CHAPTER 6

The Human Population

Either we limit our population growth or the natural world will do it for us.

SIR DAVID ATTENBOROUGH

Key Questions

6.1 How many people can the earth support?

6.2 What factors influence the size of the human population?

6.3 How does a population's age structure affect its growth or decline?

6.4 How can we slow human population growth?

Slum in Jaipur, India.

Zanskar/iStock/Getty Images Plus/Getty Images

Core Case Study

Planet Earth: Population 7.3 Billion

It took about 200,000 years—from the time that the latest version of our species *Homo sapiens sapiens* evolved to the 1920s—for our population to reach an estimated 2 billion. It took less than 50 years to add the second 2 billion people (by about 1974), and 25 years to add the third 2 billion (by 1999). Sixteen years later, in 2015, the earth had 7.3 billion people. Figure 1.11 (p. 16) lists the world's 10 most populous countries. In 2015 the top three, in order, were China with 1.37 billion people (Figure 6.1), India with 1.31 billion people, and the United States with 321 million people.

Does it matter that there are now 7.3 billion people on the earth—almost 3 times as many as there were in 1950? Does it matter that each day, 241,000 more people show up for dinner and many of them will go hungry? Some say it does not matter, and they contend that we can develop new technologies that could easily support billions more people.

Many scientists disagree and argue that the current exponential growth of the human population (see Figure 1.11, p. 16) is unsustainable. The reason is that as our population grows, we use more of the earth's natural resources and our ecological footprints expand and degrade the natural capital that keeps us alive and supports our lifestyles and economies.

According to *demographers*, or population experts, three major factors account for the rapid rise of the human population. *First*, the emergence of early and modern agriculture about 10,000 years ago increased food production. *Second*, additional technologies helped humans expand into almost all of the planet's climate zones and habitats (see Figure 1.8, p. 12). *Third*, death rates dropped sharply with improved sanitation and health care and the development of antibiotics and vaccines to control infectious diseases.

What is a sustainable level for the human population? Population experts have made low, medium, and high projections of the human population size by the end of this century, as shown in Figure 1.11, p. 16. No one knows whether any of these population sizes are sustainable or for how long.

In this chapter, we examine population growth trends, the environmental impacts of the growing population, and proposals for dealing with human population growth and decline.

MACDUFF EVERTON/National Geographic Creative

FIGURE 6.1 This crowded street is located in China, where almost one-fifth of the world's people live.

6.1 HOW MANY PEOPLE CAN THE EARTH SUPPORT?

CONCEPT 6.1 The rapid growth of the human population and its impact on natural capital raises questions about how long the human population can keep growing.

Human Population Growth

For most of history, the human population grew slowly (see Figure 1.11, p. 16, left part of curve). However, it has grown rapidly for the last 200 years, resulting in the characteristic J-curve of exponential growth (Figure 1.11, right part of curve).

Demographers recognize three important trends related to the current size, growth rate, and distribution of the human population. *First*, the rate of population growth decreased in most years since 1965, slowing to 1.2%, but the world's population is still growing (Figure 6.2). This growth rate may not seem very high, but in 2015 it added about 88 million people to the population—an average of 241,000 people every day. In 2015 China had 19% of the world's population and was growing at a rate of 0.5% a year, India had 18% and was growing at 1.3% a year, and the United States with 4.4% was growing at 0.8% a year.

Second, human population growth is unevenly distributed and this pattern is expected to continue (Figure 6.3). About 2% of the 88 million new arrivals on the planet in 2015 were added to the world's more-developed countries. The other 98% were added to the world's less-developed countries.

At least 95% of the 2.5 billion people projected to be added to the world's population between 2015 and 2050 will be born into the less-developed countries. Most of these countries are not equipped to deal with the pressures of rapid population growth.

The *third* important trend is large numbers of people moving from rural areas to *urban areas*, or cities and their surrounding suburbs. In 2015, 53% of the world's people lived in urban areas, and this percentage is increasing. Most of these urban dwellers live in less-developed countries where resources for dealing with rapidly growing populations are limited. Scientists and other analysts have long pondered the question: How long can the human population continue to grow while sidestepping many of

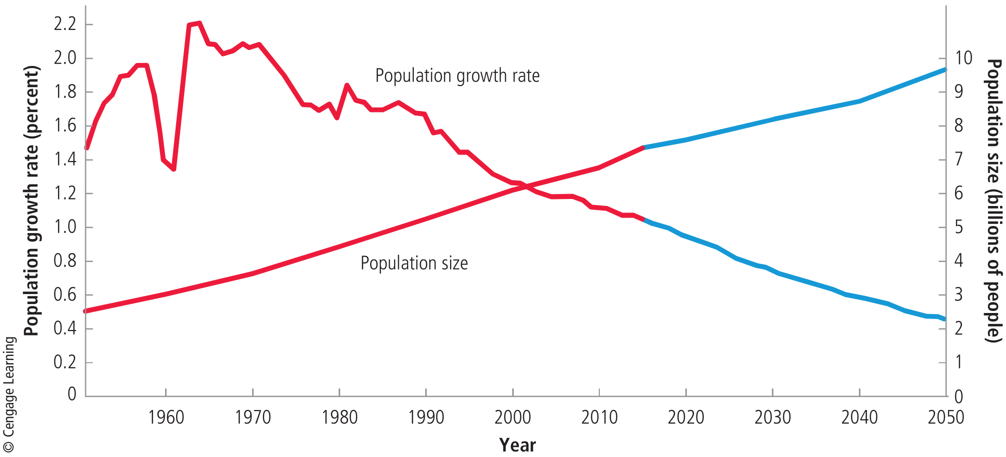

FIGURE 6.2 Global human population size compared with population growth rate, 1950–2015, with projection to 2050 (in blue). ***Critical thinking:*** Why do you think that while the annual growth *rate* of world population has generally dropped since the 1960s, the population has continued to grow?

(Compiled by the authors using data from United Nations Population Division, U.S. Census Bureau, and Population Reference Bureau.)

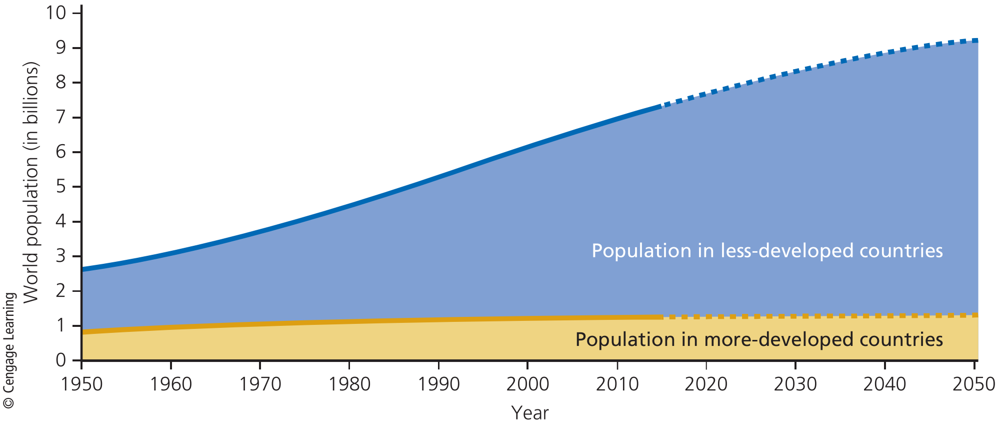

FIGURE 6.3 Most of the world's population growth between 1950 and 2015 took place in the world's less-developed countries. This gap is projected to increase between 2015 and 2050.

(Compiled by the authors using data from United Nations Population Division and Population Reference Bureau.)

SCIENCEFOCUS 6.1

How Long Can the Human Population Keep Growing?

Are there physical limits to human population growth and economic growth on a finite planet? Some say yes. Others say no. This debate has been going on since 1798 when Thomas Malthus, a British economist, hypothesized that the human population tends to grow exponentially, while food supplies tend to increase more slowly at a linear rate. However, food production has grown at an exponential rate instead of at a linear rate because of technological advances in industrialized food production.

One current view is that we have already exceeded some of those limits, with too many people collectively degrading the earth's life-support system (see Science Focus 3.3, p. 69). To some analysts, the key problem is the large and rapidly growing number of people in less-developed countries, which have 83% of the world's population. To others, the key factor is *overconsumption* in affluent, more-developed countries with high rates of resource use per person.

Another view of population growth is that technology has allowed us to overcome the environmental limits that all populations of other species face. According to this view, technological advances have increased the earth's carrying capacity for the human species. Some analysts point out that average life expectancy in most of the world has been steadily rising despite warnings from some environmental scientists that we are seriously degrading our life-support system.

These analysts argue that because of our technological ingenuity, there are few, if any, limits to human population growth and resource use per person. They believe that we can continue increasing economic growth and avoid serious damage to our life-support systems by making technological advances in areas such as food production and medicine, and by finding substitutes for resources that we are depleting. They see no need to slow the world's population growth or resource consumption.

Proponents of slowing or stopping population growth point out that currently, we are failing to provide the basic necessities for about 1 billion people—one of every seven on the planet—who struggle to survive on the equivalent of about $1.25 per day. This raises a serious question: How will we meet the basic needs of the additional 2.5 billion people projected to be added mostly to less-developed countries between 2015 and 2050?

Proponents of slowing population growth warn of two potentially serious consequences if we do not sharply lower birth rates. First, death rates could increase because of declining health and environmental conditions and increasing social disruption in some areas, as is happening today in parts of Africa. A worst-case scenario for such a trend is a crash of the human population from more than 7 billion to a more sustainable level of 4 billion or perhaps as low as 2 billion. Second, resource use and degradation of normally renewable resources may intensify as more consumers increase their already large ecological footprints in more-developed countries and in rapidly developing countries such as China, India, and Brazil.

So far, advances in food production and health care have prevented widespread population declines. But there is extensive and growing evidence that we are steadily depleting and degrading much of the earth's irreplaceable natural capital (see Figure 1.3, p. 7). We can get away with this for a while, because the earth's life-support system is resilient. However, such disturbances could reach various *tipping points* beyond which there could be damaging and long-lasting change. In 2015 a team of researchers estimated that we have likely exceeded four key tipping points, or *planetary boundaries* (see Science Focus 3.3).

No one knows how close we are to environmental limits that, many scientists say, eventually will control the size of the human population primarily by raising the human death rate. These analysts call for us to confront this scientific, political, economic, and ethical issue.

CRITICAL THINKING

Do you think there are environmental limits to human population growth? Explain. If so, how close do you think we are to such limits? Explain.

2.5 billion
Projected increase in the world's population between 2015 and 2050

the factors that sooner or later limit the growth of any population? These experts disagree over how many people the earth can support indefinitely (Science Focus 6.1).

Human Population Growth and Natural Capital

As the human population grows, so does the global human ecological footprint (see Figure 1.8, p. 12), and the bigger this footprint, the higher the overall impact of humanity on the earth's natural capital. The 2005 Millennium Ecosystem Assessment concluded that human activities have degraded about 60% of the earth's ecosystem services (Figure 6.4).

Some say that asking how many people the earth the can support indefinitely is asking the wrong question. Instead, they call for us to estimate the planet's **cultural carrying capacity**—the maximum number of people

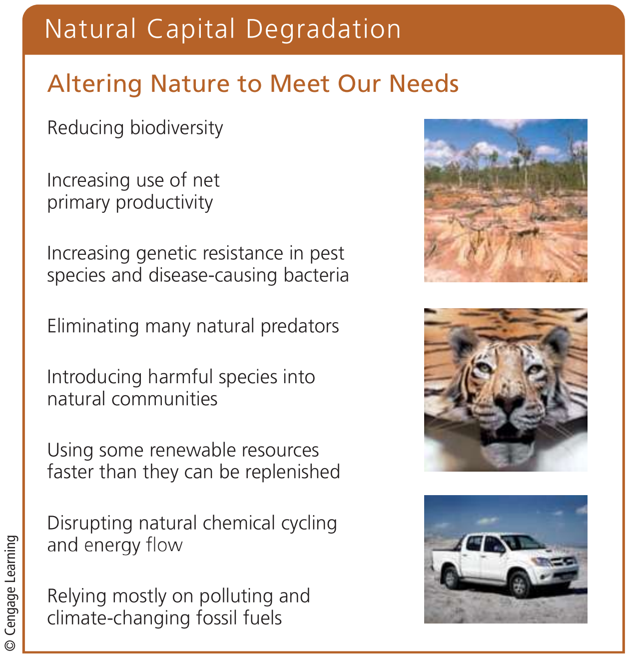

FIGURE 6.4 Humans have altered the natural systems that sustain their lives and economies in at least eight major ways to meet the increasing needs and wants of their growing population (**Concept 6.1**). ***Critical thinking:*** In your daily living, do you think you contribute directly or indirectly to any of these harmful environmental impacts? Which ones? Explain.

Top: Dirk Ercken/Shutterstock.com. Center: Fulcanelli/Shutterstock.com. Bottom: Werner Stoffberg/Shutterstock.com.

who could live in reasonable freedom and comfort indefinitely, without decreasing the ability of the earth to sustain future generations.

6.2 WHAT FACTORS INFLUENCE THE SIZE OF THE HUMAN POPULATION?

CONCEPT 6.2A Population size increases through births and immigration, and decreases through deaths and emigration.

CONCEPT 6.2B Many factors affect birth rates and death rates and the size of the human population, but the key factor is the average number of children born to the women in the population (*total fertility rate*).

The Human Population Can Grow, Decline, or Stabilize

The basics of global population change are simple. When there are more births than deaths, the human population increases; when there are more deaths than births, the population decreases. When the number of births equals the number of deaths, population size does not change.

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

The human population in a particular area grows or declines through the interplay of three factors: *births (fertility)*, deaths *(mortality)*, and *migration*. We can calculate the **population change** of an area by subtracting the number of people leaving a population (through death and emigration) from the number entering it (through birth and immigration) during a year (**Concept 6.2A**):

Population change = (Births + Immigration) − (Deaths + Emigration)

See Figure 9, p. S24, in Supplement 4 for a map comparing generalized rates of population growth among countries and regions in 2014. See Figure 8, pp. S22–S23, in Supplement 4 for more detailed population data for high-, middle-, and low-income countries.

Fertility Rates

Demographers distinguish between two types of fertility rates. One is the **replacement-level fertility rate**: the average number of children that couples in a population must bear to replace themselves. It is slightly higher than two children per couple (typically 2.1) because some children die before reaching their reproductive years, especially in the world's poorest countries.

If we were to reach a global replacement-level fertility rate of 2.1 tomorrow, would it bring an immediate halt to population growth? No, because there is a large number of potential mothers under age 15 who will be moving into their reproductive years.

The second type of fertility rate is the **total fertility rate (TFR)**. It is the average number of children born to the women of childbearing age in a population (**Concept 6.2B**).

Between 1955 and 2015, the global TFR dropped from 5.0 to 2.5. Those who support slowing the world's population growth view this as good news. However, to eventually halt population growth, the global TFR must drop to and remain at the fertility replacement level of 2.1. (See Figure 10, p. S25, in Supplement 4 for a map showing how TFRs vary globally.)

With a TFR of 4.7, Africa's population is growing more than twice as fast as any other continent and is projected to more than double from 1.2 billion in 2015 to 2.5 billion in 2050. Africa is also the world's poorest continent.

Estimates of any population's future numbers can vary considerably, depending mostly on TFR projections. Demographers also have to make assumptions about death rates, migration, and a number of other variables. If their assumptions are wrong, their population forecasts can be inaccurate (Science Focus 6.2).

SCIENCEFOCUS 6.2

Projecting Population Change

Estimates of the human population size in 2050 range from 7.8 billion to 10.8 billion people—a difference of 3 billion. The range of estimates varies because many factors affect birth rates and TFRs.

First, demographers have to determine the reliability of current population estimates. While many more-developed countries such as the United States have reliable estimates of their population size, most countries do not. Some countries deliberately inflate or deflate the numbers for economic or political purposes.

Second, demographers make assumptions about trends in fertility. They might assume that fertility is declining by a certain percentage per year. If this estimate is off by a few percentage points, the resulting percentage increase in population can be magnified over a number of years and be quite different from the projected population size increase.

For example, United Nation (UN) demographers assumed that Kenya's fertility rate would decline. Based on that, in 2002 they projected that Kenya's total population would be 44 million by 2050. In reality, the fertility rate rose from 4.7 to 4.8 children per woman. As a result, the UN revised its projection for Kenya's population in 2050 to 81.4 million, which was 85% higher than its earlier projection.

Third, population projections are made by a variety of organizations. UN projections are often cited but the U.S. Census Bureau, the International Institute for Applied Systems Analysis (IIASA), and the U.S. Population Reference Bureau also make projections. Their projections vary because they use differing sets of data and differing methods (Figure 6.A).

CRITICAL THINKING

If you were in charge of the world and making decisions about resource use based on population projections, which of the projections in Figure 6.A would you rely on? Explain.

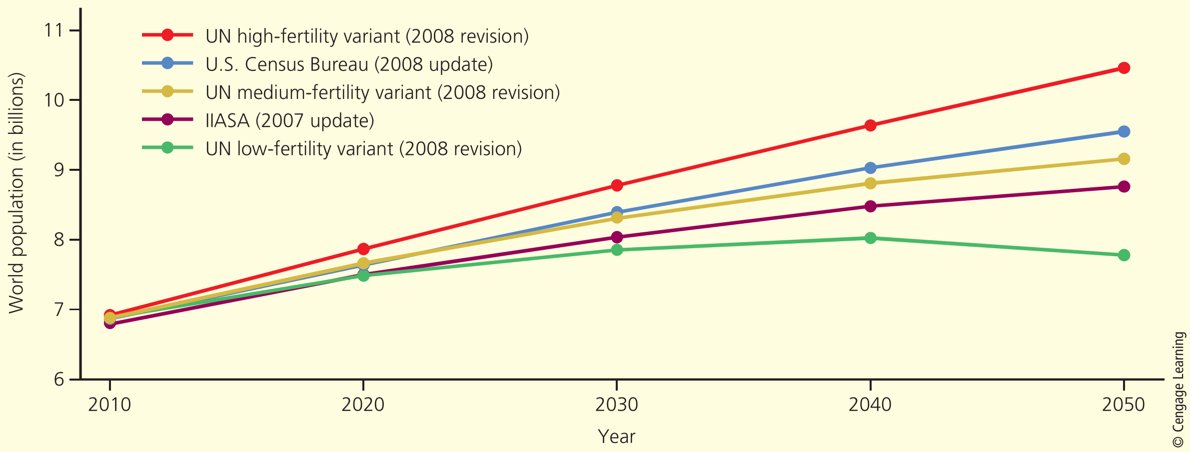

FIGURE 6.A World population projections to 2050 from three different organizations: the UN, the U.S. Census Bureau, and IIASA. Note that the uppermost, middle, and lowermost curves of these five projections are all from the UN, each assuming a different level of fertility. ***Data analysis:*** What are the ranges (differences between the lowest and highest) in these projections for 2030, 2040, and 2050?

(Compiled by the authors using data from United Nations, U.S. Census Bureau, and IIASA.)

CASE STUDY

The U.S. Population—Third Largest and Growing

The population of the United States grew from 76 million in 1900 to 321 million in 2015. This happened despite oscillations in the country's TFR (Figure 6.5) and population growth rate. It took the country 139 years to reach a population of 100 million people, 52 years to add another 100 million (by 1967), and 39 years to add the third 100 million (by 2006).

During the period of high birth rates between 1946 and 1964, known as the *baby boom*, 79 million people were added to the U.S. population. At the peak of the baby boom in 1957, the average TFR was 3.7 children per woman. In most years since 1972, it has been at or below 2.1 children per woman—1.9 in 2015, compared to a global TFR of 2.5.

The drop in the TFR has slowed the rate of population growth in the United States, but the country's population is still growing. In 2015 about 2.5 million people were added to the U.S. population, according to the U.S. Census

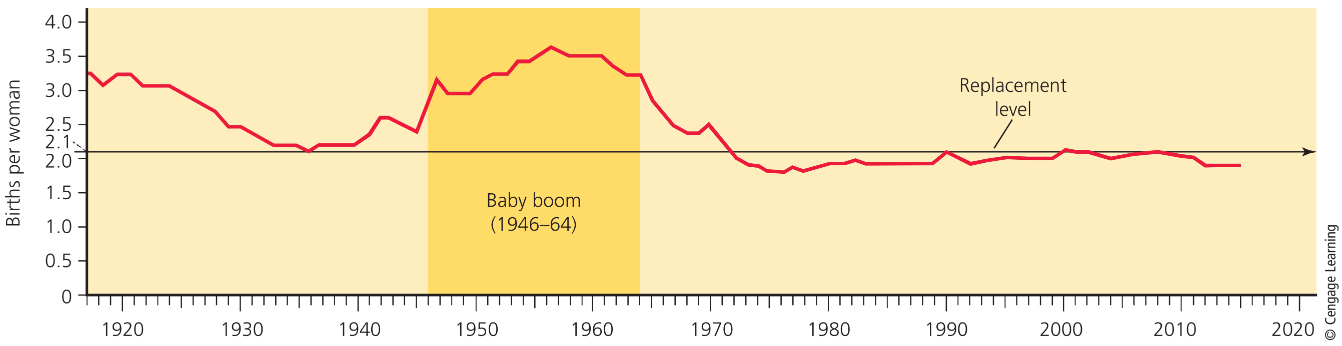

FIGURE 6.5 Total fertility rates for the United States between 1917 and 2015. ***Critical thinking:*** The U.S. fertility rate has declined and remained at or below replacement levels since 1972. So why is the population of the United States still increasing?

(Compiled by the authors using data from Population Reference Bureau and U.S. Census Bureau.)

Bureau. About 1.5 million (60% of the total) were added because there were more births than deaths, and about 1 million (40% of the total) were legal immigrants.

Since 1820, the United States has admitted almost twice as many legal 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 6.6).

Since 1965, nearly 59 million people have legally immigrated to the United States, most of them from Latin America and Asia, with the government giving preferences for those with technical training or with family members of U.S. citizens. A 2015 study by the U.S. Census Bureau noted that in 2013, China surpassed Mexico as the largest source of new U.S. immigrants. A 2015 study by the Pew Research Center found that between 2009 and 2014, more legal and illegal immigrants in the United States returned to Mexico (where economic conditions are improving) than migrated to the United States.

According to population experts, the country's influx of immigrants has made the country more culturally diverse and has increased economic growth as these citizens worked and started businesses. An estimated 11.7 illegal immigrants also live in the United States. There is controversy over whether to deport those who can be found or to allow these individuals to meet strict criteria for becoming U.S. citizens.

In addition to the fourfold increase in population since 1900, some amazing changes in lifestyles took place in the United States during the 20th century (Figure 6.7), which led to Americans living longer. Along with this came dramatic increases in per capita resource use and much larger total and per capita ecological footprints.

The U.S. Census Bureau projects that between 2015 and 2050, the U.S. population will likely grow from 321 million to 398 million—an increase of 77 million people. Because of a high per-person rate of resource use and the resulting waste and pollution, each addition to the U.S. population has an enormous environmental impact (see Figure 6, p. S20, in Supplement 4).

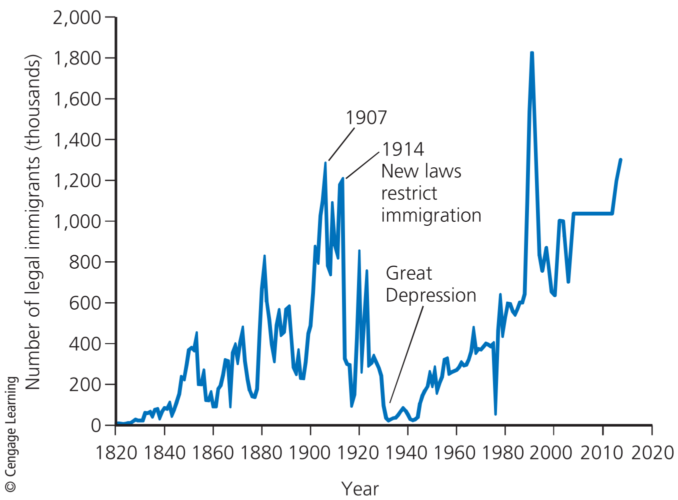

FIGURE 6.6 Legal immigration to the United States, 1820–2013 (the last year for which data are available). The large increase in immigration since 1989 resulted mostly from the Immigration Reform and Control Act of 1986, which granted legal status to certain illegal immigrants who could show they had been living in the country prior to January 1, 1982.

(Compiled by the authors using data from U.S. Immigration and Naturalization Service, the Immigration Policy Institute, and the Pew Hispanic Center.)

77 million

Projected increase in the U.S. population between 2015 and 2050

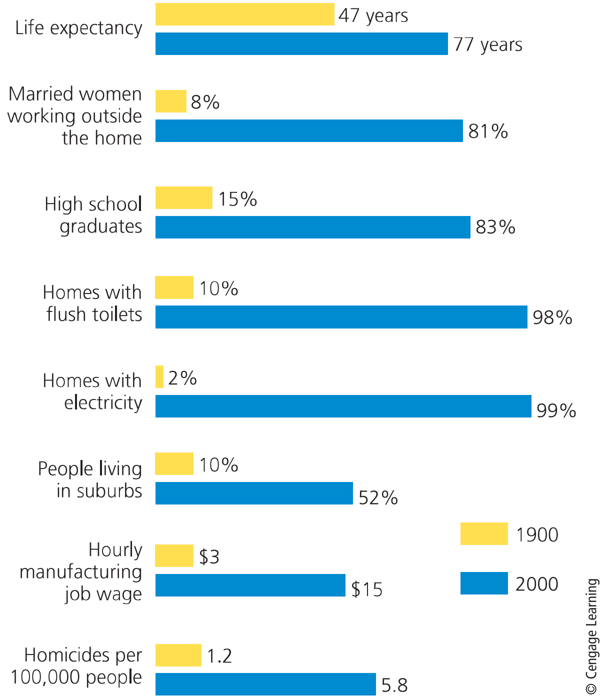

FIGURE 6.7 Some major changes took place in the United States between 1900 and 2000. ***Critical thinking:*** Which two of these changes do you think had the biggest impacts on the U.S. ecological footprint?

(Compiled by the authors using data from U.S. Census Bureau and Department of Commerce.)

FIGURE 6.8 This young boy spends much of his day carrying bricks.

Factors That Affect Birth 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*, especially in less-developed countries. Many poor couples in those countries struggle to survive on less than $2.25 a day. Some of these couples have a large number of children to help them haul drinking water, gather wood for heating and cooking, and grow or find food. Worldwide, 1 of every 10 children between ages 5 and 17 work to help their families survive (Figure 6.8).

Another economic factor is the *cost of raising and educating children*. Birth and fertility rates tend to be lower in more-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, the average cost of raising a child born in 2013 to age 18 ranged from $169,000 to $390,000 depending on household income (latest data available).

The *availability of pension systems* can influence the number of children couples have, especially poor people in less-developed countries. Pensions reduce a couple's need to have several children to replace those that die at an early age and to help support them in old age.

Urbanization also 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 the rural areas of less-developed countries.

Another important factor is the *educational and employment opportunities available for women*. Total fertility rates tend to be low when women have access to education and paid employment outside the home. In less-developed countries, a woman with no education typically has two more children than does a woman with a high school education.

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 reliable birth control methods* that allow women to control the number and spacing of their children.

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

Factors That Affect Death Rates

The rapid growth of the world's population over the past 100 years is largely the result of declining death rates, especially in less-developed countries. More people in some of these countries live longer, and fewer infants die because of larger food supplies, improvements in food distribution, better nutrition, improved sanitation, safer water supplies, and medical advances such as immunizations and antibiotics.

A useful indicator of the overall health of people in a country or region is **life expectancy**: the average number of years a person born in a particular year can be expected to live. Between 1955 and 2015, average global life expectancy increased from 48 years to 71 years. In 2015 Japan had the world's longest life expectancy of 83 years. Between 1900 and 2015, the average U.S. life expectancy rose from 47 years to 79 years. Research indicates that poverty, which reduces the average life span by 7 to 10 years, is the single most important factor affecting life expectancy.

GOOD NEWS

Another important indicator of the overall health of a population is its **infant mortality rate**, the number of babies out of every 1,000 born who die before their first birthday. It is viewed as one of the best measures of a society's quality of life because it indicates the general level of nutrition and health care. (See Figure 11, p. S26, in Supplement 4 for a map comparing generalized infant mortality rates among the world's countries.) A high infant mortality rate usually indicates insufficient food (*undernutrition*), poor nutrition (*malnutrition*; see Figure 1.13, p. 18), and a high incidence of infectious disease. Infant mortality also affects the TFR. In areas with low infant mortality rates, women tend to have fewer children because fewer of their children die at an early age.

Infant mortality rates in most countries have declined dramatically since 1965 (Figure 6.9). Even so, every year more than 4 million infants die of *preventable* causes during their first year of life, according to UN population experts. Most of these deaths occur in less-developed countries.

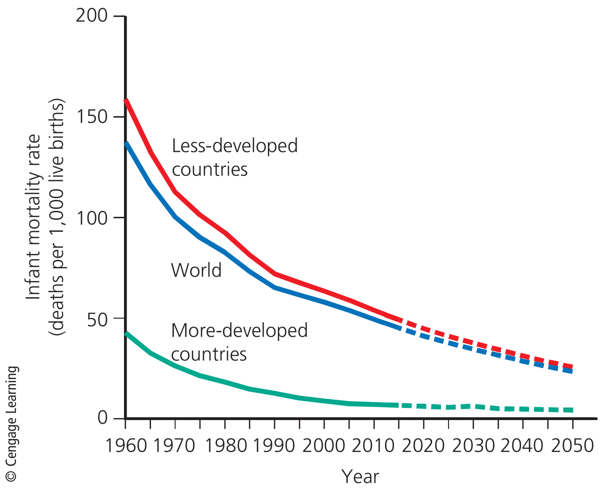

FIGURE 6.9 Comparison of infant mortality rates in more-developed countries and less-developed countries, 1950–2015, with projections to 2050 based on medium population projections.

(Compiled by the authors using data from United Nations Population Division and Population Reference Bureau.)

This average of nearly 11,000 mostly unnecessary infant deaths per day is equivalent to 55 jet airliners, each loaded with 200 infants, crashing *every day* with no survivors.

Between 1900 and 2015, the U.S. infant mortality rate dropped from 165 to 6. This sharp decline was a major factor in the marked increase in U.S. average life expectancy during this period. However, 47 other nations had lower infant mortality rates than the United States in 2015. They include Canada, Cuba, Israel, Japan, South Korea, and most European nations.

Migration

A third factor in population change is **migration**: the movement of people into (*immigration*) and out of (*emigration*) specific geographic areas. Most people who migrate to another area within their country or to another country are seeking jobs and economic improvement. Others are driven by religious persecution, ethnic conflicts, political oppression, or war. There are also *environmental refugees*—people who have to leave their homes and sometimes their countries because of water or food shortages, soil erosion, or some other form of environmental degradation.

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.

Age Structure

The **age structure** of a population is the numbers or percentages of males and females in young, middle, and older age groups in that population (**Concept 6.3**). In addition to total fertility rates, age structure is an important factor in determining whether the population of a country increases or decreases.

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: *pre-reproductive* (ages 0–14), consisting of individuals normally too young to have children; *reproductive* (ages 15–44), consisting of those normally able to have children; and *post-reproductive* (ages 45 and older), with individuals normally too old to have children. Figure 6.10 presents generalized age-structure diagrams for countries with rapid, slow, zero, and negative population growth rates.

A country with a large percentage of people younger than age 15 (represented by a wide base in Figure 6.10, far left) will experience rapid population growth unless death rates rise sharply. Because of this *demographic momentum*,

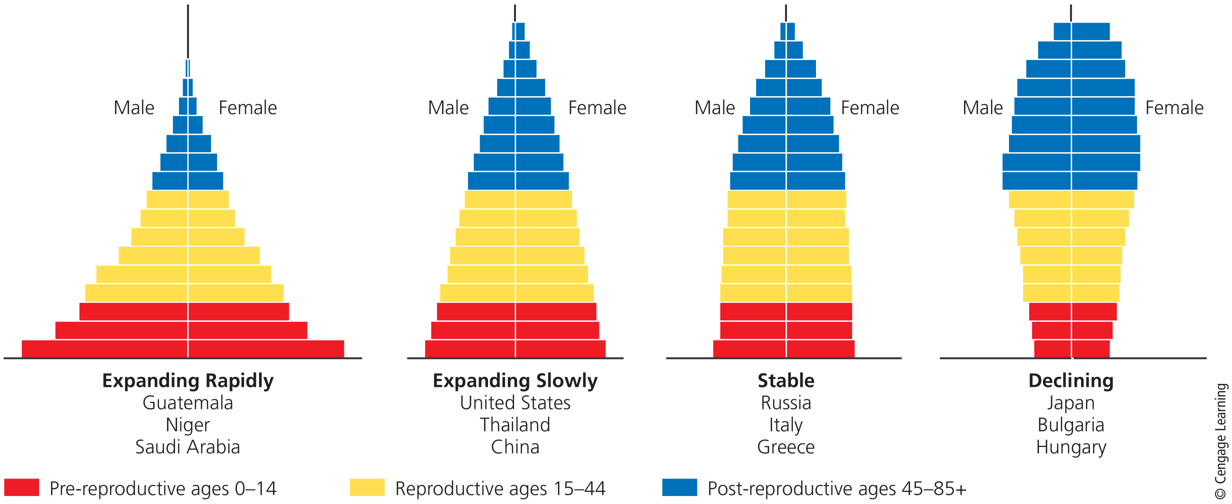

FIGURE 6.10 Generalized population age-structure diagrams for countries with rapid (1.5–3%), slow (0.3–1.4%), zero (0–0.2%), and negative (declining) population growth rates. ***Question:*** Which of these diagrams best represents the country where you live?

(Compiled by the authors using data from U.S. Census Bureau and Population Reference Bureau.)

the number of births in such a country will rise for several decades. This will occur even if women each have an average of only one or two children because of the large number of girls entering their prime reproductive years. Most future human population growth will take place in less-developed countries because of their typically youthful age structure and rapid population growth rates.

The global population of seniors—people who are 65 and older—is projected to triple between 2015 and 2050, when one of every six people will be a senior. (See the Case Study that follows.). An aging population combined with a lower fertility rate results in fewer working-age adults having to support a large number of seniors. For example, in China and the United States between 2010 and 2050, the working-age population is projected to decline sharply. This could lead to a shortage of workers and friction between the younger and older generations in these countries.

CASE STUDY

The American Baby Boom

Changes in the distribution of a country's age groups have long-lasting economic and social impacts. For example, the American baby boom (Figure 6.5) added 79 million people to the U.S. population between 1946 and 1964. Over time, this group looks like a bulge as it moves up through the country's age structure, as shown in Figure 6.11.

For decades, the baby-boom generation has strongly influenced the U.S. economy because it makes up about 25% of the U.S. population. Baby boomers created the youth market in their teens and twenties and are now creating the late-middle-age (ages 50 to 60) and senior markets. In addition to having this economic impact, the large baby-boom generation plays an increasingly important role in deciding who is elected to public office and what laws are passed or weakened.

Since 2011, when the first baby boomers began turning 65, the number of Americans older than age 65 has grown at the rate of about 10,000 a day and will do so through 2030. This process has been called the *graying of America*. As the number of working adults declines in proportion to the number of seniors, there may be political pressure from baby boomers to increase tax revenues to help support the growing senior population. However, in 2015, according to the Census Bureau, the Millennial Generation—Americans born between 1980 and 2005—overtook Baby Boomers to become the largest generation living in the United States. Eventually, this will change the political and economic power balance.

Aging Populations Can Decline Rapidly

The graying of the world's population is due largely to declining birth rates and medical advances that have extended life spans. The UN estimates that by 2050, the global number of people age 60 and older will equal or exceed the number of people under age 15 (Figure 6.12).

As the percentage of people age 65 or older increases, more countries will begin experiencing population declines. If population decline is gradual, its harmful effects usually can be managed. However, some countries are experiencing rapid declines and feeling such effects more severely.

Japan has the world's highest percentage of people age 65 or over and the world's lowest percentage of people under age 15. In 2015 Japan's population was 127 million. By 2050 its population is projected to be 97 million, a 24% drop. As its population declines, there will be fewer adults

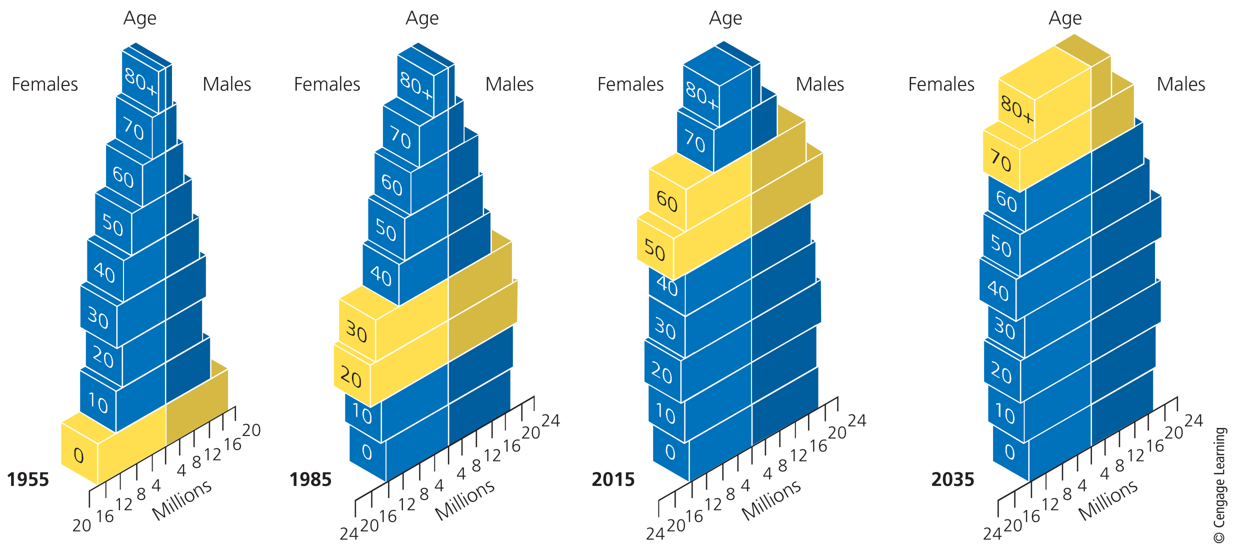

FIGURE 6.11 Age-structure diagrams tracking the baby-boom generation in the United States, 1955, 1985, 2015, and 2035 (projected). ***Critical thinking:*** How might the projected age structure in 2035 affect you?

(Compiled by the authors using data from U.S. Census Bureau and Population Reference Bureau.)

working and paying taxes to support an increasingly elderly population. Because Japan discourages immigration, this could threaten its economic future. In recent years, Japan has been feeling the effects of a declining population. For example, houses in some suburbs have been abandoned and cannot be sold because of a lack of buyers. They could be demolished, but who will pay the costs—the owners who have abandoned them, or the government?

Figure 6.13 lists some of the problems associated with rapid population decline. Countries with rapidly declining populations, in addition to Japan, include Germany, Italy, Bulgaria, Hungary, Romania, Cuba, and Portugal. Other countries facing population declines in the not-too-distant future are China, South Korea, Iran, Russia, Spain, Singapore, and the Netherlands. Population declines are difficult to reverse.

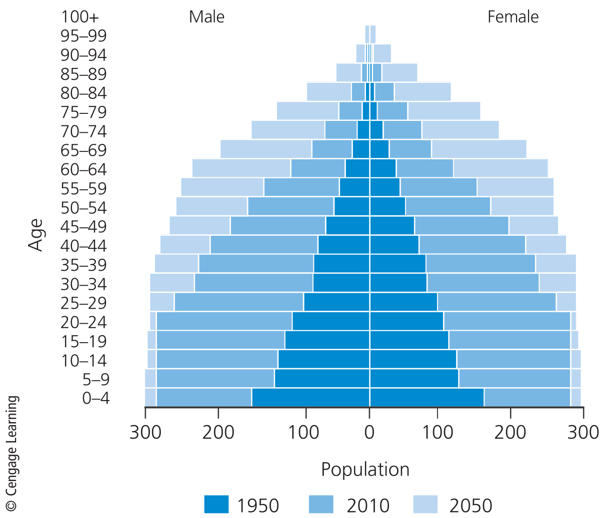

FIGURE 6.12 The world's age structure 1950, 2010, and 2050 (projected). ***Critical thinking:*** How might the projected age structure in 2050 affect you?

(Compiled by the authors using data from U.S. Census Bureau and United Nations Population Division.)

FIGURE 6.13 Rapid population decline can cause several problems. ***Critical thinking:*** Which two of these problems do you think are the most important?

Top: Slavoljub Pantelic/Shutterstock.com. Center: Iofoto/Shutterstock.com. Bottom:sunabesyou/Shutterstock.com.

6.4 HOW CAN WE SLOW HUMAN POPULATION GROWTH?

CONCEPT 6.4 We can slow human population growth by reducing poverty through economic development, elevating the status of women, and encouraging family planning.

Economic Development

There is controversy over whether we should slow population growth (Science Focus 6.1). Some analysts argue that because population growth can be linked to environmental degradation, we need to slow population growth in order to reduce such degradation. They have suggested several ways to do this, one of which is to reduce poverty through economic development.

Demographers have examined the birth and death rates of western European countries that became industrialized during the 19th century. Using such data, they developed a hypothesis on population change known as the **demographic transition**. It states that as countries become industrialized and economically developed, their per capita incomes rise, poverty declines, and their populations tend to grow more slowly. According to the hypothesis, this transition takes place in four stages, as shown in Figure 6.14. Some good news for those who view population growth as a serious environmental problem is that by 2015, 31 countries, mostly in Europe, had stabilized their populations or were experiencing population declines.

GOOD NEWS

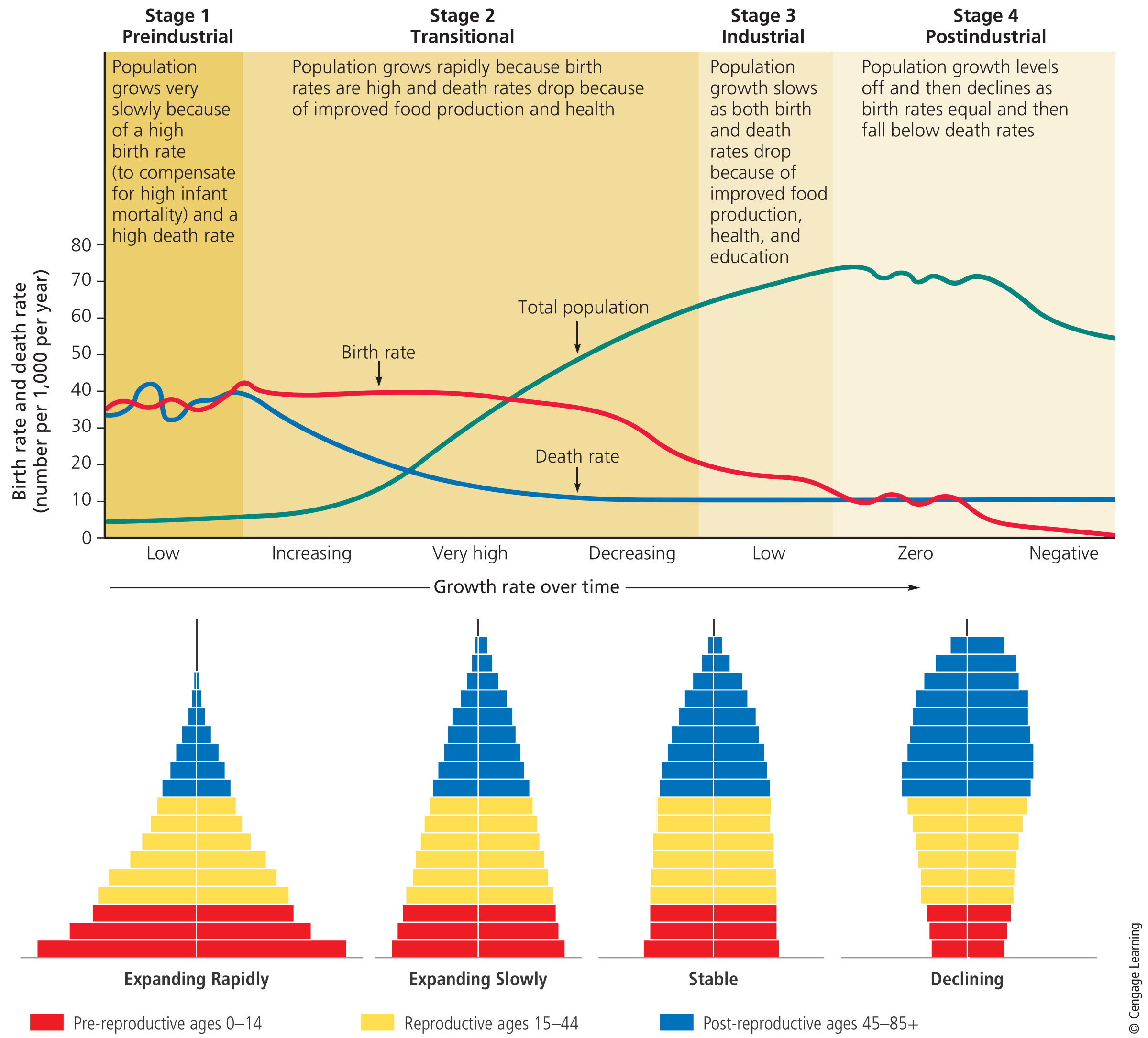

FIGURE 6.14 The *demographic transition*, which a country can experience as it becomes industrialized and more economically developed, can take place in four stages. ***Question:*** At what stage is the country where you live?

Some analysts believe that most of the world's less-developed countries will make a demographic transition over the next few decades. They hypothesize that the transition will occur because newer technologies will help them to develop economically and to reduce poverty.

Other analysts fear that rapid population growth, extreme poverty, war, increasing environmental degradation, and resource depletion could leave some countries with high population growth rates (2.5% to 3%) stuck in stage 2 of the demographic transition. Such countries include Afghanistan, Iraq, Guatemala, Pakistan, Yemen, and Nigeria and a number of other African countries. This highlights the need to reduce poverty as a key to improving human health and stabilizing the population.

Educating and Empowering Women

A number of studies show that women tend to have fewer children if they are educated, can control their own fertility, earn an income of their own, and live in societies that do not suppress their rights.

Only about 30% of the world's girls are enrolled in secondary education, so widespread education of girls is important for their future and for trying to slow population growth. In most societies women have fewer rights and educational and economic opportunities than men have.

Women do almost all of the world's domestic work and child care for little or no pay. They provide more unpaid health care (within their families) than do all of the world's organized health-care services combined. In rural areas of Africa, Latin America, and Asia, women do 60–80% of the work associated with growing food, hauling water, and gathering and hauling wood (Figure 6.15) and animal dung for use as fuel. As one Brazilian woman observed, "For poor women, the only holiday is when you are asleep."

Iv Nikolny/Shutterstock.com

FIGURE 6.15 This woman in Nepal is bringing home firewood. Typically, she spends 2 hours a day, two or three times a week, on this task.

Women make up slightly more than 50% of the world's poor and 66% of the world's 800 million illiterate adults. In many societies, boys are more likely to get an education than are girls because of traditional views of a woman's role in a household. Studies show that one of the major factors for slowing population growth is the widespread education of girls.

Poor women who cannot read often have an average of five to seven children, compared with two or fewer children in societies where most women can read. This highlights the need for all children to get at least an elementary school education.

A growing number of women in less-developed countries are taking charge of their lives and reproductive behavior. As this number grows, such change driven by individual women will play an important role in stabilizing populations. This change will also improve human health, reduce poverty and environmental degradation, and allow more access to basic human rights.

Family Planning

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

According to studies by the UN Population Division and other population agencies, family planning has been a major factor in reducing the number of unintended pregnancies, births, and abortions. In addition, family planning has reduced rates of infant mortality and the number of mothers and fetuses dying during pregnancy. According to the UN, had there not been the sharp drop in TFRs since the 1970s, with all else being equal, the world's population today would be about 8.5 billion instead of 7.3 billion (**Core Case Study**). Family planning has played an important role in countries that have stabilized their populations.

Family planning also has financial benefits. Studies show that each dollar spent on family planning in countries such as Thailand, Egypt, and Bangladesh saves $10 to $16 in health, education, and social service costs by preventing unwanted births.

Despite these successes, certain problems have hindered progress in some countries. There are three major problems. *First*, according to the UN Population Fund and the Guttmacher Institute, about 40% of all pregnancies in less-developed countries were unplanned and about half of these pregnancies end with abortion. So ensuring access to voluntary contraception would play a key role in stabilizing the populations and reducing the number of abortions in such countries.

Samrat35/Dreamstime.com

FIGURE 6.17 Homeless people in Kolkata, India.

India's and the earth's natural capital as rates of per capita resource use rise. On the other hand, economic growth may help India to slow its population growth by accelerating its demographic transition.

world's fourth most populous country in 2015. The UN also estimates that by 2030, the country is likely to have too few young workers (ages 15 to 64) to support its rapidly aging population. To help deal with this problem, China plans to become the world's largest manufacturer of industrial robots to be used for manufacturing. It will also sell such robots to other countries.

Because of these concerns, in 2015 the Chinese government abandoned its one-child policy and replaced it with a two-child policy. Married couples can apply to the government for permission to have two children. However, the Chinese people have gotten used to small families. In addition, many married couples may have only one child because of the high cost of raising a second child and the greatly increased educational and employment opportunities for young women.

Nikada/iStock/Getty Images Plus/Getty Images

FIGURE 6.18 Old and new housing in heavily populated Shanghai, China, in 2015.

BIG IDEAS

- The human population is growing rapidly and may soon bump up against environmental limits.
- The combination of population growth and the increasing rate of resource use per person is expanding the overall human ecological footprint and putting a strain on the earth's natural capital.
- We can slow human population growth by reducing poverty, elevating the status of women, and encouraging family planning.

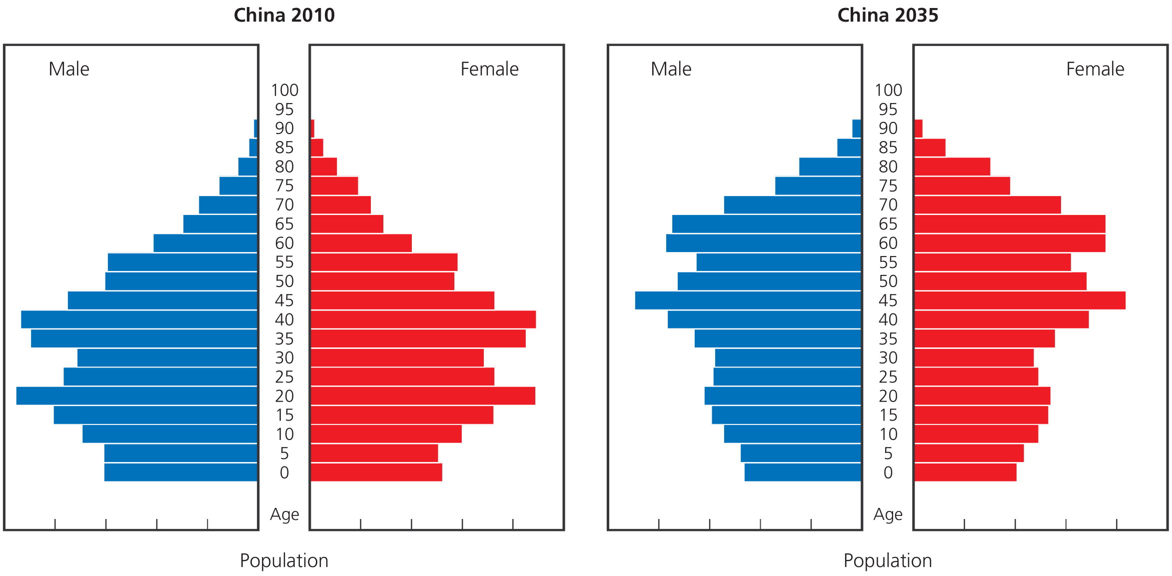

FIGURE 6.19 Age structure in China: 2010 and 2035 (projected). ***Critical thinking:*** How might the projected age structure in 2035 affect China's economy?

(Compiled by the authors using data from U.S. Census Bureau and United Nations Population Division.)

Tying It All Together

World Population Growth and Sustainability

This chapter began with a discussion of the fact that the world's human population has now passed 7.3 billion (**Core Case Study**). We noted that this is a result of exponential population growth and that many environmental scientists believe such growth to be unsustainable in the long run. We briefly considered some of the environmental problems brought on by exponential human population growth. We looked at factors that influence the growth of populations, as well as at how some countries have made progress in controlling population growth.

JeremyRichards/Shutterstock.com

In the first six chapters of this book, you have learned how ecosystems and species have been sustained throughout the earth's history, in keeping with the three **scientific principles of sustainability**, by nature's reliance on solar energy, nutrient cycling, and biodiversity (see inside back cover of this book). These three principles can guide us in dealing with the problems brought on by population growth and decline. By greatly increasing our use of solar, wind, and other renewable-energy technologies, we can cut pollution and emissions of climate-changing gases that are increasing as the population and resource use per person grow. By reusing and recycling more materials, we can cut resource waste and reduce our ecological footprints. By focusing on preserving biodiversity, we can help sustain the life-support system on which we and all other species depend.

Chapter Review

Core Case Study

1. Summarize the story of how human population growth has surpassed 7.3 billion and explain why this is significant to many environmental scientists (**Core Case Study**). List three factors that account for the rapid growth of the human population over the past 200 years.

Section 6.1

2. What is the key concept for this section? What is the range of estimates for the size of the human population in 2050? Summarize the three major population growth trends recognized by demographers. About how many people were added to the world's population in 2015? What are the world's three most populous countries? List eight major ways in which we have altered natural systems to meet our needs. Define **cultural carrying capacity**. Summarize the debate over whether and how long the human population can keep growing.

Section 6.2

3. What are the two key concepts for this section? Define and distinguish between **crude birth rate** and **crude death rate**. List three variables that affect the growth and decline of human populations. Explain how a given area's **population change** is calculated.
4. Define and distinguish between the **replacement-level fertility rate** and the **total fertility rate (TFR)**. How has the global TFR changed since 1955? List three major factors that demographers have to consider in making population projections.

5. Summarize the story of population growth in the United States and explain why it is high compared to population growth in most other more-developed countries. About how much of the annual U.S. population growth is due to immigration? List six changes in lifestyles that have taken place in the United States during the 20th century, leading to a rise in per capita resource use. What is the end effect of such changes in terms of the U.S. ecological footprint?

6. List eight factors that affect birth rates and fertility rates. Explain why there are more boys than girls in some countries. Define **life expectancy** and **infant mortality rate** and explain how they affect the population size of a country. What is **migration**? What are environmental refugees?

Section 6.3

7. What is the key concept for this section? What is the **age structure** of a population? Explain how age structure affects population growth and economic growth. What is demographic momentum? Describe the baby boom in the United States and some of its economic and social effects. What are some problems related to rapid population decline due to an aging population?

Section 6.4

8. What is the key concept for this section? What is the **demographic transition** and what are its four stages? What factors could hinder some less-developed countries in making this transition?

9. Explain how education, reduction of poverty, and empowerment of women can help countries to slow their population growth. What is **family planning** and how can it help to stabilize populations? Describe India's efforts to control its population growth. Describe China's population control program and compare it with that of India.

10. What are this chapter's *three big ideas*? Summarize the story of human population growth and explain how the three **scientific principles of sustainability** can guide us in dealing with the problems that stem from population growth and decline.

Note: Key terms are in bold type.

Critical Thinking

1. Do you think that the global population of 7.3 billion (**Core Case Study**) is too large? Explain. If your answer was *yes*, what do you think should be done to slow human population growth? If your answer was *no*, do you believe that there is a population size that would be too big? Explain.

2. If you could say hello to a new person every second without taking a break and working around the clock, how many people could you greet in a day? How many in a year? How long would it take you to greet the 88 million people who were added to the world's population in 2015? At this same rate, how many years would it take you to greet all 7.3 billion people on the planet?

3. Of the three major environmental worldviews summarized on p. 20, which do you think underlies each of the two major positions on whether the world is overpopulated, as described in Science Focus 6.1?

4. 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?

5. Is it rational for a poor couple in a less-developed country such as India to have four or five children? Explain.

6. Do you think that projected increases in the earth's population size and economic growth are sustainable? Explain. If not, how is this likely to affect your life?

7. Some people think the most important environmental goal is to sharply reduce the rate of population growth in less-developed countries, where at least 95% of the world's population growth is expected to take place between 2015 and 2050. Others argue that the most serious environmental problems stem from high levels of resource consumption per person in more-developed countries. What is your view on this issue? Explain.

8. Experts have identified population growth as one of the major causes of the environmental problems we face. The population of the United States is growing faster than that of any other more-developed country. This fact is rarely discussed and the U.S. government has no official policy for slowing U.S. population growth. Why do think this is so? Do you think there should be such a policy? If so, explain your thinking and list three steps you would take as a leader to slow U.S. population growth. If not, explain your thinking.

Doing Environmental Science

Prepare an age-structure diagram for your community. You will need to estimate how many people belong in each age category (see p. 127). To do this, interview a randomly drawn sample of the population to find out their ages and then divide your sample into age groups. (Be sure to interview equal numbers of males and females.) Then find out the total population of your community and apply the percentages for each age group from your sample to the whole population in order to make your estimates. Create your diagram and then use it to project future population trends. Write a report in which you discuss some economic, social, and environmental effects that might result from these trends.

Global Environment Watch Exercise

Go to your MindTap course to access the GREENR database. Using the "Basic Search" box at the top of the page, search for *aging population*. Choose an article from those that appear. Read the article, take notes, and summarize its main idea. List three major arguments or pieces of evidence cited in the article to support this main idea. Write a report summarizing your findings and answering the following questions: Is there anything in the article that contradicts anything you read in Chapter 6? Is there anything in the article that adds to the knowledge you gained from reading Chapter 6? Explain.

Data Analysis

The chart below shows selected population data for two different countries, A and B. Study the chart and answer the questions that follow.

	Country A	Country B
Population (millions)	144	82
Crude birth rate (number of live births per 1,000 people per year)	43	8
Crude death rate (number of deaths per 1,000 people per year)	18	10
Infant mortality rate (number of babies per 1,000 born who die in first year of life)	100	3.8
Total fertility rate (average number of children born to women during their childbearing years)	5.9	1.3
% of population under 15 years old	45	14
% of population older than 65 years	3	19
Average life expectancy at birth	47	79
% urban	44	75

1. Calculate the rates of natural increase (due to births and deaths, not counting immigration) for the populations of country A and country B. Based on these calculations and the data in the table, for each of the countries, suggest whether it is a more-developed country or a less-developed country and explain the reasons for your answers.
2. Describe where each of the two countries might be in the stages of demographic transition (Figure 6.14). Discuss factors that could hinder either country from progressing to later stages in the demographic transition.
3. Explain how the percentages of people under age 15 in each country could affect its per capita and total ecological footprints.