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Biology Baseline Cornerstone Assessment: Part A. Experimental Design

Directions: Read the paragraph below and then respond to the questions.

Students in a biology class were discussing outbreaks of food-borne illness. Modern practices of refrigeration are aimed at curbing these bacteria. They wanted to know exactly what happened to bacterial colony growth at varying temperatures. The teacher explained that scientists study bacteria in the laboratory by counting colonies that grow on plates filled with agar, which is a nutrient substance. Design an appropriate experiment to test the effect of temperature on bacterial growth. You will have 5 days to conduct your experiment. The following materials are available to you:

1. prepared agar plates
2. one freezer set to 0°C
3. one refrigerator set to 5°C
4. five incubators that can be set from 15 to 45 °C
5. classroom countertop (varying temperature from 25 to 30 °C)
6. tape
7. markers/wax pencils
8. prepared liquid bacteria (*E. coli*) culture in 500 mL flask
9. droppers/inoculating loop (for dipping into bacteria culture)
10. glass stir rods
11. balance
12. ruler
13. paper towels

1. State your **hypothesis**. Explain your reasoning.

   If the temperature is changed the bacteria growth will be the highest at 25 C. Bacteria growth should be the best at room temperature (25 C) because the temperature allows for growth processes.

2. What should be the **independent variable** in the experiment? Explain your choice.

   The independent variable is the temperature of the environment in degrees Celsius. This is the manipulated variable.

3. What should be the **dependent variable** in your experiment? Explain your choice.

   The dependent variable is the number of colonies. This is what we are measuring (counting) and it depends on the temperature.

4. Are there conditions that should **remain constant** in this experiment? Explain your answer, and give examples, if necessary.

Example of constants would be time of incubation, size of the dish, amount of agar, the type of agar, and the amount of light…etc. These things must stay constant to show that temperature alone is responsible for changes in the dependent variable.

5. Is there a need for a **control group** in this experiment? Explain your answer, and identify the control, if necessary.

   There is no need for a control since you are comparing levels of varying temperature and there is no such thing as absence of temperature. Although a natural room temperature setting is an appropriate comparison for the physically varied temperatures in the experiment, it is not a control group.

6. Describe the procedures you will use to carry out the experiment. List the steps below and the materials needed.

   Take five prepared agar plates and drop 5 mL of prepared liquid bacteria onto each plate. Use the in dropper or inoculating loop to evenly distribute the bacteria on all plates the same way. Tape the dishes shut and mark each of the dishes in the following way:

   0 C
   5 C
   15 C
   30 C
   40 C

Place the 0 C dish in the freezer, the 5 C dish in the refrigerator, and the rest of the dishes in the preset incubators according to labels. Check all of them at the same time once a day. Record qualitative (color, changes in agar, etc) and quantitative (number of colonies) observations.

List of materials:

Prepared agar plates
Freezer (0 C)
Refrigerator (5 C)
Incubators (15 C, 30 C, 40 C)
Prepared liquid bacterial culture
Droppers
Inoculating loops
Tape and wax pencils

7. Create a data table that can hold all the data you would gather through your experiment.

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Quantitative Table

Bacterial colonies on agar plates at varying temperatures over a four day period

	Number of colonies			
Temperature (C)	Day 1	Day 2	Day 3	Day 4
0				
5				
15				
30				
40				

Qualitative observations

Bacterial colonies on agar plates at varying temperatures over a four day period

	Observations			
Temperature (C)	Day 1	Day 2	Day 3	Day 4
0				
5				
15				
30				
40				

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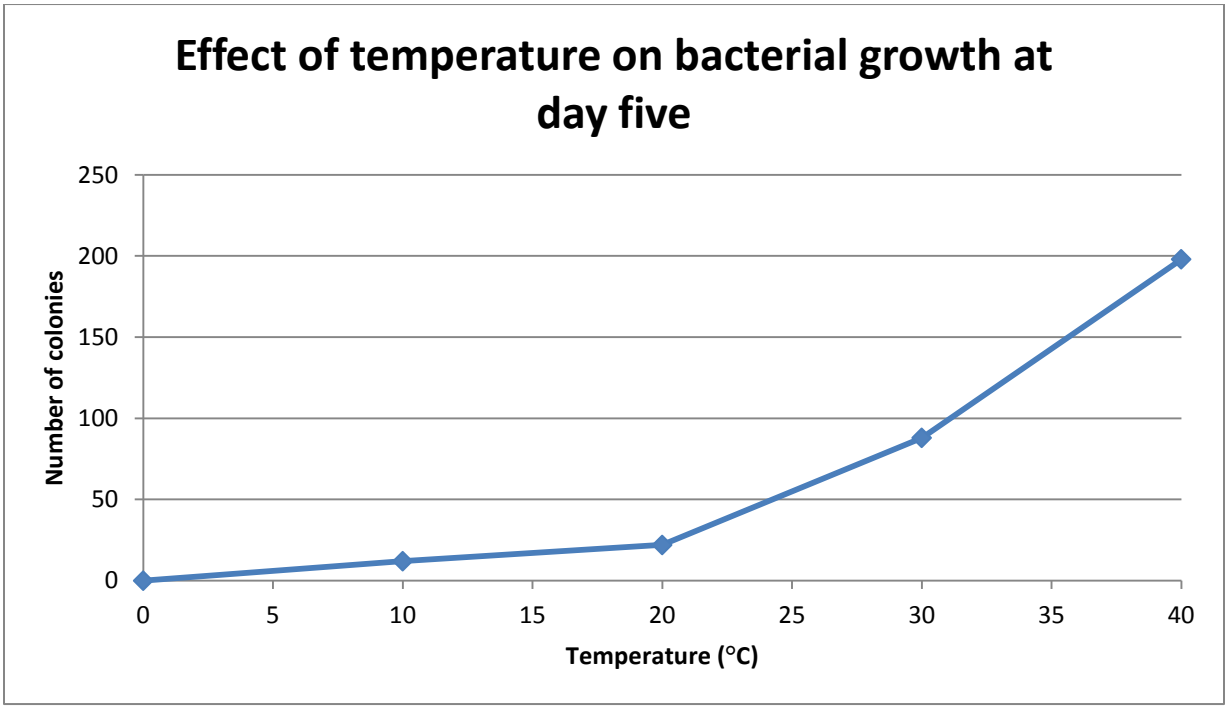
Biology Baseline Cornerstone Assessment: Part B. Data Analysis and Scientific Reasoning

Directions: Review the data table below. Then, answer the questions that follow.

The students believed that more bacteria colonies would grow at warmer temperatures. The data collected is listed below:

Temperature (°C)	Number of *E. coli* colonies after 5 days
0	0
10	12
20	22
30	88
40	198

1. Using the grid below, create a line graph from these data.



2. What is your **independent variable**? Explain your choice.

   The independent variable is the temperature (C). This is the condition that was changed by the experimenters.

3. What is the **dependent variable**? Explain your choice.

   The dependent variable is the number of colonies after 5 days. This is the variable that changes depending on the temperature.

4. At what temperature do the most *E. coli* colonies grow? (Include units)

   40 C.

5. *E. coli* live in the intestinal tracts of many animals, including humans. Human body temperature stays at 37°C. How many bacterial colonies would you predict would be seen on the prepared agar plates if *E. coli* is grown at 37°C? Explain your reasoning.

   One would expect 170-180 colonies at 37 C. Based on the graph, there is a trend of an increasing number of colonies as the temperature increase. The line connecting 30 C and 40 C crosses 37 C at about 175 colonies.

6. Based on the data provided, what temperature prevents *E.coli* bacteria from growing? Explain.

   Since zero bacteria colonies were observed at 0 C, this temperature must prevent *E. coli* growth.

7. What conclusion(s) can be made based on these results?

   Colder temperatures inhibit bacterial growth and warmer temperatures up to 40 C promote bacterial growth in a direct relationship.

8. Describe a way in which this experiment can be improved or expanded to further explore the effects of temperature on bacterial growth?

   One way to further explore the effects of temperature on bacterial growth would be to include a wider range of temperatures, including higher temperatures and temperature in between those previously tested.
   Another way to expand on the experiment would be to test the effect of temperatures on other types of bacteria.

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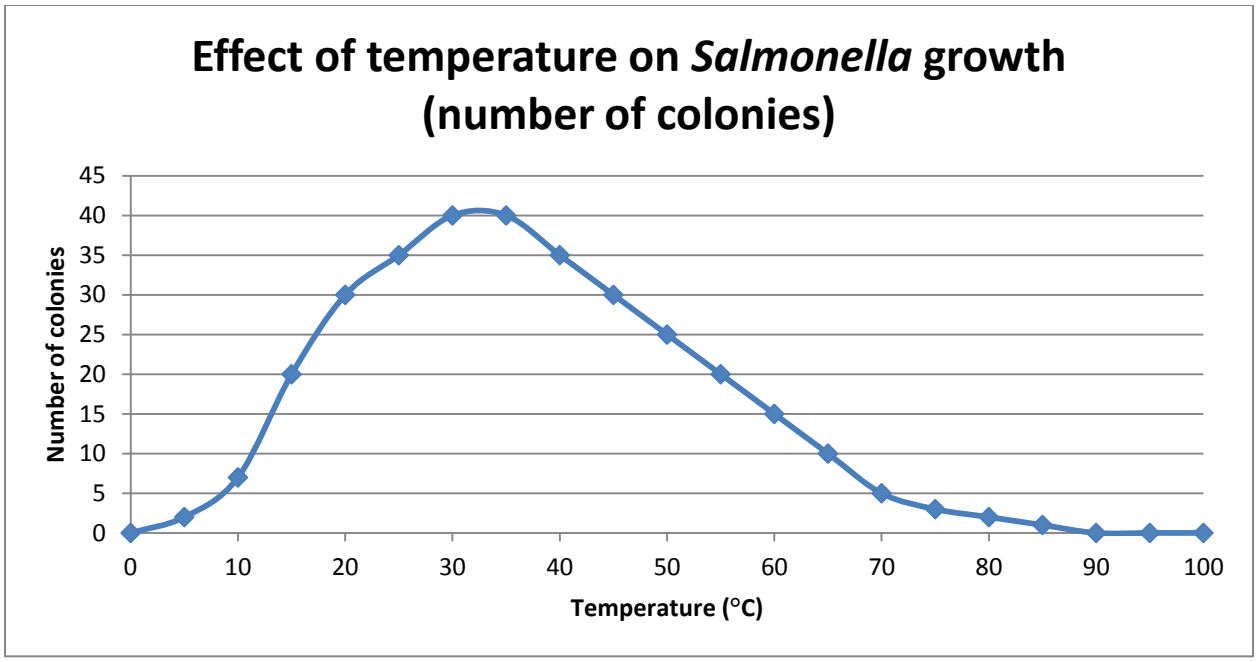

9. Describe what happens to the number of colonies as temperature changes.

At lower temperatures there are fewer colonies, which increase rapidly as the temperature increases up to 35 C. From 35 C to 100 C the number of colonies steadily decreases to zero. At temperatures of 0 C and 90 C – 100 C there is no growth.

10. Within what temperature range do Salmonella grow the best?

In between 30 C – 35 C

11. Salmonella is a type of bacteria that causes food poisoning. At what temperature should food be stored to prevent salmonella growth? Using data from the graph, explain your answer.

Food should be stored close to 0 C because no growth is shown at that temperature and this is close to the temperature of most refrigerators and freezers. (A temperature of 100 C kills bacteria, but is not suitable for storage)