Science

HANDS ON

FOOD SAFETY

A program of the GMA Science and Education Foundation

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Acknowledgments

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The lessons and activities in this unit were created or adapted by Dr. Jennifer Richards, Assistant Professor, Department of Agricultural Leadership, Education, and Communications, The University of Tennessee.

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SCIENCE

Summary of Activities:

Setting the Stage

Bacterial Growth Experiment: Set Up

Brainstorming

Introduction to Bacteria PowerPoint

R.A.F.T. Activity

Bacterial Growth Experiment: Aggregating Data

Researchable Questions

Edible Cell Models

Preparing and Staining Slides

Student Reflections

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Day	Delaware Science Standards	
Day 1	MS-LS1-1	Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
Day 2	MS-LS1-A	All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).
	MS-LS-3	Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
Day 4	MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
	MS-LS1-8	Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported and or not supported by evidence
Day 5	MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms
Day 6	MS-LS1-2	Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

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Inquiry Learning 5 E's-Science

Inquiry Event	Description	Science Activity
Engage	Make connections between past and present learning experiences, lay the organizational ground work for the activities ahead and stimulate their involvement in the anticipation of these activities	Setting the Stage Inform Learners of the Objectives
Explore	Provides an opportunity to get directly involved with the scientific materials and develop a base of experience with new concepts	Bacterial Growth Lab
Explain	Helps students begin to understand, in greater depth, the materials and concepts they explored in the previous activities	Brainstorming About Bacteria Introduction to Bacteria Presentation
Elaborate	Provides opportunities for students to expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them	RAFT Aggregating Data Generating a Researchable Question Edible Cell Models
Evaluate	Determines if students are successfully meeting the learning objectives for this lesson	Reflective paragraph response

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Unit Activities:	Setting the Stage, Objectives, Bacteria Lab	*Learning Objectives:*	Students will be able to: 1. Apply Scientific Method to conduct an investigation 2. Identify the variable and control in a scientific investigation 3. Follow appropriate lab rules and safety procedures
Inquiry Learning:	1. Engage 2. Explore		
Materials:	Petri plates, Parafilm, Hand Sanitizer, Hand Soap, Sharpie Markers	*Content Standards:*	MS-LS1-1
Student Handouts:	*Bacterial Growth Experiment: Set Up*		

Activities:

Setting the Stage (10 minutes)

Purpose: To help students make connections between past and present learning experiences, lay the organizational ground work for the activities ahead and stimulate their involvement in the anticipation of these activities.

Displayed on board as students enter the room: **On a scale of 1-10, how clean do you think your hands are right now? (1=dirtiest, 10=cleanest). Make a list of 10 things you have touched since you last washed your hands.**

- Ask students to write down their response to the question. Allow 3-5 minutes for students to do so.
- Allow students to share their responses with the class.
- Pose questions for discussion.
  - **After considering the things you've touched, do any of you want to change your score?**

Inform the Learner of the Objectives (3 minutes)

Tell students: **Today we are going to conduct a lab to learn about bacteria, where it grows, and how you can avoid getting sick from bacteria.**

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Activities:
Bacteria Growth Lab: Set Up (40 minutes)

Purpose: To provide students with an opportunity to get directly involved with the scientific materials and develop a base of experience with the new concepts.

- To set up the lab exercise, conduct the following discussion with students:
  - As you ask students the following discussion, walk around the room with a petri plate and allow each student to touch the surface of the agar.
    - What am I holding? (A petri plate)
    - What do you think it is used for? (The petri plate contains a substance called Agar that is used to grow bacteria.)
    - What does it feel like?
    - Any ideas as to what the agar is made of? (Nutrients the bacteria need to grow. It is very similar to gelatin used to make Jell-o, but instead uses extracts from seaweed because it allows the agar to be stable at room temperature instead of melting like Jell-o would.)
  - Today we are going to use petri plates and agar to conduct an experiment that compares the effectiveness of various hand washing techniques.
- Follow the procedures of **Bacterial Growth Experiment: Set-Up** sheet.
- Provide each student with a lab sheet handout.
- Remind student that there are 3 variables in their treatments:
  1. Temperature of water
  2. Length of time
  3. Presence/absence of soap
- Ask students to consider what the dependent and independent variables are for this experiment.
- Ask each student (or lab group) to brainstorm a hypothesis for this experiment.
- Students will observe their Petri plates for two days and record their observations on their lab sheet.
- Refer to **Bacterial Colony Growth Descriptors** to help students describe their observations.

Be sure to review **SAFETY Procedures** for Science Laboratories and Materials**.**

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Safety Procedures

Bacterial Growth Lab: Set Up

- Petri plates should be sealed with Parafilm, then placed upside down in a secure location and not touched until observations are made
- Anytime students and/or teachers/instructors have contact with the Petri plates, all should wear gloves. Immediately after removing gloves, students should wash their hands vigorously for 15 seconds with water and soap.

Disposal of Plates and Disinfection: TO BE COMPLETED BY THE TEACHER/INSTRUCTOR

- Using the spray bottle, dissolve the bleach tablet in warn water. Bleach solutions should not be used after two weeks of mixing, as the solution will degrade.
    - Petri plates—Open each plate and spray 2-3 sprays of the bleach solution, close the plate, and place in the ziplock bag. Once full, seal the bag and place into regular trash. A 10-15 minute contact time with the bleach solution should kill all bacteria present.
    - Gloves—Dispose into a regular trash bag with zipped bags of Petri plates and at least 5 sprays of the bleach solution.
    - Countertops and Equipment—Use sanitizing wipes and/or bleach solution with paper towels to clean all surfaces used or touched during the lab activity.
    - Sanitize student desks after each class period on days Petri plates are handled or performing lab activities.
    - In the event of a spill, which is highly unlikely, spray the bleach solution around the spill area and wipe toward the center of the spill.

Any student or teacher/instructor who is immune compromised due to current chemotherapy or radiation treatment, organ transplant, or pregnancy should be excused from laboratories.

Bacterial Growth Experiment: SET UP
Teacher's Copy

Objective/Problem: The purpose of this experiment is:

Possible problem:

- What is the best method of handwashing?
- How dirty are your hands?

Hypothesis:

Possible hypotheses include:

- A lot of bacteria will grow on the plates with unwashed hands.
- The plates with just cold water will have more bacteria than those with warm water and soap for 20 seconds.
- Plates with hand sanitizer will not have any bacteria.

Materials:
1 pre-poured SMA plate
Hand Soap
Hands Sanitizer
Secure location for plate incubation
Sharpie Marker
Parafilm (1"x 4" strips)

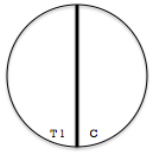
Treatment _____ **Name _____**

Procedures: List the step-by-step procedures of your experiment below (Step 1 has been listed for you along with the first word of each step. You must fill in the details.):

1. **Shake** hands with at least 5 people.

2. **Draw** a line to divide the Petri plate into two halves.

3. **Label** one side of the Petri plate along the edge of the bottom of the plate (side with printed writing) using small letters with your name and C (control) Label the other side with the treatment you used (T1, T2, or T3).



4. **Touch** the surface of the control (C) side of your Petri plate with all five fingers as if you are being fingerprinted.

5. **Wash** hands according to the treatment you are given.
   i. Wash hands in cold water with no soap for 5 seconds.
   ii. Wash hands in warm water with soap for 20 seconds.
   iii. Use a hands sanitizer with no water or soap.

6. **Touch** the surface of the treatment side of your Petri plate with all 5 fingers.

7. **Wrap** the plate in Para film and incubate the plate upside down at room temperature for 48 hours.

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Bacterial Growth Experiment: SET UP
Teacher's Copy

Treatment _____ **Name _____**

Data: Fill in your data in the charts below:

Day 2: Observations

	Control	Treatment
Colony Count	80	32
Describe Colonies	• Round, yellow-ish • Size of a pen tip • Some round, pink ovals • Lots of clusters	• Round, white • Not many clusters

Do NOT touch colonies growing on your plate. Once you have finished recording your observations, wash your hands thoroughly with soap and warm water.

Day 3: Observations – Recount the entire plate to ensure you account for all new growth.

	Control	Treatment
Colony Count	140	50
Describe Colonies	• Round, yellow-ish • Larger circles (nail size)	• Round, yellow-ish • Few circles or clusters

Do NOT touch colonies growing on your plate. Once you have finished recording your observations, wash your hands thoroughly with soap and warm water.

Post-Lab Discussion Questions:

1. **What changes took place in colony growth from Day 2 and Day 3?**
   Possible changes might include:
   - More colorful growth on control side.
   - Equal amount of growth on each side.

2. **Looking at the data, what differences do notice between the control and treatment?**
   Possible differences might include:
   - Treatment has more growth than the control.
   - Control side has more growth than the treatment.

3. **Discuss your conclusions based on the data collected in this experiment.**
   Possible conclusions might include:
   - Treatment didn't reduce the bacteria on my hands.
   - Treatment reduced the bacteria on my hands.

4. **What problems might have occurred in this experiment that might lead you to question the validity of your results?**
   Possible problems might include:
   - Touched a desk before touching plates with "cleaned hands".
   - Using a different handwashing method than others.

Conclusions: might include the following

- Create a more uniform procedure for consistent results, like measuring the water temperature.
- Handwashing can reduce the number of bacteria on my hands.

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Bacterial Growth Experiment: SET UP **Treatment _____** **Name _____**

Objective/Problem: The purpose of this experiment is:

Hypothesis:

Materials:
1 pre-poured SMA plate
Hand Soap
Hands Sanitizer
Secure location for plate incubation
Sharpie Marker
Parafilm

Procedures: List the step-by-step procedures of your experiment below (Step 1 has been listed for you along with the first word of each step. You must fill in the details.):

1. Shake hands with at least 5 people.

2. Draw

3. Label

4. Touch

5. Wash

6. Touch

7. Wrap

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Bacterial Growth Experiment: SET UP

Treatment _____ **Name _____**

Data: Fill in your data in the charts below:

Day 2: Observations

	Control	Treatment
Colony Count		
Describe Colonies		

Do NOT touch colonies growing on your plate. Once you have finished recording your observations, wash your hands thoroughly with soap and warm water.

Day 3: Observations – Recount the entire plate to ensure you account for all new growth.

	Control	Treatment
Colony Count		
Describe Colonies		

Do NOT touch colonies growing on your plate. Once you have finished recording your observations, wash your hands thoroughly with soap and warm water.

Post-Lab Discussion Questions:

1. What changes took place in colony growth from Day 2 and Day 3?

2. Looking at the data, what differences do notice between the control and treatment?

3. Discuss your conclusions based on the data collected in this experiment.

4. What problems might have occurred in this experiment that might lead you to question the validity of your results?

Conclusions:

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Unit Activities:	Review, Collect Data, Bacteria Brainstorm, Bacteria Lecture	*Learning Objectives*	Students will be able to: 1. Accurately collect data in a scientific investigation 2. Connect prior knowledge to new concepts about bacteria 3. Understand basic differences between bacteria cells and plant and animal cells
Inquiry Learning:	3. Explain		
Materials:	Student Petri plates, Gloves, *Introduction to Bacteria* PowerPoint, computer	*Content Standards:*	MS-LS1-A
Student Handouts:	*Bacteria Growth Experiment: Set Up* *Bacteria Concept Map*		

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday we set up a bacterial growth experiment. What do you think the bacteria will look like when you look at your Petri plates today? Today we are going to observe and collect data from your experiments and we are going to learn about bacteria.**

Collect Data (10 minutes)

- Have students put on gloves and observe Petri plates. Students should write down observation of plates on Bacterial Growth Experiment worksheet.

Brainstorming About Bacteria (10 minutes)

- On a large piece of drawing paper (or the board) write the word **Bacteria** large enough that all students can see it.
- Ask students to volunteer any information they know about bacteria.
- Record student responses in the format of a concept map on the drawing paper.
- At this stage, the focus is not on correct answers but merely on brainstorming to assess prior knowledge of the concept.
- Student knowledge will vary depending on how much prior learning they have had on bacteria.

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Activities:
Introduction to Bacteria Presentation (20 minutes)

Purpose: To help students begin to understand, in greater depth, the materials and concepts they explored in the previous activities.

Learner Level: Average-High

- Use the PowerPoint presentation ***Introduction to Bacteria***
- Students should complete the graphic organizer **Bacteria Concept Map** during the presentation.
- Be sure to allow time for students to fill in their concept map throughout the presentation.

Learner Level: Low-Average

- Use the PowerPoint presentation ***Introduction to Bacteria.***
- Divide students into small groups of 2-3.
- Assign each group one main heading from the **Bacteria Concept Map** graphic organizer.
- Each group should listen carefully for all information related to their heading and fill in only their section during the presentation.
- After the presentation, have each group share what they recorded with the rest of the class so that each group has a complete concept map.

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Bacterial Colony Growth Descriptors

- **Size**
  - pinpoint
  - small
  - medium
  - large

- **Shape and Margins**
  - round
  - regular or irregular
  - flat, rounded, craterlike (with depressed center)

- **Consistency**
  - Shiny or rough

- **Color**
  - Describe the color or shades accurately.
  - gray
  - white
  - yellows
  - red

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Introduction to Bacteria

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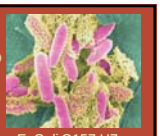
What are bacteria?

- Single celled organisms
- Very small
- Need a microscope to see
- Can be found on most materials and surfaces
  - Billions on and in your body right now



E. Coli O157:H7 can make you very sick.

Streptococcus can cause strep throat.

This *E. coli* helps you digest food.

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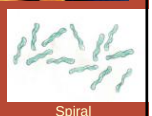
What do they look like?

- Three basic shapes
  - Rod shaped called bacilli (buh-sill-eye)
  - Round shaped called cocci (cox-eye)
  - Spiral shaped
- Some exist as single cells, others cluster together

Bacilli

Cocci



Cluster of cocci

Spiral

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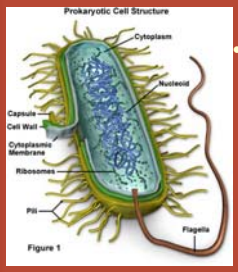
Bacteria are ALIVE!



- What does it mean to be alive?
  - They reproduce (make more of themselves)
  - They need to eat

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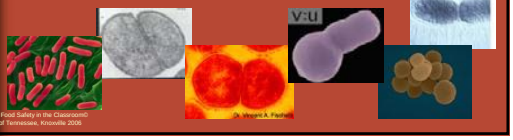
How do bacteria reproduce?

- Grow in number not in size
  - Humans grow in size from child to adult
- Make copies of themselves by dividing in half
  - Human parents create a child



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How do bacteria eat?

- Some make their own food from sunlight—like plants
- Some are scavengers
  - Share the environment around them
    - Example: The bacteria in your stomach are now eating what you ate for breakfast
- Some are warriors (pathogens)
  - They attack other living things
    - Example: The bacteria on your face can attack skin causing infection and acne

Photosynthetic bacteria

Harmless bacteria on the stomach lining

E. Coli O157:H7 is a pathogen

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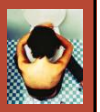
What is a pathogen?

- Bacteria that make you sick
  - Why do they make you sick?
    - To get food they need to survive and reproduce



  - How do they make you sick?
    - They produce poisons (toxins) that result in fever, headache, vomiting, and diarrhea and destroy body tissue

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Where do you get a pathogen?

Indirect contact

- Contact with people who are sick
  - Direct or indirect
- Food, Water, or other Surfaces that are contaminated

Foods that could be contaminated

Direct contact

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A Closer Look – Where do you get a pathogen

Indirect Contact

Direct Contact

Foods and water may be contaminated

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Are all bacteria pathogens?

- No, most are harmless
- Some are even helpful
  - Examples of helpful bacteria:
    - *Lactobacillus*: makes cheese, yogurt, & buttermilk and produces vitamins in your intestine

    - *Leuconostoc*: makes pickles & sauerkraut
    - *Pediococcus*: makes pepperoni, salami, & summer sausage

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A Closer Look – Helpful Bacteria

www.bioweb.usu.edu

Pediococcus - used in production of fermented meats

Lactobacillus casei – found in human intestines and mouth to improve digestion

Leuconostoc cremoris – *used in the production of buttermilk and sour cream*

Lactobacillus bulgaricus – *used in the production of yogurt*

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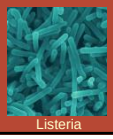
What are some common pathogens?

E. coli O157:H7

- Pathogenic *E. coli* (like O157:H7)
  - Found in ground beef, contaminated fruits and vegetables

Salmonella

- *Salmonella*
  - Found in raw meats, poultry, eggs, sprouts, fruit and vegetables



Listeria

- *Listeria*
  - Found in deli foods, lunch meats, smoked fish and vegetables

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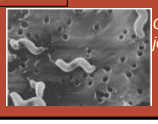
Examples of Pathogens

Salmonella

E. coli O157:H7

What shape are these bacteria?
Cocci, bacilli, or spiral?

Staphylococcus aureus



Campylobacter jejuni

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How can I avoid pathogens?

- Wash your hands often so you won't transfer bacteria to your mouth or food
  - Warm water with soap for 20 seconds, rub hard between fingers and nails

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How can I avoid pathogens?

- Cook food thoroughly to kill any pathogens that may be in your food

- Store food properly to limit pathogen growth
  - Cold temperatures (40°F)

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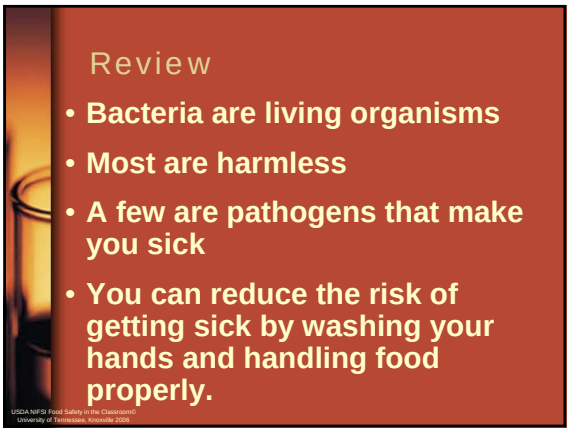
Review
• Bacteria are living organisms
• Most are harmless
• A few are pathogens that make you sick
• You can reduce the risk of getting sick by washing your hands and handling food properly.
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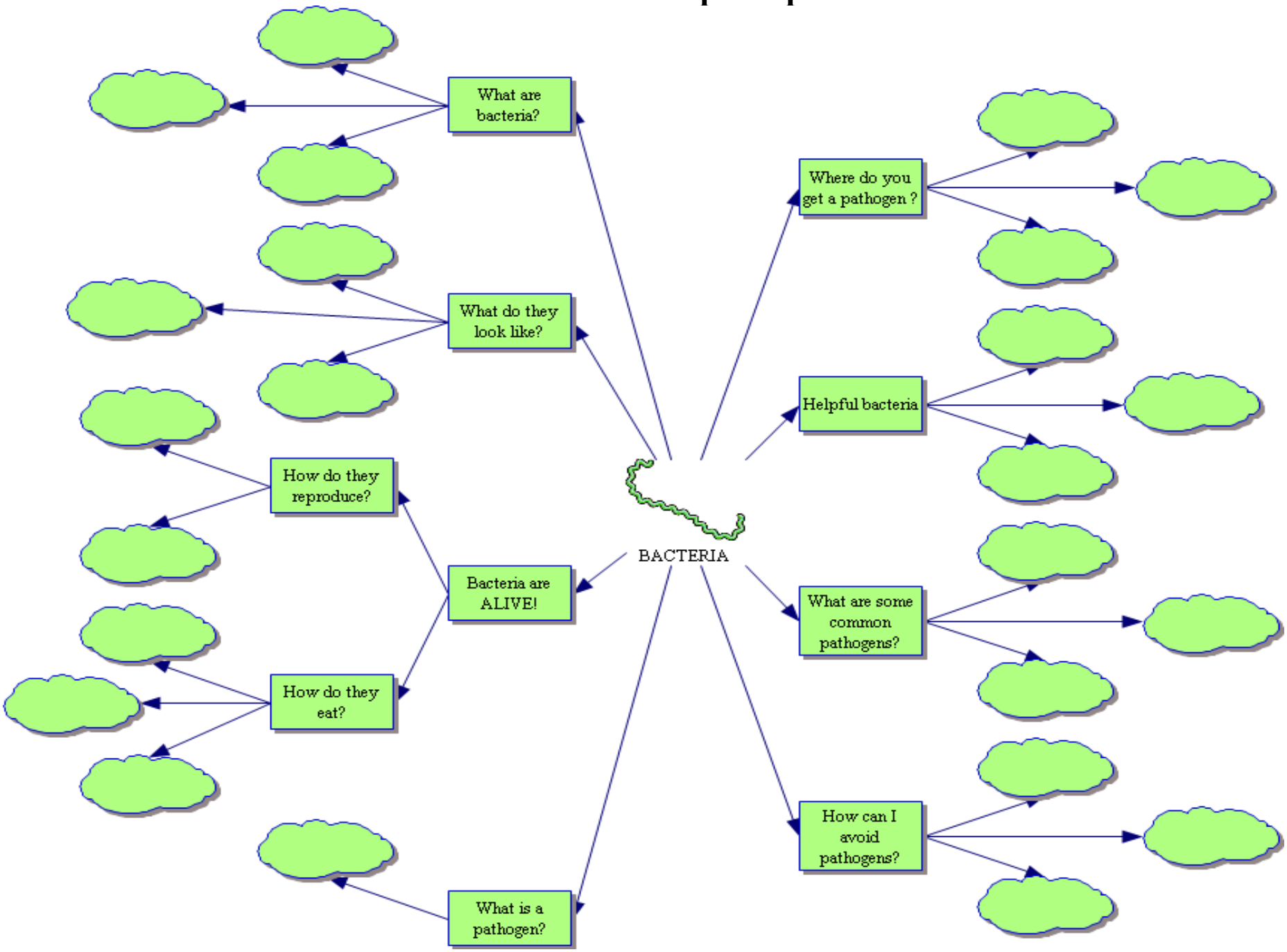
Bacteria Concept Map



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Unit Activities:	Review, Collect Data, Complete Lecture, R.A.F.T.	*Learning Objectives:*	Students will be able to: 1. Accurately collect data 2. Synthesize information about pathogens and helpful bacteria into a product that clearly communicates an understanding of bacterial growth
Inquiry Learning:	4. Elaborate		
Materials:	Gloves, Markers, Construction Paper	*Content Standards:*	MS-LS1-3
Student Handouts:	*Bacterial Growth Experiment: Set Up*		

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday we learned about bacteria**. **What did you learn yesterday that you did not know before? Today you are going to use your imaginations to share what you've learned about bacteria with others.**

Collect Data (10 minutes)

Have students put on gloves and observe Petri plates. Students should write down observations of plates on **Bacterial Growth Experiment** worksheet.

Complete Lecture (10 minutes)

- Finish discussing information from day before.
- Make sure students have concept maps filled out.
- Add to brainstorming chart about bacteria from previous day.

R.A.F.T. Activity (20 minutes)

Purpose: To provide opportunities for students to expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them.

- Display the **R.A.F.T. chart** on the overhead or board.
- Assign each student (or pair of students) one of the roles. You may allow students to choose groups and assignments based on ability levels and learning styles.
- Students will then assume the role of their assignment and create the prescribed product.
- Once the products have been completed, students should present their work to the class.

Example: Students will write as though they are a helpful bacteria writing to a group of teenagers. The writing will take the form of a rap song on the topic of "Can I help U?"

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R.A.F.T. Chart

Role	Audience	Format	Topic
Helpful bacteria	Teenagers	Rap song	"Can I help U?"

Points to include:

- Examples of helpful bacteria
- Foods made with helpful bacteria
- Other interesting information and helpful bacteria

Role	Audience	Format	Topic
Bacteriologist	Patients in a doctor's waiting room	Most Wanted Poster of foodborne pathogens	"Wanted: Dead or Alive"

Points to include:

- What is a pathogen?
- Describe how you might come in contact with a pathogen.
- What is the best way to avoid getting sick from pathogens?
- Descriptions, aliases, or known associates

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Unit Activities:	Review, R.A.F.T., Aggregating Data
Inquiry Learning:	4. Elaborate
Materials:	Student Petri plates, Gloves, Sharpie Markers
Student Handouts:	*Bacterial Growth Experiment: Aggregating Data*

Learning Objectives:	Students will be able to: 1. Interpret data collection from scientific investigation 2. Recognize sources of error and bias 3. Draw conclusions from data from a scientific investigation
Content Standards:	MS-LS1-5 MS-LS1-8

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday you started creating your R.A.F.T. assignments to share your new knowledge of bacteria. Was it hard pretending to be bacteria? What was the hardest part of this assignment? Today you are going to present your R.A.F.T. products to the class and we are going to complete the lab experiment that you started on Monday.**

Complete R.A.F.T. Activity (20 minutes)

- Have students finish and present R.A.F.T. activity from previous day.

Aggregating Data (30 minutes)

- Aggregate the class data by recording student plate counts by treatment.
  - To save class time, consider passing around a form for students to record their plate counts on one day and presenting them with a completed data set when you begin this activity.
- Total and average amount of growth in each treatment.
- Ask student to consider explanations for the trends and discrepancies they notice in the data.
- Pose questions for discussion:
  - Why are plate counts so different even in the same treatments? (washed for different amounts of time, touched doors after washing hands, pressed harder on Petri plates, etc.)
  - What surprises you about the results?
  - Do you think our data is accurate?
  - What could we do to make our results more reliable?
  - Were your hypotheses correct?
- Students should then draw conclusions based on the experiment results and answer **Questions for Consideration.**
- Be sure to review **SAFETY Procedures** for Science and Laboratories and Materials.

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Teacher's Copy

Bacterial Growth Experiment:
Aggregating Data

Class Data*

Treatment 1:

Unwashed	Cold H_2O 5 Seconds
15	10
36	30
18	19
20	5
24	22

Treatment 2:

Unwashed	Warm H_2O Soap 20 Seconds
16	5
18	2
29	10
7	5
22	15

Treatment 3:

Unwashed	Hand Sanitizer
14	2
38	10
62	5
23	8
16	2

Totals: **113 / 86** **92 / 37** **153 / 27**

Totals: Determine the total for each column in each treatment.

Averages: **22.6 / 17.2** **18.4 / 7.4** **10.6 / 5.4**

Averages: Average the totals for all unwashed and for each of the other treatments.

*To save class time, consider gathering this data from students the day before and preparing a completed data set to give to students when you conduct this activity.

This can be done with any of the following modifications:

- Passing around a form for students to fill in their plate totals and running copies.
- Entering student data into a spreadsheet and running copies.
- Entering student data into an excel graph and giving a copy to each student.

Class Data Observations: What trends do you notice in the data?

After recording each student's plate counts, encourage students to make observations about the data. What trends do they notice? How do they explain discrepancies?

Do these trends hold true when the counts are totaled? When they are averaged?

Conclusions: Based on the data, what is the answer to your hypothesis?

Based on the results of the data, have students generate conclusions. Were they able to answer their hypothesis?

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Questions for Consideration: Answer each of the following questions.

1. What could have happened in the Lab Set Up that led to unexpected outcomes in your data?

   Have students reflect on their procedure and what they did to lead to the results seen (i.e., did they touch anything before they touched their plate like a door, paper towel, chair, desk, etc.)

2. Did the amount of time spent washing your hands and the use of soap or sanitizer affect the amount of growth on the plates? If so, how?

   Students should answer this question based on the class data collected. Results will vary from class to class.

3. It is common for children to get sick more often once they start school. Why do you think this happens? How could a school child avoid getting sick more often?

   Possible answers include:

   Children are around more people at school than they were at home, and germs are easily spread from person to person by contact with toys, books, each other, etc. They could avoid getting sick by washing their hands regularly.

4. Why is it important to wash your hands before handling food?

   Possible answers include:

   The bacteria on your hands can be easily transferred to your food and make you sick.

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Bacterial Growth Experiment:
Aggregating Data

Class Data

Treatment 1:

Unwashed	Cold H_2O 5 Seconds

Treatment 2:

Unwashed	Warm H_2O Soap 20 Seconds

Treatment 3:

Unwashed	Hand Sanitizer

Totals:
Averages:

Class Data Observations: What trends do you notice in the data?

Conclusions: Based on the data, what is the answer to your hypothesis?

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Questions for Consideration: Answer each of the following questions.

1. What could have happened in the Lab Set Up that led to unexpected outcomes in your data?

2. Did the amount of time spent washing your hands and the use of soap or sanitizer affect the amount of growth on the plates? If so, how?

3. It is common for children to get sick more often once they start school. Why do you think this happens? How could a school child avoid getting sick more often?

4. Why is it important to wash your hands before handling food?

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Unit Activities:	Review, Researchable Question, Reflection Writing	*Learning Objectives*	Students will be able to: 1. Design a scientific investigation 2. Demonstrate understanding of controls 3. Select appropriate tools and methods for a scientific investigation
Inquiry Learning:	4. Elaborate 5. Evaluate		
Materials:	none		
Student Handouts:	*Bacterial Growth Experiment: Generating a Researchable Question* *Bacterial Growth Self-Assessment*	*Content Standards:*	MS-LS1-5

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday we gathered class data from your bacterial growth experiment. Were you surprised by the number of bacteria on your hands? Did any of you find yourselves washing your hands more often after class yesterday? Today you are going to work in groups to design a new experiment.**

Generating a Researchable Question (30 minutes)

- Allow students to work in small groups to complete **Generating a Researchable Question**. Examples and possible answers for all lab follow-up activities are included on the Teacher's Copy of the **Bacterial Growth Lab: Generating a Researchable Question sheet**.
- Encourage students to share their researchable questions and experiment design with the class.
- Students should complete the **Bacterial Growth Lab Self-Assessment** once these activities are completed.

Reflection Writing (20 minutes)

Purpose: To determine if students are successfully meeting the learning objectives for this lesson.

- Ask students to consider all they've learned about bacteria.
- Have students write a paragraph response to the following:
  - **Imagine you have a sister in 1st grade. In language she can understand, explain to her what bacteria are, how it can make you sick, and how you can avoid getting sick from bacteria.**
- Encourage students to share their responses with the class.

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Bacterial Growth Experiment:
Generating a Researchable Question

1. As a group, brainstorm three things you would like to know more about as a result of this experiment or its results.

Possible ideas could include:

a. **Changing only on variable in the treatment (temperature of water, length of time, presence/absence of soap)**
b. **Transfer of bacteria to food, various growth conditions of bacteria (temperature, light, application of chemicals)**
c. **Bacteria found on surfaces throughout the classroom and school, cleanliness of cafeteria/food handlers, etc.**

Try to steer students away from the obvious change of washing hands for 40 seconds, 90 seconds, etc.

2. Choose one of your ideas from above and reword it as a researchable question.

(Example: What would happen if we stored our bacterial growth plates under a heat lamp instead of at room temperature?)

Researchable Question:

3. Design a simple experiment to test your researchable question: (What steps would you take to get an answer to your question?)

There is no right or wrong way to design an experiment to test their researchable question, however, the experiment design should be reasonable, logical, well thought out, and have a reasonable chance of successfully addressing their question.

4. As a group, brainstorm a hypothesis for your researchable question. (What do you think would happen if you did the experiment you outlined above?)

Hypotheses will vary widely, but they should be directly related to the researchable question and experiment design.

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Bacterial Growth Experiment:
Generating a Researchable Question

1. As a group, brainstorm three things you would like to know more about as a result of this experiment or its results.

   a.

   b.

   c.

2. Choose one of your ideas from above and reword it as a researchable question.

(Example: What would happen if we stored our bacterial growth plates under a heat lamp instead of at room temperature?)

Researchable Question:

3. Design a simple experiment to test your researchable question: (What steps would you take to get an answer to your question?)

4. As a group, brainstorm a hypothesis for your researchable question. (What do you think would happen if you did the experiment you outlined above?)

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Bacteria Growth Lab Self-Assessment

0	1	2	3	4	5	I followed all lab procedures and safety rules.
0	1	2	3	4	5	I recorded observations from each of my Petri plates for two days.
0	1	2	3	4	5	I completed each of the questions found on my lab sheet.
0	1	2	3	4	5	I participated in the collection and analysis of class data.
0	1	2	3	4	5	My group produced at least one researchable question.
0	1	2	3	4	5	My group designed an experiment to test our researchable question.

TOTAL: /30 points

Bacterial Growth Lab Self-Assessment

0	1	2	3	4	5	I followed all lab procedures and safety rules.
0	1	2	3	4	5	I recorded observations from each of my Petri plates for two days.
0	1	2	3	4	5	I completed each of the questions found on my lab sheet.
0	1	2	3	4	5	I participated in the collection and analysis of class data.
0	1	2	3	4	5	My group produced at least one researchable question.
0	1	2	3	4	5	My group designed an experiment to test our researchable question.

TOTAL: /30

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Unit Activities:	Review, Edible Cells
Inquiry Learning:	4. Elaborate
Materials:	Cookie Cell or Tortilla Pizza Cell model edible ingredients
Student Handouts:	*Cookie Cell Model* or *Tortilla Pizza Cell Model* Handout

Learning Objectives	Students will be able to: 1. Recognize and understand major organelles in bacterial cells 2. Compare and contrast bacteria cells with plant and animal cells 3. Apply safe food handling behaviors
Content Standards:	MS-LS1-2

Activities:

Review (5 minutes)

Daily Review Question: **Last week we learned a lot about bacteria, how it can help us, and how it can make us sick. Today we are going to build a model of a bacterial cell using food. What are some important safe food handling rules that we need to follow?**

Edible Cells (40 minutes)

Purpose: To familiarize students with the structure of a bacterial cell while allowing them an opportunity to practice safe food handling.

- Decide which version of the **Bacteria Cell Model** activity you will use. Give each student a copy of the **Bacterial Cell Model** handout.
- Remind students to wash their hands thoroughly before beginning this activity and before eating.
- Use sanitizing wipes to clean and disinfect students' desks and other surfaces used in this activity before you begin.
- Lead students through the construction of their cell models.
- Explain each cell "component" as students are constructing their models.

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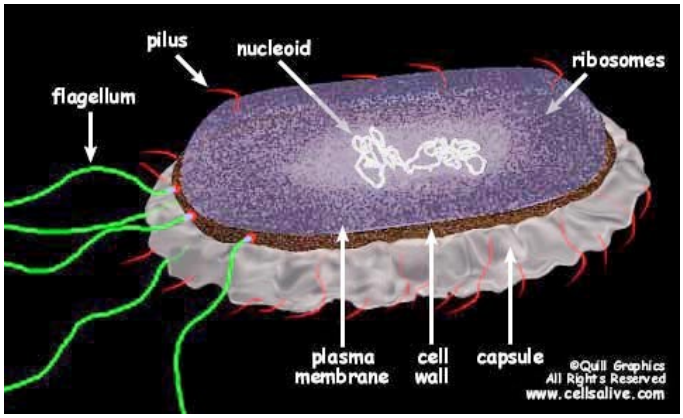
Bacterial Cell Model: Cookie Cell

Ingredients:

Paper plates	Chocolate chips
Sugar cookies	Twizzler bites
Frosting	M&Ms
Coconut, shredded	
Gummy worms	



Parts of a bacterial cell:

The **cell capsule** lets some things in and keeps other things out. It includes a cell wall and plasma membrane. This layer protects the bacterial cell and is often associated with pathogenic bacteria because it serves as a barrier against phagocytosis by white blood cells.

The **cytoplasm** is the liquid material inside the cell where the functions for cell growth, metabolism, and replication are carried out.

The **ribosomes** make proteins. Ribosomes give the cytoplasm of bacteria a granular appearance in electron micrographs. Though smaller than the ribosomes in eukaryotic cells, these inclusions have a similar function in translating the genetic message in messenger RNA into the production of proteins.

Flagella – The purpose of flagella (singular, flagellum) is to move the cell around. Flagella are long appendages, which rotate by means of a "motor" located just under the cytoplasmic membrane. Bacteria may have one, few, or many flagella in different positions on the cell.

Pili are hair-like structures on the surface of a cell that connect the bacterium to another of its species and build a bridge between the cytoplasm of either cell so that plasmids can be exchanged.

Nucleoid – DNA in the bacterial cell is generally confined to this central region. Although a membrane does not bind it, it is visibly distinct (by transmission microscopy) from the rest of the cell interior.

Plasmids – Along with chromosomal DNA, most bacteria also contain small independent pieces of DNA called plasmids that often encode for traits that are advantageous but not essential to their bacterial host.

Instructions for building a cell model:

1. Your sugar cookie is the **cell capsule**. Lay it flat on the plate.
2. Cover the top of the cookie with frosting. This is the **cytoplasm**!
3. Add a Twizzler bite. That is the **nucleoid** (DNA).
4. Cover with a few pieces of M&Ms. They are the **plasmids**.
5. Attach the **flagella** by placing a gummy worm on the edge of the cell.
6. Add **pili** by sprinkling shredded coconut around the edges of the cookie.
7. Add the **ribosomes** or chocolate chips throughout the cell.
8. You are ready to eat your cell model. Enjoy!

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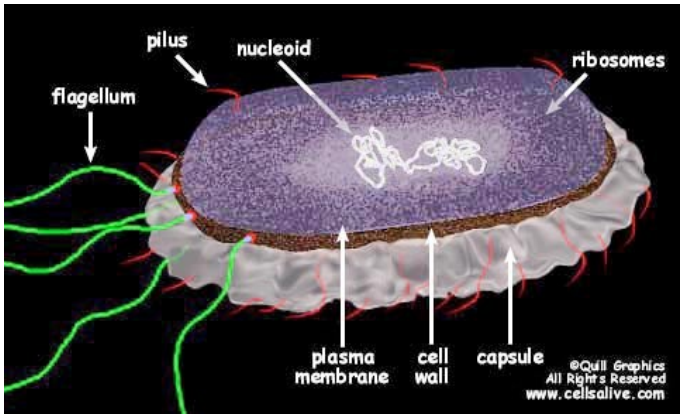
Bacterial Cell Model: Tortilla Pizza Cell

Ingredients:

Paper plates	Pepperoni
Large, flour tortilla	Canned, sliced olives
Pizza sauce	
Cheddar cheese, shredded	
Canned, sliced mushrooms	



Parts of a bacterial cell:

The **cell capsule** lets some things in and keeps other things out. It includes a cell wall and plasma membrane. This layer protects the bacterial cell and is often associated with pathogenic bacteria because it serves as a barrier against phagocytosis by white blood cells.

The **cytoplasm** is the liquid material inside the cell where the functions for cell growth, metabolism, and replication are carried out.

The **ribosomes** make proteins. Ribosomes give the cytoplasm of bacteria a granular appearance in electron micrographs. Though smaller than the ribosomes in eukaryotic cells, these inclusions have a similar function in translating the genetic message in messenger RNA into the production of proteins.

Flagella – The purpose of flagella (singular, flagellum) is to move the cell around. Flagella are long appendages, which rotate by means of a "motor" located just under the cytoplasmic membrane. Bacteria may have one, few, or many flagella in different positions on the cell.

Pili are hair-like structures on the surface of a cell that connect the bacterium to another of its species and build a bridge between the cytoplasm of either cell so that plasmids can be exchanged.

Nucleoid – DNA in the bacterial cell is generally confined to this central region. Although a membrane does not bind it, it is visibly distinct (by transmission microscopy) from the rest of the cell interior.

Plasmids – Along with chromosomal DNA, most bacteria also contain small independent pieces of DNA called plasmids that often encode for traits that are advantageous but not essential to their bacterial host.

Instructions for building a cell model:

1. Your tortilla is the **cell capsule**. Lay it flat.
2. Spread the pizza sauce on it. This is the **cytoplasm**!
3. Add the sliced mushrooms or **ribosomes** throughout the cell.
4. Add the **flagella** and **pilli** by sprinkling shredded cheddar cheese on the tortilla.
5. Add a sliced olive. This is the **nucleoid**.
6. Cover with a few pieces of pepperoni. These are the **plasmids**.
7. You're ready to eat your tortilla cell! Enjoy! (Optional: Heat the tortilla cell to melt cheese.)

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