Math

HANDS ON

FOOD SAFETY

A program of the GMA Science and Education Foundation

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Acknowledgments

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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

Table of Contents:

Mathematics 6th Grade Standards	M2
Gagne Instructional Design	M3
Day 1 – Lesson Plan	M4
Carousel Prompts	M6
Carousel Explanations	M18
Day 2 – Lesson Plan	M22
Day 3 – Lesson Plan	M24
Understanding Bacterial Growth (Teacher's Copy)	M26
Applying Bacterial Growth Rates (Teacher's Copy)	M27
Day 4 – Lesson Plan	M29
Is It Safe to Eat? (Teacher's Copy)	M31
Day 5 – Lesson Plan	M35
Analyzing Data Self-Assessment	M37

Day	Florida 6th Grade Math Standards	
Day 1	MAFS.6.SP.1.1	Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.
	MAFS.6.RP.1.3C	Find a percent of a quantity as a rate per 100 (e.g. 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.
Day 2	MAFS.6.EE.1.2C	Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations).
	MAS.6.RP.A.3d	Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.
Day 3	MAFS.6.EE.1.2C	Evaluate expressions at specific values of their variables. Include expressions that arise from formulas used in real-world problems. Perform arithmetic operations, including those involving whole-number exponents, in the conventional order when there are no parentheses to specify a particular order (Order of Operations).
	MAFS.6.EE.2.7	Solve real-world and mathematical problems by writing and solving equations of the form $x + p = q$ and $px = q$ for cases in p, q, and x are all nonnegative rational numbers.
Day 4	MAFS.6.EE.1.1	Write and evaluate numerical expressions involving whole-number exponents.
	MAFS.6.EE.1.2a	Write expressions that record operations with numbers and with letters standing for numbers
	MAFS.6.EE.2.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set
Days 5	MAFS.6.SP.1.2	Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.
	MAFS.6.SP.2.4	Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
	MAFS.6.SP.5c	Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

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

Unit Activities:	Setting the Stage, Objectives, Carousel Survey	*Learning Objectives:*	Students will be able to: 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.
Materials:	Carousel prompts Calculators (optional)	*Common Core Standards:*	6.SP.A.1 6.RP.A.3c
Student Handouts:	*Data Investigation* *Data Investigation Reporting Sheet*		

Activities:

Setting the Stage (8 minutes)

Purpose: To capture attention and prepare students to learn and participate.

Learner Level: All

Write the following question on the board or overhead: **Describe what we mean when we say a human grows.**

- 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:
  - 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?

Inform the Learner of the Objectives (2 minutes)

Purpose: To help students understand what they are responsible for learning.

- 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**, and 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

Because everyone didn't answer each question in the exact same way there is a difference in the responses, or VARIABILITY, and we can use statistical thinking to investigate the data and summarize the results.

- What are some statistical questions we can about the data we just collected? Discuss some possible questions as a class. Then have students work alone or in pairs to write 3 statistical questions for PART 1 on the ***Data Investigation*** handout for the data collected.
  Example questions:
  - How many people ALWAYS wash their hands before and after preparing meals and snacks? FREQUENCY
  - What percent of people said meats are defrosted in their home by placing them in the refrigerator? PERCENT
- Walk through the example data summary for PART 2 on the ***Data Investigation*** handout with students, reviewing percent, ratio, and fractions as needed.
- Assign each group a question from the Carousel Activity and have them complete the ***Data Investigation Reporting Sheet***.
- When completed, have each group post their reporting sheet below the Carousel Question.
- Students may then use the posted data to complete PART 3 of the ***Data Investigation*** handout.
- After students finish, have them share some of their findings 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:
   a. Made with raw eggs, and I sample 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

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Carousel Prompts

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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 <u>not</u> 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 <u>not</u> 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.

Unit Activities:	Review, Understanding Scale	*Learning Objectives:*	Students will be able to: 1. Apply use of scale to create 3-D scale models of a 6-sided die. 2. Recognize the impact of magnifying an object by 4x, 10x, and 40x. 3. Calculate area, surface area, and volume of a cube in scaled relationships.
Instructional Events:	Present the stimulus		
Materials:	Rulers, calculators, dice, construction paper, tape		
Student Handouts:	*Understanding Scale* worksheet *Understanding Scale in 3D* worksheet	*Common Core Standards:*	6.EE.2c 6.RP.3d

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday we completed a survey to determine how safe your kitchen is and compared responses. 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.**

Understanding Scale (50 minutes)

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 and then 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 ***Understanding Scale*** worksheet.

- Have students complete the inch column first. OPTIONAL: Allow students to go outside and, using a measuring stick, mark off their heights at 4x, 10x, and 40x. You can explain to students that proportional scale actually occurs in all dimensions, not just one.
- If necessary, bring students back together for instruction on unit conversions.

  Pick an object in your classroom that is greater than 12 inches.

  1. Convert inches to feet and inches using a ratio.
     If our object is 29" and 12 inches = 1 foot, or written as a ratio $\frac{12\text{ in}}{1\text{ ft}}$, then $\frac{12\text{ in}}{1\text{ ft}} = \frac{29\text{ in}}{x}$.
     Cross multiply and $12x = 29$, divide each side by 12, so x = 2' 5"

  2. Convert inches to centimeters using a ratio.
     If our object is 29" and 1 inch = 2.54 centimeters, then $\frac{1\text{ in}}{2.54\text{ cm}} = \frac{29\text{ in}}{x}$. Cross multiply and $1x = 2.54(29)$, so x = 73.66 cm.

Activities:

Understanding Scale (continued)

If you do not want to use ratios to solve, then use:

Centimeters * 0.39 = Inches

Inches * 2.54 = Centimeters

So, 29 inches * 2.54 = 73.66 centimeters.

Extend the understanding by having students construct a die at actual size (1x), 4x, and 10x.

- Have students measure a standard six-sided die (1.5cm).
- 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.
- Repeat this for to construct a die at 4x (1.5cm x 4 = 6cm) and 10x (1.5cm x 10 = 15cm).
- 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: $A_{square} = l \times w$ or s^2
        - Surface Area of a Cube: $SA_{cube} = 6(s^2)$
        - Volume of a Cube: $V_{cube} = l \times w \times h$ 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: 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:	*Understanding Bacterial Growth* handout *Applying Bacterial Growth Rates* worksheet	*Common Core Standards:*	6.EE.A.2c 6.EE.B.7

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)

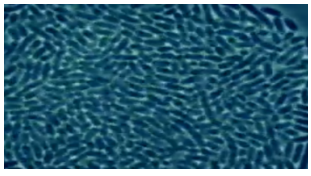
Distribute a copy of ***Understanding Bacterial Growth*** to each student.

- 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**

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.

- Show students the following YouTube clip: http://www.youtube.com/watch?v=gEwzDydciWc





- Explain that some bacteria, including strains that make us sick like *E. coli*, can divide as often as every 20 minutes under optimal conditions.

Bacterial Growth Demonstration (15minutes)

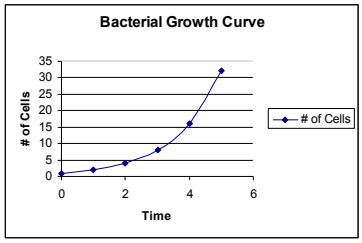
Purpose: To facilitate the transfer of new knowledge to long-term retention by providing a concrete demonstration of an abstract concept.

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.

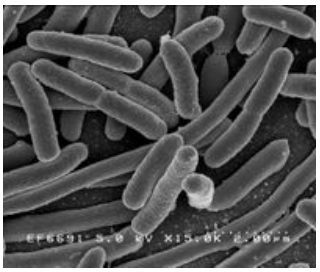
- Give each student a copy of ***Applying Bacterial Growth Rates*** worksheet**.**
- Remind students that some bacteria, including strains that make us sick like *E. coli*, can divide as often as every 20 minutes under optimal conditions.
- Allow students time to answer the questions.
- Discuss answers

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

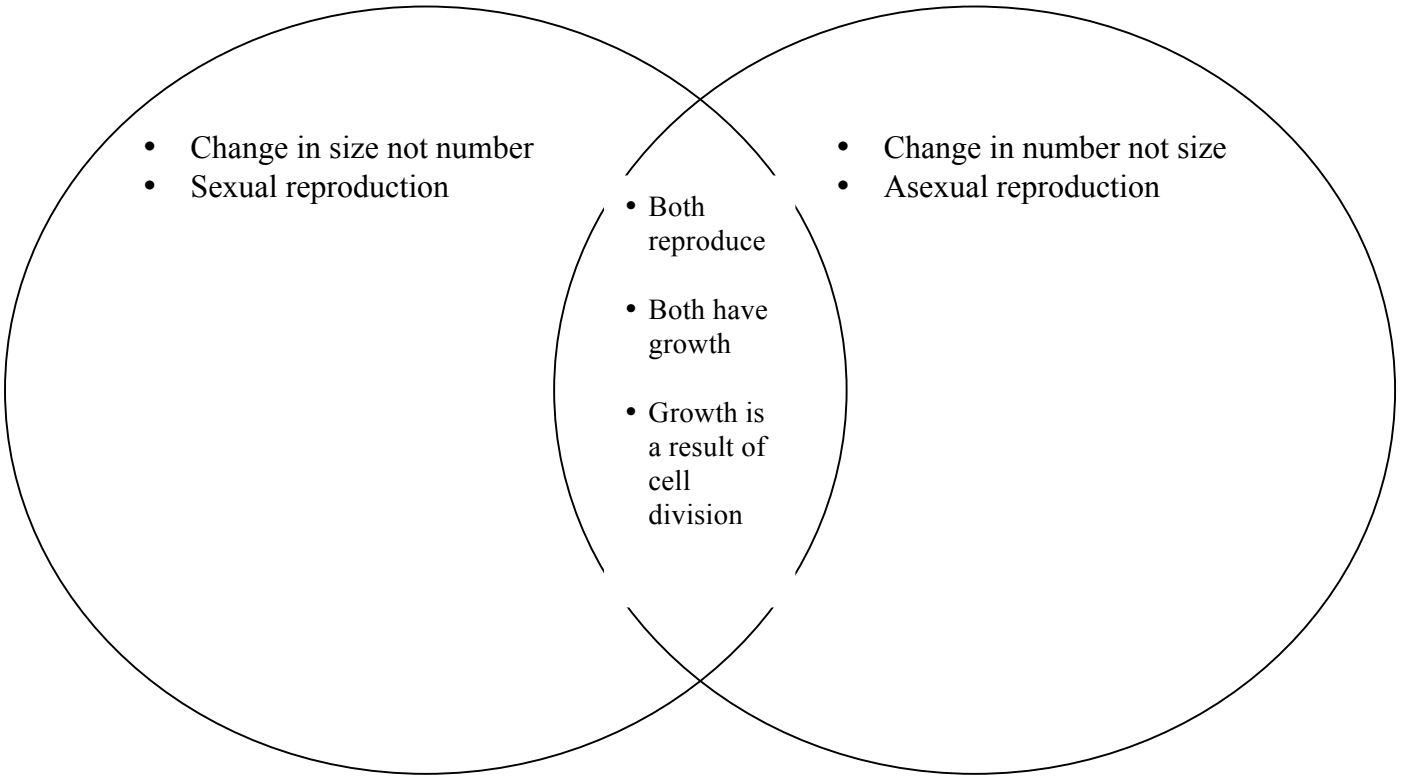
Understanding Bacterial Growth



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

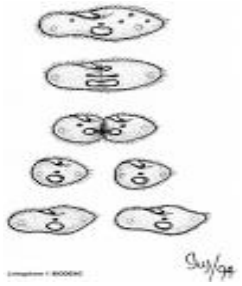
  Brainstorm ways in which bacterial growth is similar to and different from animal and plant growth using the Venn diagram below.

Animal and Plant Growth	Bacterial Growth



Teacher's Copy

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

Teacher's Copy

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 minutes

2 hrs = **120** min

Step 2: Divide Total Time by Generation Time

120 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

Unit Activities:	Review, Application of Knowledge, Is it Safe to Eat?	*Learning Objectives:*	Students will be able to: 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:	*Is it Safe To Eat?* worksheet	*Common Core Standards:*	6.EE.A.1 6.EE.A.2a 6.EE.B.6

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.**

Purpose: To assess and facilitate further student learning.

Is it Safe to Eat? (15 minutes)

Learner Level: All

- Give each student a copy of ***Is it Safe to Eat?*** 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)

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*.**

- 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 ***Is it Safe to Eat?*** 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:

$y = a(1+b)^x$
$y = 4(1 + 1)^3$
$y = 4(2)^3$
$y = 4(8)$
$y = 32$

- 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

$y = 4(1 + 1)^{12}$
$y = 4(2)^{12}$
$y = 4(4096)$
$y = 16{,}384$

- 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.

Wrap Up (5 minutes)

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.**

Instructor Copy

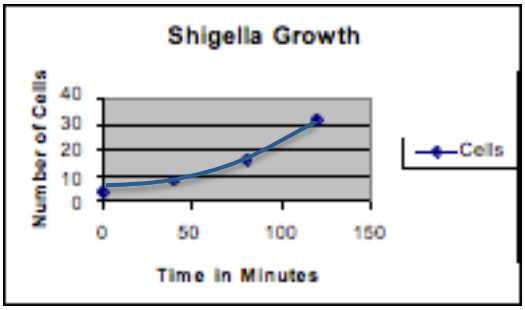
Is it Safe to Eat?

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:	*Shigella*
Total Time:	2 hours	Infectious dose:	10 cells
Generation Time:	40 minutes	# of cells at start:	4 cells

# 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.

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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:	*E. coli O157:H7*
Total Time:	20 minutes	Infectious dose:	10 cells
Generation Time:	20 minutes	# of cells at start:	2 cells

# 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:	*Salmonella*
Total Time:	2.5 hours	Infectious dose:	15-20 cells
Generation Time:	30 minutes	# of cells at start:	3 cells

# 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:	*Campylobacter jejuni*
Total Time:	3 hours	Infectious dose:	400-500 cells
Generation Time:	90 minutes	# of cells at start:	150 cells

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	**2 cells**
Generation Time:	**20 minutes**	Growth Rate	b	**100% or 1**
Infectious dose:	**10 cells**	# of times cells divide	x	

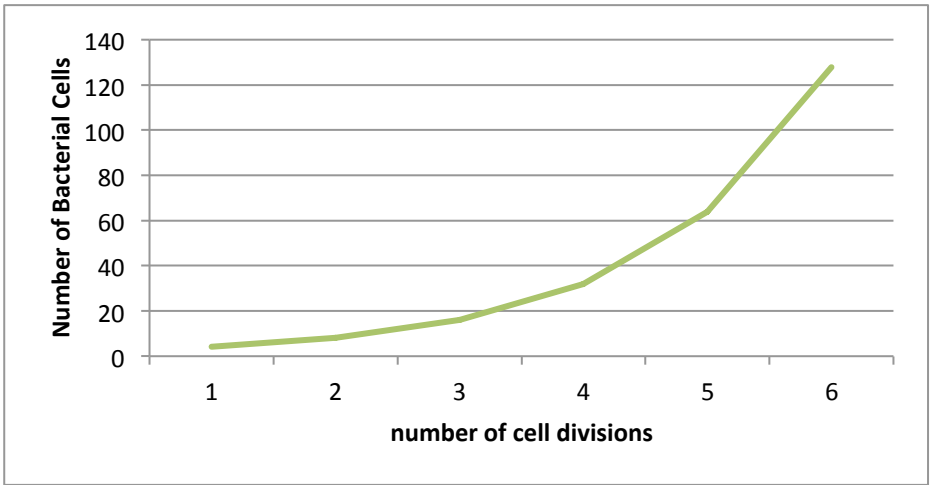
a. How many *E. coli* cells would be present (y) if she waited 40 minutes to eat the hamburger? Is it safe to eat?

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 infections 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 does 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?

$y = 2(1 + 1)^9 = 1024$ 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	**2 cells**
Generation Time:	**30 minutes**	Growth Rate	b	**100% or 1**
Infectious dose:	**15-20 cells**	# of times cells divide	x	

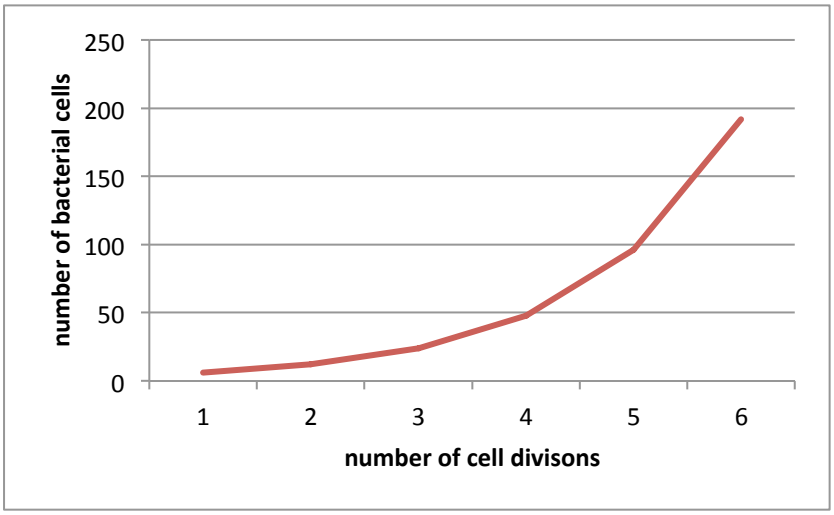
a. How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 1 hour? Is it safe to eat?

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?

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

Unit Activities:	Review, Student Reflection, Analyzing Data	*Learning Objectives:*	Students will be able to: 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.
Instructional Events:	Assessing Performance, Enhance Retention & Transfer		
Materials:	Construction Paper, Calculators (optional)		
Student Handouts:	*Analyzing Data* worksheet *Analyzing Data Self-Assessment*	*Common Core Standards*	6.SP.A.2 6.SP.B.4 6.SP.5c

Activities:

Review (5 minutes)

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?**

Student Reflection (15-20 minutes)

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

Learner Level: All

- 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