Ninth through Twelfth Grade:
Biology and Life Science

Case of the Bad Lunch

Medical Alert! Local hospitals and urgent care centers are reporting that in the past six hours, there have been over 50 cases of young adults seeking medical attention for symptoms of nausea, fever, headache, diarrhea, abdominal cramps, and vomiting. Hospital spokespersons have stated that at the moment they do not know the cause of the illness. All of the victims appear to be students who attended the high school picnic. Hundreds of students who attended the picnic could be at risk!

Headlines like these are not uncommon. Similar stories have appeared, for example, about the SARS epidemic in China. These situations must be handled with the utmost speed and accuracy of scientific investigation. What is causing this illness?

Investigation

Your job is to find the primary source of the disease so proper care can be provided. The latest scientific digital tools are at your disposal to help determine the cause of the illness. From the preliminary investigation, you know that all of the patients attended the same picnic, ate the same lunch, and are displaying similar symptoms. Bacterial food poisoning is high on the list of suspects. You need to test the lunch and provide answers.

Bacteria comprise an important group of organisms found in the environment. Some bacteria are harmful and some are beneficial. Under prime environmental conditions, bacteria can double their numbers every 20 minutes. This time period is known as the doubling rate of bacteria, which is a very important characteristic of pathogenic bacteria. Because of this rapid doubling rate, bacteria can infect large numbers of people if it is present in food. Once in the body, bacteria continue to grow and cause the rapid onset of symptoms.

Objectives

In this experiment, you will:

- Determine the cause of the rapidly spreading illness
- Understand the importance of rapid testing and accurate data
- Learn to use a pH Sensor, a Temperature Probe, and a ProScope digital microscope
- Examine and record the physical characteristics of various samples
- Record, organize, and analyze your data
- Report your findings in a presentation format using iPhoto

Materials

- Macintosh computer with Mac OS X
- iPhoto
- Bodelin ProScope with 50X lens
- Bodelin USB Shot software
- Bodelin C-Mount Adapter
- Bodelin Microscope Tube Adapter
- Vernier Temperature Probe
- Vernier Go! Link interface
- Vernier pH Sensor
- Vernier Logger Lite software
- Standard compound microscope
- Bunsen burner
- Hair dryer (as an alternative to Bunsen burner)
- Pyrex microscope slides and cover slips
- Gram or other commercial stain for bacteria
- Eyedropper or plastic Beral pipet
- pH 7 water
- Distilled or sterile water
- Food samples for testing (fruit, lunch meat, pickle relish, cookies)
- Unpasteurized yogurt culture or sour cream
- Plastic gloves
- Q-Tips

Procedure

1. Read the introduction. What facts and clues can you determine about the students who attended the picnic, ate the prepared lunch, and are now getting sick? Visit the following website, which summarizes food poisoning symptoms and causes:

   http://www.vdacs.state.va.us/foodsafety/poisoning.html

   Write your hypothesis based on the information given from this site and the information in the introduction as to why students are getting sick.

2. Obtain and wear goggles.

3 Make sure you put on protective plastic gloves, then follow these steps:

- **a** On the clean slide, add one drop of distilled water—sterile water would be best.
- **b** Allow the slide to dry.
- **c** Fix the bacteria to the slide by using a Bunsen burner and passing the slide through the flame several times using a slide holder.

  Note: Allow the slide to cool to room temperature before handling it in any manner.
- **d** If open flames are not permitted in your school, allow the slide to air dry and then pass the slide in front of a hair dryer at the high setting for several seconds.

4 Use a commercial stain to stain the bacteria. Follow the directions provided. Your instructor may ask you to perform a gram stain. A gram stain is the standardized initial stain that is performed on all bacterial slides in medical facilities.

5 While the slides are drying, prepare the computer to collect temperature data:

- **a** Connect the Temperature Probe 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 Collect your first data run:

- **a** Place the Temperature Probe in direct contact with a large sample of the food.

  Note: In a real investigation, temperatures would have been taken at the picnic site. In this case, the samples may be old enough that they are at room temperature. In laboratories, samples are either kept cold to retard the bacterial growth or kept in incubators to promote growth.
- **b** Click the Collect button to begin data collection. Data collection will last for 30 seconds.
- **c** Record the data on your sheet or in your science journal.

7 Prepare the computer to collect pH data:

- **a** Disconnect the Temperature Probe from the Go! Link.
- **b** Connect the pH Sensor to the Go! Link.
- **c** Make sure the Go! Link is connected to the computer.
- **d** Click the NEW button on the toolbar.
- **e** Choose Data Collection from the Experiment menu and set the experiment length to 30 seconds.
- **f** Click Done. You are now ready to collect pH data.

8 For the pH measurement, follow these steps:

a Place 10 mL of distilled water in a small beaker (50 mL). Add several pieces of your sample material to the water.

b Allow the sample to sit for several minutes to wash any residues into the water.

c Remove the pH Sensor from the storage bottle. Rinse the tip of the sensor thoroughly with distilled water.

d Place the sensor into the sample. Submerge the sensor tip to a depth of 3-4 cm.

Note: If your sample is liquid and you have a sufficient quantity, you can measure the pH directly. Make sure the tip of the sensor is covered by the sample.

9 If the pH value displayed in the meter is fluctuating, determine the mean (or average) value. To do this, follow these steps:

a Click the Collect button to begin a 30-second sampling run.

Important: Leave the sensor tip submerged for the 30 seconds that data is being collected.

b When the sampling run is complete, click the Statistics button to display the statistics box on the graph.

c Record the mean pH value on your sheet or in your science journal.

10 Set up the ProScope with the Microscope Tube Adapter attached to the C-Mount Adapter, then follow these steps:

a Remove the ocular, or eyepiece, and replace it with the ProScope fitted with the Microscope Tube Adapter and C-Mount Adapter.

b Open the USB Shot application.

The ProScope should now be active.

c Place your slide on the stage and focus until you can see it clearly on the computer.

Note: Bacteria are very small and you will not be able to see them at 10X. The high dry lens and the oil lens will work best.

d Record your results as images.

11 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.

12 Based on your findings and Internet research, which bacteria is the best candidate for this case? Which is the most likely food source of the bacteria? Prepare an iPhoto presentation of the microscopic examination to support an oral presentation of your findings.

13 Create an outline of necessary information to inform parents, students, and the general public at large about food poisoning.

Data

Team Name	Temperature	pH	Pathogen Image	Bacterial Pathogens Present
Fruit	°C			
Pickle Relish	°C			
Sandwich (Turkey or Ham)	°C			
Potato Salad	°C			
Cookie	°C			

Processing the data

As a class, summarize the findings into a single document and iPhoto slideshow in preparation for informing the public about the source of infection.

Analyze your data

1 Bacteria divide rapidly, so why do you think the world is not covered in bacteria?

2 From your observations and Internet research, what type of bacteria is most likely the cause of infection? Are there ingredients used in any of the foods that make them more likely to allow dangerous bacteria to rapidly reproduce?

3 What preventative measures can be taken to retard the growth of pathogenic bacteria?

4 From your microscopic observations, what differences can you see between eukaryotic cells and prokaryotic cells?

Teacher Information

This investigation is designed to promote the development of student skills in the areas of observation, questioning, experimental design, analysis of data, development of possible explanations, and the presentation of findings. Students may be familiar with experiencing such symptoms, but they may have very limited knowledge of how epidemics spread and the impact of such events. Because of the nature of these situations, the driving questions are always the same: What is causing the illness and what is the source? In this case, the suspect was already narrowed down to bacterial food poisoning. Allow the students to form their own hypothesis and modify the hypothesis based on their research.

Hypothesis

Allow each team of students to form a hypothesis as to the type of disease and its source.

Model hypothesis. The basic disease symptoms are usually caused by a bacterial source. Since all of the students attended the same picnic and ate the same food, one of the components of the lunch may be the source of the bacteria. The most common of the possible suspects, and the one that causes similar symptoms, is salmonella.

Science concepts

Bacterial contamination of foods is a real danger in our society. The contamination can come from improper handling of the food, from the food itself, or from workers that carry the organisms. In the United States last year, a small outbreak of viral hepatitis was caused by contaminated scallions. Unchecked, these outbreaks can rapidly spread and grow into an epidemic. Bacterial infections generally can cause disease by two major mechanisms. The first is bacteria causing direct damage to the tissue, as seen in tuberculosis infections of the lungs. This type of infection is caused by Mycobacterium tuberculosis. The second mechanism is by the production of a toxin, with the classic example of botulism, caused by the exotoxin of the bacteria, Clostridia botulinum. In this case, the most common cause of the symptoms presented here is Salmonella choleraesuis, which may result in a superficial invasion of the gastrointestinal track and/or the mere release and absorption of an endotoxin into the body.

In this scenario, the failure to store the food at a sufficiently low temperature allowed the rapid growth of the pathogenic bacteria. The mayonnaise and potatoes act as medium and food source for the bacteria. Because the food was eaten in a narrow period of time, the onset of the symptoms will also occur in a narrow window of time. In this event, most of the cases will occur in the first 48 hours. If the cases continue to occur past this window, other sources must be sought. For instance, if an entire production run of mayonnaise was contaminated, cases would begin to appear over an increasing time window and geographical area.

Facilitation tips

If there is insufficient time to have every student perform each experiment on every sample, divide the class into teams as follows, based on the contents of the lunch.

Research teams

a Fruit team (cold, acidic pH)

b Pickle Relish team (cold, basic pH)

c Sandwich team (room temperature, neutral pH)

d Potato Salad team (warm or room temperature, neutral pH)

Note: This sample should be unpasteurized yogurt or sour cream. Do not use real potato salad. You may accidentally introduce a real pathogen into the lab.

e Cookie team (room temperature, neutral pH)

If you prefer to have each team specialize in a type of equipment, rather than in a particular food item, have one team test the pH of each sample, one team prepare slides, and so on.

Results are relatively simple. If the sample is too acidic or too cold, the bacteria would not be likely to be there. A stained slide from each source will allow students to confirm or eliminate the possible presence of bacteria. Students will trace it down to a sample from the potato salad. (This is actually a sample of liquid from the top of a sour cream sample or unpasteurized yogurt, safe, friendly bacteria Streptococcus lactic.) The team makes a slide and observes lots of bacteria! The other samples don't have any so they are rejected as the source. The collection of temperature data is relatively simple using only contact reading from the inside. The samples should be old enough that they are mostly at room temperature.

The pH readings pose a little more of a problem. In an actual laboratory, the samples would all be turned to liquid in a high speed blender. If you have one, you can liquify the samples. If not, washing the sample and allowing some of the food to sit in the water will at least give you some indications of the pH nature of the sample.

Extensions

- Science. Have students produce a food safety brochure for use by students and parents. List the common agents of food poisoning, their symptoms, and treatments.
- Research question. There are many antibiotics available today. Ask students to list at least five different antibiotics and how they work against bacteria.

- History. Ask students to research related historical questions: When was the germ theory developed and by who? How were infections treated before antibiotics? Explain why a wound received by a soldier in the Civil War was so serious.
- Mathematics. Have students research how scientific and medical facilities count bacteria. If you can and have the resources, see if you can do a count on a sample of sour cream.
- Science. Have students design an experiment to show how environmental factors can slow the growth rate of bacteria.
- Internet research. Have students identify the worst case of food poisoning in history.

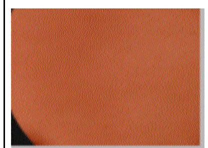
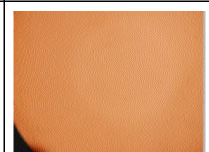
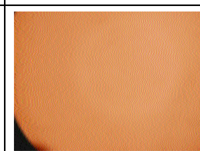
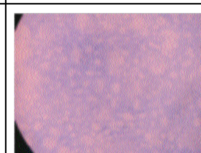
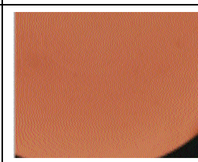
Expected outcomes

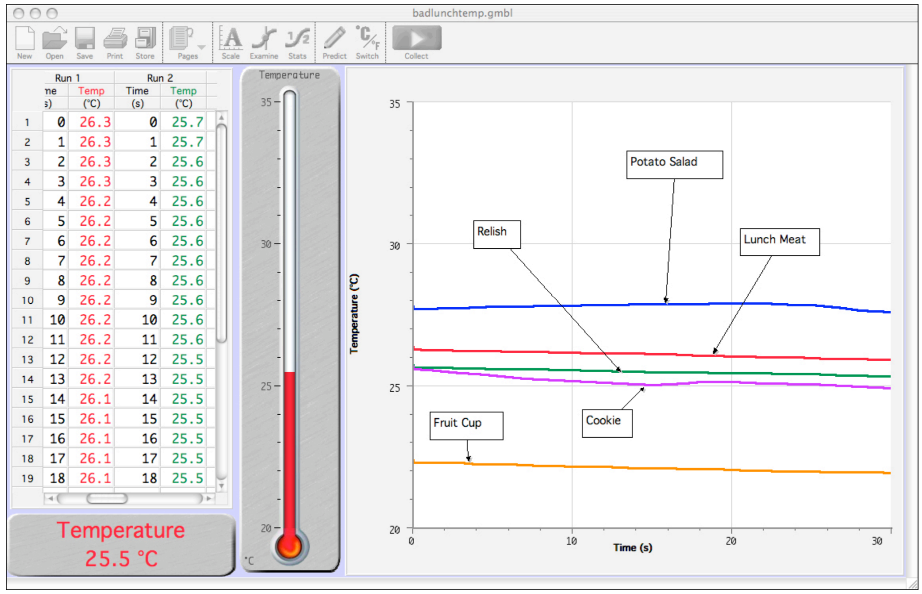
This experiment is a basic investigation into bacteria and the process of rapid dissemination and reproduction of a disease-causing bacteria. Although there are no pathogenic bacteria present in the activity, students should try to take the same safety precautions as they would in a real-life situation. Generally, the students will not be able to find any bacteria in any significant numbers in any of the food sources except the sour cream or yogurt culture. This ensures the safety of the students. However, the techniques and pressure to find the answers are real factors in these types of occurrences. In fact, this situation is similar to many real-life events.

Data

Students collect data on each of the food items in the prepared lunch. The data from each item is temperature, pH, and ProScope and microscopic examination photos.

Sample results

Team Name	Temperature	pH	Pathogen Image	Bacterial Pathogens Present
Fruit	22.3°C	6.5		No
Pickle Relish	25.6°C	3.8		No
Sandwich (Turkey or Ham)	26.3°C	7.4		No
Potato Salad	27.9°C	3.9		Yes
Cookie	25.6°C	7.5		No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New Open Save Print Store Pages Scale Examine Stats Predict Switch Collect
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Time (s) Temp (°C)
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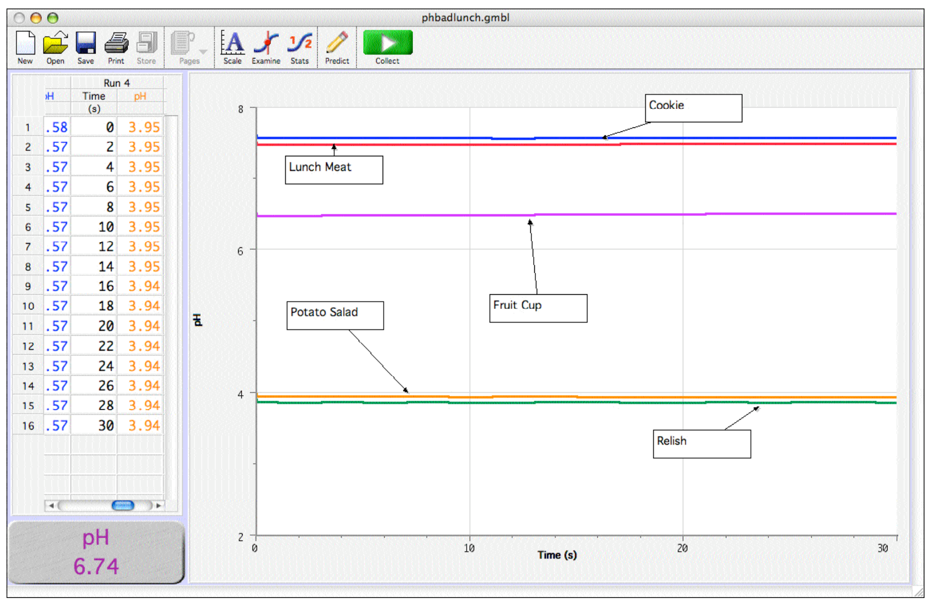
1 26.3
2 26.3
3 26.3
4 26.2
5 26.2
6 26.2
7 26.2
8 26.2
9 26.2
10 26.2
11 26.2
12 26.2
13 26.2
14 26.1
15 26.1
16 26.1
17 26.1
18 26.1
Run 2
Time (s) Temp (°C)
0 25.7
1 25.7
2 25.6
3 25.6
4 25.6
5 25.6
6 25.6
7 25.6
8 25.6
9 25.6
10 25.6
11 25.6
12 25.5
13 25.5
14 25.5
15 25.5
16 25.5
17 25.5
18 25.5
Temperature
Temperature
25.5 °C
Temperature (°C)
Time (s)
Potato Salad
Relish
Lunch Meat
Fruit Cup
Cookie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New Open Save Print Store Pages Scale Examine Stats Predict Collect
Run 4
Time (s) pH
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2 3.95
4 3.95
6 3.95
8 3.95
10 3.95
12 3.95
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16 3.94
18 3.94
20 3.94
22 3.94
24 3.94
26 3.94
28 3.94
30 3.94
pH
6.74
pH
Time (s)
Cookie
Lunch Meat
Fruit Cup
Potato Salad
Relish

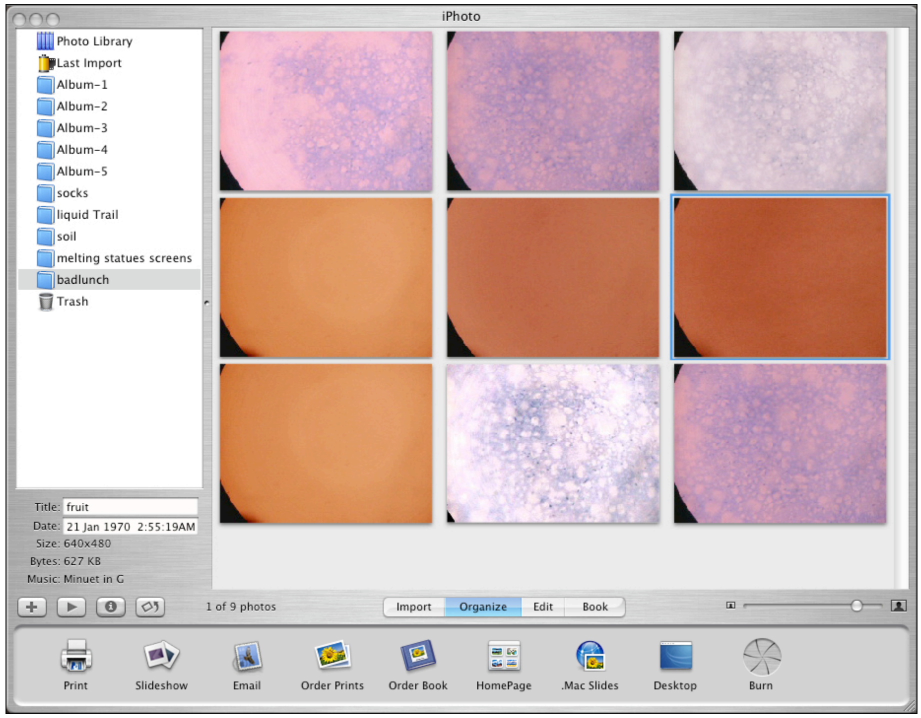
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Photo Library
Last Import
Album-1
Album-2
Album-3
Album-4
Album-5
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liquid Trail
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melting statues screens
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Date: 21 Jan 1970 2:55:19AM
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Bytes: 627 KB
Music: Minuet in G
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Organize
Edit
Book
Print
Slideshow
Email
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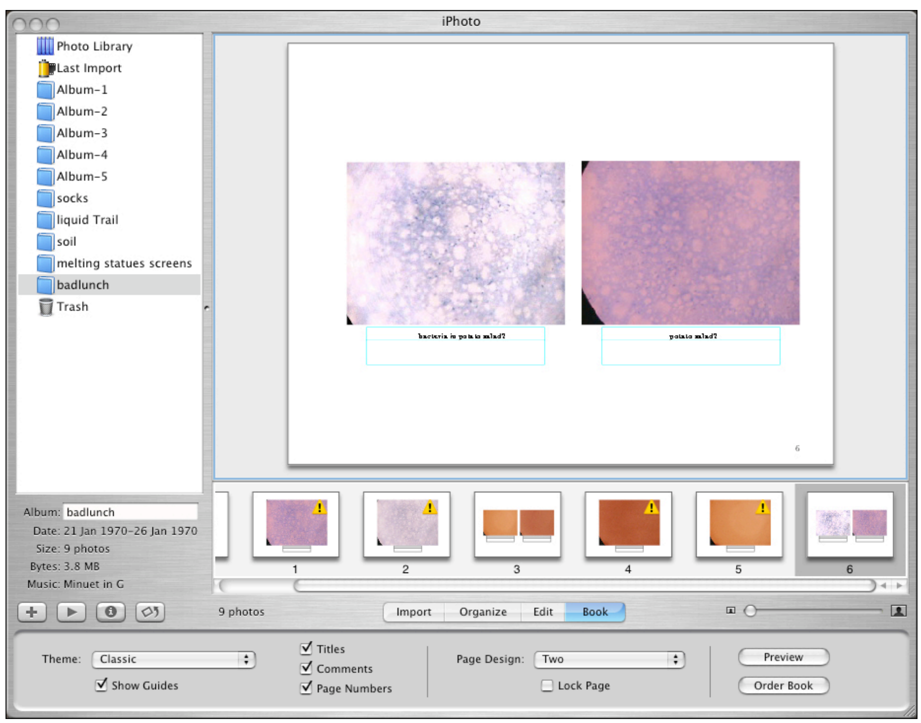
Order Book
HomePage
.Mac Slides
Desktop
Burn


iPhoto
Photo Library
Last Import
Album-1
Album-2
Album-3
Album-4
Album-5
socks
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melting statues screens
badlunch
Trash
Album: badlunch
Date: 21 Jan 1970-26 Jan 1970
Size: 9 photos
Bytes: 3.8 MB
Music: Minuet in G
9 photos
Import
Organize
Edit
Book
Theme:
Classic
Show Guides
Titles
Comments
Page Numbers
Page Design:
Two
Lock Page
Preview
Order Book

Answers to analyzing your data questions

1 Environmental factors and limited food sources limit the growth rates of bacteria.

2 Salmonella

3 Limit food sources, regulate temperatures, and use anti-bacterial agents.

4 In eukaryotic cells, there is the presence of a true membrane-bound nucleus that can be seen as a darkly staining area of the cell. In bacteria, no such membrane-bound structure is found and most bacteria contain only a single naked chromosome.

Additional online resources

- http://www.ucmp.berkeley.edu/bacteria/bacteria.html
- http://www.microbe.org/microbes/bacterium1.asp
- http://www.bacteriamuseum.org/
- http://www.bacteriamuseum.org/niches/foodsafety/foodsafety.shtml
- http://www.tulane.edu/~dmsander/WWW/Video/pneumo.html
- http://www.dmacc.cc.ia.us/instructors/scottie.htm
- http://www.cdc.gov/health/foodill.htm
- http://www.cdc.gov/ncidod/dbmd/diseaseinfo/botulism_g.htm#What%20are%20the%20ymptoms%20of%20botulism

Science standards alignment

This experiment provides direct alignment to national standards by allowing students to actually see, identify, and differentiate between basic types of cells and some of the structures in cells. The design of the experiment also emphasizes alignment with measurement, inquiry, and investigative standards by having students use technology to practice skills necessary to the solving of the problem that are widely used in real-world investigations. In addition, the experiment provides insights on how the simple structure of the genetic material of bacteria allows for rapid growth and reproduction rates. The activity also promotes student knowledge of the interactions of bacteria with environmental conditions and with human physiology.

National Science Standards

Unifying Concepts and Processes

1 Evidence, models, and explanation.

2 Change, constancy, and measurement.

3 Form and function.

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.

3 Use Technology and Mathematics to improve investigations and communications.

4 Formulate and revise scientific explanations and models using logic and evidence.

5 Recognize and analyze alternative explanations and models.

National Content Standards

Level 9-12. Life Science Content Standard C

The Cell:

Cells have particular structures that underlie their functions.

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 an 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 by Dr. Bruce Ahlborn, Technology Coordinator of the Northbrook School District, Northbrook, IL, and edited by Bruce Payne, Apple Professional Development consultant.