THE POWER OF DOUBLING

PURPOSE: Demonstrate exponential growth and determine the doubling time and growth of a simulated population.

BACKGROUND: Growth is defined as exponential when the increase of a quantity is proportional to the size of the quantity. Exponential growth is very slow in the early stages, but quickly accelerates. A frequent measure of exponential growth is doubling time, that is, the amount of time required for the quantity to double. The shorter the doubling time, the faster is the rate of growth.

The human population, like all populations of organisms, grows exponentially when unchecked. Although it took 130 years, from 1800 to 1930 for the world population to double, it doubled again by 1975, a mere 45 years. In 1993, the doubling time of the world population was 42 years. At this rate, the world population of 5.5 billion would be expected to reach 11 billion by 2035. Different areas of the world, however, have vastly different doubling times. While the doubling time for developed areas in 1993 was 162 years, that for the less developed areas was 35 years.

MATERIALS:

2 pennies	Approximately 200 dried beans
2 50-mL beakers	1 400-mL beaker
graph paper	marking pen
styrofoam cup (for shaking the pennies)	

PART I

1. Label one small beaker, "Parents" and the other one "Offspring." Label the large beaker, "Bean Pot." Place 10 beans in the "Parents" cup and the rest in the "Bean Pot." Each bean represents an individual in the population.
2. Prepare a table with 2 columns and 12 rows (see below). Label the left-hand column "Generation number" and the right-hand column "Population Size."
3. Toss the 2 pennies. If both pennies show heads, toss again. If both pennies show tails, one member of the population has died and you should remove a bean from the "Parents" cup and put it into the "Bean Pot." If one head and one tail show, a member of the population has had a child. To simulate the birth, take one bean from the "Parents" cup and one from the "Bean Pot" and place them into the one marked "Offspring."
4. Continue tossing until there are no longer any beans in the "Parents" cup. Count the number of beans in the "Offspring" cup and record the number in the data table. The "Offspring" now become the parents, so move all of the beans from the "Offspring" cup into the now empty "Parents" cup.
5. Repeat steps 3 and 4 until you have completed 10 generations.
6. Make a graph of your data with generation number on the horizontal axis and population size on the vertical axis.

	Part I	Part II
Generation #	Population Size	Population Size
0	10	
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

ANALYSIS AND CONCLUSIONS:

1. From the graph determine the doubling times for the population at the beginning, the middle and the end of the graph. Are they all the same? Explain why?
2. Assume that a generation is equal to 20 years. Use the doubling time from your graph to calculate the growth rate of the population using the formula below:

Annual growth rate = 70/doubling time

	Population Range	Duration, Generations	Doubling Time, yrs	Doubling Rate, %
Beginning				
Middle				
End				

3. Write a paragraph explaining the implications of this activity for the human population.

PART II

1. Repeat the activity, beginning with step 2. Only this time assume that when a head shows to the right of the tail, the individual decides not to have a child. In that case, place one bean from the "Parents" cup into the "Offspring" cup, but do not add a bean from the "Bean Pot". On the other hand, if the heads shows to the left of the tail, proceed as you did before, taking one bean from the "Parents" cup and one from the "Bean Pot" and placing them both in the "Offspring" cup. When you have finished 10 generations, graph your data on the same graph with the data from PART I.

2. Calculate doubling time and growth rate for the second set of data as you did for the first. Compare the two data sets.

3. Write a paragraph explaining the implications of this activity for the human population.