

Biology and Society

Unit Seven: The Human Impact on the Earth

Introduction

The beginning of the twenty-first century is a critical moment in our history. Human beings using the tools created by science and technology have become the dominant force on this planet. But our domination of the world is unstable and undirected. If we take up Buckminster Fuller's challenge to be the architects of the future and not its victims, then the decisions we make now will have long reaching effects for generations to come. It is, therefore, time for a careful examination of the state of our world and what we want for the future.

Topic One: The History of Human Population Growth

Humanity's effect on the Earth's environment has many components. One of which is the sheer size of our population. But to understand how our population has changed the world we need to know more than just its current size. We need to know its history.

As with all the topics we have covered so far, we will divide the history of human population growth into what science can tell us about it and the ethical issues it creates.

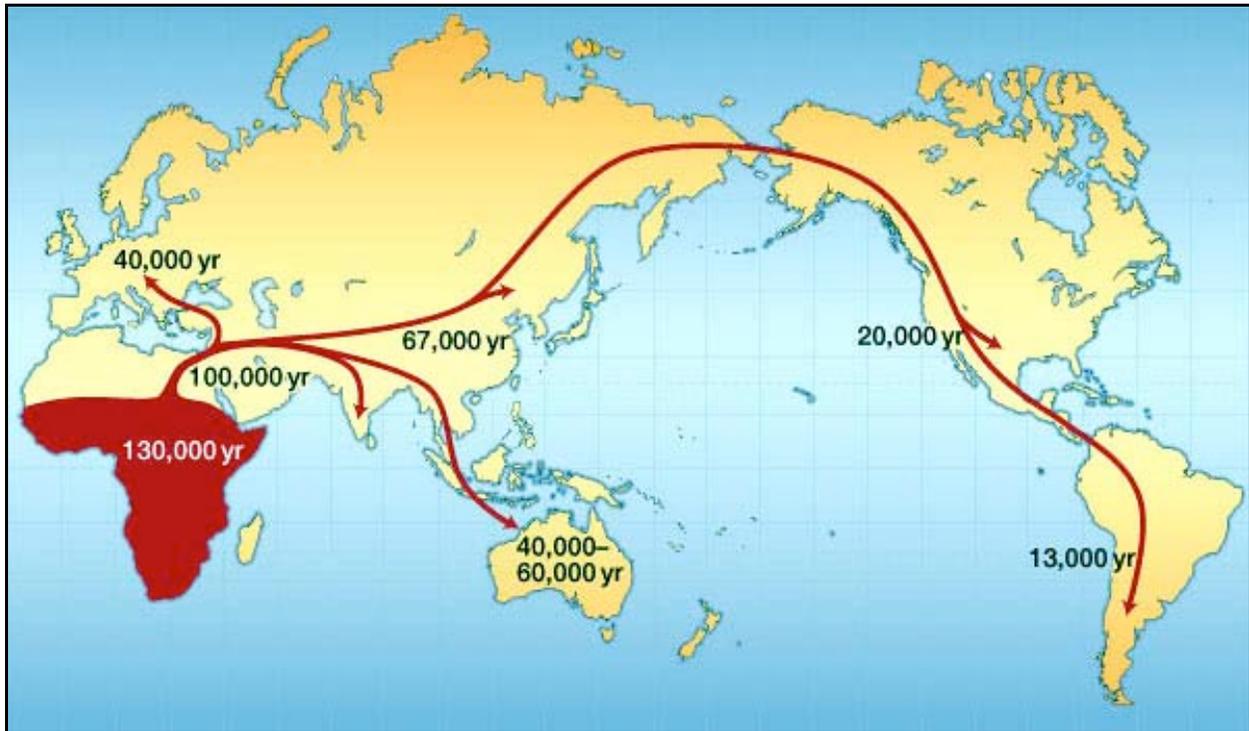
The History of the Human Population

The population history of modern humans can be broken into three phases:

- Population increase caused by the dispersal of modern humans out of Africa roughly from 60,000 to 11,000 years ago
- Population increase caused by the invention of agriculture starting between 12,000 and 11,000 years ago and extending to the 1500s
- Population increase caused by the advent of modern science and technology from the mid-1500s to the present

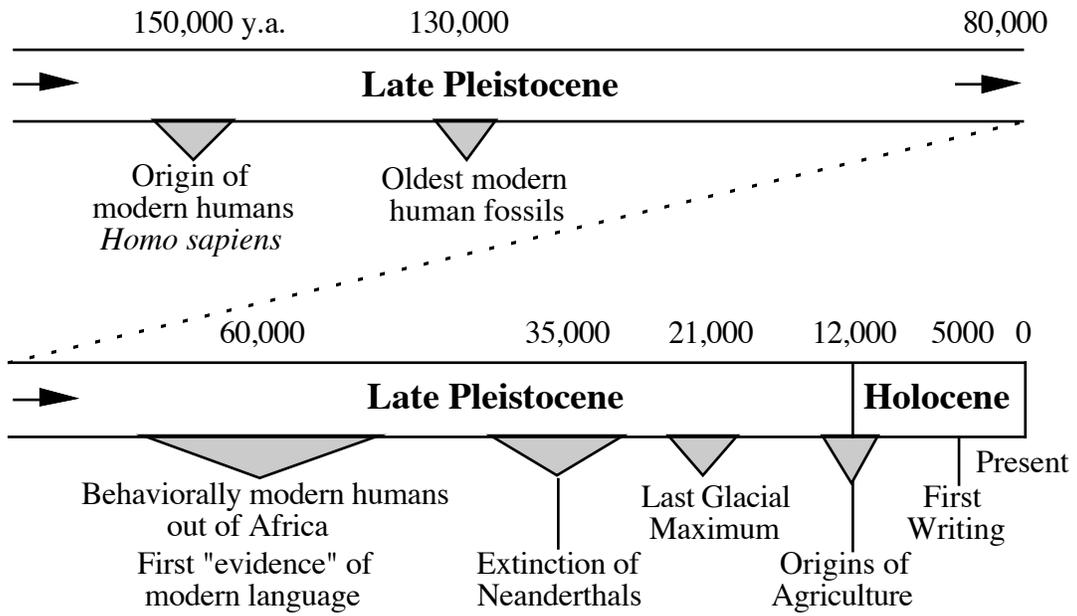
Phase One: The Dispersal of Modern Humans out of Africa

During the Middle Paleolithic (200,000 to 44,000 y.a.) “early human populations were exceptionally small, even by later Paleolithic standards and [it appears] that early Middle Paleolithic humans did not spend much time foraging in any one vicinity.” (Stiner 1999) At some point, however, early modern humans in Africa developed new hunting technologies which lead to their expansion out of Africa ~ 60,000 years ago. This expansion into virgin territories, together with new hunting technology, caused the first period of exponential growth in human numbers. Although the human population did grow exponentially during this period, densities were kept low by the combination of reliance on hunting and the violent climate swings of the Late Pleistocene.



The time of origin of modern humans is not well known but may have been about 150,000 years ago based on genetic evidence. New evidence from mitochondrial and Y-chromosome studies bolsters the hypothesis that the place of origin was sub-Saharan Africa and that the dispersal from Africa occurred within the past 100,000 years. The earliest known fossil and archaeological evidence on each continent, shown on the map, is consistent with this view (Hedges 2000).

Late Pleistocene to the Present



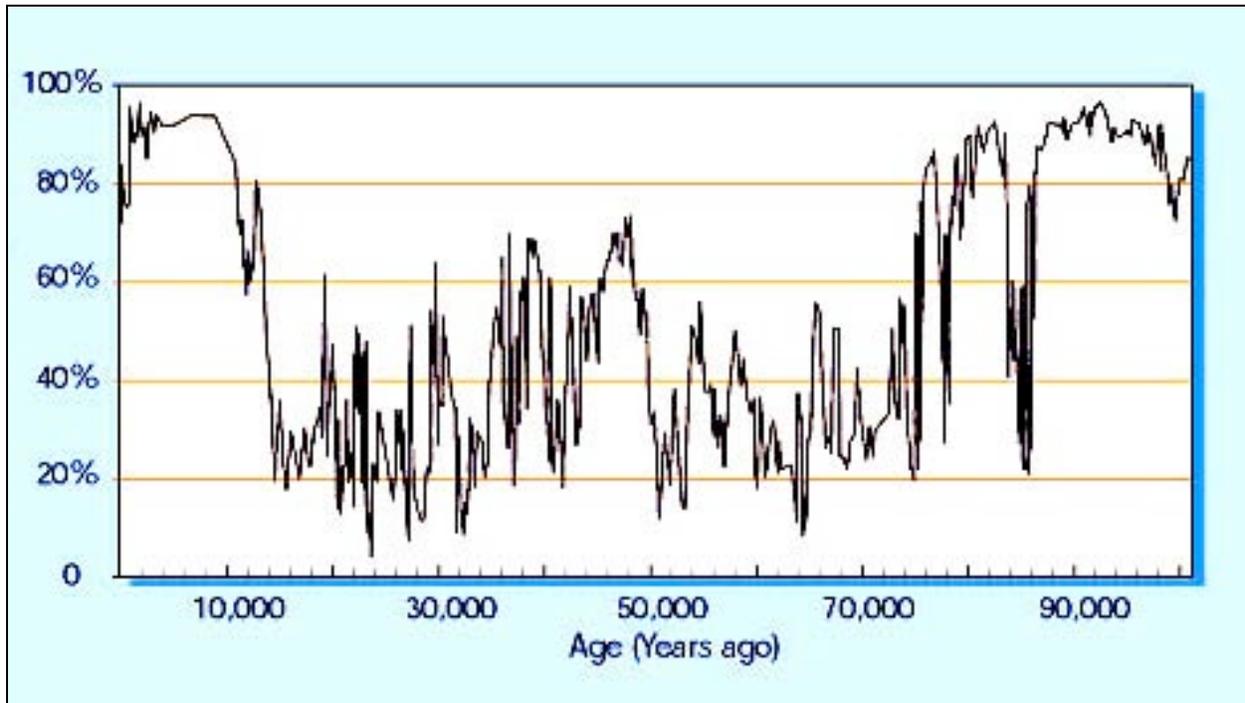
Phase Two: The Invention of Agriculture

The second major pulse in human population growth is associated with the invention of agriculture. But if you have been successful as hunters and gathers for thousands of years, why invent agriculture? The answer lies in the combination of three events.

First, the climate changed 11,500 y.a.. Why didn't humans invent agriculture a hundred thousand years ago? The first modern humans were identical to us and, therefore, surely intelligent enough to do so. Why did the invention of agriculture and the population explosion that followed have to wait until 12,000 to 10,000 years ago? Part of the answer is in the weather.

All during the Pleistocene Ice Age violent weather was the norm, and not until the interglacial climate shift 11,500 years ago did the violent swings in climate settle down to our present calm state. Peter Ward provides this picture:

“The analysis of oxygen isotopes from the Greenland ice cores have shown that the climate over the past 250,000 years has changed frequently and abruptly; the magnitude of the global temperature changes has been far greater, and their intervals far shorter, than anyone imagined. Dr. J. White of the University of Colorado, noted in a recent summary that between 200,000 and 10,000 y.a., average global temperature had changed as much as 18° F in a few decades. The current average global temperature is 59° F. Imagine that it suddenly shot up to 75° F or sank to 40° F in a century or less. At a minimum, these sudden changes would create catastrophic storms of unbelievable magnitude and fury. Yet such changes were common until 10,000 years ago. Imagine a world where storms that dwarf Hurricane Andrew lash the continents not once a century but several time each year, every year. Imagine a world where tropical belts are suddenly assaulted by snow each year. This was our world until 10,000 years ago, when, according to the studies of the Greenland ice cores, a miracle happened: The sudden shifts in the weather stopped.” (Ward 1997)



From the end of the last interglacial period ~ 100,000 years ago until ~ 12,000 years ago the Earth's climate has experienced severe and abrupt changes.

Second, modern humans in area after area reached their density limit as hunters. By the Upper Paleolithic (44,000 to 19,000 y.a.) hunting pressure had forced people's attention from slow moving prey to fleeter prey types. This is, after all, what happens when you spread out and then kill off your preferred (which usually means easier to catch) prey species. Once your population spreads out and fills all available habitats, however, you can't do it again (this is the notion of demographic packing). So if your population increases, it must increase your density per unit area, thereby putting even greater pressure on food resources. "Mobility was the preferred solution to local resource scarcity throughout much of prehistory. Any loss of mobility options is a grave matter for people who live by hunting and gathering. The changes in prey species during the Mediterranean Paleolithic nonetheless indicate demographic packing and associated reductions in mobility." (Stiner 1999)

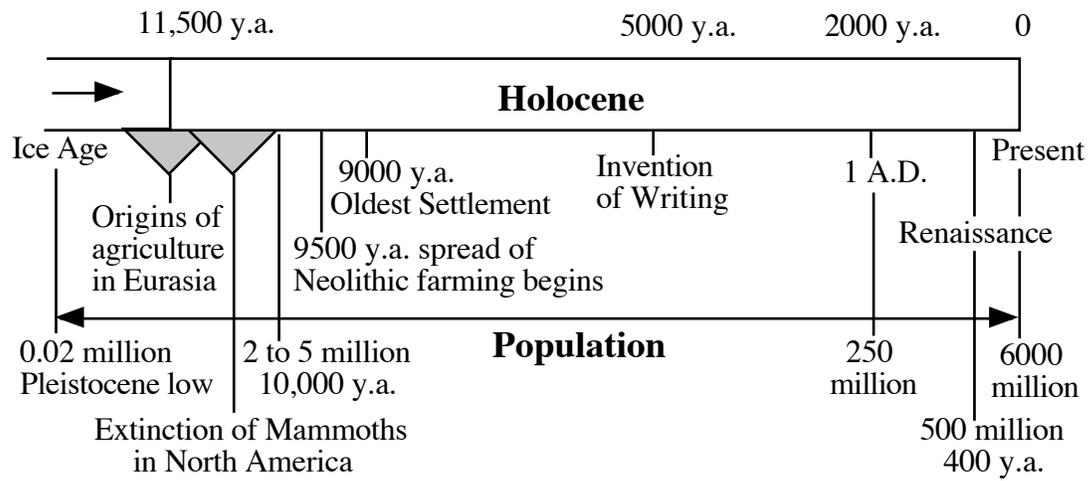
And third, by 11,000 y.a. modern humans had killed off the Pleistocene megafaunas, the mammoths, mastodons and ground sloths along with many other large species, of both the old and new worlds. In North America 73% of all genera weighing more than 100 pounds went extinct between 12,500 to 11,000 y.a., not long after humans arrived on the continent (Ward 1997; Flannery 1999). "But Australia suffered the most severely of all the continents, losing every terrestrial vertebrate species larger than a human," (Flannery 1999). Most telling of all is that the Australian extinctions again coincided with the arrival of humans, only this time around 50,000 years ago during a period of climate stability, and at least 30,000 years before humans reached the Americas.

On the one hand the extinction of the Pleistocene megafauna put selective pressure on early human hunters to find other food sources, at the very least smaller game, whereas the climate change allowed that new food source to be cultivated plants. An example in support of this hypothesis comes from Pringle:

“In a layer dated to at least 13,000 y.a. the [rice] phytoliths show that hunter-gathers in the cave were dining on wild rice. But by 12,000 y.a., those meals abruptly ceased—Zhao suspects because the climate became colder and the wild grain, too tender for such conditions, vanished from this region. Studies of the Greenland ice cores have revealed a global cold spell called the Younger Dryas from about 13,000 to 11,500 y.a.. As the big chill waned, however, rice returned to the region. And people began dabbling in something new around 11,000 y.a.—sowing, harvesting, and selectively breeding rice.” (Pringle 1998)

The invention of agriculture caused the second period of exponential growth in the human population by allowing increases in population density per unit area rather than range expansion. Note that new studies of the origin of agriculture clearly place the origin at the interglacial climate shift 11,500 years ago.

The Holocene Epoch



Phase Three: The Scientific Revolution

Survival Value & Control

There is tremendous survival value in having reliable knowledge about our world. With it comes control over nature and for the first time in human history we are no longer at the mercy of an indifferent universe. The most significant change in our world in the last four hundred years is that science and technology have immensely extended our control over natural events. But with this control has come an explosion in our population size as the limiting factors of disease and famine have one after another been removed.

Human Population Increase

Based on genetic evidence, at some point in the Late Pleistocene the ancestral population of humans dropped to a low of ~ 20,000 individuals.

From this Late Pleistocene population modern humans spread throughout the world and then invented agriculture so that by the year

1 A.D. the human population had reached 1/4 billion. It then took --

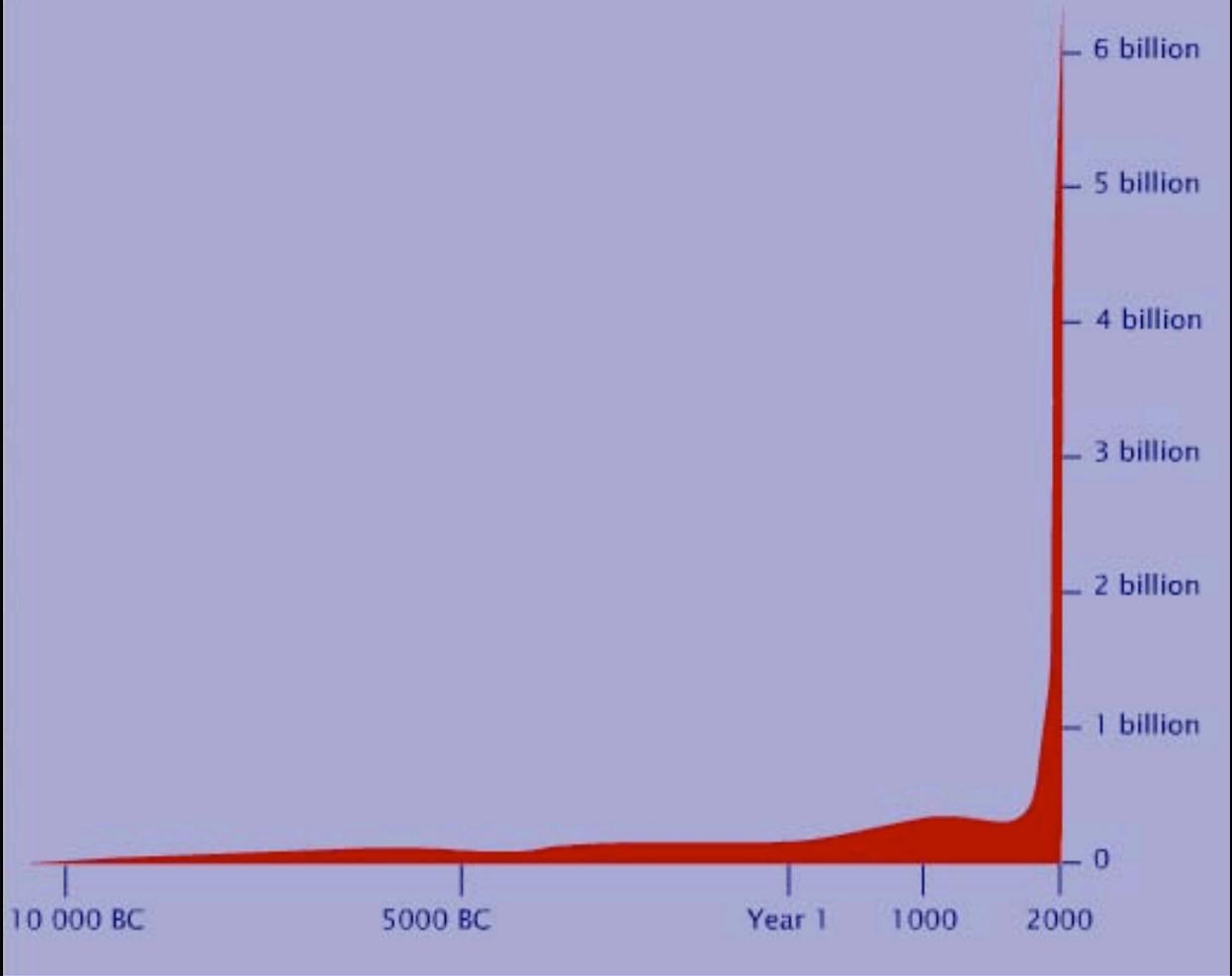
from 1 A.D. to 1600	-- to reach 1/2 billion	(1600 years doubling time)
from 1600 to 1830	-- to reach 1 billion	(230 years doubling time)
from 1830 to 1930	-- to reach 2 billion	(100 years doubling time)
from 1930 to 1960	-- to reach 3 billion	(30 years to add a billion)
from 1960 to 1974	-- to reach 4 billion	(14 years to add a billion)
from 1974 to 1987	-- to reach 5 billion	(13 years to add a billion)
from 1987 to 1999	-- to reach 6 billion	(12 years to add a billion)

(after Cohen 1995)

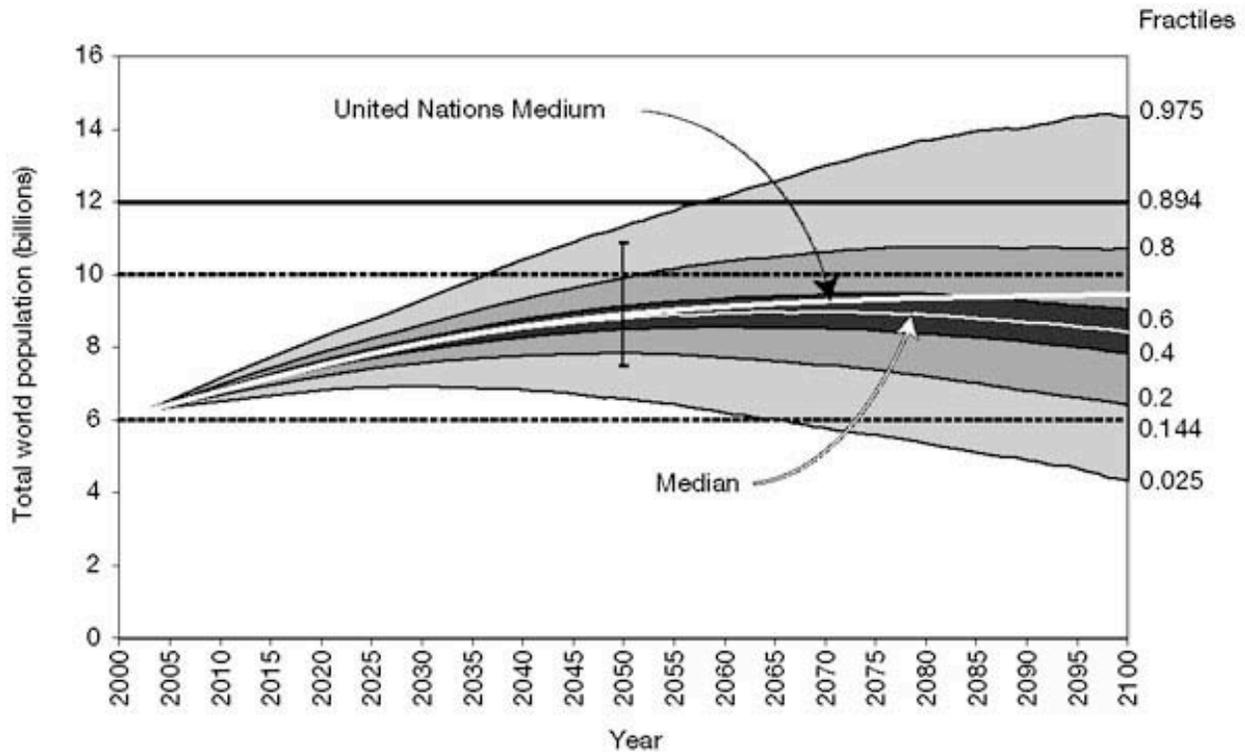
Web Reference

<http://www.census.gov/ipc/www/clock.html>

World Population Growth



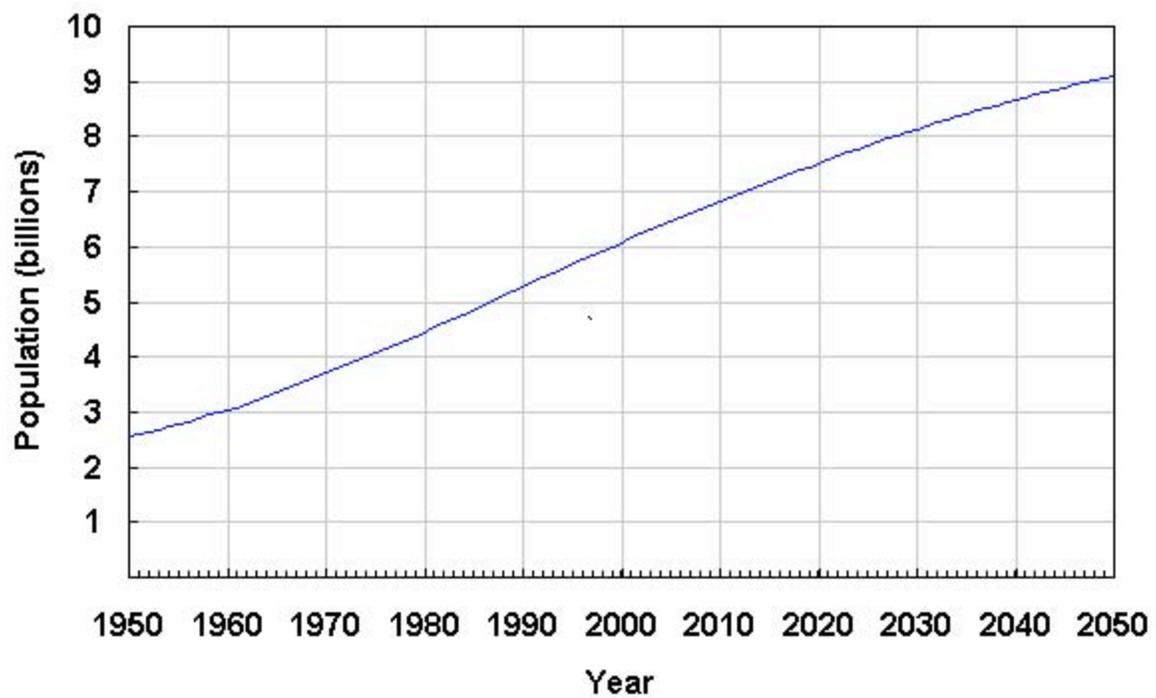
What are the projections for population growth in the future?



Predicted population growth showing degree of confidence interval per size projection (Lutz, et al. 2001)

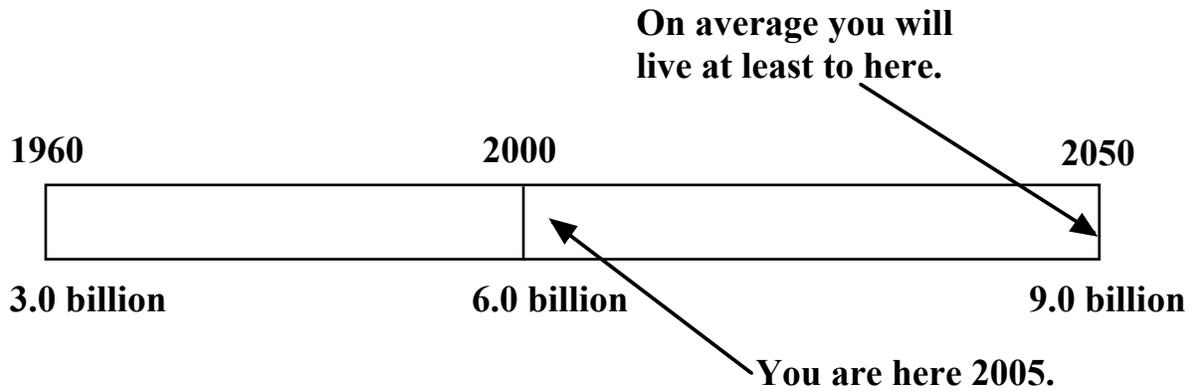
These projections show that it is highly likely that by the year 2050, the human population will reach 9 billion.

World Population: 1950-2050



Source: U.S. Census Bureau, International Data Base 5-10-00.

Why is your generation different?



It is improbable that humanity will ever again experience the phenomenal population growth that is occurring now. Given current projections, the lifetime of today's college students will span the final phase of this population increase. Their lives, unique to all the history of mankind, will witness fundamental changes that will determine the future for generations to come.

References

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