Engaging Your Students in Inquiry

Lessons from the UCLA GK-12 Program

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Objectives for this talk:

- **Describe context of the UCLA GK-12 lessons**
- **Share Model Lesson - Where is bacteria found? What destroys bacteria?**
- **Lessons**
  - **UCLA GK-12 lessons**
  - **Implementing Inquiry-based lessons**
- **Questions/Comments**

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GK-12 Science and Mathematics Inquiry in Los Angeles Urban Schools

- Our mission is to develop inquiry-based activities that are affordable, and easy to implement.
- When possible we try to use readily available items, most of which can be purchased in drug stores & markets.
- Each lesson contains teacher materials and students handouts and many include supplemental materials such as PowerPoint presentations, and illustrations.

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Participants -
Fellows, Teachers, and UCLA Staff

Guidelines to Teacher Materials

- **Title**
- **California State Standards**
- **Synopsis**
- **Background**
- **Objectives**
- **Suggested Timeline**
- **Materials (for each group, cost)**
- **Teacher's Tips**
- **Classroom Activities-Learning Cycle**
- 1. Concept Exploration - students learn through involvement and action
- 2. Concept Introduction - teacher directs student attention to specific aspects of the exploration experience.
- 3. Concept Application – Students apply learned concept to other examples
- **Sample Test Questions**

Share Model Lesson

Where is bacteria found? What destroys bacteria?

Sources
Protocol of The Discovery Channel Antibacterial Action Activity
New York Times

California Standards Addressed: 9-12 Grade Biology/Life Science and Investigation and Experimentation

- 10d. *Physiology*. Students know there are important differences between bacteria and viruses with respect to their requirements for growth and replication, the body's primary defenses against bacterial and viral infections, and effective treatments of these infections.
- 1a. *Investigation and Experimentation.* Students will select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data.
- 1b. *Investigation and Experimentation.* Students will identify and communicate sources of unavoidable experimental error.
- 1c. *Investigation and Experimentation.* Students will identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- 1d. *Investigation and Experimentation.* Students will formulate explanations using logic and evidence.
- 1f. *Investigation and Experimentation.* Students will distinguish between hypothesis and theory as scientific terms.

Synopsis

- Groups of students sample different areas of their school where they think they will find bacteria and culture that bacteria on agar plates. One of their agar plates will be impregnated with ampicillin, on the others, they will use one half of the plate as a control and apply a household antibacterial agent (e.g. antibacterial dish soap, hand soap, bleach, alcohol, antibacterial ointment, etc.) to the other half to test its effectiveness in killing bacteria. By comparing the number of colonies on their plates with those of other groups, students will get an idea of which places in their school harbor the most bacteria. Comparing the growth on plates treated with antibacterials will give them an idea of which antibacterial is the most effective. This activity also seeks to introduce the concept of experimental controls, and challenges students to think about experimental design and possible sources of error.

Background Information

- Microscopic bacteria can be found just about anywhere, but some areas harbor more than others. This activity will allow students to culture bacteria from different parts of their school and to visually see the colonies as the bacteria multiply into the millions and billions. Agar is nutrient medium for bacteria, created to provide optimum conditions for many bacteria to grow and multiply. Many bacteria can live and multiply at room temperature, but the optimum temperature for the growth and multiplication of bacteria is about 37C, so an incubator or heater, if it is available, will speed growth, to get students results sooner. However, bacteria should grow just fine at room temperature. Agar plates should always be stored with the agar side up so that condensation from the lid does not drip onto the agar.

Background Information

- Manufacturers often add anti-bacterial drugs such as triclosan to household products, ranging from hand soaps to dishwashing detergents, in order to market them as antibacterial. Health officials caution that widespread use of some surface antibacterials, such as triclosan, may lead to strains of bacteria that are resistant to those drugs:http://www.kidsource.com/health/enzyme.html. Furthermore, they have found that products with these agents don't necessarily eliminate more bacteria than products without the drugs. This activity gives students the opportunity to test and compare household antibacterial agents of all kinds for their ability to kill bacteria.

Suggested Class Time Overview

- 2.5 class periods total time
- Day 1 – 0.5 class period
  - Read and discuss article: "On Germ Patrol, at the Kitchen Sink"
  - Demo of pouring agar plate
- Day 2 – full class period
  - Review technique of swabbing plate
  - As a group, decide where they want to sample, write it down.
  - Follow procedure on Student Handout to infect plates, apply antibacterial agents, and label.
  - Place in incubator
- Day 3 or 4 – 5 min. for monitoring plates
- Day 5 – analysis and presentation of results

Advance Preparation/Materials:

- Agar
- Ampicillin
- Covered plastic Petri dishes
- Sterile swabs
- Markers for writing names on plastic petri dishes
- Some household antibacterial products, just in case students don't bring in their own. (examples)
- incubator (optional, but recommended)
- Agar plates should be prepared before the activity begins. (Description is included.)

Engagement: Have the students read the New York Times article, "On Germ Patrol, At the Kitchen Sink," by Wendy Marston:

http://www.nytimes.com/learning/teachers/featured_articles/19990223tuesday.html

write answers to the following questions:

- 1. Who was Thomas Crapper?
- 2. Why does Dr. Gerba recommend that you keep your toothbrush in the medicine cabinet?
- 3. What is *E. coli*?
- 4. Why does the kitchen sometimes have the most bacteria?

- This engagement activity not only introduces the subject and will start students thinking about where they can find germs and bacteria, but also helps students build literacy and reading comprehension skills
- Ask the students to bring in anti-bacterial products from home: these can include hand-soaps, dishwashing soaps, germicidal gels, antibiotic ointment, disinfectant spray, bleach, alcohol, etc.

Exploration/Activities:

- Students can work in small groups for this activity, ideally between 3-5 students in a group. Most of the instructions for this activity are clearly written in the student handout. However, it will be important to have a discussion with the students before they start the activity so know some of the basics (see also *Lesson Outline*)
  - What is a bacteria?
  - What is agar? Agar plate is a scientific tool. Scientists have designed agar to be the favorite food of bacteria.
  - How fast does bacteria grow?
  - How can we make bacteria grow faster? Introduce incubator.
  - Technique of swabbing plate – why we do it that way
  - Safety information – don't open infected plates.

Exploration/Activities:

- 1. Decide where to sample – Each group of students should decide where in the school they would like to sample. In order to make the activity more interesting, the instructor should make sure that each group is sampling a different area or aspect of the school or classroom. Sampling areas should be specific (e.g. handrail of stairway, computer keyboard, doorknob, refrigerator shelf, Juan's chair).
- 2. Streaking the plates – Directions on the student handout. Make sure to emphasize to the students that if they touch the tips of the swabs with their fingers, they will contaminate them with bacteria from their fingers.
- 3. Monitoring the plates – Students should monitor the plates for 3 days before analyzing the results. Each day, they should count the number of bacterial colonies on their plates and write these tallies in the chart on their student handouts. This should only take 5-10 minutes each day.

4. Analyzing the results – On the third day of incubation, students should make their final tallies and record them in the chart on the student handout. Each group should send a representative to put the results from the CONTROL halves of plates 1, 2, and 3 on the class data table on the board. Class data table should look something like this:

Group Name	Javier's group	Duane-O	Germies	etc.		
Sampling area	boys bathrm sink	computer keyboard	doorknob			
Plate 1	120	55	215			
Plate 2	96	32	50			
Plate 3	88	73	99			
Average	101.3	53.3	121.3			

- 5. Graphing and interpreting results
  - **Discuss and define control** – by this time, the students will probably have gained some understanding of the concept of a control, just by preparing their plates. However, one can present them with the following scenario, "Let's say we swabbed a whole plate with bacteria from Julia's forehead, then applied antibacterial soap to the whole plate, without using a control. On day 3, we look at the plate and we find this [draw a circle on the board with no dots on it (no bacterial colonies)]. What does this tell you?" Hopefully the students will come up with two scenarios: (1) the soap killed all the bacteria or (2) there are no bacteria on Julia's forehead. Ask them how we can know the difference [we can't]. Now draw two plates on the board and divide them into control and treated. For one of the plates, put lots of bacterial colonies on the control half (leaving the treated side blank) for the other plate, leave the whole plate blank – ask the students to interpret the results. Now ask them what the purpose of a control is.
- Have students graph class results (sampling area on the x-axis, average number of bacteria on y-axis). Discuss why we are using the control regions to compare between groups and why we use averages instead of just picking one of the samples as a representative.

- *6. Optional*: have students calculate percentage difference between # of bacteria colonies on control and treated for each of their plates using the following formula to get a percent effectiveness that can be compared between products:

$$\frac{(\text{Control} - \text{Treated})}{\text{Control}} \times 100$$

- 7. Discussion questions:
  - Did you get the results you were expecting?
  - What were the possible sources of experimental error?
  - Were some of the antibacterial agents better than others? Which worked well, which did not?

Concept Application/Assessment

- The questions in the INTERPRETATION OF RESULTS and GOING FURTHER section of Student Handout are designed to assess the student's comprehension of the activity. Some additional activities and/or assessments:
  - 1. Present students with a hypothetical table of class results (similar to the one that you put on the board) and ask them to interpret them in essay form.
  - 2. As a quiz, draw four hypothetical plates that result from students sampling in a particular area and applying three different antibacterial agents, ask them specific questions, first about the number of bacterial colonies present in each of the portions of each of the plates (maybe filling in a table), then which of the antibacterial agents are effective in killing bacteria and which ones are not.
  - 3. One of the reasons why some of the anti-bacterial products may not prevent bacterial colonies from growing on the plates is that in this activity, we are not using them exactly the way they are designed to be used. Have the students come up with a better way to test these products and then carry out that test (e.g. streaking the "control" side with one finger, washing that finger with antibacterial soap, then streaking the "treated" side with the cleaned finger).

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Lessons are categorized by Content Standard at this website:

http://www.nslc.ucla.edu/STEP/GK12/Default.htm

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Implementing Inquiry-based lessons

- Students need scaffolding
- Teachers need professional development and practice
  - Explicit discussions about IBI
  - Commitment to Inquiry

Questions/Comments