

# POPULATION AND PLANET

BY JOEL E. COHEN

**H**OW WILL THE NEXT CENTURY DIFFER from this one? I write about the twenty-first century as if I knew something about it. But almost nothing is inevitable about any of the human trends I survey. Each is a result of choices, individual and collective.

**SLOWING POPULATION GROWTH.** For most of the last five centuries, including most of the twentieth century, the rate of growth of the human population was increasing. The all-time peak rate of growth was reached around 1965. Since then, the population growth rate has dropped by one-third. The absolute increase in population peaked around 1990, when the number of human beings added each year rose to more than 90 million. Since then, the absolute annual increase has fallen to fewer than 80 million additional people. The population growth rate is dropping so rapidly that some demographers think there is a better-than-even chance that the world's population will never double again from the current 6 billion people. Absolute population growth is very likely to slow further, and perhaps even to end. If that occurs, then the twentieth century was and will be the only century in the history of humanity to see a doubling of Earth's population within a single lifetime.

**A MORE POPULOUS WORLD.** The next century will have more people in it. During the past 100 years, the human population more than tripled, from fewer than 1.7 billion in 1900 to more than 6 billion by 2000. More young men and women than ever before are now entering the age of childbearing. Barring catastrophe, their children are likely to increase the world population by perhaps 2 billion to 4 billion people by the middle of the twenty-first century.

**AN URBAN SPECIES.** The twentieth century will be the last in human history in which most people live in rural areas. Modern urbanization, dating to the eleventh century in Europe, has occurred worldwide for at least two centuries; 47 percent of people live in cities now, as the number of urbanites rose nearly fourteenfold, from 200 million to 2.9 billion, during the 1900s. At the beginning of the century, no cities had 10 million people or more. By mid century, one city did: New York. Today, there are 20 cities of 10 million people or more. The

United Nations estimated recently that almost all population growth in the next half century will be located in cities, while the world's rural population will remain near 3 billion people. In the twenty-first century, humanity will be predominantly urban.

**AN OLDER POPULATION.** The twentieth century is most likely the last in human history in which younger people outnumbered older ones. During the century now ending, the proportion of children aged four years and under gradually declined, and that of people aged 60 years and older gradually increased. Each group will constitute 10 percent of humanity in the year 2000. This convergence reflects improved survival and reduced fertility. Improved survival raised the average length of life from perhaps 30 years at the beginning of the century to more than 66 years at its end. Reduced fertility rates added smaller cohorts to the younger age groups. The aging of the human population is likely to continue. According to a UN estimate, by the year 2050 there will be 3.3 people aged 60 years or older for every child four years old or younger.

**WHAT WILL THE CONDITIONS** of life be for a population that is growing more slowly—and becoming larger, more urban, and older—than twentieth-century humanity? These four demographic changes will interact with equally dramatic changes in information technology, biotechnology, and access to the fruits of economic growth.

**INFORMATION TECHNOLOGY.** In 1900, automated information processing was largely limited to the use of punched cards to control looms. By mid century, a very few general-purpose digital computers had been developed to wage war. Today, personal computers are abundant in homes and landfills; microprocessors tend quietly to domestic, commercial, industrial, and military appliances. What should we expect in the twenty-first century? Consider the history of plastics. Until 1909, when Leo Hendrik Baekeland patented Bakelite, plastic was expensive and rare. In 1997, we used 130 billion kilograms of plastics—nearly 22 kilograms for every man, woman, and child. Before the end of the next century, we will be equally saturated by information tech-

nology. Microprocessors will be as ubiquitous and disposable as plastic bags are today. They will improve security, transport, sanitation, and energy efficiency in cities. They will continuously monitor the health and safety of people and the status of the environment. They will carry out a significant fraction of the scholarly, scientific, artistic, and professional work that humans perform today—and they will do it better. The twenty-first century will be saturated by information technology, with all its potential for control and liberation.

**BIOTECHNOLOGY.** In 1900, scientists rediscovered the 1865 experiments of Gregor Mendel and established the chromosomal basis of genetics. By 1944, DNA was known to be the genetic material. By 1953, the chemical structure of DNA was understood. In 1995, the first completed genome of a nonviral self-replicating organism, *Hemophilus influenzae*, was published. Early in the next century, we will see a nearly complete description of the three billion nucleotides of human genomes, as well as the first genome of a plant. Biotechnology will progressively become cheap and universal, permeating fields from medicine, mining, manufacturing, and military strategy to food processing, forestry, and fisheries.

**NARROWER INEQUALITY.** During the twentieth century, the average annual gross domestic product per person more than quadrupled, to \$5,200, as the aggregate world economy grew sixteenfold. But the world's people shared very unequally in the

rising incomes. Between 1870 and 1985, the ratio of average incomes per person in the richest countries to incomes in the poorest countries increased sixfold. Adjusted for purchasing power, in 1997 the poorest 2 billion people had incomes of \$1,400 per year—less than one-sixteenth the average incomes of the richest billion. So despite unprecedented economic growth, most of the world's people have lived in poverty in this century. Looking into the future, if the globalization of the economy continues; if the rich countries see their self-interest in making the poor countries richer; if the spread of effective democratic governments continues; and if the political and religious cultures of rich and poor countries permit an integrated global economy to make constructive use of information technology and biotechnology, the poor parts of the world could become richer in an absolute sense—perhaps even catching up partially with the rich countries.

**T**HE TWENTY-FIRST CENTURY'S distinctive demographic and economic possibilities hold the potential for major cultural changes, particularly in education and the status of women.

**UNIVERSAL SCHOOLING.** In the twentieth century, primary education spread across the world, becoming the norm in western Europe, North America, and the most industrialized nations of Asia and the Pacific. The number of children in school, almost zero in much of Latin America, the Caribbean, East Asia, and

Southeast Asia at the beginning of the 1900s, increased dramatically. But today, only three-quarters of the children eligible to attend primary schools in developing countries do so; the 130 million children who are out of school are disproportionately girls, and are mainly illiterate. In the next century, all children will complete primary schooling of vastly better quality than is now offered.

**EQUALITY FOR WOMEN.** Women won the right to vote in the United States in 1920, and the United Nations Commission on the Status of Women was formed to monitor and enhance the situation of women in 1946. Yet by 1991 fewer than 5 percent of the world's heads of state, of major corporations, and of international organizations were women. More change, however, was apparent for the mass of women than among the elites. Worldwide, female participation in the cash economy nearly doubled in less than a generation, from 37 women per 100 men in 1970 to 62 women per 100 men in 1990, with particularly dramatic changes in the developing regions. If education is extended to all children in the next century, the status of women will continue to improve.

**F**INALLY, the changing size and activities of humanity imply different effects on nature in the future.

**THE ENVIRONMENT.** In the twenty-first century, the human enterprise will no longer be small compared to the size of the earth. During the century now ending, humans' aggregate impacts on biotic and geological processes grew enormously. Human-induced emissions of carbon to the atmosphere grew from a half billion tons to 73 billion tons per year, raising the carbon dioxide concentration in the atmosphere by about 20 percent. Today's level is higher than at any time in the last 150,000 years, a period that includes the emergence of modern humans and the multiple inventions of agriculture. Emissions of nitrogen from the combustion of fossil fuels grew twentyfold, to 25 million tons per year. The mass fraction of nitrates in ice grew from 45 parts per billion at the beginning of the century to 120 parts per billion at the end. Human activities account for 40 percent of the nitrous oxide, 70 percent of the ammonia, and at least 80 percent of the nitric oxide emitted to the atmosphere from all sources. World water withdrawals from all renewable freshwater sources grew eightfold, to roughly 4,000 cubic kilometers per year currently. Humans now withdraw annually roughly a quarter to half of all available renewable fresh water. In the course of our demographic and economic expansion, humans have altered the habitats and populations of many other species, raising widespread concerns about extinctions. For example, the area of

cultivated land nearly doubled, along with the human population, between 1900 and 1960. (Since 1960, the area cultivated has not grown substantially. Rather, new lands have been converted to agriculture to replace lands abandoned or converted to non-agricultural uses, and the intensity of cultivation and the yields per cultivated hectare have increased globally.)

In the aggregate, human interventions in global processes have grown faster than our understanding of the likely consequences of these interventions. And nature, in its turn, has surprised us.

Chlorofluorocarbons have created ozone holes. The Aral Sea has shrunk from the fourth to the eighth largest lake in the world. Human immunodeficiency viruses, antibiotic resistance, and mad-cow disease have emerged. The future of many natural systems, and their effects on us, depend in part on how well we come to understand our options, and what we decide to do.

**S**EEN in that light, the future condition of our environment is of a piece with the other forecasts I have made. In human terms, almost nothing is inevitable about the twenty-first century. People may choose to have more or fewer children than anticipated, to pursue or to abandon biotechnology, to educate all children or not. A healthy aging population offers unprecedented opportunity for longer use of acquired skills and experience, but threatens to bring unprecedented

numbers of abandoned oldsters unless we anticipate the consequences of smaller and differently constructed families. Urbanization offers exciting opportunities for educational and cultural enrichment—but it also threatens frightening hazards from infectious diseases unless adequate sanitation supplies clean water and removes wastes.

Until we understand better the interaction between humanity and our planetary home, we will not be able to choose how the natural world will treat us; surprises from the natural world will continue, and not all of the surprises may be pleasant. We are making choices about our human and environmental future every day. Shall we continue to make those choices in ignorance of their likely effects on us and our children? How we answer that question is also a choice. ▽

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