Introduction to Population Growth

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Purpose: As policy makers plan for the future, they often need to estimate the future needs of the world's population, in terms of food, housing, energy consumption, etc. The first question should be how to predict the world's population in, say, 2050 or 2100. (In a future module, we will consider energy needs specifically).

The following population data is taken from two separate websites: the United Nations population division (for 1950-2000; http://esa.un.org/unpp) and the US Census website [for 1700-1940 (these are estimates) http://www.census.gov/ipc/www/worldhis.html]. The following questions refer to the numbers in the table:

Year	Population
1700	600,000,000
1750	629,000,000
1800	813,000,000
1850	1,128,000,000
1900	1,550,000,000
1910	1,750,000,000
1920	1,860,000,000
1930	2,070,000,000
1940	2,300,000,000
1950	2,519,495,000
1955	2,754,717,000
1960	3,020,177,000
1965	3,333,716,000
1970	3,690,925,000
1975	4,065,508,000
1980	4,429,747,000
1985	4,824,509,000
1990	5,254,820,000
1995	5,661,862,000
2000	6,056,715,000

1. Is the world's population increasing or decreasing over time?
2. How many more people were there in 1960 than in 1950? How much did the population change from 1960 to 1970? What is the average increase in population per year for 1960 to 1970 (hint: divide your previous answer by the number of years).
3. Based on your answers to #2, is the population increasing at a constant rate (this means that the change between each 10 year period is the same), more quickly over time, or more slowly over time? Based on your general knowledge of how population grows, why do you think this is?
4. Do any of these numbers surprise you? Why or why not?
5. Using this chart of data, make rough estimates of the population in 2050 and in 2100. Explain how you found your estimates. (It is very likely that your estimate will be different than your neighbors – that's okay.)

One way that scientists think about tables of data is to make a visual representation of the numbers on a graph. Usually graphs have two axes represented by separate columns in a data table; often the *x*-axis (also called the independent variable by mathematicians) is in the left hand column. A LITTLE ASIDE: Time must be the independent variable because population depends on time and not vice versa.

Plot the data as points on the graph paper.

Draw a smooth curve/line that best fits the points you just plotted (approximate the shape of the data – your line doesn't have to go through EVERY point).

6. What's the shape of the curve?
7. Where is the curve steep?
8. What does the shape of the graph tell you about the rate of population increase over time? Compare it to your answer in question 3 that was based solely on the numbers in the table.
9. Find the slope (remember -- rise/run) between 1960 and 1970. How does your number compare with the answer in question 2?
10. Could you use this graph to refine your estimate in #5? How?

Mathematicians and scientists often write equations to approximate data sets and graphs. It turns out that this curve can be approximated well by the equation:

$$P = 29e^{0.0095t}$$

Where t = the date
P = the population at that date
e = a constant (approximately 2.72; you can use the e^x button on your calculator)

11. Have you ever seen this type of equation before? Did you know it approximates a curved line? (it's okay if you didn't)

12. Use the equation to calculate the population in 1800. Does this agree with the data table? How close is it?
13. Use the formula to predict the population in 2050 and 2100. Compare these predictions to your estimates in question 5. Which do you think is a better estimate?

DEEPER THOUGHT QUESTIONS

14. Your predictions for number 13 are probably very large. Do you think they will come true? Is there any way to change the pattern? What are some of the factors that control population growth? Come up with at least one thing that could change to reduce the rate of population growth.
15. According to our equation, there is no limit to how big population can get. In other words, the larger the year we plug in, the larger the population will get. However, if you think about world population in a practical sense, is there really a limit to how large our population can get? What are some factors that might limit the size of population? Do any of them have relevance to this course?