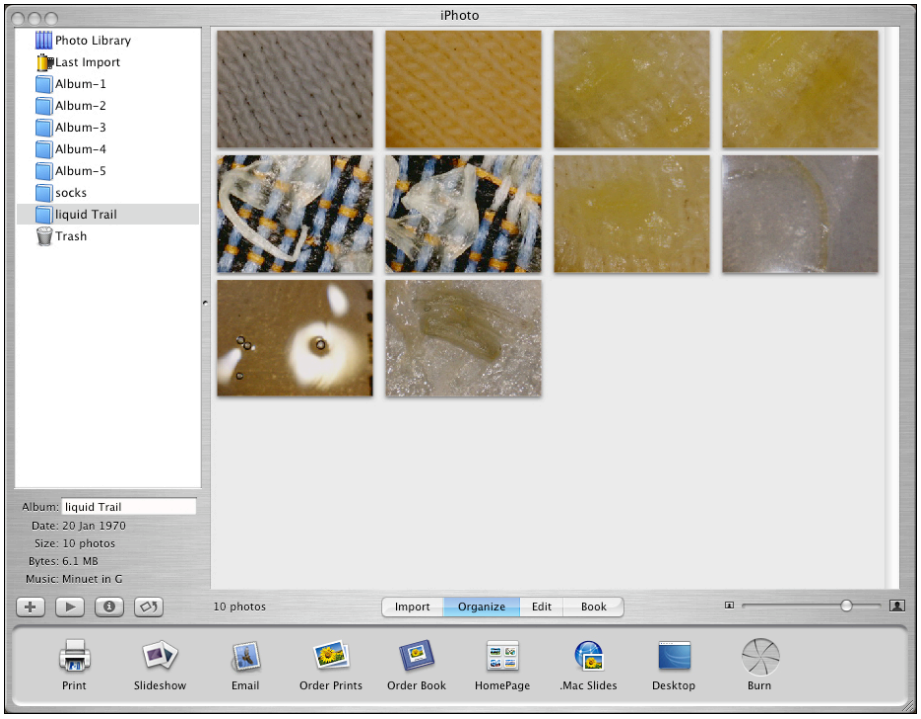

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Photo Library
Last Import
Album–1
Album–2
Album–3
Album–4
Album–5
socks
liquid Trail
Trash
Album: liquid Trail
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Size: 10 photos
Bytes: 6.1 MB
Music: Minuet in G
10 photos
Import
Organize
Edit
Book
Print
Slideshow
Email
Order Prints
Order Book
HomePage
.Mac Slides
Desktop
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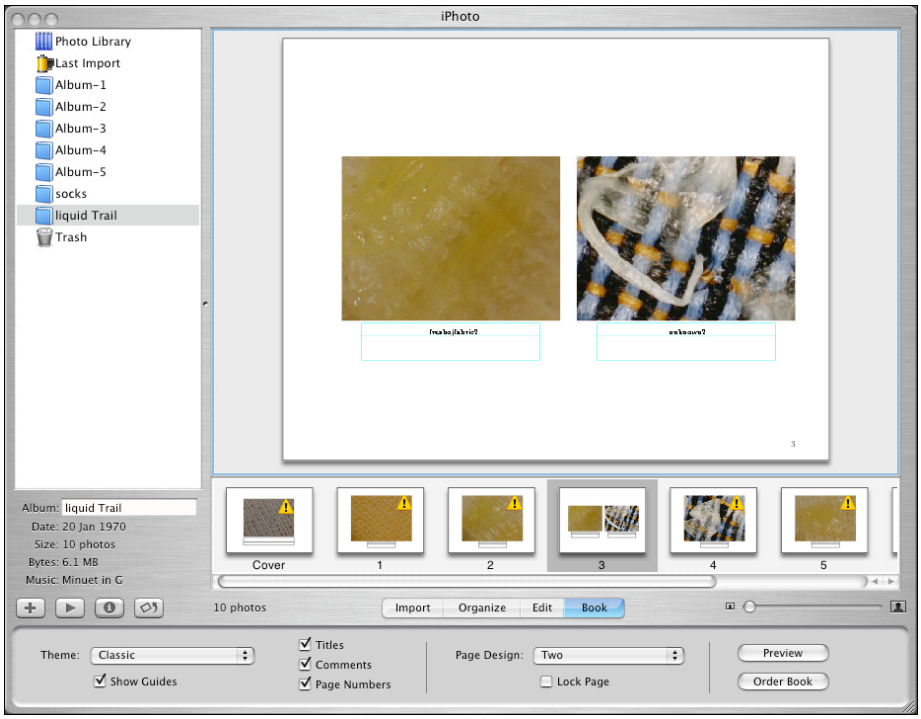
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Photo Library
Last Import
Album–1
Album–2
Album–3
Album–4
Album–5
socks
liquid Trail
Trash
Album: liquid Trail
Date: 20 Jan 1970
Size: 10 photos
Bytes: 6.1 MB
Music: Minuet in G
Cover
1
2
3
4
5
10 photos
Import
Organize
Edit
Book
Theme:
Classic
Show Guides
Titles
Comments
Page Numbers
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Order Book

Answers to analyzing your data questions

1 Mark is the most likely candidate. He likes freshly-squeezed orange juice—this should match student findings.

2 All three of the substances have different levels of acid in them. The lower the pH, the more acid present. Freshly-squeezed orange juice should have the lowest pH.

3 Cellular debris from the orange, also known as pulp

4 Good experimentation techniques leave as little as possible to chance. To have good comparisons, data must be collected from each sample in the same fashion.

5 The concentration of the hydrogen ions

Science standards alignment

This experiment provides direct alignment to national standards by allowing students to actually see and measure physical properties of similar substances and to separate the substances based on differences in physical characteristics of the substance. In this case, pH is one of the physical characteristics of the liquids that students investigate. 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 amount of the sample.

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 curriculum lessons that can be used for concentrated science investigations at http://www.apple.com/education/sciencecsikit.

Special thanks

This lesson was written collaboratively by Apple Computer, Inc. and Vernier Software & Technology, and edited by Bruce Payne, Apple Professional Development consultant.