6 The Human Population and Its Impact

CORE CASE STUDY Are There Too Many of Us?

Each week, about 1.6 million people are added to the world's population. As a result, the number of people on the earth is projected to increase from 6.7 to 9.3 billion or more between 2008 and 2050, with most of this growth occurring in the world's developing countries (Figure 6-1). This raises an important question: *Can the world provide an adequate standard of living for a projected 2.6 billion more people by 2050 without causing widespread environmental damage?* There is disagreement over the answer to this question.

According to one view, the planet already has too many people collectively degrading the earth's natural capital. To some analysts, the problem is the sheer number of people in developing countries with 82% of the world's population. To others, it is high per capita resource consumption rates in developed countries—and to an increasing extent in rapidly developing countries such as China and India—that magnify the environmental impact, or ecological footprint, of each person (Figure 1-10, p. 15). Many argue that both population growth and resource consumption per person are important causes of the environmental problems we face (**Concept 1-5A**, p. 17).

CONCEPT LINK

Another view is that technological advances have allowed us to overcome the environmental resistance that all populations face (Figure 5-11, p. 111) and to increase the earth's carrying capacity for our species. Some analysts argue there is no reason we cannot continue doing so, and they believe that the planet can support billions more people. They also see a growing population as our most valuable resource for solving environmental and other problems and for stimulating economic growth by increasing the number of consumers. As a result, they see no need to control the world's population growth.

Some people view any form of population regulation as a violation of their religious or moral beliefs. Others see it as an intrusion into their privacy and their freedom to have as many children as they want. These people also would argue against any form of population control.

Proponents of slowing and eventually stopping population growth have a different view. They point out that we are not providing the basic necessities for about one of every five people—a total of some 1.4 billion. They ask how we will be able to do so for the projected 2.6 billion more people by 2050.

They also warn of two serious consequences we will face if we do not sharply lower birth rates. *First,* death rates may increase because of declining health and environmental conditions in some areas, as is already happening in parts of Africa. *Second,* resource use and environmental degradation may intensify as more consumers increase their already large ecological footprints in developed countries and in rapidly developing countries, such as China and India (Figure 1-10, p. 15). This could increase environmental stresses such as infectious disease, biodiversity losses, water shortages, traffic congestion, pollution of the seas, and climate change.

This debate over interactions among population growth, economic growth, politics, and moral beliefs is one of the most important and controversial issues in environmental science.

L Young/UNEP/Peter Arnold, Inc.

Figure 6-1 Crowded street in China. Together, China and India have 36% of the world's population and the resource use per person in these countries is projected to grow rapidly as they become more modernized (Case Study, p. 15).

Key Questions and Concepts

6-1 How many people can the earth support?

CONCEPT 6-1 We do not know how long we can continue increasing the earth's carrying capacity for humans without seriously degrading the life-support system for humans and many other species.

6-2 What factors influence the size of the human population?

CONCEPT 6-2A Population size increases because of births and immigration and decreases through deaths and emigration.

CONCEPT 6-2B The average number of children born to women in a population (*total fertility rate*) is the key factor that determines population size.

6-3 How does a population's age structure affect its growth or decline?

CONCEPT 6-3 The numbers of males and females in young, middle, and older age groups determine how fast a population grows or declines.

6-4 How can we slow human population growth?

CONCEPT 6-4 Experience indicates that the most effective ways to slow human population growth are to encourage family planning, to reduce poverty, and to elevate the status of women.

Note: Supplements 2 (p. S4), 3 (p. S10), 4 (p. S20), and 13 (p. S78) can be used with this chapter.

The problems to be faced are vast and complex, but come down to this:
6.7 billion people are breeding exponentially.
The process of fulfilling their wants and needs is stripping earth
of its biotic capacity to support life;
a climactic burst of consumption by a single species
is overwhelming the skies, earth, waters, and fauna.

PAUL HAWKEN

6-1 How Many People Can the Earth Support?

CONCEPT 6-1 We do not know how long we can continue increasing the earth's carrying capacity for humans without seriously degrading the life-support system for humans and many other species.

Human Population Growth Continues but It Is Unevenly Distributed

For most of history, the human population grew slowly (Figure 1-1, p. 5, left part of curve). But for the past 200 years, the human population has experienced rapid exponential growth reflected in the characteristic J-curve (Figure 1-1, right part of curve).

Three major factors account for this population increase. *First,* humans developed the ability to expand into diverse new habitats and different climate zones. *Second,* the emergence of early and modern agriculture allowed more people to be fed for each unit of land area farmed. *Third,* the development of sanitation systems, antibiotics, and vaccines helped control infectious disease agents. As a result, death rates dropped sharply below birth rates and population size grew rapidly.

About 10,000 years ago when agriculture began, there were about 5 million humans on the planet; now there are 6.7 billion of us. It took from the time we arrived until about 1927 to add the first 2 billion people to the planet; less than 50 years to add the next 2 billion (by 1974); and just 25 years to add the next 2 billion (by 1999)—an illustration of the awesome power of exponential growth (Chapter 1 Core Case Study, p. 5). By 2012 we will be trying to support 7 billion people and perhaps 9.3 billion by 2050. Such growth raises the question of whether the earth is overpopulated (**Core Case Study**). (See Figure 4, p. S12, in Supplement 3 for a timeline of key events related to human population growth.)

The rate of population growth has slowed, but the world's population is still growing exponentially at a rate of 1.22% a year. This means that 82 million people were added to the world's population during 2008—an average of nearly 225,000 more people each day, or 2.4 more people every time your heart beats. (See *The Habitable Planet,* Video 5, at **www.learner.org/resources/series209.html** for a discussion of how demographers measure population size and growth.)

Geographically, this growth is unevenly distributed. About 1.2 million of these people were added to the

SCIENCE FOCUS

How Long Can the Human Population Keep Growing?

To survive and provide resources for growing numbers of people, humans have modified, cultivated, built on, or degraded a large and increasing portion of the earth's natural systems. Our activities have directly affected, to some degree, about 83% of the earth's land surface, excluding Antarctica (Figure 3, pp. S24–25, in Supplement 4), as our ecological footprints have spread across the globe (**Concept 1-3**, p. 12, and Figure 1-10, p. 15). In other words, human activities have degraded the various components of earth's biodiversity (Figure 4-2, p. 79) and such threats are expected to increase.

We have used technology to alter much of the rest of nature to meet our growing needs and wants in eight major ways (Figure 6-A).

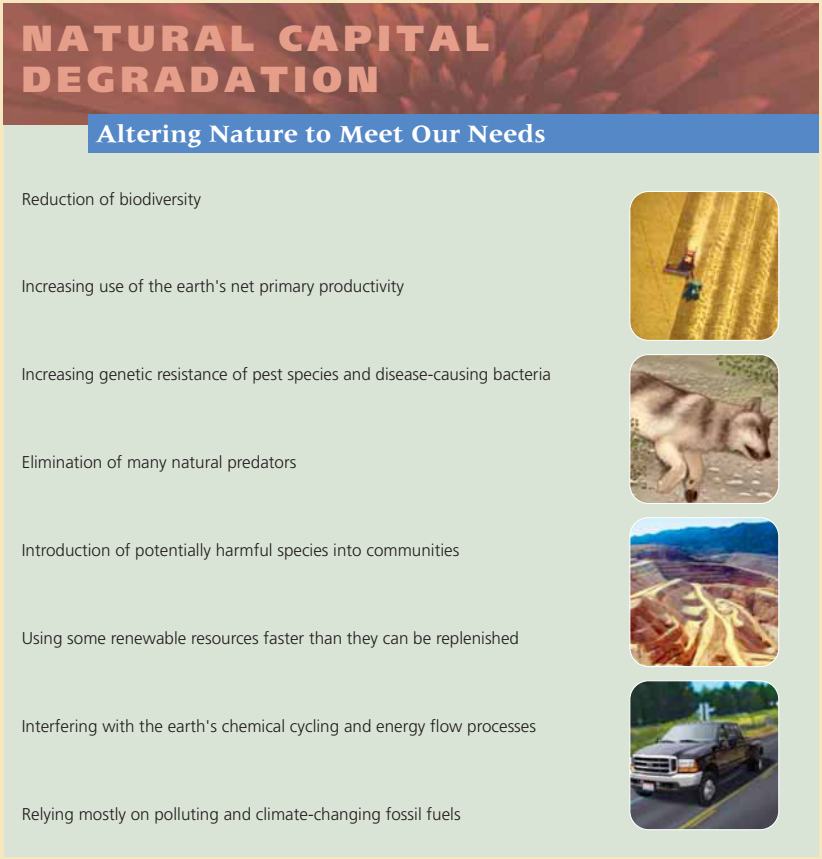
Scientific studies of populations of other species tell us that *no population can continue growing indefinitely* (**Concept 5-3**, p.108), which is one of the four **scientific principles of sustainability** (see back cover). How long can we continue increasing the earth's carrying capacity for our species by sidestepping many of the factors that sooner or later limit the growth of any population?

The debate over this important question has been going on since 1798 when Thomas Malthus, a British economist, hypothesized that the human population tends to increase exponentially, while food supplies tend to increase more slowly at a linear rate. So far, Malthus has been proven wrong. Food production has grown at an exponential rate instead of at a linear rate because of genetic and technological advances in industrialized food production.

No one knows how close we are to the environmental limits that sooner or later will control the size of the human population, but mounting evidence indicates that we are steadily degrading the natural capital, which keeps us and other species alive and supports our economies (**Concept 6-1**).

Critical Thinking

How close do you think we are to the environmental limits of human population growth?



CENGAGENOW™ **Active Figure 6-A**
Major ways in which humans have altered the rest of nature to meet our growing population's resource needs and wants. *See an animation based on this figure at* CengageNOW. **Questions:** Which three of these items do you believe have been the most harmful? Explain. How does your lifestyle contribute directly or indirectly to each of these three items?

world's developed countries, growing at 0.1% a year. About 80.8 million were added to developing countries, growing 15 times faster at 1.5% a year. In other words, most of the world's population growth takes place in already heavily populated parts of world most of which are the least equipped to deal with the pressures of such rapid growth. In our demographically divided world, roughly 1 billion people live in countries with essentially a stable population size while another billion or so live in countries whose populations are projected to at least double between 2008 and 2050.

How many of us are likely to be here in 2050? Answer: 7.8–10.7 billion people, depending mostly on projections about the average number of babies women are likely to have. The medium projection is 9.3 billion people (Figure 6-2). About 97% of this growth is projected to take place in developing countries, where acute poverty is a way of life for about 1.4 billion people.

The prospects for stabilization of the human population in the near future are nil. However, during this century, the human population may level off as it moves from a J-shaped curve of exponential growth to an S-shaped curve of logistic growth because of various factors that can limit human population growth (Figure 5-11, p. 111).

HOW WOULD YOU VOTE?

Should the population of the country where you live be stabilized as soon as possible? Cast your vote online at **academic.cengage.com/biology/miller**.

This raises the question posed in the **Core Case Study** at the beginning of this chapter: How many people can the earth support indefinitely? Some say about 2 billion. Others say as many as 30 billion. This issue has long been a topic of scientific debate (Science Focus, at left).

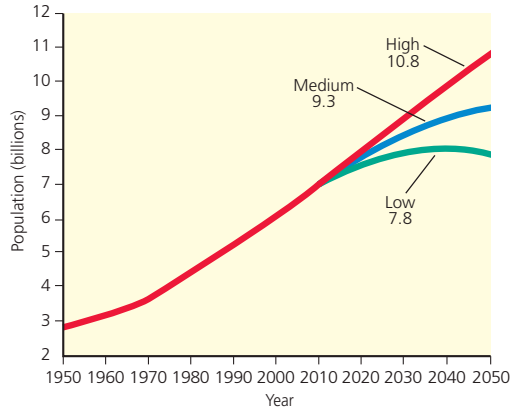


Figure 6-2 *Global connections:* UN world population projections, assuming that by 2050 women will have an average of 2.5 children (high), 2.0 children (medium), or 1.5 children (low). The most likely projection is the medium one—9.3 billion by 2050. (Data from United Nations).

Some analysts believe this is the wrong question. Instead, they say, we should ask what the *optimum sustainable population* of the earth might be, based on the planet's **cultural carrying capacity.** This would be an optimum level that would allow most people to live in reasonable comfort and freedom without impairing the ability of the planet to sustain future generations. (See the Guest Essay by Garrett Hardin at CengageNOW™.)

RESEARCH FRONTIER

Determining the optimum sustainable population size for the earth and for various regions. See **academic.cengage.com/biology/miller**.

6-2 What Factors Influence the Size of the Human Population?

CONCEPT 6-2A **Population size increases because of births and immigration and decreases through deaths and emigration.**

CONCEPT 6-2B **The average number of children born to women in a population *(total fertility rate)* is the key factor that determines population size.**

The Human Population Can Grow, Decline, or Remain Fairly Stable

On a global basis, if there are more births than deaths during a given period of time, the earth's population increases, and when the reverse is true, it decreases. When births equal deaths during a particular time period population size does not change.

Human populations of countries and cities grow or decline through the interplay of three factors: *births* (*fertility*), *deaths* (*mortality*), and *migration.* We can calculate **population change** of an area by subtracting the

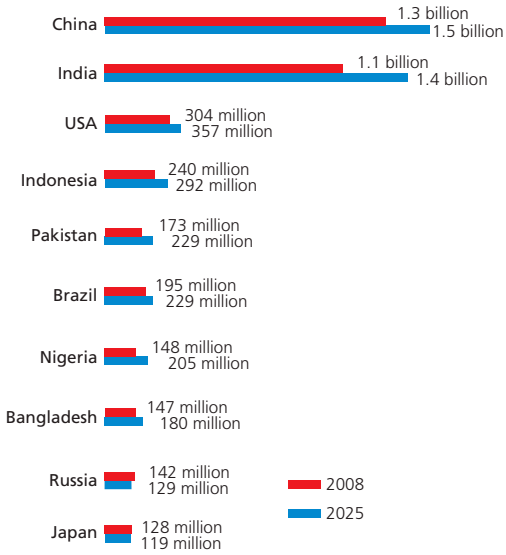


Figure 6-3 *Global connections:* the world's 10 most populous countries in 2008, with projections of their population sizes in 2025. (Data from World Bank and Population Reference Bureau)

number of people leaving a population (through death and emigration) from the number entering it (through birth and immigration) during a specified period of time (usually one year) (**Concept 6-2A**). See Figures 5 and 6, p. S13, in Supplement 3.

$$\text{Population change} = (\text{Births} + \text{Immigration}) - (\text{Deaths} + \text{Emigration})$$

When births plus immigration exceed deaths plus emigration, population increases; when the reverse is true, population declines.

Instead of using the total numbers of births and deaths per year, population experts (demographers) use the **birth rate,** or **crude birth rate** (the number of live births per 1,000 people in a population in a given year), and the **death rate,** or **crude death rate** (the number of deaths per 1,000 people in a population in a given year).

What five countries had the largest numbers of people in 2008? Number 1 was China with 1.3 billion people, or one of every five people in the world (Figures 6-1 and 6-3). Number 2 was India with 1.1 billion people, or one of every six people. Together, China and India have 36% of the world's population. The United States, with 304 million people in 2008—had the world's third largest population but only 4.5% of the world's people. Can you guess the next two most populous countries? What three countries are expected to have the most people in 2025? Look at Figure 6-3 to see if your answers are correct.

Women Are Having Fewer Babies but Not Few Enough to Stabilize the World's Population

Another measurement used in population studies is **fertility rate,** the number of children born to a woman during her lifetime. Two types of fertility rates affect a country's population size and growth rate. The first type, called the **replacement-level fertility rate,** is the average number of children that couples in a population must bear to replace themselves. It is slightly higher than two children per couple (2.1 in developed countries and as high as 2.5 in some developing countries), mostly because some children die before reaching their reproductive years.

Does reaching replacement-level fertility bring an immediate halt to population growth? No, because so many *future* parents are alive. If each of today's couples had an average of 2.1 children, they would not be contributing to population growth. But if all of today's girl children also have 2.1 children, the world's population will continue to grow for 50 years or more (assuming death rates do not rise).

The second type of fertility rate, the **total fertility rate (TFR),** is the average number of children born to women in a population during their reproductive years. This factor plays a key role in determining population size (**Concept 6-2B**). The average fertility rate has been declining. In 2008, the average global TFR was 2.6 children per woman: 1.6 in developed countries (down from 2.5 in 1950) and 2.8 in developing countries (down from 6.5 in 1950). Although the decline in TFR in developing countries is impressive, the TFR remains far above the replacement level of 2.1, not low enough to stabilize the world's population in the near future. See Figures 7 and 8, p. S14, in Supplement 3.

THINKING ABOUT

The Slower Rate of Population Growth

Why has the world's exponential rate of population growth slowed down in the last few decades? What would have to happen for the world's population to stop growing?

CASE STUDY

The U.S. Population Is Growing Rapidly

The population of the United States grew from 76 million in 1900 to 304 million in 2008, despite oscillations in the country's TFR (Figure 6-4) and birth rates (Figure 6-5). It took the country 139 years to add its

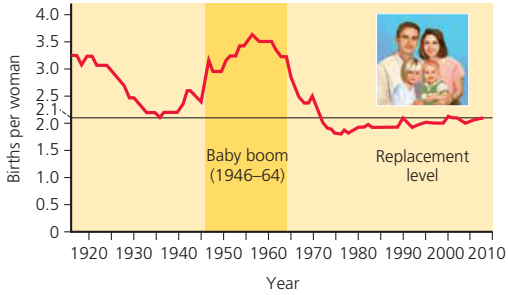


Figure 6-4 Total fertility rates for the United States between 1917 and 2008. **Question:** The U.S. fertility rate has declined and remained at or below replacement levels since 1972, so why is the population of the United States still increasing? (Data from Population Reference Bureau and U.S. Census Bureau)

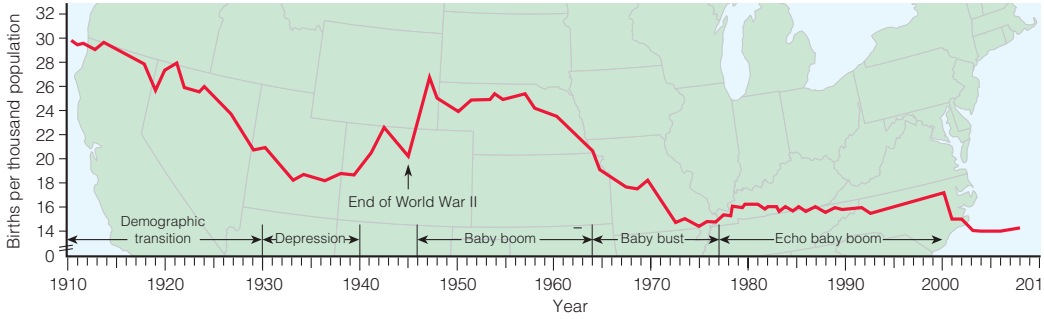


Figure 6-5 Birth rates in the United States, 1910–2008. Use this figure to trace changes in crude birth rates during your lifetime. (Data from U.S. Bureau of Census and U.S. Commerce Department)

first 100 million people, 52 years to add another 100 million by 1967, and only 39 years to add the third 100 million in 2006. The period of high birth rates between 1946 and 1964 is known as the *baby boom*, when 79 million people were added to the U.S. population. In 1957, the peak of the baby boom, the TFR reached 3.7 children per woman. Since then, it has generally declined, remaining at or below replacement level since 1972. In 2008, the TFR was 2.1 children per woman, compared to 1.6 in China.

The drop in the TFR has slowed the rate of population growth in the United States. But the country's population is still growing faster than that of any other developed country, and of China, and is not close to leveling off. About 2.9 million people (one person every 11 seconds) were added to the U.S. population in 2008. About 66% (1.9 million) of this growth occurred because births outnumbered deaths and 34% (1 million) came from legal and illegal immigration (with someone migrating to the U.S. every 32 seconds).

In addition to the almost fourfold increase in population growth since 1900, some amazing changes in lifestyles took place in the United States during the 20th century (Figure 6-6, p. 128), which led to dramatic increases in per capita resource use and a much larger U.S. ecological footprint (**Concept 1-3**, p. 12, and Figure 1-10, top, p. 15).

Here are a few more changes that occurred during the last century. In 1907, the three leading causes of death in the United States were pneumonia, tuberculosis, and diarrhea; 90% of U.S. doctors had no college education; one out of five adults could not read or write; only 6% of Americans graduated from high school; the average U.S. worker earned $200–400 per year and the average daily wage was 22 cents per hour; there were only 9,000 cars in the U.S., and only 232 kilometers (144 miles) of paved roads; a 3-minute phone call from Denver, Colorado, to New York city cost $11; only 30 people lived in Las Vegas, Nevada; most women washed their hair only once a month; marijuana, heroin, and morphine were available over the counter at local drugstores; and there were only 230 reported murders in the entire country.

According to U.S. Census Bureau, the U.S. population is likely to increase from 304 million in 2008 to 438 million by 2050 and then to 571 million by 2100. In contrast, population growth has slowed in other major developed countries since 1950, most of which are expected to have declining populations after 2010. Because of a high per capita rate of resource use and the resulting waste and pollution, each addition to the U.S. population has an enormous environmental impact (Figure 1-9, bottom, p. 14, Figure 1-10, p. 15, and Figure 7 on pp. S28–S29 in Supplement 4).

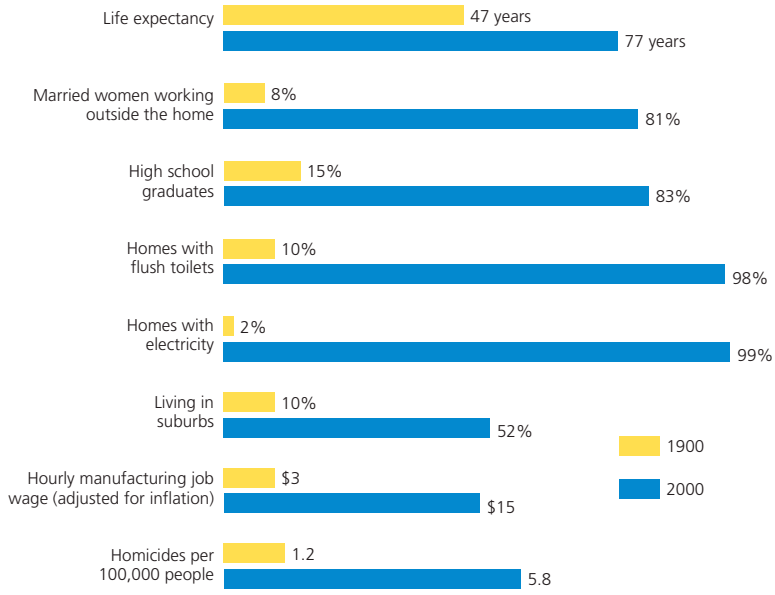


Figure 6-6 Some major changes that took place in the United States between 1900 and 2000. **Question:** Which two of these changes do you think were the most important? (Data from U.S. Census Bureau and Department of Commerce)

Several Factors Affect Birth Rates and Fertility Rates

Many factors affect a country's average birth rate and TFR. One is the *importance of children as a part of the labor force.* Proportions of children working tend to be higher in developing countries.

Another economic factor is the *cost of raising and educating children.* Birth and fertility rates tend to be lower in developed countries, where raising children is much more costly because they do not enter the labor force until they are in their late teens or twenties. In the United States, it costs about $290,000 to raise a middle-class child from birth to age 18. By contrast, many children in poor countries have to work to help their families survive.

The *availability of private and public pension systems* can influence the decision for some couples on how many children to have, especially the poor in developing countries. Pensions reduce a couple's need to have many children to help support them in old age.

Urbanization plays a role. People living in urban areas usually have better access to family planning services and tend to have fewer children than do those living in rural areas (especially in developing countries) where children are often needed to help raise crops and carry daily water and fuelwood supplies.

Another important factor is the *educational and employment opportunities available for women.* TFRs tend to be low when women have access to education and paid employment outside the home. In developing countries, a woman with no education typically has two more children than does a woman with a high school education. In nearly all societies, better-educated women tend to marry later and have fewer children.

Another factor is the **infant mortality rate**—the number of children per 1,000 live births who die before one year of age. In areas with low infant mortality rates, people tend to have fewer children because fewer children die at an early age.

Average age at marriage (or, more precisely, the average age at which a woman has her first child) also plays a role. Women normally have fewer children when their average age at marriage is 25 or older.

Birth rates and TFRs are also affected by the *availability of legal abortions.* Each year about 190 million women become pregnant. The United Nations and the World Bank estimate that 46 million of these women get abortions—26 million of them legal and 20 million illegal (and often unsafe). Also, the *availability of reliable birth control methods* allows women to control the number and spacing of the children they have.

Religious beliefs, traditions, and cultural norms also play a role. In some countries, these factors favor large families and strongly oppose abortion and some forms of birth control.

Several Factors Affect Death Rates

The rapid growth of the world's population over the past 100 years is not primarily the result of a rise in the crude birth rate. Instead, it has been caused largely by a decline in crude death rates, especially in developing countries.

More people started living longer and fewer infants died because of increased food supplies and distribu-

tion, better nutrition, medical advances such as immunizations and antibiotics, improved sanitation, and safer water supplies (which curtailed the spread of many infectious diseases).

Two useful indicators of the overall health of people in a country or region are **life expectancy** (the average number of years a newborn infant can expect to live) and the **infant mortality rate** (the number of babies out of every 1,000 born who die before their first birthday). Between 1955 and 2008, the global life expectancy increased from 48 years to 68 years (77 years in developed countries and 67 years in developing countries) and is projected to reach 74 by 2050. Between 1900 and 2008, life expectancy in the United States increased from 47 to 78 years and, by 2050, is projected to reach 82 years. In the world's poorest countries, however, life expectancy is 49 years or less and may fall further in some countries because of more deaths from AIDS.

Even though more is spent on health care per person in the United States than in any other country, people in 41 other countries including Canada, Japan, Singapore, and a number of European countries have longer life expectancies than do Americans. Analysts cite two major reasons for this. First, 45 million Americans lack health care insurance, while Canada and many European countries have universal health care insurance. Second, adults in the United States have one of the world's highest obesity rates.

Infant mortality is viewed as one of the best measures of a society's quality of life because it reflects a country's general level of nutrition and health care. A high infant mortality rate usually indicates insufficient food (undernutrition), poor nutrition (malnutrition), and a high incidence of infectious disease (usually from drinking contaminated water and having weakened disease resistance due to undernutrition and malnutrition).

Between 1965 and 2008, the world's infant mortality rate dropped from 20 to 6.3 in developed countries and from 118 to 59 in developing countries (see Figures 9 and 10, p. S15, in Supplement 3). This is good news, but annually, more than 4 million infants (most in developing countries) die of preventable causes during their first year of life—an average of 11,000 mostly unnecessary infant deaths per day. This is equivalent to 55 jet airliners, each loaded with 200 infants younger than age 1, crashing *each day* with no survivors!

The U.S. infant mortality rate declined from 165 in 1900 to 6.6 in 2008. This sharp decline was a major factor in the marked increase in U.S. average life expectancy during this period. Still, some 40 countries, including Taiwan, Cuba, and most of Europe had lower infant mortality rates than the United States had in 2008. Three factors helped keep the U.S. infant mortality rate high: *inadequate health care for poor women during pregnancy and for their babies after birth, drug addiction among pregnant women,* and *a high birth rate among teenagers* (although this rate dropped by almost half between 1991 and 2006).

Migration Affects an Area's Population Size

The third factor in population change is **migration:** the movement of people into (*immigration*) and out of (*emigration*) specific geographic areas.

Most people migrating from one area or country to another seek jobs and economic improvement. But some are driven by religious persecution, ethnic conflicts, political oppression, wars, and environmental degradations such as water and food shortages and soil erosion. According to a U.N. study, there were about 25 million *environmental refugees* in 2005 and the number could reach 50 million by 2010. Environmental scientist Norman Myers warns that, in a warmer world, the number of such refugees could soar to 250 million or more before the end of this century. (See more on this in the Guest Essay by Norman Myers at CengageNOW.)

■ **CASE STUDY**

The United States: A Nation of Immigrants

Since 1820, the United States has admitted almost twice as many immigrants and refugees as all other countries combined. The number of legal immigrants (including refugees) has varied during different periods because of changes in immigration laws and rates of economic growth (Figure 6-7). Currently, legal and illegal immigration account for about 40% of the country's annual population growth.

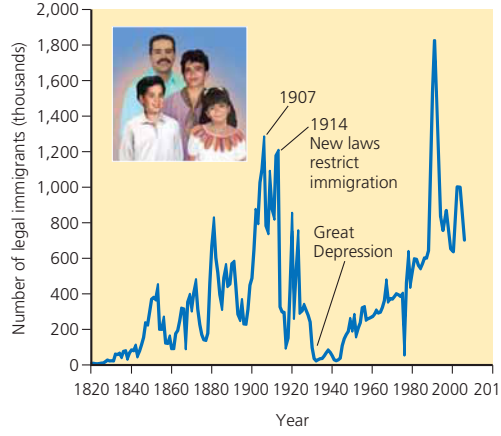


Figure 6-7 Legal immigration to the United States, 1820–2003 (the last year for which data are available). The large increase in immigration since 1989 resulted mostly from the Immigration Reform and Control Act of 1986, which granted legal status to illegal immigrants who could show they had been living in the country for several years. (Data from U.S. Immigration and Naturalization Service and the Pew Hispanic Center)

Between 1820 and 1960, most legal immigrants to the United States came from Europe. Since 1960, most have come from Latin America (53%) and Asia (25%), followed by Europe (14%). In 2007, Latinos (67% of them from Mexico) made up 15% of the U.S. population, and by 2050, are projected to make up 25% of the population. According to the Pew Hispanic Center, 53% of the 100 million Americans that were added to the population between 1967 and 2007 were either immigrants or their children.

There is controversy over whether to reduce legal immigration to the United States. Some analysts would accept new entrants only if they can support themselves, arguing that providing legal immigrants with public services makes the United States a magnet for the world's poor. Proponents of reducing legal immigration argue that it would allow the United States to stabilize its population sooner and help reduce the country's enormous environmental impact from its huge ecological footprint (Figure 1-10, p. 15; and **Concept 1-3**, p. 12).

CONCEPT LINK

Polls show that almost 60% of the U.S. public strongly supports reducing legal immigration. There is also intense political controversy over what to do about illegal immigration. In 2007, there were an estimated 11.3 million illegal immigrants in the United States, with about 58% of them from Mexico and 22% from other Latin American countries.

Those opposed to reducing current levels of legal immigration argue that it would diminish the historical role of the United States as a place of opportunity for the world's poor and oppressed and as a source of cultural diversity that has been a hallmark of American culture since its beginnings. In addition, according to several studies, including a 2006 study by the Pew Hispanic Center, immigrants and their descendants pay taxes, take many menial and low-paying jobs that most other Americans shun, start new businesses, create jobs, add cultural vitality, and help the United States succeed in the global economy. Also, according to the U.S. Census Bureau, after 2020, higher immigration levels will be needed to supply enough workers as baby boomers retire.

According to a recent study by the U.N. Population Division, if the United States wants to maintain its current ratio of workers to retirees, it will need to absorb an average of 10.8 million immigrants each year—more than 13 times the current immigration level—through 2050. At that point, the U.S. population would total 1.1 billion people, 73% of them fairly recent immigrants or their descendants. Housing this influx of almost 11 million immigrants per year would require the equivalent of building another New York City every 10 months.

HOW WOULD YOU VOTE?

Should legal immigration into the United States be reduced? Cast your vote online at **academic.cengage.com/biology/miller**.

6-3 How Does a Population's Age Structure Affect Its Growth or Decline?

CONCEPT 6-3 The numbers of males and females in young, middle, and older age groups determine how fast a population grows or declines.

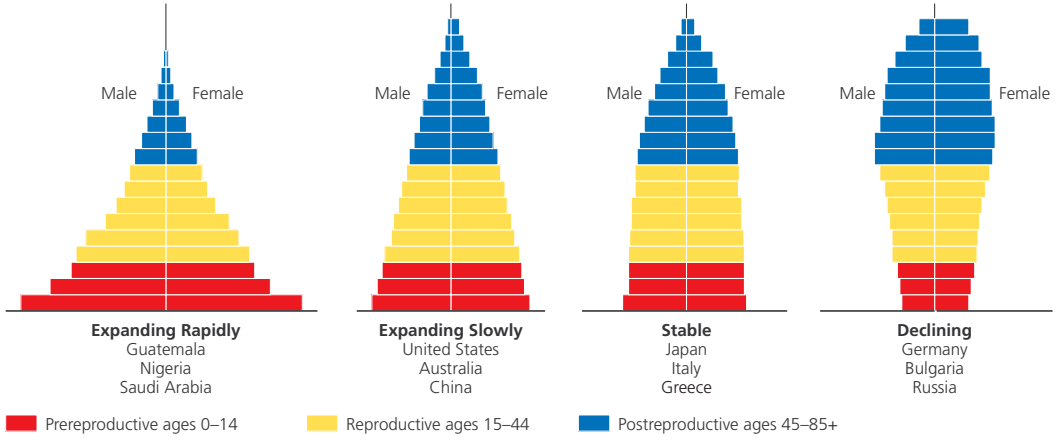
Populations Made Up Mostly of Young People Can Grow Rapidly

As mentioned earlier, even if the replacement-level fertility rate of 2.1 children per woman were magically achieved globally tomorrow, the world's population would keep growing for at least another 50 years (assuming no large increase in the death rate). This results mostly from the **age structure:** the distribution of males and females among age groups in a population—in this case, the world population (**Concept 6-3**).

Population experts construct a population *age-structure diagram* by plotting the percentages or numbers of males and females in the total population in each of three age categories: *prereproductive* (ages 0–14), *reproductive* (ages 15–44), and *postreproductive* (ages 45 and older). Figure 6-8 presents generalized age-structure diagrams for countries with rapid, slow, zero, and negative population growth rates.

Any country with many people younger than age 15 (represented by a wide base in Figure 6-8, far left) has a powerful built-in momentum to increase its population size unless death rates rise sharply. The number of births will rise even if women have only one or two children, because a large number of girls will soon be moving into their reproductive years.

What is one of the world's most important population statistics? *Nearly 28% of the people on the planet were under 15 years old in 2008.* These 1.9 billion young people are poised to move into their prime reproductive



CENGAGENOW™ **Active Figure 6-8** Generalized population age structure diagrams for countries with rapid (1.5–3%), slow (0.3–1.4%), zero (0–0.2%), and negative (declining) population growth rates. A population with a large proportion of its people in the prereproductive age group (far left) has a large potential for rapid population growth. *See an animation based on this figure at* CengageNOW. **Question:** Which of these figures best represents the country where you live? (Data from Population Reference Bureau)

years. In developing countries, the percentage is even higher: 30% on average (41% in Africa) compared with 17% in developed countries (20% in the United States and 16% in Europe). These differences in population age structure between developed and developing countries are dramatic, as Figure 6-9 reveals. This figure also shows why almost all of future human population growth will be in developing countries.

We Can Use Age-Structure Information to Make Population and Economic Projections

Changes in the distribution of a country's age groups have long-lasting economic and social impacts. Between 1946 and 1964, the United States had a *baby boom,* which added 79 million people to its population. Over time, this group looks like a bulge moving up through the country's age structure, as shown in Figure 6-10, p. 132.

Baby boomers now make up almost half of all adult Americans. As a result, they dominate the population's demand for goods and services and play increasingly important roles in deciding who gets elected and what laws are passed. Baby boomers who created the youth market in their teens and twenties are now creating the 50-something market and will soon move on to create a 60-something market. After 2011, when the first baby boomers will turn 65, the number of Americans older than age 65 will grow sharply through 2029 in what

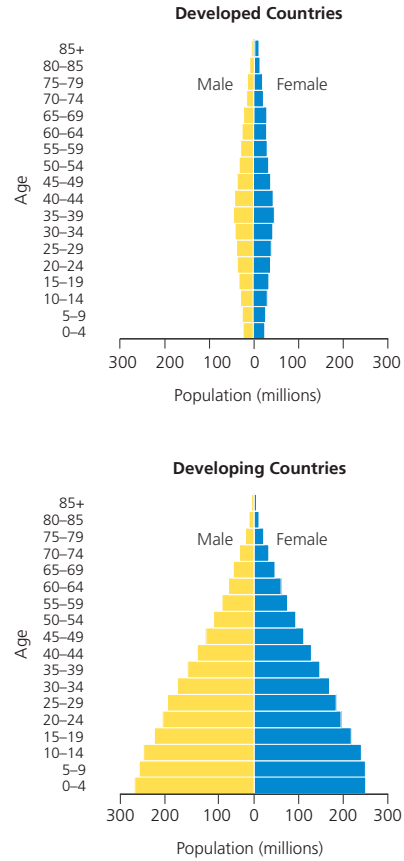
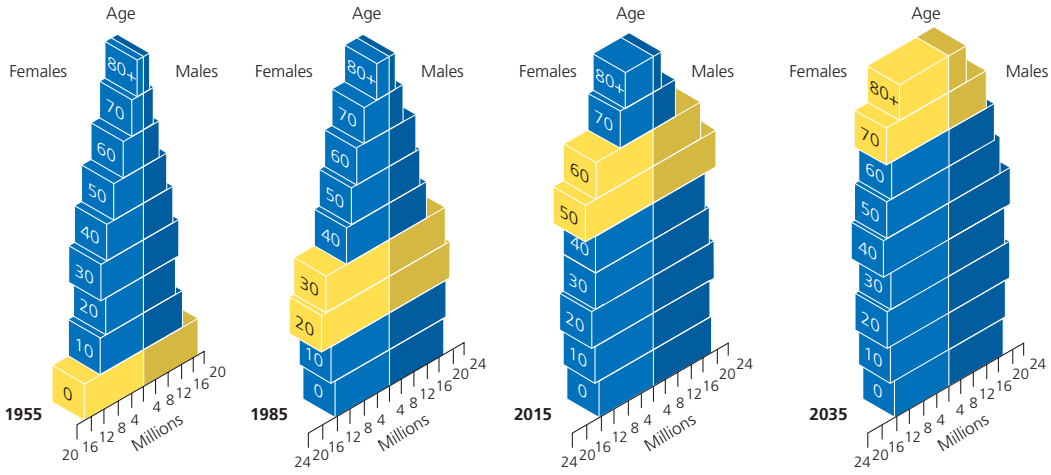


Figure 6-9 *Global outlook:* population structure by age and sex in developing countries and developed countries, 2006. **Question:** If all girls under 15 had only one child during their lifetimes, how do you think these structures would change over time? (Data from United Nations Population Division and Population Reference Bureau)



CENGAGENOW™ **Active Figure 6-10** Tracking the baby-boom generation in the United States. U.S. population by age and sex, 1955, 1985, 2015, and 2035 (projected). *See an animation based on this figure at* CengageNOW. (Data from U.S. Census Bureau)

has been called the *graying of America*. In 2008, about 13% of Americans were 65 or older, but that number is projected to increase to about 25% by 2043.

According to some analysts, the retirement of baby boomers is likely to create a shortage of workers in the United States unless immigrant workers or various forms of automation replace some of them. Retired baby boomers may use their political clout to have the smaller number of people in the baby-bust generation that followed them pay higher income, health-care, and social security taxes. However, the rapidly increasing number of immigrants and their descendants may dilute their political power. Their power may also be weakened by the rise of members of the echo baby boom generation (Figure 6-5).

CENGAGENOW™ Examine how the baby boom affects the U.S. age structure over several decades at CengageNOW.

Populations Made Up Mostly of Older People Can Decline Rapidly

As the age structure of the world's population changes and the percentage of people age 60 or older increases, more countries will begin experiencing population declines. If population decline is gradual, its harmful effects usually can be managed.

Japan has the world's highest proportion of elderly people and the lowest proportion of young people. Its population, at 128 million in 2008, is projected to decline to about 96 million by 2050.

Rapid population decline can lead to severe economic and social problems. A country that experiences a fairly rapid "baby bust" or a "birth dearth" when its TFR falls below 1.5 children per couple for a prolonged period sees a sharp rise in the proportion of older people. This puts severe strains on government budgets because these individuals consume an increasingly larger share of medical care, social security funds, and other costly public services, which are funded by a decreasing number of working taxpayers. Such countries can also face labor shortages unless they rely more heavily on automation or massive immigration of foreign workers. In the next two to three decades, countries such as the United States and many European nations with rapidly aging populations will face shortages of health workers. For example, the United Nations will need half a million more nurses by 2020 and twice as many doctors specializing in health care for the elderly (geriatrics).

Figure 6-11 lists some of the problems associated with rapid population decline. Countries faced with a rapidly declining population in the future include Japan, Russia, Germany, Bulgaria, the Czech Republic, Hungary, Poland, Ukraine, Greece, Italy, and Spain.

Populations Can Decline from a Rising Death Rate: The AIDS Tragedy

A large number of deaths from AIDS can disrupt a country's social and economic structure by removing significant numbers of young adults from its age

Some Problems with Rapid Population Decline

Can threaten economic growth

Labor shortages

Less government revenues with fewer workers

Less entrepreneurship and new business formation

Less likelihood for new technology development

Increasing public deficits to fund higher pension and health-care costs

Pensions may be cut and retirement age increased

Figure 6-11 Some problems with rapid population decline. **Question:** Which three of these problems do you think are the most important?

structure. According to the World Health Organization, AIDS had killed 25 million people by 2008. Unlike hunger and malnutrition, which kill mostly infants and children, AIDS kills many young adults.

This change in the young-adult age structure of a country has a number of harmful effects. One is a sharp drop in average life expectancy. In 8 African countries, where 16–39% of the adult population is infected with HIV, life expectancy could drop to 34–40 years.

Another effect is a loss of a country's most productive young adult workers and trained personnel such as scientists, farmers, engineers, teachers, and government, business, and health-care workers. This causes a sharp drop in the number of productive adults available to support the young and the elderly and to grow food and provide essential services. Within a decade, countries such as Zimbabwe and Botswana in sub-Saharan Africa could lose more than a fifth of their adult populations.

Analysts call for the international community—especially developed countries—to create and fund a massive program to help countries ravaged by AIDS in Africa and elsewhere. This program would have two major goals. *First,* reduce the spread of HIV through a combination of improved education and health care. *Second,* provide financial assistance for education and health care as well as volunteer teachers and health-care and social workers to help compensate for the missing young-adult generation.

6-4 How Can We Slow Human Population Growth?

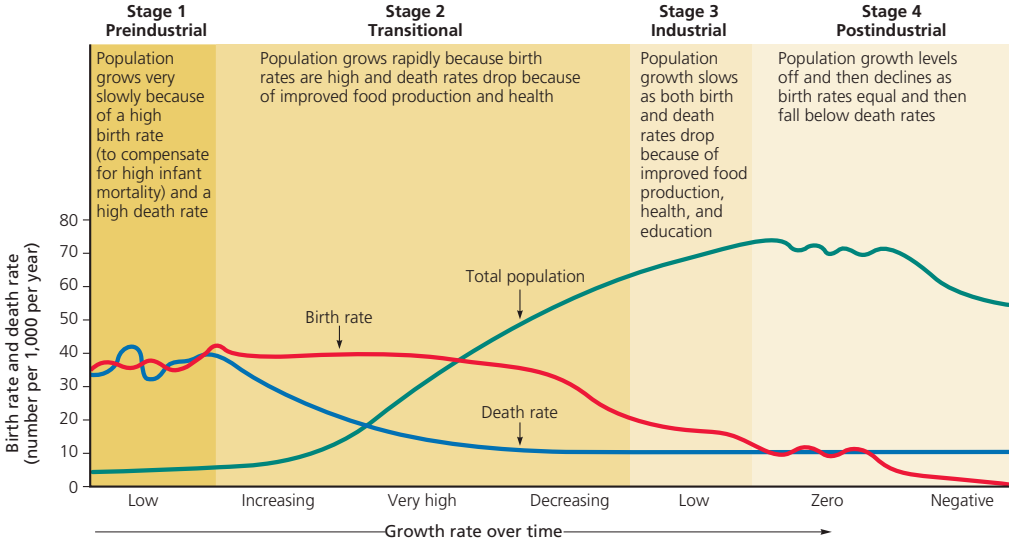
CONCEPT 6-4 Experience indicates that the most effective ways to slow human population growth are to encourage family planning, to reduce poverty, and to elevate the status of women.

As Countries Develop, Their Populations Tend to Grow More Slowly

Demographers examining birth and death rates of western European countries that became industrialized during the 19th century developed a hypothesis of population change known as the **demographic transition:** as countries become industrialized, first their death rates and then their birth rates decline. According to the hypothesis, based on such data, this transition takes place in four distinct stages (Figure 6-12, p. 134).

Some analysts believe that most of the world's developing countries will make a demographic transition over the next few decades mostly because modern technology can bring economic development and family planning to such countries. Others fear that the still-rapid population growth in some developing countries might outstrip economic growth and overwhelm some local life-support systems. As a consequence, some of these countries could become caught in a *demographic trap* at stage 2. This is now happening as death rates rise in a number of developing countries, especially in Africa. Indeed, countries in Africa being ravaged by the HIV/AIDS epidemic are falling back to stage 1.

Other factors that could hinder the demographic transition in some developing countries are shortages of scientists and engineers (94% of them work in the industrialized world), shortages of skilled workers,



CENGAGENOW™ **Active Figure 6-12** Four stages of the *demographic transition*, which the population of a country can experience when it becomes industrialized. There is uncertainty about whether this model will apply to some of today's developing countries. *See an animation based on this figure at* CengageNOW. **Question:** At what stage is the country where you live?

insufficient financial capital, large debts to developed countries, and a drop in economic assistance from developed countries since 1985.

CENGAGENOW™ Explore the effects of economic development on birth and death rates and population growth at CengageNOW.

Planning for Babies Works

Family planning provides educational and clinical services that help couples choose how many children to have and when to have them. Such programs vary from culture to culture, but most provide information on birth spacing, birth control, and health care for pregnant women and infants.

Family planning has been a major factor in reducing the number of births throughout most of the world, mostly because of increased knowledge and availability of contraceptives. According to the U.N. Population Division, 58% of married women ages 15–45 in developed countries and 54% in developing countries used modern contraception in 2008. Family planning has also reduced the number of legal and illegal abortions performed each year and decreased the number of deaths of mothers and fetuses during pregnancy.

Studies by the U.N. Population Division and other population agencies indicate that family planning is responsible for at least 55% of the drop in total fertility rates (TFRs) in developing countries, from 6.0 in 1960 to 3.0 in 2008. Between 1971 and 2008, for example, Thailand used family planning to cut its annual population growth rate from 3.2% to 0.5% and its TFR from 6.4 to 1.6 children per family. Another family planning success involves Iran, which between 1989 and 2000, cut its population growth rate from 2.5% to 1.4%.

Despite such successes, two problems remain. *First,* according to the U.N. Population Fund, 42% of all pregnancies in developing countries are unplanned and 26% end with abortion. *Second,* an estimated 201 million couples in developing countries want to limit the number and determine the spacing of their children, but they lack access to family planning services. According to a recent study by the U.N. Population Fund and the Alan Guttmacher Institute, meeting women's current unmet needs for family planning and contraception could *each year* prevent 52 million unwanted pregnancies, 22 million induced abortions, 1.4 million infant deaths, and 142,000 pregnancy-related deaths.

Some analysts call for expanding family planning programs to include teenagers and sexually active unmarried women, who are excluded from many existing programs. Another suggestion is to develop programs that educate men about the importance of having fewer children and taking more responsibility for raising them. Proponents also call for greatly increased research on developing more effective and more acceptable birth control methods for men.

In 1994, the United Nations held its third Conference on Population and Development in Cairo, Egypt.

One of the conference's goals was to encourage action to stabilize the world's population at 7.8 billion by 2050 instead of the projected 9.2 billion.

The experiences of countries such as Japan, Thailand, South Korea, Taiwan, Iran, and China show that a country can achieve or come close to replacement-level fertility within a decade or two. Such experiences also suggest that the best ways to slow and stabilize population growth are through *investing in family planning, reducing poverty,* and *elevating the social and economic status of women* (**Concept 6-4**).

Empowering Women Can Slow Population Growth

Studies show that women tend to have fewer children if they are educated, hold a paying job outside the home, and live in societies where their human rights are not suppressed. Although women make up roughly half of the world's population, in most societies they do not have the same rights and educational and economic opportunities as men do.

Women do almost all of the world's domestic work and child care for little or no pay and provide more unpaid health care than all of the world's organized health services combined. They also do 60–80% of the work associated with growing food, gathering and hauling wood (Figure 6-13) and animal dung for use as fuel, and hauling water in rural areas of Africa, Latin America, and Asia. As one Brazilian woman put it, "For poor women the only holiday is when you are asleep."

Globally, women account for two-thirds of all hours worked but receive only 10% of the world's income, and they own less than 2% of the world's land. Also, about 70% of the world's poor and 64% of all 800 million illiterate adults are women.

Because sons are more valued than daughters in many societies, girls are often kept at home to work instead of being sent to school. Globally, some 900 million girls—three times the entire U.S. population—do not attend elementary school. Teaching women to read has a major impact on fertility rates and population growth. Poor women who cannot read often have five to seven children, compared to two or fewer in societies where almost all women can read.

According to Thorya Obaid, executive director of the U.N. Population Fund, "Many women in the developing world are trapped in poverty by illiteracy, poor health, and unwanted high fertility. All of these contribute to environmental degradation and tighten the grip of poverty."

An increasing number of women in developing countries are taking charge of their lives and reproductive behavior. As it expands, such bottom-up change by individual women will play an important role in stabilizing population and reducing environmental degradation.

■ CASE STUDY

Slowing Population Growth in China: The One-Child Policy

China has made impressive efforts to feed its people, bring its population growth under control, and encourage economic growth. Between 1972 and 2008, the country cut its crude birth rate in half and trimmed its

Mark Edwards/Peter Arnold, Inc.

Figure 6-13 Women from a village in the West African country of Burkina Faso returning with fuelwood. Typically they spend 2 hours a day two or three times a week searching for and hauling fuelwood.

TFR from 5.7 to 1.6 children per woman, compared to 2.1 in the United States. Despite such drops China is the world's most populous country and in 2008 added about 6.8 million people to its population (compared to 2.9 million in the United States and 18 million in India). If current trends continue, China's population is expected to peak by about 2033 at around 1.46 billion and then to begin a slow decline.

Since 1980, China has moved 350 million people (an amount greater than the entire U.S. population) from extreme poverty to its consumer middle class and is likely to double that number by 2010. However, about 47% of its people were struggling to live on less than $2 (U.S.) a day in 2006. China also has a literacy rate of 91% and has boosted life expectancy to 73 years. By 2020, some economists project that China could become the world's leading economic power.

In the 1960s, Chinese government officials concluded that the only alternative to mass starvation was strict population control. To achieve a sharp drop in fertility, China established the most extensive, intrusive, and strict family planning and population control program in the world. It discourages premarital sex and urges people to delay marriage and limit their families to one child each. Married couples who pledge to have no more than one child receive more food, larger pensions, better housing, free health care, salary bonuses, free school tuition for their child, and preferential employment opportunities for their child. Couples who break their pledge lose such benefits.

The government also provides married couples with free sterilization, contraceptives, and abortion. However, reports of forced abortions and other coercive actions have brought condemnation from the United States and other national governments.

In China, there is a strong preference for male children, because unlike sons, daughters are likely to marry and leave their parents. A folk saying goes, "Rear a son, and protect yourself in old age." Some pregnant Chinese women use ultrasound to determine the gender of their fetuses, and some get an abortion if it is female. The result: a rapidly growing *gender imbalance* or "bride shortage" in China's population, with a projected 30–40 million surplus of men expected by 2020. Because of this skewed sex ratio, teen-age girls in some parts of rural China are being kidnapped and sold as brides for single men in other parts of the country.

With fewer children, the average age of China's population is increasing rapidly. By 2020, 31% of the Chinese population will be over 60 years old, compared to 8% in 2008. This graying of the Chinese population could lead to a declining work force, higher wages for younger workers, a shortage of funding for continuing economic development, and fewer children and grandchildren to care for the growing number of elderly people. These concerns and other factors may slow economic growth and lead to some relaxation of China's one-child population control policy in the future.

China also faces serious resource and environmental problems that could limit its economic growth. It has 19% of the world's population, but only 7% of the world's freshwater and cropland, 4% of its forests, and 2% of its oil. In 2002, only 15% of China's land area was protected on paper (compared to 23% in the United States, 51% in Japan, and 63% in Venezuela) and only 29% of its rural population had access to adequate sanitation.

In 2005, China's deputy minister of the environment summarized the country's environmental problems: "Our raw materials are scarce, we don't have enough land, and our population is constantly growing. Half of the water in our seven largest rivers is completely useless. One-third of the urban population is breathing polluted air."

China's economy is growing at one of the world's highest rates as the country undergoes rapid industrialization. More middle class Chinese (Case Study, p. 15) will consume more resources per person, increasing China's ecological footprint (Figure 1-10, p. 15) within its own borders and in other parts of the world that provide it with resources (**Concept 1-3**, p. 12). CONCEPT LINK This will put a strain on the earth's natural capital unless China steers a course toward more sustainable economic development.

■ CASE STUDY
Slowing Population Growth in India

For more than 5 decades, India has tried to control its population growth with only modest success. The world's first national family planning program began in India in 1952, when its population was nearly 400 million. By 2008, after 56 years of population control efforts, India had 1.1 billion people.

In 1952, India added 5 million people to its population. In 2008, it added 18 million—more than any other country. By 2015, India is projected to be the world's most populous country, with its population projected to reach 1.76 billion by 2050.

India faces a number of serious poverty, malnutrition, and environmental problems that could worsen as its population continues to grow rapidly. India has a thriving and rapidly growing middle class of more than 300 million people—roughly equal to the entire U.S. population—many of them highly skilled software developers and entrepreneurs.

By global standards, however, one of every four people in India is poor, despite the fact that since 2004 it has had the world's second fastest growing economy, and by 2007, was the world's fourth largest economy. Such prosperity and progress have not touched many of the nearly 650,000 villages where more than two-thirds of India's population lives. In 2002, only 18% of its rural population had access to adequate sanitation. In 2006, nearly half of the country's labor force was unemployed or underemployed and 80% of its people

were struggling to live on less than $2 (U.S.) day (see Photo 2 in the Detailed Contents).

Although India currently is self-sufficient in food grain production, about 40% of its population and more than half of its children suffer from malnutrition, mostly because of poverty. In 2002, only 5% of the country's land was protected on paper.

The Indian government has provided information about the advantages of small families for years and has also made family planning available throughout the country. Even so, Indian women have an average of 2.8 children. Most poor couples still believe they need many children to work and care for them in old age. As in China, the strong cultural preference for male children also means some couples keep having children until they produce one or more boys. The result: even though 90% of Indian couples know of at least one modern birth control method, only 48% actually use one.

Like China, India also faces critical resource and environmental problems. With 17% of the world's people, India has just 2.3% of the world's land resources and 2% of the forests. About half the country's cropland is degraded as a result of soil erosion and overgrazing. In addition, more than two-thirds of its water is seriously polluted, sanitation services often are inadequate, and many of its major cities suffer from serious air pollution.

India is undergoing rapid economic growth, which is expected to accelerate. As members of its huge and growing middle class increase their resource use per person, India's ecological footprint (**Concept 1-3**) (Figure 1-10, p. 15) will expand and increase the pressure on the country's and the earth's natural capital.

CONCEPT LINK

On the other hand, economic growth may help to slow population growth by accelerating India's demographic transition. By 2050, India—the largest democracy the world has ever seen—could become the world's leading economic power.

THINKING ABOUT

China, India, the United States, and Overpopulation

CORE CASE STUDY

Based on population size and resource use per person (Figure 1-10, p. 15) is the United States more overpopulated than China? Explain. Answer the same question for the United States versus India.

REVISITING

Population Growth and Sustainability

CONCEPT LINK CORE CASE STUDY SUSTAINABILITY

This chapter began with a discussion of whether the world is overpopulated (**Core Case Study**). As we have noted, some experts say this is the wrong question to be asking. Instead, they believe we ought to ask, "What is the optimal level of human population that the planet can support *sustainably?*" In other words, "What is the maximum number of people that can live comfortably without seriously degrading the earth's biodiversity and other forms of natural capital and jeopardizing the earth's ability to provide the same comforts for future generations?"

In the first six chapters of this book, you have learned how ecosystems and species have been sustained throughout history in keeping with four **scientific principles of sustainability**—relying on solar energy, biodiversity, population control, and nutrient recycling (see back cover and **Concept 1-6**, p. 23). In this chapter, you may have gained a sense of the need for humans to apply these sustainability principles to their lifestyles and economies, especially with regard to human population growth, globally and in particular countries.

In the next five chapters, you will learn how various principles of ecology and these four **scientific principles of sustainability** can be applied to help preserve the earth's biodiversity.

Our numbers expand but Earth's natural systems do not.

LESTER R. BROWN

REVIEW

1. Review the Key Questions and Concepts in this chapter on p. 123. Do you think the world is overpopulated? Explain.
2. List three factors that account for the rapid growth of the world's human population over the past 200 years. Describe eight ways in which we have used technology to alter nature to meet our growing needs and wants. How many of us are likely to be here in 2050?
3. What is the **cultural carrying capacity** of a population? How do some analysts apply this concept in considering the question of whether the earth is overpopulated?
4. List four variables that affect the **population change** of an area and write an equation showing how they are related. Distinguish between **crude birth rate** and **crude death rate.** What five countries had the largest numbers of people in 2008?

5. What is **fertility rate?** Distinguish between **replacement-level fertility rate** and **total fertility rate (TFR).** Explain why reaching the replacement-level fertility rate will not stop global population growth until about 50 years have passed (assuming that death rates do not rise).

6. Describe population growth in the United States and explain why it is high compared to those of most other developed countries and China. Is the United States overpopulated? Explain.

7. List ten factors that can affect the birth rate and fertility rate of a country. Distinguish between **life expectancy** and **infant mortality rate** and explain how they affect the population size of a country. Why does the United States have a lower life expectancy and higher infant mortality rate than a number of other countries? What is **migration?** Describe immigration into the United States and the issues it raises.

8. What is the **age structure** of a population. Explain how it affects population growth and economic growth. What are some problems related to rapid population decline from an aging population?

9. What is the **demographic transition** and what are its four stages? What factors could hinder some developing countries from making this transition? What is **family planning?** Describe the roles of family planning, reducing poverty, and elevating the status of women in slowing population growth. Describe China's and India's efforts to control their population growth.

10. How has human population growth (**Core Case Study**) interfered with natural processes related to three of the **scientific principles of sustainability**? Name the three principles, and for each one, describe the effects of rapid human population growth.

Note: Key Terms are in **bold** type.

CRITICAL THINKING

1. List three ways in which you could apply some of what you learned in this chapter to making your lifestyle more environmentally sustainable.

2. Which of the three major environmental worldviews summarized on p. 20 do you believe underlie the two major positions on whether the world is overpopulated (**Core Case Study**)?

3. Identify a major local, national, or global environmental problem, and describe the role of population growth in this problem.

4. Is it rational for a poor couple in a developing country such as India to have four or five children? Explain.

5. Do you believe that the population is too high in **(a)** the world (**Core Case Study**), **(b)** your own country, and **(c)** the area where you live? Explain.

6. Should everyone have the right to have as many children as they want? Explain. Is your belief on this issue consistent with your environmental worldview?

7. Some people have proposed that the earth could solve its population problem by shipping people off to space colonies, each containing about 10,000 people. Assuming we could build such large-scale, self-sustaining space stations (a big assumption), how many of them would we have to build to provide living spaces for the 82 million people added to the earth's population this year? If space shuttles could each carry 100 passengers, how many shuttles would have to be launched each day for a year to offset the 82 million people added to the population this year? According to your calculations, determine whether this proposal is a logical solution to the earth's population problem. What effect might the daily launching of these shuttles have on global warming? Explain.

8. Some people believe our most important goal should be to sharply reduce the rate of population growth in developing countries where 97% of the world's population growth is expected to take place. Others argue that the most serious environmental problems stem from high levels of resource consumption per person in developed countries, which use 88% of the world's resources and have much larger ecological footprints per person (Figure 1-10, p. 15) than do developing countries. What is your view on this issue? Explain.

9. Congratulations! You are in charge of the world. List the three most important features of your population policy.

10. List two questions that you would like to have answered as a result of reading this chapter.

Note: See Supplement 13 (p. S78) for a list of Projects related to this chapter.

ECOLOGICAL FOOTPRINT ANALYSIS

The chart below shows selected population data for two different countries A and B.

	Country A	Country B
Population (millions)	144	82
Crude birth rate	43	8
Crude death rate	18	10
Infant mortality rate	100	3.8
Total fertility rate	5.9	1.3
Percentage of population under 15 years old	45	14
Percentage of population older than 65 years	3.0	19
Average life expectancy at birth	47	79
Percentage urban	44	75

Source: Data from Population Reference Bureau 2007, *World Population Data Sheet.*

1. Calculate the rates of natural increase for the populations of Country A and Country B. From the rates of natural increase and the data in the table, suggest whether A and B are developed or developing countries, and explain the reasons for your answers.
2. Describe where each of the two countries may be in terms of their stage in the demographic transition (Figure 6-12, p. 134). Discuss factors that could hinder Country A from progressing to later stages in the demographic transition.
3. Explain how the percentage of people under 15 years of age in Country A and in Country B could affect the per capita and total ecological footprints of each country.

LEARNING ONLINE

Log on to the Student Companion Site for this book at **academic.cengage.com/biology/miller**, and choose Chapter 6 for many study aids and ideas for further reading and research. These include flash cards, practice quizzing, Weblinks, information on Green Careers, and InfoTrac® College Edition articles.