PreMiEr Precision Microbiome Engineering

NSF Engineering Research Center

This lesson plan was created by a teacher participating in the Research Experiences for Teachers program from the Precision Microbiome Engineering Research Center. Are you interested in spending part of your summer in a lab getting paid to do microbiome research and create lesson plans?

Learn more here: https://premier-microbiome.org/for-teachers-ret/

Lesson plan written by Charlie Hiatt

AG Tier 3 (Grade 3)

Unit Title: Let's Build Up Some "STEAM"

Lesson Title: Where are Bacteria?

Purpose/Central Focus of Lesson:
Students will learn about bacteria and how to reduce the spread of harmful bacteria through hygienic practices.

Student Learning Targets:
Learn the difference between animal and bacterial cells. Learn about skin as an organ. Learn relative vocabulary. How to increase good hygiene awareness and practices.

Standard Alignment:
Structures and Functions of Living Organisms 3.L.1 Understand human body systems and how they are essential for life: protection, movement and support. 3.L.1.2 Explain why skin is necessary for protection and for the body to remain healthy 3.L.1.2 Students know that the skin is the largest organ of the human body, that it covers and protects the human body from external conditions and forces. Students know that the skin contains nerve receptors that provide information about external conditions.

Prior Academic Learning and Prerequisite Skills:
Knowledge of the existence of microscopic organisms.

Culturally Inclusive Instruction:

This lesson is inclusive due to the ever presence of microorganisms, their benefits, and detriments to all of humanity. Knowledge of microorganisms is increasingly important for all cultures in a post pandemic world. It is estimated by scientists that many bacterial pathogens will be resistant to antibiotics by 2050. Knowing about the existence, parts, and functions of bacteria provides students of all cultures with background knowledge that could be scaffolded into a deeper understanding of these organisms. A generation armed with comprehensive knowledge of microorganisms could potentially mitigate future bacterial, fungal, or viral illnesses which could benefit all cultures.

Instructional Materials:

Bread
Ziplock bags
Pre-made agar plates (optional)
Soap
Hand sanitizer

Procedures:

Motivation/Hook:

Ask students if they think they have things living on their skin, then discuss. After establishing that microscopic organisms live on skin, have students participate in an optical illusion that appears to make skin crawl.

Stare at the spinning pinwheel for approximately 20 seconds while placing your righthand down on a table or flat surface. After the 20 seconds, keep your hand still and then look at your hand without moving it. If done correctly, the hand appears to have things crawling on or below the skin or moving in a weird way.

(60) pinwheel illusion - YouTube

The above illusion can be projected or have students search for it on YouTube.

Activation of Prior Knowledge:

Ask students if they know what an organism is. Students should understand that an organism is a living thing or life form.

Ask students what they know about cells. Students should understand that cells are the smallest structures that can sustain life. Cells carry out all life processes through organelles. Organelles are tiny organs within the cell that carry out functions like making proteins and disposing of waste.

Ask students to describe the parts of a city or town and why they are important. Explain that cities have different departments and services that carry out various functions important to the residents that live within it. A cell is like a tiny city with organelles conducting various functions that sustain life.

Make sure that students understand the differences between animal cells (eukaryotes) and bacterial cells (prokaryotes).

Major differences:

Prokaryotes – single celled organisms, cells that do not contain a defined nucleus.
Example: bacteria cell

Eukaryotes – animal cells that contain a nucleus.
Examples: Muscle cells, skin cells

Humans are made up of eukaryotic cells. Humans are multicellular organisms, meaning we are comprised of many different specialized cells working together.

Ask students what they know about their skin and discuss. If it is not covered in the discussion, explain to students that their skin is their largest organ and one of its main functions is to protect us from harmful bacteria (pathogens).

Although some bacteria can be harmful, most bacteria are beneficial to us. These bacteria are called commensals. Commensals live within our body systems and carry out beneficial functions such as aiding in digestion.

Depending on student responses, the teacher should relay that bacteria are single-celled organisms. Yes, the organisms have everything they need contained in one cell to sustain life!

Show illustration of the relative size of bacteria located in the lesson plan folder and discuss. After discussion, it may be relevant to note that a virus is at least 10 x smaller than a bacterial cell.

Here it may be beneficial to compare single-celled organisms to multi-celled organisms like the human body. The link below provides an organized comparison of various cells.

Major Differences Between Plant, Animal and Bacterial Cells (collegedunia.com)

Delivery of Lesson Content:

Show students images of bacteria located in lesson plan folder and discuss.

Introduce the parts of a bacterium cell using the website below by projection and oral introduction. Then have students review the tutorial on their own. You could have students pair up and take turns reading to each other or conduct the tutorial individually.

Bacteria Cell Tutorial

Animal Cell - Tutorial - Science - Sheppard Software

After completing these two tutorials have a class discussion about the differences and similarities between bacterial and animal cells. Students can use the T chart in the resources folder delineate between the two.

Explain to students fungal cells are eukaryotic but have some differences from animal cells. See Animal vs Fungal Cell illustration in the resources folder. Students may use the Animal vs. Fungal T-chart to document the differences.

Introduce vocabulary using Cell Vocabulary document from the unit resources.

Teacher may have students copy words and definitions or give them a handout with the words and definitions already present and conduct vocabulary activities. See below for suggestions.

Suggested vocabulary activities:

1. Make flash cards and quiz each other. This could be done with index cards or virtually. See below for a virtual flash card creator.
    a. https://www.cram.com/

2. I have, who has……
3. Create your own crossword puzzle: crossword puzzle
4. Write a sentence using the word
5. Charades or Pictionary
6. Have students come up with their own vocabulary activity!

Explain to students that bacteria come in many different forms and vary in their function. Explain that most bacteria are actually beneficial, but some can be harmful. Return to the previous discussion regarding bacteria being present on their skin. Explain that because our skin is our first line of defense against harmful bacteria, it is important to have good hygiene regarding skin care.

One way to practice good skin hygiene is to wash your hands often and thoroughly. Tell students that they are going to participate in a lab that may demonstrate the extent of bacteria on our bodies and in the environment. Further, the lab may reveal results from hygiene practices.

How does soap reduce bacteria? Soap has polar characteristics that allow it to isolate and mechanically remove bacteria. However, if you wash your hands long enough, soap can actually puncture bacterium cell membrane thereby destroying it. For more in-depth information, read the article below:

How Soap Kills Germs

(25) How does hand sanitizer kill germs? - YouTube

Explain that one way to capture a sample of bacteria is by transferring bacteria from skin to a piece of bread by physical contact. Refer to the Bacteria Lab sheet as a guide in this activity which provides

structure using the scientific method. The link below provides information on the lab and illustrations of what to expect.

Bacteria Lab

Next, for comparison, have students wash their hands and then repeat the previous procedure.

Let the samples incubate and document changes by photographing bacterial growth on the bacteria lab sheet. Refer to the Bacteria Lab Teacher lab sheet for directions and examples.

Explain to students that fungal growth is common when conducting this experiment. It is important to note that fungal growth is usually indicated by fussy looking growth. Students should not make the mistake of thinking all the growth on the bread is bacterial.

Guided or Individual Practice: Have students state the problem, guide them or give them the problem and fill out the "problem" portion of the Bacteria Lab sheet. Refer to the Bacteria Lab Sheet Teacher Copy for direction.

Next, have student fill out the hypothesis section of Bacteria Lab Sheet. Also, see Bacteria Lab Sheet Teacher Copy for directions and examples.

Disclaimer: Make sure you have permission from the district or school because it involves microbial growth.

Lab instructions:

1. Give students a piece of plain white bread and have them spread their fingers slightly and press their hands into a piece of bread.
2. Place the used piece of bread in a plastic sandwich bag and seal it up.
3. Label the outside of the bag with a number, initials, and the treatment given.
4. Continue the experiment in this way by varying the treatment to each slice of bread and labeling them.
5. Observe over the coming days and weeks and document.
6. **Do not open the samples because this may contaminate the air. Dispose of properly by putting closed samples in a sealed waste bag and put directly in the dumpster.**

"PLUS" Extensions:

Students will play the bacteria cell game linked below.

Bacteria Cell Game

Have students create a Venn Diagram to compare and contrast various types of cells. Look below for an example:
Cell Venn Diagram

The Venn Diagram could also be used to compare fungal cells with other cells.

Closure: Have a class discussion regarding their findings and how they related to their hypothesis.

Now that students have some knowledge about microbes, inform them that when microbes make you sick they require specific treatment.

For example, strep throat is a bacterial infection that should be treated with antibiotics.
The Corona Virus is a virus that does not respond to antibiotic medicine so to treat it, scientist have development antiviral medications. Lastly, fungal infections should be treated with antifungal medications.

Assessments:
Completed lab sheet Paragraph explaining what they learned, what challenges they faced, what was the best or worst part of the experience. Vocabulary test

Supplemental Lesson Plan Elements

Differentiation:
English Language Learners: Partner with a fluent speaking student if possible.
Exceptional Children: Collaborate with a student partner. One on one attention.
Highly Gifted: Design an experiment or lab centered around bacteria, skin, or hygiene. Design a vocabulary activity.
Underperforming Students: Have them suggest related activities that may help them learn the content to build ownership.

Accommodations:
Extended Time: Provide as needed
Read Aloud: Computer reads text aloud. Provide a digital copy of instruction and lab sheet.
Language Demands & Support: Google translate
Other: Provide other accommodations as needed.

Extension:
Experiment with different types of bread to determine if the growth rate of bacteria varies. Use the same Shepard software to learn about animal and plant cells. Animal Cell Game Plant Cell Game Have students create a 3D or 2D model of a cell. Have them relate the cell organelles to cities. What part of a cell would be analogous to city hall? Answer: the nucleus.

More examples: Parts of a cell related to a city

Conduct a role play activity: One group of students will be the patients and another group will be the doctors. The doctors will examine their patients and try to determine a diagnosis and subsequent treatment. When examining the patients, the patients are to read off their symptoms. The doctor then finds those symptoms from a master list of diseases to diagnose and treat the illness. See Disease Role Play Activity document in folder to for an example of how to facilitate this activity.
To extend this activity, research and add more diseases and symptoms or assign this task to the students but the teacher should guide or give suggestions for the examples. This is due to the graphic nature of some diseases and their effect on the human body.

Technology:

Projector for instructions

Bacteria Lab Sheet Teacher Copy

Problem: What hygienic practices help reduce the spread and proliferation of bacteria?

Hypothesis: Ex: The practice of using hand sanitizer will be most effective at reducing the amount of bacteria on student's hands.

Independent Variable: Method of hygienic practice, example soap and water, hand sanitizer.

Dependent Variable: Amount of bacteria growing on bread.

Constants: Type of bread, amount of imprint time, number of impressions, imprint impression technique

Control: Slice of bread without hand imprint.

Observations: Record visual observations below.
Test: Example

Results	No Wash	Wash	Sanitizer	No Treatment	Mis. Surface
Day 1	**No change**	**No change**	**No change**	**No change**	**No change**
Day 2	**Some microbial growth. Green in color.**				
Day 3	**Some microbial growth. Green in color. 50% of surface area covered.**		**Some microbial growth. Green in color. Some white fuss growing on the upper lefthand corner.**		
Day 4					
Day 5	**Heavy microbial growth. Green and blue in**				

	color. 90% coverage.				

Analysis: Summarize the data from the observation section. Example: On day 5 the control sample had no bacterial growth on it.

Conclusion: Relate your findings back to your hypothesis. Example: The hand sanitizer sample had more microbial growth than the soap and water sample. Hence, my hypothesis was incorrect and soap and water is more effective at reducing the amount of bacteria on skin.

Bacteria Lab Sheet

Problem: _____

Hypothesis: _____

Independent Variable:_____

Dependent Variable:_____

Constants: _____

Control: _____

Observations:
Test:

Results	No Wash	Wash	Sanitizer	No Treatment	Mis. Surface
Week 1					
Week 2					
Week 3					
Week 4					
Week 5					

Analysis:

_____

_____

Conclusion:

_____

Differences between the cell

Plant	Animal	Bacteria
Nucleus	Nucleus	No nucleus – chromosomal DNA and Plasmids
Cell wall	No cell wall	Cell wall
Chloroplasts	No Chloroplasts	No chloroplasts
Mitochondria	Mitochondria	No Mitochondria
No Slime coat/capsule	No Slime coat/capsule	Slime coat/capsule
No pili	No pili	pili
No flagellum	flagellum	flagellum

Disease Role Play Activity

Diseases, symptoms, and treatment:

1. **Strep throat –**
    a. Throat pain that usually comes on quickly.
    b. Painful swallowing.
    c. Red and swollen tonsils, sometimes with white patches or streaks of pus.
    d. Tiny red spots on the area at the back of the roof of the mouth (soft or hard palate)
    e. Swollen, tender lymph nodes in your neck.
    f. Fever.
    g. Headache.
    h. Rash.

    Treatment – antibiotics
2. **Mononucleosis, or mono -** is a viral infection that causes
    a. Fever
    b. sore throat
    c. swollen lymph glands most often in the neck
    d. fatigue and headache
    e. spleen enlargement.

    Treatment – antiviral medications
3. **Ringworm –**
    a. Itchy skin
    b. Ring shaped rash
    c. Red, scaly cracked skin
    d. Hair loss

    Treatment – antifungal medications
4. **Thrush –**
    a. white, raised, cottage cheese-like lesions (spots) on your tongue and cheeks.
    b. mouth pain and redness.

    Treatment – antifungal medications
5. **Influenza –**
    a. fever* or feeling feverish/chills.
    b. cough.
    c. sore throat.
    d. runny or stuffy nose.
    e. muscle or body aches.
    f. headaches.
    g. fatigue (tiredness)

    Treatment – antiviral medications

Symptoms Only Sheet

Disease symptoms:

a. Throat pain that usually comes on quickly.
b. Painful swallowing.
c. Red and swollen tonsils, sometimes with white patches or streaks of pus.

d. Tiny red spots on the area at the back of the roof of the mouth (soft or hard palate)
e. Swollen, tender lymph nodes in your neck.
f. Fever.
g. Headache.
h. Rash.

Disease symptoms:

a. Fever
b. sore throat
c. swollen lymph glands most often in the neck
d. fatigue and headache
e. spleen enlargement.

Disease symptoms:

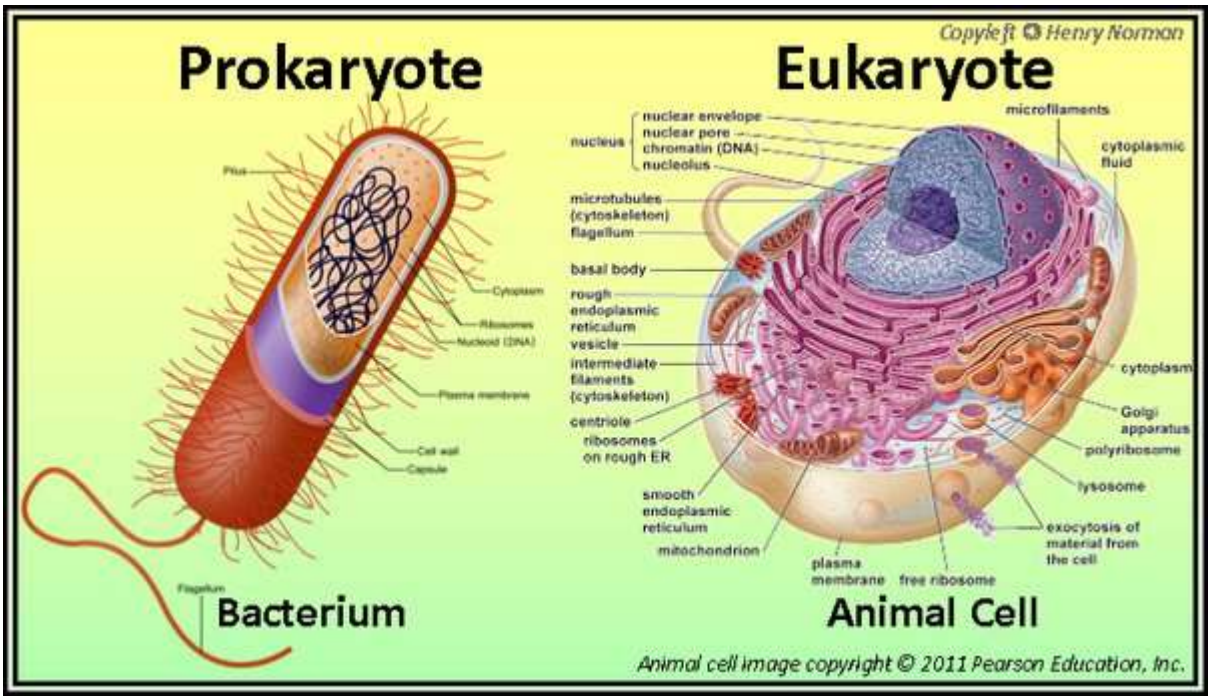
a. Itchy skin
b. Ring shaped rash
c. Red, scaly cracked skin
d. Hair loss

Disease symptoms:

a. white, raised, cottage cheese-like lesions (spots) on your tongue and cheeks.
b. mouth pain and redness.

Disease symptoms:

a. fever* or feeling feverish/chills.
b. cough.
c. sore throat.
d. runny or stuffy nose.
e. muscle or body aches.
f. headaches.
g. fatigue (tiredness)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Cytoplasm
Ribosomes
Nucleoid (DNA)
Plasma membrane
Cell wall
Capsule
Flagellum
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nucleus
nuclear envelope
nuclear pore
chromatin (DNA)
nucleolus
microfilaments
cytoplasmic fluid
microtubules (cytoskeleton)
flagellum
basal body
rough endoplasmic reticulum
vesicle
intermediate filaments (cytoskeleton)
centriole
ribosomes on rough ER
cytoplasm
Golgi apparatus
polyribosome
lysosome
smooth endoplasmic reticulum
mitochondrion
exocytosis of material from the cell
plasma membrane
free ribosome
Animal Cell
Animal cell image copyright © 2011 Pearson Education, Inc.

Cell Vocabulary

1. Organism - is a living thing or life form.
2. Cell - the smallest unit that can live on its own and that makes up all living organisms and the tissues of the body.
3. Bacteria – single cell organism.
4. Organelles – organs within the cell.
5. Pathogen – an organism that causes illness to its host.
6. Commensals – bacteria that carry out beneficial functions.
7. Prokaryotes – single celled organisms, cells that do not contain a defined nucleus.
8. Eukaryotes – animal cells that contain a nucleus.

Cell Vocabulary Pretest

Define the terms:

1. Organism –
2. Cell –
3. Bacteria –
4. Organelles –
5. Pathogen –
6. Commensals
7. Prokaryotes –
8. Eukaryotes –

Cell Vocabulary Test

1. Organism –
2. Cell –
3. Bacteria –
4. Organelles –
5. Pathogen –
6. Commensals
7. Prokaryotes –
8. Eukaryotes –

a. the smallest unit that can live on its own and that makes up all living organisms and the tissues of the body.

b. single cell organism

c. organs within the cell.

d. an organism that causes illness to its host.

e. is a living thing or life form.

f. single celled organisms, cells that do not contain a defined nucleus.

g. animal cells that contain a nucleus.

h. bacteria that carry out beneficial functions.

Cutibacterium acnes

- **Skin commensal** with pathogenic potential
- bacteria that can cause acne—most healthy adults have this on skin!
- Feeds on sebum (oily substance produced by skin)
- Lives deep in pores, sometimes on surface

Antibiotic resistant group B *Streptococcus*

- Clindamycin resistant, also known as GBS
- **Gut commensal** that's generally harmless, but leading cause of **serious bacterial infections in infants**!
    - Can cause severe illness ranging from skin infections to bloodstream infections and pneumonia

Borrelia burgdorferi (Lyme disease)

- Pathogen
- Unique corkscrew shape: spirochetes
- Transmitted through a tick bite—spread through bloodstreams then settle into skin, joints, heart, brain, etc…
- **Pathogen**: Lyme disease ~500,000 new cases of Lyme disease in the US every year; affect joints, heart, central nervous system, etc.

Intestinal Bacteria (diverse Arten)

- Description from author: A stool sample shows a high number of different intestinal bacteria - and at the same time appears surprisingly tidy. Many of these types of bacteria have hardly been researched. Some help digest food, absorb nutrients, and protect the intestinal walls. They may also control our weight and ward off autoimmune diseases. A plant-based dietary fiber has passed through the intestinal tract undigested. The cyst of an intestinal parasite (Giardia lamblia) can also be seen on the right edge of the image, immediately behind the dietary fiber.

Escherichia coli

- Model organism in lab! Also a **ubiquitous commensal** in humans (and other animals)
- **Specific strains are pathogenic**: think Chipotle / packaged salad outbreaks where products get recalled because people suffer from bacterial infections in the gut

Staphylococcus epidermidis

- **Skin commensal** that's generally harmless but can cause harm in immunocompromised people
- Can cause infections, especially in medical settings! Ex) cardiac devices, catheters
- Green grape-looking spheres are the bacteria, purple is extracellular matrix (connects cells and tissues; help with attachment and communication between cells)