EXPLORATIONS

Activity 8

Objectives

- To produce a scatter plot and a best-fit model for existing data
- To interpolate and extrapolate using a best-fit model
- To explain how limiting factors control populations
- To prove an understanding of carrying capacity

Is There a Limit?

In this activity you will

- examine some data about bacteria.
- graph the data.
- draw some conclusions based on the data and the graph.

Introduction

Of all the organisms in the world, few could compete with bacteria for the title of "Fastest Reproducer." Bacteria are unicellular, like lots of other organisms, but the unique characteristic they possess is the absence of a true nucleus. Organisms that do not have a nucleus are called *prokaryotes*. Because the cells of a tree, a frog, a mushroom, and even an amoeba *do* have a nucleus, they are called *eukaryotes*.

Problem

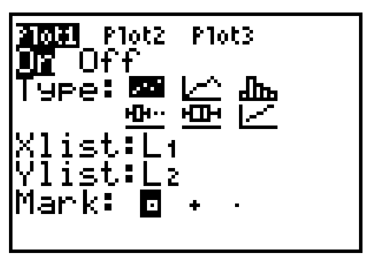
Which group do you think you fit into—the prokaryotes or the eukaryotes? On the next page is a table that shows the reproductive capability of bacteria. After looking at the table, you will graph the data to get an idea of the type of population growth the bacteria can accomplish. These bacteria were grown in a flask in a laboratory setting, and kept in the same container throughout the experiment.

Time in minutes	Number of bacteria
30	4,000
60	4,500
90	5,200
120	6,100
150	7,200
180	8,500
210	10,000
240	11,700

Procedure

Enter the data from the table above into your TI-83 Plus.

1. Press [STAT] [ENTER].
2. Press [▲] to move to the heading **L1**. Press [CLEAR] [ENTER].
3. Follow the same procedure to clear **L2** of all data.
4. Navigate back to **L1**, making sure that your cursor is in the first row of the list, and not at the very top. Using the data table, enter the data from the first column (**Time in Minutes**) in **L1**. Type in the number and then press [ENTER] or [▼]. Repeat this until you have entered all of the data in **L1**.
5. Enter the data from the **Number of Bacteria** column in the data table into **L2**. Make sure you have the same number of data entries in **L1** as you do in **L2**.
6. Press [2nd] [STAT PLOT] to define the plot.
7. Press [ENTER] to select **1:Plot1.** Set your TI-83 Plus as shown at the right.



8. Press [2nd] [FORMAT] and make sure the defaults are set.
9. Press [MODE] and make sure the defaults are set.
10. Press [WINDOW] and set an appropriate window for the data you have entered. Which of the variables (time or number of bacteria) is dependent on the other? Set **Xmin** and **Xmax** appropriately, according to your data, then choose whatever **Xscl** (scale along the X-axis) you would like. Set **Ymin** and **Ymax** appropriately, and choose a **Yscl** (scale along the Y-axis).

11. Press [Y=]. If there are any equations on this screen, press [▼] to place the cursor next to **Y1=**, and then press [CLEAR] to clear the equation. Repeat this sequence to clear all equations.

12. Press [GRAPH].

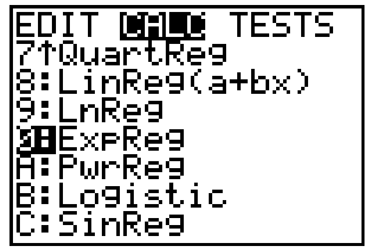
✐ *Answer the questions on the Data Collection and Analysis page.*

Extension

- Build a best-fit (regression) model for the data in your graph.

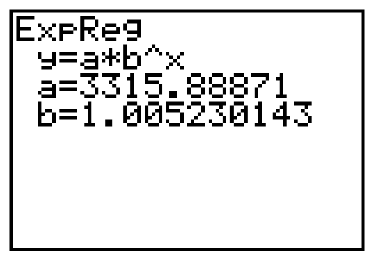
1. Go to the Home screen by pressing [2nd] [QUIT].

2. Press [STAT], and then press [▶] to highlight **CALC**. You will see a list of regression models from which to choose. Press [▲] a few times until **0:ExpReg** is highlighted, and then press [ENTER].



3. You will now be back on the Home screen. Press [2nd] [L1] [,] [2nd] [L2] [,] [VARS] [▶] [ENTER] [ENTER].

4. Press [ENTER]. You just told the TI-83 Plus to build an exponential regression model based on the data in **L1** (time) and **L2** (number of bacteria), and then write the regression equation in **Y1**. To check this, press [Y=]. You should see an equation next to **Y1=**.



5. Press [GRAPH] to see your original data points and observe the best-fit line being drawn.

6. Press [TRACE] and then press [▲] or [▼]. Where do you see the cursor?

7. Press [◀] and [▶] and notice what is displayed at the bottom of the screen. What do these numbers mean?

Data Collection and Analysis

Name ____________________________

Activity 8: Is There a Limit?

Date ____________________________

Data Analysis

1. What will you plot along the X-axis (the independent variable)?

What will you plot along the Y-axis (the dependent variable)?

2. Is there a constant difference between consecutive values in the **Time in Minutes** data list (the X list)? If so, what is that difference? If not, explain.

3. Is there a constant difference between consecutive values in the **Number of Bacteria** data list? If so, what is that difference? If not, explain.

4. Look at the graph of your data. Does the graph look linear? Explain.

5. Press [TRACE] and move from point to point on your graph by using [◄] or [►]. Estimate how many bacteria you would expect to find after 300 minutes.

6. Without using the [TRACE] button, estimate how many you would have expected to find after 100 minutes.

7. Now use [TRACE] to estimate the number of bacteria you would have after 100 minutes. How does your answer compare to the one you estimated in #6?

8. Estimate how many bacteria you would expect to find after 12 hours. Hint: you will need to change your [WINDOW] settings!

9. Estimate how many you would expect to find after 24 hours.

10. In reality, can this rate of growth in bacterial numbers continue forever? Explain.

11. Populations of organisms can only grow as large as their environments allow them to grow. Natural population controls are called *limiting factors*, and the number of organisms of a particular species that can be supported by the environment is called the environment's *carrying capacity* for that species. You may want to consider these things as you look again at your answer to #10. What are some limiting factors influencing the population sizes of plants and animals in a deciduous forest?

12. What are some limiting factors at work in the desert? In the arctic? In the tropical rain forest?

13. Go back into the lists of your TI-83 Plus (press [STAT] [ENTER]), and extend your list of times in **L1** to 600 minutes, using increments of 30. In **L2**, enter what you think would be realistic population data to correspond with the new times you entered in **L1**. Remember this data is not linear. Before you press [GRAPH], make sure you take a look at your [WINDOW] and make necessary adjustments. How long do you think the bacteria population can grow at an unrestricted rate? Then what happens?

14. What do you think is the carrying capacity of your classroom for people? On what did you base your answer?

Teacher Notes

Activity 8

Is There a Limit?

Objectives

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Concepts

- Exponential population growth rates
- Limiting factors

Extension

4. $Y1 = 3315.89 * 1.005^{x}$

6. The cursor will be on the data points.

7. Answers will vary, but the numbers represent the time in minutes and the number of bacteria.

Data Analysis – Answer Key

1. **X-axis**: Time

Y-axis: Number of bacteria

2. There is a constant difference of 30 between the data points.

3. There is not a constant difference between the data points. The difference changes—it increases.

4. The graph is not linear. The graph is curved.

5. The estimate should be close to 15,700.

6. The estimate should be close to 5,500.

7. Approximately 5,586 bacteria.

8. Approximately 150,000 bacteria.

9. Approximately 5 to 6 million bacteria.

10. No, this rate of growth in bacterial numbers cannot continue forever. The population will reach a limit because of limited space, food, and so on.

11. Some limiting factors influencing the population sizes of plants and animals in a deciduous forest include food supply, sunlight, water, weather, predation, competition, and so on.

12. Some limiting factors at work in the desert include lack of water and extreme temperatures.

Some limiting factors in the arctic include cold, lack of water, and limited sunlight.

Some limiting factors in the tropical rain forest include nutrients in the soil, space, light, and so on.

13. Answers will vary for how long the bacteria population can grow at an unrestricted rate.
The bacteria will start to die off because they will have reached the carrying capacity of the environment.

14. Answers will vary, and they should be based on space, air supply, and so on.