

# USEFUL KNOWLEDGE

THE AMERICAN  
PHILOSOPHICAL SOCIETY  
MILLENNIUM  
PROGRAM



ALEXANDER G. BEARN

*Editor*

AMERICAN PHILOSOPHICAL SOCIETY  
*Independence Square • Philadelphia*

1999

# Population in the Twentieth and Twenty-first Centuries\*

JOEL E. COHEN

Professor of Populations, Rockefeller University and Columbia University

**T**HE TWENTIETH century will differ dramatically from the twenty-first century in demography, economics, culture and environment. Demographic changes can be expected in the growth rate, size, urbanization, and aging of the global human population.

In the twentieth century, world population increased 3.8-fold. The United Nations estimated that the world population in 1900 was 1.65 billion, and in the year 2000 will be 6.1 billion. World population is very unlikely to increase 3.8-fold in the twenty-first century. Some demographers think there is a better-than-even chance that the world's population will never double to 12 billion people. At the end of the twentieth century, after 35 years of slowing population growth, a continued slowing of population growth in the twenty-first century seems very likely. If the rate of increase of population continues to fall, 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. Human numbers will probably never again nearly quadruple within a century.

Despite a slowing rate of increase, the twenty-first century is unlikely to see a reversal of world population growth for several decades at least. The 1998 long-term *low-fertility* projection of the UN estimated that global population will peak near 7.7 billion in the middle of the twenty-first century, and will fall to 5.6 billion by 2100. The world previously had 5.6 billion people around 1993. Unless future population growth is much lower than anti-

---

\*Copyright © 1999 by Joel E. Cohen. Based on a paper read 23 April 1999 to the Millennium Meeting of the American Philosophical Society, Philadelphia

pated in the UN's low projection, the twenty-first century will have billions more people than the twentieth century.

The twentieth century saw the fraction of world population living in cities rise from 13 percent in 1900 to 47 percent by the year 2000. That is a 3.6-fold increase. The absolute number of city dwellers increased even more dramatically, by nearly 14-fold, from 0.2 billion people to 2.9 billion. At the beginning of the twentieth century, no cities had 10 million people or more. One city did in 1950 — New York. By the century's end, there will be 20 cities of 10 million people or more. These figures on urbanization disguise ambiguities and variations in definitions of "urban." While the numbers should not be taken too literally, the trend toward urbanization is clear. In Europe, the rush of people from the countryside to cities dates back to the eleventh century. Urbanization has occurred worldwide for at least two centuries.

The twenty-first century is unlikely to see a reversal in the relative growth of urban population. The UN estimated in 1996 that almost all population growth in the next half century will be located in cities, while the rural population of the world will remain nearly constant around 3 billion people. If urbanization occurs as anticipated, then the twentieth century was and will be the last century in human history in which most people live in rural areas. In the next century, humanity will be predominantly urban.

The twentieth century saw the world fraction of children aged 0–4 years gradually decline, and the world fraction of older people aged 60 years or more gradually increase. Both percentages will meet at 10 percent in the year 2000. This trend results from improved survival and reduced fertility. Improved survival raised the world's expectation of life from perhaps 30 years at the beginning of the twentieth century to more than 66 years at the beginning of the twenty-first century. Reduced fertility rates added smaller cohorts to the younger age groups.

The twenty-first century is unlikely to see a reversal in the aging of world population. In its 1998 medium-variant projection, the UN estimated that by the middle of the twenty-first century, the fraction of the population aged 0–4 years will fall from 10 percent to less than 7 percent while the fraction of the population aged 60 years or more will rise from 10 percent to more than 22 percent. In this projection, the ratio of older people to young children is expected to rise from 1-to-1 now to 3.3-to-1 in half a century. In all

the variant projections developed by the UN, the ratio of elderly to young children is expected to grow. The lower future fertility, the higher the ratio of elderly people to young children. If the future resembles any of the UN projections, then the twentieth century was and will be the last century in human history to see younger people outnumber older people. The next century will be a world of predominantly older people.

PLAUSIBLE FORECASTS of a more slowly growing, larger, more urban and older world population presuppose that the next century will not be afflicted by lethal global pandemics of novel infectious diseases, by massively destructive warfare, nor by a meteoric impact that darkens the skies for years. These forecasts assume no abrupt shift in oceanic circulation, global climate, and sea level and no collapse of conventional agriculture. All of these catastrophes are conceivable. None is exceptionally unlikely. For example, it has been suggested that every past 10-fold increase in human population density has been associated with new human infectious diseases. Unless the sanitary infrastructure of the next century's megacities improves dramatically, large cities could become incubators for new infectious diseases. The difference between the future and the historical record for infectious diseases is that people know far more now than in the past about how to prevent and contain the spread of infection. I exclude catastrophic possibilities because I have nothing useful to say about what would follow.

The world experienced a drastic decline in the human population growth rate once before in the present millennium. In the fourteenth and fifteenth centuries, waves of the Black Death, brigands, war lords, and famines killed somewhere between one-third and two-thirds of the people between India and Iceland. Economic and medieval historians have argued that the Black Death shook Europe loose from a stable equilibrium of high population density, intensive grain production, and widespread poverty. Before the Black Death, admission to guilds had been hereditary or strictly limited. A scarcity of workers following the drop in population forced guilds to recruit more widely from among the poor. Parents shifted much of their bequests from pietistic charity to their children. Increased lands per person shifted diets toward more meat, previously the food of the rich. The scarcity of people raised the wages of both agricultural and urban laborers and stimulated the

development and spread of labor-saving technology. From an over-simplified economic perspective, when the supply of people dropped, the price of people rose. A dramatic fall in the abundance of people was followed by an increase in their value.

Other key factors in the development of Europe were urbanization and technological innovation. The rise of urban society in Europe in the eleventh to thirteenth centuries gave professionals a prominent place. Technological innovations in both agriculture and manufacturing occurred as people moved to cities. The Black Death saved these gains from being eaten up, as they were in Asia, by the rise of population. These trends seem relevant to the twenty-first century if population growth slows and cities grow rapidly as expected.

However, the effects on well-being of major demographic changes depend as much on the relations of power in a society as on numbers. Many localities in Europe passed anti-labor laws in the fourteenth and fifteenth century in unsuccessful attempts to control the demands of workers. If the decimation of the Amerindians following the European conquests raised the price of people in the New World, it led the European colonists to tighten their control of the subjugated populations.

In the twentieth century, the supply of people surged to unprecedented levels. To judge by the preventable ills of the human population today, people are collectively valued cheaply. Perhaps three-quarters of a billion people are chronically undernourished. At least another billion are malnourished. A billion adults are illiterate. Roughly 2 billion people— one in three people on the planet—are infected with the bacillus of tuberculosis, though isoniazid, an inexpensive drug that can cure tuberculosis when taken properly, was discovered in 1952. Hundreds of millions of people are under threat from other infectious diseases.

WILL THE relations between the rich world and the poor world follow the European experience, with growing equity and wealth for all, or will it follow the Amerindian experience, with prolonged subjugation and deprivation for the poor? The twentieth century shows the seeds of both possibilities. The growth of economic inequality is an ominous trend. The spread of primary education is a promising trend.

Economic growth during the twentieth century more than quadrupled the average gross domestic product (GDP) per person, from less than \$1,300 to \$5,200. Measured by aggregate GDP, the size of the world economy grew sixteen-fold. Of course, the GDP has important limitations as a measure of economic well-being. To an important extent, the process of economic development substitutes market production for domestic production: eating in a restaurant replaces cooking at home; paying for childcare replaces parental rearing of children. Hence the GDP rises faster than real (including domestic) production. The GDP also includes commercial gains from market activities but neglects their drawing-down of environmental and social capital. Though the numbers that economists use to measure economic growth have uncertain interpretations as indicators of welfare, it seems clear that economic well-being has improved for many people during the twentieth century.

People shared the improvement in average incomes very unequally. Between 1870 and 1985, the ratio of average incomes per person in the richest countries to average incomes per person in the poorest countries increased sixfold. When the 1997 gross national product per person was adjusted for purchasing power parity, the poorest 2 billion people on the planet had incomes of \$1,400 per year, less than one-sixteenth of the average incomes of the richest billion. These comparisons of income between groups at different levels of economic development suffer from the same limitations as long-term comparisons of average GDP.

A more promising trend in the twentieth century is that primary education spread across the world. A standard indicator of educational activity is the primary gross enrollment ratio (PGER). A gross enrollment ratio is calculated by dividing the number of children enrolled in school by the school-age population. Because children who are over age or under age may also enroll in school, the PGER over-represents the proportions of children of school-going age who are actually enrolled in school. The PGER may exceed 100 percent.

In the wealthy regions of northwestern Europe, North America and the Anglo Pacific, the PGER rose this century from 72 percent to 103 percent. Latin America, the Caribbean, East Asia and Southeast Asia saw much more dramatic increases, from as low as 4 percent in Southeast Asia to more than

100 percent in all these regions. Sub-Saharan Africa lagged other regions. Its PGER progressed from 16 percent to 85 percent. Late in the twentieth century, about three-quarters of the children eligible to attend primary schools in developing countries did so. The 130 million children who were out of school were disproportionately girls, and were mainly illiterate.

The improved status of women and the spread of primary education, human rights and effective democratic governments are major cultural trends of the twentieth century that bode well for the twenty-first. A continuation of these trends in the next century could bring an unprecedented growth of equity and spread of prosperity. A wealthier, better-educated populace could demand environmental quality and the knowledge needed to achieve it. Changes in the composition and function of families—associated with falling fertility, rising longevity, and economic and cultural changes in the relations between men and women—will have unknown but probably very important effects.

On the other hand, the gulf between rich nations and poor, the ever-present seeds of violence and corruption, and growing material throughputs of the human economy could undermine the benign environmental assumptions of these speculations.

HUMANS HAVE been a geological force on the face of the Earth since they mastered fire hundreds of thousands of years ago. Energy consumption is one index of capacity to transform the Earth. Between 1860 and 1990, the use per person of inanimate energy from all sources grew nearly 20-fold while global population quadrupled, giving a nearly eighty-fold rise in aggregate inanimate energy consumption. Partly as a consequence of the increased production and consumption of energy, human interventions in biotic and geological processes grew tremendously in the twentieth century. I will illustrate with the global cycles of carbon, water and nitrogen.

Although individual human well-being is appropriately measured per person, human impact on global biogeochemical systems is appropriately measured on an aggregate basis. The reason is that the mass of the atmosphere, the area of the continents, the volume of the ocean, the number of species, and many other planetary systems are independent of the size of the human population.

In the twentieth century, human-induced atmospheric carbon emissions grew from 0.5 billion to 7.3 billion tons of carbon per year. The carbon dioxide concentration in the atmosphere rose in this century by about 20 percent. Atmospheric carbon dioxide concentrations are now higher than they have been in the last 150,000 years, a period that includes the emergence of modern humans and the multiple inventions of agriculture. The human and biological implications of this rise are hotly debated. Current models are the subject of controversy, some scientifically motivated and some politically motivated.

World water withdrawals grew eight-fold from 500 cubic kilometers per year around 1900 to roughly 4,000 cubic kilometers per year currently. Humans now withdraw annually roughly a quarter to half of all available renewable freshwater. The two-fold uncertainty in this estimate reflects current ignorance of humans' place in the world's water cycle. While aggregate supplies of freshwater remain ample, local water shortages currently affect billions of people.

Human emissions of nitrogen in  $\text{NO}_x$  from the combustion of fossil fuels grew from 1.5 million to 25 million tons per year between 1900 and 2000. 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. Current human activities emit 40 percent of the nitrous oxide ( $\text{N}_2\text{O}$ ), 70 percent of the ammonia ( $\text{NH}_3$ ) and at least 80 percent of the nitric oxide ( $\text{NO}$ ) emitted to the atmosphere from all sources.

People converted forests to agricultural land throughout the twentieth century. The application of chemicals to agricultural lands intensified greatly in the last third of the century. Through the uses of land for agriculture, cities, industry and infrastructure, humans have altered the habitats and populations of many non-human species.

WHETHER AND for whom the twenty-first century goes well or ill is not determined by the situation today. Nothing is inevitable about any of the human changes anticipated here. Human changes result from individual and collective choices. One choice often constrains another. People collectively choose the growth rate, size, age composition, and concentration in cities of the human population. Through investments in education, capital and



environmental protection, people choose who shall acquire the capacity to generate wealth and to share in global prosperity. People choose whether to let their interventions in the biogeochemical mechanics of the globe run ahead of their ability to foresee the impacts of those interventions.

Unfortunately, humans do not yet understand well how the interacting system of the human-natural world works. People cannot yet choose how the natural world will treat them. In the twentieth century, the physical, chemical and biological world has surprised people repeatedly. Lead in gasoline poisoned children and adults. Asbestos products injured many workers. Above-ground atomic tests put strontium in milk. Chlorofluorocarbons created ozone holes. Human immunodeficiency viruses and antibiotic resistance emerged. The Aral Sea shrank from the fourth to the eighth largest lake in the world. The Colorado River ended in a trickle.

As long as people remain stunningly ignorant of how the natural world works, surprises from the natural world will continue. Not all of the surprises may be pleasant. In the recent geological past, very abrupt, major transitions in oceanic circulation have taken place over intervals as short as a decade or a few decades. These transitions were accompanied by equally abrupt changes in climate over large parts or all of the globe. Such abrupt changes could be highly unfavorable to the well-being of humans and many other living species on which humans depend. Improved scientific knowledge of the interactions between humans and the rest of the Earth is needed to estimate the risks of such abrupt changes more realistically, and to offer guidance on how humans can avoid undesirable transitions.

Will we follow the example of Noah, who anticipated environmental change, prepared for it, and left a human and biological legacy that has enriched all following generations? Or will we follow the example of Samson, whose foolish passions led him to blind enslavement, and whose power finally brought the temple down on his own head?

**ACKNOWLEDGMENTS.** I am grateful to Nathan Keyfitz, Samuel Preston, George Whitesides, Valerie Herr, and Jonathan Messerli for helpful comments. I acknowledge with thanks the support of U.S. National Science Foundation grant BSR92-07293 and the hospitality of Mr. and Mrs. William T. Golden during this work.

## DISCUSSANT

SAMUEL H. PRESTON

University of Pennsylvania

I AM GOING to make several remarks that are stimulated by points that Joel raised. First, this has been a wonderful century. It wins the most valuable century award hands down, in this or any other millennium. Choose any indicator of human well-being, life expectancy at birth, infant mortality rate, proportion literate, per capita income, political participation, and the gains of the twentieth century exceed the gains of all previous centuries put together. This is a remarkable achievement. The gains are so persistent that I sometimes think they have acquired an air of inevitability, but of course they are not inevitable. We have just heard from Joe Stiglitz several and backsliding many others could be added. So understanding how these gains occurred I think is vitally important. I think, and this is certainly not highly original, the evidence is completely in favor of the proposition that it has been in a primitive sense the march of ideas that has made the difference—the greater understandings that we have of the natural world and of the social world. I am convinced that this is true in the improvements that I know best, those in longevity. During the twentieth century the germ theory of disease and its implementation in innovative social organizations has for the first time given us secure protection against one another's microbes. This is unquestionably one of the great advances in human welfare.

One idea did not fare so well during the twentieth century. Last year marked the 200<sup>th</sup> anniversary of Thomas Malthus' *Principle of Population*. The twentieth century was not especially kind to Reverend Malthus. That these massive twentieth century gains in human well-being occurred during a period of unprecedentedly rapid population growth is, I think, a good indication of the basic paucity of the model that Malthus proposed. Nevertheless it is possible that our liberation from Malthusian constraints is only temporary. The most worrisome constraint is no longer the availability of land, but rather as Joel has stressed, the absorptive and regenerative capacity of the biosphere. The problem here is not the mass of human beings. If

all humans in the world gathered themselves together in the circle and stood side-by-side, the radius of that circle would be nine miles. The problem, of course, is the ecological damage that this little group is capable of doing. But it's also capable of turning the Earth into English gardens and amber waves of grain. Controlling population numbers is surely one of the crudest means available for affecting outcomes. But if all else fails, if we cannot develop the incentives, the institutional structures, the international agreements that are required to direct human activity in salutary ways, it is conceivable that we would have to invoke a population solution to the problems, as has been advocated by many in the past.

Finally, I'd like to add one uncertainty to Joel's list about the twenty-first century. This relates to the future of families—the basic unit responsible for reproduction and child-raising in all societies. Malthus peered across the sea and saw a population that was liberated from land-constraints and the restrictions on marriage that those constraints implied. He saw a population in which women completed childbearing with an average of eight children. Benjamin Franklin referred to childrer swarming across the land like locusts. It's obvious that families have changed dramatically, not only in the United States but around the world. Relations between the sexes have become more tentative, rates of cohabitation and divorce have risen, rates of marriage and fertility have fallen. One-third of American births last year occurred to unmarried women. Fertility is below the replacement level in one out of every three countries in the world, a list that grows every year. And once you are on that list it appears that there is no escape. Fertility has fallen as low as 1.2 children per woman in Italy, of all places. I think we have some clues about why this has happened, why these dramatic changes have occurred. I am personally persuaded by Gary Becker's emphasis on the declining gains from trade in exchanges between the sexes, but I'm surprised at how little research is being done on this very fundamental social change. Until we understand it better, it's hard to predict where we are headed. I think it's entirely possible that the American Philosophical Society meeting a century hence is going to be faced with a very different set of questions about the human species than it is faced with today.