Math

HANDS ON
FOOD SAFETY

A program of the GMA Science and Education Foundation

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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

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Day	Math Common Core Standards	
Day 1	8.SP.4	Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected form the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.
Day 2	8.G.4	Understand that a two-dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and **dilations**.
	8.G.9	Know the formulas for the volumes of cones, **cylinders**, and spheres and use them to solve real-world and mathematical problems
Day 3	8.F.1	Understand that a function is a rule that signs to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
	8.F.5	Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or nonlinear).
Day 4	8.F.1	Understand that a function is a rule that signs to each input exactly one output. The graph of a function is the set of ordered pairs consisting of an input and the corresponding output.
Days 5	8.SP.1	Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.
	8.SP.2	Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the mode fit by judging the closeness of the data points to the line.

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. 3. Use information to present data and findings.
Materials:	Carousel prompts (pgs. M6-M17), calculators (optional), construction paper, and markers	*Standards:*	8.SP.4
Student Handouts:	*Summarizing the Results* (pg.18-19)		

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.**

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** (pgs. M8-M17). • 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, have students or partners create a graph (pie, bar, line, etc) to display their results in a creative way. They also need to include an advertising statement based on the current answers to the food safety facts they learned.
Wrap Up (5 minutes)	Tell students: **Today we collected, analyzed, and summarized data about our food safety practices. Then, we used the information to create targeted food safety messages. Tomorrow we will learn about scale and get a better grasp of how small bacteria are.**

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 Heading 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.

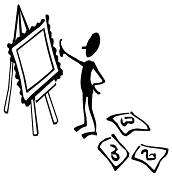
6. **The temperature of the refrigerator in my home is:**
   a. 50 degrees Fahrenheit
   b. 40 F
   c. 20 F
   d. I don't know; I've never measured it
      - Refrigerators should stay at 40°F or less because it slows the growth of most bacteria.
      - The temperature won't kill the bacteria, but it 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.

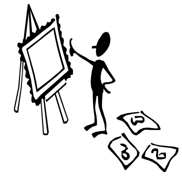
8. **I feel that it is an adult's responsibility to keep my food safe when handling food.**
   a. Strongly disagree
   b. Disagree
   c. Agree
   d. Strongly agree
      - We have an individual responsibility for the food that we eat.
      - Taking actions such as washing hands, storing foods properly, 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.



Summarizing the Results



Directions: Pick 2 of the questions from the Carousel Activity and report the frequency of responses given for each answer choice. Then, using the proportion of the frequency of response to the total # of responses given, create equivalent forms of the proportion (percent, fraction, ratio). Use the statistics of the data collected to summarize the results.

EXAMPLE:

Question #: 1 Total # of Responses: 25

CHOICE A				CHOICE B			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
2	8%	2/25	2:25	7	28%	7/25	7:25
CHOICE C				**CHOICE D**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
13	52%	13/25	13:25	3	12%	3/25	3:25

Now using the data above, write 3 statements with proportions and relationships describing the results.

1. Four out of 5 students **Usually** or **Sometimes** (*Sum of Choices B and C converted to a ratio*) cleans the area where they make food and snacks.
2. Only 8% said they **Never** (*Choice A*) clean the area where they make food and snacks; whereas 92% said they cleaned the area at least some of the time (*Sum of Choices B, C, and D*).
3. Over half of the students, indicated that they **Usually** (*Choice C*) clean the area where they make food and snacks.

PRACTICE: As a class or in groups, create two other summary sentences for the responses provided in the example.

1.

2.

YOUR TURN:

Question # ______ Total # of Responses: ______

CHOICE A				CHOICE B			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
CHOICE C				**CHOICE D**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**

Now using the data above, write 3 statements with proportions and relationships describing the results.

1.

2.

3.

Question # ______ Total # of Responses: ______

CHOICE A				CHOICE B			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
CHOICE C				**CHOICE D**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**

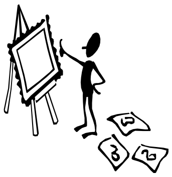
Now using the data above, write 3 statements with proportions and relationships describing the results.

1.

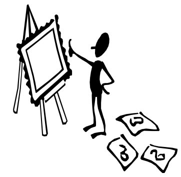
2.

3.

Think About It: After completing this carousel activity, how do you think other students would answer the questions? Would the results be the same, similar, or different? Why or why not?



Data Investigation



PART 1: Write 3 statistical questions we can ask about the data collected:

1.

2.

3.

PART 2: For your assigned question from the Carousel Activity, report the frequency of responses given for each answer choice. Then, using the proportion of the frequency of response to the total # of responses given, find the other equivalent forms of the proportion.

EXAMPLE:

Question #: 1 Total # of Responses: 25

CHOICE A				**CHOICE B**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
2	8%	2/25	2:25	7	28%	7/25	7:25
CHOICE C				**CHOICE D**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
13	52%	13/25	13:25	3	12%	3/25	3:25

PART 3: Using the posted summaries for each question, can you answer the 3 statistical questions you listed above?

1.

2.

3.

DIRECTIONS: Complete the Data Summary for your assigned question. Use the back of the page for your work. Write neatly because others will be using your results.

Question # ______ Total # of Responses: ______

CHOICE A				CHOICE B			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**
CHOICE C				**CHOICE D**			
Frequency	**Percent**	**Fraction**	**Ratio**	**Frequency**	**Percent**	**Fraction**	**Ratio**

Think About It: After completing this carousel activity, how do you think other students would answer the questions? Would the results be the same, similar, or different? Why or why not?

Unit Activities:	Review, Understanding Scale	*Learning Objectives:*	Students will be able to: 1. Recognize and understand microscope magnification an object by 4x, 10x, and 40x as an example of scale factors and dilation. 2. Apply use of scale factors and dilation to create 3-D scaled models of a cylinder. 3. Calculate surface area and volume of a cylinder in scaled relationships.
Instructional Events:	Present the stimulus		
Materials:	Rulers, calculators, construction paper, tape, scissors, soda can(s)		
Student Handouts:	*Understanding Scale* worksheet with *Grid* (pg. M22), *Understanding Scale in 3D* worksheet (pg. M23)	*Common Core Standards:*	8.G.4 8.G.9

Activities:

Review
(5 minutes)

Daily Review Question: **Yesterday we took a survey to see how likely bacteria were to grow in our kitchens. What changes did you suggest to your parents last night during dinner?**

Today we will talk about scale factors and try to get an idea of the size of bacteria.

Understanding Scale
(20 minutes)

Tell 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).

- Ask: How big is a single bacterium? Allow students to guess.
- Then, explain to students that bacteria are microscopic, meaning they can only be seen when magnified using a microscope. Later in the week students will use a microscope to look at bacteria at 4x, 10x, and 40x its actual size.

How is Magnification related to math? Magnification is a type of dilation. A *dilation* is a transformation that produces an image the same shape as the original, but is a different size. Like drawing a figure to scale. Or, in our case, using a microscope to magnify the image of the bacteria. The *scale factor* is a measure of the dilation, that is, **how much** larger or smaller the image is. The microscope has 3 lenses which allow us to view the image at scale factors of 4x, 10x, and 40x.

- To explore this concept, have students complete the ***Understanding Scale*** worksheet. HINTS: Have students draw a small quadrilateral within the first coordinates denoted by the dashed box to allow room for dilations. For beginners, you might suggest a square (trapezoid or parallelogram). For more advanced students, you might require a polygon with more than 4 points.

<u>Optional Supplemental Activities</u>: Allow students to go outside and 1) using a measuring stick, mark off their heights at 4x, 10x, and 40x or 2) using cones or people as endpoints, plot a shape on the football field and dilate by 4x and 10x.

Activities:
Understanding Scale in 3D
(30 minutes)

Explain to students that, unlike the 2-dimensional examples in the *Understanding Scale* activity, bacteria is 3-dimensional. Dilation (scale) is proportional and occurs in all dimensions.

- To explore this concept, students will construct a 3-D model of a soda can (cylinder) at actual size (1x), and scaled to 4x and 10x.
  1. Using construction paper and tape, have students construct a 3-D model of a soda can (cylinder) out of 2 circles and a rectangle. This represents the actual size or 1x. Options: Let students measure a soda can or provide them with the dimensions.
  2. Have students create 3-D dilations of the cylinder at scale factors of 4 and 10.

  Optional Supplemental Activity: Allow students to calculate how big the soda can would be at 40x, and then create a huddle of students the same size. How many students would it take?

- For each model, complete the corresponding ***Understanding Scale in 3D*** worksheet which extends from previous activity and examines how Surface Area and Volume change when dilated.

Surface Area: How much aluminum would it take to make a soda can?

What do we know: Cylinder = 2 circles + rectangle

Area of a Circle = πr^2 and Area of Rectangle = $l \bullet w$

In a cylinder, the *length* is the circumference of the circle, and the *width* is the height of the can.

So: Surface Area of a Cylinder = 2(area of a circle) + (circumference • height)

$$\mathbf{SA = 2\pi r^2 + 2\pi r \bullet h}$$

Volume: How much liquid could the soda can hold?

What do we know: Volume is the area of the base multiplied by the height.

So: Volume of a Cylinder = Area of Circle • Height of Can

$$\mathbf{V = \pi r^2 \bullet h}$$

Connect: Explain to students that when they look at their bacteria in the microscope the 4x, 10x, and 40x are the powers of magnification they will use. Encourage students to draw connections between the actual sizes of the can versus the 40x.

Wrap Up
(5 minutes)

Ask students one or two Critical Thinking Questions:

- **What does *Figure Drawn to Scale* mean?**
- **What does *Figure is NOT Drawn to Scale* mean?**

The difference between being drawn to scale and not drawn to scale is proportionality.

Tomorrow we will talk about bacterial growth using charts and exponential curves.

Understanding Scale

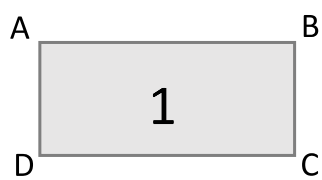
Step 1: Draw a polygon within the small box marked on the grid paper.
This is your original figure, with a scale factor of 1.

Step 2: Label the vertices and write the scale factor inside the figure.

Step 3: Fill in the properties of the original figure in the table below.

Step 4: Dilate the figure by a scale factors of 4 and 10 to complete the table.

For example:



Properties	Original Figure
Scale Factor	1
Coordinates	A(2,3), B(6,3), C(6,1), D(2,1)
Angle Measures	A: 90°, B: 90°, C: 90°, D: 90°
Length of Sides	AB: 4, BC:2, CD: 4, DA: 2
Perimeter	12 units
Area	8 $units^2$

Properties	Original Figure	Dilate <u>original</u> by a Scale Factor of 4	Dilate <u>original</u> by a Scale Factor of 10
Coordinates			
Angle Measures			
Length of Sides			
Perimeter			
Area			

Connect and Make Generalizations

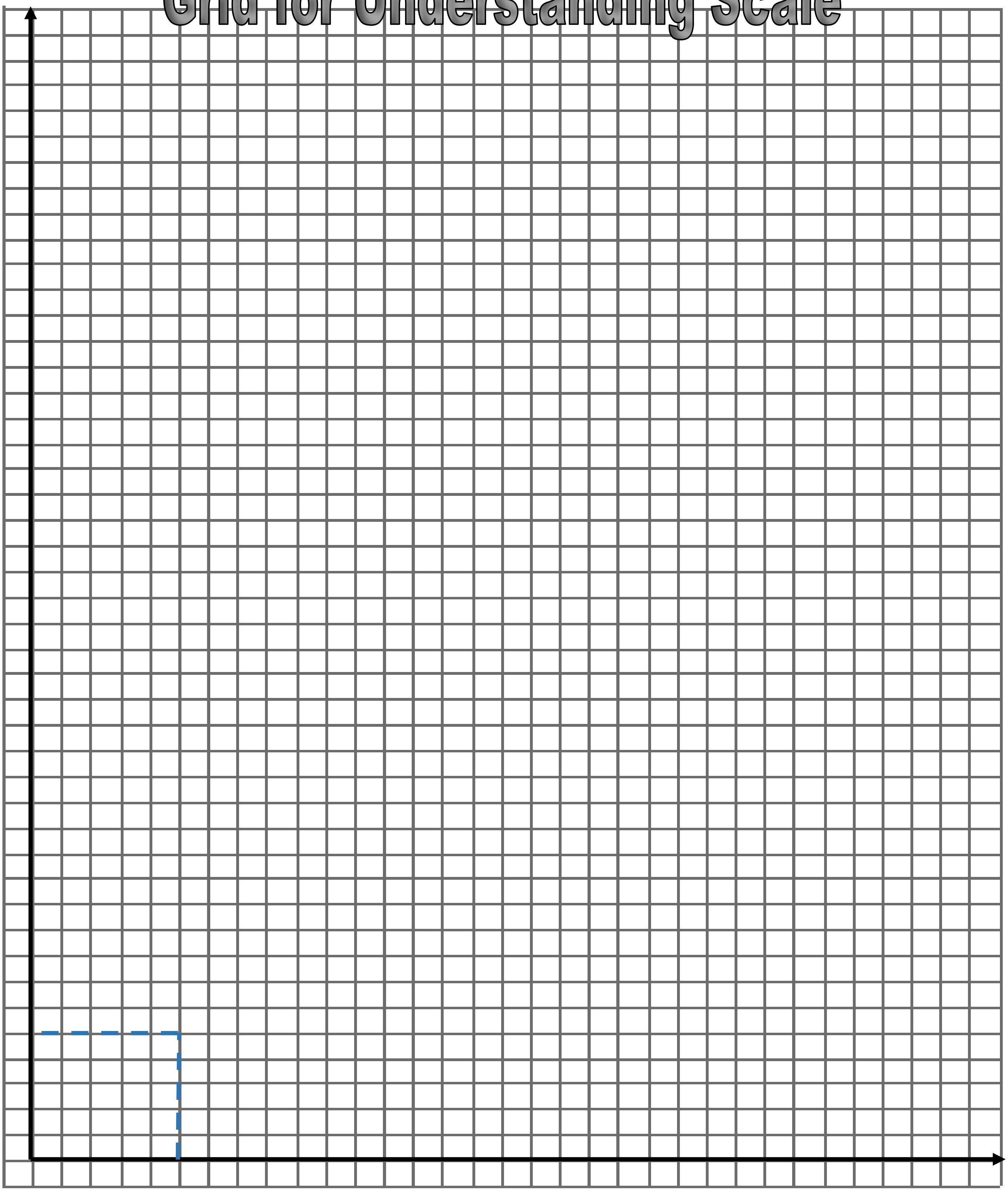
How does the scale factor influence each of the figure's properties during dilation?

Properties	Observations and Conjectures
Coordinates	
Angle Measures	
Length	
Perimeter	
Area	

CHALLENGE: Using these observations, complete the answer the following questions for the dilation of your original figure by a scale factor of 40.

Coordinates	
Angle Measures	
Length of Sides	
Perimeter	
Area	

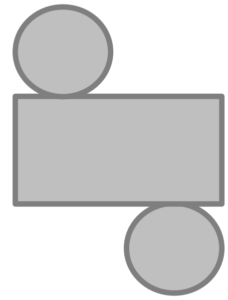
Grid for Understanding Scale



Understanding Scale in 3D

Directions: Using the 3-D scale models of the soda can, fill in the measurements, and then find the **Surface Area** and **Volume** for each dilation.

Surface Area: How much aluminum would it take to make a soda can?



What do we know: Cylinder = 2 circles + rectangle

Area of a Circle = πr^2 and Area of Rectangle = $l \cdot w$

In a cylinder, the *length* is the circumference of the circle, and the *width* is the height of the can.

So: Surface Area of a Cylinder = 2(area of a circle) + (circumference • height)

$$\mathbf{SA = 2\pi r^2 + 2\pi r \cdot h}$$

Volume: How much liquid could the soda can hold?

What do we know: Volume is the area of the base multiplied by the height.

So: Volume of a Cylinder = Area of Circle • Height of Can

$$\mathbf{V = \pi r^2 \cdot h}$$

Cylinder Properties	Original	4x	10x	40x
Diameter				
Radius				
Height				
Surface Area				
Volume				

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, a non-linear function. 2. Calculate the growth of bacteria over a given time period. 3. Deconstruct and solve word problems. 4. Describe the functional relationship between quantities in an exponential growth curve.
Instructional Events:	Present the Stimulus, Provide Learner Guidance		
Materials:	Modeling Clay		
Student Handouts:	*Understanding Bacterial Growth* handout (M27), *Applying Bacterial Growth Rates* worksheet (pg. M30)	*Standards:*	8.F.1 8.F.4 8.F.5

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 talking about scale and the size of bacteria.

Understanding Bacterial Growth (15 minutes)

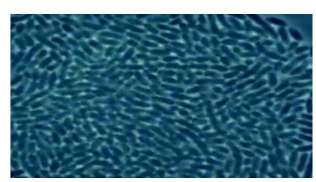
Distribute a copy of ***Understanding Bacterial Growth*** to each student.

- 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)

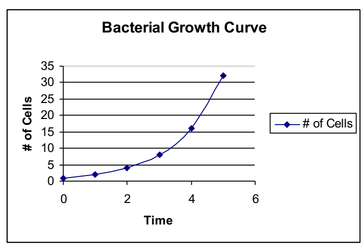
Purpose: To facilitate the transfer of new knowledge to long-term retention by providing a concrete demonstration of an abstract concept.

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 min. 30 sec.)
- 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 double*
- After students have finished dividing their "bacteria", show students how this activity represents a function, having an input and an output (*x*-axis: # of times cells divide, *y*-axis: # of bacteria cells). Plot the data points (ordered pairs) from the class chart onto a graph creating the exponential growth curve of bacterial growth, which is a non-linear function.   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

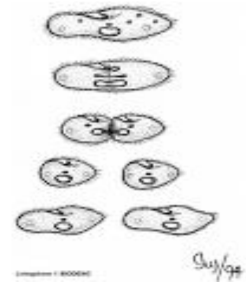
Wrap Up (5 minutes)

Tell students: Ask students:

- **How do bacteria grow?**
    - **Cell division, which causes the number of cells to increase rapidly**
- **When charted, what kind of function does bacterial growth produce?**
    - **A non-linear function.**

Tomorrow we will take what we know about bacterial growth and figure out if foods in different situations are safe for us to eat.

Applying Bacterial Growth Rates



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. Then, create a graph of the exponential growth curve where the number of cell divisions are along the *x*-axis and the total number of bacterial cells are along the *y*-axis.

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

1. One *E. coli* cell could multiply up to _________ cells in just 1 hour.

2. How many *E. coli* cells would there be after 2 hours? _______________

3. How many *E. coli* cells would there be after 3 hours? _______________

4. 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?

   ____

5. Describe the relationship of the variables represented in the graph.

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. Then, create a graph of the exponential growth curve where the number of cell divisions are along the *x*-axis and the total number of bacterial cells are along the *y*-axis.

# 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 6 hours?

Important information

Total Time: 6 hrs

Generation Time: 40 min

Step 1: Convert the Total Time from hours to minutes

6 hrs = _____ min

Step 2: Divide Total Time by Generation Time

______ min / _____ min = _______

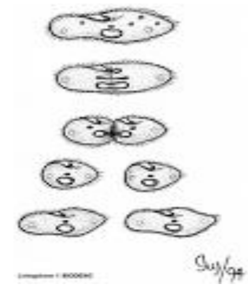
9. In optimal conditions, how many times would *Shigella* cells divide in 8 hours?

Important information

Total Time: ______

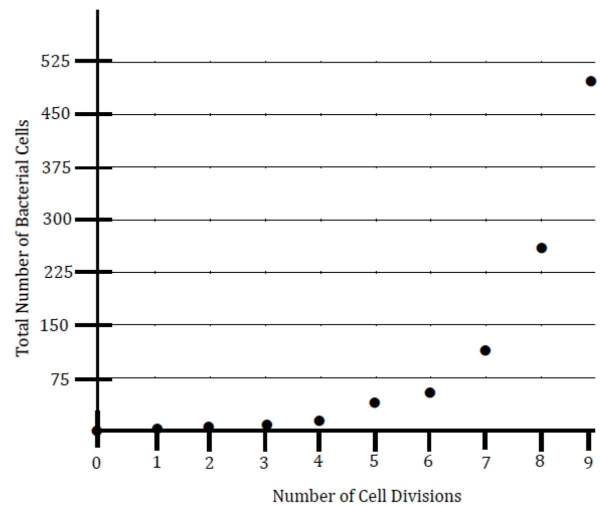
Generation Time: ______

Applying Bacterial Growth Rates



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. Then, create a graph of the exponential growth curve where the number of cell divisions are along the *x*-axis and the total number of bacterial cells are along the *y*-axis.

# 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



1. One *E. coli* cell could multiply up to ______**8**______ cells in just 1 hour.

2. How many *E. coli* cells would there be after 2 hours? ________**64**________

3. How many *E. coli* cells would there be after 3 hours? ________**512**________

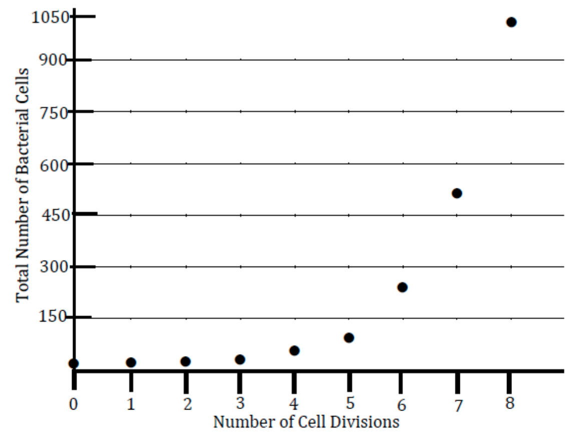
4. If it takes 128 cells of *E. coli* to make you sick, and the cells can divide as often as every 20 minutes, then how long would it take for one cell to grow enough to make you sick? ______**140 minutes**______

5. Describe the relationship of the variables represented in the graph.

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. Then, create a graph of the exponential growth curve where the number of cell divisions are along the x-axis and the total number of bacterial cells are along the y-axis.

# 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
8	320	1,024



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 6 hours?

Important information

Total Time: 6 hrs

Generation Time: 40 min

Step 1: Convert the Total Time from hours to minutes

6 hrs = **360** min

Step 2: Divide Total Time by Generation Time

360 min / **40** min = **9**

9. 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 a non-linear function. 3. Generate ordered pairs of a non-linear function. 4. 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 (pg. M38)	*Standards:*	8.F.1

Activities:

Review (5 minutes)

Ask Students:
Yesterday we learned that bacterial growth occurs when the cells divide. How many more cells are present after each division? (Twice the amount/Double)
Today we are going to solve some problems to determine if foods in different situations are safe to eat.

Is it Safe to Eat? (15 minutes)

Purpose: To assess and facilitate further student learning.

Learner Level: All

- Give each student a copy of ***Is it Safe to Eat?*** worksheet.
- Work through the example 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 (non-linear) 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.**

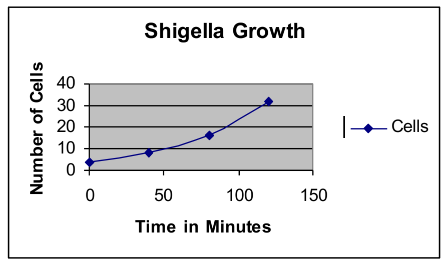
Is it Safe to Eat?

<u>PART 1 Directions:</u> 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



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

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

Scenario:

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

Is it safe to eat? __________

____

____

<u>PART 2 Directions:</u> 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:	________	Growth Rate:	*b*	100% or 1
Infectious dose:	________	# 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?

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

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?

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?

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.

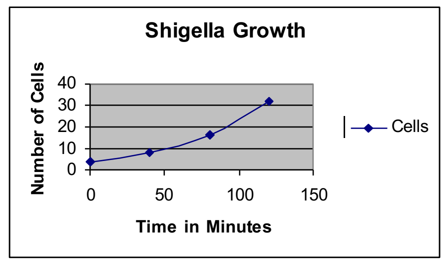
CHALLENGE: How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 6.5 hours?

<u>PART 1 Directions:</u> 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 hrs	Infectious dose:	10 cells
Generation Time:	40 min	# 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



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

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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, it is safe.

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, it is not safe

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:

# of Times Cells Divide	Time Elapsed in Minutes	Number of Cells
0	0	150
1	90	300
2	180	600

Is it safe to eat? No, it is not safe

<u>PART 2 Directions:</u> 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:	______	Growth Rate:	*b*	100% or 1
Infectious dose:	______	# of times cells divide:	*x*	______

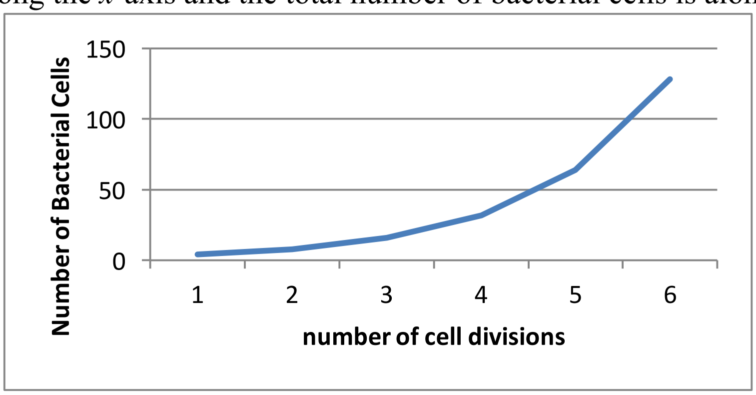
a. How many *E. coli* cells would be present (y) if she waited 40 minutes to eat the hamburger? Is it safe to eat?

Solution: If the total time is 40 minutes, then the cells divide 2 times, so $\boldsymbol{y = 2(1+1)^2}$ **= 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, the cells divide 3 times, so $\boldsymbol{y = 2(1+1)^3}$ **= 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 present (y) if she waited 3 hours to eat the hamburger?

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

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*	____________
Generation Time:	____________	Growth Rate: *b*	____________
Infectious dose:	____________	# of times cells divide: *x*	____________

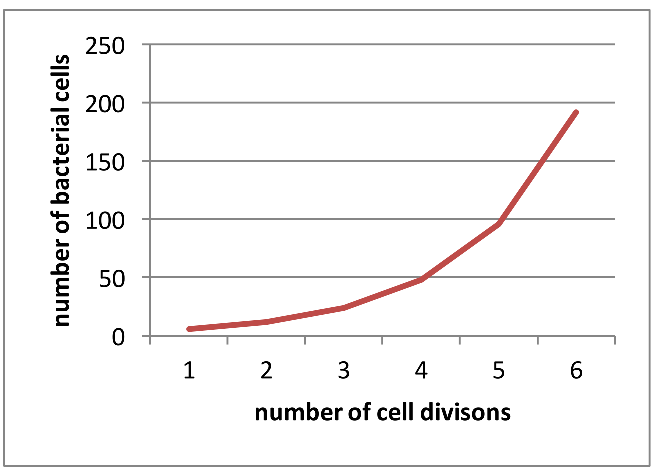
a. How many *Salmonella* cells would be present (y) if the homemade salad dressing had been sitting on the picnic table for 1 hour? Is it safe to eat?

Solution: If the total time is 60 minutes, then the cells divide 2 times, so $\boldsymbol{y = 3(1+1)^2}$ **= 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 $\boldsymbol{y = 3(1+1)^6}$ **= 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?

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

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. 4. Interpret graphical representations of data sets.
Instructional Events:	Assessing Performance, Enhance Retention & Transfer		
Materials:	Construction paper		
Student Handouts:	*Analyzing Data* worksheet (pg. M45) *Analyzing Data Self-Assessment* (pg. M47)	*Standards:*	8.SP.1 8.SP.2

Activities:

Review (5 minutes)

Daily Review Question: **Yesterday we solved some problems to determine if foods in different 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 minutes)

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

Learner Level: All

- Ask students to reflect on the math concepts they have learned so far (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" multiple-choice test question that covers the math concepts they've learned so far in this lesson.
- Post each pairs question on the front board and, as a class, try to answer each question correctly.

Analyzing Bacterial Growth Data (30 minutes)

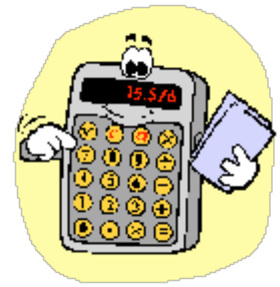
Purpose: To allow students to develop expertise with the new information and create a construct for transferring knowledge to long-term retention.

Learner Level: All

- Using the raw data collected in the science follow-up lab, have students complete the ***Analyzing Data*** worksheet.
- Students may work individually or in pairs.
- Once they have finished, have students complete the ***Analyzing Data Self-Assessment***.
- Modifications for lower level students include: completing the exercise as a group and reducing the number of problems.

Wrap Up (5 minutes)	**Ask students:** **Were your predictions correct? What treatment was the most effective?**

Analyzing Data



- List all the data points collected for the **unwashed hands treatment** from your Bacterial Growth Experiment in Science in order from least to greatest.

- List all the data points from the hands **washed with cold water for 5 seconds treatment** in order from least to greatest.

- List all the data points from the hands **washed with warm water and soap for 20 seconds treatment** in order from least to greatest.

- List all the data points from the hands **with sanitizer treatment** in order from least to greatest.

- Using data set for the **unwashed hands treatment** construct a frequency table. Be sure to choose regular intervals. Use the frequency table to create a histogram.

- What trends do you notice when you examine the histogram?

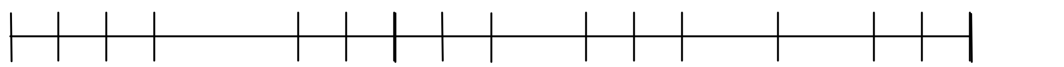
- Use the **washed with cold water for 5 seconds treatment** data set to construct a box and whiskers plot:

  a. Identify the upper and lower extremes. Upper: Lower:
  b. Identify the median. Median:
  c. Find the 1st and 3rd quartiles. 1st quartile: 3rd quartile:
  d. Draw the plot below.

Analyzing Data

- Use the **washed with warm water and soap for 20 seconds treatment** data set to construct a box and whiskers plot:

  a. Identify the upper and lower extremes. Upper: Lower:
  b. Identify the median. Median:
  c. Find the 1st and 3rd quartiles. 1st quartile: 3rd quartile:
  d. Draw the plot below.



- Answer the following questions using the two box and whiskers plots you constructed.

  a. Which treatment had the highest median colony growth?

  b. Is there a difference in the colony growth resulting from the two different treatments? For example, are the medians different? Are the middle 50%'s different? If so, explain why you think this difference exists.

  c. Which treatment had the smallest range? Why do you think this is?

- For each treatment, find the mean, median, mode, and range. Record your answers in the chart below:

Treatment	Mean	Median	Mode	Range
Unwashed hands				
Cold water for 5 sec				
Warm water & soap for 20 sec				
Sanitizer				

- Use the means for each of the four treatments to construct a scatter plot below:

- Based on the scatter plot you constructed would you say there is a positive relationship, negative relationship, or no relationship between the hand washing treatments and the number of bacterial colonies?