The People Connection

Student Reading

"Population growth may be the most pressing issue we face as we enter the new millenium."
~*National Geographic Magazine, January 1998*

Central to so many of the environmental, social and economic issues facing the planet today are people — our numbers and our behaviors. Although barely noticeable on a day-to-day basis, human population pressures threaten the health of our ecosystems and the quality of life for Earth's inhabitants.

Consider that in the six seconds it takes to read this sentence, 16 more people will inhabit the globe. In fact, the world's population grows at nearly a record pace, adding a New York City every month, a Germany each year and almost an India every decade.[1] At the turn of the century there are six billion of us and counting. This growth in human numbers has been described as a "population explosion," doubling ever faster over the past 300 years.

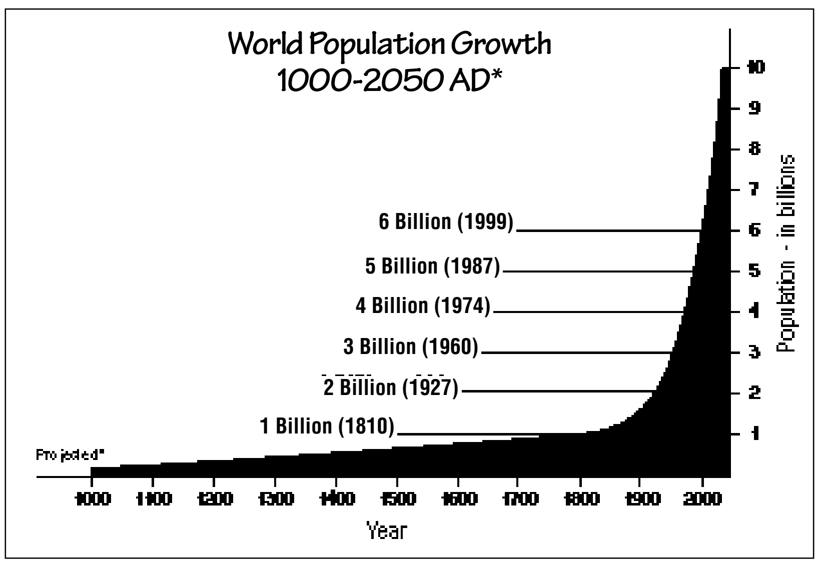
What Ignited the Explosion?

Rapid population increases have been a very recent development in the scope of human history. People lived on Earth for about three million years before the world population reached 500 million around 1600. Until then, **birth rates** and **death rates** were in balance, keeping the population stable. Although birth rates were high, death rates — particularly among children — also remained high.

By the 17th century, this balance of birth and death rates began to change as advances in medical care, sanitation, food production and nutrition increased **life expectancy** for children and adults. Death rates dropped, but birth rates remained high and the population grew steadily. By 1800, at the height of the Industrial Revolution in North America and Europe, global population reached one billion.

As industrialization grew throughout the Western world, people exchanged their agrarian lifestyles for homes and jobs in burgeoning cities. Without land to farm, large families became neither necessary nor practical. Slowly, birth rates dropped in rapidly industrializing nations. This three-part population pattern — from high birth and death rates, to high birth and low death rates, and finally to low birth and death rates — is now referred to as the **demographic transition**.

In the non-industrialized nations of Africa, Latin America and Asia, however, birth rates remained high at the same time that death rates dropped, as new agricultural and medical technologies were imported from more developed countries. Economic conditions in these nations did not always improve as life spans increased. The result has been a population explosion and stagnation in the middle of the demographic transition pattern throughout much of the globe. By 1960, the world population reached three billion. Just 15 years later, in 1975, the population soared to four billion and topped five billion in 1987. In 1999, the population reached six billion, completely doubling in less than 40 years. It now appears that global population growth is finally turning a corner as birth rates begin to fall worldwide. Even so, demographers now project that the global population will continue to grow, albeit more slowly than in the past century, adding an additional two to five billion more people by the middle of the 21st century.[2]



How does the quality of life on Earth vary now from what it was when there were half as many people? How might it be in the future when there are many more of us? How many people can the Earth support sustainably?

The People Connection

Student Reading

Crowding the Earth

No one knows for sure how many people the Earth can support. Every environment has a carrying capacity — the point at which there are not enough natural resources to support any more members of a given species. In *How Many People Can the Earth Support*, author Joel Cohen attempted to answer that very question by collecting dozens of expert estimates made in recent decades. Finding the Earth's carrying capacity is difficult because the number of people the Earth can support depends greatly on how people use the Earth's resources. Although estimates varied, Cohen was able to conclude from scholars that,

***The possibility must be considered seriously that the number of people on Earth has reached, or will reach within the next century, the maximum number the Earth can support in modes of life that we and our children and their children will choose to want.*[3]**

The population issue, then, is not one of numbers but of carrying capacity. The entire world population could fit into Texas, and each person could have an area equal to the floor space of a typical North American home. But this ignores the amount of land required to provide each of us with the raw materials for survival (food, water, shelter, clothing and energy) and all that has become essential to our modern lifestyles (transportation, electronic communication, consumer goods and services). Scientists in Vancouver, Canada tried to calculate local residents' "ecological footprint," the land and water area that would be required to support the area's population and material standard indefinitely. They found that the Vancouver area's population requires an area 19 times larger than its home territory to support its present consumer lifestyles — wheat fields in Alberta, oil fields in Saudi Arabia, tomato fields in California. [4]

While the continents are vast, only a small fraction (1/10) of all the land in the world is arable.[5] The rest has been built up into cities and towns or is inhospitable to growing crops. While the number of people continues to grow, the small portion of land which must support these people remains the same, or shrinks as cities expand. The size of the human population affects virtually every environmental condition facing our planet. As our population grows, demands for resources increase, adding to pollution and waste. More energy is used, escalating the problems of climate change, acid rain, oil spills and nuclear waste. More land is required for agriculture, leading to deforestation and soil erosion. More homes, factories and roads must be built, occupying habitat lost to other species which share the planet, leading increasingly to their extinction. Simply put, the more people inhabiting our finite planet, the greater stress on its resources.

The People Connection

Student Reading

Population Growth: North American-style

With over 90 percent of the population increase today occurring in developing countries, many North Americans feel that they neither contribute to nor are affected by the problem. In fact, the United States is the fastest growing industrialized country, growing by 2.6 million people each year. This is of particular concern to the global environment, as affluent lifestyles in North America place disproportionate demands on the world's resources and leave a much larger "ecological footprint." At current consumption levels, the next 20 million Americans, for example, will consume more barrels of oil than the over 600 million people living in Sub-Saharan Africa.[6] The 47 million people expected to be added to the U.S. population over the next 20 years will produce more carbon dioxide emissions than the 470 million people expected be added to China and India for the same time period.[7]

Evidence of population growth surrounds us — intensifying traffic congestion, urban and suburban sprawl, and landfill space too full to handle the mounting garbage and hazardous waste which North Americans create daily. In the last 200 years, the United States has lost 71 percent of its topsoil, 50 percent of its wetlands, 90 percent of its old-growth forests, 99 percent of its tallgrass prairie, and up to 490 species of native plants and animals with another 9,000 now at risk.[8] We are currently developing rural land at the rate of nine square miles per day[9], and paving 1.3 million acres each year — an area roughly the size of Delaware.[10] Many attribute these problems solely to wasteful habits. However, as we in North America increase our population, we compound our ecological impact. Efforts to relieve environmental stress by cutting consumption would be undermined, if not negated, by continued population growth or by stabilization at a size larger than our resources can sustain.

In making its policy recommendations to the President of the United States in 1996, the President's Council for Sustainable Development (PCSD) stated clearly that "human impact on the environment is a function of both population and consumption patterns" and recommends policies to move toward voluntary population stabilization at the national level.[11]

What Can Be Done?

There is much that can and has been done toward stabilizing the world population and preserving the environment. Two recent United Nations conferences have brought attention to the importance of slowing population growth. At the 1992 U.N. Conference on Environment and Development (Earth Summit) in Rio de Janeiro, Brazil, 179 governments adopted a plan of action which recognizes that "the growth of world population and production combined with unsustainable consumption patterns places increasingly severe stress on the life supporting capacities of our planet."[12]

World Population Clock, 1998

1998 Population (est.)		World 5.9 billion	United States 270 million
Births per:	Year	136,967,149	4,053,000
	Month	11,413,929	377,750
	Week	2,633,984	77,942
	Day	375,252	11,135
	Hour	15,636	463
	Minute	261	7.7
	Second	4.3	—
Deaths per:	Year	53,282,252	2,431,800
	Month	4,440,188	202,650
	Week	1,024,659	46,765
	Day	145,979	6,680
	Hour	6,082	278
	Minute	101	4.6
	Second	1.7	—
Natural Increase per:	Year	83,684,897	1,621,200*
	Month	16,973,741	175,100*
	Week	1,609,325	31,177*
	Day	229,274	4,455*
	Hour	9,553	185*
	Minute	159	3.1*
	Second	2.7	—*

These figures do not include net immigration, which is also a significant factor in U.S. population increase.

The U.N. International Conference on Population and Development (ICPD) in Cairo, Egypt, which followed two years later, expanded on many of the principles laid out in Rio. The plan of action developed at the Cairo conference states that early stabilization of world population would make a "crucial contribution" toward improving the lives of people around the planet.[13]

It only takes very small changes in **fertility rates** (the average number of children born to each woman) to make a big difference in when the population will stabilize, and how many people there will be when that happens. According to the United Nations, a drop in the average number of children a woman has in her lifetime by one child per woman could mean a difference of four billion people in the projected population for 2050![14]

Recent trends show that the population growth rate has begun to decrease, due at least in part to policies enacted or strengthened in response to the recommendations of the U.N. conferences. Programs that expand access to health care, education and family planning services, which enable women to choose the timing and number of their children, as well as those that have improved the status of women and employment opportunities, all work to lower fertility levels. In 1960, the average woman gave birth to more than five children. Today, the average woman gives birth to just over three children.

However, these positive indicators do not mean that rapid population growth no longer poses a threat to the world's people and resources. High growth rates in recent decades mean that almost one-third of the world's people are under age 15 and have not yet entered their child-bearing years.[15] This age structure means there is still potential for steady population increases and the need for international cooperation to continue successful programs. In order to achieve **zero population growth** (stable population) while maintaining low death rates, average births will need to total only about two children per woman worldwide in the years to come.

Endnotes

[1] 1997 *World Population Data Sheet,* Population Reference Bureau .

[2] *World Population Prospects, The 1996 Revision*. New York: United Nations, 1996.

[3] Joel E. Cohen. *How Many People Can the Earth Support*? New York: W.W. Norton and Co., 1995.

[4] Mathis Wackernagel and William Rees. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Canada: New Society Publishers, 1996.

[5] *1996 Human Development Report*, United Nations. Table 22: Natural Resources Balance Sheet. Figure is for 1993.

[6] Statistics on oil consumption for 1994 from *1996 World Development Report*, The World Bank. Table 8: Commercial Energy Use.

[7] Population estimates from the U.S. Census Bureau homepage, "International Database" www.census.gov/ipc/www/idbprint.html. Carbon Dioxide emission data is for 1992 found in op. cit. note 6.

[8] The World Resources Institute. *The 1993 Information Please Environmental Almanac*. Boston and New York: Houghton Mifflin, 1993.

[9] Alan T. Durning. *How Much is Enough? The Consumer Society and the Future of the Earth*. New York: W.W. Norton and Company, 1992.

[10] David Pimentel (panelist). "United States Carrying Capacity Overview," Carrying Capacity Network Conference. Washington, DC: 1993.

[11] The President's Council on Sustainable Development.*Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future*. Washington, DC: U.S. Government Printing Office, 1996.

[12] Agenda 21: United Nations Programme of Action from Rio, para. 5.3.

[13] Programme of Action adopted at the International Conference on Population and Development, Cairo, Egypt, 1994, paragraph 1.11.

[14] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. *World Population Projections to 2150*. New York: United Nations, 1998.

[15] Op. cit. note 1.

Lots of *Lemna*

Student Activity 1

Introduction:

When modeling exponential growth in the science classroom, it is useful to use living organisms whose growth can be easily measured. This activity uses a small, floating aquatic flowering plant of the genus *Lemna* (duckweed) to investigate geometric population growth. *Lemna* is small enough to have a sufficiently rapid reproduction rate yet large enough to be easily seen and counted. As individual *Lemna* leaves grow and enlarge, they break apart from the parent plant and form new plants. *Lemna* can reproduce and double its number in less than five days if the growing conditions are adequate. As *Lemna* grows and reproduces, it forms a population of floating plants on the surface of the water. Within three months, a definite J-curve can be obtained, and within five to six months, *Lemna* will entirely cover the surface of a 10-gallon aquarium with an estimated 10,000 individual plants.

Procedure:

Because of the time involved with this activity, it is necessary to start the lab five months prior to when the lesson on population is introduced.

1. Several days prior to the class period when the lesson is introduced to the students, set up the aquarium as follows: Prepare a 10-gallon aquarium with aged water aerated with a single pump. On the day you begin the activity with students, place 10 *Lemna* plants in the tank. *Lemna* can be field collected or purchased at a supply house. They often grow in aquaria at tropical fish shops. Leave the aquarium light on at all time. When water begins to evaporate from the tank, replace with aged tap water.
2. Let students know that they will be collecting data on the population growth of *Lemna*. You might like to have the class predict the reproduction rate and doubling time of *Lemna*.
3. You may wish to have the students study the *Lemna* plant under a microscope. Students can do background reading on the genus, investigating such information as the geographic range of *Lemna* and the best ecological conditions for growth.
4. Have students construct a data collection sheet in their notebooks with a column for the day recorded and one for population size. Explain how to collect and record the population size. Counting the number of plants should take only a few minutes every couple of days. The students will discover that for several days, no population increase will occur, and then within one day, the population will increase significantly. These “spurts” in reproduction are to be expected and represent important lessons in growth and development. After several months, the number of plants becomes too large to easily count. Try to get the students to devise a method of measurement that is appropriate for large numbers. One method is to:
   a) Calculate the surface area of the aquarium, (in sq. cm.).
   b) Average, from 10 samples, the number of *Lemna* plants per square cm.
   c) Estimate the percentage of the surface covered by the plants.
   d) Calculate the population size by multiplying a x b x c.

   At this point students should note on their data sheets the percentage of surface covered by the *Lemna*. Students who count on the same day may not have the same number of population sizes on their data sheets. Although students should be taught the importance of accurate data collection, the time that students count the number of plants will vary and small errors will be more common as the population size increases and as students estimate the population size with indirect measures.
5. After students have finished collecting data, (when the tank is full of *Lemna*) ask them to graph the results. The graph will be a typical geometric curve. Discuss with them the nature of the curve and how geometric growth is different from arithmetic growth. Perhaps you will want the students to predict future populations if the growth rate continues. What are the implications when population growth is “out of control?” If organisms follow a geometric growth curve, why isn’t the world hopelessly overpopulated with

Concept:
Populations grow exponentially in environments without limiting factors.

Objectives:
Students will be able to:
- Utilize direct and indirect methods for measuring population size.
- Conduct population measurements and plot results.
- Interpret a graph of population growth.
- Apply concepts of exponential growth to a theoretical example.

Subjects:
Biology, math, environmental science

Skills:
Collecting and recording data, analyzing and interpreting data, estimation, mathematical calculations, graphing

Method:
Students collect data on the geometric growth of a *Lemna* (duckweed) population and graph results. They then draw parallels between observed *Lemna* growth and human population growth.

Materials:
10 *Lemna* plants (duckweed)
10-gallon aquarium with water and aerator

Lots of Lemna

plants and animals? Why haven't most populations of organisms followed the J-curve? Why don't populations of natural organisms go out of control? Have the students identify natural factors which help control population sizes. What might limit *Lemna* growth in the wild, as in a pond?

Follow-up Activities:

Activity 1: A Human J-Curve

Students can now extend the concept of exponential growth into the area of human population growth. Copy the table below onto the chalkboard. Have the students graph human population growth. How does the human population graph compare to the *Lemna* population graph? What is the future for human populations? What decisions must be made? What are the implications of human population growth for future resource use, for disease control or for environmental quality?

World Population History

Year	Population (in millions)
1 A.D.	170
200	190
400	190
600	200
800	220
1000	265
1100	320
1200	360
1300	360
1400	350
1500	425
1600	545
1700	610
1750	760
1800	900
1850	1,211
1900	1,625
1950	2,515
2000*	6,080
2050*	9,400

**Projected*

Data: For 1 A.D. through 1975: The Atlas of World Population History *by C. McEvedy and R. Jones, New York: Penguin Books, 1978. For 1975 to 1959: Population Reference Bureau, 1875 Connecticut Avenue, N.W., Suite 520, Washington, D.C. 20009. For 2000 projection:* World Population Prospects, *The United Nations, 1994 revision, Middle Series. For 2050 Projection:* World Population Prospects, *The United Nations, 1996 Revision, Middle Series.*

Activity 2: Bacteria Bottles

This puzzle illustrates the concept of exponential growth using bacteria. Invite students to try it on friends and family.

Bacteria multiply by division. One bacterium becomes two. Then two divide into four; the four divide into eight, and so on. For a certain strain of bacteria, the time for this division process is one minute. If you put one bacterium in a bottle at 11:00 p.m., by midnight the entire bottle will be full.

1. When would the bottle be half-full? How do you know?
   The bottle was half full at 11:59 p.m. because the doubling time is one minute and the bottle was full at midnight.
2. Suppose you could be a bacterium in this bottle. At what time would you first realize that you were running out of space?
   Answers will vary. To clarify, ask students: "At 11:55 p.m., when the bottle was only 3% full and 97% empty, would it be easy to perceive that there was a space problem?"
3. Suppose that at 11:58 some bacteria realize that they are running out of space in the bottle. So they launch a search for new bottles. They look far and wide. Finally, offshore in the Arctic Ocean, they find three new empty bottles. Great sighs of relief come from all the bacteria. This is three times the number of bottles they've known. Surely, they think, their space problems are over. Is that so? Explain why the bacteria are still in trouble. Since their space resources have quadrupled, how long can their growth continue?
   With space resources quadrupled, the bacteria have two more doubling times, or two minutes before they will run out of space.
   11:58 p.m.: Bottle 1 is one-quarter full.
   11:59 p.m.: Bottle 1 is half-full.
   12:00 a.m.: Bottle 1 is full.
   12:01 a.m.: Bottles 1 and 2 are full.
   12:02 a.m.: Bottles 1, 2, 3 and 4 are all full.
4. Does what you have learned about bacteria suggest something about human population growth?

Adapted by permission from the National Association of Biology Teachers. The original activity, "Using Lemna to Study Geometric Population Growth" by Larry DeBuhr, appears in The American Biology Teacher*, Vol. 53, No. 4, April 1991, pp. 229-232.*

Toss of the Dice

Student Activity 2

Introduction:

Population, non-renewable resource consumption, food production, industrial output and pollution generation have all been increasing exponentially. To understand the resource and environmental crises, one must understand exponential growth. This lab is designed to give that understanding, while illustrating three models of population growth.

Procedure:

In this experiment, students will use dice to model population growth. Each die represents a person. Each throw represents a year. A *3* or a *6* represents the birth of a child, so each time one of them comes up, add a die to the population. If a *1* comes up, a death has occurred, so remove that die from the population. Hence, you are modeling a situation where the birth rate is twice the death rate. You also have a population growth rate of 1/6 or about 17 percent.

Have students follow these instructions:

Part A: Unrestricted Exponential Growth

Put ten ordinary dice into a container (Adam, Eve, Cain, Abel, Sally, Alice, Dick, Jane, Bob and Sue). Shake the container and dump the contents out onto a smooth, hard floor. Remove and count all the *1*'s that appear. A *1* is analogous to a death. Record the number of deaths on the chart for Part A. Count up all the *3*'s and *6*'s that appear. Since they correspond to births, add a die to the container for each of them. Then fill in the required information in the chart. Repeat the above procedure until the total population exceeds 500 people. When the population grows beyond the number of dice or cubes that you have available, either roll twice or double your results.

Part B: The Effect of Instituting a Limited Family Planning Program

Return to the year where your population was almost 100 people. Put that many dice into the container. But now introduce a limited birth control program. This will be modeled by saying that a *3* represents a birth, as before, and so does every other *6*. However, the remaining half of the *6*'s represent women who use contraceptives (or whose male partner uses contraceptives) and so a birth has been prevented. If an odd number of *6*'s comes up, round off in favor of a birth half of the time, and in favor of a prevented birth in the half of the cases. Model this situation, from where you start, for 12 throws of the dice. You have essentially cut the population growth rate from 17 percent to 8 percent.

Part C: The Zero Population Growth Plan

Again return to the year where your population was almost 100 people. Put that many dice into the container. But now introduce a large scale family planning program. This will be modeled by saying that all *6*'s represent women using effective contraceptives or women whose male partners use effective contraceptives. Hence, a *1* represents a death, a *3* represents a birth, and a *6* represents a prevented birth. Model this situation from where you start for twelve throws of the dice.

Part D: World Population Trends

See page 8 for a listing of estimates of world population from 1 A.D. to 2050. Figures such as these are compiled by the United Nations and are published in most almanacs.

Concept:
Within the last two centuries, human population growth has increased exponentially. The absence of widespread family planning contributes to the geometric growth of human populations.

Objectives:
Students will be able to:
- Model population growth using dice.
- Understand exponential growth.
- Compare and contrast three different population growth models.

Subjects:
Math, biology, environmental science

Skills:
Mathematical calculations, interpreting data

Method:
Students roll dice to model exponential growth, as well as two other population growth models.

Materials:
200-300 dice (or wood or sugar cubes with different colored sides)

2 large, open-ended container (e.g., coffee can, milk carton, etc.)

Copies of Student Worksheet

Graph paper

Note: Dice can be purchased at game stores. *The Growth Model*, including 250 dice, can be purchased for $42.00 from Scott Resources, P.O. Box 2121, Fort Collins, CO 80522; (800) 289-9299.

Toss of the Dice

Student Worksheet

Part A: Unrestricted Exponential Growth

Throw No. (Year)	Number of Births	Number of Deaths (Population)	Number of Dice	Population Growth Rate
0	—	—	10	—
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Toss of the Dice

Student Worksheet

Part B: The Effect of Instituting a Limited Family Planning Program

Throw No. (Year)	Number of Births	Number of Deaths (Population)	Number of Dice	Population Growth Rate

Part C: The Zero Population Growth Program

Throw No. (Year)	Number of Births	Number of Deaths (Population)	Number of Dice	Population Growth Rate

Power of the Pyramids

Student Activity 3

Concept:
The age and gender distribution of a regional or national population affects its growth rate.

Objectives:
Students will be able to:
- Calculate percentages using raw numbers for each age/gender group in a given population.
- Construct a population age/gender distribution graph for one of six different countries.
- Make correlations between the shapes of the graphs and the coutries' different growth patterns.

Subjects:
Math, biology, social studies, environmental science

Skills:
Calculating, graphing, analyzing and interpreting data

Method:
Students construct and interpret population pyramids and discuss differences in population growth rates among several different countries.

Materials:
Student Worksheets (one per student)
Graph paper
Colored pencils
Ruler
Calculator

Introduction:

To help them make population projections for different countries, demographers look at the profile of the countries' residents. What are the ages of the people? How many are men? How many are women? Taking this information, they construct **population pyramids** like the ones students will create in this activity. These graphs depict the configuration of a country's population as impacted by 70 to 80 years of economic, political and natural events. These graphs can also help predict future population trends.

Procedure:

1. Display the sample world population pyramid and explain that this is a kind of graph used by demographers to study the distribution of people across age categories.
2. Assign each student or group of students one of the six countries and distribute graph paper and a copy of the student worksheet for that country.
3. The figures on the worksheet represent the population (in thousands) of each age group within each gender for each particular country. In order to construct the country's pyramid, students must first calculate the percentage of the population in each gender in each age group.

   Example: According to the worksheet, the United States' total population in 1995 was 263,119,000. The population of males ages 0-4 was 10,515,000.

   $$\frac{10{,}515{,}000}{263{,}119{,}000} = .04 \text{ or } 4\%$$

   Students should complete these calculations for each **cohort** (age group).
4. Using graph paper, students can construct a population pyramid as in the example. A line drawn down the middle of the graph separates the male and female populations. The percentages of the population will be plotted along the X-axis — females to the right, males to the left of the center line. The age groups will be running up the Y-axis with the youngest at the bottom, oldest at the top. (See "World Population Pyramid" sample.) Note: Make sure the scale on the X-axis goes up to 9% in each direction to encompass everyone's data.
5. Have students graph the percentage data for their assigned country.
6. Have students hold up their finished graphs for all to see while going through the follow-up questions in class.

Discussion Questions:

1. Where are you represented on the tables and on the graphs?

   If you live in the United States and were between 10 and 15 years old in 1995 you are represented on line 3 in the U.S. data under either male or female. On the graph you and your cohorts made up the percentage presented by the third bar from the bottom, males on the left, females on the right.
2. Can you tell from the data if there are more male or female babies in each country?

   Yes, there are more male babies. There is a slightly greater probability of giving birth to male children. For every 100 girls born, there are about 105 boys born.
3. Are there more elderly women or men? Why might that be the case?

   There are more elderly women. Throughout the world, life expectancy for women is higher than for men. This is due to a number of genetic and social factors. In general, men are more predisposed to certain health risks than women. Also, men make up the vast majority of the military, and are more likely to die during wars.
4. Can you tell from the graphs which country has the most people?

   No. The graphs represent 100 percent of the population of each country broken down by age groups. Demographers use the percentage data instead of the raw data so that each graph fits on the same size paper and can be compared to the graphs of other countries.
5. Which country has the most people? How can you tell?

   From the TOTAL line on the data sheet you can tell that China has more people than any other country.
6. Of the six graphs, which two look most like pyramids? What does that indicate about their population growth rates? What factors would change the shape of the pyramids in the future?

The graphs for Kenya and Brazil look most like pyramids. This indicates a high growth rate. Population growth occurs when the segment of the population currently in its childbearing years (ages 15-44; bars 4-9 on the graphs) has produced a generation larger than itself (bars 1-3). If the birth rate goes down, this would change the shape of the graph over time from a pyramid to more of a rectangle, indicating a more stable population.

7. Looking at the pyramids, which countries appear to have the slowest rates of population growth? How can you tell?

   Austria and Japan. The graphs are closer to rectangles than pyramids, showing more uniform population size across the age groups.

8. Which are the largest age groups in the U.S.?

   People aged 30-50 (in 1995) made up the biggest portion of the United States, with babies a close second. The people who were born between 1946 to 1964 are called "Babyboomers," and were born shortly after World War II, when many husbands and wives were reunited, and the country experienced greater economic prosperity than it did during the years of the Great Depression and the war. Couples felt confident of their ability to support families, and the birth rate soared as a result.

9. In which country do children make up the largest percentage of the population?

   You can see on the graph that the bottom of the Kenyan and the Brazilian pyramids go out the farthest, representing the largest percentage. The percentages that you calculated show that Kenyan babies (males and females combined) make up about 16% (8 + 8) of the population and the older children also make up a big percentage.

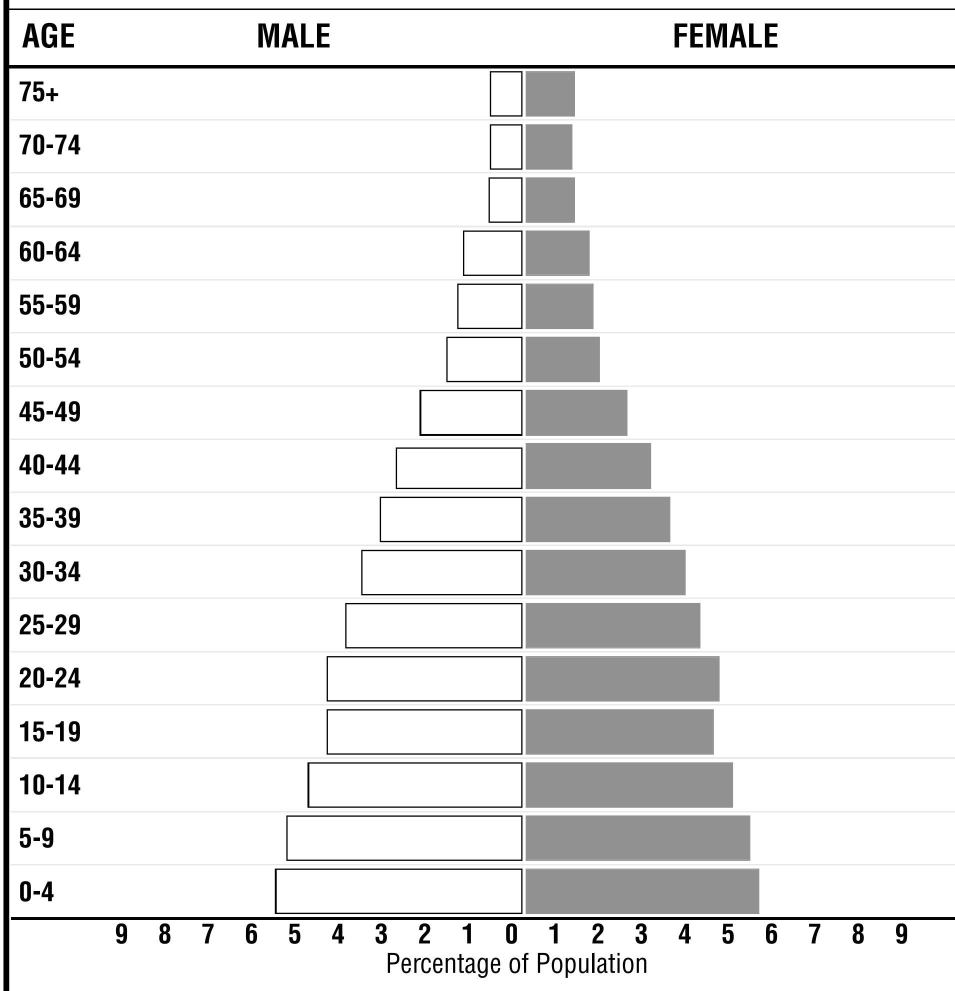
10. If you had a business and wanted to capitalize on your information about the population age distribution for the U.S. what would you sell?

    Answers might include any products for people of the Baby Boom generation or their children.

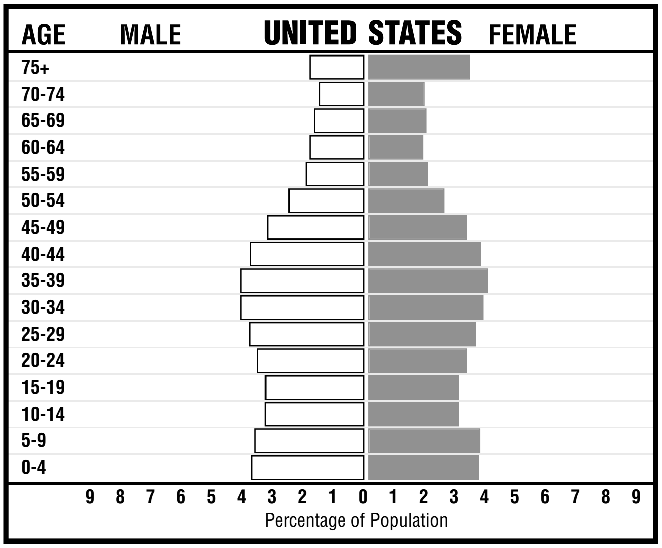
11. If you had a business in Kenya and wanted to capitalize on your information about the Kenyan population, what would you sell?

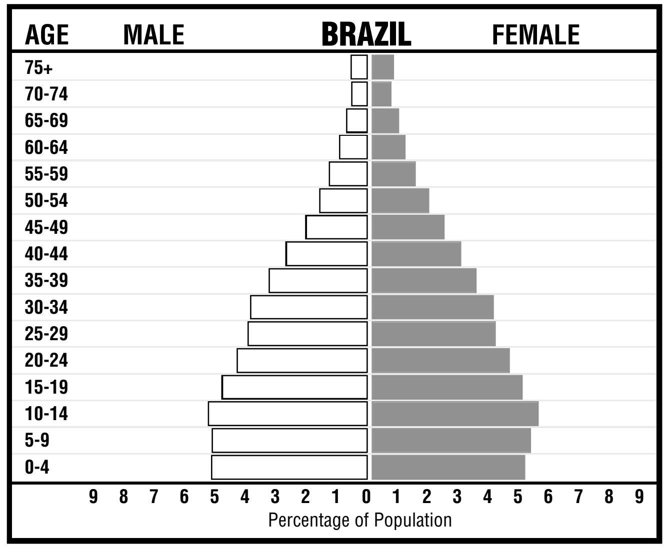
    Answers might include any products for children and infants.

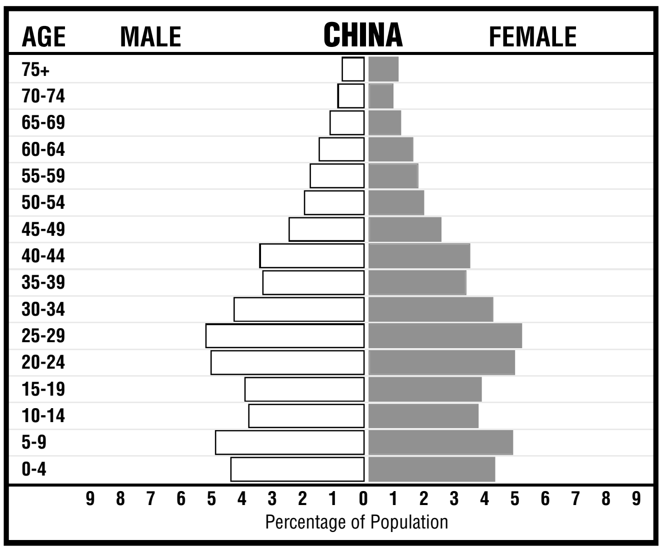
World Population Pyramid, 1995

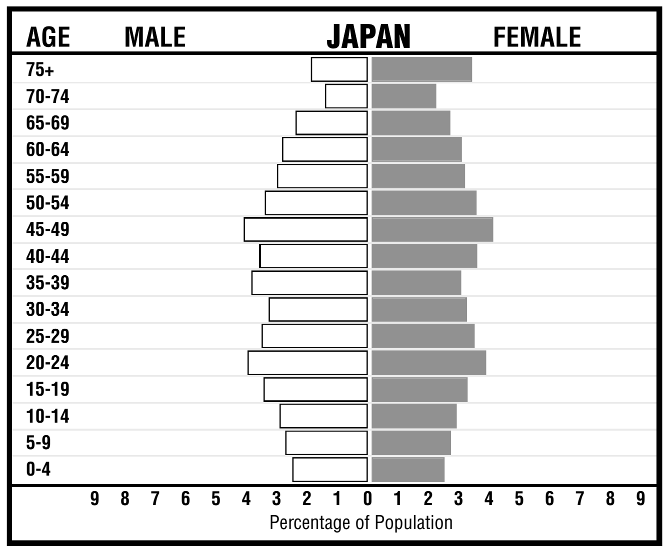


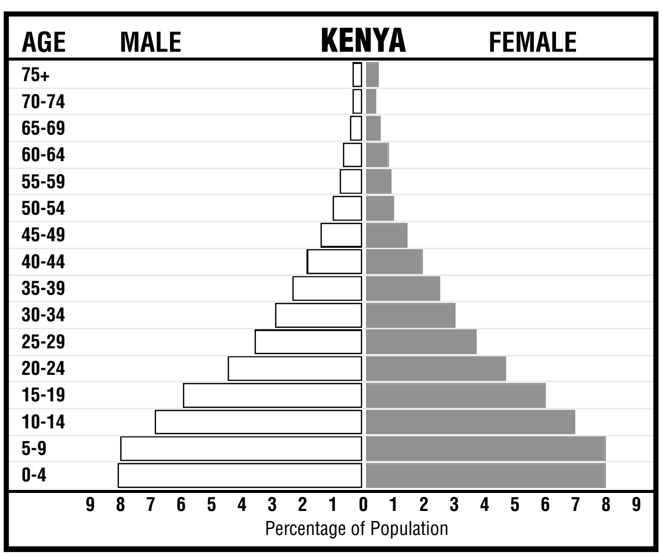
Sample Pyramids

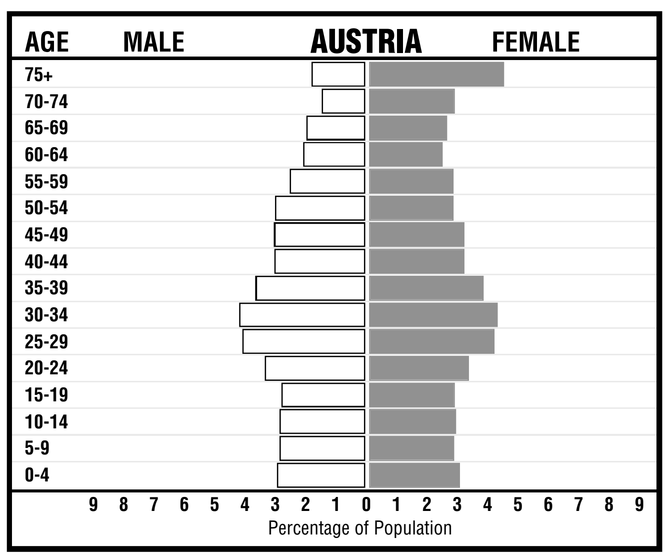












Power of the Pyramids

Student Worksheet 1

Population in Thousands (1995)

Age Group	United States M	%	United States F	%	Brazil M	%	Brazil F	%	China M	%	China F	%
0-4	10,015		10,009		8,643		8,256		55,642		51,073	
5-9	9,610		9,147		8,787		8,625		59,714		57,549	
10-14	9,445		8,982		8,874		8,800		47,233		43,974	
15-19	8,939		8,500		8,114		8,095		49,232		46,016	
20-24	9,366		8,906		7,354		7,387		62,779		58,952	
25-29	10,006		9,639		6,839		6,857		65,023		60,822	
30-34	10,990		10,848		6,652		6,690		54,417		50,205	
35-39	11,096		11,140		5,638		5,716		43,295		39,874	
40-44	10,031		10,137		4,723		4,826		44,159		41,285	
45-49	8,717		8,934		3,754		3,847		32,604		29,614	
50-54	6,739		7,026		2,911		3,005		25,235		22,416	
55-59	5,361		5,761		2,437		2,560		22,969		20,490	
60-64	4,771		5,369		1,923		2,070		20,212		18,662	
65-69	4,509		5,439		1,529		1,694		15,533		14,943	
70-74	3,876		5,173		1,060		1,224		10,807		11,324	
75+	5,043		9,097		1,083		1,373		10,272		13,007	
Total	129,012		134,107		80,319		81,055		619,126		580,206	
Total	263,119				161,374				1,199,332			

Source: The World Bank, World Population Projections 1994-95 Edition. *(Baltimore: The Johns Hopkins University Press, 1994).*

Power of the Pyramids

Student Worksheet 2

Population in Thousands (1995)												
	Japan				Kenya				Austria			
Age Group	M	%	F	%	M	%	F	%	M	%	F	%
0-4	3,224		3,074		2,249		2,214		249		236	
5-9	3,491		3,330		2,232		2,219		237		224	
10-14	3,809		3,622		1,928		1,919		242		232	
15-19	4,359		4,141		1,655		1,656		233		221	
20-24	5,116		4,868		1,290		1,296		279		267	
25-29	4,558		4,351		1,016		1,024		346		332	
30-34	4,123		4,006		820		828		354		346	
35-39	4,904		3,843		654		665		306		305	
40-44	4,494		4,450		517		531		259		258	
45-49	5,286		5,264		380		396		254		252	
50-54	4,401		4,490		265		282		253		227	
55-59	3,877		4,024		233		255		215		222	
60-64	3,608		3,839		205		225		178		195	
65-69	2,985		3,365		152		169		166		209	
70-74	1,920		2,722		105		117		127		226	
75+	2,433		4,236		112		146		151		352	
Total	61,587		62,626		13,811		13,940		3,849		4,133	
Total	125,213				27,751				7,981			

Source: The World Bank, World Population Projections 1994-95 Edition. *(Baltimore: The Johns Hopkins University Press, 1994).*

Power of the Pyramids

Answers to Student Worksheet 1

Population in Thousands (1995)												
	United States				Brazil				China			
Age Group	M	%	F	%	M	%	F	%	M	%	F	%
0-4	10,015	3.8	10,009	3.8	8,643	5.4	8,256	5.1	55,642	4.6	51,073	4.3
5-9	9,610	3.7	9,147	3.5	8,787	5.4	8,625	5.3	59,714	5.0	57,549	4.8
10-14	9,445	3.6	8,982	3.4	8,874	5.5	8,800	5.5	47,233	4.0	43,974	3.7
15-19	8,939	3.4	8,500	3.2	8,114	5.0	8,095	5.0	49,232	4.1	46,016	3.8
20-24	9,366	3.6	8,906	3.4	7,354	4.6	7,387	4.6	62,779	5.2	58,952	4.9
25-29	10,006	3.8	9,639	3.7	6,839	4.2	6,857	4.2	65,023	5.4	60,822	5.1
30-34	10,990	4.2	10,848	4.1	6,652	4.1	6,690	4.1	54,417	4.5	50,205	4.2
35-39	11,096	4.2	11,140	4.2	5,638	3.5	5,716	3.5	43,295	3.6	39,874	3.3
40-44	10,031	3.8	10,137	3.9	4,723	2.9	4,826	3.0	44,159	3.7	41,285	3.4
45-49	8,717	3.3	8,934	3.4	3,754	2.3	3,847	2.4	32,604	2.7	29,614	2.5
50-54	6,739	2.6	7,026	2.7	2,911	1.8	3,005	1.9	25,235	2.1	22,416	1.9
55-59	5,361	2.0	5,761	2.2	2,437	1.5	2,560	1.6	22,969	1.9	20,490	1.7
60-64	4,771	1.8	5,369	2.0	1,923	1.2	2,070	1.3	20,212	1.7	18,662	1.6
65-69	4,509	1.7	5,439	2.1	1,529	0.9	1,694	1.1	15,533	1.3	14,943	1.2
70-74	3,876	1.5	5,173	2.0	1,060	0.7	1,224	0.8	10,807	1.0	11,324	0.9
75+	5,043	1.9	9,097	3.5	1,083	0.7	1,373	0.9	10,272	0.9	13,007	1.1
Total	129,012	49	134,107	51	80,319	50	81,055	50	619,126	52	580,206	48
Total	263,119				161,374				1,199,332			

Source: The World Bank, World Population Projections 1994-95 Edition. *(Baltimore: The Johns Hopkins University Press, 1994).*

Power of the Pyramids

Answers to Student Worksheet 2

Population in Thousands (1995)

Age Group	Japan M	Japan %	Japan F	Japan %	Kenya M	Kenya %	Kenya F	Kenya %	Austria M	Austria %	Austria F	Austria %
0-4	3,224	2.6	3,074	2.5	2,249	8.1	2,214	8.0	249	3.1	236	3.0
5-9	3,491	2.8	3,330	2.7	2,232	8.0	2,219	8.0	237	3.0	224	2.8
10-14	3,809	3.0	3,622	2.9	1,928	6.9	1,919	6.9	242	3.0	232	2.9
15-19	4,359	3.5	4,141	3.3	1,655	6.0	1,656	6.0	233	2.9	221	2.8
20-24	5,116	4.1	4,868	3.9	1,290	4.6	1,296	4.7	279	3.5	267	3.3
25-29	4,558	3.6	4,351	3.5	1,016	3.7	1,024	3.7	346	4.3	332	4.2
30-34	4,123	3.3	4,006	3.2	820	3.0	828	3.0	354	4.4	346	4.3
35-39	4,904	3.9	3,843	3.1	654	2.4	665	2.4	306	3.8	305	3.8
40-44	4,494	3.6	4,450	3.6	517	1.9	531	1.9	259	3.2	258	3.2
45-49	5,286	4.2	5,264	4.2	380	1.4	396	1.4	254	3.2	252	3.2
50-54	4,401	3.5	4,490	3.6	265	1.0	282	1.0	253	3.2	227	2.8
55-59	3,877	3.1	4,024	3.2	233	0.8	255	0.9	215	2.7	222	2.8
60-64	3,608	2.9	3,839	3.1	205	0.7	225	0.8	178	2.2	195	2.4
65-69	2,985	2.4	3,365	2.7	152	0.5	169	0.6	166	2.1	209	2.6
70-74	1,920	1.5	2,722	2.2	105	0.4	117	0.4	127	1.6	226	2.8
75+	2,433	1.9	4,236	3.4	112	0.4	146	0.5	151	1.9	352	4.4
Total	61,587	49*	62,626	50*	13,811	50	13,940	50	3,849	48	4,133	52
Total	125,213				27,751				7,981			

Source: The World Bank, World Population Projections 1994-95 Edition. (Baltimore: The Johns Hopkins University Press, 1994). *Due to rounding, Japan's male and female percentages do not add up to 100%.

Demographic Facts of Life

Student Activity 4

Introduction:

Birth and death rates determine the rate of population growth. If the birth and death rates are similar, a population experiences little or no growth. When the birth rate far exceeds the death rate, the population soars. These rates are expressed as the number of births or deaths for every 1,000 people in a given year. For instance, in 1998 the world's birth rate was 23 per 1,000 and the death rate was 9 per 1,000. Using the formulas below, we can determine the world's annual growth rate and the number of years it will take the population to double if the growth rate remains constant.

$$\text{\% annual natural increase} = \frac{\text{birth rate} - \text{death rate}}{10}$$

$$\frac{23 - 9}{10} = 1.4\ \%$$

$$\text{doubling time (in years)} = \frac{70}{\text{rate of increase}}$$

$$\frac{70}{1.5} = 49 \text{ years}$$

(Note: 70 is the approximate equivalent of 100 times the natural log of 2.)

Procedure:

Part 1: On the Double

Distribute copies of the *Student Worksheet 1* and have students complete the table.

Answers to table on Student Worksheet 1

Country	Percent annual natural increase	Doubling time (years)
Brazil	1.4	50
Canada	0.5	140
China	1.0	70
India	1.8	39
Italy	0.0	No doubling
Japan	0.3	233
Mexico	2.2	32
Nigeria	3.0	23
Russia	-0.5	No doubling
U.S.	0.6	116
U.K.	0.2	350

Discussion:

1. Why do you think some countries are doubling much more rapidly than others? Why do you think some countries, such as Italy, have reached **zero population growth** (z.p.g.)?

   The doubling time is shorter in countries where the rate of growth is higher. The greater the difference between the birth rate and the death rate, the faster the population growth. Many European counties, such as Italy, have reached zero population growth because their birth and death rates are about the same.

2. Which figures differ most greatly between countries, the birth rates or the death rates? How would you explain the wide disparity in birth rates among different countries? Why are the death rates relatively low in many of the countries with high birth rates?

   The birth rates differ greatly due to differences in average family size. Death rates are relatively low in many of the countries with high birth rates because the majority of the population is young. In Kenya, for instance, 46 percent of the population is under age 15, and only three percent is age 65 or older.

3. If you were a national leader in Kenya or Iraq, would you be concerned about the rapid population growth? Why or why not? Similarly, if you were a national leader in Italy, would you be concerned that your country has reached z.p.g.? Why or why not?

   Yes. As a national leader of Kenya, you would be responsible for seeing that there are sufficient services for the expanding population such as homes, roads, jobs, health care, etc. You would find it difficult for your country to prosper in the world market, if it cannot meet the needs of its own people. As a national leader of Italy, you would not be faced with these problems and could plan for your nation's future progress.

4. The population of the United States is actually growing at the rate of about one percent each year, more than its rate of natural increase. Where is the additional population growth coming from?

Concept:
The discrepancy between a population's birth and death rates determines rate of growth. Our rapid growth rate means that even the deaths from large-scale disasters have little effect on our population size.

Objectives:
Students will be able to:
- Describe how birth and death rates affect population growth.
- Calculate rates of population growth given birth and death rates.
- Calculate doubling time at the given rate of increase.
- Draw connections between population growth and social/political and economic conditions.
- Calculate population increase per unit of time, given rate of increase.

Subjects:
Math, biology, environmental science, social studies

Skills:
Collecting, analyzing and interpreting data, math calculations

Method:
Students calculate the rate of natural increase and corresponding doubling times for several countries and discuss differences. Students also calculate the time it has taken for the world to replace the number of people lost in historic disasters.

Materials:
Copies of Student Worksheet
Calculator

Demographic Facts of Life

Student Activity 4

Immigration accounts for roughly 30 percent of population growth in the United States. In recent years, the greatest number of new Americans have come from the following countries: Mexico, Philippines, Vietnam, India, Dominican Republic, and China (mainland).

Part 2: Grim Reaper's Revenge

We are currently adding 84 million people (net growth) to the world each year, or 229,000 people each day. Conveying the importance of such figures to students can be difficult since the numbers are so large they lose their meaning. The table in *Student Worksheet 2* makes these numbers more concrete by illustrating that the numbers of people lost in history's major disasters are currently being replaced in a matter of days or weeks.

Have students complete the table in *Student Worksheet 2*.

Answers to table on Student Worksheet 2

Disaster	Replacement time
All U.S. accident deaths, 1995	9.8 hours
Bangladeshi Cyclone, 1991	14.7 hours
Total American deaths in all wars	2.6 days
Great flood, Hwang Ho River, 1887	3.9 days
Total U.S. automobile deaths through 1995	1.8 weeks
Indian famine, 1769-70	1.9 weeks
Total AIDS dead through 1996	4.0 weeks
Chinese famine, 1877-78	5.9 weeks
Influenza epidemic, 1918	3 months
Global deaths in all wars, past 500 years	5 months
Bubonic plague, 1347-51	10.8 months

Demographic Facts of Life

Student Worksheet 1

On the Double

Using the table below, determine the percentage of annual increase and the population doubling times for the following countries.

$$\% \text{ annual natural increase} = \frac{\text{birth rate - death rate}}{10}$$

$$\text{doubling time (in years)} = \frac{70}{\text{rate of increase}}$$

Country	Birth Rate in 1998 (per 1,000 people)	Death Rate in 1998 (per 1,000 people)	% Annual Natural Increase	Doubling Time (Years)
China	17	7		
India	29	10		
Iraq	38	10		
Italy	9	9		
Japan	10	7		
Kenya	38	12		
Mexico	27	5		
Russia	9	14		
South Africa	27	12		
United Kingdom	13	11		
United States	15	9		

Birth and death rates obtained from the 1998 World Population Data Sheet: Demographic Data and Estimates for the Countries and Regions of the World *(1998, Population Reference Bureau, Washington, DC).*

Demographic Facts of Life

Student Worksheet 2

Grim Reaper's Revenge

We are currently adding 84 million people (net growth) to the world's population each year. This means we are adding 229,000 people each day. Even the deaths from large-scale disasters have little effect on a population growing so rapidly. Below is a listing of some of the world's worst disasters, along with an approximate death toll. At today's present rate of growth, determine how many days, weeks or months it would take to replace those lost. Round off to one decimal place.

Some past disasters	Approximate # of deaths	Present world population growth replaces this # in approximately what time span?
All U.S. accident deaths, 1995	93,300	
Bangladeshi cyclone, 1991	140,000	
Total American deaths in all wars	600,000	
Great flood, Hwang Ho River, 1887	900,000	
Total U.S. automobile deaths through 1995	2,600,000	
India famine, 1769-70	3,000,000	
Total AIDS dead through 1996	6,400,000	
China famine, 1877-78	9,500,000	
Influenza epidemic, 1918	21,000,000	
Global deaths in all wars in the past 500 years	35,000,000	
Bubonic plague, 1347-51	75,000,000	

Casualty figures obtained from the 1998 World Almanac and Book of Facts *(Mahwah, NJ: K-III Reference Corp., 1997),* 1998 Information Please Almanac *(New York: Houghton Mifflin Company, 1997),*

Population Scavenger Hunt

Student Activity 5

Introduction:

This scavenger hunt encourages students to further investigate many of the concepts introduced in this curriculum. We recommend that you give students time to gather a variety of items from the list, anywhere from a week to a month. Ideally this would be a good activity to have running during the duration of a unit on population.

Procedure:

Students can work individually or in groups to collect as many items as possible on this list. Since some items involve more work than others, points are assigned to designate degree of difficulty.

1. Collect 3 newspaper clippings about an environmental or social problem that relates to overpopulation. Write a summary of each article, explaining the link to population growth. *8 points (1 extra point for each additional article, up to 5).*
2. Make a poster showing the many effects (environmental, economic, social, etc.) of more people. *5 points.*
3. Watch a news show or special program discussing population, the environment, hunger, or poverty. Write a brief summary of the show, stating at least 5 new facts you learned about the issue. *5 points.*
4. Write an article about population growth and its effects and submit it to the school or community paper. (Or write a letter to your Congressional representatives, telling them how you feel about the issue). *10 points.*
5. Write a public service announcement about the environmental health risks of ozone layer depletion. *4 points. (5 extra points for performing it in front of the class or 10 extra for making a video of the announcement).*
6. Make a map of North America depicting areas where the effects of acid rain have been chronicled. *4 points.*
7. Graph world temperatures as far back as you can. Write a paragraph explaining the phenomenon of global warming and whether the trend appears on your graph. *5 points.*
8. Contact the Environmental Protection Agency, or the equivalent state, provincial or local agency, about whether your city meets the national standards set for air pollution. Report your findings in writing. *5 points.*
9. Using pH paper, test a local lake, stream and drinking water for acidity levels. Turn in the pH paper and an explanation of its meaning. *10 points.*
10. Research the amount of arable land in the world. Using a map, designate the areas with fertile land. *5 points.*
11. Organize a canned food drive to help feed the hungry in your area. Record the number of cans collected and the group which received the food. *20 points.*
12. Chart your personal diet for a week. Put a star next to all of the items which came from the top of the food chain. Circle all of those you could have substituted with something lower on the food chain and write the substitution. *10 points.*
13. Make a collage or mobile using pictures or photographs of the rainforests. *6 points.*
14. Make snack food using mostly rainforest products (include your recipe). *5 points.*
15. Plant a tree in your community. *10 points (10 extra points for organizing an event where a group goes to plant trees on a certain day).*
16. Find out rates of deforestation and reforestation in the United States. Chart or graph these rates and superimpose a population growth chart for the United States. *10 points.*
17. Monitor your household waste generation for a week. Chart your findings, including a list of the items most frequently found in your garbage can. Put a star next to those that could be recycled or composted. *10 points.*
18. Research home composting, and then start a compost pile at home. Take photographs of the system and include a written description of the progress of the compost. *20 points.*

Concept:
Population pressures affect nearly every environmental and social concern facing humankind.

Objectives:
Varies according to each of 35 tasks

Subjects:
All

Skills:
Research, creative and persuasive writing, drawing/painting, organizing

Method:
Students complete a wide variety of activities which illustrate the many areas involved with population, the environment and social issues.

Materials:
Varies according to each of 35 tasks

Population Scavenger Hunt

Student Activity 5

19. Make a poster showing various recyclable items and then the new materials they become after recycling. *6 points*.
20. Create a list of ways to reuse the following items: a shoe box, an unmatched sock, a coffee can and/or lid, a toilet paper tube, a milk carton. *1 point for every 3 ideas*.
21. Write an investigative report about the Chinook salmon (or another threatened species), explaining how human habits have contributed to the species' decrease in numbers. *10 points*.
22. Visit the zoo nearest you and record which animals are considered endangered. If possible, record how many are estimated to be in existence in the wild and in captivity. *10 points (1 extra point for each drawing or written description of the animals)*.
23. Develop a campaign to save an endangered species of your choice. Design posters, buttons, bumper stickers, etc. *5 points*.
24. Design a house dependent only on alternative energy (no fossil fuels). *8 points*.
25. Make a graph showing the per capita energy use of six different countries (3 industrialized countries and 3 less developed countries). *5 points*.
26. Do an energy audit on your home. A local power company may be of assistance. Check the meter and bills to determine how much energy your family uses. *5 points*.
27. Get to school without depending on a motorized vehicle. *1 point for each day*.
28. Research the latest technology for non-fossil fuel powered cars. Make a chart showing the advantages and disadvantages of each. *8 points*.
29. Chart how your country spends money to help the poor in your country. *5 points (3 extra points for also charting local money spent)*.
30. Find out the number of homeless or unemployed in your community. Explain how you found this information. *5 points*.
31. Make a chart or diagram illustrating how poverty can affect the environment. *5 points*.
32. Interview a woman from a less developed country. Write a report based on her observations of the differences between the role of women in the U.S. or Canada and her home country. *10 points*.
33. Conduct a survey in your community to determine the average family size. Graph your results. *10 points*.
34. Conduct a survey among classmates to determine how many children, on average, they wish to have. Chart the results. *5 points*.
35. Make up your own activity related to population growth and its environmental and social effects. *Points will be determined by the teacher*.