Bacterial growth

Subject Area(s)	Biology, measurement
Associated Unit	None
Associated Lesson	None
Lesson Title	Bacteria are everywhere!

Header Insert Figure 1 here, right justified

Figure 1

ADA Description: Photo of a Petri dish containing multi-colored bacterial colonies grown from a student's hand.

Caption: These colorful bacterial colonies were grown from bacteria present on our hands!

Image file: Figure 1_bacterial colonies.jpg

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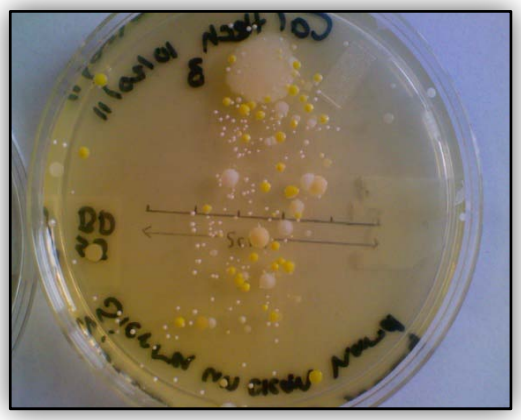

Grade Level	7 (5-7)
Lesson Dependency	None
Time Required	Three one hour sessions, over the length of one week
Group size	4-5
Expendable cost/group	US$5

Summary

In this exercise, students will learn that bacteria can be found everywhere, including on the surface of our own hands. Students will study three different conditions and compare the growth of bacteria from these surfaces: (1) unwashed hand, (2) hand washed with soap and water, and (3) hand sanitized with antibacterial hand gel. The students will take swabs of their hands in these three different conditions and streak the swabs on Petri dishes containing agar gel which supports bacterial growth. After creating these three samples, over the period of one week the Petri dishes will show growth of several different kinds of bacteria, and the students will quantitatively compare the amount of bacteria growing from each test condition. Quantitative analysis of these samples will be done by taking photos of the Petri dishes at different time points and analyzing the images through imaging software. In addition to monitoring the quantity of bacteria from differ conditions, they will also be able to record the growth of bacteria over time, which is an excellent tool to study binary fission and the reproduction of unicellular organisms.

Engineering Connection

Students will learn to design an experiment to test the effect of environmental conditions on the growth of living organisms. This experiment teaches students that bacteria, and other microorganisms, can be, and are found everywhere.

Not only do students get to visualize the growth of bacteria over a few days time, but they will also quantize the growth by analyzing images of the Petri dishes. This type of lesson is eye-opening for students, as a unit covering microorganisms is often quite difficult to grasp due to the fact that bacteria are not visible to the naked eye. An engineering connection is also made in that students will learn that bacteria can both be harmful, as well as helpful to our bodies. There are also bacteria that are being genetically engineered to produce compounds such as therapeutic proteins and other synthetic molecules which are being developed for use as medicines and other beneficial substances. The engineering of biological organisms is something that students will be introduced to in this activity.

Engineering Category #1

Keywords bacterial, image processing, microorganism, biology, growth

Educational Standards

- New York State standards for “Living Environment”:
  - Standard 1 (scientific inquiry), key ideas 2 and 3
  - Standard 4 (understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment), key ideas 1 and 4
- New York State standards for “Intermediate Science”:
  - Standard 1 (analysis, inquiry, and design), key ideas 2 and 3
  - Standard 4 (the living environment), key idea 4

Pre-Requisite Knowledge

None.

Learning Objectives

After this lesson, students should be able to: Students will also understand the overwhelming amount of bacteria surrounding our daily lives and their positive and negative roles in our lives – including medicinal uses like antibiotics and gram-staining.

Materials list

Per group:

- 3 Petri dishes (10 cm diameter)
- 75 ml tryptic soy agar (TSA)
    - Preparation instructions: add 10 g TSA to 250 ml water in a microwaveable container. Microwave the solution for about 3 minutes (until boiling). Pour the hot solution into the Petri dishes, so that you just cover the bottom completely. Let Petri dishes stand for 20 minutes while the agar solidifies. 250 ml TSA solution will make 30 Petri dishes; adjust quantities appropriately depending on how many dishes you want to prepare.
- 3 Q-tips (1 per sample)
- Camera and computer
- ImageJ software (free download at http://rsbweb.nih.gov/ij/download.html)

Introduction / Motivation

The growth of bacteria over time provides an excellent model for the study of prokaryotes reproduction of through binary fission. Students will be able to determine what factors influence bacterial growth, and quantify the effects of these various factors. The common perception among middle school students is that bacteria are malevolent, whereas in reality there are a plethora of different bacteria that can be beneficial to us. Not only do these organisms have effects on the exterior and interior of our bodies, but bacteria such as *E. Coli* are also used by biochemists and protein engineers to produce important proteins for therapeutic purposes through biosynthesis.

Lesson Background & Concepts for Teachers

Bacteria are found all around us, and can be harmful or beneficial to our health. This lesson visually shows students that bacteria are found even in large amounts on our hands. It also teaches them that there are things that we do to prevent the growth of bacteria or kill them, such as washing our hands and applying antibacterial hand sanitizer.

The use of image processing software in this experiment teaches students not only that we can qualitatively study bacterial growth, but we can actually obtain measurements on how much bacteria is growing, and if studied over time, the speed of this growth.

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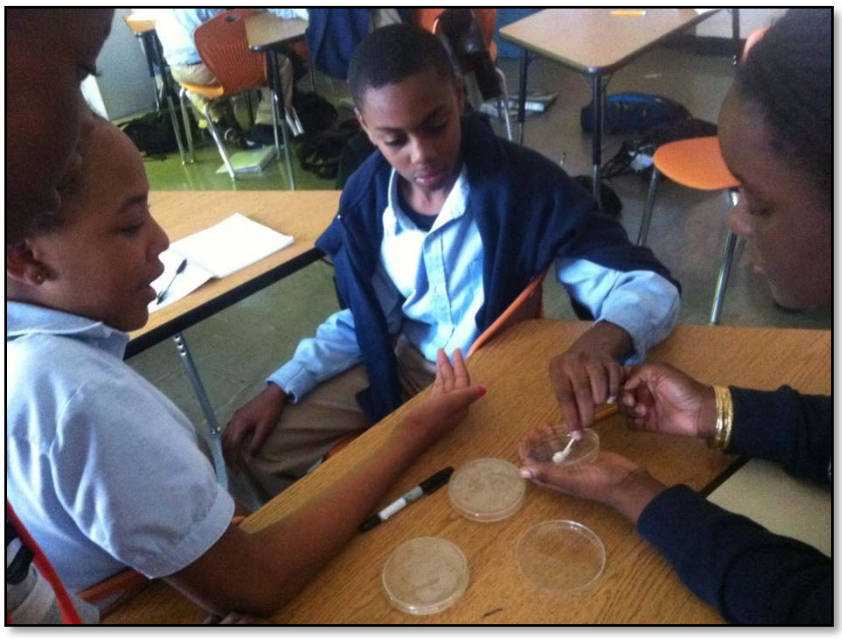

Figure 2

ADA Description: Photo of students using a Q-tip to streak bacteria from their hands onto Petri dishes containing agar.

Caption: Students take turns streaking plates from bacterial that is on their hands.

Image file: Figure 2_streaking plates.jpg

Vocabulary / Definitions

Word	Definition
Bacteria	A unicellular microorganism with no nucleus
Colony	A visible cluster of bacteria
Fission	One cell divides into two, bacteria reproduce this way
Aerobic respiration	Respiration that requires oxygen
Anaerobic respiration	Respiration that does *not* require oxygen
Eukaryotic	Cell that has a nucleus
Prokaryotic	Cell that lacks a nucleus

Procedure

Procedure for making TSA plates: see “preparation instructions” in **Materials List** section of this document.

Samples of bacteria on the surface of student’s hands will be taken and the bacterial will be grown over time. Samples will be taken from one student’s hand under three different conditions:

1. Unwashed hand
2. Hand washed with soap and water
3. Hand sanitized with antibacterial hand gel

Procedure for streaking plates:

1. Chose one student from the group to obtain samples from (it is important to have all samples come from the same person to reduce experimental error).
2. Label 3 Petri dishes by writing the group number, sample name (unwashed, washed, or sanitized), and class on the lid with a Sharpie.
3. Start with the “unwashed” hand. Gently rub a Q-tip on the surface of the student’s palm. Open the Petri dish (labeled “unwashed”) containing agar and rub the Q-tip back and forth on the agar. Students must be careful not to apply too much pressure when doing this, otherwise the agar will tear.
4. Close the Petri dish.
5. Student will wash one hand with soap and water (may need assistance from a teacher or group member) and repeat Steps 3 and 4 for this hand; being careful to streak the plate labeled “washed” this time.
6. Hand sanitizer will be applied to the student’s other hand (may need assistance from a teacher or group member). Allow it to air dry until all gel has evaporated. Repeat Steps 3 and 4, except being careful to streak the plate labeled “sanitized” this time.

Procedure for data acquisition:

1. Take a photo of each plate approximately 4 days after streaking.
2. Open Image J software.
3. Select File, then Open from the drop down menu.
4. Select the image file you would like to analyze.
5. Trace a line over your scale bar. Select Analyze then Set scale. Fill in the "Known distance" box for the length of your scale bar, and set the "Units".
6. Click Image > Adjust > Threshold. For the Threshold Color, select B&W. Adjust the Hue, Saturation, and Brightness levels until you obtain your bacterial colonies in black and the background agar in white.
7. From the toolbar, select the circle image. Draw a circle around the edge of the Petri dish to define where the software will measure from.
8. Next, from the Analyze menu, select Analyze Particles. Set an upper limit to the size (generally bacterial colonies would not by larger than 4 cm^2). Circularity should be 0-1, and select Nothing from the Show drop down menu. Select Summarize from the checklist. Click Ok.
9. The Summary window will open and will provide data on the area of the Petri dish that is covered in bacterial colonies. This data is found under the column "Total Area", and is given in square units of what you entered in step 5. The Summary window also displays the "Area fraction". Students may record the area fraction (given as a % of the total area measured) and use this as their data for the amount of the Petri dish covered by bacteria.
10. If you chose, you can save the adjusted photo by File > Save As.

Image Insert Figure 3 here, centered

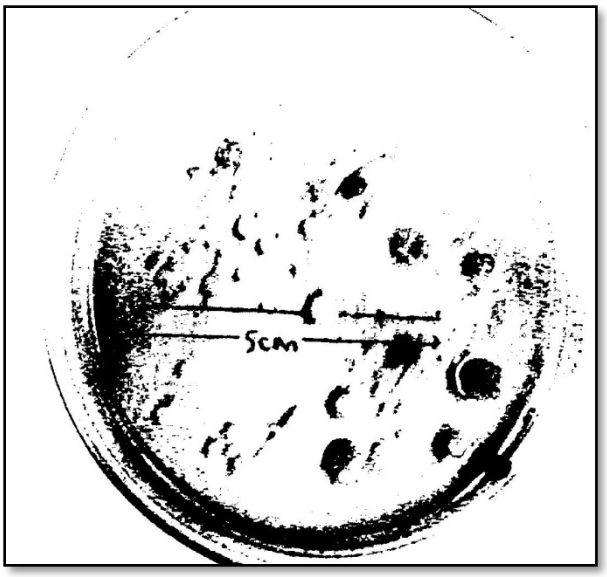

Figure 3

ADA Description: Black and white threshold adjusted photo of Petri dish with bacterial colonies grown from an unwashed hand. This is done in ImageJ software and is necessary for data acquisition.

Caption: Black and white photo of a dish with bacterial colony growth. ImageJ analyzes the size of the circular black particles (colonies) and expresses it as a fraction of the area analyzed.

Image file: Figure 3_black and white dish.jpg

Image Insert Figure 4 here, centered

Figure 4

ADA Description: Students working together as a group to streak Petri dishes with bacteria from their own hands and answering questions pertaining to the experiment.

Caption: Figure 4.

Image file: Figure 4_group work.jpg

Attachments

- Pre-evaluation survey
- Post-evaluation survey
- Worksheet
- Bacterial colonies photo (Figure 1)
- Streaking plates photo (Figure 2)
- Black and white photo of bacterial plate (Figure 3)
- Group work photo (Figure 4)

Safety issues

As this activity involves growing bacteria from students' hands, there are several safety precautions that should be taken. As soon as the plates have been streaked, the lid should be replaced and two pieces of tape can be applied to keep them shut (any closure should not be air-tight, however). These plates should be kept away from

students until the time of data analysis. *No one, at any time, should touch the agar or the bacteria.* When taking pictures, the lid should be opened briefly and replaced immediately after data collection is complete.

When the activity is complete and pictures have been taken of all samples, the Petri dishes should be discarded immediately.

Troubleshooting tips

For optimal growth of the bacteria, make sure that they are grown between room temperature (22 ºC/72 ºF) and body temperature (37 ºC/99 ºF) and in a well ventilated area.

Assessment

Pre-Activity Assessment

- See “Pre-evaluation survey” attachment.

Activity Embedded Assessment

- See “Worksheet” attachment.

Post-Activity Assessment

- See “Post-evaluation survey” attachment.

Activity Scaling

- For lower grades: For lower grades, the analysis of the images can be omitted and bacterial growth can simply be visualized by eye. A relative quantization of the amount of bacterial growth in the Petri dishes by comparing the three samples against one another.
- For upper grades: For upper grades, images of the samples can be taken more frequently and quantified and plotted. This plot should show and exponential growth of bacteria over time. The data can be fitted to exponential curves mathematically and regression can be performed to determine how closely the experimental data matches the theoretical predictions.

Additional Multimedia Support

None.

References

None.

Redirect URL

http://gk12.poly.edu/amps/

Owners

Jasmin Hume

Contributors

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