



Activity 4: MedBay: One Cell, Two Cells, Four Cells, Eight

In this activity, the student will learn about bacterial growth and personal health by culturing bacteria found on themselves and in their environment.

Background

Many different microorganisms live in, on, or around us. Two very different types can be grown in the classroom. Bacteria are single-celled prokaryotic organisms. These organisms lack membrane-bound organelles found in animal and plant cells. Fungi are either single-celled or multi-celled eukaryotic organisms found frequently in air, soil, or moist places inside buildings. Neither bacteria nor fungi can make their own food. Instead, they consume organic material.

Bacteria grow in almost all environments. Normally, millions of bacteria are found in the human body and trillions of bacteria are found in a single teaspoon of garden soil. Bacteria can live in many diverse environments and under conditions that are too severe for other living things. For example, some bacteria have adapted to the hot springs in Yellowstone National Park, where the water temperature can reach above the boiling point. Fungi are important decomposers in the environment. Most prefer dark, moist places. Some fungi also perform special jobs for humans. Yeast is involved in making bread, and the first antibiotic discovered, penicillin, is produced naturally by a mold fungus.

In addition to being able to live in many different environments, bacteria can reproduce quickly. Bacteria reproduce by a process called binary fission. During this process, a single cell will increase in size and divide into two new daughter cells. Therefore, one cell becomes two, two cells become four, four cells become eight, and so on. Different bacteria divide at different rates, but this process of doubling can take as little as 20 minutes to occur in ideal conditions. The bacterium usually divides in a way that the two daughter cells are exact copies of the parent cell. Fungi reproduce either asexually, by a process called budding, or sexually, by producing spores. Many fungi have complicated life cycles that depend on the environment.

So, why don't bacteria overpopulate and take over all other living things? First, bacteria are dependent on their environment to provide nutrients. When the nutrients run out, bacteria stop dividing. Second, there are many things that are able to kill bacteria. Simply using soap and water is one of the most effective methods of ridding your skin of bacteria. Third, many types of bacteria compete for the same resources. Finally, like all living things, different bacteria require different environments in which to live. Temperature, pH, sunlight, oxygen content, and food are a few factors that affect the growth of bacteria. Alter just one of these factors, and the bacteria may stop dividing or even die. Fungi also depend on their environment for nutrients. In many environments, fungi compete with bacteria for nutrients and space. Although spores are found in most places around the world, fungi do not grow everywhere.

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Learning Objectives

The student will:

1. learn the phases of bacterial growth.
2. conduct an experiment to discover the presence of microorganisms in the environment
3. conduct an experiment to determine the effect of good hygiene on the growth of microorganisms.

Materials per Group of 3 Students

1. **3** *MedBay: MedBay: One Cell, Two Cells, Four Cells, Eight Student Activity Sheets*
2. **3** *Phases of Bacteria Growth Student Activity Sheets*
3. **3** *Microbe Growth Table Sheets*
4. **6** slices/chunks of boiled potato
5. **6** sterile Petri dishes
6. **6** clean cotton swabs
7. **1** new sandwich-sized zipper-top bag
8. **1** clean plastic fork
9. **1** clean cup or beaker
10. tap water
11. permanent marker

If your students will be boiling their own potatoes, each group will also need the following:

12. 500 ml beaker
13. rings and ring stands (Bunsen burner)
14. wire gauze (Bunsen burner)
15. raw, peeled potato
16. knife
17. **6** sterile Petri dishes
18. protective hand wear (kitchen mitt)
19. metal fork or tongs

For the whole class, you will also need:

20. water
21. hand soap
22. cleaning product such as dish soap, all-purpose cleaner
23. paper towels
24. duct tape
25. masking tape

To clean the Petri dishes after the activity

26. dishpan with soapy water
27. small sponge or brush
28. one 1 gallon-size sealable bag
29. one pair disposable gloves, optional
30. about 200 mL rubbing alcohol, preferably in a squirt bottle

Notes from the Trenches

- Dishes from the dishwasher and freshly washed hands are nearly sterile.
- Potatoes can be sliced and boiled at home and stored covered in a clean dish overnight. Although raw potatoes can be sterilized using dish soap, they turn grey quickly, making it more difficult to see microorganism growth.
- At room temperature, bacterial growth can be observed beginning at Day two.
- If bacteria are particularly plentiful, a smear will be seen instead of individual colonies.
- It is easy to see the first three phases of growth (lag, log, and steady state). Seeing decline may require incubations longer than one week.
- Petri dishes can be washed on the top rack of the dishwasher.

Spotlight on Safety

Have students observe good laboratory techniques. In addition, have students observe plates **WITH THE LIDS ON**. Depending on what they chose to swab, some of the bacteria can be harmful. If large amounts of fungi are growing, sensitive students could show an allergic reaction to breathing the spores.

Procedure

Preparation

1. Prior to class, place six cotton swabs into sealable sandwich bags without touching the ends, one bag for each student group. Close bags.

During Class

2. Distribute the diagram of the *Phases of Bacterial Growth*.
3. Discuss the factors that may affect each stage.
4. Describe the investigation at hand. Public health officer Sirius requires everyone to test for the presence of microorganisms on themselves and in their environment. In addition, he wants to know how effective the Reconstructor's hygiene techniques are by culturing bacteria that appear after cleaning another surface and washing hands.
5. Using the diagram of the *Phases of Bacterial Growth*, describe how the bacteria that are grown in class will follow a pattern of phases.
6. Divide students into groups of three.
7. Distribute the *MedBay: One Cell, Two Cells, Four Cells, Eight Student Activity Sheet* and the *Microbe Growth Table Sheet*.
8. Have each student group brainstorm an additional surface they would like to test. Encourage each group to choose a different place. Suggestions include floor, door

- knob/handle, computer mouse, pencil sharpener. Ask students to record their choice on the data sheet.
9. Have students follow the instructions on their sheet and have the groups record the necessary data in the microbe growth table.
 10. Alterations can be made to the procedure to test different growth environments. If a group chooses to alter the growing conditions, have them make a note on the data sheet.
 - a. Influence of UV light – bacteria grown in sunlight vs. the dark
 - b. Influence of temperature – bacteria grown in cold area or warm area
 - c. Influence of oxygen – bacteria grown with dish cover taped closed vs. not taped at all
 11. Stack the dishes from each group and tape the stack together using masking tape
 12. Store Petri dishes on the counter away from direct sunlight unless a group is testing sunlight.
 13. Have the groups analyze the colonies on Days Three through Six and answer the questions on the Data Analysis sheet. Ask them to **KEEP THE LIDS ON**.
 14. If you have time or want to introduce students to the vocabulary used by microbiologists to describe colonies, have them fill out the Colony Description Sheet for one colony.

Clean Up

15. On Day Six or Seven, prepare a dishpan with soapy water
16. Set plastic bag open on the counter next to Petri dishes.
17. Dump contents of Petri dishes in plastic bag. Potatoes may stick, so grab using the plastic bag or wear gloves, if you feel more comfortable.
18. Seal bag and place in trash, or put in biohazardous waste if that is an option.
19. Put dishes in soapy water and scrub using sponge.
20. Drain water.
21. Rinse dishes with plenty of water and set out to dry.
22. Before next use, apply rubbing alcohol to all inside surfaces of each dish.
23. Alternatively, run through dishwasher on top rack.

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Answers to Data Analysis

1. *Why were the potatoes boiled in water?*
Boiling the potatoes should kill off any bacteria that are currently living on the potato.
2. *How does incubation time affect the growth of bacteria?*
According to the phases of bacterial growth diagram, bacteria undergo an initial lag phase. During this time the bacteria are getting used to their environment. Therefore, during a very short incubation period you do not see any growth. Once the cells have passed through the phase of exponential growth, longer incubation periods do not increase cell number. For example, during the Death Phase the number of cells decreases due to a reduction in nutrients.

***MISSION DEBRIEFING:* Teacher Guide**

3. *Which sample had the largest/most colonies in the shortest amount of time?*
It will vary. (It should not be the control.)
4. *Do you think temperature would affect the growth of bacteria?*
Yes, bacteria grow best at 37° C. Lower temperatures do not stop growth, but may slow it down. Higher temperatures can destroy the bacterial proteins and, thus, kill the bacteria.
5. *What is the purpose of the control plate?*
The control is to show what types of bacteria grow on the potatoes, which were not killed by boiling.
6. *How did hand washing change the results?*
Data will probably show that there is a decrease in the number of colonies on the plate of bacteria from hands that have been washed. If not, maybe the amount of time washing the hands or the amount of soap used should be increased.

Extension Activities

- *Science:* Determine the effects of different detergents on the growth of bacteria or examine the effects of different mediums (potato, agar, bread) on the growth of bacteria
- *Visual Arts:* Identify the different shapes of bacteria that grow and then using household items try to create models of the different shapes.
- *History:* Research Robert Koch, who developed techniques for obtaining pure bacterial cultures.
- *Mathematics:* Calculate the growth rate of colonies in each plate (number or size of colonies over time).

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Standards

National Science Education Standards, Grades 5-8

- Science Content Standard A: all students should develop abilities necessary to do science
- Science Content Standard C: all students should develop understanding of the structure and function of living systems
- Science Content Standard C: all students should develop understanding of reproduction and heredity
- Science Content Standard C: all students should develop understanding of regulation and behavior
- Science Content Standard F: all students should develop understanding of personal health

Books and Articles

- Alexander, S.K., and Strete, D. 2000. Microbiology: A Photographic Atlas for the Laboratory. San Francisco: Benjamin Cummings.
- Brown, W.E., and Williams, R.P. 1990. "Cultured Taters." Science Scope. Feb. 19-21.
- Collard, P. 1976. The Development of Microbiology. New York: Cambridge University Press.
- Sankaran, N. 2000. Microbes and People: An A-Z of Microorganisms in Our Lives. Phoenix: Oryx Press.

Web Sites

Starred sites are geared toward students.

- CELLS alive! Dividing Bacteria*
<http://www.cellsalive.com/>
- Encyclopedia: Bacteria Reproduction
http://www.encyclopedia.com/html/section/bacteria_reproduction.asp
- The Microbe Zoo*
<http://commtechlab.msu.edu/sites/dlc-me/zoo/>
- Scientist Hero: Robert Koch*
http://www.myhero.com/hero.asp?hero=robert_koch
- Bacteriology
<http://gsbs.utmb.edu/microbook/toc.htm>
- To help students talk about the characteristics of their colonies, look at
http://www.rlc.dcccd.edu/mathsci/reynolds/micro/lab_manual/colony_morph.html

Examples of Bacteria and Mold on Potato

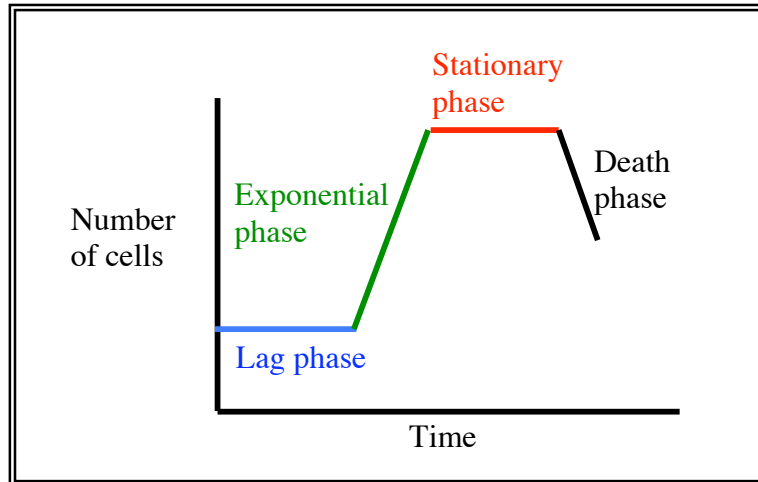


Bacteria and possibly yeast



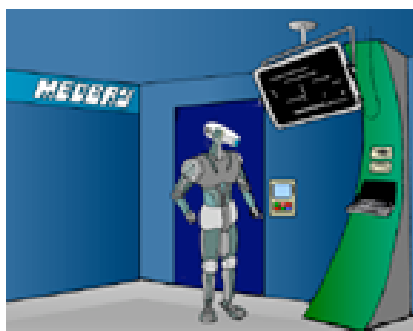
Mold

Phases of Bacterial Growth



The process by which bacteria reproduce is called binary fission. It is the division of one cell into two. When bacteria begin to grow, they normally proceed through four phases of growth.

1. **LAG PHASE**: During this phase the bacteria are adapting to a new environment. The number of cells does not change during this time.
2. **EXPONENTIAL or LOGARITHMIC PHASE** of growth: This is the phase where binary division occurs. During this phase, the number of cells doubles approximately every 20 minutes.
3. **STATIONARY PHASE**: During this phase, the number of bacteria remains essentially constant. This is because the dividing rate equals the rate of cell death. Cells begin to die due to the accumulation of waste and the depletion of the nutrients.
4. **DEATH or DECLINE PHASE**: During this phase, the death rate is greater than the dividing rate, and the number of cells decreases.



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Sirius requires all Reconstructors to test themselves and their area for microorganisms. Everyone must also show that he/she can perform basic hygiene.

Materials

Boldface materials are required, others are only necessary if you will be boiling your own potato.

1. *MedBay: One Cell, Two Cells, Four Cells, Eight Student Activity Sheet*
2. *Phases of Bacteria Growth Student Activity Sheet*
3. *Microbe Growth Table*
4. *Colony Description Sheet (if your teacher decides to include it)*
5. hot plate or Bunsen burner
6. 500 ml beaker
7. set of rings and ring stands (Bunsen burner)
8. wire gauze (Bunsen burner)
9. raw, peeled potato
10. knife
11. metal fork or tongs
12. kitchen mitt or hot pad
13. **six sterile Petri dishes**
14. **sealable bag of cotton swabs**
15. **six slices or pieces of boiled potato**
16. **fork or tongs**
17. **Hand soap and water**

Procedure*

Day 1:

Preparing Boiled Potato

Note: If your teacher is providing you with potato slices already boiled, skip this section of the procedure.

1. Cut potato into six slices, each about 2 cm thick.
2. Put slices in beaker and fill with water to 400 ml.
3. Heat water and potatoes to boiling and boil for **four min.**
4. Carefully pour water out of beaker. It's ok if there is a little left.
5. Wearing a mitt, heat the fork or tongs until the tines turn red-hot. Use the fork to transfer each slice of potato to a separate, sterile, Petri dish. (slices may break; piece(s) will be fine).
6. Cover the dish, and let the potato cool to room temperature (can cool overnight).

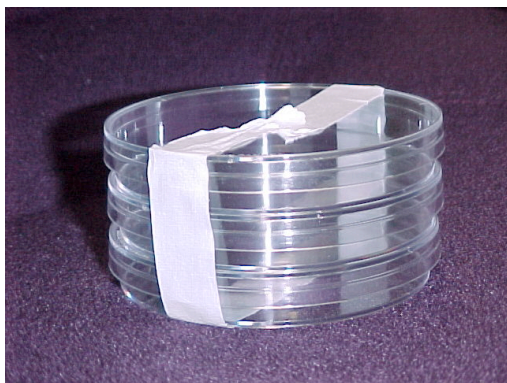
***MISSION DEBRIEFING:* Student Activity Sheet**

Gathering Samples

7. As a group, look at the data sheet and decide which surface in the classroom you will test, for example, door knob, floor, pencil sharpener, etc.) Write it in the blank rows.
8. Using a clean fork or tongs, place some potato in each Petri dish.
9. Label the six Petri dishes: **Control**, **Table**, (your surface of choice), (your surface of choice cleaned), **Hands**, and **Clean Hands**.
10. Set the dish labeled **Control** aside. You will not apply anything to it.
11. Carefully remove one cotton swab from your bag by holding it in the middle. **DO NOT TOUCH** the end.
12. Dip the cotton swab in tap water and rub it over the surface you have chosen.
13. Open the Petri dish with the correct label and roll the cotton swab across the potato slice. Repeat to leave sufficient sample on the potato. Close dish immediately after finished.
14. Wash hands thoroughly. Collect sample from clean hands with swab, and place in proper dish.
15. Wash surface you have chosen using the cleaner provided by your teacher. Swab and apply to appropriate Petri dish.
16. Get a long piece of masking tape. Lay it sticky side up on the table.
17. Stack your dishes on top of one another.
18. Put the stack on top of the tape. See picture below.
19. Write the names of your group members and any other information your teacher requests on the tape.
20. Let plates sit at room temperature for 48 hours. Do not open the dishes, but do not seal because some bacteria and fungi need oxygen to grow.

Day 3- 6:

1. Observe the Petri dishes for growth. **DO NOT OPEN THE DISHES.**
2. Record the observations on the provided table.
3. Fill out the Colony Description Page if instructed by your teacher.



Taped-together Petri dishes

MISSION DEBRIEFING Student Activity Sheet

Name _____ Class _____ Date _____

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Microbe Growth Table

Observations			
Plate	Day	Number of colonies	Color of colonies
Control	3		
	4		
	5		
	6		
Table	3		
	4		
	5		
	6		
_____	3		
	4		
	5		
	6		
Cleaned _____	3		
	4		
	5		
	6		
Hands	3		
	4		
	5		
	6		
Cleaned Hands	3		
	4		
	5		
	6		

Name _____ Class _____

Date _____

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Data Analysis

1. Why were the potatoes boiled in water?
2. How does the incubation time affect the growth of bacteria?
3. Which sample had the largest/most colonies in the shortest amount of time?
4. Do you think temperature would affect the growth of bacteria? Explain.
5. What is the purpose of the control plate?
6. How did hand washing change the results?

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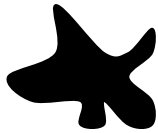
Colony Description Page

7. Use the following vocabulary words to describe 1 colony. Fill in your descriptions in the space provided. Remember, not all colonies will fit into these categories. Use your own words if the words below don't describe your colony.

Form - Refers to the overall appearance of the colony. View from the top.



Circular



Irregular



Filamentous



Punctate (less than 1 mm)

Elevation - How much the colony sticks up above the potato. Carefully turn plate and look sideways.



Raised

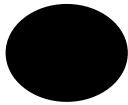


Flat



Has stalks (this goes for molds)

Margin - What the edge looks like. Look from the top and use a magnifying lens **WITHOUT** opening the lid, if available.



Entire (smooth)



Undulate



Filiform

Colony 1
Form

Elevation

Margin

Color

Appearance (shiny, waxy, dull, transparent, opaque, translucent)