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PART I

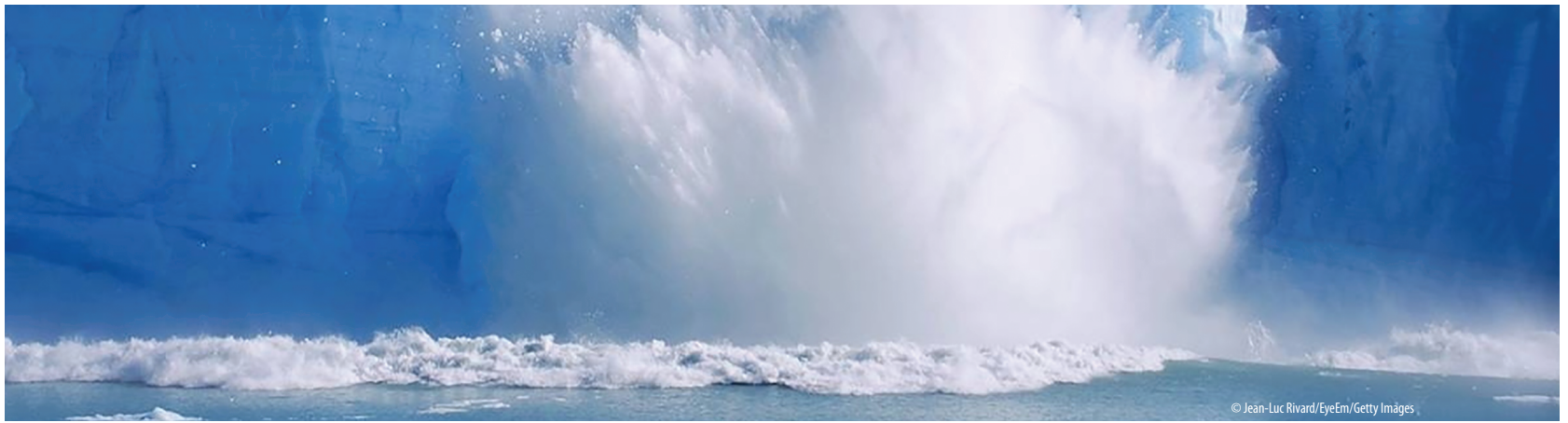
Background of the Field

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CHAPTER 1

Introduction: The Environment At Risk

LEARNING OBJECTIVES

By the end of this chapter the reader will be able to:

- Describe how environmental health problems influence our lives.
- Discuss the potential impacts of population growth upon the environment.
- State a definition of the term *environmental health*.
- List at least five major events in the history of environmental health.
- Summarize employment opportunities in the environmental health field.

► Introduction

This chapter will illustrate how the environment impacts the health of people and survival of every living being on the planet. You will learn about key terms used in environmental health and the scope of the field. The focus will be on distinguishing features of the field and the basic concepts, which are essential to this discipline. For example, one of these concepts is the relationship between world population growth and the environment. Another concept relates to historically significant environmental events and how they influenced the topics that are of current importance to the environmental health field. An additional topic involves employment classifications, career roles, and opportunities for environmental health workers. The chapter will conclude with an overview of the textbook: the roles of **environmental**

epidemiology and **toxicology**, policy aspects of environmental health, examples of environmentally related agents and diseases, and specific content areas of environmental health such as air quality, water quality, food safety, and waste disposal.

► Progress and Challenges in Protecting Our Environment

Although much progress has been made in protecting our environment, many lingering challenges confront humanity. Maintaining environmental quality is a pressing task for the 21st century. Often achievements in environment quality are limited primarily to the developed world, which has the financial wherewithal to address environmental health.

Improvement in environmental quality is an official goal of the US government, as articulated in *Healthy People 2020*. This goal (number 8, Environmental

Health) is formatted as follows: “Promote health for all through a healthy environment.”¹ A list of environmental objectives is shown in **TABLE 1.1**.

TABLE 1.1 Objectives for <i>Healthy People 2020</i> —Environmental Health Goal: Promote Health for All through a Healthy Environment	
Outdoor Air Quality	
EH-1	Reduce the number of days the Air Quality Index (AQI) exceeds 100, weighted by population and AQI.
EH-2	Increase use of alternative modes of transportation for work.
EH-3	Reduce air toxic emissions to decrease the risk of adverse health effects caused by mobile, area, and major sources of airborne toxics.
Water Quality	
EH-4	Increase the proportion of persons served by community water systems who receive a supply of drinking water that meets the regulations of the Safe Drinking Water Act.
EH-5	Reduce waterborne disease outbreaks arising from water intended for drinking among persons served by community water systems.
EH-6	Reduce per capita domestic water withdrawals with respect to use and conservation.
EH-7	Increase the proportion of days that beaches are open and safe for swimming.
Toxics and Waste	
EH-8	Reduce blood lead levels in children.
EH-9	Minimize the risks to human health and the environment posed by hazardous sites.
EH-10	Reduce pesticide exposures that result in visits to a health care facility.
EH-11	Reduce the amount of toxic pollutants released into the environment.
EH-12	Increase recycling of municipal solid waste.
Healthy Homes and Healthy Communities	
EH-13	Reduce indoor allergen levels.
EH-14	Increase the proportion of homes with an operating radon mitigation system for persons living in homes at risk for radon exposure.
EH-15	Increase the proportion of new single-family homes (SFH) constructed with radon-reducing features, especially in high-radon-potential areas.
EH-16	Increase the proportion of the Nation’s elementary, middle, and high schools that have official school policies and engage in practices that promote a healthy and safe physical school environment.
EH-17 (Developmental)	Increase the proportion of persons living in pre-1978 housing that has been tested for the presence of lead-based paint or related hazards.

EH-18 Reduce the number of U.S. homes that are found to have lead-based paint or related hazards.

EH-19 Reduce the proportion of occupied housing units that have moderate or severe physical problems.

Infrastructure and Surveillance

EH-20 Reduce exposure to selected environmental chemicals in the population, as measured by blood and urine concentrations of the substances or their metabolites.

EH-21 Improve quality, utility, awareness, and use of existing information systems for environmental health.

EH-22 Increase the number of States, Territories, Tribes, and the District of Columbia that monitor diseases or conditions that can be caused by exposure to environmental hazards.

EH-23 Reduce the number of public schools located within 150 meters of major highways in the United States.

Global Environmental Health

EH-24 Reduce the global burden of disease due to poor water quality, sanitation, and insufficient hygiene.

Modified from US Department of Health and Human Services, Office of Disease Prevention and Health Promotion. *Healthy People 2020: Environmental Health*. Available at: <https://www.healthypeople.gov/2020/topics-objectives/topic/environmental-health/objectives>. Accessed January 17, 2017.

According to *Healthy People 2020*:

Humans interact with the environment constantly. These interactions affect quality of life, years of healthy life lived, and health disparities.... Maintaining a healthy environment is central to increasing quality of life and years of healthy life. Globally, nearly 25 percent of all deaths and the total disease burden can be attributed to environmental factors. Environmental factors are diverse and far reaching.... Poor environmental quality has its greatest impact on people whose health status is already at risk. Therefore, environmental health must address the societal and environmental factors that increase the likelihood of exposure and disease.¹

Protecting the environment means creating a world in which the air is safe to breathe, the water is safe to drink, the land is arable and free from toxins, wastes are managed effectively, infectious diseases are kept at bay, and natural areas are preserved. **FIGURE 1.1** illustrates a beautifully maintained natural area in the United States. Crucial environmental dimensions also include the impacts of disasters, the built environment, and availability of nutritious foods.¹

The requirements of a growing world population need to be balanced against the demands for environmental preservation. Although developed countries such as the United States have made substantial progress in clearing the air and reducing air pollution,

significant challenges to the environment and human health remain. For example, among the current and persistent threats to the environment in the United States are the following: trash that fouls our beaches, hazardous wastes (including radioactive wastes) leaching from disposal sites, continuing episodes of air pollution, exposures to toxic chemicals, destruction of the land through deforestation, and global warming.

The hallmarks of environmental degradation are not difficult to find: Warning signs posted on beaches advise bathers not to enter ocean water that is unsafe because of sewage contamination. In some areas of the United States, drinking water is threatened by toxic chemicals



FIGURE 1.1 A natural ecosystem in the United States. Maintaining environmental quality is a pressing task for the 21st century.

that are leaching from disposal sites. Too many factories continue to belch thick, black smoke or emit unseen pollutants. Avoidance of air pollution, which at best insults our aesthetic senses and at worst endangers our health, is often impossible. Society's appetite for lumber and new housing to satisfy the burgeoning population has resulted in clear-cutting of forests and destruction of wildlife habitats in order to accommodate new habitations for humans. Continued use of fossil fuels contributes to poor air quality and climate change.

Pollution and population growth, often associated with adverse economic circumstances, are closely connected with environmental health. In his classic article, the late Professor Warren Winkelstein wrote that "the three P's—pollution, population, and poverty—are principal determinants of health worldwide. . . ." ^{2(p932)} The three P's are interrelated: Population growth is associated with poverty, and both poverty and population growth are associated with pollution.

An example of the first "P" is pollution from combustion of fossil fuels (e.g., petroleum and coal), which disperses greenhouse gases along with other pollutants into the atmosphere. This process is believed to be a cause of global warming that in turn may have wide-ranging adverse effects. One such effect is to advance the range of disease-carrying insects, bringing them into new geographic areas; for example, mosquito-borne diseases such as the West Nile virus and dengue fever may appear in areas that previously were free from these conditions. (Refer to the chapter on zoonotic and vector-borne diseases for more information.) The second "P" is population, which is growing exponentially in many parts of the world, especially the less-developed areas, and may result in a worldwide population of up to 10 to 12 billion people during the 21st century; the presence of so many people may exceed the carrying capacity (defined later in the chapter) of the earth by a factor of two. The third "P," poverty, is linked to population growth; poverty is one of the well-recognized determinants of adverse health outcomes.

A recent environmentally related adverse health outcome may be attributed, at least in part, to one of the three P's: population growth (which is associated with urban crowding). As a result of known and unknown environmental and other factors, threats to the human population periodically arise from infectious disease agents. (This topic is discussed in the chapter on zoonotic and vector-borne diseases.) For example, influenza viruses threaten the world's population from time to time. Environmental factors that are likely to advance the spread of influenza viruses include intensive animal husbandry practices needed to supply food to the world's growing population. These practices create extremely crowded conditions

among food animals coupled with their close residential proximity to humans. Often such farm animals are treated with antibiotics that contribute to the proliferation of antibiotic resistant strains of bacteria.

Several years ago, public health officials became concerned about the possible occurrence of a human pandemic of avian influenza, caused by the avian influenza A (H5N1) virus. Large outbreaks of avian influenza occurred on poultry farms in Asia. Apparently, some transmission of the virus from birds to humans also occurred. The disease (called bird flu) produces a severe human illness that has a high fatality rate. Health officials were concerned that the virus might mutate, enabling human-to-human transmission; if human-to-human transmission of the virus erupted, a pandemic might result. Contributing to the possible epidemic transmission of influenza (and other communicable diseases) is the ability of human beings to travel rapidly from one area of the globe to another.

An example of a global outbreak of influenza was the pandemic caused by swine flu (H1N1 influenza). In 2009, swine flu spread through North America to other parts of the globe. The World Health Organization (WHO) declared a pandemic of influenza was underway.

Another example of a condition that threatens the human population as well as all life on earth is global climate change. **EXHIBIT 1.1** presents a case study of global climate change. More information on this topic appears in the chapter on air quality. Refer to **FIGURE 1.2** for ways climate change threatens your health.

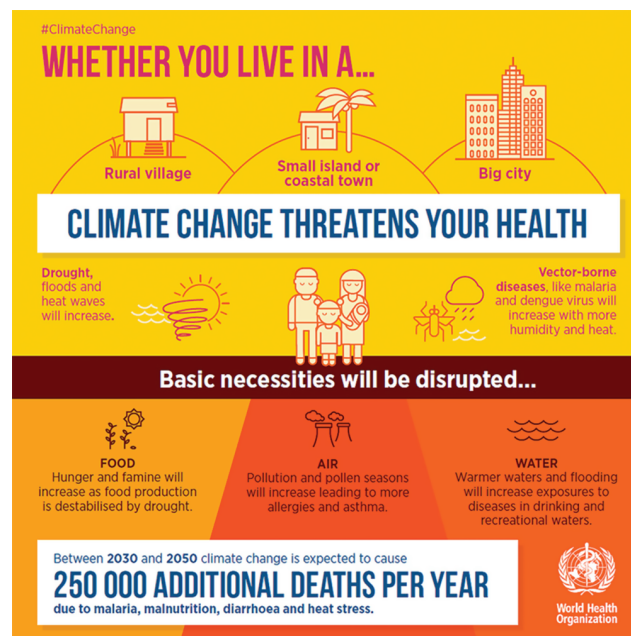


FIGURE 1.2 Climate change threatens your health.

Reproduced from World Health Organization. Climate change and human health. Available at: <http://www.who.int/globalchange/mediacentre/events/climate-health-conference/climatechange-infographic2.jpg?ua=1>. Accessed March 22, 2017.

EXHIBIT 1.1

Case Study: Climate Change: the Most Pressing Environmental Health Issue for the 21st Century

Two leading health bodies, a US governmental agency and a global health organization, have made the following declarations:

Climate change endangers human health, affecting all sectors of society, both domestically and globally. The environmental consequences of climate change, both those already observed and those that are anticipated, such as sea-level rise, changes in precipitation resulting in flooding and drought, heat waves, more intense hurricanes and storms, and degraded air quality, will affect human health both directly and indirectly. Addressing the effects of climate change on human health is especially challenging because both the surrounding environment and the decisions that people make influence health. For example, increases in the frequency and severity of regional heat waves—likely outcomes of climate change—have the potential to harm a lot of people.

—National Institute of Environmental Health Sciences

* * * * *

- “Climate change affects the social and environmental determinants of health—clean air, safe drinking water, sufficient food and secure shelter.
- Between 2030 and 2050, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhea, and heat stress.
- The direct damage costs to health (i.e., excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between US\$ 2–4 billion/year by 2030.
- Areas with weak health infrastructure—mostly in developing countries—will be the least able to cope without assistance to prepare and respond.
- Reducing emissions of greenhouse gases through better transport, food, and energy-use choices can result in improved health, particularly through reduced air pollution.”

—World Health Organization

Modified and reproduced from Portier CJ, Thigpen TK, Carter SR, et al. *A Human Perspective on Climate Change: A Report Outlining the Research Needs on the Human Health Effects of Climate Change*. Research Triangle Park, NC: Environmental Health Perspectives/National Institute of Environmental Health Sciences; 2010; and World Health Organization. Climate change and health. June 2016. Available at: <http://www.who.int/mediacentre/factsheets/fs266/en/>. Accessed March 22, 2017

► Significance of the Environment for Human Health

The environment is intimately connected with human health, illness, and mortality. For example, although figures on the role of environmental factors in global mortality vary considerably, the environment is undoubtedly a salient influence on human deaths. Some estimates from the 1990s placed the toll of the world’s deaths caused by environmental factors at around 40%.³ World Health Organization data from 2012 suggested that almost one-quarter of global deaths result from an unhealthy environment. Exposures to potentially hazardous agents such as microbes, toxic chemicals and metals, pesticides, and ionizing radiation account for many of the forms of environmentally associated morbidity (acute and chronic conditions, allergic responses, and disability) and mortality that occur in today’s world. These environmentally related determinants are believed to be important

for the development of chronic diseases such as cancer, although most chronic diseases are thought to be the result of complex interactions between environmental and genetic factors.⁴ All human beings are affected in some way by exposure to environmental hazards associated with lifestyle: at work, at home, during recreation, or while traveling on the expressway. **TABLE 1.2** provides examples of the scope of disease burden associated with exposure to environmental hazards.

Vulnerable Subgroups of the Population

The elderly, persons with disabilities and chronic diseases, pregnant women, and children are more likely to be affected by environmental hazards than are members of the general population. With respect to age, research from WHO underscored the differential effects of environmental influences across the life course.⁵ Age groups most likely to be impacted are children younger than 5 years, children as old as 10 years to a lesser degree, and older adults from 50 to 75 years.

TABLE 1.2 The Scope of Environmental Health Problems in the World and the United States

- The World Health Organization (WHO) estimated that in 2012, approximately 12.6 million deaths across the globe (23% of all deaths) were linked to environmental sources.^a
- The US Environmental Protection Agency reported that in 2015, industry released 881 million pounds (400 million kilograms) of toxic chemicals into the air and water (690 million pounds [313 million kilograms] into the air and 191 million pounds [87 million kilograms] into the water). On the positive side, a declining trend in the release of these chemicals occurred between 2005 and 2015.^b
- Elevated blood levels of lead continue to be an important problem in the United States, with children living in at least 4 million households that expose them to excessive amounts of lead.^c
- The number of people with asthma in the United States increased to 8% of the population in 2009; environmental factors such as tobacco smoke and air pollution are asthma triggers.^d
- "Strong evidence exists that industrial chemicals widely disseminated in the environment are important contributors to... the global, silent pandemic of neurodevelopmental toxicity."^e
- "Using air quality standards established by WHO, experts have estimated that 1.3 billion of the world's urban inhabitants breathe air that exceeds these quality standards."^f
- Environmental factors are thought to contribute significantly to various forms of cancer, including cervical cancer, prostate cancer, and breast cancer.

Data from:
^aPrüss-Üstün A, Wolf J, Corvalan CF, et al. Preventing disease through healthy environments. Geneva, Switzerland: World Health Organization; 2016.
^bUS Environmental Protection Agency. Introduction to the 2015 TRI national analysis. Available at: https://www.epa.gov/sites/production/files/2017-01/documents/tri_na_2015_complete_english.pdf. Accessed June 29, 2017.
^cCenters for Disease Control and Prevention. Lead home page. Available at: <https://www.cdc.gov/nceh/lead>. Accessed June 30, 2017.
^dCenters for Disease Control and Prevention. Vital signs. Asthma in the US. Available at: <https://www.cdc.gov/vitalsigns/asthma/index.html>. Accessed June 30, 2017.
^eGrandjean P, Landrigan PJ. Neurobehavioural effects of developmental toxicity. *Lancet Neurol*. 2014;13(3):330-338.
^fButterfield PG. Upstream reflections on environmental health: An abbreviated history and framework for action. *Advances in Nursing Science*. 2002;25:34.

Children represent an especially vulnerable group with respect to exposure to hazardous materials, including pesticides and toxic chemicals. Their immune systems and detoxifying organs are still developing and are not fully capable of responding to environmental toxins.⁶ Children may be exposed more often than adults to toxic chemicals in the ambient outdoor air and in the soil because they spend more time outside.^{7,8}

Environmental Health and the Developing World

Residents of developing countries suffer far more from problems associated with environmental degradation than do those who live in developed countries; this observation holds true despite the fact that developed countries are highly industrialized and disseminate vast quantities of pollutants into the environment from industrial processes and motor vehicles. In comparison with developing countries, wealthy nations provide better access to medical care and are better able to finance pollution controls.

In the developing world, the pursuit of natural resources has caused widespread deforestation of tropical rain forests and destruction of wildlife habitat. Although these two issues have been the focus of much publicity, less widely publicized

environmental hazards such as water contamination, air pollution, unsanitary food, and crowding take a steep toll in both morbidity and mortality in developing countries.⁹

One region of the world that at present confronts serious environmental threats is Asia. Many of the countries in this region are experiencing declines in the amount of forest land, unintentional conversion of arable land to desert, and rising levels of pollution. In order to meet the demands of the rapidly increasing populations of South Asia, rural farmers clear forests and cultivate land that erodes easily and eventually becomes useless for agriculture.¹⁰ **Runoff** from the land contributes to water pollution. The world's most populous country, China, faces many challenging environmental problems including water shortages in the northwest; severe air pollution in major cities, such as Beijing; and increasing desertification.¹¹

Environmental Risk Transition

The term **environmental risk transition** has been used to characterize changes in environmental risks that happen as a consequence of economic development in the less-developed regions of the world. Environmental risk transition is characterized by the following circumstances:

In the poorest societies, household risks caused by poor food, air, and water quality tend to dominate. The major risks existing in developing countries today are of this type—diarrhea is attributable to poor water/sanitation/hygiene, acute respiratory diseases to poor housing and indoor air pollution from poor quality household fuels, and malaria to poor housing quality, although all are of course influenced by other factors as well (malnutrition in particular). . . . As these problems are brought under control, a new set tends to be created at the regional and global level through long-term and long-range pollutants, such as acid rain precursors, ozone-depleting chemicals, and greenhouse gases.^{12(p38)}

► Population and the Environment

Currently increasing at a geometric rate, the human population threatens to overwhelm available resources; some areas of the world face periodic food scarcity and famine. A number of factors have contributed to population growth, including increases in fertility and reductions in mortality. One of the consequences of population growth has been to encourage the conversion of large rural and forested areas of the earth into cities. Urbanization is linked to numerous adverse implications for the health of populations, including increasing rates of morbidity and mortality. Refer to the following text box, which discusses the consequences of continued population growth.

HOMO SAPIENS—A SUICIDAL SPECIES?

Largely as a result of human action, profound changes are occurring in our environment. . . . The basic cause of almost all of these problems is the world's large and growing human population, which consumes so much energy and produces such large quantities of toxic wastes. . . . Environmental changes, if accompanied by economic and political instability, could lead to the collapse of organized health services. In an era of scarcities of food, water, and other resources, and of a threat to survival, priorities should be reassessed.^{13(pp121,123)}

Population Growth Trends

The human population has grown exponentially over the past 200 years and reached 6 billion in June 1999.¹⁴ By 2017, this number reached 7.5 billion. The current trend is for world population growth to continue at a high rate, as noted in the following passage:

Every day we share the earth and its resources with 250,000 more people than the day before. Every year there are another 90 million mouths to feed. That is the equivalent of adding a city the size of Philadelphia to the world population every week; a Los Angeles every two weeks; a Mexico every year; and a United States and Canada every three years.^{15(p30)}

FIGURE 1.3 characterizes this burgeoning growth for a single year—2002. During that year the world population increased by $2\frac{1}{3}$ persons per second, or 141 persons per minute. This annual growth rate would be equivalent to a Boeing 737 jetliner carrying a new group of 141 passengers each minute.

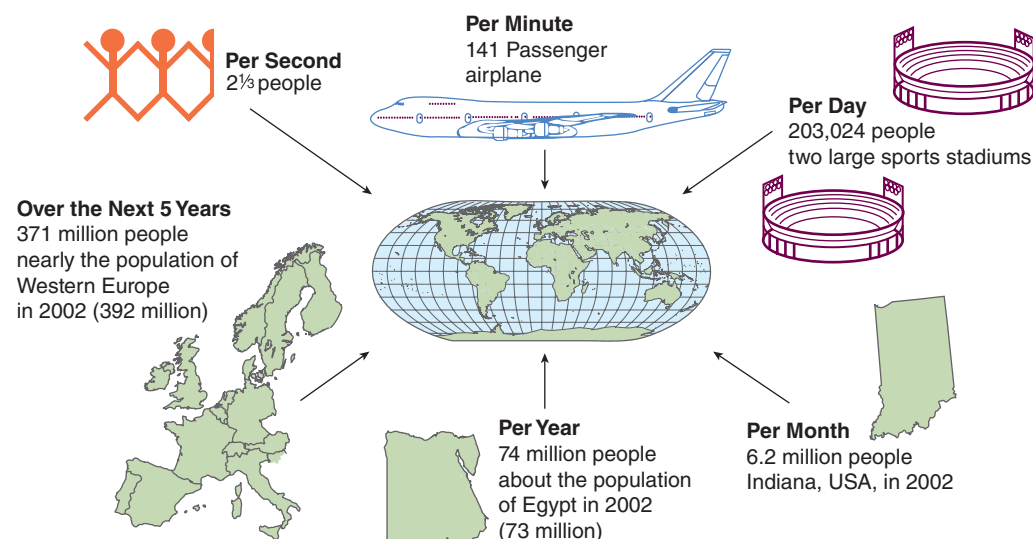


FIGURE 1.3 Net additions to the world: 2002. In 2002, the world gained $2\frac{1}{3}$ people per second.

Modified from US Census Bureau. International Population Reports WP/02. *Global Population Profile: 2002*. Washington, DC: US Government Printing Office; 2004:14.

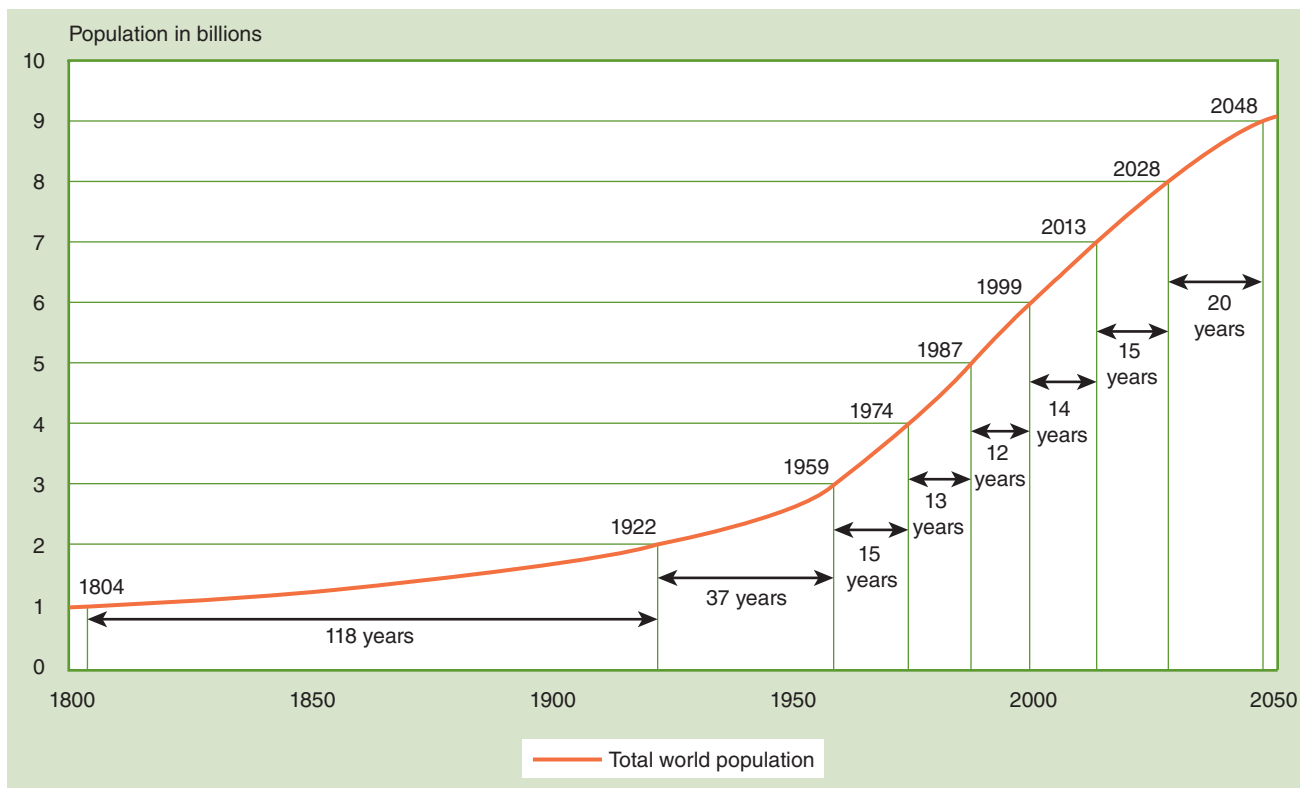


FIGURE 1.4 Time to successive billions in world population: 1800 to 2050.

Reproduced from US Census Bureau, International Population Reports WP/02. *Global Population Profile: 2002*. Washington, DC: US Government Printing Office; 2004:11.

From the origin of the species *Homo sapiens* (assumed to be about 250,000 years ago) to CE 1800, the population of the world grew by 1 billion individuals.¹⁶ From 1800 to 1922 (122 years), the population added another 1 billion persons. Since 1922, the population has increased at a phenomenal rate: Another billion persons were added after 37 years, 15 years, and 13 years, respectively. Only 12 years elapsed before an additional billion persons were added between 1987 and 1999. See **FIGURE 1.4**.

Another perspective on population growth is the time that it takes for the population to double. From 1931 to 1974 (a 43-year interval), the earth's population doubled; it is projected to double again during approximately the same interval (1974 to 2018).¹⁷ Estimates suggest that the world's population will reach 8 billion persons between the years 2018 and 2028.

In 1950, the world's five most populous countries were China, India, the United States, Russia, and Japan; at the turn of the 21st century, Russia and Japan were replaced by Indonesia and Brazil. In 2050, India will become the world's most populous country; China will fall to second place, the United States will remain in third place, Indonesia will be in fourth place, and Brazil will be replaced by Nigeria.

Around the 1960s, annual rates of population increase topped out at slightly more than 2% (an 81 million absolute increase annually since the 1980s).¹⁸ Demographers project that the human population eventually may

stabilize at a size—about 10 billion persons—that is about three quarters larger than it was around 2000.

Population Dynamics

The term **population dynamics** refers to the ever-changing interrelationships among the set of variables that influence the demographic makeup of populations as well as the variables that influence the growth and decline of population sizes. Among the factors that relate to the size as well as the age and sex composition of populations are fertility, death rates, and migration.

Fertility

One of the measures of fertility is the **completed fertility rate (total fertility rate)**, which is the "[n]umber of children a woman has given birth to when she completes childbearing."^{19(p2)} In the United States, the completed fertility rate in 2012 was around 2.0 children per woman;¹⁹ the natural population replacement rate is estimated to be around 2.1. (See the breaking news box about the decline in fertility).

During the baby boom era at the end of the 1950s, the US fertility rate exceeded 3.5 births per woman. Presently, western European countries have low fertility rates; also, the rates are declining in most regions of the developing world.²⁰ The United States, Canada, Japan, South Korea, Thailand, China, and many countries in

BREAKING NEWS:

"The US fertility rate fell [in 2016] to the lowest point since record keeping started more than a century ago, according to statistics released by the Centers for Disease Control and Prevention." (CNN, August 11, 2016). The general fertility rate (total number of births per 1,000 women aged 15–14) declined to 62.0 in the fourth quarter of 2016. In comparison, the general fertility rate was 118.0 in 1960.

Europe are at or below the replacement rate for fertility. Despite the declines in fertility rates in some Asian countries to levels approaching replacement rates, the

populations in these countries will continue to increase because of births among the large cohort of persons of childbearing age who were born when fertility rates were high. Those individuals form a substantial proportion of the population in China and other rapidly industrializing countries. However, the overall trend is for the world's population to age and be composed of increasing numbers of older individuals.

In comparison with the developed world, the fertility rates are considerably higher (at about 4.0 births per woman) in many Asian countries, Latin American countries, and African countries. In the future, their relatively higher fertility rates will enable these regions of the developing world to claim the largest population sizes. (See **FIGURE 1.5**.)

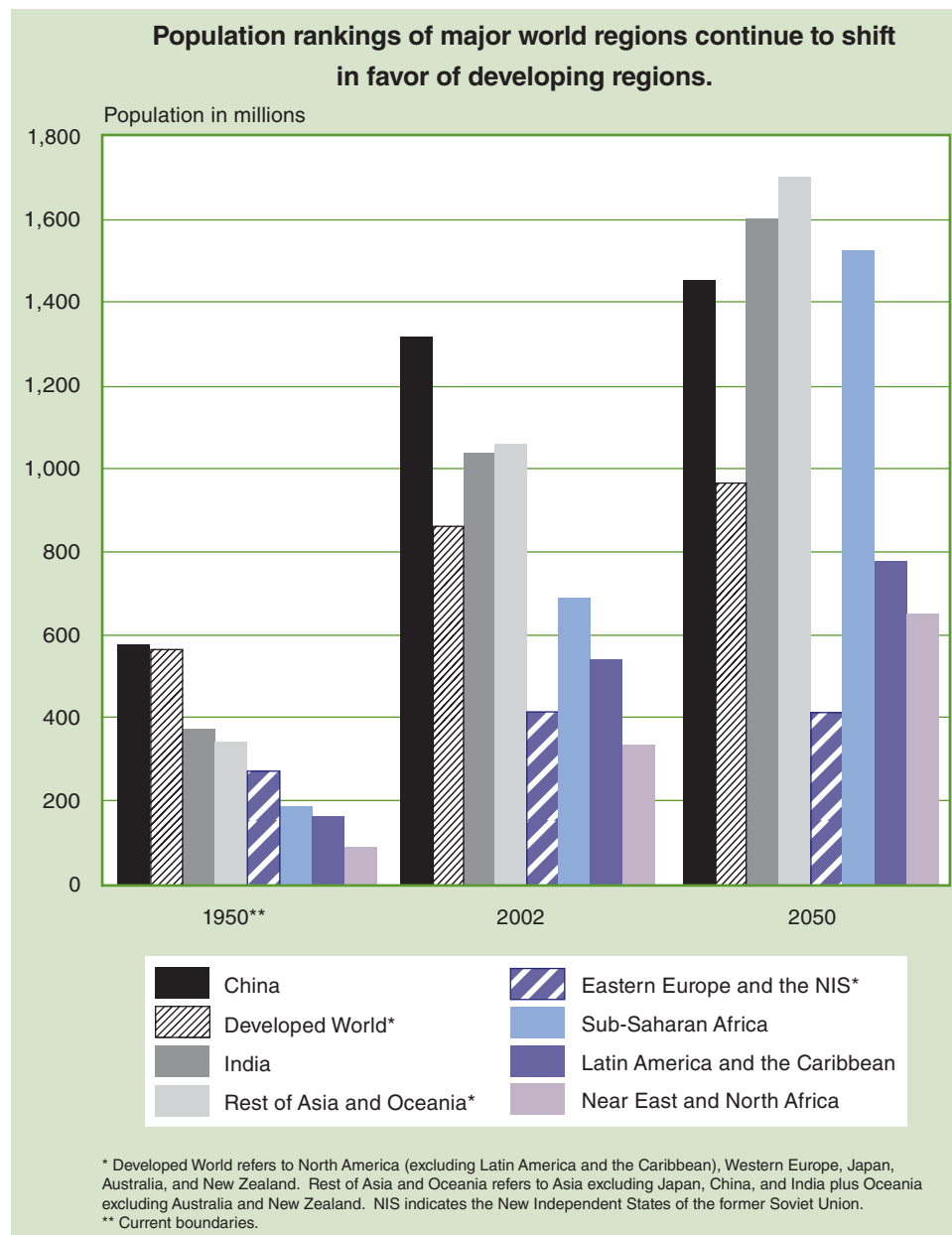


FIGURE 1.5 Regional distribution of global population: 1950, 2002, and 2050.

Reproduced from US Census Bureau. International Population Reports WP/02. *Global Population Profile: 2002*. Washington, DC: US Government Printing Office; 2004:12.

MORTALITY TERMS

Burden of disease is defined as “[t]he impact of disease in a population. An approach to the analysis of health problems, including loss of healthy years of life.” One measure of the burden of disease is disability-adjusted life years (DALYs).

Life expectancy (expectation of life) refers to “[t]he average number of years an individual is expected to live if current mortality rates continue to apply.” *Life expectancy at birth* is the “[a]verage number of years a newborn baby can be expected to live if current mortality trends continue.”

Disability-adjusted life years (DALYs) refer to “adjustment of life expectancy to allow for long-term disability as estimated from official statistics.” “A DALY lost is a measure of the burden of disease on a defined population.”

Porta M, ed. *A Dictionary of Epidemiology*. 6th ed. New York, NY: Oxford University Press; 2014.

Mortality

Mortality has declined markedly over time in both industrialized and less-developed countries. Adult mortality and infant and child mortality have demonstrated downward trends. Declining mortality in the developed world began approximately 200 years ago; in the developing world, substantial declines in mortality have occurred more recently during the past 50 years or so. The reduction in mortality has been accomplished through measures that have included public health improvements, famine control, and increased availability of drugs and vaccines. Some additional terms related to mortality are burden of disease, life expectancy, and disability-adjusted life years. (Refer to the text box.)

Migration

Migration has continued to feed global population growth; more than 1 billion of the world’s residents are migrants. Census estimates indicate that by the year 2050, the US population will grow by another 100 million and that about one-third of this growth will be from migration. Persons who migrate tend to cluster in a limited group of 10 countries. In 2015, the three leading countries for receiving international migrants were the United States, Germany, and the Russian Federation.²¹ Reasons for migration include the search for economic betterment; a large proportion of those who relocate are migrant workers. Forced migration (forcible displacement of persons) is a means of escaping from persecution for religious and political reasons and to obtain relief from unstable conditions in one’s home country. Toward the conclusion of 2015, more than 65 million persons were

displaced. Many were refugees from Syria, Afghanistan, and Somalia.²¹

Demographic Transition

Demographic transition is the alteration over time in a population’s fertility, mortality, and makeup.¹⁴ (Note that demographic transition theory does not include the effects of migration upon the age and sex composition of a population.) According to the demographic transition theory, developed societies have progressed through three stages that have affected their age and sex distributions.

The three phases can be demonstrated by hypothetical population pyramids, which are graphs that show the distribution of a population according to age and sex. Examples of the population pyramids at stages 1 through 3 are shown in **FIGURE 1.6**. Stage 1 characterizes a population at the first stage of demographic transition when most of the population is young and fertility and mortality rates are high; overall, the population remains small. Stage 2 shows a drop in mortality rates that occurs during the demographic transition; at this stage fertility rates remain high, and there is a rapid increase in population, particularly among the younger age groups. In comparison with the narrow triangular shape of the population distribution at stage 1, this population pyramid also is triangular in shape but has a wider base. Stage 3 reflects dropping fertility rates that cause a more even distribution of the population according to age and sex.

Epidemiologic Transition

The term **epidemiologic transition** is used to describe a shift in the pattern of morbidity and mortality from causes related primarily to infectious and communicable diseases to causes associated with chronic, degenerative diseases. The epidemiologic transition accompanies the demographic transition. The epidemiologic transition already has taken place in the populations of most developed countries (a process that required approximately one century) but has not occurred yet in many developing countries.

One reflection of the epidemiologic transition is the growing burden of chronic, degenerative diseases, especially in developed countries and to a lesser extent in developing countries, as a consequence of population aging. Chronic, degenerative diseases include cardiovascular diseases, cancer, neuropsychiatric conditions, and injuries; these conditions are becoming the major causes of disability and premature death in many nations. Nevertheless, in developing countries communicable and infectious diseases remain the leading causes of morbidity and mortality.

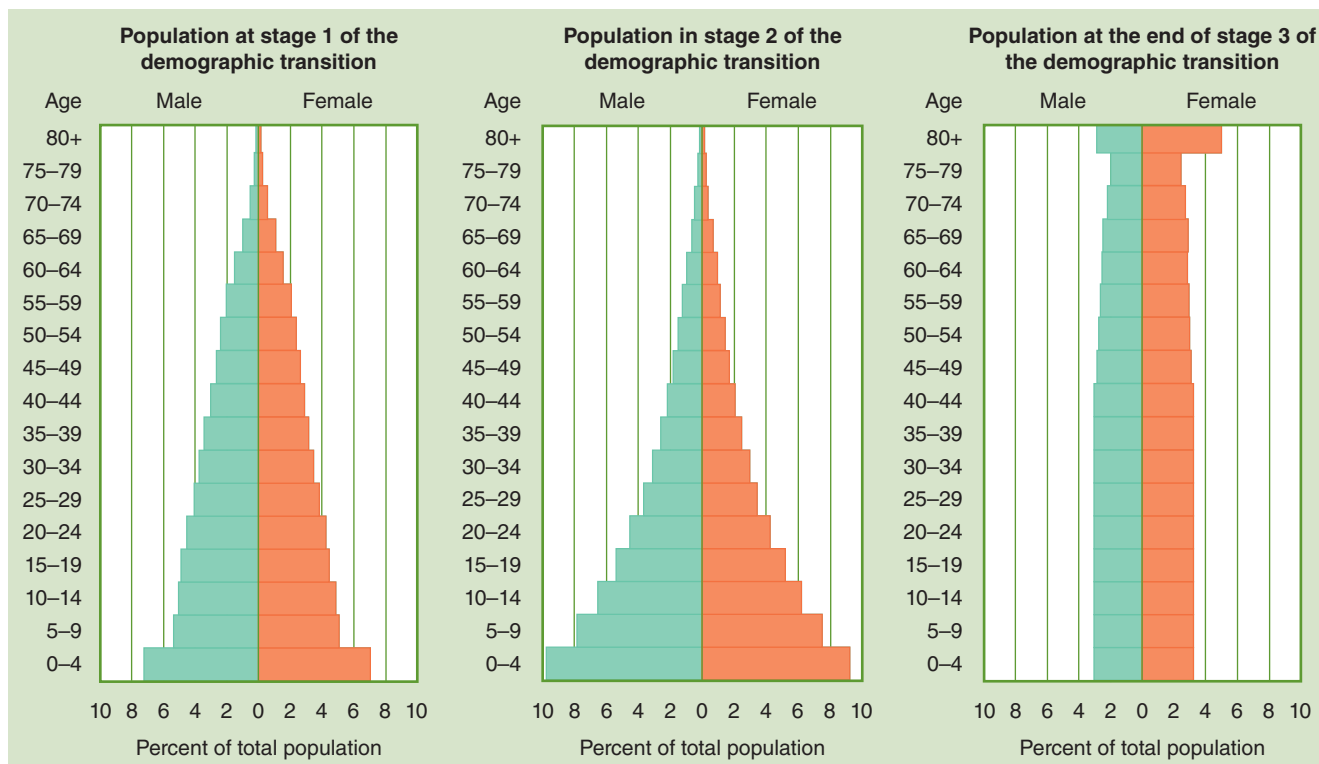


FIGURE 1.6 The demographic transition in three stages of age and sex composition: stage 1 (left), stage 2 (middle), and stage 3 (right). Reproduced from Kinsella K, He W. US Census Bureau. International Population Reports P95/09-1. *An Aging World: 2008*. Washington, DC: US Government Printing Office; 2009:20.

Consequences of Population Increases

Rapid growth of the world's population contributes to the deterioration of the environment through widespread depletion of natural resources and by causing the levels of air, water, and other forms of pollution to increase. Also, the resources available per person decrease as the total number of individuals on the planet continues to increase geometrically. Consequently, population growth is a determinant of the number of persons who live in poverty. In already crowded regions, an even larger population means that the size of most people's living spaces must decline and population density must increase. Population density and associated urban crowding are dimensions of environmental degradation associated with increases in the spread of infectious and communicable diseases.

Unless significant technological innovations can be introduced, merely feeding the world's hungry population will become problematic. Many developing countries, where population growth rates are among the highest in the world, are reaching the limit of their abilities to provide for the economic and social needs of their citizens. The United Nations Secretariat states that:

...excessive population pressure in specific geographical areas can pose serious ecological hazards, including soil erosion, desertification, dwindling supplies of firewood, deforestation

and the degradation of sources of fresh water. Often the link between population pressure and those types of environmental stress is the growth in the relative and absolute number of persons living in poverty. The result is marginalization of small-scale farmers and pressure on larger numbers to migrate from distressed areas. In many cases the result is also the prevalence of environmentally related diseases.^{22(p32)}

The effects of rapid growth of the world's population include:

- Urbanization
- Overtaxing carrying capacity (defined later in this chapter)
- Food insecurity
- Loss of biodiversity

Urbanization and the Environment

The past two centuries have seen a rapid increase in the number of cities over the entire globe.²³ The proportion of urban residents has increased from about 5% in 1800 to 50% in 2000 and is expected to reach about 66% by 2030.²² **FIGURE 1.7** illustrates the growth of the world's urban population between 1975 and 2015 for low- and middle-income countries in comparison with high-income countries. Although the

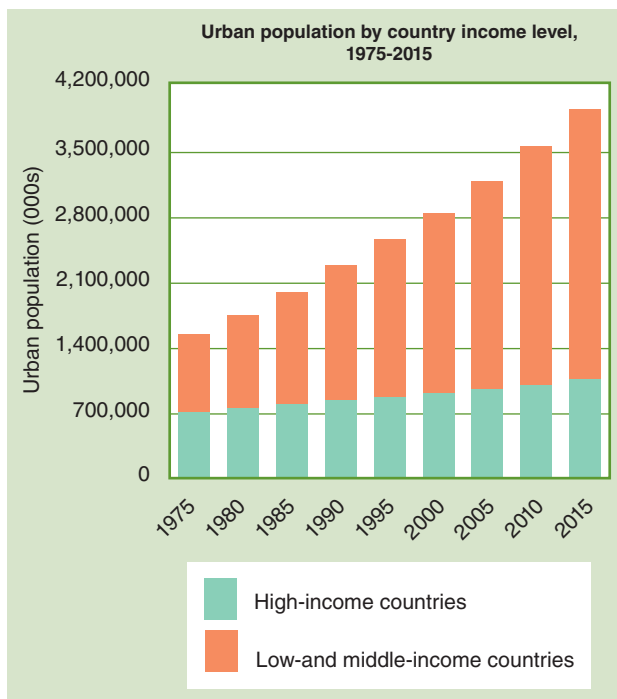


FIGURE 1.7 Urban population by country income level, 1975-2015 (1.84% total annual urban population growth between 2015 and 2020).

Reproduced from World Health Organization. *Urban population growth*. Available at: http://who.int/gho/urban_health/situation_trends/urban_population_growth/en/index1.html. Accessed July 2, 2017.

proportion of urban residents has increased in both categories, a relatively larger growth in the number of urban residents is projected to occur among low-income countries. This trend is apparent in the figure and is forecast to continue into the future. On average, the total urban population will grow by 1.84% annually between 2015 and 2020. (See Figure 1.7.)

The factors that lead to urbanization include industrialization, availability of food, employment opportunities, lifestyle considerations, and escape from political conflict.²³ Tied to increases in urbanization are numerous adverse health impacts, particularly in developing countries. Among the most important causes of morbidity and early death in urban environments of developing countries are environmentally related diseases and accidents.²⁴ According to McMichael:

Large cities in the least developed countries typically combine the traditional environmental health problems of poverty, particularly respiratory and enteric infections, with those of poor quality housing and unregulated industrialization. Residents therefore are often at **risk** from diseases and injuries associated with poor sanitation, unsafe drinking water, dangerous roads, polluted air, indoor air pollution and toxic wastes.^{23(p1119)}

The following text box lists hazards associated with the urban environment.

Megacities

The term **megacity** denotes an urbanized area that has 10 million or more inhabitants; in 2016, there were 31 megacities that contained slightly more than 6.8% of the world's population.²⁵ Examples of megacities and their respective 2016 populations (in millions) are Tokyo (38.1), Shanghai (24.5), Mumbai (formerly known as Bombay; 21.4), Sao Paulo (21.3), and Mexico City (21.2). The two megacities in the United States are New York (18.6) and Los Angeles (12.3).

HAZARDS TO HEALTH WITHIN THE URBAN ENVIRONMENT

1. Biological pathogens or pollutants within the human environment that impair human health—including pathogenic agents and their vectors (and reservoirs); for instance, the many pathogenic microorganisms in human excreta, airborne pathogens (for instance, those responsible for acute respiratory infections and tuberculosis), and disease vectors such as malaria-carrying (*Anopheline*) mosquitoes
2. Chemical pollutants within the human environment, including those added to the environment by human activities (e.g., industrial wastes) and chemical agents present in the environment independent of human activities
3. The availability, cost, and quality of natural resources on which human health depends—for instance, food, water, and fuel
4. Physical hazards (e.g., high risks of flooding in houses and settlements built on floodplains or of mud slides or landslides for houses on slopes)
5. Aspects of the built environment with negative consequences on physical or psychosocial health (e.g., overcrowding, inadequate protection against noise, inadequate provision of infrastructure, services, and common areas)
6. Natural resource degradation (e.g., of soil and water quality) caused by wastes from city-based producers or consumers that impacts on the health/livelihoods of some urban dwellers
7. National/global environmental degradation with more indirect but long-term influences on human health

Modified and reproduced with permission from Satterthwaite D. The impact on health of urban environments. *Environ Urban*. 1993;5:88.



FIGURE 1.8 Street scene in a crowded megacity (Mexico City).

Megacities have major influences upon the environment in a number of ways (e.g., demands for energy, potable water, construction materials, food, sewage processing, and solid waste disposal). **FIGURE 1.8** shows street life in a crowded megacity.

Carrying Capacity

Carrying capacity is “[t]he maximum number of individuals that can be supported sustainably by a given environment.”²⁶ Both human and nonhuman populations may be threatened with disastrous consequences when available resources are exhausted. “Like a bacterial colony in a culture medium, we are susceptible to depletion of nutrients and to poisoning by our own waste products.”^{15(p123)}

Animal Populations

In the animal kingdom, the carrying capacity of an environment governs population size. In nature, the factors of food availability, reproductive behavior, and infectious diseases tend to keep animal populations in check. An example of an animal population kept in check by food availability follows: The U.S. Coast Guard shipped 29 reindeer to St. Matthew Island in the Bering Sea during the World War II era.²⁶ The deer were intended as a source of meat for personnel on the island; however, no deer were ever culled and all 29 remained when the war ended. An abundance of deer fodder was available on the island. By the early 1960s, the original deer population had swelled to 6,000 animals. Soon afterward, as a result of overgrazing and depletion of food sources for the deer, the population—having declined to fewer than 50 animals in 1966—faced extinction.

In a given area, the growth of animal populations appears to be sequenced according to the following characteristic patterns:

“Logistic growth, responding to immediate negative feedback, as carrying capacity is approached

Domed or capped growth, responding to deferred negative feedback but necessitating a period of excess mortality

Irruptive growth, with a chaotic post-crash pattern.”^{18(p978)}

Human Populations

The factors that lead to the crash of animal populations are similar to those that could threaten the survival of the human race. Human life is not possible without adequate food, breathable air, and safe water. Agricultural land must continue to be arable. There needs to be a diversity of plant and animal species. If these components of the human life support system are disrupted by overpopulation of the planet, the species *Homo sapiens* could suffer a population crash. This outcome would be in line with Malthusian predictions.

In 1798, Thomas Malthus authored *First Essay on Population*, which theorized that the human population had the potential to grow exponentially.¹⁶ According to this scenario, the population could outstrip available resources. Malthus suggested that “positive checks” for excessive population growth rates were epidemics of disease, starvation, and population reduction through warfare. The growth of the population could be constrained also through “preventive checks” such as not allowing people to marry.

Endangerment of the human population through ecological damage is not far fetched: Previous history has recorded incidents of decimation and collapse of civilizations that were associated with disruption of the environment. It is believed that approximately 5,000 years ago, Mesopotamia, a renowned ancient civilization, declined as a result of agricultural practices that caused soil erosion, buildup of salt in the soil, and the filling of irrigation channels with silt.²⁷ During medieval times, crowded cities of Europe were devastated by plague and other infectious diseases. In the interval between the 13th and 16th centuries, global temperatures declined by approximately 1°C (1.8°F), contributing to the decimation of societies that were located in the far north (e.g., Viking settlements in Greenland).

Food Insecurity and Famine

The term **food insecurity** refers to a situation in which supplies of wholesome foods are uncertain or may have limited availability. Food insecurity and famine may occur when the carrying capacity in a

particular geographic area is exceeded. An illustration of the effect of exceeding the carrying capacity in a local geographic area is the occurrence of a local subsistence crisis, which follows when the ability of land and available water to produce food are overtaxed.¹⁸ In theory, low nutritional levels that accompany local subsistence crises may cause population mortality to increase so that mortality is brought into balance with fertility, stabilizing the population size. Periodically, food insecurity is a reality in some developing regions. For example, food insecurity endangers as much as one-third of Africa, and the prognosis for increasing the food supply in some African countries is poor.²⁷

Loss of Biodiversity

The word *biodiversity* is formed from the combination of *biological* and *diversity*. An adequate definition of biodiversity is not readily available. Nevertheless, the term **biodiversity** generally refers to the different types and variability of animal and plant species and ecosystems in which they live.²⁸ With respect to a particular geographic area, biodiversity involves diversity in the genes of a population of a given species, diversity in the number of species, and diversity in habitats. Biodiversity is considered to be an essential dimension of human health.²⁹

The dramatic human population growth during the past few decades and concomitant increases in urbanization and industrialization have caused the physical environment to be degraded substantially; one of the consequences of unchecked population growth is hypothesized to be accelerated loss of biodiversity. Human activities are thought to be related to the spread of harmful insect vectors, extinctions of species, and loss of flora; some of these plants and trees could be the source of valuable commodities such as new pharmaceuticals. Ultimately, loss of biodiversity may pose a danger to food production as a result of the growth in numbers of invasive species and the eradication of helpful plants and insects. An example of the loss of biodiversity is the destruction of tropical rain forests that has culminated in the extinction of some flowering plants that may have had future medical value.²⁹

► Definitions Used in the Environmental Health Field

The Environment

The term **environment** refers to “the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an

ecological community and ultimately determine its form and survival.”³⁰ This definition pertains to the physical environment. Examples of physical environmental factors (as noted previously) that affect human health include toxic chemicals, metallic compounds, ionizing and nonionizing radiation, and physical and mechanical energy. These factors will be discussed in more detail later in the text.

The term *environment* captures the notion of factors that are external to the individual, as opposed to internal factors such as genetic makeup. In contrast to the physical environment, described in the foregoing definition, the **social environment** encompasses influences upon the individual that arise from societal and cultural factors. Among the major determinants of health are the environment (physical and social), personal lifestyle factors, constitutional factors such as heredity and human biology, and healthcare systems dimensions such as access to and quality of medical care and methods for organization of healthcare systems.³¹ A model that describes these aspects of health is the **ecological model**, which proposes that the determinants of health (environmental, biological, and behavioral) interact and are interlinked over the life course of individuals. (Refer to **FIGURE 1.9**.) From the model it may be inferred that the environment is one component of many interacting dimensions that affect the health of populations.

Ecological System (Ecosystem)

Ecosystems are one of the important dimensions of life in the biosphere. All life on earth survives in the biosphere, which consists of the atmosphere and the earth's surface and oceans. The biosphere covers a narrow range from about 6 miles (9.6 kilometers) above the earth to the surface of the earth to the deepest ocean trenches, some of which are 36,000 feet deep (about 11,000 meters). One of the crucial aspects of the earth's biosphere is energy flow; the ultimate source of energy for all living beings on earth is the sun. Energy flows from the sun in the form of electromagnetic radiation (e.g., ultraviolet radiation, infrared radiation, and visible light). Only a small percentage of the energy produced by the sun impinges upon the earth. Plants absorb some portions of the sun's electromagnetic radiation and convert them into nutrients and oxygen via the process known as photosynthesis. This energy is then transferred to other life forms through the food chain, for example, via herbivores that eat the plants themselves or carnivores that eat other animals.

“An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional

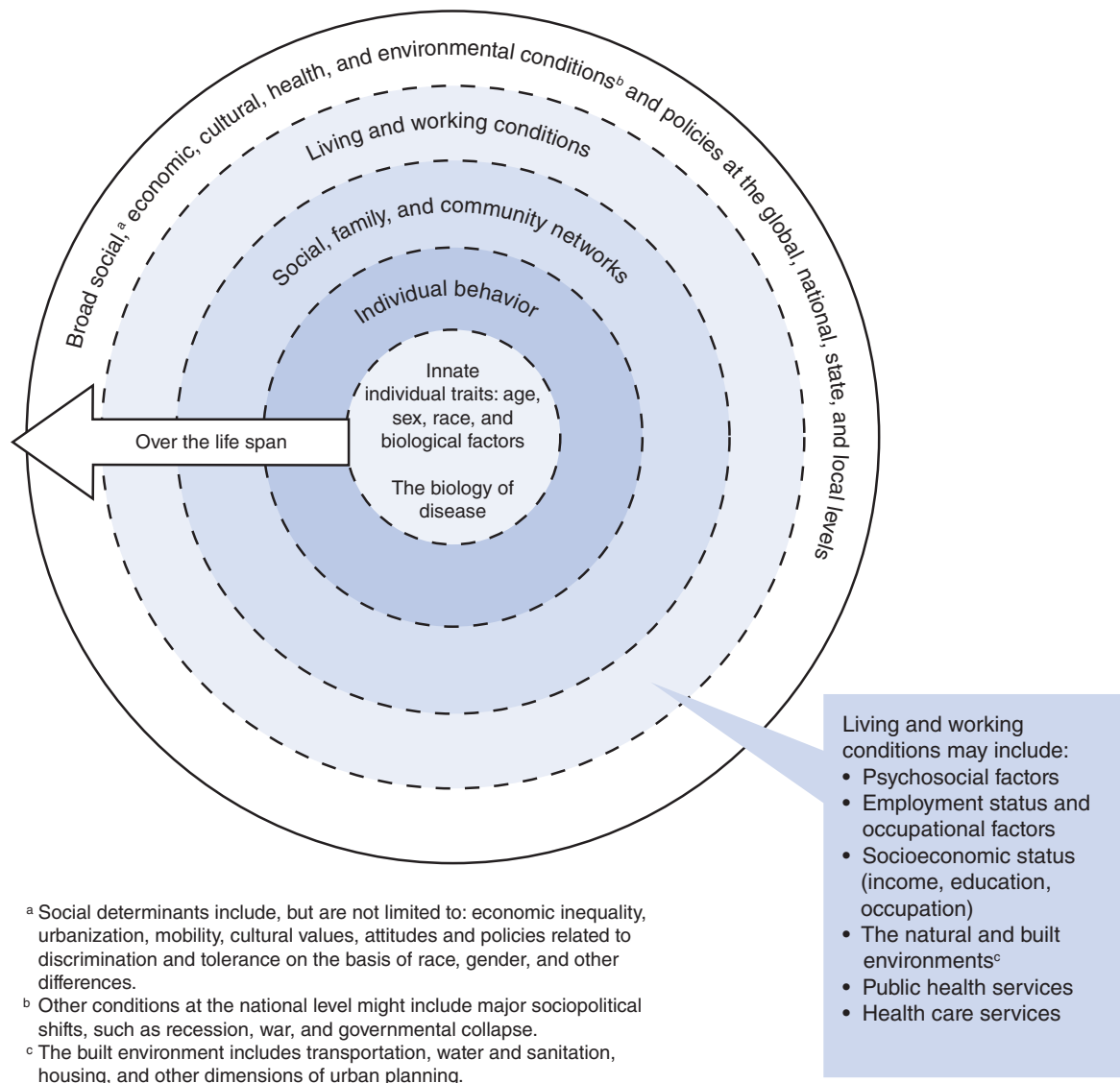


FIGURE 1.9 The ecological model of population health.

Modified and reproduced with permission from *Who Will Keep the Public Healthy? Educating Public Health Professionals for the 21st Century*, © 2003 by the National Academy of Sciences, courtesy of the National Academies Press, Washington, D.C., p. 33; and from Dahlgren G, Whitehead M. *Policies and Strategies to Promote Social Equity in Health*. Stockholm, Sweden: Institute for Futures Studies; 1991.

unit. Humans are an integral part of ecosystems. Ecosystems vary enormously in size: a temporary pond in a tree hollow and an ocean basin can both be ecosystems.^{32(p3)} The interconnected components of an **ecosystem** are in a steady state; disrupting one of the components can disrupt the entire ecosystem. **FIGURE 1.10** suggests that the health of the ecosystem is associated with the health of human beings as well as that of domestic animals and wildlife.

Survival of the human population depends upon ecosystems, which aid in supplying clean air and water as part of the earth's life support system.³³ Ecosystems are being degraded with increasing rapidity because of human environmental impacts such as urbanization and deforestation. Degradation of ecosystems poses environmental dangers such as loss of the oxygen-producing capacity of plants and loss of biodiversity.

Environmental Health

The field of **environmental health** has a broad focus and includes a number of subspecializations. For example, occupational health often is regarded as a topic that is closely allied with environmental health and is a subset of broader environmental health concerns. Consequently, in view of its broad reach, the term *environmental health* does not have a single definition, nor is it easy to define. According to the World Health Organization:

Environmental health addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviours. It encompasses the assessment and control of those environmental factors that can potentially affect health. It is targeted towards preventing disease and creating health-supportive environments.³⁴

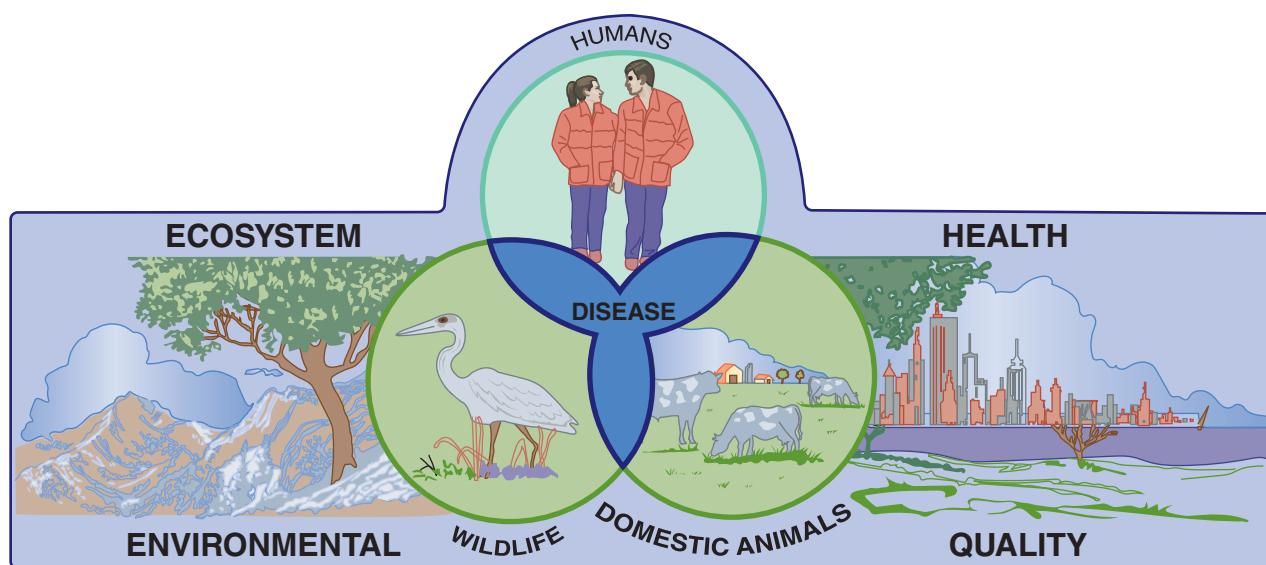


FIGURE 1.10 Ecosystem health.

Reproduced from Friend M. *Disease Emergence and Reemergence. The Wildlife-Human Connection*. Reston, VA: US Geological Survey, Circular 1285, p. 131. Illustration by John M. Evans.

► Historical Background

This section presents a brief review of environmental health history, categorized as follows: ancient history, occupational health (contributions from about 1500 to the mid-1800s), and environmental history post-1800. **FIGURE 1.11** summarizes some of the highlights in environmental health history.

Ancient History

Negative human impacts on the environment are thought to have begun many thousands of years ago. One of the initial targets of human activity was forests, which were cut down for use as timber and burned to clear land for agriculture and human settlements. Deforestation subsequently led to soil erosion that caused rivers and bays to be fouled with silt.

The observations, insights, and writings of the ancient Greeks are noteworthy for the history of environmental health.³⁵ Around the 5th century BCE, the ancient Greek philosophers had developed the concept of the relationship between environmental factors and human health; instead of advocating for the workings of supernatural factors and the belief that magic potions would have curative powers, their philosophical position linked the influence of environment to disease.

Hippocrates, who lived between 460 and 370 BCE, often is referred to as “the father of medicine.” (See **FIGURE 1.12**.) Hippocrates emphasized the role of the environment as an influence on people’s health and health status in his work titled *On Airs, Waters,*

and Places (ca 400 BCE). The Greek philosopher proposed that environmental and climatic factors such as the weather, seasons, and prevailing winds; the quality of air, water, and food; and one’s geographic location were influential in causing changes in human health. He espoused the doctrine of maintaining equilibrium among the body’s four humors, known as yellow bile, black bile, phlegm, and blood; imbalance among the four humors caused by environmental influences led to the onset of infectious diseases.

Many of the principles identified by Hippocrates regarding the impact of the environment on human health and disease remain credible despite the great increases in medical knowledge that have occurred since Hippocrates’ time.³⁵ For example, now it is known that polluted water is associated with many types of waterborne infections (e.g., cholera and cryptosporidiosis [discussed later in this text]). Consistent with the belief that air is a factor in diseases is the origin of the term *malaria* (bad air), a disease that is carried by airborne mosquitoes that dwell in standing pools of water.

For many years, people have known about the harmful effects of heavy metals.³⁶ Hippocrates identified the toxic properties of lead.³⁷ The toxic properties of sulfur and zinc were pointed out by the Roman scholar Pliny the Elder (CE 29–79) during the 1st century CE; Pliny invented a mask constructed from the bladder of an animal for protection against dusts and metal fumes. During the 2nd century CE, the renowned Greek physician Galen (CE 129–200) outlined the pathological aspects of lead toxicity and

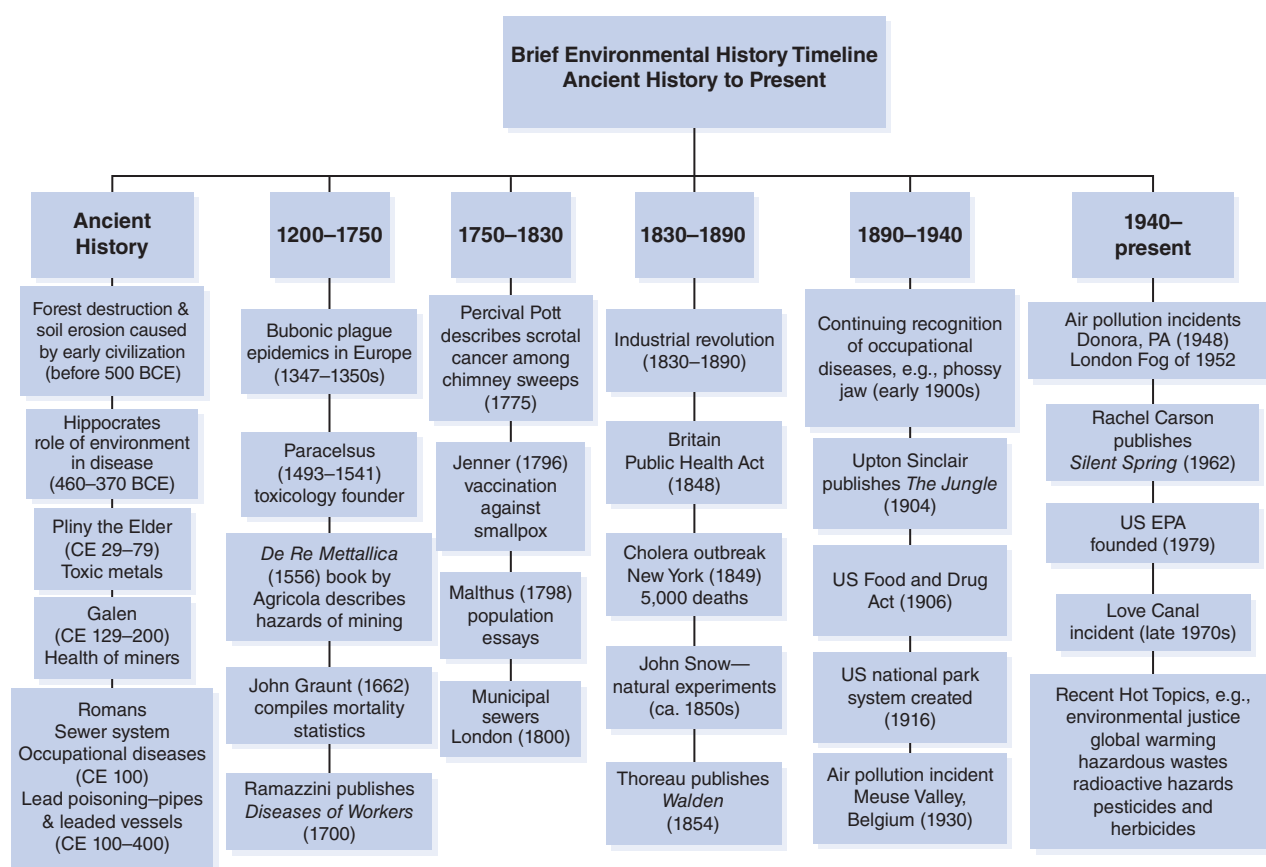


FIGURE 1.11 Brief environmental history time line: ancient history to the present.

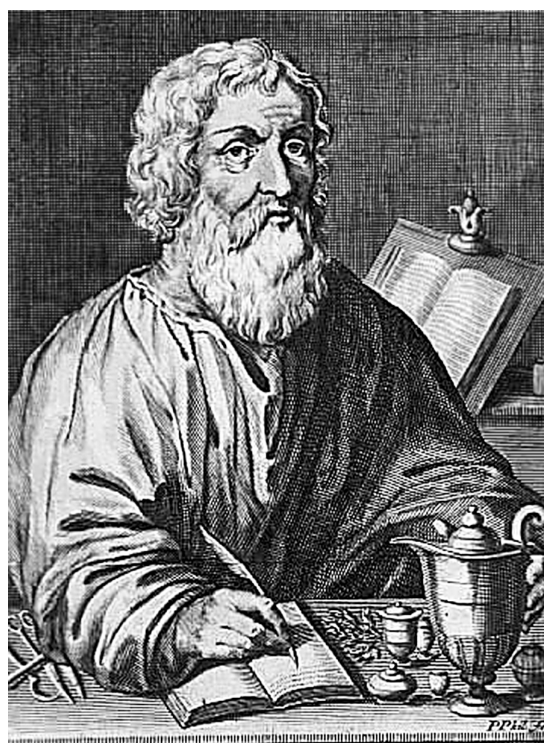


FIGURE 1.12 Hippocrates.

Courtesy of US National Library of Medicine, National Institutes of Health. History of medicine division. Available at: <http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B014553>. Accessed July 1, 2017.

suggested that mists from acids could endanger the health of copper miners.³⁷

The ancient Romans developed the first infrastructure for maintaining public health. Among their innovations were systems for the transport of water and sewage, heating devices for water and for rooms, and communal baths.^{38,39} Beginning about 500 BCE, the Etruscans constructed a sewer called the Cloaca Maxima in Rome. As the city grew, a system of aqueducts that supplied fresh water and a web of sewers called cloacae were installed.

The Romans brought many of these innovations to their settlements all over Europe. Roman aqueducts and baths can be seen today in many parts of Europe. An example of the Roman baths at Baden-Baden, Germany is shown in **FIGURE 1.13**. The Romans used lead pipes to supply the homes of the affluent, who probably suffered from chronic lead poisoning. After the decline of their empire (possibly due, in part, to chronic lead poisoning), many of the hygiene-related contributions of the Romans were forgotten; for several centuries, the European world endured the abhorrent sanitary conditions of the medieval era, with its periodic outbreaks of epidemics of plague, cholera, and other pestilence.



FIGURE 1.13 Roman baths at Baden-Baden, Germany.

Occupational Health (Contributions from About 1500 to the Mid-1800s)

The field of occupational health has made numerous contributions to environmental health history. From about 1500 to the mid-1800s, recognition grew regarding the contribution of occupationally related exposures to adverse health conditions. There are many examples of explorations of the impacts of unsafe and hazardous working environments on the health of workers, especially the effects of exposures to toxic metals and hazards that occurred among miners. Among the historically important figures in occupational health were Paracelsus (1493–1541), Agricola (1494–1555), Bernardino Ramazzini (1633–1714), Percival Pott (1714–1788), and Alice Hamilton (1869–1970). See the chapter on environmental toxicology for information on Paracelsus, the chapter on environmental epidemiology for information about Percival Pott, and the chapter on occupational health for a discussion of Agricola, Ramazzini, and Hamilton; the chapter on occupational health also provides information on other historically important individuals in the field of occupational health.

Although his contributions were not limited specifically to occupational health, John Graunt (one of the early compilers of vital statistics data) published *Natural and Political Observations Made upon the Bills of Mortality* in 1662. Sometimes Graunt is referred to as the Columbus of statistics because his book made a fundamental contribution by attempting to demonstrate the quantitative characteristics of birth and death data.

Environmental History Post-1800

Just before the commencement of the 1800s, Jenner (in 1796) devised a method for vaccinating against smallpox; in 1798, Malthus wrote his well-known essays on population, mentioned earlier in this chapter. The

history of environmental health since 1800 may be classified into three major eras:⁴⁰ the first wave of environmental concern (19th century to mid-20th century), the second wave of environmental awareness (mid-20th century to the 1980s), and the third period of environmental concern (1980s to the present).

The period of approximately 1850 to 1950 was marked by growing awareness of existing threats to public health from unsanitary conditions, detrimental social conditions, and hazardous work environments. For example, a common employment practice in Europe was the use of child labor. This era coincided approximately with the Industrial Revolution and marked the introduction of public health reforms to improve environmental conditions. In 1800, construction began on sewers that served the city of London. The British Parliament enacted the Public Health Act in 1848 to promote clean water and control infectious diseases. There were major outbreaks of cholera, including an outbreak in New York City in 1849 that killed 5,000 people.

About the same time, John Snow hypothesized that sewage-contaminated water was associated with cholera and conducted a “natural experiment” to demonstrate the cause of an outbreak in the present Soho district of London. John Snow (1813–1858) was an English anesthesiologist who innovated several of the key epidemiologic methods that remain valid and in use today. In Snow’s time, the mechanism for the causation of infectious diseases was largely unknown. The Dutchman Anton van Leeuwenhoek (1632–1723) had used the microscope to observe microorganisms (bacteria and yeast). However, the connection between microorganisms and disease had not yet been ascertained. During Snow’s time, one of the explanations for infectious diseases such as cholera was the miasmatic theory of disease, which alleged that illnesses were caused by clouds of noxious matter. Snow rejected the miasmatic theory and showed the connection between polluted water and cholera. Because of his pioneering work, Snow is regarded as an icon in the history of public health and continues to be influential during the 21st century. (More information about Snow’s work is provided in the chapter on environmental epidemiology.)

In the United States, Lemuel Shattuck published the 1850 *Report on the Sanitary Conditions of Massachusetts*. Shattuck argued for the creation of a state health department and local health boards. Among other issues, Shattuck’s report dealt in detail with the topic of environmental sanitation and its connection with health. Although not implemented by the state legislature at the time, Shattuck’s proposed recommendations were extremely farsighted and innovative and became a major influence in the development of subsequent public health practice. Ultimately, years later,

many of Shattuck's proposals were adopted by public health departments and are in use today.

Several additional developments marked the late 19th century and early 20th century. Henry David Thoreau published *Walden* in 1854; this book extolled the virtues of a simple life in a beautiful natural environment. Thoreau suggested that nature enriched the lives of human beings and therefore should be respected.

Beginning in 1900, Walter Reed, who was a US Army medical officer, investigated the causes of yellow fever, which was a scourge of US troops in the Caribbean. He showed that yellow fever was a mosquito-borne affliction. Following this discovery, Major William Gorgas was dispatched to Havana, Cuba, where he implemented a highly successful mosquito eradication program. This action led to a drastic reduction in yellow fever cases in Havana; later Gorgas conducted a mosquito control program in the Panama Canal Zone, making possible the construction of the canal.

In *The Jungle* (1906), Upton Sinclair described the deplorable conditions in the meat processing industry in Chicago. Sinclair's exposé was instrumental in passage of the first Food and Drug Act that was instituted in the United States in 1906. (Some of the US laws regarding food safety are described in the chapter on food safety.) One other development that reflected the public's concern for the environment was creation of the US National Park System in 1916.

During the second wave of environmental concern, defined approximately from the middle of the 1950s to the 1980s, environmental issues continued to come to the forefront. The period witnessed the occurrence of several noteworthy air pollution incidents, including the fatal 1930 incident in the Meuse Valley, Belgium; an air pollution episode that caused numerous deaths in Donora, Pennsylvania, in 1948; and the deadly London fog of 1952.⁴¹ (More information on these incidents is presented in the chapter on air quality.)

Awareness increased regarding the potential health hazards of toxic chemicals. In the United States, efforts were made to protect ecologically sensitive areas from toxic hazards and from overdevelopment. Additional legislation in the United States modified food and drug laws designed to regulate toxins and the use of additives in food. Rachel Carson published *Silent Spring* in 1962, which highlighted the potential dangers of pesticides. In 1970, the Environmental Protection Agency (EPA) was founded to address environmental concerns at the federal government level (more information on this topic is presented in the chapter on environmental policy and regulation).

The topic of toxic waste disposal also was the focus of much attention during the 1970s. For example, when residents discovered that their homes had been constructed on a former toxic waste site referred to as the Love Canal, they became alarmed about possible adverse health effects that might be linked to the waste site. Love Canal became a cause célèbre for environmental activists. (This topic is covered in more detail in the chapter on solid and liquid waste.)

The most recent period in environmental history (the third wave of environmental concern—1980s to the present) has been marked by high population growth rates, industrialization, and urbanization. Specific concerns have continued regarding the effects of toxic chemicals in the environment.

A new topic has been the emission of greenhouse gases and their possible contribution to global warming.

TABLE 1.3 presents a compilation of some of the contemporary issues that are relevant to environmental health. Although this list is not exhaustive, it identifies several of the major “hot topics” in the environmental health field.

The topics shown in Table 1.3 will be covered in this text. However, let us select four of the issues—global climate change, pesticides and herbicides, air quality, and war and terrorism—and consider them briefly. For example, one issue that commands our attention (and that has generated extensive coverage in the media) is the prospect of global climate change including global warming (and production of greenhouse gases). Refer back to Exhibit 1.1. Among the outcomes believed to be associated with global warming are changes in the distribution of insect vectors that can carry diseases such as malaria and the West Nile virus. Elsewhere in this text, in the chapter on air quality, global warming—its hypothesized causes, extent, and effects—will be considered in more detail.

The impact of toxic pesticides and toxic chemicals is a major issue for environmental health. For example, toxic materials have been introduced into the drinking water supplies of some communities. In November 2005, an explosion at a factory in northeastern China caused about 100 tons (about 91 metric tons) of benzene and other hazardous chemicals to be released into the Songhua River. This incident led Chinese officials to shut off the water taps in Harbin because of potential contamination of the water supply in that city. A noteworthy incident in the United States was contamination of municipal water in Flint, Michigan in 2015, when the EPA detected lead contamination in the water used by households there. The events in China and Michigan, as well as many other similar occurrences in which toxic chemicals

TABLE 1.3 Examples of Hot Topics in Environmental Health	
Air quality	Nuclear power
Conservation	Oceans
Endangered species/Wildlife impacts	Pesticides and herbicides
Energy resources	Pollution
Environmental justice	Radioactive waste
Environmental protection	Recycling
Forests	Solid waste
Global warming/Global climate change	War and terrorism
Greenhouse gases	Water resources
Hazardous wastes	Wetlands
Land use	

Partial data from LexisNexis, Environment issues. Copyright 2002, LexisNexis, a division of Reed Elsevier Inc. All Rights Reserved.

have intruded into the public water supply, raise the issue of what can be done to prevent and abate such hazards.

A related issue concerns the runoff of rainwater that overtaxes sewage processing facilities and results in pollution of public beaches and groundwater. Carelessly discarded solvents and other toxic chemicals pose dangers to aquifers; the author will provide more information on toxic pesticides and toxic chemicals in the chapter on pesticides and other organic chemicals.

Still another issue is the impact of air quality on human health, including the role of air pollution in causing cancer and lung diseases as well as aggravating chronic conditions such as heart disease. Some regions face a continuing and growing threat to the environment from air pollution. Several US cities, such as those located in the Los Angeles basin of southern California, face occasional episodes of significant air pollution. Fortunately, air quality has shown improvement in southern California and elsewhere in the United States during the past few decades. In contrast, many cities in the rapidly industrializing nations of the developing world are experiencing declines in air quality due to the increasing use of fossil fuels.

Finally, war and terrorism can have devastating impacts upon the environment. Some of these potential impacts include the destruction of fauna and flora,

exposure of the population to hazardous radiation from spent munitions, and water pollution caused by the manufacture of nuclear weapons. (Refer to the chapter on ionizing and nonionizing radiation.) Recently, health officials and the public have been concerned about threats to the environment from the intentional release of infectious biological agents such as the agent that causes anthrax. (Refer to the chapter on zoonotic and vector-borne diseases.)

Careers in the Environmental Health Field

The field of environmental health provides numerous career roles and possible occupations. Private industry, government units, universities, and private research organizations employ environmental health workers in diverse functions. **TABLE 1.4** gives a detailed, although not exhaustive, list of occupations that have a connection with environmental health. Following is a description of some of these occupations.

Hygienist

In the work environment, professional industrial hygienists are responsible for control of hazards that

TABLE 1.4 Professions Involved in Environmental Health

Academics, lecturers, teachers, teacher trainers	Ergonomists
Agriculturists	Fire safety officers
Agronomists	Food inspectors
Architects	Food safety specialists
Bacteriologists	Geneticists
Biochemists	Geographers
Chemical process engineers	Geologists
Civil engineers	Health promotion experts
Climatologists	Hydrogeologists
Communications experts	Hydrologists
Disaster preparedness specialists	Hygienists
Ecologists	Information scientists
Economists	Laboratory assistants/technicians
Engineering specialists (with postgraduate qualifications)	Marine scientists
Entomologists	Materials technologists
Environmental biologists	Medical specialists (with postgraduate qualifications in the public health area)
Environmental chemists	Meteorologists
Environmental engineers	Microbiologists
Environmental health administrators	Noise inspectors
Environmental health educators	Nuclear safety managers
Environmental health managers	Nutritionists
Environmental health officers	Occupational health nurses
Environmental health planners	Occupational health physicians
Environmental health technicians	Occupational hygienists
Environmental lawyers	Physicists
Epidemiologists (with medical degree)	Political scientists
Epidemiologists (without medical degree)	Pollution inspectors

(continues)

TABLE 1.4 Professions Involved in Environmental Health (continued)	
Psychologists	Social scientists
Public health nurses	Social workers
Public health physicians	Soil scientists
Public health veterinarians	Statisticians
Public relations experts	Technical assistants
Risk assessors	Toxicologists
Rural and urban planners	Transport planners/managers
Safety inspectors	Water quality inspectors
Sanitary engineers	Zoologists
Sanitary officers	

Reproduced with permission from Fitzpatrick M, Bonnefoy X. *Environmental Health Services in Europe 4: Guidance on the Development of Educational and Training Curricula*. Copenhagen, Denmark: World Health Organization Regional Office for Europe; 1999:12. WHO Regional Publications, European Series, No. 84.

may affect the workers as well as hazards that may impact the community. They are involved with the design and installation of control systems for hazards in the occupational and environmental setting. They require training in the epidemiologic and biologic aspects of environmental hazards and also in toxicology. Industrial hygienists work closely with engineers who design and maintain industrial processes.⁴²

Toxicologist

As a general description of the field, it may be said that toxicology concerns the effects of poisons. Among the many subspecializations in the field of toxicology are medical, veterinary, forensic, and environmental applications. The field of environmental toxicology specializes in the effects of toxic chemicals upon the environment and living creatures such as human beings and wildlife. Occupational and industrial toxicologists investigate the effects of chemicals found in the workplace upon the health of workers. Toxicologists are employed in academia as professors and researchers, by government agencies, by hospitals, and in various private industry settings. (See [FIGURE 1.14](#).)



FIGURE 1.14 Researchers in a toxicology laboratory. Courtesy of Dr. Arezoo Campbell, Department of Community and Environmental Medicine, University of California, Irvine.

Environmental Health Inspector

Public health departments provide many job opportunities for environmental health workers. Environmental health inspectors, who work mainly for state and local governments, are responsible for monitoring and enforcing government regulations for environmental quality. This employment category includes pollution inspectors, noise inspectors, and water quality inspectors. Such personnel help to monitor the treatment

and disposal of sewage, refuse, and garbage. They also may visit toxic waste dumps, factories, and other sources of pollution in order to collect air, water, and waste samples for testing. They may be sent out to follow up on complaints from the community, attempt to determine the sources and nature of environmental pollution, and provide necessary background data for enforcement actions.

Food Inspector/Food Safety Specialist

Food inspectors and food safety specialists are involved with the cleanliness and safety of foods and beverages consumed by the public. They inspect restaurants, dairies, food processing plants, and other food preparation venues in order to control biological hazards from sources such as *Escherichia coli*, *Salmonella*, and other foodborne agents. Their purview of responsibility also may extend to hospitals and other institutional settings. They may be responsible for examining the methods for handling, processing, and serving of food so that these procedures are in compliance with sanitation rules and regulations. **FIGURE 1.15** demonstrates a food safety inspector examining a batch of food.



FIGURE 1.15 Public health inspector checking a kitchen's sanitary conditions.

Courtesy of CDC/Amanda Mills

Vector Control Specialist

Vector control specialists (not listed in Table 1.4) are responsible for the enforcement of various public health laws, sanitary codes, and other regulations related to the spread of disease by vectors. Examples of vectors are insects such as mosquitoes and flies, rodents, and other animals and arthropods that carry disease organisms. Vector control specialists are involved with controlling rabies, mosquito-borne encephalitis, tick-borne diseases, and zoonotic diseases. At the local government level, vector control specialists may be responsible for conducting community education programs, monitoring animal bites, collecting specimens for testing, and developing other procedures for control of diseases carried by vectors. **FIGURE 1.16** illustrates a vector control specialist at work.



FIGURE 1.16 Vector control specialist spraying insecticidal dust for control of plague, 1993.

Courtesy of CDC

Researcher/Research Analyst

In universities and research units, individuals who have specialized training in environmental health conduct basic research on the risks associated with exposures to certain specific hazards and conduct statistical analyses of the impact of such exposures on human populations. Although this category is

not listed in Table 1.4, examples of employment titles found in research settings are laboratory scientist and technician, epidemiologist, and statistician.

Occupational Health Physician/ Occupational Health Nurse

These professionals are involved with the prevention and treatment of occupationally related illnesses and injuries. They investigate hazards in the work environment and develop procedures for their abatement. They also conduct health education programs for the prevention of work-related diseases.

Environmental Lawyer

Beyond the research environment, there is an active field known as environmental health law. Closely linked with environmental health law are environmental policies. Specialists in this field provide input to government agencies, assist in the formulation of environmental policies, and may be involved in litigation concerning environmental health problems.

► Conclusion and Overview of the Text

The study of environmental health is crucial to one's understanding of the hazards and potential adverse effects posed by environmental agents and the extent to which environmental factors play a role in human disease. This foundation is essential for being an effective advocate for preventing environmentally caused diseases and for more advanced study of environmental health issues. This chapter has provided an introduction to the environmental health field: definitions, terminology and concepts, historical background, and career opportunities. The field of environmental health draws heavily upon **epidemiology** and toxicology.⁴³ As a result, environmental health makes abundant use of terminology from these disciplines. Epidemiologic aspects of environmental health include such well-known methods as case ascertainment, continuous surveillance of hazards, and development of tools for evaluation of intervention programs. Epidemiologic studies have been crucial for delineating the health effects of exposure to pollutants at the population level. Chapter 2 will introduce the topic of environmental epidemiology.

One of the contributions of toxicology to the environmental health field is in assessing **dose-response relationships**, which describe the responses of organisms to exposures to toxic substances. A dose-response relationship can be illustrated by an S-shaped curve known as a dose-response curve.⁴⁴ An additional concern of toxicology is exposure assessment, which

involves procedures for determining what levels of specific hazards (e.g., a toxic chemical such as DDT) produce symptoms, disease, or other adverse effects. Chapter 3 provides more information on toxicology. Chapter 4 provides a discussion of environmental policy making and environmental health, including regulatory agencies and specific environmental laws that have been enacted in the United States. Chapters 5 through 9 cover agents such as microbes, toxic metals, radiation, and organic chemicals; these agents pose risks of disease from environmental factors. Chapter 5 focuses on environmental aspects of zoonotic and vector-borne diseases. Chapter 6 describes hazards that arise from toxic metals and elements (e.g., arsenic and chromium). Chapter 7 reveals hazards that arise from toxic chemicals such as pesticides, herbicides, and organophosphates. Chapter 8 focuses on ionizing radiation (for example, radiation emitted during the Chernobyl nuclear power plant accident and from X-ray machines used in body scans) and nonionizing radiation (for example, radio frequency radiation from cell phones and ultraviolet radiation from the sun). Chapter 9 covers water quality and pollution. Chapter 10 focuses on air quality and the impact of climate change. Chapter 11 covers the broad topic of food safety, including foodborne diseases caused by microbial agents and how additives and chemicals affect the food supply. Chapter 12 covers solid waste disposal and sewage processing. Chapter 13 presents information on occupational health. Finally, Chapter 14 demonstrates the role of environmental factors in unintentional injuries, a leading cause of mortality.

Study Questions and Exercises

1. Define the following terms:
 - a. Population dynamics
 - b. Completed fertility rate (total fertility rate)
 - c. Environmental health
 - d. Environmental risk transition
 - e. Environment, physical and social
 - f. Demographic transition
 - g. Epidemiologic transition
2. Discuss three of the six major objectives (Outdoor Air Quality) for goal number 8, environmental health, as described in *Healthy People 2020*. What steps can be taken in your community to accomplish the objectives you have selected?
3. Describe the three P's that are principal determinants of health worldwide. Discuss how the three P's could be considered interrelated characteristics. Can you think of other

- consequences of the three P's that are not discussed in the text?
4. This chapter discussed how environmental exposures affect our daily lives.
 - a. Illustrate the types of environmental health problems that you have in your own community.
 - b. Review and summarize at least three articles on environmental health that you have seen in the media, e.g., on the web or in a newspaper, during the past week. Are any of these articles relevant to the community where you live?
 - c. Why is maintenance of environmental quality important for human health?
 5. Discuss the role of population growth in human health. How might recent outbreaks of diseases such as the bird flu or pandemic H1N1 be linked to population growth? In addition to population growth, what other environmental factors could lead to pandemics such as those associated with influenza viruses?
 6. Describe the types of environmental health problems that prevail in the developing world. Give at least three examples.
 7. Demonstrate population growth trends over the past two centuries. What is the likelihood that current exponential population growth rates will continue? Take a stand for or against population growth at present high levels.
 8. Describe variables that affect the size of a population. What countries or regions of the world are projected to experience stable or declining population sizes? What areas are expected to have the greatest increases in population size?
 9. Define and discuss the following terms:
 - a. Ecological model of population health
 - b. Ecosystem
 10. Summarize the contributions of the early Greeks to environmental health. How do Hippocrates' explanations of disease etiology compare with current beliefs about the role of the environment in human illness?
 11. List and discuss five of today's most pressing environmental health issues ("hot topics"). In addition to the material presented in the text, you also may use your own ideas.
 12. Explain why environmental health is an important field of employment. List specific employment roles in environmental health. Consult the World Wide Web for employment listings (e.g., published by state, local, and federal government agencies) and summarize the requirements and functions of three job titles.

For Further Reading

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Walden, Henry David Thoreau, 1854
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