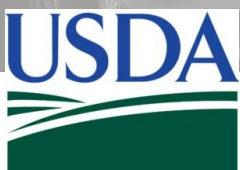


HANDS ON

FOOD SAFETY

A program of the GMA Science and Education Foundation

Approved and Endorsed by



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.

Endorsements



Sponsorships





MATHEMATICS

Summary of Activities:

Setting the Stage

Carousel Activity

Summarizing the Results

Understanding Scale

Understanding Bacterial Growth

Bacterial Growth Demonstration

Application of Knowledge

Is it Safe to Eat?

Student Reflection

Analyzing Bacterial Growth Data

Analyzing Data Self-Assessment

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Math Alabama Standards	
Day 1	7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
	7.SP.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples of the same size to gauge the variation in estimates or predictions.
Day 2	7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
	7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.
Day 3	7.EE.2 Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.
	7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Day 4	7.EE.2 Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.
	7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Days 5	7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers

Robert Gagne's Nine Events of Effective Instruction-Math

Stage of Instruction	Event	Description	Math Activity
Pre-Instruction	Gaining Attention	Stimulates readiness to learn and participate. Stimuli like surprises or questions are typically used for this event.	Setting the Stage
	Informing learners of the objectives	Generates expectancy by helping them understand what they will be learning	Inform learners of the objectives
	Stimulating recall of prior learning	Relating new information to something they already know or have experienced helps learners make sense of the lesson	Carousel Activity Graphing Data
Instruction	Presenting the stimulus	New information is presented. Strategies like providing examples or presenting vocabulary should be used to present the lesson content to provide more effective instruction	Understanding Scale Understanding Bacterial Growth
	Providing learning guidance	Helps facilitate the process of long-term information storage	Bacterial Growth Demonstration
	Eliciting performance	Requires the learner to practice the new skill or behavior. The repetition further increases the likelihood of retention of the new information	Application of Knowledge
Post-Instruction	Providing feedback	Assess and further facilitate learning. Typically, activities designed for feedback are for comprehension, not scoring	Is it Safe to Eat?
	Assessing performance	To evaluate the effectiveness of the instructional events, you must test to see if the expected learning outcomes have been achieved	Student Reflection
	Enhancing retention and transfer	Helps learners develop expertise by internalizing the new information. Methods for helping learners internalize are paraphrasing, generating examples, creating concept maps or outlines, and repetition	Analyzing Bacterial Growth Data

<p><i>Unit Activities:</i></p>	<p>Setting the Stage, Objectives, Carousel Survey</p>	<p><i>Learning Objectives:</i></p>	<p>Students will be able to:</p> <ol style="list-style-type: none"> 1. Develop and organize a data set generated from class responses. 2. Use equivalent forms of proportions, ratios, and percent to describe, summarize, and interpret survey results.
<p><i>Materials:</i></p>	<p>Carousel prompts, calculators (optional)</p>	<p><i>Common Core Standards:</i></p>	<p>7.EE.3 7.SP.2</p>
<p><i>Student Handouts:</i></p>	<p><i>Summarizing the Results</i></p>		
<p>Activities: <i>Setting the Stage (8 minutes)</i></p>	<p><i>Purpose: To capture attention and prepare students to learn and participate.</i></p> <p>Learner Level: All</p> <ul style="list-style-type: none"> • Write the following question on the board or overhead: Describe what we mean when we say a human grows. <ul style="list-style-type: none"> ○ 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: <ul style="list-style-type: none"> ▪ How much have you grown over the last year? ▪ As we know, humans are a type of animal. What has to happen biologically to make an animal, such as a human, grow? (cell division) ▪ Is this process also required for other types of organisms such as plants or bacteria to grow? 		
<p><i>Inform the Learner of the Objectives (2 minutes)</i></p>	<p><i>Purpose: To help students understand what they are responsible for learning.</i></p> <ul style="list-style-type: none"> • Tell students: This week we are going to study the difference in the growth of animals and the growth of bacteria. Our first activity is going to investigate how likely bacteria is to grow in your kitchen at home. 		

Activities:

*Carousel
Activity
(30 minutes)*

Purpose: To familiarize students with new words, activate prior knowledge, and provide a guide to the concepts they will learn in this lesson.

Learner Level: All

- Before beginning this activity, copy each question from the **Carousel Activity**.
- Post each page in a different place around the room.
- Divide students into 10 groups and send each group to a different page.
- Give students 1-2 minutes to read the question on their page and then tally their response in the appropriate box in the answer grid.
- Rotate student groups to a new page every 2-3 minutes until each group has answered every question.
- Discuss each question with the class, noting the various answers. Discuss the best answer choice(s) for each question.

*Summarizing
the Results
(20 minutes)*

Learner Level: All

- Assign each group of students one of the question pages from the Carousel Activity above.
- Each group should convert the data (student responses tallied) from their assigned questions to a number representing the frequency of students who selected each response per question.
- Post the frequency for each response per item on the board and instruct students to use this data to complete the **Summarizing the Results** handout. You may need to review finding percent, ratio, and fractions with students.
- On this handout, students will practice representing the responses given as equivalent forms of fractions, percentages, and ratios, and then write 3 sentences describing results.
- Walk through the example problem on the **Summarizing the Results** handout with students.
- After students finish, have them share some of their sentences with a partner or with the class.

*Wrap Up
(5 minutes)*

Tell students: Today we collected data from a carousel activity about how safe your kitchen is for preparing food. We used the data we collected to create proportions and summarize the results. Tomorrow we will learn about scale and how big a bacterium is and how fast it grows.

1. I clean the area where I make food and snacks before and after making food and snacks.
- a. Never
 - b. Sometimes
 - c. Usually
 - d. Always

A	B
C	D

2. The last time there was cookie dough in my home, the dough was:
- a. Made with raw eggs, and I sampled some of it
 - b. Made with raw eggs and refrigerated, then I sampled some of it
 - c. Store-bought, and I sampled some of it
 - d. Not sampled until baked

A	B
C	D

3. Meat, poultry, and fish products are defrosted in my home by:
- a. Setting them on the counter
 - b. Placing them in the refrigerator
 - c. Microwaving
 - d. I don't know

A	B
C	D

4. I know the types of foods that put me at a higher risk for getting food poisoning.
- a. Strongly disagree
 - b. Disagree
 - c. Agree
 - d. Strongly agree

A	B
C	D

5. When cooking meat I use a thermometer to check the temperature and doneness of the meat.
- a. Never
 - b. Sometimes
 - c. Usually
 - d. Always

A	B	
C	D	

6. The temperature of the refrigerator in my home is:
- a. 50 degrees Fahrenheit
 - b. 40 degrees Fahrenheit
 - c. 20 degrees Fahrenheit
 - d. I don't know; I've never measured it

A	B
C	D

7. I can positively impact the safety of my food by keeping cooked foods at room temperature for longer than 2 hours.

- a. Strongly disagree
- b. Disagree
- c. Agree
- d. Strongly agree

A	B	
C	D	

8. I feel that it is an adult's responsibility to keep my food safe when handling food.
- a. Strongly disagree
 - b. Disagree
 - c. Agree
 - d. Strongly agree

A	B
C	D

9. If a cutting board is used in my home to cut raw foods and it is going to be used to chop another food, the board is:
- a. Reused as is
 - b. Wiped with a damp cloth
 - c. Washed with soap and hot water
 - d. Washed with soap and hot water and then sanitized

A	B
C	D

10. I wash my hands before and after preparing snacks and meals

- a. Never
- b. Rarely
- c. Sometimes
- d. Always

A	B
C	D

Carousel Prompts

1. I clean the area where I make food and snacks before and after making food and snacks.
 - a. Never
 - b. Sometimes
 - c. Usually
 - d. Always
2. The last time there was cookie dough in my home, the dough was:
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 - b. Made with raw eggs and refrigerated, then I sampled some of it
 - c. Store-bought, and I sampled some of it
 - d. Not sampled until baked
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 - a. Setting them on the counter
 - b. Placing them in the refrigerator
 - c. Microwaving
 - d. I don't know
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 - d. Always
6. The temperature of the refrigerator in my home is:
 - a. 50 degrees Fahrenheit
 - b. 40 F
 - c. 20 F
 - d. I don't know; I've never measured it
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Carousel Prompts

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 - a. Reused as is
 - b. Wiped with a damp cloth
 - c. Washed with soap and hot water
 - d. Washed with soap and hot water and then sanitized

10. I wash my hands before and after preparing snacks and meals
 - a. Never
 - b. Rarely
 - c. Sometimes
 - d. Always

Carousel Explanations

1. I clean the area where I make food and snacks before and after making food and snacks.

- a. Never
- b. Sometimes
- c. Usually
- d. Always
 - The kitchen is one of the most dangerous places in the house because of the infectious bacteria that are sometimes found in raw foods.
 - Germs are easily spread to other people in the kitchen because food is prepared here.
 - Dirt and germs live on tables, countertops, and other places in the kitchen where food is prepared.

2. The last time there was cookie dough in my home, the dough was:

- a. Make with raw eggs, and I sampled some of it
- b. Make with raw eggs and refrigerated, then I sampled some of it
- c. Store-bought, and I sampled some of it
- d. Not sampled until I ate the baked cookies
 - Eating raw cookie dough may put you at risk for infection with *Salmonella enteritidis*, a bacterium that can be inside eggshells.
 - Refrigerating will not kill the bacteria.
 - Other foods containing raw eggs, such as homemade ice cream, cake batter, mayonnaise, and eggnog, carry a *Salmonella* risk, too.
 - Their commercial counterparts are usually made with pasteurized eggs; that is, eggs that have been heated sufficiently to kill bacteria. However, there is still a risk to consuming the commercial cookie dough products without baking them.

3. Meat, poultry, and fish products are defrosted in my home by:

- a. Setting them on the counter
- b. Placing them in the refrigerator
- c. Microwaving
- d. I don't know
 - Gradual defrosting overnight in the refrigerator is best because it helps maintain quality
 - Using the microwave oven or putting the packaging in a water-tight plastic bag submerged in cold water and changing the water every 30 minutes are also safe ways to defrost.
 - Do not thaw meat, poultry, and fish products on the counter or in the sink without cold water; bacteria can multiply rapidly at room temperature.
 - Marinate food in the refrigerator, not on the counter. Discard the marinade after use because it contains raw juices, which may harbor bacteria.

4. I know the types of foods that put me at a higher risk for getting food poisoning.

- a. Strongly disagree
- b. Disagree
- c. Agree
- d. Strongly agree
 - *Salmonella*: Raw meats, poultry, eggs, dairy products
 - *E. coli* O157:H7: Ground beef, fruits, vegetables, raw milk
 - *Listeria*: Deli meats, hot dogs, soft cheese, imported seafood products
 - *Campylobacter jejuni*: Raw poultry, meat, and unpasteurized milk
 - *Staphylococcus aureus*: Meats, poultry, egg products, mayonnaise based products

5. When cooking meat I use a thermometer to check the temperature and doneness of the meat.

- a. Never
- b. Sometimes
- c. Usually
- d. Always
 - Using a digital or dial food thermometer is important.
 - Cooking by color is misleading.
 - Some ground meat may prematurely brown before a safe internal temperature has been reached.

6. The temperature of the refrigerator in my home is:

a. 50 degrees Fahrenheit

b. 40 F

c. 20 F

d. I don't know; I've never measured it

- Refrigerators should stay at 40°F or less because it slows the growth of most bacteria.
- The temperature won't kill the bacteria, but it will keep them from multiplying, and the fewer there are, the less likely you are to get sick.
- According to surveys, in many households, the refrigerator temperature is above 50 F.
- Measure the temperature with a thermometer and, if need, adjust the refrigerator's temperature control dial.

7. I can positively impact the safety of my food by keeping cooked foods at room temperature for longer than 2 hours.

a. Strongly disagree

b. Disagree

c. Agree

d. Strongly agree

- Refrigerator or freeze leftovers within 2 hours or sooner to prevent harmful bacteria from multiplying.
- Cold temperatures keep most harmful bacteria from growing and multiplying.
- Bacteria grow most rapidly at unsafe temperatures between 40°F – 140°F.

8. I feel that it is an adult's responsibility to keep my food safe when handling food.

a. Strongly disagree

b. Disagree

c. Agree

d. Strongly agree

- We have an individual responsibility for the food that we eat.
- Taking actions such as washing hands, storing foods properly, cooking foods properly, and being aware of the foods that cause foodborne illness outbreaks will help in preventing a foodborne illness.

9. If a cutting board is used to cut raw foods and it is going to be used to chop another food, the board is:

- a. Reused as is
- b. Wipes with a damp cloth
- c. Washed with soap and hot water
- d. Washed with soap and hot water and then sanitized

- Use smooth cutting boards of hard maple or plastic and free of cracks and crevices.
- Wash cutting boards with hot water, soap, and a scrub brush to remove food particles. Then sanitize the boards by putting them through the automatic dishwasher or rinsing them in a solution of 1 teaspoon of chlorine bleach in 1 quart of water.
- Always wash and sanitize cutting boards after using them for raw foods and before using them for ready-to-eat foods.

10. I wash my hands before and after preparing snacks and meals

- a. Never
 - b. Rarely
 - c. Sometimes
 - d. Always
- The most important thing that you can do to keep from getting sick is to wash your hands.
 - Frequently washing hands allows you to wash away germs that could have been picked up from other people, contaminated surfaces, or from animals and animal waste.



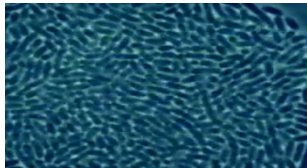
<i>Unit Activities:</i>	Review, Understanding Scale	<i>Learning Objectives:</i>	Students will be able to:
<i>Instructional Events:</i>	Present the stimulus		1. Apply use of scale to create 3-D scale models of a 6-sided die.
<i>Materials:</i>	Rulers, calculators, dice, construction paper, tape		2. Recognize the impact of magnifying an object by 4x, 10x, and 40x.
<i>Student Handouts:</i>	<i>Understanding Scale</i> worksheet <i>Understanding Scale in 3D</i> worksheet	<i>Common Core Standards:</i>	3. Calculate area, surface area, and volume of a cube in scaled relationships.
<i>Activities:</i> <i>Review</i> <i>(5 minutes)</i>	Daily Review Question: Yesterday we took surveys to determine how safe your kitchen is and compared percentages. Did any of you suggest changes to your parents last night during dinner? Today we are going to learn about scale and try to get an idea of how big a bacterium is.		
<i>Understanding Scale</i> <i>(50 minutes)</i>	<ul style="list-style-type: none"> Ask students: In science class you are conducting an experiment to grow bacteria. You may have learned in science class that bacteria is plural (more than one bacterium). How big is a single bacterium? Allow students to guess. Explain to students that bacteria are microscopic, which means they can only be seen using a microscope. Tell students that later in the week they will use a microscope to look at bacteria. The microscope will allow them to see the bacteria at 4x, 10x, and 40x its actual size. To demonstrate this scale, have students complete the <i>Understanding Scale</i> worksheet. Optional: Allow students to go outside and, using a measuring stick, mark off their heights at 4x, 10x, and 40x. Explain to students that proportional scale actually occurs in all dimensions, not just one. Students should construct a die at actual size (1x), 4x, and 10x. <ul style="list-style-type: none"> a) Have students measure a standard six-sided die (1.5cm). b) Using a ruler and construction paper, have students measure out six 1.5cm squares. Students should cut out the squares and construct a die. This die represents the actual size or 1x. c) Have students determine the dimensions of a 4x die (1.5cm x 4 = 6cm). 		

Activities:**Understanding Scale**
(continued)

- d) Using a ruler and construction paper, have students measure out six 6cm squares. Students should then cut out each square and construct a die. This die represents the actual size of 4x.
- e) Have students determine the dimensions of a 10x die ($1.5\text{cm} \times 10 = 15\text{cm}$).
- f) Using a ruler and construction paper, have students measure out six 15cm squares. Students should then cut out each square and construct a die. This die represents the actual size or 10x.
- g) While students are constructing their dice, draw examples of 1x, 4x, 10x, and 40x (60cm) squares on the board for students to use as a comparison.
- Explain to students that when they look at their bacteria in the microscope these are the powers of magnification they will use.
- Encourage students to draw connections between the actual sizes of the die versus the 40x.
- Have students complete the **Understanding Scale in 3D** worksheet where they will fill in the information they found.
- Students must fill in the equations listed in the Quick Review (below) and then use those equations to solve for each box.
 - Equations:
 - Area of a Square: $A_{\text{square}} = l \times w$ or s^2
 - Surface Area of a Cube: $SA_{\text{cube}} = 6(s^2)$
 - Volume of a Cube: $V_{\text{cube}} = l \times w \times h$ or s^3
 - Critical Thinking:
 - The difference between being drawn to scale and not drawn to scale is proportionality.
- Review student answers after they have completed all problems.

Wrap Up
(5 minutes)

Tell students: **Today we learned about scale by constructing dice at different magnifications, and then we examined the proportional relationships of the area, surface area, and volume of these figures. Tomorrow we will talk about bacterial growth using charts and exponential curves.**

Unit Activities:	Review, Understanding Bacterial Growth, Bacterial Growth Demonstration	Learning Objectives:	Students will be able to: <ol style="list-style-type: none"> 1. Recognize bacterial growth as an example of exponential growth. 2. Calculate the growth of bacteria over a given time period. 3. Deconstruct and solve word problems.
Instructional Events:	Present the Stimulus, Provide Learner Guidance		
Materials:	Modeling Clay		
Student Handouts:	<i>Understanding Bacterial Growth</i> handout <i>Applying Bacterial Growth Rates</i> worksheet	Common Core Standards:	7.EE.2 7.EE.4
Activities:			
Review (5 minutes)	Daily Review Question: Yesterday we learned about the size of bacteria. What surprised you the most about what you learned yesterday? How big is a single bacterium cell? Is it big or small? Today we are going to continue learning about scale and the size of bacteria.		
Understanding Bacterial Growth (15 minutes)	<p>Distribute a copy of <i>Understanding Bacterial Growth</i> to each student.</p> <ul style="list-style-type: none"> • Have students brainstorm ideas to compare and contrast bacterial growth with growth in animals and plants and record in the Venn diagram. • Ask students to share ideas with the class. • Ask students: If cells are so small, how do they grow fast enough to ever create an object you can see or one that could affect you? • Take away point: ALL growth is a result of Cell Division <p>Display the following definition on the board: Bacterial growth means an orderly increase in the number of bacteria. Every cell divides into 2 cells, causing the number of cells present to double each time the cells regenerate.</p> <ul style="list-style-type: none"> • Show students the following YouTube clip: http://www.youtube.com/watch?v=gEwzDydcIWc <div style="display: flex; justify-content: space-around; align-items: center;">    </div> <ul style="list-style-type: none"> • Explain that some bacteria, including strains that make us sick like <i>E. coli</i>, can divide as often as every 20 minutes under optimal conditions. 		

*Bacterial
Growth
Demonstration
(15 minutes)*

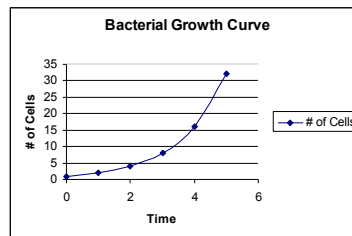
Purpose: To facilitate the transfer of new knowledge to long-term retention by providing a concrete demonstration of an abstract concept.

Learner Level: All

- Give each student a golf-ball sized piece of clay that represents a single bacterium.
- Every 30 seconds, have each student divide his/her “bacteria”: first two, then four, then eight, then 16, then 32 to demonstrate bacterial growth. (Total time: 2 minutes 30 seconds)
- Track bacterial growth on a class chart. Example:

# of Divisions	Time Elapsed in Seconds	# Cells
0	0	1
1	30	2
2	60	4

- Ask students: What happens each time the cells divide?
 - the number of cells present doubles
- After students have finished dividing their “bacteria”, plot the data points from the class chart onto a graph (x-axis: # of times cells divide, y-axis: # of bacteria cells) illustrating the exponential growth curve of bacterial growth. Example:



- Ask students to consider how their model bacteria are different from real life (size, structure, dividing bacteria do not get smaller and smaller with each generation and growth rates are not limitless).

*Application of
Knowledge
(20 minutes)*

Purpose: To allow the learner to practice the new knowledge. The repetition further increases the likelihood of retention of the new information.

- Give each student a copy of **Applying Bacterial Growth Rates** worksheet.
- Remind students that some bacteria, including strains that make us sick like *E. coli*, can divide as often as every 20 minutes under optimal conditions.
- Allow students time to answer the questions.
- Discuss answers

*Wrap Up
(5 minutes)*

Tell students: Today we learned that bacteria grow by cell division, causing the number of cells to rapidly increase. We used tables to chart bacterial growth over time. Tomorrow we will learn another way to calculate bacterial growth. Then, we will apply this knowledge to determine if foods in certain situations are safe to eat.



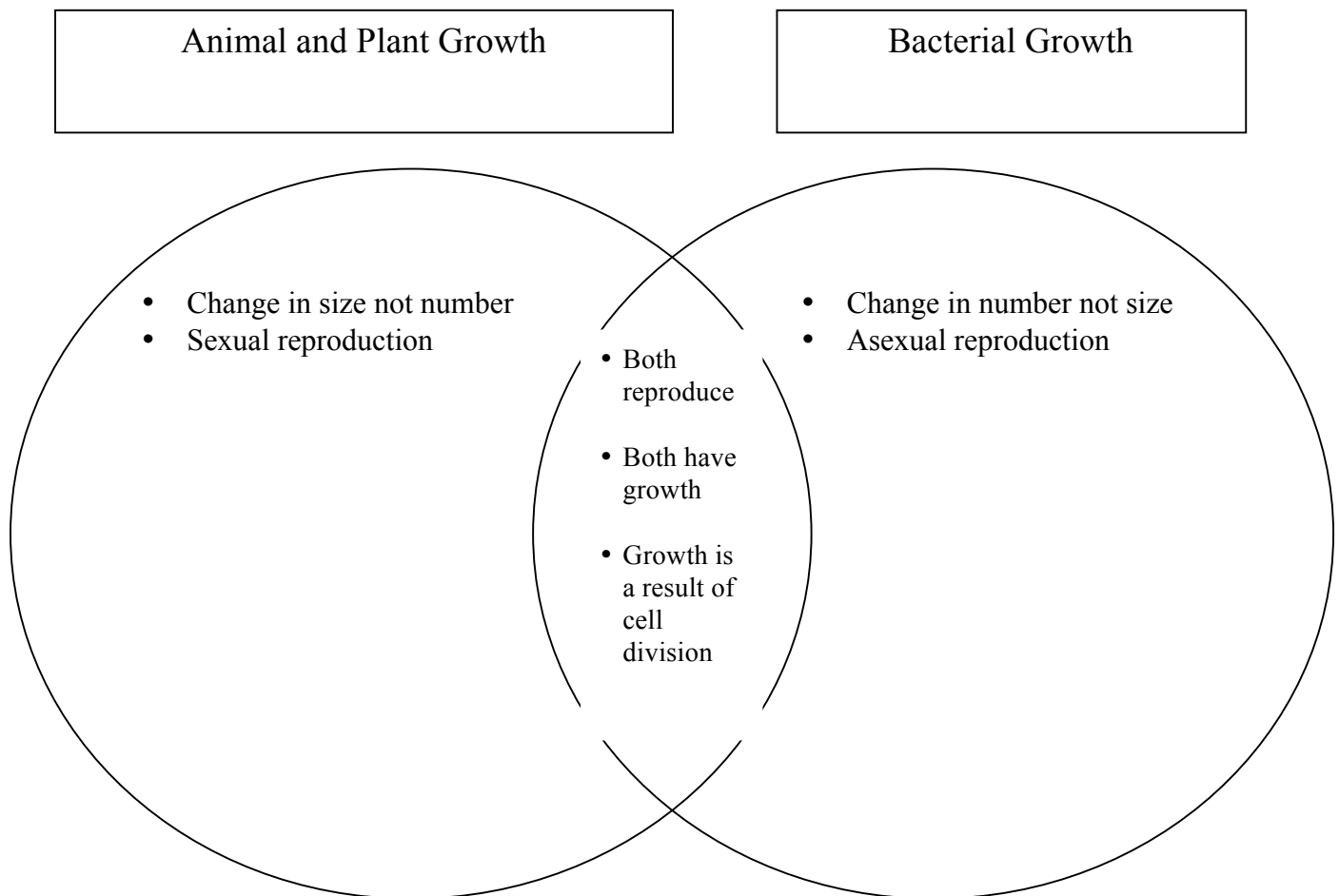
Teacher's Copy

Understanding Bacterial Growth



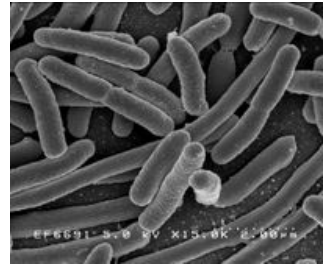
- ❖ Objective: Identify the rate of bacterial growth.
- ❖ Bacterial Growth means an orderly increase in the number of bacteria.
- ❖ Compare and Contrast:

Brainstorm ways in which bacterial growth is similar to and different from animal and plant growth using the Venn diagram below.





Understanding Bacterial *Growth*

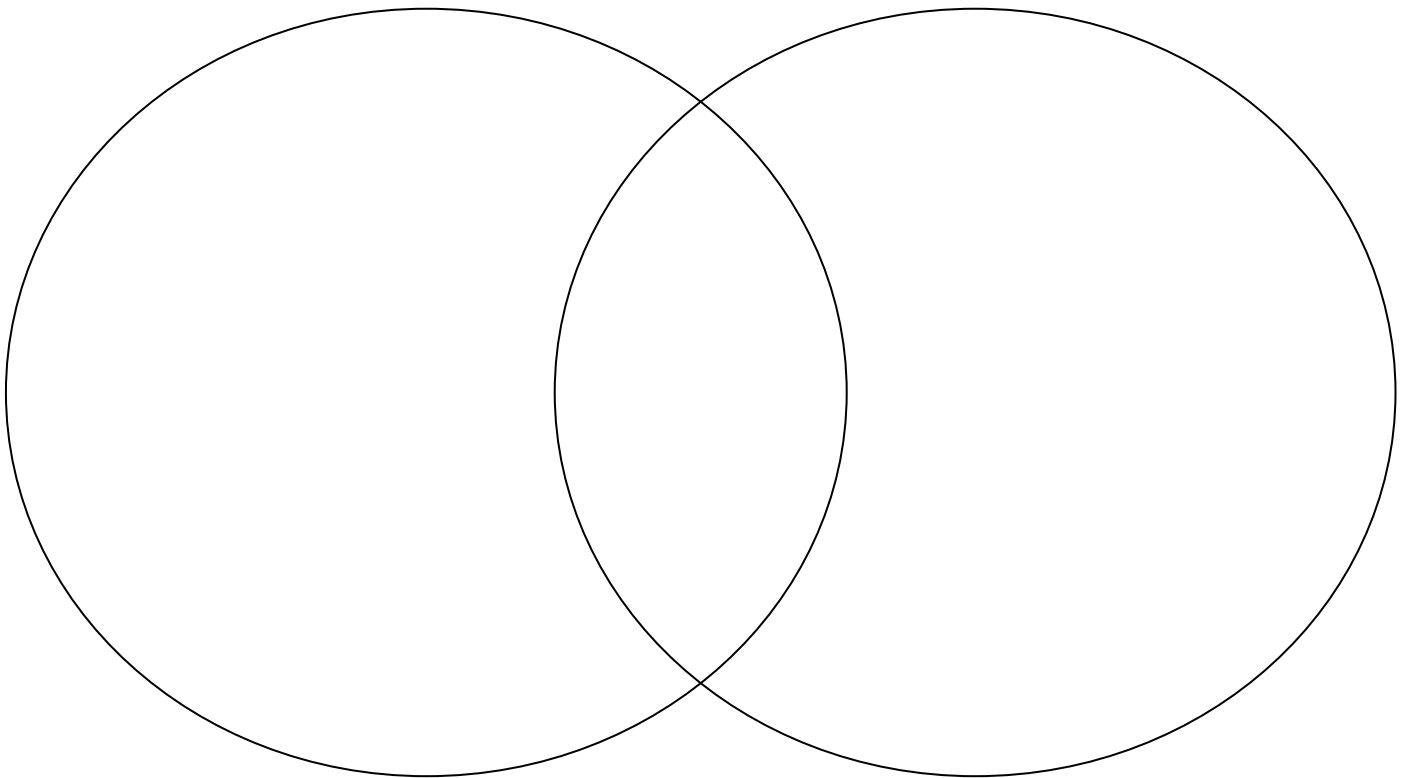


- ❖ Objective: Identify the rate of bacterial growth.
- ❖ Bacterial Growth means an orderly _____ in the number of _____.
- ❖ Compare and Contrast:

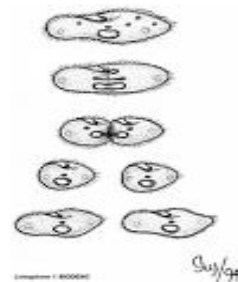
Brainstorm ways in which bacterial growth is similar to and different from animal and plant growth using the Venn diagram below.

Animal and Plant Growth

Bacterial Growth



Applying Bacterial Growth Rates



1. Under the best conditions, bacteria can divide every 20 minutes.

Tracking Bacterial Growth:

Use the chart below to track the growth of a single *E. coli* bacterium cell over several hours. Assume the cell has a generation time of 20 minutes. This means that every 20 minutes the cells divide, causing the amount of cells to double.

# of Divisions	Time Elapsed in Minutes	# of Cells
0	0	1
1	20	2
2	40	4
3	60	8
4	80	16
5	100	32
6	120	64
7	140	128
8	160	256
9	180	512

2. One *E. coli* cell could multiply up to 8 cells in just 1 hour.
3. How many *E. coli* cells would there be after 2 hours? 64
4. How many *E. coli* cells would there be after 3 hours? 512
5. If it takes 128 cells of *E. coli* to make you sick, and the cells can divide as often as every 20 minutes, then how long would it take for one cell to grow enough to make you sick?
140 minutes

Tracking Bacterial Growth:

Shigella (a type of bacteria) has a generation time of 40 minutes. Use the chart below to track the growth over several hours. Assume there are 4 cells present at start time.

# of Divisions	Time Elapsed in Minutes	# of Cells
0	0	4
1	40	8
2	80	16
3	120	32
4	160	64
5	200	128
6	240	256
7	280	512

6. How many *Shigella* cells would there be after 2 hours? 32

7. How many *Shigella* cells would there be after 4 hours? 256

8. In optimal conditions, how many times would *Shigella* cells divide in 2 hours?

Important information

Total Time: 2 hrs

Generation Time: 40 min

Step 1: Convert the Total Time from hours to minutes2 hrs = 120 min**Step 2:** Divide Total Time by Generation Time120 min / 40 min = 3

9. In optimal conditions, how many times would *Shigella* cells divide in 6 hours?

Important information

Total Time: 360 min

Generation Time: 40 min

9 cell divisions

10. In optimal conditions, how many times would *Shigella* cells divide in 8 hours?

Important information

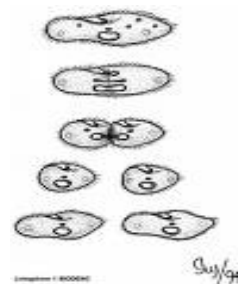
Total Time: 480 min

Generation Time: 40 min

12 cell divisions

Applying

Growth Rates



1. Under the best conditions, bacteria can divide every _____ minutes.

Tracking Bacterial Growth:

Use the chart below to track the growth of a single *E. coli* bacterium cell over several hours. Assume the cell has a generation time of 20 minutes. This means that every 20 minutes the cells divide, causing the amount of cells to double.

# of Divisions	Time Elapsed in Minutes	# of Cells
0	0	1
1	20	
2	40	
3	60	

2. One *E. coli* cell could multiply up to _____ cells in just 1 hour.
3. How many *E. coli* cells would there be after 2 hours? _____
4. How many *E. coli* cells would there be after 3 hours? _____
5. If it takes 128 cells of *E. coli* to make you sick, and the cells can divide as often as every 20 minutes, then how long would it take for one cell to grow enough to make you sick?

Tracking Bacterial Growth:

Shigella (a type of bacteria) has a generation time of 40 minutes. Use the chart below to track the growth over several hours. Assume there are 4 cells present at start time.

# of Divisions	Time Elapsed in Minutes	# of Cells
0	0	4
1	40	
2	80	

6. How many *Shigella* cells would there be after 2 hours? _____

7. How many *Shigella* cells would there be after 4 hours? _____

8. In optimal conditions, how many times would *Shigella* cells divide in 2 hours?

Important information

Total Time: 2 hrs

Generation Time: 40 min

Step 1: Convert the Total Time from hours to minutes

2 hrs = _____ min

Step 2: Divide Total Time by Generation Time

_____ min / _____ min = _____

9. In optimal conditions, how many times would *Shigella* cells divide in 6 hours?

Important information

Total Time: _____

Generation Time: _____

10. In optimal conditions, how many times would *Shigella* cells divide in 8 hours?

Important information

Total Time: _____

Generation Time: _____

Unit Activities:	Review, Application of Knowledge, Is it Safe to Eat?	Learning Objectives:	Students will be able to: <ol style="list-style-type: none"> 1. Calculate the growth of bacteria over a given time period. 2. Recognize bacterial growth as an example of exponential growth. 3. Deconstruct and solve word problems involving exponential growth.
Instructional Events:	Elicit Performance, Provide Feedback		
Materials:	Calculators (optional)		
Student Handouts:	<i>Is it Safe To Eat?</i> worksheet	Common Core Standards:	7.EE.2 7.EE4
Activities:			
Review (5 minutes)	Daily Review Question: Yesterday we learned that bacterial growth occurs when the cells divide. Each time the cells divide, the number of bacterial cells present doubles. Today you are going to solve some problems to determine if foods in certain situations are safe to eat.		
<i>Is it Safe to Eat?</i> (15 minutes)	<p><i>Purpose: To assess and facilitate further student learning.</i></p> <p>Learner Level: All</p> <ul style="list-style-type: none"> • Give each student a copy of <i>Is it Safe to Eat?</i> worksheet. • Work through the example problem with students and then let students complete Part 1. • It is important to remind students that these are only examples and should not be used as a guide for whether food is safe. • Remind students that in real life they would not know the number of pathogenic cells contaminating their food. • Encourage students to share individual stories regarding food safety. 		
Exponential Growth Curve (35 minutes)	<p>Tell students: We have been solving word problems about bacterial growth. Notice how we can plot our points from the table to create an exponential growth curve. Bacterial growth is one type of exponential growth.</p> <ul style="list-style-type: none"> • Remind students of the exponential growth curve you created as a class yesterday with the data from the table. • Instruct students that just as a line has a standard equation: $y = mx + b$ or $Ax + By = C$, the exponential growth curve also has an equation: $y = a(1+b)^x$. • Inform learners that the exponential growth curve equation can be used to solve the problems in another way besides in a chart or table. • Solve the example problem from the <i>Is it Safe to Eat?</i> worksheet again this time using the exponential growth curve equation. 		

*Exponential
Growth Curve
(35 minutes)*

Display the parts of the equation for students and discuss:

Variable	Represents	For Bacterial Growth
y	Final count	Final # of cells
a	Original amount	# of cells present at start
$1+b$	Growth factor, where b is the % of change	Bacterial growth is 100% (it doubles), so b is 100% or 1.
x	Time	# of times the cells divide

For the sample problem:

Variable	Value	Comments
y	?	This is what we want to know
a	4	Problem tells us that 4 cells are present at start
b	$b = 100\%$ or 1	$b = 1$, so $(1+b) = (1 + 1) = 2$
x	3	Total Time 2 hours (120 minutes) divided by Generation Time (40 minutes), then the cells will divide 3 times

Solving the equation:

$$\begin{aligned}
 y &= a(1+b)^x \\
 y &= 4(1+1)^3 \\
 y &= 4(2)^3 \\
 y &= 4(8) \\
 y &= 32
 \end{aligned}$$

- Ask students: Is this the same answer we got the first time we solved this and worked it using the table? If it takes 10 cells to make you sick, is it safe to eat?

Tell students: **Right now you may not see how this would be a good tool, but what if I asked you how many cells would be present after 8 hours? How many of you have ever left food out overnight? That would take a long time to solve using the table.**

Important Information		FORMULA:		$y = a(1+b)^x$
Total Time:	8 hrs = 480 min	# of cells at start	a	4 cells
Generation Time:	40 min	Growth Rate	b	100% or 1
Infectious dose:		# of times cells divide	x	$(480/40) = 12$

$$\begin{aligned}
 y &= 4(1+1)^{12} \\
 y &= 4(2)^{12} \\
 y &= 4(4096) \\
 y &= 16,384
 \end{aligned}$$

- Graph the curve using data from both the table and the equation results.
- Now have students complete **Part 2** of the *Is it Safe to Eat?* worksheet where they will practice solving for the exponential growth curve.

Tell students: **Today we learned how to solve word problems to determine if food is safe to eat in specific situations. We used both tables and formulas to solve problems and realized they both lead you to the same answer. Tomorrow we will analyze the results of your bacterial growth labs from Science.**

*Wrap Up
(5 minutes)*

Is it Safe to Eat?

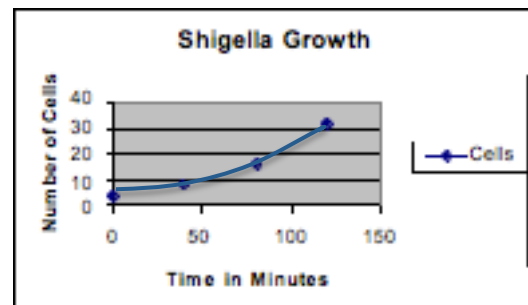


Part I Directions: For each of the scenarios, using the information provided, complete the table and determine if the food is safe to eat.

Example: *Shigella* has a generation time of 40 minutes and an infectious dose of 10 cells. Mom's tuna salad was infected with 4 cells of *Shigella* and has been sitting on the dining room table for 2 hours. Is it safe to eat?

Important Information		Bacteria type: <u><i>Shigella</i></u>
Total Time: <u>2 hours</u>		Infectious dose: <u>10 cells</u>
Generation Time: <u>40 minutes</u>		# of cells at start: <u>4 cells</u>

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells
0	0	4
1	40	8
2	80	16
3	120	32



No, the tuna salad is not safe to eat after 2 hours of sitting on the table.

1. *E. coli* O157:H7 has a generation time of 20 minutes and can make you sick with as few as 10 cells. Judy likes to eat her hamburgers medium rare. If her hamburger was contaminated with 2 *E. coli* O157:H7 cells that were not killed during cooking and she waited 20 minutes to eat the hamburger, is it safe to eat?

Important Information		Bacteria type: <u><i>E. coli</i> O157:H7</u>
Total Time: <u>20 minutes</u>		Infectious dose: <u>10 cells</u>
Generation Time: <u>20 minutes</u>		# of cells at start: <u>2 cells</u>

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells
0	0	2
1	20	4

Is it safe to eat?

Yes, the hamburger is safe to eat after waiting 20 minutes to eat the hamburger.

2. Under ideal conditions, *Salmonella* has a generation time of 30 minutes and an infectious dose of 15-20 cells. Aunt Susie's homemade Ranch salad dressing has been sitting on the picnic table for 2.5 hours. If the dressing started out infected with 3 *Salmonella* cells, is it safe to eat now?

Important Information		Bacteria type: <u><i>Salmonella</i></u>
Total Time: <u>2.5 hours</u>		Infectious dose: <u>15-20 cells</u>
Generation Time: <u>30 minutes</u>		# of cells at start: <u>3 cells</u>

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells
0	0	3
1	30	6
2	60	12
3	90	24
4	120	48
5	150	96

Is it safe to eat?

No, the Ranch salad dressing is not safe to eat after sitting on the picnic table for 2.5 hours or 150 minutes.

3. Using the information provided, write your own food safety scenario. Then, complete the table and to determine if the food is safe to eat.

Important Information		Bacteria type: <u><i>Campylobacter jejuni</i></u>
Total Time: <u>3 hours</u>		Infectious dose: <u>400-500 cells</u>
Generation Time: <u>90 minutes</u>		# of cells at start: <u>150 cells</u>

Scenario:

Is it safe to eat?

No, it is not safe to eat.

Part II Directions: Now, rather than using a table, use the formula for exponential growth to determine if the food is safe to eat. Show your work. Then create a line graph for each scenario illustrating the exponential growth curve.

4. *E. coli* O157:H7 has a generation time of 20 minutes and can make you sick with as few as 10 cells. If Judy's hamburger was contaminated with 2 *E. coli* O157:H7 cells that were not killed during cooking, determine if it is safe to eat in each of the following situations.

Important Information		Formula: $y = a(1 + b)^x$		
Total Time:	_____	# of cells at start	a	<u>2 cells</u>
Generation Time:	<u>20 minutes</u>	Growth Rate	b	<u>100% or 1</u>
Infectious dose:	<u>10 cells</u>	# of times cells divide	x	_____

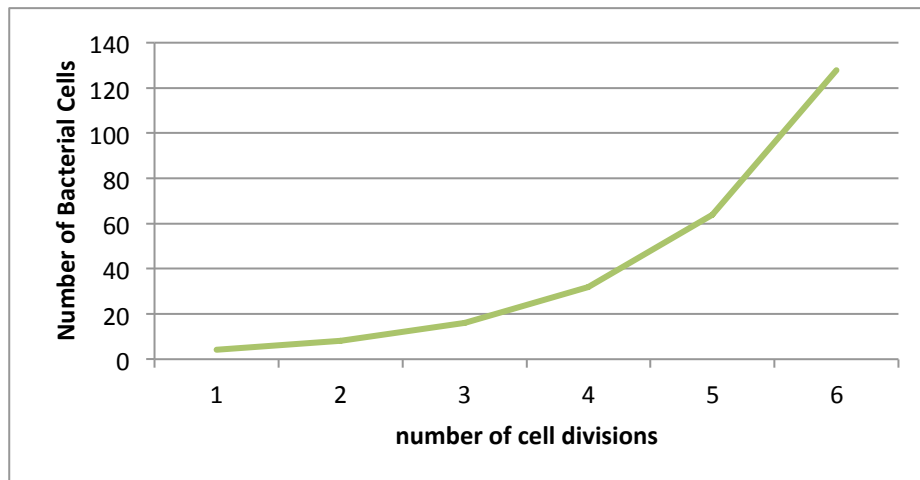
- a. How many *E. coli* cells would be present (y) if she waited 40 minutes to eat the hamburger? Is it safe to eat?

Solution: If the total time is 40 minutes, then the cells divide 2 times, so
 $y = 2(1 + 1)^2 = 8$ cells. This is less than the infectious dose of 10 cells. Yes, it is safe to eat.

- b. How many *E. coli* cells would be present (y) if she waited 1 hour to eat the hamburger? Is it safe to eat?

Solution: If the total time is 60 minutes, then the cells divide 3 times, so
 $y = 2(1 + 1)^3 = 16$ cells. This is more than the infectious dose of 10 cells. No, it is not safe to eat.

- c. Create a graph of the exponential growth curve where the number of times the cells divide is along the x -axis and the total number of bacterial cells is along the y -axis.



Challenge: How many *E. coli* cells would be presented (y) if she waited 3 hours to eat the hamburger?

$$y = 2(1 + 1)^9 = 1024 \text{ cells}$$

5. Under ideal conditions, *Salmonella* has a generation time of 30 minutes and an infectious dose of 15-20 cells. If the dressing started out infected with 3 *Salmonella* cells, determine if it is safe to eat in each of the following situations.

Important Information		Formula: $y = a(1 + b)^x$	
Total Time:	_____	# of cells at start	a <u>2 cells</u>
Generation Time:	<u>30 minutes</u>	Growth Rate	b <u>100% or 1</u>
Infectious dose:	<u>15-20 cells</u>	# of times cells divide	x _____

- a. How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 1 hour? Is it safe to eat?

Solution: If the total time is 60 minutes, then the cells divide 2 times, so

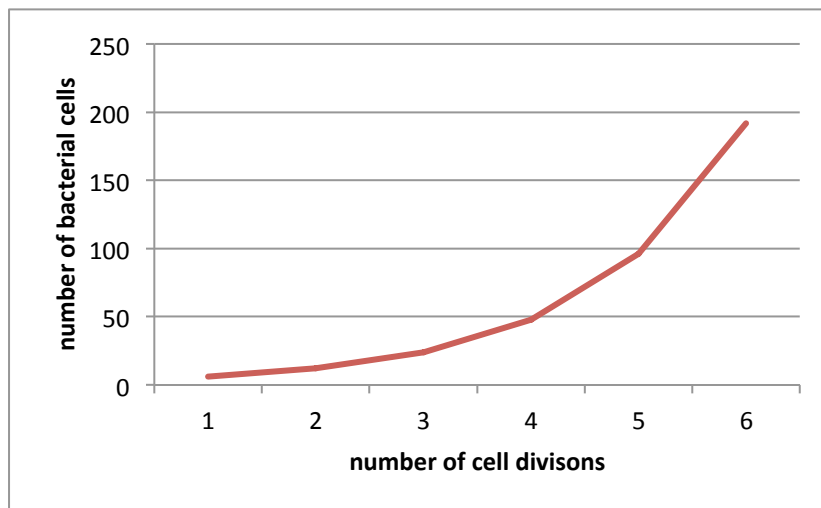
$y = 3(1+1)^2 = 12$ cells. This is less than the infectious dose of 15-20 cells. Yes, it is safe to eat.

- b. How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 3 hours? Is it safe to eat?

Solution: If the total time is 90 minutes, then the cells divide 3 times, so

$y = 3(1+1)^3 = 192$ cells. This is more than the infectious dose of 15-20 cells. No it is not safe to eat.

- c. Create a graph of the exponential growth curve where the number of times the cells divide is along the x -axis and the total number of bacterial cells is along the y -axis.



CHALLENGE: How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 6.5 hours?

$$y = 3(1 + 1)^{13} = 24,576 \text{ cells}$$

Is it Safe to Eat?

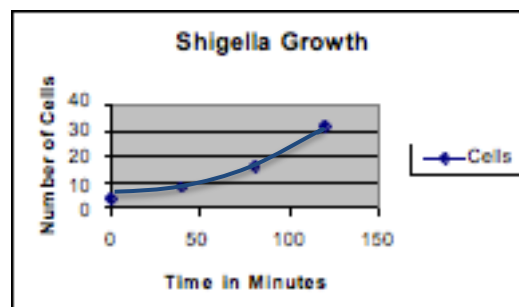


Part I Directions: For each of the scenarios, using the information provided, complete the table and determine if the food is safe to eat.

Example: *Shigella* has a generation time of 40 minutes and an infectious dose of 10 cells. Mom's tuna salad was infected with 4 cells of *Shigella* and has been sitting on the dining room table for 2 hours. Is it safe to eat?

Important Information		Bacteria type: <u><i>Shigella</i></u>
Total Time: <u>2 hours</u>		Infectious dose: <u>10 cells</u>
Generation Time: <u>40 minutes</u>		# of cells at start: <u>4 cells</u>

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells
0	0	4
1	40	8
2	80	16
3	120	32



No, the tuna salad is not safe to eat after 2 hours of sitting on the table.

1. *E. coli* O157:H7 has a generation time of 20 minutes and can make you sick with as few as 10 cells. Judy likes to eat her hamburgers medium rare. If her hamburger was contaminated with 2 *E. coli* O157:H7 cells that were not killed during cooking and she waited 20 minutes to eat the hamburger, is it safe to eat?

Important Information		Bacteria type: _____
Total Time: _____		Infectious dose: _____
Generation Time: _____		# of cells at start: _____

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells

Is it safe to eat?

2. Under ideal conditions, *Salmonella* has a generation time of 30 minutes and an infectious dose of 15-20 cells. Aunt Susie's homemade Ranch salad dressing has been sitting on the picnic table for 2.5 hours. If the dressing started out infected with 3 *Salmonella* cells, is it safe to eat now?

Important Information	Bacteria type: _____
Total Time: _____	Infectious dose: _____
Generation Time: _____	# of cells at start: _____

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells

Is it safe to eat?

3. Using the information provided, write your own food safety scenario. Then, complete the table and to

determine if the food is safe to eat.

Important Information	Bacteria type: <u><i>Campylobacter jejuni</i></u>
Total Time: <u>3 hours</u>	Infectious dose: <u>400-500 cells</u>
Generation Time: <u>90 minutes</u>	# of cells at start: <u>150 cells</u>

Scenario:

Is it safe to eat?

Part II Directions: Now, rather than using a table, use the formula for exponential growth to determine if the food is safe to eat. Show your work. Then create a line graph for each scenario illustrating the exponential growth curve.

4. *E. coli* O157:H7 has a generation time of 20 minutes and can make you sick with as few as 10 cells. If Judy's hamburger was contaminated with 2 *E. coli* O157:H7 cells that were not killed during cooking, determine if it is safe to eat in each of the following situations.

Important Information		Formula: $y = a(I + b)^x$		
Total Time:	_____	# of cells at start	a	_____
Generation Time:	_____	Growth Rate	b	_____
Infectious dose:	_____	# of times cells divide	x	_____

- How many *E. coli* cells would be present (y) if she waited 40 minutes to eat the hamburger? Is it safe to eat?
- How many *E. coli* cells would be present (y) if she waited 1 hour to eat the hamburger? Is it safe to eat?
- Create a graph of the exponential growth curve where the number of times the cells divide is along the x -axis and the total number of bacterial cells is along the y -axis.

Challenge: How many *E. coli* cells would be presented (y) if she waited 3 hours to eat the hamburger?

5. Under ideal conditions, *Salmonella* has a generation time of 30 minutes and an infectious dose of 15-20 cells. If the dressing started out infected with 3 *Salmonella* cells, determine if it is safe to eat in each of the following situations.

Important Information		Formula: $y = a(1 + b)^x$		
Total Time:	_____	# of cells at start	a	_____
Generation Time:	_____	Growth Rate	b	_____
Infectious dose:	_____	# of times cells divide	x	_____

- How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 1 hour? Is it safe to eat?
- How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 3 hours? Is it safe to eat?
- Create a graph of the exponential growth curve where the number of times the cells divide is along the x -axis and the total number of bacterial cells is along the y -axis.

CHALLENGE: How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 6.5 hours?

<i>Unit Activities:</i>	Review, Student Reflection, Analyzing Data	<i>Learning Objectives:</i>	Students will be able to: <ol style="list-style-type: none"> 1. Use mean, median, mode and range to analyze a data set. 2. Use statistical analysis to compare treatments in a data set. 3. Create graphical representations of data.
<i>Instructional Events:</i>	Assessing Performance, Enhance Retention & Transfer		
<i>Materials:</i>	Construction Paper, Calculators (optional)		
<i>Student Handouts:</i>	<i>Analyzing Data</i> worksheet <i>Analyzing Data Self-Assessment</i>	<i>Common Core Standards</i>	7.NS.3
<i>Activities:</i>			
<i>Review (5 minutes)</i>	Daily Review Question: Yesterday you solved problems about bacterial growth to determine if foods in certain situations are safe to eat. Today we are going to analyze the results of your bacterial growth labs from science class. What predictions do you have as to which treatment was the most effective in getting rid of bacteria?		
<i>Student Reflection (15-20 minutes)</i>	<p><i>Purpose: To determine if students are successfully meeting the learning objectives for this lesson.</i></p> <p>Learner Level: All</p> <ul style="list-style-type: none"> • Tell students, “Before we analyze your science data, let’s take a moment to reflect on the math concepts you’ve learned so far this week (bacterial growth and scale).” • Allow students to work in pairs and provide each pair with a piece of construction paper. • Each pair should write one “really good” word problem or discussion question regarding the material they have learned so far this week. • Post each pairs’ question on the board and, as a class, try to answer each question correctly. 		

*Analyzing
Bacterial
Growth Data
(30 minutes)*

Purpose: To allow students to develop expertise with the new information and create a construct for transferring knowledge to long-term retention.

Learner Level: All

- Using the raw data collected in the science follow-up lab, have students complete the **Analyzing Data** worksheet individually.
 - Optional Modifications: complete the exercise as a group and reducing the number of problems.
 - Optional Modifications to page 2 of worksheet:
 - Use the data set for the unwashed hands treatment to construct a frequency table. Use the frequency table to create a histogram.
 - What trends do you notice when you examine the histogram?
 - Use the means for each of the four treatments to construct a scatterplot. Based on the scatterplot you constructed, examine if there is a positive relationship, negative relationship, or no relationship between the hand washing treatments and the number of bacterial colonies?

Discussion Questions:

1. What are some of the differences between each set of data?
2. What do you notice about the values used in each set of data?
3. What do the graphs tell you about each treatment?

*Self-
Assessment
(5 minutes)*

- Once students have finished, have them complete the **Analyzing Data Self-Assessment**.

*Wrap Up
(5 minutes)*

Tell students: Today we analyzed data collected from the experiment conducted in Science. We used information from each treatment conducted and compared the data to the other treatments. We also graphed the data using box and whisker plots.

Analyzing Data Self-Assessment

0	2	4	6	8	10	You complete each task for questions 1-5.
0	1	2	3	4	5	All of your graphs are labeled correctly, have a title, and use regular intervals.
0	1	2	3	4	5	Your responses to questions are thoughtful and accurate.
0	1	2	3	4	5	Your work represents your best effort, is neat, and easy to read.
TOTAL:						/25 points

Analyzing Data Self-Assessment

0	2	4	6	8	10	You complete each task for questions 1-5.
0	1	2	3	4	5	All of your graphs are labeled correctly, have a title, and use regular intervals.
0	1	2	3	4	5	Your responses to questions are thoughtful and accurate.
0	1	2	3	4	5	Your work represents your best effort, is neat, and easy to read.
TOTAL:						/25 points

Analyzing Data Self-Assessment

0	2	4	6	8	10	You complete each task for questions 1-5.
0	1	2	3	4	5	All of your graphs are labeled correctly, have a title, and use regular intervals.
0	1	2	3	4	5	Your responses to questions are thoughtful and accurate.
0	1	2	3	4	5	Your work represents your best effort, is neat, and easy to read.
TOTAL:						/25 points