Performance Task: Changes in Human Population Size

More than 1 million years ago, long before humans evolved, our early ancestors began to walk upright, had large brains, and could fashion and use tools, including fire. By about 100 000 years ago, anatomically modern humans were living as successful hunter-gatherers and were rapidly spreading across the globe. Their extraordinary ability to learn and communicate, make tools, and control fire enabled them to invade and live in environments unsuitable to their earlier ancestors. Their great success as hunters enabled them to feed on herds of large wild animals, reducing their dependence on wild plants that had once supplied the bulk of their natural diets (**Figure 1**). By about 12 000 years ago, humans had reached and inhabited all the world's major landmasses, with the exception of Antarctica.

The entire world's human population probably numbered at little more than 5 million. Groups of hunter-gatherers could not increase quickly in number. A nomadic, wandering lifestyle with no permanent residence placed a variety of biological and social restrictions on average family size. Although birth rates were low, death rates were often very high, especially among the very young, the old, and the ill. As a result, the populations dependent on hunting, while often very successful, tended to remain small.

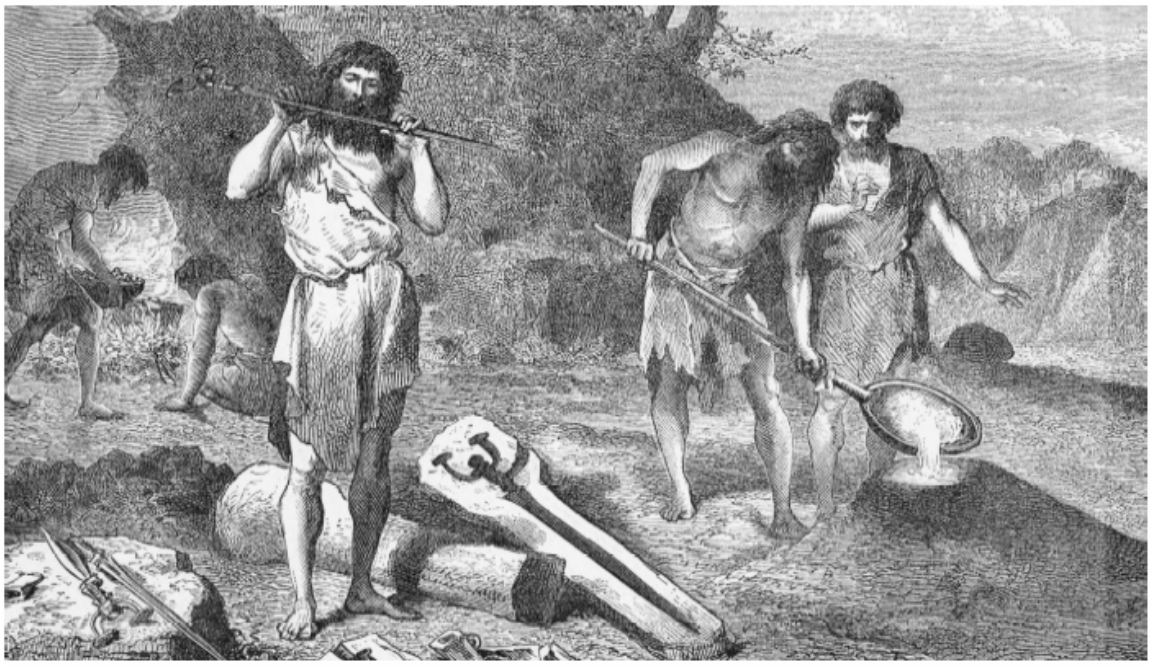

Figure 1
Skills, such as tool-making, enabled hunter-gatherers to move into environments unsuitable for their earlier ancestors.

Seeds and Breeds of Change

One of the most profound changes in human history came with the intentional planting of seeds and the beginnings of agriculture. In different places and at different times, humans discovered that certain plants and animals were ideally suited for cultivation and domestication (**Table 1**).

Table 1 Earliest Known Times and Locations of Domestication of Important Plant and Animal Species

Area	Domesticated		Earliest attested date of animal domestication
	Plants	***Animals***	
Independent origins of domestication			
Southwest Asia	wheat, pea, olive	sheep, goat, cow	8500 B.C. 6000 B.C.
China	rice, millet	pig, silkworm water buffalo	by 7500 B.C. 4000 B.C.
Ukraine/central Asia	none	horse	4000 B.C.
Mesoamerica	corn, beans, squash	turkey	by 3500 B.C.
Andes and Amazonia	potato, cassava	llama	by 3500 B.C.
eastern United States	sunflower	none	2500 B.C.
Sahel	sorghum, African rice	guinea fowl	by 5000 B.C.
tropical West Africa	African yams, oil palm	none	by 300 B.C.
New Guinea	sugar cane, banana	none	7000 B.C.

In Asia, native species of wheat and oats were first cultivated about 10 500 years ago. Within 1000 years, native species of rice were being domesticated in China, and 5500 years ago, corn was successfully cultivated in Mesoamerica. The most important examples of the domestication of animals include the following: sheep, goats, and pigs about 10 000 years ago in Asia; cattle 8000 years ago in Southwest Asia, India, and possibly North Africa; and the horse 6000 years ago in Eastern Europe.

The dramatic impact on human history of the adoption of agricultural practices cannot be overstated. Human populations dependent on the cultivation of plants were stationary. As a consequence, having large families was now possible. In addition, growing crops and raising livestock could support much higher population densities than hunting and gathering. Only a relatively small number of individuals were needed to plant, tend, and harvest the bulk of the food needed to feed a large population. This altered the pattern of life for most. Many people, freed from the need to obtain food for themselves and their families,

became specialized artisans, scholars, and merchants. Free time and a stationary dwelling allowed for major advances in technology. The combined effect of large food surpluses, stationary living, large populations, and specialization of the workforce led to the establishment of complex political organizations and the creation of large states.

The adoption of agricultural practices was neither uniform nor predictable. Indeed, the fate of much of human history has been a direct consequence of geographic accident rather than human planning. The geographic distribution of suitable wild plants and animals largely determined the regions in which agriculture would arise and where human societies would follow. The vast majority of wild plant and animal species are unfit for domestication (**Table 2**) and those that are fit are not uniformly distributed around the globe.

Table 2 Mammalian Candidates[1] for Domestication

	Continent			
	Eurasia	***Sub-Saharan Africa***	***The Americas***	***Australia***
Candidates	72	51	24	1
Domesticated species	13 (pig, goat, sheep, horse, cow, water buffalo, camels (2), donkey, reindeer, yak, guar, banteng)	0	1 (llama)	0
Percentage of candidates domesticated	18%	0%	4%	0%

[1] A candidate is defined as a terrestrial herbivore or omnivore with an average mass of 50 kg or more.

Almost half of the 148 large mammalian herbivore and omnivore species of Earth are native to Europe and Asia. Of these 72 species, 13 have been successfully domesticated. Of the remaining 76 species distributed among sub-Saharan Africa, the Americas, and Australia, only one, the llama, has been domesticated. In sub-Saharan Africa, of 51 candidate species, not a single mammal has been successfully domesticated. The vast majority of large mammals are simply unsuitable for domestication. Although many individual large mammals can been “tamed,” they are often difficult or impossible to breed in captivity, do not exhibit social behaviour suitable to “herding,” or are simply too dangerous. Grizzly bears for example, are mostly vegetarian, able to consume a wide variety of foods, and grow quickly. However, it is very unlikely that they will ever be reared in large numbers for food!

Table 3 World Distribution of Large-Seeded Grasses

Area	Number of Species
West Asia, Europe, North Africa	33 Mediterranean zone (32), England (1)
East Asia	6
sub-Saharan Africa	4
Americas	11 North America (4), Mesoamerica (5), South America (2)
northern Australia	2
Total	56

An uneven distribution is also the case for large-seeded grass species—such as wheat, rice, and corn—the plants most suitable for easy cultivation. **Table 3** shows the world distribution of 56 large-seeded grasses. These species have seeds that are 10 times larger than the average seed and account for less than 1% of the world's grasses. They are unevenly distributed, with much greater numbers occurring in the Mediterranean region. It is noteworthy that corn, domesticated in Mesoamerica, had a number of characteristics that made it particularly difficult to use as a food source and that might well account for the thousands of years that separate its cultivation from that of wheat and rice (**Figure 2**).

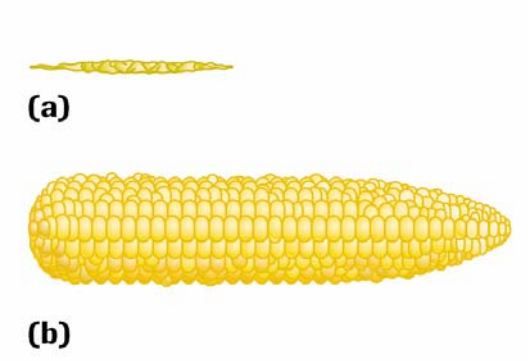

Figure 2
The probable ancestor of modern corn, teosinte grass **(a)** has a hard outer casing making it difficult to process as a food. Humans living in Mesoamerica bred this original grass into the useful crop plant corn (**b)**.

Thus, the geographic distribution of suitable plant and animal species largely determined which human populations had the opportunity to switch to an agricultural lifestyle. Even today, after thousands of years and many attempts, human populations remain almost entirely dependent on the same few food crops and domestic animals that launched our population boom: wheat, rice, and corn, and sheep, pigs, and cattle (see **Figure 3**). Although not used as a major food animal, the horse played a critical role as a mode of transportation and a source of power.

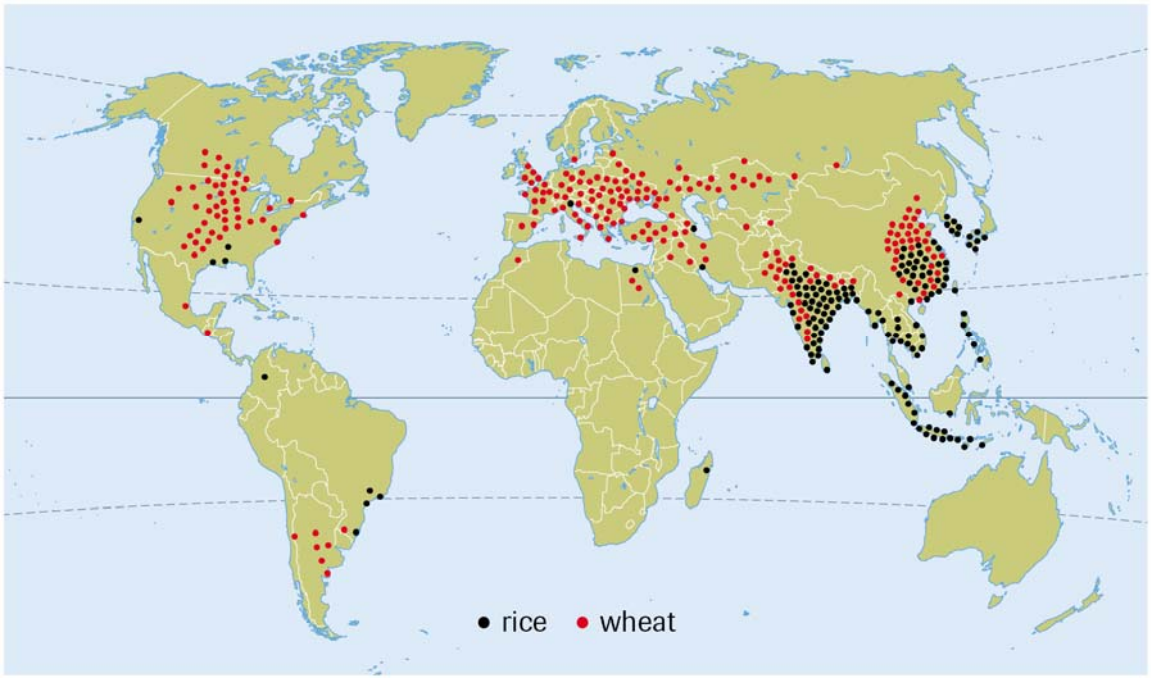

Figure 3
The two most important food crops, wheat (in red) and rice (in black), are produced in very large quantities in different regions of the world. Each dot represents an annual production of 2 million tonnes of grain. Today, wheat, rice, and corn (maize) provide more than 60% of the total food energy consumed by the world's population.

Not surprisingly, those human populations that experienced rapid growth based on large agricultural food surpluses began to spread out across the globe. In most cases, they brought their domesticated plants and animals and their technological innovations with them. A striking example of this was seen in North America where wheat, barley, and other crops, as well as cattle and pigs, arrived from Europe and became the dominant food sources for future generations. Often this was not to the benefit of the indigenous human populations, which were often displaced, or worse, by the invaders who brought not only assorted plants and animals, but also guns, steel, and germs.

The Impact of Disease

The establishment of large sedentary human populations has a profound impact on the evolution of pathogens. Many epidemic diseases—those capable of spreading rapidly through large populations and causing significant mortality—can only evolve where population densities are high. For example, recent studies indicate that the measles virus dies out in any human population numbering fewer than one half million. In addition, many of the epidemic diseases that have significantly reduced local populations, such as small pox, tuberculosis, and influenza, are believed to have been diseases of domestic animals that later evolved into diseases that could infect humans (**Table 4**). Epidemic diseases arose in regions of the world where human populations were dense and where animal domestication was widespread: Europe, North Africa, Southeast Asia,

India, and China. The best known example is the Black Death, or bubonic plague, caused by the bacterium *Yersinia pestis*. During the fourteenth century this epidemic spread from China to Europe resulting in millions of deaths. In turn, human populations continuously exposed to these diseases evolved some resistance.

Table 4 Probable Origins of Epidemic Diseases

Human disease	Animal with most closely related pathogen
measles	cattle (rinderpest)
tuberculosis	cattle
smallpox	cattle (cowpox) or other livestock with related pox viruses
flu	pigs and ducks
pertussis (whooping cough)	pigs and dogs
falciparum malaria	birds (chickens and ducks?)

When European explorers reached the shores of the Americas and made contact with populations of Aboriginal peoples, they brought with them many serious diseases to which the Aboriginals had little or no resistance. In many cases, large epidemics decimated Aboriginal populations. For example, in 1837, smallpox was introduced into a Mandan village and, within a few weeks, the population plummeted from 2000 to fewer than 40 individuals.
Although on a local scale tragedy and devastation were commonplace, on a global scale the human population was steadily increasing in size. In terms of sheer numbers, the global human population is thought to have increased to an estimated 300 million by A.D. 1 and, as agricultural practices continued to spread around the world, is thought to have reached 500 million by the year 1650.

The Impact of Science and Medicine
In the 17th century, science-based knowledge and technology started to become major influencing factors in European societies. Biology, chemistry and physics began to shed new light on the natural world. During a brief period of a few hundred years, our understanding of and interaction with the natural environment would be revolutionized. The cell and germ theories in biology would provide the foundation for modern medicine. Advances in chemistry and physics would permit the harnessing and conversion of fossil fuel energy into mechanical energy. The result was the Industrial Revolution, in which power-driven manufacturing resulted in the mass production of industrial and consumer goods. Further advances in chemistry led to the production of countless new compounds, including fertilizers, which further increased and intensified food production. The steam engine and, later, the internal combustion engine would provide unrivalled sources of power for industry and lead us into the modern world.

Although many of these changes would begin to have a negative impact on the environment, the most dramatic and immediate effect on human populations was the significant increase in food supply and the reduction in the number of people required to work the land. Populations became increasingly urbanized as tractors and trains replaced teams of men and horses. In addition, death rates dropped with improved access to safe drinking water, sewage systems, and the development and widespread use of vaccines. In this same few hundred years, Earth's population would double to 1 billion and go on to double once more in the following hundred years. Science and technology allowed humans to sidestep, at least temporarily, the natural limits to growth that had existed for millions of years. By the mid-twentieth century, humans had what seemed like unlimited access to energy, water, food, and mineral resources while, at the same time, modern medicine had dramatically reduced rates of mortality—most significantly, mortality due to infectious disease. The greatest effect was on the death rate of the very young, which decreased sharply. The human population explosion was under way, with the population doubling about every 50 years.

Summary

Humans have employed their tool-making skills to successfully inhabit almost every terrestrial environment on Earth.

• Approximately 11 000 years ago, humans began to cultivate food crops and domesticate livestock. Domestication first arose in those regions of the world that possessed ideally suited plant and mammal species. Many regions had few or no suitable candidates.

• Epidemic diseases evolved in large human populations. As these populations spread around the world, they carried these deadly diseases to other human populations, often with devastating consequences.

• Advances in science and technology revolutionized human understanding of biology, chemistry, and physics and lead to the Industrial Revolution and rapid progress in food production, sanitation, and medicine.

• These changes allowed humans to avoid the natural limits to growth that had existed for millions of years. The result has been a dramatic decline in death rates—particularly among the very young—and a rapidly growing human