A Global Environmental History

HUMANS VERSUS NATURE

DANIEL R. HEADRICK

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Humans versus Nature

Introduction

Global Environmental History

In 1928, John Widtsoe, director of the US Federal Bureau of Reclamation, wrote: "The destiny of man is to possess the whole earth; and the destiny of the earth is to be subject to man. There can be no full conquest of the earth, and no real satisfaction to humanity, if large portions of the earth remain beyond his highest control."[1]

Since Widtsoe wrote these words, the conquest of the Earth has proceeded apace. World population has more than tripled. Consumer goods are more plentiful, living standards have risen, and new technologies have transformed the lives of millions. Roads, railroads, airports, cities, and mines cover far more of the surface of the planet. Land once forested has been turned into pastures and farmland. Large parts of the oceans have been depleted of fish and polluted with trash and oil. The atmosphere contains more methane and carbon dioxide. And more species of wild animals and plants have become extinct or reduced to tiny numbers. The changes in the world since 1928 have largely been man-made, at the expense of wild plants and animals and natural landscapes.

Until recently, most people in the West applauded this achievement. After all, didn't it have divine sanction? As the Bible said, "And God blessed them, and God said unto them, Be fruitful, and multiply, and replenish the earth, and subdue it: and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth."[2]

Yet in recent decades, an increasing number of voices have decried the "possession of the earth" as an environmental crisis, marked by pollution, depletion of resources, deforestation, and the extinction of species. This raises the question: When did humans begin to damage the Earth; in other words, when did the "crisis" begin? Historians and scientists have answered this question in a variety of ways.

In 2000, Nobel Prize–winning atmospheric chemist Paul Crutzen and ecologist Eugene Stoermer coined the term "Anthropocene" to refer to the

era when humans began to have a major impact on the environment.[3] He argued that this era began with the Industrial Revolution of the late eighteenth century, "when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane." He even gave a specific date—1784—to coincide with James Watt's design of the steam engine.

Historian Stephen Mosely has argued that the root causes of the current crisis can be found back in the sixteenth century, when "the world of nature was reconceptualised as machine-like to meet the needs of an emergent capitalism. . . . [T]his new scientific worldview saw nature as dead matter for human utilisation."[4]

Going further back in time, medievalist Lynn White Jr. in a famous article entitled "The Historical Roots of Our Ecologic Crisis" argued that indifference to nature originated in early medieval Europe when "the distribution of land was no longer based on the needs of a family but, rather, on the capacity of a power machine [the eight-oxen plow] to till the Earth. Man's relation to the soil was profoundly changed. Formerly man had been part of nature; now he was the exploiter of nature." Behind the machine, White continued, was a new religious view of the world: "By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects."[5]

Long before the Middle Ages, environmental scientist Earle Ellis and his colleagues argued, "Relatively small human populations likely caused widespread and profound ecological changes more than 3,000 years ago."[6]

Taking an even wider chronological view, environmental historian Sing Chew claimed that "the history of civilizations, kingdoms, empires, and states is also the history of ecological degradation and crisis. Such a historical trajectory of human 'macro-parasitic' activity has occurred at the systemwide structural level for at least the last five thousand years."[7]

Finally, climatologist William Ruddiman traced the beginning of the human impact on the planet to the first farmers and herders of the Neolithic Age, some 10,000 years ago.[8]

What this debate shows is the very human, yet futile, custom of attaching dates to a long-term process. The human impact on the environment began in a very small way very long ago, but grew gradually—in fits and starts—until the eighteenth century, then began to rise ever more sharply at an accelerating pace until the present. What has changed over time was not the desire of humans to exploit their environments, but the technological

and organizational means they developed and employed against the rest of nature—and their consequences.

Humans and Nature

All living beings survive by extracting resources from their environments. In the process, they compete with other living beings: some flourish, some barely survive, and some become extinct. Yet nature has ways of preventing any one species from overwhelming and destroying the others. One way is by limiting the supply of resources available in a given environment. For each species, the environment's carrying capacity fluctuates widely, due to predation, diseases, climate change, and other factors. Lynxes survive by eating rabbits, so once they have decimated the rabbits in their area, many lynxes will starve, allowing the rabbit population to recover, followed by a recovery of the lynx population, and so on. Another way is by limiting the amount of resources any given creature can absorb at one time; a lion, having lunched on a gazelle, will take a nap in the shade of a tree, digesting his meal before undertaking another hunt.

Humans, however, continue to take resources from their environment long after their needs are met. In nineteenth-century America, hunters armed with rifles killed as many bison as they could, taking only their tongues, sometimes shooting them for the sheer pleasure of killing. Long before Europeans came with their rifles, American Indians stampeded herds of bisons over cliffs in order to take the meat from a few of them. Everywhere they went, Stone Age hunters exterminated many of the largest and fiercest animals that roamed the Earth. Since the appearance of *Homo sapiens*, the motivation to take as many resources from the environment as technology allows has been a human characteristic.

Much of history consists of humans' gradual acquisition of the means to realize their desires at the expense of the rest of nature. Humans have time and again found ways to overcome the limitations of their physical abilities through ingenious technological and organizational innovations, allowing them to thrive in almost every environment. Already in prehistoric times, they set fire to forests, drained wetlands, plowed the soil, domesticated plants and animals, and built elaborate irrigation systems. Most of these activities allowed more people to survive and reproduce, and later to create states and high cultures.

Despite many setbacks, human victories over nature have outnumbered their defeats. In modern times, as technological changes have accelerated, humans have acquired ever greater powers to transform the natural environment for their own benefit. Today, humans have the means to clear-cut entire forests, appropriate all accessible fresh water, change the climate, and "possess the whole earth."

Yet it would be wrong to think of the human impact on the environment in solely negative terms. Domesticated animals, as well as hangers-on such as roaches and sparrows, are far more numerous than they would be without us; the same is true of domesticated plants and weeds.

At the same time, the natural world still has agency and periodically disrupts the human urge to subdue, dominate, and possess. Droughts, floods, hurricanes, and other weather anomalies are reminders of this power. Volcanoes, earthquakes, and tsunamis wreak havoc. And periodically epidemics put entire populations at risk.

Some natural events that harm humans are themselves the unintended consequences of human actions. Burning fossil fuels emits greenhouse gases that cause global warming, and global warming in turn causes weather anomalies that affect human societies. New means of transportation allow diseases like cholera, SARS, and Zika to spread quickly. Antibiotics fed to farm animals encourage the emergence of antibiotic-resistant bacteria that endanger human health.

Finally, humans are highly dependent on the natural world—not just those parts of nature we have domesticated, but also those we have not: the forests that absorb carbon and emit oxygen; the wildernesses that offer respite from the stresses of civilization; and the myriad plants, animals, and microorganisms that promise scientific breakthroughs to benefit humanity. In other words, as ecologists stress, everything in nature, including humans, is interconnected and interacts in complex feedback loops.

This book examines these complex interactions between humans and the rest of nature. Two aspects particularly stand out. One is the human impacts on the rest of nature and how they have changed over time. The other is how nature, in turn, has affected humans and human civilizations, especially the "natural disasters" that have disrupted (and sometimes reversed) the advancing power of humans over the natural world. Examples of both kinds of interactions abound in the chapters that follow.

Chapters 1 through 3 are largely chronological, following the evolution of human societies from hunters and gatherers to farmers and herders and to

the first civilizations. Not all regions of the world went through all of these phases, and those that did followed the sequence at different times.

The first chapter relates the difficult and contentious relations between early humans and the environments in which they lived. Early humans were extremely vulnerable to the forces of nature and at one point almost went extinct. Yet their descendants migrated to every continent except Antarctica and learned to survive in environments for which their bodies were totally unsuited. Once arrived in a new environment, using only fire and simple handheld weapons, they exterminated numerous species of large animals as no creature had done before.

Chapter 2 describes the domestication of plants and animals that allowed the rise of two kinds of communities: settled agricultural villages and nomadic herding bands. In the process, humans changed landscapes by transforming forests and natural grasslands into farms and pastures. Though the human population increased, their health and stature declined, and new diseases appeared.

Chapter 3 recounts the appearance of complex hierarchical societies around the world. Remarkably, many early civilizations were organized around the control of water: irrigation, drainage, and the struggle against floods. Some societies were almost destroyed by droughts while others proved more resilient.

Starting in Chapter 4, the narrative takes a geographical turn as the history of the two hemispheres diverges. Chapter 4 describes how humans increasingly farmed on rain-watered lands and vastly expanded the area in Eurasia and Africa they occupied from the mid-second millennium BCE to the seventh century CE. But the increased contacts between large-scale societies made them vulnerable to pandemics, such as the plague.

The following chapter recounts the consequences of the Medieval Climate Anomaly (a particularly warm period from the eighth to the fourteenth centuries) for the development of large-scale societies throughout Eurasia and sub-Saharan Africa. In many parts of the Eastern Hemisphere, however, human encroachments on nature were reversed by the beginnings of the Little Ice Age and the calamity of the Black Death.

Chapter 6 describes the enormous biological changes that accompanied the opening of contacts between the Eastern and Western Hemispheres from the sixteenth to the eighteenth centuries. Diseases imported from Europe and Africa reduced the indigenous population of the Americas by nine-tenths or more, allowing the recovery of forests and wildlife. At the same time, the

Americas were invaded by Old World plants and animals, some of which went feral and dramatically changed the environments of the New World.

Chapter 7 looks at this period in the Eastern Hemisphere. Climatically, this was the Little Ice Age that precipitated major economic and political crises. The peoples of the Eastern Hemisphere survived the crisis (and in a few places even flourished) thanks to the bounty provided by New World crops.

Chapters 8 and 9 focus on industrialization and the sudden increase in the power of humans over nature that it provided. Its effects diverged sharply, with the Western nations as centers of power, and non-Western regions as objects of transformations imposed from outside.

Chapter 8 introduces the Industrial Revolution and its impact on the environments of two major industrializing countries. In both Great Britain and the United States, cities and industries expanded dramatically, polluting local air and water. The impact of American industrialization was especially severe and widespread, leading to the plunder of natural resources, the destruction of arable soils and forests, and the decimation or the extinction of several species of wildlife. At the same time, industrialization encouraged the population to grow fast and reduced people's vulnerability to natural shocks.

Chapter 9 looks at the non-industrializing part of the world, especially monsoon Asia in the same period. India, China, and Southeast Asia (but also Egypt and Brazil) were profoundly affected by Western industrialization, especially by the demand for tropical crops that led to a vast expansion of arable land at the expense of forests and their fauna and flora. Although the population of the affected regions increased, standards of living did not and people remained as vulnerable as ever to floods, droughts, and epidemics.

Two thematic chapters cover the twentieth century. Chapter 10 deals with the environmental impact of both world wars and conflicts such as the Vietnam War. It also discusses major development schemes, as in the Soviet Union, the United States, China under Mao, and Brazil, and the effect of these schemes and projects on forests, wildlife, and other environments. Chapter 11 looks at peacetime economies and the rise of mass consumerism and its environmental costs, especially the impact of automobiles, petroleum, and industrial agriculture. The areas covered include the United States, Western Europe, Japan, and China after Mao.

The next three chapters take up current environmental issues in their historical contexts. Chapter 12 describes the recent climate change and its

causes, as well as scientific predictions and possible future scenarios. It also discusses the politics of global warming, both nationally and internationally, and the public reaction to the issue and to the debates.

Chapter 13 goes underwater to reveal the impact of hunting on whale populations and the collapse of cod stocks through overfishing. It discusses the sustainability of salmon populations through farming and the control of wild salmon fishing. It also describes the impact of humans on the oceans in the form of dead zones, coral bleaching, and the accumulation of garbage.

Chapter 14 addresses the extinction of terrestrial species as a natural phenomenon, and with the five extraordinary mass extinctions in the history of the Earth, such as the one that wiped out the dinosaurs. We are currently witnessing a sixth mass extinction, this one caused by human beings through habitat destruction, hunting, and global warming, especially in the tropical rainforests and in the Arctic. The chapter also deals with the survival and multiplication of plants and animals selected and encouraged by humans, but also weeds, pests, and pathogens that benefit from unintentional human actions.

The last two chapters address responses to the current environmental crisis. Chapter 15 considers human attitudes toward nature. Traditional societies devised rules and taboos to protect aspects of the natural world that they valued, such as sacred woods or hunting preserves. While deeply held, these beliefs and behaviors slowed down, but never reversed, people's desire to use nature for their own benefit.[9] Since the nineteenth century, environmentalists have been decrying the damage that untrammeled development has inflicted on the natural environment. In recent decades, their voices have entered the political discourse. As a result, modern states have tried to mitigate the impact on the natural world through restrictions on pollution, laws to protect endangered species, national parks and wilderness areas, international agreements on fishing and whaling, and nuclear arms limitation treaties.

In the twenty-first century, humanity faces difficult decisions, as discussed in the Epilogue. The need to protect what is left of the natural environment is clear. At the same time, the pressure to continue along the path of expansion and development is more powerful than ever. We humans have now outsmarted all other living beings and taken over much of the planet. Yet we march backward into the future, blind to what is to come. What can the story of the past teach us about ourselves and how we should interact

with the planet we live on? Will technological breakthroughs allow us to continue enjoying the benefits of past innovations while mitigating the harm they have inflicted on the environment? As we take ever greater control over the Earth as though it were the Planet Machine, will we operate it with wisdom, restraint, and balance, qualities humans have so seldom displayed in the past?

1
The Foragers

It is tempting, looking back at the history of humanity, to believe that it was our destiny—by divine right or because of our superior intelligence—to become the dominant species on Earth. Yet, 200,000 years ago, when the first *Homo sapiens* appeared, there were other members of the genus *Homo*—*Homo erectus*, Denisovans, Neanderthals, to name a few. One by one, they went extinct, and only *Homo sapiens* survived. It is by chance that we survived while other species died out.

Yet humans differed from other species of the genus *Homo* from very early times. Even as they lived at the mercy of natural forces, they also began transforming their environments in ways no other species did. At a site in the Czech Republic, archaeologists found the bones of a thousand mammoths killed by humans. At sites in Colorado and Wyoming, they found the remains of herds of bison stampeded over cliffs. And in New Zealand, hundreds of thousands of skeletons of moas—gigantic flightless birds—were found near Maori hunting sites.[1] In many parts of the world, humans killed large numbers of great animals, some of whom went extinct soon after humans arrived on the scene. Humans also transformed plant life, either directly by setting fire to forests to encourage open grasslands, or indirectly by killing the animals that kept certain plants in check. In short, *Homo sapiens* caused major changes in the environment almost as soon as they appeared on Earth.

Homo Erectus

The designation *Homo* is an honorific bestowed upon a genus of bipedal animals by those of us who call ourselves *Homo sapiens*, or knowing man. Between australopithecines and ourselves were many hominid species. Most went extinct, but one lineage survived to become the ancestors of *Homo* sapiens. The most recent of our now-extinct ancestors were creatures we call *Homo erectus* ("standing man"), a species that appeared in Africa between 1.9 and 1.6 million years ago.

Unlike earlier hominins who spent part of their time in trees, *Homo erectus* were full-time ground dwellers. Their teeth and jaw muscles were smaller than those of their predecessors, too small to chew raw meat efficiently. They had a smaller gut than earlier hominins, indicating that they did not need to spend as much energy and time digesting as other carnivores. They may also have lost the fur that covered other primates and instead developed sweat glands that allowed them to spend long stretches under the hot sun. Their brain volume measured up to 950 cubic centimeters, two-thirds the size of ours. Such a brain required a lot of energy, which they obtained from a diet that included meat.[2]

With a larger brain came better tools. Because the only tools that have survived were those made of stone, archaeologists call this period of prehistory the Paleolithic, or Old Stone Age. Earlier hominins, as far back as the australopithecines 3 to 4 million years before, had made rough choppers by breaking a piece off a cobble, leaving a sharp edge. *Homo erectus* were able to obtain 60 centimeters of cutting edge from a kilogram of flint, four times more than previous hominins. They created a tool kit consisting of stones carved to form hammers, cleavers, or choppers, along with the associated flakes.[3] Such tools remained in use, with some refinements, for a million years. In addition, *Homo erectus* almost certainly used wooden sticks or, in East Asia, bamboo, though evidence thereof has long since perished.

Homo erectus were the first hominins to migrate out of Africa, probably following herds of herbivores seeking better grazing lands during a dry period some 1.8 million years ago.[4] In many places, they joined the ranks of the dominant predators. In Africa, they displaced sabertooth cats and the remaining australopithecines.[5] Archaeologists have found remains of *Homo erectus* and the animals they killed in China, the Caucasus, Hungary, Java, Spain, and France, as well as Africa. At two sites in Spain, Torralba and Ambrona, they found the bones of thirty elephants, as well as deer, aurochs (wild cattle), and rhinoceroses. That does not mean that *erectus* attacked such large and dangerous prey in the open; they killed and butchered animals mired in a swamp.[6]

Fire and Food

What most sharply distinguished *Homo erectus* from all other creatures was their systematic use of fire. According to some anthropologists, direct

physical remains of their fires, such as charcoal, burned bones, and hearths made of stones, occur at Bouche de l'Escale in France, dated between 350,000 and 250,000 years ago, followed by Vertesszölös in Hungary and Terra Amata in France around 250,000 years ago and by 150,000-year-old ash deposits in Hayonim Cave in Israel. Traces of fire become more numerous after that, both in western Europe and in China; after 110,000 years ago, there are abundant remains.

Earlier hominins may have made use of natural fires started by lightning. Archaeologists have found burned seeds, wood, and flint at Gesher Benot Ya'akov dating back at least 790,000 years.[7] In addition, according to anthropologist Richard Wrangham, there are "provocative hints" of fire control at two sites in Kenya—Chesowanja dating back 1.42 million years and Koobi Fora from 1.5 million years ago—and more definitive evidence of human control of fire at Swartkrans, South Africa, 1 million years ago.[8] These findings remain controversial, however.

This does not mean that *Homo erectus* knew how to start a fire. As recently as the early twentieth century, some of the indigenous people of Tasmania and the Andaman Islands knew how to keep a fire going but not how to start one. More likely, *Homo erectus* found natural fires caused by lightning and used a burning branch to set fire to other wood. These activities—seizing a burning branch, carrying it to a safe place, collecting firewood, and feeding the fire—had to be learned over thousands of years.[9]

Wrangham argues that besides the physical remains of fires, there is other evidence that *Homo erectus* used fire. Kill sites prove that *Homo erectus* ate meat. Yet their small teeth, jaw muscles, and guts could not efficiently chew or digest raw meat. Therefore they must have roasted it. Tubers and roots also needed to be cooked to make them edible by softening them or removing toxins. Hence they must have used fire systematically.[10]

Control of fire had other consequences. It scared away other animals, making it possible for *Homo erectus* to spend the night on the ground, safe from nocturnal predators and snakes. They may have used fire to harden the points of wooden spears or objects of bone. Having lost their body hair, they needed fire to keep warm at night, especially in cooler regions like Europe and China.[11] Keeping a fire going and sitting around it at night may also have helped them socialize and communicate, maybe even take the first step toward language.[12]

Possession of fire provides a clue as to the evolution of *Homo erectus*. Climate change probably played a role, but it is more likely that fire was the

determining factor. While the ancestors of *Homo erectus* ate their food raw, a few may have chanced upon meat or tubers roasted in a natural fire, or may accidentally have dropped a piece of meat or a tuber into a fire and found the results delectable enough to try again. Armed with this new method of preparing food, those willing to approach fires may have become more successful hunters, been less often the victims of predators, and seen more of their children survive. Eventually, the fire users predominated over the others, and their descendants developed jaws and guts adapted to their new diets.

Fire control also challenged their brains, for the use of fire gave an advantage to those with bigger brains, whose offspring then survived in larger numbers than their smaller-brained counterparts. If so, it was the first instance of cultural evolution preceding, even causing, biological evolution. In Wrangham's words, "The reduction in tooth size, the signs of increased energy availability in larger brains and bodies, the indication of smaller guts, and the ability to exploit new habitats all support the idea that cooking was responsible for the evolution of *Homo erectus*."[13]

Did the appearance of *Homo erectus* also transform the environments in which they lived? Forest historian Michael Williams thinks so: "With fire humans accomplished the first great ecological transformation of the earth." But that transformation came later, for other scholars have found no evidence of environmental changes caused by *Homo erectus.* They may have been human, but they were not human enough to transform the natural world in which they lived.[14]

From *Erectus* to Neanderthals

Some 600,000 years ago or more, a new creature, *Homo heidelbergensis*, appeared in Africa, probably descended from African *erectus*. Its brain, measuring about 1,200 cubic centimeters, was close to that of *Homo sapiens*. It too migrated out of Africa, reaching Europe half a million years ago. Most anthropologists believe that it was the ancestor of *Homo neanderthalensis* (in Europe and the Middle East) and *Homo sapiens* (in Africa).[15]

Until they vanished 28,000 years ago, Neanderthals inhabited Europe and much of the Middle East. They were short (1.67 meters on average), stocky, and barrel-chested. They weighed, on average, 76 kilograms, considerably more than most humans before the twentieth century.[16] Their bones, heavier

than those of modern humans, supported powerful muscles. At 1,300 cubic centimeters, their brains were larger than those of modern humans. Their genes and vocal tract indicate that they were able to articulate more sounds than any earlier hominin, although we do not know whether they had a vocabulary. These were not the simpletons depicted in cartoons but humans like us, albeit built like weightlifters.

The reason for their squat, muscular bodies is that they evolved in Eurasia during the Ice Age, when temperatures were much lower than today. Theirs was a case of successful biological evolution, though they probably also draped themselves in animal pelts to keep warm. They made a variety of stone flake-tools such as spear points and curved scrapers, which remained much the same for over 5,000 generations.

Where they differed from later *Homo sapiens* is that Neanderthals were big-game hunters. Maintaining their muscular bodies in frigid weather required a diet of 5,000 calories a day. Analysis of their teeth shows that this diet consisted largely of meat. To obtain enough, they hunted relentlessly. Wielding spears and clubs, they attacked large animals at close quarters, such as woodland elephants, red deer, wild boar, and bears. This was a dangerous way of life, as shown by the fractures found on many of their remains. But they took care of the injured, the handicapped, and the elderly. They buried their dead. All their campsites show signs of fire, even stone firepits. In winter they retreated into caves and rock shelters. In short, they were specialists in an age of ice.[17]

What Makes Us Human

Meanwhile in Africa other descendants of *Homo heidelbergensis* had become recognizably the ancestors of *Homo sapiens*. These new creatures were creative and imaginative; used language and symbolic thought; shared their knowledge and passed it on to younger generations; relied on tools and other devices in almost everything they did, and changed them with increasing frequency; and, rather than adapting to their environments as Neanderthals did, began to change the environment to meet their needs. With an intelligence far greater than they needed to survive, they often overshot the mark, hunting other animals to extinction, pushing beyond the carrying capacity of their environment, eventually enslaving and murdering each other in huge numbers.

Homo sapiens

The earliest known remains of *Homo sapiens*, recently discovered in Morocco, date back between 300,000 and 350,000 years ago.[18] Other remains, discovered in Ethiopia, date back some 195,000 years. Analysis of mitochondrial DNA shows that all humans can trace their ancestry back to a single woman who lived between 200,000 and 95,000 years ago. Similarly, recent analyses of Y-chromosomes, transmitted from fathers to sons, show an early male ancestor at about 200,000 years ago. These estimates will certainly be revised as the technology of genetics improves.[19]

A question that has been much debated is whether the earliest *Homo sapiens* were only anatomically, or also behaviorally and intellectually, like humans today and, if so, when they began to exhibit modern behavior and symbolic thought. Until recently, archaeologists associated modern behavior with the cave paintings and other symbolic artifacts found in Europe dating to 40,000 years ago. These findings led scientists to believe that a dramatic increase in intelligence, creativity, and culture took place in Europe at that time, but they have now been discredited, thanks to recent archaeological evidence that the transition to modern behavior and symbolic thinking began in Africa long before anywhere else.[20]

During a cold and arid period that lasted from 195,000 to 90,000 years ago, a small number of *Homo sapiens*, perhaps only a few hundred, found shelter in caves on the coast of South Africa. Excavations at Pinnacle Point show evidence of human habitation between 164,000 and 35,000 years ago. The inhabitants of these caves survived by eating shellfish as well as whales and seals washed up on the shore. They probably also harvested tubers. They attached stone points onto spears with tree sap and other sticky substances; if so, these are the oldest composite tools known. To prepare stones, they heated them in a fire, a technique used sporadically at Pinnacle Point as early as 164,000 years ago, and consistently from 72,000 years ago.[21]

People who lived at Blombos Cave 100,000 years ago used to pound and grind red ochre and abalone shells, then mixed the powder with bone marrow and charcoal, perhaps to decorate their bodies. These objects, of no immediate practical use, are evidence of a higher level of symbolic thinking.[22]

Further evidence of modern behavior, such as perforated seashells probably used as beads, have been found in South Africa, Algeria, Morocco, and Israel perhaps as far back as 135,000 years ago, but certainly 70,000 to 80,000 years ago. More practical objects, such as spearhead points meant

to be attached to wooden handles and intentionally marked ostrich shells, have also been found in South Africa.[23] Barbed harpoon points found in the Democratic Republic of the Congo date back 80,000 years. *Homo sapiens* also killed and butchered zebra and Cape warthog, animals previously too dangerous to hunt. These objects and behaviors show a sophistication unknown among earlier hominins.[24]

Nonetheless these advances did not lead right away to a flowering of new cultures because humans at the time were so few in number and so widely scattered. As archaeologist Chris Stringer explains: "It is as if the candle glow of modernity was intermittent, repeatedly flickering on and off again. Most of the suite of modern features does not really take root strongly and consistently until much later, close to the time when humans began their final emergence from Africa about 55,000 years ago."[25]

Bottleneck and Exodus

Like *Homo erectus, Homo heidelbergensis*, and Neanderthals before them, *Homo sapiens* migrated from Africa in search of resources as soon as environmental conditions permitted.[26] At Jebel Faya on the east coast of Arabia, archaeologists have found stone tools dated about 125,000 years ago that are similar to those used by *Homo sapiens* in Africa around the same time. At the time, with the most recent ice age at its peak and the oceans at their lowest level, the Straits of Bab el-Mandeb that separate Eritrea from Arabia were at their narrowest and the climate of Arabia was wetter than it is today.[27] After that, the next *Homo sapiens* remains outside of Africa were found at Skhul and Qafzeh in Israel, dated between 80,000 and 110,000 years ago, near Neanderthal artifacts using the same Mousterian technology.[28]

No sooner had *Homo sapiens* shown the ability to think in symbols and travel the world than they almost vanished. Their population, which geneticists estimate at some tens of thousands of members 100,000 years ago, crashed. How low it fell is a matter of much speculation: "a few thousand, perhaps even a few hundred, members," according to Ian Tattersall; "a few thousand breeding pairs," according to Kate Ravilious; "as low as ten thousand individuals," according to Jonathan Wells and Jay Stock; "no more than a mere two thousand people," according to Spencer Wells.[29]

The most likely cause of the crash was the eruption of the volcano Toba in Indonesia sometime between 75,000 and 71,000 years ago. This was the

largest natural disaster since the Chicxulub asteroid hit the Earth 65.5 million years ago and exterminated the dinosaurs.[30] Toba expelled 2,800 cubic kilometers of magma and sent 800 cubic kilometers of ash into the atmosphere.[31] It deforested most of Southeast Asia and covered much of India with a layer of ash. It caused six years of winter throughout the Northern Hemisphere, followed by a thousand years in which the temperatures remained lower than during the worst of the Ice Age, decimating the flora and fauna and causing widespread famine. *Homo sapiens* living in Arabia and the Middle East died. Others found refuge in equatorial Africa, southern India, and the Malay Peninsula, but in greatly reduced numbers; the Neanderthals migrated to Europe.[32]

Once the volcanic cold abated, the remaining *Homo sapiens* in Africa began to multiply again and seek new lands. With the return of warmth and vegetation, descendants of the survivors increased in numbers. Those who survived the catastrophe were the toughest, most energetic, and most adaptable of their species. Between 65,000 and 45,000 years ago, some of them ventured out of Africa, carrying with them more complex and effective tools than their predecessors had, including composite weapons and sharper spearheads.[33] From analyzing the DNA of different peoples around the world, geneticists have determined that the number of emigrants was tiny: "at most 550 women of childbearing age, and probably considerably fewer" according to Vincent Macaulay; "at most a few hundred colonists" according to Paul Mellars.[34]

For a long time, it was believed that they could have left Africa only by walking down the Nile Valley, across the Sinai Peninsula, and into western Asia. Increasing evidence now points to a more likely route across the Straits of Bab el-Mandeb to Arabia. Even during the Ice Age, when the sea was at its lowest and the straits at their narrowest, this would have required a boat or a raft. Once having mastered that technology, the pioneers and their descendants could have followed the coasts of Arabia, India, and Southeast Asia. This route had the advantage of a warmer climate than the interior of Eurasia during the Ice Age. Unfortunately for archaeologists, the sea level has since risen, obliterating their campsites.[35]

From the small number of survivors grew the humanity we know today. Until about 12,000 years ago, it grew exceedingly slowly, for foragers deliberately kept their numbers low. They did so by avoiding sexual intercourse as long as a woman was nursing her child, which took up to three years; as a result, the average time between births was four years. Foragers also

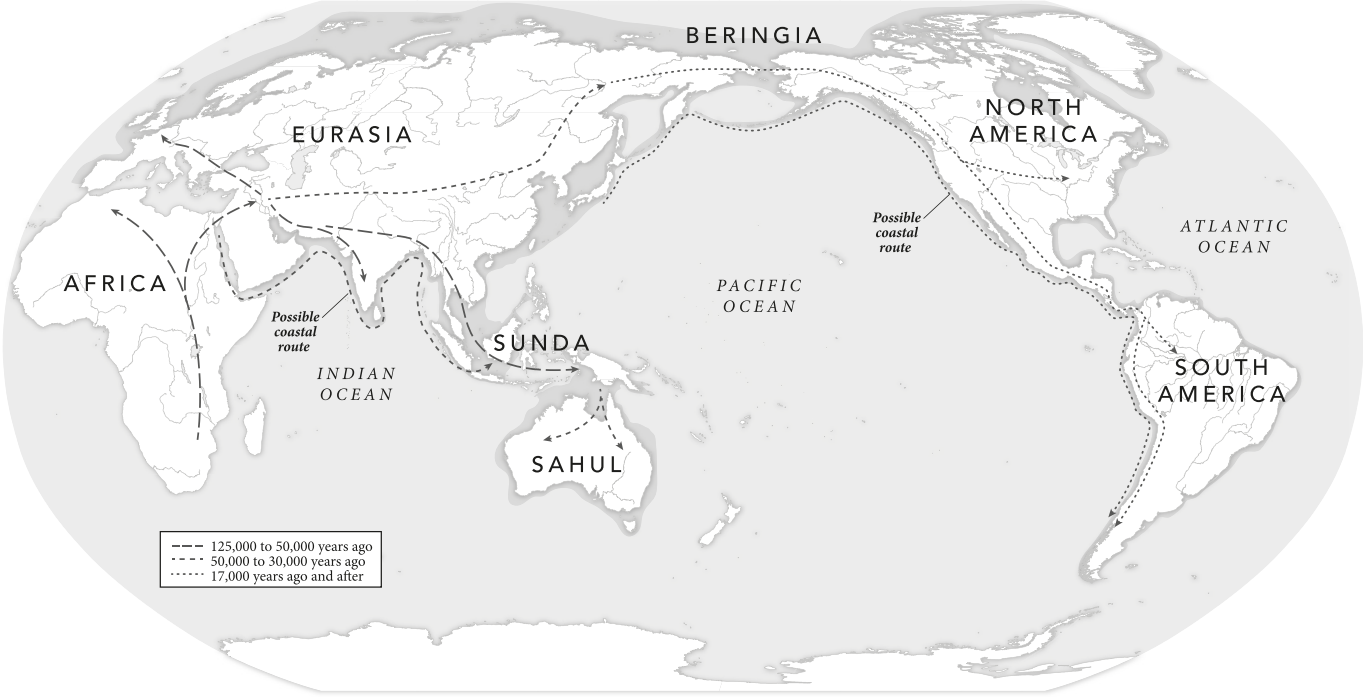

Figure 1.1. Map of migrations of *Homo sapiens* from Africa to Eurasia, Sahul, and the Americas.

practiced abortion, infanticide, and the elimination of the handicapped and the severely injured who could not keep up with the frequently moving band. They took all these measures to avoid exhausting the resources on which their survival depended. This is not to say that late Paleolithic foragers led healthy lives. Hunting big game was very efficient in terms of calories of food gained per hour of labor, but it entailed serious risk of death or injury. By constantly moving, foragers were relatively free from parasites; the exceptions were those who risked trichinosis by eating the meat of bears and wild boars. However, they all suffered from a number of chronic diseases that could persist even in small hunting bands, such as yaws, salmonella, herpes, staphylococcus, and streptococcus. According to anthropologist Mark Nathan Cohen, the population of Paleolithic foragers grew very slowly; at a rate of 0.01 percent a year, it doubled about every 7,000 years.[36]

Diaspora And Extinctions

From these small numbers came the population of the world outside of Africa. Wherever they went, they changed the environments they occupied. In particular, these intelligent, well-armed humans proved more than a match for all the other large animals they encountered. In 1876 the noted biologist Alfred Wallace wrote:

> We live in a zoologically impoverished world, from which all the hugest, and fiercest, and strangest forms have recently disappeared; and it is, no doubt, a much better world for us now that they have gone. Yet it is surely a marvelous fact, and one that has hardly been dwelt upon, this sudden dying out of so many large Mammalia, not in one place only but in over half the land surface of the globe.[37]

How did this happen, and what role did *Homo sapiens* play in this "marvelous fact"? Where *Homo sapiens* diverged from earlier species is the impact they had on the environments they inhabited. All other creatures found a niche to inhabit, subject to the forces of nature, as did *Homo sapiens* in Africa before and during the volcanic cold spell. When they left Africa, however, they began to transform their new environments, sometimes for their own benefit, but often in ways that backfired.

The first immigrants into a formerly human-free environment often found what must have seemed like infinite resources there for the taking. Unrestrained by resource scarcities or predators, they lived richly and multiplied—for a while at least. Once they had depleted the landscape, a period of disillusionment and recrimination must have followed. After this, some, as in Australia, reached a sustainable relationship with the now-depleted environment. Others, elsewhere, developed new technologies that allowed them to exploit new resources.

We now know what Wallace could only speculate about. Australia lost 86 percent of its megafauna (animals with an adult weight of over 44 kilograms); South America lost 80 percent; North America lost 73 percent; and Europe lost 14 percent. Among mammals, the extinction rates are even starker: 94 percent in Australia, 73 percent in North America, 29 percent in Europe, and 5 percent in Africa.[38] The enormous contrasts between these rates of extinction reflect the kinds of animal *Homo sapiens* encountered, but, more important, the reactions of these animals to humans. Where animals had long been in contact with hunter-gatherers of the genus *Homo*, as in Africa and (to a lesser degree) in Europe, they were wary, hence better able to survive. Where they encountered humans for the first time, as in Australia and the Americas, they were naive and trusting, and more easily killed.

What caused these extinctions is the subject of intense controversy. Two hypotheses—climate change and human predation—have been proposed, while some scholars suggest that it was a combination of the two that drove so many large animals to extinction. The combination of human predation and climate change applies best to North America, where the extinctions took place at a time of rapidly fluctuating climate. Elsewhere, the extinctions occurred at times—from 35,000 years ago or more in Australia to less than 800 years ago in New Zealand—that rarely coincided with a major change in the climate. Furthermore, the animals in question had survived repeated climate changes over thousands of millennia. Unlike earlier mass extinctions that affected animals of all sizes, the more recent extinctions affected only large animals.[39]

Finally, there is the coincidence that these large animals died at about the same time that humans entered their environments. So we cannot exonerate *Homo sapiens*. Yet hunter-gatherers were thinly scattered on the ground; geographer Ian Simmons estimates that in Upper Paleolithic Europe there may have been one for every 10 square kilometers, in Australia as few as one per

250 square kilometers, and globally one per 25 square kilometers.[40] How could so few hunter-gatherers have exterminated entire species of animals? To understand this, we must look at the human migrations out of Africa after Toba and their impact on the megafauna of the regions they invaded.

Australia

Until recently, archaeologists believed that the earliest humans reached Australia between 46,000 and 42,000 years ago, long before they reached Europe, despite its far greater distance from Africa. Newer research, however, showed that humans inhabited the arid interior of the continent as early as 49,000 years ago.[41]Among the migrants who left Africa, those who crossed the Red Sea at the straits of Bab el-Mandeb were able to continue along the Indian Ocean coast, surviving on fish, mollusks, seabirds, turtles, and seashore vegetation until they reached Indonesia. Archaeologists have found evidence of humans in the Malay Peninsula before the Toba eruption.[42] Even at the height of the Ice Age, there was still a 100-kilometer stretch of open water between Sunda (a continent that included Southeast Asia and most of Indonesia) and Sahul (a continent that included New Guinea and Australia). Having learned to build seaworthy rafts or boats, *Homo sapiens* finally reached and colonized Sahul. This was evidently a brief episode, for the indigenous peoples of these lands share genetic markers found nowhere else, showing that they did not return to Sunda. All evidence of navigation and coastal life disappeared under water when the Ice Age ended and the seas rose.[43]

Before humans arrived, Australia was a different world from the other continents. It had been separated by seas from Eurasia and the Americas for so many millions of years that the plants and animals that evolved there were quite unique; for instance, in place of placental mammals, there evolved marsupials like kangaroos that continued their gestation in an external pouch, or monotremes like platypuses that laid eggs but nursed their babies after they were hatched.

Many Australian animals were also very large. Three species of marsupials, including *Diprotodon*, a wombat the size of a rhinoceros, weighed up to 3 tons. *Procoptodon* was a 250-kilogram, 3-meter-high kangaroo. There were enormous flightless birds, such as *Dromornis* that stood 4 meters tall and weighed up to 500 kilograms and *Genyornis*, over 2 meters tall and weighing

220–240 kilograms. A reptile named *Megalania* was over 7 meters long and weighed up to 1,950 kilograms.[44]

Australian Extinctions and Environmental Changes

To the first humans who landed in Australia, these animals must have seemed not only strange, but tame, for they had no reason to fear humans. As late as 1802, there were still emus, wallabies, wombats, and elephant seals on islands off the southern coast of Australia that Aborigines had evidently never visited, for the first European visitors had no trouble catching (and exterminating) them.[45]

After humans arrived, fifteen out of sixteen species of large mammals, or nineteen out of twenty species including large birds and reptiles, vanished. Numerous smaller animals also went extinct around the time that humans arrived or soon after. All in all, sixty species of vertebrate animals went extinct. Whether humans caused their extinction, or merely witnessed it, is still controversial.[46] Ecologist Tim Flannery is convinced that "the weight of evidence is now clearly in favour of a very rapid, human-caused extinction for the Australian megafauna."[47] However, archaeologist Donald Grayson calls the idea that humans hunted these animals to extinction "even more speculative than it is in North America."[48] So far, archaeologists have found no butchering sites, bones with butchering marks, or other evidence of human killing. However, it is not necessary to believe that humans killed all the large animals they encountered. Almost all large animals breed slowly and have very few offspring. By killing a few breeding females, hunters lowered their birth rate below their natural death rate, until there were none left. Furthermore, there is proxy evidence of their extinction in the form of spores of the fungus *Sporormiella* that reproduces by being ingested and excreted by large herbivores. Around 41,000 years ago, these spores disappeared—evidence that their hosts had also disappeared.[49]

Not all large animals became extinct, of course. Those that are left—kangaroos, wallabies, walleroos, and quolls (small carnivorous marsupials)—are smaller than their pre-human ancestors because hunters killed off the larger ones. Small animals (up to 5 kilograms) did not shrink. Humans migrated to Australia several times before Europeans arrived. On one such migration, some 3,000 or more years ago, they introduced the dingo, or wild Australian dog, causing the extinction of the thylacine, a carnivorous

marsupial in Australia, although a small number survived in Tasmania until the twentieth century.[50]

The disappearance of the largest animals had ripple effects throughout the Australian biota. Big herbivorous animals kept the soil fertile by recycling the nutrients in the vegetation they ate. Fires burned more fiercely because, in the absence of large herbivores, the vegetation they would have eaten was left to accumulate and, when lightning struck, it burned uncontrollably. Without herbivores to recycle the nutrients in plants, fires impoverished the soil, turning the carbon in plants into carbon dioxide in the atmosphere and leaving the ground open to erosion. As they burned, fire-sensitive plants were replaced by fire-promoting ones like eucalyptus.[51] In Flannery's view, "fire has made Australia—originally the most resources-poor land—an even poorer one."[52]

Eventually, after the largest animals were gone, the ancestral Aborigines adapted to their new homeland. Abel Tasman, the first European to see Tasmania in 1642, noted fire and smoke all along the coast. What he saw was "firestick farming," fires deliberately set by the inhabitants before so much dead vegetation accumulated that natural firestorms would burn out of control. This burning also encouraged the growth of new grass and encouraged the population of kangaroos, bandicoots, and wallabies that were the Aborigines' main food source. On the Cape York Peninsula, their fires stimulated the growth of fire-resistant cycad trees that produced edible kernels.[53] The inhabitants also set aside "story places," off-limits to humans, where favored game animals like tree-kangaroos could reproduce and then repopulate nearby hunting grounds.

Thus did the Aborigines of Australia learn to survive for tens of thousands of years in an unpredictable environment, living in small numbers close to the carrying capacity of their arid land and devoting much time to cultural activities and to maintaining social relationships over long distances. To Nicholas Wade, they "settled into a time warp of perpetual stagnation." To Tim Flannery, this demonstrates the sustainability of their way of life.[54]

Homo sapiens in Eurasia

From the Middle East, some *Homo sapiens* made their way to Central Asia, Europe, and Siberia between 40,000 and 35,000 years ago, to East Asia some 35,000 years ago, and by land to India around 30,000 years ago. Whether any

Homo erectus were there to receive them or had long since vanished is not known. At the same time, others migrated to Europe, becoming the ancestors of today's European population.[55]

Eurasia at the time was in the midst of the Ice Age. Ice sheets covered the northern half of the continent, tundra and steppe covered the southern half. This vast open grassland was home to herds of reindeer, bison, antelope, and wild horses, but also to solitary animals like wooly mammoths and wooly rhinos. Though cold and windy, it was a hunter's paradise.

Then the climate turned even colder, reaching the Last Glacial Maximum between 26,000 and 19,000 years ago. Ice sheets covered Scandinavia and Scotland and the northern half of Germany and France, while alpine glaciers covered Switzerland, Austria, northern Italy, and parts of southern France. South of the ice, arctic conditions prevailed. With a sixty-day growing season, only the hardiest grasses, mosses, and lichens could survive. Dry dusty winds whipped across the treeless land. Then, 18,800 years ago, the climate began to warm, fluctuating quickly between warm and cold until 12,700 years ago.[56] In this rapidly changing environment, *Homo sapiens* flourished.

The first *Homo sapiens* in Europe, called Cro-Magnon, are famous for their cave paintings representing the mammoths, reindeer, bison, horses, lions, and other dangerous animals that they hunted, for their relationship with the animals in their world was filled with symbolism and spirituality. Just as astonishing were their technology and their customs. Instead of using the same hand axes that earlier *Homo sapiens* and Neanderthals had used for hundreds of thousands of years, the Cro-Magnon devised new tool kits, changing them periodically. Their earliest tool kit, called Aurignacian, lasted from 40,000 to 28,000 years ago and included carved bone and antler and oil lamps to light the way in the caves in which they painted; they also used throwing spears rather than the handheld lances of their predecessors. The next, known as Gravettian (28,000 to 22,000 years ago), involved carved "Venus" figurines as well as elaborate burials. During the Solutrean period from 22,000 to 17,000 years ago, craftsmen heated rocks and used a pressure-flaking technique to produce bifacial points, tanged spearheads, and flint knives and saws. Finally, the Magdalenian period from 18,000 to 10,000 years ago saw the introduction of spear-throwers and bows and arrows, as well as elaborate carvings on bone and antler. Out of a core of flint, these inhabitants made blades, chisels, scrapers, and microliths, tiny sharp shards embedded in spear or arrow shafts. They also carved flutes and made harpoons and fish traps. In short, the Cro-Magnon were creative and sophisticated people.[57]

Since they flourished during the Ice Age, their most important invention may well have been the needle. The earliest one found, in Russia, is dated at 40,000 years ago. With needles and sinew the Cro-Magnon—or more likely Cro-Magnon women—could sew fitted garments of animal pelts that protected wearers from the cold. Geneticists have uncovered other evidence for the appearance of fitted clothing: body lice (*Pediculus humanus corporis*) that live in clothing.[58]

With fitted garments, *Homo sapiens* ventured out onto the steppes of eastern Europe and central Asia, a land without trees or caves and with few edible plants, places so cold that even Neanderthals avoided them. *Homo sapiens* reached Lake Baikal in Siberia 30,000 to 35,000 years ago. Their diet was mostly meat, some of which they stored frozen in underground pits during the winter. For shelter, they dug substantial houses into the ground and covered them with mammoth bones and animal skins or sod, as archaeological excavations in Ukraine have shown. For fuel, they burned animal bones. Thanks to their culture and ingenuity, they flourished in environments for which their bodies were totally unsuited. During the Last Glacial Maximum, when conditions got too harsh even for them, they retreated to the lands closer to the Mediterranean. But after it passed, they moved back north and east, reaching Beringia, the land bridge that connected Siberia and Alaska when the seas were lower, 28,000 years ago.[59]

How can the extraordinary efflorescence of human culture and technology in Upper Paleolithic Eurasia be explained? Thousands of years earlier, *Homo sapiens* in Africa had demonstrated the capacity for symbolic thought, language, and the ability to adapt their technology to changing conditions. If neither brains nor language were the crucial factors, the efflorescence may have been a response to the climate. Africa also underwent climatic changes—sometimes cooler and drier, sometimes warmer and wetter—but humans there were able to adapt to these shifts without radically changing their behavior. The natural conservatism of hominins, so amply demonstrated over the previous millions of years, still sufficed for survival and reproduction, and humans could occasionally experiment with new behaviors and cultural expressions without introducing major changes in their way of life. No doubt, further archaeological research will narrow the gap between our knowledge of Middle Stone Age Africa and that of Upper Paleolithic Eurasia.

In Eurasia, Neanderthals had adapted to the glacial climate of the Ice Age, physically by becoming stockier and more powerful, and culturally by

building fires and wrapping themselves in animal skins. *Homo sapiens*, in contrast, remained biologically animals of the tropics, but they adapted to the cold by sewing fitted clothing and experimenting with new objects and behaviors. The challenge of the Ice Age unleashed the potential for rapid innovation that had been dormant for thousands of years.

Anthropologist Rachel Caspari has recently investigated the ratio of older (defined as twice the reproductive age) to younger individuals (up to reproductive age) among the remains of Neanderthals and Cro-Magnon. She found that ratio was five times higher among the Cro-Magnon than among Neanderthals. What caused the higher longevity among the Cro-Magnon is not known. But the consequences were dramatic, for cultural evolution depended on the transmission of knowledge between generations. Older people, grandparents in particular, could pass on their knowledge and experience to the younger generations. By contributing their social and intellectual resources, they could increase the number of surviving grandchildren. Thus, Caspari points out, "the hallmark features of the Upper Paleolithic—the explosive increase in the use of symbols, for instance, or the incorporation of exotic materials in tool manufacture—look as though they might well have been the consequence of swelling population size."[60]

Eurasian Extinctions

Not only were humans ingenious in adapting to a new environment, but they were also intent on adapting their environment to their own desires. Painting pictures of large animals on cave walls is one sign of this eagerness. Another is what they did to the fauna of Eurasia.

They hunted the largest animals first. These animals had had half a million years to adapt to hunters, first *Homo erectus*, then Neanderthals, and finally *Homo sapiens*. In the process, they had become wary. The impact of the newcomers was therefore not nearly as severe as it was among the naive animals of places that humans had never visited. Nonetheless, many large animals became extinct during the first 20,000 years of human occupation, among them the wooly mammoth, the wooly rhinoceros, the Irish elk or giant deer, and the cave bear and cave lion. The last mammoth died in northern Siberia between 11,000 and 9,600 years ago. Dwarf elephants, the size of circus ponies, survived on Wrangel Island in the Arctic Ocean until 3,700 years ago. Others, such as the musk ox and the bison, disappeared

from Eurasia but found a refuge in the Americas, while the wild horse (*Equus przewalskii*) survived only in the most remote area of Mongolia.[61]

Just as interesting is what happened to the Neanderthals. From the time *Homo sapiens* returned to Eurasia after the eruption of Toba, the two species coexisted for close to 15,000 years. *Sapiens* and Neanderthals occasionally mated, at least outside of Africa; between 2 and 5 percent of the genes of Europeans are from Neanderthals.[62]

Why then did the Neanderthals vanish? There is no evidence that they and *Homo sapiens* ever fought; *Homo sapiens* occasionally fought one another, so the possibility cannot be ruled out.[63] Perhaps it was competition for prey by the newcomers, who could improve their weapons and hunting techniques faster than could the Neanderthals. On the steppe-tundra of Ice Age Eurasia, animals adapted to the frigid climate—wooly mammoths, wooly rhinos, musk oxen, reindeer, and antelopes—replaced the woodland animals that Neanderthals had previously hunted. Out in the open, such animals could not be ambushed, and evidently the Neanderthals did not learn the cooperative hunting techniques required to stampede them.

Homo sapiens had three other advantages. One was fitted clothing, which allowed them to survive in temperatures that Neanderthals could not withstand. Another was the willingness of *Homo sapiens* to eat things that the carnivorous Neanderthals seldom did, such as plant foods, small game, and fish.[64] A third possible advantage is the partnership between human hunters and wild dogs, a stage in the evolution of wolves into domesticated dogs.[65] In the competition for scarce resources during the Last Glacial Maximum, *Homo sapiens*' cultural adaptations proved more effective than the Neanderthals' biological adaptations. As *Homo sapiens* multiplied, the Neanderthals retreated. Trapped between the cold treeless land to the north and the Mediterranean Sea and deserts and mountains to the south, they took refuge in the Balkans, Iberia, and the Caucasus, surviving in ever declining numbers. The last known trace of them, found in Gorham's Cave in Gibraltar, dates back 28,000 years.[66]

Humans Reach the Americas

Because of the climate barrier, the Americas were among the last places to be settled by human beings. Until about 12,000 years ago, ice sheets covered northern Siberia and blocked access to Beringia and the route to America.

In North America, the Cordilleran ice sheet extended along the West Coast, while the Laurentide ice sheet covered the rest of the continent. At its maximum extent from 21,000 to 17,000 years ago, the Laurentide sheet reached Ohio and southern Illinois. As the Ice Age tapered off, it retreated to the northern Great Lakes 14,000 years ago and to northern Canada 11,000 years ago. The warming climate opened an ice-free corridor between the two ice sheets that allowed animals and humans to wander south from Alaska into a new continent.

Genetic analyses of Native Americans and indigenous inhabitants of northeast Asia confirm that the newcomers came from Siberia.[67] Archaeologists have only begun to investigate northeastern Siberia, but it seems that until about 1,000 years ago, this vast region was too cold and game too scarce to support much human life. Perhaps what made it possible for humans to survive there was the domestication of the dog, which could pull a sled, help them hunt game, protect them from predators, keep them warm at night, and, if necessary, be eaten.[68] From Siberia, hunting bands migrated to Beringia, a land that included northeastern Siberia, Alaska, and the nearby continental shelves then covered with steppe-tundra and inhabited by wooly mammoths, giant sloths, steppe bison, musk oxen, and caribou. After several thousand years, as the climate warmed, their descendants began drifting south.[69]

When and how humans arrived in the Americas has been a contentious question for many years. The long-held belief that hunters equipped with Clovis points (a unique shape of spearheads dated between 13,500 and 12,900 years ago) were the first humans in the Americas has been discredited by more recent findings. Most remarkable is the discovery at two sites in Texas of thousands of stone tools and other man-made objects dating back 15,500 years, long before the first Clovis points were made. A site at Monte Verde, in southern Chile, shows evidence of human habitation dating back at least 12,500 and possibly 16,000 years. Other still disputed pre-Clovis sites include the Meadowcroft Rockshelter in Pennsylvania, which may be 19,000 years old; Pedro Furtado in Brazil, dated to 17,000 years ago; and Paisley Five Mile Point Cave in Oregon of 14,400 years ago. In other words, there were humans in the Americas before an ice-free corridor opened up, but their numbers were small and the evidence they left behind is subject to controversy.[70]

How small hunting bands could have made the trip from Beringia to northwestern North America before the opening of the ice-free corridor is

a mystery. Archaeologist Jon Erlandson and others have argued that these people traveled by boat or raft along the west coast of the continent, just as others made their way by boat to Australia. All along the North Pacific coast, from Japan to Baja California, the shallow coastal waters were rich in kelp, which attracted sea otters, fish, and birds. This rich ecosystem would have provided more nutrition for coastal navigators than the harsher and more dangerous interior of the continent. The hypothesis has been disputed, for the northern Pacific is a cold and violent ocean, and during the Ice Age it would have been filled with icebergs. Besides, it was argued, what traces these early navigators might have left behind have long since been covered by the rising sea. But recent findings have revealed that 12,200 to 11,200 years ago, humans periodically visited an island off the coast of Southern California to hunt Canada geese, cormorants, seals, and sea lions and to collect mollusks.[71]

American Extinctions

Interesting from an ecological point of view are the changes in the natural environments that coincided with the multiplication of humans in the Americas. Around the time of their arrival, 73 percent of all mammal species over 44 kilograms and all species over 1,000 kilograms vanished from the continent. Among them were mammoths, mastodons, *Eremotherium* (giant ground sloths that stood 2 meters tall and weighed 3 tons), *Smilodon* (saber-toothed cats the size of lions), *Castoroides* (beavers the size of black bears), *Glyptodon* (giant armadillos), straight-horned American bison, five species of horses, short-faced bears, dire wolves, and many others.[72] With their extinctions, the fauna of the Americas were dramatically diminished.

These extinctions did not happen overnight. Analysis of lake sediments in Indiana show that giant animals began to disappear between 14,800 and 13,700 years ago, long before the first Clovis points. Others died out between 13,800 and 11,400 years ago, coinciding with the Clovis period. And in Alaska, mammoths and horses survived until at least 10,500 years ago. In short, the extinctions took a long time.[73]

What could have caused them? One answer might be climate changes. The climate began warming 18,000 years ago. Then it cooled abruptly 12,800 years ago, possibly caused by the impact of an extra-terrestrial object.[74] Then, 1,300 years later, it began warming again. Although such climate changes

may have stressed some animals, the native American megafauna had survived many climate shocks before. In a few thousand years, the Americas lost more genera of large land mammals than in the preceding 1.8 million years. In the 2 million years before humans arrived, the Americas lost fifty species of large mammals. Then, in just 2,000 years after humans came, fifty-seven species went extinct. If climate change could cause extinctions, it would have affected smaller animals as well, but it hardly affected smaller land mammals or marine mammals.[75] Furthermore, there is evidence that the megafauna collapse began a thousand years before the cooling phase and continued after it. In short, the climate hypothesis is unconvincing.[76]

That leaves humans. In 1967, anthropologists Paul Martin and H. E. Wright Jr. advanced the so-called blitzkrieg or overkill hypothesis that when humans first entered the Americas, they advanced like a wave front at a rate of 16 kilometers a year, killing every large animal they encountered.[77] It is not necessary to accept such a dramatic scenario to identify the role of humans in the extinction of large animals. In place of the "blitzkrieg" analogy, a more complex picture is emerging.

The animals of the Americas had never met humans before and had no instinct to flee from them. As in Australia, the larger animals reproduced so slowly that culling a few reproductively active females each year could have driven their population into an irreversible decline. In biologist Edward Wilson's words, "As a rule, inbreeding starts to lower population growth when the number of breeding adults falls below five hundred. It becomes severe as the number dips below fifty and can easily deliver the coup de grâce to a species when the number reaches ten."[78] Humans did not need a blitzkrieg to exterminate the American megafauna.

The megafauna did not go without a fight. The small number of sites of human occupation before the Clovis "explosion" is probable evidence that few of the earlier human migrants survived. Naturalist and grizzly bear expert Doug Peacock offers an intriguing hypothesis to explain the failure of the first migrants to thrive and multiply, namely, short-faced bears (*Arctodus pristinus* and *A. simus*). Weighing almost a ton and up to 3.7 meters tall on their hind legs, these were the largest of all carnivorous land mammals and could have kept human numbers very low until the introduction of Clovis points led to the extinction of their prey, the large herbivores.[79]

Not all large animals became extinct, of course. Bison, elk, moose, and grizzly bears still roam, because they were recent arrivals that crossed over

the land bridge of Beringia from Siberia. Having survived millennia of encounters with humans in the Old World, they knew to keep their distance. Thus the grizzly, descendant from the Eurasian brown bear, replaced the American short-faced bear; the moose replaced the American stag-moose; the gray wolf replaced the dire wolf. The original bison, related to the Eurasian wisent, inhabited the Americas for 3 million years; its descendant, a large long-horned herbivore, evolved under the pressure of human hunting into the familiar *Bison bison* or "American buffalo," a smaller animal with short horns that travels in herds for protection. Among the larger native American animals, only the black bear and the mule deer survived the arrival of *Homo sapiens*.[80]

Unlike Neanderthals, Paleo-Indians were not exclusively hunters. They were opportunists who hunted and gathered all sorts of foods—fish, mollusks, small animals, seeds, and nuts—even before the easy hunting had petered out. They used fire to open up forests and encourage herbivores to multiply.[81] After about 11,000 years ago, they learned to stampede herds of bison into narrow canyons or over cliffs, probably using fire.[82] In the varied environments of the New World, the simple Clovis hunting culture was replaced with a great diversity of cultures, some of which grew food and created complex societies.

Melting and Mesolithic

Ice cores taken from Greenland glaciers tell the story of the earth's climate over the past hundred thousand years, as do tree rings and pollen and shells brought up from the bottoms of lakes. After about 18,000 years ago, the climate began to warm, melting the great northern ice sheets. As the oceans rose, Beringia, the land bridge between Siberia and Alaska, was flooded. Sunda became the archipelagos of Indonesia and the Philippines. The British Isles were severed from Europe, as was New Guinea from Australia. Many islands that dotted the sea shrank or vanished under the waters. In the northern parts of Eurasia and North America, tundra gave way to forests. As reindeer, horses, and other herd animals moved north with the retreating steppe, they were replaced by forest dwellers like elk and moose and, farther south, by deer and boars. In the Middle East, as the climate grew warm and moist, grasses with edible seeds spread widely, while the Sahara became a grassland dotted with lakes and wetlands.[83]

The Mesolithic

The changes in climate, flora, and fauna posed a challenge to all living beings. Many succumbed; others survived in reduced numbers; yet others multiplied. Among the winners in this changed environment were *Homo sapiens*. As large animals became rare, humans turned to catching fish that abounded in the rivers as well as mollusks, birds, eels, and sea-mammals along the coasts; they also collected nuts, acorns, tubers, berries, and other plant foods.[84] With more abundant foods, their population rose. One demographer estimated that the number of *Homo sapiens* in Europe increased from about 6,000 during the Last Glacial Maximum (25,000–19,000 years ago) to almost 29,000 by 13,000 years ago.[85]

To kill the smaller or more skittish animals that inhabited the forests, such as rabbits, beavers, boars, and deer and also fur-bearing carnivores like foxes and wolves, hunters had to learn new techniques and create new weapons. Throwing spears replaced the heavy thrusting spears of their ancestors. The bow and arrow was especially well adapted to the new way of life. Instead of a single spear, a hunter could carry a quiver full of arrows, each one with tiny blades embedded in the shaft. A 1.5-meter-long bow could propel an arrow at up to 100 kilometers per hour accurately up to 50 meters. Even at that distance, it could pass through a bear.[86]

For hundreds of thousands of years, humans and their predecessors had used fire for heating, cooking, and protection. The first evidence that fire was used in hunting was at the end of the Ice Age, when *Homo sapiens* deliberately set fire to forests. In North America, hunters set fire to forests to clear the underbrush and open up pastures to attract grazing animals like deer and elk and to create habitats for beavers, turkeys, and quail. The prairie that stretched from Wisconsin to Texas was created and maintained by Indians to encourage the herds of bison that were their main prey. A similar use of fire was true of foraging people in the Middle East and in much of tropical America.[87] Humans were no longer living off the bounty of nature but deliberately manipulating nature for their own benefit. Anthropologists refer to them as Mesolithic (Middle Stone Age) peoples.[88]

The luckiest of the Mesolithic foragers lived in environments so rich that they could settle down and build permanent dwellings. Five thousand years ago some Indians of California lived in villages of a thousand or more inhabitants. Along the northwest coast of North America, the Haida built long houses of planks that they could disassemble and transport from one

location to another, living through the winter off dried salmon and herring and the berries that abounded in the nearby forests. Along the shores of some Mexican lakes, foragers found enough fish and wildfowl to sustain them year-round. Foragers and fishermen built the first permanent (or at least seasonal) settlement in Europe about 8,400 years ago. In short, humans were eager to settle down and did so whenever they could, even before they learned to produce their own food. In order to settle down, however, they needed to store food, for few environments provided food year-round. In the steppe-tundra, hunters dug pits to keep frozen meat in the permafrost; in grasslands, they stored seeds in baskets or pots. In Japan, a foraging and fishing people called Jomon began making pottery 16,000 years ago.[89]

After the Ice Age, the climate of the Fertile Crescent—a part of the Middle East that stretches from the eastern Mediterranean through Syria and into northern Iraq—turned mild and rainy in the winter, with long, hot, dry summers. Foragers living in the area found an abundance of edible plants and animals. The region, at the crossroads of North Africa and western Asia, had a very rich biota, with several hundred species of native trees and plants with edible seeds or fruits, many of which could be harvested and stored for future use. Some hillsides were covered with forests of pistachio trees. Herds of gazelles roamed the open grasslands.[90]

In this rich environment, a nomadic foraging people called Kebarans hunted gazelles, sheep, and goats and collected pistachios, almonds, and acorns that they pounded into meal with mortars and pestles. To harvest wild grains, they used bone-handled sickles with flint blades. Their successors (or perhaps their descendants) the Natufians fished and hunted waterfowl and collected enough wild wheat and barley during a few weeks in the fall to eat during the rest of the year, or as insurance during times when foraging failed to satisfy their hunger. They settled into permanent villages of ten to twenty houses with hearths and grindstones. They gathered wild grains and acorns, hunted gazelles, and caught fish, turtles, and birds in nearby lakes. With enough food at hand, they had more children and their population grew.[91]

The Younger Dryas

Then the climate turned against them. In far-away North America, as the huge Laurentide ice sheet melted, the remaining ice dam held back an enormous body of water in central Canada. Some time around 12,900 years ago,

the waters of this lake broke through the ice barrier and cascaded down the St. Lawrence Valley into the Atlantic Ocean or northward into the Arctic Ocean. Once there, it formed a layer over the denser saltwater of the ocean and froze. This shut down the flow of the Gulf Stream that normally warmed western Europe. Within a decade, the average temperature of the North Atlantic fell by 10 to 15 degrees Celsius (18° to 27°F) and that of the world fell by 5 to 7 degrees Celsius (9° to 13°F). This return of the Ice Age, which lasted for approximately 1,300 years, is known as the Younger Dryas.[92]

During that time, the climate of North America and Europe turned as cold as that of Siberia today, with severe winter storms. Ice covered Scandinavia and Scotland while tundra replaced forests south of the ice. Drought descended upon the Middle East. Gazelles, once abundant, became rare. Grasslands replaced the oak, almond, and pistachio forests. As wild nuts became scarce, Natufians relied more on gathering the seeds of wild grasses such as wheat, barley, and rye. Even wild grasses became less abundant as a decline in atmospheric carbon dioxide stunted their growth, and scrub replaced grasslands. As the fertility of the land declined, the Natufians abandoned their villages and became nomads again. However, there were too many people and too few resources to return to a hunting and gathering way of life.[93]

Animals, when faced with a natural calamity, migrate if they can, or starve. So had humans many times before. This time, however, the inhabitants of the Middle East reacted in a new way. Here and there, some of them—probably women, who had always gathered while men hunted—experimented with planting the seeds of edible grasses in a few moist spots in river valleys, returning a few months later to gather the grain.

Conclusion

Human evolution has been the subject of scientific investigation for over a century, with remarkable results. Though there is still much to discover, we now know when and where hominins originated, how they changed over time, and how *Homo sapiens* evolved from earlier hominins. The evidence of paleontology shows a shift from biological to cultural evolution. Over the millions of years of evolution, members of the genus *Homo* that were best adapted to particular environments were replaced by those that could learn and adapt more readily to new or changing environments. They did so by

possessing larger brains, hence greater intelligence, and by creating a communal knowledge base that could be transmitted from individual to individual and from generation to generation.

Humans have long thought of themselves as different but always superior to all other animals. The study of ancient humans confirms this difference, but in a very different way. While all living beings extract resources from their environments, humans regularly go beyond the needs of survival and reproduction. Before *Homo sapiens,* hominins scavenged, gathered, and hunted as best they could but were limited in their ability to change their environments by the difficulty and cost in energy of obtaining food. Even big predators stop when they have killed enough to satisfy their hunger and that of their kin, after which they spend long hours digesting.[94] Of all the animals, only *Homo sapiens* kills to the point of exterminating other species of animals.

Our intelligence and ability to communicate have made it easy. The technological innovations of Paleolithic humans—better stone weapons, the use of fire, spears and bows and arrows, and the domestication of dogs—allowed them to kill more animals with less effort and danger. Hunting was not just a means of providing meat; when it was easy and safe enough, it became a sport. Throughout the world, wherever humans appeared, many other species of large animals vanished. Other species of the genus *Homo* went extinct, and the eruption of Toba came close to extinguishing *Homo sapiens* as well. For humans in the Old Stone Age, survival was neither smooth nor certain.

Yet humans are also adaptable to changing circumstances. They had evolved in Africa, yet they were able to flourish in Ice Age Eurasia. Then, when the Ice Age ended, they adapted their skills and way of life to the new climate. Their creative ability to extract new resources from their environments led humankind in an entirely new direction: from depending on the bounty of nature to producing food and multiplying in numbers, bringing about the next major transformation of the planet.

2
Farmers and Herders

Nineteenth-century archaeologists coined the term "Neolithic" or "New Stone" Age to refer to the polished stone tools that succeeded the chipped stone tools of the earlier Paleolithic or Old Stone Age. Though later anthropologists realized that polished stone tools were part of a much more important change, the beginnings of food production, the name has stuck.

Despite its name, the Neolithic Revolution was not a sharp break with the past but a continuation of the more intense exploitation of resources that began in the Mesolithic. For the people who lived through this period, the change would have been almost imperceptible, not only because it took centuries but also because they retained their old way of life even as they experimented with new ways.

Just how they moved from gathering to cultivating plants is unclear. There must have been intermediate stages, such as weeding competing plants or watering desirable plants in dry weather. In a few instances, people manipulated plants but stopped just short of cultivating them, as in the following story that environmental historian Neil Roberts tells:

> The fine dividing line between farming and foraging is well illustrated by aboriginal Australia, where women customarily exhort plants to be generous and yield a big tuber as they dig them up. Once out of the ground, no matter how large the tuber, tradition decrees that the woman should now complain and berate the plant, "Oh you worthless plant, you lazy thing, You stingy plant. Go back and do better." Saying this, she would chop off the top of the plant, put it back in the hole from which it came, and urinate on it.[1]

Archaeologists have long discussed the motives that compelled people to begin growing crops and raising animals: Was it overpopulation or climate change that made them do so? Or was it a desire to settle down? It is likely that in many parts of the world, Mesolithic foragers had filled up the landscape, so when a hunting-gathering band had depleted its local resources, it could not simply move into a new unoccupied territory. If, in addition, the

carrying capacity of the land was reduced, the need for new resources was even more urgent. The search for security might have been a strong motive as well. In many places, sharp seasonal variations provided an incentive for people to put aside food for the lean months of the year by storing grains and nuts or by capturing and confining animals to be eaten later. Besides, even the richest natural environments went through cycles of abundance and scarcity and seasons of plenty and want. Certain food sources, such as nut-bearing trees, varied their yields from year to year, even in a steady climate. Finding sources of food that could tide people over through hard times must have been a powerful motivation to experiment.

Knowledge and Technologies

Since the Neolithic people left no writings, it is impossible to know what their motives were. But we have good evidence of the means they used in the transition from foraging to producing food. Those who tried to produce their own food rather than rely on nature needed to understand wild plants and animals. Knowledge of nature was not personal but collective. In many places, during seasons when wild foods were abundant, people gathered in large numbers to celebrate, exchange ideas, find mates, and maintain ties with friends and kin. Celebrations often involved feasting, and bands competed to be seen as the most successful and the most generous. *Homo sapiens* were naturally curious and eager to learn from others and to share their considerable knowledge of wild foods.

Mesolithic technologies—flint-bladed sickles, baskets, digging sticks, and mortars and pestles—were just as useful in dealing with cultivated as with wild plants. In this assembly of tools, those used to process foods by soaking, grinding, or boiling were as important as those used to catch or harvest foods. The technological innovations of the Neolithic—polished stone tools and, later, pottery—were elaborations of tools used in earlier times. In short, the Mesolithic broad spectrum diet and the intensification of hunting and gathering it required were prerequisites to producing food.[2]

The Domestication of Plants

What mattered as much as motives and means were the opportunities that allowed people to begin producing food, such as locally available plants and

animals suitable for domestication and the area's climate and water supply. Great disparities between different parts of the world influenced the development of farming and herding, in some cases determining how feasible and easy food production was.

Domestication means accelerating the evolution of plants and animals through human selection, partly to develop certain desirable characteristics and partly to make it difficult or impossible for them to return to the wild. According to biologist Jared Diamond, among the 200,000 known species of wild plants in the world, only a hundred were amenable to domestication.[3] Those plants had to have large seeds or fruits with thin coats, a good taste, or some other feature, such as fibers, that humans found attractive. Useful plants had to be easy to harvest—for instance, by ripening at the same time. And within such a species, some individuals had to contain a mutation useful to humans, such as seeds that did not fall to the ground when ripe but stayed attached to their stalks "waiting for the harvester." To prevent a favorable mutation from being diluted in the next generation by hybridizing with plants that lacked it, domesticable plants had to be either self-pollinating or deliberately planted at a distance from their wild relatives.

Domestication was a mutual arrangement between humans and particular plants and animals. Michael Pollan, exaggerating slightly, explains the role of plants and animals in their own domestication:

> Though we insist on speaking of the "invention" of agriculture as if it were our idea, like double-entry bookkeeping or the lightbulb, in fact it makes just as much sense to regard agriculture as a brilliant (if unconscious) evolutionary strategy on the part of the plants and animals involved to get us to advance their interests. By evolving certain traits we happen to regard as desirable, these species got themselves noticed by the one mammal in a position not only to spread their genes around the world, but to remake vast swaths of that world in the image of the plants' preferred habitat.[4]

The Domestication of Animals

To be candidates for domestication, animals had to tolerate being crowded together in a small space without panicking and be willing to reproduce in captivity. Only a few animals possessed these qualities.[5] Their domestication usually involved a mutation called neoteny, or retaining youthful physiology and behavior into adulthood. Young mammals are full of curiosity, unafraid

of animals of other species, and eager to learn new tricks; house cats, for instance, act like the kittens of wild cats. Such qualities were particularly useful when animals migrated to a new territory, as happened frequently during and after the Ice Age. Humans took advantage of these behaviors by capturing young animals, keeping those who retained their juvenile behaviors longest, and letting them mate. After a few generations, they had animals that were permanently juvenile in behavior and kept their juvenile appearance, such as shorter muzzles, rounded heads, crowded teeth, and smaller brains. After many generations, their captors found that they had bred out the undesirable traits. Not all animals lent themselves to this. Steers became bulls, dangerous and violent animals. Male boars easily returned to the wild. Even rams and billy goats could be violent. For aggressive male animals, humans found another means of control, namely, castration.[6]

In addition to the recognizable domesticated animals, others occupy a niche between wild and domesticated. Asian elephants, if captured young, can be trained to carry logs. The Lapps of northern Scandinavia follow reindeer herds as they migrate across the tundra, occasionally culling one. Most reindeer are skittish, but they tolerate humans in their proximity. Some even let themselves be milked or harnessed to a sled.

Then there are the commensals, literally animals that "share the table" with humans. Mice, rats, and sparrows like to live close to humans because of the garbage they produce and the foods (especially grains) they store. The same is true of flies, fleas, roaches, and other human-loving insects. Then there are those that follow humans at a slightly greater distance: seagulls, barn swallows, raccoons, deer, rabbits, and pigeons, among others.[7]

Cats occupy a position somewhere between commensal and domesticated. The earliest evidence of domesticated cats is found in ancient Egyptian tomb paintings and in the temples of the sun-god Ra, represented as a male cat, and of the fertility goddess Bast, a female cat. But long before that, wild cats (*Felis sylvestris libyca*) were attracted to the rats, mice, and sparrows that proliferated wherever grain was stored in Neolithic villages. Eventually, their descendants became social among humans.[8]

Herbivorous herd animals like wild sheep, goats, cattle, and horses found it useful to associate with humans, as did omnivorous animals like pigs.[9] Humans and their dogs provided protection from other predators, especially for vulnerable young. Individual animals might be eaten by the humans they lived with, but for the species, domestication was clearly beneficial. Today while domesticated animals are in the millions, few of their wild relatives,

such as wolves, bobcats, wild boars, and wild horses, have survived. Some, like aurochs, the ancestors of cattle, have vanished.

How dogs became domesticated is controversial. Some scholars maintain that Paleolithic hunters adopted wolf-pups that were the most cooperative and the least aggressive; after many generations, their descendants evolved into hunting companions.[10] Others argue that the ancestors of dogs were not hunting wolves but commensal scavengers that hung around Mesolithic villages.[11] Having settled among Mesolithic foragers, dogs later adapted to the world of Neolithic herders. When people began to herd sheep and goats, dogs raised among these animals imprinted on them and became their guardians. Sheepdogs herd sheep the same way wolves attack herds of wild herbivore, circling the herd and cutting off stragglers, except they do not kill.

The Spread of Farming and Herding

For food production, climate and water mattered as much as available plants and animals. Some regions were too cold. Others, like the Sahara that was once covered in grass and supported herds of cattle, had become too arid.[12] Food production therefore originated in only a few places on Earth: China, the Fertile Crescent, Mesoamerica, the Andes, Amazonia, New Guinea, West Africa, and Ethiopia. All the world's domesticated plants and animals come from these eight regions. Because each of these regions had its own set of domesticable plants and animals, the forms of agriculture and animal husbandry that arose varied enormously, as did their history, both human and environmental, for millennia thereafter.

For hundreds of thousands of years during the Ice Age, humans had survived by hunting, fishing, and gathering. Why then did people in those eight regions turn to farming and herding within a few thousand years of each other? The most likely explanation is that by 10,000 years ago, the growing population of Mesolithic farmers had occupied most of the good hunting, fishing, and gathering areas. After that, climate changes were sufficient to challenge foragers to seek new sources of food but not so violent as to frustrate their efforts.[13]

The locus of domestication was less important than the diffusion of plants and animals to other regions. Geography favored some regions over others. Eurasia, oriented east-west, made it easy for plants domesticated in one region to be transplanted to other regions, like wheat from the Middle East

to northern China and Europe or rice from southern China to South Asia and the Middle East. Sub-Saharan Africa, however, is oriented north-south, and its tropical climate made it impossible to grow Middle Eastern crops. The Americas, too, were oriented north-south, so it took thousands of years before maize (American corn) was bred to thrive in what is now the United States.[14]

Since the process of domestication, and its consequences for humans and for the environment, varied so much from one region of the world to another, the experience of the regions where agriculture began must be considered separately.

China and Southeast Asia

China lies between two climate zones: monsoon Asia to the south and Siberia to the north. These two zones, and their climatic fluctuations, have determined the agrarian history of China from the early Neolithic. According to recent research, the earliest domestication of plants occurred in central and southern China, with tropical warmth and abundant rains during the summer months. As far back as 12,000 years ago, foragers began collecting the grains of wild rice (*Oryza rufipogen*) growing in seasonally flooded areas along riverbanks and in low-lying wetlands in the lower Yangzi Valley and around Hangzhou Bay. By 9000 BCE, they began to gather and cultivate a mutant form, *Oryza sativa*, that has non-brittle ears and therefore could not reproduce on its own. By 6400 BCE, farmers had learned to build low dams to trap the rainy season runoff in order to reproduce the conditions preferred by the wild plants. From then on, they were able to rely more on domesticated rice than on wild plants. Archaeological sites in the lower Yangzi Valley include pottery in which rice was boiled and stored. In the prosperous village of Hemudu, built around 5000 BCE, archaeologists have found pottery, bone, stone, and wooden tools, and the bones of water buffalo, pigs, chickens, and dogs.[15]

From southeastern China, rice-based agriculture spread throughout eastern and southern Eurasia. It reached Thailand in the fifth millennium; southern China, India, and Vietnam in the third; Indonesia in the second; and Japan in the first millennium. People who took up rice farming soon outnumbered those who remained foragers.

The original inhabitants of southeastern China spoke proto-Austronesian, the ancestor of the languages spoken today in Malaysia and in the

archipelagos of the western Pacific. Everywhere they settled, Austronesian-speaking people brought with them a vocabulary that clearly proves that they were farmers. In the sub-tropical regions north of Indonesia, they used words for field, paddy, garden, rice, sugarcane, plow, cattle, water buffalo, ax, and canoe. When they reached the tropics in Indonesia and beyond, they acquired words for taro, breadfruit, yam, banana, sago, and coconut. Corroborating the linguistic evidence is archaeological evidence of pottery, polished stone adzes and knives, and spindle-whorls, all of them used by farmers but not foragers. Finally, pollen evidence shows that the farmers set fire to large areas of forest. Throughout much of Southeast Asia and the Pacific, the practices and languages of farmers spread together.[16]

Unlike the south, northern China has a harsh continental climate; summers are hot, winters are bitterly cold. Rainfall varies enormously from droughts to floods; half or more falls between June and August, much of it as sudden downpours. The North China Plain is covered with over 150 meters of loess, a soft and fertile soil deposited by dust storms from Mongolia. The Yellow River, which flows through it, carries a tiny fraction of the amount of water carried by the Amazon or the Mississippi, yet it carries as much silt as these much larger rivers. Of that silt, 40 percent to 50 percent is deposited before it reaches the sea, causing the riverbed to rise above the floodplain and periodically change its course.[17]

Along the Yellow River, the first farming villages appeared around 6500 BCE, after the inhabitants had learned to grow drought-resistant foxtail and broomcorn millet. Later they added bottle gourds, sorghum, hemp, and mulberries and domesticated water buffaloes, chickens, and pigs. They obtained wheat seeds from the Middle East, perhaps brought by the same people who domesticated horses and used them to cross the great Eurasian steppe. They built substantial houses of clay and made distinctive pottery.[18] In many ways, their experience parallels that of the first farmers in the Fertile Crescent, with one difference: since the soils of China were easily cultivated with digging sticks and hoes, farmers had little need for draft animals.

The Middle East

The inhabitants of the Middle East had numerous domesticable plants and animals from which to choose. Among the wild plants that lent themselves to domestication were emmer and einkorn wheat, rye, and barley, and later

chickpeas, lentils, and flax. Domesticating them took decades or even centuries.[19] Sheep and goats, the most amenable animals, were domesticated in the Zagros highlands of Iran in the tenth millennium, as were pigs soon thereafter. Domesticating cattle occurred a millennium later because their wild ancestors, aurochs or *Bos primigenius*, were very large (approximately 2 meters at the shoulder) and fierce.[20]

Sometime between 9700 and 9500 BCE, temperatures rose by 7° Celsius (13°Fahrenheit) in less than fifty years, in some places in less than ten. The new climate, with cool rainy winters and hot dry summers, favored annual plants like grasses that completed their life cycle by late spring and left dried seeds that could survive until winter rains made them germinate. This encouraged people to gather and store enough seeds to carry them through the rest of the year and to settle in villages where they could protect their food stores.

The place where the climate change was most acutely felt was the valley of the Jordan River, which had once been dotted with lakes. When it became drier, only three lakes remained: Huleh, Galilee, and the Dead Sea, the last of which was too salty to sustain life. People and animals congregated near the remaining sources of fresh water. It is here, around 8000 BCE, that the Natufians intensified their gathering of wild seeds, and then, to supplement them, began to sow seeds of emmer wheat, barley, lentils, and peas. The practice of sowing seeds then spread to other parts of the Fertile Crescent. People began to store their harvests in jars, clay-lined baskets, or bins kept off the ground. They learned to roast grains without scorching them, to prevent them from sprouting in storage. Small hamlets turned into substantial villages, some with protective walls. Though their inhabitants still engaged in hunting and gathering, they relied increasingly on domesticated crops. Soon thereafter, hundreds of villages lived entirely from agriculture.[21]

The village of Abu Hureya near the Euphrates River in northern Syria epitomizes the long and complicated dance between humans and plants and animals known as the Neolithic Revolution. Sometime before 11,000 BCE, foragers built twenty small mud-brick houses with thatch roofs that they inhabited at least part of the year. Though blessed with abundant wild foods, they also experimented with planting rye and wheat. They continued to do so until they abandoned the village around 9500 BCE. When people returned to the site a thousand years later, they built a much larger village for up to 6,000 inhabitants.

Until around 6400 BCE, 80 percent of the animal food they consumed consisted of the meat of gazelles. So abundant were the gazelles that the inhabitants continued to rely on them for meat for a thousand years after they had begun to grow grains. Then, between 6400 and 6100 BCE, among the animal bones excavated at Abu Hureya, the proportions shifted to 80 percent sheep and goats and only 20 percent gazelles. The reason is probably that other hunters along the gazelle migration paths were decimating the herds. As the gazelle herds vanished, the people of Abu Hureya turned to domesticated sheep and goats for their meat supply. With the grain they grew and the sheep and goats they raised, the people of Abu Hureya flourished off and on until about 5000 BCE, when they finally abandoned the village.[22]

Europe

Compared to other sub-continents such as India or China, Europe has an unusually high ratio of coastlines to land area; it is, in fact, an archipelago of peninsulas. Europe has three very different climatic and geographic zones with very different environmental responses to human actions: a southern zone, with a climate similar to that of the eastern Mediterranean; a northeastern zone, with a continental climate similar to that of northern China; and a northwestern zone, with a temperate oceanic climate. The Alps and Carpathian mountains form a sharp boundary between the Mediterranean and the two northern zones. Between the two northern zones, however, there is only a continuum along the great northern European plain.

Around the Mediterranean, farmers planted the same crops and raised the same animals as in the Middle East. Soon after 6400 BCE, farmers at Nea Nikomedeia in Greece built mud-walled houses; grew wheat, barley, peas, and lentils; and raised sheep and goats, while still foraging. By 6000 BCE, there were many small farming communities in Greece. Later, farmers began growing olive trees and vineyards and building terraces. By 5000 BCE, this kind of mixed farming had spread throughout the Mediterranean region, from Egypt to Tunisia and from Greece to Spain.[23]

North and west of the Alps, farmers found a very different climate from that of the Mediterranean. Western European summers were warm, winters ranged from cool to cold, and rains fell year-round. The soils were heavy and often waterlogged. A colder climate with frequent rains delayed the spread of farming until 6000 BCE or later. Farmers from Anatolia may have brought

their way of life to Europe after being forced to move by a natural catastrophe. The Mediterranean Sea, having risen 17 meters as a result of global warming, stood almost 200 meters above the level of the Euxine Lake, a small shallow inland sea located where the Black Sea is now. According to a controversial hypothesis, in 5600 BCE, the waters of the Mediterranean suddenly burst through the Bosphorus, filling up the lake until it became the Black Sea. As the water rose, it moved inland at a rate of nearly 2 kilometers a day. The people who lived and farmed near the lake had to flee suddenly, losing their land and homes and many of their animals. Some may have escaped up the Danube River into the Hungarian plain. When they took up farming again, their skills and way of life persuaded the native foragers to follow their example.[24]

Once in the interior of Europe, farming people settled in areas of rich soils, such as river bottoms that they could cultivate with hoes and digging sticks, and left the forested uplands to hunters and gatherers with whom they coexisted for thousands of years.[25] Like Middle Eastern and Mediterranean farmers, they cultivated wheat, barley, rye, peas, lentils, and flax. Rather than goats, however, they raised sheep, cattle, and pigs. These animals foraged in the nearby woods and their manure fertilized the fields. Woods also provided game and edible wild plants to supplement the domesticated foods.

After about 4400 BCE farmers started to move beyond the river valleys. The spread of agriculture to the forests required a powerful but docile animal that could pull a plow. When farmers learned to castrate young steers, they obtained such an animal. The first pictures of a pair of oxen yoked to a plow appeared in Mesopotamian art around 3500 BCE. The plow and the animals to pull it mark the transition from gardening to agriculture and opened up the possibility of farming the forested uplands. Farmers also began to cultivate rye, which grew well in the climate of central and western Europe.

By 3500 BCE, those parts of Europe were filling up with hamlets and villages of wooden houses surrounded by fields, meadows, and wood lots. Cows that grazed in the meadows gave milk. They and oxen not only plowed the land but also produced manure that renewed the fertility of the soil. Sheep ate stubble and weeds and furnished wool. Pigs foraged in nearby forests, returning to the farms at night. Hunter-gatherers living in nearby forests and coastal wetlands traded their catch for farm products. Mixed farming, with its symbiosis between plants, animals, and humans, was an almost closed system that required only modest amounts of energy from outside, such as cutting firewood, letting pigs forage in the forest, or supplementing home-grown

foods with some hunting and gathering. It proved to be a sustainable way of life that lasted, in places, until well into the twentieth century.[26]

Nomads of the Steppe

While China and the Middle East developed agriculture, an entirely different way of life arose in the grasslands of southern Russia where the climate was too dry and too extreme for farming, yet the natural vegetation could support herbivores. In the region lying between the Black and Caspian seas, called the Pontic-Caspian Steppe, residents began herding cattle and sheep in the river valleys in the sixth millennium. Sometime after 4800 BCE, they succeeded in domesticating the horse, not to ride but as a source of meat, for horses can forage for grass through the snow during the winter, when cattle will stand and starve. By 4000 BCE, they had bred more docile horses and learned to ride them. This gave them unprecedented mobility and the ability to herd far more cattle than they could on foot.[27]

Meanwhile in the mid-fourth millennium, the inhabitants of lower Mesopotamia had created the first wheeled vehicle, a cart with four solid wheels pulled by oxen. This invention spread to the Pontic-Caspian Steppe between 3500 and 3300 BCE. The combination of ox-drawn carts and horses that could be ridden opened up the grasslands between the river valleys that had previously been too difficult for pedestrian herders. The people who possessed these tools, called Yamnaya, could herd far more animals and move them from place to place to find fresh pastures. On horseback, they could scout, raid, and trade over long distances, while their ox-carts slowly carried water, food, shelter, and other necessities across the plains. Here and there, they cultivated barley or millet, mined ores, and made metal tools and weapons.[28]

So wealthy and powerful did the Yamnaya people become that they began to migrate with their herds into the lower Danube Valley, overcoming the resident farmers.[29] To the causes of their success—their wealth in horses and cattle and their prowess as horseback-riding warriors—anthropologists Gregory Cochran and Henry Harpending have added another, a genetic mutation that allowed them to drink milk after weaning. Lactose tolerance is common among people who raise cattle, such as the Maasai of East Africa, but is rare in the rest of the world. This mutation first appeared among the Yamnaya and gave them far more food per animal than was available to

lactose-intolerant herding peoples, who could digest only the meat of their animals. It also made them mobile and self-sufficient in their encounters with farmers. When the Yamnaya entered the Balkans, the farmers abandoned their villages and fled, or died. Their graves show them to be four inches shorter than the invaders, signaling their inferior health and strength.[30]

To the north and west of eastern China, the land is covered with steppe, giving way to evergreen forests in Siberia and to the Gobi Desert in Mongolia. The steppe, too dry to farm, was the native habitat of wild cattle and horses. Steppe dwellers coming from the west in the late fourth millennium brought domesticated horses that helped them herd cattle, horses, and sheep. Living in areas too marginal for any settlements and with a climate that varied enormously from year to year, herding peoples had to keep moving to find fresh grass for their animals. Tribes of nomadic herders often engaged in warfare with one another and with farmers to the south and east. These were the ancestors of the Huns and Mongols who would cast a shadow on Chinese history for centuries.[31]

New Guinea

At about the same time that people in China and the Middle East were producing food, so too were the inhabitants of New Guinea. That island has a rugged topography, a hot and rainy climate, and thick rainforest vegetation. In this unique environment, farming developed in ways that were very different from both the open-field and the rice-paddy farming of other lands.

Hunting and gathering never flourished in New Guinea as it did elsewhere because of the scarcity of game and of edible plants in the rainforest and because of the mountainous terrain. Instead, it seems the inhabitants were manipulating their environment as early as the seventh millennium BCE. At a place called Kuk Swamp, archaeologists have found artificial mounds dating to the late seventh millennium and drainage ditches from the early fourth millennium BCE. Foragers may have started by selecting sago palms or mountain pandanus and clearing away competing trees, keeping channels open in sago swamps, and felling mature trees in order to promote new shoots.

When the inhabitants began farming, they cleared the land by felling the trees, then setting fire to the resulting deadwood, a method of farming called swidden or slash-and-burn. Not only did this open up land and kill weeds, but the ashes also fertilized the soil. Farmers who cleared land this way, then

moved on when its fertility was exhausted, could not continue doing so indefinitely. When untouched land ran out, they returned to fields they had used once before and then left fallow. After a field had lain fallow for a time, wild plants that had invaded it could be burned to replenish its nutrients for the next crop. The length of the fallow—from a year to several decades—depended in part on how quickly vegetation regenerated on it and in part on whether farmers were able to provide other fertilizers besides ashes, such as organic wastes. Fallowing was therefore not one system but a continuum.

Some plants could be reproduced by taking a cutting from an existing plant and sticking it in the ground. In this way, New Guineans encouraged the growth of plants with edible parts: sago, pandanus, yams, sugarcane, banana, and taro. Unlike the grains that nourished farmers in other parts of the world, the edible roots and fruits of the New Guinea rainforest could not be stored for long, nor was there any need to store food because the warm wet climate produced food year-round.[32]

No animals are known to have been domesticated in New Guinea; the animals that people eventually kept—pigs, chickens, and dogs—were all introduced from Southeast Asia. In this food production system, pigs were almost the only source of meat in a protein-deficient diet. The inhabitants raised sows and let them forage in the forest and mate with wild boars during the day but return to the village at night; these pigs were feral rather than fully domesticated. Since the forest provided too little food even for pigs, the farmers grew crops to fatten them up for special occasions.[33]

Tropical Africa

Africa, the homeland of the human race, has always been a particularly difficult region in which to grow food. The climate, mostly tropical, varies from extremely wet rainforests to the driest of deserts. Furthermore, it has fluctuated enormously between wet and dry. In many places, the soil is poor in nutrients. The disease ecology of sub-Saharan Africa—homeland to many pathogens that prey upon humans—kept the population density much lower than in the inhabited parts of Eurasia.

Between circa 10,000 and 4000 BCE, northern and eastern Africa received considerably more rain than today. The Sahara was covered with grasslands and lakes. Forests of oak, pistachio, lime, elm, and pine grew in the moister areas. Foragers hunted gazelles, hares, and Barbary sheep; caught fish, turtles,

snails, and mollusks; and painted pictures of giraffes, crocodiles, and other animals on rock walls at Tassili n'Ajjer, now in the desert.

During these lush times, the people of the Sahara began to manipulate nature. They started with animals. Sometime after about 8000 BCE, they captured and penned Barbary sheep in a cave in the eastern Sahara, the first step toward domestication. Around 7000 BCE, migrants brought herds of cattle to the Sahara. This breed of longhorn cattle was probably domesticated independently of the western Eurasian cattle of the time. As nomadic pastoralism spread across the Sahara, new paintings at Tassili n'Ajjer show these longhorn cows with their herders.

Then the monsoon winds that had brought rain to the northern half of the continent shifted northward toward Europe, causing a permanent desiccation of the Sahara and unreliable rains in the Sahel to the south of it. Herders abandoned the Sahara, some migrating to the Nile Valley. Between 5000 and 4000 BCE, as the flood levels of the Nile declined, Neolithic farmers in Egypt began cultivating crops like wheat, barley, and flax and raising sheep and goats, all of them adopted from the people of the nearby Fertile Crescent.[34]

Elsewhere in Africa, the domestication of plants occurred independently in several different places. The idea of farming may have come from the Middle East, but as Middle Eastern crops would not grow south of the Sahara, the crops that Africans domesticated were entirely different: African red rice (*Oryza glaberrima*) in West Africa, yams (*Dioscorea cayennensis rotundata*) and oil palms (*Elaeis guineensis*) in the savanna south of the Sahel, drought-resistant finger millet (*Eleusina coracana*) and sorghum (*Sorghum bicolor*) in the Sahel, and coffee (*Coffea*) and teff (*Eragrostis tef*) in Ethiopia.[35]

During the mid-second millennium BCE, a people who spoke a language we call proto-Bantu began migrating out of their homeland in northeastern Nigeria and northern Cameroon, perhaps pushed out by a drying climate.[36] Some migrated south along the Atlantic coast into the equatorial rainforest of the Congo basin, while others made their way into the savanna belt of East Africa. As farmers, they outnumbered and either absorbed or overwhelmed the indigenous foragers. After settling for a few years, the farmers moved on, for tropical soil was quickly depleted of nutrients. Canoes aided their travels on the rivers of equatorial Africa. By 1500 BCE they had populated the Great Lakes region and by 500 CE they had reached South Africa. In some areas, Bantu-speaking herders preceded farmers.

Whatever drove their early migrations, another factor—iron—helps explain the success of the migrants. By the mid-first millennium BCE,

Bantu-speaking ironsmiths were producing farming tools such as axe and hoe blades and weapons such as cutlasses and spears. Iron was used not only to fell trees, cultivate land, and smite enemies but also as a form of wealth. As a result, smiths attained high social status in Bantu-speaking societies.

During the first millennium BCE, Bantu-speakers settled along rivers and in open forests. What allowed them to penetrate the deeper forests of equatorial Africa was the introduction of the banana and plantain from Southeast Asia by Malay mariners in the early first millennium CE. These crops were ideally suited to the rainforest, where they produced ten times the yield of yams. Furthermore, they did not require full clearing like yam fields and hence created fewer habitats for *Anopheles* mosquitoes, carriers of malaria. With farming, pottery, iron tools, and bananas, Bantu-speaking peoples occupied every environment in central, eastern, and southern Africa, except a few pockets of dense rainforests in the Congo basin and the Kalahari deserts of the south, gradually replacing the foragers who had occupied sub-Saharan Africa before them.[37]

Diseases affected both humans and domesticated animals. In the moister parts of Africa, along the West African coast and in the equatorial rainforest, nagana, the animal analogue of human sleeping sickness, made it impossible to keep cattle. In the Sahel and the savannas of East Africa, cattle could survive in many places, but not others. Horses, however, could not survive even where cattle could. Thus, cattle herders like the Maasai in East Africa herded their animals on foot, which limited their mobility and their wealth compared with that of the herders of Central Asia and Mongolia. Wild animals were evidently not affected by nagana, which is why there are still herds of wild herbivores in Kenya, Tanzania, and South Africa.[38] In Somalia, an area too dry for cattle, camels imported from Arabia served Somali herders as a source of milk and meat, but not as a means of transportation.[39]

The Americas

In the Americas, as in Eurasia, population growth and climatic instability led people to try domesticating plants and animals. After about 6000 BCE, as the climate turned cooler and drier, people began to experiment with cultivating edible plants.[40] Yet the differences between the Old World and the New are stark. Native Americans found many plants that lent themselves to domestication, and many of the ones they domesticated have since become staples of

diets around the world: potatoes, maize, tomatoes, avocados, manioc (or cassava), squash, sweet potatoes, many varieties of beans, and many peppers—and also tobacco. Plant domestication began about the same time as in China and the Middle East but, due to the nature of these plants, it took much longer than it had in Eurasia before Native Americans could rely on farming alone for their subsistence.

Though rich in domesticable plants compared to the Old World, they were at a disadvantage in animals. After the megafauna extinctions of the Pleistocene, the Americas had few animals amenable to domestication: dogs, which had accompanied the first human immigrants across Beringia; guanacos, vicuñas, and guinea pigs in South America; and turkeys and Muscovy ducks in Mesoamerica. None of them were strong enough to carry a person or pull a cart or a plow.[41]

Plants were first domesticated in four distinct parts of the Americas: Mesoamerica, Peru and the Andes, eastern North America, and Amazonia. The first three have been carefully investigated by archaeologists; the fourth is still largely unknown. Because the Americas lie on a north-south axis, distances and climate barriers delayed the diffusion of domesticated plants and animals between the regions. As there was no trade and few human contacts between South and North America, llamas, alpacas, guinea pigs, quinoa, and potatoes were never transferred from the Andes to Mesoamerica or to North America, nor were turkeys brought to South America. Maize, manioc, and sweet potatoes, found on both continents, were the exception. Even between Mesoamerica and North America, plant transfers were difficult; it took several thousand years for maize, a sub-tropical plant, to be bred into a variety that could tolerate the short summers of the temperate zone.[42]

Mexico

The inhabitants of Mexico faced a situation similar to that of the eastern Mediterranean, namely, good soil and abundant sunshine, but highly seasonal rainfall. As large game became scarce after 7000 BCE, they increasingly came to rely on collecting the seeds of wild plants. The first cultivated plant in the Americas was the bottle gourd (*Lagenaria siceraria*), a native of Africa that had reached the Americas about 10,000 years earlier. It probably came by drifting across the Atlantic on ocean currents and then being dispersed by

animals before it was cultivated by Paleo-Indians. After it came squash, cultivated in Mexico from the seventh millennium on.[43]

The origin of maize (*Zea mays*) has been the subject of research and controversy for decades because there is no comparable wild plant, and the domesticated variety cannot reproduce without human help. Archaeologists have found cobs of a grass called *Zea tripsacum*, a possible ancestor of maize, in the Tehuacán and Balsas river valleys south of Mexico City.[44] Another possible ancestor of maize is the weedy grass teosinte that grows in Mexico and Guatemala. Whichever it was, hundreds of years went by before farmers produced a domesticated maize with inch-long cobs.

Excavations at Guilá Naquitz, a rock shelter near Oaxaca, showed that the inhabitants grew maize, beans, and squash. But they continued to rely heavily on hunting and gathering, returning to the site to harvest what they had planted. Not until about 2000 BCE did they grow cobs large enough and in sufficient quantity to support permanent villages. Because it took so long to create a productive form of maize and because domesticable animals were so few, the transition from pure foraging to fully developed agriculture took over four millennia, much longer than in the Middle East.[45]

In addition to the difficulty of finding suitable plants, Mexican farmers had to cope with rainy winters and dry summers. Some early farmers made the most of their environment by tapping springs. Starting around 800 BCE, they created a network of canals and aqueducts 1,200 kilometers long that irrigated 330 square kilometers of farmland. In the Tehuacán Valley, as early as 750 BCE, they constructed the Purrón Dam, the largest in the Americas before the eighteenth century. On hillsides above the Oaxaca Valley in south-central Mexico, early farmers built long narrow terraces out of stones and filled them with soil brought up from the valley floor mixed with organic wastes and potsherds. In these they planted their crops. To water the plants during the dry season, they constructed 6.5 kilometers of canals from a spring to their fields. All of this work was done by the farmers without the benefit of draft animals, wheeled vehicles, or metal.[46]

Western South America

The west coast of South America, from Ecuador to central Chile, contains more diverse environments in a small area than anywhere else on Earth. Just off the coast, the Humboldt Current that brings cold water up from

Antarctica teems with fish that in turn nourish huge numbers of sea birds. The predominant winds, coming from the Atlantic, lose all their moisture while crossing the Andes. As a result, the coast is among the driest places in the world, where the only water is in the rivers that flow down from the mountains. In the midst of the Andes lies the Altiplano, a high plateau that was home to herds of guanacos and vicuñas, distant relatives of the camels of Eurasia. Finally, on the eastern slopes of the Andes begins the rainforest of Amazonia.

Humans foraged in all three environments. On the Altiplano, hunters domesticated llamas from wild guanacos for their meat and as pack animals, and alpacas from the smaller vicuñas for their wool. By the time maize appeared in Peru around 3200 BCE, the inhabitants of the Altiplano had already begun domesticating quinoa and, soon thereafter, potatoes and lima beans.

Of the three environments, the most challenging was the coast. Around 2500 BCE, its inhabitants turned from hunting and gathering on land to exploiting marine resources full time. After 1700 BCE, some gave up fishing for farming, building irrigation channels to water the fields closest to the rivers. The combination of rich alluvial soils, irrigation water, and guano (the excrement of sea birds that roosted along the coast) as fertilizer produced astonishing yields, hence attracting dense populations.[47]

Amazonia

The ecology and prehistory of Amazonia, like that of other tropical rainforests, is far less well known than that of the dry tropics or the temperate zone. To outsiders, the rainforest seems to offer very little edible vegetation or game. Today, those parts of the forest not yet invaded and "developed" by people of European or African descent are inhabited by a few widely scattered tribes of hunter-gatherers who practice a limited form of slash-and-burn agriculture. Much of the forest seems uninhabited, hence the common belief that before Europeans arrived Amazonia was a virgin forest, an illusion produced by this strange and hostile environment.

It was not always the case. The first Europeans to visit Amazonia had astonishing tales to tell. In 1542, Francisco de Orellana, one of the Spanish conquistadors who accompanied Pizarro, led an expedition down the Amazon River from Peru to the Atlantic Ocean. The chaplain on the expedition, Gaspar de Carvajal, wrote a report of the expedition's adventures in which