Jared Diamond - Guns, Germs, and Steel; The Fates of Human Societies.
ISBN: 0-393-31755-2

Understanding is more often used to try to alter an outcome than to repeat or perpetuate it. That's why psychologists try to understand the minds of murderers and rapists, why social historians try to understand genocide, and why physicians try to understand the causes of human disease. (17)

... compared with hunter-gatherers, citizens of modern industrialized states enjoy better medical care, lower risk of death by homicide, and a longer life span, but receive much less social support from friendships and extended families. (18)

... modern "Stone Age" peoples are on the average probably more intelligent, not less intelligent, than industrialized people. (19)

... our cognitive abilities as adults are heavily influenced by the social environment that we experienced during childhood. [...] tests of cognitive abilities (like IQ) tend to measure cultural learning and not pure innate intelligence, whatever that is. (20)

Almost all studies of child development emphasize the role of childhood stimulation and activity in promoting mental development, and stress the irreversible mental stunting associated with reduced childhood stimulation. (21)

New Guinea, though it accounts for only a small fraction of the world's land area, encompasses a disproportionate fraction of its human diversity. Of the modern world's 6,000 languages, 1,000 are confined to New Guinea. (27)

Far more Native Americans and other non-Eurasian peoples were killed by Eurasian germs than by Eurasian guns or steel weapons. Conversely, few or no distinctive lethal germs awaited would-be European conquerors in the New World. Why was the germ exchange so unequal? Here, the results of recent molecular biological studies are illuminating in linking germs to the rise of food production, in Eurasia much more than in the Americas. (29)

By enabling farmers to generate food surpluses, food production permitted farming societies to support full-time craft specialists who did not grow their own food and who developed technologies. (30)

Our closest living relatives are three surviving species of great ape: the gorilla, the common chimpanzee, and the pygmy chimpanzee (also known as bonobo). Their confinement to Africa, along with abundant fossil evidence, indicates that the earliest states of human evolution were also played out in Africa. Human history, as something separate from the history of animals, began there about 7 million years ago (estimates range from 5 to 9 million years ago). Around that time, a population of African apes broke up into several populations, of which one proceeded to evolve into modern gorillas, a second into the two modern chimps, and the third into humans. The gorilla line apparently split off slightly before the split between the chimp and the human lines. (36)

After half a million years ago, the human populations of Africa and western Eurasia

proceeded to diverge from each other and from East Asian populations in skeletal details. The population of Europe and western Asia between 130,000 and 40,000 years ago is represented by especially many skeletons, known a Neanderthals and sometimes classified as a separate species, *Homo neanderthalensis*. (38)

Human history at last took off around 50,000 years ago, at the time of what I have termed our Great Leap Forward. The earliest definite signs of that leap come from East African sites with standardized stone tools and the first preserved jewelry (ostrich-shell beads). Similar developments soon appear in the Near East and in southeastern Europe, where abundant artifacts are associated with fully modern skeletons of people termed Cro-Magnons. Thereafter, the garbage preserved at archaeological sites rapidly becomes more and more interesting and leaves no doubt that we are dealing with biologically and behaviorally modern humans. (39)

The Great Leap Forward poses two major unresolved questions, regarding its triggering cause and its geographic location. As for its cause, I argued in my book *The Third Chimpanzee* for the perfection of the voice box and hence for the anatomical basis of modern language, on which the exercise of human creativity is so dependent. Others have suggested instead that a change in brain organization around that time, without a change in brain size, made modern language possible. (40)

... skulls of humans living in China and Indonesia hundreds of thousands of years ago are considered by some physical anthropologists to exhibit features still found in modern Chinese and in Aboriginal Australians, respectively. If true, that finding would suggest parallel evolution and multiregional origins of modern humans, rather than origins in a single Garden of Eden. (40)

During the Ice Ages, so much of the oceans' water was locked up in glaciers than worldwide sea levels dropped hundreds of feet below their present stand. As a result, what are now the shallow seas between Asia and the Indonesian islands of Sumatra, Borneo, Java and Bali became dry land. (So did other shallow straits, such as the Bering Strait and the English Channel). The edge of the Southeast Asian mainland then lay 700 miles east of its present location. Nevertheless, central Indonesian islands between Bali and Australia remained surrounded and separated by deep water channels. To reach Australia / New Guinea from the Asian mainland at that time still required crossing a minimum of eight channels, the broadest of which was at least 50 miles wide. Most of those channels divided islands visible from each other, but Australia itself was always invisible from even the nearest Indonesian islands, Timor and Tanimbar. Thus, the occupation of Australia / New Guinea is momentous in that it demanded watercraft and provides by far the earliest evidence of their use in history. Not until about 30,000 years later (13,000 years ago) is there strong evidence of watercraft anywhere else in the world, from the Mediterranean. (41)

The settlement of Australia / New Guinea was perhaps associated with still another big first, besides humans' first use of watercraft and first range extension since reaching Eurasia: the first mas extermination of large animal species by humans. (42)

Those extinctions eliminated all the large wild animals that might otherwise have been candidates for domestication, and left native Australians and New Guineans with not a single native domestic animal. (44)

... it is uncertain when, between about 14,000 and 35,000 years ago, the Americas were first colonized. The oldest unquestioned human remains in the Americas are at sites in Alaska dated around 12,000 B.C., followed by a profusion of sites in United States south of the Canadian border and in Mexico in the centuries just before 11,000 B.C. (45)

... the earliest secure evidence of human presence in Alaska dates from around 12,000 B.C. Soon thereafter, a north-south ice-free corridor opened in the Canadian ice sheet, permitting the first Alaskans to pass through and come out into the Great Plains around the site of the modern Canadian city of Edmonton. That removed the last serious barrier between Alaska and Patagonia form modern humans. The Edmonton pioneers would have found the Great Plains teeming with wild game. They would have thrived, increased in numbers, and gradually spread south to occupy the whole hemisphere. (46)

The settlement of the world's remaining islands was not completed until modern times: Mediterranean islands such as Crete, Cyprus, Corsica, and Sardinia between about 8500 and 4000 B.C.; Caribbean islands beginning around 4000 B.C; Polynesian and Micronesian islands between 1200 B.C and A.D. 1000; Madagascar sometime between A.D. 300 and 800; and Iceland in the ninth century A.D. Native Americans, possibly ancestral to the modern Inuit, spread throughout the High Arctic around 2000 B.C. (50)

... human genetic diversity is highest in Africa (51)

...[it took] 9,000 years to occupy the High Arctic after the occupation of the rest of North America. (51)

... at high population densities only a portion of the people came to be farmers, but they were mobilized to devote themselves to intensive food production, thereby yielding surpluses to feed nonproducers. The nonproducers mobilizing them included chiefs, priests, bureaucrats, and warriors. (62)

The most dramatic moment in subsequent European-Native American relations was the first encounter between the Inca emperor Atahuallpa and the Spanish conquistador Francisco Pizarro at the Peruvian highland town of Cajamarca on November 16, 1532. Atahuallpa was absolute monarch of the largest and most advanced state in the New World, while Pizarro represented the Holy Roman Emperor Charles V (also known as King Charles I of Spain), monarch of the most powerful state in Europe. Pizarro, leading a ragtag group of 168 Spanish soldiers, was in unfamiliar terrain, ignorant of the local inhabitants, completely out of touch with the nearest Spaniards (1,000 miles to the north in Panama) and far beyond the reach of timely reinforcements. Atahuallpa was in the middle of his own empire of millions of subjects and immediately surrounded by his army of 80,000 soldiers, recently victorious in a war with other Indians. Nevertheless, Pizarro captured Atahuallpa within a few minutes after the two leaders first set eyes on each other. Pizarro proceeded to hold his prisoner for eight months, while extracting history's largest ransom in return for a promise to free him. After the ransom - enough gold to fill a room 22 feet long by 17 feet wide to a height of over 8 feet - was delivered, Pizarro reneged on his promise and executed Atahuallpa. (68)

We easily forget that horses and rifles were originally unknown to Native Americans. They were bought by Europeans and proceeded to transform the societies of Indian

tribes that acquired them. Thanks to their mastery of horses and rifles, the Plains Indians of North America, the Araucanian Indians of souther Chile, and the Pampas Indians of Argentina fought off invading whites longer than did any other Native Americans, succumbing only to massive army operations by white governments in the 1870s and 1880s. (75)

... in 1808 a British sailor named Charlie Savage equipped with muskets and excellent aim arrived in the Fiji Island. The aptly named Savage proceeded single-handedly to upset Fiji's balance of power. Among his many exploits, he paddled his canoe up a river to the Fijian village of Kasavu, halted less than a pistol shot's length from the village fence, and fired away at the undefended inhabitants. His victims were so numerous that surviving villagers piled up the bodies to take shelter behind them, and the stream beside the village was red with blood. (76)

The Spaniards' steel or chain mail armor and [...] their steel helmets usually provided an effective defense against club blows, while the Indians' quilted armor offered no protection against steel weapons. [...] Horsemen could easily outride Indian sentries before the sentries had time to warn Indian troops behind them and could ride down and kill Indians on foot. The shock of a horse's charge, its maneuverability, the speed of attack that it permitted, and the raised and protected fighting platform that it provided left foot soldiers nearly helpless in the open. (76)

The transformation of warfare by horses began with their domestication around 4000 B.C., in the steppes north of the Black Sea. (77)

... a smallpox epidemic devastated the Aztecs after the failure of the first Spanish attack in 1520 and killed Cuitlahuac, the Aztec emperor who briefly succeeded Montezuma. Throughout the Americas, diseases introduced with Europeans spread from tribe to tribe far in advance of the Europeans themselves, killing an estimated 95 percent of the pre-Columbian Native American population. The most populous and highly organized native societies of North America, the Mississippian chiefdoms, disappeared in that way between 1492 and the late 1600s, even before Europeans themselves made their first settlement on the Mississippi River. A smallpox epidemic in 1713 was the biggest single step in the destruction of South Africa's native San people by European settlers. Soon after the British settlement of Sydney in 1788, the first of the epidemics that decimated Aboriginal Australians began. A well-documented example from Pacific islands is the epidemic that swept over Fiji in 1806, brought by a few European sailors who struggled ashore from the wreck of the ship *Argo*. Similar epidemics marked the histories of Tonga, Hawaii, and other Pacific islands. (77-78)

My fellow farmhands were, for the most part, tough whites whose normal speech featured strings of curses, and who spent their weekdays working so that they could devote their weekends to squandering their week's wages in the local saloon. (85)

By selecting and growing those few species of plants and animals that we can eat, so that they constitute 90 percent rather than 0.1 percent of the biomass on an acre of land, we obtain far more edible calories per acre. As a result, one acre can feed many more herders and farmers - typically, 10 to 100 times more - than hunter-gatherers. That strength of brute numbers was the first of many military advantages that food-producing tribes gained over hunter-gatherer tribes. In human societies possessing

domestic animals, livestock fed more people in four distinct ways: by furnishing meat, milk, and fertilizer and by pulling plows. First and most directly, domestic animals became the societies' major source of animal protein, replacing wild game. [...] Milked mammals [...] yield several times more calories over their lifetime than if they were just slaughtered and consumed as meat. (88)

... the first prehistoric farmers of central Europe, the so-called Linearbandkeramik culture that arose slightly before 5000 B.C., were initially confined to soils light enough to be tilled by means of hand-held digging sticks. Only over a thousand years later, with the introduction of the ox-drawn plow, were those farmers able to extend cultivation to a much wider range of heavy soils and tough sods. [...] People of many hunter-gatherer societies move frequently in search of wild foods, but farmers must remain near their fields and orchards. The resulting fixed abode contributes to denser human populations by permitting a shortened birth interval. [...] Nomadic hunter-gatherers space their children about four years apart by means of lactational amenorrhea, sexual abstinence, infanticide, and abortion. (89)

Hunter-gatherer societies tend to be relatively egalitarian, to lack full-time bureaucrats and hereditary chiefs, and to have small-scale political organization at the level of the band or tribe. [...] In contrast, once food can be stockpiled, a political elite can gain control of food produced by others, assert the right of taxation, escape the need to feed itself, and engage full-time in political activities. [...] Those complex political units are much better able to mount a sustained war of conquest than is an egalitarian band of hunters. [...] A stored food surplus built up by taxation can support [...] professional soldiers. That was the decisive factor in the British Empire's eventual defeat of New Zealand's well-armed indigenous Maori population. While the Maori achieved some stunning temporary victories, they could not maintain an army constantly in the field and were in the end worn down by 18,000 full-time British troops. (90)

... the availability of domestic plants and animals ultimately explains why empires, literacy, and steel weapons developed earliest in Eurasia and later, or not at all, on other continents. (92)

... what cries out for explanation is the failure of food production to appear, until modern times,in some ecologically very suitable areas that are among the world's richest centers of agriculture and herding today. Foremost among these puzzling areas, where indigenous peoples were still hunter-gatherers when European colonists arrived, were California and the other Pacific states of the United States, the Argentine pampas, southwestern and southeastern Australia, and much of the Cape region of South Africa. [...] When we trace food production back to its beginnings, the earliest sites provide another surprise. Far from being modern breadbaskets, they include areas ranking today as somewhat dry or ecologically degraded: Iraq and Iran, Mexico, the Andes, parts of China, and Africa's Sahel zone. (93-94)

... cattle were domesticated independently in India and western Eurasia, within the last 10,000 years, starting with wild Indian and western Eurasian cattle subspecies that had diverged hundreds of thousands of years earlier. (98)

... areas in which food production arose altogether independently, with the domestication of many indigenous crops (and, in some cases, animals) before the arrival of any crops

or animals [...]: Southwest Asia, also known as the Near East of Fertile Crescent; China; Mesoamerica (the term applied to central and souther Mexico and adjacent areas of Central America); the Andes of South America, and possibly the adjacent Amazon Basin as well; and the easter United States. (98)

In short, only a few areas of the world developed food production independently, and they did so at widely differing times. From those nuclear areas, hunter-gatherers of some neighboring areas learned food production, and peoples of other neighboring areas were replaced by invading food producers from the nuclear areas - again at widely differing times. Finally, peoples of some areas ecologically suitable for food production neither evolved nor acquired agriculture in prehistoric times at all; they persisted as hunter-gatherers until the modern world finally swept upon them. The peoples of areas with a head start on food production thereby gained a head start on the path leading toward guns, germs, and steel. (103)

Time budget studies shot that [farmers] may spend more rather than fewer hours per day at work than hunter-gatherers do. Archaeologists have demonstrated that the first farmers in many areas were smaller and less well nourished, suffered from more serious diseases, and died on the average at a younger age than the hunter-gatherers they replaced. (105)

... food production *evolved* as a by-product of decisions made without awareness of their consequences. (106)

Even in the cases of the most rapid independent development of food production from a hunter-gathering lifestyle, it took thousands of years to shift from complete dependence on wild foods to a diet with very few wild foods. In early stages of food production, people simultaneously collected wild foods *and* raised cultivates ones, and diverse types of collecting activities diminished in importance at different times as reliance on crops increased. (107)

... around 3000 B.C. the hunter-gatherers of southern Sweden adopted farming based on Southwest Asian crops, but abandoned it around 2700 B.C. and reverted to hunting-gathering for 400 years before resuming farming. (109)

... over the last 10,000 years, the predominant result has been a shift from hunting-gathering to food production. [...] What were the factors that tipped the competitive advantage away from the former and toward the latter? (109-112)
•decline in the availability of wild foods
•an increase availability of domesticable wild plants made steps leading to plant domestication more rewarding
•cumulative development of technologies on which food production wold eventually depend - technologies for collecting, processing, and storing foods
•two-way link between the rise in human population density and the rise in food production
•the much denser populations of food producers enabled them to displace or kill hunter-gatherers by their sheer numbers

... in most areas of the globe suitable for food production, hunter-gatherers met one of two fates: either they were displaced by neighboring food producers, or else they

survived only by adopting food production themselves. (112)

... peas were domesticated by 8000 B.C., olives around 4000 B.C., strawberries not until the Middle Ages, and pecans not until 1846. Many valuable wild plants yielding food prized by millions of people, such as oaks sought for their edible acorns in many parts of the world, remain untamed even today. (115)

When strawberry seeds are still young and not yet ready to be planted, the surrounding fruit is green, sour, and hard. When the seeds finally mature, the berries turn red, sweet, and tender. The change in the berries' color serves as a signal attracting birds like thrushes to pluck the berries and fly off, eventually to spit out or defecate the seeds. (116)

You prefer large berries, because it's not worth your while to get sunburned and mosquito bitten for some lousy little berries. That provides part of the explanation why many crop plants have much bigger fruits than their wild ancestors do. (117)

Another obvious difference between seeds that we grow and many of their wild ancestors is in bitterness. Many wild seeds evolve to be bitter, bad-tasting, or actually poisonous, in order to deter animals from eating them. Thus, natural selection acts oppositely on seeds and on fruits. Plants whose fruits are tasty get their seeds dispersed by animals, but the seed itself within the fruit has to be bad-tasting. Otherwise, the animal would also chew up the seed, and it couldn't sprout. (118)

Lima beans, watermelons, potatoes, eggplants, and cabbages are among the many [...] familiar crops whose wild ancestors were bitter or poisonous. (118)

Especially instructive are cases in which a single wild plant species was variously selected for different purposes and thereby gave rise to quite different-looking crops. [...] Ancestral cabbage plants, possibly grown originally for their oily seeds, underwent even greater diversification as they became variously selected for leaves (modern cabbage and kale), stems (kohlrabi), buds (brussel sprouts), or flower shoots (cauliflower and broccoli). (122)

... Darwin, in his great book *On the Origin of Species*, didn't start with an account of natural selection. His first chapter is instead a lengthy account of how our domesticated plants and animals arose through artificial selection by humans. Rather than discussing the Galapagos Island birds that we usually associate with him, Darwin began by discussing - how farmers develop varieties of gooseberries! He wrote, "I have seen great surprise expressed in horticultural works at the wonderful skill of gardeners, in having produced such splendid results from such poor materials; but the art has been simple, and as far as the final result is concerned, has been followed almost unconsciously. It has consisted in always cultivating the best-known variety, sowing its seeds, and, when a slightly better variety chanced to appear, selecting it, and so onwards." Those principles of crop development by artificial selection still serve as our most understandable model of the origin of species by natural selection. (130)

The world holds only about 148 species of large wild mammalian terrestrial herbivores or omnivores, the large mammals that could be considered candidates for domestication. [...] A mere dozen species account for over 80 percent of the modern world's annual

tonnage of all crops. Those dozen blockbusters are the cereals wheat, corn, rice, barley, and sorghum; the pulse soybean; the roots or tubers potato, manioc, and sweet potato; the sugar sources sugarcane and sugar beet; and the fruit banana. Cereal crops alone now account for more than half of the calories consumed by the world's human population. (132)

Many Fertile Crescent plants, especially species of cereals and pulses, have adapted in a way that renders them useful to humans: they are annuals, meaning that the plant itself dries up and dies in the dry season. [...] Annual plants [...] waste little energy on making inedible wood or fibrous stems, like the body of trees and bushes. (136)

The combination of [...] two factors - a high diversity of species and a high percentage of annuals - means that western Eurasia's Mediterranean zone is the one with by far the highest diversity of annuals [plants]. (139)

In the Fertile Crescent the transition from hunter-gathering to food production took place relatively fast: as late as 9000 B.C. people still had no crops and domestic animals and were entirely dependent on wild foods, but by 6000 B.C. some societies were almost completely dependent on crops and domestic animals. The situation in Mesoamerica contrasts strongly: that area provided only two domesticable animals (the turkey and the dog), whose meat yield was far lower than that of cows, sheep, goats, and pigs; and corn, Mesoamerica's staple grain, was [...] difficult to domesticate and perhaps slow to develop. As a result, domestication may not have begun in Mesoamerica until around 3500 B.C. (the date remains very uncertain); those first developments were undertaken by people who were still nomadic hunter-gatherers; and settled villages did not arise there until around 1500 B.C. (142)

For the last 33 years, while conducting biological exploration in New Guinea, I have been spending my field time there constantly in the company of New Guineans who still use wild plants and animals extensively. One day, when my companions of the Fore tribe and I were starving in the jungle because another tribe was blocking our return to our supply base, a Fore man returned to camp with a large rucksack full of mushrooms he had found, and started to roast them. Dinner at last! But then I had unsettling thought: what if the mushrooms were poisonous? I patiently explained to my Fore companions that I had read about some mushrooms' being poisonous, that I had heard of even expert American mushroom collectors' dying because of the difficulty of distinguishing safe from dangerous mushroom,s and that although we were all hungry,it just wasn't worth the risk. At that point my companions got angry and told me to shut up and listen while they explained some things to me. After I had been quizzing them for years about names of hundreds of trees and birds, how could I insult them by assuming they didn't have names for different mushrooms? Only Americans could be so stupid as to confuse poisonous mushrooms with safe ones. They went on to lecture me about 29 types of edible mushrooms species, each species' name in the Fore language, and where in the forest one should look for it. This one, the *tanti*, grew on trees, and it was delicious and perfectly edible. (144)

... the first farmers in the Jordan Valley selected the 2 very best of the 23 best wild grass species available to them. Of course, the evolutionary changes (following cultivation) in seed dispersal and germination inhibition would have been unforeseen consequences of what those first farmers were doing. But their initial selection of barley and emmer wheat

rather than other cereals to collect, bring home, and cultivate would have been conscious and based on the easily detected criteria of seed size, palatability, and abundance. (146)

... indigenous crops from different parts of the globe were not equally productive. (147)

People have been living in New Guinea for at least 40,000 years - much longer than in the Americas, and slightly longer than anatomically modern peoples have been living in western Europe (147)

Children in the New Guinea highlands have the swollen bellies characteristic of a high-bulk but protein-deficient diet. New Guineans old and young routinely eat mice, spiders, frogs, and other small animals that people elsewhere with access to large domestic mammals or large wild game species do not bother to eat. Protein starvation is probably also the ultimate reason why cannibalism was widespread in traditional New Guinea highland societies. (149)

... even though people had been farming in the New Guinea highlands for many thousands of years before sweet potatoes were introduced, the available local crops had limited them in the population densities they could attain, and in the elevations they could occupy. [...] Like hunter-gatherers of the Fertile Crescent, those of New Guinea did evolve food production independently. However, their indigenous food production was restricted by the local absence of domesticable cereals, pulses, and animals, by the resulting protein deficiency in the highlands, and by limitations of the locally available root crops at high elevations. (149)

... the limitations on indigenous food production in the eastern United States were not due to Native American peoples themselves, but instead depended entirely on the American biota and environment. (152-153)

Peoples of the Fertile Crescent domesticated local plants much earlier. They domesticated far more species, domesticated a much wider range of types of crops, developed intensified food production and dense human populations more rapidly, and as a result entered the modern world with more advanced technology, more complex political organization, and more epidemic diseases with which to infect other peoples. (153)

Australia, supposedly the most "backward" continent, illustrates [the] point well. In southeastern Australia, the well-watered part of the continent most suitable for food production, Aboriginal societies in recent millennia appear to have been evolving on a trajectory that would eventually have led to indigenous food production. They had begun to manage their environment intensively for fish production by building fish traps, nets, and even long canals. Had Europeans not colonized Australia in 1788 and aborted that independent trajectory, Aboriginal Australians might within a few thousand years have become food producers, tending ponds of domesticated fish and growing domesticated Australian yams and small-seeded grasses. (155)

... the reason Native Americans did not domesticate apples lay with the entire suite of wild plant and animal species available to Native Americans. That suite's modest potential for domestication was responsible for the late start of food production in North America. (156)

Domesticable animals are all alike; every undomesticable animal is undomesticable in its own way. [...] the famous first sentence of Tolstoy's great novel *Anna Karenina*: "Happy families are all alike; every unhappy family is unhappy in its own way." By that sentence, Tolstoy meant that, in order to be happy, a marriage must succeed in many different respects: sexual attraction, agreement about money, child discipline, religion, in-laws, another vital issues. Failure in any one of those essential respects can doom a marriage even if it has all the other ingredients needed for happiness. (157)

... small domestic mammals and domestic birds and insects have [...] been useful to humans. Many birds were domesticated for meat, eggs, and feathers: the chicken in china, various duck and goose species in parts of Eurasia, turkey in Mesoamerica, guinea fowl in Africa, and the Muscovy duck in South America. Wolves were domesticated in Eurasia and North America to become our dogs used as hunting companions, sentinels, pets, and, in some societies, food. Rodents and other small mammals domesticated for food included the rabbit in Europe, the guinea pig in the Andes, a giant rat in West Africa, and possibly a rodent called the hutia on Caribbean islands. Ferrets were domesticated in Europe to hunt rabbits, and cats were domesticated in North Africa and Southwest Asia to hunt rodent pests. Small mammals domesticated as recently as the 19th and 20th centuries include foxes, mink, and chinchillas grown for fur and hamsters kept as pets. Even some insects have been domesticated, notably Eurasia's honeybee and China's silkworm moth, kept for honey and silk, respectively. (158)

... a domesticated animal is defined as an animal selectively bred in captivity and thereby modified from its wild ancestors, for use by humans who control the animals breeding and food supply. That is, domestication involves wild animals' being transformed into something more useful to humans. Truly domesticated animals differ in various ways from their wild ancestors. These differences result from two processes: human selection of those individual animals more useful to humans than other individuals of the same species, and automatic evolutionary responses of animals to the altered forces of natural selection operating in human environments as compared with wild environments. [...] Several species of domestic animals have smaller brains and less developed sense organs than their wild ancestors, because they no longer need the bigger brains and more developed sense organs on which their ancestors depended to escape from wild predators. To appreciate the changes that developed under domestication, just compare wolves, the wild ancestors of domestic dogs, with the many breeds of dogs. Some dogs are much bigger than wolves (Great Danes), while others are much smaller (Pekingese). Some are slimmer and built for racing (greyhounds), while others are short-legged and useless for racing (dachshunds). They vary enormously in hair form and color, and some are even hairless. Polynesians and Aztecs developed dog breeds specifically raised for food. Comparing a dachshund with a wolf, you wouldn't even suspect that the former had been derived from the latter if you didn't already know it. (159-161)

The lack of domestic mammals indigenous to sub-Saharan Africa is especially astonishing, since a main reason why tourists visit Africa today is to see its abundant and diverse wild mammals. (161)

... part of the explanation for Eurasia's having been the main site of big mammal domestication is that it was the continent with the most candidate species of wild mammals to start out with, and lost fewest candidates to extinction in the last 40,000 years. (163)

... facts indicate that the explanation for the lack of native mammal domestication outside Eurasia lay with the locally available wild mammals themselves, not with the local people. (164)

New Guineans [...] regularly capture chicks of wild cassowaries (an ostrich-like large, flightless bird) and raise them to eat as a delicacy - even though captive adult cassowaries are extremely dangerous and now and then disembowel village people. (165)

Perhaps the most unlikely pet is the European brown bear (the same species as the American grizzly bear), which the Ainu people of Japan *regularly* captured as young animals, tamed, and reared to kill and eat in a ritual ceremony. (165)

All species for whose dates of domestication we have archaeological evidence were domesticated between 8000 B.C. and 2500 B.C. - that is, within the first few thousand years of the sedentary farming-herding societies that arose after the end of the last Ice Age. (165-166)

... big mammal domestication virtually ended 4,500 years ago. By then, all of the world's 148 candidate big species must have been tested innumerable times, with the result that only a few passed the test and no other suitable ones remained. (166)

... the San Diego and Los Angeles zoos are now subjecting the last surviving California condors to a more draconian control of breeding than that imposed upon any domesticated species. All individual condors have been genetically identified, and a computer program determines which male shall mate with which female in order to achieve human goals (in this case, to maximize genetic diversity and thereby preserve this endangered bird). Zoos are conducting similar breeding programs for many other threatened species, including gorillas and rhinos. (168)

Playing marriage counselor to the zebra / human couple and other ill-sorted pairs, we can recognize at least six groups of reasons for failed domestication: diet, growth rate, problems of captive breeding, nasty disposition, tendency to panic, social structure. (169-172)

Zebras have the unpleasant habit of biting a person and not letting go. They thereby injure even more American zookeepers each year than do tigers! (172)

... no gazelle species has ever been domesticated. Just imagine trying to herd an animal that bolts, blindly bashes itself against walls, can leap up to nearly 30 feet, and can run at a speed of 50 miles per hour! (172)

... herds of wild horses consists of one stallion, up to half a dozen mares, and their foals. [...] When the herd is on the move, its members maintain stereotyped order: in the read, the stallion; in the front, the top-ranking female, followed by her foals in order of age, with the youngest first; and behind her, the other mares in order of rank, each followed by her foals in order of age. In that way, many adults can coexist in the herd without constant fighting and with each knowing its rank. (172-173)

Axis orientations affected the rate of spread of crops and livestock, and possibly also of writing, wheels, and other inventions. (176)

Most of the wild plant species from which our crops were derived vary genetically from area to area, because alternative mutations had become established among the wild ancestral populations of different areas. Similarly, the changes required to transform wild plants into crops can in principle be brought about by alternative new mutations or alternative courses of selection to yield equivalent result (178-179)

... if a productive crop is already available, incipient farmers will surely proceed to grow it rather than start all over again by gathering its not yet so useful wild relative and redomesticating it. (179)

... most of the Fertile Crescent's founder crops were never domesticated again elsewhere after their initial domestication in the Fertile Crescent. [...]Localities distributed east and west of each other at the same latitude share exactly the same day length and its seasonal variations. To a lesser degree, they also tend to share similar diseases, regimes of temperature and rainfall, and habitats or biomes (types of vegetation). For example, Portugal, northern Iran, and Japan, all located at about the same latitude but lying successively, 4,000 miles east or west of each other, are more similar to each other in climate than each is to a location lying even a mere 1,000 miles due south. (182-183)

... African agriculture south of the Sahara was launched by the domestication of wild plants (such as sorghum and African yams) indigenous to the Sahel zone and to tropical West Africa, and adapted to the warm temperatures, summer rains, and relatively constant day lengths of those low latitudes. Similarly, the spread southward of Fertile Crescent domestic animals through Africa was stopped or slowed by climate and disease, especially by trypanosome diseases carried by tsetse files. The horse never became established farther south than West Africa's kingdoms north of the equator. [...] Only when European settlers arrived by sea in 1652, bringing with them their Fertile Crescent crop package, could agriculture thrive in South Africa's Mediterranean zone. (186-187)

The distance between Mesoamerica and South America – say, between Mexico's highlands and Ecuador's – is only 1,200 miles, approximately the same as the distance in Eurasia separating the Balkans from Mesopotamia. The Balkans provided ideal growing conditions for most Mesopotamian crops and livestock, and received those domesticates as a package within 2,000 years of its assembly in the Fertile Crescent. That rapid spread preempted opportunities for domesticating those and related species in the Balkans. Highland Mexico and the Andes would similarly have been suitable for many or each other's crops and domestic animals. A few crops, notably Mexican corn, did indeed spread to the other region in pre-Columbian era. But other crops and domestic animals failed to spread between Mesoamerica and south America. [...] Five thousand years after llamas had been domesticated in the Andes, the Olmecs, Maya, Aztecs, and all other native societies of Mexico remained without pack animals and without any edible domestic mammals except for dogs. (187-188)

... crop diffusion between the U.S. Southeast and Southwest was very slow and selective although these two regions are at the same latitude. That's because much of the intervening area of Texas and the southern Great Plains was dry and unsuitable for agriculture. A corresponding example with Eurasia involved the eastern limit of Fertile

Crescent crops, which spread rapidly westward to the Atlantic Ocean and eastward to the Indus Valley without encountering a major barrier. However, father eastward in India the shift from predominantly winter rainfall to predominantly summer rainfall contributed to a much more delayed extension of agriculture, involving different crops and farming techniques, into the Ganges plain of northeastern India. (189)

... around 3,000 B.C. The invention of the wheel in our near Southwest Asia spread rapidly west and east across much of Eurasia within a few centuries, whereas the wheels invented independently in prehistoric Mexico never spread south to the Andes. Similarly, the principle of alphabetic writing, developed in the western part of the Fertile Crescent by 1500 B.C., spread west to Carthage and east to the Indian subcontinent within about a thousand years, but the Mesoamerican writing systems that flourished in prehistoric times for at least 2,000 years never reached the Andes. (190)

... one part of the explanation for farmer power lies in the much denser populations that food production could support: ten naked farmers certainly would have an advantage over one naked hunter-gatherer in a fight. The other part is that neither farmers nor hunter-gatherers are naked, at least not figuratively. Farmers tend to breathe out nastier germs, to own better weapons and armor, to own more-powerful technology in general, and to live under centralized governments with literate elites better able to wage wars of conquest. (195)

Some of us adults, and even more of our children, pick up infections diseases from our pets. Usually they remain no more than nuisance, but a few have evolved into something far more serious. The major killers of humanity throughout our recent history – smallpox, flu, tuberculosis, malaria, plague, measles, and cholera – are infectious diseases that evolved from diseases of animals, even though most of the microbes responsible for our own epidemic illnesses are paradoxically now almost confined to humans. (196-197)

... microbes are as much a product of natural selection as we are. Basically, microbes evolve like other species. Evolution selects for those individuals most effective at producing babies and at helping them spread to suitable places to live. For a microbe spread may be defined mathematically as the number of new victims infected per each original patient. That number depends on how long each victim remains capable of infecting new victims, and how efficiently the microbe is transferred from one victim to the next. Microbes have evolved diverse ways of spreading from one person to another, and from animals to people. [...] The most effortless way a germ could spread is by just waiting to be transmitted passively to the next victim. That's the strategy practiced by microbes that wait for one host to be eaten by the next host: for instance, salmonella bacteria, which we contract by eating already infected eggs or meat; the worm responsible for trichinosis, which gets from pigs to us by waiting for us to kill the pig and eat it without proper cooking; and the worm causing anisakiasis, with which sushi-loving Japanese and Americans occasionally infect themselves by consuming raw fish. Those parasites pass to a person from an eaten animal, but the virus causing laughing sickness (kuru) in the New Guinea highlands used to pass to a person from another person who was eaten. It was transmitted by cannibalism, when highland babies made the fatal mistake of licking their fingers after playing with raw brains that their mothers had just cut out of dead kuru victims awaiting cooking. Some microbes don't wait for the old host to die and get eaten, but instead hitchhike in the saliva of an insect that bites the old host and flies off to find a new host. [...] Other germs take matters into their own hands,

figuratively speaking. They modify the anatomy or habits of their hosts in such a way as to accelerate their transmission. [...] More vigorous yet is the strategy practiced by the influenza, common cold, and pertussis (whooping cough) microbes, which induce the victim to cough or sneeze, thereby launching a cloud of microbes toward prospective new hosts. [...] Thus, from our point of view, genital sores, diarrhea, and coughing are "symptoms of disease." From a germ's point of view, they're clever evolutionary strategies to broadcast the germ. [...] But why should a germ evolve the apparently self-defeating strategy of killing its host? From the germ's perspective, that's just an unintended by-product (fat consolation to us!) of host symptoms promoting efficient transmission of microbes. (198-200)

For almost any disease, some people prove to be genetically more resistant than are others. In an epidemic those people with genes for resistance to that particular microbe are more likely to survive than are people lacking such genes. As a result, over the course of history, human populations repeatedly exposed to a particular pathogen have come to consist of a higher proportion of individuals with those genes for resistance – just because unfortunate individuals without the genes were less likely to survive to pass their genes on to babies. (2001)

The greatest single epidemic in human history was the one of influenza that killed 21 million people at the end of the First World War. The Black Death (bubonic plague) killed one-quarter of Europe's population between 1346 and 1352, with death tolls ranging up to 70 percent in some cities. When the Canadian Pacific Railroad was being built through Saskatchewan in the early 1880s, that province's Native Americans, who had previously had little exposure to whites and their germs, died of tuberculosis at the incredible rate of 9 percent per year. (2002)

Studies show that measles is likely to die out in any human population numbering fewer than half a million people. Only in larger populations can the disease shift from one local area to another, thereby persisting until enough babies have been born in the originally infected area that measles can return there. (2003)

The close similarity of the measles virus to the rinderpest virus suggests that the latter transferred from cattle to humans and then evolved into the measles virus by changing its properties to adopt to us. (2006)

... in 1519 Cortes landed on the coast of Mexico with 600 Spaniards, to conquer the fiercely militaristic Aztec Empire with a population of many millions. That Cortes reached the Aztec capital of Tenochtitlan, escaped with the loss of "only" two-thirds of his force, and managed to fight his way back to the coast demonstrates both Spanish military advantages and the initial naivety of the Aztecs. But when Cortes' next onslaught came, the Aztecs were no longer naive and fought street by street with the utmost tenacity. What gave the Spaniards a decisive advantage was smallpox, which reached Mexico in 1520 with one infected slave arriving from Spanish Cuba. The resulting epidemic proceeded to kill nearly half of the Aztecs, including Emperor Cuitlahuac. Aztec survivors were demoralized by the mysterious illness that killed Indians and spared Spaniards, as if advertising the Spaniards' invincibility. By 1618, Mexico's initial population of about 20 million had plummeted to about 1.6 million. (210)

The two indisputably independent inventions of writing were achieved by the Sumerians

of Mesopotamia somewhat before 3000 B.C. and by Mexican Indians before 600 B.C.; Egyptian writing of 3000 B.C and Chinese writing (by 1300 B.C.) may also have arisen independently. Probably all other peoples who have developed writing since then have borrowed, adapted, or at least been inspired by existing systems. [...] In the last centuries before 3000 B.C., developments in accounting technology, format, and signs rapidly led to the first system of writing. One such technological innovation was the use of flat clay tablets as a convenient writing surface. Initially, the clay was scratched with pointed tools, which gradually yielded to reed styluses for neatly pressing a mark into a tablet. Developments in format included the gradual adoption of conventions whose necessity is now universally accepted: that writing should be organized into ruled rows or columns (horizontal rows for the Sumerians, as for modern Europeans); that the lines should be read in a constant direction (left to right for Sumerians, as for modern Europeans); and that the lines should be read from top to bottom of the tablet rather than vice versa. (218)

Perhaps the most important single step in the whole history of writing was the Sumerians' introduction of phonetic representation, initially by writing an abstract noun (which could not be readily drawn as a picture) by means of the sign for a depictable noun that had the same phonetic pronunciation. For instance, it's easy to draw a recognizable picture of *arrow*, hard to draw a recognizable picture of *life*, but both are pronounced ti in Sumerian, so a picture of an arrow came to mean either *arrow* or *life*. The resulting ambiguity was resolved by the addition of a silent sign called a determinative, to indicate the category of nouns to which the intended object belonged. Linguists term this decisive innovation, which also underlies puns today, the rebus principle. (220)

Besides Sumerian cuneiform, the other certain instance of independent origins of writing in human history comes from native American societies of Mesoamerica, probably southern Mexico. Mesoamerican writing is believed to have arisen independently of Old World writing, because there is no convincing evidence for pre-Norse contact of New World societies with Old World societies possessing writing. In addition, the forms of Mesoamerican writing signs were entirely different from those of any Old World scripts. About a dozen Mesoamerican scripts are known, all or most of them apparently related to each other (for example, in their numerical and calendrical systems), and most of them still only partially deciphered. At the moment, the earliest preserved Mesoamerican script is from the Zapotec area of southern Mexico around 600 B.C., but by far the best-understood one is of the Lowland Maya region, where the oldest known written date corresponds to A.D. 292. Despite its independent origins and distinctive sign forms, Maya writing is organized on principles basically similar to those of Sumerian writing and other western Eurasian writing systems that Sumerian inspired. Like Sumerian, Maya writing used both logograms and phonetic signs. Logograms for abstract words were often derived by the rebus principle. That is, an abstract word was written with the sign for another word pronounced similarly but with a different meaning that could be readily depicted. Like the signs of Japan's kana and Mycenean Greece's Linear B syllabaries, Maya phonetic signs were mostly signs for syllables of one consonant plus one vowel (such as *ta, te, ti, to, tu*). Like letters of the early Semitic alphabet, Maya syllabic signs were derived from pictures of the object whose pronunciation began with that syllable (for example, the Maya syllabic sign "*ne*" resembles a tail, for which the Maya word is *neh*). (222)

Cyrillic alphabet itself (the one still used today in Russia) is descended from an adaptation of Greek and Hebrew letters devised by Saint Cyril, a Greek missionary to the Slavs in the ninth century A.D. The first preserved texts for any Germanic language (the language family that includes English) are in the Gothic alphabet created by Bishop Ulfilas, a missionary living with the Visigoths in what is now Bulgaria in the fourth century A.D. Like Saint Cyril's invention, Ulfilas' alphabet was a mishmash of letters borrowed from different sources: about 20 Greek letters, about five Roman letters, and two letters either taken from the runic alphabet or invented by Ulfilas himself. (225)

Alphabets apparently arose only once in human history: among speakers of Semitic languages, in the area from modern Syria to the Sinai, during the second millennium B.C. All of the hundreds of historical and now existing alphabets were ultimately derived from that ancestral Semitic alphabet, in a few cases (such as the Irish ogham alphabet) by idea diffusion, but in most by actual copying and modification of letter forms. (226)

The third and last innovation leading to modern alphabets was to provide for vowels. Already in the early days of the Semitic alphabet, experiments began with methods for writing vowels by adding small extra letters to indicate selected vowels, or else by dots, lines, or hooks sprinkled over the consonantal letters. In the eight century B.C. The Greeks became the first people to indicate all vowels systematically by the same types of letters used for consonants. Greeks derived the forms of their vowel letters *α – ε – η – ι - ο* by "co-opting" five letters used in the Phoenician alphabet for consonantal sounding lacking in Greek. (227)

... first [Chinese writing] attested around 1300 B.C. but with possible earlier precursors, it too has unique local signs and some unique principles, and most scholars assume that it evolved independently. Writing had developed before 3000 B.C. in Sumer, 4,000 miles west of early Chinese urban centers, and appeared by 2200 B.C. in the Indus Valley, 2,6000 miles west, but no early writing systems are known from the whole area between the Indus Valley and China. Thus, there is no evidence that the earliest Chinese scribes could have had knowledge of any other writing system to inspire them. (231)

The *Iliad* and *Odyssey* were composed and transmitted by nonliterate bards for nonliterate listeners, and not committed to writing until the development of the Greek alphabet hundreds of years later. (235)

Early Egyptian hieroglyphs recorded religious and state propaganda and bureaucratic accounts. Preserved Maya writing was similarly devoted to propaganda, births and accessions and victories of kings, and astronomical observations of priests (235)

The *intended* restricted uses of early writing provide a positive disincentive for devising less ambiguous writing system. (235)

... the first preserved example of Greek alphabetic writing, scratched onto an Athenian wine jug of about 740 B.C., is a line of poetry announcing a dancing contest: "Whoever of all dancers performs most nimbly will win the vase as a prise." (236)

... invention is often the mother of necessity, rather than vice versa. A good example is the history of Thomas Edison's phonograph, the most original invention of the greatest inventor of moder times. When Edison built his first phonograph in 1877, he published an

article proposing ten uses to which his invention might be put. They included preserving the last words of dying people, recording books for blind people to hear, announcing clock time, and teaching spelling. Reproduction of music was not high on Edison's list of priorities. A few years later Edison told his assistant that his invention had no commercial value. Within another few years he changed his mind and did enter business to sell phonographs – but for use as office dictating machines. When other entrepreneurs created jukeboxes by arranging for a phonograph to play popular music at the drop of a coin, Edison objected to this debasement, which apparently detracted from serious office use of his invention. Only after about 20 years did Edison reluctantly concede that the main use of his phonograph was to record and play music. (243)

All recognized famous inventors had capable predecessors and successors and made their improvements at a time when society was capable of using their product. (245)

... technology develops cumulatively, rather than in isolated heroic acts, and [...] it finds most of its uses after it has been invented, rather than being invented to meet a foreseen need. (245-246)

... at least four factors influence acceptance [of an invention]. The first and most obvious factor is relative economic advantage compared with existing technology. [...] A second consideration is social value and prestige, which can override economic benefit (or lack thereof). [...] Still another factor is compatibility with vested interests. [... the last] is the ease with which their advantages can be observed. (247-249)

We are all familiar with the supposed generalization that rural Third World societies are less receptive to innovation than are Westernized industrial societies. Even within the industrialized world, some areas are much more receptive than others. Such differences, if they existed on a continental scale, might explain why technology developed faster on some continents than on others. [...] A laundry list of at least 14 explanatory factors has been proposed by historians of technology. One is long life expectancy, which in principle should give prospective inventors the years necessary to accumulate technical knowledge, as well as the patience and security to embark on long development programs yielding delayed rewards. Hence the greatly increased life expectancy brought by modern medicine may have contributed to the recently accelerating pace of inventions. The next five factors involve economics or the organization of society: (1) The availability of cheap slave labor in classical times supposedly discouraged innovation then, whereas high wages or labor scarcity now stimulate the search for technological solutions. [...] (2) Patents and other property laws, protecting ownership rights of inventors, reward innovation in the modern West, while the lack of such protection discourages it in modern China. (3) Modern industrial societies provide extensive opportunities for technical training, as medieval Islam did and modern Zaire does not. (4) Modern capitalism is, and the ancient Roman economy was not, organized in a way that made it potentially rewarding to invest capital in technological development. (5) The strong individualism of U.S. Society allows successful inventors to keep earnings for themselves, whereas strong family ties in New Guinea ensure that someone who begins to earn money will be joined by a dozen relatives expecting to move in and fed and supported. Another four suggested explanations are ideological, rather than economic or organizational: (1) Risk-taking behavior, essential for efforts at innovation, is more widespread in some societies than in others. (2) the scientific outlook is a unique feature of post-renaissance European society that has contributed heavily to its modern

technological preeminence. (3) Tolerance of diverse views and of heretics fosters innovation, whereas a strongly traditional outlook (as in China's emphasis on ancient Chinese classics) stifles it. (4) Religions vary greatly in their relation to technological innovations: some branches of Judaism and Christianity are claimed to be especially compatible with it, while some branches of Islam, Hinduism, and Brahmanism may be especially incompatible with it. [...] The remaining four proposed factors – war, centralized government, climate, and resource abundance – appear to act inconsistently: sometimes they stimulate technology, sometimes they inhibit it. (1) Throughout history, war has often been a leading stimulant of technological innovation. For instance, the enormous investments made in nuclear weapons during World War II and in airplanes and trucks during World War I launched whole new fields of technology. But wars can also deal devastating setbacks to technological development. (2) Strong centralized government boosted technology in late-19th-century Germany and Japan, and crushed it in china after A.D. 1500. (3) Many northern Europeans assume that technology thrives in a rigorous climate where survival is impossible without technology, and withers in a benign climate where clothing is unnecessary and bananas supposedly fall off the trees. An opposite view is that benign environments leave people free from the constant struggle for existence, free to devote themselves to innovation. (4) There has also been debate over whether technology is stimulated by abundance or by scarcity of environmental resources. Abundant resources might stimulate the development of inventions utilizing those resources, such as water mill technology in rainy northern Europe, with its many rivers – but why didn't water mill technology progress more rapidly in even rainier New Guinea? The destruction of Britain's forests has been suggested as the reason behind its early lead in developing coal technology, but why didn't deforestation have the same effect in China? (249-251)

In 1964 [in New Guinea] I met a 50-year-old Chimbu man, unable to read, wearing a traditional grass skirt, and born into a society still using stone tools, who had become rich by growing coffee, used his profits to buy a sawmill for $100,000 cash, and bought a fleet of trucks to transport his coffee and timber to market. (252)

Today the most numerous Native American tribe in the United States is the Navajo, who on European arrival were just one of several hundred tribes. But the Navajo proved especially resilient and able to deal selectively with innovations. They incorporated Western dyes into their weaving, became silversmiths and ranchers, and now drive trucks while continuing to live in traditional dwellings. (252-253)

... the development and reception of inventions vary enormously from society to society on the same continent. They also vary over time within the same society. Nowadays, Islamic societies in the Middle East are relative conservative and not at the forefront of technology. But medieval Islam in the same region was technologically advanced and open to innovations. It achieved far higher literacy rates than contemporary Europe; it assimilated the legacy of classical Greek civilization to such a degree that many classical Greek books are now known to us only through Arabic copies; it invented or elaborated windmills, tidal mills, trigonometry, and lateen sails; it made major advances in metallurgy, mechanical and chemical engineering, and irrigation methods; and it adopted paper and gunpowder from china and transmitted them to Europe. In the Middle Ages the flow of technology was overwhelmingly from Islam to Europe, rather than from Europe to Islam as it is today. Only after around A.D. 1500 did the net direction of flow begin to reverse. Innovation in China too fluctuated markedly with time. Until around

A.D. 1450, China was technologically much more innovative and advanced than Europe, even more so than medieval Islam. The long list of Chinese inventions includes canal lock gates, cast iron, deep drilling, efficient animal harnesses, gunpowder, kites, magnetic compasses, movable type, paper, porcelain, printing (except for the Phaistos disk), sternpost rudders, and wheelbarrows. China then ceased to be innovative for reasons about which we shall speculate in the Epilogue. Conversely, we think of western Europe and its derived North American societies as leading the modern world in technological innovation, but technology was less advanced in western Europe than in any other "civilized" area of the Old World until the late Middle Ages. (253)

... it is untrue that there are continents whose societies have tended to be innovative and continents whose societies have tended to be conservative. On any continent, at any given time, there are innovative societies and also conservative ones. In addition, receptivity to innovation fluctuates in time within the same region. (254)

The relative importance of local invention and of borrowing depends mainly on two factors: the ease of invention of the particular technology, and the proximity of the particular society to other societies. (254)

Pottery appeared in Japan around 14,000 years ago, in the Fertile Crescent and in China by around 10,000 years ago, and in Amazonia, Africa's Sahel zone, the U.S. Southeast, and Mexico thereafter. (254)

... the wheel [...] is first attested around 3400 B.C. near the Black Sea, and then turns up within the next few centuries over much of Europe and Asia. (255)

Firearms reached Japan in A.D. 1543, when two Portuguese adventurers armed with harquebuses (primitive guns) arrived on a Chinese cargo ship. The Japanese were so impressed by the new weapon that they commenced indigenous gun production, greatly improved gun technology, and by A.D. 1600 owned more and better guns than any other country in the world. But there were also factors working against the acceptance of firearms in Japan. The country had a numerous warrior class, the samurai, for whom swords rated as class symbols and works of art (and as means for subjugating the lower classes). Japanese warfare had previously involved single combats between samurai swordsmen, who stood in the open, made ritual speeches, and then took pride in fighting gracefully. Such behavior became lethal in the presence of peasant soldiers ungracefully blasting away with guns. In addition, guns were a foreign invention and grew to be despised, as did other things foreign in Japan after 1600. The samurai-controlled government began by restricting gun production to a few cities, then introduced a requirement of a government license for producing a gun, then issued licenses only for guns produced for the government, and finally reduced government orders for guns, until Japan was almost without functional guns again. (257-258)

Because technology begets more technology, the importance of an invention's diffusion potentially exceeds the importance of the original invention. Technology's history exemplifies what is termed an autocatalytic process: that is one that speeds up at a rate that increases with time, because the process catalyzes itself. (258)

In [...] long history of accelerating development, one can single out two especially significant jumps. The first, occurring between 100,000 and 50,000 years ago, probably

was made possible by genetic changes in our bodies: namely, by evolution of the modern anatomy permitting modern speech or modern brain function, or both. That jump led to bone tools, single-purpose stone tools, and compound tools. The second jump resulted from our adoption of a sedentary lifestyle, which happened at different times in different parts of the world, as early as 13,000 years ago in some areas and not even today in others. For the most part, that adoption was linked to our adoption of food production, which required us to remain close to our crops, orchards, and stored food surpluses. (260)

... all other things being equal, technology develops fastest in large productive regions with large human populations, many potential inventors, and many competing societies. (261)

Eurasia's considerable initial advantage thereby was translated into a huge lead as of A.D. 1492 – for reasons of Eurasia's distinctive geography rather than of distinctive human intellect. (264)

Probably all humans lived in bands until at least 40,000 years ago, and most still did as recently as 11,000 years ago. (268)

Why do people of the Lakes Plains [area of New Guinea where some hunter-gatherer societies known as Fayu live] continue to live as nomadic bands, when most other New Guinea peoples, and almost all other peoples elsewhere in the world, now live in settled larger groups? The explanation is that the region lacks dense local concentrations of resources that would permit many people to live together, and that (until the arrival of missionaries bringing crop plants) it also lacked native plants that could have permitted productive farming. The bands' food staple is the sago palm tree, whose core yields a starchy pith when the palm reaches maturity. The bands are nomadic, because they must move when they have cut the mature sago trees in an area. Band numbers are kept low by diseases (especially malaria), by the lack of raw materials in the swamp (even stone for tools must be obtained by trade), and by the limited amount of food that the swamp yields for humans. (269-270)

... the tribe differs [from bands] in being larger (typically comprising hundreds rather than dozens of people) and usually having fixed settlements. However, some tribes and even chiefdoms consist of herders who move seasonally. (270)

... evidence suggests that tribal organization began to emerge around 13,000 years ago in the Fertile Crescent and later in some other areas. (271)

... as of A.D. 1492, chiefdoms were still widespread over much of the eastern United States, in productive areas of South and Central America and sub-Saharan Africa that had not yet been subsumed under native states, and in all of Polynesia. The archaeological evidence [...] suggests that chiefdoms arose by around 5500 B.C. in the Fertile Crescent and by around 1000 B.C. in Mesoamerica and the Andes. (273)

With the rise of chiefdoms around 7,5000 years ago, people had to learn, for the first time in history, how to encounter strangers regularly without attempting to kill them. (273)

... chiefdoms consisted of multiple hereditary lineages living at one site. [...] all members of the chief's lineage had hereditary perquisites. [...] The most distinctive economic feature of chiefdoms was their shift from reliance solely on the reciprocal exchanges characteristic of bands and tribes, by which A gives B a gift while expecting that B at some unspecified future time will give a gift of comparable value to A. [...] While continuing reciprocal exchanges and without marketing or money, chiefdoms developed an additional new system termed a redistributive economy. (274-275)

The difference between a kleptocrat and a wise statesman, between a robber baron and a public benefactor, is merely one of degree: a matter of just how large a percentage of the tribute extracted from producers is retained by the elite, and how much the commoners like the public uses to which the redistributed tribe is put. We consider President Mobutu of Zaire a kleptocrat because he keeps too much tribute (the equivalent of billions of dollars) and redistributes too little tribute (no functioning telephone system in Zaire). We consider George Washington a statesman because he spent tax money on widely admired programs and did not enrich himself as president. Nevertheless, George Washington was born into wealth, which is much more unequally distributed in the United States than in New Guinea villages. (276)

... why do the commoners tolerate the transfer of the fruits of their hard labor to kleptocrats? [...] Kleptocracies with little public support run the risk of being overthrown, either by downtrodden commoners or by upstart would-be replacement kleptocrat seeking public support by promising a higher ratio of services rendered to fruits stolen. (276)

What should an elite do to gain popular support while still maintaining a more comfortable lifestyle than commoners? (277)

1. Disarm the populace, and arm the elite.
2. Make the masses happy by redistributing much of the tribute received, in popular ways.
3. Use the monopoly of force to promote happiness, by maintaining public order and curbing violence.
4. [...] construct an ideology or religion justifying kleptocracy.

Besides justifying the transfer of wealth to kleptocrat, institutionalized religion brings two other important benefits to centralized societies. First, shared ideology or religion helps solve the problem of how unrelated individuals are to live together without killing each other – by providing them with a bond not based on kinship. Second, it gives people a motive, other than genetic self-interest, for sacrificing their lives on behalf of others. At the cost of a few society members who die in battle as soldiers, the whole society becomes much more effective at conquering other societies or resisting attacks. (278)

... states arose around 3700 B.C. in Mesopotamia and around 300 B.C. in Mesoamerica, over 2,000 years ago in the Andes, China, and Southeast Asia, and over 1,000 years ago in West Africa. (278)

Cities differ from villages in their monumental public works, palaces of rulers, accumulation of capital from tribute or taxes, and concentration of people other than food producers. (279)

Even in democracies today, crucial knowledge is available to only a few individuals, who control the flow of information to the rest of the government and consequently control decisions. (279)

The most fundamental [...] distinction is that states are organized on political and territorial lines, not on the kinship lines that defined bands, tribes, and simple chiefdoms. Furthermore, bands and tribes always, and chiefdoms usually, consist of a single ethnic and linguistic group. States, though -especially so-called empires formed by amalgamation or conquest of states – are regularly multiethnic and multilingual. State bureaucrats are not selected mainly on the basis of kinship, as in chiefdoms, but are professionals selected at least partly on the basis of training and ability.(280-281)

Over the past 13,000 years the predominant trend in human society has been the replacement of smaller, less complex units by larger, more complex ones. (281)

Obvious [...] part of the reason for states' triumphs over simpler entities when the two collide is that states usually enjoy an advantage of weaponry and other technology, and a large numerical advantage in population. But there are also two other potential advantages inherent in chiefdoms and states. First, a centralized decision maker has the advantage at concentrating troops and resources. Second, the official religions and patriotic fervor of many states make their troops willing to fight suicidally. The latter willingness is one so strongly programmed into us citizens of modern states, by our schools and churches and governments, that we forget what a radical break it marks with previous human history. Every state has its slogan urging its citizens to be prepared to die if necessary for the state: Britain's “For King and Country,” Spain's “Por Dios y Espana,” and so on. Similar sentiments motivated 16-th century Aztec warriors: “There is nothing like death in war, nothing like the flowery death so precious to Him {The Aztec national god Huitzilopochtli} who gives life: far off I see it, my heart years for it!” (281)

... the size of the regional population is the strongest single predictor of societal complexity. (284)

... chiefdoms with large populations prove to be the most centralized, stratified, and complex ones. (284)

... population growth leads to societal complexity, [...] while societal complexity in turn leads to intensified food production and thereby to population growth. (285)

... competition between societies at one level of complexity tends to lead to societies on the next level of complexity if conditions permit. (288-289)

... large units potentially enjoy an advantage over individual small units if – and that's a big “if” - the large units can solve the problems that come with their larger size, such as perennial threats from upstart claimants to leadership, commoner resentment of kleptocracy, and increased problems associated with economic integration. (289)

Amalgamation [of smaller societies] occurs in either of two ways: by merger under the threat of external force, or by actual conquest. (289)

The 'Cherokees were originally divided into 30 or 40 independent chiefdoms, each

consisting of a village of about 400 people. Increasing white settlement led to conflicts between Cherokees and whites. When individual Cherokees robbed or assaulted white settlers and traders, the whites were unable to discriminate among the different Cherokee chiefdoms and retaliated indiscriminately against any Cherokees, either by military action of by cutting off trade. In response, the Cherokee chiefdoms gradually found themselves compelled to join into a single confederacy in the course of the 18th century. Initially, the larger chiefdoms in 1730 chose an overall leader, a chief named Moytoy, who was succeeded in 1741 by his son. The first task of these leaders was to punish individual Cherokees who attacked whites, and to deal with the white government. Around 1758 the Cherokees regularized their decision making with an annual council modeled on previous village councils and meeting at one village (Echota), which thereby became a de facto "capital." Eventually, the Cherokees became literate and adopted a written constitution. (289)

Why should wars tend to cause amalgamations of societies when populations are dense but not when they are sparse? The answer is that the fate of defeated peoples depends on population density, with three possible outcomes: Where population densities are very low, as is usual in regions occupied by hunter-gatherer bands, survivors of a defeated group need only move farther away from their enemies. [...] Where population densities are moderate, as in regions occupied by food-producing tribes, no large vacant areas remain to which survivors of a defeated band can flee. [...] The victors have no use for survivors of a defeated tribe, unless to take the women in marriage. The defeated men are killed, and their territory may be occupied by the victors. Where population densities are high, as in regions occupied by states of chiefdoms, the defeated still have nowhere to flee, but the victors now have two options for exploiting them while leaving them alive. Because chiefdoms and state societies have economic specialization, the defeated can be used as slaves, as commonly happened in biblical times. Alternatively, because many such societies have intensive food production systems capable of yielding large surpluses, the victors can leave the defeated in place but deprive them of political autonomy, make them pay regular tribute in food or goods, and amalgamate their society into the victorious state or chiefdom. (291-292)

... food production, and competition and diffusion between societies, led as ultimate causes, via chains of causation that differed in detail but that all involved large dense populations and sedentary living, to the proximate agents of conquest: germs, writing, technology, and centralized political organization. (292)

Australia is by far the driest, smallest, flattest, most infertile, climatically most unpredictable, and biologically most impoverished continent. (296)

Australia is the sole continent where, in modern times, all native peoples still lived without any of the hallmarks of so-called civilization – without farming, herding, metal, bows and arrows, substantial buildings, settled villages, writing, chiefdoms, or states. Instead, Australian Aborigines were nomadic or seminomadic hunter-gatherers, organized into bands, living in temporary shelters or huts, and still dependent on stone tools. During the last 13,000 years less cultural change has accumulated in Australia than in any other continent. [...] Yet, as of 40,000 years ago, Native Australian societies enjoyed a big head start over societies of Europe and the other continents. Native Australians developed some of the earliest known stone tools with ground edges, the earliest hafted stone tools (that is, stone ax heads mounted on handles), and by far the

earliest watercraft, in the world, Some of the oldest known painting on rock surfaces comes from Australia. Anatomically modern humans may have settled Australia before they settled western Europe. [...] During the Pleistocene Ice Ages, when much ocean water was sequestered in continental ice sheets and sea levels dropped far below its present stand, the shallow Arafura Sea now separating Australia from New Guinea was low, dry land. With the melting of ice sheets between around 12,000 and 8,000 years ago, sea levels rose, that low land became flooded, and the former continent of Greater Australia became sundered into the two hemi-continents of Australia and New Guinea. (297)

... it is now generally acknowledged that agriculture arose indigenously in the New Guinea highlands by domestication of New Guinea wild plant species. (303)

New Guinea swamps [...] provide a clear instance of an environment where people remained hunter-gatherers because farming could not compete with the hunting-gathering lifestyle. (305)

With a mere 1,000,000 people, New Guinea could not develop the technology, writing, and political systems that arose among populations of tens of millions in China, the Fertile Crescent, the Andes, and Mesoamerica. (306)

The Aboriginal Australian substitute for food production has been termed "firestick farming." The Aborigines modified and managed the surrounding landscape in ways that increased its production of edible plants and animals, without resorting to cultivation. In particular, they intentionally burned much of the landscape periodically. That served several purposes: the fires drove out animals that could be killed and eaten immediately: fires converted dense thickets into open parkland in which people could travel more easily; the parkland was also an ideal habitat for kangaroos, Australia's prime game animal; and the fires stimulated the growth both of new grass on which kangaroos fed and of fern roots on which Aborigines themselves fed. (309)

The reason we think of Aborigines as desert people is simply that Europeans killed or drove them out of the most desirable areas, leaving the last intact Aboriginal populations only in areas that Europeans didn't want. (310)

At Pleistocene times of low sea level, the shallow Bass Strait now separating Tasmania from Australia was dry land, and the people occupying Tasmania were part of the human population distributed continuously over an expanded Australian continent. When the strait was at last flooded around 10,000 years ago, Tasmanians and mainland Australians became cut off from each other because neither group possessed watercraft capable of negotiating Bass Strait. Thereafter, Tasmania's population of 4,000 hunter-gatherers remained out of contact with all other humans on Earth, living in an isolation otherwise knows only from science fiction novels. [...] Human populations of only a few hundred people were unable to survive indefinitely in complete isolation. A population of 4,000 was able to survive for 10,000 years, but with significant cultural losses and significant failures to invent, leaving it with a uniquely simplified material culture. (312-313)

European settlement reduced the number of [Australia's] Aborigines by two means. One involved shooting them, an option that Europeans considered more acceptable in the 19th and late 18th centuries than when they entered the New Guinea highlands in the 1930s.

The last large-scale massacre, of 31 Aborigines, occurred at Alice Springs in 1928. The other means involved European-introduced germs to which Aborigines had had no opportunity to acquire immunity or to evolve genetic resistance. Within a year of the first European settlers' arrival at Sydney, in 1788, corpses of Aborigines who had died in epidemics became a common sight. The principal recorded killers were smallpox, influenza, measles, typhoid, typhus, chicken pox, whooping cough, tuberculosis, and syphilis. (326)

How, except by postulating deficiencies in the Aborigines themselves, can one account for the fact that white English colonists apparently created a literate, food-producing, industrial democracy, within a few decades of colonizing a continent whose inhabitants after more than 40,000 years were still nonliterate nomadic hunter-gatherers? Doesn't that constitute a perfectly controlled experiment in the evolution of human societies, forcing us to a simple racist conclusion? The resolution of this problem is simple. White English colonists did not create a literate, food-producing, industrial democracy in Australia. Instead, they imported all of the elements from outside Australia: the livestock all of the crops (except macadamia nuts), the metallurgical knowledge, the steam engines, the guns, the alphabet, the political institutions, even the germs. All these were the end products of 10,000 years of development in Eurasian environments. By an accident of geography, the colonists who landed at Sydney in 1788 inherited those elements. Europeans have never learned to survive in Australia or New Guinea without their inherited Eurasian technology. (321)

... Russia, once a small Slavic state centered on Moscow, did not even begin its expansion beyond the Ural Mountains until A.D. 1582. From then until the 19th century, Russia proceeded to swallow up dozens of non-Slavic peoples, many of which retain their original language and cultural identity. (322-323)

... China appears politically, culturally, and linguistically monolithic, at least to laypeople. It was already unified politically in 221 B.C. and has remained so for most of the centuries since then. From the beginnings of literacy in China, it has had only a single writing system, whereas modern Europe uses dozens of modified alphabets. Of China's 1.2 billion people, over 8000 million speak Mandarin, the language with by far the largest number of native speakers in the world. Some 3000 million others speak seven other languages as similar to Mandarin, and to each other, as Spanish is to Italian. [...] While a coarse racial classification of world peoples lumps all Chinese people as so-called Mongoloids, that category conceals much more variation than the differences between Swedes, Italians, and Irish within Europe. In particular, North and south Chinese are genetically and physically rather different: North Chinese are most similar to Tibetans and Nepalese, while South Chinese are similar to Vietnamese and Filipinos. (323)

... in addition to China's eight “big” languages – Mandarin and its seven close relatives (often referred to collectively simply as “Chinese”), with between 11 million and 800 million speakers each – China also has over 130 “little” languages, many of them with just a few thousand speakers. All these languages, “big” and “little,” fall into four languages families, which differ greatly in the compactness of their distributions. (324)

... in contrast to western Eurasia, which produced a plethora of early writing systems, such as Sumerian cuneiform, Egyptian hieroglyphics, Hittite, Minoan, and the Semitic alphabet, China developed just a single well-attested writing system. It was perfected in

North China, spread and preempted or replaced any other nascent system, and evolved into the writing still used in china today. (331)

... tropical southeast Asia's former inhabitants may have been dark-skinned and curly-haired, like modern New Guineans and unlike the light-skinned, straight-haired South Chinese and the modern tropical southeast Asians who are their offshoots. (332-333)

... either tropical southeast Asians or South Chinese speaking Austronesian languages recently spread through the Philippines and Indonesia, replacing all the former inhabitants of those islands except the Philippine Negritos, and replacing all the original island languages. That event evidently took place too recently for the colonists to evolve dark skins, distinct language families, or genetic distinctiveness or diversity. (338)

... Taiwan is the homeland where Austronesian languages have been spoken for the most millennia and have consequently had the longest time in which to diverge. All other Austronesian languages, from those on Madagascar to those on Easter Island, would then stem from a population expansion out of Taiwan. (339)

To anyone interested in world history, human societies of East Asia and the Pacific are instructive, because they provide so many examples of how environment molds history. (352)

... the sole missing ingredients required to sustain food production in large areas of the Americas were domestic animals and crops themselves. (356)

- ... differences in food production constituted a major ultimate cause of the disparities between Eurasian and Native American societies. [...] Most of the microbes responsible for the infectious diseases of crowded human societies evolved from very similar ancestral microbes causing infectious diseases of the domestic animals with which food producers began coming into daily close contact around 10,000 years ago. Eurasia harbored many domestic animal species and hence developed many such microbes, while the Americas had very few of each.
- Rivaling germs as proximate factors behind Europe's conquest of the Americas were the differences in all aspects of technology.
- military technology was far more potent in Eurasia than in the Americas. [...] Eurasian societies enjoyed a huge advantage in their sources of power to operate machines. [...] Long before the wheel began to be used in power conversion in Eurasia, it had become the basis of most Eurasian land transport
- Eurasian and Native American societies differed in their political organization.
- The last proximate factor [...] is writing. [...] Writing empowered European societies by facilitating political administration and economic exchanges, motivating and guiding exploration and conquest, and making available a range of information and human experience extending into remote places and times. (357-360)

... the Indo-European language family, which includes English as well as French, Russian, Greek, and Hindi, comprises about 144 languages. Quite a few of those families occupy large contiguous areas – in the case of Indo-European, the area encompassing most of Europe east through much of the western Asia to India. [...] With the exception of the Eskimo-Aleut language family of the American Arctic and the Na-Dene language family of Alaska, northwestern Canada, and the U.S. Southwest, the Americas lack examples of

large-scale language expansions widely accepted by linguists. (368)

There were no Native American attempts to colonize Eurasia, except at the Bering Strait, where a small population of Inuit (Eskimos) derived from Alaska established itself across the strait on the opposite Siberian coast. (370-371)

The five major human groups to which Africa was already home by A.D. 1000 are those loosely referred to by laypeople as blacks, whites, African Pygmies, Khoisan, and Asians. [...] Blacks were formerly confined to Africa, Pygmies and Khoisan still live only there, while many more whites and Asians live outside Africa than in it. (378)

... the Pygmies and Khoisan, include hunter-gatherer without crops or livestock. Like blacks, Pygmies have dark skins and tightly curled hair. However, Pygmies differ from blacks in their much smaller size, more reddish and less black skins, more extensive facial and body hair, and more prominent foreheads, eyes, and teeth. Pygmies are mostly hunter-gatherers living in groups widely scattered through the Central African rain forest and trading with (or working for) neighboring black farmers. Formerly distributed over much of southern Africa [Khoisans] consisted not only of small-sized hunter-gatherers, known as San, but also of large herders, known as Khoi. [...] Both the Khoi and the San look (or looked) quite unlike African blacks: their skins are yellowish, their hair is very tightly coiled, and the women tend to accumulate much fat in their buttocks. [...] the present fragmented distribution of the 200,000 Pygmies, scattered amid 120 million blacks, suggests that Pygmy hunters were formerly wide spread through the equatorial forests until displaced and isolated by the arrival of black farmers. (379-380)

The large island of Madagascar lies only 250 miles off the East African coast [...] Madagascar's people prove to be a mixture of two elements. Not surprisingly, one element is African blacks, but the other consists of people instantly recognizable, from their appearance, as tropical Southeast Asians. Specifically, the language spoken by all the people of Madagascar – Asians, blacks, and mixed – is Austronesian and very similar to the Ma'anyan language spoken on the Indonesian island of Borneo, over 4,000 miles across the open Indian ocean from Madagascar. No other people remotely resembling Borneans live within thousands of miles of Madagascar. (380-381)

We're taught that Western civilization originated in the near East, was brought to brilliant heights in Europe by the Greeks and Romans, and produced three of the world's great religions: Christianity, Judaism, and Islam. Those religions arose among peoples speaking three closely related languages, termed Semitic languages: Aramaic (the language of Christ and the Apostles), Hebrew, and Arabic, respectively. We instinctively associate Semitic peoples with the Near East. However, Greenberg determined that Semitic languages really form only one of six or more branches of a much larger language family, Afroasiatic, all of whose other branches (and other 222 surviving languages) are confined to Africa. Even Even the Semitic subfamily itself is mainly African, 12 of its 19 surviving languages being confined to Ethiopia. This suggests that Afroasiatic languages arose in Africa, and that only one branch of them spread to the near East. Hence it may have been Africa that gave birth to the languages spoken by the authors of the Old and New Testament and the Koran, the moral pillars of Western civilization. (383)

... distributional and linguistic clues combine to suggest that the Pygmy homeland was

engulfed by invading black farmers, whose languages the remaining Pygmies adopted, leaving only traces of their original languages in some words and sounds. (383)

The [...] surprise is that all of Africa's indigenous crops – those of Sahel, Ethiopia, and West Africa – originated north of the equator. 9388)

Recent evidence suggests that cattle may have been domesticated independently in North Africa, Southwest Asia, and India, and that all three of those stocks have contributed to modern African cattle breeds. (389)

... between 9000 and 4000 B.C. the Sahara was more humid, held numerous lakes, and teemed with game. In that period, Saharans began to tend cattle and make pottery, then to keep sheep and goats, and they may also have been starting to domesticate sorghum and millet. Saharan pastoralism precedes the earliest known date (5200 B.C.) for the arrival of food production in Egypt, in the form of a full package of Southwest Asian winter crops and livestock. (390)

... Austronesians had arrived [in Madagascar] at least by A.D. 800, possibly as early as A.D. 300. There the Austronesians encountered (and proceeded to exterminate) a strange world of living animals as distinctive as if they had come from another planet, because those animals had evolved on Madagascar during its long isolation. They included giant elephant birds, primitive primates called lemurs as big as gorillas, and pygmy hippos. Archaeological excavations of the earliest human settlements on Madagascar yield remains of iron tools, livestock, and crops, so the colonists were not just a small canoeload of fishermen blown off course; they formed a full-fledged expedition. (392)

The proximate reasons behind the outcome of Africa's collision with Europe are clear. Just as in their encounter with Native Americans, Europeans entering Africa enjoyed the triple advantage of guns and other technology, widespread literacy, and the political organization necessary to sustain expensive programs of exploration and conquest. Those advantages manifested themselves almost as soon as the collisions started: barely four years after Vasco da Gama first reached the East African coast, in 1498, he returned with a fleet bristling with cannons to compel the surrender of East Africa's most important port, Kilwa, which controlled the Zimbabwe gold trade. But why did Europeans develop those three advantages before sub-Saharan Africans could? As we have discussed, all three arose historically from the development of food production. But food production was delayed in sub-Saharan Africa (compared with Eurasia) by Africa's paucity of domesticable native animal and plant species, its much smaller area suitable for indigenous food production, and its north-south axis, which retarded the spread of food production and inventions. (398)

... the striking differences between the long-term histories of peoples of the different continents have been due not to innate differences in the peoples themselves but to differences int heir environments:

- continental differences in the wild plant and animal species available as starting materials for domestication
- factors [...] affecting rates of diffusion and migration, which differed greatly among continents, [...] diffusion of technological innovations, insofar as they are best suited without modification to specific environment

- factors influencing diffusion between continents, which may also help build up a local pool of domesticates and technology
- continental differences in area or total population size (407)

All human societies contain inventive people. It's just that some environments provide more starting materials, and more favorable conditions for utilizing inventions, than do other environments. (408)

Why [...] did the fertile Crescent and China [...] lose their enormous leads of thousands of years to late-starting Europe? One can, of course, point to proximate factors behind Europe's rise: its development of a merchant class, capitalism, and patent protection for inventions, its failure to develop absolute despots and crushing taxation, and its Greco-Judeo-Christian tradition of critical empirical inquiry. Still, for all such proximate causes one must raise the question of ultimate cause: why did these proximate factors themselves arise in Europe, rather than in China or the Fertile Crescent? For the Fertile Crescent, the answer is clear. Once it had lost the head start that it had enjoyed thanks to ts locally available concentration of domesticable wild plants and animals, the Fertile Crescent possessed no further compelling geographic advantages. The disappearance of that head start can be traced in detail, as the westward shift in powerful empires. After the rise of Fertile Crescent states in the fourth millennium B.C., the center of power initially remained in the Fertile Crescent, rotating between empires such as those of Babylon, the Hittites, Assyria, and Persia. With the Greek conquest of all advanced societies from Greece east to India under Alexander the Great in the fourth century B.C., power finally made its first shift irrevocably westward. It shifter farther west with Rome's conquest of Greece in the second century B.C., and after the fall of the Roman Empire it eventually moved again, to western and northern Europe. (410)

Thus, Fertile Crescent and eastern Mediterranean societies had the misfortune to arise in an ecologically fragile environment. They committed ecological suicide by destroying their own resource base. Power shifted westward as each eastern Mediterranean society in turn undermined itself, beginning with the oldest societies, those in the east (the Fertile Crescent). Northern and western Europe has been spared this fate, not because its inhabitants have been wiser but because they have had the good luck to live in a more robust environment with higher rainfall, in which vegetation regrows quickly. Much of northern and western Europe is still able to support productive intensive agriculture today, 7,000 years after the arrival of food production. In effect, Europe received its crops, livestock, technology, and writing systems from the Fertile Crescent, which then gradually eliminated itself as a major center of power and innovation. That is how the Fertile Crescent lost its huge early lead over Europe. Why did China also lose its lead? Its falling behind is initially surprising, because China enjoyed undoubted advantages: a rise of food production nearly as early as in the Fertile Crescent; ecological diversity from North to South China and from the coast to the high mountains of the Tibetan plateau, giving rise to a diverse set of crops, animals, and technology; a large and productive expanse, nourishing the largest regional human population in the world; and an environment less dry or ecologically fragile than the Fertile Crescent's, allowing China still to support productive intensive agriculture after nearly 10,000 years, though its environmental problems are increasing today and are more serious than western Europe's. These advantages and head start enabled medieval China to lead the world in technology. The long list of its major technological firsts includes cast iron, the compass, gunpowder, paper, printing, and many others mentioned earlier. It also led the world in

political power, navigation, and control of the seas. In the early 15th century it sent treasure fleets, each consisting of hundreds of ships up to 400 feet long and with total crews of up to 28,000, across the Indian Ocean as far as the east coast of Africa, decades before Columbus's three puny ships crossed the narrow Atlantic Ocean to the Americas' east coast. Why didn't Chinese ships proceed around Africa's souther cape westward and colonize Europe, before Vasco da Gama's own three puny ships rounded the Cape of Good Hope eastward and launched Europe's colonization of East Asia? Why didn't Chinese ships cross the Pacific to colonize the Americas' west coast? Why, in brief, did China lose its technological lead to the formerly so backward Europe? The end of China's treasure fleets gives us a clue. Seven of those fleets sailed from China between A.D. 1405 and 1433. They were then suspended as a result of a typical aberration of local politics that cold happen anywhere in the world: a power struggle between two factions at the Chinese court (the eunuchs and their opponents). The former faction had been identified with sending and captaining the fleets. Hence when the latter faction gained the upper hand in a power struggle, it stopped sending fleets, eventually dismantled the shipyards, and forbade oceangoing shipping. The episode is reminiscent of the legislation that strangled development of public electric lighting in London in the 1880s, the isolationism of the United States between the First and Second World Wars, and any number of backward steps in any number of countries, all motivated by local political issues. But in China there was a difference, because the entire region was politically unified. One decision stopped fleets over the whole of China. That one temporary decision became irreversible, because no shipyards remained to turn out ships that would prove the folly of that temporary decision, and to serve as a focus for rebuilding other shipyards. (411-412)

From time to time the Chinese court decided to halt other activities besides overseas navigation: it abandoned development of an elaborate water-driven spinning machine, stepped back from the verge of an industrial revolution in the 14th century, demolished or virtually abolished mechanical clocks after leading the world in clock construction, and retracted from mechanical devices and technology in general after the late 15th century. Those potentially harmful effects of unity have flared up again in modern China, notably during the madness of the Cultural Revolution in the 1960s and 1970s, when a decision by one or a few leaders closed the whole country's schools systems for five years. (413)

... the real problem in understanding China's loss of political and technological preeminence to Europe is to understand China's chronic unity and Europe's chronic disunity. The answer is again suggested by maps. Europe has a highly indented coastline, with five large peninsulas that approach islands in their isolation, and all of which evolved independent languages, ethnic groups, and governments: Greece, Italy, Iberia, Denmark, and Norway / Sweden. China's coastline is much smoother, and only the nearby Korean Peninsula attained separate importance. Europe has two islands (Britain and Ireland) sufficiently big to assert their political independence and to maintain their own languages and ethnicities, and one of them (Britain) big and close enough to become a major independent European power. But even China's two largest islands, Taiwan and Hainan, have each less than half the area of Ireland; neither was a major independent power until Taiwan's emergence in recent decades; and Japan's geographic isolation kept it until recently much more isolated politically from the Asian mainland than Britain has been from mainland Europe. Europe is carved up into independent linguistic, ethnic, and political units by high mountains (the Alps, Pyrenees, Carpathians, and Norwegian border mountains), while China's mountains east of the Tibetan plateau

are much less formidable barriers. China's heartland is bound together from east to west by two long navigable river systems in rich alluvial valleys (the Yangtze and Yellow Rivers), and it is joined from north to south by relatively easy connections between these two river systems (eventually linked by canals). As a result, China very early became dominated by two huge geographic core areas of high productivity, themselves only weakly separated from each other and eventually fused into a single core. Europe's two biggest rivers, the Rhine and Danube, are smaller and connect much less of Europe. Unlike China, Europe has many scattered small core areas, none big enough to dominate the others for long, and each the center of chronically independent states. (413-414)

... societies developed differently on different continents because of differences in continental environments, not in human biology. Advanced technology, centralized political organization, and other features of complex societies could emerge only in dense sedentary populations capable of accumulating food surpluses – populations that depended for their food on the rise of agriculture that began around 8,500 B.C. But the domesticable wild plant and animal species essential for that rise of agriculture were distributed very unevenly over the continents. (426)