EXPLORATIONS

Activity 1

A Tall Story

Math Concepts

- Measurement
- Data analysis
- Algebra

Science Concepts

- Data collection
- Life science

Materials

- TI-73 calculator
- CBR™ or CBL™ with motion probe
- Data link cable
- Meter stick or tape measure
- TI-GRAPH LINK™ (optional)

In this activity, you will:

- Collect data
- Examine data statistically
- Graph the data and produce mathematical models
- Convert units
- Relate the heights of humans with their age
- Relate the rate of growth to the slope of a line generated by your growth data
- Explore rates of growth in young children
- Deal with measured data

Introduction

Bob Wadlow was born in Alton, Illinois on February 22, 1918, weighing 3.86 kilograms (8.5 pounds). By the age of six months, he weighed 13.61 kilograms (30 pounds). At 5 years of age he was measured to be 163 centimeters (5' 4") tall. When he died on July 15, 1940 he had obtained a height of 272 centimeters (8' 11.1") and a mass of 199.13 kilograms (439 pounds) making him the tallest person in history, as recorded in the Guinness Book of Records. His remarkable growth rate and resulting size was attributed to an over-active pituitary gland, which produced much higher than normal levels of growth hormone. Today, medicine can compensate, or enhance, this problem, but Bob had no such support in the age that he lived. How unusual

was Bob's growth rate? What is a normal rate of growth and how could you determine your own growth rate?

The Problem

To explore your rate of growth, you will need to have some information about your height (length) at various ages. In many homes, the growth of a baby is watched very carefully and detailed records are kept. Even as the baby grows up and goes to school, periodic measurements are made of his/her height. In this investigation, you will collect current and historical data about your height and age and look for a rate (of growth) associated with this information. In class you will need to get your current height using the Calculator-Based Ranger™ (CBR™) with the TI-73 in the **GAUGE** mode. In addition to this information, you will need to collect, from home, any information about your heights, at various ages. It has become a tradition to record the height (length) of children at birth (age = 0) so this information should be easy to obtain. The more data you can collect, the better!

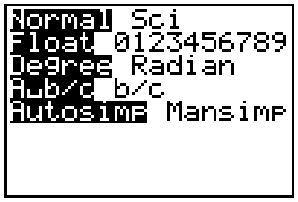
Activity

Collecting Data

1. Collect three readings of your height in meters using the CBR attached to the TI-73.

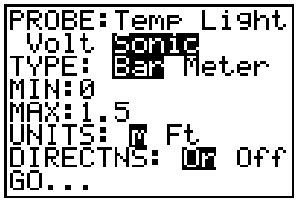
a. Set the Mode as shown below.

b. Press APPS and select option **2:CBL/CBR** from the **APPLICATIONS** menu.



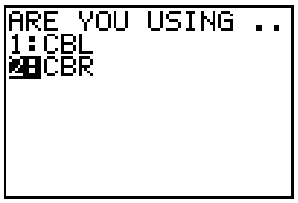
c. Press any key to get to the **CBL/CBR APP:** menu and select option **1:GAUGE**.

d. Set up the experiment as shown below.



The maximum height (**MAX**) will vary with different individuals. This value should be about 20% more than your height. If you don't know your height, just pick a value and then change it if you are not getting the kind of data display from the **Bar** or **Meter** that you desired.

e. You will be asked if you are using the Calculator-Based Laboratory™ (CBL™) or the CBR™. Indicate the appropriate selection (in this example, the CBR).



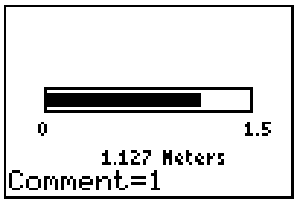
The CBR will need to be oriented so that the surface of the "eye" of the CBR is parallel to the floor. The signal should be bouncing off of the floor, and the face of the CBR should be held at the "top" of the person being measured, recording the height of the probe, and therefore the height of the person. This technique will only work with individuals who are more than 50 centimeters tall.

Objects other than the floor may be picked up by the sonic signal of the CBR, so wait until your signal is fairly constant. If you are picking up an extraneous object the values will either be wrong (not your height) or they will jump between your height and a shorter distance, the distance to the other object.

2. When you are conformable with the reading, press ENTER and record 1 as the Comment, indicating the first reading.

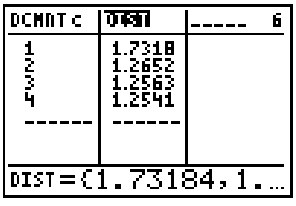
a. Repeat this sequence until you have 3 readings of your height.

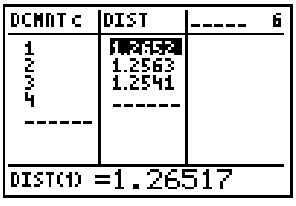
b. If you press ENTER and get a "bad" reading, just key in the next number and continue until you have 4 or more readings.



3. When you are finished, press CLEAR 2nd [QUIT]. Select option **4:QUIT** from the **CBL/CBR APP:** menu. The values that you collected may be viewed and edited by pressing LIST.

If you had any miscues, locate them and delete by highlighting the incorrect measure in the **DIST** list and pressing DEL. Also delete the values in the **DCMNT** list to avoid an error.





✎ Answer question 1 on the student data sheet.

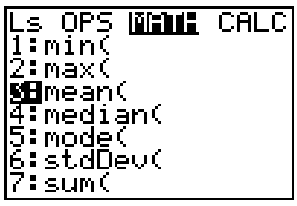
Examining Data Statistically

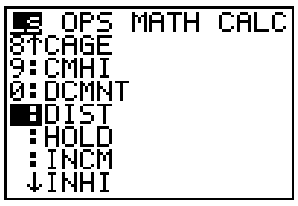
1. You now need to calculate the mean (average) of the heights.

   a. From the Home screen, press [2nd] [STAT] [▶] [▶]. Select option **3:mean(** from the **MATH** menu.

   b. Press [2nd] [STAT] and select the list named **DIST** from the **Ls** menu.

   c. Close the parenthesis [)] and press [ENTER].



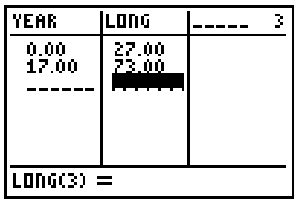


✎ Answer question 2 on the student data sheet.

✎ Place the data you collected on your growth in the table on the student data sheet question 3. Include just the two values for height now. More extensive analysis may be done later.

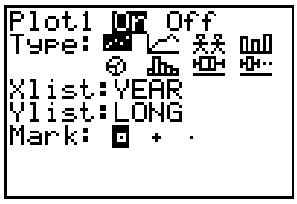
2. Key this data into the TI-73 in lists named **MONTH** and **LONG**.

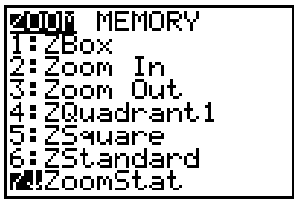
	BIRTH	NOW
AGE (years)	0	17
LENGTH (inches)	27	73

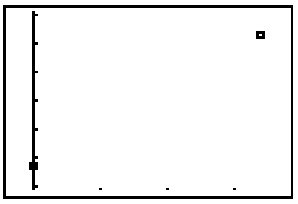


Graphing Data

1. Now set up a scatter plot of the data as shown below. Press [ZOOM] and select option **7:ZoomStat** from the **ZOOM** menu.

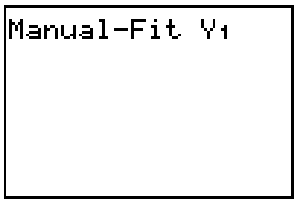






2. You now need to get a **Manual-Fit** on the collected data.

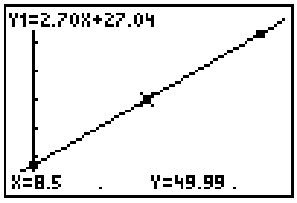
a. From the Home screen, press [CLEAR] [2nd] [STAT] [◂]. Select option **3:Manual-Fit** from the **CALC** menu.



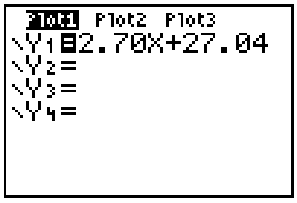
b. Press [2nd] [VARS], and select option **2:Y-Vars** from the **VARS** menu. Press [ENTER] [ENTER].

c. Move the cursor to the first length, at 0 age, and press [ENTER].

d. Move to the second point (representing your current age and length) and press [ENTER] again.



e. If this is correct, then press [ENTER] again to place the equation that represents your average growth pattern to this point in your life.



If this is not the line you wanted, you may still adjust the line using the cursor lines.

f. Press [ENTER] when finished.

g. Press [Y=] to examine the equation.

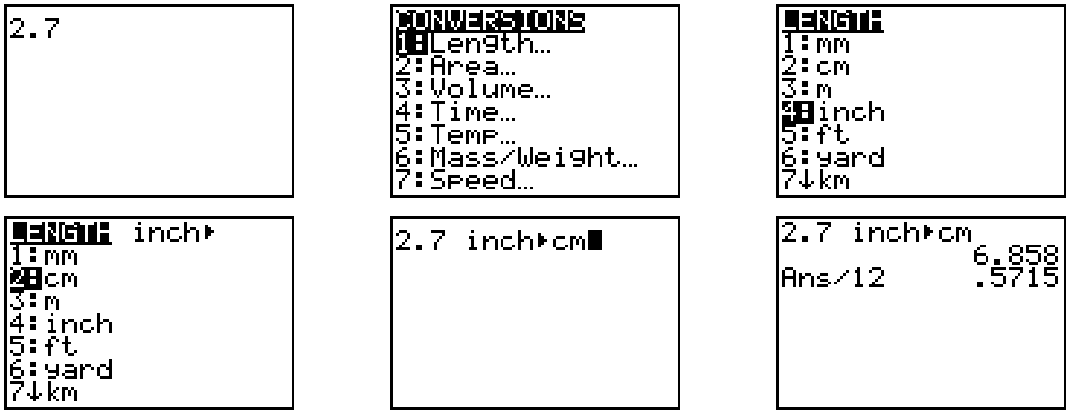
✎ Answer questions 4 and 5 on the student data sheet.

In the case above, the growth rate was 2.70 inches per year, stating with a length of 27.04 inches.

✎ Answer questions 6 - 8 on the student data sheet.

Converting Units

To convert your growth rate, use the **CONVERT** option on the TI-73. In this example, the conversion is from inches per year to centimeter per year (6.858), and then to centimeters per month (0.5715).



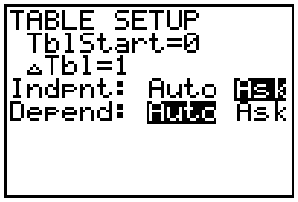
✎ Answer question 9 on the student data sheet.

Relating Heights

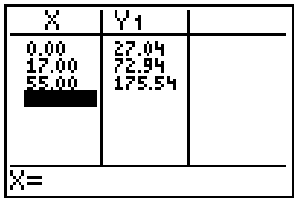
1. Use the **TABLE** option on the TI-73 to predict your height at various ages. Remember the units of **X** (age) and **Y1** (height).

a. Press [2nd] [TBLSET] and set the screen as shown below.

b. Press [2nd] [TABLE].



c. Key in your age at birth and press [ENTER].



d. Enter your age now in the second row and press [ENTER].

These values should be close to the numbers in the table from question 3 on the student data sheet. You may also guess heights for particular ages. In the example above, the prediction is that at age 55 the person will be 175.54 inches tall.

✎ Answer questions 10 and 11 on the student data sheet.

Compare your growth rate with the growth rate from the mean height values in the Table of Standards* chart below. The average length of a newborn baby is 52 centimeters (20.6 inches).

✎ Answer questions 12 and 13 on the student data sheet.

Category	Age Years	Height Centimeters	Height Inches
Infants	0 to 0.5	61	24
	0.5 to 1	71	28
Children	1 to 3	89	35
	4 to 6	112	44
	7 to 10	132	52
Females	11 to 14	157	62
	15 to 18	163	64
	19 to 22	163	64
Males	11 to 14	157	62
	15 to 18	175	69
	19 to 22	178	70

***U.S. Department of Health and Human Services**

Going Further

1. Bob Pershing was 8 feet and 11.1 inches tall. How many meters is this? Inches?
2. If he reached this height at age 22 from a height at birth of 33 inches, what was the mean growth rate in inches per year?
3. How does this compare to your mean growth rate?
4. How old were you on May 3, 1991? In months? In years? In days?
5. If you had grown at this rate, how tall would you be now?
6. The shortest mature person in the world in 1812 was Calvin Phillips, who at age 21 was 27.5 inches tall. If he had the same mean growth rate as you have, how tall would he have been at birth? Is this possible? Why?

Student Data Collection and Analysis Sheet

Name(s)_____

Date _____

Activity 1

A Tall Story

1. Place the values for your height in the table below.

Height in Meters

2. Give the mean of your height in meters:

_____

How did you get that way?

3. Place the data for your age and height in the table below. Use the **CONVERT** menu on the TI-73 if needed.

	BIRTH	NOW
AGE (months)	0	
LENGTH (meters)		

4. Save the graph and the data in list **MONTH** and **LONG** using the TI-GRAPH LINK™ or place them in a program (see *Appendix A: Saving Lists*) and store the graph as a **Pic**. Give the names of the files and their location, or the name of the program and **Pic**.

5. Explain what the graph is showing.

_____

_____

_____

_____

6. What is your growth rate from the equation? (include units)

_____

7. What is the meaning of the other value in the equation?

_____

8. Give the function from your Manual-Fit. _____

9. Give your average growth rate in centimeters per year._____

10. Use the **TABLE** option on the TI-73 to check on your height at any particular age. How close were you?

_____

11. Give the three values requested below in the table.

AGE (months)	84	324	
LENGTH (meters)			2.81

12. Find yourself in the table of standards and give the growth rate in centimeters per year.
My Group's Name: _____
My Group's Growth Rate: _____

13. Compare your calculated growth rate with your group's growth rate from the table of standards.

_____

_____

_____

Teacher Notes

Math Strands: Measurement, Data Analysis, and Algebra

Students will deal with measuring data, converting units, examining the data statistically, graphing the data and producing mathematical models (functions) that reflect the patterns in the data. Rates of growth will be related to the slope of lines generated by these models.

Science Strands: Data Collection, Life Science

Collecting data, looking for a statistical analysis of this data. Relating the heights of humans as they grow, looking at rates of growth in younger children.

Classroom Management and Safety

When the students collect the data with the CBR™, care should be taken to stabilize the equipment, watching the cords connecting the parts. A student should be assigned to watch and drive the TI-73, and one should be in charge of keeping objects, rather than those that are to be measured, away from the sonic beam. Great effort should be taken to see that the CBR is positioned to only see the floor when no people are standing under it.

Getting Ready

1. You will need to give some lead-time to collect the student's length at birth. This might be a good thing to ask if you collect information on the student at the start of the school year, or to ask at the Parent-Teacher Conference. This might even be a good reason to call the child's parent to ask for this measure to give the impression that all teacher-initiated contact need not indicate some problem with the student! If this value is difficult, you might use the average length at birth 52 centimeters (20.6 inches).
2. Additional heights and ages can be used by the student to fine-tune his/her analysis of growth rate. An interesting aspect of this data will be the quantification of the age data (that is, on May 3, 1991 how old were you?).

Activity

1. Setting the mode to 2 or 3 decimal places might be best for younger children since the stability of the reading is a matter of place value, in some cases.
2. It is very important that the holder of the CBR keep it at the correct height (the top of the student) and that the face of it is perpendicular to the floor. The beam is wide, so make sure it is only picking up the floor. If something is in the way, it will either give a false reading (too short), or the reading will jump between the distance to the floor and the distance

to the interfering object. Have the students check around for interfering objects. This will be good practice for data collection in their future.

3. Each time you run the **GAUGE** the lists of heights (**DIST**) is erased, so students should take care to record their values before moving to another person or accidentally running the application again.

4. When doing the Manual-Fit for the individual student data, the screen won't be set to integer values. This may be done by setting **ΔX** to some nice value with an integer value for **Xmin**, or by using the appropriate Zoom option.

5. Growth rates for girls under 13 and boys under 15 may range up to 3.5 inches per year for girls, and 2.5 inches per year for boys, as they move through puberty. These variations for kids in the range of ages from 11 to 15 should give a great variation in heights of students. Younger and older groups of children should have more consistent heights (less variations). On the average, there is a 2-year difference in height spurts between boys and girls.

6. Data for Bob Pershing can be found at the Alton Museum of History and Art web site (**http://www.altonweb.com/museum/index.html**). Sample data for Mr. Tall guy are in the lists named **AGE**, **TALL**, and **NTS**. Recall that 1 Newton = 102 grams on earth. Weight = Mass ∗ Acceleration due to gravity, G = 9.8 m/s/s or 980 cm/s/s.

Student Data and Analysis Sheet - Key

1. The values will vary, but they should be about the same numbers. Look for consistent and appropriate number of digits.

2. Average of the numbers in question 1.

3. Information from home and current age and the answer from question 2.

4. Location of data on computer with file names or program and **Pic** names.

5. How you get taller as you get older, in a linear way!

6. They should report the value for the slope in meters per month.

7. Your length at birth.

8. **Y** = mX + b, or height = rate of growth ∗ age in months plus length at birth in meters.

9. Answers will vary.

10. Compare the two numbers.

11. Answers will vary depending on the answer to question 8.

12. Group name and rate from table below, based on average length at birth 52 centimeters (20.6 inches) and average of age group.

Category	Age in Years = Average	Growth Rate Centimeters/Year	Growth Rate Inches/Year
Infants	0 to 0.5 = 0.25	36	13.6
	0.5 to 1 = 0.75	25	9.9
Children	1 to 3 = 2	18.5	7.2
	4 to 6 = 5	12	4.7
	7 to 10 = 8.5	9.4	3.7
Females	11 to 14 = 12.5	8.4	3.3
	15 to 18 = 16.5	6.7	2.6
	19 to 22 = 20.5	5.4	2.1
Males	11 to 14 = 12.5	8.4	3.3
	15 to 18 = 16.5	7.5	2.9
	19 to 22 = 20.5	6.1	2.4

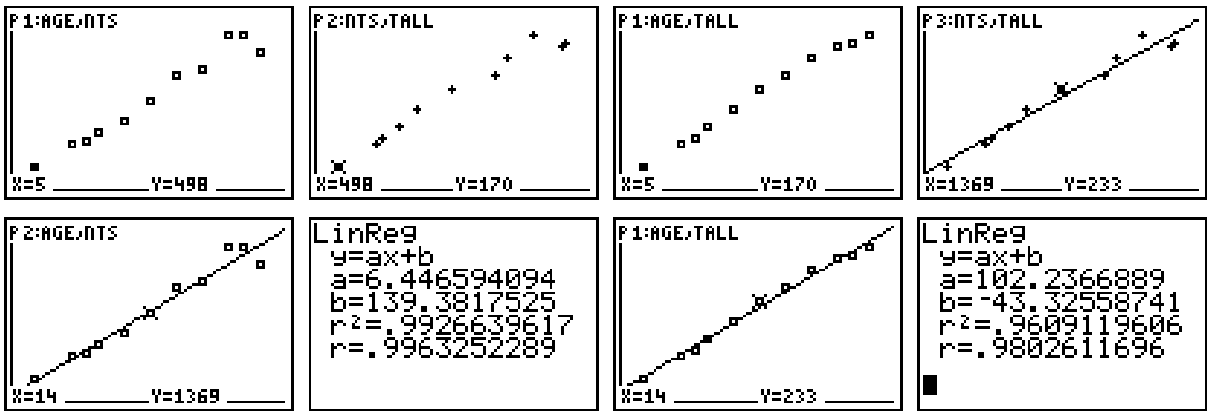
13. Answers will vary.

14. The following information is for Mr. Tall Guy. Make a graph that helps explain the pattern in this data. Give rates to go with each relationship explored.

Age	Height in Centimeters	Weight in Newtons
5	170	498
8	190	782
9	195	831
10	203	965
12	218	1102
14	233	1369
16	246	1694
18	261	1769
20	269	2200
21	271	2218
22.4	279	1983

Going Further - Key

1. 2.72 meters; 107.1 inches
2. 3.4 inches/year
3. Answers will vary
4. Answers will vary
5. Birth height in inches + 3.4 inches/year ∗ age in years = number of inches, then convert to feet and inches, or something like 7 10/12 feet.
6. Negative length has no meaning.
7. Display graphs showing pattern of age and weight:



8. Notice drop off of weight in last year before death.
9. Linear in all three cases, they should provide Window and rate of growth/slope.
10. Above you have 6.45 cm/year, 102 Newtons/year, and 0.06 cm/Newton, or 16.4 Newtons/cm!

Extensions

- This experiment can be done with other objects, such as balls rolled under the probe, cars driven under, dogs, chairs, and so forth.
- Examine the mean heights of infants, young children, and adolescents for different races.
- Study the Census in the U.S., and look at the issue of sampling.
- Discuss the use of growth hormones such as Genotropin Pen 12 as it relates to growth disorders, including dysfunctional pituitary glands. In addition, the ethics of using these hormones to boost the size of athletes could be a topic for class investigation.

References

1. *Baby and Child Care* by Dr. Benjamin Spock, 1962.
2. *The New Child Health Encyclopedia*, Boston Children's Hospital, 1987.
3. *Guinness Book of World Records* by Norris and Ross McWhirter, 1966.
4. *The World Almanac and Books of Facts 1997*.
5. **http://dogpile.com** or other search engines.
6. **http://www.census.gov**