SIEMENS STEM DAY | Science Technology Engineering Math

GRADES 9–12

SIEMENS STEM DAY ACTIVITY

BACTERIA EVERYWHERE

OBJECTIVES

Students will be able to:

- **Understand** that bacteria are single-celled organisms that can be harmful and helpful
- **Analyze** bacteria from a swab investigation lab
- **Evaluate** the relative effectiveness of antibacterial wipes

THIS LESSON FOCUSES ON

Engineering Design Cycle

- Communicating Results

21st Century Skills

- Collaboration
- Communication

OVERVIEW

Students will swab different commonly used surfaces (phones, tables, keyboards, etc) for the presence of bacteria. Students will then wipe the same surface(s) with an antibacterial wipe, and then re-swab the newly cleaned surface(s) to determine the relative effectiveness of the antibacterial wipes. Students will use this investigation as a springboard to discuss antibiotic-resistant bacteria known as superbugs.

STEM incorporates Science, Technology, Engineering, and Mathematics to focus on real-world issues and problems guided by the engineering design process. This type of instruction supports students in developing critical thinking, collaboration, reasoning, and creative skills to be competitive in the 21st century workforce.

Each Siemens STEM Day classroom activity highlights one or more components of the engineering design cycle and an essential 21st century skill.

MATERIALS

- **Comparing Bacteria Cultures Lab** handout, one per student
- **prepared petri dishes with agar,** two per small group
- **disinfectant wipes, two per small group**
- **swabs, four per small group**
- **permanent makers, one per small group**
- **incubator or light source**
- **biomedical hazard disposal bags**

HAVE YOU EVER WONDERED . . .

How effective are antibacterial wipes? Many brands claim to kill 99.9% of bacteria and viruses, but how can you tell if they really make a difference?

MAKE CONNECTIONS!

How does this connect to students?

Many people associate bacteria with negative implications and think that bacteria only make people sick. However, the truth is that there are both harmful and helpful bacteria in our bodies and all around us. Our digestive systems require healthy bacteria to function properly. Yogurt and cheese are just a few examples of ways that we consume helpful bacteria.

How does this connect to careers?

A **microbiologist** is responsible for understanding the growth and development of microscopic organisms. This role may be involved in the development of new medicine, vaccines, and other pharmaceutical products. Microbiologists are needed in almost every industry. Aside from working in a hospital or for a university, microbiologists are employed in the space and agricultural industries.

A **doctor** is responsible for being able to tell the difference between viral and bacterial infections. To confirm their hypothesis, doctors often order lab work for their patients. A doctor can prescribe antibiotics to help patients with bacterial infections; however, viral infections can't be treated this way.

How does this connect to our world?

Superbugs are bacteria that have become resistant to the antibiotics that should kill them. The overuse of antibiotics is one known cause for the development of superbugs.

Preventative measures need to be taken to help reduce the spread of bacteria. Washing your hands regularly is a critical preventive measure that everyone can take. Also, shielding a cough or sneeze helps reduce the spread of germs. Additionally, not sharing personal items such as a lip gloss is another preventative measure.

BLUEPRINT FOR DISCOVERY

Day 1

1. To engage students in what they will be learning, tell the students that they are "more bacteria than human". Ask students what this statement means? Continue to explain that according to research, "For every human cell that makes up your body, there are 10 cells of bacteria living on your body." Students will most likely be amazed to learn this information.
2. Explain to students that today they are going to learn about bacteria, swab surfaces for bacteria, and evaluate the relative effectiveness of antibacterial wipes. Many brands of antibacterial wipes claim to kill 99.9% of bacteria and viruses, but how can you tell if they really make a difference?

3. Arrange students into small groups of 3–4 students. Distribute the **Comparing Bacteria Cultures Lab** Handout and instruct students to carefully read through the handout. After students have read the handout gather and distribute the lab materials needed by each group. Materials per group:
    - 2 petri dishes with agar
    - 4 sterile swabs
    - 2 disinfecting wipes
    - 1 black permanent marker
    - medical gloves, two per student
    - goggles, one per student
4. Facilitate a conversation about what they learned about bacteria from reading the background information included in the handout.
    - *Note:* A few significant facts to emphasize include that bacteria are single cellular, reproduce through binary fission, have different shapes, and are both harmful and helpful.
5. Instruct the students to put on their protective gear (gloves and goggles). Explain that they are to follow the directions in the lab step-by-step for successful results.
    - *Note:* The lab instructions suggest taking observations across three days. However, if this is not possible, a minimum of one day is needed for the bacteria to reproduce.
6. After students have performed the lab, properly dispose of the gloves, swabs, and antibacterial wipes. It is critical to instruct the students to wash their hands.
7. Store the cultured dishes either in an incubator or under a light source to provide heat for the bacteria to reproduce.
8. Conclude today's activity, by asking the students to share their hypotheses with the class. This will give them an opportunity to learn about the different surfaces that were swabbed.

Day 2

9. Before the students return, remove the cultured dishes from under the light source.
10. Instruct the students to get into their small groups and put on their protective gear (gloves and goggles). Explain that they are going to gather their results and make observations today.
11. Before passing out the cultured dishes, remind the students that it is extremely important that you **NEVER** open any of the petri dishes. While gathering observations, the petri dishes **MUST** remain closed. Also explain that although this is day two of their lab experience, this is really day one for their results.
12. After students gathered their results and made their observations, collect the petri dishes. Instruct the students to properly dispose of the gloves, swabs, and antibacterial wipes. It is also critical to instruct the students to wash their hands.
13. If you plan to continue the lab, return the cultured dishes to the light source. If this is the end of the lab experience, then be sure to properly dispose of the cultured dishes using biomedical hazard bags.
14. If this is the conclusion of the lab, instruct the students to complete the follow-up questions.

15. Upon completion of the follow-up questions, facilitate a group discussion about their results and their answers to the follow-up questions.

Days 3 and 4 (optional)

16. Follow the same procedure as day two above.

TAKE ACTION!

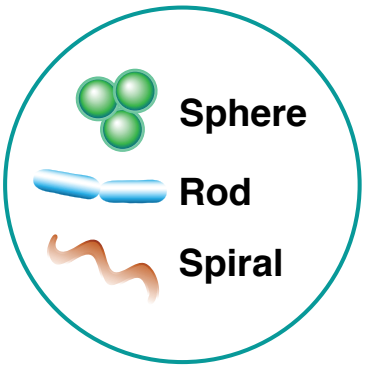
- Students can create infographics to communicate their findings to the public. This can include pictures of their results along with reminders about the importance of preventive measures for guarding against germs.

NATIONAL STANDARDS

Next Generation Science Standards	HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. SEP 3. Planning and Carrying Out Investigations
Standards for Technology Literacy	Standard 13. Students will develop Abilities for a Technological World. This includes becoming able to assess the impact of products and systems.

COMPARING BACTERIA CULTURES LAB

Background Information: **Bacteria** are single-celled microorganisms that do not have a distinct cell nucleus enclosed by a membrane, unlike most other cells. Instead, the genetic material (a single strand of DNA) floats in a tangle in the interior of the cell. Microorganisms like this are called **prokaryotic** organisms. Bacteria are classified by their shape. There are three basic bacteria shapes: sphere, rod, and spiral. **Spherical** (cocci) bacteria are round or oval in shape. **Rod** (bacilli) ones are longer and look like a rectangle or long oval. **Spiral** bacteria have long bodies with a twist that forms a spiral pattern when connected to each other.



Bacteria reproduce most often by **binary fission**: a single parent bacterium divides to form two independent bacteria. This type of reproduction is called **asexual** because there is no exchange or combination of genetic material between two organisms. Fission occurs rapidly in as little as 20 minutes. Under perfect conditions a single bacterium could grow into over one billion bacteria in only 10 hours!

Some bacteria can also reproduce asexually by forming thick-walled **endospores** that are very resistant to conditions of extended heat, cold, or dryness. An endospore is formed within the cell body of a bacterium. Usually a bacterium forms only one endospore, which will produce only a single bacterium. Endospores are difficult to kill except by strong chemicals or high heat.

Generally, when people think of "bacteria," they think of harmful germs. Many bacteria are disease-causing **pathogenic** bacteria. However, "good" bacteria are an essential aid to our digestion process, and organic materials such as dead trees would not be broken down into dirt if not for bacteria.

Scientists grow **bacteria cultures** when they want to study bacteria in a lab. The bacteria are grown in a sterile **petri dish** containing **agar**. Agar is a gelatinous material extracted from seaweed that forms a moist surface favorable for bacteria reproduction. In addition, nutrients are added to the agar to provide a food source for the bacteria culture. The **nutrient agar** in this kit is a general-purpose media for growing a wide range of bacteria. A petri dish filled with agar is called a **culture dish**.

Bacteria grow in **colonies**, groups of thousands of individual bacterium. You should be able to tell different colonies of bacteria apart by their shape, texture, and color. In order to study a certain kind of bacteria, the bacteria from one colony are **isolated**: a sample of the bacteria from an individual colony is transferred to a new sterile culture dish. The new culture will contain only the isolated bacteria.

SAFETY

The bacteria you will grow in these experiments are called **nonpathogenic bacteria** that are normally present around you, but you are culturing them to grow in greater numbers than usual. Follow these safety guidelines:

1. Always wash your hands thoroughly **before and after** handling the culture dishes.
2. Minimize the time you leave the covers off your culture dishes. This helps prevent contamination of the cultures and limits your exposure to the bacteria. Be careful not to breathe on an open culture or to breathe the air directly above an open culture.

Materials per Group:

- 2 petri dishes with agar
- 4 sterile swabs
- 2 disinfecting wipes
- 2 different selected surfaces
- 1 black permanent marker
- 1 microscope (optional)

Independent Variable: _____

Dependent Variable: _____

Control Group: _____

Constants (3+): _____

Hypothesis: Make a prediction about the outcome of the lab.

_____

_____

_____

_____

_____

_____

_____

_____

_____

PROCEDURE

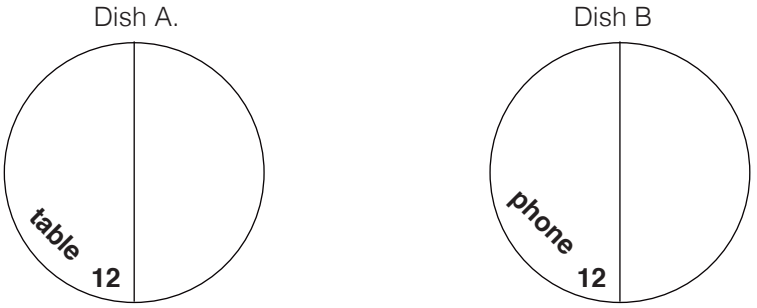
Bacteria are also present on every surface, indoors and out, that is not sterilized. You can find some bacteria on almost every surface. In this experiment, you'll compare bacteria cultures that you grow from different surfaces around our school. Additionally, you will analyze the effects of disinfecting wipes by cleaning each surface and swabbing the same area again.

1. Decide on two different surfaces that you want to collect bacteria from.

   Petri Dish with Surface A: _____

   Petri Dish with Surface B: _____

2. Turn each petri dish upside down and use a permanent marker to divide each dish in half. Write on the side of the Petri dish containing the agar.



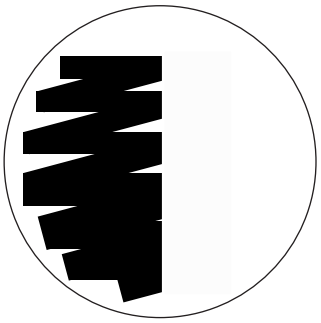
3. Then *along the perimeter* of the dish, label one half of the first petri dish with the name of your chosen surface A. Write very small and DO NOT write in the middle of the dish; this will obstruct your view when analyzing the results. **See example above.*

4. Label a "1" on the left side of dish A is for the swabbed bacteria, and label a "2" on the right side for the same surface that was swabbed after cleaning it with a disinfecting wipe. **See example above.*

5. Take the second dish and repeat steps 3 and 4 for your chose surface B.

6. Write the group members' initials very small along the top perimeter of the dish. Remember to NOT write in the middle of the dish; this will obstruct your view when analyzing the results.

7. Use one sterile swab (being careful not to contaminate the tip by touching it) and drip it into filtered water. Shake off any excess water and use this swab to gather bacteria off of the selected surface A by rotating the swab tip while rubbing it over the surface area.



8. Remove the cover from dish A and lightly rub the swab back and forth over the agar in the dish as illustrated. This zigzag technique effectively transfers some of the bacteria from the surface to the culture dish. **Remember to ONLY rub the swab on the left half of the dish labeled with the "1"**. Cover the petri dish immediately.
9. Use a disinfecting wipe to clean surface A. Next use a NEW sterile swab to collect any bacteria still left on surface A and rub the swabbed sample on the right half of the dish labeled with the "2".
10. Repeat the process again for the second selected surface. Use a new sterile swab (being careful not to contaminate the tip by touching it) to gather bacteria off of surface B by rotating the swab tip while rubbing it over the surface area.
11. Remove the cover from the dish B and lightly rub the swab back and forth over the agar in the dish as illustrated. This zigzag technique effectively transfers some of the bacteria from the surface to the culture dish. **Remember** to ONLY rub the swab on the left half of the dish labeled with the "1". Cover the petri dish immediately.
12. Use a disinfecting wipe to clean surface B. Wait 1 minute for the wiped surface to dry and then use a NEW sterile swab to collect any bacteria still left on surface B and rub the swabbed sample on the right half of the dish labeled with the "2".
13. Properly dispose of your gloves and used swabs.

SAFETY NOTE

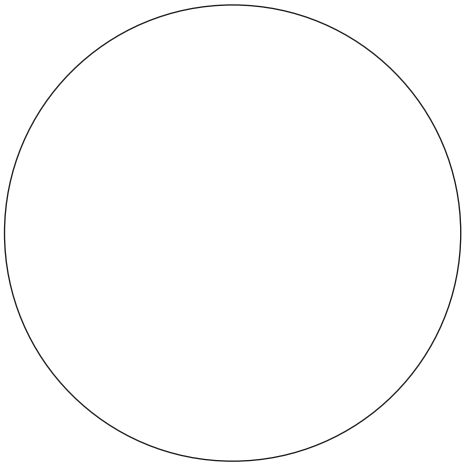
After swabbing the surfaces, it is extremely important that you never open any of the petri dishes. While gathering observations, the petri dishes MUST remain closed.

Data:

Surface A: _____

Surface B: _____

Dish A Day _____:



Observations Dish A

Section 1:_____

_____

_____

Section 2:_____

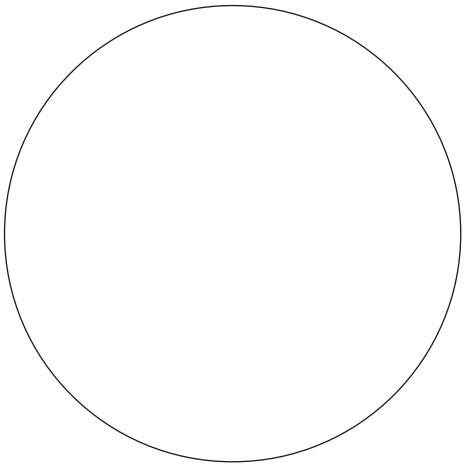
_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Dish B Day _____:



Observations Dish B

Section 1:_____

_____

_____

Section 2:_____

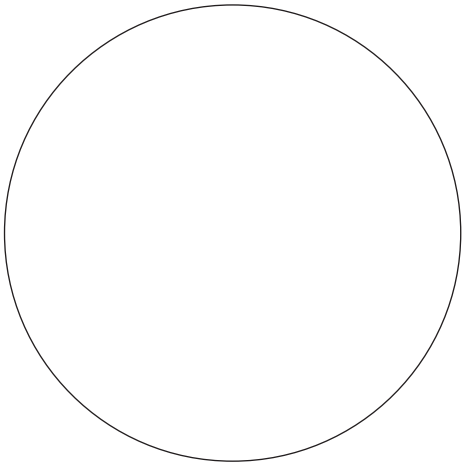
_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Dish A Day _____:



Observations Dish A

Section 1:_____

_____

_____

Section 2:_____

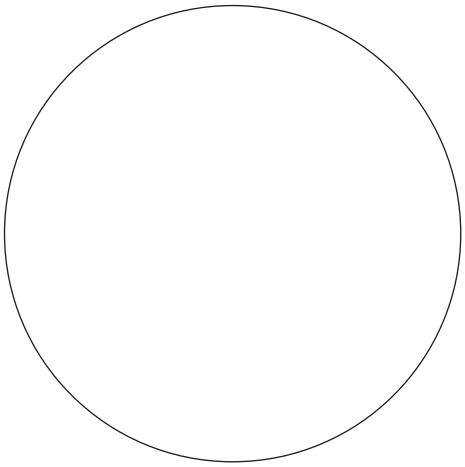
_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Dish B Day _____:



Observations Dish B

Section 1:_____

_____

_____

Section 2:_____

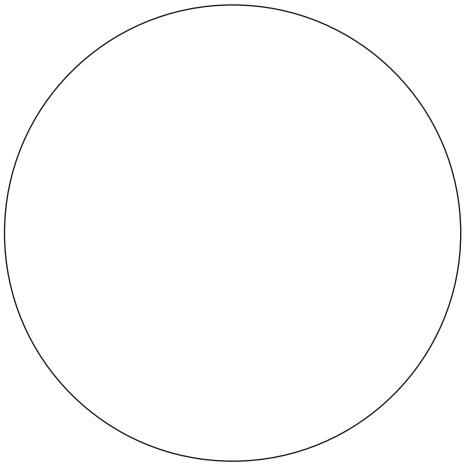
_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Dish A Day _____:



Observations Dish A

Section 1:_____

_____

_____

Section 2:_____

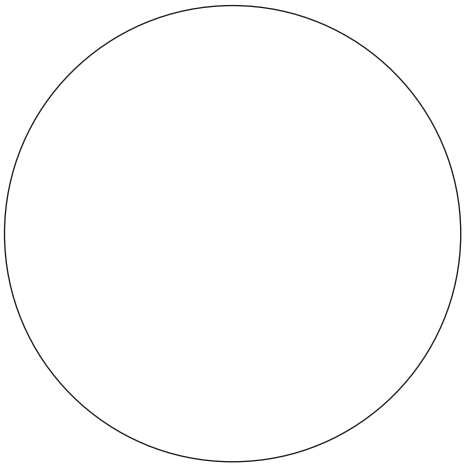
_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Dish B Day _____:



Observations Dish B

Section 1:_____

_____

_____

Section 2:_____

_____

_____

Number of colonies:

Section 1: _____ Section 2: _____

Number of Colonies

Sample	Day 1	Day 2	Day 3
A1			
A2			
B1			
B2			

Follow-up Questions

1. Which surface had the most bacteria? Which surface had the least bacteria?

2. What were some of the similarities between the bacteria you collected from the different surfaces?

3. What were some of the differences between the bacteria you collected from the different surfaces?

4. How do bacteria increase so rapidly?

5. What was a specific observation that was surprising or unexpected?

6. Describe what people can do to avoid contact and infections from bacteria. Be specific and describe a minimum of three different ideas.

7. How does this lab experiment connect to the real world?

Works Cited

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