# | 4 ㄴㅇㅇㅇ FOOD SAFETY 

## A program of the GMA Science and Education Foundation

## Approved and Endorsed by

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## Acknowledgments

The Grocery Manufacturers Association Science and Education Foundation provides support and manages the daily operations of the Hands On: Real World Lessons for Middle School Classrooms program.

The program is funded by a grant from the USDA National Integrated Food Safety Initiative. Additional support is provided by the University of Tennessee's 4-H Youth Development Department in conjunction with UT Extension.

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

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## 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.A. 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.A. 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.C. 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.A. 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.A. 3 | Give examples of functions that are not linear. |
|  | 8.F.B. 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.A. 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.A. 3 | Give examples of functions that are not linear. |
|  |  |  |
| Days 5 | 8.SP.A. 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.A. 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 |
| :---: | :---: | :---: | :---: |
|  | Gaining <br> 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 |
|  | 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 <br> Understanding Bacterial Growth |
|  | Providing learning guidance | Helps facilitate the process of longterm 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 |
| 0000000 | 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: <br> 1. Develop and organize a data set generated from class responses. <br> 2. Use equivalent forms of proportions, ratios, and percent to describe, summarize, and interpret survey results. <br> 3. Use information to present data and findings. |
| :---: | :---: | :---: | :---: |
| Materials: | Carousel prompts (pgs. M6-M17), calculators (optional), construction paper, and markers | Common Core Standards: | 8.SP.A. 4 |
| Student <br> Handouts: | Summarizing the Results (pg.18-19) |  |  |
| Activities: <br> 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 |  |  |
|  | - Allow students to sh | their response | with the class. |
|  | - Pose questions for d | ussion: |  |
|  | - How much | you grown ov | the last year? |
|  | - As we know, biologically t | mans are a typ make an animal | of animal. What has to happen <br> uch as a human, grow? (cell division) |
|  | - Is this proces or bacteria to | lso required fo row? | ther types of organisms such as plants |
| Inform the | Purpose: To help students understa | hat they are r | nsible for learning. |
| Learner of the Objectives (2 minutes) | - Tell students: This week we animals and the growth of likely bacteria is to grow in | re going to stu cteria. Our fir our kitchen at | the difference in the growth of activity is going to investigate how ome. |


|  | 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. M8M17).
- 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.

Learner Level: AII

- 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.
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

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

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

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

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

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

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

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

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


## 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 not kill the bacteria.
- Other foods containing raw eggs, such as homemade ice cream, cake batter, mayonnaise, and eggnog, carry a Salmonella risk, too.
- Their commercial counterparts are usually made with pasteurized eggs; that is, eggs that have been heated sufficiently to kill bacteria. However, there is still a risk to consuming the commercial cookie dough products without baking them.


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

a. Setting them on the counter
b. Placing them in the refrigerator
c. Microwaving
d. I don't know

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

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

- Salmonella: Raw meats, poultry, eggs, dairy products
- E. coli 0157: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 $40^{\circ} \mathrm{F}$ 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 $40^{\circ} \mathrm{F}-140^{\circ} \mathrm{F}$.

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.


## Sumnmaximine the IResults

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 \#

| CHOICE A |  |  |  |  | Cotal \# of Responses: |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 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?


Review, Understanding Scale

Present the stimulus

Rulers, calculators, construction paper, tape, scissors, soda can(s)

Understanding Scale worksheet with Grid (pg. M22), Understanding Scale in 3D worksheet (pg. M23)


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.

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 $4 \mathrm{x}, 10 \mathrm{x}$, and 40 x 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 4 x , 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.

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


## Undersfeanding 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 | $\mathrm{A}(2,3), \mathrm{B}(6,3), \mathrm{C}(6,1), \mathrm{D}(2,1)$ |
| Angle Measures | $\mathrm{A}: 90^{\circ}, \mathrm{B}: 90^{\circ}, \mathrm{C}: 90^{\circ}, \mathrm{D}: 90^{\circ}$ |
| Length of Sides | $\mathrm{AB}: 4, \mathrm{BC}: 2, \mathrm{CD}: 4, \mathrm{DA}: 2$ |
| Perimeter | 12 units |
| Area | 8 units $^{2}$ |


| Properties | Original Figure | Dilate original by a <br> Scale $\overline{\text { Factor of 4 }}$ | Dilate original by a <br> 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 forlmalertanding scale



## Understending scale in 3 -

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: $\quad$ Cylinder $=2$ circles + rectangle

$$
\text { Area of a Circle }=\pi r^{2} \text { and Area of Rectangle }=l \bullet w
$$

In a cylinder, the length is the circumference of the circle, and the width is the height of the can.
So: $\quad$ Surface Area of a Cylinder $=2($ area of a circle $)+($ circumference $\cdot$ height $)$


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

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: $\quad$ Volume of a Cylinder $=$ Area of Circle $\bullet$ Height of Can

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

| Cylinder <br> Properties | Original | $\mathbf{4 x}$ | $\mathbf{1 0 x}$ | $\mathbf{4 0 x}$ |
| :---: | :--- | :--- | :--- | :--- |
| Diameter |  |  |  |  |
| Radius |  |  |  |  |
| Height |  |  |  |  |
| Surface <br> Area |  |  |  |  |
| Volume |  |  |  |  |


| Unit Activities: |
| :---: |
| Instructional Events: |
| Materials: |
| Student <br> Handouts: |
| Activities: <br> Review <br> (5 minutes) |
| Understanding <br> Bacterial <br> Growth <br> (15 minutes) |

Learning
Objectives:

Present the Stimulus, Provide Learner Guidance

Modeling Clay
Understanding Bacterial Growth handout (M27), Applying Bacterial Growth Rates worksheet (pg. M30)

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.
8.F.A. 1
8.F.A. 4
8.F.B. 5

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.
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


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 <br> 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).

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

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 <br> Divisions | Time Elapsed <br> in Minutes | \# of Cells |
| :---: | :---: | :---: |
| 0 | 0 | 1 |
| 1 | 20 |  |
| 2 | 40 |  |
| 3 | 60 |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

1. One E. coli cell could multiply up to $\qquad$ 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 <br> Divisions | Time Elapsed <br> 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? $\qquad$
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

$$
6 \mathrm{hrs}=\ldots \quad \mathrm{min}
$$

Step 2: Divide Total Time by Generation Time
$\qquad$
9. In optimal conditions, how many times would Shigella cells divide in 8 hours?

## Important information

Total Time: $\qquad$
Generation Time: $\qquad$

## 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 <br> Divisions | Time Elapsed <br> 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 $\qquad$ 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?

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 <br> Divisions | Time Elapsed <br> 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

$$
6 \mathrm{hrs}=\mathbf{3 6 0} \mathrm{min}
$$

Step 2: Divide Total Time by Generation Time $\mathbf{3 6 0} \min / \underline{\mathbf{4 0}} \min =\underline{9}$
9. In optimal conditions, how many times would Shigella cells divide in 8 hours?

## Important information

| Total Time: | $\underline{480 \mathrm{~min}}$ |
| ---: | :--- |
| Generation Time: | $\underline{40 \mathrm{~min}}$ |

## 12 cell divisions

| Unit |  |
| :--- | :--- |
| Activities: | it |
|  |  |
|  |  |
| Instructional |  |
| Events: | E |

## Activities:

Review
(5 minutes)

Is it Safe to Eat?
(15 minutes)

Exponential Growth Curve (35 minutes)
Student
Handouts:

Review, Application of Knowledge, Is it Safe to Eat?

Elicit Performance, Provide
Feedback

Calculators (optional)

Ask Students: are safe to eat.

Purpose: To assess and facilitate further student learning.

## Learner Level: All

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

- 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.

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: $y=m x+b$ or $A x+B y=C$, 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 <br> the \% of change | Bacterial growth is $100 \%$ (it <br> 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 <br> Time 40 minutes), then the cells will divide 3 times |

Solving the equation:

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

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

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

| Important Information |  | FORMULA: |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Total Time: | $8 \mathrm{hrs}=480 \mathrm{~min}$ | \# of cells at start | $a$ | 4 cells |
| Generation Time: | 40 min | Growth Rate | $b$ | $100 \%$ or 1 |
| Infectious dose: |  | \# of times cells divide | $x$ | $(480 / 40)=12$ |

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

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

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

PART 1 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 <br> Cells Divide | Time Elapsed in <br> Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
| 0 | 0 | 4 |
| 1 | 40 | 8 |
| 2 | 80 | 16 |
| 3 | 120 | 32 |



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

1. E. coli $\mathrm{O} 157: \mathrm{H} 7$ 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 $\mathrm{O} 157: \mathrm{H} 7$ 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: | $\square$ |
| :---: | :---: | :--- |
| Total Time: | Infectious dose: | - |
| Generation Time: |  | \# of cells at start: |


| \# of Times <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Is it safe to eat?
$\qquad$
$\qquad$
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 <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Is it safe to eat?
$\qquad$
$\qquad$
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: $\frac{3 \text { hours }}{}$ Infectious dose: | $400-500$ cells |  |
| Generation Time:90 minutes | \# of cells at start: | 150 cells |

Scenario:

| \# of Times <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

## Is it safe to eat?

$\qquad$
$\qquad$

PART 2 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 $\mathrm{O} 157: H 7$ 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: | $\mathrm{y}=\mathrm{a}(1+\mathrm{b})^{\mathrm{x}}$ |  |
| :---: | ---: | :---: | :---: |
| Total Time: |  | \# of cells at start: | $a$ |
| Generation Time: |  |  | 2 cells |
| Infectious dose: |  | Growth Rate: $\quad b$ | $100 \%$ or 1 |

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: $\quad \mathrm{y}=\mathrm{a}(1+\mathrm{b})^{\mathrm{x}}$ |
| :---: | :---: |
| Total Time: | \# of cells at start: $a l$ |
| 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?


## PART 1 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: <br> Infectious dose: \# of cells at start: | Shigella |
| :---: | :---: | :---: | :---: |
| Total Time: | 2 hrs |  | 10 cells |
| Generation Time: | 40 min |  | 4 cells |


| \# of Times <br> Cells Divide | Time Elapsed in <br> Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
| 0 | 0 | 4 |
| 1 | 40 | 8 |
| 2 | 80 | 16 |
| 3 | 120 | 32 |



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

1. E. coli $O 157: H 7$ 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: | $\underline{\text { E. coli } \mathrm{O} 157: \mathrm{H7}}$ |  |
| ---: | ---: | :--- | :--- |
| Total Time: $\quad \underline{20 \text { minutes }}$ | Infectious dose: | $\underline{10 \text { cells }}$ |  |
| Generation Time: | $\underline{20 \text { minutes }}$ | \# of cells at start: | $\underline{2 \text { cells }}$ |


| \# of Times <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
| 0 | 0 | 2 |
| 1 | 20 | 4 |
|  |  |  |
|  |  |  |

Is it safe to eat? Yes, it is safe.
$\qquad$
$\qquad$
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: $\underline{\text { Salmonella }}$ |
| :---: | :---: |
| Total Time: $\underline{2.5 \text { hours }}$ | Infectious dose: $\underline{15-20 \text { cells }}$ |
| Generation Time: $\underline{30 \text { minutes }}$ | \# of cells at start: $\underline{3 \text { cells }}$ |


| \# of Times <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> 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
$\qquad$
$\qquad$
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 <br> Generation Time: <br> 90 minutes | Infectious dose: | $400-500$ cells |

## Scenario:

| \# of Times <br> Cells Divide | Time Elapsed <br> in Minutes | Number of <br> Cells |
| :---: | :---: | :---: |
| 0 | 0 | 150 |
| 1 | 90 | 300 |
| 2 | 180 | 600 |

Is it safe to eat? No, it is not safe
$\qquad$
$\qquad$

PART 2 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 $O 157: H 7$ 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: | $\mathrm{y}=\mathrm{a}(1+\mathrm{b})^{\mathrm{x}}$ |  |
| :---: | ---: | :---: | :---: |
| Total Time: |  | \# of cells at start: | $a$ |
| Generation Time: |  |  | 2 cells |
| Infectious dose: |  | Growth Rate: $\quad b$ | $100 \%$ or 1 |

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 $\boldsymbol{y}=\mathbf{2 ( 1 + 1})^{\mathbf{2}}=\mathbf{8}$ 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 $\boldsymbol{y}=\mathbf{2 ( 1 + 1 )} \mathbf{3}^{\mathbf{3}}=\mathbf{1 6}$ 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?

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

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: $y=\mathrm{a}(1+\mathrm{b})^{\mathrm{x}}$ |
| :---: | :---: |
| Total Time: | \# of cells at start: $a l$ |
| 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 $\boldsymbol{y}=\mathbf{3}(\mathbf{1}+\mathbf{1})^{\mathbf{2}}=\mathbf{1 2}$ 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 $\boldsymbol{y}=\mathbf{3 ( 1 + 1}+\mathbf{1}=\mathbf{1 9 2}$ 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 <br> Activities: | Review, Student Reflection, Analyzing <br> Data |
| :--- | :--- |
| Instructional <br> Events: | Assessing Performance, Enhance <br> Retention \& Transfer |
| Materials: | Construction paper <br> Student <br> Handouts: |
| Analyzing Data worksheet (pg. M45) <br> Analyzing Data Self-Assessment (pg. <br> M47) |  |


|  |  |  |  |
| :--- | ---: | :--- | :--- |
| Learning | Students |  |  |
| Objectives: |  |  |  |

## Activities:

Review
(5 minutes)

Student
Reflection (15 minutes)

Analyzing
Bacterial
Growth Data
(30 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.

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.


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 $1^{\text {st }}$ and $3^{\text {rd }}$ quartiles. $\quad 1^{\text {st }}$ quartile: $\quad 3^{\text {rd }}$ 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 $1^{\text {st }}$ and $3^{\text {rd }}$ quartiles. $1^{\text {st }}$ quartile: $\quad 3^{\text {rd }}$ 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?

