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ABSTRACT

This collection of lessons and class activities covers two major concepts: (1) population growth and (2) genetic engineering. Lessons consist of readings, questions and answers, and problems of projects where appropriate. Issues are posed in as much as possible in a manner intended to cause the student to reach conclusions and values without being directed to specific answers. (Author/RE)

BIOMEDICAL SOCIAL SCIENCE

UNIT VI

POPULATION GROWTH AND GENETIC ENGINEERING

STUDENT TEXT

REVISED VERSION, 1977

THE BIOMEDICAL INTERDISCIPLINARY CURRICULUM PROJECT

SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION

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pulation growth.

he second topic is genetic engineering. The science of genetics is progressing idly that it might soon be possible for the human species to change its own c nature, and some people believe that this should not be allowed to happen.

oth these topics are closely related to the content of Biomedical Science Unit ch is about reproduction and genetics. However, in Science the emphasis is on ical processes, and in Social Science the emphasis is on social processes. he viewpoint of Science, reproductive and genetic processes are important be- they keep the human species alive. From the viewpoint of Social Science, human uction and the science and technology of genetics are important primarily be- they might, within your lifetime, make human life as we know it impossible.

n Science, the questions to be answered are about the events--most of them copic in scale--that make it possible for human life to continue from gener- to generation. These questions can be answered by observation and scientific ment.

n Social Science, however, the questions are different. Most of them are not ons about the way things are, but questions about the way things should be: rge should the human population be? Should its size be controlled? If so, how it be controlled? What should the genetic nature of the human population be? people manipulate the genetic material of other people's cells to change human ? If so, how should human nature be changed? And if the interest of an indi- conflicts with the interest of a society or the survival of the human species, is more important? Should individual rights be violated in the interest of the society or the race? If so, which rights may be violated and which rights t be violated? How should these questions be answered in a democratically gov- society?

n summa most of the material in this unit consists of questions, not answers; st of t estions are value questions, not empirical questions. This unit is ed to he you learn how to seek answers to these value questions--not the an- chat we, the developers of the Biomedical Curriculum, believe are right, and not swers that any particular group of professors, politicians, religious teachers iness leaders think are right, but the answers that you, as a citizen in a self- ing nation, believe to be consistent with your own value principles.

any of the readings in this Student text present answers that individuals, and governments have put forward in response to value questions about popula- rowth and genetic engineering. Many of the readings contradict one another, e they represent the views of writers who have different value principles. We ncluded these readings not to confuse you, but to show you the range of answers thers have offered in response to these questions. The objective of this unit to get you to remember all these conflicting answers, but to help you find the s that you believe are right.

s you read in this Student Text, keep a sharp eye out for value statements. er that, when an author says, "People shoud..." or "People should not...," you have the right to ask, "Why?" When an author states a value principle, you have the right to disagree. And, finally, when an author states a value ques- the right answer is always the one that agrees with your own value principles.

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FILLING UP THE COMMONS

The population of any species is limited by the amounts of space and food available to it and by the ability of its environment to absorb and disperse its wastes so that they do not start killing off the population. The human population is no exception.

The space available to the human population on earth is limited. So is the amount of food that can be produced on the earth. And so is the amount of environmental pollution that can enter the earth's ecosystem without killing large numbers of the people.

Since the earth is limited, the human population is limited. It may not have reached its limit yet, but if it keeps growing it is bound to reach its limit eventually. Sooner or later, the human population will have to stop growing.

How many people should there be on the earth? This is a value question, and there are many possible answers. One is, "As many as it will hold." If the human population were allowed to grow to the maximum size that the earth can support, what would life be like? People would have just enough food to keep them alive and reproducing; there would be no "excess" calories to fuel human pursuits such as science, sports,music, education, literature or art. There would be no excess space, either: every available patch of useful ground would be used to provide the bare necessities of survival. And the ecosystem would be loaded with poisons until it was almost--but not quite--poisonous enough to wipe us out.

If we wanted to prevent this from happening--if we wanted to stop the growth of the human population before it reached the maximum that the earth will hold--could we do it? Would it be possible?

We will return to this question in a moment. But before we try to figure out how to stop the population from growing, we must figure out why it is growing as it is. After all, people are not lemmings, or deer, or bacteria. It has been known for some time that we must limit our population if we do not want the earth to limit it for us. Yet the population of the earth keeps growing by leaps and bounds. Why is that?

People populating the earth are like farmers putting livestock out to pasture on a commons. The commons is a model of the earth. Like any other model, it leaves out some features of the real thing, and therefore its usefulness is limited. On the commons, each farmer wants to get as much out of his herd as he can. When it comes time to decide whether to buy another cow, the farmer asks himself two questions: (1) What do I have to gain by adding one cow? and (2) What do I have to lose by adding one cow? If he stands to gain more than he loses, he buys another cow and turns it loose on the commons.

The interesting thing about the commons model is that the farmer will always get the same answer--buy another cow--until the commons is overgrazed, and everybody loses. How does this happen?

If the farmer buys another cow, he stands to gain all the produce from that cow. But what does he stand to lose? That depends on how many cows there are on the commons already. If there are very few, the farmer stands to lose nothing: there will be plenty of grass for his cow to eat, and none of the cows on the commons will suffer.

But suppose there are already a lot of cows on the commons--so many that each cow is going to the barn just a little bit hungry each night. If the farmer adds another cow, the food shortage will be even worse. But the shortage will be shared equally among all the cows on the commons, including those that belong to other farmers. So each of this farmer's cows will be coming to the barn even hungrier, but just a little bit hungrier; they will produce less milk, but just a little bit less milk. And the farmer will lose less than he gains by adding another cow. So he adds another cow.

In this way, every farmer with cows on the commons keeps coming up with the same answer: add another cow. Farmers keep adding cows to the commons until, at some point, there is so little food available that some of the cows--the weakest or sickest--

begin to die of starvation. In this way the commons itself limits the number of cows, even if the farmers keep adding more cows.

(In the dairy-farmer simulation you participated in, all the cows stopped producing milk when the commons became overgrazed. This result is one of the ways in which the simulation is different from reality. The simulation could have continued past this point, but it would have become more complicated.)

What happens to cows on a commons is a very simple model of what happens to people on the earth. When people decide whether or not to have a baby, they may think of many reasons for and many reasons against having a baby. One reason not to have a baby, for some people, is that there are too many people on the earth already. But what are the effects on the parents and on the baby of the world's population being increased by just one tiny person? Even if the parents believe there are too many people already, neither they nor their baby stands to lose very much by the addition of this one person to the population. If overpopulation were the only reason not to have a baby that these parents could think of, they might well decide that they had much more to gain by having a baby than they had to lose. And if all the parents reached this same conclusion, then they would all go on having babies, and the human population would keep increasing. Eventually, "the commons" would be full.

People do not treat the earth as a commons for growing food. They learned long ago to fence off parts of it and restrict the number of people who could use the fenced-off parts. That is, they learned to claim and defend private property or some other form of territory, to ensure that their own small groups would have enough to eat.

It is impossible to fence off the air and water, so it is harder to prevent the use of the earth as a commons for dumping wastes. But in recent years people have begun to restrict the pollution of the environment by making pollution expensive--by charging taxes and levying fines. But for some polluters--for example, people who drive automobiles--the air is a commons into which they can dump as much poisonous exhaust as they like, by driving as much as they like.

And when it comes to population, we still treat the earth very much as a commons. People can have as many children as they want. In some parts of the world, a family with too many children will begin to starve. The local commons is already full; the local population has reached its limit.

But in other parts of the world, including ours, there is still room left. And people still believe that it is their right to have as many children as they want. In the late 1960's about thirty member nations of the United Nations said that:

> The universal Declaration of Human Rights describes the family as the natural and fundamental unit of society. If follows that any choice and decision with regard to the size of the family must irrevocably rest with the family itself, and cannot be made by anyone else.

We return, now, to our question: Suppose we wanted to limit the growth of the human population. How could we stop its increase before the commons is full--while there is still enough food left for more than bare survival?

One way that has been suggested is to appeal to the conscience of the prospective parent, asking him or her to have few or no children and thus to help control the population. The trouble with this method is that it is like asking a farmer to hold his herd down to two cows so that the commons will not be overgrazed--while everyone else, or almost everyone else, goes right on buying more cows, getting more milk and making more money off the commons. The farmer would be foolish to accept that argument.

How, then, do we control access to the commons? Another possibility is to control access by law, with penalties for violations. Government prohibits many activities, and controls many others, in this way. How do we prevent people (or most people) from robbing banks? Not by appealing to their consciences, but by promising to take away their freedom if they rob a bank (and get caught). How do we prevent people from hogging parking space in the middle of a large city? By charging small amounts of money for short stays (with parking meters) and charging large amounts of money for longer stays (with fines).

Laws are the means by which the society forces its own members not to do certain things, in the interest of the whole society. When a new law is passed that prohibits people from doing something that they have always done--such as grazing their cattle on a meadow that has become private property, or dumping their wastes into the air or water--individuals lose some freedom. Even if we only limit their behavior, rather than prohibiting it--for example, even if we only limit the number of cows a farmer may graze on the commons, or limit the number of tons of acid that a factory may dump into a river or the volume of carbon monoxide that an automobile may dump into the air--still, individuals lose some freedom.

Individuals may protest when they lose freedom. But, many times in the past, a majority of the people have come to the conclusion that they must sacrifice some freedom in order to gain--or to preserve from destruction--something else that they value.

Should the government restrict the freedom of a family to have children?

What about families in other countries? Controlling the growth of the population in the US will not control the population of the earth. Of course, it is possible that the governments of all or most of the nations of the earth will decide to control their own populations, and that in this way the nations of the earth, working together, will control the population of the earth.

But there are nations that do not want to control their populations. In fact, there are nations that want larger populations, so that they can have larger and stronger economies. A nation like this is in the position of the farmer who is trying to decide whether to buy another cow. What the farmer has to gain always outweighs what he has to lose, and he always buys another cow. A small, poor nation that wants to grow and to become economically powerful may have everything to gain and nothing to lose by letting its population grow--at least for a time.

How can such a nation be persuaded that it should limit its population? The appeal to conscience works no better with national governments than it does with families or farmers. What about using laws to force nations to give up some of their own freedom for the benefit of the human race? It might be possible. But at the present time, no government on earth has the authority to limit the freedom of nations in the interest of the human race.

Should there be a government with such authority?

A MATHEMATICAL MODEL OF POPULATION GROWTH

TWO KINGS A-COUNTING:

Fecundland and Sterilia are two ancient kingdoms buried in the forests of northern Europe.

A few years back, King Carl the Curious of Fecundland got curious about the number of subjects in his kingdom. The king appointed a man named Actuarius to be Minister of Population and ordered him to find out how many subjects there were in the kingdom, how many were being born, how many were dying, how many were coming into the country and how many were leaving. Actuarius was to report back on December 31, 1974.

Several months later, news reached Sterilia that this survey was going on in Fecundland. King Elmer the Unprepared of Sterilia thought it sounded like a good idea. So he appointed a man named Census to be Minister of Population and ordered Census to report back on December 31, 1974, with all the same kinds of information.

When reporting day came, Census informed King Elmer the Unprepared that 2×10^3 persons had been born in Sterilia since the minister started counting.

King Elmer asked about the outcome of Fecundland's survey. He was informed that 4×10^3 persons had been born in Fecundland since they had started counting.

King Elmer remarked that, apparently, his subjects in Sterilia were producing new persons only half as fast as the subjects of King Carl of Fecundland. Census informed him this was not true.

Fecundland had been counting births for two years, and Sterilia had been counting only one year. And for the first of many times, Census undertook to speak to King Elmer the Unprepared in the language known as algebra.

Let the number of persons born in a kingdom be called ΔB.

Let the interval of time during which births are counted be called ΔT.

(The Greek letter Δ is called "delta." Because its name begins with a "d" it is used as a symbol for "difference." So the notation ΔB, pronounced "delta bee," signifies a difference in whatever the "B" stands for, and ΔT, pronounced "delta tee," signifies a difference in whatever the "T" stands for. Here, ΔT stands for a "difference" in time: the difference between the time when counting started and the time when it stopped, or, more simply, the length of the period of time during which counting went on. Similarly, ΔB stands for a "difference" in births: the difference between the total number of people who had been born up to the beginning of the period ΔT and the total number of people who had been born up to the end of the period ΔT, or, more simply, the number of people born during the period ΔT.)

FECUNDLAND	STERILIA
$\Delta B = 4 \times 10^3$ persons	$\Delta B = 2 \times 10^3$ persons
$\Delta T = 2$ years	$\Delta T = 1$ year

How fast are the subjects of a kingdom producing new persons? The answer to this question may be expressed as a rate: "The subjects are producing new persons at the rate of a certain number of persons per year." A rate is a ratio. This one is a ratio of persons to years. It compares a change in number of persons to a change in time. The rate at which persons are born in a kingdom is

$\frac{\Delta B}{\Delta T}$

FECUNDLAND	STERILIA
$\frac{\Delta B}{\Delta T} = \frac{4 \times 10^3}{2} \frac{\text{persons}}{\text{year}}$	$\frac{\Delta B}{\Delta T} = \frac{2 \times 10^3}{1} \frac{\text{persons}}{\text{year}}$
$\frac{\Delta B}{\Delta T} = 2 \times 10^3 \frac{\text{persons}}{\text{year}}$	$\frac{\Delta B}{\Delta T} = 2 \times 10^3 \frac{\text{persons}}{\text{year}}$

This demonstration delighted King Elmer the Unprepared. (He was easily delighted.) He concluded from the last pair of equations above that his subjects and the subjects of Fecundland were producing new persons at exactly the same rate. Census informed him that this was true in one sense but not true in another.

The rate of persons born per year is called an absolute rate; it is a simple ratio of one quantity to another. It does not take into account any other quantity--such as how many subjects there were in the kingdom to begin with.

How fast are the subjects of a kingdom producing new persons, relative to the number of subjects there were to begin with?

Let the number of subjects in the kingdom at the beginning of the period of time ΔT be called P.

If we divide the rate of births per year $\frac{\Delta B}{\Delta T}$ by the initial population P, we obtain a relative rate, a rate of births per year per person in the initial population.

When Fecundland started counting births it had one million people. When Sterilia started counting it had only one hundred thousand.

FECUNDLAND	STERILIA
$P = 1 \times 10^6$ persons	$P = 1 \times 10^5$ persons
$\frac{\frac{\Delta B}{\Delta T}}{P} = \frac{2 \times 10^3}{1 \times 10^6} \frac{\text{persons}}{\text{year}} \frac{}{\text{person}}$	$\frac{\frac{\Delta B}{\Delta T}}{P} = \frac{2 \times 10^3}{1 \times 10^5} \frac{\text{persons}}{\text{year}} \frac{}{\text{person}}$
$\frac{\frac{\Delta B}{\Delta T}}{P} = 2 \times 10^{-3} \frac{\text{persons}}{\text{year}} \frac{}{\text{person}}$	$\frac{\frac{\Delta B}{\Delta T}}{P} = 2 \times 10^{-2} \frac{\text{persons}}{\text{year}} \frac{}{\text{person}}$

The King of Sterilia listened to this argument, but he was not too sure what the results meant. His Minister of Population proposed one further improvement in the relative rate he had developed.

The relative rate developed above yields very small numbers--on the order of 10^{-2} for Sterilia and 10^{-3} for Fecundland. To remedy this situation, we can convert the relative rate of births per year per person in the initial population to a rate of birtns per year per thousand persons in the initial population. This last relative rate is called the birthrate*.

Let the birthrate be called R_B.

$$R_B = \frac{\frac{\Delta B}{\Delta T}}{P} \quad \frac{\text{persons}}{\text{year}} \frac{}{\text{person}} \times 10^3 \quad \frac{}{1000 \text{ population}}$$

$$\text{(1) Birthrate } R_B = \frac{\frac{\Delta B}{\Delta T}}{P} \times 10^3 \frac{\text{persons}}{\text{year-1000 population}}$$

FECUNDLAND	STERILIA
$R_B = (2 \times 10^{-3})(10^3) \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_B = (2 \times 10^{-2})(10^3) \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_B = 2 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_B = 20 \frac{\text{persons}}{\text{yr-1000 pop}}$

King Elmer the Unprepared was really unprepared for this. The birthrate of his subjects in Sterilia was ten times the birthrate of King Carl's subjects over in Fecundland. Clearly, something was wrong. Perhaps the names of the two kingdoms had got switched around at some drunken royal party. He certainly didn't remember trading names, but then if it were a drunken party he wouldn't remember it anyway.

The king asked his Minister of Population if that were all, or if there were more. For example, could it be concluded from this information that the population of Sterilia was growing ten times as fast as the population of Fecundland? For if it could, then the king would have to send out scouts to find the borders of his kingdom, so he could calculate how much room there was, so he could calculate when the kingdom would be full, so he could get prepared.

Census informed King Elmer that this was, in fact, not all. There were some other things to take into account besides the birthrate. When all these things were taken into account, it would be seen that the population of Fecundland was actually shrinking, while that of Sterilia was growing.

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* The birthrate is sometimes defined as a rate per 100 initial population.

The King wanted to know how Census knew. Census explained.

What other things, besides the birthrate, influence the size of the population? One is the rate at which people are dying. Another is the rate at which people immigrate into the kingdom, and another is the rate at which people emigrate from the kingdom.

King Elmer stopped Census there. He wanted to know how to remember the difference between "immigrate" and "emigrate." Census told him a simple way to remember: Those who Immigrate come Into the kingdom; those who Emigrate make an Exit.

Census lapsed into algebra again.

Let the number of persons who die in a kingdom be called ΔD.

Let the number of persons who immigrate into a kingdom be called ΔI.

Let the number of persons who emigrate from a kingdom be called ΔE.

We can convert each of these quantities to an absolute rate of persons (dying, immigrating or emigrating) per year, by dividing each of them by ΔT, the interval of time during which deaths, immigrants and emigrants were being counted. These absolute rates are represented as follows; all are in units of $\frac{\text{persons}}{\text{yr}}$:

$$\frac{\Delta D}{\Delta T} \qquad \frac{\Delta I}{\Delta T} \qquad \frac{\Delta E}{\Delta T}$$

We can further convert each of these quantities to a relative rate of persons (dying, immigrating or emigrating) per year per person in the initial population, as follows; all are in units of $\frac{\frac{\text{persons}}{\text{yr}}}{\text{person}}$:

$$\frac{\frac{\Delta D}{\Delta T}}{P} \qquad \frac{\frac{\Delta I}{\Delta T}}{P} \qquad \frac{\frac{\Delta E}{\Delta T}}{P}$$

Finally, we can convert each of these relative rates into a rate of persons (dying, immigrating or emigrating) per year per thousand persons in the initial population. These rates are given the names R_D, R_I and R_E. R_D is called the death rate, R_I is called the immigration rate and R_E is called the emigration rate.*

(2) Death Rate $\quad R_D = \frac{\frac{\Delta D}{\Delta T}}{P} \times 10^3 \frac{\text{persons}}{\text{yr-1000 pop}}$

(3) Immigration Rate $\quad R_I = \frac{\frac{\Delta I}{\Delta T}}{P} \times 10^3 \frac{\text{persons}}{\text{yr-1000 pop}}$

(4) Emigration Rate $\quad R_E = \frac{\frac{\Delta E}{\Delta T}}{P} \times 10^3 \frac{\text{persons}}{\text{yr-1000 pop}}$

There is one simplification to be introduced. If we subtract R_E from R_I, we get a quantity called the net migration rate. The net migration rate, called R_M, is the net increase in the population due to all migration. If there are more emigrants than

* Like the birthrate, these are sometimes defined as rates per 100 initial population.

immigrants in a given ΔT, then the net migration rate is a negative quantity: people are leaving faster than they are entering; there is a net decrease rather than a net increase due to migration.

$$R_M = R_I - R_E \quad \frac{\text{persons}}{\text{yr-1000 pop}}$$

$$= \frac{\frac{\Delta I}{\Delta T}}{P} \times 10^3 - \frac{\frac{\Delta E}{\Delta T}}{P} \times 10^3 \quad \frac{\text{persons}}{\text{yr-1000 pop}}$$

(5) Net Migration Rate

$$R_M = \frac{\frac{\Delta I - \Delta E}{\Delta T}}{P} \times 10^3 \quad \frac{\text{persons}}{\text{yr-1000 pop}}$$

Next, Census pointed out that all these rates could be combined to show just how fast the population of the kingdom was growing or shrinking. To find the rate of population growth per year per thousand persons in the initial population, one needed only start with the birthrate, subtract the death rate, and add the net migration rate.

Let the rate of population growth per year per thousand persons in the initial population be called R_G.

$$R_G = R_B - R_D + R_M \quad \frac{\text{persons}}{\text{yr-1000 pop}}$$

Census concluded his algebraic discourse by bringing up one last rate. This was another relative rate, very similar to R_G. The new one was the rate of population growth per year per hundred persons in the initial population. It could be obtained from R_G by dividing by 10.

Let the rate of population growth per year per hundred persons in the initial population be called G.

$$G = \frac{R_G \quad \frac{\text{persons}}{\text{yr - 1000 pop}}}{10 \quad \frac{100 \text{ pop}}{1000 \text{ pop}}}$$

$$= \frac{R_G}{10} \quad \frac{\text{persons}}{\text{yr - 100 pop}}$$

(6) Growth Rate

$$G = \frac{R_B - R_D + R_M}{10} \quad \frac{\text{persons}}{\text{yr-100 pop}}$$

Census pointed out that this last quantity, G, expresses the growth in population in one year as a percentage of the initial population. For example, if the growth rate $G = 2 \quad \frac{\text{persons}}{\text{yr-100 pop}}$, that means the increase in population in a year is equal to 2% of the number of persons in the country at the beginning of the year. The equation defining G is a mathematical model of the process by which a population grows or shrinks with time.

The king was growing weary of all this algebra. He asked the minister to come to the point.

Census came to the point. He showed the king the following information about the two kingdoms, Fecundland and Sterilia.

FECUNDLAND	STERILIA
$P = 1 \times 10^6$ persons	$P = 1 \times 10^5$ persons
$\Delta T = 2$ yr	$\Delta T = 1$ yr
$\Delta B = 4 \times 10^3$ persons	$\Delta B = 2 \times 10^3$ persons
$\Delta D = 4 \times 10^3$ persons	$\Delta D = 2 \times 10^2$ persons
$\Delta I = 8 \times 10^3$ persons	$\Delta I = 5 \times 10^3$ persons
$\Delta E = 1 \times 10^4$ persons	$\Delta E = 4 \times 10^3$ persons
$R_B = 2 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_B = 20 \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_D = 2 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_D = 2 \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_I = 4 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_I = 50 \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_E = 5 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_E = 40 \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_M = -1 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_M = 10 \frac{\text{persons}}{\text{yr-1000 pop}}$
$R_G = -1 \frac{\text{persons}}{\text{yr-1000 pop}}$	$R_G = 28 \frac{\text{persons}}{\text{yr-1000 pop}}$
$G = -0.1 \frac{\text{person}}{\text{yr-100 pop}}$	$G = 2.8 \frac{\text{persons}}{\text{yr-100 pop}}$

The king looked at the numbers. He concluded that each year Fecundland was losing a number of persons equal to 0.1% of its population at the beginning of the year, and each year Sterilia was gaining a number of persons equal to 2.8% of its population at the beginning of the year.

SOURCES OF UNCERTAINTY AND ERROR:

Aside from the imposing number of variables, the mathematical model of population growth described above is rather simple. The only quantities that need to be measured when one uses this model are numbers of people: number who are living at a given time (P), number who are born during a given period (ΔB), number who die (ΔD), number who immigrate (ΔI) and number who emigrate (ΔE). All these are numbers of people, and a number of people is something that can be measured precisely. How, then, can there be error?

There are two sources of error. One is that the quantities do not really get counted every year. The other is that, when they do get counted, some people are always missed.

Population: In the US, the government makes a measurement of P only once every five years.* On April 1 of every fifth year, census enumerators scour the nation in the attempt to count every living human body. In 1960, according to the results of a survey taken after the census, the enumerators missed 3% of the population, or nearly six million bodies.

* The Constitution requires that a census be taken every ten years. The Congress has provided for additional censuses.

In counting population in the US, then, there are two main problems: the count is taken only once every five years, so that values of P for the intervening years must be calculated with mathematical models; and when the count is finally taken, it is not accurate. In some other countries it is much harder to find out what P is. Many countries do not have such sophisticated transportation and communication equipment as have the US and other industrialized nations, so their counts are even more inaccurate. And some countries do not conduct any census at all.

Birthrate: In the US, public agencies keep registers of births. However, not everybody gets registered. It is relatively easy, in this country, to find out how many registered births occurred during a given year; the actual number of births that occurred must be calculated on the basis of estimates of how many weren't registered. This calculation produces an estimated value for ΔB (the number of births that occurred during the year). This value must be divided by another estimate, P (the population at the beginning of the year), to calculate the birthrate R_B for the year. Thus both the error in counting births and the error in counting the population (or, for non-census years, the error in estimating the population from the last inaccurate count) are propagated in the calculation of the birthrate.

Again, in some other countries it is more difficult to find out how many people were born during a given year. Even if records are kept locally, they may not be assembled in a central record-keeping agency. Anyone who wanted to know how many people were born in a given year might have to travel around and find the local agencies that kept count.

Death Rate: Death rates are subject to the same kinds of errors as birthrates. There are public records of all the deaths that the public record-keeping agencies hear about. But there are deaths they don't hear about, and consequently the values of ΔD and R_D reflect the error inherent in calculating a value on the basis of an estimate of how many didn't get counted. And, as with birthrates, there are countries that lack sophisticated data-collecting systems, and in these countries it is even harder to find out how many people have died in a given year.

Net Migration Rate: This quantity is the difference between the number of people immigrating and the number emigrating, divided by the population at the beginning of the year and multiplied by 10^3. We have already seen that the division by P introduces some error in the result. In addition, there is error in the counting of immigrants and emigrants. The Bureau of Customs keeps records of all the immigrants and emigrants it knows about, but it doesn't know about all of them. Consequently, these values, too , must be estimated.

Growth Rate: The growth rate for a given country during a given year is calculated from the birthrate, the death rate and the net migration rate. It therefore includes all the uncertainties that are propagated in the calculation of those quantities.

If one has figures for the population of the country at the beginning of the year and at the end the year, one can calculate the growth rate more simply--by subtracting to find out the amount of change in the population during the year, then finding out what percentage of the initial population that change represents. However, since the population is not counted every year, at least one of the population figures used in this calculation would have to be an estimate based on an earlier census, and would include all the uncertainties inherent in the measurements that went into it. These errors would be propagated in the calculation of the growth rate.

PROBLEMS

1. Use the numbered equations and the data given in the first part of the reading to show:

a. that the number of persons who emigrate from Fecundland in one year is equal to the number who immigrate into Sterilia in one year; and

b. that the number of persons who emigrate from Sterilia in one year is equal to the number who immigrate into Fecundland in one year.

2. Using Equation (2) and the data given for ΔD, ΔT and P, show that the death rate of Fecundland is equal to the death rate of Sterilia.

Use the numbered equations in the first part of the readi .g to solve Problems 3, 4, 5 and 6. Do not use any of the data given in the reading; use only the data given in the problems.

3. In 1066, Fecundland started off with a population of 100,000. During the year, 2000 Fecundlanders were born. What was the birthrate of Fecundland that year? (Show your work and include units.)

4. In 1492, Sterilia started off with a population of 1000. During the yea., 500 immigrants arrived in Sterilia and 400 emigrants left the country. What was Sterilia's net migration rate for that year? (Show your work and include units.)

5. In 1776, Fecundland had a birthrate of two persons per year per thousand population, a death rate of six persons per year per thousand population and a net migration rate of negative two persons per year per thousand population. What was Fecundland's growth rate for that year?

6. In 1812, Sterilia started the year with 10,000 persons. During the year 6000 persons were born, 100 persons died, 50 emigrated and none immigrated. What was Sterilia's growth rate that year? (Show your work and include units.)

7. If you knew only the population of Fecundland at the beginning of a particular year, what one piece of additional information would enable you to find out the growth rate of Fecundland for that year?

8. If you knew only the number of persons born in Sterilia during a time interval, what additional information would enable you to find the birthrate of Sterilia for that time interval?

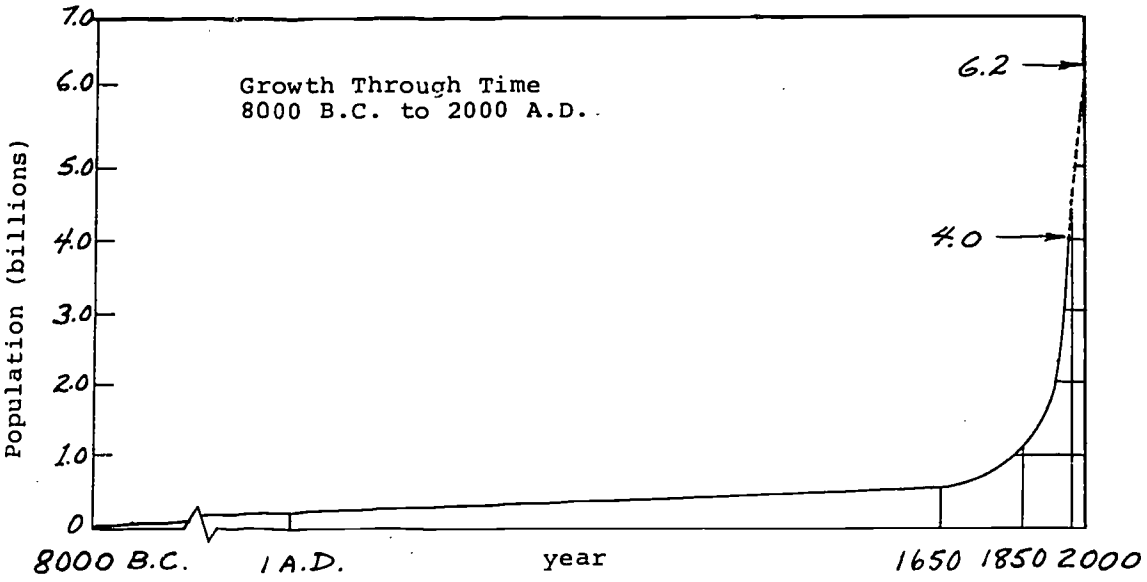
9. If you knew the death rate for Fecundland during a given year, what one piece of additional information would enable you to find out how many people had died in Fecundland during that year?

10. If you knew the number of people who immigrated to Sterilia during a given year and the number who emigrated from Sterilia during the same year, what one piece of additional information would enable you to find out how many people had been in Sterilia at the beginning of that year?

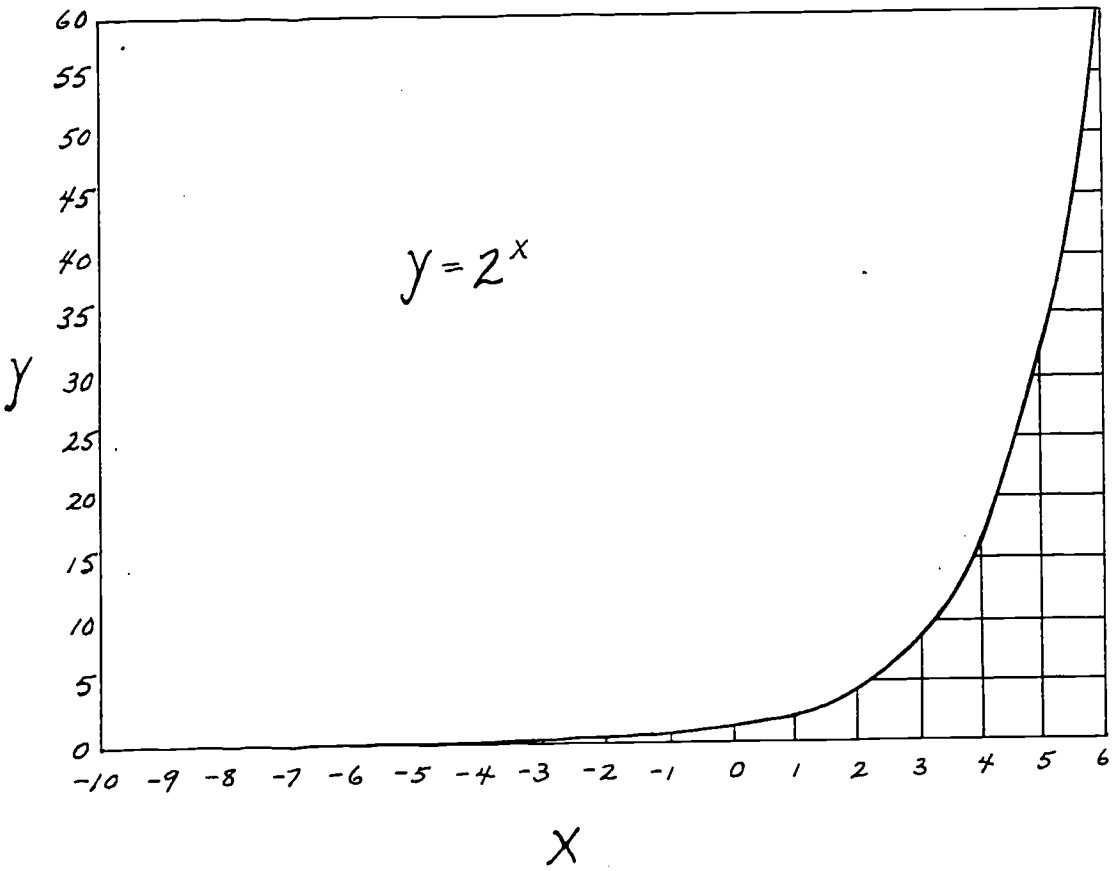
THE GROWTH OF HUMAN POPULATIONS

In March of 1976 the population of the world reached four billion. At that time the annual growth rate of the world's population was 1.8 percent. If that growth rate continues unchanged theworld's population will double in less than forty years:by the year 2015 there will be about eight billion people living on earth. The growth rate of the human population is determined by the difference between birthrate and death rate. (The net migration rate is always zero, because migration to or from the earth does not occur at the present time.) The world annual birthrate of thirty births per thousand people in 1976 means that about 228 babies were born every minute. The world annual death rate of twelve per one thousand people means that 91 people died every minute. So every minute in 1976 about 137 people were added to the population of the world. That's 197,000 people every day; in any one week the world population grew by about the size of Detroit.

The graph "Growth Through Time, 8000 BC to 2000 AD" shows how the size of the human population has changed over time. As you can see, there was very little change for thousands of years; then, around the 17th century, the size of the population began to increase at an accelerating pace.



The shape of this curve has reminded many people of the shape characteristic of graphs of exponential functions. An exponential function is one in which the independent variable appears in an exponent. You will be learning more about exponential functions and their uses in Mathematics Unit VII. For now, you should have a general idea how the graphs of these functions look. Below is a graph of the exponential function $y = 2^x$. Notice the similarity between the shape of this graph and the shape of the population curve shown above.



As another illustration of exponential increase, suppose that you are employed and your employer tells you that you will not get a raise you have been expecting. You then suggest an alternative. Beginning on the first work day of the next month, you will be paid only one cent for one day's work. For the second day you will be paid two cents, for the third day four cents, for the fourth day eight cents and so on. Each day, your daily wage will double. How much will you make on the 20th working day of the month? If you work another two weeks (ten working days), how much will you make on the thirtieth working day?

If the size of a population were increasing exponentially with time, two things would be true. First, the time it took to double would be a constant. (You can verify this statement by looking at the graph of $y = 2^x$ and imagining that the numbers on the x axis are units of time, such as centuries, and the units on the y axis are units of population, such as billions of people.) Second, the growth rate G, defined in the reading "A Mathematical Model of Population Growth," would be a constant. If the growth rate G of some population is a constant positive number, then that population's doubling time is also a constant.

If a population has a constant growth rate of 1 percent (that is, $G = 1 \frac{\text{person}}{\text{yr-100 pop}}$) then it will double in seventy years. If the growth rate increases, the doubling time of the population will decrease. For example, if the population's growth rate increases to 2 percent, then the time the population takes to double will decrease to 35 years.

During the past few hundred years, the size of the human population has not increased as an exponential function of time. The time the population takes to double has not been a constant: it has been getting shorter. The world population doubled from one billion to two billion in 80 years. But the time it took to double again, from two billion to four billion, was less than fifty years. It is possible that the world population growth rate will remain constant at its 1976 level for the indefinite future, and that the world population will thus grow at an exponential rate for some time. But even if that happens, the next doubling, from four billion to eight billion, will take less than 40 years because the 1976 growth rate is higher than the average growth rate for the preceding fifty years.

Obviously, the growth rate of the human population has been increasing. What has caused the growth rate to increase? Throughout the world there has been a gradual but steady decrease in the death rate. The birthrate has decreased, too, but the death rate has decreased faster. The fact that the death rate has decreased faster than the birthrate accounts for the increase in the growth rate, and thus for the fact that the human population has been doubling faster and faster.

Some countries have experienced what is called a "demographic transition" (demography is the study of changes in the size, distribution and other characteristics of populations) in which the gap between birthrate and death rate is narrowed and the growth rate therefore approaches zero. For the most part this transition has occured only in Western, industrialized nations. Most Asian, African and Latin American countries have had declining death rates without declining birthrates. The table "Estimated Population of the World's Ten Largest Countries" demonstrates this point. Note that five industrialized nations that were among the ten largest countries in 1932 are not expected to be among them in the year 2000. These industrialized countries have experienced a demographic transition, and their growth rates are approaching zero.

ESTIMATED POPULATION OF THE WORLD'S
TEN LARGEST COUNTRIES
(IN MILLIONS)

1932		1976		2000*	
1. China	425	China	837	China	1126
2. India	360	India	621	India	1051
3. USSR	160	USSR	257	USSR	314
4. United States	125	United States	215	United States	263
5. Japan	66	Indonesia	135	Indonesia	230
6. Germany	66	Japan	112	Brazil	208
7. Indonesia	63	Brazil	110	Pakistan	146
8. United Kingdom	46	Bangladesh	76	Bangladesh	145
9. France	42	Pakistan	73	Nigeria	135
10. Italy	42	Nigeria	65	Mexico	134

Source: 1932: Demographic Yearbook, 1948, United Nations, New York, 1949. 1976 and 2000: 1976 World Population Data Sheet. Population Reference Bureau, Inc.
* Data for 2000 are estimates, based on the assumption that each country's growth rate will remain the same throughout the period 1976-2000 as it was in 1976.

As an example of the consequences of a demographic transition, consider the cases of Mexico and the United Kingdom. (The United Kingdom consists of England, Scotland, Wales and Northern Ireland.) In 1932 the population of Mexico was 16.6 million; the population of the United Kingdom was 46 million, nearly three times that of Mexico. But Mexico, with a constant growth rate of 3.5 percent, would have a population of over 134 million in the year 2000. In contrast, the United Kingdom, with a constant growth rate of 0.1 percent, would have a population of about 62 million in the year 2000--less than half the size of the population Mexico would have.

What is the probable future of the human race, assuming a constant population growth rate of 1.8 percent? Laboratory studies of the effects of crowding on animals produce some disturbing results. In chickens, rats and mice, crowding causes an enlargement of the adrenal glands. It upsets normal growth and reproductive functions. In some studies overcrowded rats have stopped eating and starved to death. And crowding makes animals more susceptible to infectious diseases; in a crowded population such diseases can spread more rapidly.

Results of experiments with animals may not be directly transferable to human beings. Human beings have a greater ability to adapt to new situations, and to develop safeguards against potentially dangerous conditions. Persons living in rural areas are often shocked when they encounter the noise, pollution, emotional stress and physical congestion of cities. But to people who have lived their lives in cities, these are normal conditions of life. The ability to adapt, to develop technologies that allow a more efficient use of resources, and to cope with the increased stress and risk of disease, are all characteristics that will help the human race adjust. But there are limits. If the present world population were to double fifteen more times, there would be one person for each square meter of land. This includes Antarctica, Greenland and the Sahara Desert. At our present growth rate, this would occur in less than 600 years.

No one really knows what the limits are--at what point there will be too little land to support the population. However, many countries are already unable to support their people with adequate food and housing. Some decline in the growth rate, or some large-scale reduction in the size of the population, will surely occur. The growth rate could decline. In fact, it appears that it may be declining at this time. (If the world's population growth rate begins to decline, then the time it takes the population to double will begin getting longer instead of shorter.) More countries are recognizing relationships between population growth and problems in other aspects of life. Many have begun programs to reduce their birthrates. These efforts may help slow the growth rate.

There are still arguments about population control, and some countries are doing much less than others to reduce their rates of population growth. But there is, today, a more widespread agreement that some measures must be taken, and that our present growth rate simply cannot continue indefinitely.

SELECTED 1976 WORLD POPULATION DATA

	Population estimate mid-1976 (millions)	Birthrate	Death rate	Annual rate of population growth (percent)	Number of years to double population	Population projection to 2000 (millions)	Infant mortality rate	Population under 15 years (percent)	Median age (years)	Life expectancy at birth (years)	Per-capita gross national product (US $)
WORLD	4,019	30	12	1.8	38	6,214	105	36	22.9	59	1,360
AFRICA	413	46	20	2.6	27	815	152	44	18.0	45	340
NORTHERN AFRICA	100	43	16	2.6	27	190	124	44	18.0	52	440
Algeria	17.3	49	15	3.2	22	36.7	126	48	16.0	53	650
Egypt	38.1	38	15	2.3	30	64.0	98	41	19.4	52	280
Libya	2.5	45	15	3.7	19	5.1	130	44	17.8	53	3,360
Morocco	17.9	46	16	2.9	24	35.6	130	44	18.2	53	430
Sudan	18.2	48	18	2.5	28	37.9	141	45	17.2	49	150
Tunisia	5.9	38	13	2.4	29	10.9	128	44	17.4	54	550
WESTERN AFRICA	120	49	23	2.6	27	242	175	45	17.7	41	230
Benin (Dahomey)	3.2	50	23	2.7	26	6.0	185	45	17.3	41	120
Cape Verde Islands	0.3	33	10	2.3	30	0.4	91	44	17.7	50	340
Gambia	0.5	43	24	1.9	36	0.9	165	41	20.3	40	170
Ghana	10.1	49	22	2.7	26	21.2	156	47	16.7	44	350
Guinea	4.5	47	23	2.4	29	8.5	175	43	18.5	41	120
Guinea-Bissau	0.5	40	25	1.5	46	0.8	208	37	22.1	38	330
Ivory Coast	6.8	46	21	2.5	28	13.1	164	43	18.5	44	420
Liberia	1.6	50	21	2.9	24	3.0	159	42	19.8	45	330
Mali	5.8	50	26	2.4	29	11.1	188	44	18.0	38	70
Mauritania	1.3	39	25	1.4	50	2.3	187	42	19.0	38	230
Niger	4.7	52	25	2.7	26	9.6	200	46	17.2	38	100
Nigeria	64.7	49	23	2.7	26	135.1	180	45	17.4	41	240
Senegal	4.5	48	24	2.4	29	8.1	159	43	18.3	40	320
Sierra Leone	3.1	45	21	2.4	29	5.8	136	43	18.6	44	180
Togo	2.3	51	23	2.7	26	4.6	127	46	17.2	41	210
Upper Volta	6.2	49	26	2.3	30	11.0	182	43	18.3	38	80
EASTERN AFRICA	117	48	21	2.8	25	238	152	45	17.6	44	200
Burundi	3.9	48	25	2.4	29	7.3	150	45	18.4	39	80
Comoro Islands	0.3	44	20	2.4	29	0.5	160	43	18.4	42	170
Ethiopia	28.6	49	26	2.6	27	53.6	181	44	18.2	38	90
Kenya	13.8	49	16	3.4	20	31.3	119	46	16.7	50	200
Malagasy Republic	7.7	50	21	2.9	24	16.7	102	45	17.3	44	170
Malawi	5.1	48	24	2.4	29	9.7	148	45	17.5	41	130
Mauritius	0.9	28	7	1.2	58	1.2	46	38	20.1	66	480
Mozambique	9.3	43	20	2.3	30	17.4	165	43	18.8	44	420
Reunion	0.5	28	7	2.1	33	0.7	47	43	18.6	63	1,210
Rhodesia	6.5	48	14	3.4	20	15.2	122	46	16.9	52	480
Rwanda	4.4	50	24	2.8	25	8.8	133	44	17.9	41	80
Somalia	3.2	47	22	2.5	28	6.5	177	45	17.2	41	80

	Population estimate mid-1976 (millions)	Birthrate	Death rate	Annual rate of population growth (percent)	Number of years to double population	Population projection to 2000 (millions)	Infant mortality rate	Population under 15 years (percent)	Median age (years)	Life expectancy at birth (years)	Per-capita gross national product (US $)
EASTERN AFRICA (continued)											
Tanzania	15.6	50	22	2.7	26	33.4	162	47	16.6	44	140
Uganda	11.9	45	16	3.3	21	24.6	160	44	17.7	50	160
Zambia	5.1	51	20	2.1	22	11.3	160	46	17.4	44	480
MIDDLE AFRICA	47	44	21	2.4	29	88	165	43	18.6	42	250
Angola	6.4	47	24	1.6	43	12.3	203	42	18.8	38	580
Cameroon	6.5	40	22	1.8	38	11.6	137	40	19.6	41	260
Central African Republic	1.8	43	22	2.1	33	3.4	190	42	19.0	41	200
Chad	4.1	44	24	2.0	35	6.9	160	41	19.1	38	90
Congo (People's Republic of)	1.4	45	21	2.4	29	2.7	180	42	18.8	44	380
Equatorial Guinea	0.3	37	20	1.7	41	0.5	165	37	23.3	44	260
Gabon	0.5	32	22	1.0	69	0.7	178	32	29.8	41	1,560
Sao Tome e Principe	0.1	45	11	2.0	35	0.1	64	33	-	-	470
Zaire	25.6	45	20	2.8	25	50.3	160	44	17.8	44	150
SOUTHERN AFRICA	29	43	17	2.7	26	56	119	41	19.5	51	1,120
Botswana	0.7	46	23	2.3	30	1.4	97	46	17.0	44	270
Lesotho	1.1	39	20	2.1	33	1.8	114	38	21.1	46	120
Namibia	0.9	46	23	2.2	32	1.6	177	41	19.7	41	1,200
South Africa	25.6	43	16	2.7	26	50.6	117	41	19.5	52	1,200
Swaziland	0.5	49	22	3.2	22	1.0	149	46	16.7	44	400
ASIA	2,287	33	13	2.0	35	3,612	121	38	21.1	56	450
SOUTHWEST ASIA	87	43	14	2.9	24	166	114	44	18.2	55	1,050
Bahrain	0.2	44	15	2.9	24	0.5	78	44	17.8	61	2,250
Cyprus	0.7	18	10	0.8	87	0.8	28	32	24.7	71	1,385
Gaza	0.4	50	16	3.4	20	0.9	-	49	-	52	-
Iraq	11.4	48	15	3.3	21	24.3	99	48	16.0	53	970
Israel	3.5	28	7	2.9	24	5.5	23	33	25.1	71	3,380
Jordan	2.0	48	15	3.3	21	5.9	97	48	16.2	53	400
Kuwait	1.1	45	8	5.9	12	3.0	44	43	19.1	69	11,640
Lebanon	2.7	40	10	3.0	23	5.7	59	43	18.6	63	1,080
Oman	0.8	50	19	3.1	22	1.6	138	-	-	-	1,250
Qatar	0.1	50	19	3.1	22	0.2	138	-	-	-	5,830
Saudi Arabia	6.4	49	20	2.9	24	12.9	152	45	17.6	45	2,080
Syria	7.6	45	15	3.0	23	16.0	93	49	15.4	54	490
Turkey	40.2	39	12	2.6	27	71.3	119	42	19.0	57	690
United Arab Emirates	0.2	50	19	3.1	22	0.5	138	34	21.3	-	13,500
Yemen Arab Republic	6.9	50	21	2.9	24	13.8	152	45	17.6	45	120
Yemen (People's Rep. of)	1.7	50	21	2.9	24	3.4	152	45	17.6	45	120
MIDDLE SOUTH ASIA	851	37	16	2.2	32	1,493	137	41	19.2	49	160
Afghanistan	19.5	43	21	2.2	32	36.3	182	44	17.9	40	100
Bangladesh	76.1	47	20	2.7	26	144.8	132	46	16.7	43	100
Bhutan	1.2	44	21	2.3	30	2.2	-	42	18.9	44	70

	Population estimate mid-1976 (millions)	Birthrate	Death rate	Annual rate of population growth (percent)	Number of years to double population	Population projection to 2000 (millions)	Infant mortality rate	Population under 15 years (percent)	Median age (years)	Life expectancy at birth (years)	Per-capita gross national product (US $)
MIDDLE SOUTH ASIA (cont.)											
India	620.7	35	15	2.0	35	1,051.4	139	40	19.6	50	130
Iran	34.1	45	16	3.0	23	67.0	139	47	16.4	51	1,060
Maldive Islands	0.1	50	23	3.3	21	0.2	-	44	-	-	90
Nepal	12.9	43	20	2.3	30	23.2	169	40	20.3	44	110
Pakistan	72.5	44	15	2.9	24	146.4	124	46	16.6	50	130
Sikkim	0.2	-	-	2.0	35	0.4	208	40	19.5	-	90
Sri Lanka	14.0	28	8	2.0	35	21.0	45	39	19.9	68	130
SOUTHEAST ASIA	327	38	15	2.4	29	583	108	43	18.3	51	220
Burma	31.2	40	16	2.4	29	53.5	126	41	19.6	50	90
Indonesia	134.7	38	17	2.1	33	230.3	125	44	18.1	48	150
Khmer Republic	8.3	47	19	2.8	25	15.8	127	45	17.2	45	-
Laos	3.4	45	23	2.4	29	5.7	123	42	18.9	40	-
Malaysia	12.4	39	10	2.9	24	22.0	75	44	17.7	59	660
Philippines	44.0	41	11	3.0	23	86.3	74	43	18.4	58	310
Portuguese Timor	0.7	44	23	2.1	33	1.1	184	42	18.9	40	130
Singapore	2.3	20	5	1.6	43	3.1	16	39	19.7	67	2,120
Thailand	43.3	36	11	2.5	28	86.0	81	45	17.3	58	300
*Vietnam (Dem. Rep. of)	24.8	32	14	1.8	38	44.1	-	41	19.1	48	130
*Vietnam (Republic of)	21.6	42	16	2.6	27	34.9	-	41	19.3	40	170
EAST ASIA	1,023	26	9	1.7	41	1,369	23	33	23.9	63	710
China (People's Rep. of)	836.8	27	10	1.7	41	1,126.0	-	33	23.5	62	300
Hong Kong	4.4	19	5	2.1	33	5.8	18	36	22.0	71	1,540
Japan	112.3	19	6	1.2	58	132.7	11	24	29.6	73	3,880
Korea (Dem. People's rep. of)	16.3	36	9	2.7	26	27.5	-	42	18.5	61	390
Korea (Republic of)	34.8	29	9	2.0	35	52.3	47	40	19.6	61	470
Macau	0.3	25	7	1.8	38	0.4	78	38	18.9	-	270
Mongolia	1.5	40	10	3.0	23	2.7	-	44	18.1	61	620
Taiwan (Rep. of China)	16.3	23	5	1.9	36	22.0	26	43	18.2	69	720
NORTH AMERICA	239	15	9	0.8	87	294	16	27	27.9	71	6,580
Canada	23.1	15	7	1.3	53	31.6	16	29	26.5	73	6,080
United States	215.3	15	9	0.8	87	262.5	17	27	28.1	71	6,640
LATIN AMERICA	326	37	9	2.8	25	606	75	42	18.9	62	940
MIDDLE AMERICA	81	45	9	3.4	20	172	65	46	16.9	62	900
Costa Rica	2.0	28	5	2.3	30	3.6	45	42	18.2	69	790
El Salvador	4.2	40	8	3.2	22	8.8	54	46	16.9	58	390
Guatemala	5.7	43	15	2.8	25	11.1	79	44	17.6	53	570
Honduras	2.8	49	14	3.5	20	6.2	117	47	16.5	54	340
Mexico	62.3	46	8	3.5	20	134.4	61	46	16.8	63	1,000
Nicaragua	2.2	48	14	3.3	21	4.8	123	48	15.7	53	650
Panama	1.7	31	5	2.6	27	3.2	44	43	18.2	66	1,010

*The two Vietnams have become politically united since these data were assembled.

	Population estimate mid-1976 (millions)	Birthrate	Death rate	Annual rate of population growth (percent)	Number of years to double population	Population projection to 2000 (millions)	Infant mortality rate	Population under 15 years (percent)	Median age (years)	Life expectancy at birth (years)	Per-capita gross national product (US $)
CARIBBEAN	27	31	9	2.1	33	44	71	41	19.9	64	820
Bahamas	0.2	22	6	4.2	16	0.3	32	44	18.7	66	2,460
Barbados	0.2	21	9	0.8	87	0.3	38	34	22.3	69	1,110
Cuba	9.4	25	6	1.8	38	14.9	29	37	22.4	70	640
Dominican Republic	4.8	46	11	3.0	23	10.8	98	48	16.1	58	590
Grenada	0.1	26	8	0.4	173	0.1	32	47	-	63	300
Guadeloupe	0.4	28	7	1.5	46	0.5	44	40	19.2	69	1,050
Haiti	4.6	36	16	1.6	43	7.1	150	41	18.8	50	140
Jamaica	2.1	31	7	1.9	36	2.8	26	46	17.3	68	1,140
Martinique	0.3	22	7	0.5	139	0.5	32	41	19.0	69	1,330
Netherlands Antilles	0.2	25	7	1.8	38	0.4	28	38	-	73	1,530
Puerto Rico	3.2	23	6	2.4	29	4.0	23	37	21.6	72	2,400
Trinidad & Tobago	1.1	26	7	1.5	46	1.4	26	40	19.3	66	1,490
TROPICAL SOUTH AMERICA	178	38	9	2.9	24	338	82	43	18.1	60	840
Bolivia	5.8	44	18	2.6	27	10.6	108	43	18.3	47	250
Brazil	110.2	37	9	2.8	25	207.5	82	42	18.6	61	900
Colombia	23.0	41	9	3.2	22	44.3	76	46	16.9	61	510
Ecuador	6.9	42	10	3.2	22	14.0	78	47	16.3	60	460
Guyana	0.8	36	6	2.2	23	1.2	40	44	17.2	68	470
Paraguay	2.6	40	9	2.7	26	5.1	65	45	16.6	62	480
Peru	16.0	41	12	2.9	24	30.9	110	44	17.6	56	710
Surinam	0.4	41	7	3.2	22	0.9	30	50	15.1	66	870
Venezuela	12.3	36	7	2.9	24	23.1	54	44	17.4	65	1,710
TEMPERATE SOUTH AMERICA	39	24	9	1.5	46	52	67	32	25.7	67	1,540
Argentina	25.7	22	9	1.4	50	32.9	64	29	27.4	68	1,900
Chile	10.8	28	8	1.7	41	15.9	78	39	20.5	63	820
Uruguay	2.8	21	10	1.1	63	3.4	45	28	29.4	70	1,060
EUROPE	476	15	10	0.6	116	540	22	24	32.2	71	3,680
NORTHERN EUROPE	82	13	12	0.2	347	91	15	24	33.4	72	3,960
Denmark	5.1	14	10	0.4	173	5.4	12	23	32.5	73	5,820
Finland	4.7	13	10	0.4	173	4.8	10	24	30.1	69	4,130
Iceland	0.2	20	7	1.3	53	0.3	11	32	24.7	74	5,550
Ireland	3.1	22	11	0.7	99	4.0	17	31	26.8	72	2,370
Norway	4.0	15	10	0.6	116	4.5	12	24	32.4	74	5,280
Sweden	8.2	13	11	0.4	173	9.3	9	21	35.3	75	6,720
United Kingdom	56.1	13	12	0.1	693	62.3	16	24	34.0	72	3,360
WESTERN EUROPE	153	13	11	0.5	139	171	16	24	33.1	72	5,460
Austria	7.5	13	12	0.1	693	8.1	23	24	33.7	71	4,050
Belgium	9.8	13	12	0.3	231	10.7	16	23	34.3	71	5,210

	Population estimate mid-1976 (millions)	Birthrate	Death rate	Annual rate of population growth (percent)	Number of years to double population	Population projection to 2000 (millions)	Infant mortality rate	Population under 15 years (percent)	Median age (years)	Life expectancy at birth (years)	Per-capita gross national product (US $)
WESTERN EUROPE (continued)											
France	53.1	15	10	0.8	87	61.9	12	24	32.6	73	5,190
Germany (Fed. Rep. of)	62.1	10	12	0.2	347	66.5	21	23	34.4	71	5,890
Luxembourg	0.4	11	12	0.7	99	0.4	14	21	35.2	71	5,690
Netherlands	13.8	14	8	0.9	77	16.1	11	27	28.9	74	4,880
Switzerland	6.5	13	9	0.7	99	7.3	13	24	32.1	73	6,650
EASTERN EUROPE	107	17	10	0.7	99	122	26	23	31.4	70	2,670
Bulgaria	8.8	17	10	0.7	99	10.0	25	22	33.5	72	1,770
Czechoslovakia	14.9	20	12	0.8	87	16.9	20	23	31.8	70	3,220
Germany (Dem. Rep. of)	16.8	11	14	-0.3	-	17.9	16	23	34.5	71	3,430
Hungary	10.6	18	12	0.6	116	11.1	34	20	34.2	70	2,140
Poland	34.4	18	8	1.0	69	40.1	24	25	28.4	70	2,450
Romania	21.5	20	9	1.0	69	25.8	35	25	31.0	69	-
SOUTHERN EUROPE	134	18	9	0.8	87	156	26	26	31.1	71	2,130
Albania	2.5	30	8	2.4	29	4.1	87	40	19.2	71	530
Greece	9.0	16	8	0.4	173	9.7	24	25	33.4	72	1,970
Italy	56.3	16	10	0.8	87	61.7	23	24	32.7	72	2,770
Malta	0.3	18	9	0.4	173	0.3	21	26	27.1	70	1,060
Portugal	8.5	19	11	-0.4	-	9.6	38	28	29.4	68	1,540
Spain	36.0	19	8	1.1	63	45.1	14	28	30.2	72	1,960
Yugoslavia	21.5	18	8	0.9	77	25.7	40	27	28.8	68	1,250
USSR	257	18	9	0.9	77	314	28	28	29.7	70	2,300
OCEANIA	22	22	10	1.8	38	33	53	33	25.7	68	3,800
Australia	13.8	18	9	1.5	46	20.0	16	29	27.6	72	4,760
Fiji	0.6	28	5	1.9	36	0.8	21	41	18.9	70	720
New Zealand	3.2	19	8	2.2	32	4.4	16	32	25.8	72	4,100
Papua-New Guinea	2.8	41	17	2.6	27	5.1	159	45	17.8	48	440

WORLD AND REGIONAL POPULATION (Millions)

	World	Asia	Europe	USSR	Africa	North America	Latin America	Oceania
MID-1976	4019	2287	476	257	413	239	326	22
ESTIMATE, 2000	6214	3612	540	314	815	294	606	33

NOTES

This table was excerpted from World Population Data Sheet, Population Reference Bureau, Inc., Washington, D.C., 1976. It includes all UN members and all geopolitical entities with populations larger than 200,000.

Birth rate: Annual number of births per 1,000 population.

Death rate: Annual number of deaths per 1,000 population.

Population growth rate: Annual rate of natural increase combined with the plus or minus factor of net immigration or net emigration. (*Natural increase* is the birth rate minus the death rate in a given year.)

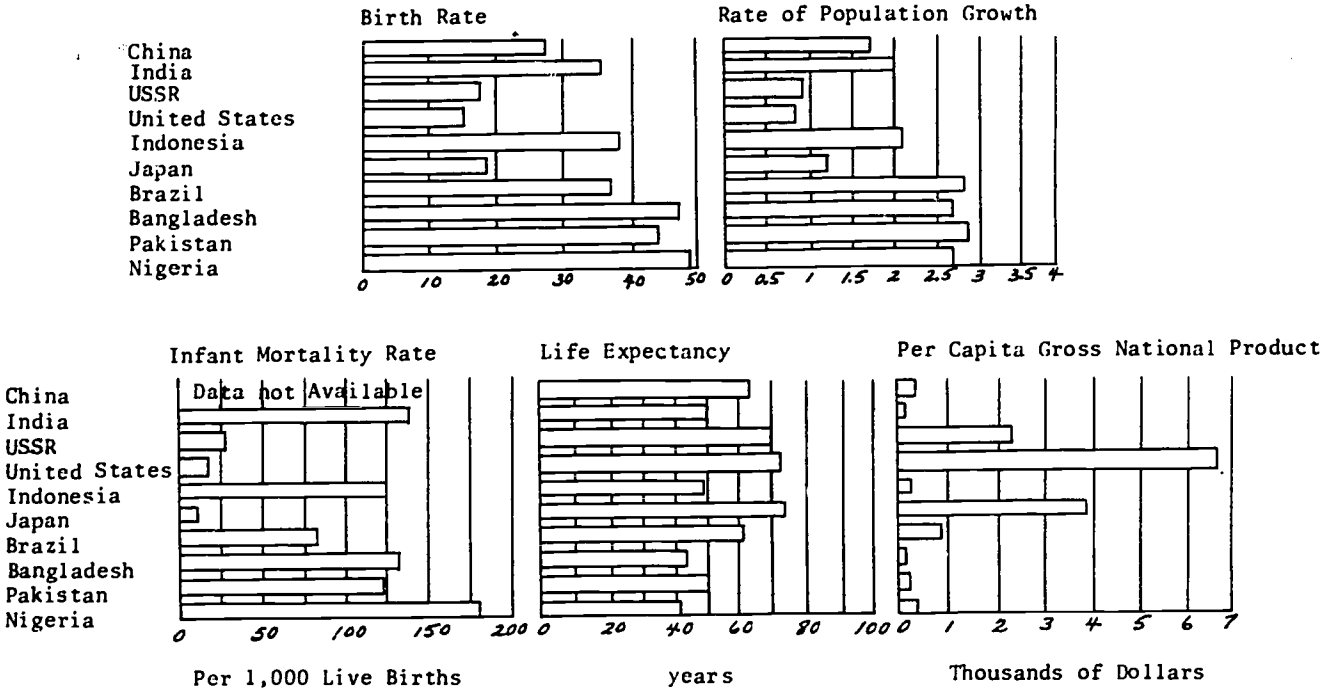
Infant mortality rate: Annual number of deaths to infants under one year of age per 1,000 live births.

Population figures are rounded to the nearest 100,000.

Demographic data for developing countries are often incomplete or inaccurate. In many cases, therfore, UN estimates are used.

Dashes indicate data are unavailable.

1976 DATA FOR THE WORLD'S LARGEST COUNTRIES



Source: 1976 World Population Data Sheet
Population Reference Bureau, Inc.

CHINA ON THE POPULATION QUESTION

The People's Republic of China has the largest population of any nation in the world. Current estimates of China's population run from 800 million to one billion. China's territory is about the same size as ours, but her population is four times as large as ours. Of every four or five humans on the earth, one is Chinese.

China is what is known as a developing country. Relatively little of its work is done by machines, and relatively much is done by human labor. China also has very rich natural resources, including oil, iron and many other valuable minerals, which she is just beginning to extract from the earth in massive quantities. In general, China's economy is far "behind" the economies of the US, the USSR and the other industrially developed nations--but it is catching up fast.

Since 1949, China has been ruled by the Chinese Communist Party, whose theory of government is a combination of Marxism and traditional Chinese peasant revolutionary ideas. For many years China has considered herself to be an ally neither of the US nor of the USSR, and has worked hard to become the leader of all those countries in the world which, like China, are economically developing and are not allies of either the US or the USSR.

This combination of circumstances makes China's population policy a matter of interest to other nations. Some of the developed nations are especially concerned that China's population policy might become the policy of many other nations as well. The reason this possibility concerns them is that China's population policy does not call for stopping population growth, but only for controlling it--and for doing so in a way that some developed countries perceive as a threat to their own economies.

Recent magazine articles from China have described China's population policy in some detail. What follows is a summary of that policy.

First, the Chinese government does not believe that such problems as unemployment, poverty, hunger, disease and high death rates are caused by overpopulation. Rather, it claims that these problems are caused by economic underdevelopment. Especially in developing nations, according to the Chinese government's view, these problems occur because those nations' economies have been prevented from developing by the influence

of colonial and imperial powers: more powerful and economically more developed nations that have bought raw materials from developing countries at low prices and have sold them manufactured goods at high prices. In China's view, these practices have left the developing countries without the resources they would need to build up their own industrial economies and thus to become wealthy, healthy, well fed and fully employed.

In support of this proposition, the Chinese government claims that the developing countries have become poor and backward (compared to other countries) only during the past few centuries, when industrial nations have exploited their natural resources. Furthermore, population density in most developing countries is, according to the Chinese, lower than that in the developed countries; the problem therefore must not be population, but economics. Finally, the Chinese point out that their own economy has developed rapidly since they threw off the domination of foreign powers in the 1940's, and claim that the other developing countries would develop equally rapidly if they threw off the influence of other powers, but especially of two other powers: the US and the USSR.

Second, the Chinese government believes that the way for a developing country to become a developed country is to rely on people, not machines, to do most of the work. Since 1949, China's centrally controlled, socialist economy (one in which the central government allocates nearly all economic resources) has provided the Chinese people with food, clothing, housing, health care and, most importantly from the Chinese viewpoint, jobs. The Chinese admit that their living standard is still far below that of the developed nations. But they point out that it is much better than it was before the revolution of 1949, when the country was ravaged by warfare that had been going on intermittently since 1840. The Chinese believe that any developing nation can make equally impressive progress by throwing out foreign powers, instituting a centrally controlled, socialist economy and relying on people rather than on machines to do the work. One requirement for this sort of development is a large population.

Third, China's policy for controlling her own population growth is to control both the distribution and the size of the population. In areas where population density is high, such as Shanghai, the most populous city on earth, the Chinese government advocates that people marry late and practice birth control. In areas where population density is low, such as the vast and nearly empty provinces of northwest China, the government advocates large families. The government also encourages people to move from densely populated areas to thinly populated areas--especially people who have skills that can be used to develop the economy (mainly agriculture) in the thinly populated areas.

According to Chinese publications, all this is voluntary. In particular, people who want to have small families may have small ones, and people who want large families may have large ones. The government's policies are widely publicized and thoroughly explained to everybody, but individuals make up their own minds about family planning and birth control.

The Chinese government claims that its population policy has produced encouraging results. The rate of population growth is down in Peking, Shanghai and the densely populated coastal provinces of southeast China. In the thinly populated northwest, meanwhile, the rate of growth is higher than it used to be.

China does not declare that the growth rate of its entire population is either satisfactory or unsatisfactory. In general, to quote one Chinese magazine article, "Progress is uneven and continued effort is needed."

POPULATION POLICIES IN DEVELOPED AND DEVELOPING COUNTRIES

More than two thirds of the world's population lives in developing countries. Less than one third lives in the developed countries. Although the distinction between these two types of countries is not always absolute, some general distinctions can be made. In developing countries, more work is done with human labor and less with machines. The per-capita gross national product of developing countries is generally much lower. The annual infant mortality rate (the number of children who die before reaching age one per thousand live births per year) is generally much higher in developing countries. And the birth rate is generally much higher in developing countries.

In the most general terms, developing countries are much poorer, and have much higher rates of population growth, than developed countries.

Developed countries have annual growth rates of about 1.0 percent, and their populations will double in about 70 years. Developing countries have annual growth rates of about 2.5 percent, and their populations will double in about 28 years. The most rapid rate of population growth occurs in the poorer countries, where the burden of supporting a growing population is greatest. Should these countries encourage efforts to slow their rates of population growth? Or should they encourage growth so that more human labor will be available? What have the nations of the world done about the growth of their populations?

In the developed countries there has been steadily increasing interest in the establishment of policies regarding population growth. Official national commissions have been appointed in many countries. They have recommended such measures as increased availabilty of contraceptives, legalization of abortion, and monetary incentives for family planning. Some concerns have been expressed over the possibility that population growth will stop and population size will decline, but for the most part the developed nations have adopted policies that seek to bring the population growth rate down near zero. Two developed countries, Hungary and Israel, are exceptions: they have adopted policies that tend to raise birthrates.

The population policies of developed nations are frequently not stated explicitly as population policies. Rather, they are parts of more general social policies (e.g., health or economic policies). Most means of birth control are easily available and widely used in only about one third of the developed countries. Few of these countries provide free or inexpensive birth control, although some provide abortion without charge and some provide birth control pills without charge. However, the high per-capita gross national products of these countries indicate that larger proportions of their citizens can afford to pay for birth control.

The developing countries have been much more active than the developed countries in the establishment of national policies regarding population growth. In most of them the objective of the policy is to reduce the rate of population growth by reducing the birthrate. The most common method is the establishment of family planning programs. These are designed to provide information on birth control techniques for use by couples who wish to limit the size of their families. Only a few of the large developing countries--Brazil, Burma and Ethiopia--do not have a national policy.

However, there is opposition to limited-growth policies in many of these countries, and the national policies are seldom put into widespread practice. In Mexico, the Philippines and several African nations the opposition has been strong. Mexico, for example, stated in 1973 that reducing the rate of population growth was no longer a national goal. In 1975 this position was reversed. Most Mexican citizens are unaffected by any program that encourages them to have either fewer or more children.

Opposition to national policy in developing countries is based on several arguments. The one most frequently mentioned is that the "threat of overpopulation" is a phrase used by the developed countries to prevent the developing countries from becoming more powerful by increasing their populations. Because some of the developed countries have predominantly Caucasian populations and some developing nations do not, some opposition to national growth-reduction policy is based on the claim that the developed countries fear an increase in the non-Caucasian population of the world. A third opposition argument is that funds spent for limiting population growth would be better spent in other, badly needed programs such as improving health care and encouraging national economic development.

What this means is simply that most developing nations have taken positions on the growth of population, but that the national positions are not actively put into practice. There are, of course, exceptions to this generalization. The following summary indicates what is being done on a national level in a dozen countries with populations of more than fifty million people.

BANGLADESH: In 1971 Bangladesh became an independent country, freeing itself from Pakistan and allying itself with India. As a consequence, war between India and Pakistan erupted in Bangladesh. This has resulted in a general social and economic disarray, and a population that is not easily influenced by national policies. Population policy is linked with more general health policies, but they are for the most

part ineffective. Bangladesh has the highest density (people per square kilometer) of any Asian nation except the city-state of Singapore. Although government policies clearly support strong birth control measures, the birth rate is still one of the highest in the world.

BRAZIL: There is no national policy to reduce population growth. In fact, there is official support for an increase in the birthrate. Brazil's coastal cities have large and dense populations, but the interior is sparsely populated. Rapid population growth in the interior is officially encouraged.

FRANCE: Fifty percent of the growth is accounted for by immigration. Abortions are forbidden by law, although there are probably 300,000 illegal abortions each year. The sale of contraceptives was made legal in 1967, although the opposition of the Roman Catholic Church has limited their use. There is no official policy favoring the control of the population growth rate, and much support is given to the establishment of families. Physicians are prohibited by law from performing sterilizations.

INDIA: The government has adopted a series of "five year plans." Sterilization and contraception are openly encouraged, and the minimum age for marriage has been raised to 18. India's goal is to reduce the annual birthrate to 25 per thousand by 1980, but present measures do not seem able to meet that goal. India still has a very high birthrate, and is the second most populous country in the world. There is no apparent opposition to the official policy of reducing the population growth rate.

INDONESIA: Indonesia also has a very high birthrate. Official policy is to reduce the growth rate, and the policy has been gaining wide support. Foreign aid has been used to establish family planning programs that have been accepted by about half the population. The training of personnel to staff these programs has been a problem.

JAPAN: There is no national policy favoring a reduction in population growth, although a very large proportion of Japanese practice some form of birth control. Japan is the most industrialized of Asian nations, and it has very crowded cities. Concern for environmental protection has been given much official support, and this has encouraged the use of birth control methods. The pill and IUD are not approved for general use, but abortion and sterilization are widely used. Birth and death rates stabilized in the 1950's, and Japan is growing much more slowly than other Asian nations.

MEXICO: Government population policies have taken several turns; at present the official policy is to limit growth by supporting family planning programs and distributing birth control information. Partly because government policy has changed so often, it seems to have little effect on the people.

NIGERIA: The government officially permits but does not support family planning. In some regions there is support for population growth. Even if a different, low-growth policy were adopted, staffing would be a problem and there is reason to believe few citizens would be affected. Although no laws prohibit the use of contraceptives or abortions, few Nigerians are able to afford the pill, IUD's, or medical care for an abortion. Nigeria has the highest birthrate of the twelve nations listed here, but the death rate is also very high.

UNITED KINGDOM: Official policy supports the control of population growth rates through free access to contraceptives, legal abortions and public information campaigns. The United Kingdom has been successful in reaching one of the lowest growth rates.

WEST GERMANY: Although there is no government policy, over 80 percent of couples practice birth control, 25 percent with the pill. Abortions are illegal, though widely performed. West Germany is very near zero population growth.

PAKISTAN: Government policy has changed frequently, and therefore has little effect on the citizens. Family planning receives little government support. Pakistan has one of the highest growth rates, one of the highest birthrates and a high population density. The Islamic culture is male-dominated, and women have little access to birth control techniques. A mass effort to encourage the use of IUD's in 1965-70 was never widely accepted. Even if there were a strong national policy, it is doubtful whether it would be effective.

SOVIET UNION: No formal policy exists. Abortion is widely practiced. Women form a large proportion of the labor force and are encouraged to limit the size of their families. Although higher than in most developed nations, the birthrate is still much lower than in developing nations. Population growth in the Soviet Union does not appear to be a major concern of the government.

VALUE CONFLICTS AND POPULATION CONTROL

Experts disagree on the nature of the worldwide population problem and on what should be done about it. In fact, experts disagree on the question whether the growth of the human population is a problem at all. Some believe that population growth endangers the freedom or even the survival of people all over the world. Others believe population growth threatens only the comfort of people in the richest countries.

The view of the US government is that population growth is a problem because it slows economic growth, depletes food and other resources, overburdens government social welfare programs, increases environmental pollution and threatens the stability of social and political systems.

There are other views. Some experts claim that population growth does not slow economic growth at all, and point out that some countries, such as Taiwan and Brazil, have managed to have both growing populations and growing economies at the same time. Others argue that economic underdevelopment causes rapid population growth (rather than the other way around) by leaving masses of people unemployed and causing a feeling of despair. Others believe that rapid population growth is a positive force, encouraging societies to do away with old ways of doing things and to create modern economies and social systems. Some countries, such as Brazil, hold that it is necessary for them to have much larger populations than they now have before they can modernize their economies or become important military powers.

The US, however, consistently maintains that population growth is a worldwide problem. And, because the US is one of the most powerful nations in the world, its policies affect other nations. The US pays about forty percent of the cost of a variety of worldwide programs for controlling population growth, such as the UN's Fund for Population Activities and the International Planned Parenthood Federation. The major justification that is given for this expenditure is that many countries have decided that their populations are growing too fast, and have asked the US, the World Bank, the UN and other agencies for help.

Because the population problem (if there is one) is controversial, and because the US government pays for such a large proportion of the activities designed to slow population growth, American citizens need to be informed about population growth, and to think about a variety of value questions related to population control. The remainder of this reading outlines some of these questions.

1. Some countries that depend heavily on the US and the World Bank for loans to develop their economies feel that they are being pressured into setting up population-control programs in order to get the money they need. Should the US and other donors of funds exert pressure on developing nations to set up population-control programs?

2. Some developing countries believe that they are being denied aid that they need to develop their economies, and are being given fee population control instead. Should the US and other donors use population-control assistance as a substitute for other kinds of assistance?

3. Many countries that request help with population control have policies that are openly racist: they want to keep the population of one race or ethnic or religious group from growing, and to encourage the growth of the population of another race or ethnic or religious group. Should the US provide help with population control to a country with a policy like that?

4. In some countries, population-control measures are forced on people. For example, some countries have denied women abortions unless they agreed to be sterilized. Should the US provide help with population-control programs that are used in this way?

5. Some countries use "incentives" to get people to have fewer children. That is, they give money, food, clothes, radios, etc., to poor, illiterate people who come in to be sterilized, and also to the "motivators" who go out and bring them in for treatment. Several value problems have been pointed out in connection with this practice.

a. Many people agree to be sterilized simply because they want to get the incentive. A program that allows this to happen is ignoring the fact that these people might really want to have children.

b. Incentive programs are most successful among populations that are illiterate and very poor. In such populations there is a great probability that individuals will be misled because of their own ignorance.

c. Many motivators lie, cheat and bend the truth to get their incentives. For example, they steal part of the patients' incentives; they bring in people who are unmarried or too old to have children or people who have had only one child or no children; or they lie to the patient about the nature of the operation.

Some people believe that incentive programs in which these things happen are wrong because they violate the rights and sometimes threaten the health of poor and ignorant individuals, in order to assure the successful completion of government programs for controlling population growth. Should the US support other nations with programs that do that?

6. There is some evidence that rich nations are using the people of poor nations as guinea pigs. For example, the rich country gives grants to scientists in the poor country to a carry out contraceptive drug studies on the people in the poor country. If the new contraceptive drug works and is safe, the rich country can use it. If not, nobody in the rich country has suffered--but some people in the poor country have suffered. Should the US take part in programs such as this?

7. Some countries have an offical policy of encouraging their populations to grow, or encouraging population growth in some parts of the country and discouraging it in others. The government of such a country might keep some of its people from getting information about birth control, to ensure that those people will have a lot of children. Should the US provide population-control assistance to a country that treats its citizens unequally in this way?

VALUE CONFLICTS AND GENETIC ENGINEERING

Whenever science brings forth a new technology, it enables people to do things they could not do before. But it also presents people with value questions they have never had to answer before. Either the individual or society or both must decide whether the new technology should be used and, if so, for what purposes.

The science of genetics has already produced, or will probably produce in the near future, a variety of technologies that will enable humans to control the genetic composition of their own population. The value questions raised by "genetic engineering" are important ones, for the way we answer these questions will affect not only the present generation, but also all future generations of human beings. Much of this technology is already being used, but most of the value questions about it are still unanswered. This reading will outline some of the value questions that result from the availability of genetic engineering technology.

1. One use of genetic technology that many people are interested in is called eugenics. Eugenics is the attempt to improve the genetic composition of a population. Another use of genetic technology is to benefit individuals who are born with genetic abnormalities. Sometimes there is a conflict between these two objectives.

Consider, for example, the early detection and treatment of PKU, which has become possible only in recent years. When a child is born with PKU and the disease is detected immediately and treated correctly, the child is able to grow into a normal adult. Clearly, the use of this new technology benefits the individual. But does it

benefit the population? Formerly, people born with PKU were unlikely to reproduce, and therefore unlikely to pass on the genes for PKU to later generations. But now, when an individual with PKU is able to grow to a normal maturity, that individual is able to pass the PKU gene on to his or her children. It often happens that the use of a new technology to improve the lot of individuals results in an increase in the prevalence of disease-causing genes in the population as a whole--which is the opposite of eugenics.

How should a technology like this be used? Should individuals with genetically caused diseases be allowed simply to die, in the interest of the human species? Should they be saved, but prohibited from having children? Should they be saved and allowed to reproduce? How should an individual who has been treated for a disease like PKU make decisions about having children? Should such a person have children to satisfy his or her own desires, or avoid having children in the interest of the human species?

2. Sickle-cell anemia is an example of a disease that one has only if one inherits the gene for it from both parents. If two people who are carriers* of this gene have a child, the chances are one out of four that the child will have the disease, two out of four that the child will (like the parents) be a carrier of the disease, and only one out of four that the child will be neither diseased nor a carrier.

Thanks to the science of genetics, carriers of sickle-cell anemia and of several other diseases that are inherited in this way can be identified by simple, inexpensive tests. What should two people do if they know they are carriers of one of these genes and they want to have children? What should the society do? Should it test everybody who might have the gene and tell each person whether or not he or she is a carrier? Should it encourage people who carry the gene not to have children? Should it try to prevent them from having children?

Many diseases that are inherited in this way, including sickle-cell anemia, have no known cure, and they cause great suffering in people who are born with them. What are the responsibilities of parents, if they carry such a gene, to their unborn children? What are the responsibilities of society to these children? What are the responsibilities of the parents, and of society, to future generations? Should the gene be passed on, or should there be attempts to reduce its prevalence in the population?

3. Amniocentesis is a minor surgical procedure whereby cells from a fetus can be extracted from the amniotic fluid inside the uterus. These cells can be used to prepare a karyotype, and the karyotype can be used to detect a great variety of chromosomal abnormalities, and also to determine the sex of the fetus. Amniotic fluid can be tested biochemically for a variety of genetic diseases, such as PKU and cystic fibrosis.

If parents think that their yet-unborn child may have a chromosomal or genetic abnormality that can be detected in this way, should the mother undergo amniocentesis and find out for sure? If she does, and if the fetus is defective, what should be done? If the fetus has a genetic defect that can be treated, should the fetus be allowed to be born and possibly to pass on the defect? Should it be allowed to be born and then be sterilized? If the fetus has a disorder that cannot be treated, should it be allowed to be be born and then to suffer? Under what conditions, if any, should an abortion be performed and the fetus destroyed?

Amniocentesis can be used to determine the sex of the fetus. What should parents do if they very much want to have a girl, but not a boy (or vice versa)? If the mother undergoes amniocentesis and the fetus is the wrong sex, should it be aborted? Surveys have shown that more people would prefer to have boys than would prefer to have girls. Should parents be allowed to choose the sex of their child? What if they were allowed to do so, and a serious imbalance resulted? What if, in one year, 75% of the babies born in the US were males? Should the society prohibit abortion of fetuses just because they are the wrong sex? Should the society decide what the best percentages of males and females in the society would be, and use amniocentesis and abortion to "balance" the population?

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* A "carrier" of a recessive gene is an individual who is heterozygous for the gene.

4. Artificial insemination is the mechanical insertion of sperm in a woman's vagina to fertilize her ovum. This practice is widely used in the US. Should this practice be controlled by society? Should it be used for eugenics, i.e., to produce genetically "superior" children? Should the decision to use this practice be left entirely up to the mother? Should it be prohibited? If it is not prohibited, should the society control the selection of sperm donors for artificial insemination?

5. Artificial inovulation is the practice of removing an ovum from one female and transferring it to another female for fertilization and development. This has been accomplished in several mammals other than humans, and it will probably be done successfully with humans in the near future. Should it be allowed? If so, under what conditions? Should it be allowed for women who want to have children but are unable to have them any other way?

Should artificial inovulation and artificial insemination both be used, with ova and sperm from carefully selected donors, to improve the genetic composition of the species? If we decide that we cannot allow this to be done in our country, what should we do if some other country that is a potential enemy of ours begins doing it--perhaps attempting to produce a "master race" of soldiers?

6. Cloning is a process whereby cells from a living individual are stimulated to grow into another individual with exactly the same genetic characteristics. Many plants reproduce in this way naturally: if a piece of the plant comes into contact with the ground, it roots and produces a new plant. Cloning has been done in the laboratory with lower animals, such as frogs, and it has been estimated that within fifty years it will be possible to do it with people.

If cloning becomes possible for people, should it be done? Should society try to produce extra copies of its most productive, or most intelligent, or most brave, or otherwise most valuable citizens? How should society decide whom to clone and how many "copies" to produce? If we decide that we should not clone people, what should we do if some other society attempts to clone statesmen, soldiers, workers or scientists? If we allow cloning, who will serve as families for the clones?

Recent research has shown that it may be possible to produce hybrids--organisms that are part one species and part another--by mixing the genetic material of two species and then cloning. If this becomes possible, should it be done? Should our society raise animal-human hybrids as a source of transplant organs, or as a force of subhuman workers or soldiers? Again, what if some other society starts doing it? Do we have the right to create a species that is almost in our image, but not quite?

VALUE CONFLICTS AND AMNIOCENTESIS

Until the early 1960's, it was impossible to detect genetic or chromosomal abnormalities in an unborn fetus except by the use of X-rays. It was often possible to calculate the probability of one or another disease--for example, the 25% chance that the child of two carriers of the sickle-cell anemia gene would have the disease. But there was no method of knowing whether a particular child actually would have that disease until after the child was born. And even if there had been such a method, it would have been illegal to abort a fetus just because it was genetically defective. Many people who were carriers of defective genes, or who had an increased chance of having a baby with a chromosomal abnormality, could only gamble on a healthy child, or not have children.

The availability of amniocentesis and abortion has changed this picture. It is now possible to determine, without X-rays, whether a particular fetus has any of several dozen genetic or chromosomal abnormalities, and to abort it if it does. Of course, the fact that it is possible does not necessarily mean that it should be done. This reading outlines several value questions arising from the availability of amniocentesis.

Risks to the Health of Mother and Child: Because amniocentesis is a surgical procedure and not a drug, there is no requirement that any agency decide that it is safe and effective before it can be used. There are several risks associated with amniocentesis, and there is disagreement over just how serious they are.

1. One or two percent of women tested spontaneously abort after the test is done. These abortions might have occurred even if amniocentesis had not been performed.

2. Perhaps as many as three percent of women tested contract infections from the procedure, but most of the infections can be treated with antibiotics.

3. Eight to ten percent of women tested suffer some bleeding as a consequence of the test. In a smaller percentage of cases the needle may puncture the placenta, the bladder or the intenstines. Such injuries may cause serious disease.

4. Some physicians fear that the intrusion of the needle into the uterus may harm the fetus in unpredictable ways, perhaps even psychologically.

5. There is no record of a mother's having died as a consequence of the test.

Should a mother expose herself and her fetus to these risks? Should the society allow her to do so--especially when some of the risks threaten the fetus? Who is to judge how great the risk is? Consider the situation of an expectant mother who is in her forties, is desperate to have a child and would rather bear a defective child than lose it and perhaps never conceive again. To this woman, the risks of amniocentesis may appear very great. But to a younger woman who already has children and is only mildly interested in having another one, the risks might appear unimportant. Should these mothers be allowed to make their own decisions?

Anxiety: Some physicians have suggested that a mother should not be told about amniocentesis unless she asks about it. They fear that the test would cause the mother anxiety--even if it shows no abnormality--and that the anxiety might harm the mother and the fetus. Should society allow this to happen? Would the risk of anxiety be acceptable if psychotherapy were automatically given to mothers who undergo amniocentesis? Should society guarantee that the mother receive information about amniocentesis and, if she decides to have the test, that she receive psychiatric support? Or should the decision whether to provide the information and the follow-up treatment be left to the individual physician?

Individual vs. Society: Some scholars argue that it is not a good idea to abort abnormal fetuses, because the genetic traits that we find undesirable now might become desirable at some time in the future due to a change in our environment. For example, the gene for sickle-cell anemia might become desirable if we are threatened with annihilation by malaria. Should amniocentesis and abortion be withheld in order to preserve a variety of genetic traits in the human population? Or should the potential suffering of parents and child be given greater weight than potential suffering of the society or the race?

Eugenics Inside-Out: Many genetic abnormalities produce individuals who are abnormal and who may suffer a great deal, yet who can make great contributions to human society. Lord Byron had a clubfoot; Woody Guthrie had Huntington's chorea. When a fetus is aborted, its good qualities go with its bad ones. Should amniocentesis and abortion be available to anyone, no matter how slight the potential abnormality of the fetus, or should either or both of these techniques be restricted to prevent the destruction of potentially creative, productive individuals with flawed bodies?

Control of Information: Who should decide who has access to information about health? Should physicians be allowed to decide whether they will tell patients about the possibility of amniocentesis? Should society require that every mother have this information? Should society identify certain classes of mothers who should have it--for example, mothers who are so old that they have an increased risk of bearing a defective child--and leave the decision to the physician in other cases?

Authority over the Mother's Body: Who should decide whether a mother will undergo amniocentesis? The mother alone? The mother and the father together? Who should decide whether a woman should have an abortion? What should the physician do if the mother and father disagree? Who should have the last word?

Genetic research has produced a great deal of new knowledge in recent decades. Much of this knowledge has proved useful in the prevention and treatment of disease. But this knowledge can be used in other ways as well. As genetic research continues, it appears very likely that people will be able to control the genetic inheritance of future generations of human beings.

Should such research be controlled? Should the resulting knowledge be used only to cure diseases, or should it also be used to improve, somehow, the nature of the human race? Is it possible to put new knowledge to "good" uses and yet prevent it from being put to "bad" uses? Who should make decisions like these? What criteria should be used in the making of the decisions?

The five short readings that follow present five different viewpoints on these questions. There are other views, of course; for example, one view not represented here is that genetic research should be stopped altogether because it is too dangerous. But these readings do present a wide range of views of people who believe that genetic research, in some form, should continue.

Scientists Should Monitor Genetic Research and Technology

Scientific and technological advances often have both desirable and undesirable consequences. Research on nuclear energy might someday bring us an inexhaustible source of energy; it has already brought us the hydrogen bomb. Improvements in health care have brought us longer lives; they have also brought us a population that some people consider excessive.

Genetic research also has desirable consequences and, at least potentially, undesirable ones. The desirable consequences are new ways of preventing or treating diseases that are caused by genetic abnormalities. But the same research that has made these medical advances possible has also made it likely that humans will someday be able to control human genetics and human evolution.

The possibility of controlling our own genetic future is not in itself undesirable. But some people fear that mistakes will be made or that power to control human genetics will fall into evil hands.

How should we protect ourselves and future generations against this danger? Some people suggest that genetic research simply be stopped, because it is too dangerous. There are three things wrong with that position. One is that stopping genetic research would prevent us from discovering more new ways of preventing suffering. Another is that stopping genetic research would violate the freedom to learn. And the third is that, even if genetic research were stopped in this country, it would go on in other countries; action by our government would not protect us against the results of research carried on elsewhere.

A better alternative would be to establish commissions, made up of professional scientists, to keep track of all genetic research and all practical applications of the resulting technology. These commissions could keep government agencies informed of what is going on, and these agencies could then control genetic research and technology so as to serve the best interests of humanity.

Scientists Should Pursue Genetic Research and Educate the Public

Genetic research has made it possible for us to treat many genetically caused diseases. But when we treat these diseases, we often enable the person to grow to maturity, to have children and thus to pass on disease-causing genes to future generations. Over a long period of time, therefore, the treatment of genetic disorders in individuals results in an increase in the proportion of genetic disorders in the population.

How can we prevent genetic medicine from changing the genetic characteristics of the species for the worse? Genetic research has provided several ansers. One is amniocentesis and abortion, whereby defective fetuses can be identified and destroyed. Another is artificial insemination, whereby a woman whose husband carries a defective gene can have a baby free of the defect. A third is genetic counseling, whereby

Prospective parents can be provided the information they need to make informed decisions about whether or not they should have children.

Scientists and medical professionals can use these methods, and any new ones that genetic research may produce in the future, to reduce the proportions of defective genes in the population. There are three things that should be done right now. One is to do a lot of research to find ways of detecting more genetic abnormalities in fetuses, through amniocentesis; many genetically caused diseases cannot yet be detected in this way. The second thing that should be done is to improve the education of the general public about the facts and the problems of genetic engineering. And the third thing that should be done is to encourage the public to select their mates with care, so as to reduce the probability of passing on defective genes to future generations.

Society Should Prevent People with Defective Genes from Reproducing

Genetic diseases are similar to infectious diseases in many ways.

First, both categories of disease are passed from one person to another.

Second, within both categories there are some diseases that are highly "contagious" (i.e., among genetic diseases, there are some that are highly likely to be passed on) and some that are less so.

Third, within both categories the prevalence of disease is affected by the environment. For example, malaria, which is infectious, is common in certain areas where the mosquito that carries the disease-causing microbe is common. Sickle-cell anemia, which is genetic, is common in certain areas where there is a lot of malaria, because the sickle-cell gene provides some protection against malaria.

Fourth, in both categories there are diseases that are more common in some population groups than in others. For example, tuberculosis, which is infectious, is more common among Eskimos and American Indians than among other Americans. (Genetic predisposition may contribute to this difference, but socioeconomic variables such as diet, housing and access to medical care, and cultural variables such as attitudes toward health, disease and health care, are also important contributing factors.) Tay-Sachs disease, which is genetic, is more common among descendants of central European Jews than among other groups.

Fifth, in both categories, some diseases are worse than others. For example, the common cold is merely bothersome, but rabies is usually fatal. Webbed fingers may be embarrassing, but they are no menace to physical health; Huntington's chorea, in contrast, is completely disabling and fatal.

Sixth, medicine has provided cures for many infectious diseases and for many inherited diseases.

And finally, many diseases within both categories can be prevented.

How does society control infectious diseases? If a disease poses a serious threat to society--not just to the individual who has the disease--then society takes measures to prevent that disease from spreading. Some of these measures would be viewed as violations of the rights of citizens if they were not done for the purpose of protecting larger numbers of citizens. For example, people with some infectious diseases are quarantined (isolated from other people); they are deprived of one of the most basic rights of citizens, the right to go where they want to go and see whom they want to see.

In dealing with infectious disease, society holds that its own interest must take precedence over the rights of the individual. In view of the many similarities between infectious diseases and genetic diseases, why should society not treat genetic diseases in the same way? The way to prevent a genetic disease from spreading is to prevent individuals who carry the disease from passing it on. To do this society does not need to isolate the carrier from the rest of society, even temporarily. However, society does need to isolate the carrier's defective genes. And the only ways in which society can do that are to require amniocentesis and abortion, in the case of a gene that may or may not be passed on to a particular fetus; and to require sterilization

of the prospective parent, in the case of a gene that is certain to be passed on to any fetus.

These measures would be viewed as violations of the rights of citizens, and they are. The practice of a quarantining victims of infectious diseases is also a violation of the rights of citizens. But society quarantines people to protect itself from infectious diseases. Does not society have an equal right to protect itself against genetic diseases?

Scientists Should Help Control the Application of Genetic Engineering

Scientists have not always been free to learn whatever they wanted to, and they are in danger of losing that freedom again. The danger is especially great now because government pays for the majority of the research that scientists do. Many people are afraid that science has become the servant of political power, and they are ready to limit the freedom of scientists in order to preserve their own freedom.

It is impossible to predict what scientific researchers will discover, and it is equally impossible to predict what technologies will result from their discoveries. However, the danger that some people perceive in the science of genetics does not come entirely from the research; much of it comes from the application of the knowledge that the research produces.

It might be necessary for society to control genetic engineering. However, the way to do so is not to stop the search for new knowledge, but to control the application of new knowledge.

If scientists do not want society to stop them from doing genetic research, they must become the leaders in controlling the use of genetic technology. In order to do this, they must begin doing two things immediately. One thing they must do is to see that all scientists become better educated about things that lie outside their scientific specialties. Scientists must take an interest not only in the search for new knowledge, but also in the processes whereby society makes its decisions about the use of new knowledge.

The second thing that scientists must do is to see that the people who make society's decisions for it--business people, politicians, religious leaders, educators and so forth--become better educated about science. The leaders of society must learn what science is about and how it works, so that they can make intelligent decisions about controlling the uses of new knowledge.

All Segments of Society Should Share Responsibility for Genetic Engineering

How should society control the use of genetic knowledge? This is a value question, and it must be answered on the basis of value principles. The question is complicated, and so are the value principles related to it.

The first part of the question is, What should genetic knowledge be used for? What are the proper purposes of genetic engineering? There may be long-range purposes, such as improving the genetic characteristics of the human species (eugenics), and short-range purposes, such as preventing suffering in individuals.

This question leads to others: What is an "improvement" when we are talking about the human race? What is an "unacceptable" level of suffering in an individual? These questions boil down to one: What do we value about human life? Our culture and our traditions have provided us with a variety of answers to this question: intelligence, happiness, spiritual bliss, pleasure, freedom, love, survival of the species--the list is long.

If we have a great many reasons for valuing human life, then we have a great many criteria for deciding how to use genetic engineering. Who will apply these criteria? Where they conflict, who will decide which ones are the most important ones?

Answering this question is difficult. In a democratic society, the people are supposed to make the final value decisions. But most of the people know almost nothing about genetics or genetic engineering. Should the decisions therefore be left up to

scientists, because they know more? Or should they be left up to the people and their representatives in government, because we live in a democratically governed society?

We can avoid this dilemma if we can get everybody--scientists, politicians, poets, philosophers and so on--to participate in open, public discussions on the problem of controlling genetic engineering. Only in this way can all the many values and the many kinds of knowledge in our society be combined to produce the best possible decisions. Scientists should not make all the decisions. And, when something goes wrong, scientists should not take all the blame.

GOVERNMENT AND GENETICS

What does government have to do with genetics? More than you might think. Genetics, like most other natural sciences, requires a great deal of expensive equipment for research. Where does the money come from? A lot of it comes from government.

An important feature of our system of government is the right of citizens to decide, through their elected representatives, how public money will be spent. This is not a right of citizens in all countries, but in the US it is guaranteed by the Constitution.

However, an important feature of science in present-day Western societies is the freedom of scientists to decide what they will study and how they will study it. Scientists have not always had this freedom; in the past they have lost it when their ideas began to conflict with the teachings of powerful religious groups. But in our society scientists have traditionally enjoyed freedom of inquiry.

These two values, the right of citizens to control the use of public money and the freedom of scientists to pursue knowledge as they see fit, are potentially in conflict when government pays for a large proportion of the scientific research that goes on in the society. Who should control the direction of government-supported research? If scientists control it, then citizens are forced to pay for research that they have no control over. But if government controls it, then scientists whose work is supported by government are forced to pursue knowledge only in areas that the government allows them to investigate.

How should this conflict be resolved? The answer will always be a value statement that involves government: either government should control government-supported research, or government should allow scientists to control government-supported research, or some compromise should be worked out that will protect both the rights of citizens and the freedom of scientists. Since this is a value question about government, it is one that, under the Constitution, should be decided by the citizens through their elected representatives.

This reading, about the conflict between the rights of citizens and the freedom of scientists, is in four parts. The first part suggests some reasons why citizens might want to control the use of genetic knowledge. The second part outlines the ways in which government will try--and fail--to control the use of genetic knowledge if present trends continue. The third explains why it is practically impossible, under present conditions, for government to control the use of any knowledge that comes from government-supported scientific research. And the fourth suggests one way of resolving the conflict.

How Is Genetic Engineering Dangerous?

It is generally agreed that one legitimate function of government is to protect the health of the public. The government has authority to identify people with contagious diseases and to prevent those diseases from spreading, even if it has to violate some rights of the original victims of the disease.

It is widely agreed that the government has authority not only to protect the health of the present population, but also to protect the health of future generations. For example, government agencies require that people who want to marry be tested for VD, to prevent the passing of VD to their children; and some jurisdictions prohibit the marriage of people who are closely related (e.g., first cousions) to prevent the passing of genetic diseases to their children.

Some jurisdictions now require that certain people be tested to determine whether they are carriers of sickle-cell anemia, either at birth, on entering school or on applying for a marriage license.

There are some ethical and possibly some legal problems with such screening requirements. One problem is that it is hard to justify the screening of children. The information gained by testing for carriers of sickle-cell anemia is really not useful except to people who are deciding whether to marry or whether to have children. Screening children might result in some children's being labeled as ill or different, and those children might suffer discrimination on account of that label.

This problem is serious. But there is another thing about sickle-cell screening programs that some people believe is more serious, because it is a potential threat to the rights of many more people: not just certain children, but all citizens. Some people believe that the most dangerous marriage is not that between two people who carry the sickle-cell trait, but that between the power of scientific technology and the power of government.

How might this "marriage" become dangerous? First, it is possible that government will decide that screening people and informing them about their genetic traits is not enough, that it is necessary to take stronger steps to protect the health of future generations. It would be much more effective to prohibit the marriage of couples who might pass genetic diseases to their offspring, or to require that all pregnant women undergo amniocentesis and, if a genetic or chromosomal abnormality is found in the fetus, that the fetus be aborted.

It is possible that government will decide to use genetic technology not only to prevent the passing of "bad" genes to future generations, but also to encourage or even to guarantee the passing on of "good" genes--"good" as defined by government. That is, it is not only possible that government will prohibit certain people from having children, or from having certain kinds of children. It is also possible that government will require certain people to have children or (through methods such as artificial insemination) to have certain kinds of children, in order to improve the genetic nature of the society.

How Can Genetic Engineering Be Controlled?

How does our society make decisions about the use of genetic technology? Individuals--patients and their physicians--make many of the decisions.

Many other decisions are made by organizations of health-care professionals and scientists: medical associations, hospital decision-making bodies, and institutions such as the National Institutes of Health, the National Science Foundation and the National Academy of Sciences. The decisions of such organizations do not have the force of law, but they do greatly influence the behavior of individual health-care professionals and scientists.

Still other decisions will eventually be made by the courts. As lawsuits over the uses of genetic technology work their way through the court system, a body of "judge-made law"--that is, precedents that later judges will follow--will begin to emerge. This kind of decision-making is slow and unpredictable. There will be a long period of trial and error before the courts develop a coherent body of legal precedents about the uses of genetic technology.

Finally, decisions will be made by legislatures. But legislatures seldom have the time to write laws about anything that is not an immediate, pressing problem for society. They are unlikely to produce any decisions about the uses of genetic technology until after the technology has been in use for a long time, and various groups in society have already staked out positions that are in their own interests. When events show that there is an urgent need for regulation of the uses of genetic technology, our lawmakers will begin to investigate.

In summary, it will be a long time before institutions of government--courts and legislatures--begin to control the uses of genetic engineering in ways that they think are best for the society as a whole. In the meantime, genetic technology will be put to use a little at a time. When a patient appears who, it seems, will be helped by some new genetic technique, the technique will be tried. If it works, it will start

to be used on more and more patients. If it doesn't work, it will be changed and then tried again.

At each point in this process, it will be obvious that someone has something to gain from the new technique. It will not be obvious that anyone has anything to lose. And there will be no attempt to determine what the long-range consequences of this technique, for our society or for the human species, might be. Only over a long period of time--during which more and more new genetic techniques will be used on more and more patients--will any undesirable consequences become obvious.

Why Can't Government Control Genetic Engineering?

Some people argue that genetic research should be allowed to go on without any limits, that geneticists should be allowed complete freedom to learn what they want to learn. The undesirable consequences of research come not from the research itself, but from the ways in which the knowledge is used. Therefore it is necessary only to control the application of knowledge, not the search for knowledge.

Unfortunately, that kind of control will not work in our society. Government pays a large part of the bill for scientific research in this country--so large that government has been accused of suppressing certain lines of research simply because it refuses to pay for them. And when government pays for some research, government is practically forced, by the nature of our political system, to put the resulting knowledge to use. No politician wants it said that he or she voted to spend a huge bundle of money to get some knowledge, and then refused to allow the knowledge to be used. This would be seen as a waste of money.

Government pays not only for the research but also, in large part, for the development of the resulting technology. In the marriage of science and government, the period of pure scientific research--the pursuit of new knowledge--is just the engagement. The publication of the new knowledge is the wedding. Then comes the marriage.

First, government encourages (pays for) the development of technology that will benefit society--for example, a new method of detecting or preventing or curing a disease. If there are undesirable consequences they do not become known immediately. When undesirable consequences do appear, there is an attempt to offset them with more new technology--a drug antidote, a new surgical procedure, etc.--that will "fix" the adverse effects. If the technological "fix" does not work, laws will be passed to regulate the use of the new technology. At this point the marriage is becoming strained, but it has not yet fallen apart. Only as a last resort--when there are still unacceptable consequences even with controlled use of the new technology--will there be any thought of prohibiting the use of that technology. And by that time, of course, the damage--which may or may not be reversible--is done. The ill effects of a hasty courtship are not eliminated by a divorce. They are only put to a stop. At what cost?

Can Government Control Science in the Interest of Society?

The science and technology of genetics have made giant strides forward largely because of government's willingness to pay for genetic research and development. The decisions about what government will pay for have been made by experts, both in government and outside it. These experts are aware that genetic research may have undesirable consequences, that there are ethical and legal problems with some uses of genetic technology. They should continue to discuss these problems not only among themselves, but also in front of the public. The public has a right to know what the consequences of research and development are likely to be, and it has a right to decide through its elected representatives whether it wants to risk those consequences.

The public, of course, does not know very much about science. Would it be a mistake to let the public make decisions about the future of scienctific research and development? Is there a danger that the public might cut off the money, thus depriving itself of all the benefits that science and technology have to offer?

Our system of government is founded on the value principle of self-government, the idea that the people have an unalienable right to determine how they will be governed and, more specifically, how the government will spend their money. The system of government based on this principle is not designed to ensure that all decisions will be right. It is designed to ensure that the people will make the decisions that will

influence their lives. The Constitution requires that all decisions about the way the government spends the people's money be made by the people's representatives and in the people's view.

Scientists have an obligation to continue telling the public, in language the public can understand, what is likely to come of the scientific work the public is paying for. If it is possible that the work will have undesirable consequences, then these should continue to be discussed as fully and as openly as the hoped-for desirable consequences are discussed. With this information, the public can make decisions that follow its own values.

A PRACTICE SESSION IN COUNSELING

During the next three class sessions you will participate in a simulated counseling session. There are three or more participants in this session: a client, a counselor and one or more observers. You will play each role at least once. Through this activity you will become aware of the perspectives of clients and counselors.

As you go through the activity, try to remember what you think is most important, what seems to work for you as a counselor, what you as a client see as useful or helpful behavior on the part of the counselor, and what you believe are important elements of a good counseling session.

A timetable for each simulated session is given below; your instructor may modify this timetable to fit the demands of the schedule in your school.

MINUTES	ACTIVITY
5	Observer gets ready to take notes, counselor thinks about the strategy he or she will use, and client decides what problem he or she will describe.
15-20	Client describes problem, receives counseling. Observer takes notes, watches time and notifies client and counselor when a few minutes remain.
5	Client critiques the counseling he or she has received, tells counselor how he or she reacted to what was said.
5	Counselor reacts to critique, suggests ways in which client might have helped to improve the situation.
5-10	Observer shares his or her reactions to the session and the critiques, points out how he or she thinks the situation might have been improved.

You are attempting to improve your communication skills and your ability to give and receive counseling. By hearing first-hand what other students think of your performance, you can learn what you do well and what you can improve. You will play each role, so you will need to read instructions for all three roles. They are given below.

Instructions for Client: Your first task is to think of a personal problem that you are willing to share with the other members of your group. The problem should be relatively simple so as to be manageable within the time available. It may be something related to your family, such as how to help a younger brother or sister, to your life in school, such as how to succeed in an unpleasant or difficult class, or to some other area of personal concern. Finally, it should be a problem over which you have some control. When you have selected a problem, present it to the counselor, describing it as you wish. When the counseling time has elapsed, you will have a few minutes to react to what the counselor said or did. How was he or she helpful? Did you think the approach used was the best available? Would you return to the counselor with another problem? Did the counselor accept your problem as a serious matter for you, and help you discover possible solutions? When you have evaluated the counselor's work, you will receive a critique from the counselor and later from the observer. These people will tell you how well they thought you played the role, how helpful you were in stating your problem and thinking through the alternatives suggested, and how you might have been a better client.

Instructions for Counselor: Your first task is to decide what approach you wish to use. You may want to help the client work out his or her own solution to the problem. If this is your choice, you will ask many questions, trying to get the client to refine his or her understanding of the problem. You will not offer much (if any) advice and you won't volunteer information on similar problems you may have experienced. If you choose to be more direct, first listen to the problem and then make any suggestions you think appropriate. Offer your opinion and the reason you have for holding it.

When you have completed the counseling session, your client will tell you his or her feelings about what you said and did, how helpful you were and so on. Then the observer will tell you and the client his or her impressions of the session. The three of you may have time to discuss what might have been better actions on the part of client and counselor.

Instructions for Observer: You serve as timekeeper and as an impartial observer. One part of your role will be to inform the other two participants when they have run out of time. You should also jot down anything you may want to say in class when the sessions and critiques are over. Listen carefully to the problem and the reactions of the counselor. Look for unspoken feelings of each person. Note which proposals were accepted or rejected by the client and the reasons given. What efforts were made to establish an atmosphere of trust and openness? How did the counselor obtain information from the client? Did the counselor help the client see possible alternatives? How might he or she have done this? Would you want to be counseled in this way?

When the other two participants have expressed their reactions, you will have time to provide your own. Because you are an observer, you will be able to see things differently. Take advantage of this opportunity to tell both people what you think went well, what went not so well, and how the session might have been improved.

Finally, all three participants should consider the role of the counselor. The counselor may have chosen to be direct, offering personal opinions and suggesting solutions. Or the counselor may have been indirect, attempting to get the client to figure out solutions and not offering any opinions.

Many professional counselors feel strongly that an indirect approach is best. They believe that if the client is caused to become reflective--to look inward and decide independently what should be done--then the client will be better prepared to deal with other problems when they arise. On the other hand, people do come to counselors for help. If a counselor has worked with others who resolved similar problems, why not share this knowledge? Clients frequently report that the direct counselor seems more helpful.

Which approach did the counselors take during your sessions? Was it the best role that could have been assumed? Do you favor a more direct or a more indirect role on the part of the counselor? An important reason for these practice sessions is to help you decide which type of counseling you think is more appropriate. (It may be that different situations call for different approaches.)

WHAT IS GENETIC COUNSELING?

Genetic counseling is a way of providing information, about genetics and related matters, to people who seek such information. Clients may be interested in such information for any of several reasons: because they have (or think they might have) a genetic abnormality, because they have a chance of passing a genetic abnormality to any children they may have, because they want to choose a husband or wife with whom they can have children free of genetic defects, or because a physician or other health-care professional has recommended that they seek counseling (as might happen in the case of a woman who is old enough to have an increased risk of bearing children with defective chromosomes).

Genetic counseling has two possible goals. One is to help individuals with problems such as those outlined above. The other is to improve the genetic characteristics

of a population by influencing the decisions of individuals about reproduction. As you know, these two goals are sometimes in conflict, but in many cases they are not.

Many persons who seek genetic counseling have already had one child with a birth defect, or have family members, such as siblings or parents, who they suspect are carriers of genetic defects. An informed genetic counselor can often help such clients by predicting the probability of recurrence of a given abnormality in the same family.

A counselor may need to be well informed about the clients' family history. A pedigree chart is often made. The counselor must determine whether there may be defects transmitted by genes passed from parents to children and whether there may be defects due to some other cause, such as infection during pregnancy. If a defect in the clients' first child or in a relative was not inherited, the counselor can reassure the clients that the risk of its recurring is much less than they fear. For example, the defect may have been caused by maternal infection with rubella during pregnancy. Rubella can cause severe birth defects, but it affects only the child in the womb at the time the mother has the disease. The infant's birth defect is environmental, not genetic, in origin. Additional offspring from the same parents would not be threatened with the same birth defect.

In a different case, a genetic counselor may determine that the clients are fearful for good reason: that there is a high risk they will have a child with a genetically transmitted birth defect. Even in a case such as this, the counselor can be of help--by providing information about the nature and degree of the risk. The risk that a child will be born with an abnormality may be high, moderate or low. The degree of risk is important information for a couple considering having a child.

What should a genetic counselor do? Should he or she offer advice, or only information? If a counselor concluded that the risk a couple faced was very high--that their child would very likely be born with a serious defect--the counselor might urge the couple not to have a child. He or she might suggest adoption. If the defective genetic characteristic is carried by the man, the counselor might suggest artificial insemination with donor sperm. Or the counselor might tell the couple the nature and extent of the risk and leave the decision entirely with the couple, offering no personal opinion.

These are important alternatives. A genetic counselor faces other important questions as well. For example, what should one say to a woman who is pregnant, but not far along, if one knows there is a chance her fetus has a serious genetic defect? Should an abortion be advised? Should the counselor's decision be based only on the probability that the fetus will be born defective, or should the woman's moral beliefs about abortion also be considered? Should the counselor withhold information from the client? If so, what kinds of information, and under what conditions?

Genetic counseling is almost always given by a physician, although there are exceptions. Several considerations enter into each counseling session:

1. knowledge about the clients' genetic inheritance

2. knowledge about the clients in addition to knowledge about their genetic inheritance

3. decisions about what the counselor should and should not tell, and why

4. decisions about whether to inform or advise or both.

In a few days some of you will play roles in genetic counseling situations. Some will assume the role of genetic counselor, and others the roles of persons seeking counseling. The sessions, and the feelings of the participants, will be discussed afterward in class. Alternative approaches to counseling that might have been used will be considered. Although you may never be asked to give genetic counseling in real situations, you may seek counseling yourself. And, if you work as a health care professional, you may encounter persons who need genetic counseling and who turn to you for information. Knowing what genetic counseling involves can be helpful in such situations.

COUNSELING ABOUT HEMOPHILIA

Ruth Mason is 21 years old. She has had no children, but she and her husband would like to have two.

Ruth has three older sisters. One has had no children. One has had a girl and two boys, and one of the boys has hemophilia. And one has just had her first child--a boy with hemophilia.

The disease that Ruth's two nephews have inherited is caused by a gene in an X chromosome. Each of these boys inherited the gene from his mother; each of the two mothers inherited it from their mother, who is also Ruth's mother. Ruth's father does not have hemophilia.

There is a 50% chance that Ruth Mason has also inherited the gene for hemophilia. If she is a carrier of this gene, and she has a child, there is a 50% chance that she will pass the gene on to her child. If the child is a male and inherits the gene, then the child will be a hemophiliac. If the child is a female and inherits the gene she will not be a hemophiliac but will be a carrier, with the capability of passing the gene on to yet another generation.

Ruth Mason is worried. She consults her obstetrician, who tells Ruth about a new test she could take, before she becomes pregnant, to determine whether she carries the gene for hemophilia. The doctor says that if the test is positive then it is certain that Ruth carries the gene; but she adds that if the test is negative then Ruth might still carry the gene, for the test detects only 80 to 95 percent of women who are carriers.

The doctor also tells Ruth about amniocentesis. No matter which way the carrier test came out, Ruth could undergo amniocentesis during the pregnancy. This test would tell whether the fetus was a male or a female. However, this test would not tell whether the fetus had inherited the gene for hemophilia.

The doctor summarized: If Ruth has the carrier test and it is positive, then she carries the gene for hemophilia. If Ruth then becomes pregnant and amniocentesis shows that the fetus is a male, there is a 50 percent chance that he will be a hemophiliac; if the fetus is a female, there is a 50 percent chance that she will be a carrier. On the other hand, if the carrier test is negative, then there is only a 5 to 20 percent chance that Ruth carries the gene and, for each child she has, only about half the chance that a male child will be a hemophiliac or a female child a carrier. No matter which way the carrier test turns out, Ruth will have the option of aborting a male fetus to prevent the birth of a hemophilic child--but if the carrier test were positive she would have a 50 percent chance of aborting a perfectly normal male fetus. If the carrier test were negative her chance of aborting a normal male fetus would be 90 percent or more.

Wanting to know more about this disease, Ruth contacts the National Hemophilia Foundation. There she learns that recent advances in medical technology have reduced the cost of caring for a hemophilic boy at home to about $6000 a year. She also learns about prophylactic (preventive) treatments which greatly reduce the internal bleeding that disables many hemophiliacs.

Ruth returns to her obstetrician. She is no less worried than she was before, and she is uncertain what she should do. Should she have the first test--the one that might tell her whether she carries the gene for hemophilia? No matter which way the carrier test turns out, or whether she takes it at all, should she become pregnant? If she does, should she undergo amniocentesis? If she does, and the fetus is a male, should she have an abortion?

Two opposing viewpoints on this question follow. (These statements are presented for analysis only. They do not necessarily represent the views of the Biomedical Interdisciplinary Curriculum Project.)

The Case for Limiting Births

Before it was possible to test women for the hemophilia gene, a woman could not be considered responsible for the birth of a hemophilic son. Now, however, a woman has the opportunity to find out what the risk is that any son she has will be a

hemophiliac. In this situation, she is responsible to do all she can for her child. Therefore, she must have the carrier test.

If she finds that she definitely is a carrier, she must weigh her desire to be the biological mother of her children against her desire to give her children the healthiest possible lives. If Ruth finds out that she is a carrier, then she has three options.

First, she can avoid becoming pregnant. She and her husband can either remain childless or try to adopt children, among other possiblilities. In this way they can avoid having a hemophilic son and also avoid having a daughter who, like Ruth, might carry the gene for the disease.

Second, she can undergo amniocentesis each time she is pregnant and, if the fetus is a male, abort it. There are several problems with this option. One is that abortion following amniocentesis is done late in the pregnancy (in the second half of the second trimester), and is therefore relatively more difficult for the mother and for the physician than an abortion performed earlier in the pregnancy. Another problem is that, whenever Ruth aborts a male fetus, there will be a 50 percent chance that the fetus is free of disease. A third problem is that, if the fetus is a female, it still has a chance of being a carrier of the gene for hemophilia.

The third option is to go ahead and have children. The problem with this option is that, if Ruth is certain she carries the gene for hemophilia, then she has a 25 percent chance of giving birth to a hemophilic son on each pregnancy: a 50 percent chance of giving birth to a son rather than a daughter and, if a son, a 50 percent chance that he will be hemophilic. This high risk of giving birth to a seriously diseased child could have been avoided by either of the other two options, and therefore one of the other two options is preferable: to avoid having children or, if Ruth's values permit it, to undergo amniocentesis and abort any male fetus. And only by avoiding childbirth altogether can Ruth be certain that she will not have a daughter who is a carrier.

If the first test is negative, then there is only a relatively small chance that any child Ruth bears will be a hemophiliac or a carrier. In that case, Ruth will have to weigh this small chance against her desire to have children of her own, her desire to have healthy children and her value position on abortion. She still has the same three options, but she might consider the smaller risk worth taking in order to have her own children and in order to avoid the large chance of aborting a normal male fetus.

The Case for Having a Child

If it were possible to know, before the birth of a child, that the child would be born a hemophiliac, then it would be immoral for Ruth to have such a child: she would be irresponsible not to abort the fetus.

But it is not possible to know for sure whether a male fetus will be a hemophiliac. In fact, the only way Ruth can be certain of having no hemophilic sons is to have no sons at all: either to have no children, or to abort all male fetuses and have only daughters. Ruth and her husband might decide that bringing a hemophiliac into the world is worse than aborting one or more normal male fetuses.

However, Ruth and her husband might be able to decide that they could morally bring into the world a child who had a chance of being hemophilic. In order to reach this decision, the Masons would have to consider several questions. (1) Is abortion moral under any circumstances? (2) Is abortion moral when there is a 50 percent chance that the fetus is not diseased? When there is a 90 percent chance that the fetus is not diseased? (3) Do Ruth and her husband have the psychic strength to love and nurture a child who will suffer both physical and psychic pain? (4) Do Ruth and her husband have enough money to provide the best available care for a hemophilic child? (5) Are Ruth and her husband prepared for the life style dictated by having a hemophilic son? (6) Are Ruth and her husband willing to bring into the world a child who will suffer greatly, even with the best of love and care? (7) Are Ruth and her husband willing to bring into the world a daughter who will eventually have to face exactly the same dilemma that Ruth is facing now?

Depending on their answers to these questions--none of which is easy--Ruth and her husband might be able to decide that it is moral for them to go ahead and have children, not to abort any fetuses and perhaps not even to have the preliminary test to see whether Ruth carries the gene for hemophilia.

ROLE-PLAYING IN GENETIC COUNSELING SITUATIONS

For the next few days members of the Social Science class will play roles in situations that might occur in actual genetic counseling. Some students will play the roles of clients seeking counseling and others will play the role of genetic counselor. The particular procedures will depend to some extent on the size of your class. Your instructor may wish to modify some of the procedures described here.

What Will Happen? Some students will be seated in separate locations--parts of adjoining classrooms, corners of your own classroom or some other areas nearby. These students will play the roles of clients. In each location there will be either an individual client or a couple. Each client or couple will have instructions. The students playing the roles of clients will pretend to know little about the particular genetic conditions that concern them. They will all act as though they had voluntarily come in for genetic counseling (though some won't know why).

The remaining students will be working in smallgroups. Each group will move around from one to another of the clients (or couples of clients). Each time the group confronts a new client or couple, the group will find out the case number of the client(s). The group will then read the information that the counselor is supposed to know about this particular case. Then the group will select one of its members to play the role of counselor for this case. The other group members will be observers.

One round of counseling (counseling one client or couple) and discussion with observers will take up most of a class period. (Detailed instructions on the counseling session are found in the separate instruction sheets for counselors and clients, following this reading.) When it is time for the next round of counseling (probably at the beginning of the next class meeting), the group will visit a different client or couple, and a different member of the group will serve as counselor. The group will continue moving from one counseling area to another until the group has confronted every client or couple, and until every member of the group has had at least one opportunity to counsel.

Each client or couple will remain in the same counseling area throughout this activity, and will play the same role(s) in each round of counseling. However, the client(s) will have a different counselor to deal with each time, and may play the role differently each time--within the limits set by the instructions to clients.

What Happens After the Counseling? After all counseling rounds are completed, the class will convene for a general evaluation. Each client will be allowed to compare and contrast the different counselors he or she has met and to discuss the ways counselors handled (or failed to handle) the particular problems raised by his or her counseling situation. Similarly, members of the counseling groups will have time to react to differences among clients and among cases. Finally, there will be a discussion of what constitutes effective genetic counseling.

INSTRUCTIONS FOR CLIENTS IN ROLE-PLAYING SITUATIONS

Please read "Role-Playing in Genetic Counseling Situations" before you read these instructions.

You will play the role of a client who has come for genetic counseling. You will receive a handout, "Information for Clients," which gives information about nine genetic counseling cases. Your teacher will tell you which case you represent; the other cases need not concern you.

The information sheet for your case will tell you whether you appear as an individual client or as one of a couple. It will also tell you what genetic condition you are concerned with, how much you know about it and why you have come for counseling.

When you are in the role of client, you will have to pretend to know less than you actually do about the genetic condition that concerns you. Part of the counselor's role is to inform you about the condition that concerns you; he or she will be unable to perform this role if you say "I already know all about that."

You will be counseled by several counselors in turn. Each time a new group arrives in your counseling area, you will have to start your role over again from the beginning: ignore not only what you already knew about the condition, but also what the previous counselor told you.

One part of your information sheet will be called, "What the Counselor Doesn't Know." The information in this section will help you to play the role of a real client. Look over this information carefully. You will present the counselor with particular problems that he or she should try to help you with. Some of the things you can say about yourself will be a complete surprise to the counselor; some of them will make it difficult for the counselor to give you any advice about what you (the client) should do. These complications will help make the role-playing situation realistic.

You will be counseled for ten minutes; then you will be excused for five minutes while the counseling group discusses your case; then you will be counseled for another ten minutes. (The group may decide to start over again at this time if the first ten minutes didn't go well.) After the counseling is over, you will be given five minutes to tell the counseling group how you reacted to the counseling you got. You are expected to be critical; your job here is to help the counseling group identify things the counselor did right and things the counselor did wrong. Try not to leave out either side of the counselor's performance. After your five minute response, the counseling group will ask you questions about the counseling sessions or about your responses to it. Observers will be free to discuss the counseling session at this time.

INSTRUCTIONS FOR COUNSELORS IN ROLE-PLAYING SITUATIONS

Please read "Role-Playing in Genetic Counseling Situations" before you read these instructions.

You will be one member of a counseling group. Your group will move around to one client or couple after another. You will serve as the counselor for at least one client or couple, while the other members of your group observe. For the other clients and couples, you will be one of the observers.

Here is what your group will do when it confronts a new client or couple.

1. Ask the client's or couple's case number. Find that case in "Information for Counselors" (following these instructions) and read it.

2. Select a counselor from among the members of your group. That person will do all the counseling for this round (this client or couple).

3. Select a timekeeper for this round and see that the timekeeper has a watch or can see a wall clock.

4. The counselor proceeds with a ten-minute counseling session while the other members of the group observe. At the end of ten minutes, the timekeeper will interrupt the session. (Your group may wish to arrange for the timekeeper to give a signal, such as raising his hand, when the counselor has used up a certain amount of his time--say, eight minutes or nine minutes.)

5. Excuse the client(s) from the area for five minutes. Use the five minutes as a group to discuss how the session is going. The group might advise the counselor, tell him or her to stop doing something or start doing something, report on his or her performance of the counseling skills you have identified earlier, and so forth. The

group should also decide whether the counselor should resume the same counseling session where he or she left off, or start again and use a different approach. The same member of the group should continue to be the counselor.

6. Tell the client(s) whether you are continuing the same session or starting over. Proceed with a second ten-minute counseling session. Again, the timekeeper will stop the session when the time is up.

Note: Real genetic counseling sessions are not limited to ten or twenty minutes. When you are playing the role of counselor, it is not necessary that you get in everything you think a counselor should get in. If a particular aspect of the case is worth the whole ten or twenty minutes, spend the time on that aspect. In the class discussion afterward, you can report on what other things you would have discussed with the client(s) if there had been more time.

7. Give the client(s) five minutes to tell your group how they would react to this counseling if they were real clients in a real counseling situation. Expect clients to be critical; counselors will probably make some mistakes, and the feedback from the clients can help you and the other members of your group identify your own mistakes.

8. Take no more than five minutes to ask the client(s) any questions you or other group members think appropriate. Your group may want to have a general discussion of the session. (The "clients" will no longer be playing a role.) This is the last phase of your work with this client or couple.

9. Move on to the next counseling area for the next round. This will probably begin during the next class meeting. Do not go to a counseling area your group has already been to. If there are more counseling areas than there are people in your group, some members of your group may get to counsel more than once. However, no member of the group should take a second turn counseling until each member has taken one turn.

Timekeeper: The timekeeper should be a different person for each round of counseling. The sequence for each round is shown below. (Again, your instructor may wish to make modifications.)

5 minutes--read information on case, select counselor

10 minutes--counsel

5 minutes--group discussion without client(s)

10 minutes--continue counseling (or start over)

5 minutes--client(s) report reactions to counseling

5 minutes--group questions client(s)

Observers: For a given round of counseling, those group members who are neither counseling nor watching the clock are observers. (The timekeeper can be an observer too, as long as he or she doesn't forget to watch the clock.) If you wish, you can assign particular tasks for each round. One observer might keep an eye on the list of counseling skills developed in class to see whether the counselor uses them. Another might note all genetic or medical information offered by the counselor and note whether it is accurate. Another observer might keep track of the proportions of time the counselor spends talking and listening. Members of your group may think of other things to observe. Since every member of the group will eventually do one round of counseling, those who are observers in the earlier rounds can benefit by the experience of those who are counselors in the earlier rounds.

INFORMATION FOR COUNSELORS

The following pages contain information about nine genetic counseling cases. Each time your group encounters a new client or couple, ask what the number of the case is

and locate the appropriate section of this information sheet. There you will find some information about the client(s), some ideas about how the counselor (or the client[s]) might start off the counseling session, and a short list of things the counselor doesn't know about the client(s).

You also have at your disposal the information sets on genetic diseases or disorders, which your class prepared previously, and the list of counseling skills your class has discussed.

Note: For the purposes of this role-playing activity, assume that every individual who inherits the genes for a condition also shows the manifestations of the condition, except in the case of diabetes. This assumption is not entirely accurate for all these conditions, but it is close enough for all of them except diabetes.

CASE I

ABOUT THE CLIENTS:

John Robert, 23, and Mary Robert, 19, have been married about a year. Mary is two months pregnant. Both John and Mary have just been tested by electrophoresis for sickle-cell anemia. They have come to find out the results of the test.

STARTING THE SESSION:

It will be up to the counselor to start off the session by informing the Roberts that they are both carriers of the trait for sickle-cell anemia. The counselor may then ask any questions or give any information or advice he or she thinks appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how much the Roberts know about genetics or about sickle-cell anemia; whether the Roberts want more children or, if so, how many; how they feel about the possibility of having a child with a birth defect; how they feel about birth control, amniocentesis or abortion; or how they feel about adoption or artificial insemination.

CASE II

ABOUT THE CLIENTS:

Harry Nelson, 22, and Sue Nelson, 21, have been married only a few months. Their family doctor has referred them for counseling, told the counselor they are concerned about the possibility of having a diabetic child, and sent the counselor their medical records.

STARTING THE SESSION:

The counselor has only a general idea what the Nelsons want counseling about, and may begin by asking them what he or she can do for them. However, the counselor has looked at their medical records and noted that they are both chronically 20 to 30 percent overweight. The counselor may want to talk to them about this fact at an appropriate time during the session, and may ask any questions or give any information or advice that seems appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor knows nothing about the Nelsons' family histories, and doesn't know how much they know about genetics or about diabetes, how they would feel about having children with genetic defects, how they feel about birth control or abortion or how they feel about adoption.

CASE III

ABOUT THE CLIENTS:

Wally Well, 20, and Kate Well, 19, have been married one year. They have one child, a newborn; Kate and the baby have just recently returned home from the maternity ward. The Wells have been asked to come in and discuss the results of some screening tests that were done on the baby shortly after it was born.

STARTING THE SESSION:

The Wells know they have been asked to come in to hear the results of the tests. They might ask how the tests came out. The counselor must inform them that, according to a preliminary blood test, their baby might have phenylketonuria. (The screening test was positive. However, it is not a very reliable test for phenylketonuria, and its results must be confirmed by additional studies, for which blood samples should be taken immediately. Only about 15 percent of the infants who test positive on the screening test actually turn out to have PKU.) The counselor should go on to ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how much the Wells know about genetics, about the causes of PKU or about the consequences and management of the disease; doesn't know how they will feel about the possibility that their child has a birth defect, or about the chances that any children they have in the future will have the defect; and doesn't know how they feel about having more children, about birth control or abortion, or about adoption.

CASE IV

ABOUT THE CLIENTS:

Abraham Smith, 30, and Martha Smith, 25, have been married two years and have one child. Their family doctor has recently informed them that their child has cystic fibrosis. The family doctor has explained the management of the disease to them, but has referred them for genetic counseling because they are concerned about the possibility that any children they have in the future will also have the disease.

STARTING THE SESSION:

Both the clients and the counselor know what the Smiths want counseling about, so either the Smiths or the counselor may start. The counselor may ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how strongly the Smiths desire more children, how they would feel about having more children with birth defects, how much they know about genetics in general or the inheritance of this disease in particular, or how they feel about birth control, abortion or adoption.

CASE V

ABOUT THE CLIENTS:

Axel Sturdevant, 27, and Henrietta Sturdevant, 28, have been married three years. They are seeking counseling about the chances that Rh incompatibility will cause complications with future pregnancies.

STARTING THE SESSION:

The counselor has only a general idea what the Sturdevants want counseling about, and might begin by asking what he or she can do for them. When they have described their problem, the counselor can ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know whether either Axel or Henrietta is Rh positive or Rh negative; doesn't know whether Henrietta has had any children or, if she has, whether she has had an Rh positive child; doesn't know how much the Sturdevants know about genetics, about the inheritance of the Rh factor or about the possible consequences of Rh incompatibility; doesn't know whether Henrietta knows anything about amniocentesis; and doesn't know how the Sturdevants feel about birth control, abortion or adoption.

CASE VI

ABOUT THE CLIENT:

Andrea Lane, 23, wants counseling about the possibility that any children she has will grow up to have Huntington's chorea. There is some history of Huntington's chorea among her forebears.

STARTING THE SESSION:

The counselor has only a general idea of what Andrea wants counseling about, and might begin by asking Andrea what he or she can do for her. When Andrea has explained her problem, the counselor should ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know anything specific about the history of Huntington's chorea in Andrea's background; doesn't know whether she is married, has children, is about to marry or is about to have children; doesn't know how strongly she wants to have children or how she feels about the possibility of having children with Huntington's chorea; doesn't know how much she knows about genetics or about the inheritance of this particular disease; and doesn't know how she feels about birth control, abortion or adoption.

CASE VII

ABOUT THE CLIENT:

Angela Inwood is 45. She has one child, 25 years old, by a previous marriage. Since she remarried, at 35, she has been trying to have another child, but she has suffered a series of miscarriages. Her family doctor has told her that she has an increased risk of giving birth to a child with Down's syndrome, has asked her to see the genetic counselor about the advisability of continued pregnancies and has sent her medical record to the counselor.

STARTING THE SESSION:

The counselor knows nothing about Angela at first hand, and might begin by asking her to describe her situation. The counselor could then go on to ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how badly Angela wants to have a child, how much she knows about genetics and birth defects, how she feels about the possibility of having a defective child, or how she feels about birth control, amniocentesis, abortion or adoption.

CASE VIII

ABOUT THE CLIENTS:

Willie Jonas, 32, and Sarah Jonas, 32, have been married 17 years. They have two children, a son of 15 and a daughter of 9. Because their son's development appeared to be abnormal, their family doctor advised that the boy and his parents be tested for chromosomal abnormalities. Willie and Sarah have come to the counselor to learn the results of the testing. The counselor has the family's medical records.

STARTING THE SESSION:

Both the clients and the counselor know that the Jonases have come to learn the test results. The son's karyotype shows two X chromosomes and a Y chromosome: the boy has Klinefelter's syndrome. The karyotypes of the parents show nothing abnormal. Based on the karyotypes and the family's medical records, the counselor concludes that there is no indication that Sarah has an unusually high chance of giving birth to another child with a genetic defect.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how the Jonases feel about having a child with a genetic defect or how it will influence their desires (if any) to have more children; doesn't know how much they know about genetics and birth defects in general or about Klinefelter's syndrome in particular; and doesn't know how they feel about birth control, abortion or adoption.

CASE IX

ABOUT THE CLIENTS:

Lyle Billing, 19, and Frieda Billing, 20, have been married one year. They have no children. Frieda has a sister with Turner syndrome. The Billings have come to the counselor to find out what the chances are that, if they have a child, it will have Turner syndrome or some other, similar defect.

STARTING THE SESSION:

The counselor has only a general idea of what the Billings want counseling about, and might begin by asking them what he or she can do for them. Later, the counselor may ask questions or give information or advice as appropriate.

WHAT THE COUNSELOR DOESN'T KNOW:

The counselor doesn't know how badly the Billings want a child or how they feel aboutthe possibility of having children with genetic defects; knows nothing about their family history except that Frieda has a sister with Turner syndrome; doesn't know how much they know about genetics, about chromosomal abnormalities or about Turner syndrome; and doesn't know how they feel about birth control, abortion or adoption.

Rh INCOMPATIBILITY

The Rh factor, or Rh antigen, is an antigen that exists on the red blood cells (RBC's) of most humans. (It also exists in the rhesus monkey, from which the Rh antigen takes its name.)

The presence or absence of Rh antigen on a person's RBC's is determined genetically. Among US population groups, Rh antigen is found in proportions ranging from about 85 percent of Caucasoid individuals to about 100 percent of Negroid and Mongoloid individuals.

The genetics of the Rh factor is complicated by the fact that it is really not one factor but several factors, each controlled by a different gene. However, one of these genes is of more concern than any of the others. It produces an antigen called antigen D, which is far more powerful than other Rh antigens as a stimulator of antibody production--and it is the power of Rh antigen to stimulate antibody production that makes the antigen important in medicine.

The presence of Rh antigen is an autosomal dominant trait. A person who is Rh positive--that is, one whose RBC's have the antigen--may be homozygous for antigen D (i.e., have the genotype DD) or be heterozygous for it (i.e., have the genotype Dd).

When Rh-positive blood (having Rh antigen) enters the body of a person who is Rh negative, the Rh antigen stimulates the production of Rh antibodies in the body of the Rh-negative person. These antibodies proceed to attack the Rh-positive RBC's and to destroy them by hemolysis (i.e., making them burst). For this reason, it is important that a transfusion of Rh-positive blood not be given to a person who is Rh negative: the recipient's body will destroy the Rh-positive blood cells.

Destruction of RBC's also occurs if Rh-negative blood containing Rh antibodies enters the bloodstream of an Rh-positive person. In this case, the intruding antibodies begin to destroy the RBC's of the person into whom they have been introduced. This process underlies a disease called hemolytic disease of the newborn, or erythroblastosis fetalis. It occurs only when the fetus is Rh positive (has the Rh antigen on its RBC's) and the mother is Rh negative (lacks the Rh antigen and can manufacture Rh antibodies, which destroy Rh-positive RBC's).

Erythroblastosis fetalis is not a very common disease. First, it occurs only when the fetus is Rh positive and the mother is Rh negative. This combination can come about only if the baby's father is Rh positive (DD or Dd), since the mother, being Rh negative (dd) cannot have passed the gene (D) to the fetus. Assuming random mating, a marriage of an Rh-positive man and an Rh-negative woman will occur in only about 12.8 percent (.15 x .85 x 100) of Caucasoid marriages (smaller percentages in other population groups). And each fetus of an Rh-positive father and an Rh-negative mother will have only about a 61 percent chance of being Rh positive. (It is not 100 percent because the Rh-positive father's genotype may be either DD or Dd; if it is Dd, the fetus has only a 50 percent chance of inheriting the D gene and thus being Rh positive.)

Even when an Rh-negative mother has an Rh-positive fetus, the fetus may or may not have erythroblastosis fetalis. If the fetus is the mother's first Rh-positive fetus, the chance that it will have the disease is less than 1 percent. However, if it is her second Rh-positive fetus the chance is 3 to 5 percent, and with later Rh-positive fetuses the chance goes even higher.

The risk is lower with the first Rh-positive fetus because the RBC's of the fetus do not normally pass through the placental barrier during fetal development. Therefore the fetus' Rh antigens do not contact the mother's blood, the mother's body does not produce Rh antibodies, and no hemolysis occurs. The chance is not zero, however, because it does sometimes happen that fetal RBC's enter the mother's bloodstream during fetal development--due to a rupture in the placental barrier.

During childbirth there is an increased risk of fetal RBC's entering the mother's bloodstream. When this does happen during childbirth, it poses no threat to the infant then being born; for the mother's body is slow to manufacture the antibodies, and there will not be time for them to harm the infant being delivered.

However, the Rh antibodies do not go away once they have been produced. Consequently, if the mother has another Rh-positive fetus later on, her blood will already contain Rh antibodies. And these antibodies <u>can</u> cross the placental barrier, enter the fetal bloodstream and begin destroying fetal RBC's.

One clinical advance in recent years has made it possible to reduce this risk to the second and later Rh-positive fetuses. It is possible to determine by clinical methods whether fetal blood has entered the mother's bloodstream during the birth of the first Rh-positive fetus. If it has, it is often possible to inject the mother with antibodies against the Rh antigen--before her body has had time to produce its own antibodies--so that the Rh-positive RBC's can be destroyed immediately. The mother's body

will then produce no Rh antibodies of its own, and the risk to the next Rh-positive fetus will be no greater than the risk to the first one--less than 1 percent.

Even if the mother is not injected with Rh antibodies following the birth of her first Rh-positive child, the outlook for the second and later Rh-positive children is now better than it used to be. It is now possible to use amniocentesis, around the 32nd week of pregnancy, to remove amniotic fluid; analysis of the amniotic fluid for bilirubin content shows the extent of destruction of the fetus' RBC's. If the destruction is extensive, the physician may decide to terminate the pregnancy as early as the 34th week rather than letting it go to full term (38 or 39 weeks).

Whether or not the pregnancy is terminated early, further treatment of the baby may be required. Depending on the extent of loss of fetal RBC's, the physician may decide to give the baby a blood tansfusion, in which the baby's blood is exchanged for a donor's.

Even with early delivery and transfusions, erythroblastosis fetalis is fatal to a small percentage of Rh-positive children of Rh-negative mothers. However, injection with Rh antibodies, combined with early detection through amniocentesis, has greatly reduced the risk.